

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

on the

**Rapids Clubtail**  
*Gomphus quadricolor*

in Canada



**ENDANGERED**  
**2008**

**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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Production note:

COSEWIC would like to acknowledge Allan G. Harris and Robert F. Foster for writing the status report on the Rapids Clubtail (*Gomphus quadricolor*) in Canada, prepared under contract with Environment Canada. The report was overseen by Paul Catling, Co-chair, COSEWIC Arthropods Specialist Subcommittee.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le gomphe des rapides (*Gomphus quadricolor*) au Canada.

Cover illustration:

Rapids Clubtail — A male Rapids Clubtail (*Gomphus quadricolor*) photographed as it paused on a rock surrounded by rapids in the Mississippi River at Pakenham, Ontario (45.3445 N, 75.0115 W). Photo by P.M. Catling on 13 June 2001.

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## COSEWIC Assessment Summary

### Assessment Summary – April 2008

**Common name**

Rapids Clubtail

**Scientific name**

*Gomphus quadricolor*

**Status**

Endangered

**Reason for designation**

This distinctive species of dragonfly has a fragmented distribution with a very small extent of occurrence and area of occupancy, and is currently only found in small portions of two southern Ontario rivers. The species is believed to be extirpated at two historic sites and there is evidence for continuing decline of habitat.

**Occurrence**

Ontario

**Status history**

Designated Endangered in April 2008. Assessment based on a new status report.



**COSEWIC**  
**Executive Summary**

**Rapids Clubtail**  
*Gomphus quadricolor*

**Species information**

*Gomphus (Gomphus) quadricolor* Walsh 1863, Rapids Clubtail, is a member of the family Gomphidae, the clubtail dragonflies. It is a small dragonfly, with a wingspan of 25-27 mm and a contrasting pattern of brownish-black and yellowish-green stripes on the thorax. The abdomen is slender, but in males is expanded slightly at the tip.

**Distribution**

The range of *Gomphus quadricolor* includes Ontario and 25 states in the northeastern and northcentral U.S. The global maximum extent of occurrence encompasses about 1.7 million km<sup>2</sup>. In Canada, it was historically known from four sites in southern and eastern Ontario, but is extant at only two sites. Its extent of occurrence in Canada is about 1570 km<sup>2</sup> and its area of occupancy is approximately 26 km<sup>2</sup>.

**Habitat**

Larvae live in muddy pools in clear, cool streams. Adult males perch on rocks in rapids. Adult females inhabit forests on the riverbanks, moving to the rapids when ready to mate.

**Biology**

Adult *Gomphus quadricolor* fly between early June and early July in Ontario and live about three to four weeks. Mating takes place over the river and females deposit eggs on the water surface over rapids. Eggs or recently hatched larvae are carried downstream to pools. Larvae spend most of their time buried just below the surface of the sediment in the bottom of the pool, breathing through the tip of the abdomen raised above the sediments.

The duration of the larval stage of *Gomphus quadricolor* is unknown, but is probably two or more years. Before the final moult, larvae crawl onto vegetation on the edge of the stream. Newly emerged adults disperse inland to avoid predation until the exoskeleton hardens and they are able to fly swiftly.

Adults are generalist and opportunist predators, feeding on small flying insects. Larvae ambush prey from the sediments using their prehensile labium to capture it.

### **Population sizes and trends**

*Gomphus quadricolor* is believed extirpated at two of its four known Canadian sites. The Canadian population is estimated at a minimum of 318 individuals including 106 adults. Although only adult males were observed for population estimates at the two extant sites, equal numbers of adult males and females were assumed to be present at each site and that for every adult there were at least two larvae (based on the assumption of a three-year life cycle). The number of larvae is thus a minimum estimate.

### **Limiting factors and threats**

Habitat degradation is the most significant threat to *Gomphus quadricolor*, although accidental deaths through vehicle collisions may be significant. Impoundment of running waters by dams, pollution, and introduction of exotic species are potential threats in all known Canadian sites.

### **Special significance of the species**

Stream-dwelling gomphids in general are potential indicators of well-oxygenated, unpolluted streams. Although *Gomphus quadricolor* is too uncommon and obscure through most of its range to be known by most people, dragonflies in general are increasingly popular as indicated by increasing numbers of field guides and organized dragonfly count events.

### **Existing protection or other status designations**

*Gomphus quadricolor* is ranked globally as G3G4. Nationally, it is ranked as N1 in Canada and N3N4 in the U.S., but is not protected under the endangered species legislation in either country. In Ontario it is ranked as S1 and is mostly ranked as S1 or S2 in the 25 states in which it occurs and is secure (S4) only in Wisconsin. No known Canadian sites are within provincial or federal parks, but the Humber River site is surrounded by land owned by a conservation authority. River habitats in Canada are nominally protected under the federal *Fisheries Act* with respect to fish habitat.



### 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 (2008)

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 Canada  
Canadian Wildlife Service

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Service canadien de la faune

Canada

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

# **COSEWIC Status Report**

on the

## **Rapids Clubtail** *Gomphus quadricolor*

**in Canada**

2008

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## SPECIES INFORMATION

Kingdom: Animalia - Animal, animals, animaux  
Phylum: Arthropoda - arthropodes, arthropods, Artrópode  
Subphylum: Hexapoda - hexapods  
Class: Insecta - hexapoda, insectes, insects, insecto  
Subclass: Pterygota - insects ailés, winged insects  
Infraclass: Palaeoptera - ancient winged insects  
Order: Odonata Fabricius, 1793 - damselflies, dragonflies, libélula  
Suborder: Anisoptera Selys, 1854 - dragonflies, libellules  
Family: Gomphidae - clubtails, Clubtails  
Genus: Gomphus Leach, 1815  
Subgenus: Gomphus (Gomphus) Leach, 1815  
Species: *Gomphus quadricolor* Walsh, 1863 - Rapids Clubtail

### Name and classification

*Gomphus (Gomphus) quadricolor* Walsh 1863, or Rapids Clubtail (Figure 1), is a member of the family Gomphidae, the clubtail dragonflies, and the order Odonata, the dragonflies and damselflies. The type species for this genus is the Eurasian *G. vulgatissimus* (Linnaeus 1758), and much of the controversy regarding the taxonomy of North American *Gomphus s. lat.* results from the continuing uncertainty about which species, if any, belong with *G. vulgatissimus* (Needham *et al.* 2000). Most authors treat *G. quadricolor* as belonging to the subgenus *Gomphus* (Leach 1815). However Carle (1986) placed this species and the 16 other North American *Gomphus s. str.* within a new subgenus *Phanogomphus*. *G. alleni* Howe 1922 is a synonym. Recent North American authors use the name "*G. quadricolor*". No subspecies of *G. quadricolor* are recognized and the species is distinct.

### Morphological description

*Gomphus quadricolor* is a small dragonfly, with a wing length of 25-27 mm (Needham *et al.* 2000). The face is light green with two transverse dark lines. The thorax has a contrasting colour-pattern of brownish-black and yellowish green stripes. The dorsal pale thoracic stripe has a small pale spot off its posterior end. The slender abdomen is black with mostly linear yellow spots on the top of the first seven segments and small lateral spots. It usually lacks dorsal spots on the last three abdominal segments, but will rarely have a small yellow dot on the 8<sup>th</sup> or 10<sup>th</sup> segments. The 7<sup>th</sup> to 9<sup>th</sup> abdominal segments are expanded slightly in males, less so in the females, with large yellow lateral spots on the sides of the 8<sup>th</sup> and 9<sup>th</sup> segments. The legs and claspers are all black.

The anterior hamule of the male's secondary genitalia is sickle-shaped, terminating in a slender hook. The vulvar lamina of the female is short, less than 1/6 the length of the 9<sup>th</sup> abdominal segment and V-notched to nearly its base. Illustrations of the diagnostic shape of the male and female genitalia are presented in Walker (1958).

Larvae (Figure 2) have a lanceolate abdomen with lateral spines on the sixth to ninth segments, vestigial dorsal hooks distinct only on the ninth and tenth segments, and well-developed tibial burrowing hooks (Walker 1932). *G. quadricolor* larvae are similar to but smaller than those of *G. spicatus* (Dusky Clubtail) and *G. exilis* (Lancet Clubtail).

*Gomphus quadricolor* may be confused with other small gomphids in its range, but they have a yellow dorsal stripe on the 9<sup>th</sup> abdominal segment and/or differ in the shape of the genitalia. *G. adelphus* (Mustached Clubtail) and *G. viridifrons* (Green-faced Clubtail) are similar but the tip of the male's anterior hamule is blunt and the female's vulvar lamina is much longer (Catling and Brownell 2000). *G. spicatus* (Dusky Clubtail) and *G. descriptus* (Harpoon Clubtail) are slightly larger, have some yellow on their legs, and more extensive yellow abdominal markings.



Figure 1. *Gomphus quadricolor* (male) at Humber River, 2005.

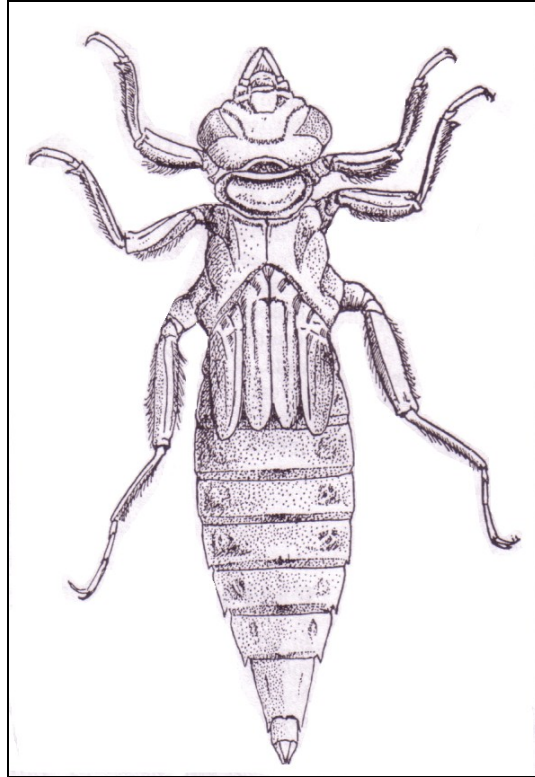


Figure 2. *Gomphus quadricolor* male larva (Walker 1932). Reproduced with permission of the Entomological Society of Canada.

### **Genetic description**

Genetic studies have not been conducted in this species.

## **DISTRIBUTION**

### **Global range**

The range of *Gomphus quadricolor* includes Ontario and 25 states in the United States but there appear to be large areas of unsuitable habitat within this range where the species does not occur. The global maximum extent of occurrence encompasses about 1.7 million km<sup>2</sup>. Most populations are in the U.S. Midwest but its range extends from northern Alabama and Georgia to southern Ontario and from Maine, west to eastern Minnesota (Figure 3). Populations have been discovered in Ontario and several states in recent years. It is extirpated from Illinois, where the species was originally described (Tim Cashatt pers. comm. 2007). *Gomphus quadricolor* is probably most common in northern Wisconsin (30 counties; William Smith pers. comm. 2007), Ohio (17 counties; Robert Glotzhober pers. comm. 2007), and Minnesota (6 counties; Richard Baker and Wayne Steffens pers. comm. 2007).

## Canadian range

The known historical Canadian range of *Gomphus quadricolor* consists of four rivers in southern and eastern Ontario: the Thames, Humber, Credit and Mississippi (Figure 4). Walker (1958) collected adults and larvae near Erindale on the Credit River between 1926 and 1939. He also collected exuviae on the Humber River near Kleinburg in 1939. There were no subsequent known Canadian records until 1989, when the species was collected on the Thames River between London and Ingersoll. In 2001, *Gomphus quadricolor* was discovered on the Mississippi River at two locations 8 km apart (Catling and Brownell 2002). The Credit, Humber, and Thames rivers are in the Mixedwoods Plain Ecozone, while the Mississippi River site is on the border between the Boreal Shield Ecozone and the Mixedwood Plains Ecozone (Environment Canada 2007). The Boreal Shield has a colder climate and typically shallower soils over Precambrian granitic bedrock. The Mixedwoods Plain has a greater proportion of hardwood tree species, but has been largely cleared since the early 1800s.

No *Gomphus quadricolor* were detected on the Thames or Credit rivers during a 2005 survey or in several other surveys (P. Catling, P. Pratt and others) of these rivers over the past decade and these populations are believed to be extirpated (Harris and Foster 2006). The Humber River population was extant in 2005 (Harris and Foster 2006). A survey of potential habitat on the Sydenham, Ausable, and Grand rivers in 2005 and a search of the Ontario Odonata Atlas database (2005) found no additional sites for the species.

The Humber River site extends over about 4.5 km of river. The Mississippi River sites where adults have been observed include a 50 m long stretch of rapids at Pakenham and a 200 m long rapids at Blakeney Rapids (Catling and Brownell 2002). The two Mississippi River sites are treated as a single occurrence since they are connected by a continuous stretch of river habitat with a minimum separation distance of less than 10 km (NatureServe 2007). In the Humber, only adult males were observed. Females are difficult to detect because they disperse to forest cover after emerging. Both sexes have been observed at the Mississippi River.

The maximum extent of occurrence (EO) in Canada (including the Thames and Credit sites) encompasses 94 km<sup>2</sup> in a narrow strip 460 km long and up to 34 km wide. The maximum area of occupancy (AO) encompasses 26 km<sup>2</sup> consisting of an 800 m zone on either side of the river length occupied by the species (800 m is the approximate maximum known dispersal distance inland for *Gomphus quadricolor*).

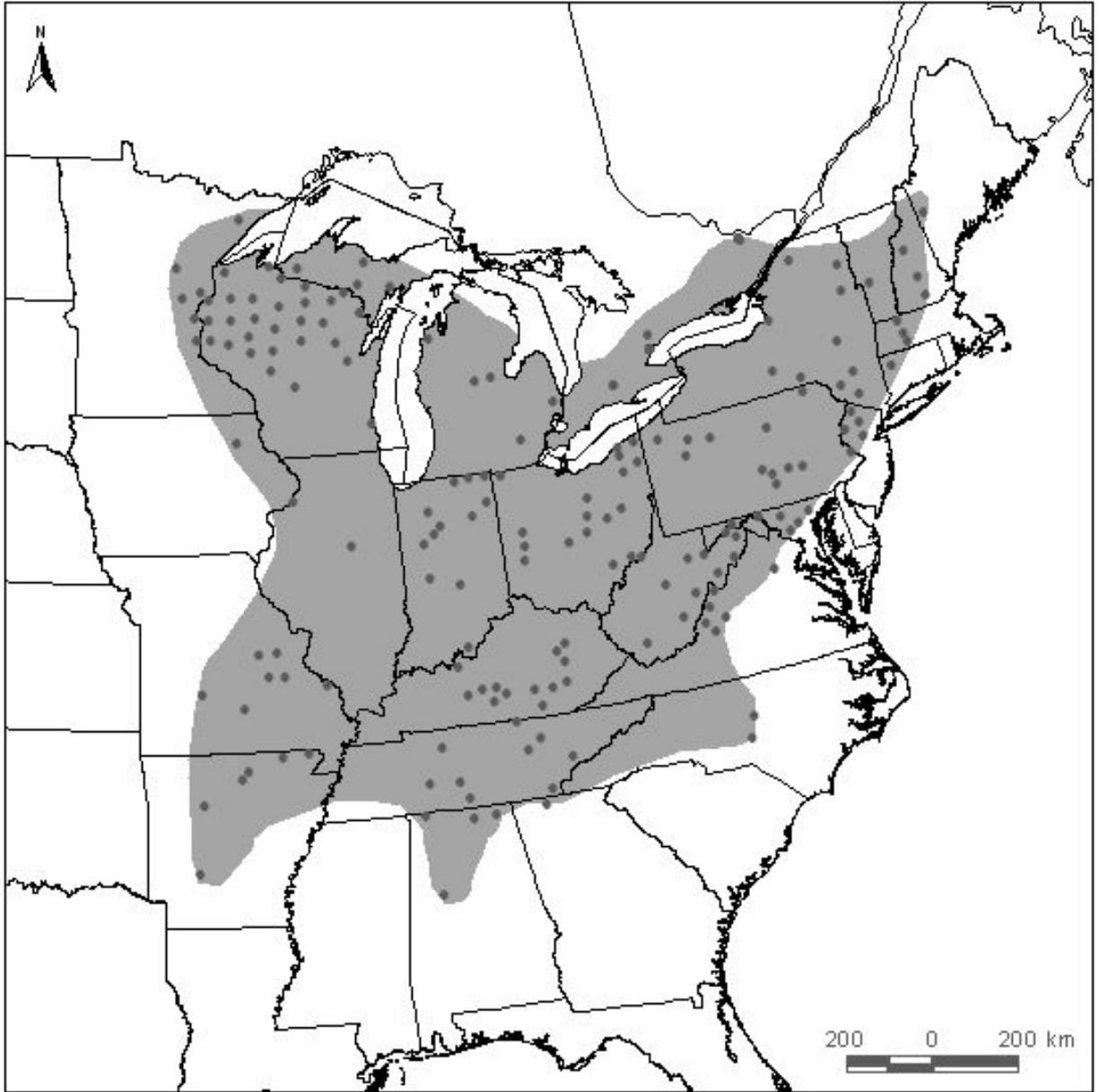


Figure 3. Distribution of *Gomphus quadricolor* in North America (based on Donnelly 2004).

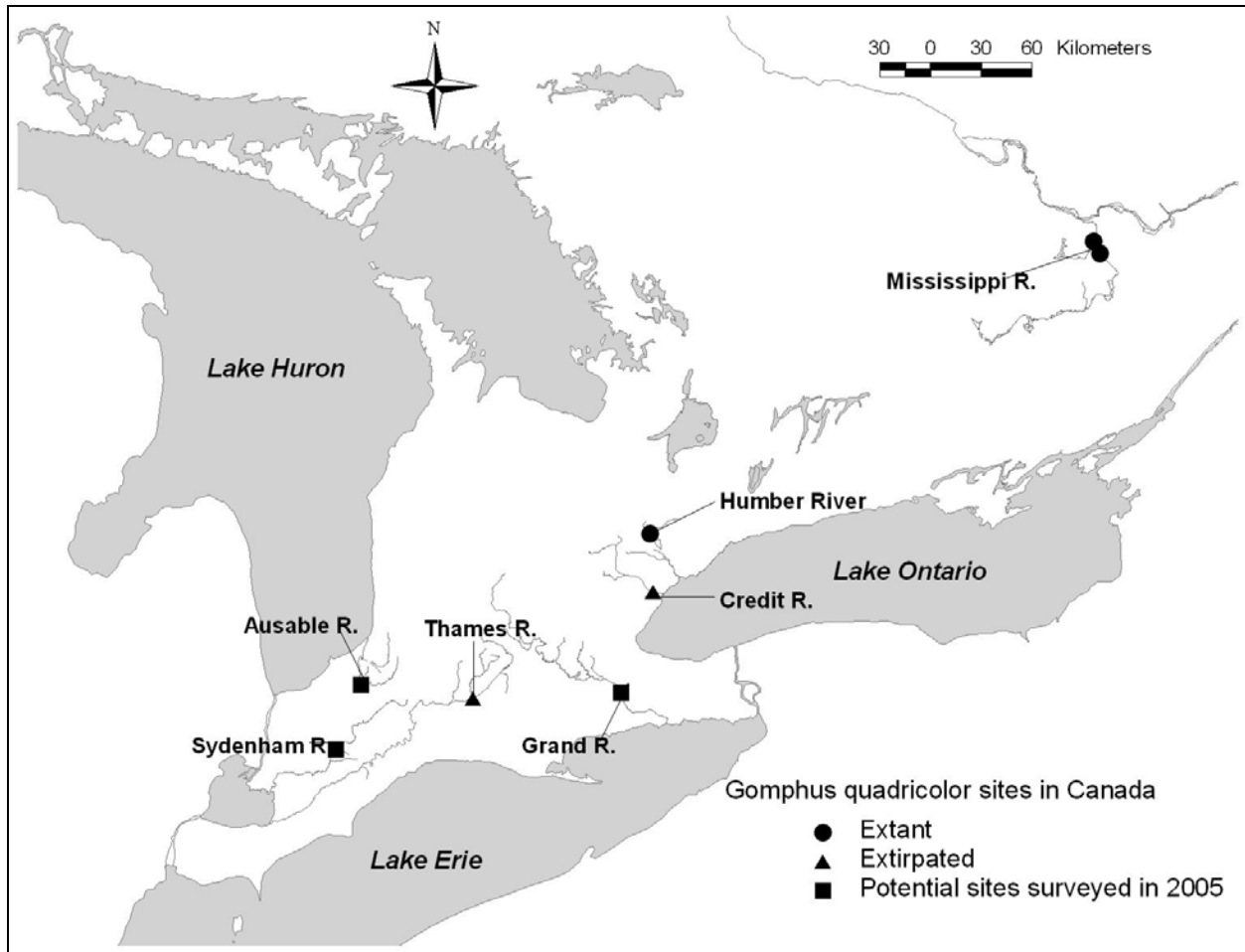


Figure 4. Distribution of *Gomphus quadricolor* in Canada.

## HABITAT

### Habitat requirements

*Gomphus quadricolor* inhabits medium to large streams and rivers. The four Ontario rivers where this species has been recorded have mean annual discharge levels of 2.5 to 31 m<sup>3</sup>/sec (Figure 5, Table 1). The Mississippi is the largest and shows much more year to year variability than the other rivers. The rivers are typically clear and cool, with gravel and cobble riffles and projecting boulders interspersed with muddy pools (Walker 1958, Cuthrell 2000, Tim Cashatt pers. comm. 2007). The species occurs in some sluggish mud-bottomed rivers in Wisconsin (Wisconsin Odonata Survey 2007). The river channels at the Credit, Mississippi, and Thames River sites are 30 to 50 m wide, while the Humber site is about 20 m wide (Figure 6) (Catling and Brownell 2002, Harris and Foster 2006). The Mississippi River has the clearest water (lowest turbidity and suspended solids) and the lowest biological oxygen demand and chloride concentrations (Table 1). Mean July water temperature of the four rivers is 21 to 23 °C (Table 1).

Interspersion of small rapids or riffles with quiet muddy pools is probably important for *Gomphus quadricolor*. Oviposition occurs over rapids and eggs or young larvae drift downstream to quiet pools, as is a common pattern among gomphids (Walker 1958). At the Humber River, most male *Gomphus quadricolor* were observed on exposed boulders in gravel and cobble riffles 10 to 30 cm deep. Riffles were interspersed with pools with a soft, clay substrate (Figure 6) (Harris and Foster 2006). Rapid and riffle habitat on the Mississippi River is isolated by long sections of slow-moving river (Catling and Brownell 2002). The historical sites on the Credit and Thames rivers are similar (Harris and Foster 2006) to the Humber site. All known Ohio sites have steep cliff faces on the stream banks (Larry Rosche pers. comm. 2007).

Adult males preferentially use boulders or bedrock protruding from the river as perches from which they make short flights over the riffle, repeatedly returning to the same stone (Walker 1958, Catling and Brownell 2002, Larry Rosche pers. comm. 2007). Shoreline rocks or vegetation may also be used, particularly where mid-stream boulders are absent.

Larvae are typically found in quiet muddy pools downstream from shallow rapids. Patches of *Typha* and other emergent vegetation may be present (Walker 1958). Larvae probably burrow into the top few centimetres of the bottom sediment, as do most Gomphidae (Corbet 1999). Larvae crawl into dense grass and other emergent vegetation on the riverbank before moulting into adults (Walker 1958).

Forest cover on the riverbank provides cover for teneral and adult females, which disperse from the river after emerging. Female *Gomphus quadricolor* move as much as 800 m inland from the edge of the river in Ohio (Larry Rosche pers. comm. 2007).



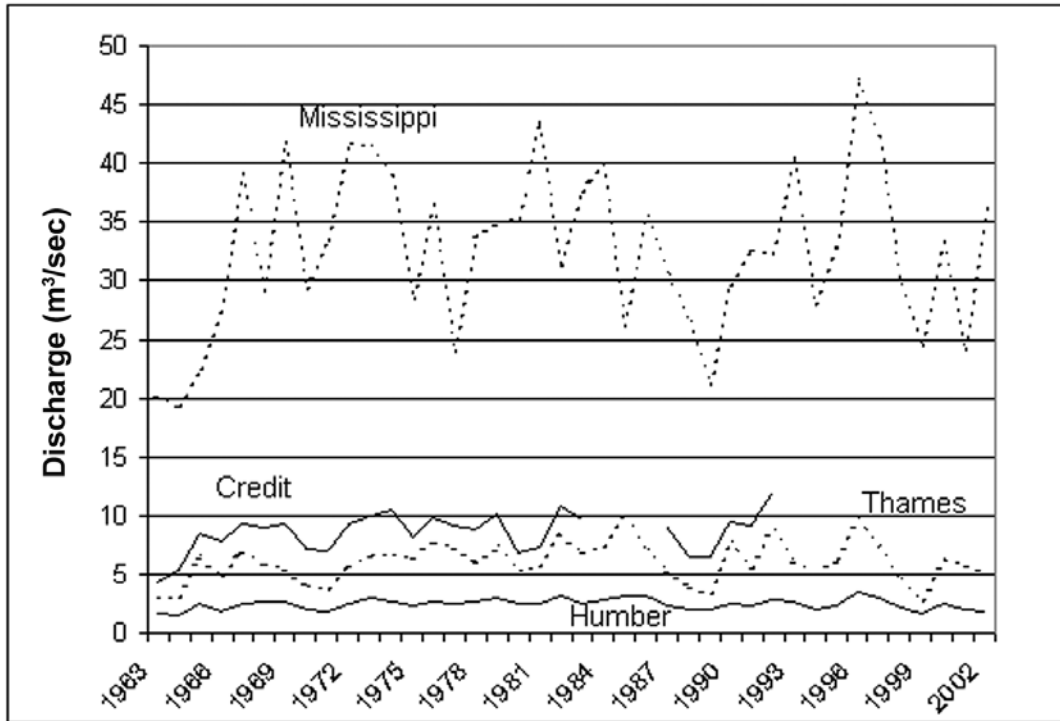


Figure 5. Mean annual discharge of four Ontario rivers where *Gomphus quadricolor* has been recorded (data from Water Survey of Canada 2007). Monitoring stations are as follows: Credit River at Erindale, Humber River at Eden Mills, Mississippi River at Appleton, Thames River at Ingersoll.

**Table 1. Water quality attributes of four Ontario rivers where *Gomphus quadricolor* has been recorded (data from Water Survey of Canada 2007 and Ontario Ministry of Environment 2007).**

	Mean July Water Temp. (°C)	Mean Annual Discharge (m³/s)	Surface Water Biological Oxygen Demand (mg/l)	Turbidity (Jackson Turbidity Unit)	Suspended Solids (mg/l)	Chloride (mg/l)
Credit	23.1	8.1	1.8	20.5	38.5	51.2
Humber	21.8	2.5	1.6	20.3	32.9	23.1
Mississippi	23.3	31.4	0.8	2.8	3.0	6.4
Thames	21.6	5.8	2.7	14.0	29.6	61.1

The specific locations (all within a km of the location of the *G. quadricolor* population) and their durations are: South Thames River downstream from Ingersoll, N of County Rd 9 (1975 to 2006); Credit River at Dundas St. W, E of Mississauga Rd., Erindale (1965 to 1995); Humber River at Caledon King Townline, Bolton (1964 to 1988); Mississippi River at dam, downstream of Pakenham (1970 to 2006).



Figure 6. *Gomphus quadricolor* habitat on the Humber River, June 2005.

### Habitat trends

Much of the Canadian and global range of *Gomphus quadricolor* has been subject to intensive agricultural and urban development since the early 1800s. Such development can alter the aquatic environment by increasing water temperatures, altering stream chemistry, and increasing sedimentation.

The Credit River watershed is one of the most rapidly urbanizing parts of Canada with the vast majority of the forest cover having been cleared (Credit Valley Conservation 2004). The South Thames River subwatershed has only 11% forest cover (Upper Thames River Conservation Authority 2001), while the Humber River watershed has 17% forest cover (Humber Watershed Alliance 2000). In contrast, the Mississippi River watershed is about 70% forested and forest cover has been increasing since the early 1900s as abandoned farmland reverts to forest (Alex Broadbent pers. comm. 2007). Loss of forest cover on the riverbanks has been extensive. Forest cover at the Credit, Thames, and Humber river *Gomphus quadricolor* sites is mostly discontinuous and less than 50 m wide.

Dams have been in place on many southern Ontario streams since the mid-1800s for recreation, mills, and hydroelectricity generation. Potential impacts on *Gomphus quadricolor* habitat include the loss of riffle habitat in reservoirs, higher water temperatures (as groundwater-fed streams are held in reservoirs), and sediment accumulation resulting from the loss of flushing effect from spring freshets. Alteration of floodplain vegetation could impact habitat for adults. All four Ontario rivers are regulated for flood control, but the effects are most evident on the Credit and Humber where spring peak flows have been truncated to minimize downstream flooding.

Another stream-dwelling gomphid, *Ophiogomphus rupinsulensis*, is commonly associated with *Gomphus quadricolor* in Ontario. *Ophiogomphus rupinsulensis* was observed historically on the Credit River at Erindale, Streetsville, and Meadowvale, and 50 km upstream at The Forks, but none have been recorded on the Credit River since the 1920s. This is suggestive of habitat deterioration because most *Ophiogomphus* species are intolerant of pollution (Bode *et al.* 1996), although *O. rupinsulensis* is probably the most pollution-tolerant member of the genus (P. Brunelle pers. comm. 2007). Also suggestive of habitat deterioration on both the Credit and Humber Rivers is the decline of certain species of mayflies and other aquatic insects that are now limited to only a few short stretches (H. Frania, Royal Ontario Museum, pers. comm. to P.M. Catling, 2006). Over the past few years local residents have reported a substantial decline in volume of both of these rivers.

Water quality in most southern Ontario streams has been altered due to urban and agricultural runoff, which probably has had impacts on *Gomphus quadricolor* larvae. Chloride concentrations associated with road salting, sewage treatment plant effluent, and other human sources are increasing in the Credit, Humber, and Thames rivers and probably other southern Ontario rivers. Spikes in chloride levels in the Humber River are high enough to impact sensitive aquatic species (Credit Valley Conservation 2004, Todd and Kaltnecker 2004). Phosphorus levels in the Thames and Humber rivers consistently exceed the provincial water quality objective of 30 ug/l, and Ontario rivers are generally declining in water quality (Todd and Kaltnecker 2004, D'Amelio 2007). Nitrate levels in the Thames River routinely exceed the Canadian water quality guideline (2.9 mg/l) for protection of aquatic species (Todd and Kaltnecker 2004, D'Amelio 2007). Dragonfly larvae are sensitive to Biological Oxygen Demand (BOD) levels in excess of 10 mg/l (Corbet 1999). Surface water BOD in excess of this value has been reported only once at water monitoring stations on the four rivers. This was on the Credit River in March 1989.

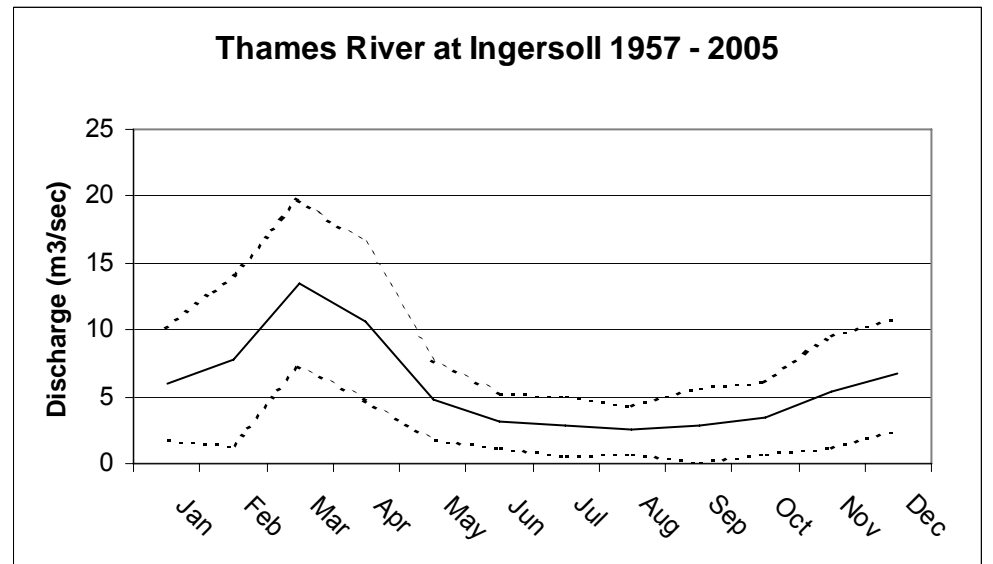
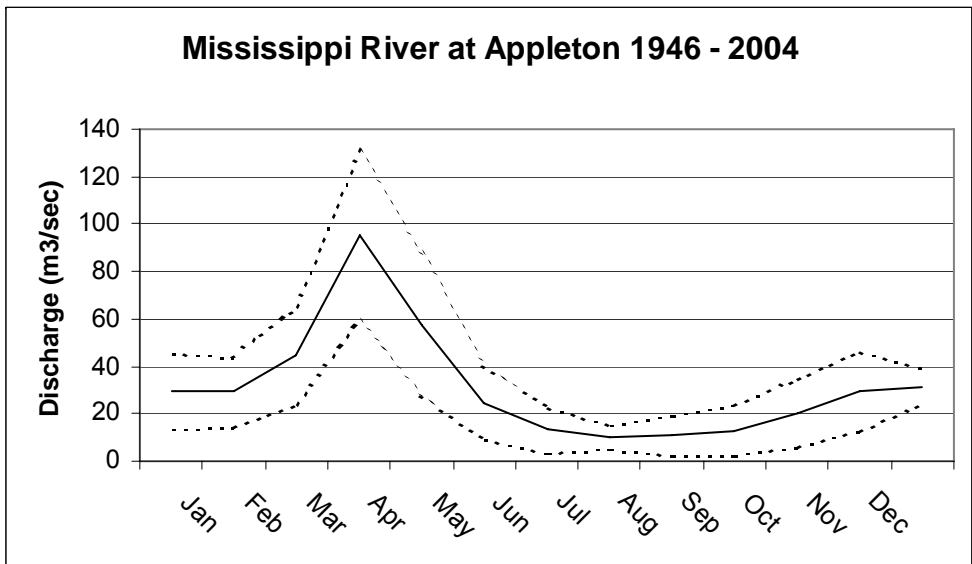
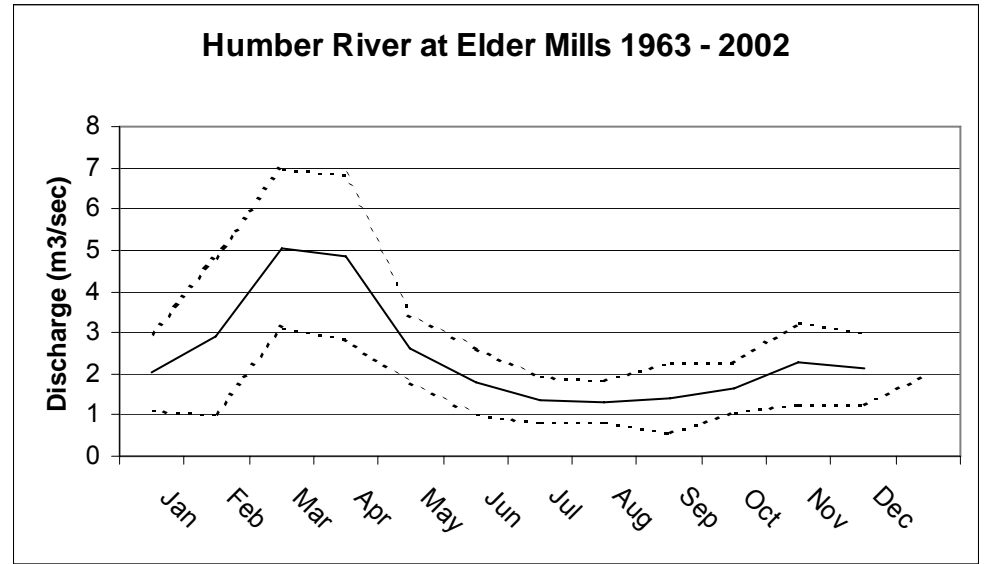
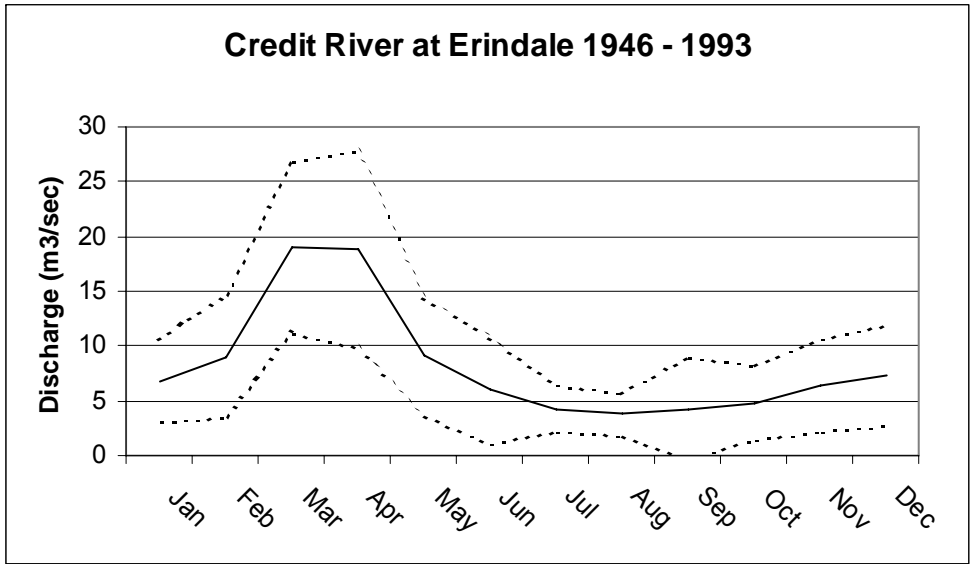


Figure 7. Hydrographs for rivers (Water Survey of Canada 2007). Dotted lines = Mean +/- 1 standard deviation.

## **Habitat protection/ownership**

Most of the land surrounding the Humber River site is owned by the Toronto Region Conservation Authority (Humber Watershed Alliance 2000). Lands adjoining the Credit River site include a municipal park and the University of Toronto Erindale campus. The Thames River site is surrounded by private land. The Mississippi River sites are surrounded by private land and municipal parks.

Most of the land upstream of the Humber, Credit and Thames sites is in private ownership. The watershed of the Mississippi River is a mixture of private and crown land.

All sites are potentially at risk from urban development, agricultural runoff and water level regulation in the watershed. The Oak Ridges Moraine Conservation Plan provides some protection of water quality and habitat connectivity for parts of the headwaters of the Humber and Credit rivers (MMAH 2007). Conservation authorities at all sites monitor water quality and invasive species and work with municipalities and landowners to protect the river environment.

## **BIOLOGY**

Little information is available about many aspects of *Gomphus quadricolor* biology. Much of the information in this section was derived from descriptions of other riverine gomphids in Walker (1958), supplemented with information on behaviour and ecology from Corbet (1999).

### **Life cycle and reproduction**

The dragonfly life cycle consists of an aquatic larval stage and terrestrial adult stage. Adult *Gomphus quadricolor* fly between early June and early July in Ontario and from early May to late July in the U.S. midwest (Walker 1958, Cuthrell 2000). Adults live about three to four weeks, while the larvae probably live two to four years. Generally, adult gomphids are active in daytime, and inactive at dusk and on dull days (Walker 1958).

Adult males typically perch on rocks in midstream, making short forays over the riffles to forage, find mates and drive away competitors. Females inhabit the forest adjacent to the river, perching in trees and shrubs and basking in grassy clearings and bare sandy spots up to 800 m inland from the river (Walker 1958, Larry Rosche pers. comm. 2007). They move to the river only when ready to breed. As a consequence of their more cryptic behavior, adult females are far less frequently collected than males (Walker 1958).

Before copulation, the male transfers sperm from the end of the abdomen to the secondary genitalia beneath the second abdominal segment. The male patrols over the rapids until encountering a female. The courtship flight, if any, is undescribed. After grasping the female by the thorax with his legs, the male clasps the female at the base of her head with his abdominal claspers. The pair flies in tandem while the female bends her abdomen forward so that her ovipositor contacts the male's secondary genitalia, where she picks up the sperm. The pair separate shortly thereafter. Unlike some dragonfly species, the females of *Gomphus quadricolor* oviposit unattended by males, typically flying low over rapids and depositing eggs at irregular intervals on the water surface (Walker 1958). On average, female dragonflies deposit 200 to 300 eggs, but over 5000 were produced by a female *Gomphus externus* (Plains Clubtail - Walker 1953).

Eggs probably require at least five days and perhaps up to a month or more to hatch (Walker 1953, Corbet 1999). Eggs or recently emerged larvae are carried downstream to pools. Larvae spend most of their time buried just below the surface of the sediment in the bottom of the pool, breathing through the tip of the abdomen raised above the sediments.

The duration of the larval stage of *Gomphus quadricolor* is unknown, but the presence of two or more size classes of larvae in Wisconsin streams suggests that the larval stage lasts two or more years (William Smith pers. comm. 2007). Larval sizes suggest a two-year life cycle farther south in Tennessee and Alabama (Ken Tennessen pers. comm. 2007). Species of *Gomphus* and *Ophiogomphus* at temperate latitudes in Europe require at least three to four years to reach adulthood (Walker 1953, Corbet *et al.* 1960). Duration of the larval stage may be shorter where food is abundant.

Before the final moult, larvae crawl onto vegetation on the edge of the stream. Newly emerged adults (teneral) disperse inland to avoid predation until the exoskeleton hardens and they are able to fly strongly. After a period of feeding (generally lasting a week or more in other dragonfly species), adult males return to the stream to establish territories (Walker 1953).

Adults are generalist opportunist predators, feeding on flying small insects, especially Trichoptera, Ephemeroptera, small Lepidoptera, and Diptera (Walker 1953). Males feed on prey species emerging from streams, while females perch on the ground in patches of sunlight in forest making short flights to capture aerial insects. Larvae ambush prey from the sediments using their prehensile labium. Early instars feed on very small prey (e.g. ciliates and rotifers) and the size of the prey increases as the larvae grow. Larger larvae feed on macroinvertebrates, small fish, and tadpoles.

## Predation

Predators on adult dragonflies include birds (especially small raptors such as American kestrel, merlin, and sharp-shinned hawk), frogs, larger dragonflies, and spiders (Walker 1953).

Fish are probably the most significant predators on stream-dwelling dragonfly larvae (Corbet 1999). Waterbirds, including pied-billed grebe, mallard, American black duck, and wood duck, all consume large numbers of odonate larvae (Walker 1953). Blackbirds, swallows and particularly purple martins take newly emerged adult dragonflies, and these birds often occur in higher numbers in residential areas. Wading birds, especially herons, also feed on larvae. Insect predators include larvae of larger dragonflies, aquatic hemiptera, and aquatic beetles. Turtles and amphibians (including frogs and mudpuppies) also eat larvae.

Several introduced species of fishes inhabiting the Humber and Credit rivers are potential predators on *Gomphus quadricolor* larvae and could limit their populations or impede their restoration. The most significant of these may be brown trout, rainbow trout, species of pacific salmon, common carp, and round goby. Common carp and round goby also inhabit the Thames River. Degrading water quality could cause further shifts in fish species composition with unknown impacts on odonate populations.

Odonates have few known host-specific parasites (Corbet 1999). Parasitic mites attack adults of some odonate species and egg parasites (Hymenoptera; Chalcidoidea) have also been documented (Walker 1953).

## Physiology

Physiological requirements of *Gomphus quadricolor* are not documented. The preferred habitat of the species is generally considered to be cool, clear streams (e.G. Cuthrell 2000, NHESP 2003). The Humber River site is fairly turbid and possibly warmer than usual but would still be considered cool by stream biologists. Biological oxygen demand (BOD) greater than 10 mg/l cannot be tolerated by most odonate larvae (Corbet 1999).

Larvae are probably sensitive to pesticides, especially organochlorides and organophosphates (Corbet 1999). Metals, chloride, and lampricides may also affect larvae in southern Ontario rivers. 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.

## Dispersal/migration

Adults are capable of strong flight. The average distance travelled between reproductive and roosting or foraging sites is generally < 200 m in dragonflies (Corbet 1999). Maiden flights of up to 800 m into surrounding forest have been recorded for *Gomphus quadricolor* (Larry Rosche pers. comm. 2007). No migratory behaviour has been observed for this or any other North American gomphid.

Other stream-dwelling odonates tend to remain close to their breeding sites, moving short distances upstream and downstream and very short distances inland (Corbet *et al.* 1960). Unlike odonates inhabiting ephemeral pools or other seasonal habitats, *Gomphus quadricolor* lives in relatively stable habitats where the requirement for dispersal is lower and the likelihood of finding unoccupied suitable habitat is small. Their flight behaviour of remaining close to the river surface or in forest cover makes them less vulnerable to passive dispersal by winds than odonates that habitually swarm above the canopy. Downstream dispersal of eggs or young larvae by river currents could result in establishment of new populations where suitable unoccupied habitat exists.

All known current and historical Canadian sites are separated by 40 to 300 km from the nearest population in Canada or the U.S. and probably constitute separate populations.

## Interspecific interactions

*Gomphus quadricolor* has no known symbiotic relationships. Both adults and larvae are probably generalist predators, feeding on a wide range of prey species within the suitable size range.

*Gomphus quadricolor* typically coexists with other riverine species of odonates, especially *Calopteryx maculata* and *Ophiogomphus rupinsulensis*, which are known at both extant Ontario sites. Larvae of these species may compete for prey with *Gomphus quadricolor* but adults may minimize competition by foraging more widely and having somewhat different emergent periods. These other odonate species may also reduce predation on *Gomphus quadricolor* by distracting predators from that species.

## Adaptability

The disappearance of *Gomphus quadricolor* from two Canadian sites and some U.S. sites (Table 2) suggests that it is unable to adapt to the pressures of broad landscape changes. No artificial rearing has been attempted, but late instar larvae have been raised to adulthood in the laboratory (Walker 1932).



**Table 2. Province and state ranks for *Gomphus quadricolor* (NatureServe 2007).**

Province / State	S-Rank	Notes
Ontario	S1	
Alabama	S3S4	Historically known from 4 counties, but declining (R. Stephen Krotzer pers. comm. 2007). Proposed reranking to S1 (Jim Godwin pers. comm. 2007)
Arkansas	SNR	Known from 4 counties (Missouri Odonata 2007)
Connecticut	S1	2 recent observations. Recently revised from SH (Dawn M. McKay pers. comm. 2007)
Georgia	S1	1 record (Giff Beaton pers. comm. 2007)
Illinois	SNR	No records since early 1900s (Tim Cashatt pers. comm. 2007)
Indiana	S2	3 sites on Pigeon River, most recently from 1995 (Tom Swinford, Roger Hedge pers. comm. 2007)
Iowa	S1	No recent records (Daryl Howell pers. comm. 2007)
Kentucky	S2S3	
Maine	S1	1 known population. Recommended for Endangered status (Phillip deMaynadier pers. comm. 2007)
Maryland	S1	
Massachusetts	S1	Known from 2 sites. Ranked as Threatened (Michael W. Nelson, pers. comm. 2007)
Michigan	S2S3	Known from 8 sites in 6 counties. Ranked as Special Concern (Cuthrell 2000).
Minnesota	SNR	Records from 6 counties. Likely will be revised to S4 or S5 (Richard Baker pers. comm. 2007, Wayne Steffens pers. comm. 2007)
Missouri	SNR	
New Hampshire	SNR	5 records (Pamela Hunt, Jeffery Tash pers. comm. 2007)
New Jersey	S2	3 discrete populations, 2 of which are apparently declining (Allen Barlow pers. comm. 2007)
New York	S1S2	7 records, 2 of which are historical only (Jeffrey D. Corser pers. comm. 2007)
North Carolina	S1S2	2 records (Steve Hall pers. comm. 2007)
Ohio	SNR	Records from 17 counties (Robert C. Glotzhober pers. comm. 2007)
Pennsylvania	S1S2	11 extant and 1 historical record from 3 river watersheds (Betsy Ray Leppo pers. comm. 2007)
Tennessee	S3S4	
Vermont	SNR	1 known population. Probably S1S2 (Mark Ferguson pers. comm. 2007)
Virginia	S1	
West Virginia	S2S3	Only 3 recent records (Barbara Sargent pers. comm. 2007)
Wisconsin	S4	Known from 30 counties (William Smith pers. comm. 2007)

## POPULATION SIZES AND TRENDS

### Search effort

In 2005, surveys of the historical *Gomphus quadricolor* sites on the Credit, Humber, and Thames rivers were conducted from June 9 to 14, as well as at three other potential sites on the Grand, Sydenham, and Ausable rivers, all of which appeared optimal on the respective rivers (Figure 4 in Harris and Foster 2006). Survey conditions were ideal throughout the survey period, and the ease of survey of adult *Gomphus quadricolor* at the Humber site suggests that extant populations do not exist on the other rivers. A survey of the Humber site on July 2, 1995 failed to find any *Gomphus quadricolor* but was hampered by cool, windy weather (Don Sutherland pers. comm. 2007). Catling and Brownell (2002) discovered *Gomphus quadricolor* at two sites on the Mississippi River in 2001 and surveyed three other sets of rapids on the same day without locating the species.

The Ontario Odonata Atlas (Ontario Odonata Atlas 2005) is an extensive database of Ontario odonate observations from published sources, institutional collections, and reports from amateur naturalists and professional entomologists. Of the over 12,000 Atlas records from June for Ontario south of the Canadian Shield including all of the Mixedwood Zone, no additional *Gomphus quadricolor* sites are recorded. Furthermore over 41,000 records of dragonflies in Ontario over the past 6 year period included this species only 8 times from two locations.

Although *Gomphus quadricolor* is believed to be extirpated on the lower Credit River, potential habitat may exist upstream at the Forks of the Credit. *Stylurus scudderii*, another gomphid associated with relatively unpolluted, swift rivers, has been recently observed there (Don Sutherland, pers. comm. 2007), but *G. quadricolor* has not been seen. Other unsurveyed Ontario rivers where *Gomphus quadricolor* could potentially occur include the Sydenham and Maitland rivers in southwestern Ontario (P. Pratt, pers. comm. 2007) and the Salmon River in eastern Ontario (P. Catling, pers. comm. 2007). These rivers have bouldery riffles and support *Ophiogomphus rupinsulensis*, suggesting that water quality is acceptable (Ontario Odonata Atlas 2005). Other Ontario rivers which may have suitable habitat include the Eramosa, Grand, Nith, Speed, Bayfield, North Saugeen, Rocky Saugeen, Beaver, Bighead, Boyne, Indian, Mad, Nottawasaga, Black, Crowe, Ganaraska, Gananoque, Moira, Napanee, Skootamatta, Tay, Trent, Madawaska, Fall, Indian Creek and Clyde (S. Thompson, D. Sutherland and A. Dextrase, pers. comm. 2007). However, it is important to remember that at least half of these rivers have been visited in June by experienced Odonatists and while other river-dwelling gomphids have been found, the obvious *G. quadricolor* has not.

Following its discovery at two locations on the Mississippi River near Ottawa in 2001, it was searched for elsewhere along the Mississippi, in the Rideau River and in rivers draining into the Ottawa River from Quebec (P. Catling, pers. comm. 2008) and was not found. Other eastern Ontario rivers are well surveyed (Petawawa) and some that are well surveyed are also seriously polluted (South Nation and its tributaries).

The Ottawa River, and rivers in Quebec draining into it, have been particularly well surveyed (Ménard 1996). Other flora and fauna extend north to the Ontario portion of the Ottawa valley but do not extend into Quebec (P.Catling, pers. comm.2008). Consequently there is little reason to expect that it is much more widespread in eastern Ontario.

Based on the fact that *G. quadricolor* is an obvious species, easy to observe where it occurs, and considering the extent of both directed and undirected search effort, and the fact that it is evidently confined to the Carolinian zone and its subunits, we conclude that if it does occur elsewhere in Ontario, it will continue to have a very small area of occupancy. Additionally since it has a ranking of S1 or S2 over most of its range to the south, suggesting habitat specialization, there seems little reason to expect it to be present at very many more sites in Ontario, if any.

### Abundance

Estimating total population sizes for odonates is difficult (Corbett 1999). A rough estimate of the minimum number of individuals in Canada is provided in Table 3. Although only adult males were observed during population estimates at the extant sites, equal numbers of adult males and females were assumed to be present and at least two larvae for every adult (based on the assumption of a three year life cycle). The number of larvae is thus a minimum estimate. This gives a minimum Canadian population estimate of 318 individuals including 106 adults. The number of larvae is probably grossly underestimated. Although this population estimate is of interest, the level of uncertainty is such that it cannot be used in assessment.

Global abundance is estimated at 2500 - 10,000 individuals with an average population of more than 100 individuals in all life stages at each occurrence (NatureServe 2007). This estimate is based on a survey of biologists throughout the species range. According to NatureServe (2007), no range-wide changes in abundance, area occupied, or number of occurrences have been noted and the species is considered to be secure globally; however, declining populations have been noted in some U.S. states (in the east and south).

**Table 3. Minimum population estimates for extant Canadian occurrences of *Gomphus quadricolor* (Harris and Foster 2006, Catling and Brownell 2002).**

Site	Adult males (counted)	Adult females (estimated)	Larvae (estimated)*	Total
Humber	28	28	112	168
Mississippi at Pakenham	20	20	80	120
Mississippi at Blakeney Rapids	5	5	20	30

\* 2 x adult estimate; assuming 3-year life cycle

## Fluctuations and trends

There are no data on fluctuations or trends of *Gomphus quadricolor* populations. The species is believed to be extirpated at two of its four known occurrences in Canada. Few concerted surveys for this species have been conducted and adult surveys are highly dependent on weather conditions and phenological development. Globally, the population is considered to be stable (unchanged or within +/- 10% fluctuation in population, range, area occupied, and/or number or condition of occurrences) (NatureServe2007).

## Rescue effect

Given the high potential dispersal capability of adult *Gomphus quadricolor* (estimated 3 km per day along the waterway), localized extirpations in some areas might be recolonized within a few years. However, *Gomphus quadricolor* appears not to move far from streams, suggesting that long-distance dispersal may be very infrequent. Extirpations at the periphery of the range, including all Canadian sites, would presumably take a very long time to be recolonized, or never happen. Genetic exchange between Canadian and U.S. populations is probably very infrequent, given the minimum distances of 300 km or more between them.

The largest number of populations of *Gomphus quadricolor* probably occurs in Minnesota and northern Wisconsin. The likelihood of natural invasion from U.S. populations is perhaps the greatest in northwestern Ontario near Thunder Bay where populations occur within about 200 km of the Canadian border. This area has more or less continuous forest cover and relatively unimpaired stream habitat, but has not been thoroughly surveyed for dragonflies.

## LIMITING FACTORS AND THREATS

Habitat degradation is the most significant threat to *Gomphus quadricolor*, although accidental deaths through vehicle collisions and inbreeding are also potential limiting factors. Impoundment of running waters by dams, stream channelization leading to scour of microhabitats, pollution, and introduction of exotic species threatens the species in much of its range (NatureServe 2007). Threats appear minor over much of the species' range in the northern U.S., but habitat threat is probably significant in the south where loss of forest cover and pollution are more extensive (NatureServe 2007). In Canada, three out of four sites are in the heavily developed part of southern Ontario where continued urbanization threatens water quality in the riverine habitats and natural terrestrial vegetation is declining.

As described in *Habitat Trends*, all four Canadian rivers where the species has been recorded have numerous dams and other water control structures and are actively regulated for flood control. This results in changes to natural patterns of sediment accumulation, reduces new sediment accumulation and can alter water temperature

regimes. Rapid drawdown of reservoirs for power generation can result in scouring of downstream habitats. The effects of water regulation on *G. quadricolor* larvae are unclear.

Water quality in most southern Ontario streams has been degraded (see *Habitat Trends*). High chloride, phosphorus, and nitrate levels and possibly pesticides may threaten *Gomphus quadricolor* larvae.

Invasive aquatic species are present in all four rivers. The upper Humber River supports chinook salmon, rainbow trout, brown trout, goldfish, and common carp (OMNR and TRCA 2005). Six other exotic species occur below a downstream dam, which acts as a dispersal barrier for most fish species. Eleven invasive fish species occur in the Credit River, including those listed above (Credit Valley Conservation 2002). Common carp are found throughout the Thames River and round goby and zebra mussels inhabit the river at and below Fanshawe Lake (downstream of the *Gomphus quadricolor* site) (A. Dextrase pers. comm. 2007). Round Goby is moving upstream in the Thames system. Zebra mussels and spiny waterflea occur in the Mississippi River watershed, but their status in the river itself is unknown. The impacts of these species, if any, on *Gomphus quadricolor* are unknown, but could include predation, competition, increased turbidity (common carp), and changes in the stream community structure. Other invasives are a continued threat especially to the Humber and Credit sites that are close to Lake Ontario. Rusty crayfish are not known to occur in any of the four Ontario rivers, but are spreading in Ontario and may pose a threat to *Gomphus quadricolor* by consuming aquatic vegetation, thereby destabilizing sediments.

Loss of riparian forest due to agriculture and residential development could threaten adult *Gomphus quadricolor* by exposing them to increased predation by birds and other dragonfly species. Females, which spend most of their three to four week life span in forest cover adjacent to the river, may be particularly vulnerable.

Collisions with cars could be source of adult mortality where road crossings fragment the stream habitat, as occurs in a population of Hines Emerald (*Somatochlora hineana*) (U.S. Fish and Wildlife Service 2001) but its significance has not been quantified in this or other species. Road kill could be a significant factor with *Gomphus quadricolor* when teneral disperse to forest cover if forest cover is lacking adjacent to the stream. 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 (P. Brunelle pers. comm. 2007). At the Humber River, there are five secondary highway crossings of the river with speed limits greater than 50 km / hour within 10 km of the *Gomphus quadricolor* population. About 10 other roads are near the river (within 100 m). Slower traffic crosses the bridge at the Mississippi River site. Currently the potential impact of vehicle-related mortality is unclear.

## **SPECIAL SIGNIFICANCE OF THE SPECIES**

Stream-dwelling gomphids in general are potential indicators of well-oxygenated, unpolluted streams (Bode *et al.* 1996). Although *Gomphus quadricolor* is too uncommon and obscure through most of its range to be known by most people, dragonflies in general are increasingly popular as indicated by increasing numbers of field guides and organized dragonfly count events.

## **EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS**

The species is not protected under the *Species at Risk Act* in Canada, nor is it on the U.S. Endangered Species list. It is not covered by the IUCN Red List or CITES. Its general status in Wild Species 2005 is “May be at Risk” (Canadian Endangered Species Conservation Council 2006). River habitats in Canada are nominally protected under the federal *Fisheries Act* where fish habitat is concerned.

*Gomphus quadricolor* is ranked globally as G3G4 (81 to > 300 occurrences; NatureServe 2007). Nationally, it is ranked as N1 in Canada and N3N4 in the U.S. (NatureServe 2007). At the state / provincial level, it is ranked as secure ( $\geq$ S4) only in Wisconsin (although it is likely to be revised to S4 or S5 in Minnesota, Richard Baker pers. comm. 2007). It is listed as Threatened in Massachusetts (NHESP 2003), Threatened in Connecticut (Connecticut Department of Environmental Protection 2007), Special Concern in Michigan (Cuthrell 2000), and proposed for listing as Endangered in Maine (deMaynadier 2006). Less than 12 of the occurrences are appropriately protected and managed in State and National forests in Wisconsin and in the St. Croix National Scenic Riverway on the Minnesota – Wisconsin border (NatureServe 2007).

## **ABORIGINAL AND TRADITIONAL KNOWLEDGE**

Aboriginal and traditional knowledge was not found for this rare species.

## TECHNICAL SUMMARY

### ***Gomphus quadricolor***

Rapids Clubtail

Range of occurrence in Canada: Ontario

Gomphe des rapides

#### **Extent and Area Information**

<ul style="list-style-type: none"> <li><i>Extent of occurrence (EO)(km<sup>2</sup>)</i> Narrow strip 8.25 km (Pakenham to Blakeney) by 314 km (Pakenham to Kleinburg) by 3 km (distance on Humber), thus about 1570 km<sup>2</sup>. See <i>Canadian Range</i>.</li> </ul>	1570 km <sup>2</sup>
<ul style="list-style-type: none"> <li><i>Specify trend in EO</i></li> </ul>	Declining (extirpated at two historical locations based on surveys over the past decade)
<ul style="list-style-type: none"> <li><i>Are there extreme fluctuations in EO?</i></li> </ul>	No
<ul style="list-style-type: none"> <li><i>Area of occupancy (AO) (km<sup>2</sup>)</i> The maximum area of occupancy encompasses an 800 m zone on either side of the stream length occupied by the species (800 m is the approximate maximum known dispersal distance inland for <i>Gomphus quadricolor</i>) See <i>Canadian Range</i>.</li> </ul>	26 km <sup>2</sup> (maximum) or using the 1X1 km grid system 4 km <sup>2</sup> currently and 6 km <sup>2</sup> historically
<ul style="list-style-type: none"> <li><i>Specify trend in AO</i></li> </ul>	Declining (extirpated at two historical locations based on surveys over the past decade)
<ul style="list-style-type: none"> <li><i>Are there extreme fluctuations in AO?</i></li> </ul>	No
<ul style="list-style-type: none"> <li><i>Number of known or inferred current locations</i></li> </ul>	Two
<ul style="list-style-type: none"> <li><i>Specify trend in #</i></li> </ul>	50% decline
<ul style="list-style-type: none"> <li><i>Are there extreme fluctuations in number of locations?</i></li> </ul>	No
<ul style="list-style-type: none"> <li><i>Specify trend in area, extent or quality of habitat</i></li> </ul>	Quality of habitat apparently declining (See <i>Habitat Trends</i> )

#### **Population Information**

<ul style="list-style-type: none"> <li><i>Generation time (average age of parents in the population)</i></li> </ul>	Unknown; probably 2 years or more
<ul style="list-style-type: none"> <li><i>Number of mature individuals</i></li> </ul>	Minimum of 106 estimated in 2005, maximum number is unknown
<ul style="list-style-type: none"> <li><i>Total population trend:</i></li> </ul>	Declining (extirpated at two historical locations)
<ul style="list-style-type: none"> <li><i>% decline over the last/next 10 years or 3 generations.</i></li> </ul>	Unknown
<ul style="list-style-type: none"> <li><i>Are there extreme fluctuations in number of mature individuals?</i></li> </ul>	Unknown
<ul style="list-style-type: none"> <li><i>Is the total population severely fragmented?</i></li> </ul>	Yes
<ul style="list-style-type: none"> <li><i>Specify trend in number of populations</i></li> </ul>	Declining
<ul style="list-style-type: none"> <li><i>Are there extreme fluctuations in number of populations?</i></li> </ul>	No
<ul style="list-style-type: none"> <li>List populations with number of mature individuals in each: Mississippi River 50; Humber River 56.</li> </ul>	

**Threats (actual or imminent threats to populations or habitats)**

1. Water pollution
2. Water level regulation
3. Invasive aquatic species
4. Loss of forest cover in watershed
5. Collisions with vehicles

**Rescue Effect (immigration from an outside source)**

<ul style="list-style-type: none"> <li>• <i>Status of outside population(s)?</i> USA: Stable nationally, although declining in some states, especially in south and east</li> </ul>	
<ul style="list-style-type: none"> <li>• <i>Is immigration known or possible?</i></li> </ul>	Possible but unlikely
<ul style="list-style-type: none"> <li>• <i>Would immigrants be adapted to survive in Canada?</i></li> </ul>	Possibly
<ul style="list-style-type: none"> <li>• <i>Is there sufficient habitat for immigrants in Canada?</i></li> </ul>	Possibly
<ul style="list-style-type: none"> <li>• <i>Is rescue from outside populations likely?</i></li> </ul>	No (See Rescue Effect)

**Quantitative Analysis**

Not applicable

**Current Status**

COSEWIC: Endangered, April 2008.  
 Global: G3G4  
 Canada: N1  
 US: N3N4  
 S1: ON, CT, GA, IA, ME, MD, MA, VI  
 S2: IN, NJ  
 S1S2: NC, NY, PA  
 S2S3: KY, WV, MI  
 S3S4: AL, TN  
 S4: WI  
 SNR: AR, IL, MN, MO, NH, OH, VT

**Status and Reasons for Designation**

<b>Status:</b> Endangered	<b>Alpha-numeric code:</b> B1ab(iii)+2ab(iii)
<b>Reasons for Designation:</b> This distinctive species of dragonfly has a fragmented distribution with a very small extent of occurrence and area of occupancy, and is currently only found in small portions of two southern Ontario rivers. The species is believed to be extirpated at two historic sites and there is evidence for continuing decline of habitat.	

**Applicability of Criteria**

<b>Criterion A</b> (Declining Total Population): Population information inadequate.
<b>Criterion B</b> (Small Distribution, and Decline or Fluctuation): Meets Endangered B1ab(iii)+2ab(iii) since the known extent of occurrence (1570 km <sup>2</sup> ) is less than 5000 km <sup>2</sup> and the area of occupancy (26 km <sup>2</sup> ) is less than 500 km <sup>2</sup> . Also, the habitat, area, extent and number of locations have declined over the last several decades.
<b>Criterion C</b> (Small Total Population Size and Decline): Population information is not adequate.
<b>Criterion D</b> (Very Small Population or Restricted Distribution): Population information is inadequate but comes close to meeting criteria D2 since the population is suspected to be small with a minimum estimate of 106.
<b>Criterion E</b> (Quantitative Analysis): Not applicable.



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## INFORMATION SOURCES

- Baker, R.J., pers comm. 2007. Email correspondence to A. Harris. January 2007. Minnesota Natural Heritage and Nongame Research Program.
- Barlow, A., pers comm. 2007. Email correspondence to A. Harris. January 2007. NJ Endangered and Non-game Species Program.
- Beaton, G., pers comm. 2007. Email correspondence to A. Harris. January 2007.
- Bode, R.W., M.A. Novak, and L.E. Abele. 1996. Quality assurance work plan for biological stream monitoring in New York State. NYS Department of Environmental Conservation Technical Report. 89 pages.
- Broadbent A., pers comm. 2007. Email correspondence to A. Harris. January 2007. Mississippi Valley Conservation.
- Brunelle, P., pers comm. 2007. Email correspondence to R. Foster.
- Canadian Endangered Species Conservation Council (CESCC). 2006. Wild Species 2005: The General Status of Species in Canada.  
<http://www.wildspecies.ca/wildspecies2005/search.cfm?lang=e&sec=9>
- Carle, F.L. 1986. The classification, phylogeny and biogeography of the Gomphidae (Anisoptera). I. Classification. *Odonatologica* 15:275-326.
- Cashatt, T., pers comm. 2007. Email correspondence to A. Harris. January 2007.
- Catling, P., pers comm. 2007. Email correspondence to A. Harris. January 2007.
- Catling, P., pers. comm. 2008. Email and phone to A. Harris. January 2008.
- Catling, P.M. and V.R. Brownell. 2002. Rapids Clubtail (*Gomphus quadricolor*) in eastern Ontario. *Ontario Odonata* 3: 1-4.
- Catling, P.M. and V.R. Brownell. 2000. Damselflies and Dragonflies (Odonata) of Ontario: Resource Guide and Annotated List. ProResources, 2326 Scrivens Drive, Metcalfe, Ontario, Canada.

- Connecticut Department of Environmental Protection. 2007. Endangered, Threatened and Special Concern Species. Website:  
<http://dep.state.ct.us/cgnhs/nddb/species.htm> Accessed January 2007.
- Corbet, P.S. 1999. Dragonflies Behavior and Ecology of Odonata. Comstock Publishing Associates.
- Corbet, P.S., C. Longfield, and N.W. Moore. 1960. Dragonflies. London. Collins.
- Corser, J.D., pers comm. 2007. Email correspondence to A. Harris. January 2007. Zoologist NY Natural Heritage Program.
- Credit Valley Conservation. 2004. Watershed report card. Website:  
<http://www.creditvalleycons.com/bulletin/downloads/wsreports.pdf> Accessed January 2007.
- Credit Valley Conservation. 2002. Fishes of the Credit River watershed. Website:  
<http://www.creditvalleycons.com/programsandservices/downloads/Fish-COMplete.pdf> Accessed January 2007.
- Cuthrell, D.L. 2000. Special animal abstract for *Gomphus quadricolor* (rapids clubtail). Michigan Natural Features Inventory, Lansing, MI. 2 pp.
- deMaynadier, P., pers comm. 2007. Email correspondence to A. Harris. January 2007. Reptile, Amphibian, and Invertebrate Group Leader Maine Department of Inland Fisheries and Wildlife.
- deMaynadier, P., 2006. 2006 Endangered and Threatened species listing recommendation: *Gomphus quadricolor*. Maine Department of Inland Fisheries and Wildlife. 2 pp.
- D'Amelio, S. 2007. Preliminary water quality at Springbank dam, Thames River, London. Trout Unlimited Canada Technical Report No. ON-020.  
[www.tucanada.org/reports/ON-020\\_SpringbankDam\\_2007.pdf](http://www.tucanada.org/reports/ON-020_SpringbankDam_2007.pdf)
- Dextrase, A., pers comm. 2007. Email correspondence to A. Harris. January 2007. Ontario Ministry of Natural Resources.
- Donnelly, T.W. 2004. Distribution of North America Odonata. Part 1. Aeshnidae, Petaluridae, Gomphidae, Corduligastridae. Bulletin of American Odonatology. 7(4): 61-90.
- Environment Canada. 2007. A National Ecological Framework for Canada. Website;  
<http://www.ec.gc.ca/soer-ree/English/Framework/default.cfm> Accessed January 2007.
- Ferguson, M., pers comm. 2007. Email correspondence to A. Harris. January 2007. Zoologist Nongame & Natural Heritage Program Vermont Department of Fish & Wildlife.
- Godwin J., pers comm. 2007. Email correspondence to A. Harris. January 2007. Aquatic Zoologist Alabama Natural Heritage Program.
- Glotzhober, R.C., pers comm. 2007. Email correspondence to A. Harris. January 2007. Senior Curator, Natural History Ohio Historical Society.
- Hall, S., pers comm. 2007. Email correspondence to A. Harris. January 2007.. Invertebrate Zoologist NC Natural Heritage Program
- Harris, A.G. and R.F. Foster 2006. Summary of field surveys for Rapids Clubtail (*Gomphus quadricolor*). Unpublished report.
- Hedge R., pers comm. 2007. Email correspondence to A. Harris. January 2007. Ecologist Indiana Natural Heritage Data Center.

- Howell, D., pers comm. 2007. Email correspondence to A. Harris. January 2007. Coordinator/Zoologist Iowa Natural Areas Inventory Department of Natural Resources.
- Humber Watershed Alliance. 2000. A report card on the health of the Humber River Watershed. Toronto Region Conservation Authority. Website: [http://www.trca.on.ca/water\\_protection/strategies/humber/](http://www.trca.on.ca/water_protection/strategies/humber/) Accessed January 2007.
- Hunt, P., pers comm. 2007. Email correspondence to A. Harris. January 2007.
- Krotzer R. S., pers comm. 2007. Email correspondence to A. Harris. January 2007.
- Leppo, B.R., pers comm. 2007. Email correspondence to A. Harris. March 2007. Invertebrate Zoologist, Pennsylvania Natural Heritage Program.
- Massachusetts Natural Heritage and Endangered Species Program (NHESP). 2003. Rapids Clubtail Dragonfly *Gomphus quadricolor*. Massachusetts Division of Fisheries and Wildlife.
- Ménard, B. 1996. Liste annoté des odonates de la vallée de l'Outaouais. *Fabriques* 21(2): 29-64.
- McKay, D., pers comm. 2007. Email correspondence to A. Harris. March 2007. Zoologist, Bureau of Natural Resources, Wildlife Division. Department of Environmental Protection. Hartford, Connecticut, USA
- Ministry of Municipal Affairs and Housing (MMAH). 2007. The Oak Ridges Moraine. Website: [http://www.mah.gov.on.ca/userfiles/HTML/nts\\_1\\_31\\_1.html](http://www.mah.gov.on.ca/userfiles/HTML/nts_1_31_1.html) Accessed January 2007.
- Mississippi Valley Conservation. 2007. Mississippi Valley Conservation. Website <http://www.mvc.on.ca/index.html> Accessed January 2007.
- Missouri Odonata. 2007. Missouri Odonata. Website <http://www.windsofkansas.com/Bodonata/MOODSources.html> Accessed January 2007.
- NatureServe. 2007. NatureServe Explorer: An online encyclopedia of life [web application]. Version 6.1. NatureServe, Arlington, Virginia. Available <http://www.natureserve.org/explorer>. Accessed January 2007.
- Needham, J.G., M.J. Westfall, and M.L. May. 2000. *Dragonflies of North America*. Scientific Publishers.
- Nelson M.W., pers comm. 2007. Email correspondence to A. Harris. January 2007. Invertebrate Zoologist. Natural Heritage & Endangered Species Program. Massachusetts Division of Fisheries & Wildlife
- Ontario Ministry of Environment. 2007. Unpublished data.
- OMNR, TRCA, 2005. Humber River Fisheries Management Plan. Published by the Ontario Ministry of Natural Resources and the Toronto and Region Conservation Authority. Queens Printer for Ontario.
- Ontario Odonata Atlas. 2005. Natural Heritage Information Centre, Ontario Ministry of Natural Resources. <http://www.mnr.gov.on.ca/MNR/nhic/odonates/ohs.html> (updated 15-02-2005).
- Pratt, P., pers comm. 2007. Email correspondence to R. Foster. January 2007.
- Rosche L. pers comm. 2007. Email correspondence to A. Harris. January 2007. Ohio CMNH Natural Areas Conservation Outreach Program.
- Sargent B., pers comm. 2007. Email correspondence to A. Harris. January 2007.

- Smith, W., pers comm. 2007. Email correspondence to A. Harris. January 2007.
- Steffens W. pers comm. 2007. Email correspondence to R. Foster. January 2007.
- Sutherland D., pers comm. 2007. Email correspondence to A. Harris. January 2007. Ontario Natural Heritage Information Centre.
- Swinford T., pers comm. 2007. Email correspondence to A. Harris. January 2007.
- Tash Jeff pers. comm. 2007 Wildlife and Conservation Information Specialist. NH Natural Heritage Bureau / The Nature Conservancy New Hampshire Division of Forests & Lands – DRED.
- Tennessee, K. pers comm. 2007. Email correspondence to A. Harris. January 2007. Research Associate, Florida State Collection of Arthropods.
- Todd, A. and G. Kaltenecker. 2004. Water Quality Trends in Ontario's Heritage Rivers. 2004 River Conference Proceedings. Guelph, Ontario. June 7 – 9 2004.
- Upper Thames River Conservation Authority. 2001. Upper Thames River Watershed Report Cards 2001. Website: <http://www.thamesriver.on.ca/> Accessed January 2007.
- U.S. Fish and Wildlife Service. 2001. Hine's Emerald Dragonfly (*Somatochlora hineana*) Recovery Plan. Fort Snelling, MN. 120 p. [www.fws.gov/endangered/recovery/index.html](http://www.fws.gov/endangered/recovery/index.html)
- Walker, E.M. 1932. The nymph of *Gomphus quadricolor* Walsh (Odonata). *Can. Ent.*, 64: 270-273.
- Walker, E.M. 1953. The Odonata of Canada and Alaska. Vol 1, part 1: General. Univ. Toronto Press, Toronto, Canada. 292 pp.
- Walker, E.M. 1958. The Odonata of Canada and Alaska. Vol 2, part 3: The Anisoptera - four families. Univ. Toronto Press, Toronto, Canada. 318 pp.
- Water Survey of Canada. 2007. Archived Hydrometric Data. Website: [http://www.wsc.ec.gc.ca/hydat/H2O/index\\_e.cfm](http://www.wsc.ec.gc.ca/hydat/H2O/index_e.cfm) Accessed January 2007.
- Wisconsin Odonata Survey. 2007. Wisconsin Odonata Survey. Website: <http://atriweb.info/Inventory/Odonata/> Accessed January 2007.

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