COSEWIC
Assessment and Status Report

on the

Laura's Clubtail
Stylurus laurae

in Canada

ENDANGERED
2010

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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Laura's Clubtail — photo by Linda Gilbert, Naturalist Geauga Park District.

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COSEWIC
Assessment Summary

Assessment Summary – April 2010

Common name
Laura's Clubtail

Scientific name
Stylurus laurae

Status
Endangered

Reason for designation
This attractive dragonfly of eastern North America is known from only two locations in unusual fast-moving sandy streams in southwestern Ontario. The species has a very small range in Canada and there is evidence of continuing decline of habitat.

Occurrence
Ontario

Status history
Designated Endangered in April 2010.

COSEWIC
Executive Summary

Laura's Clubtail
Stylurus laurae

Species information

Laura's Clubtail *Stylurus laurae* is a member of the family Gomphidae, the clubtail dragonflies, and the order Odonata, the dragonflies and damselflies. Laura's Clubtail is a relatively large member of the genus, with a total length of 60 - 64 mm. The front of the thorax has two divergent pale stripes that do not connect with the collar. The collar is broken with a dark line. The abdomen is dark laterally with a narrow yellow middorsal stripe that breaks into dashes at the tip of the abdomen which is moderately clubbed in males, less so in the females.

Distribution

The range of Laura's Clubtail includes Ontario and 17 states in the eastern US. The global maximum extent of occurrence encompasses about 1.5 million km^2. The known Canadian range of Laura's Clubtail consists of Big Creek and Big Otter Creek in southern Ontario. The species was first discovered in Canada in 1999. The maximum extent of occurrence in Canada encompasses 256 km^2, but it occupies an area of less than 22 km^2 (using a 1 km X 1 km grid) or 60 km^2 (using a 2 km X 2 km grid).

Habitat

Larvae typically inhabit small to medium sized unpolluted streams with sand or silt substrate. Streams usually have overhanging trees and shrubs. Adults disperse to riparian forest after emerging and typically perch by hanging from vegetation, 0.5 to 6 m above the water. Males are seldom seen and apparently spend most of their time high in trees. Logging and land clearing for agriculture in the late 1800s caused extensive soil erosion but in the early 1900s, reforestation efforts were implemented and forest cover increased to present levels. Although terrestrial habitat may have improved, aquatic habitat appears to be declining with trends toward increased pollution with chloride, nitrate and phosphorous, this made more serious by concentration due to continuing water removal for irrigation. Irrigation and other water uses within the watershed can significantly reduce stream flow within both creeks, particularly during dry summers, increasing oxygen demand and reducing habitat. Dams in the watersheds of Big and Big Otter creeks have likely already caused loss of riffle habitat in reservoirs, higher water temperatures, and altered erosion and sedimentation.

Biology

Adults fly between mid July and mid August in Ontario. Mating habits have not been described. Larvae spend most of their time buried just below the surface of the sediment, breathing through the tip of the abdomen raised above the sediments.

The duration of the larval stage is unknown, but is probably two or more years. Before the final molt, larvae crawl onto the sandy riverbank. Newly emerged adults disperse inland to avoid predation until the exoskeleton hardens and they are able to fly swiftly.

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

Predators on adults include birds, frogs and larger dragonflies. Larvae are eaten by waterbirds, fish, turtles, larger dragonfly larvae, and other predatory insects.

Population sizes and trends

Laura's Clubtail was first discovered in Canada in 1999 and is known to occur at two locations. An accurate estimation of population size is not available. No population trend information is available.

Threats and limiting factors

Aquatic habitat degradation through pollution, water removal for irrigation and invasive species (especially Round Goby) are the most significant threats to Laura's Clubtail. Accidental deaths through vehicle collisions and impoundment of running waters by dams are potential threats at Canadian locations.

Special significance of the species

Laura's Clubtail is too uncommon and obscure through most of its range to be known by most people, but dragonflies in general are increasingly popular as indicated by increasing numbers of field guides and organized dragonfly count events. It is also an indicator species of good water quality.

Existing protection, status, and ranks

Laura's Clubtail is ranked globally as apparently secure. It is ranked as critically imperilled in Canada and apparently secure in the US, but is not protected by species at risk legislation in either country. At the state / provincial level, it is ranked as critically imperilled in Ontario and critically imperilled to vulnerable in eight of the 17 states in which it occurs. No known Canadian sites are within provincial or federal parks. River habitats in Canada are 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 (2010)

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.

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

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2010

TABLE OF CONTENTS

List of Figures

List of Tables

SPECIES INFORMATION

Name and classification

Stylurus laurae (Williamson), or Laura's Clubtail (gomphe de Laura), is a member of the family Gomphidae, the clubtail dragonflies, and the order Odonata, the dragonflies and damselflies. *Stylurus* was formerly treated as a subgenus of *Gomphus*, but is now universally recognized as a distinct genus (Needham *et al*. 2000). The species was first described by Williamson (1932). Larvae were first described by Louton (1982). *Stylurus laurae* closely resembles *S. notatus*, but is perhaps most closely related to *S. amnicola* and *S. ivae* (Williamson 1932). No subspecies of *S. laurae* are recognized and the species is distinct.

The English name is derived from the scientific name in honour of Laura Ditzler, a member of Williamson's collecting party in 1931 (Williamson 1932). Similarly the French name is gomphe de Laura.

Morphological description

Stylurus laurae is a relatively large member of the genus, with a total length of 60 - 64 mm and hind wing length of 36-42 mm (Needham *et al*. 2000). The face is dark brown with a dark cross stripe and green eyes. Legs are dark brown to black with longitudinal pale marks. Lateral thoracic stripes are pale green in males and yellow in females. The front of the thorax has two divergent pale stripes that do not connect with the collar. The collar is broken with a dark line. The abdomen is dark laterally with a narrow yellow middorsal stripe that breaks into dashes on segments 8 and 9. Abdominal segments 7 and 8 have yellow to rusty brown lateral spots. The abdomen is moderately clubbed in males, less so in the females (Dunkle 2000, Needham *et al*. 2000, Williamson 1932).

The posterior hamule of the male’s secondary genitalia has a prominent shoulder. The terminal hook is relatively short and thin. The female subgenital plate is shorter than the sternum of abdominal segment 10 (Needham *et al*. 2000).

In contrast, *S. amnicola* (Riverine Clubtail), which shares habitat with *S. laurae* in Ontario, has an unbroken collar and pale middorsal thoracic stripe. *S. laurae* has a longer hind wing (36 to 42 mm) than *S. amnicola* (29 to 33 mm). Catling and Catling (1999) noted that the Ontario *S. laurae* have smoky wings while *S. amnicola* has clear wings.

Stylurus larvae are distinguished from most other gomphid larvae by the lack of tibial burrowing hooks. Mature *S. laurae* larvae are about 35 mm long and strongly patterned in brown (Louton 1982). The abdomen tapers evenly posteriorly and segment 9 is about 1.3 times the dorsal length of segment 8. In contrast with *S. amnicola, S. laurae* has a straight or slightly convex, rather than strongly curved ligula (leading edge of the prementum) (Bright and O'Brien 1999, Catling 2000).

Figure 1. *Stylurus laurae* adult female (Ohio) (Photo by Linda Gilbert).

Figure 2. *Stylurus laurae* teneral and exuvia Big Creek, Ontario 2008.

Genetic Description

No genetic or dispersal studies have been completed on *Stylurus laurae* to define population structure below the species level. Canadian locations are separated by Lake Erie from the nearest known populations in the US and are probably genetically isolated.

Designatable Unit

No subspecies have been recognized in this species. The two streams constituting the Canadian range of *Stylurus laurae* are within 23 km of each other and Canadian locations represent a single designatable unit.

DISTRIBUTION

Global range

The range of *Stylurus laurae* includes Ontario and 17 states in the United States (Figure 3). The global maximum extent of occurrence encompasses about 1.5 million km^2. *Stylurus laurae is* probably most common in the southern central United States, particularly east of the Appalachians in Virginia, North Carolina, and Tennessee. West of the Appalachians its range extends from the Florida Panhandle to east Texas, north to Michigan and southern Ontario (Figure 3). New populations have been discovered in Texas, Mississippi, and Ontario in the last 10 years and it may be much more common than records indicate in Alabama and elsewhere in the south (R. S. Krotzer pers. comm. 2008). The southern Michigan, northeastern Ohio and Ontario occurrences are apparently disjunctions from a more continuous range that extends north to southern Ohio. The Ontario population is disjunct across Lake Erie 120 km from the occurrence in northeastern Ohio.

Canadian range

The known Canadian range of *Stylurus laurae* consists of Big Creek and Big Otter Creek in southern Ontario (Figure 4). The species was first discovered in Canada in 1999 at Big Otter Creek (Catling and Catling 1999). Catling and others subsequently collected adults and larvae at Big Creek in 2002 and 2004. A search of eight other streams in the area in 2008 failed to discover additional locations (Harris and Foster 2009).

The Canadian range is in the Lake Erie Lowlands Ecoregion of the Mixedwoods Plain Ecozone (Environment Canada 2009). The ecoregion has one of the warmest climates in Canada with humid, warm to hot summers, mild, snowy winters, and a mean annual temperature of 8^{o}C. Soils are mostly deep lacustrine and outwash deposits. The ecoregion encompasses the Carolinian Forest Region, home to many species at the northern limit of their range. The landscape was formerly dominated by deciduous forest, but was largely cleared for agriculture in the early 1800s. Big Creek and Big Otter Creek are on the Norfolk Sand Plain, a deep glacial delta deposit of fine sand (Chapman and Putnam 1966).

The Big Creek and Big Otter Creek areas of occurrence extend along about 11 km and 24 km of stream respectively. These areas are separated by about 23 km and are therefore treated as two areas of occurrence (10 km is considered the minimum separation distance for occurrences of river-breeding odonates; NatureServe 2009) and two locations. Any of the major threats could operate through the entire area of each location. The creek channels are relatively uniform, consisting of slow moving, relatively turbid waters, meandering through sand deposits and unbroken by rapids or falls.

The maximum extent of occurrence (EO) in Canada encompasses 256 km^2. The maximum index of area of occupancy (IAO) encompasses 22 km^2 (using a 1 km x 1 km grid) or 60 km^2 (using a 2 km X 2 km grid). About 0.01 % of the global range is in Canada.

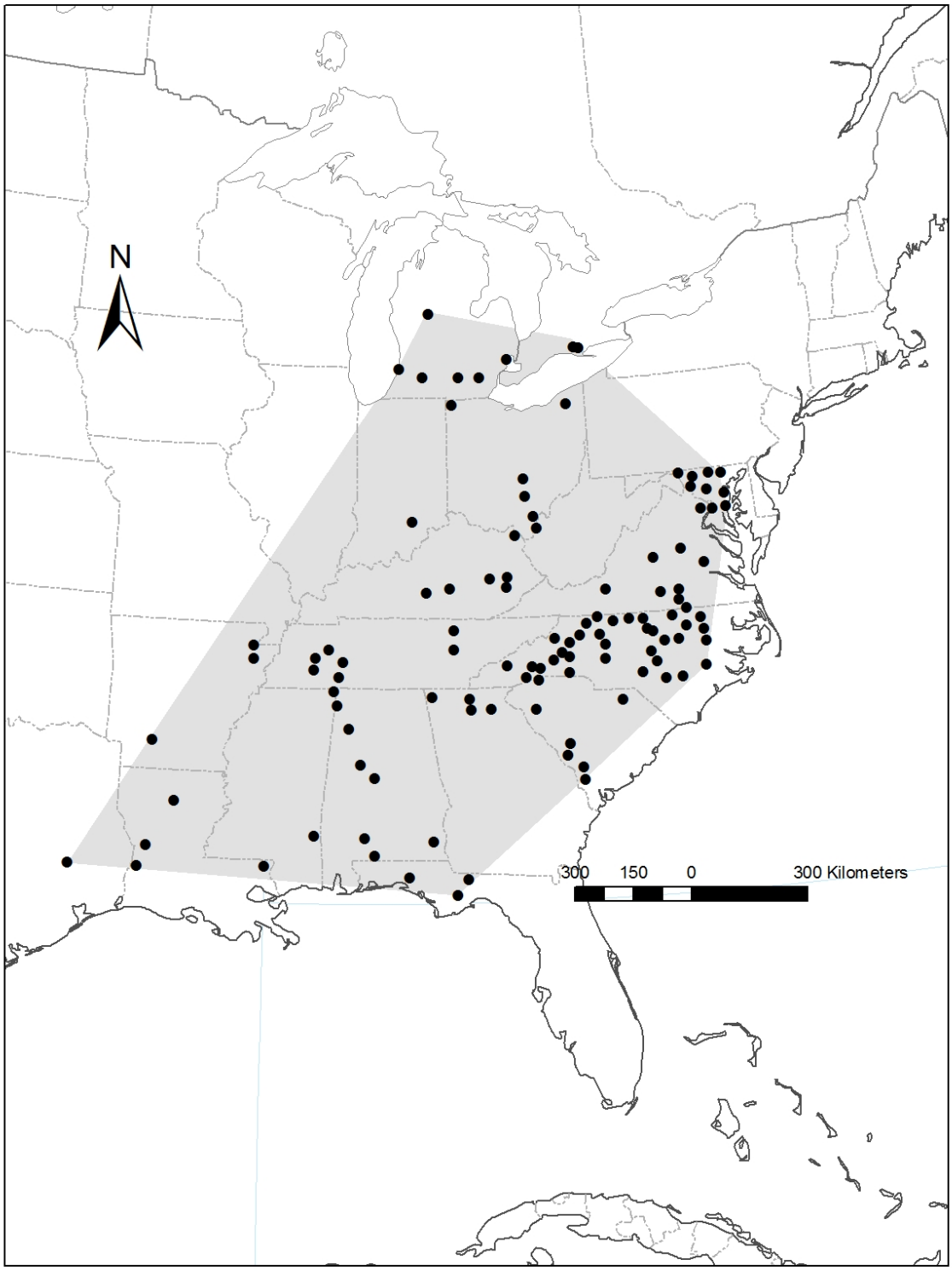

Figure 3. Distribution of *Stylurus laurae* in North America (based on Donnelly 2004).

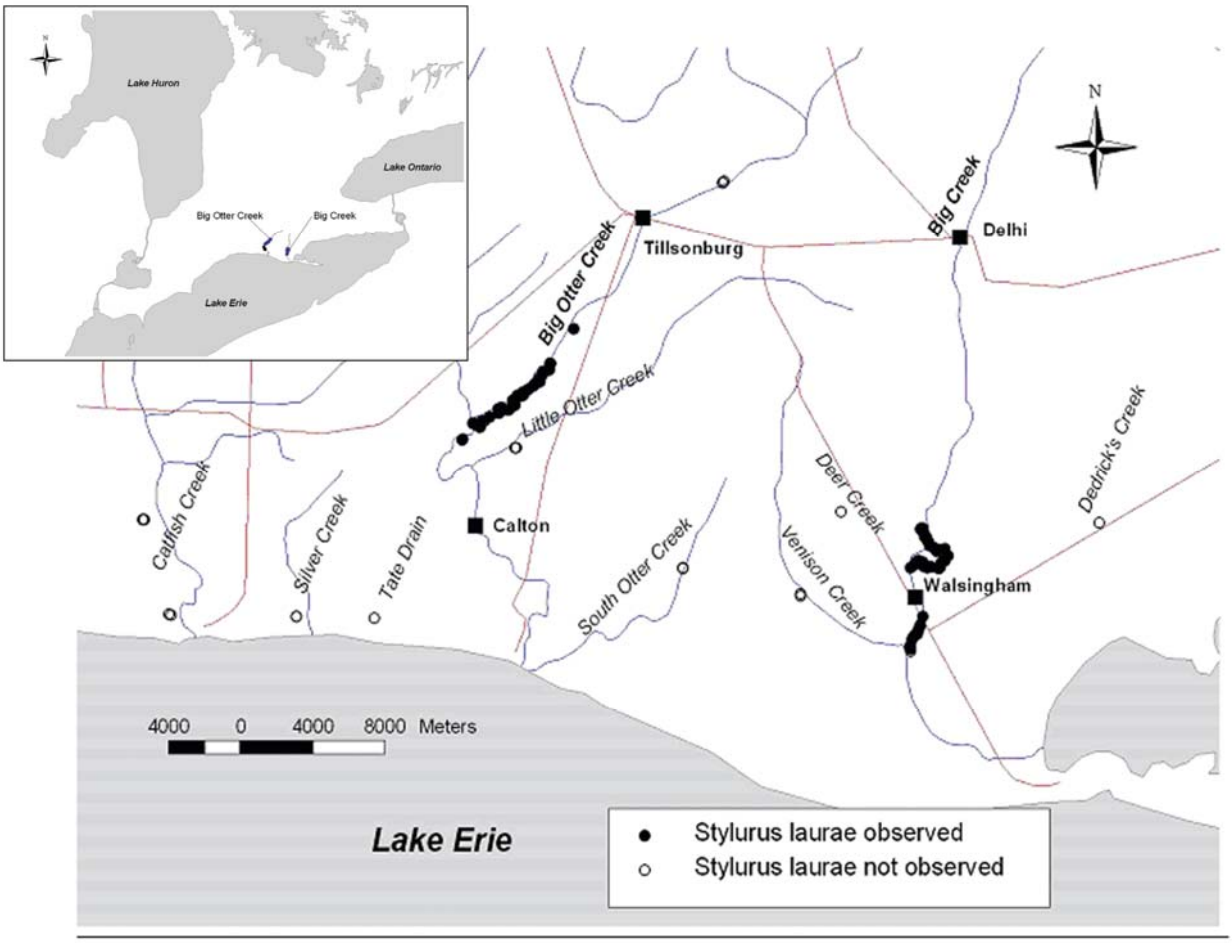

Figure 4. Distribution of *Stylurus laurae* in Canada.

HABITAT

Habitat requirements

Larvae of *Stylurus laurae* typically inhabit small to medium streams with sand or silt substrate, sometimes interspersed with rocks (Bright and O'Brien 1999, J.J .Daigle pers. comm. 2008, T.W.Donnelly pers. comm. 2009, R.C. Glotzhober pers. comm. 2009, Louton 1982, NatureServe 2009). Streams usually have overhanging trees and shrubs (J.J. Daigle pers. comm. 2009, Williamson 1932).

Streams supporting *Stylurus laurae* are typically unpolluted (Bright and O'Brien 1999) and range from clear (J.J. Daigle pers. comm. 2008) to stained with dissolved organic material (Louton 1982) to moderately turbid (Harris and Foster 2009). The species is reportedly very sensitive to changes in the surrounding drainage basin (J.J. Daigle pers. comm. 2008).

Big Creek and Big Otter Creek have mean annual discharge rates of 6.6 to 9.2 m^3/sec respectively (Figure 5, Table 1). The channels have alternating deeper pools and shallow sandbars and range from 4 to 12 m wide and 0.3 to 3 m deep (mostly less than 1 m deep). Both streams are relatively turbid (Table 1) and are primarily groundwater-fed due to the high percolation rate of the sandy soils in the watershed (Lake Erie Source Protection Region Technical Team 2008). Some water quality data is included in Table 1 and is mentioned under trends, but extensive information is lacking.

Riparian forest provides cover for tenerals and adults, which disperse from the river after emerging (Rosche *et al*. 2008). Adults typically perch by hanging from vegetation, 0.5 to 6 m above the water (Catling and Catling 1999, Williamson 1932). Males are seldom seen and apparently spend most of their time high in trees (Rosche *et al*. 2008). In some US streams, adults prefer to perch at head of riffles (Williamson 1932).

Larvae probably burrow into the top few centimetres of the bottom sediment, as do most Gomphidae (Corbet 1999). Larvae were sieved in Big Otter and Big creeks in upper sediments in 20 to 40 cm of water from creek margins to almost mid-channel (Harris and Foster 2009). Exuviae at Ontario locations were collected on sand banks and exposed root mats within 1 m of the river and occasionally on floating logs (Harris and Foster 2009). In Ohio, exuviae were collected on emergent vegetation (*Sparganium* sp.) and on shrub and tree branches that hang into the water (L. Gilbert pers. comm. 2009).

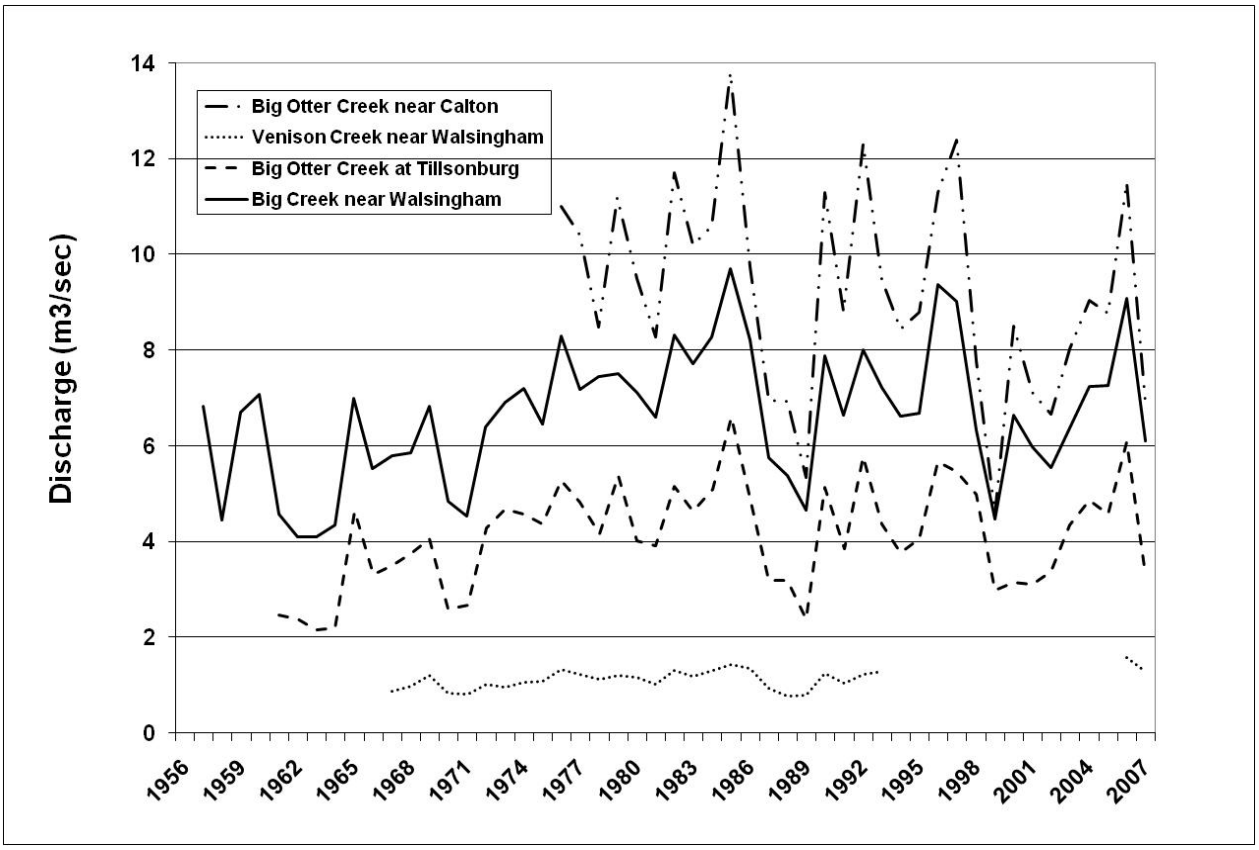

Figure 5. Mean annual discharge of Big Creek, Big Otter Creek and Venison Creek (data from Water Survey of Canada 2009).

Table 1. Mean annual water quality attributes as well as discharge and watershed area of Big Creek , Big Otter Creek and Venison Creek (data from Water Survey of Canada 2009 and Ontario Ministry of Environment 2009).

Stream	Dissolved Oxygen (mg/l)	Mean Annual Discharge (m^3/s)	Watershed Area (km^2)	pH	Turbidity (Formanzin Turbidity Unit)	Chloride (mg/l)
Big Creek	7.3	6.63	750	8.3	18.4	23.6
Big Otter Creek	12.3	9.24	712	8.4	49.9	30.2
Venison Creek	12.0	1.13		8.3	9.6	13.8

Figure 6. *Stylurus laurae* habitat on Big Otter Creek, July 2008.

Habitat trends

Compared to many streams in southern Ontario, the habitats of Big Creek and Big Otter Creek are relatively intact. The Norfolk Sand Plain area presently has about 20% forest cover and about 78% of the area is farmland (Lake Erie Source Protection Region Technical Team 2008). This compares with 5% forest cover for southwestern Ontario as a whole (McLachlan and Bazely 2003). Most of the stream banks are forested and unaltered by channelization or hardening with concrete and rip-rap (boulders placed on a stream bank to reduce erosion). There are no large urban or industrial developments in the watersheds. The streams, although relatively turbid due to the very fine sand substrate, probably experience fairly natural levels of erosion and sedimentation.

Logging and land clearing for agriculture in the late 1800s caused extensive soil erosion of the fine sands of the Norfolk Sand Plain (Chapman and Putnam 1966). Although the impacts on the aquatic habitat of Big Creek, Big Otter Creek and other streams are unknown, increased water temperatures associated with deforestation and increased sedimentation may have impacted *Stylurus laurae* populations. In the early 1900s, reforestation efforts were implemented and forest cover increased to present levels.

Dams have been in place on many southern Ontario streams since the mid 1800s for recreation, mills, and hydroelectricity generation. Potential impacts on *Stylurus laurae* 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. There are reservoirs on Big Otter Creek upstream of Tillsonburg at Norwich and Otterville. Big Creek has a dam and reservoir at Teeterville (upstream from Delhi) and dams on its tributaries; North Creek and South Creek. Deer Creek, a major tributary of Big Creek, also has a reservoir. The dams are operated for recreation, water supply, flood control and flow augmentation (Lake Erie Source Protection Region Technical Team 2008). Flow regimes, show the influence of reservoirs with spring flood peaks that are somewhat attenuated compared to an unregulated stream (Figure 5).

Numerous tributaries are also regulated to supply water for irrigation. Irrigation and other water users within the watershed can significantly reduce stream flow within both creeks, particularly during dry summers (Lake Erie Source Protection Region Technical Team 2008). A trend towards decreasing amounts of water in Big Otter Creek near Calton (nearest location where measurements have been made to the largest concentration of dragonflies) is apparent in Figure 5. With increased temperature and drought, it is anticipated that this discharge will decline even further. This water removal can substantially reduce available habitat and may also lead to a decline in habitat quality by concentrating pollutants and increasing predation.

Although there is little urbanization in the watersheds of Big Creek and Big Otter Creek, degraded water quality could have impacts on Canadian *Stylurus laurae* larvae. Nitrate and phosphorus concentrations within both watersheds consistently exceed the Canadian Guideline and Provincial Water Quality Objectives and are the most serious nutrient issues in the watersheds (Lake Erie Source Protection Region Technical Team 2008). Big Creek has high nitrate concentrations in the upstream reaches, but concentrations diminish downstream due to dilution by tributary streams. (Lake Erie Source Protection Region Technical Team 2008). Elevated phosphorous and nitrate concentrations are likely associated with intensive agriculture and fertilizer application in the watersheds. The Delhi wastewater treatment plant is another potential source of excess nutrients. Chloride concentrations associated with road salting, sewage treatment plant effluent, and other human sources are increasing at most sites in the Norfolk Sand Plain and generally in southern Ontario rivers (Lake Erie Source Protection Region Technical Team 2008, Todd and Kaltnecker 2004). Chloride levels are greatest in the upper parts of Big Creek. Although chloride levels in Big Creek and Big Otter Creek are still low relative to the Environment Canada benchmark, the increasing trend is of concern (Lake Erie Source Protection Region Technical Team 2008).

Dragonfly larvae are sensitive to dissolved oxygen availability (Corbet 1999). Dissolved oxygen levels in Big Creek, Big Otter Creek and other streams in the Norfolk Sand Plain rarely drop below 6 mg per litre, which is above the 4 mg per litre lower threshold for cold water biota and is considered to be generally adequate for aquatic life (Lake Erie Source Protection Region Technical Team 2008). Dissolved oxygen concentrations in early July 2008 ranged from 7.7-8.5 mg per litre in Big Creek and from 8.0-9.5 mg per litre in Big Otter Creek (Alan Dextrase, pers. comm. 2009). Stream oxygen tends to be lowest first thing in the morning and then increases through the day as oxygen is produced through photosynthesis. However, the range of diurnal fluctuations of oxygen availability are unknown (Lake Erie Source Protection Region Technical Team 2008).

In summary, the habitat appears to be declining with trends toward increased pollution and continuing water removal.

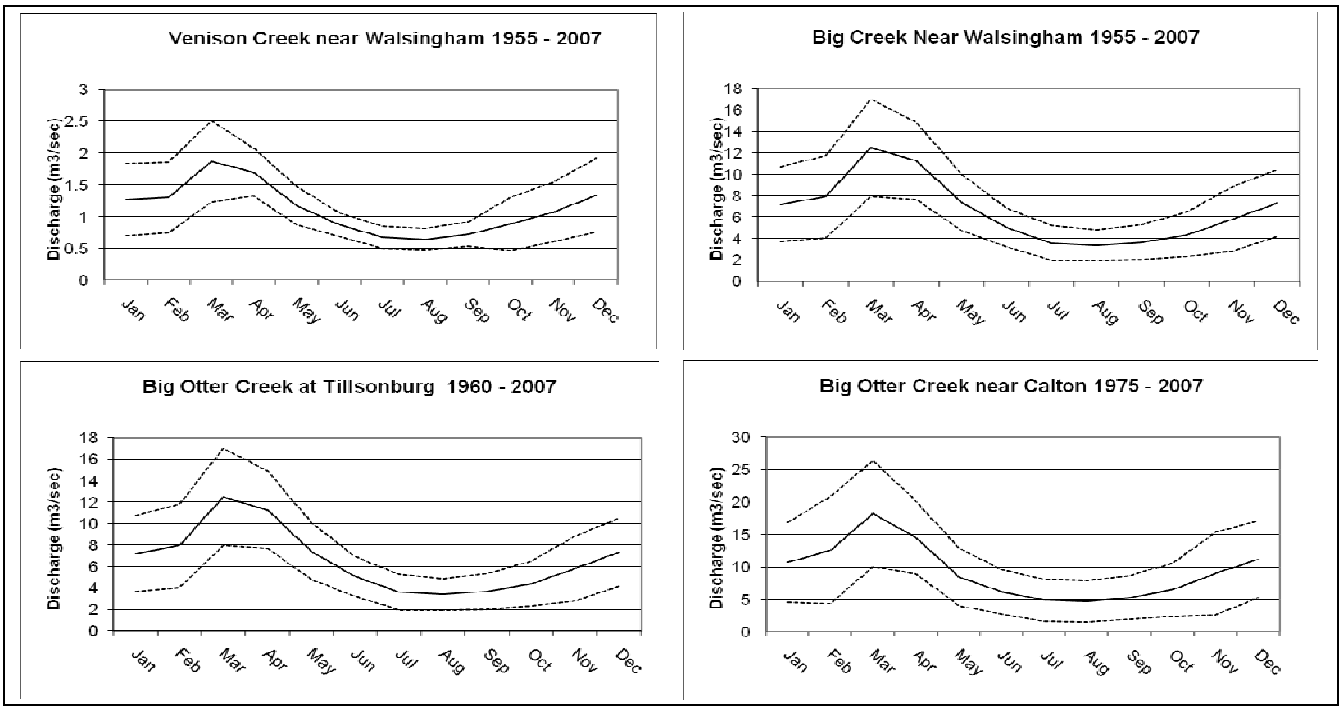

Figure 7. Hydrographs for Venison, Big, and Big Otter creeks (data from Water Survey of Canada 2009). The dashed lines represent 66% confidence intervals. The graphs are based on data averaged over a month.

Habitat protection/ownership

Most (over 75%) of the lands along the banks of Big Creek and Big Otter Creek and within their watersheds are privately owned. About 4700 ha of the combined watersheds are owned and managed by the Long Point Region Conservation Authority, of which almost 3845 ha are forested (Long Point Region Conservation Authority 2009). The Long Point Region Conservation Authority monitors water quality and invasive species and works with municipalities and landowners in the area to protect the aquatic environment.

BIOLOGY

Little information is available about most aspects of *Stylurus laurae* 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 *Stylurus laurae* fly between mid July and mid August in Ontario and Ohio (Rosche *et al*. 2008) and from early July to early October in Georgia (Mauffray and Beaton. 2005). Males arrive at the stream in mid-morning, but are most active in the evening (Dunkle 2000).

Before copulation, the male transfers sperm from the end of the abdomen to the secondary genitalia beneath the second abdominal segment. Male gomphids typically patrol over the stream until encountering a female. The courtship flight for *S. laurae* (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. Ovipositing behaviour ç apparently undescribed for *S. laurae*. On average, female dragonflies deposit 200 to 300 eggs, but over 5000 were produced by a female *Gomphus externus* (Walker 1953).

Eggs probably require at least 5 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. Gomphid larvae typically spend most of their time buried just below the surface of the sediment in the bottom of the pool, with the tip of the abdomen raised above the sediments.

The generation time for *Stylurus laurae* is probably 2 to 4 years. The duration of the larval stage is unknown, but probably lasts 2 or more years (T.W. Donnelly pers. comm. 2009). Other gomphids at temperate latitudes in Europe require at least 3 to 4 years to reach adulthood (Walker 1953, Corbet *et al*. 1960). Duration of the larval stage may be shorter where food is abundant. Adult dragonflies typically breed within a few weeks of emerging and die by early autumn.

Before the final molt, larvae crawl onto the stream bank or vegetation close to the edge of the stream. Newly emerged adults (tenerals) apparently 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). Males of *Stylurus laurae* are rarely collected (Rosch *et al*. 2008), suggesting that they spend most of their time in the forest canopy and relatively little time cruising the streams.

Adult *S. laurae* are probably generalist opportunist predators, feeding on flying small insects (Walker 1953). Much of their feeding presumably takes place in the forest canopy, where adults tend to spend most of their time (Rosche *et al*. 2008). Larvae ambush prey from the sediments using their prehensile labium. Early gomphid 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 blackbirds, swallows, flycatchers and 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 Grebes, Mallards, 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. 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 (Walker 1953).

Several introduced species of fishes inhabiting Big Creek and Big Otter Creek are potential predators on *Stylurus laurae* larvae and could limit their populations or impede their restoration. These species include common carp, rainbow trout, and perhaps most significantly round goby (see *Limiting Factors and Threats*). Further water quality degradation could cause further shifts in fish species composition with unknown impacts on odonate populations.

Physiology

Physiological requirements of *Stylurus laurae* are not documented. Larvae are probably sensitive to pesticides, especially organochlorides and organophosphates (Corbet 1999). Effects of pollutants on odonate larvae include slow growth, developmental deformities, and behavioural abnormalities (Corbet 1999). Biological accumulation of persistent chemicals may be significant given their predatory diet and relatively long life cycle. Biological oxygen demand (BOD) greater than 10 mg/l cannot be tolerated by most odonate larvae (Corbet 1999).

Dispersal and Migration

Adults are capable of strong flight. The average distance traveled between reproductive and roosting or foraging sites is generally less than 200 m in dragonflies (Corbet 1999). 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, *Stylurus laurae* lives in relatively stable streams where the requirement for dispersal is lower and the likelihood of finding unoccupied suitable habitat is small. However within streams, larvae inhabit highly oxygenated fine sand on river bends, which are subject to erosion and deposition. Locations of these habitats may change within or between years. Adults remain 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.

The Canadian sites are separated by Lake Erie from the nearest location in Ohio (about 120 km to the southwest) and US and Canadian sites probably constitute separate populations.

Interspecific interactions

Stylurus laurae 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.

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).

A closely related species, *Stylurus amnicola*, also occurs in Big Otter Creek and these two species may compete for food in both the larval and adult stages. *S. amnicola* apparently flies somewhat earlier than *S. laurae*, but the flight period overlapped in 2008 (Harris and Foster 2009).

Adaptability

The persistence of *Stylurus laurae* at two Canadian locations in broadly agricultural landscapes suggests it is at least somewhat tolerant of landscape changes. However in other areas it is reportedly very sensitive to water pollution and changes in the surrounding drainage basin (J.J. Daigle pers. comm. 2009). Larvae are easily reared to adulthood in captivity (T.W. Donnelly pers. comm. 2009).

POPULATION SIZES AND TRENDS

Search effort

The species was discovered in Canada in August 1999 at Big Otter Creek (Catling and Catling 1999). A total of six adults and six larvae were collected. Catling and others subsequently collected adults and larvae at Big Creek in 2002 to 2004. On Aug 10 to 12 2004, Peter Burke, Colin Jones, Richard Russell and Don Sutherland canoed Big Otter Creek from Eden Line south to Heritage Line and surveyed the creek at bridge crossings downstream of this section. A total of 20 larvae were collected (Colin Jones pers. comm. 2008). *Stylurus laurae* was probably established in these streams prior to 1999, but undetected by surveyors.

On July 13 to 15, 2008 Harris and Foster (2009) surveyed by canoe a 6 km stretch of Big Otter Creek and 7.5 km of Big Creek and checked 13 stream crossings. This survey was conducted near the end of the emergence period of adults in 2008. A single teneral adult *Stylurus laurae* was discovered, and eight larvae and 143 exuviae were collected on Big Otter Creek. On Big Creek, five teneral adult *Stylurus laurae* were discovered, and six larvae and 162 exuviae were collected. No mature adults were observed.

A survey of potential habitat from July 13 to 15, 2008 on Big Otter Creek upstream from Tillsonburg and other streams in the area (Little Otter Creek, Catfish Creek, South Otter Creek, Venison Creek, Deer Creek, Silver Creek, Tate Drain, Dedrick's Creek) found no additional sites for *Stylurus laurae.* Survey effort at these latter sites consisted of a search for exuviae and adults within 100 m of bridges (Harris and Foster 2009). Many of these sites have also been checked by other surveyors since 1999 (C. Jones pers. comm. 2008). No other targeted surveys for *Stylurus laurae* are known to have been completed in Ontario. Other sand bend rivers in southwestern Ontario with potential habitat include the Grand River (near Brantford), the Thames River (Delaware to Kent Bridge), the Sydenham River (Florence to Croton), and the Ausable River (Haye Swamp) (A. Dextrase and D. Sutherland, pers. comm. 2009). All of these rivers have been surveyed over the past decade for dragonflies as part of an ongoing provincial survey that has accumulated approx. 60,000 records.

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 60,000 Atlas records from Ontario, no other locations for *Stylurus laurae* are reported. This coverage suggests to Ontario Odonata experts that S. laurae is truly confined to the two Ontario locations indicated here.

A closely related species with similar habitat requirements, Riverine Clubtail *(Stylurus amnicola)*, was also discovered at Big Otter Creek in 1999 (Catling and Brownell 1999). Distinguishing these two species will be an important consideration for future work on population size of *S. laurae*. No other locations for Riverine Clubtail have been discovered at other streams in the area despite survey effort by several observers. Harris and Foster (2009) found 11 exuviae and about seven adults of *Stylurus amnicola* at Big Otter Creek in July 2008.

Abundance

Estimating total population sizes for odonates is difficult (Corbett 1999). A rough estimate of the minimum number of individuals in Canada in 2008 is provided in Table 2. The estimate is based on the number of exuviae and tenerals observed in 2008. Several sections of Big Creek and Big Otter Creek were paddled by canoe and the creek bank was searched for exuviae. This technique was generally effective given the species preference of emerging on relatively bare sand banks. Counts of exuviae for these sections were doubled since only one bank of the creek was surveyed. This gives

a minimum Canadian population estimate of 580 adults at emergence. Note that this number does not constitute a total population estimate since (i) not all potential habitat in Big Creek and Big Otter Creek was surveyed, (ii) the number of adults yet to emerge in 2008 was unknown, and (iii) the probability of detection of exuviae is unknown. The estimate does not include larvae since the duration of the larval stage and ratio of adults to larvae are unknown.

Global abundance is estimated at 10,000 to greater than 1,000,000 individuals at 68 known locations (NatureServe 2009). This estimate is based on a survey of biologists throughout the species range. According to NatureServe (2009), no range-wide changes in abundance, area occupied, or number of occurrences have been noted and the species is considered to be secure globally.

Table 2. Minimum population estimates for Canadian occurrences of *Stylurus laurae* based on 2008 survey (Harris and Foster 2009).

Location	Exuviae Observed	Exuviae Estimated*	Tenerals Observed	Tenerals Estimated*	Total Observed	Total Estimated
Big Otter Creek	143	248	1	2	144	250
Big Creek	162	318	6	12	168	330
Grand Total	305	566	7	14	312	580

* see text

Fluctuations and trends

There are no data on fluctuations or trends of *Stylurus laurae* populations. The Ontario population is relatively recently discovered and no numerical estimates prior to 2008 or long term population trend data are available. 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) (NatureServe 2009).

Rescue effect

The likelihood of natural invasion from US locations is relatively low given the distance of 120 km across Lake Erie to the nearest population in Ohio, the lack of suitable intervening habitat, and the apparently non-migratory behaviour of adults. Recolonization at the periphery of the range, including the Canadian locations, would presumably take a very long time or may never happen. Genetic exchange between Canadian and US locations is probably very infrequent or non-existent.

LIMITING FACTORS AND THREATS

Aquatic habitat degradation is probably the most significant threat to Stylurus laurae, although invasive species (especially round goby), accidental deaths through vehicle collisions, and inbreeding are also potential limiting factors.

This species is apparently sensitive to water quality degradation, but less sensitive than other clubtails (NatureServe 2009). Threats include impoundments, channelization, dredging, siltation, agricultural non-point pollution, and municipal and industrial pollution. Logging may increase siltation and cause a decrease in dissolved oxygen as canopy cover is removed and water temperature rises. Water quality in Big Creek and Big Otter Creek have been degraded by agricultural runoff and large amounts of water are removed from the rivers for agricultural irrigation (see *Habitat Trends*). Irrigation can significantly reduce summer flows in these creeks, particularly in years with little precipitation (Lake Erie Source Protection Region Technical Team 2008). Increasing development in the town of Tillsonburg is expected to place additional pressure on Big Otter Creek. Increasing phosphorous and nitrate levels could threaten *Stylurus laurae* larvae by promoting eutrophication and decreasing dissolved oxygen availability. The frequency of water quality monitoring (eight samples per station annually) may be insufficient to adequately determine trends since changes can occur rapidly due to floods, rains, removals, spills, and discharges (Lake Erie Source Protection Region Technical Team 2008).

Invasive aquatic species are present in Big Creek and Big Otter Creek and their tributaries. Common carp, round goby, and curly pondweed are present in both creeks. Zebra mussels apparently occupy the reservoir on Big Otter Creek upstream from Tillsonburg (A. Dextrase pers. comm. 2009). In large numbers, zebra mussels can alter the aquatic environment by decreasing water turbidity through filter feeding. Rainbow trout are known from Big Otter Creek. The impacts of these species on *Stylurus laurae* are unknown, but likely include predation, competition, increased turbidity (common carp), and changes in the stream community structure. Round gobies are probably the greatest threat. These highly aggressive and often abundant predators have apparently invaded these creeks since about 2004 and are now fairly common and widespread (A. Dextrase pers. comm. 2009). Round gobies feed on a wide range of benthic invertebrates (Phillips no date), and *Stylurus laurae* larvae would be particularly vulnerable when leaving the sediment at the time of emergence. Invasion of round gobies has altered the benthic invertebrate community of several eastern Lake Erie tributary streams (Krakowiak and Pennuto 2008). Other aquatic invasives are a continued threat given the proximity to Lake Erie where numerous other invasive species exist.

Approximately 75 km of both Big Creek and Big Otter Creek have been treated with TFM (3-trifluoromethyl-4-nitrophenol) every 3-4 years on average since 1986-87 to control sea lamprey (*Petromyzon marinus*)(Sea Lamprey Control Centre, Sault Ste. Marie, unpublished data). Although dragonfly larvae appear fairly resistant to TFM (Smith 1967; Maki *et al*. 1975), impacts on their prey species and other aspects of the stream ecosystem are unknown.

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 2009). As described in the Habitat Trends section, Big Creek and Big Otter Creek and their tributaries have dams and other water control structures and are regulated for flood control and other purposes. Water level regulation can cause changes to natural patterns of sediment accumulation and reduces new sediment accumulation and can alter water temperature regimes. With increasing urbanization in the watershed and increased removal of ground water, the problems associated with water regulation are expected to increase.

Loss of riparian forest due to agriculture and residential development could threaten adults by exposing them to increased predation by birds and other dragonfly species. Of course it will also lead to loss of habitat and food as well as increased exposure to pesticides.

Collisions with cars could be source of adult mortality where road crossings fragment the stream habitat, as occurs in a population of Hines Emerald Dragonfly (*Somatochlora hineana*) (U.S. Fish and Wildlife Service 2001) and with regard to other large dragonflies (Catling and Kostiuk 2008). 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). There are 12 bridges on Big Otter Creek and seven bridges on Big Creek in or near *Stylurus laurae* habitat. All these roads have speed limits greater than or equal to 50 km / hour.

SPECIAL SIGNIFICANCE OF THE SPECIES

Dragonflies are increasingly popular amongst naturalists as indicated by increasing numbers of field guides and organized dragonfly count events. However, *Stylurus laurae* was discovered in Canada only in 1999 and is not well known in this country. Even in parts of the US where the species is more common adults are infrequently seen or collected. The ecological role of this species is unknown. Stream-dwelling gomphids in general are potential indicators of well-oxygenated, unpolluted streams (Bode *et al*. 1996).

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

The species is not protected under the *Species at Risk Act* in Canada or Ontario's *Endangered Species Act*, 2007, nor is it on the US Endangered Species list. It is not covered by the IUCN Red List or CITES. River habitats in Canada are protected under the federal Fisheries Act where fish habitat is concerned. It is not listed as Special Concern, Threatened or Endangered in any of the jurisdictions where it occurs.

Stylurus laurae is ranked globally as G4 (Apparently Secure—Uncommon but not rare; some cause for long-term concern due to declines or other factors) (NatureServe 2009). Nationally, it is ranked as N1 in Canada and N4 in the US (NatureServe 2009). It is ranked as S1 in Ontario and from S1 to S3 in eight states (table 3). It is secure (>S4) in North Carolina and Tennessee and unranked in the remaining six states. Six of the occurrences are appropriately protected and managed in State and National forests, parks or other protected areas in Texas, South Carolina, North Carolina, Virginia, Maryland and Mississippi (NatureServe 2009)

Table 3. State ranks for *Stylurus laurae* in North America (NatureServe 2009). 1 = critically imperilled; 2 = imperilled; 3 = vulnerable; 4 = apparently secure; 5 = secure; SH = possibly extirpated; SNR = unranked.

Province / State	S-Rank	Notes
Ontario	S1	
Alabama	SH	Documented from 5 counties (plus one or two more undocumented records). Perhaps much more common than records indicate (R.S. Krotzer pers. comm. 2008).
Arkansas	SNR	Not tracked (Cindy Osborne pers. comm. 2009).
Florida	S3	Recently discovered populations in NW Florida and just west of Tallahassee (D. Almquist, J.J. Daigle pers. comm. 2008)
Georgia	S3	About 10 known records, but probably occurs at more locations. None of the populations are large, but most are considered stable (B. Albanese, G. Beaton pers. comm. 2009)
Indiana	S1	Very uncommon and no recent records (T. Swinford pers. comm. 2008)
Iowa	SNR	No verified records (D. Howell pers. comm. 2009)
Kentucky	S2	Known from 6 counties (E. Laudermilk pers. comm. 2008).
Louisiana	SNR	Not tracked and not much information (B. Gregory pers. comm. 2008)
Maryland	S2	Recorded in 3 major rivers (Potomac, Patuxent, Patapsco) and several of their larger tributaries, which together probably represent 3 metapopulations. Uncommon to sparse where present. (J. McCann pers. comm. 2008)
Michigan	S1S2	Known from 8 locations in 7 counties in the Lower Peninsula (Michigan Natural Features Inventory 2007)
Mississippi	SNR	Known from 13 of 82 counties, scattered from north to south across the state, but apparently absent from the western counties that comprise the Mississippi River delta (R. S. Krotzer pers. comm. 2008). Tentative S-rank of S3 (Tom Mann pers. comm. 2009)

Province / State	S-Rank	Notes
North Carolina	S4	
Ohio	S2	Records from 7 counties (R.C. Glotzhober pers. comm. 2009, T. Arbour pers. comm. 2008)
South Carolina	SNR	
Tennessee	S4?	Seven records from 7 counties from across the state, with the most recent from 2008 near Alcoa (Blount Co.) (R. Connors pers. comm. 2009).
Texas	SNR	Known in east Texas from larval collections (Sam Houston National Forest) and a single adult female (Abbott 2005, M. Quinn pers. comm. 2008)
Virginia	S2	2 recent records (1990s), 6 historical (1915-1978), and 1 extirpated (site flooded by a reservoir). Probably more unconfirmed populations (S. Roble pers. comm. 2009)

ABORIGINAL AND TRADITIONAL KNOWLEDGE

No aboriginal and traditional knowledge was available for this species (based on assistance of Gloria Goulet, COSEWIC secretariat).

TECHNICAL SUMMARY

Stylurus laurae
Laura's Clubtail gomphe de Laura
Range of Occurrence in Canada : Ontario

Demographic Information

Generation time (average age of parents in the population)	Unknown; probably 2 years or more
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 or 5 years, or 3 or 2 generations].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible?	not applicable
Are the causes of the decline understood?	not applicable
Have the causes of the decline ceased?	not applicable
[Observed, inferred, or projected] trend in number of populations	Unknown
Are there extreme fluctuations in number of mature individuals?	Unknown
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	256 km²
[Observed, inferred, or projected] trend in extent of occurrence	Unknown
Are there extreme fluctuations in extent of occurrence?	Unknown
Index of area of occupancy (IAO) Based on the number of 1 km X 1 km grid squares in which there are records of the species. Based on the number of 2 km X 2 km grid squares in which there are records of the species = 60 km²	22 km²
[Observed, inferred, or projected] trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	2
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Trend in quality of habitat Invasive species, water quality degradation, water removals, are likely causing decline in habitat quality	Declining

Number of mature individuals in each population

Population	**N Mature Individuals**
Big Creek	Unknown
Big Otter Creek	Unknown
Total	Unknown
Number of populations (locations)	2

Quantitative Analysis

	None

Threats (actual or imminent, to populations or habitats)

1. Water pollution
2. Water level regulation and water removal
3. Invasive aquatic species

Rescue Effect (immigration from an outside source)

Status of outside population(s)? USA: USA: Stable nationally, although declining in parts of the northeast. Probably undetected populations in the southeast	
Is immigration known?	Unlikely
Would immigrants be adapted to survive in Canada?	Probable
Is there sufficient habitat for immigrants in Canada?	Possibly
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Endangered (April 2010)
Global: G4
Canada: N1
US: N4
S1: ON, IN
S2: KY, OH, MD, VI
S1S2: MI
S3: FL, GA
S4: NC, TN
SH: AL
SNR: AR, IO, LA, MS, SC, TX

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Endangered	B1ab(iii)+2ab(iii)

Reasons for designation:
This attractive dragonfly of eastern North America is known from only two locations in unusual fast-moving sandy streams in southwestern Ontario. The species has a very small range in Canada and there is evidence of continuing decline of habitat.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable as there is no accurate population data.

Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Endangered B1ab(iii)+2ab(iii) as both the index of area of occupancy (60 km²) and extent of occurrence (256 km²) are below the Endangered thresholds, there are less than 5 locations and there is a projected decline in habitat.

Criterion C (Small and Declining Number of Mature Individuals): Not applicable as there is no accurate population data.

Criterion D (Very Small Population or Restricted Distribution): Meets Threatened D2 as there are less than 5 locations and the populations are subject to rapid loss due to pollution or water withdrawal.

Criterion E (Quantitative Analysis): Not undertaken.

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