COSEWIC
Assessment and Status Report

on the

Olive Clubtail
Stylurus olivaceus

in Canada

ENDANGERED
2011

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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Olive Clubtail — Photo by Jim Johnson. Permission granted for reproduction.

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COSEWIC
Assessment Summary

Assessment Summary – May 2011

Common name
Olive Clubtail

Scientific name
Stylurus olivaceus

Status
Endangered

Reason for designation
This highly rare, stream-dwelling dragonfly with striking blue eyes is known from only 5 locations within three separate regions of British Columbia. It is restricted to small areas along warm lowland rivers, and infrequently lakes, where continuing decline in the quality of habitat is occurring. Threats include loss and disturbance of habitat due to human activity, such as beach recreation, impacts of invasive species of fish, invasive aquatic plants, and pollution by pesticides and fertilizing nutrients.

Occurrence
British Columbia

Status history
Designated Endangered in May 2011.

COSEWIC
Executive Summary

Olive Clubtail
Stylurus olivaceus

Wildlife species description and significance

The Olive Clubtail is a dragonfly in the clubtail family. Adults are 56-60 mm long, have widely separated eyes and the tip of the abdomen, especially in males, is swollen; the wings are clear. The thorax is grey-green with broad, brown shoulder stripes and the black abdomen bears a yellow mark on the top of each segment and has yellow on the sides. The elongate larvae are distinguished by vestigial burrowing hooks on the tibiae (middle of front legs). All larval records of the Olive Clubtail in Canada are of exuviae (singular "exuvia"), the cast exoskeletons of the final larval stage, left on the shore after adult emergence.

The Olive Clubtail is the only representative of the genus *Stylurus* in British Columbia. Few odonates (damselflies and dragonflies) in British Columbia develop in streams; this species may prove to be a good indicator of stream ecosystem health for warm, mesotrophic lowland rivers – a scarce habitat in the province.

Distribution

The Olive Clubtail lives in scattered populations across western North America from south-central British Columbia south through the interior of Washington and Oregon, Idaho, Utah, Nevada, and California. There are five locations in three separate regions in British Columbia and Canada – South Thompson River, Christina Creek and the Okanagan Valley (including three locations). Based on substantial search effort, it is a rare species throughout its Canadian range.

Habitat

Larvae burrow in the bottom of mud- or sand-bottomed rivers or streams, rarely along lakeshores. The rivers can be as large as the lower Columbia River below Portland, Oregon and the streams may be as small as the 10 m-wide Christina Creek. Because the habitat requirements of the larvae are imprecisely known, it is difficult to determine whether there has been a decline in quality and quantity of habitat. Most of the Canadian length of the Okanagan River was channeled in the 1950s; presumably this has reduced both quantity and quality of habitat. The South Thompson River is relatively natural, except for agricultural, transportation and housing developments along some stretches. Christina Creek remains mostly in a natural state.

Biology

The larvae of Olive Clubtails are aquatic predators, living for about two years in the bottom sediments of streams or lakes until emerging as adults. They eat bottom-dwelling invertebrates. Adults, like other dragonflies, consume a great variety of small, flying insects. In British Columbia, adults fly from mid-July to mid-October. Males fly over open water, as opposed to along the shore. Females lay eggs on the water surface. Adults rest in riparian perennials, shrubs and trees; sometimes they perch on the ground.

Population sizes and trends

Populations in British Columbia are not known well enough to provide good size estimates. The data set used in this report consists of 31 specimens and 26 sight records; each record may relate to more than one individual. Specimens total 18 adults and 69 larval exuviae. Speculative estimates for the whole Canadian population are: Christina Creek – <500; Okanagan Valley – 1000-50,000; South Thompson River – 1000-40,000; total population – 2500-90,000. The large ranges in these estimates renders them unsatisfactory and more comprehensive counts of exuviae are required before any useful population estimates can be reached.

Although its preference for flying over water and perching inconspicuously in trees may reduce the chances of *S. olivaceus* adults being encountered, it is still clearly a rare species in British Columbia. There is no reliable trend information for British Columbia although populations appear to be stable based on their long persistence.

Threats and limiting factors

Much of the Olive Clubtail's habitat in the south Okanagan has been altered by river channeling. Urban, residential, transportation and marina developments; pollution from power boats; and disturbance at popular swimming beaches all have potential impact on larval survival. Introduced fish have altered the ecology of the Okanagan and Christina watersheds and are major predators of odonate larvae. Both watersheds have also been invaded by Eurasian Milfoil, an aggressive aquatic weed that changes aquatic environments.

Pollutants may come from land development, agricultural practices, storm water runoff, sewage systems, forestry and range activities, and other sources. Pesticides are a potential problem in the South Okanagan, as the Okanagan River flows through many orchard and vineyard lands. Eutrophication resulting from agricultural runoff and sewage is a worry in the Okanagan and along the Thompson River, although major nutrient from sewage have been reduced dramatically through tertiary treatment of sewage, which was implemented in all major centres in the 1980s.

Protection, status, and ranks

The Olive Clubtail has a global NatureServe rank of G4 ("apparently secure but perhaps potential future conservation concerns"). The British Columbia Conservation Data Centre gives it a rank of S1S2 (imperiled) and the British Columbia Ministry of Environment's Conservation Framework rank is 1, the highest priority rank for action. The species is ranked "May be at Risk" nationally and provincially under the national General Status program. Most of the provincial parks within the distribution of this species occur on lakes where the Olive Clubtail is rarely present and are managed primarily for recreation. Only a few protected areas are associated with the rivers that are the main habitat of the Olive Clubtail.

TECHNICAL SUMMARY

Stylurus olivaceus
Olive Clubtail gomphe olive
Range of occurrence in Canada:British Columbia

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines(2008) is being used	2 years
Is there an inferred continuing decline in number of mature individuals?	No
Estimated percent of continuing decline in total number of mature individuals within 5 years	Unknown
Suspected percent reduction in total number of mature individuals over the last 10 years.	Probably stable
Suspected percent reduction in total number of mature individuals over the next 10 years.	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Probably stable in past
Are the causes of the decline clearly reversible and understood and ceased?	Not applicable
Are there extreme fluctuations in number of mature individuals?	Unknown

Extent and Occupancy Information

Estimated extent of occurrence	10,936 km²
Index of area of occupancy (IAO) (based on a 2 km x 2 km grid)	184 km²
Is the total population severely fragmented? *3 of 5 locations separated by at least 100 km. However, despite their isolation, the Thompson River location, the Christina Creek location and the three Okanagan River locations seem to function as viable populations based on persistence for several decades.*	No
Number of "locations." *This calculation assumes 3 locations for the Okanagan River—between Okanagan, Skaha, Vaseux, and Osoyoos Lakes. Most of the threats could be confined to an area the size of any of these 5 locations.*	5
Is there a continuing decline in extent of occurrence?	No
Is there a continuing decline in index of area of occupancy?	No
Is there a continuing decline in number of populations?	No
Is there a continuing decline in number of locations?	No
Is there a continuing decline in area, extent and/or quality of habitat? *There is a decline in area and quality of habitat, but the effects of ongoing habitat alterations on the species are unknown.*	Yes
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations∗?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	Number of Mature Individuals
Christina Creek	<500
Okanagan River and lakes	1000-50,000
South Thompson River	1000-50,000
Total	2500-100,000
Note: These are very rough estimates based on limited survey data and include a number of assumptions.	

Quantitative Analysis

Probability of extinction in the wild is at least:	Not done

Threats (actual or imminent, to populations or habitats)

Limited habitat is available in Canada, and habitat degradation and loss is a key potential threat, as are invasive species of fish and aquatic plants, and pollution by pesticides and fertilizing nutrients.

Rescue Effect (immigration from outside Canada)

Status of outside populations: *Stable; relatively large populations are present in the Columbia Basin of Washington State and on the lower Columbia River; presence on the adjacent Okanogan River of Washington State is unknown, but suspected*.	
Is immigration known or possible? [*not known in adjacent US drainages*]	Unlikely
Would immigrants be adapted to survive in Canada?	Probably
Is there sufficient habitat for immigrants in Canada? *But appropriate habitat is probably all occupied now, and its degradation may be the ultimate cause of any future extirpation*.	Perhaps
Is rescue from outside populations likely? *A rescue effect cannot be assumed until populations are confirmed in northern Washington.*	No but possibly for Okanagan population only

Current Status

COSEWIC: Designated as Endangered in May 2011

Status and Reasons for Designation

Status:	Alpha-numeric code:
Endangered	B2ab(iii)

Reasons for designation:

This highly rare, stream-dwelling dragonfly with striking blue eyes is known from only 5 locations within three separate regions of British Columbia. It is restricted to small areas along warm lowland rivers, and infrequently lakes, where continuing decline in the quality of habitat is occurring. Threats include loss and disturbance of habitat due to human activity, such as beach recreation, impacts of invasive species of fish, invasive aquatic plants, and pollution by pesticides and fertilizing nutrients

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable as the total number of mature individuals is not definitely known.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Endangered B2ab(iii) because the index of area of occupancy (184 km²) is less than the Endangered threshold, there are only 5 locations and there is a projected continuing decline in the quality of habitat. Also meets Threatened B1ab(iii) as the extent of occurrence (10,936 km²) is less than the Threatened threshold, there are only 5 locations and there is a projected continuing decline in the quality of habitat.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable as the total number of mature individuals is not definitely known.
Criterion D (Very Small or Restricted Total Population): Meets Threatened D2 as there are only 5 locations and the species is prone to the effects of human activities over a short time.
Criterion E (Quantitative Analysis): Not available.

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
(2011)

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

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

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

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

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

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and classification

Kingdom: Animalia – animals, animaux
Phylum: Arthropoda – arthropods, arthropodes
Class: Insecta – insects, insectes
Subclass: Pterygota – winged insects, insectes ailés
Order: Odonata Fabricius, 1793 – dragonflies and damselflies, libellules
Suborder: Anisoptera Selys, 1854 – dragonflies, libellules
Family: Gomphidae – Clubtails
Genus: *Stylurus* Needham, 1897
Species: *Stylurus olivaceus* (Selys, 1873) – Olive Clubtail
Synonyms: *Gomphus olivaceus* Selys, 1873

Stylurus olivaceus was originally described in the genus *Gomphus* (Selys 1873, Bull. Acad. Belg. (2) 35:749). *Stylurus* was described by Needham as a subgenus of *Gomphus* in 1897 and subsequent authors (e.g., Williamson 1932, Needham 1948) raised this group to the generic level. Walker (1958), however, was hesitant to accept this designation and retained *Gomphus* in its broader sense; this arrangement was followed by Cannings and Stuart (1977). In the last decade, however, *Stylurus* has been accepted as a full genus in all official lists (Garrison 2002; Catling *et al*. 2005; Schorr *et al.* 2009). There are 30 species of *Stylurus* recognized worldwide; 11 occur in North America (Dragonfly Society of America 2010, Schorr and Paulson 2011).

Kennedy (1917) described the subspecies *G. o. nevadensis* for the pale populations of the arid American interior but this taxon has not been recognized by Needham *et al*. (2000) and Garrison (2002). However, it is used in Dunkle (2000). If subspecies are recognized, the form in British Columbia is the nominate *S. olivaceus olivaceus* (Selys) (Walker 1958).

Stylurus is derived from the Latin *stylus*, meaning “stake” or “stem”, and the Greek *urus*, referring to the tail; this describes the relatively long, slender abdomen of either the larvae or the adults. The official English common name of the genus is “Hanging Clubtails”; typically, adults perch on twigs and leaves, often hanging almost vertically. The specific epithet *olivaceus* refers to the olive colour of the adult thorax. The English common name is that accepted by the Dragonfly Society of The Americas in the official North American list of Odonata (Paulson and Dunkle 1996, 1999). The French common name is Gomphe olive.

Morphological description

As its name suggests, the Olive Clubtail is a dull, grey-green species (Figures 1-4). The adults are relatively large, 56-60 mm long with hind wing lengths of 35-36 mm (Paulson 2009). They have bright blue eyes in life and a pale green face with a thin, dark horizontal line. The robust thorax is grey-green with broad, brown shoulder stripes. The abdomen is boldly marked in black with a pale or yellow stripe or spot on the top of each segment, and with yellow on the sides; in the male the yellow is more prominent on the flared segments near the tip of the abdomen (Dunkle 2000; Cannings 2002, Paulson 2009). The female is coloured as the male but the lateral thoracic stripes may be faint and the yellow on the sides of the abdomen is more extensive, making most segments largely pale. The female can be distinguished from the male by the generally thicker abdomen with a reduced terminal club, the lack of secondary genitalia on the venter of abdominal segments 2 and 3, the presence of a subgenital plate and in the different form of the abdominal appendages on segment 10.

Figure 1. Dorsolateral view of male *Stylurus olivaceus.* Near Wintler Park, Vancouver, Clark County, Washington (approximately 45.6ºN, 122.6ºW). 15 August 2008. Photo by Jim Johnson; permission granted for reproduction.

Figure 2. Lateral view of male *Stylurus olivaceus*. Near Wintler Park, Vancouver, Clark County, Washington (approximately 45.6ºN, 122.6ºW). 15 August 2008. Photo by Jim Johnson; permission granted for reproduction.

Figure 3. Copulating pair of *Stylurus olivaceus*. Near Wintler Park, Vancouver, Clark County, Washington (approximately 45.6ºN, 122.6ºW). 19 September 2006. Photo by Jim Johnson; permission granted for reproduction.

Figure 4. Recently emerged female *Stylurus olivaceus*. North side of South Thompson River at Lafarge Road Bridge (50.6588ºN, 120.0608ºW). 15 August 2008. Photo: Darren Copley; permission granted for reproduction.

Individuals from some populations in the Great Basin of the United States have more extensive pale areas than do specimens from other populations (Kennedy 1917, Manolis 2003, Paulson 2009).

There are three additional gomphid species sympatric with *Stylurus olivaceus* in south-central British Columbia and the larva of *Stylurus* is readily differentiated from the larvae of these species. *Stylurus* larvae are more elongate (Figure 5) than those of any other clubtail in British Columbia. They can be distinguished from the two species of *Ophiogomphus* (*O. occidentis* Hagen and *O. severus* Hagen) often found with *Stylurus*, by the shape of the labial palps: *Ophiogomphus* has the apex of the palp bluntly rounded; *Stylurus* and *Gomphus* have the apex hooked. *Stylurus olivaceus* larvae are distinguished from the larvae of the sympatric *Gomphus graslinellus* Walsh by the size of the burrowing hook on the apex of the tibiae. Those of *Stylurus* are vestigial or absent; those of *Gomphus* are well-developed (Cannings and Stuart 1977).

All larval records of the Olive Clubtail in Canada are of exuviae (singular “exuvia”), the cast exoskeletons of the final larval stadium (Figure 5), left on the shore after adult metamorphosis and emergence.

Figure 5. Exuvia of Olive Clubtail. North bank of South Thompson River at Stobbart Creek, approximately 50.6722ºN, 120.1514ºW. 25 August 2008. Photo: Robert A. Cannings.

Population spatial structure and variability

Little information is available on Olive Clubtail populations in British Columbia but a few generalities about spatial distribution are noted. A few collections of exuviae on the South Thompson River indicate that larval densities (or at least densities at emergence sites) vary considerably along the river. In addition, no individuals have been recorded on this river for several kilometres east of Kamloops and between Pritchard and Chase where the South Thompson River flows out of Little Shuswap Lake, although the habitat, especially in the latter stretch of river, seems appropriate. The frequency of observations of adults along the Okanagan River indicates that the dragonfly is most abundant between Okanagan Falls and Vaseux Lake.

Olive Clubtail appears to develop (grow from egg to mature larva) much more frequently in rivers than in lakes. Of 57 specimen and sight records, only three (one in Okanagan lake and two in Vaseux Lake) are from lake habitats. Thus, in the southern Okanagan Valley, the population is more or less divided into three sections of river– between Okanagan and Skaha lakes; between Skaha and Vaseux lakes; and between Vaseux and Osoyoos lakes. The weakest separation is at Vaseux Lake, which is much smaller than Skaha Lake and supports two records of larval development.

Designatable units

There is only one Canadian population of the Olive Clubtail in the southern interior of British Columbia. The designatable unit is the species.

Special significance

The Olive Clubtail is the only representative of the genus *Stylurus* in British Columbia. Few dragonflies in British Columbia develop in streams; this species may prove to be a good indicator of stream ecosystem health for warm, mesotrophic lowland rivers in the province. This type of lotic habitat is relatively scarce in British Columbia.

DISTRIBUTION

Global range

Stylurus olivaceus is distributed in scattered populations across western North America (Figure 6), in warm, lowland valleys from south-central British Columbia south through the interior of Washington and northern and southeastern Oregon (reaching almost to the coast along the Columbia River), southeastern Idaho, northern and central Utah, northwestern Nevada and parts of California (Needham *et al.* 2000; Bick and Mauffray 2005; Manolis 2003). Some authorities state that the range includes Arizona (Needham *et al*. 2000, NatureServe 2009) but the record indicating this is dismissed by Paulson (2009) and others (Odonata Central 2009).

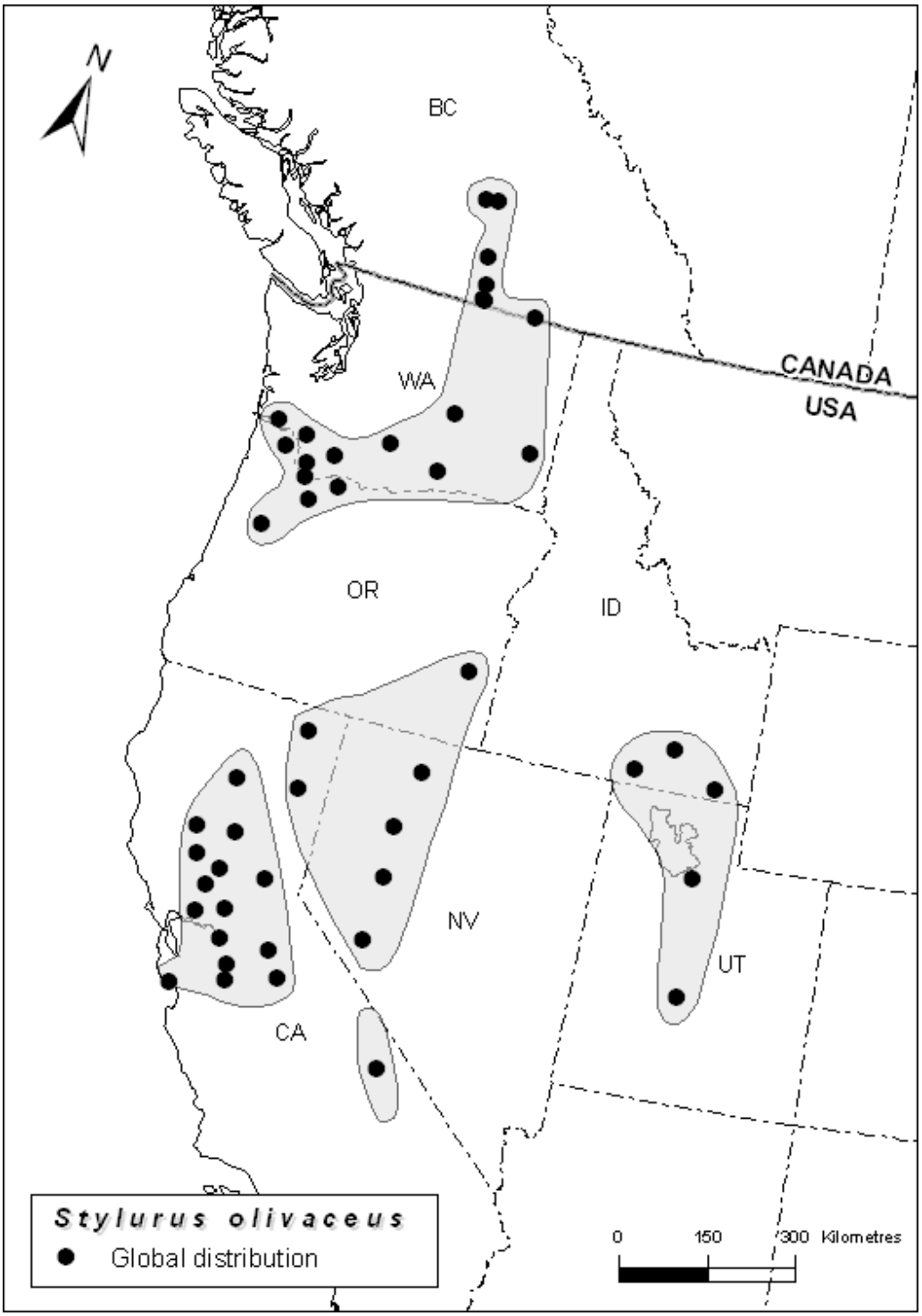

Figure 6. Global (North American) range of *Sylurus olivaceus*. Data from the Odonata Central (2009) website (Distribution maps) except for Canadian localities, which are replaced by selected coordinates from data documented in this report. Localities grouped according to Paulson (2009) to show probable isolated populations.

Paulson (2009) divides this scattered range into five separate areas based on general continuity of appropriate habitat: southern British Columbia, Washington and northern Oregon; southeastern Idaho and northern and central Utah; southeastern Oregon, northwestern Nevada and northeastern California; Central Valley of California; east of the Sierra Nevada in Inyo County, California (Owens River Valley). These areas are separated from each other, usually by high or extensive mountain ranges and the clubtails inhabiting them may be genetically isolated.

Although the Canadian population is probably connected to the eastern Washington one via the Okanagan, Kettle and Pend d'Oreille valleys of the Columbia River drainage, the Olive Clubtail has never been recorded in northeastern Washington. In particular, there have been few searches along the Okanogan River (Note: the name of this river in Canada and the US is spelled differently) in Washington at the proper season and the Olive Clubtail has never been observed there (D. Paulson, pers. comm. 2009). However, it almost certainly does occur in the American portion of the river, which is not channelized.

The species and its distribution are not well known in much of its range in the United States. One of the best documented populations is along the lower Columbia River and its main tributaries (Washougal, Sandy, Lewis, Cowlitz, Willamette rivers) in Washington and Oregon (Johnson 1998; Cannings 2003, J. Johnson, pers. comm. 2009; D. Paulson, pers. comm. 2009; S. Valley, pers. comm. 2009). The species has not been observed upstream from Skamania County, Washington and Hood River County, Oregon (J. Johnson, pers. comm. 2009). This may be the result of the reservoir effect of the big dams that have radically changed the flow of the Columbia River (J. Johnson, pers. comm. 2009). However, the species is local in some of the sandy rivers of the Columbia Basin of eastern Washington (Paulson and Garrison 1977; Paulson 1983, 1999; Johnson 1998; D. Paulson pers. comm. 2002, 2009). In this region the Yakima River at Horn Rapids Park (Benton County) was the only place where the species was regularly found. Few records have come from there since the 1980s (J. Johnson, pers. comm. 2009) although there has not been much searching there recently. That there is little or no decline in *Stylurus* numbers at Horn Rapids is indicated by the results of observations by Kogut (2008), who documented six individuals there between 15 and 29 August 2008. In Oregon there is only one record east of the Cascade Range (S. Valley, pers. comm. 2009, Figure 6)

Paulson (1998) found the Olive Clubtail common along the Snake River at Massacre Rock State Park, Power County, Idaho, on 8 and 12 August 1997. All Idaho records are in the southeast corner of the state. On the other hand, the two records in adjacent Utah are historical and the populations there may be extirpated (NatureServe 2009).

The majority of the records in California have been generated in four rivers: the American River near Sacramento, the Owens River (Inyo County), the Feather River (Butte, Yuba and Sutter counties) and the Susan River near Susanville (Lassen County). Most of the other records are single captures at widely scattered locations. Manolis (2003, pers. comm. 2009) describes the species as scarce and local in the state.

Canadian range

The Olive Clubtail develops in warm lowland rivers and, infrequently (three of 57 records), in warm lakes in the southern interior of British Columbia (Figure 7). It is known from three distinct regions in British Columbia: 1) Christina Creek (Figure 8), just below the outlet of Christina Lake in the Kettle River drainage east of the Okanagan Valley; 2) the Okanagan drainage (Figure 9), especially parts of the Okanagan River from Penticton (Walker 1927, 1958; Whitehouse 1941) south to the north end of Osoyoos Lake, but also from Vaseux Lake and Peachland on Okanagan Lake (Whitehouse 1941); 3) the South Thompson River (Figure 10) between Kamloops and Pritchard (Whitehouse 1941; Walker 1958; Scudder *et al*. 1976; Cannings and Stuart 1977; Cannings *et al.* 1998; Cannings *et al.* 1999; Cannings 2003).

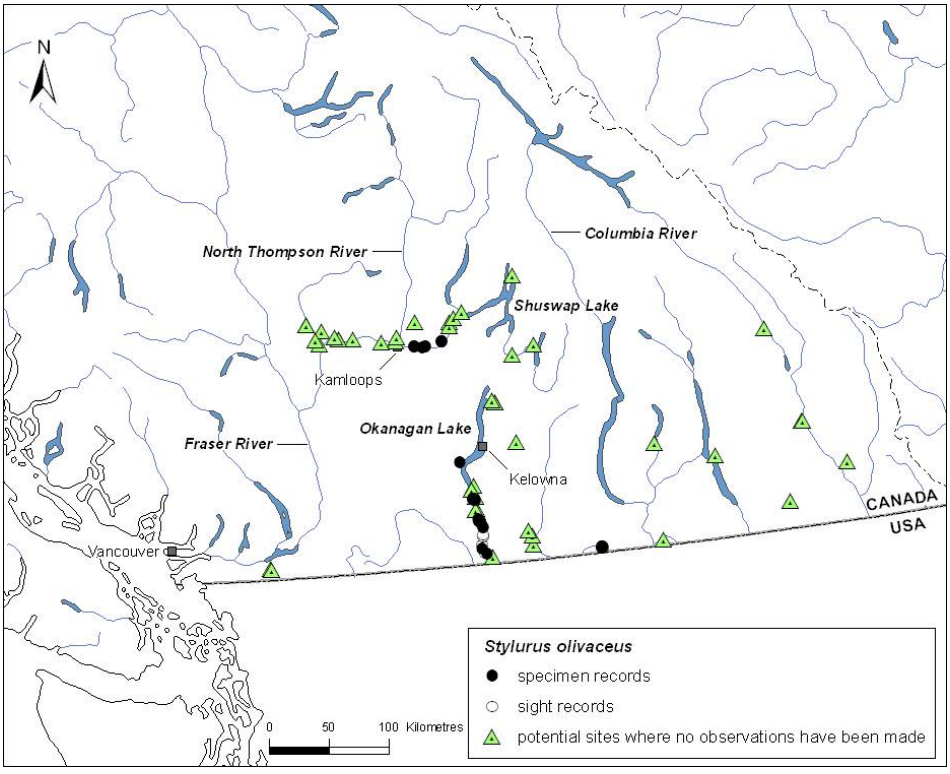

Figure 7. Canadian range of *Stylurus olivaceus*. The three main areas of distribution – Christina Creek, the Okanagan Valley and the South Thompson River, are mapped separately in Figures 8, 9 and 10, respectively. Potential sites that were searched without success are also shown.

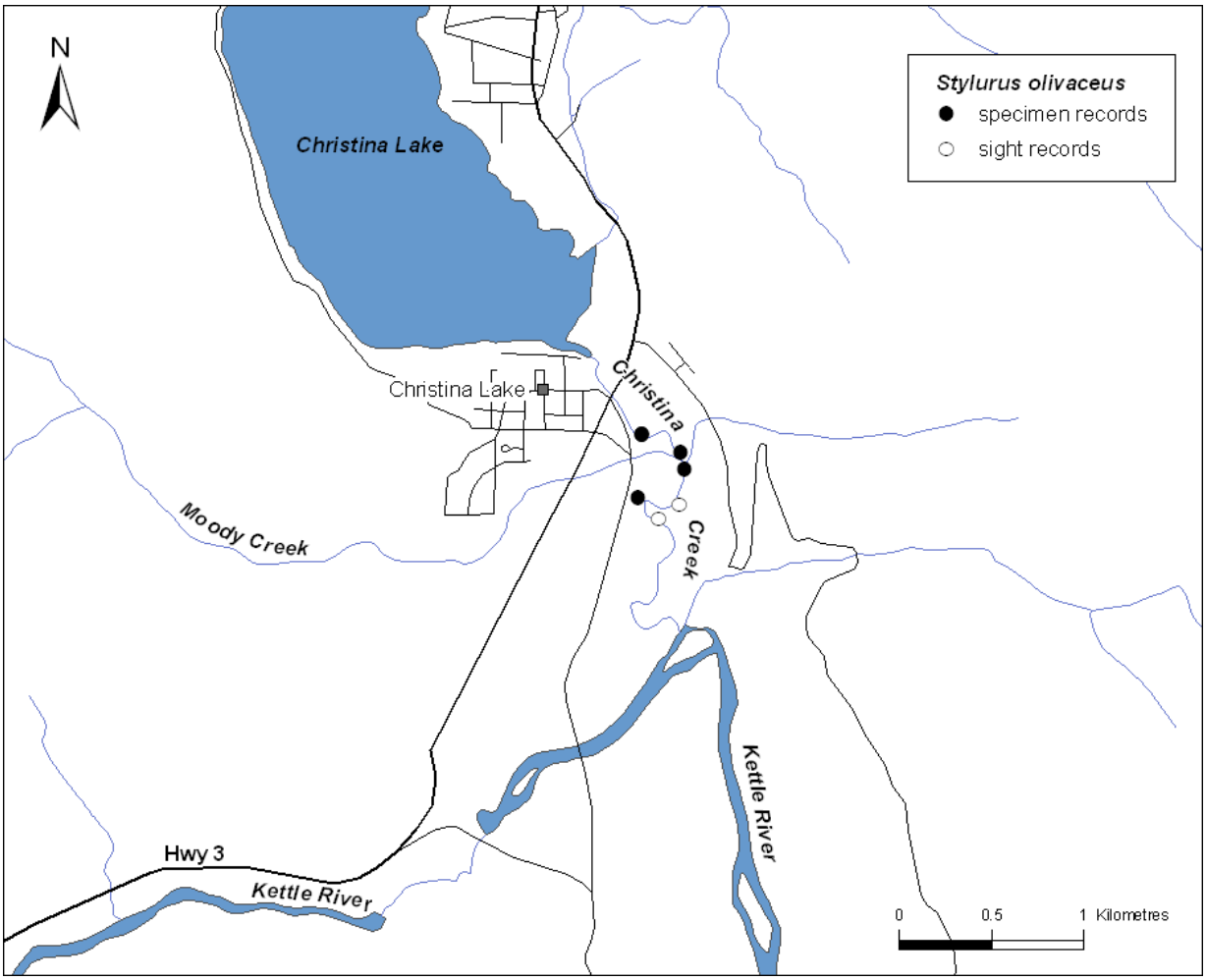

Figure 8. The distribution of specimen and sight records of *Stylurus olivaceus* at Christina Creek, British Columbia.

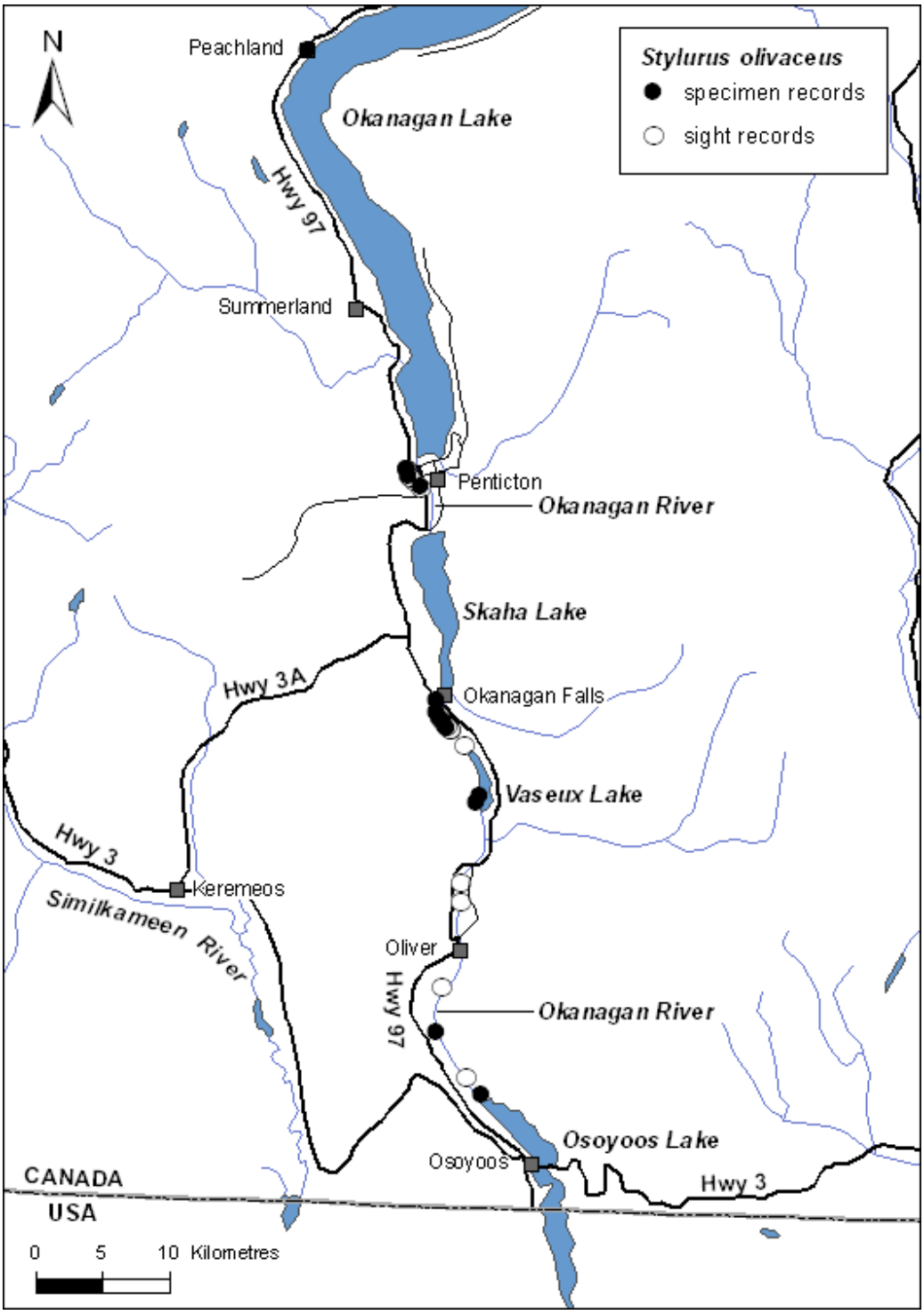

Figure 9. The distribution of specimen and sight records of *Stylurus olivaceus* in the Okanagan Valley, British Columbia.

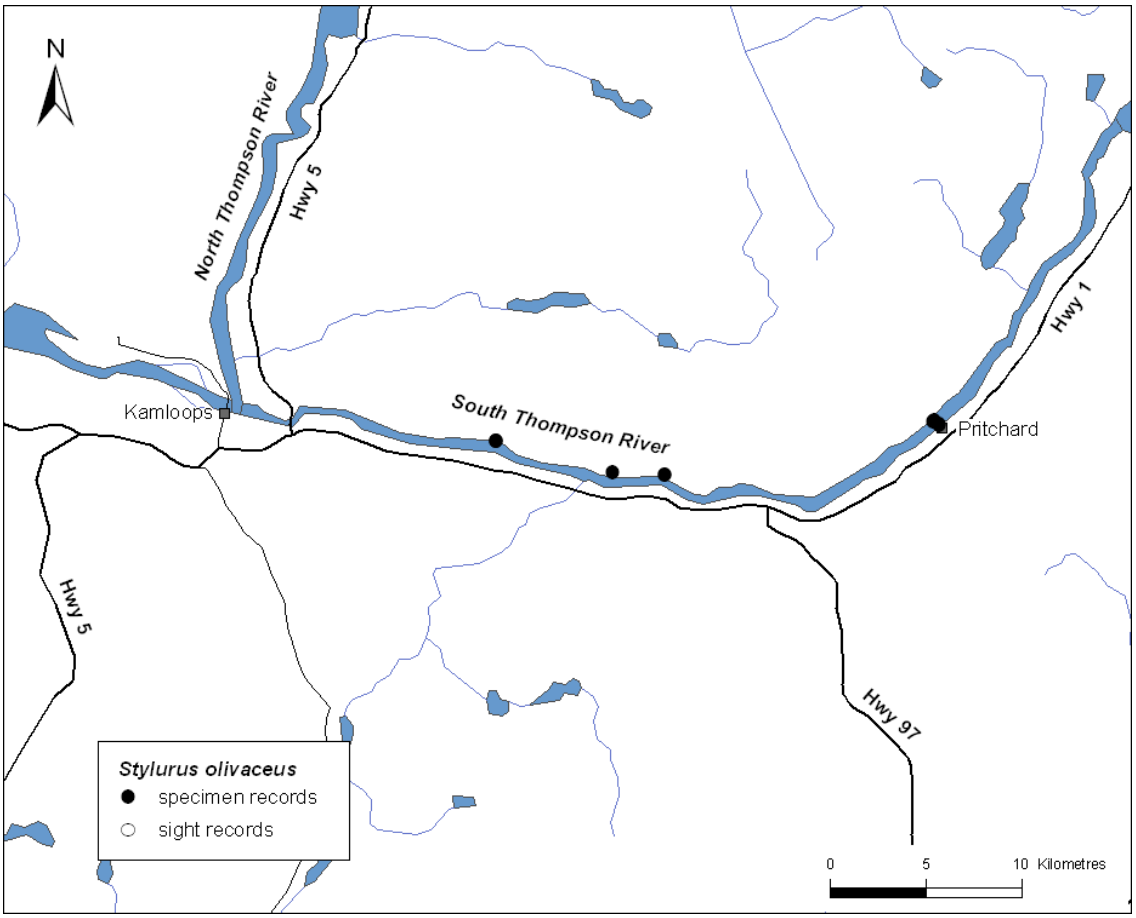

Figure 10. The distribution of specimen records of *Stylurus olivaceus* in the South Thompson Valley, British Columbia.

There is no Aboriginal Traditional Knowledge (ATK) concerning the distribution of this species available at this time.

Although the Olive Clubtail has been reported from Chase (Walker 1958, Scudder *et al*. 1976), where the South Thompson River flows out of Little Shuswap Lake, this is an error owing to a misreading of comments in Whitehouse (1941), who never found it there. In fact, although much of the riverbank habitat from Chase to Pritchard (about 19 km) appears appropriate for the development of the dragonfly, and although recently this stretch of river has been searched several times over several years, no dragonflies have been recorded east of Pritchard. Likewise, there are no records from the mouth of Stobbart Creek west to Kamloops. Much of the riverbank in this area is more modified than it is to the east. Despite this lack of records, the species probably does develop in these sections of river. However, in the index of area of occupancy calculations, the area of occupancy is limited to the river between Stobbart Creek and Pritchard. The Olive Clubtail evidently does not breed north of the South Thompson River or west of Kamloops Lake.

The Olive Clubtail has not been seen in the rivers around Christina Creek (e.g., Kettle River, Granby River), probably because of their colder temperatures. Nor has it been recorded east of Christina Creek. Most southern damselflies and dragonflies that are scarce inhabitants of the warmer, low-lying valleys of southcentral British Columbia (e.g., *Argia emma* Kennedy*, Aeshna constricta* Say*, Gomphus graslinellus* Walsh*, Macromia magnifica* McLachlan*, Libellula pulchella* Drury) are even rarer in, or absent from, the East and West Kootenay regions. *Stylurus olivaceus* is not an exception.

Whitehouse (1941) states, "At Chilliwack, July 20th-25th, 1936, I saw a large gomphine settled on a path that was, I think, unquestionably *olivaceus*". This record is unacceptable because of its unusual coastal location and the lack of physical evidence, although it is not impossible that the species could occur in the lower Fraser Valley. Two odonates of interior origin living in similar habitats to those of *Stylurus* – *Macromia magnifica* and *Argia emma* – have populated coastal environments via the Fraser drainage and are found in the Fraser Valley at Chilliwack. The possibility of an historical coastal population of the Olive Clubtail has been raised before. There are a few *Stylurus olivaceus* exuviae collected in the late 1800s, apparently near Seattle in King County, Washington; these specimens are normally dismissed as having uncertain provenance (Paulson and Garrison 1977, D. Paulson, pers. comm. 2009) and much searching in the area over the past four decades has failed to locate any *Stylurus* specimens around Puget Sound (D. Paulson, pers. comm. 2009). The old exuvial collections, however, suggest the possible existence, at least in the past, of coastal populations in Washington (Johnson 1998). The presence of a significant population near the mouth of the Columbia River might act as a source for populations along other rivers near the Washington and Oregon coast.

Based on present known populations in British Columbia, the extent of occurrence (EO) is 10, 936 km² and the index of area of occupancy (IAO) using a 2 km x 2 km grid is 184 km^2. The individual IAOs for the three distinct regions are: Christina Creek – 4 km²; Okanagan Drainage – 100 km²; South Thompson River – 80 km².

There are 24 specimen collection sites (different coordinates) of *Stylurus olivaceus* in Canada (Figures 8, 9 and 10; Table 1) and additional sight record locations, but it is more difficult to determine the number of locations. Clearly, the South Thompson River and Christina Creek populations represent two separate locations in different watersheds. The Okanagan population(s), however, are more difficult to describe. Because the primary riverine populations are separated by lakes where the Olive Clubtail is rare or absent, and because threats such as polluting spills may be contained somewhat by the lakes, we count the different reaches of the Okanagan River (one at Penticton, one south of Okanagan Falls, and a third south of Vaseux Lake) as separate locations. This gives three locations for the Okanagan and five for the Canadian total. Although the species has been recently found in all areas of Canada where it was previously known to occur, it is likely less common since the channelization of the Okanagan River reduced habitat by up to 90% in that area.

Search effort

In British Columbia, the range of *Stylurus olivaceus,* especially within the Okanagan Valley, coincides with an area famous for its unusually diverse insect fauna (Cannings and Cannings 1995). Many rare species occur here; most of these are Great Basin taxa that reach the northern extent of their range here, making them special in Canada. Thus, the area is a popular collecting ground for both professional and amateur entomologists and the Odonata here have been collected and studied for decades. The odonate fauna in the Okanagan is perhaps better known than anywhere else in the province. Until the late 1990s, other areas in the range of *S. olivaceus* – the Kettle River drainage east of the Okanagan and the Thompson River Valley around Kamloops and Shuswap Lake to the north – were less well known.

The data below (and summarized in Figure 7 and Tables 1-3) emphasize the rarity of the Olive Clubtail. Within southern British Columbia south of 51ºN, since about 1900, there have been more than 3000 person-hours spent surveying adult Odonata populations. Approximately 1200 localities have been visited, all this resulting in about 18,000 records of many different species of damselflies and dragonflies. The recent targeted surveys for *S. olivaceus* include about 160 person hours and 50 locations, of which 80% did not produce any records. This amount of search effort is unusually extensive for an insect.

Table 1. Specimen records for *Stylurus olivaceus* in Canada.

Locality	#	sex	stage	collector	d	m	year	Latitude (N)	Longitude (W)	el. (m)	collection	Comments
Christina Lake, Christina Creek	1	m	adult	S.G. Cannings	7	8	1999	49.03962	118.20477	460	RBCM	
Christina Lake, Christina Creek	1	m	adult	Ian Hatter	28	8	1999	49.03962	118.20477	460	RBCM	
Christina Lake, Christina Creek	1	m	adult	Ian Hatter	28	8	1999	49.03962	118.20477	460	RBCM	
Christina Lake, Christina Creek	1	m	adult	L.R. Ramsay	28	8	1999	49.03656	118.20505	460	RBCM	
Christina Lake, Christina Creek	1	m	adult	R.J. Cannings	6	8	2000	49.03799	118.20160	460	RBCM	Dermestid damage
Christina Lake, Christina Creek	1	m	adult	R.J. Cannings	23	8	2009	49.03876	118.20187	460	RBCM	perched on cedar

Locality	#	sex	stage	collector	d	m	year	Latitude (N)	Longitude (W)	el. (m)	collection	Comments
Kamloops, N side South Thompson River, 2.9 km E of Lafarge bridge	1	f	adult	C. & D. Copley, J. Miskelly	15	8	2008	50.65907	120.02213	340	RBCM	teneral and exuvia
Kamloops, N side South Thompson River, 2.9 km E of Lafarge bridge	5		exuviae	C. & D. Copley, J. Miskelly	15	8	2008	50.65907	120.02213	340	RBCM	
Kamloops, N side South Thompson River at Lafarge bridge	12		exuviae	C. & D. Copley, J. Miskelly	15	8	2008	50.65881	120.06081	336	RBCM	2 tenerals released
Kamloops, N side South Thompson River at Stobbart Creek	1	f	adult	C. & D. Copley, J. Miskelly	15	8	2008	50.67183	120.14794	347	RBCM	teneral, deformed wings; exuvia
Kamloops, S. Thompson R. at Stobbart Cr.	18		exuviae	C. & D. Copley, J. Miskelly	15	8	2008	50.67183	120.14794	347	RBCM	
Kamloops, S. Thompson R. at Stobbart Cr.	7		exuviae	R.A. Cannings, L.R. Ramsay	25	8	2008	50.67183	120.14794	345	RBCM	
Okanagan Falls, Okanagan River	1	m	adult	D. St. John	10	9	1997	49.33237	119.57785	335	RBCM	
Okanagan Falls, Okanagan River	1	m	adult	D. St. John	9	9	1997	49.32919	119.57429	333	RBCM	
Okanagan Falls, Okanagan River	1	m	adult	R.J. Cannings	24	9	2009	49.32356	119.56865		RBCM	On milkweed
Oliver, Okanagan River, Road 18	1	m	adult	R.J. Cannings	26	8	2009	49.11647	119.56757		RBCM	on sumac
Osoyoos Lake, Okanagan River mouth	1	m	adult	R.A. Cannings	15	7	1981	49.07634	119.51960		RBCM	Teneral
Peachland	1	f	adult	J.B. Wallis	12	8	1909	49.77472	119.73537		UBC	
Pritchard, South Thompson River	1	f	adult	E.R. Buckell	1	10	1934	50.68763	119.82146		UBC	
Pritchard, South Thompson River, S side	1		adult	L.R. Ramsay	20	7	2004	50.68769	119.82133		RBCM	teneral and exuvia

Locality	#	sex	stage	collector	d	m	year	Latitude (N)	Longitude (W)	el. (m)	collection	Comments
Pritchard, South Thompson River, N side	7		exuviae	L.R. Ramsay, L. Gelling	13	8	2005	50.68984	119.82516		RBCM	
Pritchard, South Thompson River, N side	16		exuviae	R.A. Cannings, L.R. Ramsay	19	8	2008	50.68916	119.82558		RBCM	
Penticton, Okanagan River	1	m	adult	E. M. Walker	12	7	1926	49.49572	119.61686		ROM	
Penticton, Okanagan River	1	u	adult	E. M. Walker	23	7	1926	49.49572	119.61686		ROM	
Penticton, Okanagan River	1	m	adult	E.M. Walker	28	7	1926	49.49572	119.61686		?	Walker (1927,1958)
Penticton, Okanagan River, west dyke	1	m	adult	R.J. Cannings	10	9	1998	5484460	311450	345	RBCM	on blue elderberry
Penticton, Okanagan River	1	m	adult	R.J. Cannings	21	8	2009	49.48347	119.60327		RBCM	perched in grass
Penticton, Okanagan River	1	f	adult	R.J. Cannings	22	8	2009	49.32623	119.57155		RBCM	On dogbane, ground
Penticton, Okanagan River	1	m	adult	R.J. Cannings	22	8	2009	49.32623	119.57155		RBCM	
Vaseux Lake, SW shore	1		exuvia	R.A. Cannings	26	7	1975	49.27707	119.53100	328	RBCM	1.5 feet up on *Scirpus* stem
Vaseux Lake, SW lagoon	1		exuvia	R.A. Cannings	17	7	1981	49.27263	119.53363	329	RBCM	

Table 2. Sight records for *Stylurus olivaceus* in Canada.

Location	#	sex	observer	day	month	year	Latitude (N)	Longitude (W)	comments
Christina Lake, Christina Creek	10		Jeremy Gatten	4	8	2008	49.03625	118.20198	
Christina Lake, Christina Creek	1	f	Richard J. Cannings	23	8	2009	49.03554	118.20344	on birch
Oliver, Road 9, Okanagan River,	1		Richard J. Cannings	26	8	2009	49.14718	119.56417	on sumac and elms
Oliver, Okanagan River	1		Richard J. Cannings	27	8	2009	49.20579	119.54701	in sumac
Oliver, Okanagan River	1		Richard J. Cannings	27	8	2009	49.21839	119.54672	in cottonwood
Okanagan Falls, Okanagan River	2		Richard J. Cannings	22	8	2009	49.32753	119.57264	on tansy
Okanagan Falls, Okanagan River	1	m	Richard J. Cannings	22	8	2009	49.32621	119.57132	on rock on river edge
Okanagan Falls, Okanagan River	2	m	Richard J. Cannings	22	8	2009	49.32189	119.56585	on ground and grass

Location	#	sex	observer	day	month	year	Latitude (N)	Longitude (W)	comments
Okanagan Falls, Okanagan River	1	m	Richard J. Cannings	22	8	2009	49.32093	119.56400	on weeping willow
Okanagan Falls, Okanagan River	1		Richard J. Cannings	22	8	2009	49.32094	119.56349	on ground; flew across river
Okanagan Falls, Okanagan River	1		Richard J. Cannings	22	8	2009	49.32668	119.57175	on tansy
Okanagan Falls, Okanagan River	1		Richard J. Cannings	22	8	2009	49.32734	119.57252	on birch
Okanagan Falls, Okanagan River	1		Richard J. Cannings	22	8	2009	49.32755	119.57260	photographed on tansy
Okanagan Falls, Okanagan River	1		Richard J. Cannings	22	8	2009	49.32785	119.57300	on tansy
Okanagan Falls, Okanagan River	1		Richard J. Cannings	22	8	2009	49.32834	119.57353	on willow
Okanagan Falls, Okanagan River	1		Richard J. Cannings	22	8	2009	49.32879	119.57404	on rose
Okanagan Falls, Okanagan River	1		Richard J. Cannings	22	8	2009	49.32903	119.57429	on willow
Okanagan Falls, Okanagan River	1		Richard J. Cannings	22	8	2009	49.32969	119.57498	on knapweed
Okanagan Falls, Okanagan River	1	m	Richard J. Cannings	24	9	2009	49.32286	119.56763	on rock
Osoyoos Lake, Okanagan River, Rd 22	2	m,f	Jeremy Gatten	2	8	2008	49.08739	119.53581	
Penticton, Okanagan River	1	m	Richard J. Cannings	12	9	1998	49.48316	119.60284	on Siberian elm
Penticton, Okanagan River			Frank C. Whitehouse	18-22	7	1938	49.49572	119.61686	Whitehouse (1941), "scarce"
Penticton, Okanagan River	1	f	Richard J. Cannings	21	8	2009	49.48722	119.61000	high in elm
Penticton, Okanagan River	1	f	Richard J. Cannings	21	8	2009	49.49092	119.61534	on Russian thistle
Penticton, Okanagan River	2	m	Richard J. Cannings	23	9	2009	49.48959	119.61377	patrolling midriver
Vaseux Lake, Okanagan River	1	m	Avery Bartels	25	8	2007	49.31022	119.54800	hanging on twig

Table 3. Potential localities for *Stylurus olivaceus* in Canada where it was not found.

Location	Latitude (N)	Longitude (W)	Elev. (m)	Habitat/ indicator species	Date	Observer
Ashcroft, South Thompson River at inlet of Bonaparte River	50.73940	121.26047	297	Eroded gravel banks, no vegetation; flow fast; *Ophiogomphus severus* exuviae	16 Aug 2008	C. and D. Copley, J. Miskelly
	50.83781	121.23326	297			
Ashcroft, 4.1 km N on Evans Road, South Thompson River	50.77314	21.30327	415	Channel behind gravel bars; *Ophiogomphus occidentis* exuviae	16 Aug 2008	C. and D. Copley, J. Miskelly
Ashcroft, Boston Flats Community Estates; Bonaparte River	50.88744	121.40644	499	*Ophiogomphus severus* exuviae	16 Aug 2008	C. and D. Copley, J. Miskelly
Cache Creek, Bonaparte River at Hwy 99 bridge	50.88744	121.40644	499	Sand bottom; *Ophiogomphus severus*	16 Aug 2008	C. and D. Copley, J. Miskelly
Cache Creek, Bonaparte River at Hwy 99 bridge	50.82608	119.70326	348	Sand bottom	25 Aug 2008	R.A. Cannings, L.R. Ramsay
Chase, mouth of Chase Creek at South Thompson River				Sand/gravel	19 Aug 2008	R.A. Cannings, L.R. Ramsay
Chase, South Thompson River at south end Veteran Road	50.79672	119.71207	346	Backwater behind large gravel bars; much emergent vegetation, little current	19 Aug 2008	R.A. Cannings, L.R. Ramsay
Chopaka, Similkameen River	49.00972	119.72416	370		21 Jul 1997	R.J. Cannings
Crawford Bay, Kootenay Lake, Gray Creek	49.62273	116.79075	532	*Ophiogomphus severus* collected	24 Jul 1979	G.P. Doerksen
Cultus Lake, Sweltzer Creek	49.08333	121.98335		*Macromia* collected	10 Sep 1937	W.E. Ricker
Cultus Lake, Sweltzer Creek	49.07611	121.98000		*Argia emma* collected	21 Aug 1984	R.A. Cannings
Enderby, Ashton Creek	50.54308	119.00910		Sand with small cobble, some emergent vegetation	12 Aug 2005	L. R. Ramsay, L. Gelling
Invermere, Athalmer Beach, north end of Windermere Lake	50.50984	116.02389	799	Sand beach	20 Aug 1983	R.A. Cannings, S.G. Cannings
Jaffray, Little Sand Creek	49.43583	115.28861		Sand with small cobble	30 Jul 1999	L. R. Ramsay
Kamloops, North Thompson River at Walker Road	50.71875	120.35755	360	Sandy shore; disturbed; *Ophiogomphus occidentis*	15 Aug 2008	C and D Copley, J Miskelly
Kamloops, North Thompson River at Oakhills Blvd.	50.74777	120.34642	346	Gravel/sand shore; *Ophiogomphus occidentis*	15 Aug 2008	C. and D. Copley, J. Miskelly
Kamloops, end of Tranquille Road at east end of Kamloops Lake	50.72016	120.52032	337	Sand beach; some emergent vegetation; disturbed	15 Aug 2004	L. Ramsay, I. Hatter
Kamloops, end of Tranquille Road at east end of Kamloops Lake	50.71959	120.53081	337	Sand beach; some emergent vegetation; disturbed	15 Aug 2008	C. and D. Copley, J. Miskelly
Kamloops, Aviation Road	50.69873	120.43572		Disturbed banks with sand and some small cobble	13 Aug 2005	L. Ramsay, L. Gelling
Kamloops, Aviation Road	50.69873	120.43572		Disturbed banks with sand and some small cobble	3 Sep 2009	L. Ramsay

Location	Latitude (N)	Longitude (W)	Elev. (m)	Habitat/ indicator species	Date	Observer
Kamloops, Kamloops Lake, west end, S. Thompson River outlet, Steelhead Prov. Park	50.75773	120.86594	349	Emergent vegetation along rocky/ sandy riverbank	16 Aug 2008	C. and D. Copley, J. Miskelly
Kamloops, Heffley Creek at Cold Creek Road bridge (near outlet of Heffley Lake)	50.84778	120.11144	940	Water warm 22degC	18 Aug 2008	C. and D. Copley, J. Miskelly
Kelowna, Mission Creek	49.89084	119.05638	920	*Macromia* collected	13 Aug 1997	D. St. John
Little Shuswap Lake	50.85719	119.65999		Some emergent vegetation along lake edge	11 Aug 2007	L. R. Ramsay, L. Gelling
Mabel Lake	50.60339	118.73916	395	*Ophiogomphus severus* collected	5 Sep 1932	E.R. Buckell
Moyie Lake, Moyie River	49.20000	116.00000	910	*Ophiogomphus severus* collected	13 Aug 1999	D. Nicholson
Naramata, Manitou Beach	49.59305	119.59583	343	*Macromia* collected	22 Jul 1997	R.C.H. Cannings
Osoyoos Lake, White Sands Point	49.05084	119.45528	283	*Gomphus graslinellus* collected	22 Jul 1997	R.J. Cannings
Penticton, Okanagan Lake marina	49.50716	119.58106	343	Sand and silt shoreline	8 Sep 1978	R.J. Cannings
Penticton, Skaha Lake	49.41694	119.583890	340	Sand and fine gravel	8 Sep 1981	S.G. Cannings
Penticton, Skaha Lake	49.40945	119.60000	340	*Argia emma* collected	25 Jul 1997	R.J..Cannings
Rock Creek, West Kettle River	49.11139	118.98000	620	*Ophiogomphus severus* collected	29 Aug 1999	I. Hatter
Shuswap Lake, Adams River mouth	50.89509	119.55059	345	*Ophiogomphus occidentis* collected	30 Aug 1931	E.R. Buckell
Shuswap Lake, Anstey Arm	51.13147	118.91022	345	*Argia emma* collected	7 Aug 1942	E.R. Buckell
Slocan, Slocan Lake at river exit	49.76800	117.47386	541		14 Aug 1932	E.R. Buckell
Summerland, Okanagan Lake	49.60806	119.65153	343	*Macromia magnifica* collected	20 Aug 2000	M. Poncelet
Summerland, Trout Creek	49.56423	119.62788		Wide silty creek	14 Aug 2005	L. R. Ramsay, L. Gelling
Vernon, Kalamalka Lake, Cosens Bay	50.19828	119.26266	392	Sand beach	9 Sep 1976	R.A. Cannings
Vernon, Kalamalka Lake, Cosens Bay	50.19828	119.26266	392	Sand beach	21 Aug 1987	S.G. Cannings
Vernon, Kalamalka Lake, northwest end	50.21666	119.28750	392	Sand beach	20 Aug 1997	G. Hutchings
Walhachin, Walhachin Road bridge over South Thompson River	50.76517	121.03350	323	Bouldery shoreline; *Ophiogomphus occidentis*	16 Aug 2008	C. and D. Copley, J. Miskelly
Walhachin, Walhachin Road bridge over South Thompson River	50.76517	121.03345	323	Bouldery shoreline	20 Aug 2008	R.A. Cannings, L.R. Ramsay
Walhachin, Juniper Beach Prov. Park, South Thompson River	50.77931	121.07868	320	Sand/ gravel/ rocks; some emergent vegetation	16 Aug 2008	C. and D. Copley, J. Miskelly
Waneta, Pend D'Oreille Reservoir	49.04047	117.49154	537	*Macromia magnifica* captured	22 Aug 2008	J. Miskelly
Wasa Lake	49.78462	115.74025	775	sand	18 Aug 1933	E.R. Buckell
Wasa Lake	49.78665	115.73756	775	sand; *Gomphus graslinellus* collected	20 Jul 1998	D. Nicholson
West Kettle River	49.17668	118.98088		Gravel and boulder substrate	29 Aug 2007	L. R. Ramsay, O. Dyer
West Kettle River	49.21650	119.01503		Gravel and boulder substrate	29 Aug 2007	L. R. Ramsay, O. Dyer

Although general collecting in the southern interior of British Columbia during the last century resulted in a relatively well-known odonate fauna, specific surveys of Odonata were conducted as the entomological component of the *Living Landscapes* project of the Royal British Columbia Museum in partnership with the British Columbia Conservation Data Centre. The Okanagan was surveyed in 1997 (Cannings *et al.* 1998), the Columbia Basin east of the Okanagan in 1998-99 (Cannings *et al.* 1999), central and northern British Columbia from 2000 to 2005, and the southern Cariboo north of the Thompson Valley in 2008. The determination of the northern margin of the range of *S. olivaceus* was one of the results of the targeted surveys in the Thompson region beginning in 2004.

Sampling site selection was based on historical records of *S. olivaceus* and other odonates with similar habitat preferences (*Macromia magnifica, Argia emma, Ophiogomphus occidentis, Gomphus graslinellus*) as well as an examination of suitable habitat within the assumed range that appeared to have similar habitat to known occupied sites. Searches were made for adults and exuviae and were concentrated between the last week of July and the end of September. These searches are considered "targeted" for the species (Table 4). In this discussion, a 'visit' is defined as a survey of at least 30 minutes at one site on one particular day, when the weather is fine enough to expect dragonfly activity.

Table 4. Search effort in targeted surveys of *Stylurus olivaceus* in British Columbia, 1997-2009.

Area	years	person hours	visits	comments
South Thompson River: Chase	2004	2	1	Not found
	2005	4	2	Not found
	2008	1	2	Not found
	2009	1	1	Not found
South Thompson River: west of Kamloops	2004	1	1	Not found
	2005	0.5	1	
	2008	5	8	
	2009	1	1	
South Thompson River: Kamloops to Pritchard	2004	1.25	2	Collections
	2005	5	2	Collections
	2008	5.75	6	Collections and sight records
	2009	5	3	Collections
North Thompson River and nearby streams	2008	4.5	4	Not found
Bonaparte River	2008	3.5	4	Not found
Okanagan Lake	1997	2	2	Not found
Kalamalka Lake	1997	2	2	Not found
Skaha Lake	1997	3	1	Not found
Vaseux Lake	1997	3	2	Not found
Osoyoos Lake	1997	2	1	Not found
Okanagan River: Penticton	1997	3	2	Collections
	1998	2	2	Collections and sight records
	2009	4.1	3	Collections and sight records

Area	years	person hours	visits	comments
Okanagan River: Okanagan Falls	1997	5	3	Collections
	2009	3.8	2	Collections and sight records
Okanagan River: Oliver	1997	2	1	Not found
	2009	9	2	Collections and sight records
Okanagan River: Osoyoos Lake	1997	3	2	Not found
	2008	2	1	Sight records
Christina Creek	1999	6	2	Collections
	2000	3	1	Collections
	2008	3	1	Sight records
	2009	2.5	1	Collections
Kettle River	1999	1	1	Not found
	2007	0.75	2	Not found

Okanagan Valley

A survey of the Okanagan drainage in 1997 was led by Richard Cannings (Cannings *et al.* 1998). It focused on eight species considered at risk or possibly at risk, including *S. olivaceus*. General collections of Odonata were also made. Nine localities (some extensive: e.g., Okanagan River between Okanagan Falls and Vaseux Lake) were surveyed (16 visits, 24 person-hours searching) within the assumed range and flight period of *S. olivaceus*. Some of these localities were along lakeshores (5 localities, 8 visits, 11 person-hours searching) and the lack of success in finding *Stylurus* in such habitats confirmed that it is mostly a riverine species in the region.

In 2009, Richard Cannings again surveyed the South Okanagan from Penticton to Osoyoos Lake. This effort focused on the Okanagan River channel. Five sections of channel were walked on 9 different days for a total of 27.85 km over 20.4 person-hours. Observations (collections or sight records) were made at 25 different coordinates.

Christina Creek

Christina Creek was first examined during the general surveys of the *Living Landscapes* project in 1999. Two visits during the *S. olivaceus* flight period were made in that year (total of 6 person-hours). Totals for other years: 2000 (1 visit, 3 person-hours), 2008 (1 visit, 3 person-hours), 2009 (1 visit, 2.5 person-hours). *S. olivaceus* was recorded on all these visits. However, three visits to the Kettle River near Rock Creek in 1999 (1 visit, 1 person-hour) and 2007 (2 visits, 0.75 person-hour) failed to record the species.

South Thompson Valley

The South Thompson River between Kamloops and Pritchard has produced all the records in this region. In four years between 2004 and 2009, 13 visits, totaling 16.75 person-hours of searching produced records in each year. *S. olivaceus* has not been recorded from the eastern end of the river from Pritchard to Chase (6 visits in 4 years, 8 person-hours). West of Kamloops, from Kamloops Lake downstream to Ashcroft, no *S. olivaceus* have been found (8 visits, 5 person-hours). Likewise, north of the South Thompson, the North Thompson River and several nearby streams (e.g., Heffley Creek, Deadman River) evidently do not support the species (4 visits, 4.5 person-hours). The Bonaparte River at the northwest corner of the Thompson Valley was searched in 2008 (4 visits, 3.5 person-hours); no *S. olivaceus* specimens were recorded.

HABITAT

Habitat requirements

Larvae of *Stylurus olivaceus* generally burrow in the bottoms of warm, mud- or sand-bottomed rivers or streams (Dunkle 2000, Paulson 2009). However, in British Columbia, at the northern end of its range, the species at least occasionally develops along sandy lakeshores (e.g., Vaseux Lake and Okanagan Lake at Peachland; Cannings and Stuart 1977). Although the habitat is described by Needham *et al.* (2000) as “muddy, often alkaline, western rivers”, the streams are probably often clear. However, they can be ‘yellow,’ as a California site is described by Walker (1958). The streams can be as large as the lower Columbia River below Portland (over a kilometre wide), where *Stylurus olivaceus* is the most common dragonfly (J. Johnson, pers. comm. 2002), or as small as Christina Creek (about 10 metres wide). Christina Creek has large sections of bank consisting of both pebbly/cobbled and sandy/muddy substrates (Cannings *et al.* 1999). On the lower Columbia River, the species lives commonly within tidal waters, and has been observed emerging on rocks exposed only at low tide (Andrew Emlen, pers. obs., *fide* J. Johnson, pers. comm. 2002). There may be some adaptations in the population for emergence during low tide only (D. Paulson, pers. comm. 2009). There is such a huge volume of fresh water in the lower reaches of the Columbia River that moves back and forth with the tides, that the salinity where *Stylurus* develops is probably not affected by the ocean’s salt water (D. Paulson, pers. comm. 2009). The volume of water may also reduce the impact of disturbance in this area.

There are no records of the Olive Clubtail developing in lakes in the United States (J. Johnson, T. Manolis, D. Paulson, S. Valley, all pers. comm. 2009) although Paulson recorded an adult at Soap Lake, Grant County, Washington, far from any river (D. Paulson, pers. comm. 2009). Paulson (pers. comm. 2009) also notes that in North America a number of gomphid species, normally purely lotic, also develop in lakes at the northern edge of their ranges. Presumably, the shoreline wave action in these lakes sufficiently mimics the flowing water of more typical lotic habitats. The old record from Peachland (1909) does not give any details and there are no suitable streams to support *Stylurus* in the area. The adult captured probably developed in Okanagan Lake. The exuvia collected in the lagoon at the south end of Vaseux Lake (1981) comes from a more sheltered, perhaps even more eutrophic habitat, than the other Vaseux Lake site (exuvia collected in 1976) or that of the even more oligotrophic Okanagan Lake at Peachland. Despite these few records and the potential for lentic development of *Stylurus olivaceus* in the mainstem Okanagan or Thompson valley lakes, the species has otherwise never been seen along the shores of these lakes.

In the Kamloops area, the Olive Clubtail is found in the warm South Thompson River (Figures 11, 12), which empties out of Shuswap and Little Shuswap lakes, but it has not been found in the colder North Thompson River (Figure 13), which directly drains the snowy Cariboo and Columbia Mountains. It is also apparently absent from the Thompson River downstream of Kamloops Lake, the river reaches there are swifter than those of the South Thompson, and generally have a cobble/boulder floor (Figure 14). Both of these habitats produce *Ophiogomphus occidentis*. Smaller streams in the Thompson drainage apparently do not support *Stylurus.* For example, the dragonfly has never been found in the Bonaparte River, a few sections of which seem to be suitable (Figure 15), Heffley Creek, Deadman River or Monte Creek. The related *Ophiogomphus severus* develops in the Bonaparte and Deadman rivers, but this species can tolerate faster flowing, colder streams with less fine substrate (R.A. Cannings, pers. obs.).

Figure 11. North bank of South Thompson River at Stobbart Creek, Kamloops. View E (upstream) from approximately 50.6722ºN 120, 1514ºW. 25 August 2008. Main tree species is the introduced *Eleagnus angustifolia*. Photo: Robert A. Cannings.

Figure 12. North bank of South Thompson River at Pritchard, B.C. View NE upstream from approximately 50.6881ºN, 119.8278ºW. 19 August 2008. Main emergent plants are *Eleocharis, Equisetum* and *Carex* species. Photo: Robert A. Cannings.

Figure 13. View from west bank of North Thompson River near Oakhills Boulevard, Kamloops, B.C. N (upstream) from about 50.7477ºN, 120.3464ºW. 15 August 2008. No *Stylurus* have been recorded on this river, possibly because the water is colder than in the South Thompson. Photo: Claudia R. Copley.

Figure 14. South Thompson River north of Ashcroft, B.C. View approximately E (upstream) from about 50.7477ºN, 121.2331ºW. 16 August 2008. No *Stylurus* have been recorded on the Thompson River downstream from Kamloops Lake, possibly because of the bouldery substrate and faster flow than is found upstream of the lake. Photo: Claudia R. Copley.

Figure 15. Bonaparte River from Highway 99 bridge, just west of junction with Highway 97 north of Cache Creek. View is north at 50.8874ºN, 121.4064ºW. 16 August 2008. No Olive Clubtails have been recorded at this stream although some sections, such as this one pictured here, seem appropriate for the species. The related *Ophiogomphus severus* occurs here. Photo: Claudia R. Copley.

Males of *Stylurus olivaceus* usually fly over open water, as opposed to along the edge (J. Johnson, D. Paulson, pers. comm. 2002; Paulson 2009). This makes them difficult to observe on wide rivers such as the Columbia and even the South Thompson as compared to the much narrower Okanagan River and Christina Creek. They also prefer to patrol over riffles, where the females often oviposit (Dunkle 2000; L. Ramsay, pers. obs.). Adults rest in riparian shrubs and trees and, less commonly, land on sandy or rocky ground along the shore (Walker 1958, Cannings *et al*. 1999, Paulson 2009).

Christina Creek lies within a dry coniferous forest dominated by Ponderosa Pines (*Pinus ponderosa* Dougl.) and Douglas-firs (*Pseudotsuga menziesii* (Mirbel) Franco) (Figure 16). Sections of the banks are lined with both Paper (*Betula papyrifera* Marsh.) and Water Birches (*B. occidentalis* Hook.), alder (*Alnus incana* (L.) Moench), and other riparian tree and shrub species. The Okanagan River in Canada is mostly channeled and the riparian zone is reduced to steep gravel or boulder banks sometimes lined with perennials such as Purple Loosestrife (*Lythrum salicaria* L.) and other weedy species. This is backed by a wide gravel dyke carrying a walking and biking trail and supporting a highly disturbed habitat of scattered trees, shrubs, and weedy perennials and annuals (Figure 17). The South Thompson River flows mostly through big sagebrush (*Artemisia tridentata* Nutt.) steppe. The riverbed is mostly natural but is significantly disturbed along many stretches of the shoreline. Along with several species of willows (*Salix* spp.) a dominant tree here is *Eleagnus angustifolia* L., the introduced Russian Olive. Where the shoreline is least disturbed the mud and sand margins are often clothed in emergent vegetation such as *Eleocharis*, *Carex* and *Equisetum* (Figures 11, 12).

Figure 16. Christina Creek, B.C, approximately 49.0391ºN, 118.2027ºW. View NW upstream. Dominant trees are *Pinus ponderosa* and *Pseudostuga menziesii*. 23 August 2009. Photo: Richard J. Cannings.

Figure 17. Okanagan River south of Okanagan Falls, B.C, approximately 49.3264ºN, 119.5694ºW. View SE downstream towards Vaseux Lake. 24 September 2009. Photo: Richard J. Cannings.

Olive Clubtail adults may move some distance from streams after emergence and then return to reproduce. The distances covered by any such movements are unknown, but they do expand the concept of habitat for the species beyond the immediate area of the stream.

Other species of damselflies and dragonflies can serve as indicators of Olive Clubtail habitat. The species shares its riverine habitats with *Ophiogomphus occidentalis*, *Macromia magnifica, Argia emma* and, at Christina Creek, with the rare damselfly *Calopteryx aequabilis* Say. Its lake habitat is also used by *Gomphus graslinellus* and *Macromia magnifica.*

Habitat trends

The habitat requirements of Olive Clubtail larvae are imprecisely known and it is difficult to determine whether there has been a decline in quality and quantity of habitat. Most of the Okanagan River in Canada was channeled in the 1950s for flood management; it was straightened, leveled and dyked with dams and drop structures added (Figures 18-20). During the actual construction of the channel, much of the river bed was destroyed and flow in the remaining oxbows eliminated. Presumably this has reduced both quantity and quality of habitat, but no studies have been attempted to demonstrate this assumption.

Figure 18. Left: Air photo (BC 800-31) taken of the Okanagan River entering Skaha Lake at Penticton, 1949 (south at top). Right: The same view, taken in 1982 (BC 82024:204).

Figure 19. The Okanagan River flowing through the large marsh, now destroyed, at the outlet of Okanagan Lake, Penticton, photographed in 1912. View north at about 49.5012ºN, 119.6134ºW (Photo: Penticton Museum).

Figure 20. The same site pictured in Figure 18, as seen in 1983. The lake and river levels are now controlled by a dam and the river has been straightened, channeled and bordered by dykes. (Photo: Robert A. Cannings).

The South Thompson River is relatively natural, except for agricultural development along its banks and the proliferation of some exotic riparian species such as Russian Olive (*Eleagnus angustifolia*). Railways and roads along the banks have changed the shore in places as has fill, runoff and dock construction associated with riverside housing, especially just east of Kamloops (Figure 21). In some areas riverside cattle yards cause pollution and erosion.

Figure 21. Riverside residential development at Dallas, east of Kamloops, on the south bank of the South Thompson River. View from near mouth of Stobbart Creek, approximately 50.6728ºN, 120.1559ºW, looking southeast to houses on Chukar Drive. 25 August 2008. Photo: Robert A. Cannings.

Residential, tourism, and recreational development has altered much of the accessible shorelines of the lakes in the Okanagan and Shuswap, as well as Christina Lake. Christina Creek remains largely in a natural state, with some residential development along its western shores.

BIOLOGY

As in other dragonflies, the larvae of *Stylurus* are aquatic predators, living for approximately two years in the bottom sediments of streams or lakes until emerging as adults. *Stylurus* larvae are classified as “deep burrowers” by Corbet (1999), and eat bottom-dwelling invertebrates such as chironomid midges, tubificid worms and burrowing mayflies (Bright and O’Brien 1999). The generation time is two years with larva overwintering as nymphs.

Adults are aerial predators, returning to the water body to mate and lay eggs. Adult *Stylurus* are usually referred to by the name “hanging clubtails” because they normally hang vertically from trees or large shrubs, in contrast to many other gomphids that prefer to land on the ground (Dunkle 2000, Cannings 2002, Paulson 2009). The two collected by Cannings *et al*. (1998) along the Okanagan River in 1997 were perched in Siberian Elms (*Ulmus pumila* L.). Other plants used as perches are listed in Tables 1 and 2. Olive Clubtails do, however, often rest on the ground (Tables 1 and 2; Dunkle 2000; Paulson 2009).

Life cycle and reproduction

Adult flight dates of Olive Clubtails from British Columbia range from 12 July to 1 October (Whitehouse 1941, RBCM collection records). The earliest Washington State flight record is 8 July (Paulson 1999). Cannings (2002) gives the flight period for British Columbia as mid-July to mid-October. Along the lower Columbia River (below Vancouver, Washington), “adults are easy to find from early August to early November” (J. Johnson, pers. comm. 2002). In California, the flight season ranges from late June to early September, with most records in July (Manolis 2003).

Emergence has been recorded in British Columbia on 20 July (2004, Pritchard) and 18 August (2008, South Thompson River at Stobbart Creek) and tenerals (weakly flying, recently emerged adults) have been reported on 15 July and 15 August (Table 1, Royal British Columbia, Museum collection records).

Males do not hold territories as some dragonflies do; instead they patrol the open water frequented by ovipositing females (Corbet 1999). When a male encounters another male over the water, he chases him low over the water (J. Johnson, pers. comm. 2002). Both males and females rest in shrubs and trees. J. Johnson (pers. comm. 2002) has noted very little intraspecific interaction over land; in his experience it is common to see a number of males and females perching within sight of each other, or flying past each other, but the males do not act aggressively toward other males or harass females.

On the very wide Columbia River downstream of Portland, Oregon, males are never seen patrolling at or near the shore; when a male is flushed from shore it flies about 100-200 m offshore before beginning any chasing activity (J. Johnson, pers. comm. 2002). On Christina Creek, a much narrower stream (about 10 m wide), males patrolled up and down the centre of the river (S. Cannings, pers. obs.). Along the original Okanagan River at Penticton (before channeling), Whitehouse (1941) noted that the males "pursued a zigzag course" in the middle of the river. Males prefer patrolling over "rippling but deep" water (Dunkle 2000), a habit also observed at Christina Creek, B.C. (L. Ramsay, pers. obs.). The females are "swifter and more direct in their flight than the males" (Kennedy 1917). Copulating pairs head to shore and hang up in trees or shrubs (J. Johnson, pers. comm. 2002). Kennedy (1917) states that the pair "would fly away in a short nuptial flight, soon coming to rest on bushes where they remained in copulation indefinitely."

Females lay eggs by merely dropping them at the surface of the water; J. Johnson (pers. comm. 2002) describes oviposition along the Washougal River in Oregon as "a quick flight down to the middle of the river, three taps of the abdomen, then a quick return to the taller trees." L. Ramsay (pers. obs.) noted females ovipositing in riffles at Christina Creek.

Physiology and adaptability

No information is available.

Dispersal and migration

Gomphid dragonflies are relatively strong fliers and are probably capable of dispersing a number of kilometres. For some time after emergence, Olive Clubtails are difficult to find near water and probably disperse some distance back from the riparian zone. Tim Manolis (pers. comm. 2010) found one dead in his swimming pool 1.4 km (air miles) from the nearest point of the American River at Sacramento, a documented *Stylurus olivaceus* habitat. In the same city, Rosser Garrison (pers. comm. 2010) found a recently emerged female about 0.5 km from the Sacramento River on 8 June 2010. Jim Johnson (pers. comm. 2010) sees them regularly in late summer perched in ornamental vegetation in downtown Vancouver, Washington, about 1 km from the Columbia River, where they develop.

Interspecific interactions

Little information is available. At Horn Rapids Park in Washington on 29 August 2008, Kogut (2008) observed an adult male devouring the damselfly *Archilestes californicus* McLachlan.

POPULATION SIZES AND TRENDS

Sampling effort and methods

See also **Search effort.** No comprehensive and rigorous quantitative studies of Olive Clubtail population size have been undertaken in Canada, although some information has been gathered. Even less has been done in the United States (J. Johnson, pers. comm. 2009). Most specimen and sight records gathered before 2008 were the result of general insect or dragonfly collecting. The exception was the survey in the Okanagan drainage in 1997 (Cannings *et al*. 1998), which targeted a number of rare odonates, including *Stylurus olivaceus*. In that study, sampling simply involved searching appropriate habitat and collecting adults when found. Roughly 10 person-hours were spent during 5 days collecting along the dykes of the Okanagan River.

In 2009 more extensive searches for *Stylurus* adults along sections of the Okanagan River dykes were undertaken by Richard and Russell Cannings. Because the dykes are steep-walled, exuviae are difficult to sample and, in order to maximize the amount of dyke travelled, exuviae collecting was minimized. The method used was simple transect walking along the dykes: adult dragonflies, along with their coordinates and behaviour, were documented.

Only along the South Thompson River have there been limited counts of exuviae along measured sections of shore (Table 1); in fact, all but two of the Canadian larval specimens (exuviae) come from this river. In 2008, three stretches of riverbank were searched for exuviae. The river edge here is open, often gently sloping and finding exuviae is much easier than along the Okanagan River. Indeed, it is easier here to find exuviae than adults, a characteristic of the study of many gomphid species. All exuviae found were collected by hand and collected into vials of 70% ethanol. The amount of riverbank searched, both length and width, was recorded.

These counts allow the calculation of a few rough population estimates. However, the densities of exuviae vary greatly from place to place because of many factors ranging from habitat quality to larval behavior (e.g., drift just before emergence), and clearly there is a clumped distribution of larvae in the river. Other factors such as the ability of collectors and the timing of collecting are also important.

On 15 August 2008 two sites were sampled, one along 30 metres of shore (2.5 metres wide) near the outlet of Stobbart Creek, the other in a wider piece of shore, 10 by 10 metres, at the north end of the Lafarge Road bridge. At Pritchard on 19 August, exuviae were sampled along 400 metres of shoreline. The exuviae counts were 18, 12 and 16, respectively. These give estimates of 6, 12 and 0.4 exuviae per 10 metres of shore. In 2009, three visits were made to the river between Kamloops and Pritchard, but no exuviae were found. The water level was extremely low that summer; but whether this had an effect on larval emergence is not known.

The area of occupancy of *Stylurus* along the South Thompson River contains about 50 km of riverbank with more or less suitable habitat for larval development although, as emphasized above, the numbers of specimens emerging in different stretches of river vary widely, probably even more than the three estimates above indicate. In particular, many parts of the 50 km of riverbank used in the calculations probably produce even fewer emerging adults than the lowest figure calculated.

Abundance

Populations of the Olive Clubtail in British Columbia are not known well enough to provide good population estimates. The data set used in this report consists of 31 specimen records and 26 sight records; each record may relate to more than one individual. Specimens total 18 adults and 69 larval exuviae, which, as far as is known, represents all Canadian specimens.

Although its preference for flying over water and perching inconspicuously on trees may reduce the chances of *S. olivaceus* adults being observed compared to some other species, it is still clearly a rare species in British Columbia. Despite searches in the south Okanagan in the summer of 1997, Cannings *et al.* (1998) located it only twice along the Okanagan River south of Okanagan Falls. They noted that it was considerably rarer than its sympatric relative, *Ophiogomphus occidentalis*. The surveys in 2009, however, resulted in 26 observations between Penticton and Osoyoos Lake, 15 of these on a single day. About ten were seen at Christina Creek on 4 August 2008 (J. Gatten, pers. comm. 2008), although only two were seen there on 23 Aug. 2009 (Table 2). Along the South Thompson River only one mature adult has ever been recorded, despite much searching; E.R. Buckell collected a female on 1 October 1934 at Pritchard. This may be because the river is quite wide, varying from about 150 m to about 380 m, and the adults may be flying along the middle of the river. In contrast, the Okanagan River channel is considerably narrower, being only approximately 25 m wide, and the open dykes make searching for adults much easier than along the South Thompson. A few teneral adults were recorded on the South Thompson. One was collected at Pritchard on 20 July 2004 while emerging. Four other tenerals were recorded on 15 August 2008 at three separate locations along the river.

Exuviae have never been found at Christina Creek and only two have been collected in the Okanagan drainage. The main concentrations of the species in the Okanagan occur along the river channel, especially between Okanagan Falls and Vaseux Lake. Unfortunately, the sides of the channel are steep and often bouldery or heavily vegetated with grass and weeds and difficult to survey for exuviae, and none have been found. The situation on much of the South Thompson River is different, however. The river's edge is often gently sloping and beachlike, with stretches of emergent vegetation and flotsam that prevent exuviae from being quickly washed away. Although far fewer adult Olive Clubtails have been observed along the South Thompson River than along the Okanagan River, the larger amount of apparently good habitat and the presence of significant numbers of exuviae in the former area suggest that the Thompson Valley may support the larger population.

However, assuming the production of dragonflies is similar along the suitable shoreline, the observed densities give a minimum number of emerged adult dragonflies in the South Thompson River ranging from 2000 to 60,000. This calculation assumes, probably incorrectly, that all the exuviae of the emerging 2008 population along the shorelines examined were available on 15-19 August. On the other hand, the density of exuviae is probably quite patchy and these numbers might represent only density in relatively good habitat. The numbers of exuviae also overestimate the numbers of mature individuals, because an unknown percentage of emerging adults die in the first few days of their adult life. With these factors in mind, a more informed estimate might be 1000 to 50,000 mature individuals for this stretch of the South Thompson River. The speculative estimates for the whole Canadian population are: Christina Creek – <500; Okanagan Valley – 1000-50,000; South Thompson River – 1000-40,000; total population – 2500-90,000. The large ranges in these estimates render them unsatisfactory and more detailed and comprehensive counts of exuviae are required before any useful population estimate can be reached.

Fluctuations and trends

There is no information on population trends of the Olive Clubtail in British Columbia. The larger number of records along the Okanagan River in the 2009 surveys as compared to those of the survey in 1997 (Cannings *et al*. 1998) is the result of more directed search effort in the former survey. Observers were focused specifically on *Stylurus* and not on Odonata in general and more time was spent searching. There have been few records in eastern Washington since the late 1980s but this can also be ascribed to lack of search effort rather than an actual decline in numbers (D. Paulson pers. comm. 2009). The species remains common along the Snake River in Idaho and along the Columbia River near its mouth (Cannings *et al.* 1998; Paulson 1998, pers. comm. 2002, 2009; J. Johnson, pers. comm. 2002, 2009). The channeling of the Okanagan River in British Columbia in the 1950s has likely resulted in a decline in the amount and quality of habitat and a large proportion of the *Stylurus* larval population between Penticton and Osoyoos Lake was probably extirpated. The impact of this change is unknown. Whitehouse (1941) described them as “very scarce” along the Okanagan River in 1938, but he was sampling the area from July 18 to 22, relatively early in the flight season.

Rescue effect

Although there are no records of the Olive Clubtail from the Okanogan River in the United States (Figure 6), this is probably an artifact of low search effort (Dennis Paulson, pers. comm. 2009). The Canadian population in the Okanagan, therefore, is probably loosely connected to the Columbia Basin populations of Washington State, and could be repopulated from those should they be extirpated. However, until populations are confirmed in northern Washington State, a rescue effect cannot be assumed. Gomphid dragonflies are relatively strong fliers and are probably capable of dispersing a number of kilometres. See also **Dispersal and migration**.

However, habitat is a limiting factor, and if extirpation were caused by degradation of habitat, whether through destruction or pollution, then the rescue effect would be negligible.

The populations in the South Thompson River and Christina Creek are more isolated from populations in the United States, and repopulation would be less likely in the short term. The Kettle River forms most of the additional potential riverine habitat for the Christina Creek population, especially the approximately 50 kilometres of the river in the United States. However, Christina Creek is warmer than the less suitable Kettle River and no specimens of *Stylurus olivaceus* have ever been recorded in the Kettle River in either country.

THREATS AND LIMITING FACTORS

Threats calculator

The COSEWIC Threats Calculator, adapted from IUCN-CMP, was used to analyze potential threats (available upon request; contact COSEWIC Secretariat) to the Olive Clubtail; the overall impact of the threats was calculated to be High. There are a large number of actual and potential threats. The region of occurrence is subject to increasing pressure of urbanization with which many of the threats are associated. However, the impacts of some individual threats have not been established at this time.

Habitat loss/degradation

The Canadian range of *Stylurus olivaceus* lies mainly in the low valleys of the Thompson-Okanagan region, an area of rapid human population growth and increasing land development. In particular, the population of the Okanagan Valley has tripled every 30 to 40 years since 1940, reaching 300,000 in 2002 (Jensen and Epp 2002). Coincident with this growth is the increasingly intensive and extensive imprint of humans on the landscape. This is the basis of most of the threats to Olive Clubtail populations in the region. Habitat loss and threats come from channeling and damming of rivers; industrial, agricultural, residential and recreational development along river and lake shores; water pollution from power boats and swimming beaches as well as from agricultural, industrial and sewage sources; and introduced plant and animal species.

The primary limiting factor in the survival of the Olive Clubtail is the current and historical alteration, degradation and loss of the natural shorelines and littoral zones of lakes and rivers that support diverse invertebrate communities. For example, along a 42 km stretch of the southwestern shoreline of Okanagan Lake, 80% of this length has been altered by various developments: 41% by lakeshore housing and cottages, 27% by lakeshore road riprap, and 12% by swimming beaches and other recreational developments (Northcote and Northcote 2006).

In addition, in the 1950s, much of the species' habitat in the south Okanagan was altered by the dredging and channeling of the Okanagan River as part of a flood management program (Cannings *et al.* 1987, Cannings *et al.* 1998). The effect of this single drastic event on its population over half a century ago is unknown. However, the silt generated by this catastrophic habitat modification must have travelled downstream, smothering larvae and radically changing larval habitat. In addition, much of the channel bottom was then filled with large cobbles and boulders. Possibly, large parts of the South Okanagan population may have been lost after the initial channel construction when sections of the river, once flowing with water, were cut off as still, eutrophicated oxbows.

Dredging and channeling reduce habitat heterogeneity and aquatic diversity (Watters 2000); this may affect the success of *Stylurus olivaceus* larvae. Channeling alters river hydrology, usually resulting in increased water velocities that lead to scouring and erosion. In particular, scouring in both channeled and unchanneled sections of Okanagan River is significant during high flow periods when lake levels are being regulated to control flooding (Gelling *et al.* 2009). Scouring and high flows presumably reduce the availability of fine burrowing materials.

Creation of the dykes lining the channel decreased 85% of streamside vegetation, resulting in increased water temperatures in some sections of the river (Rae 2005). Among Odonata, many Gomphidae, especially lotic species, are particularly averse to temperatures higher than those to which they are adapted (Corbet 1999). Higher water temperatures may have reduced larval viabilty in *Stylurus olivaceus*, especially in conjunction with heavy silt loads, although this species, which is adapted to slow-moving, silty waters in hot climates, is probably less susceptible to such changes than are many cool-adapted clubtails. Loss of riparian trees and shrubs also exposes adult dragonflies along the dykes to increased predation by birds and other dragonfly species.

In the Okanagan Valley, the removal of littoral vegetation, the dumping of sand to create beaches, and many other shoreline changes are illegal and almost all require permits under the British Columbia *Water Act*. However, a recent compliance analysis indicated that for developed sites on both Okanagan Lake (35 sites assessed in 30 km of shoreline) and Skaha Lake (194 sites assessed for entire shoreline), non-compliance was almost 100% (Gelling *et al*. 2009).

Despite all the pressures indicated above, *Stylurus olivaceus* still persists along the dyked portions of the Okanagan River.

In contrast to the shoreline of the Okanagan River, the habitat structure along Christina Creek remains in a relatively natural state, but this is a very short stream supporting a small population of *Stylurus*. Along the much larger South Thompson River, areas of riverbank are developed to a greater or lesser extent (Figure 21), but exuviae are frequently found along stretches of stable and relatively unaltered shoreline consisting of gently sloping, muddy sand supporting emergent *Equisetum*, *Carex, Eleocharis* and other plants (Figures 11, 12).

Exotic species

The Okanagan River and associated lakes have had their fish populations altered considerably through the introduction of non-native predatory species including Largemouth Bass (*Micropterus salmoides* (Lacepede)), Smallmouth Bass (*M. dolomieui* Lacepede), Pumpkinseed (*Lepomis gibbosus* (L.)), Yellow Perch (*Perca flavescens* (Mitchill)), Black Crappie (*Pomoxis nigromaculatus* (Lesueur), Black Bullhead (*Ameiurus melas* (Rafinesque)), Brown Bullhead (*Ameiurus nebulosus* (Lesueur)) and Carp (*Cyprinus carpio* L.). In most cases, these species have originated via illegal releases directly into the Okanagan system (S. Pollard, pers. comm. 2010). Largemouth Bass have been known from Osoyoos and Vaseux Lakes for over 100 years (Mitchell 2008). The provincial government transplanted additional Smallmouth Bass into Vaseux and Skaha Lakes from Christina Lake in 1987 (Mitchell 2008). Christina Lake and Christina Creek have substantial populations of all the above species, with the exception of Black Crappie, but with the addition of Walleye (*Sander vitreus* (Mitchill)) and Tiger Muskellunge (a sterile hybrid of *Esox masquinongy* Mitchill and *E. lucius* L.). Smallmouth Bass were stocked in Christina Lake in 1901, but the other exotic species have entered the drainage primarily through introductions into the Columbia River system in Washington State (Mitchell 2008).

Fish are major predators of odonate larvae (Hilton 1987, Corbet 1999); in an experimental study in North Carolina, ten times as many dragonfly larvae were found within fish exclusion cages as outside them (Morin 1984). Specifically, bass, sunfish, and perch are all known to prey heavily on odonates. In an Iowa study, odonate larvae made up 62-70% of the food of Largemouth Bass more than 9 cm long (Wright 1946). Large dragonfly larvae were the main food of perch (*Perca* sp.) in a Russian study (Pushkin *et al.* 1979). In Minnesota, coenagrionid damselfly and libellulid dragonfly larvae were prominent among food of *Lepomis* sunfish (Crowder and Cooper 1982). In Tennessee, *Lepomis* sunfish preyed heavily on *Epitheca cynosura* (Say) (a medium-sized corduliid dragonfly) larvae; the mean number of larvae per fish when caught was 30 (Martin 1986). Carp not only eat the larvae, but in the Okanagan, at least, damage the substrate and have had a major impact on the vegetation structure of the littoral zone (Cannings *et al*. 1987).

The Okanagan system and Christina Lake/Creek have also been invaded by Eurasian Milfoil (*Myriophyllum spicatum* L.). This aquatic weed is increasing annually in Christina Creek and at the outlet of Christina Lake (Haberstock 2005). Its effect on habitat suitability for *Stylurus olivaceus* is unknown. Rototilling the substrate in lakes has been used as a major method of control and it apparently negatively affects other bottom-dwelling animals such as the Rocky Mountain Ridged Mussel (*Gonidea angulata* (Lea)) (Gelling *et al.* 2009). This procedure is restricted to lakes, however, and is unlikely to affect the main habitat of the Olive Clubtail.

Pollution/pesticides

Pollutants may come from several sources, including land development, agricultural practices, storm water runoff, sewage systems, forestry and range activities, atmospheric deposition and boating and marine activities. Even small amounts of contaminants in small amounts of runoff can result in cumulative effects, impacting aquatic life in the watershed (Ministry of Environment 1999).

Eutrophication resulting from agricultural runoff may be a problem in the Okanagan and along the Thompson River. The Penticton city sewage outlet in the Okanagan River is in the middle of a population of *Stylurus olivaceus*. However, this is apparently not detrimental, at least for major nutrient elements, as inputs of nitrates and phosphates have been reduced dramatically through tertiary treatment of sewage, which was implemented in all major centres in the 1980s. Smaller towns and rural areas are not treating sewage in this manner. Tertiary sewage treatment has effectively eliminated any concerns of nutrient loading in Okanagan Lake, which is still considered oligotrophic. Nutrient loading associated with agricultural practices may have been a concern historically but levels have been reduced significantly. Elevated inputs of nitrates may still occur locally on tributaries to the lakes (Gelling *et al*. 2009).

Osoyoos Lake has the highest nitrogen content of the Okanagan River watershed lakes (Rae 2005) and is warmer than either Skaha or Okanagan lakes. Although high nutrient levels there are partly the result of the shallow depth, agricultural and urban runoff likely contribute to this condition. The lake is highly productive and organic material on the bottom decomposes rapidly, resulting in reduced oxygen levels (Rae 2005). The north end of the lake historically became anoxic but now only the bottom 20 m or so becomes depleted of oxygen. However, the water above the thermocline never suffers from anoxia (Gelling *et al*. 2009). *Stylurus olivaceus* has not been collected in the lake, although adults have been found along the river nearby. The related *Gomphus graslinellus* does develop in the lake itself.

The levels of copper, an element known to be toxic to many freshwater invertebrates, are tracked in the Okanagan watershed. Some tributaries show concentrations (8.5-9.5 ppm) that produce low chronic effects in mussels (Wang *et al.* 2007), but most tributaries are in the 2-3 ppm range and the dilution in the lakes results in much lower levels there (Gelling *et al*. 2009). Pharmaceuticals (those acting as endocrine disruptors) in treated sewage are a concern, particularly in localized areas downstream of the treatment plants at Okanagan Falls and Penticton. Studies to establish baseline information are currently underway (Gelling *et al.* 2009).

No specific information is available on the effects of pesticides on the Olive Clubtail. Pesticides are a potential problem in the South Okanagan, because the Okanagan River flows through many orchard and vineyard lands. In the Saskatchewan River, Saskatchewan, *Stylurus intricatus* (Hagen) larvae were featured in a catastrophic kill of aquatic insects, 21 and 38 km downstream from an application site of methoxychlor, a DDT-like insecticide used to control black fly larvae (Dosdall and Lehmkuhl 1989) in the prairie provinces. *Stylurus intricatus* larvae are similar to those of *Stylurus olivaceus* and are also deep burrowers in sediment. Although this insecticide may not have been used yet in British Columbia, there is potential for it use.

Where roads and railway lines are adjacent to rivers, spills of toxic chemicals are a threat. This is especially true along the South Thompson River, where both the CP mainline and the Trans-Canada Highway follow the southern bank of the river. The southern transprovincial Highway 3 crosses Christina Creek immediately downstream from its outlet from Christina Lake and any spill here could potentially damage the entire length of this short but valuable stream.

There is probably little spraying of insecticides for control of forest pests or biting flies in the Canadian range of *Stylurus olivaceus*, although herbicide spraying along road and rail rights-of-way used by adult dragonflies likely occurs. This would potentially harm the dragonflies directly as well as reducing the important vegetation in which they rest and forage.

Road-kill

Dragonflies are frequently killed by cars and other vehicles. Large numbers have been killed along major highways in Canada (Catling and Kostiuk 2006). Both mature adults and tenerals leaving the water's edge after emergence can be killed crossing roads that follow the river bank or nearby, along which vehicles travel at more than 50 km/hr. This velocity apparently represents the upper limit of the ability of dragonflies to avoid approaching vehicles (COSEWIC 2010). The amount of traffic and the nature of the road are significant. Well-constructed forest roads and secondary highways, which allow high speed but have narrow rights-of-way, are particularly dangerous for dragonflies. Roads follow both banks of most of the length of the South Thompson River known to support *Stylurus olivaceus* and two-thirds of the 6 km of river in Penticton is bordered by a highway. Several road bridges cross all three of the streams known to produce the species in Canada. Vehicles on all these roads usually drive faster than

50 km/hr. However, none of the recorded specimens have ever been collected dead on a road or on a vehicle and the mortality of the Olive Clubtail in Canada from collisions is probably low compared to that of some other more common species. Although lower than for other species, it may be higher than generally assumed for two reasons: (1) Road-killed dragonflies are often eaten by birds within minutes of a collision and thus are not detected, and (2) entomologists are rarely looking for road-killed dragonflies due to excess damage.

Predation

Stylurus olivaceus larvae are probably eaten by many animals, including ducks, shorebirds, many fish species, and predaceous aquatic insects including other dragonfly larvae. Bird predation is one of the most significant agents of adult dragonfly mortality. Adult dragonflies are killed by small falcons such as American Kestrels (*Falco sparverius* L.) and Merlins (*Falco columbarius* L.), by Cedar Waxwings (*Bombycilla cedrorum* Vieillot), Eastern Kingbirds (*Tyrannus tyrannus* (L.)) and others. Western Kingbirds (*Tyrannus verticalis* Say) have mostly flown south by the time *Stylurus olivaceus* has emerged). Emerging adults are especially vulnerable to blackbirds; weakly flying teneral adults on their maiden flight are frequently captured by insectivorous birds. Paul Catling (pers. comm. 2010) once recorded swallows feeding on *Ophiogomphus occidentis* tenerals under the Highway 97 bridge at Penticton. Both Cliff (*Hirundo pyrrhonota* Vieillot) and Barn (*Hirundo rustica* L.) swallows nest under most Okanagan River bridges.

Recreation

Any relatively clean, freshwater body is a magnet for the recreational activities of people in the hot Okanagan summer. The height of this activity coincides with the emergence period of the Olive Clubtail. The South Thompson has hundreds of visitors including fishers, boaters, and water-skiers. The Okanagan River in Penticton is a popular swimming stream and thousands of people float on it in inner tubes and air mattresses. The lakes are jammed with thousands of boats and Jet Skis. At least some Olive Clubtail adults emerge during the day, and may be injured or killed by the waves generated by these craft. Motorized watercraft are frequently used even on shallow Christina Creek. The wakes from these craft break down the banks as has been observed directly by the report writers, and ultimately the banks collapse and the streamside vegetation is lost.

PROTECTION, STATUS, AND RANKS

Legal protection and status

The Olive Clubtail has no status under the federal *Species at Risk Act* or under the U.S. *Endangered Species Act*.

The *British Columbia Parks Act* protects species within parks and other provincially protected areas. Some of these are listed below under **Habitat protection and ownership**, although few support populations of the dragonfly. The most important protected area for the Olive Clubtail is Pritchard Provincial Park on the north side of the South Thompson River at Pritchard.

Under the provincial *Forest and Range Practices Act*, the Identified Wildlife Management Strategy provides procedures and guidelines for managing Identified Wildlife. The goals of the strategy are to minimize the effects of forest and range practices on Identified Wildlife situated on Crown land. However, the legislation probably would provide little protection for the Olive Clubtail, even if it were listed, as there is little Crown land with grazing or logging activity where the species occurs.

The provincial *Riparian Areas Regulation* under the *British Columbia Fisheries Act* helps manage development in riparian zones and may have some positive impact on clubtail habitat, especially along Christina Creek and the South Thompson River, where natural riparian zones are still intact in some places. The dyked Okanagan River has little remaining unmodified riparian habitat.

Non-legal status and ranks

The Olive Clubtail is given a global rank of G4 by NatureServe, which indicates a species that is “apparently secure,” but for which there are some potential future conservation concerns (NatureServe 2009). The British Columbia Conservation Centre has given it a rank of S1S2, meaning that it is considered imperiled in the province. The provincial and national General Status rank is 2, ‘May be at Risk.’ The British Columbia Ministry of Environment has given it a Conservation Framework priority rank of 1, the highest priority rank for conservation action (B.C. Conservation Data Centre 2009). Elsewhere in the North American west, *S. olivaceus* is ranked S4 in Washington (apparently secure) and SH (historical, possibly extirpated) in Utah; it is not yet ranked in Oregon, California, Idaho, Nevada, and Arizona (NatureServe 2009). As stated in the **Global range** section, the Arizona record is not accepted by most experts and is not mapped in the present report.

Habitat protection and ownership

A number of sites are protected or managed for conservation, especially in the Okanagan; however, most of these relate to lake habitat, which is of minor concern for the Olive Clubtail. Most of the provincial parks on lakes (e.g., Sunoka, Bear Creek, Fintry, and Ellison parks) within the distribution of this species are managed primarily for recreation (swimming and boating), and may not adequately protect the littoral and shoreline zones, even if these habitats were important for the species.

The most important riverine protected areas in the Thompson-Okanagan (from south to north) are: South Okanagan Wildlife Management Area (British Columbia Ministry of Environment), Vaseux-Bighorn National Wildlife Area (Canadian Wildlife Service), Okanagan Falls Prov. Park, Pritchard Prov. Park and Banana Island Prov. Park; the last two are on the South Thompson River. Other protected areas, all associated with lakeshores, include Haynes Point Prov. Park, Vaseux Lake Prov. Park, Okanagan Mountain Prov. Park, Sunoka Provincial Park, Okanagan Lake Prov. Park, Bear Creek Provincial Park, Fintry Provincial Park, Ellison Lake Prov. Park, Kalamalka Lake Prov. Park and Shuswap Lake Prov. Park. At Christina Lake, Christina Lake Nature Park (managed locally), and possibly Christina Lake and Gladstone Prov. parks might be of minor importance.

ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

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Odonatological colleagues in the western United States – Rosser Garrison, Jim Johnson, Dennis Paulson, Tim Manolis and Steve Valley – freely gave their expert knowledge of the status and biology of *Stylurus olivaceus* in their regions. Jim Johnson provided his beautiful portraits of the species (Figures 1-3).

Collection managers and curators of various collections checked their holdings for specimens: Owen Lonsdale (Canadian National Collection of Insects, Arachnids and Nematodes), Karen Needham (Spencer Entomological Collection, Beaty Biodiversity Museum), Doug Currie and Antonia Guidotti (Royal Ontario Museum) and Dennis Paulson (Paulson Odonata Collection).

Naturalists and dragonfly enthusiasts supplied information on their observations. Special thanks to Avery Bartels, Jeremy Gatten, Jamie Fenneman and Dennis St. John for their records of *Stylurus*.

Claudia Copley, Entomology Collections Manager at the Royal BC Museum provided specimen data. She, along with Darren Copley and James Miskelly, energetically searched for the Olive Clubtail during general entomological field work in the Thompson region in 2008. They also provided photographs. Russell Cannings helped survey the South Okanagan in 2009, and Lea Gelling found many of the specimens during the 2005 surveys. Ian Hatter and Orville Dyer also collected field data.

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BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Rob Cannings has worked since 1980 as Curator of Entomology at the Royal British Columbia Museum in Victoria. From 1987 to 1996 he also led the Natural History Section there. He has been active on the Scientific Committee of the Biological Survey of Canada (Terrestrial Arthropods), the British Columbia Invertebrate Recovery Team and the Entomological Societies of British Columbia and Canada. He is a member of the Arthropod Subcommittee of COSEWIC. In former lives, Rob was a biologist and nature interpreter for British Columbia Parks and the Canadian Wildlife Service and served as a lecturer and museum curator at the University of British Columbia. His BSc and MSc are from the University of British Columbia; his PhD comes from the University of Guelph. Rob studies insect systematics, especially the taxonomy, evolution and biogeography of dragonflies (Odonata) and robber flies (Diptera: Asilidae). However, he has published on groups in all the major orders of insects. He has authored several books, including The Dragonflies of British Columbia (1977), Introducing the Dragonflies of British Columbia and the Yukon (2002) and The Systematics of *Lasiopogon* (Diptera: Asilidae) (2002). Rob and his brothers, Syd and Richard were made Honorary Fellows of Okanagan College in 2008. In 2009 Rob won the Bruce Naylor Award from the Alliance of Natural History Museums of Canada for outstanding contributions to museum-based natural history studies in Canada.

Syd Cannings is a zoologist working on rare and endangered species for Environment Canada (Canadian Wildlife Service) in Whitehorse. Born and raised in the Okanagan Valley, he graduated with his MSc in Zoology at University of British Columbia in 1978. In 1980 he became the curator of the major insect collection there, and did wide-ranging surveys of the insects of British Columbia and the Yukon. From 1991 to 2002 he was the Program Zoologist for the British Columbia Conservation Data Centre in Victoria and, on the side, collaborated with his brothers on a number of books about the natural history of British Columbia, including: Birds of the Okanagan Valley; British Columbia: A Natural History; and The World of Fresh Water. In 2002 and 2003, he was a research zoologist for NatureServe (Washington, DC), responsible for their bird and mammal ranking and databases. Syd is a member of the Arthropod Subcommittee of COSEWIC.

Leah Ramsay is the Program Zoologist for the British Columbia Conservation Data Centre, BC Ministry of Environment, Victoria, British Columbia. She has been collecting dragonflies in British Columbia for 18 years and was a primary participant in a major province-wide Odonata survey. As part of her position, Leah is responsible for applying the criteria used in determining the conservation status of animal species in British Columbia.

Richard Cannings is a biologist and author living in Penticton, BC. Like his brothers, he was born and raised in the Okanagan Valley, in a family keenly interested in natural history. He was the Curator of the Cowan Vertebrate Museum at the University of British Columbia for 15 years, and now works half-time for Bird Studies Canada. Richard was co-chair for birds on COSEWIC for 8 years and has also served on the British Columbia Environmental Appeal Board and the British Columbia Forest Appeals Commission. He is a founding director of the Okanagan Similkameen Conservation Alliance and a present member of the British Columbia board of the Nature Conservancy of Canada. Richard has written a number of books, including The Rockies: a Natural History, Birds of Southwestern British Columbia, An Enchantment of Birds and other titles with his brothers listed above. When he’s not birding, he plays fiddle in a local Scottish country dance band.

COLLECTIONS EXAMINED

Stylurus olivaceus has been seldom collected in Canada, especially historically. Most of the known specimens date from after 1995 and the majority both adult and larval, are housed in the Royal British Columbia Museum, Victoria, British Columbia (18 adults, 69 larval exuviae). Two more adults are in the Spencer Entomological Collection, Beaty Biodiversity Museum, University of British Columbia, Vancouver, BC. The only other collection housing Canadian specimens is the Royal Ontario Museum, Toronto, ON (2 adults). These specimens and their basic data are listed in Table 1.

The Canadian National Collection of Insects, Arachnids and Nematodes (Agriculture and Agri-Food Canada, Ottawa, ON) contains no *S. olivaceus* specimens from Canada and neither does the private collection of Dennis R. Paulson (Seattle, WA), the most comprehensive collection of Odonata in the US Pacific Northwest. There are few specimens of rare British Columbia Odonata in any other American collections of which we are unaware and, although no other US collections were contacted about Olive Clubtail specimens, it is doubtful that more exist.

One male specimen, apparently collected on 28 July 1926 at Penticton by E.M. Walker (Walker 1927) cannot be located, although two other specimens collected by Walker on the same trip are housed in the Royal Ontario Museum, where he worked.

THREATS ASSESSMENT WORKSHEET

See instructions in 'Instructions' worksheet. Scroll down in top pane to view the entire table.

Species or Ecosystem Scientific Name: Stylurus olivaceus

Element ID:

Elcode:

Suggested Number of Locations: 5

Overall Threat Impact Calculation Help:

Threat Impact		Level 1 Threat Impact Counts: high range	low range
A	Very High	0	0
B	High	0	0
C	Medium	3	0
D	Low	2	5
	Calculated Overall Threat Impact:	High	Medium

Assigned Overall Threat Impact: B = High

Impact Adjustment Reasons:

Overall Threat Comments: Medium threats from habitat loss and degradation, medium threats from chemical spills, but the latter may not occur within 10 years.

Threat		Impact (calculated)		Scope	Severity	Timing	Comments	Number of Locations		
								Lowest	Most Likely	Highest
1	Residential & commercial development	CD	Medium - Low	Restricted	Serious - Slight	High	Considerable, ongoing alteration of shoreline and littoral zone, especially along Thompson River	5	5	5
1.1	Housing & urban areas	CD	Medium - Low	Restricted	Serious - Slight	High	Considerable, ongoing alteration of shoreline and littoral zone, especially along Thompson River	5	5	5
1.2	Commercial & industrial areas	D	Low	Small	Serious - Slight	High		2	2	2
1.3	Tourism & recreation areas	D	Low	Small	Slight	High		5	5	5
2	Agriculture & aquaculture									
2.1	Annual & perennial non-timber crops									
2.2	Wood & pulp plantations									
2.3	Livestock farming & ranching									

Threat		Impact (calculated)		Scope	Severity	Timing	Comments	Number of Locations		
								Lowest	Most Likely	Highest
2.4	Marine & freshwater aquaculture									
3	Energy production & mining									
3.1	Oil & gas drilling									
3.2	Mining & quarrying									
3.3	Renewable energy									
4	Transportation & service corridors									
4.1	Roads & railroads									
4.2	Utility & service lines									
4.3	Shipping lanes									
4.4	Flight paths									
5	Biological resource use									
5.1	Hunting & collecting terrestrial animals									
5.2	Gathering terrestrial plants									
5.3	Logging & wood harvesting									
5.4	Fishing & harvesting aquatic resources									
6	Human intrusions & disturbance	D	Low	Large	Slight	High		5	5	5
6.1	Recreational activities	D	Low	Large	Slight	High	Damage to littoral and shorelines from wave wash			
6.2	War, civil unrest & military exercises									
6.3	Work & other activities									
7	Natural system modifications	D	Low	Small	Moderate - Slight	Moderate		3	3	3
7.1	Fire & fire suppression									
7.2	Dams & water management/use	D	Low	Small	Moderate - Slight	Moderate	Future loss of habitat through water extraction and/or channelization	3	3	3
7.3	Other ecosystem modifications									
8	Invasive & other problematic species & genes	CD	Medium - Low	Large - Small	Moderate - Slight	High	Myriophyllum is 'out of control' at Christina Lake outlet and may invade upper reaches of creek	4	4	5
8.1	Invasive non-native/alien species	CD	Medium - Low	Large - Small	Moderate - Slight	High	Many introduced predatory fish, with potential for more; Myriophyllum in Okanagan system and at outlet of Christina Lake	4	4	5
8.2	Problematic native species									

Threat		Impact (calculated)		Scope	Severity	Timing	Comments	Number of Locations		
								Lowest	Most Likely	Highest
8.3	Introduced genetic material									
9	Pollution	CD	Medium - Low	Restricted	Extreme - Moderate	High - Low	Potential in medium to long term for deadly pesticide spill	4	4	5
9.1	Household sewage & urban waste water	D	Low	Pervasive - Large	Slight	High	Ongoing dumping of waste water and tertiary treated sewage	4	4	5
9.2	Industrial & military effluents	CD	Medium - Low	Restricted	Extreme - Moderate	Moderate	Potential in medium to long term for deadly chemical spill from train			
9.3	Agricultural & forestry effluents	CD	Medium - Low	Restricted	Serious - Moderate	Moderate	Potential in medium to long term for major pesticide spill; ongoing pesticide and fertilizer inflow into rivers.	4	4	5
9.4	Garbage & solid waste									
9.5	Air-borne pollutants									
9.6	Excess energy									
10	Geological events									
10.1	Volcanoes									
10.2	Earthquakes/tsunamis									
10.3	Avalanches/landslides									
11	Climate change & severe weather									
11.1	Habitat shifting & alteration									
11.2	Droughts									
11.3	Temperature extremes									
11.4	Storms & flooding									