COSEWIC
Assessment and Status Report

on the

Vivid Dancer
Argia vivida

in Canada

SPECIAL CONCERN
2015

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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Vivid Dancer — Photograph by Alan Harris.

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COSEWIC
Assessment Summary

Assessment Summary – May 2015

Common name
Vivid Dancer

Scientific name
Argia vivida

Status
Special Concern

Reason for designation
This damselfly is found in southern British Columbia and Banff, Alberta. Through much of its Canadian range it is restricted to thermal springs, but in the hot valleys of the Okanagan and the Fraser it is also found in cooler, spring-fed creeks. Habitat loss and degradation at most sites suggest subpopulations have declined. The species is threatened by intensive recreational use of thermal springs, livestock trampling at cool springs, and introduced fish. Sites are also vulnerable to potential tourism development and changes in springs caused by events such as droughts, earthquakes and landslides.

Occurrence
British Columbia, Alberta

Status history
Designated Special Concern in May 2015.

COSEWIC
Executive Summary

Vivid Dancer
Argia vivida

Wildlife Species Description and Significance

Vivid Dancer is a robust damselfly (Order Odonata) 29.5 – 35mm long. Adult males are typically bright blue or occasionally violet blue, both forms with black markings. Females resemble males or may have more subdued colours, typically orange or red-brown and black. Vivid Dancer is distinguished from similar damselflies in other genera by wing venation patterns, the shape of reproductive structures, and comparatively longer leg spines. Vivid Dancer larvae are short, stocky and flattened, with broad, heavily pigmented, leaf-like gills.

For much of its Canadian range, Vivid Dancer is a specialist of thermal spring habitats. The species is the only documented odonate adapted to breed in geothermal springs in North America. The floral and faunal communities within thermal springs vary from site to site.

Distribution

The range of Vivid Dancer is within the southern half of British Columbia. The westernmost site is in Pemberton, extending east through the Okanagan Valley, the Kootenays to Banff in western Alberta. The species ranges south through the western United States to the southern tip of the Baja Peninsula in Mexico, east to Nebraska.

Habitat

Vivid Dancer larvae inhabit both thermal and cold springs and associated small streams. In Canada, the species primarily inhabits thermal springs at least 10°C warmer than the mean annual air temperature. The species is also recorded from low elevation cool springs in the Okanagan Valley and near Lytton, which are also two of the warmest regions of Canada during summer months. Adults forage and roost adjacent to water habitats and nearby forests.

Biology

Vivid Dancer overwinters as larvae and emerges as adults from late-April through mid-October, depending on the temperature of the spring. The minimum temperature for egg development is 11°C. Within thermal springs the generation time is one year, but in cooler springs the generation time is up to three years. Adults disperse 700 - 800 m within the surrounding forest and feed on small flying insects, such as mosquitoes, mayflies, and small moths. On cool days adults bask in sunlit forest patches to increase body temperature. In late summer, adults return to the spring to breed. Females lay eggs on emergent vegetation below the water's surface.

Larvae are aquatic, feeding on small invertebrates and using aquatic vegetation for cover. Adults fall prey to robber flies, dragonflies, spiders, amphibians, and birds. Fish, amphibians, and possibly waterfowl likely consume Vivid Dancer larvae.

Population Sizes and Trends

Vivid Dancer population information is available for one site at Banff, with an estimate of 2,000 to 20,000 adults in 2005. Other springs lack population estimates; however, adult numbers are probably smaller based on available quality or undeveloped habitat. Population trend data are also lacking but most springs have undergone habitat damage from commercial and recreation use, suggesting populations have likely declined.

Threats and Limiting Factors

Habitat loss and degradation are the primary threats to Vivid Dancer. Threats include water diversion and degradation (e.g., cooling, pollution) by commercial thermal spring operations, alteration of springs and drainage channels by recreational users at non-commercial thermal springs, and livestock use at the cool springs sites in the Okanagan. Other potential threats include introduced fish at Banff and altered spring water discharge caused by road building. Sites are also vulnerable to changes in spring water discharge caused by stochastic events such as droughts, seismic activity, and landslides.

Protection, Status, and Ranks

Vivid Dancer is not protected under provincial legislation in BC or AB. Like all wildlife in national parks, Vivid Dancers in Banff National Park are protected under the *National Parks Act*. Some sites in Banff National Park are offered some habitat protection under the designation of sections of certain springs as critical habitat for the Banff Springs Snail. In BC, Vivid Dancer habitat occurs within heavily developed private lands and provincial parks, both with no specific habitat protection.

The global status rank is Secure (G5) and national rank in Canada is Imperilled (N2). Provincially the species is ranked Imperilled (S2) in BC and Critically Imperilled (S1) in Alberta.

TECHNICAL SUMMARY

Argia vivida

Vivid Dancer — Agrion vif

Range of occurrence in Canada: British Columbia, Alberta

Demographic Information

Generation time	1-3 years
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Yes. Inferred based on habitat loss.
Estimated percent of continuing decline in total number of mature individuals within 5 years or 2 generations	Unknown.
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Unknown.
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	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.	Unknown.
Are the causes of the decline clearly reversible and understood and ceased?	Partially understood (habitat loss), partially reversible (mitigation of threats at current sites) and not ceased.
Are there extreme fluctuations in number of mature individuals?	Unknown

Extent and Occupancy Information

Estimated extent of occurrence	106,000 km²
Index of area of occupancy (IAO) (2x2 grid value). • Cool springs populations are poorly documented and are likely more numerous than currently known.	124 km²
Is the population severely fragmented?	Unknown.
Number of locations	22
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy?	Yes. Inferred decline in IAO based on habitat loss at known sites.
Is there an [observed, inferred, or projected] continuing decline in number of populations?	Yes. Inferred based on habitat loss.
Is there an [observed, inferred, or projected] continuing decline in number of locations*?	Yes. Inferred based on habitat loss.

Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat?	Yes. Observed, inferred and projected decline in extent and quality of habitat based on threats at known sites.
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	**N Mature Individuals**
Banff National Park	2000 – 20,000 adults
All other populations	Unknown
Total	Unknown

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Not calculated.

Threats (actual or imminent, to populations or habitats)

Habitat loss and degradation are the primary threats. Additional threats include water diversion and degradation (e.g., cooling, pollution) by commercial thermal spring operations, alteration of springs and drainage channels by recreational users at non-commercial thermal springs, and livestock use at sites in the Okanagan. Other potential threats include introduced fish at Banff and altered spring water discharge caused by road building. Populations are also vulnerable to changes in spring water discharge caused by stochastic events such as droughts, seismic activity, and landslides.

Rescue Effect (immigration from outside Canada)

Status of outside population(s)?	Apparently stable in US range.
Is immigration known or possible?	Not known. Immigration unlikely
Would immigrants be adapted to survive in Canada?	Possibly
Is there sufficient habitat for immigrants in Canada?	Possibly
Is rescue from outside populations likely?	No

Data Sensitive Species

Is this a data sensitive species?	No, almost all known thermal spring subpopulations are well documented in publicly available literature.

Status History

Designated Special Concern in May 2015.

Status and Reasons for Designation:

Status: Special Concern	**Final Criteria:** Not Applicable
Reasons for designation: This damselfly is found in southern British Columbia and Banff, Alberta. Through much of its Canadian range it is restricted to thermal springs, but in the hot valleys of the Okanagan and the Fraser it is also found in cooler, spring-fed creeks. Habitat loss and degradation at most sites suggest subpopulations have declined. The species is threatened by intensive recreational use of thermal springs, livestock trampling at cool springs, and introduced fish. Sites are also vulnerable to potential tourism development and changes in springs caused by events such as droughts, earthquakes and landslides.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Rates of decline unknown but inferred based on habitat loss.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. Although the IAO (124 km^2) is below the threshold for Endangered and there is an observed continuing decline in (ii) the IAO, in (iii) area, extent and quality of habitat, in (iv) number of locations and in (v) number of mature individuals, none of the other sub-criteria are met.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Number of mature individuals exceeds threshold.
Criterion D (Very Small or Restricted Population): Not applicable. Number of mature individuals, IAO and number of locations exceed threshold.
Criterion E (Quantitative Analysis): Not possible to calculate, no data 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
(2015)

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

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

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

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

Environment Canada / Environnement Canada
Canadian Wildlife Service / Service canadien de la faune

Canada

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

Phylum: Arthropoda - arthropods

Class: Insecta - insects

Subclass: Pterygota - winged insects

Infraclass: Palaeoptera - ancient winged insects

Order: Odonata Fabricius, 1793 - damselflies and dragonflies

Suborder: Zygoptera Selys, 1854 - damselflies

Family: Coenagrionidae Kirby, 1890 - pond damsels

Subfamily: Argiinae

Genus: *Argia* Rambur, 1842 - dancers

Species: *Argia vivida* Hagen *in* Selys, 1865 - Vivid Dancer

Taxonomic synonyms: *Argia kurilis* Hagen

Type locality: Cabo San Lucas, Baja California, Mexico (Paulson and Dunkle 2012).

English common name: Vivid Dancer

French common name: Agrion vif

Taxonomic Background and Similarities:

Argia is a diverse genus with at least 110 described species, all confined to the New World (Westfall and May 1996). *Argia* vivida (Vivid Dancer) was first described in 1865 (H.A. Hagen *in* Selys-Longchamps 1865) and no subspecies are recognized. The Apache Dancer (*Argia munda* Calvert 1902) and the Springwater Dancer (*Argia plana* Calvert 1902) were formerly considered varieties of Vivid Dancer, but have long since been recognized as distinct species (Gloyd 1958; Westfall and May 1996).

Morphological Description

Vivid Dancers are relatively robust damselflies (Figure 1). The body lengths of males from Banff, Alberta (29.5-33.5 mm) are slightly smaller than those of females (30-35 mm) (Walker 1953) as is hind wing length (males 18.5-21.0 mm; females 21-24 mm). Elsewhere in their continental range, adults are 29-38 mm in total length, with a hind wing length of 18-26 mm (Paulson 2009).

Figure 1. Male Vivid Dancer at Nakusp Hotspring July 20, 2013. Photograph by Alan Harris.

Damselflies have three life stages: adults, larvae, and eggs. Adult Vivid Dancer males are typically bright blue with black markings, but may be violet-blue, brownish-violet, or brown (Westfall and May 1996). Females are polymorphic, with the andromorph ("male" form) resembling typical bright blue males with black markings, and the heteromorph ("female" form) with more subdued colours, typically orange or red-brown and black in Canadian forms (Conrad and Pritchard 1989; Acorn 2004), but also greenish-grey, brown, blue, or a mix of blue and brown (Paulson 2009; Westfall and May 1996).

Teneral individuals (newly emerged immature adults) are pale grey, tan, or cream-coloured (Conrad and Pritchard 1989; Westfall and May 1996; Paulson 2009). Males and both female morphs also experience a temperature-related physiological colour change i.e., individuals are "dark phase" at ambient shade temperatures below approximately 20°C and change to a more vivid-coloured "bright phase" at temperatures above 20-24°C, particularly when basking (Conrad and Pritchard 1989). Wings of both sexes are clear (typical form) to slightly smoky (Westfall and May 1996). See Westfall and May (1996) for more a detailed morphological description.

In Canada, Vivid Dancer is distinguished from similarly coloured bluets (*Enallagma* spp.) and other co-occurring damselflies by wing venation patterns and the shape of reproductive structures. Species of *Argia* have longer tibial spines than those found in other Canadian coenagrionid genera. Vivid Dancer males can usually be distinguished from Emma's Dancer (*A. emma*), the only other *Argia* in western Canada (Cannings 2008), by the violet, rather than blue colour of Emma's Dancer. In Vivid Dancer males, the black stripe on the top of the thorax is as wide as the adjacent pale stripes, but in Emma's Dancer the black stripe is half as wide as the pale stripes. Vivid Dancer females are most reliably separated from other *Argia* by the shape of the mesostigmal lamina (a pair of plates on the upper front thorax that engage with male reproductive structures during copulation).

Vivid Dancer larvae (nymphs) are elongate and approximately 17 mm long including the terminal gills (4.5 mm) (Walker 1953; Figure 2). Vivid Dancer larvae are shorter and more thick-set than the elongate, cylindrical larvae of other coenagrionid genera (Walker 1953). Vivid Dancer larvae have smaller gills (caudal lamellae) than those of Emma's Dancer (Kennedy 1915), with acute rather than round tips (Walker 1953).

Figure 2. Vivid Dancer larva at Upper Middle Spring, Banff National Park on January 8, 2003. Photograph by Dwayne Lepitzki.

Vivid Dancer eggs are approximately four times as wide as long and pointed at one end. The eggs are light cream-coloured when first laid, but soon turn black (Leggott and Pritchard 1985b).

Population Spatial Structure and Variability

In Canada, spatial structure, variability and genetic structure of Vivid Dancer has not been studied. Most of the Canadian sites are geographically isolated from one another and may also be genetically isolated due to limited dispersal capability (see **Dispersal and Migration**).

Designatable Units

The majority of Vivid Dancer sites occur within the Southern Mountain National Ecological Area. The Pemberton area sites occur in the Pacific National Ecological Area (see **Distribution**) (COSEWIC 2011b).

No studies of population genetic structure, discreteness, or evolutionary significance among sites have been completed. In the absence of any such evidence the species is considered to have one designatable unit in Canada.

Special Significance

The species is the only documented odonate adapted to breed in geothermal springs in North America. The damselfly is emblematic of thermal spring fauna and flora in Canada. Many of the thermal springs where Vivid Dancer occurs have additional species restricted to these habitats. In particular, some of the Banff thermal springs provide habitat for the endangered Canadian endemic Banff Springs Snail (*Physella johnsoni*) (COSEWIC 2008), and some sections were home to the extinct Banff Longnose Dace (*Rhinichthys cataractae smithi*), an endemic subspecies (Renaud and McAllister 1988). In addition, 28 species of rare mosses and three species of liverworts occur within some of the Banff area thermal springs (Krieger 2003; Lepitzki and Pacas 2010).

There is less information on the floral and faunal composition within the remaining thermal springs where Vivid Dancer occurs, although these springs hold the same ecological significance. For example, at Fairmont Springs, eight rare plants co-occur with Vivid Dancer, including the nationally endangered Southern Maidenhair Fern (*Adiantum capillus-veneris*) (Environment Canada 2013).

Vivid Dancer and other odonates are increasingly popular among naturalists, as indicated by the growing number of damselfly and dragonfly field guides and web sites as well as organized count events.

There is no Aboriginal traditional knowledge available for Vivid Dancer.

DISTRIBUTION

Global Range

Vivid Dancer ranges in western North America from south-central British Columbia south through 14 states to the southern tip of the Baja Peninsula in Mexico, and east to Nebraska (Figure 3, Paulson 2009). Although Kondratief (2000) shows Vivid Dancers as occurring in 16 counties in Oklahoma, no other source (e.g., Bick and Beckemeyer 1998; Paulson 2009; Abbott 2013) indicates it occurring in Oklahoma. Furthermore, Vivid Dancer has not been reported for adjacent Kansas (Beckemeyer 2004) or Texas (Abbott 2013). Vivid Dancer's global range encompasses approximately 3 million km^2 (based on Paulson 2009); however, it is patchily distributed within this area.

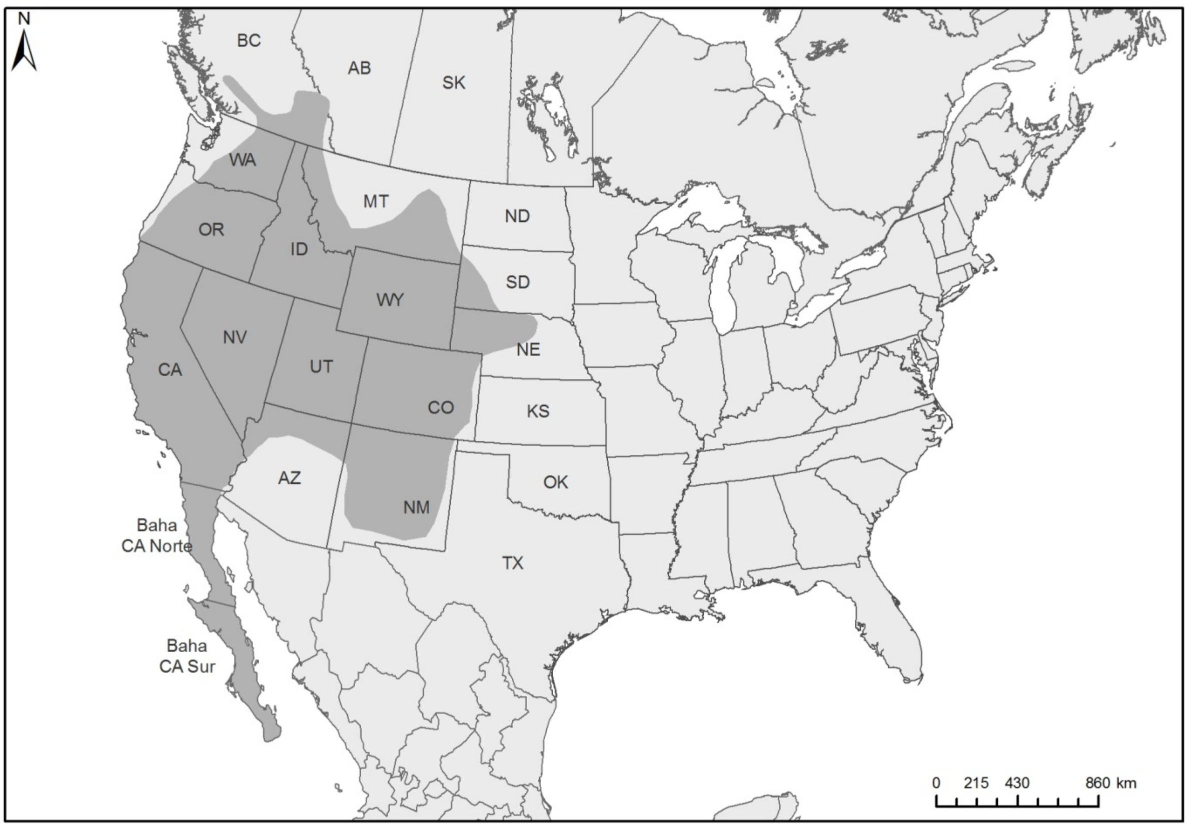

Figure 3. Global and Canadian range of Vivid Dancer modified from Paulson (2009) and Abbott (2013).

Canadian Range

Vivid Dancer is recorded from 33 sites throughout southern British Columbia and Alberta (Figure 4). Sites are defined as springs (see **HABITAT**) with confirmed breeding (e.g., presence of larvae); adjacent springs (less than approximately 100 m apart) and associated outflows are considered a single site (e.g., Middle Springs, Banff) (Table 1).

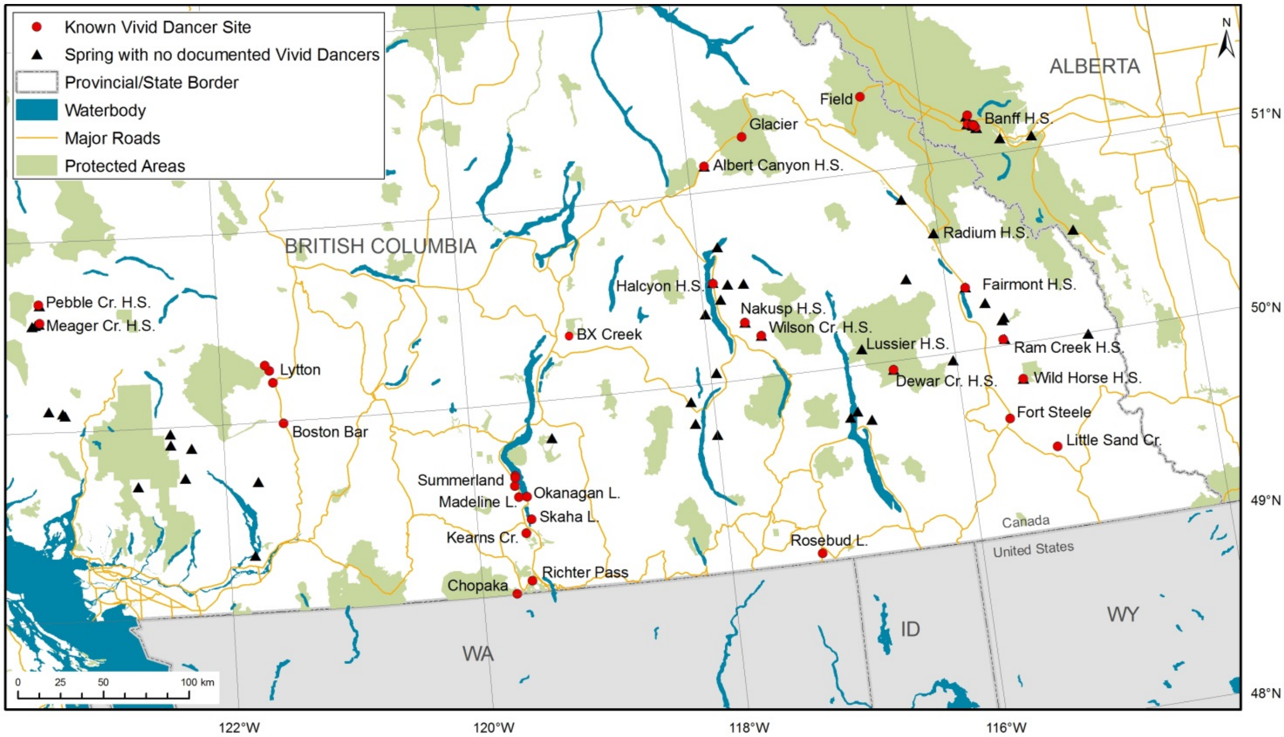

Figure 4. Canadian Vivid Dancer sites and thermal springs (with no documented records) within the Canadian range (labelled sites have been surveyed).

Table 1. Potential historical and confirmed sites[1] (alternate names are in parentheses) for Vivid Dancer in Canada.

Site Name (EO_ID[2])	Year First Recorded	Year Last Recorded	Year Last Surveyed	Land Ownership	Water Temperature (°C)	Elevation (m)
Albert Canyon EO# 956	1983	1998	2013	private	26	680
Banff, Forty Mile (Creek)	2002	2013	2013	Banff National Park	15	1605
Banff, Vermilion Cool Springs[3] EO# 2209	2002*	2002	2002	Banff National Park	17-21	1400
Banff, Cave & Basin NHS (4 separate springs: Cave, Basin, Upper C&B, and Lower C&B and associated outflow streams) EO# 2205	1908	2014	2014	Banff National Park	32-35	1460
Banff, Middle Springs - (4 separate springs: Lower, Gord's, Upper, West Cave and associated outflows) EO# 2207	1996	2014	2014	Banff National Park	21-46	1530
Banff, Middle Springs Bog	2003	2003	2003	Banff National Park		1470
Banff, above Middle Springs - Alpine Hut[3] EO# 2208	2002	2002	2002	Banff National Park (within Middle Springs Wildlife Corridor)	N/A	1550

Site Name (EO_ID[2])	Year First Recorded	Year Last Recorded	Year Last Surveyed	Land Ownership	Water Temperature (°C)	Elevation (m)
Banff, Kidney Spring EO# 2002	2002	2014	2014	Banff National Park	23-39	1558
Banff Upper Hot Spring	1996	2014	2014	Banff National Park	Up to ~ 47	1584
Banff Springs Hotel[4]				Banff National Park	N/A	N/A
Boston Bar EO# 8884	2006	2006	2006	BC crown?	N/A	290
BX Creek, Vernon	2013?	2013?	2013?	?	N/A	N/A
Chopaka	1997	1997	1997	BC crown?		360
Dewar Creek EO# 8905	2000	2001	2001	provincial park	83	1560
Fairmont Hot Spring (Indian Tubs) EO# 3758	1991	2013	2013	private	47	1000
Field	1905	1905	1905	?	N/A	1260
Fort Steele	1981	1981	1981	Private?	N/A	790
Glacier	1902	1902	1905	?	N/A	1260
Halcyon Hot Springs	1985	1986	1986	Private	50.7	550
Kearns Creek - White Lake EO# 2510	1997	1997	1997	BC crown?	N/A	530
Little Sand Creek -Jaffrey EO# 8882	1999	1999	2013	BC crown?	N/A	870
Little Wilson Lake (Wilson Lake/Creek) Warm Springs EO# 8908	2000	2001	2013	BC crown forest licence	35	1000
Lussier (Whiteswan) Hot Springs[4]				crown	43	N/A
Lytton, 2 km south of EO# 8885	2007	2007	2007	?	N/A	285
Lytton, 4.25 km north of EO# 8887	2007	2007	2007	BC crown?	N/A	280
Lytton, 8.9 km north of EO# 8888	2007	2007	2007	BC crown?	N/A	325
Madeline Lake EO# 3383	1983	1997	1997	BC crown?	N/A	495
Meager Creek Hot Spring EO# 5273	1988	1989	1989	BC crown?	N/A	910
Nakusp Hot Springs (Kuskanax Creek) EO# 388	1980	1994	2013	Village of Nakusp (public); local government	56	850
Okanagan Lake (Penticton Yacht Club) EO# 4119	1997	1997	1997	BC crown?	N/A	360
Pebble Creek (Lillooet River, Keyhole) Hot Spring EO# 8916	2000	2002	2002	BC crown?	54	600
Radium Hot Springs					44	N/A
Ram Creek Hot Springs EO# 8902	1989	2013	2013	ecological reserve	36	1415
Richter Pass EO# 4338	1991	1991	1991	BC crown?	N/A	730
Rosebud Lake	1999	1999	2013	Wildlife Refuge, Crown Land and Private Land	19	810

Site Name (EO_ID[2])	Year First Recorded	Year Last Recorded	Year Last Surveyed	Land Ownership	Water Temperature (°C)	Elevation (m)
Skaha Lake EO# 3851	1997	1997	1997	private?	N/A	340
Summerland (Crescent Beach) EO# 1504	1997	1997	1997	private?	N/A	405
Summerland (Kevin Brook / Munroe Ave Marsh) EO# 5408	1997	1997	1997	private?	N/A	493
Summerland (Switchback Road)	2011	2011	2011	private	N/A	380
Wild Horse Hot Springs (Wildhorse Creek)	2000	2002	2013	crown	21-27	1710

[1] adjacent springs and associated outflows are considered one site if within approximately 100 m of each other

[2] Element Occurrence identification number (British Columbia Conservation Data Centre and Alberta Conservation Data Centre)

[3] adults seen but no evidence of successful breeding (e.g., exuviae)

[4] potential historical site.

Canadian sites represent the northern limit of Vivid Dancer's global range, and less than 3% of Vivid Dancer's global range is in Canada (as mapped in Paulson 2009). Its high thermal flight threshold (see **BIOLOGY** and **Limiting Factors**) may limit reproductive activity at high latitudes and determine the species' northern range limits (Leggott and Pritchard 1986). Most Canadian sites are associated with thermal springs where the source water temperature is at least 10°C warmer than the mean annual air temperature of the region in which the spring occurs, which is approximately 0°C for the southern Canadian Cordillera (Grasby and Hutcheon 2001). The species may have been more widespread during the warm Hypsithermal period but has subsequently been restricted to warm sites (Pritchard 1989).

<u>British Columbia sites:</u>

Vivid Dancer sites can be grouped into four main regions within its Canadian range:

1) near Meager and Pebble creeks in the Coast Range northwest of Whistler and Pemberton;
2) Fraser River canyon near Lytton;
3) Okanagan Valley from Summerland south to the international border, with a northern outlier near Vernon (BX Creek);
4) Kootenay region east to Banff in the Rocky Mountains. In Canada, Vivid Dancer is recorded from 280 to 1620 m elevation (Table 1).

The northernmost historical Vivid Dancer record is 51.4°N at Field, BC (Walker 1953). Vivid Dancer has not been recorded from thermal springs at Liard and Deer River in northeastern BC (Salter 2003). The majority of sites are in the Kootenay region primarily because of the thermal springs in this area (Cannings pers. comm. 2013).

The cool spring Vivid Dancer sites in Canada are recorded within the warm low elevation valley bottoms of the Okanagan Valley and near Lytton. Two of the oldest Vivid Dancer records in Canada (both supported by specimens) are at sites where there are no documented thermal springs: Glacier (Osburn 1905) and Field, BC (Walker 1953). Whitehouse (1941) noted there was a spring-fed creek at Field, and speculated that the species may have been breeding in artificially warmed drainage ditches from the railway roundhouse. Walker (1953) described them as “locally abundant” at Field. At Glacier, a single Vivid Dancer male was collected in 1902 “over a stagnant pool in a small mountain meadow at an altitude of 6000 ft” (1829 m) (Osburn 1905). The specific collection sites are unknown and there have been no recent searches at either site.

<u>Alberta sites:</u>

Thermal springs in Banff National Park have not been consistently named or mapped leading to some confusion regarding Vivid Dancer distribution. There are a number of thermal springs along Sulphur Mountain and Forty Mile Creek, as well as cool springs at third Vermilion Lake (Figure 5).

Vivid Dancers adults are recorded from Cave and Basin National Historic Site (NHS) (Walker 1927), which includes four main springs that are considered one site (EO #001, Alberta Conservation Data Centre 2014): Cave Pool, Basin Pool, Lower Cave & Basin Springs, and Upper Cave & Basin Springs, as well as associated drainages that flow into a marsh on the Bow River floodplain. Adults were first collected at the Banff Cave and Basin springs in 1908 (Sanson 1908) and larvae in 1970 (Pritchard 1971). At the Cave and Basin NHS, larvae and adults have been found from the Upper Cave and Basin Springs and at least as far downstream (approximately 300 m) as the fish observation platform at the Cave & Basin Marsh (Rice 2002a).

Vivid Dancers also breed at the Lower Middle Springs and Upper Middle Springs (Hornung and Pacas 2006; Kortello and Ham 2010; Lepitzki and Lepitzki unpubl. data 1996 - 2014), as well as at the West Cave Middle Spring and Gord’s Spring (Lepitzki and Lepitzki unpubl. data 1996-2014). These four springs are treated as one site due to their close proximity. Exuviae (exoskeletons of final instar larva left after adult emergence) have been found at the nearby Middle Springs Bog (Hornung and Pacas 2006).

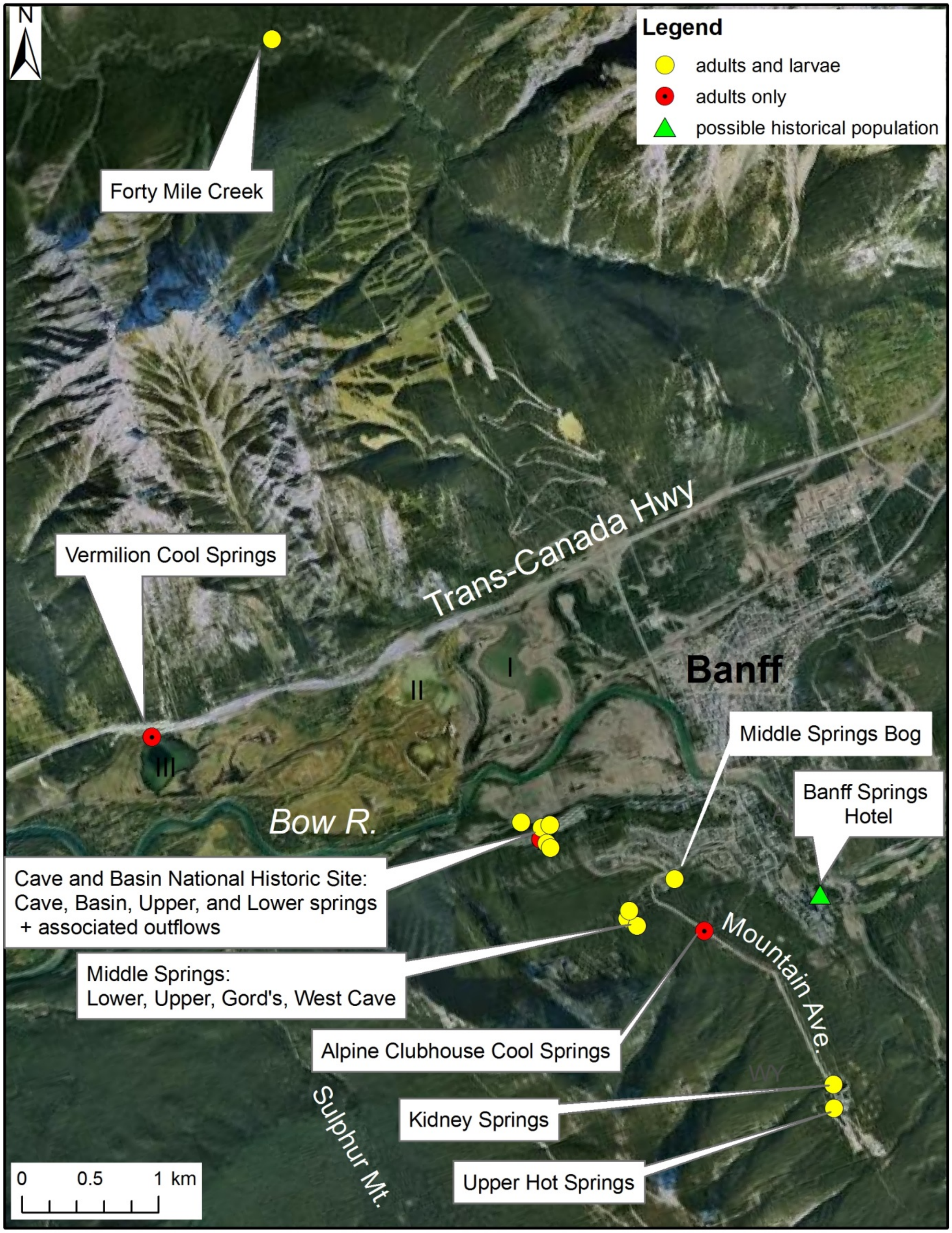

Figure 5. Vivid Dancer observations near the town of Banff, Banff National Park, Alberta (GoogleEarth™ imagery).

Vivid Dancer adults have been observed at Kidney Springs (Rice 2002b; Lepitzki and Lepitzki unpubl. data 1996-2014) paired adults, and larvae at both the Upper Hot and Kidney springs with a teneral also being seen at Kidney Springs (Lepitzki and Lepitzki unpubl. data 1996-2014). Both the Upper Hot and Kidney springs were previously thought to no longer provide suitable habitat, with the Upper Thermal spring being a commercial bath (Hornung and Pacas 2006). Adult Vivid Dancers have been observed in tandem ovipositing at third Vermilion Lake cool spring near Banff (Rice 2002b) but no larvae or exuviae have been observed there and it is not considered suitable breeding habitat (Hornung and Pacas 2006). A reproducing population of Vivid Dancers was recently recorded at a thermal spring along Forty Mile Creek beginning in 2002 (Rice 2002a; Lepitzki pers. comm. 2014; Lepitzki and Lepitzki unpubl. data 1996-2014), approximately 6 km north of the Cave and Basin NHS (Grasby and Hutcheon 2001).

The historical Glacier and Field sites may be extirpated (Table 1), although there have no recent surveys. There may have also been a loss of undocumented sites at Radium and Lussier hot springs in BC, as well as the possible loss of breeding habitat at the Banff Springs Hotel (although the species still persists elsewhere in Banff).

Extent of Occurrence and Area of Occupancy

The extent of occurrence (EO) is 106,000 km^2 as measured by minimum convex polygon. However, the distribution of Vivid Dancer within the Canadian EO is very patchy. The index of area of occupancy (IAO) encompasses 124 km^2 using a 2 km x 2 km grid (31 grid squares), although the IAO is likely larger based on lack of search effort across cooler springs.

Search Effort

Thermal springs are well documented due to their recreational popularity; approximately 50 thermal springs have been documented in the southern Canadian Cordillera between 49° and 51°N (Fairbank and Faulkner 1992; Woodsworth 1999). Most thermal springs in southern BC are within fault systems associated with major river valleys: 1) Columbia, 2) Kootenay, 3) Okanagan, 4) Lillooet, and 5) Harrison Lake valleys (Grasby and Hutcheon 2001). In southern AB, thermal springs are mostly within the Sulphur Mountain thrust fault near Banff, the Rundle Thrust (Canmore, Many Springs) and Misty Thrust (Grasby and Hutcheon 2001; Grasby and Lepitzki 2002).

The first Vivid Dancer records in Canada are from Glacier BC (1905), Field BC (1927) the Cave & Basin Springs at Banff, AB (1953) and from various BC sites during the 1970s (Cannings and Stuart 1977). Appendix 1 summarizes Vivid Dancer records in Canada.

BC Search Effort:

In BC, Odonata inventory in the Montane Cordillera has been extensive and is well documented south of 51°N. Since 1900, more than 3000 person-hours have been documented surveying adult odonates totalling approximately 18,000 records from 1200 sites (COSEWIC 2011a). Regardless, inventory in BC has not been systematic and most Odonata surveys have been along roadsides or within readily accessible aquatic habitats and few surveys have targeted remote and difficult-to-access springs. Additional inventory is needed in more remote areas (Cannings and Cannings 1998; Cannings pers. comm. 2014).

Odonata surveys have been conducted in the Okanagan and Similkameen valleys (Cannings *et al.* 1998), the Columbia Basin east of the Okanagan, central and northern BC in 2000-2005 (Cannings *et al.* 2000), and the southern Caribou north of the Thompson Valley in 2008 (COSEWIC 2011a). In 1997 inventory of the Okanagan basin (the best collected area in the zone) increased Vivid Dancer sites in the basin from three to eight (Cannings and Cannings 1998). In 2003, aquatic insect surveys in BC documented Vivid Dancer at thermal springs near Ram Creek, Dewar Creek, Wildhorse Creek, Pebble Creek, and Wilson Creek (Salter 2003), bringing the total of recent and confirmed provincial sites to thirteen. Vivid Dancers have not been recorded from Field and Glacier for over 80 years, although there has been little survey effort at these sites.

Liard and Deer River hot springs in northern British Columbia have been surveyed for aquatic insects (Salter 2003) and no Vivid Dancer larvae were found. There are approximately 38 thermal springs in southern BC that have not been surveyed or that have no detected Vivid Dancer (Table 2).

Table 2. Thermal springs (n=38) in southern Canadian Cordillera[1,2] without Vivid Dancer populations (may or may not have been surveyed).

Major Geological Feature[1]	Location Name	Water Temp. (°C)
Columbia River Fault	Fosthall Springs	N/A
Columbia River Fault	Halfway River	59
Columbia River Fault	Jorden Ranch	12
Columbia River Fault	Octopus Creek	49
Columbia River Fault	Snowshoe Rabbit Warm Spring	N/A
Columbia River Fault	St. Leon Hot Springs	47
Columbia River Fault	Taylor Warm Spring	25
Columbia River Fault	Upper Halfway River Warm Springs	N/A
Columbia River Fault	Whiskey Point	N/A
Garibaldi Volcanic Belt	Elaho River	30
Garibaldi Volcanic Belt	No Good Warm Spring	N/A

Major Geological Feature[1]	Location Name	Water Temp. (°C)
Garibaldi Volcanic Belt	Pitt River	55
Garibaldi Volcanic Belt	Placid	60
Garibaldi Volcanic Belt	Shovel Nose	57
Garibaldi Volcanic Belt	Turbid Creek	30
Harrison Lake Fault	August Jacob	43
Harrison Lake Fault	Clear Creek	60.8
Harrison Lake Fault	Glacier Creek	N/A
Harrison Lake Fault	Harrison Lake (highly developed, little natural habitat)	62.4
Harrison Lake Fault	Skookumchuck (St. Agnes Well)	50
Harrison Lake Fault	Sloquet Creek	60.8
Okanagan Valley Fault	Angel (Kelowna) - KLO Creek	N/A
Purcell Trench	Ainsworth	45
Purcell Trench	Crawford Bay (Creek) Warm Springs	32
Purcell Trench	Fry Creek	N/A
Purcell Trench	Riondel	N/A
Rocky Mountain Trench	Buhl Creek	N/A
Rocky Mountain Trench	Mutton Creek Warm Spring	N/A
Rocky Mountain Trench	Ram Creek	37
Rocky Mountain Trench	Red Rock Cool Springs	N/A
Rocky Mountain Trench	Toby Creek	11
Rocky Mountain Trench	Wolfenden	28
Rocky Mountains	Canmore Spring	12
Rocky Mountains	Fording Mountain (Sulphur) Warm Springs	21
Rocky Mountains	Many Springs	11
Rocky Mountains	Mist Mt.	33
West Coast Fault	Ahousat (Flores Island) Warm Springs	22
West Coast Fault	Sharp Point (Ramsay Hot Springs, Hot Spring Cove)	58.5

[1]Grasby and Hutcheon (2001); [2]Woodsworth (1999); Litton (2005).

Cool springs in BC are both poorly mapped and surveyed throughout the range of Vivid Dancer. The recent records of Vivid Dancers at low elevation cool springs near Lytton and in BX Creek near Vernon, BC; as well as the older records at Glacier and Field (Table 1) suggest that there may be other undocumented sites at cool springs and associated streams in the southern Cordillera. The cool springs with Vivid Dancer records though are in two of the hottest areas in Canada, and the presence of the damselfly at these sites is likely associated with the hot temperatures (see Habitat).

Alberta Search Effort:

Vivid Dancer was first collected at Banff in 1908 and has been the subject of numerous studies beginning in the 1970s. In 2002 the species was recorded at Forty Mile Creek (Rice 2002b; Lepitzki pers. comm. 2014) although a “dragonfly” nymph (which was probably Vivid Dancer) was first observed at this spring on 31 October 1998 (Lepitzki and Lepitzki unpubl. data 1996-2014).

Vivid Dancer adults have been observed at cool springs by third Vermilion Lake and the old Alpine Clubhouse cool springs near Banff (Rice 2002b), but there is no evidence of successful breeding (larvae or exuviae) (Rice 2002b; Hornung and Pacas 2006).

Seventeen separate thermal springs in Banff National Park have been surveyed once every 3 weeks from January 1996 through July 2000; and then once every 4 weeks from August 2000 to present, while studying the Banff Springs Snail (*Physella johnsoni*)(Lepitzki and Lepitzki unpubl. data 1996-2014) totalling 268 surveys. Incidental observations of flying odonates as well as odonate larvae are recorded, including Vivid Dancer at most of these seventeen thermal springs.

Thermal springs between Norquay and Brewster mountains, as well as others in the Banff Bow Valley, have been surveyed at least four times (Oct 1998 through July 2013) (Lepitzki and Lepitzki unpubl. data 1996-2014). There are no specific Odonata surveys at Miette Hot Springs (250 km north of Banff) in Jasper National Park although Lepitzki and Lepitzki have visited these springs looking for snails (COSEWIC 2008) and would have likely noticed Vivid Dancers if they were present. In AB, there are few thermal springs with suitable habitat (Table 2).

HABITAT

Habitat Requirements

General spring habitat:

Throughout their global range, Vivid Dancers are typically recorded adjacent to springs and associated small streams of varying temperatures, but also flowing irrigation canals in open country (Westfall and May 1996; Paulson 2009). In Canada, Vivid Dancers are associated with thermal springs (Leggott and Pritchard 1985b), with the exception of low elevation cool springs in the Okanagan Valley and near Lytton, and historical occurrences at Glacier (BC) and Field (BC). This habitat association is so strong that Williamson (1932, *in* Walker 1953) stated “So dependent is it on springs that its presence anywhere can be taken as positive proof of adjacent spring water”.

Larval habitat:

Vivid Dancer larvae develop in small spring-fed streams and pools. The preferred water temperature for larval Vivid Dancers at the Banff Cave & Basin Springs and Albert Canyon Springs was 28°C and the 96 hour LD50 (where 50% of individuals die) was 36.8°C, similar to those recorded for other odonates (Pritchard 1980). The water temperature at the Banff Cave & Basin Springs at Banff is approximately 22-30 °C year-round where the larvae have been observed, compared to Albert Canyon (AB), which fluctuates from 5°C in winter to 20°C in summer (Leggott and Pritchard 1985a) and Dewar Creek (BC), which has an annual range of 9-32 °C (Salter 2003). Discharge temperatures for thermal springs within the range of Vivid Dancer are variable, from the defined minimum of 10°C to a maximum of 82°C for the Dewar Creek spring, and an overall average of 39°C (Grasby and Hutcheon 2001; Table 1).

Temperatures at the hot water source may be too high for Vivid Dancer larval development but are suitable farther downstream after atmospheric cooling and/ or influx of cooler surface waters. For example, at Wilson Creek (BC) the water temperature air-cooled from 34° to 21°C 150 m downstream in October (Salter 2003). Water temperature at the main vent at Dewar Creek (BC) was 82°C but had cooled to 28°C at the site where larvae were collected (Salter 2003). At Banff (AB) and, likely, other springs, there are seasonal changes in water temperatures, with springs reaching their maximum temperature during the winter when water infiltration is lowest (Grasby and Lepitzki 2002; COSEWIC 2008).

Vivid Dancer larvae are recorded from spring runs and small to medium-sized streams with good current, as well as flowing irrigation canals in open country in other parts of its global range in the United States (Paulson 2009). Vivid Dancer larvae appear to require higher oxygen concentrations than do other coenagrionid damselflies, often moving into stream currents of appropriate speed (Pritchard 1991; Corbet 1999). Discharge is usually low (1 to 50 l/s) at thermal springs in the southern Canadian Cordillera; however, higher flow rates occur at Meager Creek (up to 500 l/s) (Fairbank and Faulkner 1992; Grasby and Hutcheon 2001). Flow stoppages have been recorded at Banff (AB) at the Upper Hot Springs, Kidney Spring, Upper Middle Spring, and Gord's Spring (Lepitzki and Pacas 2010) as well as at the West Cave Middle Spring (Lepitzki and Lepitzki 1996-2014 unpubl. data).

Oviposition sites:

Vivid Dancers oviposit in emergent vegetation below the water's surface (Hornung and Pacas 2006) including dense sedge beds (Paulson 2009). They are typically found at smaller and more heavily vegetated streams than Emma's Dancers (*Argia emma*) where they coexist (Paulson 2009). In the thermal outflow streams at the Banff Cave & Basin Springs, Vivid Dancer larvae hid in lush vegetation—primarily pondweed (*Potamogeton* sp.), and "water cress", with some non-native plant species (Pritchard 1971). Rocks and woody vegetation are typically present and used for adult perch sites (Paulson 2009).

Adult foraging habitat:

Adjacent terrestrial habitats are important for dispersal, foraging, mating and roosting (Corbet 1999). Females use terrestrial habitat away from springs more frequently than do males (Kortello and Ham 2010), as is typical of many odonates (Foster and Soluk 2006). Females and teneral males forage widely, enabling them to avoid conspecific competition and to build up energy reserves for reproduction (Kirkton and Schultz 2001; Bried and Ervin 2006).

Adult Vivid Dancers require a minimum thoracic temperature of approximately 26°C for flight (Leggott and Pritchard 1986), well above the average daily summer temperature in much of its Canadian range outside the Okanagan (BC). As a result, Vivid Dancers often bask in sunlit patches (Pritchard and Kortello 1997), and their flight activity is sporadic on overcast days (Leggott and Pritchard 1986). At Banff, adults were more frequently caught in sunny, open areas along trails and thinned areas compared to closed forest with less sunlight penetration (Ham and Kortello 2005). They most commonly perch on bare ground, logs, and rocks, as well as boardwalks and brush piles (Pritchard and Kortello 1997; Ham and Kortello 2005; Kortello and Ham 2010; Lepitzki and Lepitzki unpubl. data 1996-2014).

Roosting habitat:

At night Vivid Dancer adults roost in trees (Conrad and Pritchard 1988; Pritchard and Kortello 1997), perhaps to slow the radiant loss of heat (Kortello and Ham 2010). Night surveys at Banff recorded 21 Vivid Dancers primarily roosting in spruce (*Picea spp*.) trees, interspersed with Lodgepole Pine (*Pinus contorta*), Engelmann Spruce (*Picea engelmannii*), Poplar (*Populus balsamifera*), willow and Aspen (*Populus tremuloides*) (Ham and Kortello 2005; Kortello and Ham 2010). Many aspects of nocturnal roosting behaviour in Vivid Dancer, such as preferred tree species, diameter, and canopy closure, are poorly known and difficult to observe (Kortello and Ham 2010).

Habitat Trends

Habitat trends for Vivid Dancer are mainly attributed to recreational use, whether long-term and gradual use by non-commercial bathers or intensive infrastructure and commercial development. For the past century, the cumulative degradation of these thermal springs has been ongoing at almost all Vivid Dancer sites, the most prominent at Fairmont (BC), Albert Canyon (AB), Halcyon (BC), Nakusp (BC), and Banff (AB). Vivid Dancer has almost certainly been extirpated from some of the developed thermal springs around Radium and Banff (Cannings and Cannings 1998).

Even thermal springs within protected areas, such as Ram Creek Ecological Reserve (BC Parks) and Lussier springs (Whiteswan Provincial Park, BC) have also been degraded by bathers, the latter so modified that if Vivid Dancer historically occupied the site, they are likely now extirpated (Salter 2003).

The most prominent example of long-term and documented habitat trend information is within the Banff Springs area. There were originally several spring outlets at the Upper Hot Spring, forming a large tufa mound (Grasby and Lepitzki 2002). In the late 1800s, these sources were piped for a public swimming pool (Grasby and Lepitzki 2002). Both Vivid Dancer adults and larvae have been recorded at the Upper Hot Spring (Lepitzki and Lepitzki unpubl. data 1996-2014). However, there has been long-term habitat degradation given the recent high frequency of drying (it has dried 14 of the past 19 years: COSEWIC 2008; Lepitzki unpubl. data) and prolonged discharge of grey water (e.g., chlorinated, etc.) from the public bathing facility.

Kidney spring has been so modified it was initially thought to no longer provide suitable larval habitat (Hornung and Pacas 2006), although adults have consistently been recorded (Rice 2002b; Lepitzki and Lepitzki unpubl. data 1996-2014). These springs have dried twice over the past 19 years (COSEWIC 2008; Lepitzki unpubl. data). Kidney Spring also has been off-limits to the public since 2001 (COSEWIC 2008).

Other areas within Banff may have at one time been habitat for Vivid Dancer. The outflow stream where the Banff Springs Hotel parking lot now sits (Lepitzki and Pacas 2010) and a spring at the base of Stoney Squaw Mountain buried by the construction of the Banff interchange (Grasby and Lepitzki 2002) being two examples.

Park infrastructure improvements, maintenance and renovation have likely impacted Vivid Dancer habitat at Cave and Basin National Historic Site (Parks Canada 2007) although in the longer term have reduced trampling and disturbance to sensitive habitats. Middle Springs has been closed to the public since 1995 (COSEWIC 2008).

BIOLOGY

Vivid Dancer has three life stages; eggs and larvae (aquatic) and adult (terrestrial) (Corbet 1999). Vivid Dancer distribution, dispersal and life cycle is well studied, primarily from work at Banff (AB), Albert Canyon, Halcyon and other sites in BC, and Idaho (US) (Pritchard and Pelchat 1977; Pritchard 1980, 1982, 1988, 1989, 1991; Conrad and Pritchard 1988, 1989, 1990; Prichard and Kortello 1997; Rice 2002a; Salter 2003; Hornung and Pacas 2006; Kortello and Ham 2010).

Life Cycle and Reproduction

Vivid Dancers overwinter as larvae, and emerge as adults from late-April through late-September, peaking from mid-July to early-August and persisting in some places to mid-October (Prichard 1971; Leggot and Pritchard 1985a; Cannings 2002; Acorn 2004; British Columbia Conservation Data Centre 2013; Lepitzki and Lepitzki unpubl. data 1996-2014). Farther south, the flight season is from February through October in California (Westfall and May 1996), and potentially year-round. As is typical of many odonates, newly emerged adults forage away from their home water bodies within surrounding forests until they mature (Corbet 1999).

Males perch on rocks or vegetation adjacent to their aquatic habitat. Before midday, males bask at sunspots in the forest away from water and dart out to grab passing females for mating (Acorn 2004; Paulson 2009). Copulation lasts for more than 30 minutes, followed by a tandem flight for one or two hours before the pair arrives at water and begins to oviposit (Conrad and Pritchard 1988, 1990). As the day progresses, unmated males move slowly towards the water, arriving at about the same time as ovipositing pairs. If a tandem pair separates during oviposition, unmated males will attempt to capture the recently released gravid female (Conrad and Pritchard 1990). If successful, a male will take the female in tandem and begin another complete sequence of mating and oviposition, but with copulation lasting less than 10 minutes (Conrad 1987).

Eggs are laid singly into the stems of emergent and aquatic vegetation (Leggott and Pritchard 1985b; Paulson 2009). Documented oviposition sites at Banff sites include beds of Stonewort (*Chara*) (Kortello pers. comm. 2013), a stick, wet vegetation, outflow streams and into the water (Lepitzki and Lepitzki unpubl. data 1996-2014). Oviposition was observed at Nakusp Hot Springs in July 2013 in a hot spring drainage channel about 20 cm wide and 2 – 3 cm deep (Harris pers. obs. 2013). The tandem pair landed on a sedge stem 3 cm above the stream surface and for 30 seconds the female repeatedly dipped her abdomen into the water.

In lab trials, Vivid Dancers from Banff had 12-14 instars, with each instar approximately 1.24 times larger than the preceding one (Leggott and Pritchard 1985a,b). Growth rates and larval stage duration may depend on water temperature (Leggott and Prichard 1985a). At the Banff Cave & Basin Springs, the life cycle is approximately one year, likely due to warmer year-round water temperatures. In contrast, Vivid Dancers have a 3-year life cycle at Albert Canyon where water temperatures fluctuate from 5°C in the winter to 20°C in the summer (Leggott and Pritchard 1985a; Pritchard 1989). Vivid Dancer larvae had virtually no growth from November to April at Albert Canyon, and it appears larval diapause synchronizes emergence to allow adults to experience suitable temperatures (Pritchard 1989).

Physiology and Adaptability

Vivid Dancer is the only documented odonate adapted to breed in geothermal springs in North America (Corbet 1999). Egg development requires a minimum of 11.25°C. The species occupies a variety of temperature regimes across its global range, using thermal springs to meet the higher temperature requirements in northern regions (Pritchard 1989). In some springs, Vivid Dancer larvae diapause, otherwise the warm water temperatures would enable winter emergence when adult survival would be unlikely (Leggott and Pritchard 1985).

Dispersal and Migration

Overall, Vivid Dancer does not disperse far from water (Westfall and May 1996), which is typical of many damselflies (Corbet 1999). In arid habitats, teneral adults are commonly observed near streams and do not likely disperse far from their emergence site (Paulson 2009). In Canada, most Vivid Dancer sites are small, isolated and with habitat unlikely to form dispersal routes greater than a few kilometres apart.

Mark-recapture studies at Banff show limited dispersal. In 2003, only two males of a total of 549 marked adults moved between Middle Springs and Cave & Basin Springs (approximately 900 m) (Hornung and Pacas 2006). During a 2005 study, 59 of the 78 recaptures (1473 adults marked) moved less than 300 m and the mean flight distance of 181 ± 22 m (Ham and Kortello 2005; Kortello and Ham 2010). One male and female moved between Middle Springs and Cave & Basin Springs in 2005, with dispersal distances of 600-900 m observed within 24 to 96 hours after initial capture and release.

Observations at BC sites suggest similar dispersal distances. An adult was observed approximately 750 m downstream of Nakusp springs on July 20, 2013 and 12 adults were found along a forest access road as far as 800 m from Ram Creek spring the following day (Foster pers. obs. 2013).

Vivid Dancer sites in the Summerland BC area may act as a metapopulation (Cannings pers. comm. 2013) similar to those on Sulphur Mountain at Banff.

Interspecific Interactions

Thermal springs macroinvertebrate fauna changes along the downstream gradient of water temperature, dissolved solids, and oxygen (Corbet 1999). Extreme conditions at the spring origin are habitable by a few specialized taxa (e.g., Banff Springs Snail), while cooler downstream pools provide warm refugia to a broader suite of invertebrate taxa (Hornung and Pacas 2006). Undisturbed, thermal springs discharge pools are typically characterized by the growth of cyanobacteria and filamentous, white sulphur-oxidizing bacteria (*Thiothrix sp.*) (Jasinska pers. comm.1999 *in* Grasby and Lepitzki 2002). Amphipods (Family Gammaridae), ostracods (Custacea), fly larvae (Family Simulidae), water scavenger beetles (Hydrophilidae) and tubificid worms are common invertebrates in the outflows of Banff and other BC thermal springs (Prichard 1971; Rice 2002a; Salter 2003; Lepitzki and Lepitzki 2003). Small invertebrates are prey for Vivid Dancer larvae. Adults consume small soft-bodied flying insects, such as mosquitoes (Lepitzki and Lepitzki unpubl. data 1996-2014), mayflies, flies and small moths and will also pick aphids and other small insects from vegetation (Lung and Sommer 2001).

Larvae of other odonate species have been recorded in the thermal springs at Banff, but most do not appear to complete their life cycle (see Pritchard 1980; Rice 2002a; Hornung and Pacas 2006). Numerous native Odonate adults have also been recorded within Vivid Dancer habitat (see Rice 2002a; Harris and Foster 2013).

Vivid Dancer larvae are likely eaten by fish, amphibians, and possibly waterfowl. Adults are prey to robber flies (Family Asilidae) (Johnson 2013), dragonflies, spiders, amphibians, and birds.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Most Vivid Dancer observations have been opportunistic and data collected during general Odonata surveys where presence, relative abundance, survey duration (e.g., person-hours) or area (e.g., number of metres of stream) is recorded. These surveys are not comparative. Because adult activity is partially dependent on weather and adults typically disperse in the surrounding forest, counts at breeding pools likely underestimate abundance and repeated null surveys are required to confirm the absence of Vivid Dancers from a site. See Appendix 1 for Vivid Dancer records in Canada.

The only Vivid Dancer population study was completed at a site in the Banff thermal springs (see Hornung and Pacas 2006) and used a combination of mark-recapture, larval surveys, and visual observations to estimate the population size (see **Abundance**). Kortello and Ham (2010) also used similar methods to examine movement and habitat selection at Banff.

Abundance

Vivid Dancer population studies at Middle Springs and the Cave & Basin Springs; Banff (see Hornung and Pacas 2006) marked 549 and recaptured 35 adults from July 6 to August 17, 2003. The adult subpopulations at these sites were estimated at 3612 for Middle Springs and 1535 for the Cave & Basin Springs. Higher numbers (catch per unit effort) of Vivid Dancer larvae were also detected at Middle Springs compared to the Cave & Basin Springs (Hornung and Pacas 2006). A subsequent mark-recapture study in 2005 captured 1473 adult Vivid Dancers over 15 days of sampling in July-August at the Cave & Basin Springs and Middle Springs, with an estimated total population of 1936 to 18,780 adults (Ham and Kortello 2005).

Numerous Vivid Dancer exuviae were collected from Middle Spring Bog (Banff), indicating this as a breeding site in addition to Cave & Basin Springs and Middle Springs (Hornung and Pacas 2006). The population of Vivid Dancer at Banff is thought to be much larger than those estimated for BC sites (Cannings pers. comm. 2013).

Fluctuations and Trends

Site populations and trends are unknown for all Vivid Dancer sites. Most survey data are not comparable among years or sites due to differences in survey methods and differences in the cumulative impacts from commercial development and recreational use.

Rescue Effect

Rescue from Vivid Dancer populations in the United States is unlikely given the species' limited dispersal ability. The nearest Vivid Dancer sites to the Okanagan Valley (BC) are in the Okanogan or Pend Oreille counties in Washington State, at least 105 km south of the known occurrence at White Lake. The northernmost Vivid Dancer site south of the Kootenay region is in Idaho, approximately 250 km from the Canadian border (Romin pers. comm. 2014).

THREATS AND LIMITING FACTORS

The International Union for Conservation of Nature-Conservation Measures Partnership (2006) (IUCN-CMP) threats calculator was used to classify and list threats to Vivid Dancer (Salafsky *et al.* 2008; Master *et al.* 2009). The overall Threat Impact is Medium (Table 3).

Table 3. Threat classification for Vivid Dancer in Canada. The threat classification below is based on the IUCN-CMP (World Conservation Union–Conservation Measures Partnership) unified threats classification system (see Master *et al.* 2009).

Species Name	Vivid Dancer, *Argia vivida*			
Date	April 2, 2014.			
Assessor(s):	Rob Foster (report author), Allan Harris (report author), Jennifer Heron (Arthropods SSC Co-chair), Dwayne Lepitzki (Alberta), Angele Cyr (COSEWIC Secretariat), Syd Cannings (Canadian Wildlife Service), Rob Cannings (Royal BC Museum), Patrick Nantel (Parks Canada) Dave Fraser (BC Ministry of Environment) , Leah Ramsay (BC Conservation Data Centre), Mark Taylor (Parks Canada)			
			Level 1 Threat Impact Counts	
	Threat Impact		**high range**	**low range**
	A	Very High		
	B	High		
	C	Medium	5	5
	D	Low		
Calculated Overall Threat Impact:			Medium	

Threat		**Impact (calculated)**		**Scope (next 10 Yrs)**	**Severity (10 Yrs or 3 Gen.)**	**Timing**	**Comments**
1	Residential & commercial development	D	Low	Small (1-10%)	Extreme - Serious (31-100%)	High (Continuing)	
1.1	Housing & urban areas	D	Low	Small (1-10%)	Extreme - Serious (31-100%)	High (Continuing)	Six sites potentially impacted.
1.2	Commercial & industrial areas		Negligible	Negligible (<1%)	Extreme - Serious (31-100%)	High (Continuing)	Seven sites potentially impacted.
1.3	Tourism & recreation areas	D	Low	Small (1-10%)	Extreme - Serious (31-100%)	Moderate (Possibly in the short term, < 10 yrs)	Six sites. Much development ongoing at places already developed, including boardwalks at Banff, expansion at other areas.
2	Agriculture & aquaculture	D	Low	Restricted - Small (1-30%)	Moderate - Slight (1-30%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
2.1	Annual & perennial non-timber crops						Not applicable. No threats from vineyard or agricultural development.
2.2	Wood & pulp plantations						Not applicable.
2.3	Livestock farming & ranching	D	Low	Restricted - Small (1-30%)	Moderate - Slight (1-30%)	High (Continuing)	Three sites. Cattle and horse ranching impact sites in the Okanagan Valley, with Kearns Creek, Okanagan Falls, and other sites potentially impacted (Cannings and Cannings 1998, Cannings 2002). Watering of livestock in cool springs and associated streams tramples riparian vegetation and increases sedimentation and nutrient inputs from dung, and reduce habitat suitability for Vivid Dancer.
2.4	Marine & freshwater aquaculture						Not applicable.
3	Energy production & mining		Unknown	Small (1-10%)	Unknown	Moderate (Possibly in the short term, < 10 yrs)	
3.1	Oil & gas drilling						Not applicable.
3.2	Mining & quarrying						Not applicable.
3.3	Renewable energy		Unknown	Small (1-10%)	Unknown	Moderate (Possibly in the short term, < 10 yrs)	One site. Proposed geothermal power development near South Meager Creek.
4	Transportation & service corridors	D	Low	Small (1-10%)	Slight (1-10%)	Moderate (Possibly in the short term, < 10 yrs)	
4.1	Roads & railroads	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	Four sites. Road building is a possible threat at Okanagan Falls (Skaha Lake areas). Road kill may be a secondary threat at sites near busy roads (e.g., Banff, Fairmont). Two on east side of Skaha Creek, up on Mount Kobau is right beside a road; these sites are next to roads. Kearns creek is not threatened by road development. Road kill is happening now so it's high.
4.2	Utility & service lines						Not applicable.
4.3	Shipping lanes						Not applicable.
4.4	Flight paths						Not applicable.
5	Biological resource use		Unknown	Small (1-10%)	Unknown	Moderate (Possibly in the short term, < 10 yrs)	
5.1	Hunting & collecting terrestrial animals						Not applicable.
5.2	Gathering terrestrial plants						Not applicable.
5.3	Logging & wood harvesting		Unknown	Small (1-10%)	Unknown	Moderate (Possibly in the short term, < 10 yrs)	One site.
5.4	Fishing & harvesting aquatic resources						Not applicable.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
6	Human intrusions & disturbance	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)	
6.1	Recreational activities	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)	Applicable at 16 sites. Recreational users alter thermal springs sites by diverting water, creating pools and continued use of thermal springs for bathing.
6.2	War, civil unrest & military exercises						Not applicable.
6.3	Work & other activities		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	Ongoing research at Banff Springs; access to these sites requires permits though so this is not likely a high impact.
7	Natural system modifications	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	
7.1	Fire & fire suppression		Negligible	Small (1-10%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs)	Thinning activities at Banff Springs park
7.2	Dams & water management/use	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	Four sites. Four different springs at Cave basin in Banff, some flow into pipes, into valves and get clogged up and in the past some of the outflow streams, some go dry and the water comes back, nymph dries out some years,
7.3	Other ecosystem modifications						Unknown impacts. Invasive fish eat the damselfly larvae and they can modify the habitat too.
8	Invasive & other problematic species & genes		Unknown	Small (1-10%)	Unknown	High (Continuing)	
8.1	Invasive non-native/alien species		Unknown	Small (1-10%)	Unknown	High (Continuing)	Overall unknown impacts. People potentially putting fish in some habitats.
8.2	Problematic native species		Unknown	Small (1-10%)	Unknown	High (Continuing)	High numbers of elk have happened at Madeline Lake (Max lake is the local name), this site may have been grown over from natural vegetation succession. This is unknown. Unclear about original habitat before the human modifications took place.
8.3	Introduced genetic material						Not applicable.
9	Pollution		Unknown	Restricted (11-30%)	Unknown	High (Continuing)	
9.1	Household sewage & urban waste water		Unknown	Restricted (11-30%)	Unknown	High (Continuing)	Swimming is restricted in the Banff springs areas; salt not using next to the basin and not used in the boardwalks over these outflow streams; salt is used in access roads and then taking over outflow streams. Unknown of how this impacts water quality.
9.2	Industrial & military effluents		Unknown	Small (1-10%)	Unknown	High (Continuing)	Chlorinated water at the upper springs in Banff - if we had consistent water supply.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
9.3	Agricultural & forestry effluents		Unknown	Small (1-10%)	Unknown	High (Continuing)	Two sites. Chemical leaching from surface water runoff (e.g., fertilizers and pesticides from lawns, oil and sediments from roads) is a potential threat at developed sites (e.g., Fairmont Hot Springs). Recreational infrastructure is the potential source of the chemical (boardwalk board walk leaching). Site in southern Okanagan likely affected, the Skaha Lake ones may be impacted (northern one at the very least), from above and a ways off, it would be more from oil and road scum, the sites in Summerland (Crescent beach one), coming from Orchards, not sure about ones in Fraser Canyon.
9.4	Garbage & solid waste						Not applicable.
9.5	Air-borne pollutants						Not applicable.
9.6	Excess energy						Not applicable.
10	Geological events		Negligible	Negligible (<1%)	Moderate (11-30%)	High (Continuing)	
10.1	Volcanoes						Not applicable.
10.2	Earthquakes/tsunamis		Unknown	Unknown	Unknown	Moderate (Possibly in the short term, < 10 yrs)	Earthquakes cause water to stop flowing, Seismic activity can affect spring groundwater sources. Although fault activity is not easily predictable, a seismic shift that reduces or stops groundwater flows at a spring could cause local extirpation of Vivid Dancer sites.
10.3	Avalanches/landslides		Unknown	Unknown	Unknown	Moderate (Possibly in the short term, < 10 yrs)	Three sites. Thermal springs are small-scale ecosystems with rare microclimatic conditions dependent on local geothermal activity (COSEWIC 2008). Landslides bury springs and pools, as occurred at Ram Valley in 2011, although the population has persisted at that site (Harris pers. obs. 2013; Foster pers. obs. 2013).
11	Climate change & severe weather		Unknown	Small (1-10%)	Unknown	High (Continuing)	
11.1	Habitat shifting & alteration						Not applicable.
11.2	Droughts		Unknown	Small (1-10%)	Unknown	High (Continuing)	Two examples in Banff of a spring drying and then the population coming back in the next ten years.
11.3	Temperature extremes						Not applicable.
11.4	Storms & flooding		Unknown	Small (1-10%)	Unknown	High (Continuing)	Flooding can adversely affect populations, although impacts are unknown.

Residential and Commercial Development (1.)

Housing and urban areas (1.1)

BC: Land pressures may threaten sites (including undocumented cool springs) in the Okanagan Valley, as remaining natural habitats in the southern Okanagan Valley are under increasing threat from urban growth and agriculture (Bezener *et al.* 2004; COSEWIC 2012). This threat does not apply to other thermal springs in BC.

AB: Residential development threatened habitat quality at Middle Springs Bog in Banff, AB (Marsh 1974; Hornung and Pacas 2006) but a comparison of GoogleEarth imagery from 2001 and 2009 showed no change in residential development near the bog. The area is part of the Middle Springs Wildlife Closure, a 500 m-wide band of forest above the Middle Springs housing development that is legally closed to people to protect part of the Sulphur Mountain wildlife corridor (Parks Canada 2015).

Commercial and industrial areas (1.2)

Commercial development has altered habitat at Albert Canyon, Fairmont, Halcyon, Nakusp, and Banff (Upper Hot Springs, Cave & Basin Springs) and may have eliminated a historical population at Radium springs (Cannings 2002). Vivid Dancer appears to coexist with commercial (e.g., hotel and bathing facilities) development if thermal spring sources, free-running outflow streams and adjacent forest is retained (Cannings *et al.* 2000).

BC: At Fairmont there is a commercial development (Figure 6), but at the spring source, mossy pools and free-running streams have been retained and Vivid Dancers continue to breed (Cannings pers. comm. 2011).

Figure 6. Outflow from tufa mound at Fairmont Hot Springs where three adult Vivid Dancers were observed on July 21, 2013. Looking upstream (east) to Indian Wells. Photograph by Rob Foster.

The outflow at Albert Canyon has also been diverted, but damselflies are present where the stream is still flowing through mossy areas (Cannings pers. comm. 2011).

Diversion of water for the bathing facilities at Nakusp and Fairmont likely has an impact on habitat quality at these sites (Foster pers. obs. 2013).

AB: Rice (2001) initially noted minimal immediate threats to Banff Vivid Dancer sites; however, more recent habitat destruction from water diversion and urban development has occurred (Hornung and Pacas 2006; Lepitzki and Pacas 2010).

The replacement of a rubber pool liner at Cave & Basin NHS breeding habitat (Lepitzki and Lepitzki unpubl. data 1996-2014) has been planned for many years (Olson and Olson 2003), but the design has yet to be finalized. Construction associated with the pool liner replacement could also affect outflow streams below the buildings at the Cave and Basin NHS because water from the Upper and Lower Cave & Basin Springs, including from the lined pool, flows through a series of pipes and exits into Vivid Dancer habitat.

Agriculture and Aquaculture (2)

Livestock farming and ranching (2.3)

BC: Cattle and horse ranching affect sites in the Okanagan Valley, with Kearns Creek, Okanagan Falls, and other sites potentially impacted (Cannings and Cannings 1998; Cannings 2002). Watering of livestock in cool springs and associated streams tramples riparian vegetation and increases sedimentation and nutrient inputs from dung and urine. This is thought to reduce habitat suitability for Vivid Dancer, but impacts have not been directly demonstrated and Vivid Dancers appear to be persisting at the heavily trampled Kearn’s Creek site. This threat could potentially affect numerous undocumented sites at cool springs in the Okanagan Valley, Lytton, and elsewhere.

Nutrient inputs from watering livestock are a secondary threat for some Vivid Dancer sites in BC.

AB: Horse excrement from trails near the Cave and Basin NHS and Middle Springs Bog at Banff could potentially affect water quality.

Energy production and mining (3)

Renewable energy (3.3)

BC: Proposed geothermal power development near South Meager Creek threatens this site. Ram Power has an operating demonstration plant there, the first of its kind in Canada (CanGEO 2013; EnergyBC 2013). The impacts on the hydrogeology of Meager Creek and Vivid Dancer sites are unknown, but altered spring water discharge could threaten Vivid Dancer sites.

Transportation and Service Corridors (4)

Roads and railroads (4.1)

BC: Road building is a primary threat at Okanagan Falls (Cannings pers. comm. 2011). Road kill may be a secondary threat at sites near Fairmont, and on the east side of Skaha Lake in the Okanagan, but overall impacts are negligible.

AB: Road kill may be a secondary threat near busy roads through Banff, but overall effects are negligible.

Biological Resource Use (5)

Logging and wood harvesting (5.1)

BC: Clearcut logging threatens a small number of crown land sites. Wilson Lake thermal springs have been severely degraded by mechanical damage and siltation from logging equipment (Salter 2003; Salter pers. comm. 2014). Both Kearns Creek and Okanagan Falls are threatened by logging, forestry thinning, and road building (Cannings pers. comm. 2011). Partial cuts for pre-commercial thinning do not appear to threaten Vivid Dancer: adults often bask on open ground or low vegetation (see *7.1 Fire and fire suppression*).

Human Intrusions and Disturbance (6)

Recreational activities (6.1)

BC: Modification of natural thermal springs by bathers is a primary threat at all sites: removing native riparian vegetation, moving rocks, adjusting flows to achieve desired bathing temperatures, and lining pools with plastic, wood, or concrete structures, contribute to habitat degradation (Figure 8). At Ram Creek, bathers rebuilt pools by lining them with plastic after a recent landslide, altering the substrate and vegetation (Foster and Harris pers. obs. 2013) (Figure 9). These changes could damage habitat for Vivid Dancer larvae, particularly during sensitive winter months or low water periods. Preferred bathing temperatures are higher than tolerated by larval Vivid Dancers and aquatic vegetation is required for oviposition sites and cover.

Figure 7. Lower Cave & Basin Springs (Billy's Pond), Cave and Basin National Historic Site, Banff, AB July 19, 2013. This is the pool with the rubber liner to be replaced. Photograph by Rob Foster.

Figure 8. Wild Horse Warm Springs, July 22, 2013 looking west (downstream) from pool made by recreational users. Photograph by Rob Foster.

Figure 9. Ram Hot Springs, July 22, 2013, looking east. Photograph by Rob Foster.

Backcountry thermal springs are well publicized in several detailed field guides (e.g., McDonald 1981; Litton 2005; Woodsworth 2009) and numerous websites, and cumulative recreational use, although much less frequent than accessible sites, impacts habitat.

Cool springs such as those in the Okanagan Valley are less likely to be impacted by recreational use.

AB: Banff sites receive thousands of visitors during the summer months (Hornung and Pacas 2006), with the Cave and Basin NHS receiving more than 100,000 annual visitors (Parks Canada 2007) with future plans to triple annual visitation to Cave and Basin NHS by 2013-2014 (Parks Canada 2010).

Vivid Dancer adults perched on boardwalks (Figure 7) risk trampling by visitors (as observed by Lepitzki and Lepitzki unpubl. data 1996-2014) and frequent human disturbance could affect courtship behaviour and oviposition. Despite boardwalks, barrier fencing and signage, human and dog footprints are associated with trampled riparian vegetation along the outlet streams and pools at Banff (Lepitzki and Pacas 2010). A heavily used horse trail also bisects the outflow streams at the Cave and Basin NHS.

Swimming is not permitted at Banff Springs Snail sites and is prevented by surveillance, fencing and signage (Lepitzki and Pacas 2010). Despite these efforts, illegal swimming continues and could potentially impact co-occurring Vivid Dancers.

Natural System Modification (9)

<u>Fire and fire suppression (9.1)</u>

AB: Selective harvest, thinning and partial cuts to reduce fuel loads at Banff do not appear to have impacted sites (see Kortello and Ham 2010). In order to maintain Vivid Dancer breeding habitat quality during fuel reduction in Banff, treatments recommended a mosaic of small (i.e., <50 m across), cleared areas be interspersed with intact forest rather than a uniformly thinned forest (Kortello and Ham 2010)

Invasive and Other Problematic Species and Genes (8)

<u>Invasive non-native/alien species (8.1)</u>

BC and AB: In California, the non-native wasp *Polistes dominula* (Hymenoptera: Vespidae) has been observed preying upon a Vivid Dancer (Macmillan 2007) and this species is becoming more widespread in BC and potentially AB (Copley pers. comm. 2014).

Rainbow Trout (*Oncorhynchus mykiss*) and Brook Trout (*Salvelinus fontinalis*) have been widely introduced in Vivid Dancer's range in Canada (Scott and Crossman 1973), including Rosebud Lake and possibly Albert Canyon. Their impacts on Vivid Dancers are unknown but, as with other non-native fish species, introduced trout could predate directly upon Vivid Dancer larvae or compete with them for invertebrate prey.

AB: In 1924, Western Mosquitofish (*Gambusia affinis*) were introduced at Banff Cave & Basin Springs to control mosquito populations. Sailfin Molly (*Poecilia latipinna*), Green Swordtail (*Xiphophorus helleri*), Convict Cichlid (*Cichlasoma nigrofasciatum*), African Jewelfish (*Hemichromis bimaculatus*) and Freshwater Angelfish (*Pterophyllum scalare*) have been introduced by aquarists (Acorn 2004), although only the mollies and jewelfish persist (Parks Canada 2014). These non-native fish contributed to the extinction of the endemic Banff Longnose Dace (Lanteigne 1987) and are abundant in Billy's Pond at the Lower Cave & Basin Springs (Foster pers. obs. 2013; Harris pers. obs. 2013), in all the outflow streams at the Cave and Basin NHS and in the Cave & Basin Marsh (Lepitzki pers. obs.). Significantly higher Vivid Dancer larvae numbers occur in the Middle Springs (no non-native fish present) than at the Cave & Basin Springs where non-native fish are present (Rice 2002a; Hornung and Pacas 2006).

Pollution (9)

Household sewage and urban waste water (9.1)

BC and AB: Shampoos, soaps, suntan products, deodorants and insect repellents from bathers may threaten flora and fauna (Kroeger 1988; Lee and Ackerman 1999; Lepitzki and Pacas 2010; COSEWIC 2008). Significant alterations in water chemistry have been detected at Banff thermal springs following swimming events (Lepitzki 1998, 1999) and swimming can alter water clarity and water levels. The cumulative impacts on Vivid Dancers or their prey in outlet streams are unknown, however. Elsewhere in its global range, Vivid Dancer has been observed in flowing irrigation canals (Paulson 2009) so the species may be tolerant of some altered water quality.

Industrial and military effluents (9.2)

BC: Chlorine is used at commercial hot springs (e.g., Fairmont) but impacts on Vivid Dancers have not been documented (at least some habitat at Fairmont is above commercial outflows).

Runoff from roadways has the potential to affect Vivid Dancer habitat at Halcyon Hot Springs as well.

AB: Chlorine pollution from the historical bathhouse at the Cave & Basin Springs at Banff was partially responsible for the extinction of the Banff Longnose Dace (Lanteigne 1987; Schindler 2000). Vivid Dancer subpopulations in the marsh may have been impacted from chlorine pollution in the past, but this source of water pollution at the Cave and Basin NHS has ceased for over a decade (it is no longer used as a commercial hot spring), and unlike the dace, there were adjacent sites to serve as a source for recolonization. Chlorine is used at other sites in Banff.

The use of chemical de-icers along the Basin Spring pool boardwalk stopped in about 1999 (Lepitzki and Pacas 2010). Salt is still used for de-icing along Banff roadways, including the roads whose runoff flows into the Middle Springs Bog and Vermilion Cool Springs, but the effects on Vivid Dancers are undocumented.

Agricultural and forestry effluents (9.3)

BC: Chemical leaching from surface water runoff (e.g., fertilizers and pesticides from lawns, oil and sediments from roads) is a potential threat at developed sites (e.g., Fairmont Hot Springs). Sites in the southern Okanagan (e.g., near Skaha Lake, Summerland) are likely affected from oily or otherwise contaminated runoff from upstream although direct impacts on Vivid Dancers or their prey have not been observed.

Geological Events (10)

Earthquakes and tsunamis and 10.3 Avalanches and landslides (10.2)

BC: Thermal springs are small-scale ecosystems with rare microclimatic conditions dependent on local geothermal activity (COSEWIC 2008). Geological events such as avalanches, landslides, and earthquakes threaten many Vivid Dancer sites. Landslides bury springs and pools, as occurred at Ram Valley in 2011, although the species has persisted at that site (Foster and Harris pers. obs. 2013). The Meager Creek area is very active geologically and in 2010 experienced the largest recorded landslide in Canadian history at over 48,000,000 m^3 (Guthrie *et al*. 2012); fortunately, the landslide did not affect Vivid Dancer site. Seismic activity can affect spring groundwater sources. Although fault activity is not easily predictable, a seismic shift that reduces or stops groundwater flows at a spring could cause local extirpation of Vivid Dancer sites.

Climate Change and Severe Weather (11)

Droughts (11.2)

The thermal spring hydrogeology of Canadian Vivid Dancer sites is based on meteoric water circulating to depth, being heated, and then flowing back to the surface (Grasby and Hutcheon 2001). Climate change, particularly an increase in the frequency and intensity of extreme droughts, decreased precipitation and increased mean annual temperatures, is a potential threat to the water supply dynamics of thermal springs.

AB: There are five examples in Banff of springs drying then Vivid Dancers reusing the habitat once flows resumed (Upper Hot, Kidney, Upper Middle, Middle West Cave, Gord’s Spring) (Lepitzki and Lepitzki unpubl. data 1996-2014) so recolonization is possible if there are adjacent unaffected subpopulations.

Extremely low precipitation years may be the cause for the recent reduced flows at some Banff thermal springs (Grasby and Lepitzki 2002) and continued flow anomalies may be expected due to climate change (Scott and Suffling 2000). Flow rates typically decrease during late winter and early spring as underground reservoirs are depleted of water (Van Everdingen 1970, 1972; Grasby and Lepitzki 2002), but there is evidence that flow stoppages are increasing. The Upper Hot Spring ceased flowing every winter from 1998 through to 2005 and flow stoppages have also been recently documented from Kidney, Upper Middle, and Gord’s springs (Grasby and Lepitzki 2002; Lepitzki and Pacas 2010 and references therein). Since 1996, the Upper Hot Spring has ceased to flow in 14 of 19 years (COSEWIC 2008; Lepitzki and Lepitzki unpubl. data 1996-2014). Prior to 1998, the Upper Hot Spring is known to have run dry only once, in 1923 (Elworthy 1926; Warren 1927), and it was the only thermal spring in Banff that was known to have dried. The increased frequency of drying and addition of used public bathing facility water contaminated with chlorine and diatomaceous earth suggest that the Upper Hot Spring could be more of a sink than source of Vivid Dancers. As thermal spring drying typically occurs over winter, the aquatic larvae that will produce the next generation of adult Vivid Dancers are the life stage that is affected.

Number of Locations

There are 22 locations[1] for Vivid Dancer in Canada (Appendix 1). Springs were grouped into locations based on proximity and vulnerability to stochastic events such as droughts, seismic activity, and landslides.

The Sulphur Mountain thermal springs at Banff share similar geology and human use threats and is considered one location, with the more distant and undeveloped Forty Mile Creek site considered a separate location. The Okanagan springs are threatened primarily by livestock grazing (e.g., cattle congregate at springs) and development. The Albert Canyon, Fairmont, Nakusp, and Halcyon sites were each assigned to a separate location based on threats of potential habitat changes caused by commercial hot spring operations. The remaining sites were assigned to locations based on a combination of less well-defined threats including recreational use.

Limiting Factors

Suitable thermal spring habitat limits Vivid Dancer in Canada. At lower elevations, cool springs and adjacent streams appear to be suitable habitat for Vivid Dancers. However, these habitats are also within regions of BC that have the highest recorded ambient summer temperatures, and these springs are overall uncommon and within valley bottoms with high development pressure. Relatively poor dispersal ability of adults may also be a limiting factor.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

The federal *National Parks Act* protects Vivid Dancer individuals in Banff National Park. There are no additional federal or provincial laws that protect the species.

Non-Legal Status and Ranks

Global status rank:	G5 (Secure) (Natureserve 2013)
Canada national status rank:	N2 (Imperilled) (Natureserve 2013)
BC subnational rank:	S2 (Red-listed; Imperilled) (British Columbia Conservation Data Centre 2014)
Alberta subnational rank:	S1 (Critically Imperilled) (NatureServe 2013)

[1] In the context of COSEWIC status reports, the term ‘location’ defines a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of the taxon present. The size of the location depends on the area covered by the threatening event and may include part of one or many subpopulations.

US national rank:	N5 (Secure).
Washington, Utah and Colorado subnational rank:	S5 (Secure)
Montana subnational rank:	S4 (Apparently Secure)
All other states with confirmed occurrence records:	Status not ranked (SNR) (NatureServe 2013).

Habitat Protection and Ownership

Vivid Dancer occurs on a variety of land tenures (Table 1).

Federal ownership:

Vivid Dancer sites within Banff National Park are protected under the federal *National Parks Act*. Several sites are also within the Cave and Basin NHS, which are managed to preserve commemorative integrity (Parks Canada 1998, 2007) in accordance with the Management Plan of the site and Commemorative Integrity Statement (Lepitzki and Pacas 2010). Some sections of Cave & Basin springs, Middle Springs, and the entire Kidney Spring are identified as critical habitat for Banff Springs Snail (Lepitzki and Pacas 2010) under the federal *Species at Risk Act* and indirectly protect co-occurring Vivid Dancer habitat. For example, the Sulphur Mountain Wildlife Corridor (Upper and Lower Middle, West Cave, and Gord's Spring) has been established, permanently closed to unauthorized persons and enforced through regular patrols and electronic surveillance. Illegal swimming at the Basin Spring pool and Cave Spring pool has been reduced through signage, fencing, installation of a security system, and prosecution of trespassers.

At Fairmont Hot Springs, critical habitat identified under SARA for Southern Maidenhair Fern may provide protection for Vivid Dancer habitat located downstream of the access road as well.

There is little or no habitat protection at other Vivid Dancer sites. Even in provincial protected areas there is little monitoring or active management of spring habitats. For example, even though Ram Creek hot springs are in an ecological reserve (British Columbia Ministry of Water, Land and Air Protection 2004), they have been heavily modified by bathers without respect for potential damage to red-listed Vivid Dancer habitat (Salter 2003).

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BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Robert Foster is co-founder and principal of Northern Bioscience, an ecological consulting firm offering professional consulting services supporting ecosystem management, planning, and research. Dr. Foster has a B.Sc. in Biology from Lakehead University and a D. Phil in Zoology from the University of Oxford. Rob has worked as an ecologist in Ontario for over 20 years, and has authored or coauthored COSEWIC status reports on the Riverine Clubtail, Laura's Clubtail, Rapids Clubtail, Gibson's Big Sand Tiger Beetle, Northern Barrens Tiger Beetle, Powesheik Skipperling, Mormon Metalmark, Weidemeyer's Admiral, Bogbean Buckmoth, Hop-tree Borer, Georgia Basin Bog Spider, Broad-banded Forestsnail, Nahanni Aster, Crooked-stem Aster, Bluehearts, and Drooping Trillium, as well as recovery plans for rare plants, lichens, and odonates. Rob has conducted numerous odonate surveys for protected areas planning and environmental assessments in Ontario, as well as Manitoba, Minnesota, Quebec, and British Columbia.

Allan Harris is a biologist with over 25 years' experience in northern Ontario. He has a B.Sc. in Wildlife Biology from the University of Guelph and an M.Sc. in Biology from Lakehead University. After spending seven years as a biologist with the Ontario Ministry of Natural Resources, he co-founded Northern Bioscience, an ecological consulting company based in Thunder Bay, Ontario. Al has authored or coauthored dozens of scientific papers, technical reports, and popular articles, including COSEWIC status reports for Riverine Clubtail, Laura's Clubtail, Rapids Clubtail, Gibson's Big Sand Tiger Beetle, Northern Barrens Tiger Beetle, Powesheik Skipperling, Mormon Metalmark, Weidemeyer's Admiral, Bogbean Buckmoth, Hop-tree Borer, Georgia Basin Bog Spider, Broad-banded Forestsnail, Nahanni Aster, Crooked-stem Aster, Bluehearts, Drooping Trillium and Small-flowered Lipocarpha. Al also authored the Ontario provincial status report for woodland caribou, and has authored or coauthored national and provincial recovery strategies for vascular plants and birds.

COLLECTIONS EXAMINED

The following collections were examined for Canadian Vivid Dancer specimens:

Canadian National Collection of Insects, Arachnids and Nematodes, Ottawa, ON (O. Lonsdale)

E.H. Strickland Entomological Museum, University of Alberta, Edmonton, AB (online search)

Wallis Roughley Museum of Entomology, University of Manitoba, Winnipeg, MB. (B. Sharanowski)

Museum of Zoology, University of Calgary (J. Swann)

Royal Alberta Museum, Edmonton, AB. (M. Buck)

Royal British Columbia Museum, Victoria, BC. (online search)

Royal Saskatchewan Museum, Regina, SK. (C. Sheffield)

Spencer Entomological Collection, Beaty Biodiversity Museum, University of British Columbia, Vancouver BC (K. Needham)

Appendix 1. Documented Vivid Dancer observations at Canadian sites and locations[1].

Location[2]	Site	Date	Observers	Vivid Dancer Numbers[3]	Source
1	Banff, ("swamp off Hot Springs Road")	1908-06-21	N.D. Sanson	1 teneral male	Walker 1912
	Banff, Cave and Basin NHS Springs (and associated outflows)	1979-08-01 & 1979-08-16	G.E. Pritchard	6 adult	Swann, pers. comm. 2014
		1979-12-01	G.E. Pritchard		
		1979-12-01	G.E. Pritchard	1 imm.	BC CDC 2014
		1980-07-02	R.A. Cannings	1 adult	BC CDC 2014
		1980-07-02	G.E. Pritchard	2F adult	Swann pers. comm. 2014
		1981-06-25	G.E. Pritchard	1f, 1M in copulo	Swann pers. comm. 2014
		1982-07-30	G.E. Pritchard	1F, 1M, 12U adult	Swann pers. comm. 2014
		1982-08-30	G.E. Pritchard	1F, 1M adult	Swann pers. comm. 2014
		1985-07-17	G.E. Pritchard	2f, 3M adult	Swann pers. comm. 2014
		1985-07-26 & 1985-07-27	G.E. Pritchard	1F, 1 M adult	Swann pers. comm. 2014
		2013-07-19	A.G. Harris, R.F. Foster	4 adults	Harris pers. obs. 2013; Foster pers. obs. 2013
		2003-06-06 to 2003-08-17	C.L.R. Hornung and C. Pacas	1535 estimated total adults for 3 sampling sites	Hornung and Pacas 2006
	Cave & Basin Springs and Middle Springs	15 days of sampling in July-August, 2005	Ham and Kortello	mark-recapture study captured 1473 adults and estimated total population of 1936 to 18,780 adults	Ham and Kortello 2005
	Banff, Middle Springs (Lower and Upper)	2003-06-06 to 2003-08-17	C.L.R. Hornung and C. Pacas	3612 estimated total adults for 3 sampling sites	C.L.R. Hornung and C. Pacas
	Banff, Middle Springs (Gord's Spring and West Cave)	1996-2014 (exact years unknown)	D. Lepitzki	larvae and adults	Lepitzki pers. comm. 2014
	Banff, Middle Springs Bog	2003	C.L.R. Hornung and C. Pacas	exuviae collected	Hornung and Pacas 2006
	Banff, above Middle Springs (Alpine Hut)	2002	D. Lepitzki	adult seen but no evidence of breeding	Rice 2002a,b
	Banff, Kidney Spring	July 2 - August 29 2002	C. Rice	3 adults	Rice 2002a,b
		1996-2014 (exact years unknown)	D. Lepitzki	larvae and adults, 1 teneral	Lepitzki pers. comm. 2014
	Banff, Upper Hot Spring	1996-2014 (exact years unknown)	D. Lepitzki	larvae and adults	Lepitzki pers. comm. 2014

Location[2]	Site	Date	Observers	Vivid Dancer Numbers[3]	Source
	Banff, Vermilion Cool Springs	2002	C. Rice	adult Vivid Dancers have been observed in tandem ovipositing, but no evidence of breeding	Rice 2002b
2	Banff, Forty Mile Creek	2002-09-02	C. Rice (det. D. Lepitzki)	2 exuviae; 3 adults unknown sex	Lepitzki pers. comm. 2014
		2006-07-28	D. Lepitzki	exuviae and adults	Lepitzki pers. comm. 2014
		2013-07-28	D. Lepitzki	exuviae and adults	Lepitzki pers. comm. 2014
3	Field	pre-1953	E.M. Walker	"locally abundant"	Walker 1953
4	Glacier	1902	R.C. Osburn	1 adult	Walker 1953
5	BX Creek, Vernon	2006	BC MOE	larvae, unknown #	Salter pers. comm. 2014
6	Albert Canyon	1981-07-03	G. Pritchard	7F, 3M adult	Swann pers. comm. 2014
		1983-06-16	G. Pritchard	4 adult	Swann pers. comm. 2014
		1983-08-24	G. Pritchard	30 adult	Swann pers. comm. 2014
		1983-08-22	R.A. Cannings	1F,1M adult	BC CDC 2014
		1998-07-30	S.G. Cannings	2F adult	Cannings1998
		28/07/1983	G. Pritchard & M. Leggott	436 larvae	J. Swann
		01/10/1983	G. Pritchard & M. Leggott	226 larvae	J. Swann
		25/04/1984	G. Pritchard& M. Leggott	750 larvae	J. Swann
		26/04/1985	G. Pritchard & M. Leggott	67 larvae	J. Swann
		26/05/1985	G. Pritchard & M. Leggott	50 larvae	J. Swann
		09/06/1985	G. Pritchard & M. Leggott	60 larvae	J. Swann
		11/10/1988	G. Pritchard & M. Leggott	40 larvae	J. Swann
		06/06/1989	G. Pritchard & M. Leggott	34 larvae	J. Swann
		2013-07-20	A.G. Harris, R.F. Foster	none observed	Harris pers. obs. 2013; Foster pers. obs. 2013
		1985-07-10 to 1985-07-25	K.F. Conrad, G. Pritchard	numerous males and females on multiple visits	Conrad and Pritchard 1989
7	Fairmont Hot Springs	1991	J. Zloty	very few individuals seen, not associated with larval habitat	BC CDC 2014
		2013-07-22	A.G .Harris, R.F. Foster	2F, 5M adult	Harris pers. obs. 2013; Foster pers. obs. 2013
8	Ram Creek Hot Springs	1989-07-01	J. Zlotys		BC MAWLP 2004
		1999-01-01	S.P. Salter	1 imm.	BC CDC 2014
		1999-06-19	D. Nicholson	1F,3M adult	BC CDC 2014
		2000-07-23	S.P. Salter	2 imm.	BC CDC 2014
		2013-07-22	A.G. Harris, R.F. Foster	5+ adults at pool, and 12 adults along road	Harris pers. obs. 2013; Foster pers. obs. 2013

Location[2]	Site	Date	Observers	Vivid Dancer Numbers[3]	Source
		2000 to 2002	S.P. Salter	up to a total of 222 larvae collected at 3 sites in one day (Salter 2003).	Salter 2003; BC CDC 2014
9	Wild Horse Hot Springs Springs	2000 to 2002	S.P. Salter	1-13 larvae at 2 sites during surveys on 3 dates in 2000 to 2002.	Salter 2003; BC CDC 2014
		2013-07-22	A.G. Harris, R.F. Foster	none observed	Harris pers. obs. 2013; Foster pers. obs. 2013
10	Little Sand Creek (Sand Lake)	1999-07-30	S.G. Cannings, L.R. Ramsay	approx. 20 observed on and around creek	BC CDC 2014
		1999-08-11	D. Nicholson	1F,1M adult	BC CDC 2014
		2013-07-21	A.G. Harris, R.F. Foster	none observed	Harris pers. obs. 2013; Foster pers. obs. 2013
11	Fort Steele	1981-07-05	R.A. Cannings	1F adult	BC CDC 2014
12	Rosebud Lake	1999-07-24	D.C.A. Blades, K.A. Sendall	1F adult	BC CDC 2014
		2013-07-21	A.G. Harris, R.F. Foster	none observed	Harris pers. obs. 2013; Foster pers. obs. 2013
13	Dewar Creek	2000-07-22 to 2001-08-15	S.P. Salter	15-30 nymphs at one site during 3 sampling dates; 0-1 nymphs at other site 35 m away	Salter 2003; BC CDC 2014
14	Little Wilson Lake (Wilson Creek; Fitzstubbs Cr.)	2013-07-20	A.G. Harris, R.F. Foster	none observed	Harris pers. obs. 2013; Foster pers. obs. 2013
		2000-07-24 to 2001-10-13	S.P. Salter	27-71 larvae at one site during 4 sampling dates; 15-76 larvae at other site 5 m away	Salter 2003; BC CDC 2014
15	Nakusp Hot Springs	1980-06-30	R.A. Cannings	1 imm.	BC CDC 2014
		2013-07-20	A.G. Harris, R.F. Foster	35 adults incl. 4 pairs in tandem	Harris pers. obs. 2013; Foster pers. obs. 2013
		1994-06	S.G. Cannings, L.R. Ramsay	males and females observed and collected	BC CDC 2014
16	Halcyon Hot Springs	25/04/1984	G. Pritchard & M. Leggott	116 larvae	Swann pers. comm. 2014
		25/06/1984	G. Pritchard & M. Leggott	100 larvae	Swann pers. comm. 2014
		25/04/1985	G. Pritchard & M. Leggott	32 larvae	Swann pers. comm. 2014
		1985-07-10 to 1985-07-25	K.F. Conrad, G. Pritchard	numerous males and females on multiple visits	Conrad and Pritchard 1989; Swann pers. comm. 2014
		1986 -06-10 to 1986 -08-13	K.F. Conrad, G. Pritchard, J. Zloty	10-30+ adults on six visits, including at least 22 tandem pairs on August 13	Conrad and Pritchard 1989; Swann pers. comm. 2014
17	Kearns Creek	1996-06-29	R.A. Cannings	1F adult	BC CDC 2014

Location[2]	Site	Date	Observers	Vivid Dancer Numbers[3]	Source
	(White Lake)	1997-07-15	G.E. Hutchings, R.J. Cannings	2F, 2M adult	BC CDC 2014
	Okanagan Lake (Penticton Yacht Club)	1997-07-04	G.E. Hutchings, R.J. Cannings	1F,3M adult	BC CDC 2014
	Summerland (Crescent Beach)	1997-07-09	G.E. Hutchings	1F adult	Cannings *et al.* 1998; BC CDC 2014
	Summerland (Kevin Brook / Monro Ave. marsh)	1997-07-09	G.E. Hutchings	2F,4M adult	Cannings *et al*. 1998; BC CDC 2014
	Summerland (Switchback Road)	2011-07-31	S.G. Cannings	<10 adults observed, some in tandem	S.G. Cannings pers. comm.
	Skaha Lake	1997-06-11	D. St.John, R.J. Cannings	1F, 4M adult	Cannings *et al.* 1998; BC CDC 2014
	Madeline Lake (Mac's Lake)	1983-08-24	R.A. Cannings	2F,4M adult	BC CDC 2014
		1997-08-16	D. St. John	3M adult	Cannings *et al.* 1998; BC CDC 2014
18	Chopaka	1997-07-21	J. Terbasket, R.J. Cannings	1F teneral, 1M adult	BC CDC 2014
19	Richter Pass (Mount Kobau)	1991-07-11	D.C.A. Blades, C.W. Maier	1M adult	BC CDC 2014
20	Lytton, 2 km south of	2007-06-29	D. Knopp, J. Osterhold	2F,15M adult	BC CDC 2014
	Lytton, 4.25 km north of	2007-06-29	D. Knopp	One mating pair and a second male	BC CDC 2014
	Lytton, 8.9 km north of	2007-07-14	D. Knopp	One teneral seen	BC CDC 2014
21	Boston Bar	2006-07-05	D. Knopp	12 adults, incl. 2 mating pairs	BC CDC 2014
22	Meager Creek	1988-07-19	C.S. Guppy, G.E. Hutchings, M.C.E. McNall	8F, 24M adult	BC CDC 2014
		1989-10-08	G.E. Hutchings	2F,2M adult	BC CDC 2014
	Pebble Creek (Lillooet River, Keyhole) Hot Spring	2000-04 to 2002-05-18	S.P. Salter	32-58 larvae at Site 1 and 57-69 larvae at Site 2 during surveys on 3 dates in 2000 to 2002.	Salter 2003; BC CDC 2014

[1] Note that this appendix does not include the multiple observations by Lepitzki and Lepitzki (unpublished data 1996-2014).

[2] In the context of COSEWIC status reports, the term 'location' defines a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of the taxon present. The size of the location depends on the area covered by the threatening event and may include part of one or many subpopulations. In this context, locations refer to sites that face similar threats as per the COSEWIC definition

[3] F=female, M=male, U=unknown sex