St. John's wort control in British Columbia by the *Chrysolina* beetles

Ministry of Forests, Lands, Natural Resource Operations and Rural Development
Range Branch
Invasive Plant Program
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Background

The perennial invasive plant St. John's wort (*Hypericum perforatum*) is wide-spread in British Columbia (B.C.). As of February 2020, 7587 sites have been recorded in the province over seven decades with an estimated total of 5028 hectares (50.28 km^2) infested. The recorded elevation range of the invasive plant is from sea level to 4020 m. St. John's wort was the first invasive plant involved in a biological control program in the province which began in the early 1950's (Table 1). Seven biocontrol agents have been released on this plant at a total of 174 sites. Of the seven, five agents have established at treatment sites and spread (130 total dispersal sites) to a variety of sites as per their habitat preferences. The agents believed to be most effective have been the two closely related *Chrysolina* species; *C. hyperici* and *C. quadrigemina* which were considered to have St. John's wort under control. However, within the last decade, St. John's wort has been observed to increase in density on the landscape and is potentially moving into areas the beetles do not favour. During casual observations of the plant at a variety of locations, very few *Chrysolina* beetles have been seen. There also appear to be sites which were previously under biological control but are recently resurging. A resurgence of the plant has been seen at some sites in the U.S.A. and there appears to be the same thoughts with respect to cooler shaded sites or higher elevations not experiencing successful biological control (Philip Weyl pers. comm. March 19, 2018). In addition, since 2013, B.C. has recently experienced some years of intensive summer wild fires. As St. John's wort reacts favourably to fire, there has been increased concern that the plant is no longer under biological control. Treatment with herbicide from 2000 to 2012 ranged from 2 to 25 sites annually. However, the focus on herbicide has increased and from 2013 to 2018 the number of sites treated with herbicide has incrementally increased from 65 to over 565 in a given year.

Table 1. St. John's wort biocontrol agents in B.C.

Biocontrol Agent	**First Released in B.C.**	**Number of Treatments****	**Number of Sites****	**Dispersal sites****
Agrilus hyperici	1955	10	10	11
Aphis chloris	1979	15	13	5
Aplocera plagiata	1967	12	12	27
Chrysolina hyperici	1951	35	34	4***
Chrysolina quadrigemina	1951	24	22	18***
Chrysolina spp.	1957	94	80	65
*Chrysolina varians**	1957	2	2	0
*Zeuxidiplosis giardia**	1955	1	1	0

*Not established

**As of January 2020

***Identification to species level is not accurate with the exception of initial dispersal records prior to the species intermingling.

Question

To initiate investigation into what is taking place with St. John's wort and the two *Chrysolina* beetle species, the question was asked:

- Are *C. hyperici* and *C. quadrigemina* beetles still present in B.C. and if so, where?

Action

In 2014, a handful of St. John's wort field sites where *Chrysolina* was originally released were visited every three to four weeks throughout the growing season to attempt collection of up to 100 beetles (Figure 1). These sites were chosen to determine if populations of beetles existed long-term on sites and if a significant change in the beetle populations had occurred (Table 2). The beetles were sent to Dr. Rob Bourchier at Agriculture and Agri-Food Canada (AAFC), Lethbridge where they were sorted into similar morphological types and a representative of each type were thereafter sent to the Chrysomelidae researcher Dr. Hume Douglas of AAFC for identification.

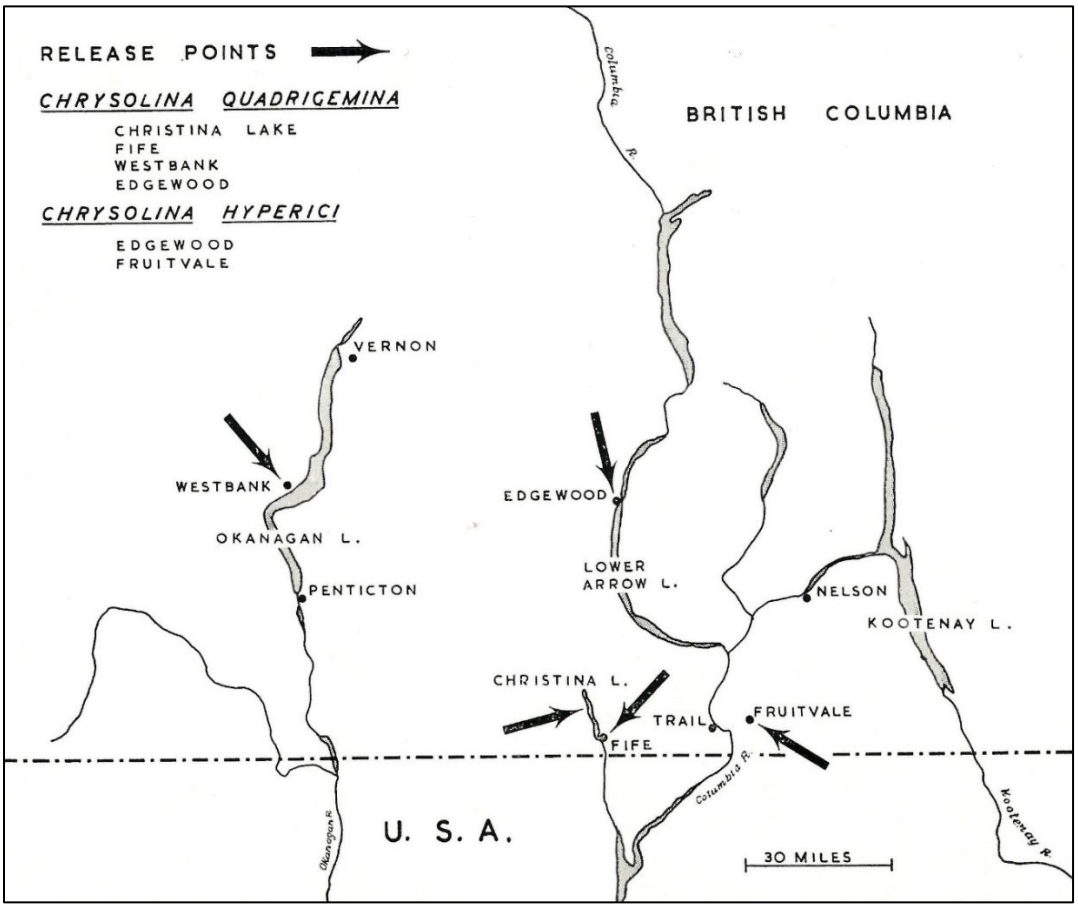


Figure 1. Original releases of *Chrysolina guadrigemina* and *Chrysolina hyperici* in B.C. (Harris 1962)

Table 2. *Chrysolina* species release sites

Site	Site Name	*Chrysolina* species released	Source	Treatment Date	BEC	Elevation (m)
296995	Edgewood	*C. hyperici* (19,000)	*C. hyperici* Britain stock via Australia and California, Enterprise, Oregon	June 21, 1952	ICHdw1	500 (iMap)
		C. quadrigemina (25,000)	*C. quadrigemina*: Webb, Idaho	June 7, 1952		
282878	Marsh Creek/HP Area N-11 Fruitvale	*C. hyperici* (200)	Unknown	May 30, 1951	ICH xw	550 (iMap)
296994	Fife, Christina Lake	*C. quadrigemina* (3,000)	Mediterranean France stock via Australia and California	May 24, 1952	ICH xw	730 (iMap)
246907	Cassidy	Unknown	Unknown	Between 2002 to 2004	CDFmm	31
299028, in immediate vicinity of Westbank historical release 101814	West Kelowna, Mt. Bourchiere Road.	*C. quadrigemina* (5000)	*C. quadrigemina* from Loftus California, via Australia	1951	PPxh1	365
		C. varians (250)	*C. varians* from Sweden	1957		
299027, in immediate vicinity of Westbank historical release 101814	West Kelowna, Grizzly Road.	As row above	As row above		PPxh1	411

Results

The results of the identification are summarized in Table 3. All identified beetles were males as their last abdominal segment is distinguishable between species (BugGuide 2011) while the distinguishing species features of females is only visible internally and would require dissection (H. Douglas pers. comm. November 2019). All site collections had mixed populations of *C. hyperici* and *C. quadrigemina* except Edgewood, Cassidy and Mt. Bourchiere. However, Edgewood and Cassidy contained a portion of female beetles that

could not be identified. As the two West Kelowna sites are close together, the *C. hyperici* beetles found at Grizzly Road likely also occupy the Mt. Bouchiere site. *C. hyperici* releases have been made approximately 50 km south of these sites since 2004 with beetles collected from the central Kootenays where most of the original releases of *Chrysolina* were made (Table 2). These two Kelowna sites are also close to the original site where *C. quadrigemina* and *C. varians* were released in the 1950's. *C. varians* has never been found established here nor anywhere else in B.C. to date. The suspected first release of *Chrysolina* beetles on Vancouver Island occurred between 2002 to 2004 at Cassidy. The beetles came from the Central Kootenays. Cassidy potentially could have a single species depending on the few releases put there, however, the source site is not known. For example, the Fife site has been an important source of subsequent collections, yet despite only having *C. quadrigemina* released there, both *Chrysolina* species are currently present (Table 3). Thereafter, an additional ten releases of *Chrysolina* were made on Vancouver Island in 2006, one of which came from the Cassidy site while nine came from other field sites near Rock Creek in the Central Kootenays. All 2006 Vancouver Island releases are listed as *C. quadrigemina*; however, it is likely the releases contained both *C. hyperici* and *C. quadrigemina* beetles.

Table 3. Morphological identification of B.C. *Chrysolina* beetles

	Action			**Result**			
Site Name	**Collection Dates**	**Number of Beetles Collected**	**Number Sorted for Identification**	**Number identified**	**Identification per Species**	**Colour**	**Size**
Edgewood 296995	June 12	100	10	*3*	*C. hyperici*	Green	Small
			10		Unknown - females		
	July 16	100	10	*3*	*C. hyperici*	Green& Bronze	Small
			10	*1*	*C. hyperici*	Bronze	Small
	August 6	4	4	*2*	*C. hyperici*	Bronze	Small

Table 3. Morphological identification of B.C. Chrysolina beetles continued

	Action			Result			
Site Name	**Collection Dates**	**Number of Beetles Collected**	**Number Sorted for Identification**	**Number identified**	**Identification per Species**	**Colour**	**Size**
Marsh Creek / Fruitvale 282878	June 11	100	10	*3*	*C. hyperici*	Green	Small
			10	*1*	*C. quadrigemina*	Green	Medium
			3	*1*	*C. quadrigemina*	Blue	Large
	July 14	100	10	*4*	*C. hyperici*	Green	Small
			10	*3*	*C. hyperici*	Bronze	Medium
			1		Unknown - females		
	August 7	100	10	*3*	*C. hyperici*	Green & Bronze	Small
			10	Unknown	*C. quadrigemina*	Bronze	Medium
			2	*1*	*C. quadrigemina*	Blue	Large
	Sept. 2	29	10	*4*	*C. hyperici*	Bronze	Small
			10	*2*	*C. quadrigemina*	Bronze & Black	Medium
			8	*3*	*C. quadrigemina*	Blue & Green	Medium & Large
Fife, Christina Lake 296994	June 25	100	10	*2*	*C. hyperici*	Green & Bronze	Small
			10	*1*	*C. quadrigemina*	Bronze	Large
			4	*1*	*C. quadrigemina*	Blue	Large
	July 15	25	10	*3*	*C. hyperici*	Bronze	Small
			5		Unknown - females		
Cassidy 246907	June 24	4	4	*1*	*C. hyperici*	Bronze	Small
	July 3	1	1	*1*	*C. hyperici*	Bronze	Small
	July 17	1	1		Unknown - females		
West Kelowna, Mt. Bourchiere Road 299028 aka 101814	June 20	Unknown	3	*1*	*C. quadrigemina*	Bronze	Medium
			10	*2*	*C. quadrigemina*	Bronze	Large
West Kelowna, Grizzly Road 299027 aka 101814	June 20	Unknown	10	*3*	*C. hyperici*	Bronze	Small
			10	*2*	C. quadrigemina	Bronze	Large
			9	*1*	C. quadrigemina	Blue	Large

Identification of *Chrysolina* beetles

According to Wilcox (1972), *C. hyperici* range in size from 5.3 to 6.1 mm while *C. quadrigemina* range in size from 6.0 to 7.0 mm. Douglas (H. Douglas pers. comm. October 2016) found a similar range using 25 specimens of each of the species from samples mentioned above for which *C. hyperici* ranged from 5.0 to 6.5 mm and *C. quadrigemina* ranged from 6.0 to 7.3 mm, in other words if the beetles are under 5.5 mm they are likely *C. hyperici* and if they are over 7.0 mm they are likely *C. quadrigemina*. Douglas found the only distinguishing difference in colour was while no *C. hyperici* were metallic blue, some of the *C. quadrigemina* were found to be this colour, i.e. *C. hyperici* can be metallic green or bronze while *C. quadrigemina* can be metallic green, bronze or blue. Based on these features, Douglas proposed it possible to determine presence or absence of each of the species at a site with a sample size of at least 20 beetles (H. Douglas pers. comm. November 2019).

Habitat of Chrysolina beetles

Harris, Peshcken and Milroy (1969) state that the three species of *Chrysolina* beetles released into B.C. would occur in moist conditions but would differ in their tolerance to aridity. According to Harris and Peschken (1971) *C. hyperici* prefers habitats with an aridity index between 30 and 40 or similar to a Douglas fir forest while *C. quadrigemina* prefers an aridity index between 24 and 45 suited to a thriving ponderosa pine forest. Adapted to the Mediterranean climate, *C. quadrigemina* must enter a dormant period during the hot or dry period of the summer and is unable to do so if it becomes too wet. In Australia, the reliability and speed of the beetles to control their host declined with increased summer rainfall (Harris and Peschken 1971). However, Harris and Peschken's (1971) early report also stated the beetles released into B.C. were not controlling their host plant in grassland sites where the aridity index was 17 to 24 and they survived in low numbers, or not at all, where the aridity index was above 30. The aridity index is calculated as average annual precipitation in mm divided by the average annual temperature in ^{o}C + 10 but is moderately precise compared to the moisture index and makes no distinction between summer and winter precipitation (Harris and Peschken 1971; Harris, Peshcken and Milroy 1969).

Figure 2 displays the aridity index calculated for the five collection sites from 1952 to 2018 using a global circulation model (ClimateBC 2019) and shows that the original 1950's release sites have aridity indexes basically within the ranges required for the two *Chrysolina* species with the exception of the West Kelowna site. *C. hyperici* were released into and have maintained populations at Marsh Creek and Edgewood. *C. quadrigemina* was released into the slightly drier Fife site and the very dry West Kelowna site and have

maintained populations there. Both species have established and maintained populations in habitats with both higher and lower aridity indexes than the original description by Harris and Peschken (1971). Notably, in 2012, prior to the collection of beetles in 2014, sites saw a sharp spike in the index. The aridity index may indicate a decline in beetles, or conversely it may indicate a flush of plants as perhaps did the wider spike seen in the late 1990's. With increasing spring rains, St. John's wort would flourish. St. John's wort seeds contain a germination inhibitor that can be washed off by heavy rains, thereby promoting germination (Piper and Rees 1996). The subsequent populations of target plants may have risen above the level of control by the predator beetles and would remain above until the beetle populations could increase again with the larger food supply (Figure 3). This type of fluctuation in habitat conditions may result in a fluctuation in the beetles' populations and therefore control of their target plant. Battle Creek Watershed Conservancy reported that in the National Bison Range, Montana, control of St. John's wort, particularly by *C. quadrigemina*, is moderate every fifth year and major every tenth.

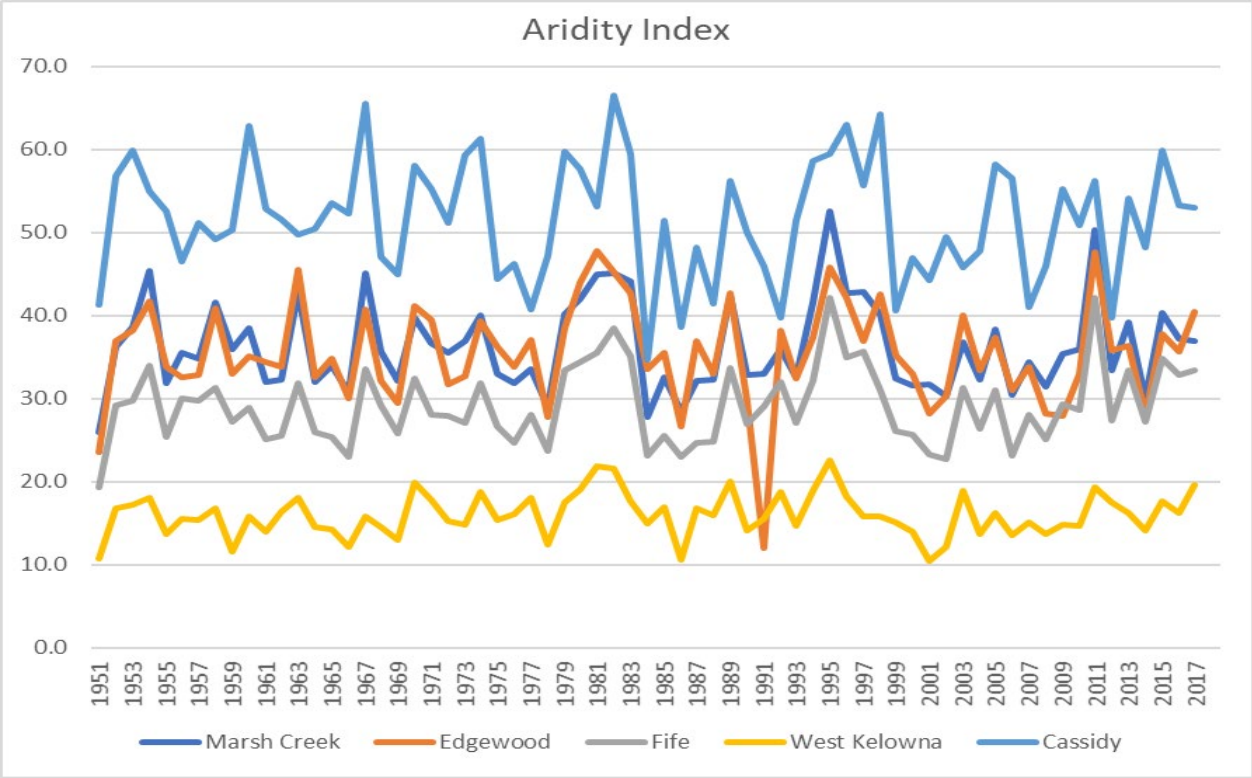
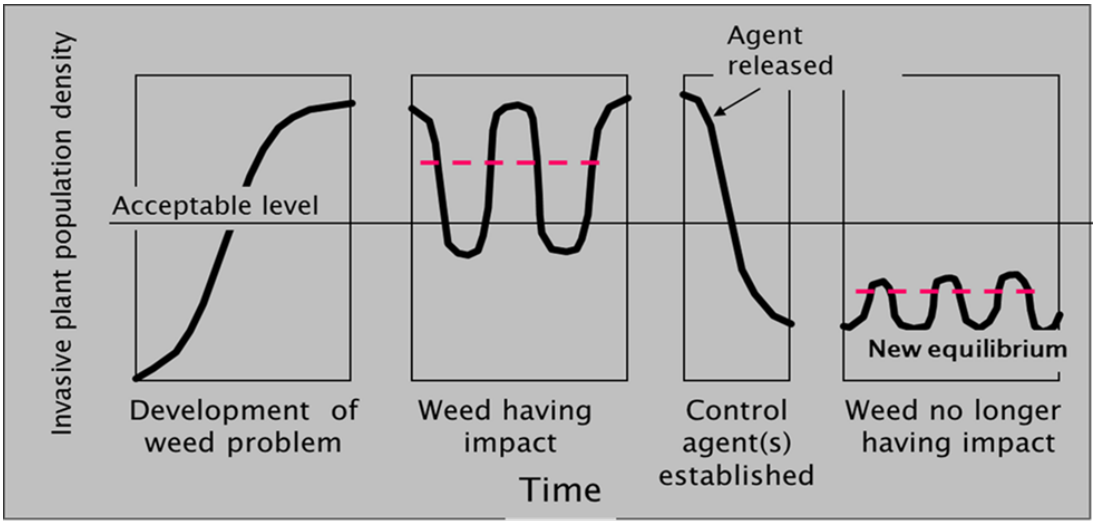


Figure 2. Aridity index of B.C. sites from 1952 to 2018

Summary

A joint St. John's wort project with FLNRORD and AAFC will be initiated in 2021. The project will look at a range of topics from comparison of new to current existence and quantities of biocontrol agents and plants, habitats, genetic analysis, etc. An informal working group consisting of both Canadian and U.S.A. invasive plant managers and scientists convened in December 2019 and will be comparing similar data sets for North America. The participants will strive to understand where St. John's wort resides on the plant population graph (Figure 3). Finally, the discussion of need for further research into new or additional strains of biological control agents will occur.



Julien, M. & White, G. (1997) Editors. Biological Control of Weeds: theory and practical application. ACIAR Monograph Series No. 49. 192 pp.

Figure 3. Changes in the population density of an invasive plant before and after the establishment of biological control agents.

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