

Sparganothis fruitworm: Current distribution and management practices

BC Cranberry Growers Association  
BC Cranberry Marketing Commission

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**FINAL REPORT**

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### **Summary**

Sparganothis fruitworm (*Sparganothis sulfureana*) is an important cranberry pest in Eastern North America. In British Columbia this pest has only recently caused economic levels of fruit damage and only on a few farms in Langley, Maple Ridge, Pitt Meadows and North Surrey. The objectives of this study were to document the current range of Sparganothis activity both on cranberry farms and "off-farm" in wild vegetation or other cultivated host crops (e.g. corn and blueberry); and to determine what factors could account for efficacy of insecticides against Sparganothis fruitworm.

In 2011, there were no Sparganothis moths found in cranberry fields in Burnaby, East Delta, Delta, Duncan or South Surrey. In Langley, we only found moths on farms that have had issues with this pest in the past three years. A single *S. sulfureana* male was caught in a pheromone trap in Richmond on September 26. No moths were caught in off-farm traps in East Delta, North Surrey, or Langley. From Sept 12 to 19 a total of eight moths were caught in off-farm traps in Port Coquitlam/Pitt Meadows; all of these moths were identified as *S. sulfureana*. The vegetation growing around the traps where moths were caught included cultivated blueberry, strawberry, raspberry and uncultivated vegetation (red cedar, creeping buttercup, horsetail, salmonberry, etc.). Overall, it appears that the only off-farm population of *S. sulfureana* is concentrated in the Port Coquitlam/Pitt Meadows area.

Although all growers should include monitoring for Sparganothis as part of their regular scouting and pheromone trapping program, most fields appear to be at low risk for infestation. At this time, the high risk areas for Sparganothis infestations in cranberry fields appears to be in Maple Ridge, North Surrey, North West Langley and in Pitt Meadows. In these areas, fields adjacent to cultivated blueberry, strawberry or raspberry and natural areas (e.g. parks or walking trails) with wild hosts of *S. sulfureana* should be monitored closely. In 2011, registrations of Intrepid and Delegate expanded the toolbox for Sparganothis. No live larvae were recovered following either Intrepid or Delegate sprays in 2011. With these new registrations growers now have effective tools for managing Sparganothis fruitworm.

### **Introduction and Objective**

Sparganothis fruitworm (*Sparganothis sulfureana*) (Clemens) is a major Lepidopteran pest of cranberries in Wisconsin and other eastern states, and a minor pest in eastern Canada (LeDuc & Turcotte, 2004). Economic damage is caused by the second generation larvae which are capable of feeding on three to five berries, damaging the surface of several others, and causing wounds that could serve as an entryway to fungal disease (Polavarapu *et al.* 2001; Teixeira & Averill 2006). Sparganothis has a wide host range that includes locally important crops (corn, red cedar, strawberry, and high bush blueberry) and many other commonly occurring plant hosts (e.g. willow, elm, loosestrife, and St. John's wort) (Marucci 1976; Teerink & Carlson 1988; Polavarapu *et al.* 2001; Turner & Liburd, 1993). Because of its wide host range migration of Sparganothis into cranberry fields from adjacent vegetation is a risk (Marucci 1976).

In addition to migration of moths into cranberry bogs from surrounding vegetation Sparganothis fruitworm outbreaks have also been attributed to the loss of organophosphate efficacy (Polavarapu *et al.* 2002) and the negative effect that the long-term use of these products has on natural enemies (Hastings 2003). In previous years we have observed inconsistent efficacy of commonly used insecticides against Sparganothis (Fig. 1). However, the same sprays do effectively kill blackheaded fireworm (E.S. Cropconsult Ltd. unpublished data). Locally, Sparganothis fruitworm has historically been found sporadically in cranberry fields but in recent years it has caused economic damage to fruit, for a few growers. Sparganothis has been detected every year since 2007 or 2008 in cranberries in Langley, North Surrey, Pitt Meadows, and Maple Ridge. A single adult was caught in Delta in 2009. In 2009 Sparganothis adults were seen in traps placed in wild vegetation outside of cranberry acreage in Coquitlam, Pitt Meadows, Langley, and North Surrey. However, it is likely that these traps were too close to infested cranberries and did not originate from an off-farm population. Also, there are several species of Sparganothis that are found locally, with similar looking adults - e.g. *Sparganothis tunicana*, *S. senecioriana* and *S. lycopodiana*. It is possible that the single capture in Delta in 2009 and any off-farm populations may be closely these related species.

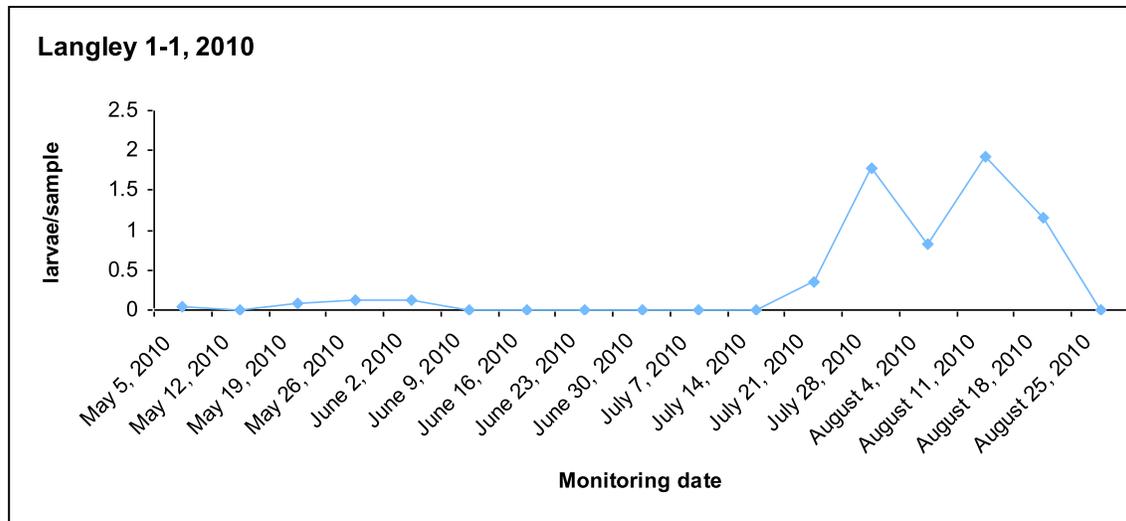


Figure 1. Season long activity of *Sparganothis* larva in a cranberry field in Langley. Arrows indicate the timing of an insecticide application either for fireworm or *Sparganothis*. The first four arrows are all for organophosphate sprays and the last arrow indicates application of Confirm.

The objectives of the current study were as follow:

1. Determine range of *Sparganothis* fruitworm activity in BC cranberries.
2. Determine *Sparganothis* activity outside of cranberry farms and the potential risk of *Sparganothis* fruitworm moving into cranberry fields from surrounding vegetation
3. Determine the reasons for poor control of *Sparganothis* with currently used products. With the new pesticide registrations in 2011, this objective was modified to: document the efficacy of the new registrations against *Sparganothis* and compare field efficacy of new registrations to previously used products.

## **Methodology**

Objective 1: Determine range *Sparganothis* fruitworm activity in BC cranberries

For farms or regions with no previous history of *Sparganothis*, a single *Sparganothis* fruitworm pheromone trap (i.e. wing trap baited with *S. sulfureana* sex pheromone (Contech Enterprises Ltd.)) was set up to monitor *Sparganothis* activity. Traps were placed on a total of 22 farms in the Fraser Valley or in Duncan (Table 1). Additionally, three traps were placed at two farms in Comox and two traps in Campbell River during the month of September (Table 1). For farms with a history of *Sparganothis* activity and berry damage - a pheromone trap was placed in each field monitored (Table 2). Traps were checked weekly by consultants or the growers. Except for the traps placed in Comox or Campbell River, lures were changed midway through the season. Sticky inserts were changed once they were no longer sticky or if moths were caught. Moths caught in

areas with no previous history were submitted to the AAFC's National Identification Service (Ottawa, ON). In addition to captures of adult moths in pheromone traps, all suspect larvae (i.e. not fireworm) encountered during crop monitoring were collected and reared until it was clear that they were not *S. sulfureana*.

Table 1. Summary of Sparganothis pheromone trap placement in cranberry fields with no previous history of Sparganothis damage

Region/Farm	Number of Sparganothis pheromone traps	Date trap placed	Number of weeks
Richmond	6 (on 6 different farms)	June 13	16 to 20
Burnaby	1	May 30	18
East Delta	5 (on 5 different farms)	June 13	18
Delta	1	June 13	18
South Surrey	1	June 13	16
Aldergrove	1	June 13	20
Chilliwack	1	May 30	18
Duncan	1	May 9	19
Comox	3	Sept 3	3
Campbell River	2	Sept 3	3
Northwest Langley	5 (on 5 different farms)	June 13	20

Table 2. Summary of Sparganothis pheromone trap placement in cranberry fields with previous history of Sparganothis damage

Region/Farm	Number of Sparganothis pheromone traps	Date trap placed	Number of weeks
Pitt Meadows 1	7	June 13	20
Pitt Meadows 2	6	June 13	20
Pitt Meadows/ Maple Ridge	10	June 13	20
Langley 1	17	June 13	20
Langley 2	6	June 13	20

Objective 2: Determine Sparganothis activity outside of cranberry farms

For the four regions where *Sparganothis* moths have been detected (Langley, Pitt Meadows/Maple Ridge, East Delta, North Surrey (Barnston Island)) a total of 37 *Sparganothis* pheromone traps were placed in either agricultural land with known plant hosts such as highbush blueberry, corn, alfalfa, strawberry or in natural areas containing plants that are known hosts. Each trap was placed at least 30m away from cranberry fields. Wing traps were either hung from surrounding foliage or suspended from a stake (Fig. 2). A survey of the plant community around each trap was done in mid-July. Traps were checked weekly and inserts were removed if moths were caught. Moths that were caught in off-farm vegetation were submitted to the AAFC's National Identification Service (Ottawa, ON).

Objective 3. Documenting the efficacy of the new registrations against *Sparganothis* and comparing field efficacy of new registrations to previously used products

Using our weekly monitoring data we examined the efficacy of insecticide sprays against *Sparganothis*. Data were compared for six fields with a history of *Sparganothis* activity since 2008 and with complete grower spray records (products and rates). Growers were interviewed regarding their chemigation practices in 2011. We compiled the data to compare the number of live *Sparganothis* larvae following insecticide application over the course of the past four years (2008, 2009, 2010, 2011).



Figure 2. Wing traps baited with *Sparganothis* pheromone were placed in cultivated highbush blueberry (top left), strawberry (top right) fields and in unmanaged vegetation

growing along roadsides (bottom left) or in regional parks (bottom right). Most trap sites were within 100 m of the nearest cranberry or other berry farm.

### **Results and Discussion**

Objective 1. Regional distribution of Sparganothis on cranberry farms:

In 2011, Sparganothis moths and larvae were found on the same cranberry farms - located in North Surrey, Langley, Pitt Meadows and Maple Ridge - where they have been found in the past. In addition, a single moth was caught in Sparganothis pheromone traps in Richmond on September 26 and a single moth was caught in Chilliwack on June 13. No moths (or larvae) were found in any of the other cranberry growing areas surveyed (Table 3). The trap in Richmond was located in a field at Richland and the insert was submitted to National Identification Service on January 11, 2012 and the identification was confirmed as *S. sulfureana* by Jean-Francois Landry (Det. Lot 2012 - 012). The specimen from Chilliwack was damaged during transport and was not suitable for submission. No Sparganothis larvae were found in either field or in any of the nearby fields (same farm or nearby farms). In 2009 a single moth was caught in cranberry farm in East Delta, however since then no moths or larvae have been observed at that farm or surrounding farms. Thus a single moth capture does not indicate the beginning of an infestation for a particular farm or growing region. However, Richmond growers should be more vigilant in their monitoring for this pest by including *S. sulfureana* pheromone traps as part of their monitoring program and ensuring that they can visually distinguish Sparganothis larvae from other larvae during crop monitoring.

Table 3. Summary of Sparganothis pheromone trap catches in cranberry fields - farms without previous damage due to Sparganothis.

Region/Farm	Number of Sparganothis pheromone traps	Number of moths caught	Date moth observed in trap and Identification status
Richmond	6 (on 6 different farms)	1 - (Richland)	Sept 26 Submitted to Ottawa for ID Confirmed as <i>S. sulfureana</i>
Burnaby	1	0	
Delta	1	0	
East Delta	5	0	
South Surrey	1	0	
Aldergrove	1	0	
Chilliwack	1	1	June 13 Sample destroyed, but no larvae observed during remainder of growing season

Duncan	1	0	
Comox	3	0	
Campbell River	2	0	
Northwest Langley	5 (on 5 different farms)	0	

## Objective 2. Determine Sparganothis activity outside of cranberry farms

Sparganothis traps were set up in vegetation off-cranberry fields in four regions - East Delta (10 traps), Langley (10 traps), Pitt Meadows/Maple Ridge/Port Coquitlam (10 traps), and Barnston Island (7 traps). Sparganothis moths were only caught in one of the four regions - Pitt Meadows/Maple Ridge/Port Coquitlam. A total of eight moths were caught - with six of them caught in traps placed in cultivated berry crops (raspberry, blueberry, strawberry) (Table 4). The single moth caught in Port Coquitlam is in a large area of blueberries and near natural bogs at Minnekhada Regional Park. All specimens were caught during a two week period in mid-September (Table 4) and all moths were confirmed to be *S. sulfureana* by Jean-Francois Landry (National Identification Services). It is surprising that more moths weren't caught from the other traps in this and in the other three areas, given the wide host range of Sparganothis fruitworm and the number of other related species in the same genera. In previous years, Sparganothis moths were caught during the first two weeks of September from a high bush blueberry field in Pitt Meadows (Soto 2009).

These findings suggest that a risk factor for Sparganothis fruitworm infestation is proximity to other berry crops. An additional risk factor based on Marucci (1976) would be if potential hosts of Sparganothis fruitworm are weeds in cranberry fields. For example, in previous work we found a Sparganothis larva on a curled dock plant growing 2 m from a cranberry field in Pitt Meadows (Soto and Prasad, 2008). Based on the findings of this study and our previous work these two factors - proximity to other cultivated host crops (especially berries) and alternate hosts growing as weeds in or near fields - appear to be the main risks for Sparganothis infestation in cranberries. However, the overall risk of infestation from surrounding vegetation appears to be very low as we did not catch Sparganothis moths in 32 out of 37 traps placed in areas containing suitable hosts. This may be one reason why the number of farms with Sparganothis issues has not increased over the past four years.

Table 4. Summary of the off-cranberry farm Sparganothis trap placements and findings in Port Coquitlam/Pitt Meadows/Maple Ridge (Information for Langley, East Delta and North Surrey in Appendix 1). All moths caught were confirmed to be *S. sulfureana*.

Trap Identification Coordinates Site type	Vegetation	Moths Caught and Date
Port Coquitlam 1 49°17'30.32"N 122°42'44.90"W  Cultivate	Highbush blueberry Lady's thumb ( <i>Polygonia persicaria</i> ) Horsetail ( <i>Equisetum sp.</i> ) Grass	0
Port Coquitlam 2 49°17'34.08"N 122°42'22.99"W  Cultivate	Highbush blueberry Horsetail Grass	1 - Sept 19
Port Coquitlam 3 49°17'49.79"N 122°41'16.27"W  Bog in regional park	Pacific rhododendron ( <i>Rhododendron macrophyllum</i> ) Himalyan blackberry ( <i>Rubus discolor</i> ) Fern ( <i>Athyrium spp</i> ) Douglas fir ( <i>Pseudotsuga menziesii</i> ) Moss ( <i>Sphagnum spp.</i> )	0
Pitt Meadows 1 49°15'03.85"N 122°42'37.21"W  Cultivated	Corn Grass Raspberry	0
Pitt Meadows 2 49°14'41.79"N 122°42'43.50"W  Cultivated	Strawberry Raspberry Sweet clover ( <i>Trifolium pratense</i> ) Salmonberry ( <i>Rubus spectabilis</i> ) Grass	1 - Sept 12  1 - Sept 19
Pitt Meadows 3 49°14'30.42"N 122°44'00.09"W  Vegetation along hiking trail	Sweet clover Horsetail Creeping buttercup ( <i>Ranunculus repens</i> ) Vetch ( <i>Vicia sativa</i> ) Foxglove ( <i>Digitalis purpurea</i> ) Plantain ( <i>Plantago major</i> ) Fireweed ( <i>Epilobium angustifolium</i> ) Nootka rose ( <i>Rosa nutkana</i> ) Thimbleberry ( <i>Rubus parviflorus</i> )	2 - Sept 19
Pitt Meadows 4 49°13'46.73"N 122°44'41.13"W  Cultivated	Highbush blueberry Cedar ( <i>Thuja spp.</i> ) Big leaf maple ( <i>Acer macrophyllum</i> ) Buttercup ( <i>Ranunclus spp.</i> ) Douglas fir Grass	1 - Sept 19

Pitt Meadows 5 49°17'36.42"N 122°38'41.80"W Cultivated	Highbush blueberry Horsetail	2 - Sept 12
Maple Ridge 1 49°15'42.26"N 122°36'03.24"W Bog in regional park	Snowberry ( <i>Symphoricarpus albus</i> ) Stinging nettle ( <i>Urtica dioica</i> ) Alder ( <i>Alnus rubra</i> ) Pond lily ( <i>Nuphar polysepalum</i> ) Himalyan blackberry	0
Maple Ridge 2 49°15'50.10"N 122°36'00.02"W Bog in regional park	Snowberry Salmonberry Alder Thimbleberry Grass Willow ( <i>Salix</i> spp.) Hardhack ( <i>Spirea douglasii</i> ) Bitter cherry ( <i>Prunus emarginata</i> ) Crabapple ( <i>Malus fusca</i> ) Poplar ( <i>Populus</i> spp.)	0

Objective 3. Documenting the efficacy of the new registrations against Sparganothis and comparing field efficacy of new registrations to previously used products

With the recent registration of Intrepid and Delegate, the concern regarding poor Sparganothis control appears to no longer be a factor. For the three (Sparganothis positive) farms for which we had full spray records, it appears that Intrepid or Delegate sprays were effective in controlling Sparganothis populations (Table 5). Each farm had at least one field where either Delegate or Intrepid or both were used and Sparganothis larval counts were 0 following application. Efficacy was especially dramatic at Pitt Meadows Farm 2 Field 3 (Table 5b) where a mid June Delegate application was followed by no Sparganothis larvae found during monitoring for the remainder of the season. In contrast, in 2010 this field had Sparganothis activity up to mid-August. In previous years applications of Diazinon, Confirm, or Sevin did not appear to control Sparganothis in a consistent way (e.g. Fig. 1). However, for three of the six fields - end of season applications of either Success or Confirm seemed to be successful in not only controlling Sparganothis for the remainder of the field season, but also into the next field season (i.e. Pitt Meadows 2 in 2009, Pitt Meadows 4 in 2010, Langley 2 in 2010). So Confirm and Success appear to be effective solutions as well, if their applications can be time correctly. Now that effective tools are available for management of this pest, it may be worthwhile to consider an action threshold for triggering treatment. Currently, detection of a single larva has triggered a recommendation, although not all growers treat based on the presence of a single larva.

In situations where Diazinon sprays were made for a combination of Sparganothis and blackheaded fireworm we always observed dead fireworm, but not dead Sparganothis in

post-spray checks (M. Soto, E.S. Cropconsult Ltd. personal observation). For the three farms represented in this report we did not see dead Sparganthis following Intrepid or Delegate sprays but we did see "sick" (i.e. sluggish and off colour) larvae following some of the applications. Additionally, on a fourth farm - not included in this report because of incomplete spray records - we did see dead Sparganthis larvae following Delegate application.

Table 5a. Summary of Sparganthis larval counts prior to and following insecticide applications for Pitt Meadows Farm 1.

Field and chemigation notes	Year	Spray Date	# live larvae (pre-spray) (larvae/sample)	Product	# live post-spray (larvae/sample)
1	2010	August 2	0.07	Diazinon (1.8 L/acre)	0.14
(Chemigate @ night for 22 minutes)		August 11	0.14	Diazinon (1.8 L/acre)	0.07 (5 days post) 0.14 (12 days post)
(Chemigate @ night for 22 minutes)	2011	August 25	0.92	Delegate (170 g/acre)	0 (14 days post)
2	2008	August 7	1.6	Diazinon 2.8 L/acre	0.8 (5 days post) 0.71 (12 days post) 0.71 (19 days post)
(Chemigate @ night for 22 minutes)	2009	July 30	2	Sevin (3L/acre) Applied for tipworm	0.38 (5 days post)
		August 5	0.38	Confirm (0.5L/acre)	0 (7 days post) 0 (7 days post) <b>no larvae in 2010</b>

Table 5b. Summary of Sparganthis larval counts prior to and following insecticide applications for Pitt Meadows Farm 2.

Field and chemigation notes	Year	Spray Date	# live larvae (pre-spray) (larvae/sample)	Product	# live post-spray (larvae/sample)
3	2010	July 21	0.25	Diazinon (3L/acre)	0.85 (6 days post)
(Chemigate @ night for 15 minutes)		August 6	1.6	Confirm (0.48 L/acre)	2.06 (4 days post)
		August 13	2.06	Success (148 ml/acre)	0.06 (3 days post) 0 (10 days post)
(Chemigate @ night for 15 minutes)	2011	May 13	0.02	Intrepid (0.4 L/acre)	0.015 (7 days post)
		May 21	0.015	Intrepid (0.4 L/acre)	0 (7 days post)
		June 10	0.04	Delegate (200 g/acre)	0.07 (6 days post) 0 (13 days post) 0 for remainder of season

4	2010	May 14	0.41	Diazinon (2 L/acre)	1 (3 days post) 1.13 (13 days post)
(Chemigate @ night for 15 minutes)		August 6	1.38	Confirm (0.48 L/acre)	1 (4 days post)
		August 13	1	Success (148 ml/acre)	0.375 (3 days post) 0.1 (7 days post) Only 2 larvae found in 2011

Table 5c. Summary of Sparganothis larval counts prior to and following insecticide applications for Langley Farm 1.

Field and chemigation notes	Year	Spray Date	# live larvae (pre-spray) (larvae/sample)	Product	# live post-spray (larvae/sample)
1	2009	July 24	5.08	Sevin (3L/acre)	0.9 (5 days post) 0.09 (12 days post) 0.2 (19 days post)
(Chemigate @ night for 8-10 minutes)	2010	July 30	1.77	Sevin (3L/acre)	0.83 (5 days post) 1.92 (12 days post)
		August 18	1.16	Confirm (400 ml/acre)	0 (7 days post) End of monitoring
(Chemigate @ night for 8-10 minutes)	2011	June 4	0.21	Intrepid (450 ml/acre via chemigation)	0.08 (4 days post)
		June 10	0.08	Intrepid (300ml/acre via Boom with 165 L water/10 acres)	0 for remainder of season
2	2010	July 30	1.64	Sevin (3L/acre)	2.08 (5 days post)
(Chemigate @ night for 15 minutes)		August 18	0.43	Confirm (400 ml/acre)	0.1 (7 days post) End of monitoring <b>Only 3 larvae in 2011</b>

In 2011, pheromone traps were left up for several additional weeks at the five farms monitored by ES Cropconsult Ltd. that have Sparganothis issues. Interestingly, at three of the five farms we found higher numbers of Sparganothis moths in traps in late September through to mid-October than in the earlier part of the season. Moth captures in pheromone traps peaked between the weeks of Sept 19 to October 3, at two of the farms (Table 6). Sparganothis moths were caught in pheromone traps located in cranberry fields until October 17. The very high trap catches in September and October in Langley Farm 1 are especially surprising given that larval counts were quite low (zero for many weeks) in many of the fields. Activity in traps at this time of year is most likely a reflection of the overall delay in insect activity in the 2011 growing season or part of the normal phenology for Sparganothis. Since this insect overwinters as a first instar larva a late summer/early fall adult generation would be required to produce the overwintering generation of larvae. In Wisconsin, recent studies are also showing that Sparganothis

fruitworm are active in all stages through October, despite periods of freezing temperatures (S. Steffan, University of Wisconsin-Madison, personal communication). It will be interesting to follow the spring 2011 Sparganothis larval populations in fields with high trap catches in the late summer/early fall of 2010.

Table 6. Summary of Sparganothis pheromone trap counts for representative fields in 2011.

Farm	Field	Week of Peak Flight	Count at Peak Flight	Total moths	Intrepid or Delegate used in field
Pitt Meadows 1	1	Sept 19	6	8	Delegate (1X)
	2	Sept 19	10	26	Intrepid (1X)
	3	Sept 5	1	1	No
	4	Sept 19	19	30	Delegate (1X)
	5	Sept 19	5	7	No
Pitt Meadows 2	1	Sept 19	2	2	Intrepid (2X) and Delegate (1X)
	2	N/A	No peak	2 total	No
Langley 1	1	Sept 26	2	3	Intrepid (3X)
	2	Sept 26	42	58	Intrepid (1X)
	3	Sept 19	55	146	Intrepid (2X)
	4	Sept 19	13	26	Intrepid (1X)
	5	Sept 19	56	89	Intrepid (1X)
	6	Sept 19	64	99	Intrepid (1X)

### **Summary and Suggestions for Future Management and Study**

Our findings suggest that the current distribution of Sparganothis remains concentrated on few farms in the Pitt Meadows, Maple Ridge, North Surrey and Langley. The only area where we found Sparganothis moths in pheromone traps placed away from cranberry farms was in Port Coquitlam/Pitt Meadows. Finally, observations also indicate that the newly registered products Intrepid and Delegate are effective at managing Sparganothis larvae in cranberry fields. However, high trap catches of moths in some fields that were sprayed with Intrepid or Delegate earlier in the season are puzzling and suggest that larvae continued to be active in these fields in late August and early September.

Suggestions for future management and study

- For farms with no previous history of Sparganothis: Those farms with one or both risk factors - adjacent to crops which are alternate hosts for Sparganothis fruitworm or with lots of weeds - should have at least one Sparganothis trap/farm included as part of the regular pest monitoring program. Sparganothis larvae, if present, can be detected on all farms when fireworm monitoring is being conducted.
- For farms with a previous history of Sparganothis: compare 2012 spring Sparganothis larval activity among fields with high and low pheromone trap catches in September and October 2011. The regular monitoring program for Sparganothis should be extended several weeks to run until the end of September, with monitoring focusing on berry damage in hot spots and pheromone trap counts.
- With effective products now available - Delegate, Intrepid, as well as Confirm - it maybe worthwhile to consider an economic threshold for Sparganothis. Currently, recommendations for treatment are made when at least one larvae is found in a field, although growers do not always spray based on the presence of a single larva.

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## Appendix 1

## East Delta/Delta off-farm trap summaries

Trap Identification	Coordinates	Vegetation	Moths caught
East Delta 1	49°06'25.44"N 122°57'22.77"W	Highbush blueberry Horsetail	0
East Delta 2	49°05'51.55"N 122°57'38.86"W	Highbush blueberry Horsetail	0
East Delta 3	49°06'24.55"N 122°57'27.34"W	Alder Blackberry Elderberry Fern Cleavers	0
East Delta 4	49°05'51.92"N 122°57'33.56"W	Corn Blackberry Grass Strawberry Potato Squash	0
East Delta 5	49°04'22.08"N 122°57'29.19"W	Blackberry Cedar Grass	0
East Delta 6	49°04'19.24"N 122°58'47.08"W	Grass Poplar Buttercup	0
East Delta 7	49°04'40.42"N 122°58'38.96"W	Corn Poplar Grass	0
Delta 8	49°05'25.07"N 122°54'44.63"W	Corn Grass Clover Cleavers Shepherd's purse	0
Delta 9	49°05'55.21"N 122°54'45.21"W	Grass Poplar Hardhack Blackberry	0
Delta 10	49°06'28.30"N 122°54'41.73"W	Highbush blueberry	0

## Langley off-farm trap summaries

Trap Identification	Coordinates	Vegetation	Moths caught
Langley 1	49°12'10.79"N 122°37'03.49"W	Alpine laurel False lily of the valley Yellow pond lily Labrador tea Bog bilberry Lodge pole pine	0
Langley 2	49°12'09.46"N 122°36'48.05"W	Lodge pole pine Labrador tea Bog bilberry	0
Langley 3	49°12'18.84"N 122°37'20.79"W	Reed canary grass Fescue Creeping buttercup Himalayan blackberry Big leaf maple	0
Langley 4	49°11'54.46"N 122°38'35.82"W	Sword fern Lady fern Holly Pacific bleeding heart Salal Elderberry Red alder Poplar Himalaya blackberry Vaccinium sp.	0
Langley 5	49°06'47.24"N 122°32'22.70"W	Strawberry	0
Langley 6	49°06'53.74"N 122°32'23.12"W	Highbush blueberry Horsetail Grass	0
Langley 7	49°06'53.60"N 122°32'30.28"W	Corn Grass	0
Langley 8	49°08'53.46"N 122°26'05.39"W	Corn Grass Creeping Buttercup	0
Langley 9	49°09'34.54"N 122°29'42.31"W	Grass Creeping Buttercup Foxglove	0
Langley 10	49°09'34.38"N 122°30'26.40"W	Salmonberry Blackberry Grass Foxglove Horsetail	0

## Barnston Island off-farm trap summaries

Trap Identification	Coordinates	Vegetation	Moths caught
Barnston 1	49°11'41.53"N 122°42'24.17" W	Poplar Nootka rose Buttercup Blackberry Red clover Oceanspray Horsetail	0
Barnston 2	49°12'30.71"N 122°43'31.66"W	Douglas fir Alder Knotweed Blackberry Maple Poplar Snowberry Canada thistle Ivy Horsetail	0
Barnston 3	49°11'12.12"N 122°42'52.70"W	Fescue Blackberry Maple Snowberry Alder Thimbleberry Buttercup Ivy Poplar Reed canary grass	0
Barnston 4	49°11'25.74"N 122°41'10.87"W	Fescue Blackberry Reed canary grass Snowberry Spirea Buttercup Willow	0
Barnston 5	49°11'24.21"N 122°40'46.53"W	Vine maple Alder Snowberry Thimbleberry Poplar Elderberry Bracken fern Stinging nettle Blackberry Reed canary grass	0

Barnston 6	49°11'14.27"N 122°41'08.05"W	Oceanspray Alder Poplar Blackberry Buttercup Reed canary grass	0
Barnston 7	49°11'40.80"N 122°40'41.37"W	Western red cedar Alder Reed canary grass Buttercup Poplar Cultivated apple	0