CLIMATE CHANGE ADAPTATION PROGRAM

Vancouver Island Pests, Pollinators and Beneficials

Project Report

Prepared for the Islands Agriculture Show Society & BC Climate Change Adaptation Program

By Bonnie's Bugs IPM

Funding for this project has been provided by the Governments of Canada and British Columbia through the Canadian Agricultural Partnership, a federal-provincial-territorial initiative. The program is delivered by the Investment Agriculture Foundation of BC.

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Investment Agriculture Foundation

FUNDING PROVIDED BY

CANADIAN AGRICULTURAL PARTNERSHIP

BRITISH COLUMBIA

Canada

Acknowledgements

This report was prepared for the Islands Agriculture Show Society by Bonnie Zand, with contributions from Kiara Jack (newsletter & communications) and Natasha Tymo (field scouting & newsletter), in partnership with the BC Climate Change Adaptation Program.

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→ BC Ministry of Agriculture, Food and Fisheries
→ Capital Regional District
→ Climate & Agriculture Initiative BC
→ Comox Valley Farmers' Institute
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→ Cowichan Agricultural Society
→ Cowichan Valley Regional District
→ Island Egg Producers
→ Island Milk Producers
→ Mid-Island Farmers' Institute
→ Nanaimo Regional District
→ Peninsula & Area Agricultural Commission
→ Wine Island Growers Association

In addition, the project team would like to thank the many collaborating agricultural producers who opened their farms for monitoring and workshops.

Citation Format:
In-text:
Bonnie's Bug IPM, 2023
Reference List:
Bonnie's Bugs IPM. 2023. Vancouver Island Pests, Pollinators and Beneficials: Project Report. Climate Change Adaptation Program.
www.bcclimatechangeadaptation.ca

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Overview

The Vancouver Island Pests, Pollinators and Beneficials Project (VIPPB) was initiated in 2021 and ran for the 2021 and 2022 growing seasons. This BC Climate Change Adaptation Program (CCAP) project had the overarching goals of implementing pest monitoring for key agricultural crops on Vancouver Island, increasing grower knowledge and engagement with Integrated Pest Management (IPM), and supporting collaborative monitoring of significant pest, pollinator and beneficial species.

To achieve these goals VIPPB initiated a three-part project:

- Part 1: Pest monitoring.
  Monitoring sites were established on multiple farms and to monitor multiple crops (berries, tree fruit, and vegetable). Sites were located in north, mid and south Vancouver Island and were monitored biweekly over the season (May to September), using a variety of trapping techniques and field walks, to detect pest and beneficial insects.

- Part 2: Beneficial insect monitoring.
  Community scientists (gardeners, farmers, naturalists) were recruited to join a project on the community science platform iNaturalist, and to record findings of any arthropods they found in agricultural settings on Vancouver Island (including pests, pollinators and beneficials).

- Part 3. Outreach / communications.
  A biweekly newsletter kept growers up to date on the findings of the project and informed their own monitoring and management efforts. Workshops were held in multiple communities, and over Zoom, introducing growers to the project and teaching IPM skills. A Facebook group was also used to disseminate information to growers.

The two-year project collected a significant amount data that forms an important baseline for future monitoring in the region. The project also introduced Vancouver Island Growers to the concepts of IPM, particularly insect identification and monitoring. Future monitoring and outreach efforts can build on these successes and continue to educate growers and gather more information about the pests and beneficial insects present on Vancouver Island.

Weather / Climate Conditions in 2021 and 2022

Vancouver Island typically has mild and wet winters and warm and dry summers. July and August are on average the hottest months, while November, December and January are the wettest. The two years of this study both deviated from the 30-year climate normals (Environment Canada, 2023). As the climate changes, warming temperatures and increasing variability is expected to impact the distribution, life cycles and prevalence of agriculturally significant pests, pollinators and beneficials. While addressing the impact of climate change is beyond the scope of a two-year project, this project was able to document how pest populations varied between the different climatic conditions in the two years of the study.

During 2021 the region experienced an unprecedented “heat dome” in late June, resulting in heat stressed plants and sunburned fruits, as well as high populations of pest that thrive in hot and dry conditions. 2021 remained hotter and dryer than average until September, which was wetter than average. 2022 started off cooler and wetter than average, particularly in April and May. This resulted in delayed blooming and fruit set for perennial crops, as well as reports of poor pollination success. Wet fields delayed planting of many annuals, and pest that thrive in cool and damp conditions were more prevalent than in 2021. Fungal diseases were also observed to be more widespread in 2022 compared to 2021.

Starting in July temperatures rose about average, matching or exceeding average temperatures from 2021 for the remainder of the summer and early fall. The typical fall rainfall was delayed by hot and dry weather into October, and precipitation remained below average until December 2022.

Table 1. Climate normals and 2021 and 2022 climate data from Victoria International Airport (Environment Canada, 2023).

	Mean Temp (^oC)			Precipitation (mm)		
Month	1981 - 2010	2021	2022	1981-2010	2021	2022
Jan	4.6	5.3	4.0	143.2	138	133.7
Feb	5.1	3.6	4.5	89.3	80.6	64.5
March	6.8	5.9	7.2	78.4	18.0	78.8
April	9.0	9.7	7.3	47.9	19.9	91.6
May	12.1	12.5	10.7	37.5	15.2	49.9
June	14.9	17.6	15.4	30.6	33.8	40.2
July	16.9	18.1	18.0	17.9	0.0	27.2
August	16.8	17.9	18.6	23.8	7.0	1.0
September	14.2	14.6	16.1	31.1	88.5	1.0
October	10.0	9.5	12.4	88.1	90.2	62.4
November	6.4	7.6	4.4	152.6	316.4	84.6
December	4.0	1.9	2.5	142.5	159.5	170.2

Pest monitoring methods and results

Pest monitoring during the VIPPB Project occurred on seventeen farms, ranging from north of Courtenay to the Saanich Peninsula. During the 2021 season twelve farms were monitored in the mid island (six farms) and north island (six farms). In 2022 eleven farms were monitored from the north island (four farms), mid island (four farms) and south island (three farms). Farms were visited every other week during a 16-week season in 2021 and a 20-week season in 2022.

Farms were chosen to represent a diversity of farm sizes and production systems. The project included farms ranging from small organic market gardens to large scale conventional vegetable and fruit growers. Three of the north island farms were included in data collection in both years and one of the mid island Farms was in the program both years. During 2021 all north Island sites were in the Comox Valley and all mid Island sites were in the Cowichan Valley. In 2022 north island sites included farms from the Comox Valley south to Qualicum, mid island farms were located between Nanaimo and the Cowichan Valley, and south island farms were located on the Saanich Peninsula and greater Victoria Area.

The same four crop groups were monitored during both seasons: brassicas, carrots, berries (blueberry, strawberry, raspberry) and apples. Details of the monitoring methodologies used in each crop type, and differences between methods in the two years are detailed in the crop sections below, along with a summary of the most relevant monitoring results from each crop.

Table 2. Farm locations and monitoring effort in the 2021 and 2022 seasons.

	2021	2022
Number of farms	12	11
Farm locations	North Island (6), Mid Island (6)	North Island (4), Mid Island (4), South Island (3)
Season length	16 weeks (May 24-September 10)	20 weeks (May 2 - September 16)
Crops	Berries, Carrots, Brassica, Apple	Berries, Carrots, Brassica, Apple
Berries	Strawberry (5), Blueberry (5), Raspberry (8)	Strawberry (8), Blueberry (5), Raspberry (6)
Carrots	9: North (5) Mid (4)	All farms (11)
Brassica	9: North (5) Mid (4)	All farms (11)
Apple	8: North (4) Mid (4)	8: North (3), Mid (3), South (2)

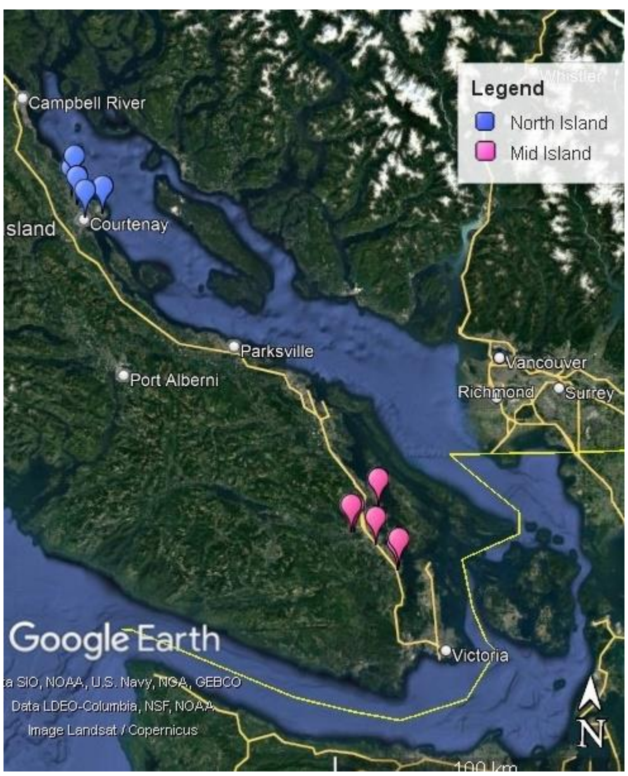


Figure 1. 2021 farm sites

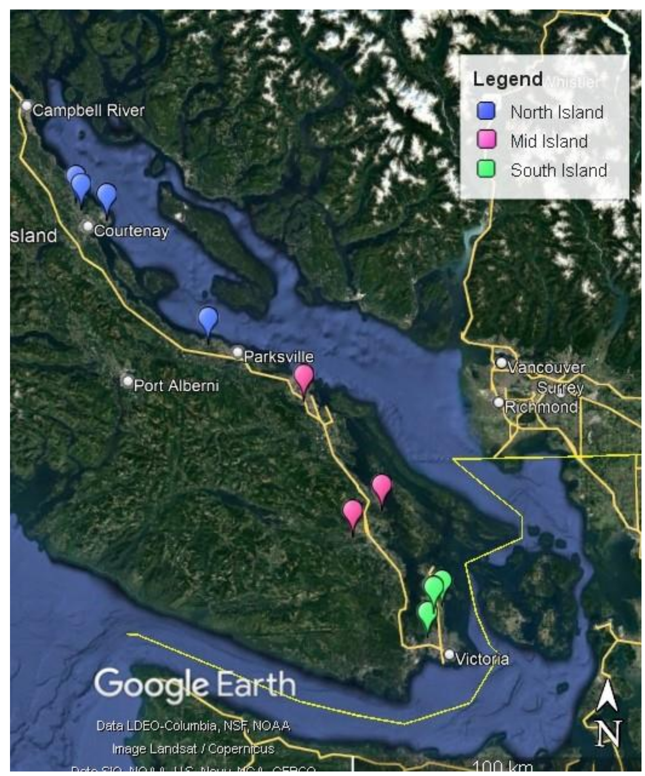


Figure 2. 2022 farm sites

Carrots:

The main arthropod pest of carrots in the Vancouver Island growing region is the carrot rust fly (*Psila rosa*). This pest is best monitored during the adult flight stage using yellow sticky traps. The number of rust fly present on traps corresponds to the relative risk to the crop, with a suggested threshold of 0.1 -0.2 rust fly / trap / day.

Yellow sticky trap for carrot rust fly

Sticky traps were placed on the edges of the carrot fields, at a rate of two to four per field, depending on the size of the field. Where row cover was in use, traps were placed outside of the row cover. Traps were attached to stakes just above the level of the crop and were collected during each visit. Rust flies were counted on each sticky card and the cards were labeled, wrapped in saran wrap and stored in a freezer.

In addition to dedicated rust fly traps, in 2022 carrot rust fly were also observed on yellow sticky cards placed in hedgerows and in berry fields to monitor for other pests. While numbers on these traps were not used to determine infestation levels, they were used to document the presence of rust fly on those farms. In 2022 many growers were late planting their carrots due to adverse weather conditions, and these non-target catches were important in determining the presence of rust fly before carrots had germinated. On one farm in 2022 rust fly traps were placed in celery and parsley prior to carrot germination.

Data Collected: Number of rust fly per card. Presence of rust fly on yellow sticky cards in other crops in 2022

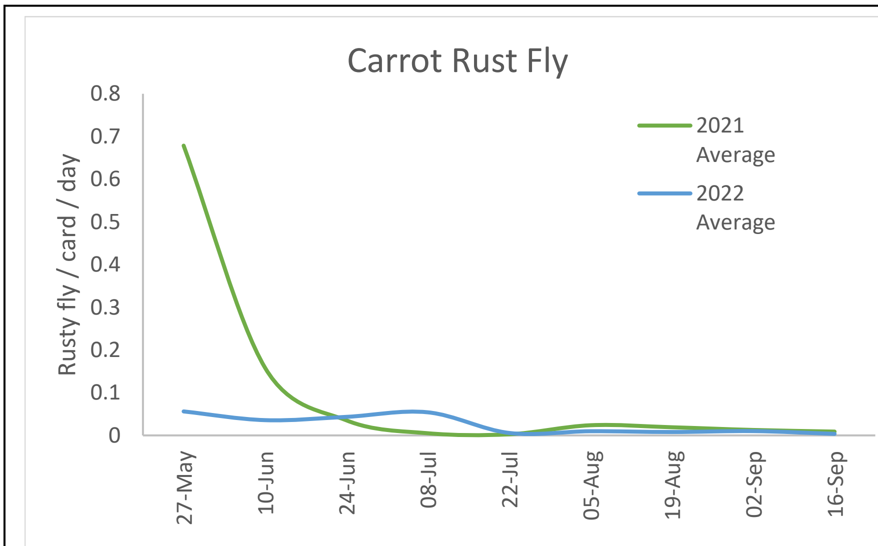


Figure 3. Average adult carrot rust fly present in 2021 and 2022 season.

Results: In both 2021 and 2022 rust fly levels were highest early in the season, and dropped to very low levels later in the season. The timing and quantity of rust fly varied between the two years. In 2021 surveys started later, and the first rust fly checks indicated very high levels of rust fly. These numbers dropped rapidly, and no farms had rust fly above a threshold of 0.1 rust fly / card / day from mid-June to late July. A small mid-season peak occurred on some farms in August, with one farm above threshold (0.14 rust fly/ cards/ day).

In 2022 monitoring began earlier, but due to the extended cold and wet spring many carrot fields were not planted until later in the season. Where traps were in place early season, rust fly were present at levels over threshold from late May to early July. Although rust fly were present for a longer period of time in 2022, the overall rust fly numbers were lower throughout this period. The mid-summer low rust fly period did not start until a full month after 2021. Similar to 2021, there was a small mid-season peak on one farm in August, but in general rust fly levels were low for the remainder of the season in 2022. Farm-level rust fly data from 2021 and 2022 can be found in the appendix.

In both years rust fly levels and timing varied greatly between farms, and the use of area wide data to make farm level decisions around management is not recommended. Many growers used row covers, delayed planting, early harvesting or insecticide application to manage rust fly, and farm-level monitoring can improve the efficiency of all these methods of rust fly control. Many growers had row cover in place when it was not needed, and in 2022 plantings delayed till the end of June would still have been exposed to rust fly.

Carrot Rust Fly

Traps placed in hedgerows around farms in 2022 for the detection of other pests also caught large numbers of rust fly in the early season, before carrots were planted. Traps in parsley and celery were also attractive to rust fly. Growers could consider placing yellow sticky cards in hedgerows or alternate hosts close to the area where they intend to plant carrots as a means of determining if rust fly are currently active before they plant their crops.

No other pests were monitored or observed by VIPPB in carrots, however several growers mentioned that wireworm were a large problem in carrots and this pest would not be evident until harvest.

Table 3. Number of farms with carrot rust fly present (on carrot sticky cards or on other cards on the farm), above threshold (more than 0.1 rust fly / card/ day) or not detected, and total number of farms where rust fly data was collected.

	2021				**2022**			
Period	Present	Above Threshold	Not Detected	Total farms	Present	Above Threshold	Not Detected	Total
13-May	1	1	0	1	1	0	0	1
27-May	2	2	1	3	6	2	2	8
10-Jun	4	1	4	8	6	0	3	9
24-Jun	3	0	5	8	6	2	3	9
08-Jul	2	0	6	8	7	2	4	11
22-Jul	1	0	7	8	3	0	8	11
05-Aug	3	1	5	8	3	0	8	11
19-Aug	2	1	7	9	2	1	9	11
02-Sep	2	0	7	9	3	0	7	10
16-Sep	1	0	5	6	1	0	9	10
Totals	21	6	47	68	38	7	53	91

Brassicas:

A wide variety of brassica crops are grown on Vancouver Island, ranging from baby salad greens to long season cabbages to root brassicas. Brassicas can be in the ground throughout the season. Many different pests impact brassicas, with their relative importance depending on crop timing, seasonal weather conditions, and crop type. The main crops monitored included kale, broccoli, cauliflower, cabbage, and brussels sprouts, although Pac choi, salad greens and other varieties were also monitored occasionally.

On many of the farms, brassica crops were planted sequentially, with multiple crop varieties and stages present at the same time. Management strategies varied widely between growers, with some applying insecticides (conventional and organic) on a schedule, while others applied insecticides when pests became an issue. Many growers used row covers for part of the season, however covers were often poorly secured and were also removed for weeding and harvest. Because of these differences in management, there was considerable variation in pest levels between farms, which obscured regional differences. However, differences in some pests were detectable between the two years of the study.

Monitoring consisted of field walks, with one to two passes through each planting, checking five sites per pass. At each site plants were inspected for pests. In 2021 five plants per site were inspected when plants were not touching, or three plants when they were touching, in 2022 three plants were inspected per site regardless of size. For each plant the top and bottom sides of leaves were inspected, as well as growing points. When plants were small and stems were accessible, the soil at the base of the stem was also examined for evidence of cabbage maggot eggs and larva. Plants that were visibly wilted were pulled to look for root maggot. In mixed fields, samples were targeted across the range of cultivars and ages.

Data Collected:

- Crop type, stage, and number of samples checked

- Aphids:
  - Cabbage or Green
  - Low (<5), medium (5-50), or high (50+) populations (2021)
  - Presence of aphids (2022)
  - Presence of winged aphids

- Caterpillars:
  - Quantity of eggs, small, medium, or large larva, pupae of each species, number of plants with caterpillars (2021)
  - Presence of eggs, larva, pupae or each species, number of plants with caterpillars (2022)
  - Presence of adult cabbage white.

- Flea Beetle:
  - Number of sites with flea beetle (low (1-2), medium (2-10), high flea beetle (10+)), as well as presence of flea beetle feeding damage (2021)
  - Number of sites with flea beetle or fresh feeding damage (2022)

- Cabbage Maggot:
  - Number of plants with eggs or larva
  - Presence of maggots in suspect plants.

- Additional notes were taken on other pests observed.

Results

Cabbage aphids:

Cabbage aphids (*Brevicoryne brassicae*) can be a major pest for brassica growers, contaminating crops even at low levels, and causing cupped and distorted leaves at higher densities. If left unmanaged there are many natural enemies of cabbage aphids that will bring populations levels back down, however, damage has often already occurred by the time the population is under control.

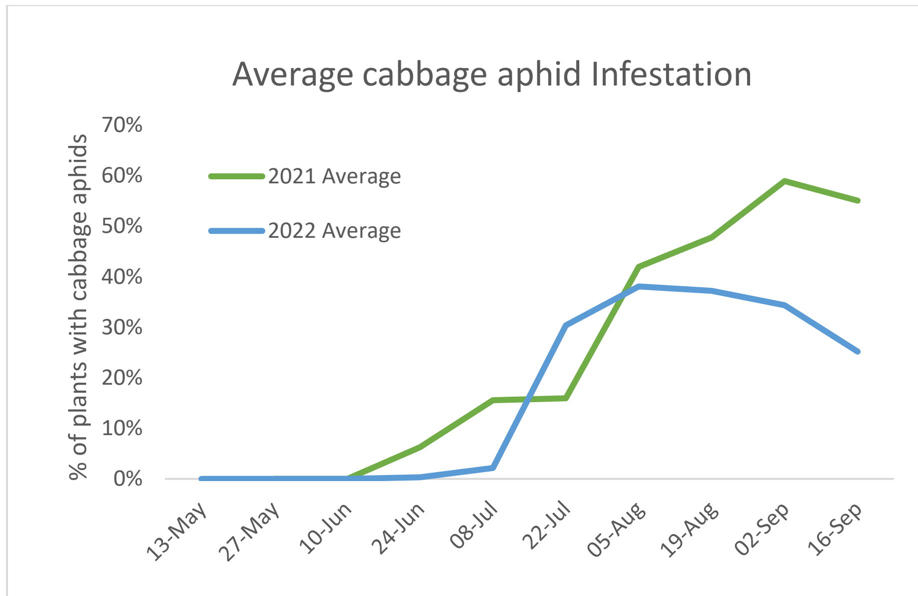


Figure 4. Average percentages of brassica plants with cabbage aphid infestation in 2021 and 2022.

In both 2021 and 2022 cabbage aphids first occurred in mid-June, and then proceeded to increase over the season. However, the rate of increase was different between years. In 2021 levels began to rise immediately after the first detection and continued to increase until late August. At the end of the season levels were still quite high, with an average of 55% during the September 16th monitoring period. Two farms reached levels of 100% infestation during 2021.

In 2022, levels rose only slowly after the first detection, and were still below 2% at the end of the July 8th monitoring period. While levels climbed quickly after that, reaching the average season maximum of 48% during the August 4th monitoring period, levels never reached the same heights as 2021. No farms reached 100% infestation during 2022, and levels began to drop soon after reaching the peak. By the September 16th monitoring period the average level had dropped to 25%.

Cabbage aphid colony and an imported cabbage worm caterpillar on a brassica leaf.

There were no regional patterns in either year, but there was considerable variation between farms. In 2021 one farm was monitored for cabbage aphids throughout the season and had no detections, even as other farms had 100% infestations. Differences between years are likely due to a slower pest build-up from the cooler spring, and possibly higher beneficial levels in 2022. Between farm variation is likely due to differences in management, beneficial levels, crop varieties and crops stages. Farm-level data is presented in the appendix. The one farm in 2022 with no cabbage aphid did not have brassicas monitored during main cabbage aphid season.

Table 4. Cabbage aphid infestation in brassica during 2021 and 2022. Values indicate the percentage of plants infested with cabbage aphid.

	2021	2022
1st cabbage aphid	June 16	June 15
Average maximum cabbage aphid infestation	August 20 – Sept 2: 59%	July 22 – Aug 5: 48%
Range of Maximum cabbage aphid infestation	0-100%	18-94%
Number of fields with cabbage aphids present (total number checked)	9/10	10/11

Caterpillars:

Three main species of brassica feeding caterpillars were monitored in 2021 and 2022: the imported cabbage worm (*Pieris rapae*), the diamondback moth (*Plutella xylostella*) and the cabbage looper (*Tichoplusia ni*). Caterpillars are an issue in brassica production due to contamination of the crop with caterpillars and feces and reduction in crop quality due to feeding holes in leaves. Except when plants are small, feeding damage does not typically result in a reduction in plant vigour.

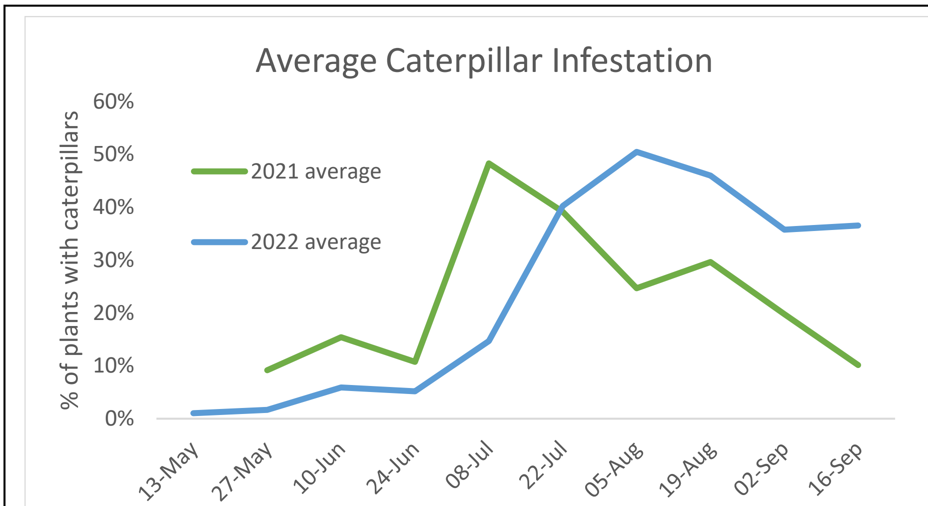


Figure 5. Average caterpillar infestation levels in brassica in 2021 and 2022.

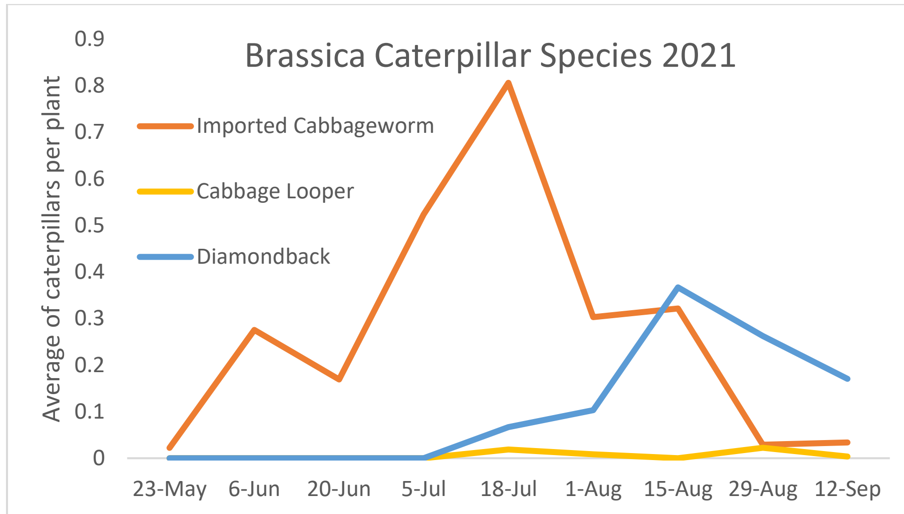
Although all three species of caterpillars were detected in both years, and caterpillars were present during all monitoring periods in both years, species composition and timing patterns were quite different between the two years.

During the 2021 season caterpillar abundance increased rapidly in the spring, to a maximum peak in abundance of 48% of plants infested during late June – early July. Numbers then declined until at the end of the monitoring season in September caterpillar abundance was approximately equivalent to spring levels, at around 10% of plants infested. The majority of caterpillars observed were imported cabbage worm, while cabbage looper were present sporadically and in low numbers, and diamond back showed up late in the season and in low numbers.

2022 caterpillar levels were initially low, with only 1-2% of plants infested, and they increased only slowly until early July, when numbers began to increase rapidly. This increase was largely driven by the arrival of large numbers of diamondback moths, which became the most commonly observed caterpillar species for the remainder of the 2022 season. The 2022 season maximum occurred a month later than in 2021, in late July - early August, and caterpillar infestations remained high for the rest of the season.

Cabbage loopers were also more common in 2022 than in 2021, although they were the least common of the three main pest species in both years.

Diamondback do not overwinter in the region, and so the abrupt arrival of this species in 2022 was likely due to weather conditions blowing large numbers of adults onto Vancouver Island. This rapid increase in caterpillars and the warning that VIPPB was able to provide to all growers that this species had arrived demonstrate the value of the monitoring program.



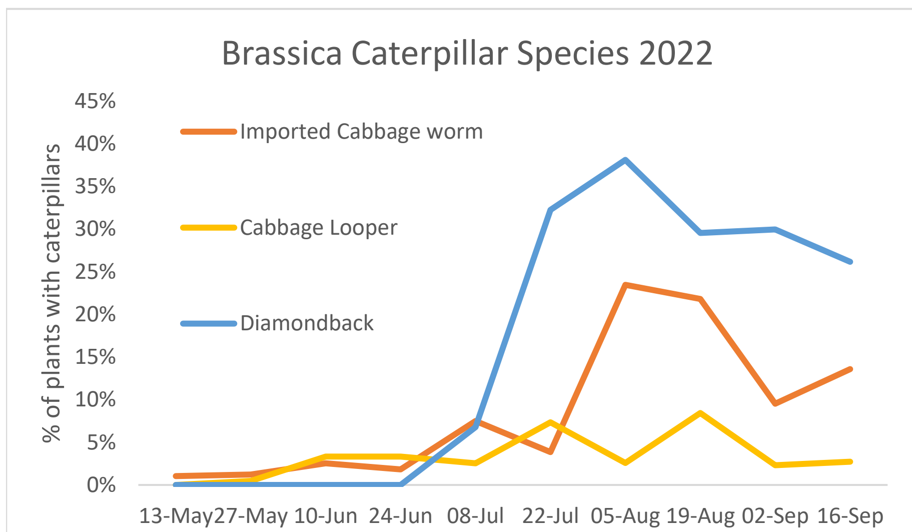


Figure 6. Brassica caterpillar species in 2021 and 2022.

Management actions for caterpillars should target small and newly hatched individuals. Given the wide size range between the three common species, knowing what species are currently present and how to distinguish between them is helpful to for growers to plan their management actions. Information collected on the presence of eggs, pupae and adults of the different species is also useful to predict future caterpillar levels.

Along with year-to-year differences, caterpillar levels also varied greatly between farms, based on the same farm-level differences in management, beneficials and crop timings that impact aphids. Regional differences were not observed.

Cutworm egg masses and caterpillars were also periodically observed in brassicas in both years.

Table 5. Levels of the three most common caterpillar species in 2021 and 2022.

	2021	2022
1st Imported Cabbage Worm Caterpillar	Present during all monitoring periods.	Present during all monitoring periods.
1st Diamond back caterpillar	July 7	June 28
1st Cabbage Looper caterpillar	July 7	Present in all monitoring periods
Maximum % of plants with caterpillars at the farm level	July 1: 100%	September 6: 100%
Average maximum % of plants with caterpillars.	June 24 – July 8: 48%	July 22 – Aug 5: 50%

Cabbage Maggot

Cabbage Maggot ((*Delia radicum*) can cause major loses to growers when present in high numbers. Eggs laid by the adult fly at the stem base of young plants hatch into maggots that feed within the roots. Once the larvae have hatched and entered the roots no control measures are effective. While eggs can be detected when plants are small by inspecting soil at the base of the plants, maggot that are lower in the soil or within the root can only be detected by destructive sampling and pulling of the plants. Cabbage maggot was present in both years of the project; however, the cooler and wetter weather of 2022 increased the amount of duration of damage observed.

VIPPB checked small plants for eggs, however once plants had grown large enough to make accessing the base of the stem difficult, egg checks ceased. While some cabbage maggot larvae were detected during stem checks for eggs, larvae were also detected later in the season when larval feeding resulted in wilted plants.

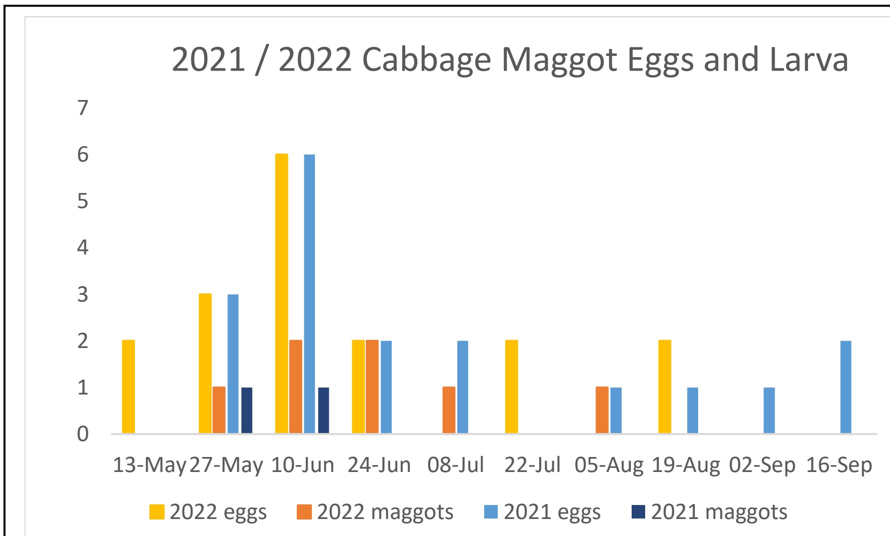
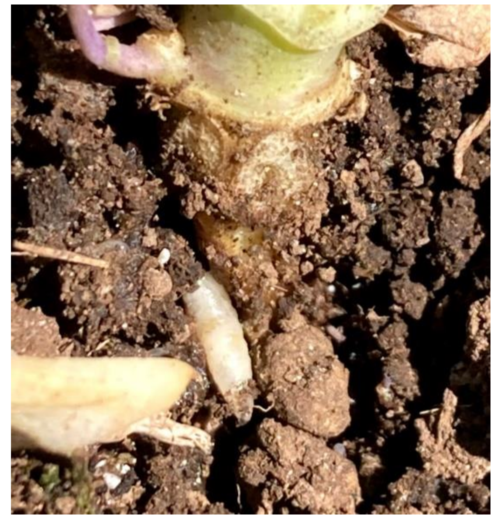


Figure 7. Number of farms where cabbage maggot eggs and larva were detected in 2021 and 2022

Because of these monitoring constraints, maggot egg detections are strongly correlated with plant size, and occur during periods of transplanting (spring and mid-season). Detecting eggs indicates that the adult flies are active and crops may be at risk, however during periods of hot dry weather eggs may not hatch. Larval detections, on the other hand, indicate that eggs laid earlier in the season successfully developed into larvae which were sufficiently numerous to wilt plants.

During 2021 egg detections occurred from May 17-September 9th, with only one monitoring periods where no eggs were detected (July 9 -22). However, larvae were detected only early in the season, suggesting that eggs laid later in the season either did not develop or the larvae did not do sufficient damage to be detectable.



Cabbage Maggot larva next to the root of a brassica.

In 2022, on the other hand, the cool and wet weather caused larval detections continued sporadically until July 26th, a month and a half later than in 2021. Egg laying, however, was detected less in the later season.

In both years two farms did not detect any cabbage maggot, however these farms did not have plants at an appropriate stage for egg checks during times when cabbage maggot was most active.

While most management strategies for cabbage maggot should occur prior to egg laying, this island wide monitoring data is useful to keep growers informed of the current risk of egg laying and demonstrates to growers the impact of different weather conditions on the risk of eggs hatching into damaging larvae.

Table 6. Cabbage maggot infestations in brassicas in 2021 and 2022.

	2021	2022
1st Cabbage Maggot Eggs	May 17: 5%	May 5: 38%
1st Cabbage Maggot Larva	May 19: 7%	May 25: 11%
Last Cabbage Maggot Eggs	September 9: 23%	August 11: (present)
Last Cabbage Maggot Larva	June 3: 5%	July 26: (present)
Maximum Eggs per Farm	May 19: 60%	July 14: 58%
Maximum Larva per Farm	May 19: 7%	May 31: 20%
Average Maximum Eggs	May 14-27: 26%	July 8 – 22: 58%
Average Maximum Larva	May 14-27: 1%	May 27 – June 10: 3%
Number of farms where Cabbage maggot occurred	8/ 10	8 / 10

Flea Beetle:

Crucifer flea beetle (*Phyllotreta cruciferae*) was another pest present in brassicas throughout the majority of the season. Early season feeding on young brassicas can kill plants, while later season feeding, particularly in salad brassicas can render the leaves unmarketable.

Crucifier flea beetle on a brassica leaf

We observed two generation of adult flea beetles in both years, with low flea beetle numbers early in the season, a peak in mid-late June, a mid-season low in July and early August and then increasing numbers later in the season.

Although the mid-season low was approximately 2 weeks later in 2022 than 2021, the majority of the variability in flea beetle levels seems to be at the farm level.

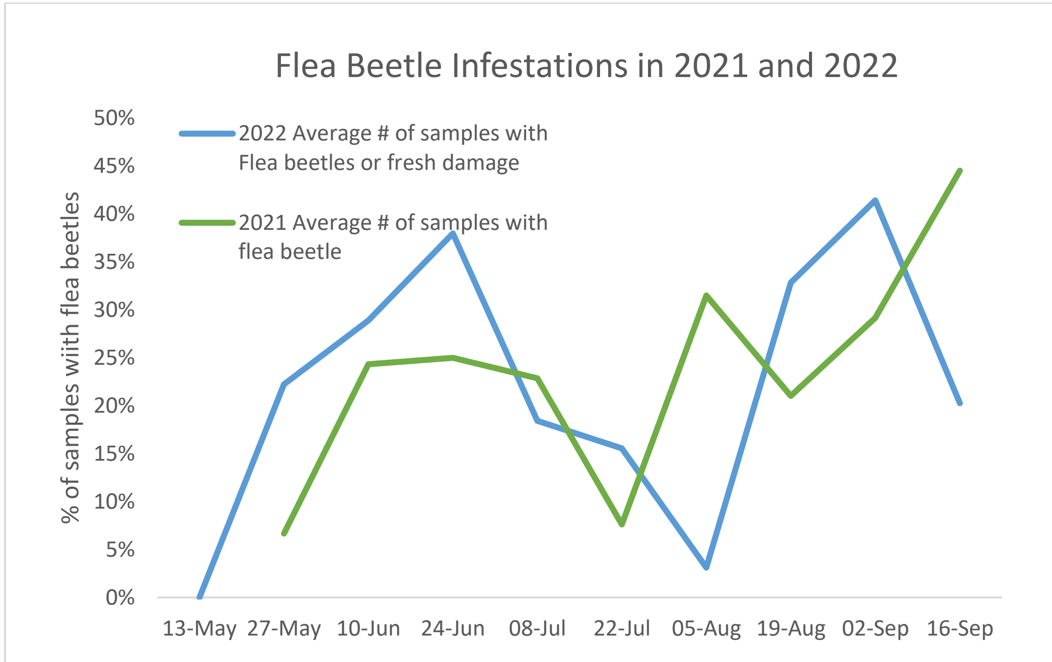


Figure 8. Flea beetle levels in brassica in 2021 and 2022.

In both years of the project, most farms could be divided into those with high (100% infestation) vs low (less than 33% infestation) levels. In the four farms where brassicas were observed in both years, three of the four were in the same category both years. Landscape level features and overall farm management likely drive total flea beetle population levels more than regional or yearly factors, while yearly weather patterns may contribute to the timing of population peaks and lows.

Table 7. Flea beetle infestation levels in brassicas in 2021 and 2022

	2021	2022
1st flea beetle	May 19: 33%	May 26: 100%
Average Maximum 1st peak	June 11 - 24: 25%	June 11 - 24: 38%
Average Mid-Season Low	July 8 - 22: 8%	July 22 - August 5: 3%
Average Maximum 2nd peak	September 3 -16: 45%	August 20 - September 2: 41%
# of farms with 100% infestation at some point in the season	3 / 9	6 / 11
# of farms never reaching above 33% infestation at any point in the season	4 / 9	4 / 11

Additional pests:

Thrips were observed in brassicas in both years. In 2021 they were casually observed beginning on July 15th remained present until the end of the season, reached high population levels and damaged crops on some farms. In 2022 thrip levels were recorded throughout the season and were first observed early in the season on May 19th. In 2021 thrips were observed on 8 / 9 farms, while in 2022 they were present on 10/11 farms. On some farms in 2022 thrip levels reached 100% of plants infested, however the amount of damage caused by thrips appeared lower in 2022. Further investigations into the impacts of thrips on brassicas on Vancouver Island is warranted.

Slug damage was also noted in both years, with more damage occurring in 2022. In 2021 spider mites were also observed on some brassica plants, but were not widespread, while no mites were observed in 2022.

Beneficials:

Beneficial insects observed while monitoring brassicas included spiders, aphid parasitoids and the aphid mummies created by them, hoverfly eggs, larvae and pupae, aphidoletes larva, adult lady beetles, rove beetles, lacewing eggs, larva and adults, orius and damsel bugs, caterpillar parasitoids wasps and their cocoons, and vesipid wasps.

Apples:

There are several serious pests of apples present on Vancouver Island. The fruits are attacked by two main pests: the codling moth (*Cydia pomonella*) and the apple maggot (*Rhagoletis pomonella*). Both these pests are internal feeders within the apples, and their presence renders the fruit unmarketable for the fresh market, although some farms do use the unmarketable fruit for juice. Foliage and blossoms can be attacked by multiple caterpillar species, mites, leafhoppers, and aphids. As these foliage pests also occur in berry crops, their monitoring results are reported with the berries.

Codling moth and apple maggot were monitored using traps, while other pests were monitored during leaf, blossom and fruit inspections. Pheromone traps (Traps: Scentry Biologicals inc, Pheromones: Trece Pherocon Codling Moth Lure) were used to record male codling moth activity, while red spheres (Olson Red Ball Traps) coated in tangle foot and baited with an attractant were used to detect apple maggots. These traps were checked during regular monitoring visits.

Timings of trap placement varied between the years, as did the type of attractant used in the apple maggot traps (see table). Tanglefoot on sticky spheres was replaced as needed, while pheromones and sticky bottoms were replaced every 6 weeks (once in 2021, and twice in 2022).

Foliage pests were monitored by checking five leaf and five blossom clusters per tree (1– 4 trees per farm).

Apples were monitored on nine farms in 2021 and eight in 2022. While some of the farms with apple trees were actively managed orchards (four farms in 2021, three in 2022), on the other farms the apple trees monitored were largely unmanaged, and in one farm in 2021 and two in 2022 the trees were part of a hedgerow and were not accessible for foliage and fruit monitoring. These three trees were only monitored with traps. On some farms both apple and pear present, and both tree types were monitored.

Data Collected:

- Crop type, stage, and number of samples checked
- Number of coddling moths per trap
- Number of apple maggot per trap.

- Aphids:
  - Low (<5), medium (5-50), or high (50+) populations (2021)
  - Presence of aphids (2022)
  - Presence of winged aphids

- Spider Mites:
  - Low (1-5), medium (5-10), or high (11+) populations (2021)
  - Presence of mites (2022)

Codling moth trap

- Caterpillars:
  - Number of leaves / flower clusters with caterpillars
  - Type present (leafroller vs spanworm)
  - Average size of caterpillars (2021 only)

- Fruit Damage:
  - Number and type of fruit damage

- Additional notes were taken on other pests and beneficials observed.

Apple maggot on a red sticky ball trap.

Results:

Apple maggot:

Apple maggot (*Rhagoletis pomonella*) is a quality limiting pest, with larvae tunneling through the fruit, resulting in rejection by growers and rot in storage. Although a relatively new pest to Vancouver Island, it was widespread and was detected in all farms where apple maggot traps were placed. In 2021 traps were baited with ammonium acetate and placed in early-mid June, however the first catches did not occur until July 29th. In 2022 the ammonium acetate could not be sourced, and a commercial lure (Apple Essence; Great Lakes IPM) was used instead. Given the delayed season and late trap catch in 2021, traps were not placed until late June – early July in 2022. In 2022 two farms had apple maggot captures on the first trap check after placement.

Dates of peak trap catches were the same in both years, however based on our two years of data it appears that the "Apple Essence" bait was able to detect apple maggot activity earlier in the season than the ammonium acetate and should continue to be used in future years.

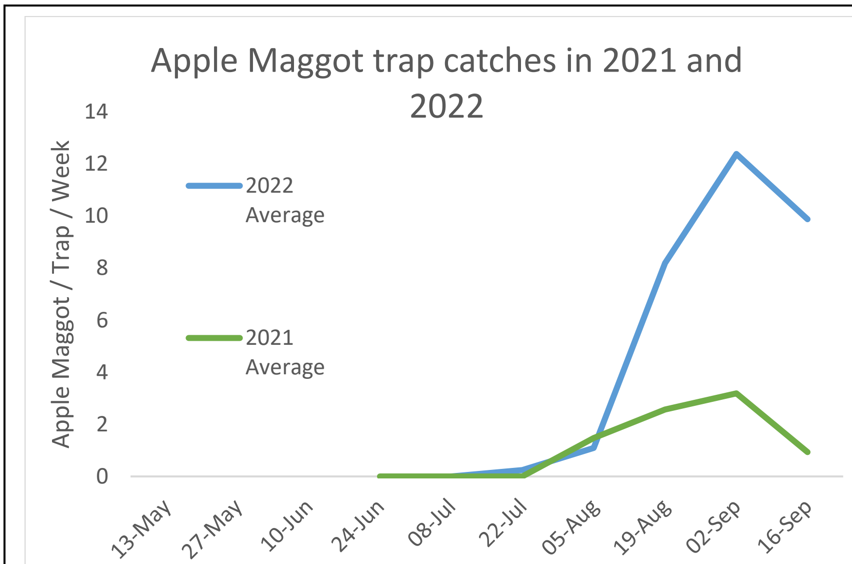


Figure 9. Apple maggot infestation levels in apple during 2021 and 2022.

There was considerable variation between farms in the levels of apple maggot present. In 2021 maximum numbers varied between one and ten adults / trap / week. In 2022 seven of the eight farms had a similar range, while the one remaining farm was a strong outlier, with a max of 69 adults / trap / week. This outlier was a large orchard which was not actively managing for apple maggot. Apple maggot did not appear to be impacted by the different weather conditions in the two years, possibly because the pest is active later in the season, when weather conditions were similar between the two years. As well, apple maggot infestation levels did not appear to vary between the regions in 2021, and regional difference in 2022 were driven by the one heavily infested outlier.

Apple maggot fruit damage is subtle, with very small egg laying "stings". In 2021 apple damage from apple maggot was observed primarily at harvest and from cutting open dropped fruit. In 2022, stings and eggs were observed starting on August 9th at the heavily infested farm.

Apple maggot continued to be present until the end of the monitoring period. Several growers expressed concern about the impact of apple maggot on their crops and the project data can assist growers in knowing when apple maggot adults are currently active in their region. Given the between farm differences, on-farm monitoring for apple maggot would be very useful for growers to understand the risk to their crop and the impact of their management practices.

Apple maggot eggs laid in the surface of an apple (stings). Photo N. Tymo.

Table 8. Apple maggot trapping in 2021 and 2022. Trapping values are adult apple maggot / trap / week.

	2021	2022
Apple Maggot Traps installed	June 4 – 17th	June 25 - July 8
Bait Used	Ammonium Acetate	Apple Essence
First Apple Maggot detection	July 29, 2021	July 12, 2022
First Fruit sting detection	Stings not observed, larval damage evident at harvest	August 9, 2022
Average Max	August 20 - September 2, 2021: 3.2	August 20-September 2, 2022: 12.4
Range of Maximum Apple Maggot	1.0-10.0	0.5-69.0
Number of farms with apple maggot detected / total farms with traps.	8/8	8/8

Codling moth:

Like apple maggot, codling moth (*Cydia pomonella*) larva infest the interior of the fruit, making it unmarketable. Codling moth were detected as adults using pheromone traps and as larva by observing entry and exit holes in fruit. Codling moth typically has two generations of adults each year, with the first generation larva infesting fruit that is typically small and may be removed during hand thinning. The second generation larva infest fruit that is close to harvest, and can result in rejected fruit and rot in storage.

Codling moth larva inside an apple.

In 2021 shipping delays meant that codling moth traps were not placed until mid-late June, after the first detection of fruit infestations on June 3rd. High codling moth catches immediately after trap placement, coupled with fruit infestations indicate that the first generation adult moth flight had already been in progress for some time, and the timing of the first generation peak may have occurred earlier in the season. In 2022 traps were placed during bloom in early May and the first adult detections were on May 31st, while the first fruit infestations were not observed until July 26th. The cool spring of 2022 clearly delayed codling moth development relative to 2021. However, the hot conditions later in 2022 appear to have allowed codling moth development to catch up, and the second generation peak in adult activity was only two weeks later in 2022 than in 2021. Because of the delay in collecting data in 2021, the timing of the first generation adult peaks cannot be accurately compared. In both years the first generation peak was larger than the second.

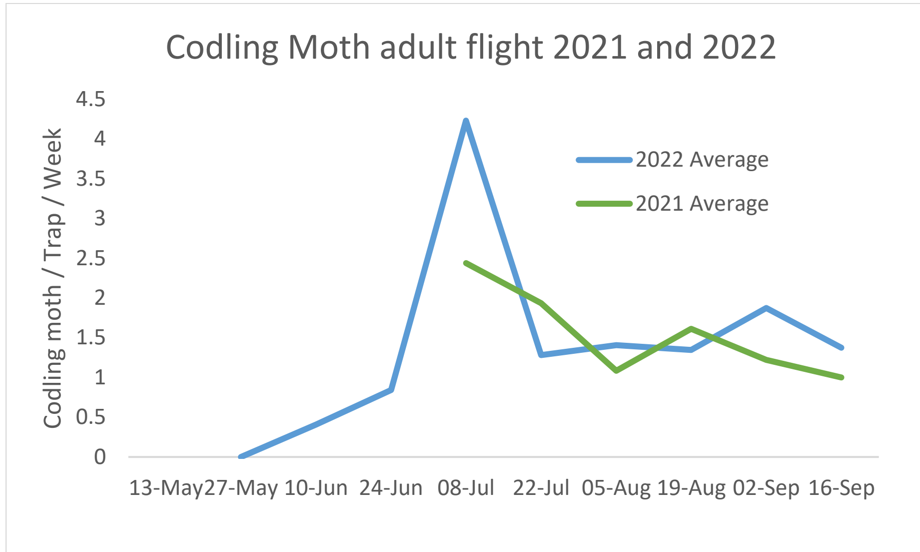


Figure 10. Codling moth adult trap catches in apple in 2021 and 2022.

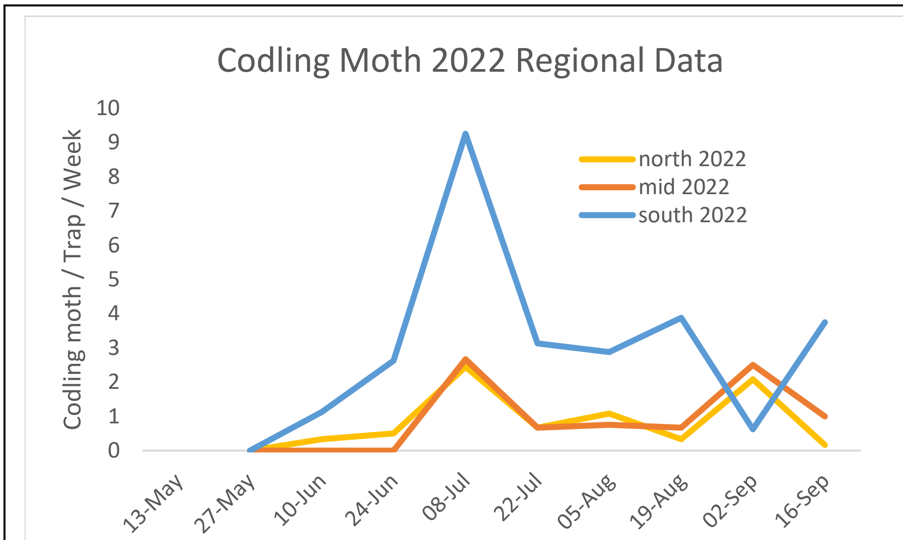


Figure 11. Adult codling moth flight in 2022 in three regions of Vancouver

As with apple maggot, there was considerable variation between farms. One farm with a newly established orchard had no codling moth detections in 2021, and a maximum of 0.25 moths / trap week in 2022. A different, well established orchard had a maximum peak of 16.5 moths / trap / week.

There is a degree day model for codling moth (Farmwest, 2022), and our trap catches in both years were in line with expectations from this model. Growers are encouraged to use the model in conjunction with pheromone trapping to determine peak codling moth egg laying periods, as well as the codling moth pressure within their own orchard.

There was some variation in timing and population levels between the north and mid island regions in 2021, however these two regions were very similar in 2022. The south island had one heavily infested outlier farm which greatly impacted population levels in that region in 2022, and makes comparisons difficult. The timing for the first generation peak in 2022 was the same between all three regions. The second generation peak in the south island in 2022 may have been earlier, and there appears to have been the beginnings of a third generation peak in that region. Microclimates in individual orchards, as well as past codling moth management likely determine timings and populations.

Table 9. Codling moth data from apple in 2021 and 2022. Values are adult moths / trap / week.

	2021	2022
Codling Moth Traps installed	June 17 – 30, 2021	April 30 – May 13, 2022
First Codling Moth Detection	June 30, 2021 (first trap check)	May 31, 2022
First Fruit damage detection	June 3, 2021	July 26, 2022
Average Max 1st peak	June 25 - July 8, 2021 2.4	June 25 -July 8, 2022: 4.3
Average Mid-season Min	July 23 - August 5, 2021: 1.1	July 8- 22, 2022: 1.3
Average 2nd peak	August 5 - 19, 2021: 1.6	August 20 - September 2, 2022: 1.9
Range in maximum trap catches (moths /trap /week)	0-7.5	.25-16.5
# of farms with coding moth detected / total farms	8/9	8 / 8

Additional pests:

Aphids, leafrollers and spanworm caterpillars were present in apples. Data on their populations is presented with the berry data. Additional apple pests included leafhoppers (Cicadellidae), apple leafcurling midge (*Dasineura mali*), thrips (Thysanoptera), apple leaf skeletonizer (*Choreutis pariana*), cherry slug sawfly (*Caliroa cerasi*), leafminer (*Phyllonorycter sp.*) and appleleaf blister mites (*Eriophyes*). In 2022 one farm in the south island also had apple sawfly (*Hoplocampa testudinea*). No spider mites were observed in apple in either year of the project.

Apple Sawfly larva

Beneficials:

Beneficial insects observed while monitoring apples included spiders, aphid mummies, hoverfly eggs and larvae, aphidoletes larva, lady beetle eggs, larva and adults, powdery mildew lady beetle eggs and adults, lacewing eggs, larva and adults, and orius bugs.

Berries:

VIPPB monitored the three main berry crops on Vancouver Island: blueberry, raspberry, and strawberry. At least one farm with each type of berry was monitored in each region. Berry crops share several generalist pests, as well as each having their own pest complexes.

One of the key pests in all three berry types is the spotted wing drosophila (*Drosophila suzukii* (SWD)), a fruit fly which is capable of infesting sound fruit. SWD were monitored using Contech SWD traps baited with apple cider vinegar and unscented dish soap. Traps were placed in hedgerows near blackberry bushes or wild habitat on every farm to measure general abundance trends in each region. In addition, traps were placed within berry fields to detect the movement of SWD into those crops. While VIPPB provided all the SWD monitoring in 2022, in 2021 the MAF regional agrologist placed SWD traps in blueberry and raspberry fields and hedgerows in the Victoria and Saanich area, providing SWD data for that region.

In both 2021 and 2022 aphids, mites and caterpillars were monitored during field walks, following specific protocols for each crop type (detailed below). Additional pests were also recorded in each crop. In 2022 additional monitoring occurred for the invasive strawberry blossom weevil (*Anthonomus rubi*). This consisted of beat samples in strawberries and yellow sticky cards placed in hedgerows and strawberry fields, as well as watching for clipped blooms in fields. Each farm, including those without berry crops also had a yellow sticky card placed in the hedgerow near the SWD trap to monitor strawberry blossom weevil. Strawberry blossom weevil data is shared in the invasive pests section.

SWD monitoring trap.

Strawberries: Make one to two diagonal passes through the field, inspecting four sites per pass. At each site inspect five plants for caterpillars, and pick five mature, fully opened leaves to inspect for aphids, spider mites and predators. Place SWD trap and collect at each visit. In 2022, once monthly during May, June and July, preform a tap sample on three plants at each site. Place yellow sticky cards on stakes within fields and label and collect monthly.
Blueberries: Inspect minimum four sites per field, spaced apart. For fields greater than ten rows, inspect two rows (four sites each). For each site inspect ten leaf and ten flower/fruit clusters. Place SWD trap and collect at each visit.
Raspberries: Inspect minimum four sites per field, spaced apart. For fields greater than ten rows inspect two rows (four sites each). For each site inspect ten leaf and ten flower/fruit clusters. Place SWD trap and collect weekly / biweekly. In 2022 once per season preform a tap sample for strawberry blossom weevil.

Data Collected:

- Crop type, stage, and number of samples checked

- SWD:
    - Number of male and female SWD in hedgerow traps
    - Presence of male and female SWD in berry crops
    - Observations of fruit damage.

- Strawberry Blossom Weevil (2022 only):
    - Presence of suspect strawberry blossom weevil in beats
    - Presence of suspect strawberry blossom weevil on yellow sticky cards
    - Presence of clipped blooms in raspberry or strawberry crops.

- Aphids:
    - Low (<5), medium (5-50), or high (50+) populations (2021)

- Presence of aphids (2022)
- Presence of winged aphids

- Spider Mites:
  - Low (1-5), medium (5-10), or high (11+) populations (2021)
  - Presence of mites (2022)

- Caterpillars:
  - Number of leaves / flower clusters with caterpillars
  - Type present (leafroller vs spanworm)
  - Average size of caterpillars (2021 only)

• Additional notes were taken on other pests and beneficials observed.

Results:

Spotted Wing Drosophila:

Spotted Wing Drosophila (*Drosophila suzukii* (SWD)) can infest many types of fruit and has multiple generations in a year. An infestation of SWD can result in fruit contaminated with maggots and it is a major concern for growers. In both 2021 and 2022 there were strong regional, seasonal and crop trends in SWD levels. Hedgerow traps on each farm were used to understand the overall seasonal patterns. The 2022 season started with SWD at fairly low levels, rising slightly in mid-June, before numbers dropped to their lowest levels in Mid July. From that point on levels rose steadily in all regions in both years, with the earliest rise and highest total levels occurring in the south island, followed by the mid island, and with the slowest and lowest rise in the north island. SWD traps were placed approximately a month later in 2021 compared to 2022, and the same general pattern occurred in both years. However, the overall SWD levels were much lower in 2022 compared to 2021.

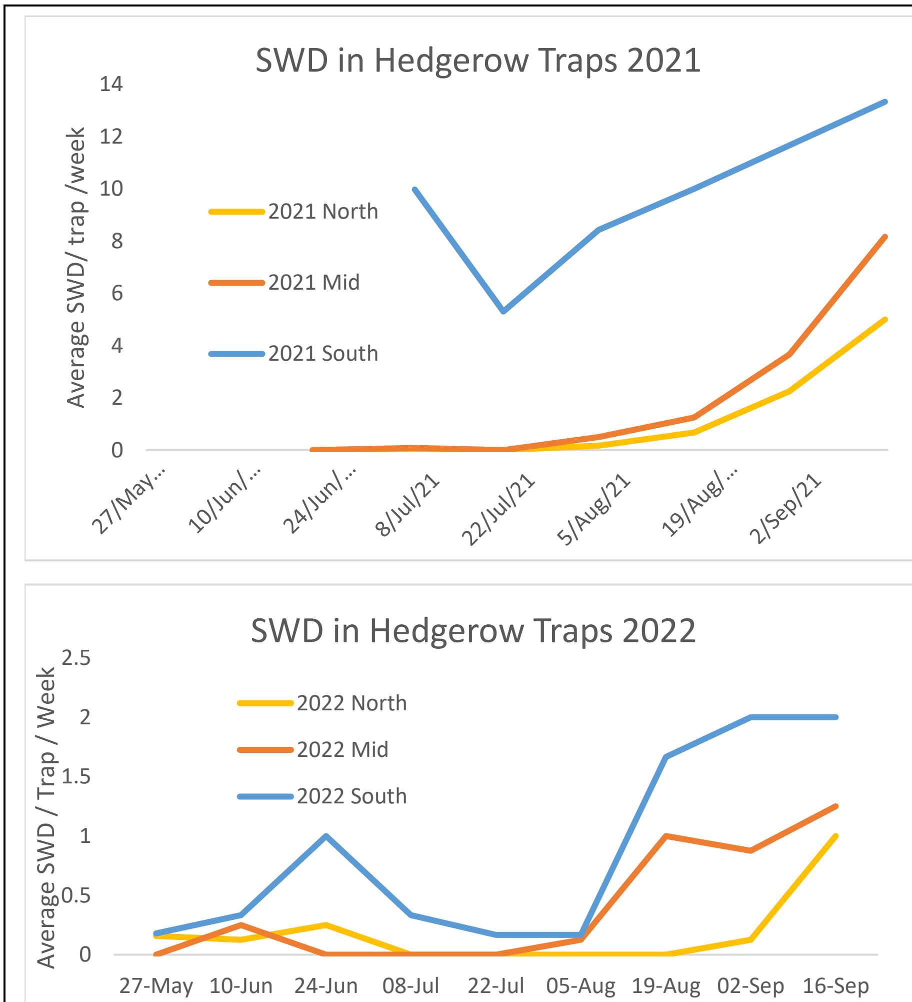


Figure 12. Spotted Wing Drosophila populations in the north, mid and south Vancouver Island regions in 2021 and 2022. Please note the different

In 2021 the average high in SWD was 13 SWD /Trap/ Week, while in 2022 it was 2 SWD / trap / week. In addition, detections of SWD in traps within crops occurred later and with less consistency in 2022 compared with 2021. However, in both 2021 and 2022 fruit infestations were observed in all regions. In 2021 they were observed in raspberries, while in 2022 they were observed in raspberries and blueberries, with some growers also reporting suspected SWD larva in strawberries.

An interesting pattern of a mid-season drop in SWD numbers occurred in all regions in 2022 and in the south island in 2021. This pattern likely indicates the increasing attractiveness of ripening fruit in fields compared to the apple cider vinegar bait in our traps, and a movement of SWD out of hedgerows and into fields. This drop also emphasizes that absolute SWD numbers in traps should not be used to make management decisions. The information provided by monitoring can be used by growers to allow them to better understand their current level of risk, based on their region, crop and seasonal progress. However, fruit testing is a better method of understanding the current level of infestation in the crop itself. While VIPPB did not regularly do fruit tests, information on this testing method was provided to growers to assist them with monitoring their own fruit.

Male and female spotted wing drosophila

Table 10. Spotted Wing Drosophila levels in berry crops in three regions of Vancouver Island in 2021 and 2022. N = north island, M = mid island, S = south island. Values indicate either the number of adult SWD caught per vinegar trap per week, or the percentage of fields where SWD were caught in traps.

	2021	2022
Date traps first placed	June 2-9	May 4-12
First Hedgerow detection (SWD / trap / week)	N: July 21 (0.5), M: June 24 (0.5), S: June 24 (0.8-4)	N: May 25 (0.6) M: June 1 (1), S: May 17 (0.5)
Average Maximum Hedgerow levels (SWD / trap / week)	N: Sept 12 (5), M: Sept 12 (8.1), S: Sept 12 (13.3)	N: September 3-16 (1), M: Sept 3-16 (1.25), S: Aug 20-September 2 (2)
Range of Max Hedgerow levels (SWD / trap / week)	N: Sept 8 (0.5-13.5), M: Sept 2 (0-27), S: June 30 (12.5-38.5)	N: Sept 15 (0-2), M: Aug 24 (0.5-3.5), N: Aug 9, Sept 6 (1-4)
First strawberry trap detection (Maximum percentage of Strawberry traps detecting SWD)	N: Aug 2-15 (100%), M: Aug 16-29 (60%)	N: August 20- Sept 2 (30%), M: Aug 6-19 (50%), S: Aug 6-19 (30%)
First Blueberry trap detection (Maximum percentage of Blueberry traps detecting SWD)	N: Aug 2-15 (50%), M: July 19-Aug 1 (25%), S: June 21 – July 5 (100%)	N: August 20 – September 2 (30%), M: Aug 5-19 (50%), S: May 28-June 10 (50%)
First Raspberry trap detection (Maximum percentage of Raspberry traps detecting SWD)	N: June 21 – July 5 (100%), M: June 21 – July 5 (100%), S: June 21 – July 5 (100%)	N: July 8-22 (100%), M: (0%), S: June 25- July 8 (100%)

There were a few outliers in the data. In 2021 one south island farm had very high SWD hedgerow numbers early in the season, and these numbers were not reached again that year. In 2022, our only raspberry field in the Mid island was very young, and had few ripe berries, resulting in low attractiveness to SWD.

Two Spotted Spider Mites:

Spider mites (*Tetranychus urticae*) were present during both years of the project, and in both years strawberries were the most heavily impacted crop, followed by raspberries. High spider mite levels can reduce plant vigour and productivity. Blueberries had no health impacts in both years, however in 2021 there was one detection of mites in blueberries bordering other infested crops, while there were no detections in blueberries in 2022. Apples did not have any detections of spider mites in either year. While similar patterns of infestation occurred in both years, the early hot and dry weather of 2021 clearly favored spider mite populations compared with the cool wet start to the 2022 season.

Mite populations were higher overall in 2021 and were much more prevalent in raspberries in 2021 than in 2022. In strawberries both years had the same pattern, with low populations at the start of the season, rising to a peak in mid summer, falling sharply in mid-August before rebounding and rising into the fall.

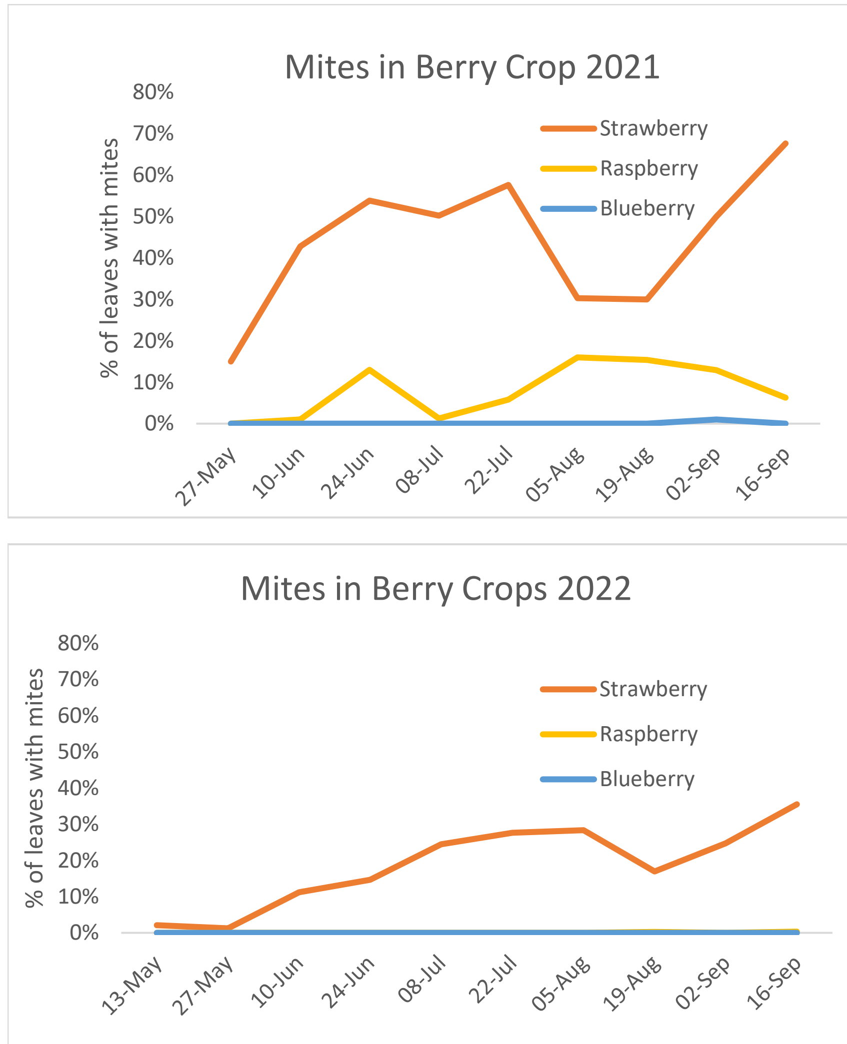


Figure 13. Mites levels in berry crops in 2021 and 2022.

In strawberries in 2021, starting mite levels were higher, and overall peaks were also larger than in 2022. The August mite drop in both years coincided with the mowing and disking of older and often more heavily infested strawberry fields, and the concurrent shift in monitoring to younger fields. Mite predators were also observed to increase over the season, reaching peaks in mid July and early August.

There was wide variation in mite levels in strawberries in both years, with some farms having 100% of leaves infested, while other farms had very low mite levels. (see appendix for individual farm graphs).

Table 11. Spider mite infestations in berry crops in 2021 and 2022. Values indicate the percentage of leaves with spider mites present. There were no spider mite detections in apple in either year.

	2021	2022
First detection Strawberry, Raspberry, Blueberry	Strawberry: May 19, Raspberry: June 2, Blueberry: September 1	Strawberry: May 5, Raspberry: August 9, Blueberry: No detections
Average Max detection	Strawberry: July 9-22 (58%), Raspberry: August 6-19 (15%), Blueberry: August 20- September 16 (1%)	Strawberry: September 3-16 (36%), Raspberry: September 3-16 (0.3%), Blueberry: No detections
Range of Maximum detection	Strawberry: 10-100%, Raspberry: 0-45%, Blueberry: 0-5%	Strawberry: 0-100%, Raspberry: 0-2%, Blueberry: No detections
Number of fields with mites	Strawberry: 5/5, Raspberry: 4/6, Blueberry: 1/ 5	Strawberry: 7/8, Raspberry: 2/6, Blueberry: 0/5

Caterpillars:

Leaf and blossom chewing caterpillars create issues in fruits and berries by destroying fruit buds in the early season, reducing yields. Later season caterpillar feeding on leaves does not typically weaken shrubs and trees, but can create harvest contaminants, and surface feeding on fruits such as apple can result in downgraded fruit.

The main caterpillar pest groups were similar in apple, raspberry, blueberry and strawberry. In 2021 and 2022 the main group observed were leafrollers (Tortricidae), with an early season peak, particularly in apple. Leafrollers also had a second smaller mid summer peak in both years. In 2022 an earlier start to monitoring and a delayed season also detected the single early season generation of spanworm (*Operophtera*), which are capable of doing substantial damage to early fruit and berry blooms. Thresholds for early season caterpillars are between 5-10% infestation, depending on crop and timing. Because of the small size, habit of

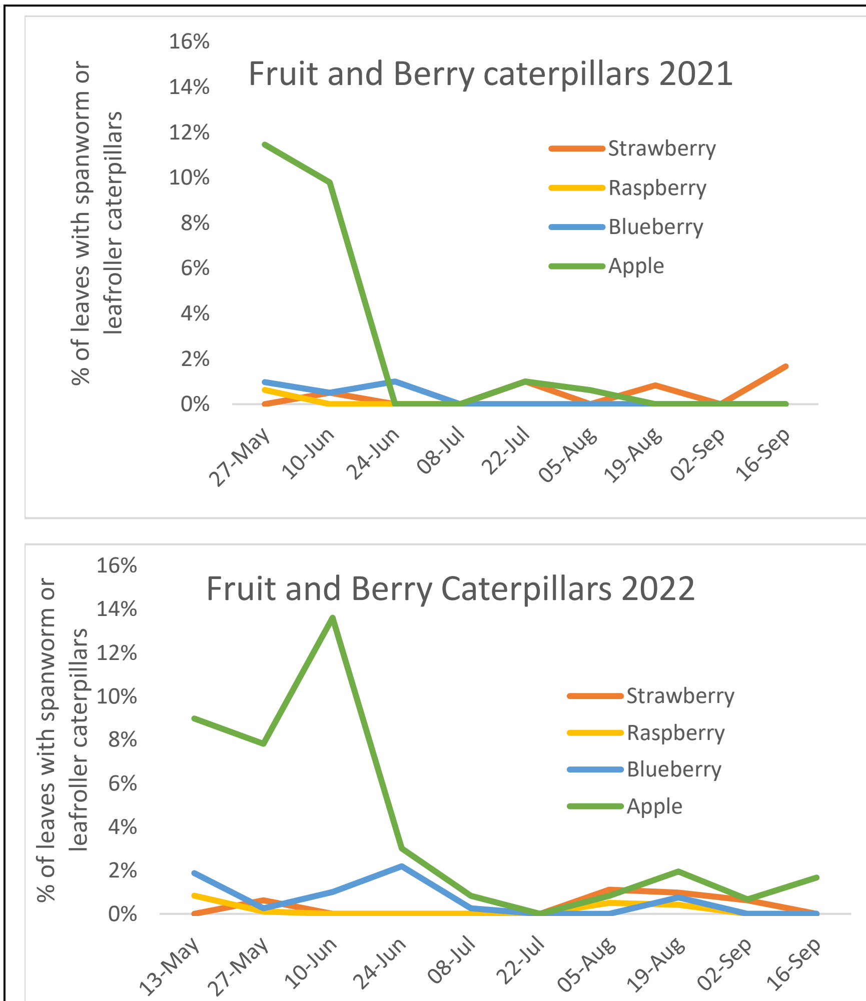


Figure 14. Spanworm and leafroller caterpillars in fruit and berry crops during 2021 and 2022.

feeding within blossoms and leaves, and early season activity, these spring caterpillars are often missed by growers. While apple was particularly hard hit in both years, some blueberry and strawberry fields also reached threshold in 2022.

Additional caterpillar species observed included apple leaf skeletonizer (*Choreutis pariana*), western tent caterpillar (*Malacosoma californicum*), and fall webworm (*Hyphantria cunea*).

Spanworm caterpillar in an apple blossom

Table 12. Leafroller and spanworm infestations in fruits and berries during 2021 and 2022. Values are percentages of leaf clusters and flower buds with caterpillars present.

	2021	2022
Average maximum leafroller and spanworm infestation	Strawberry: September 3-16 (2%) Raspberry: May 14-27 (1%) Blueberry: May 14-27, June 11-24 (1%) Apple: May 14- 27 (11%)	Strawberry: July 23- August 5 (1%) Raspberry: April 30-May 13 (1%) Blueberry: June 10-24 (2%) Apple: May 28-June 10 (14%)
Range of total maximum leafroller and spanworm infestation	Strawberry: 0-5%, Raspberry: 0-1%, Blueberry: 0-3% Apple: 0-60%	Strawberry: 0-7% Raspberry: 0-3% Blueberry: 0-6% Apple: 7-30%
Last spanworm detection	Not detected	June 2 (Blueberry)

Aphids:

Aphids of various species were present in all fruit and berry crops monitored. Depending on the crop and aphid species, aphid feeding can be an issue because it weakens the plant and reduces yield, because the contamination issues in the crop, or because of viruses spread within the crop by winged aphids. Large, healthy plants can sustain high levels of aphid feeding on leaves, and many beneficial insects will keep aphids in check. However, beneficials are unlikely to keep aphid below levels where virus spread can occur, and in crops such as blueberries the aphid mediated spread of scorch virus can lead to the death of bushes.

Blueberry leaf with aphids and a hoverfly egg.

Both years and all crops had the same pattern of a rise in aphid infestations over the season, reaching a peak and then dropping back down, however the timing and height of the peaks of aphid infestation varied between crops and years.

Peaks of aphid infestation were later by approximately one month in 2022 compared to 2021, likely due to the slow spring and delay in plant development. However, aphid levels reached higher peaks in blueberry and apple in 2022, while raspberry was more heavily infested in 2021. Strawberry maximum infestation levels were equivalent in both years. These differences may represent the different species present in each crop, and their response to the lush growth produced by the wet 2022 spring. Differences between farms were evident in strawberry (see appendix for graph), with both timing and height of peaks varying between farms. In blueberries the timing of the aphid peak was very similar between farms, while the infestation level varied between farms. In apple and raspberry, some farms had issues with aphids, while other farms were very clean.

Many aphid predators and parasitoids were observed over both years of the study. These beneficial insects typically appeared in the most heavily infested farms. The late season drop in aphid levels, particularly in crops such as blueberries, was correlated with evidence of beneficial insect activity.

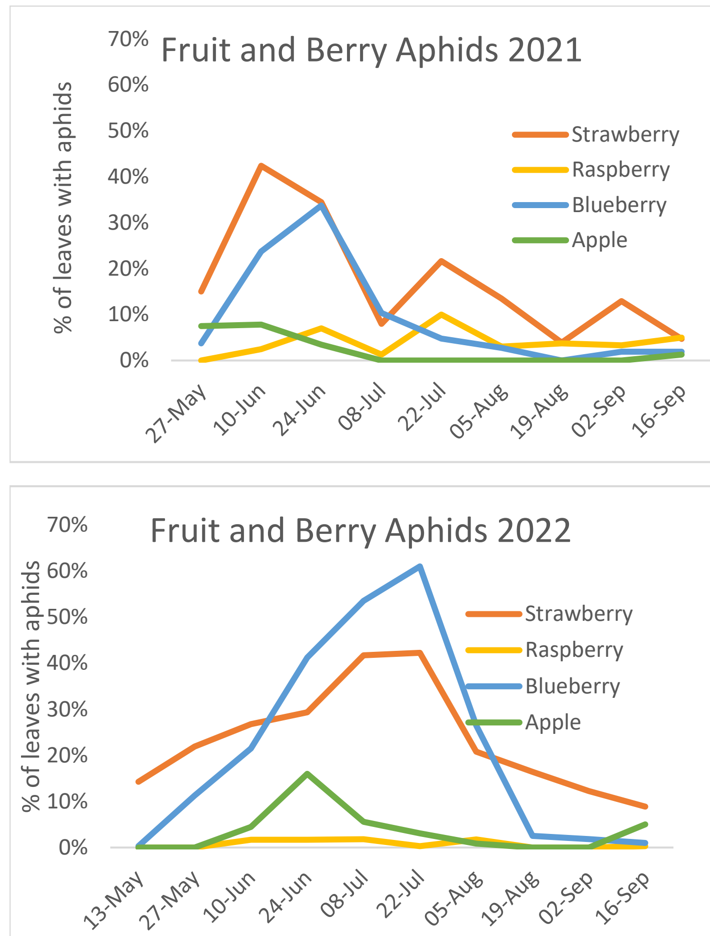


Figure 15. Aphid infestations in fruits and berries during

Table 13. Aphid infestations in fruit and berry crops during 2021 and 2022. Values are percentage of leaves with aphids present.

	2021	2022
Average maximum infestation	Strawberry: May 28- June 10 (42%), Raspberry: July 9-22 (10%), Blueberry: June 11- 24 (34%) Apple: May 14- June 10 (8%)	Strawberry: June 25 – July 22 (42%), Raspberry: May 28 – July 8, July 23- August 5 (2%), Blueberry: July 9-22 (61%), Apple: June 11-24 (16%)
Range of maximum infestation levels	Strawberry: 27-70%, Raspberry: 0-35%, Blueberry: 15-68%, Apple: 0-35%	Strawberry: 25-95%, Raspberry: 0-8%, Blueberry: 3-91%, Apple: 0-60%
Number of fields with aphids	Strawberry: 5/5, Raspberry: 6/6, Blueberry: 5/ 5, Apple: 6/8	Strawberry: 8/8, Raspberry: 5/6, Blueberry: 5/5, Apple: 3/6

Additional pests:

Over the course of the season other berry pests observed included spittlebugs (Cercopoidea), raspberry sawfly (Tenthredinidae), leafhoppers (Cicadellidae), Lygus (*Lygus sp.*), stink bugs (Pentatomidae), raspberry crown borer (*Pennisetia marginata*), thrips (Thysanoptera), blueberry gall midge (*Dasineura oxycoccana*), earwigs (*Forficula auricularia*), cyclamen mites (*Phytonemus*), whitefly (Aleyrodidae), fleabeetles (Alticini), root weevils (*Otiorhynchus*), and slugs (Gastropoda).

Beneficials:

Beneficial insects observed while monitoring berries included spiders, aphid parasitoid wasps and mummies, hoverfly eggs, larva, pupae and adults, aphidoletes and feltiella larva, lady beetle larva, pupae and adults, powdery mildew lady beetle adults, spider mite destroyer lady beetle eggs, larva, pupae and adults, rove beetles, lacewing eggs, larva and pupae, predatory mites, orius bugs and SWD parasitoid wasps.

Invasive Pest Monitoring

In 2022 additional monitoring occurred for emerging invasive pests, including corn rootworm (*Diabrotica virgifera*), Strawberry Blossom Weevil (*Anthonomus rubi*), Spotted Lanternfly (*Lycorma delicatula*), and Brown marmorated stinkbug (Halyomorpha halys).

Corn rootworm:

Yellow sticky cards were placed in corn fields on 4 of the participating farms. Traps were placed between July 12-14, 2022 and removed between August 23-25th 2022. No suspect corn rootworm were observed in the traps, and no feeding damage was observed on the corn plants.

Strawberry Blossom Weevil:

During the months of May, June and July, yellow sticky cards were placed in hedgerows on each farm, and in each strawberry field. These were collected monthly and examined for strawberry blossom weevil. In addition, beat samples occurred in each strawberry field once during May, June and July. Beat samples also occurred once on each farm in raspberry or blackberry bushes. Suspect strawberry blossom weevils were submitted to the Ministry of Agriculture for further identification. No confirmed strawberry blossom weevil were observed.

Spotted lanternfly:

Spotted lanternfly searches occurred twice on each participating farm during the 2022 season, once in late July and once in late August. Each search took 15 minutes, and occurred in crops likely to host spotted lanternfly. No evidence of spotted lanternfly was observed.

Brown Marmorated Stinkbug (BMSB):

Pheromone traps consisting of a Pherocon StinkBug STKY Dual Panel Adhesive Trap combined with a Pherocon BMSB Dual Lure were placed on each farm between July 26-August 4, 2022. Traps remained in place until the end of the season between September 6-15th, 2022.

One nymph and one adult BMSB were captured on one farm in the mid island region, and one adult was captured on a different mid island farm. No additional BMSB were captured on traps, however the iNaturalist project did receive two observations of BMSB from the same location in the Comox Valley.

Beneficial insects / Community Science Project

Pollinators, predators, and parasitoids are all important beneficial insects to agriculture, but they are often overlooked or mis-identified by growers focused on managing pest species. This aspect of the project set out to document and bring attention to the diversity of beneficial insects present in agricultural settings through engaging producers and the broader public with the citizen science platform iNaturalist. Gardeners, farmers, and naturalists were recruited to join and were invited to add photos of insects they observed in agricultural settings to the project.

During the process of adding observations, participants were also encouraged to report the agricultural scale, the type of farming practices, the crop, and any additional notes they had on the observation. The VIPPB project team also documented insects observed during crop monitoring on the iNaturalist project. The iNaturalist app automatically captures location and date information, and also provides a preliminary suggestion for identification. The VIPPB team, as well as other taxonomic experts and community scientists active on iNaturalist then refine the identification.

During 2021, 59 people joined the project, and 32 added observations. At the end of 2022 the project had 80 members and 42 observers. The project continues to be live, and additional observations continue to be added. The most up to date project information can be found on the project page here: https://www.inaturalist.org/projects/vi-pests-pollinators-and-beneficials.

Table 14. Participation in the iNaturalist project during 2021 and 2022.

	2021	2022
Members	59	80
Observers	32	42
Observations	825	1502
Species / Groups observed	277	397
Identifiers	234	337

Results

iNaturalist records as “research grade” only those observations that have been identified to species level by at least two different (and agreeing) members. Many insects are not able to be identified to species level from photos alone, and therefore all observations are reported here, rather than just research grade observations.

Most observations were made of large or showy species. The majority were insects (1350), followed by spiders (80) and slugs and snails (19). Within the insects, the bees and wasps had the most observations (509) followed by beetles (257), flies (192), butterflies and moths (190), bugs (138) and lacewings (23).

The bees and wasps with the most observations were bumble bees (185), hairy belly bees (65), Vespid wasps (44), sweat bees (38) honeybees (25), square-headed wasps (20), Ichneumonid wasps (20), ants (19) and mining bees (17).

Within the beetles, ladybeetles (121), ground beetles (26) and leaf beetles (27) were most common, while in the flies the most common group were the hover flies (82). The most common lepidoptera were butterflies (54) and cutworms (Noctuidae) (36). Within the bugs aphids (29), stink bugs (28), leafhoppers (13) and plant bugs (13) were commonly observed.

The five most commonly observed species were the Asian Lady Beetles (*Harmonia axyridis* 42), the Yellow-Fronted Bumble Bee (*Bombus flavifrons* 38), the Orange-rumped Bumble Bee (*Bombus melanopygus* 24), the Western Honey Bee (*Apis mellifera* 23) and the Seven-spotted Lady Beetle (*Coccinella septempunctata* 22).

A list of all the species observed can be found in the appendix. Out of the 392 species documented by the project, 233 achieved research grade.

The majority of observations were from hobby farms and gardens, while a smaller number were from commercial agricultural settings. There was a clear division between those who tested out the project by submitting only a few observations but did not carry on adding observations and those who found it enjoyable and proceeded to submit many observations of a wide variety of species. Nineteen of the observers in the project submitted less than 5 observations each, while eight observers submitted over 50, and two observers submitted more than 200 observations each. While some of the most prolific observers were gardeners, seven out of the top 15 participants were submitting observations from agricultural settings.

Participants who did not submit observations were still able to look through the observations submitted by other participants, use a map feature to see what was observed in their area, and contribute identifications.

INaturalist was particularly useful for documenting pest outbreaks (e.g. coreopsis beetle), the spread of invasive species (e.g. brown marmorated stink bug) and for differentiation between similar looking pest and beneficial species (e.g click beetles vs ground beetles and caterpillars vs hoverfly larva). For growers without access to professional monitoring services naturalist can be a helpful starting point for determining insect identifications.

Table 15. Observations submitted to the VIPPB iNaturalist project. Data current as of December 2022.

	Observations all	Species All	Observation Research Grade	Observations Hobby Farm / Garden	Observations Small – Large Scale Agriculture	Observations Non-Agricultural
All observations	1486	392	659	983	435	67
Bees all	355	37	163	262	59	25
Bumble bees	185	8	100	140	34	10
Flies all	192	64	78	134	58	0
Hover fly	82	22	54	69	13	0
Beetles all	257	67	138	143	98	16
Lady Beetle	121	11	85	69	45	7
Ground Beetles	26	11	17	16	9	1
Spiders	80	20	26	47	14	2

Outreach:

Since the main focus of the project was to disseminate information to growers, outreach was an important element of the project. The data collected from monitoring was used to support growers in IPM and decision making in real time. The four main methods of grower outreach were:

- A biweekly newsletter
- Social media
- The iNaturalist platform
- On-farm IPM workshops / events

Newsletter:

A biweekly newsletter was published during the 2021 and 2022 monitoring season. Nine editions were published in 2021 season, with the first edition on May 25th and the last on September 14th. In 2022 10 regular issues were produced, from May 15th to September 18th, and one extra issue went out in April 2022 to update growers on the project for the coming year. In 2022 a landing page was also created that collected links to the different parts of the project and provided updated info on workshops and educational opportunities.

Each regular edition reported on the monitoring data collected over the previous two weeks, along with extra information on various pests, beneficial insects, IPM principals, management methods and upcoming events. In 2021 initial distribution was by email to 54 contacts, including local farmers' institutes (14) and growers' associations (23). By the end of 2022 the email subscription list had 287 subscribers, however many of the subscribers forwarded the newsletter on to additional members of their organization, resulting in additional "opens". The most successful newsletter on August 7, 2022 was opened 733 times.

The initial three newsletters of 2021 were sent from google drive, and therefore had no data associated numbers of people opening them, however from the July 6, 2021 newsletter onwards Mailchimp was used to create the newsletters. This program provided a much smoother interface, and also provides data on open rates, link clicks and other metrics (See table).

Newsletters in 2021 averaged around five pages. Data from year end surveys in 2021 indicated that growers valued more detailed information on pest and beneficial insects, as well as management options. The pest and beneficial focus sections were therefore expanded in 2022, and the monitoring reports section became more detailed. A new section, authored by Kiara Jacks was also introduced in 2022. This consisted of six "IPM Basics" sections with information on management techniques. With these changes, the newsletter expanded to an average of 8-9 pages, with links allowing readers to jump to the sections of greatest interest. The newsletter was also used to promote summer on-farm workshops in 2021 and 2022 and was used to promote the iNaturalist project.

In 2022 additional links were added to the newsletter connecting to extension pages with additional information on pests and beneficials, as well as links to the "Small Farm IPM Guides". The addition of these links in 2022 increased the "click rate", with a maximum of 173 links clicked from email recipients of the June 26, 2022 newsletter. Popular links included the highlighted pests each month, as well as the Small Farm IPM Guides.

Newsletters can be viewed here: https://us6.campaign-archive.com/home/?u=9f86e069f3634feb73ae1a3a8&id=0ab22bd905

Table 16. Distribution of the VIPPB newsletter. Deliveries indicate the number of emails successfully sent from VIPPB, while email opens indicate the number of times of individual times the email was opened, including both emails that have been forwarded to additional people, and multiple readings of the email by the same person. Clicks indicate the number of times links within the newsletter were clicked from the email, while social media opens indicate the number of times the newsletter was opened from a social media post.

Date	Deliveries	Total email opens	Email clicks	Social media opens
May 25, 2021	54	N/A	N/A	N/A
June 7, 2021	54	N/A	N/A	N/A
June 22, 2021	100	N/A	N/A	N/A

July 6, 2021	113	293	6	66
July 20, 2021	117	224	9	112
August 3, 2021	131	157	7	93
August 17, 2021	136	161	29	174
August 31, 2021	137	338	74	198
September 14, 2021	141	284	68	288
April 13, 2022	162	404	77	17
May 15, 2022	200	357	41	99
May 29, 2022	205	438	82	70
June 12, 2022	211	388	162	46
June 26, 2022	235	421	173	135
July 10, 2022	272	642	120	52
July 24, 2022	276	434	113	64
August 7, 2022	276	614	64	119
August 21, 2022	278	342	38	68
September 4, 2022	277	378	112	127
September 18, 2022	279	289	30	71
Totals	3654	6161	1205	1793
Landing Page	173 visits	7 clicks	5 subscribes	

Social Media:

VIPPB ran two social media pages in 2021, and one in 2022. The VIPPB Facebook page was used in both years, with 38 posts in 2021 and 32 in 2022. In 2021 the total post reach was 10,172 while in 2022 post reach was 9,658. At the end of 2022 the Facebook page had 182 likes and 276 followers.

Although 24 tweets went out on the twitter account in 2021 and it was linked in the newsletter, twitter was not well used, with only 10 followers at the end of the 2021 season. While each edition of the newsletter was still posted to the twitter account in 2022, no additional twitter posts were made.

Facebook posts were made at least once per week during the monitoring season. Posts shared each edition of the newsletter, informed growers about upcoming events, highlighted pests and beneficials currently being observed, featured other aspects of the project such as the iNaturalist Project and shared link to other resources.

Posts from the Facebook account were shared to various Farmers' Institute pages, farming groups, and gardening groups. Popular posts with many shares and likes included posts highlighting beneficial insects and posts sharing pest alerts. The most popular post in 2021 highlighted different beneficial ground beetles and connected the iNaturalist Project (reach: 3,041; Reactions: 59), while the 2022 most popular post shared observations of a brassica caterpillar parasitoid wasp (Reach: 969, Reactions: 57). Posts with few shares and likes were typically posts containing only links to resources.

iNaturalist:

The iNaturalist project was promoted via email to multiple garden groups, bee clubs, naturalist groups and farmers' institutes on Vancouver Island. An introductory online training / webinar in 2021 was well attended, with 30 "live" participants and the link to the recording was also sent out to all registrants (71 registrants). The iNaturalist project was also promoted in each newsletter, on the Facebook page, and during events and workshops.

The newsletter and other aspects of the program were also promoted through journal posts in the iNaturalist project.

While some iNaturalist participants were not interested in other aspects of the project, there was considerable overlap between the groups using the iNaturalist and the newsletter / monitoring data, particularly for gardeners, hobby farmers and small-scale farmers.

The iNaturalist journal post feature was used to highlight and promote different beneficial insects found by the project through six posts in each year. Notifications about these journal posts were sent to all the members of the project (80), and content from many of these posts was also used in the beneficial insect focus sections of the newsletter and as Facebook posts. The Facebook posts sharing content from the iNaturalist journal posts were some of the most widely shared and liked posts.

Workshop / Events:

On-farm workshops occurred during the summers of 2021 and 2022. In both years one workshop occurred in the north, mid and south island. These events provided an opportunity for growers to observe monitoring in action and to get hand-on experience looking at and identifying some of the different pests that occur in Vancouver Island agriculture. In both years the workshops started with introductions, followed by a half hour discussion on the general concepts of the workshop. The workshop then moved into an interactive farm walk, looking at examples of different monitoring traps and techniques, and answering questions about different monitoring and management strategies and the pest and beneficial insects currently present on the host farm.

On-farm workshop in progress.

The 2021 the workshop introduced participants to general IPM principals: Prevention, Identification, Monitoring, Thresholds, Control (cultural, physical, biological and chemical options) and Evaluation.

In 2022 the workshops focused on Monitoring and Management, different insect lifecycles and patterns of abundance and how to use monitoring data to make decisions.

A handout was provided each year, with information on the focus topic, and a list of resources for further study.

Carrot rust fly was a focus pest in each of the session, both because carrot is commonly grown and was present at each of the sites and because carrot provides a clear example of the benefits of IPM and monitoring. Attendees were given the opportunity to identify carrot rust fly on sticky cards, and to take carrot rust fly samples home. SWD samples were also provided for any participants who wanted to learn to monitor for that pest. Each workshop was slightly different, based on the crops present on the host farm, the pests currently present, and the questions posed by the participants.

A display with different monitoring traps, newsletter samples, display boxes of pollinators and beneficial insects, reference books and print outs of the Small-Farm IPM-Guides was set up at each workshop so that participants could become familiar with the resources available to them. The Small-Farm IPM-Guides were also used during the interactive farm walk portion of the session, demonstrating how the protocols in the guides could be implemented.

The workshops were advertised through the newsletter, Facebook, and the farmer's institutes, and were geared towards farmers. The attendees varied from gardeners and hobby farmers to small and large scale growers. In 2022 in several south island farms sent multiple farm hands to attend the workshop.

Participants were highly engaged and came with many questions. Each workshop occurred at a different farm, with the intention of attracting different participants, but some participants found the workshop sufficiently valuable to attend both years.

In addition to the summer on-farm workshops, VIPPB also provided presentations to several farmers' institutes during the fall and winter of 2021-22, a presentation at the 2022 Island AG Show, a webinar at the beginning of both the 2021 and 2022 season, and participated in two additional webinars put on by CAI during fall 2021 discussing how VIPPB is managing pests and supporting pollinators. Additional outreach events are planned at the 2023 Island AG Show. The project also generated interest from garden clubs and other organizations that were outside of the scope of the project to attend.

Table 17. Outreach events VIPPB participated in during the 2021 and 2022 seasons.

Date	Event	Attendance
June 10, 2021	iNaturalist Webinar	30
July 8, 2021	On-Farm Workshop: North Island	14
July 14, 2021	On-Farm Workshop: South Island	12
July 28, 2021	On-Farm Workshop: Mid Island	12
November 15, 2021	Farmers' Institute: Mid Island Farmers' Institute	12
October 19, 2021	Webinar: CAI	CAI webinar series: Managing Changing Pest Pressures in a Changing Climate
October 26, 2021	Webinar: CAI	CAI webinar series: Monitoring and Supporting Pollinator Populations in a Changing Climate
April 19, 2022	Comox valley farmers institute	38
March 18, 2022	Field day Mid island	20
March 21, 2022	Field day north island	30
April 28, 2022	Spring webinar	12
June 13, 2022	On-Farm Workshop: North Island	18
June 14, 2022	On-Farm Workshop: South Island	19
June 15, 2022	On-Farm Workshop: Mid Island	9
July 7, 2022	Island AG Show	9
October 8, 2022	Denman Apple and Nut Festival	30*
February 3, 2022	Island AG Show	21

*While this event featured VIPPB data, it was outside the project scope and was attended independently

Successes, challenges, and future considerations

The Vancouver Island Pests, Pollinators and Beneficials Project (VIPPB) was a two year project, with the goal of increasing the uptake of IPM among Vancouver Island growers, as well as collecting baseline pest and beneficial occurrence data. While the project is now wrapped, the successes and challenges the project faced can be helpful for designing future projects. An end of project survey was sent out in the newsletter, on Facebook and on iNaturalist to receive feedback on the project, and the results of this survey are included below.

Pest Monitoring

Successes:

- The VIPPB project was able to provide comprehensive monitoring on a broad suite of pests, in multiple crops over a two-year period. Using this data, the project was able to demonstrate differences in pest populations between different farms, different crops, different years and different locations. This data provides an important baseline for understanding pests in the focal crops on Vancouver Island.
- Shifting to a presence / absence monitoring model in 2022 provided good data on a larger variety of pests than in 2021, and given the high variability between farms, precise data on an individual farm was not as useful to growers as general data on a wider variety of pests.
- By providing the monitoring data in real time to growers through the newsletter, growers were able to know which pest species were likely to be causing issues at any given time. The different weather conditions in the two years of the study also provided an opportunity to demonstrate the impact climate has on pest populations. Monitoring each crop on multiple farms provided data on the possible range of pest levels that growers could be facing, and on the different timings in different regions and between farms in the same region. While many pests varied more between farms than between regions, monitoring in a wide range of farm locations and farm types provided the growers who were accessing the monitoring data confidence that the data was relevant to their farms. For pests with regional differences in population levels, documenting those changes allowed growers to assess their relative risk depending on their location.
- Providing information on what pests were currently active assisted growers in their own pest identification and provided a warning system when new pests became active. This information is especially valuable to new entrant growers and growers branching out into new crops. The invasive pest monitoring included in the project also provides an early warning system for growers in case of an outbreak of a new pest species.
- Study farms were provided with copies of monitoring data collected on their farms. This was a valuable tool for them to use to understand how their management actions impacted their crops, and the experience of having data to use to make management decisions may increase the likelihood that these growers will begin their own monitoring programs in the future. One farm comment on this aspect of the program was "THIS was such an incredible bank of monitoring data that was specific to our farm, and what we would ideally have every season, but aren't able to stay on top of with just the two of us. We're already seeing the benefits of using this data in our decisions around the farm."
- Participating growers were able to observe monitoring in action and ask questions to VIPPB staff during their monitoring visits. These interactions provided context to the monitoring data and allowed participating growers to experiment with monitoring by following along during monitoring visits and inspecting traps on their own. Some comments on the monitoring visits include "Loved this aspect. I found both Natasha and Bonnie to be very responsive to questions. I really appreciated being [able] to spend some time with Natasha in the field checking traps and learning what to look for in regard to certain pests." "Natasha was a wealth of information and always helpful in answering questions / providing information". "Incredibly helpful. Educating us on the equipment and traps they were using, and letting us know where they were around the farm was so helpful, and monitoring for carrot rust fly, flea beetle, loopers and cut worms, and SWD helped us making some important decisions."
- Several of the participating growers mentioned changes they were making based on VIPPB's monitoring visits, including increased use of row cover, beginning rust fly monitoring protocols in

additional fields, identifying caterpillar species, and recognizing additional beneficial insects. As well, 75% of participants who completed the end of year survey stated that they used their farm's data to make management decisions.

- The end of project survey revealed that 55% of participants used the general monitoring data to make monitoring and management decision, while 27% planned to use the data in the future. 90% of respondents wanted additional details on pest biology and management, indicating a strong interest in using IPM strategies. Comments on the monitoring data section of the newsletter included "Easily understandable, great amount of detail!", "Amazing reporting", "I like knowing what is going on in various areas of the island", and "I love being able to identify different pests and beneficials now!"
- **While the monitoring itself provides important baseline information and an advanced warning system, the greatest use of the monitoring is in the information it provides to growers in the moment, increasing their understanding of pests, encouraging them to consider monitoring, helping with IDs and connecting them with management strategies.**

Challenges:

Logistical challenges:

- A major practical challenge of running the VIPPB project was the short lead times between receiving funding and the start of the growing season. Given that this project required hiring scouts, organizing grower collaborators and ordering monitoring supplies, multi-year funding or funding distributed in January would allow the project to be ready to go earlier in the season, and would allow for better outreach to growers.
- The large amount of time and budget spent on travel between the different regions of the island reduces the amount of time that can be spent monitoring.
- Finding suitable farms with large areas of each of the target crops in each region. Apples in particular were present on many farms as single unmanaged trees or newly established small orchards, rather than established orchards. Several of the raspberry fields monitored were also very small or newly established. While such plantings still provided valuable information, pest populations in these small and young plantings are not expected to be as high as large established plantings.
- Some farms were monitored in both years of the project, while others were monitored in only one year. Given the high value that monitoring provides to participating farms, it is beneficial to visit different farms each year in order to demonstrate the positive impacts of monitoring to as great a number of growers as possible. However, finding new farms to work with and establishing new monitoring sites requires a large amount of time compared to using the same sites each year. In addition, changing sites creates difficulties in comparing pest pressures between years, particularly for pests that are highly variable between farms.
- Choosing a selection of crops and pests that make the program interesting and accessible to all growers is also a challenge. While the crops monitored in 2021 and 2022 included a high diversity of arthropod pests, growers frequently requested that additional crops and pests be included in monitoring. Wirewom were frequently mentioned, as were disease challenges. Other pest issues growers were looking for help with included aphids and mites in outdoor cukes and aphids in greenhouse eggplant, cucumber and peppers.

Monitoring Challenges:

- Creating a monitoring protocol that is sufficiently flexible to respond to new pests as they arise while still collecting good baseline data in a reasonable time frame was a challenge, and the presence /

absence monitoring scheme used in 2022 met that challenge better than the more precise data collection on a more limited number of pests in 2021. However, the wider variety of pest data collected in 2022 would not have been possible without an experienced scout who was already familiar with a wide diversity of pests.

- Some pests that growers were particularly interested in were not easily monitored, such as wireworm and slugs.
- High variability in management strategies between farms also complicated interpreting monitoring results. This was particularly the case in brassicas, where farms grew different varieties, harvested and planted at different times and some used row cover or regular insecticide applications. In cases such as these, monitoring results cannot be used to predict pest population sizes on neighbouring farms but can only be used to determine if a pest is currently active in the area. There is always a concern that growers may use monitoring data inappropriately, assuming that if farms in their region have high pest levels that they also do, or that if pest levels are low in general that their crop is safe.
- Data collected from traps by VIPPB likely under recorded peaks in pest abundance, since traps were checked only every two weeks, averaging out the peak and valleys. As well, by the time this data was reported in the newsletter the pest occurrences could be over two weeks old.
- Growers also wanted to have management recommendations made for them. Specific area wide recommendations could not be made based on data collected from only a few farms, and the wide diversity of farm management types made concise management suggestions impossible. While better management suggestions could be made for farms where data was collected, this was outside of the expertise of the crop scout. As well, the additional time to review data and create individual management recommendations for only a few farms would reduce the budget available for more general monitoring.
- Growers were also interested in knowing what was driving different pest pressure on different farms. While small amounts of information on management strategies could be shared in the newsletter (for example, row cover use), drawing conclusions around the impacts of various monitoring strategies was beyond the scope of this project.

General Challenges

- Shipping delays in 2021 meant that SWD and codling moth traps were placed after those pests had already become active. In 2022 the wet spring meant that many fields were late to be planted, and perennials were behind in their development. The long warm and dry weather into the fall of 2022 may have resulted in interesting pest observations, but the VIPPB season had already wrapped up. While a longer season in both years would have allowed pest issues to be monitored earlier in the season and later in the fall, this was not possible with the current project budget.
- Acquiring monitoring supplies was also a challenge for growers who wanted to implement their own monitoring. Multiple growers contacted VIPPB over both seasons, looking for information on where to obtain monitoring traps, particularly for codling moth and apple maggot. Figuring out what materials to order, and where to order them from created an additional barrier to monitoring for some growers.

Future recommendations:

Growers are interested in pest management! This project has started the process of providing growers with an understanding of what pests they may encounter, the basics of IPM and resources to learn more. The foundation has been laid, and future projects can build on it.

If funding is available for a dedicated monitoring project in the future:

- Continue to monitor for pests and share that data with growers through the newsletter.
- Hiring the same contractors and crop scouts will ensure continuity of the program.
- Continue to use a presence / absence monitoring method to collect data on many species.
- Continue to monitor multiple farms with each crop across multiple regions to ensure the wide applicability of the data.
- Continue to work with some new farms each year so that multiple growers can experience IPM in action. A minimum of three farms per region should be monitored.

If additional funding is available:

- Lengthen the season to detect more pests.
- Consider adding more crops – this will likely mean adding more days of monitoring / more farms to provide a sampling of each of the crops.
- Consider creating accessible graphical displays of summary data that update each monitoring period. This would also be improved with a dedicated hosting site, allowing growers to check the data without going through the newsletter. One comment in the end of season survey mentions this "It would be nice to know if the current data is an increase or decrease from the past newsletter data. To frame the current data in the context of seasonal cycle for that pest."
- Beneficial insects, including pollinators, were collected during monitoring visits. Identification and analysis of these samples could provide import baseline information on beneficial insects.

If funding is not available for a dedicated project:

- Regional agrologists could collect general data on pests present when visiting farms during their regular duties. This very basic data could then be shared with other growers.
- Data on the general issues farms are currently dealing with could be collected by visiting farmers markets, however data quality will be low if it isn't ground-truthed by an experienced crop scout / agrologist.
- Growers who already monitor for pests or who have participated in the program in the past could be incentivized to provide data for distribution to other growers in their region. The incentive could include support from agrologists in determining management strategies and thresholds, assistance with IDs, etc. This could take the form of a mentorship program and could be combined with on-farm workshops.
- An attempt in the first year of the program to have growers voluntarily submit data on pests they were observing did not result in good data, however many growers expressed interest in having access to pest ID, on farm IPM help, and the ability to submit photos for ID. Growers would need to have the process of sharing their pest issues be easy and provide a benefit for them. For example, a phone call / zoom meeting once every two weeks with an agrologist to ask what the current issues are, and to work with the farmers on those issues.
- One challenge for growers in hiring private pest management consultants is the cost. If this cost was subsidized for growers who shared their data with other growers, more growers might be interested in purchasing this service. One way to subsidize the cost could be to cover the mileage and travel time involved in monitoring, particularly in regions where farms are small and widely spaced apart.

Other recommendations:

- Local agrologists could provide either info on where to purchase monitoring supplies or have small amounts of supplies on hand to lower barriers for growers looking to "try out" monitoring.

Workshops and Events

Successes:

- Workshops were well attended and provided growers the opportunity to experience monitoring in the field. They were also important in broadening the reach of the program. On-farm workshops reached 84 growers, and each workshop and event resulted in 5-20 new sign-ups for the newsletter. These events allowed growers to directly ask questions, see how the iNaturalist project works, observe traps in the field, examine resource materials and network with other producers. In 2022 the workshops occurred earlier in the season, and were better attended, compared to the mid-season workshop in 2021. Comments from the workshops included: "really appreciate you sharing with us!"; "it was a great workshop, I got a lot out of it!"; "I would really like to continue to have workshops"; "Could we also do a fall workshop to see how pests have changed?"
- On-Farm workshops included exploring the pests and crops currently present on the farms hosting the workshops. Because each farm and year is different, growers can attend similar workshops multiple times, and still learn new things as different pests will be present.
- Winter events again provided opportunities to share resources and demonstrate the project. Many growers appreciated the opportunity to see season long data trends, rather than the biweekly snapshot provided by the newsletter. Winter events also encourage growers to think about incorporating the principals of IPM during a time of year when they can plan changes before their upcoming season. Winter events reached 172 people.
- Successful outreach also occurred at the Island Ag show in July of 2022. While the event occurred during the busy season for growers, and attendance at the IPM presentation was low, a display of resources and insect specimens was appreciated was present during several other session, and many growers browsed the table over the course of the day. In addition, outreach for the program also occurred during cider apple sessions later in the day.
- The 2023 Island Ag show reached a greater number of participants and there was high grower engagement. A display of resource material and beneficial insect species was well received and multiple growers had questions around pest management and project materials. If the project was to carry on in the future having a display table at the Island AG show would be an excellent opportunity to engage with producers both around their current pest management issues and how they can participate in the project in the future.
- Both winter event and on-farm workshops provided growers with important opportunities to network with others and share tips and strategies for managing pests.
- The end of season survey in 2022 found that 23% of respondents had attended an on-farm workshop.

Challenges:

- Winter events during 2021-22 were heavily impacted by Covid, which created difficulties in reaching additional growers, and by the time funding was confirmed for summer 2022 many farmers' institutes were breaking for the season and did not have time to arrange for talks. As well, the yearly funding cycle creates challenges in communicating to growers how the project will be functioning in the coming year before they are already busy with spring planting.
- The two webinars created by the project were not made available for sharing to the general public, reducing their reach. Particularly the 2022 Spring Webinar would be valuable to growers as it demonstrated both the data collected by the project and provided a detailed explanation of how to use the iNaturalist project.

- Summer is a busy time for growers to be able to attend a workshop. While workshops could have been extended to 2-3 hours, this may have reduced the number of farmers who were willing to take time to participate in them. Winter workshops would not have provided growers with the same "in season" experiences.
- Growers in some regions were better organized / engaged with Farmers' Institutes than others. The Cowichan Valley, in particular, had low uptake in the project and low attendance at events. On the other hand, both Farmers' Institutes in the Comox Valley engaged with the project and invited VIPPB to speak to their members. Growers on Saltspring and some of the other Gulf Islands were also engaged in the project, however the additional travel time and logistics involved with ferries made these locations not suitable for in person events.

Future Recommendations:

- In-season workshops should continue. If there is not sufficient funding for a full scale monitoring program a monthly series of on farm workshops could continue to engage growers and increase their IPM skills, while at the same time allowing for some general pest data collection.
- Additional workshops could be added, either in season or in the winter focussing on specific issues. Wireworm, mummyberry and apple maggot are three pests growers expressed interest in learning more about.
- A winter recap of the past season trends helps to provide context to growers. If these re-caps are recorded and made available for future viewing it will increase their reach.
- Early spring (Jan-March) promotion of the program for the following season will likely increase engagement.
- Networking events with growers who have participated in the program, either as study farms, with the iNaturalist or through attending the workshops and receiving the newsletter could help growers to share how they are putting IPM into practice on their own farms and increase the value of the program.

Beneficials and citizen science

Successes:

- The iNaturalist project provided an avenue for engaging producers around the different insects found on their farms, encouraging close observation and increasing appreciation for beneficial insects.
- Robust data was collected on large and easily identified taxa such a bumble bees, hoverflies and ladybeetles.
- On groups where species level identifications were not possible (e.g. aphids) more basic identifications still help growers know if they are dealing with a pest or a beneficial insect.
- The project had good engagement with gardeners and some small-scale farmers. While iNaturalist does not provide any statistics around project engagement, the end of project survey revealed that 72% of respondents had used the iNaturalist project, including all participating farms that answered the survey.
- The iNaturalist project can continue to collect data without any inputs from outside sources.

Challenges:

- Many of the participants, and particularly the highly engaged ones, were non-farmers, and therefore the species observed will be skewed towards those present in gardens and urban spaces, rather than in large scale agricultural settings.
- Learning to effectively use iNaturalist takes some time, and growers did not always stick with it.

- Some insect groups (hemipterans, larval insects, flies) are difficult to ID from photos, and for small specimens photo quality is often poor. As well, taxonomic experts are often busy during the field season and so are not able to direct attention to observations until the off season. This results in many observations remaining at a basic level, rather than reaching species level. This can be discouraging for growers, particularly if they are hoping to receive immediate feedback.
- Many insects cannot be reliably identified to species from photos (many bees, aphids, etc.), and therefore the iNaturalist project will never be able to fully document the species level diversity of those groups.
- The aims of iNaturalist as a whole and the aims of the VIPPB program were not always in sync. Identifications that are "likely" correct are sometimes downgraded by taxonomic experts because of the impossibility of knowing they are "absolutely" correct. While this is necessary for the overall data collection purposes of iNaturalist, it is more useful for a grower to know that their caterpillar specimen is probably the cabbage looper moth, rather than a member of subfamily Plusiinae.

Future recommendations:

- The iNaturalist project can remain live and continue to collect observations without any funding directed towards it. However, some funding to engage with users, put IDs on specimens, and write journal posts will likely increase continued engagement with the project.
- Outreach to growers during the winter and early spring may increase grower use of the iNaturalist component of the project and increase the number of observations made on mid and large-scale farms.
- Continued outreach to iNaturalist identifiers may result in more observations being identified.
- Samples of pollinators and other insects were collected during the 2021 and 2022 crop monitoring. Future examination and identification of these samples could provide another source of information on the beneficial species present in Vancouver Island agro-ecosystems.

Newsletter / Communication

Successes:

- The major communication piece of the project was the newsletter. It was well received and reached 287 email subscribers at the end of 2022. Newsletters were opened more than 8000 times.
- The Facebook group also had good reach, with 276 followers, and a total reach of 19,830 people.
- iNaturalist journal posts shared information with the 80 members of the project, as well as any growers who checked the project without joining.
- An end of year survey promoted through farm participants, the newsletter and on Facebook received 12 responses, with 67% from farmers. 100% of respondents received the newsletter, 25% interacted with the Facebook page and 81% interacted with iNaturalist project.
- 75% of respondents received the newsletter by direct email subscription, while 25% received it from a farmers' institute and 17% received the newsletter through Facebook. Multiple respondents received the newsletter from more than one sources. No survey respondents received the newsletter through twitter.
- According to survey respondents the most valuable sections of the newsletter were the pest and beneficial insect focus sections (100%), followed closely by the monitoring reports and IPM Basics section (90%). 81% of participants used the pest and beneficial focus sections to make monitoring and management decisions, while 18% had not had time to use the data but intended to use it in the future. Comments on the focus sections included: "I had a wonderful experience seeing masses of aphids on my hazelnut bushes controlled and virtually eliminated by initially a few adult lady bugs

then dozens and dozens larvae and pupae and more adults." "I found it useful and educational. I learned some things that I hope to put to use and definitely can use more details between identifying pests and beneficials. How to encourage one while decreasing the other." "I love this section and have learned a TON from it".

- The information in the monitoring section was used by 55% of survey participants, while a further 18% intend to use the data in the future.
- The IPM basics section info was used by 27% of participants, while 18% intend to use the information in the future.

Challenges:

- Accessibility of the newsletter was a major challenge. Although the newsletter was promoted through Farmers' Institutes, on a MailChimp page, during events, and on Facebook, more could have been done to link the project to the Climate Change Adaptation Program and related media channels. This creates difficulties for growers searching for the project and increases reliance on word of mouth.
- Managing the length of the newsletter was difficult. With multiple crop groups, and many different pests in each crop, it was difficult to convey all the relevant data in a small space. Survey participants consistently requested more details on the current pest pressure, differences between farms and regions, and on identification and management strategies. Links within the newsletter allowed readers to jump to the sections of greatest interest, however these links often did not work on mobile devices.
- Many growers mentioned not having time to read the emails with the newsletter, or not getting around to signing up for the newsletter during their busy summer season.
- Social media was a positive way to reach new growers who were not engaged with farmers' institutes. However, social media reach was highly dependant on algorithms. Despite equivalent effort and a greater interest in the project in 2022, social media reach decline from 2021 to 2022. Posts that preformed especially poorly were posts that linked to resources such as fact sheets, webpages and documents, while posts with multiple photos were more widely shared by the algorithm. Posts sharing the newsletter had only a moderate reach. This made Facebook a poor choice as a location to share resources, while sharing multiple resources in the newsletter increased its length.
- Building an audience on social media requires time and effort, particularly if multiple platforms are used. The twitter page was poorly received in 2021, and while the newsletter continued to be posted to twitter in 2022, no additional twitter posts were made in order to focus on the already engaged audience on Facebook.

Future recommendations:

- Continue to produce the newsletter at biweekly intervals using Mailchimp.
- Have links to past newsletters and a newsletter sign up be hosted on an official webpage that could be maintained by the funding program (CCAP, MAF, etc.).
- Create a resource page where links from the newsletter can be easily accessed.
- Continue to use Facebook for reaching growers, while focusing on sharing photos rather than resources through this platform.
- Marketing the newsletter to grower groups and farmers' institutes *before* the production season starts should increase engagement during the season.
- Continue to produce pest and beneficial focus sections with links to additional details and resources.
- If it is necessary to reduce the length of the newsletter, the IPM basics section could be removed, and the pest and beneficial sections could alternate weeks.

Project Impact

Growers shared some the impacts the two years of the Vancouver Island Pests, Pollinators and Beneficials Project had on their farming practices through the end of year survey, and through discussions with the project lead and crop scout.

Comments from the survey

What was one thing you learned from VIPPB?

- “By monitoring the insect life in the garden I learned about the variety of species in our location, and their interactions with the plant life and each other. I also made natural changes to protect our food crops such as netting for the strawberries & Brassicas. Added small flowering plants to draw beneficials. Guess that's more than one thing. Thank you”
- “Learned that we need to do a better job of aphid, mite and worm management in our field crops.”
- “How to ID rustfly (I think!). More about thrips, aphids, and cabbage root worm.”
- “Natasha taught me to ID different types of cabbage worms!”
- “Just identification was helpful. In the past, "bugs have been bugs", you dusted or whatever for them. For a number of years we have released lady bugs in the asparagus to eat the asparagus beetle eggs. First year we released them too early and they all left, but it does work and works very well. “
- “That I was squishing the wrong bugs!”
- “Identifying some pests including leatherjackets/crane flys.”
- “To leave bare ground and rock walls undisturbed, and leave pithy stems for bee nesting. Then was able to watch and see bees entering and leaving. Also identify leaf cutter bee activity on plants and know they are good host plants.”
- “How to identify pests and beneficials. It’s been very helpful in making management decisions”
- “I learned how important it is to record monitoring data, even if every other week, to have down and be able to look at in order to make the most informed decisions. That being said, I am very interested to learn more about the percentages and how to record them with a better understanding."

What part of the program did you find most valuable? Why?

- “Learning about pest cycles and timing, and management strategies.”
- “Looking forward to using the data to make decisions about how we plant/ plan for increasing beneficials”
- “The monitoring process, data collecting and recording, and check-ins with Bonnie and Natasha all were so valuable in that we were able to make helpful and critical decisions with our IPM strategies."

Recommendations for improving the program in the future?

- “A recommended short term and long term IPM control action for each crop pest that exceeds threshold levels.”
- “Keeping it going in some form”
- “We would need not just monitoring but predictions as well, so we can prepare and take actions before the pest pressure goes over the threshold.”

What barriers are preventing you from incorporating IPM practices?

- “Knowledge, time and money are all limitation to more monitoring our farm, and we appreciate any monitoring happening at all”
- “$”

- “Not enough hands in the field”
- “In our experience one of the things that is missing is emphasis on the very early stages. By the time one identifies adult pests it is too late. Our experience with beetles is that they are vulnerable at the egg or larval stage. Not sure how that works with wire-worm. We tried potatoes in what was a hay field some years ago and were thwarted by wireworm. However, recently, plantings in areas that have been sod free for several years have done amazingly well, but it takes time----a lot of time.”
- “already doing it”
- “Time and labour"

Other comments?

- “I love this program, it’s incredible!”
- “I love this project and also the iNaturalist component. In my garden, I hope to maximize habitat opportunities to support as wide as possible diversity of insects and also animals higher up the food chain! A little crop damage never bothers me, since it brings so many other wonderful interactions with nature. I am also concentrating on growing as many native plants as possible.”
- “I want to hear a discussion on why some farms had pests and others didn't. To see what IPM practices are working for farmers, or to learn what other factors and management practice play into pest pressure.”
- “Super stuff”
- “This was helpful for our farm, but I also feel it is/ would be helpful to the wider ag community and is an important program heading into an uncertain climate future.”
- “We appreciated being part of the monitoring program this year. Insect pest problems seem to be a growing problem, and we are happy to have as much input as we can. Despite using introduced predators, some habitat creation, plus judicious use of organic approved insecticides, there are some pest/crop combinations that we are really struggling with. For 2023 we're looking for ways to overcome some of our worst farm pests, and would be happy to be part of pest monitoring projects again. Having pest management recommendations would also be helpful.”
- “This has been a game changer for our farm; I can only imagine how much more helpful it will be for more small scale farms as we navigate climate change and see all sorts of things popping up, such as insect breeding cycles, diseases, and cultural practices around farming changing with the climate."

Observations and comments from growers on participating farms

- Several growers spent time in the field with the crop scout, observing monitoring methods, learning to ID pests and beneficials, and learning about the traps used by VIPPB.
- Many growers had specific questions about life cycles of pests so that they could improve their pest management. Including: Brassica caterpillars, aphids in blueberries, SWD in blueberries, cabbage loopers in lettuce, onion maggot, leatherjackets, and disease issues.
- Many growers were interested in learning more about lifecycles, habitat and encouraging beneficials on their farms.
- Interest in disease identification.

Changes to management practices on participating farms:

- Leaving kale leaves with aphidoletes in the field rather than composting so the beneficial could cycle.
- Requested VIPPB to leave carrot rust fly cards after the end of the season so that the farm could continue to monitor for that pest.

- Using provided monitoring data on rust fly to make decisions, as well as placing sticky cards in another carrot field. Felt comfortable removing row cover to facilitate irrigating and weeding, and to avoid an issue with aphids in carrots that had been missed in the previous year because of the row cover.
- Did an experiment with removing row cover to facilitate irrigation, based partly on the rust fly data.
- Used monitoring data and provided resources to decide to use Btk in brassica caterpillars
- Did not prioritize spraying in berry crops because the monitoring data showed that there were few pests.
- Considering using row cover on brassicas next year, after learning about and observing brassica pests.
- Requested that apple maggot and codling moth traps be left in orchards for continued monitoring.

Interest in continued monitoring

- One grower was interested in monitoring to help with mummy berry management in blueberries.
- Another grower wondered about paying for pest monitoring to help manage pests in fields and greenhouse.
- Most growers in the project want to support the project continuing, and many commented about how valuable the project was for their farm.
- Growers expressed interest in continued monitoring (and information dissemination) about potential new pests and changing pressures due to climate change.
- One farm suggested running a similar project offering a more in-depth learning program for a small number of farms to sign up for, with pre-season learning and workshops, along with more on farm assistance during the season (with more flexibility in crops/pests/diseases to monitor/manage) to run alongside a larger monitoring program/newsletter/workshop project. This would support a small subset of farms in improving their IPM program while also gathering data and distributing information to the larger community.

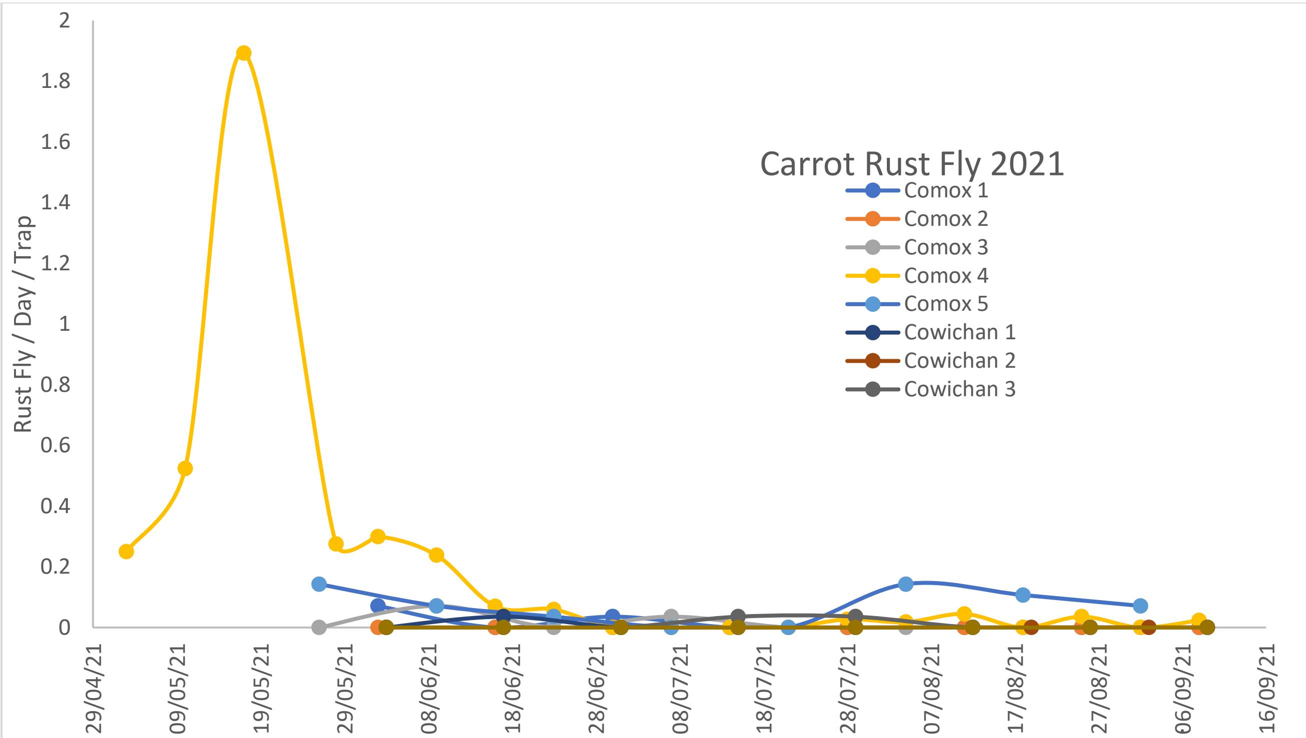
References

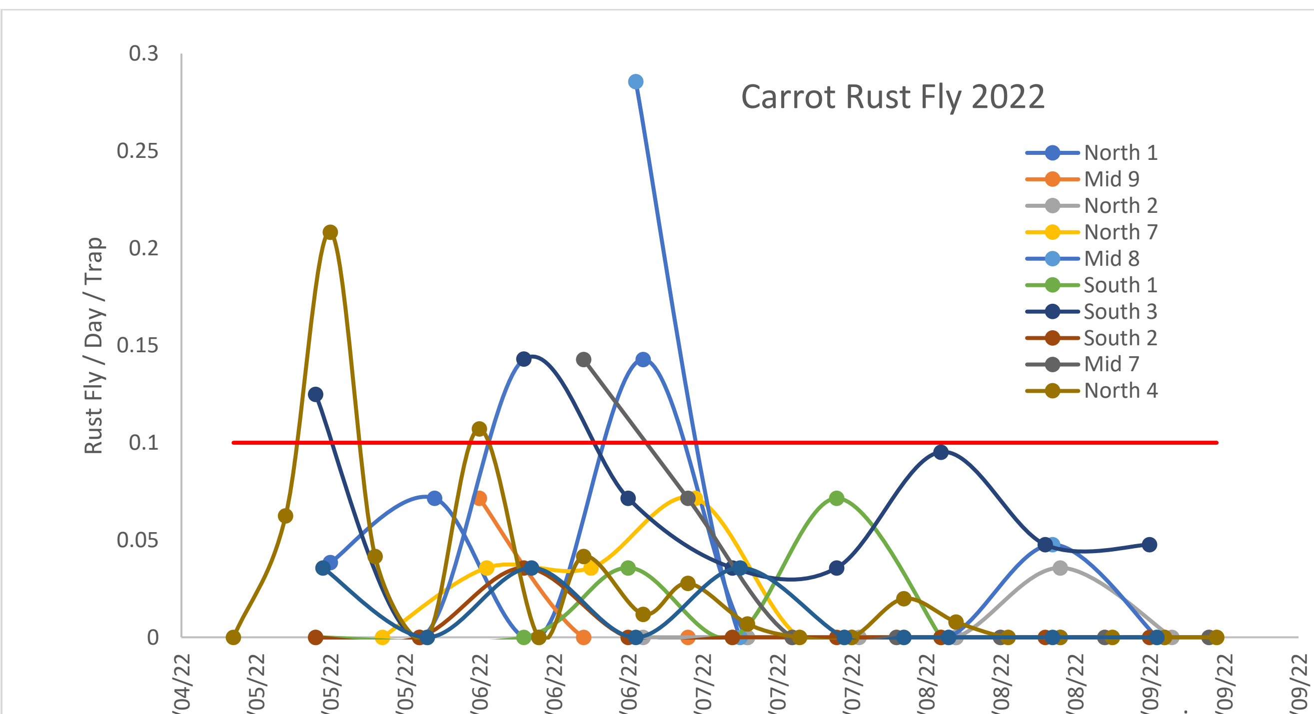
Environment Canada. (2022). Historical Data. https://weather.gc.ca/. Accessed Jan 3, 2023.

FarmWest (2022). Pest Degree Days. https://farmwest.com/climate/calculators/pest-degree-days/. Accessed Dec 15, 2022.

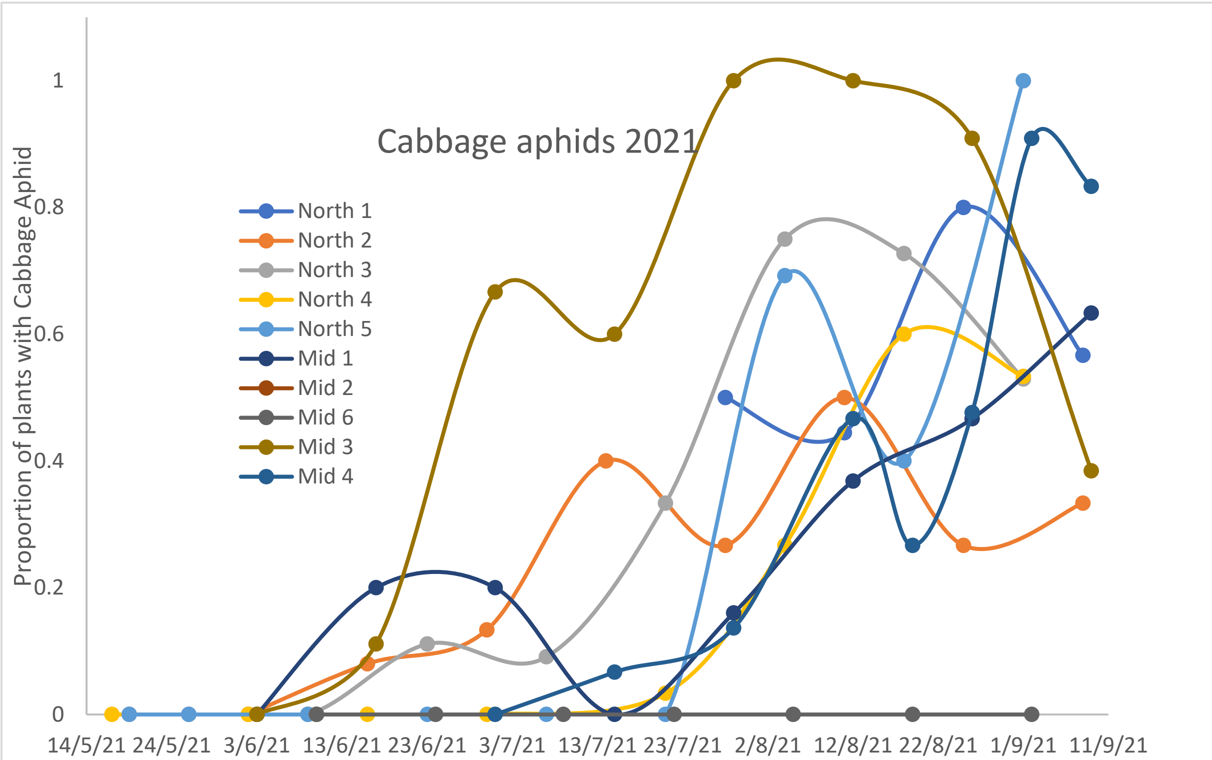
Appendix

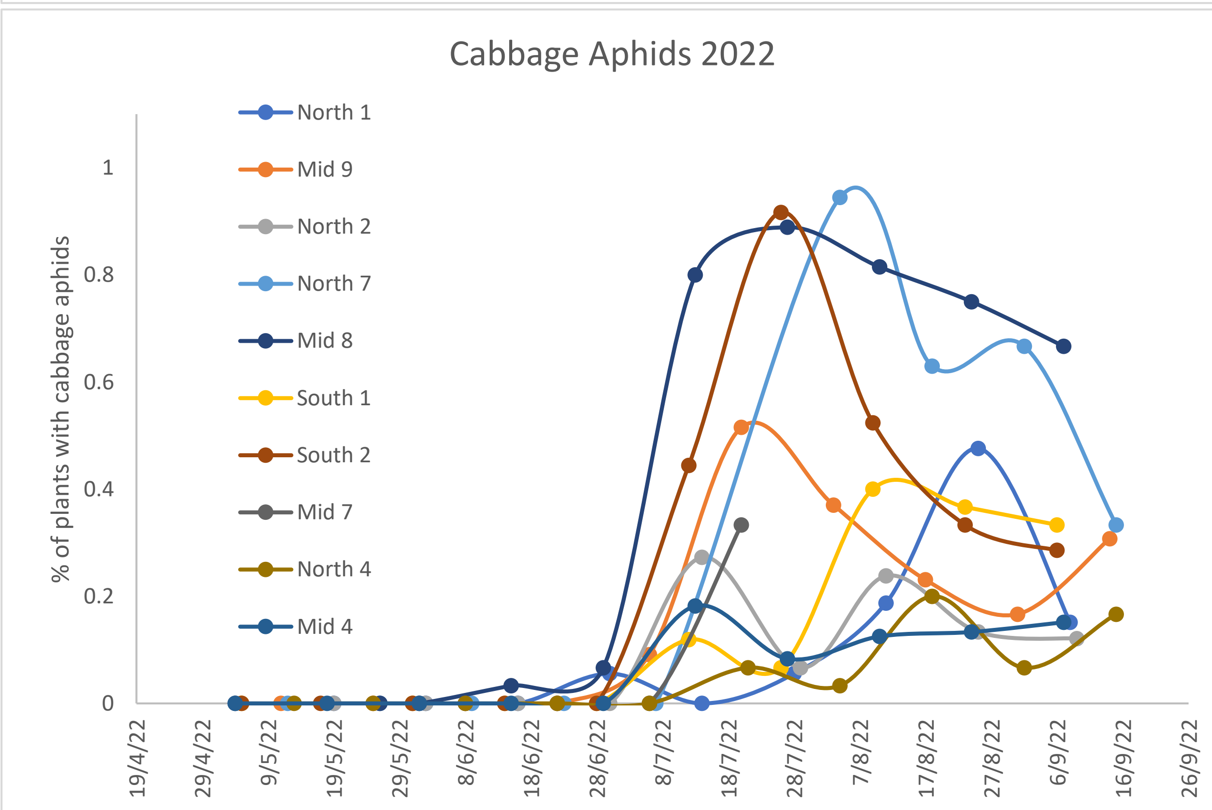
Carrots:

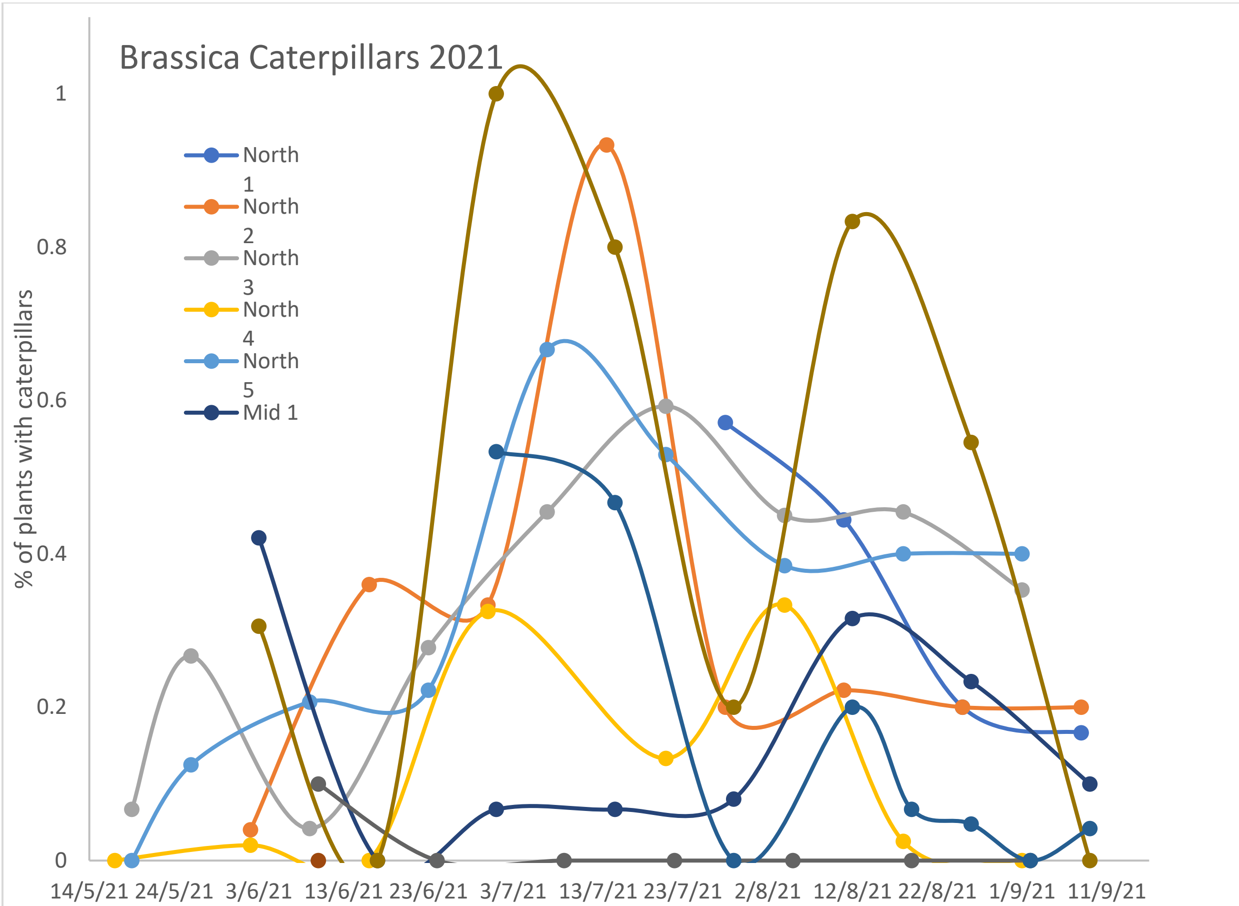


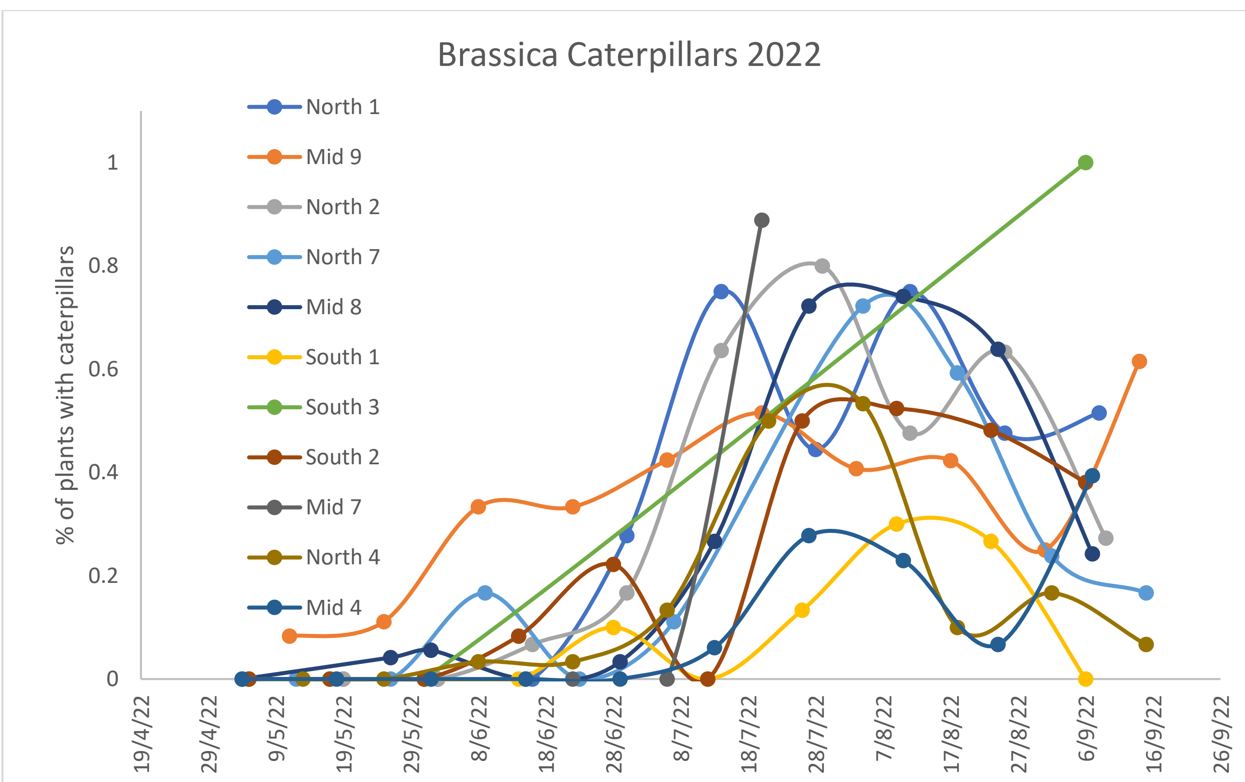


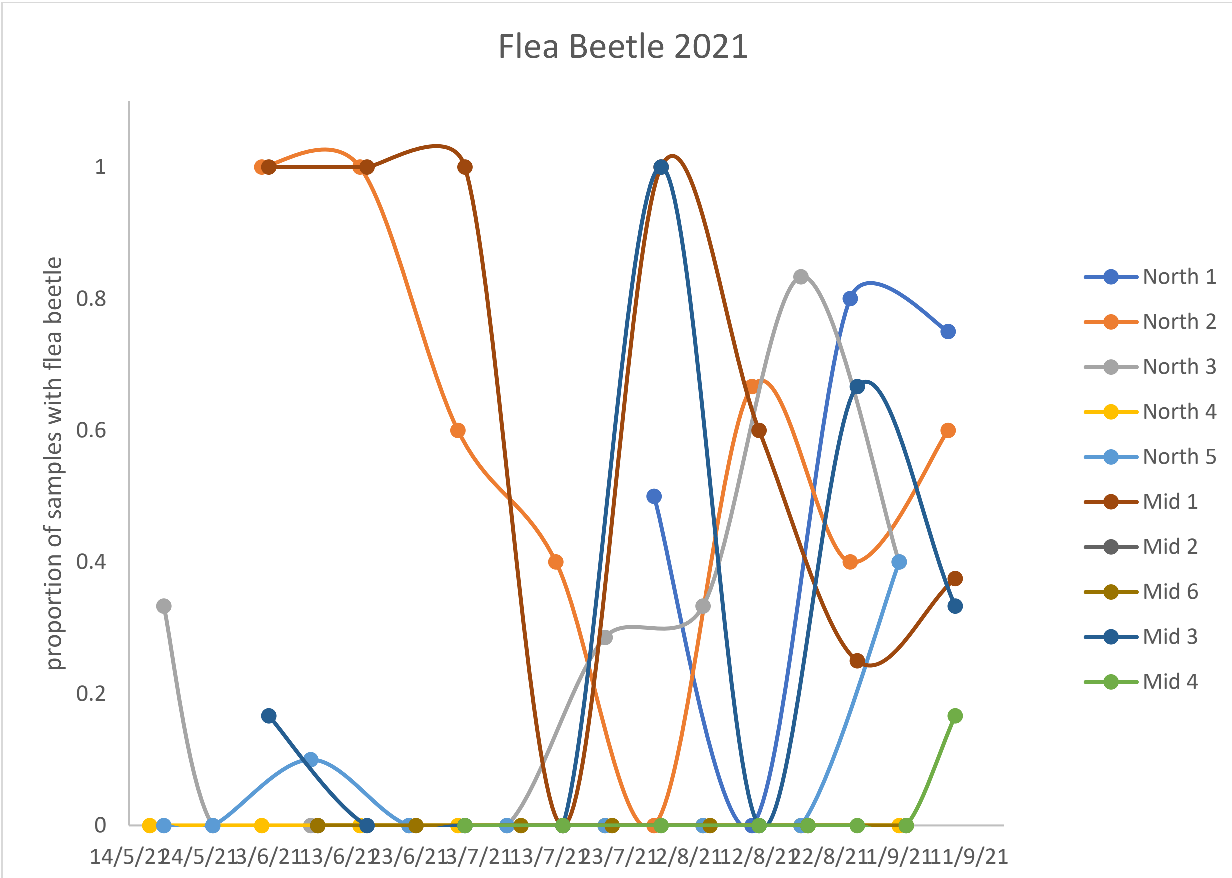
Brassicas:

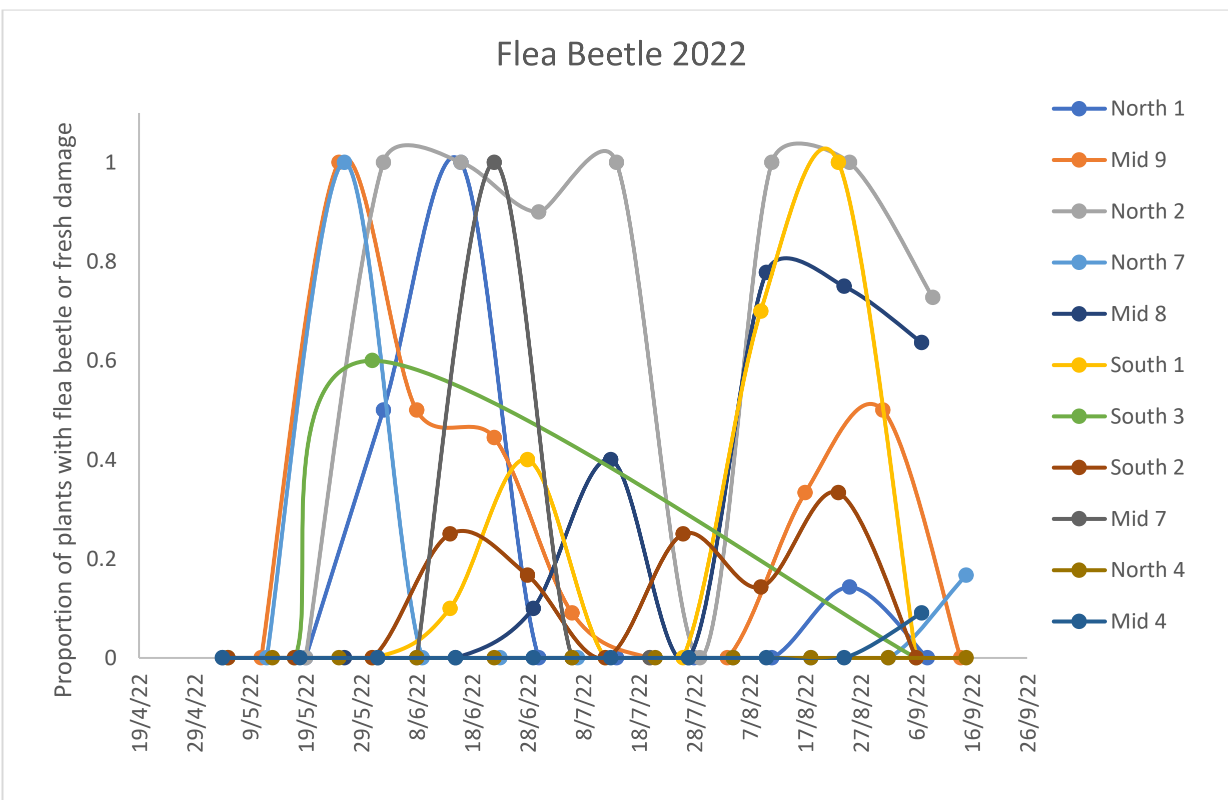

Cabbage aphids 2021
Proportion of plants with Cabbage Aphid
1
0.8
0.6
0.4
0.2
0
14/5/21 24/5/21 3/6/21 13/6/21 23/6/21 3/7/21 13/7/21 23/7/21 2/8/21 12/8/21 22/8/21 1/9/21 11/9/21
North 1
North 2
North 3
North 4
North 5
Mid 1
Mid 2
Mid 6
Mid 3
Mid 4


Cabbage Aphids 2022
% of plants with cabbage aphids
1
0.8
0.6
0.4
0.2
0
19/4/22
29/4/22
9/5/22
19/5/22
29/5/22
8/6/22
18/6/22
28/6/22
8/7/22
18/7/22
28/7/22
7/8/22
17/8/22
27/8/22
6/9/22
16/9/22
26/9/22
North 1
Mid 9
North 2
North 7
Mid 8
South 1
South 2
Mid 7
North 4
Mid 4

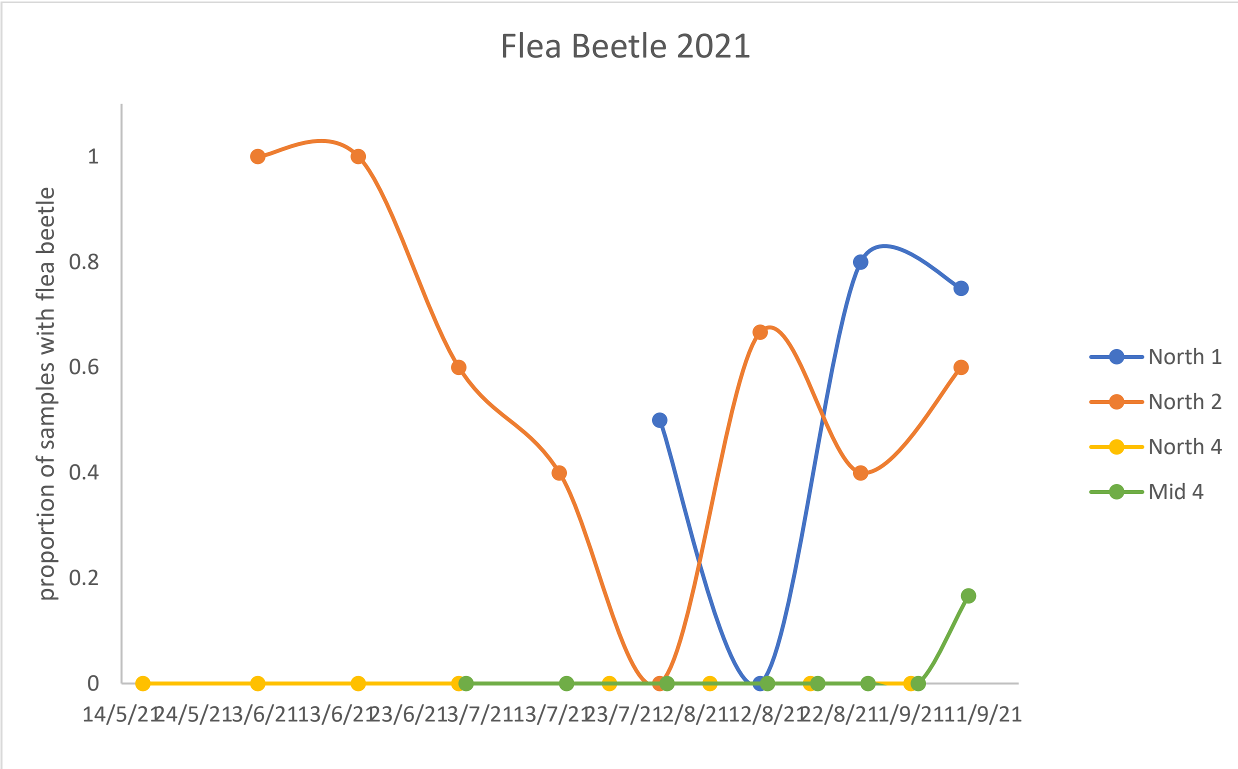

Brassica Caterpillars 2021
North 1
North 2
North 3
North 4
North 5
Mid 1
% of plants with caterpillars
0
0.2
0.4
0.6
0.8
1
14/5/21 24/5/21 3/6/21 13/6/21 23/6/21 3/7/21 13/7/21 23/7/21 2/8/21 12/8/21 22/8/21 1/9/21 11/9/21

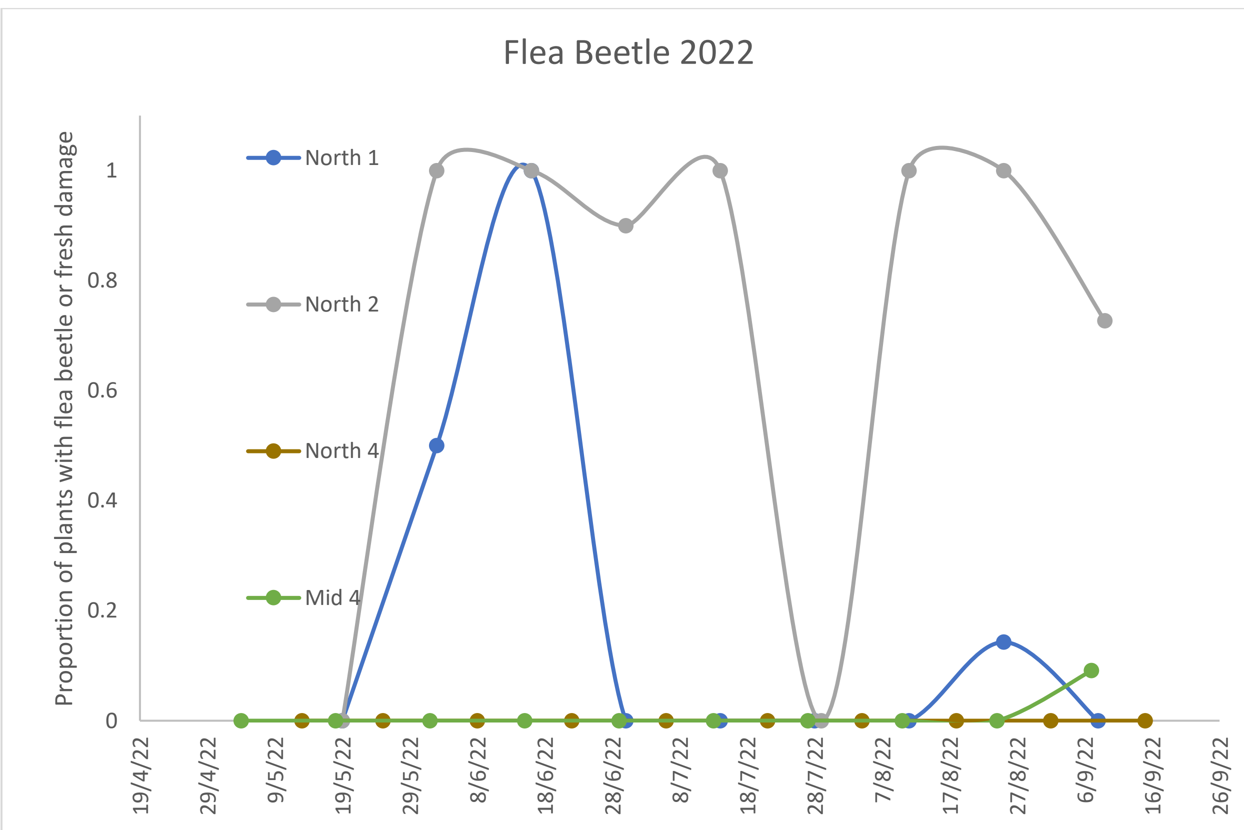

Brassica Caterpillars 2022
North 1
Mid 9
North 2
North 7
Mid 8
South 1
South 3
South 2
Mid 7
North 4
Mid 4
% of plants with caterpillars
0
0.2
0.4
0.6
0.8
1
19/4/22 29/4/22 9/5/22 19/5/22 29/5/22 8/6/22 18/6/22 28/6/22 8/7/22 18/7/22 28/7/22 7/8/22 17/8/22 27/8/22 6/9/22 16/9/22 26/9/22

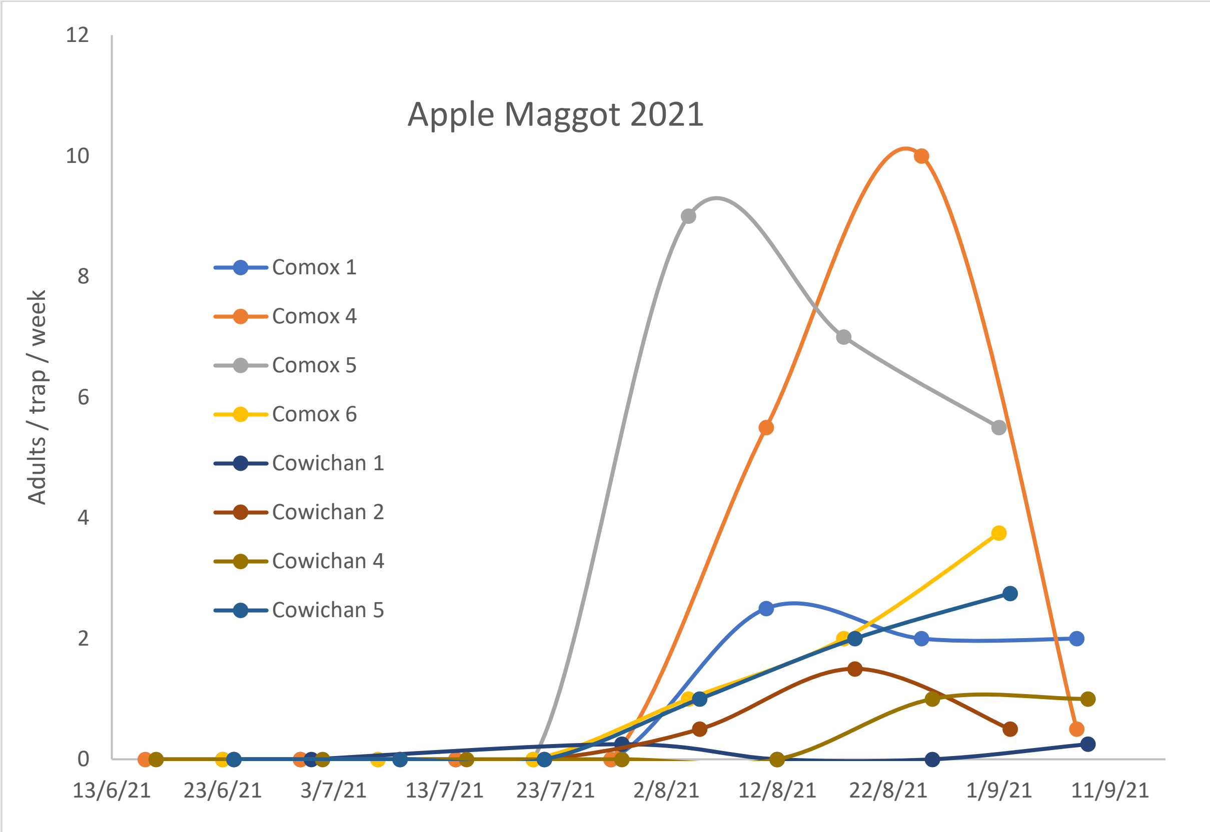

Flea Beetle 2021
proportion of samples with flea beetle
0
0.2
0.4
0.6
0.8
1
14/5/21
24/5/21
3/6/21
13/6/21
23/6/21
3/7/21
13/7/21
23/7/21
2/8/21
12/8/21
22/8/21
1/9/21
11/9/21
North 1
North 2
North 3
North 4
North 5
Mid 1
Mid 2
Mid 6
Mid 3
Mid 4

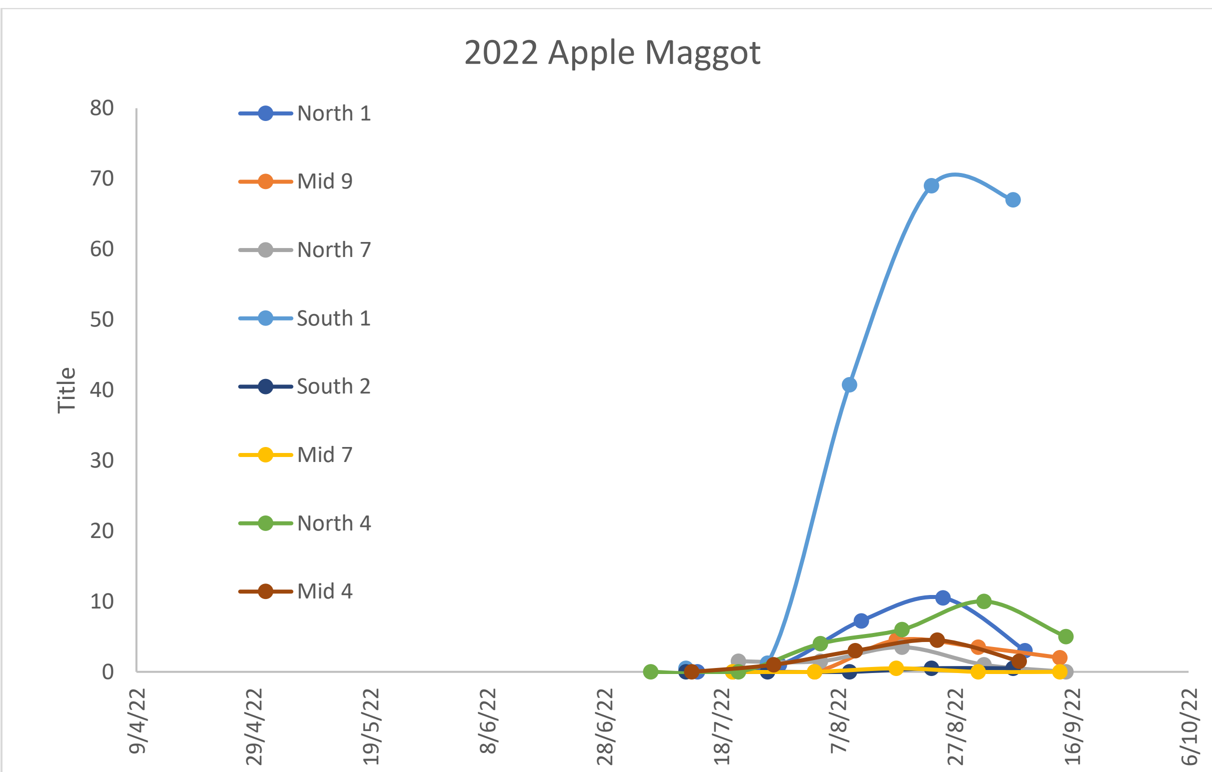

Flea Beetle 2022
Proportion of plants with flea beetle or fresh damage
0
0.2
0.4
0.6
0.8
1
19/4/22
29/4/22
9/5/22
19/5/22
29/5/22
8/6/22
18/6/22
28/6/22
8/7/22
18/7/22
28/7/22
7/8/22
17/8/22
27/8/22
6/9/22
16/9/22
26/9/22
North 1
Mid 9
North 2
North 7
Mid 8
South 1
South 3
South 2
Mid 7
North 4
Mid 4

Four farms that were monitored in both 2021 & 2022:






Apple Maggot 2021
Adults / trap / week
12
10
8
6
4
2
0
Comox 1
Comox 4
Comox 5
Comox 6
Cowichan 1
Cowichan 2
Cowichan 4
Cowichan 5
13/6/21
23/6/21
3/7/21
13/7/21
23/7/21
2/8/21
12/8/21
22/8/21
1/9/21
11/9/21


2022 Apple Maggot
Title
80
70
60
50
40
30
20
10
0
North 1
Mid 9
North 7
South 1
South 2
Mid 7
North 4
Mid 4
9/4/22
29/4/22
19/5/22
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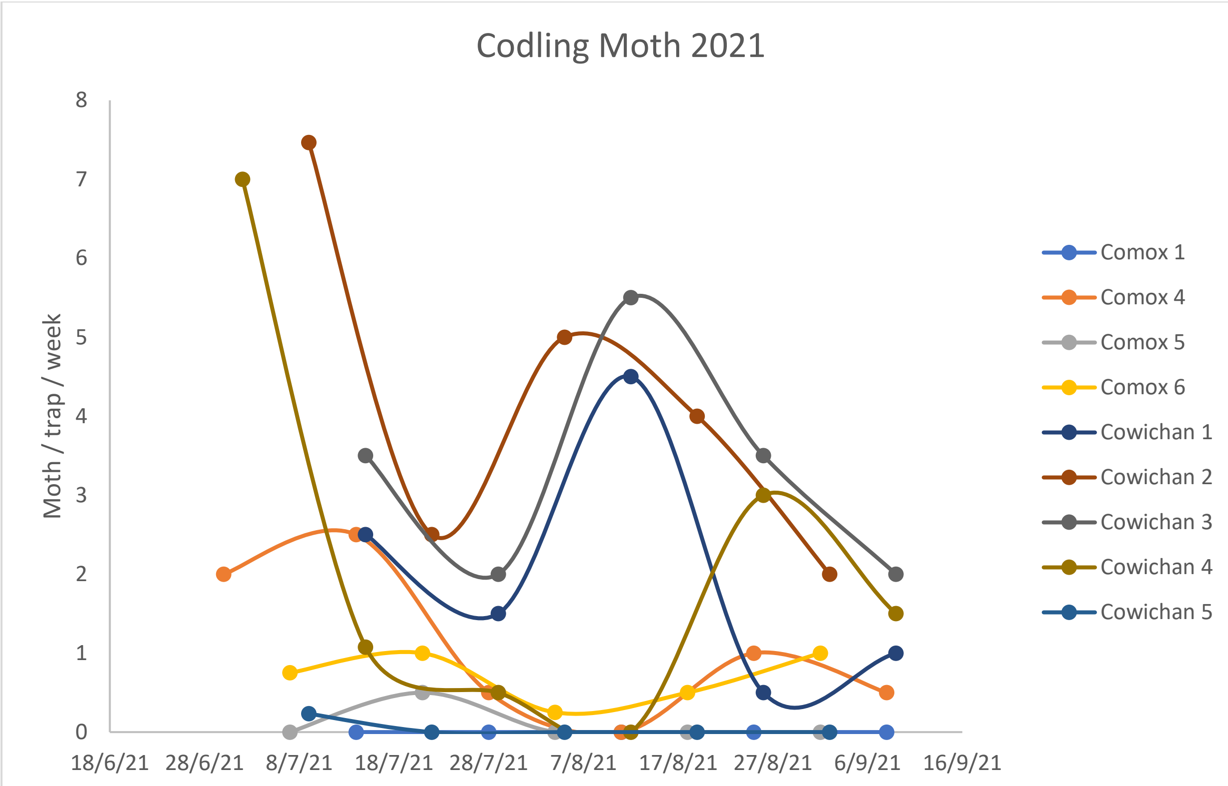
27/8/22
16/9/22
6/10/22


Codling Moth 2021
Moth / trap / week
0
1
2
3
4
5
6
7
8
18/6/21
28/6/21
8/7/21
18/7/21
28/7/21
7/8/21
17/8/21
27/8/21
6/9/21
16/9/21
Comox 1
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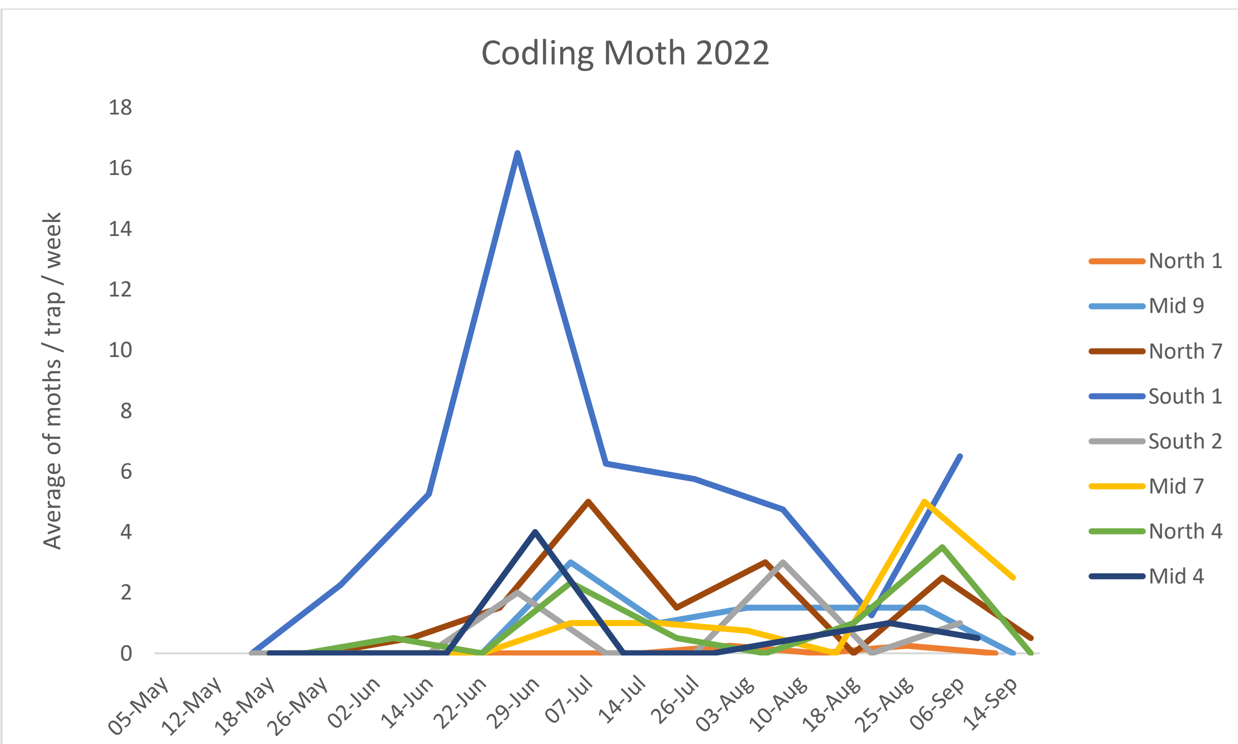
Cowichan 1
Cowichan 2
Cowichan 3
Cowichan 4
Cowichan 5


Codling Moth 2022
Average of moths / trap / week
0
2
4
6
8
10
12
14
16
18
05-May
12-May
18-May
26-May
02-Jun
14-Jun
22-Jun
29-Jun
07-Jul
14-Jul
26-Jul
03-Aug
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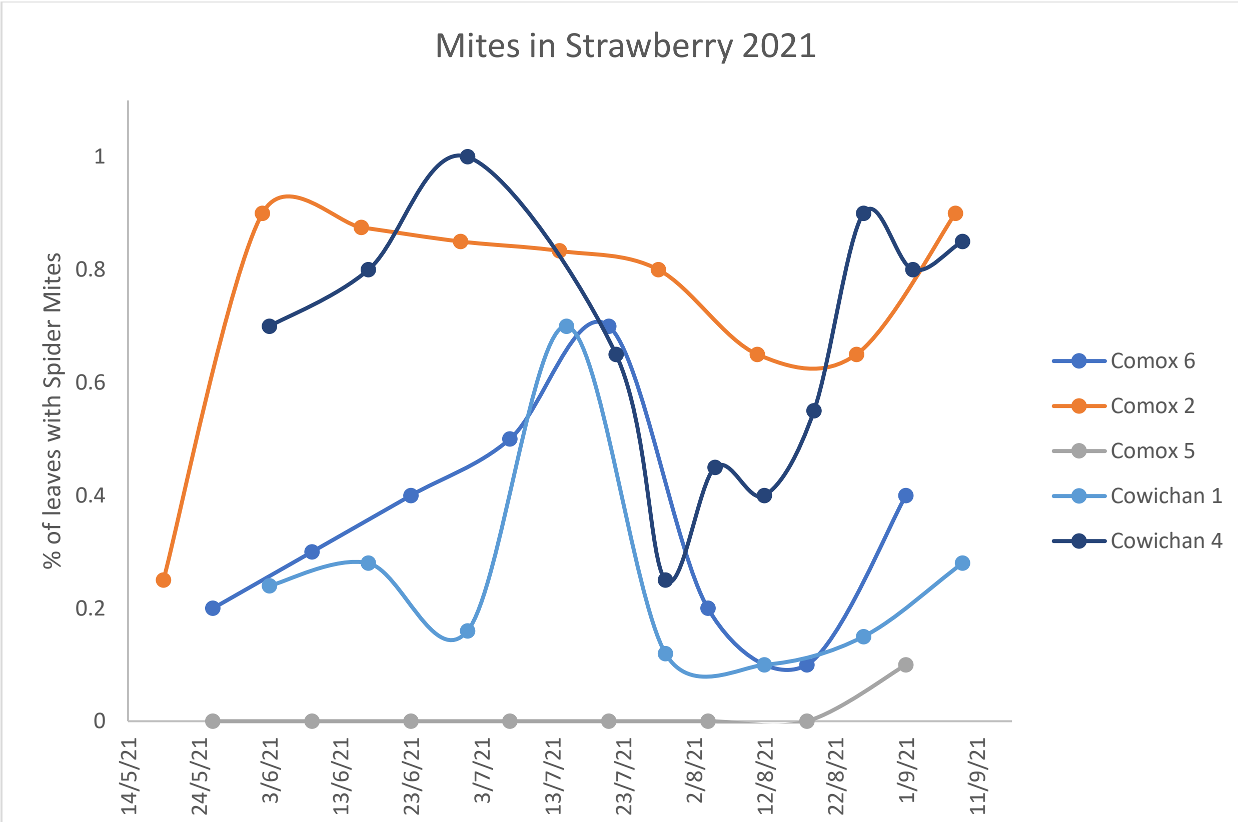
North 1
Mid 9
North 7
South 1
South 2
Mid 7
North 4
Mid 4


Mites in Strawberry 2021
% of leaves with Spider Mites
1
0.8
0.6
0.4
0.2
0
14/5/21
24/5/21
3/6/21
13/6/21
23/6/21
3/7/21
13/7/21
23/7/21
2/8/21
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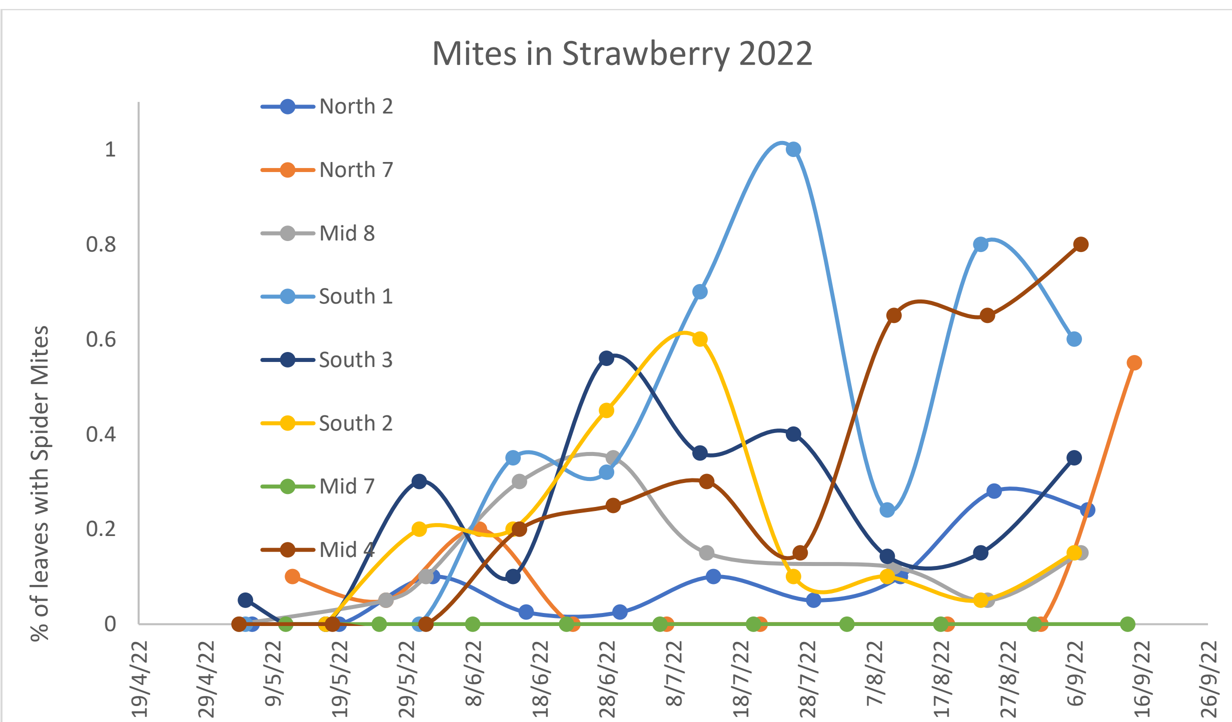
Comox 6
Comox 2
Comox 5
Cowichan 1
Cowichan 4


Mites in Strawberry 2022
% of leaves with Spider Mites
1
0.8
0.6
0.4
0.2
0
19/4/22
29/4/22
9/5/22
19/5/22
29/5/22
8/6/22
18/6/22
28/6/22
8/7/22
18/7/22
28/7/22
7/8/22
17/8/22
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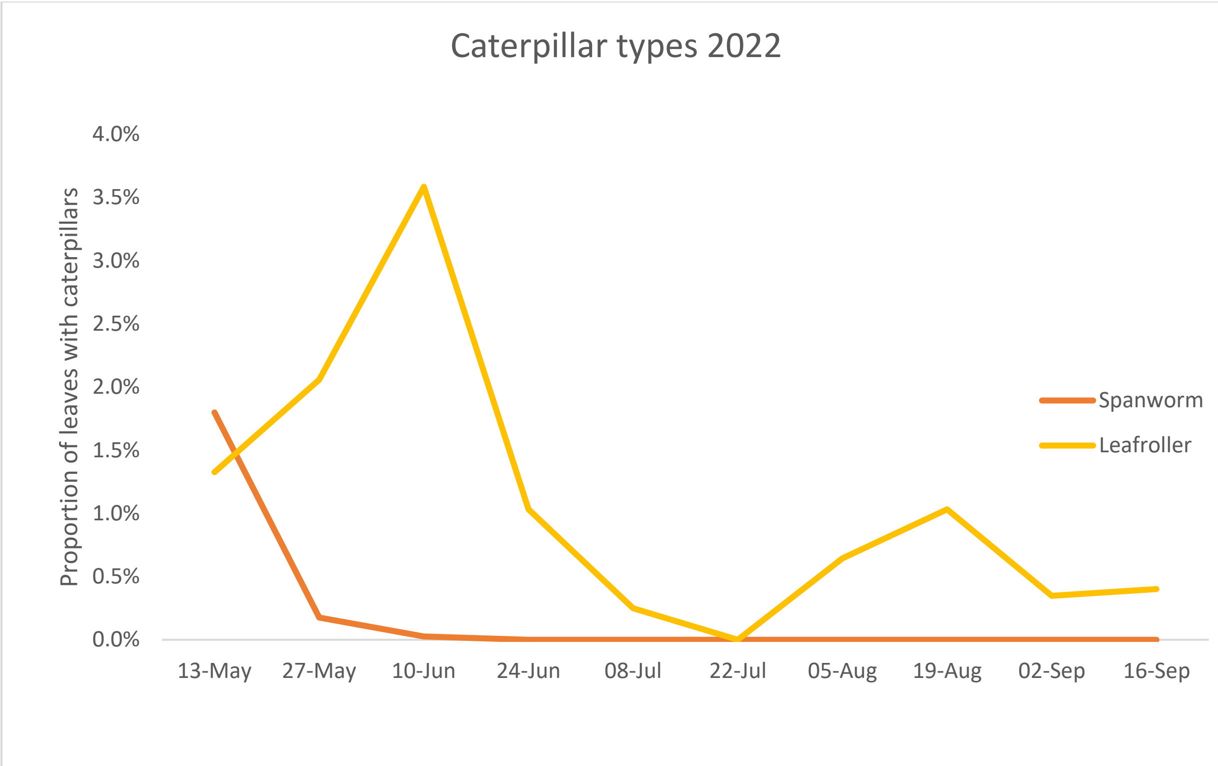
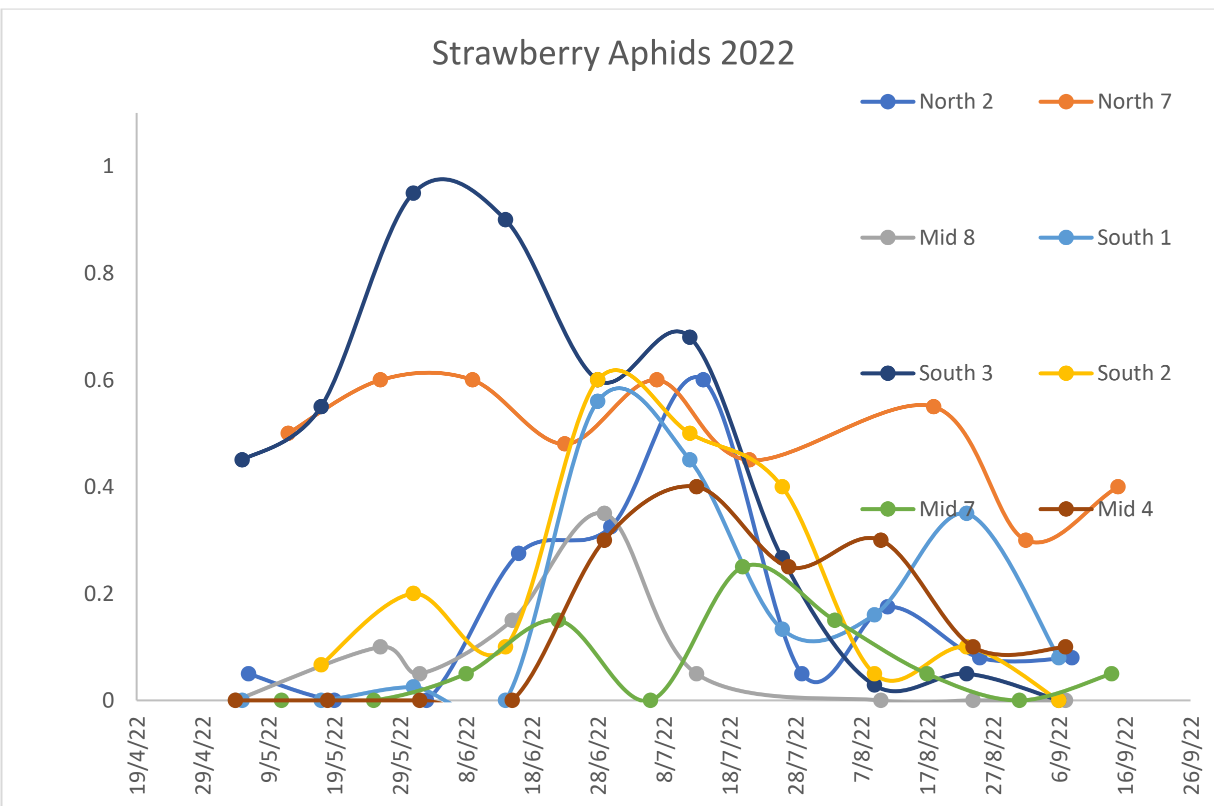
26/9/22
North 2
North 7
Mid 8
South 1
South 3
South 2
Mid 7
Mid 4


Caterpillar types 2022
Proportion of leaves with caterpillars
4.0%
3.5%
3.0%
2.5%
2.0%
1.5%
1.0%
0.5%
0.0%
13-May
27-May
10-Jun
24-Jun
08-Jul
22-Jul
05-Aug
19-Aug
02-Sep
16-Sep
Spanworm
Leafroller


Strawberry Aphids 2022
North 2
North 7
Mid 8
South 1
South 3
South 2
Mid 7
Mid 4
1
0.8
0.6
0.4
0.2
0
19/4/22
29/4/22
9/5/22
19/5/22
29/5/22
8/6/22
18/6/22
28/6/22
8/7/22
18/7/22
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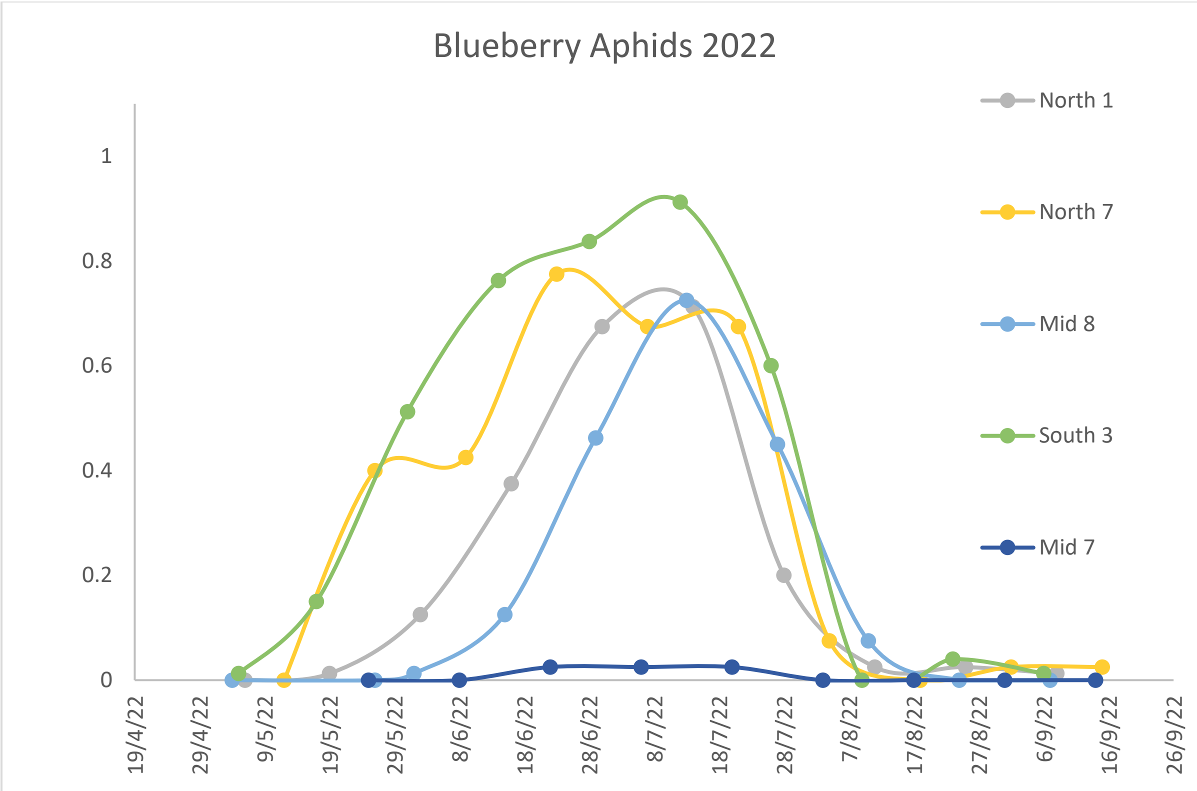
16/9/22
26/9/22


Blueberry Aphids 2022
North 1
North 7
Mid 8
South 3
Mid 7
0
0.2
0.4
0.6
0.8
1
19/4/22
29/4/22
9/5/22
19/5/22
29/5/22
8/6/22
18/6/22
28/6/22
8/7/22
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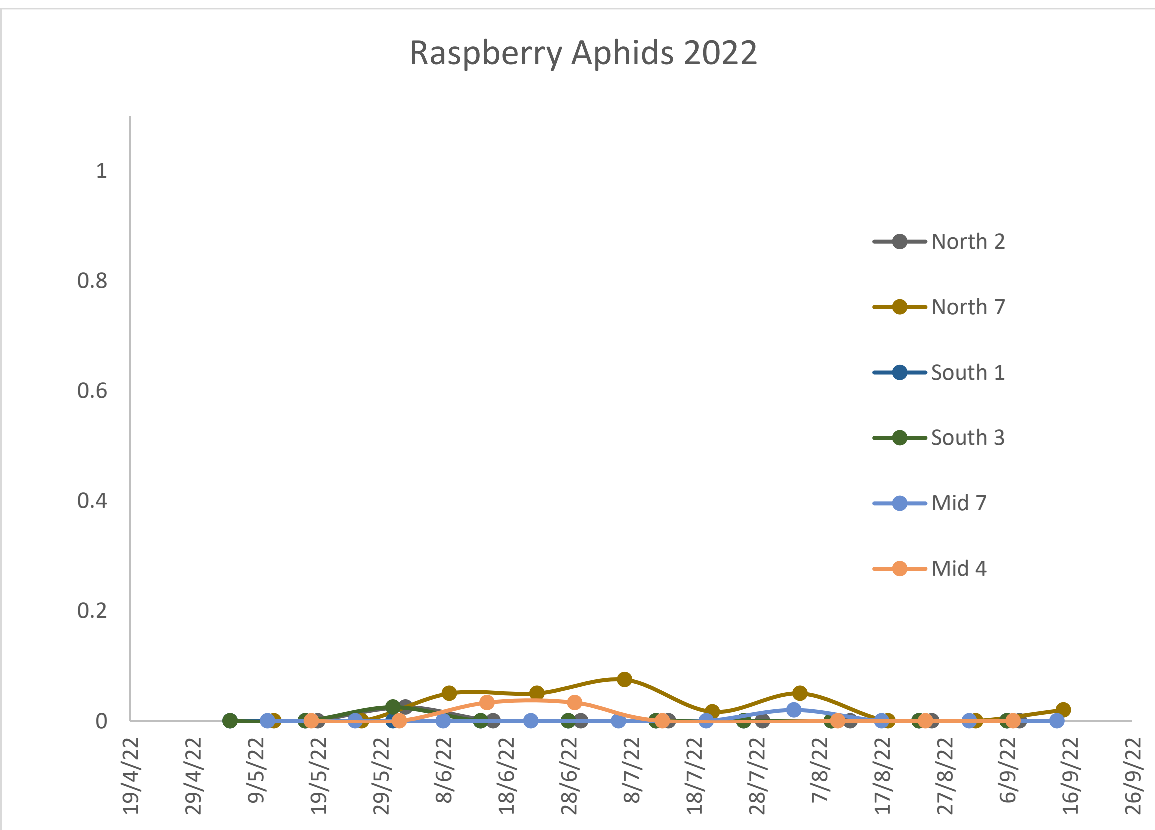
16/9/22
26/9/22


Raspberry Aphids 2022
North 2
North 7
South 1
South 3
Mid 7
Mid 4
0
0.2
0.4
0.6
0.8
1
19/4/22
29/4/22
9/5/22
19/5/22
29/5/22
8/6/22
18/6/22
28/6/22
8/7/22
18/7/22
28/7/22
7/8/22
17/8/22
27/8/22
6/9/22
16/9/22
26/9/22

Phylum	Class	Order	Family	Scientific Name	Common Name	Number of observations
Arthropods						
	Arachnids	Spiders (Araneae)				
			Agelenidae	Agelenopsis	Grass Spiders	1
			Agelenidae	Eratigena duellica	Giant House Spider	1
			Antrodiaetidae	Antrodiaetus pacificus	Pacific Foldingdoor Spider	1
			Araneidae	Araneus diadematus	Cross Orbweaver	6
			Araneidae	Argiope trifasciata	Banded Garden Spider	1
			Cheiracanthiidae	Cheiracanthium mildei	Northern Yellow Sac Spider	1
			Dysderidae	Dysdera crocata	Woodlouse Spider	1
			Lycosidae	Trochosa	Wolf Spiders	2
			Philodromidae	Philodromus	Running Crab Spiders	1
			Salticidae	Metaphidippus manni	Oak Jumping Spider	1
			Salticidae	Pelegrina aeneola	Coppered White-cheeked Jumping Spider	1
			Salticidae	Phidippus johnsoni	Johnson's Jumping Spider	6
			Salticidae	Platycryptus californicus	California Flattened Jumping Spider	2
			Salticidae	Evarcha proszynskii	Proszynski's Jumping Spider	1
			Salticidae	Salticus scenicus	Zebra Jumping Spider	2
			Tetragnathidae	Tetragnatha	Stretch Spiders	1
			Theridiidae	Enoplognatha ovata	Candy-striped Spider complex	4
			Theridiidae	Parasteatoda tepidariorum	Common House Spider	2
			Theridiidae	Steatoda grossa	False Black Widow	1
			Thomisidae	Misumena vatia	Goldenrod Crab Spider	5
		Havestmen (Opiliones)				
			Phalangiidae	Phalangium opilio	European Harvestman	3
		Mites (Acari)				
			Eriophyidae	Colomerus vitis	Grape Erineum Mite	5
			Eriophyidae	Eriophyes pyri	Pear Leaf Blister Mite	1

Phylum	Class	Order	Family	Scientific Name	Common Name	Number of observations
			Anystidae	Anystis	Whirligig Mites	1
			Bdellidae	Bdellidae	Snout Mites	1
			Tetranychidae	Tetranychus urticae	Two-spotted Spider Mite	1
	Springtails (Collembola)					
				Symphypleona	Globular Springtails	1
	Insecta					
		Beetles (Coleoptera)				
				Ground Beetles (Carabidae)		
			Carabidae	Carabus granulatus	Granulated Ground Beetle	1
			Carabidae	Carabus nemoralis	Bronze Ground Beetle	5
			Carabidae	Scaphinotus angusticollis	Narrow-collared Snail-eating Beetle	2
			Carabidae	Harpalus affinis	Ground Beetles	1
			Carabidae	Harpalus pensylvanicus	Pennsylvania Dingy Ground Beetle	1
			Carabidae	Acupalpus meridianus	Ground Beetles	1
			Carabidae	Nebria brevicollis	European Gazelle Beetle	1
			Carabidae	Calathus fuscipes	Ground Beetles	1
			Carabidae	Cicindela oregona	Western Tiger Beetle	1
			Carabidae	Omus dejeanii	Greater Night-stalking Tiger Beetle	1
			Carabidae	Pterostichus melanarius	Rain-beetle	6
				Rove Beetles (Staphylinidae)		
			Staphylinidae	Lathrobiina	Rove Beetles	1
			Staphylinidae	Tasgius	Rove Beetles	1
				Lady Beetles (Coccinellidae)		
			Coccinellidae	Chilocorus bipustulatus	Heather Lady Beetle	1
			Coccinellidae	Adalia bipunctata	Two-spotted Lady Beetle	4
			Coccinellidae	Coccinella septempunctata	Seven-spotted Lady Beetle	22
			Coccinellidae	Coccinella trifasciata	Three-banded Lady Beetle	3
			Coccinellidae	Cycloneda polita	Western Polished Lady Beetle	12

Phylum	Class	Order	Family	Scientific Name	Common Name	Number of observations
			Coccinellidae	Harmonia axyridis	Asian Lady Beetle	42
			Coccinellidae	Mulsantina picta	Painted Ladybird	1
			Coccinellidae	Psyllobora borealis	Western Fairy Lady Beetle	3
			Coccinellidae	Psyllobora vigintimaculata	Twenty-spotted Lady Beetle	3
			Coccinellidae	Scymnini	Dusky Lady Beetles	1
			Coccinellidae	Stethorus punctum	Spider Mite Destroyer	5
				Other Beetles		
			Dermestidae	Anthrenus verbasci	Varied Carpet Beetle	2
			Buprestidae	Buprestis aurulenta	Golden Buprestid Beetle	3
			Buprestidae	Phaenops	Jewel Beetles	1
			Buprestidae	Chalcophora angulicollis	Western Sculptured Pine Borer	1
			Agyrtidae	Necrophilus	Carrion Beetles	1
			Silphidae	Nicrophorus defodiens	Burying beetles	1
			Cerambycidae	Phymatodes nitidus	Sequoia Cone Borer	1
			Cerambycidae	Semanotus	Typical Longhorn Beetles	1
			Cerambycidae	Holopleura marginata	Typical Longhorn Beetles	1
			Cerambycidae	Synaphaeta guexi	Spotted Tree Borer	1
			Cerambycidae	Etorofus obliteratus	Flower Longhorn Beetles	2
			Cerambycidae	Xestoleptura crassipes	Flower Longhorn Beetles	3
			Cerambycidae	Pidonia scripta	Flower Longhorn Beetles	1
			Chrysomelidae	Epitrix tuberis	Tuber Flea Beetle	2
			Chrysomelidae	Phyllotreta cruciferae	Cruicfer Flea Beetle	2
			Chrysomelidae	Pyrrhalta viburni	Viburnum Leaf Beetle	1
			Chrysomelidae	Bruchidius villosus	Broom Seed Beetle	2
			Chrysomelidae	Bruchus	Pea and Bean Weevils	2
			Chrysomelidae	Crioceris duodecimpunctata	Spotted Asparagus Beetle	1
			Chrysomelidae	Calligrapha californica	Coreopsis Beetle	8

Phylum	Class	Order	Family	Scientific Name	Common Name	Number of observations
			Melyridae	Dasytes plumbeus	Soft-winged Flower Beetles	2
			Melyridae	Malachius aeneus	Scarlet Malachite Beetle	1
			Trogossitidae	Temnoscheila	Bark-gnawing Beetles	1
			Cleridae	Enoclerus eximius	Checkered Beetles	1
			Latridiidae	Latridiidae	Minute Brown Scavenger Beetles	1
			Nitidulidae	Epuraea	Sap-feeding Beetles	1
			Curculionidae	Scaphomorphus poricollis	True Weevils	1
			Curculionidae	Ceutorhynchus erysimi	Minute Seed Weevils	1
			Curculionidae	Otiorhynchus rugosostriatus	Rough Strawberry Root Weevil	1
			Curculionidae	Sciopithes obscurus	Obscure Root Weevil	1
			Curculionidae	Dyslobus granicollis	Broad-nosed Weevils	1
			Elateridae	Danosoma brevicorne	Short-horned Click Beetle	1
			Elateridae	Hemicrepidius morio	Click Beetles	1
			Elateridae	Agriotes lineatus	Lined Click Beetle	1
			Elateridae	Ampedus rhodopus	Click Beetles	1
			Elateridae	Megapenthes	Click Beetles	1
			Cantharidae	Rhagonycha fulva	Common Red Soldier Beetle	4
			Lycidae	Dictyoptera simplicipes	Red Net-winged Beetle	1
			Scarabaeidae	Diplotaxis	June Beetles	1
			Scarabaeidae	Polyphylla crinita	Long-haired June Beetle	1
			Scarabaeidae	Onthophagus nuchicornis	Small Black-and-brown Dung Beetle	1
			Scarabaeidae	Cetoniinae	Fruit and Flower Chafers	1
			Mordellidae	Mordellidae	Tumbling Flower Beetles	1
		Earwings (Dermaptera)				
			Forficulidae	Forficula auricularia	European Earwig	1

Phylum	Class	Order		Family	Scientific Name	Common Name
		Flies (Diptera)				
				Hover Flies (Syrphidae)		
			Syrphidae	Platycheirus	Sedgesitters	1
			Syrphidae	Eristalinus aeneus	Common Lagoon Fly	1
			Syrphidae	Eristalis arbustorum	European Drone Fly	7
			Syrphidae	Eristalis nemorum	Orange-spined Drone Fly	1
			Syrphidae	Eristalis tenax	Common Drone Fly	7
			Syrphidae	Myathropa florea	Yellow-haired Sun Fly	4
			Syrphidae	Sericomyia chalcopyga	Western Pond Fly	1
			Syrphidae	Eumerus	Drone Flies and Allies	3
			Syrphidae	Merodon equestris	Narcissus Bulb Fly	7
			Syrphidae	Spilomyia citima	Western Hornet Fly	1
			Syrphidae	Syritta pipiens	Thick-legged Hover Fly	4
			Syrphidae	Hadromyia pulchra	Yellow-shielded Quicksilver	1
			Syrphidae	Xylota	Thick-legged Hover Fly	4
			Syrphidae	Syrphini	Leafwalkers and Forest Flies	1
			Syrphidae	Eupeodes fumipennis	Western Aphideater	2
			Syrphidae	Eupeodes latifasciatus	Variable Aphideater	1
			Syrphidae	Eupeodes volucris	Large-tailed Aphideater	2
			Syrphidae	Fazia micrura	Diamond Spottail	1
			Syrphidae	Meliscaeva cinctella	American Thintail Fly	1
			Syrphidae	Scaeva affinis	White-bowed Smoothwing	4
			Syrphidae	Sphaerophoria sulphuripes	Forked Globetail	1
			Syrphidae	Syrphus opinator	Black-margined Flower Fly	7
			Syrphidae	Toxomerus occidentalis	Western Calligrapher	6
				Other Flies		
			Asilidae	Asilinae	Robber Flies	2

Phylum	Class	Order	Family	Scientific Name	Common Name	Number of observations
			Asilidae	Eudioctria sackeni	Robber Flies	3
			Asilidae	Laphria	Bee-mimic Robber Flies	2
			Bombyliidae	Bombylius major	Greater Bee Fly	3
			Bombyliidae	Exoprosopa dorcadion	Dorcadion Bee Fly	1
			Bombyliidae	Hemipenthes	Banded Bee Flies	1
			Bombyliidae	Villa lateralis	Banded Bee Flies	1
			Therevidae	Thereva	Stiletto Flies	1
			Chloropidae	Chloropidae	Frit Flies	1
			Psilidae	Psila rosae	Carrot Rust Fly	2
			Dolichopodidae	Condylostylus occidentalis	Long-legged Flies	1
			Drosophilidae	Cacoxenus indagator	Houdini Fly	1
			Drosophilidae	Drosophila suzukii	Spotted-winged Drosophila	3
			Ephydridae	Hydrellia	Shore Flies	1
			Muscidae	Coenosia tigrina	Tiger Flies	1
			Anthomyiidae	Delia radicum	Cabbage Root Fly	2
			Anthomyiidae	Pegomya hyoscyami	Spinach Leafminer	1
			Scathophagidae	Scathophaga	Dung flies	1
			Calliphoridae	Lucilia coeruleiviridis	Blue-green bottle Fly	1
			Calliphoridae	Lucilia sericata	Common European Greenbottle Fly	2
			Tachinidae	Epalpus signifer	Early Tachinid Fly	1
			Calliphoridae	Calliphora	Bluebottle flies	1
			Opomyzidae	Opomyzidae		2
			Conopidae	Physocephala burgessi	Thick-headed flies	3
			Tephritidae	Rhagoletis completa	Walnut Husk Fly	2
			Tephritidae	Rhagoletis pomonella	Apple Maggot	2
			Tephritidae	Rhagoletis indifferens	Western Cherry Fruit Fly	1
			Stratiomyidae	Exaireta spinigera	Garden soldier fly	4
			Stratiomyidae	Sargus bipunctatus	Twin-Spot Centurion Fly	1
			Lonchopteridae	Lonchoptera	Spear-winged flies	1
			Rhagionidae	Rhagio tringarius	Marsh Snipe Fly	3
			Tabanidae	Chrysops	Deer Flies	1

Phylum	Class	Order	Family	Scientific Name	Common Name	Number of observations
			Tabanidae	Hybomitra	Horse Flies	1
			Baetidae	Callibaetis	Speckled Duns	1
			Chironomidae	Chironomidae	Non-biting Midges	1
			Simuliidae	Simuliidae	Black Flies	1
			Cecidomyiidae	Aphidoletes	Gall Midges	4
			Cecidomyiidae	Dasineura mali	Apple Leafcurling Midge	1
			Cecidomyiidae	Feltiella acarisuga	Gall Midges	1
			Scatopsidae	Scatopsidae	Minute Black Scavenger Flies	1
			Tipulidae	Tipula oleracea	Marsh Crane Fly	2
			Bibionidae	Bibio	March Flies	3
			Bibionidae	Dilophus stigmaterus	March Flies	1
		True Bugs, Hoppers, Aphids, and allies (Hemiptera)				
			Aleyrodidae	Aleyrodes	Whiteflies	1
			Aphididae	Aphis pomi	Green Apple Aphid	1
			Aphididae	Aulacorthum solani	Foxglove Aphid	1
			Aphididae	Brachycaudus	Aphids	2
			Aphididae	Brevicoryne brassicae	Cabbage Aphid	3
			Aphididae	Dysaphis plantaginea	Rosy Apple Aphid	3
			Aphididae	Macrosiphum rosae	Rose Aphid	1
			Aphididae	Pemphigus bursarius	Poplar Gall Aphid	1
			Aphididae	Longistigma	Giant Aphids	1
			Nabidae	Nabis americoferus	Common Damsel Bug	1
			Cicadoidea	Cicadoidea	Cicadas	1
			Aphrophoridae	Philaenus spumarius	Meadow Spittlebug	8
			Delphacidae	Delphacini	Delphacid Planthoppers	1
			Cicadellidae	Graphocephala atropunctata	Blue-green Sharpshooter	4
			Cicadellidae	Graphocephala fennahi	Rhododendron Leafhopper	1
			Cicadellidae	Athysanini	Typical Leafhoppers	1
			Cicadellidae	Forcipata	Typical Leafhoppers	1
			Cicadellidae	Empoascini	Typical Leafhoppers	2
			Cicadellidae	Typhlocybini	Typical Leafhoppers	1

Phylum	Class	Order	Family	Scientific Name	Common Name	Number of observations
			Membracidae	Platycotis vittata	Oak Treehopper	1
			Anthocoridae	Orius	Minute pirate bugs	4
			Coreidae	Leptoglossus occidentalis	Western Conifer Seed Bug	4
			Berytidae	Neoneides muticus	Stilt Bugs	1
			Rhyparochromidae	Scolopostethus	Dirt-colored Seed Bugs	1
			Rhyparochromidae	Megalonotus sabulicola	introduced Dirt-colored Seed Bug	1
			Rhyparochromidae	Raglius alboacuminatus	White-spotted Groundbug	1
			Rhyparochromidae	Rhyparochromus vulgaris	Bright-spotted Groundbug	2
			Lygaeidae	Kleidocerys resedae	Birch Catkin Bug	1
			Lygaeidae	Neacoryphus bicrucis	White-crossed Seed Bug	2
			Miridae	Campyloneura virgula	Plant Bugs	2
			Miridae	Closterotomus norwegicus	Potato Mirid	1
			Miridae	Lygus	Lygus Bugs	6
			Miridae	Stenotus binotatus	Two-spotted Grass Bug	1
			Miridae	Malacocoris chlorizans	Delicate Apple Capsid	1
			Miridae	Phylus	Plant Bugs	1
			Pentatomoidea	Elasmostethus cruciatus	Red-cross Shield Bug	1
			Pentatomoidea	Euschistus conspersus	Consperse Stink Bugs	3
			Pentatomoidea	Holcostethus	Stink Bugs	1
			Pentatomoidea	Halyomorpha halys	Brown Marmorated Stink Bug	2
			Pentatomoidea	Brochymena affinis	Rough Stink Bugs	1
			Pentatomoidea	Brochymena quadripustulata	Four-humped Stink Bug	1
			Pentatomoidea	Chlorochroa	Stink Bugs	1
			Pentatomoidea	Nezara viridula	Southern Green Stink Bug	3
			Pentatomoidea	Banasa dimidiata	Green Burgundy Stink Bug	4
			Pentatomoidea	Thyanta	Stink Bugs	1

Phylum	Class	Order	Family	Scientific Name	Common Name	Number of observations
		Bees and Wasps (Hymenoptera)				
				Bees (Anthophila)		
			Anthophila	Andrena prunorum	Prunus Miner	3
			Anthophila	Melandrena	Mining Bees	1
			Anthophila	Anthophora pacifica	Pacific Digger Bee	1
			Anthophila	Apis mellifera	Western Honey Bee	23
			Anthophila	Bombus californicus	California Bumble Bee	1
			Anthophila	Bombus flavifrons	Yellow-Fronted Bumble Bee	38
			Anthophila	Bombus melanopygus	Orange-Rumped Bumble Bee	24
			Anthophila	Bombus mixtus	Fuzzy-Horned Bumble Bee	15
			Anthophila	Bombus occidentalis	Western Bumble Bee	7
			Anthophila	Bombus sitkensis	Sitka Bumble Bee	3
			Anthophila	Bombus vancouverensis vancouverensis	Vancouver Island Bumble Bee	22
			Anthophila	Bombus vosnesenskii	Yellow-faced Bumble Bee	18
			Anthophila	Melissodes microstictus	Small Long-horned Bee	2
			Anthophila	Epeolus olympiellus	Olympia Cellophane-cuckoo Bee	1
			Anthophila	Triepeolus paenepectoralis	Variable Longhorn-Cuckoo	1
			Anthophila	Nomada	Nomad Bees	2
			Anthophila	Zadontomerus	Small Carpenter Bees	3
			Anthophila	Colletes	Cellophane Bees	3
			Anthophila	Hylaeus punctatus	Punctate Masked Bee	1
			Anthophila	Agapostemon texanus	Texas Striped Sweat Bee	6
			Anthophila	Halictus confusus	Confusing Furrow Bee	3
			Anthophila	Halictus rubicundus	Orange-legged Furrow Bee	3
			Anthophila	Lasioglossum sisymbrii	Tansymustard Sweat Bee	2
			Anthophila	Dialictus	Metallic Sweat Bees	3

Phylum	Class	Order	Family	Scientific Name	Common Name	Number of observations
			Anthophila	Sphecodes	Blood Bees	1
			Anthophila	Anthidium manicatum	European Woolcarder Bee	14
			Anthophila	Dianthidium subparvum		1
			Anthophila	Stelis	Dark Bees	2
			Anthophila	Coelioxys	Cuckoo Leaf-cutter Bees	5
			Anthophila	Megachile	Leafcutter, Mortar, and Resin Bees	1
			Anthophila	Megachile fidelis	Horn-faced Leafcutter Bee	1
			Anthophila	Megachile melanophaea	Black-and-gray Leafcutter Bee	4
			Anthophila	Megachile perihirta	Western Leafcutter	3
			Anthophila	Megachile rotundata	Alfalfa Leafcutter Bee	1
			Anthophila	Heriades	Armored-Resin bees	1
			Anthophila	Osmia caerulescens	Blue Mason Bee	1
			Anthophila	Osmia lignaria	Blue Orchard Bee	5
				Wasps		
			Crabronidae	Astatinae	Square-headed Wasps	1
			Crabronidae	Bembix americana	American Sand Wasp	1
			Crabronidae	Crabro latipes	Shield-handed Wasps	1
			Crabronidae	Crossocerus annulipes	Square-headed Wasps	1
			Crabronidae	Rhopalum clavipes	Square-headed Wasps	1
			Crabronidae	Oxybelus	Oxybelus Wasps	1
			Crabronidae	Pemphredonina	Aphid Wasps	1
			Crabronidae	Psenini	Aphid Wasps	1
			Crabronidae	Philanthus crabroniformis		2
			Crabronidae	Philanthus gibbosus	Hump-backed Beewolf	3
			Sphecidae	Prionyx canadensis		1
			Sphecidae	Ammophila	Thread-waisted Sand Wasps	2
			Sphecidae	Sceliphron caementarium	Yellow-legged Mud-dauber Wasp	2
			Leucospidae	Leucospis affinis	Chalcidoid Wasps	1

Phylum	Class	Order	Family	Scientific Name	Common Name	Number of observations
			Chrysididae	Holopyga	Cuckoo Wasps	2
			Cynipidae	Diplolepis polita	Spiny Leaf Gall Wasp	1
			Formicidae	Tapinoma sessile	Odorous House Ant	1
			Formicidae	Camponotus modoc	Western Carpenter Ant	1
			Formicidae	Leptothorax		1
			Formicidae	Tetramorium immigrans	Immigrant Pavement Ant	1
			Formicidae	Formica Fusca	Fusca-group Field Ants	4
			Formicidae	Formica neogagates	Neogagates-group Field Ants	1
			Formicidae	Formica obscuripes	Western Thatching Ant	2
			Formicidae	Lasius pallitarsis	Subterranean Aphid-tending Ant	1
			Ichneumonidae	Therion	Ichnemonid Wasp	1
			Ichneumonidae	Limneriini	Ichnemonid Wasp	1
			Ichneumonidae	Mesostenina	Ichnemonid Wasp	1
			Ichneumonidae	Ichneumon	Ichnemonid Wasp	1
			Ichneumonidae	Ophion	Short-tailed Ichnemonid Wasp	2
			Ichneumonidae	Gelis tenellus	Ichnemonid Wasp	1
			Ichneumonidae	Pimpla pedalis	Ichnemonid Wasp	2
			Ichneumonidae	Diplazon laetatorius	Common Hover Fly Parasitoid Wasp	1
			Braconidae	Aphidius	Aphid Mummy Wasps	1
			Braconidae	Microgastrinae	Braconid Wasps	1
			Pompilidae	Pompilidae	Spider Wasps	3
			Mutillidae	Dasymutilla californica	Velvet Ant	1
			Stephanidae	Stephanidae	Crown Wasps	1
			Vespidae	Polistes dominula	European Paper Wasp	20
			Vespidae	Eumenes	Typical Potter Wasps	1
			Vespidae	Ancistrocerus catskill	Catskill Potter Wasp	1
			Vespidae	Dolichovespula arenaria	Common Aerial Yellowjacket	3
			Vespidae	Dolichovespula maculata	Bald-faced Hornet	9

Phylum	Class	Order	Family	Scientific Name	Common Name	Number of observations
			Vespidae	Vespula alascensis	Alaska Yellowjacket	3
			Vespidae	Vespula atropilosa	Prairie Yellowjacket	1
			Vespidae	Vespula consobrina	Blackjacket	2
			Vespidae	Vespula pensylvanica	Western Yellowjacket	1
			Symphyta	Onycholyda sitkensis	Web-spinning Sawfly	1
			Symphyta	Caliroa cerasi	Cherry Slug Sawfly	6
			Symphyta	Hoplocampa testudinea	Apple Sawfly	1
			Symphyta	Euura ribesii	Imported Currantworm	2
			Symphyta	Pristiphora geniculata	Mountain Ash Sawfly	1
		Butterflies and Moths (Lepidoptera)				
			Sphingidae	Smerinthus ophthalmica	Southwestern Eyed Sphinx	3
			Choreutidae	Choreutis pariana	Apple Leaf Skeletonizer Moth	1
			Sesiidae	Synanthedon albicornis	Western Willow Clearwing Moth	1
			Sesiidae	Pennisetia marginatum	Raspberry Crown Borer	2
			Geometridae	Biston betularia	Peppered Moth	2
			Geometridae	Neoalcis	Geometer Moths	1
			Geometridae	Erannis vancouverensis	Vancouver Looper	1
			Geometridae	Hemithea aestivaria	Common Emerald	1
			Geometridae	Epirrhoe plebeculata	Carpet Moths	1
			Geometridae	Mesoleuca gratulata	Western White-Ribboned Carpet	1
			Geometridae	Operophtera	Spanworm and Wintermoth	2
			Gracillariidae	Phyllonorycter blancardella group	Leaf Blotch Miner Moths	1
			Lasiocampidae	Malacosoma californica	Western Tent Caterpillar	5
			Erebidae	Tyria jacobaeae	Cinnabar Moth	4
			Erebidae	Hyphantria cunea	Fall Webworm Moth	2
			Erebidae	Lophocampa argentata	Silver-spotted Tiger Moth	1

Phylum	Class	Order	Family	Scientific Name	Common Name	Number of observations
			Erebidae	Lophocampa maculata	Spotted Tussock Moth	2
			Erebidae	Spilosoma virginica	Virginian Tiger Moth	5
			Erebidae	Orgyia antiqua	Rusty Tussock Moth	1
			Noctuidae	Acronicta	Dagger Moths	1
			Noctuidae	Schizura ipomaeae	Morning-glory Prominent	1
			Noctuidae	Plusiinae	Looper Moths	1
			Noctuidae	Trichoplusia ni	Cabbage Looper Moth	2
			Noctuidae	Dargida procinctus	Girdler Moth	1
			Noctuidae	Noctua pronuba	Large Yellow Underwing	7
			Noctuidae	Heliothinae	Cutworm Moths and Allies	1
			Papilionoidea	Callophrys augustinus	Brown Elfin	1
			Papilionoidea	Callophrys gryneus	Juniper Hairstreak	1
			Papilionoidea	Strymon melinus	Grey Hairstreak	3
			Papilionoidea	Speyeria hydaspe	Hydaspe Fritillary	1
			Papilionoidea	Ochlodes sylvanoides	Woodland Skipper	10
			Papilionoidea	Limenitis lorquini	Lorquin's Admiral	3
			Papilionoidea	Polygonia	Commas	1
			Papilionoidea	Vanessa cardui	Painted Lady	1
			Papilionoidea	Papilio eurymedon	Pale Swallowtail	4
			Papilionoidea	Papilio rutulus	Western Tiger Swallowtail	3
			Papilionoidea	Papilio zelicaon	Anise Swallowtail	1
			Papilionoidea	Neophasia menapia	Pine White	2
			Papilionoidea	Pieris rapae	Cabbage White	19
			Pterophoridae	Emmelina monodactyla	Morning-glory Plume Moth	1
			Pterophoridae	Amblyptilia pica	Geranium Plume Moth	1
			Crambidae	Pyrausta californicalis	California Pyrausta Moth	3
			Crambidae	Anania hortulata	Small Magpie	1
			Tortricidae	Archipini	Tortricine Leafroller Moths	1
			Tortricidae	Spilonota ocellana	Eye-spotted Bud Moth	1

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			Tortricidae	Rhopobota naevana	Black-headed Fireworm	1
			Tortricidae	Cydia nigricana	Pea Moth	1
			Tortricidae	Cydia pomonella	Codling Moth	3
			Tortricidae	Hedya	Leafroller	2
			Plutellidae	Plutella xylostella	Diamondback Moth	10
		Lacewings (Neuroptera)				
			Chrysopidae	Chrysopa oculata		1
			Chrysopidae	Chrysoperla carnea	carnea-group Green Lacewings	2
			Chrysopidae	Nothochrysa californica	San Francisco Lacewing	1
			Hemerobiidae	Hemerobius	Brown Lacewings	2
			Hemerobiidae	Micromus variegatus	Variegated Brown Lacewing	1
		Dragonflies (Odonata)				
			Coenagrionidae	Enallagma carunculatum	Tule Bluet	1
			Coenagrionidae	Ischnura cervula	Pacific Forktail	1
			Aeshnidae	Anax junius	Common Green Darner	1
			Libellulidae	Libellula forensis	Eight-spotted Skimmer	2
			Libellulidae	Libellula quadrimaculata	Four-spotted Skimmer	1
			Libellulidae	Pachydiplax longipennis	Blue Dasher	2
			Aeshnidae	Rhionaeschna californica	California Darner	1
			Aeshnidae	Rhionaeschna multicolor	Blue-eyed Darner	1
			Libellulidae	Sympetrum illotum	Cardinal Meadowhawk	2
		Grasshoppers (Orthoptera)				
			Acrididae	Melanoplus bivittatus	Two-striped Grasshopper	2
			Acrididae	Melanoplus sanguinipes	Migratory Grasshopper	1
			Acrididae	Trimerotropis verruculata	Crackling Forest Grasshopper	1
			Tetrigidae	Tetrix subulata	Slender Groundhopper	1
			Gryllidae	Gryllus pennsylvanicus	Fall Field Cricket	1

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			Tettigoniidae	Conocephalus fasciatus	Slender Meadow Katydid	1
		Thrips (Thysanoptera)				
				Thysanoptera	Thrips	5
		Caddisfly (Trichoptera)				
			Limnephilidae	Halesochila taylori	Caddisflies	1
	Myriapoda					
		Centipeds (Chilopoda)				
			Geophilomorpha	Geophilomorpha	Soil Centipedes	1
			Lithobiomorpha	Lithobiidae	centipiedes	1
		Millipedes (Diplopoda)				
			Nearctodesmidae	Nearctodesmidae	flat-backed millipedes	2
			Xystodesmidae	Harpaphe haydeniana	Yellow-spotted Millipede	2
	Isopoda					
			Armadillidiidae	Armadillidium vulgare	Common Pill Woodlouse	1
			Porcellionidae	Porcellio scaber	Common Rough Woodlouse	1
Mollusca						
	Gastropoda					
			Ariolimacidae	Ariolimax columbianus	Pacific Banana Slug	1
			Arionidae	Arion rufus	Chocolate Arion	1
			Helicidae	Cepaea nemoralis	Brown-lipped Snail	4
			Xanthonychidae	Monadenia fidelis	Pacific Sideband	1
			Limacidae	Limax maximus	Leopard Slug	5
Annelida						
	Clitellata					
			Hirudinea	Hirudinea	Leeches	1
			Oligochaeta	Lumbricidae	Earthworms	1
Vertebrata						
	Amphibia					
			Anura	Lithobates catesbeianus	American Bullfrog	1
			Anura	Pseudacris regilla	Northern Pacific Tree Frog	4
			Caudata	Aneides vagrans	Wandering Salamander	1
	Aves					
			Caprimulgiformes	Calypte anna	Anna's Hummingbird	1

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			Passeriformes	Haemorhous mexicanus	House Finch	2
			Passeriformes	Tachycineta thalassina	Violet-green Swallow	1
	Mammalia					
			Ruminantia	Odocoileus hemionus columbianus	Mule Deer	1
			Lagomorpha	Sylvilagus floridanus	Eastern Cottontail	1
	Reptilia					
			Sauria	Podarcis muralis	Common Wall Lizard	2
			Serpentes	Thamnophis ordinoides	Northwestern Garter Snake	1
Fungi						
			Basidiomycota	Gymnosporangium sabinae	Pear Rust	1
			Ascomycota	Podosphaera leucotricha	Apple Powdery Mildew	1
			Ascomycota	Monilinia vaccinii-corymbosi	Mummyberry	1