**Project Title:** Calibrating current NE action thresholds with lure-baited trap catch

**Report Type:** Final Project Report

**Primary PI:** Christopher Adams
**Organization**: OSU
**Telephone**: 248-850-0648
**Email**: chris.adams@oregonstate.edu
**Address**: 3005 experiment station drive
**City/State/Zip**: Hood River, OR 97031

**Co-PI 2**: Rebecca Schmidt-Jefferies
**Organization**: USDA-ARS
**Telephone**: 509-454-6556
**Email**: Rebecca.schmidt@usda.gov
**Address**: 5230 Kennowac Pass Rd.
**City/State/Zip**: Wapato, WA 98951

**Co-PI 2**: Robert Orpet
**Organization**: WSU
**Telephone**: 509-293-8756
**Email**: robert.orpet@wsu.edu
**Address**: 1100 N. Western Ave
**City/State/Zip**: Wenatchee, WA 98801

**Cooperators**: GS Long, Wilbur-Ellis, W. Ag. Improvement, Chamberlin

**Project Duration:** 3 Year

**Total Project Request for Year 1 Funding:** $ 45,000
**Total Project Request for Year 2 Funding:** $ 45,000
**Total Project Request for Year 3 Funding:** $ 45,000

**Other related/associated funding sources:** Applied for WSARE
**Funding Duration:** 2025 - 2028
**Amount:** $342,000
**Agency Name:** WSARE
**Notes:** We applied for this grant in 2023 and were highly rated but not funded. We re-submitting the grant this spring (2024) with more of an emphasis on on-farm outreach and extension.

**WTFRC Collaborative Costs:**

| Item | 2021 | 2022 | 2023 |
|---|---|---|---|
| Salaries [1] | $13,000.00 | $13,000.00 | $13,000.00 |
| Benefits | | | |
| Wages | | | |
| Benefits | | | |
| RCA Room Rental | | | |
| Shipping | | | |
| Supplies [2] | $6,000.00 | $6,000.00 | $6,000.00 |
| Travel [3] | | | |
| Plot Fees | | | |
| Miscellaneous | | | |
| | | | |
| | | | |
| | | | |
| Total | $19,000.00 | $19,000.00 | $19,000.00 |

**Footnotes:**

[1]Faculty Research Assistant at 0.15 FTE, with 3% increase in years 2 and 3; OPE 70%

[2]Research consumables

**Budget 1**
**Primary PI:** Christopher Adams
**Organization Name:** OSU
**Contract Administrator:** Charlene Wilkinson
**Telephone:** 541-737-3228
**Contract administrator email address:** Charlene.wilkinson@oregonstate.edu
**Station Manager/Supervisor:** Brian Pierson
**Station manager/supervisor email address:** brian.pierson@oregonstate.edu

| Item | 2021 | 2022 | 2023 |
|---|---|---|---|
| Salaries [1] | $13,000.00 | $13,000.00 | $13,000.00 |
| Benefits | | | |
| Wages | | | |
| Benefits | | | |
| RCA Room Rental | | | |
| Shipping | | | |
| Supplies | | | |
| Travel [2] | | | |
| Plot Fees | | | |
| Miscellaneous | | | |
| | | | |
| | | | |
| | | | |
| Total | $13,000.00 | $13,000.00 | $13,000.00 |

**Footnotes:**

[1]GS-4 technician for 4 months per year, 100% FTE at 8% benefits, Year 2 includes 2.5% COLA increase. Technician would conduct sampling in the Yakima area, process/count samples, and slide mount mites for identification (Schmidt-Jeffris will identify). This technician will also conduct surface sterilization and PCR for gut content analysis for all samples (Yakima, Wenatchee, and Hood River).

[2]Molecular supplies for gut content analysis, sticky cards for field sampling – to be purchased for entire project team.

[3]Fuel to field sites will be provided by USDA base funds and is not requested.

**Budget 2**

**Co PI 2:** Rebecca Schmidt-Jeffris
**Organization Name:** USDA-ARS
**Contract Administrator:** Mara Guttman
**Telephone:** 510-559-5619
**Contract administrator email address:** mara.guttman@usda.gov
**Station Manager/Supervisor:** Rodney Cooper
**Station manager/supervisor email address:** Rodney.cooper@usda.gov

| Item | 2021 | 2022 | 2023 |
|---|---|---|---|
| Salaries [1] | $13,000.00 | $13,000.00 | $13,000.00 |
| Benefits | | | |
| Wages | | | |
| Benefits | | | |
| RCA Room Rental | | | |
| Shipping | | | |
| Supplies | | | |
| Travel [2] | | | |
| Plot Fees | | | |
| Miscellaneous | | | |
| | | | |
| | | | |
| | | | |
| Total | $13,000.00 | $13,000.00 | $13,000.00 |

**Footnotes:**
[1]PhD student in Orpet lab at 0.15 FTE with 3% increase in years 2 and 3; OPE 30%
[3]Travel to field plots

**Budget 3**
**Co PI 2:** Rob Orpet
**Organization Name:** WSU
**Contract Administrator:** Shelli Tompkins
**Telephone:** 509-293-8803
**Contract administrator email address:** shelli.tompkins@wsu.edu
**Station Manager/Supervisor:** Chad Kruger
**Station manager/supervisor email address:** cekruger@wsu.edu

**Objectives**

**1. Use plant volatile baited monitoring traps to describe NE communities in orchard ecosystems throughout the season.**

**2. Compare capture of several key species of NEs in lure-baited traps with numbers measured from standard scouting techniques.**

**3. Establish action (or in-action) thresholds for key NEs.**

**Significant Findings**

- We have shown that lure-baited monitoring traps can be used to attract and collect natural enemies in managed pear orchards. These traps are superior to beat trays because they collect data continually over the period of a week. Plant volatile baited traps collect unbiased data that is not influenced by differences in human collection technique.

- We have measured the abundance and timing of 12 natural enemies of pear psylla across the entire Hood River valley, and in several Wenatchee valley orchards, over three years.

- We provided weekly communication about natural enemy abundance and timing to stake holders through weekly extension emails, who said they used these numbers to make management decisions.

**Methods**

Natural enemy lures containing 4 compounds acetic acid, methyl salicylate, phenylacetaldehyde, and 2-phenylethanol, a combination that has been shown to attract key indicator groups of natural enemies, were made at the OSU MCAREC lab. These lures were hung on yellow sticky traps and placed at 20 pear orchards that were recommended by collaborative crop consultants. Traps were checked and replaced weekly from April to September. Captured insects were identified to family level, species complex (e.g. Lacewings), or to species when possible.

We hope to be able to correlate numbers of natural enemies with relative levels of pear psylla control, and supply crop consultants with reliable action thresholds. While this project will likely require years of refinement, I believe that this first step is critically important to setting the expectation that action threshold for natural enemies can be quantified. Additionally, we hope to direct private industry to manufacture specific lures according to our specifications that will target key natural enemies and be available for commercial use.

To evaluate the usefulness of natural enemies traps we will need to show that trapping can be as good or better at measuring the building natural enemy population, as scouting. Scouting for natural enemies only provides a snapshot in time of the pest and predator populations and may be negatively influenced by weather or sampling technique, which makes it difficult to know if you have an accurate picture of the insect community. Traps have the advantage of collecting data continually over the period between trap checking. Lure baited traps left in the field for a week provide a more consistent measure of the local arthropod community and is more consistent than a person tapping limbs. Catch data was shared with consultants in real time during the study and reviewed retrospectively to see how recommendations and predictions of pest and natural enemy populations matched with catch data. Cooperating crop consultants have been asked to keep detailed notes of psylla and natural enemies counts made as part of their normal scouting routine, as well as recommendations they made for each week. At the end of the season, we compared

crop consultant's management decisions and scouting counts with trap capture for that same period of time.

Weekly psylla counts were sampled by randomly collecting 10 pear shoots from each site and counting the number of eggs, young nymphs, and old nymphs from 5 leaves from each shoot. This method is regularly used by crop consultants to help guide management decisions. The addition of this data will give a clearer image of how psylla populations grew or decreased each week at each site.

We believe that lure baited monitoring will be the new standard for monitoring pear orchards for natural enemies. We have approached private industry (AlphaScents) to develop a commercial lure that can be used by crop consultants.

**Results and Discussion**

A total of 837 four-part plant volatile lures were manufactured in Hood River for the three trapping seasons. The traps placed at 20 pear orchards in Hood River Co (Fig 1.A.) yielded a total of 5,037 natural enemies in 2021. Of these the most common insects found were green lacewings (1,680), Dereaocoris (1,836), Yellow Jackets (809), and earwigs (232). In 2022 traps placed in the same 20 orchards yielded a total of 5,037 natural enemies. Of these the most common insects found were green lacewings (1,091), Dereaocoris (1,303), Yellow Jackets (1,040), Syrphidae (615), Trechnites (696), and earwigs (274) (Fig. 3 A and B). In 2023 traps placed in the same 20 orchards yielded a total of 4,522 natural enemies. Of these the most common insects found were green lacewings (1,861), Trechnites (1,038), Yellow Jackets (564), Deraeocoris (464), Campylomma (136), and earwigs (107)

In Chelan County, WA 9 traps placed along US route 2 near Cahsmere (Fig 1.B.) that yielded a total of 3,773 natural enemies. Of these the most common insects found were green lacewings (1,112), Trechnites (1,743), and Dereaocoris (462), in 2022 In 2023 these same sites had a total of 3,773 natural enemies. Of these the most common insects found were green lacewings (1,112), Trechnites (1,743), and Dereaocoris (462) (Fig. 3 D and E).

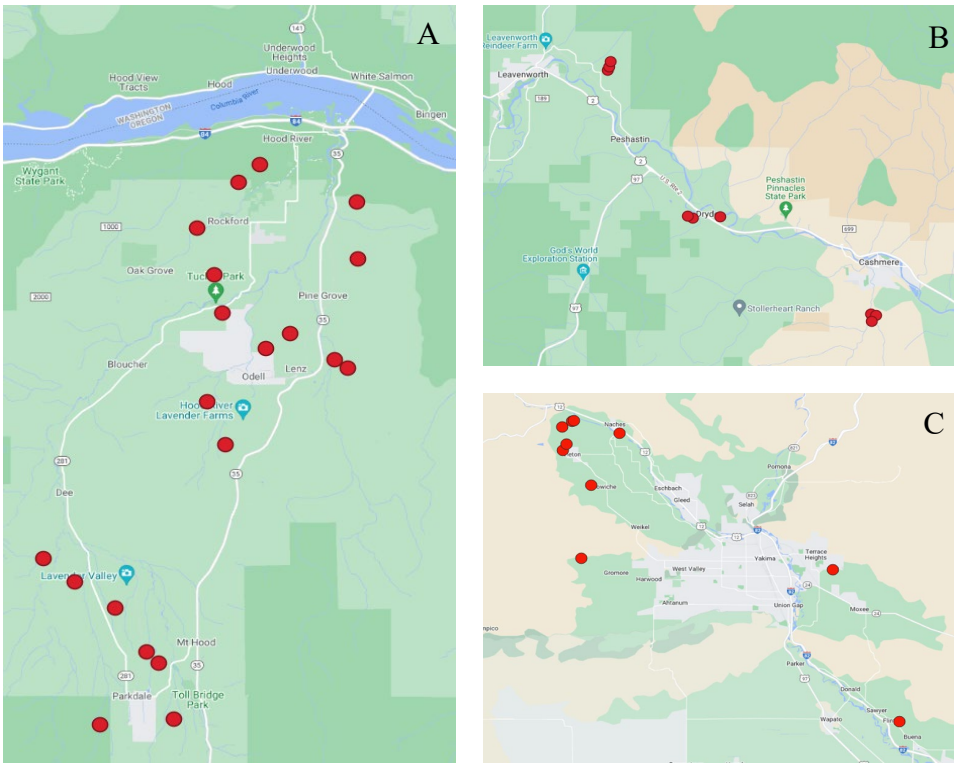
In Yakima County, WA 10 traps placed in pear orchards (Fig 1.C.) yielded a total of 1,602 natural enemies. Of these the most common insects found were green lacewings (994), Dereaocoris (409), Coccinellidae (322), and Yellow Jackets (320) in 2022. In 2023 these same sites had a total of 1,602 natural enemies. Of these the most common insects found were green lacewings (653), Dereaocoris (342), and Trechnites (142)

Lure baited yellow sticky cards effectively collected 12 key natural enemies season long and represent significant time savings over scouting the orchards with beat trays. In Addition, lure baited yellow sticky cards collected insects not typically collected in beat trays such as yellow jackets, bald faced hornets, and adult syrphid flies. Lure baited yellow sticky card provided the additional benefit of collecting data all day long over an entire week (or more). This benefit addresses some of the limitations of beat trays which are impacted by the time of day the traps are checked or from the high wind conditions. Beat tray data can also be impacted by variation between people conducting the sample, or the limb of tree selected.

Earlier researchers have suggested that natural enemies need to be present in large numbers early in the season to be effective at rendering biological control against pear psylla. In Orchards identified by crop consultants as "easy" to control with natural enemies, we find large populations

of natural enemies early in the season and at ratios of up to 100:1 (natural enemies to pear psylla). Where populations of natural enemies are not present early in the season or when ratios of natural enemies to pear psylla is not sufficient, we see lack of control. Tracking natural enemies with lure baited sticky cards also indicates where psylla sprays are impacting natural enemies and, in some cases, we can see where insecticide sprays were applied when no psylla were present. However, pesticide applications did not always correlate with reduced natural enemies or psylla control, suggesting that the system is more dynamic with both psylla and natural enemies moving between blocks at a landscape level. The lure-baited trap allowed us to see these trends with less labor and time and with more consistency than the standard limb tapping. Crop consultants reported that this tool improved their management decisions and helped them improve sprays timing.

Researchers have been working on this objective for fifty years. This same question was Larry Gut's Master's degree in 1985, his dissertation sits on my shelf. The last three seasons have been some of the most unusual in memory with snow during bloom, a heat dome in the summer, followed by an unusually wet spring. None of these past years can be considered average so finding significant trends has been challenging. However, we did see is that multi-year drop in Deraeocoris, bald-faced hornets, yellow jackets, and syrphid flies over this three-year period that corresponded with an increase in pear psylla over the same time period. While we still have great variability between sites within each year, this multi-year population trend in several key natural enemies follows the classic predator prey relationship. Despite this variability crop consultants can, for the first time, compare individual sites to area-wide averages to help make decisions. While the number of any one natural enemy has not correlated with control, we are encouraged by the high level of enthusiasm from our crop consultant collaborators, who feel that this new tool saves them considerable time and improves the quality of the data they use to inform management decisions.




Figures 1 (A-C). Maps showing the sites where traps were placed in A. Hood River County, OR, B. Chelan Co., and C. Yakima Co.

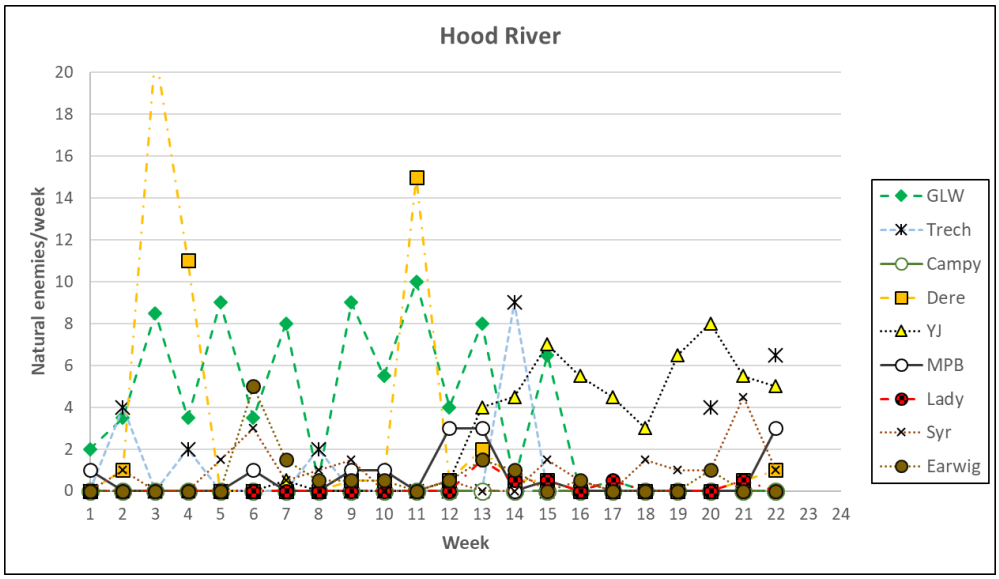



Figure 2. An example of the average natural enemy counts found in the Hood River region, sent out weekly to growers and crop consultants in 2021 - 2023. These area-wide averages were used by crop consultants, in conjunction with local trapping, to make decisions. Although crop consultants could not agree on a magic number of any one insect.

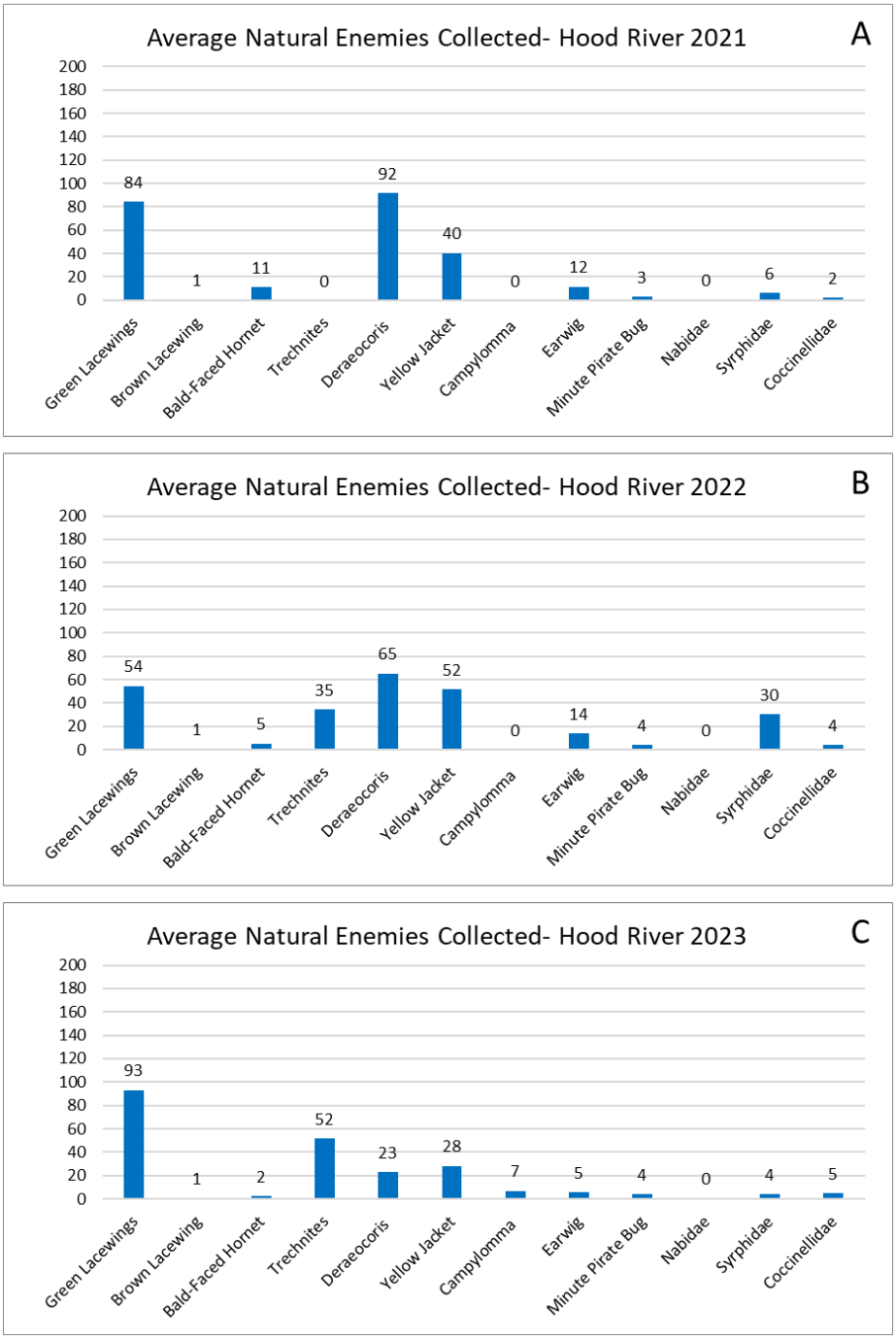



Figure 3 (A-C). Average natural enemy capture in Hood River by year shows a multi-year decreasing trend in deraeocoris that correlates with last high year's pear psylla counts. No other insect has shown a clear correlation.

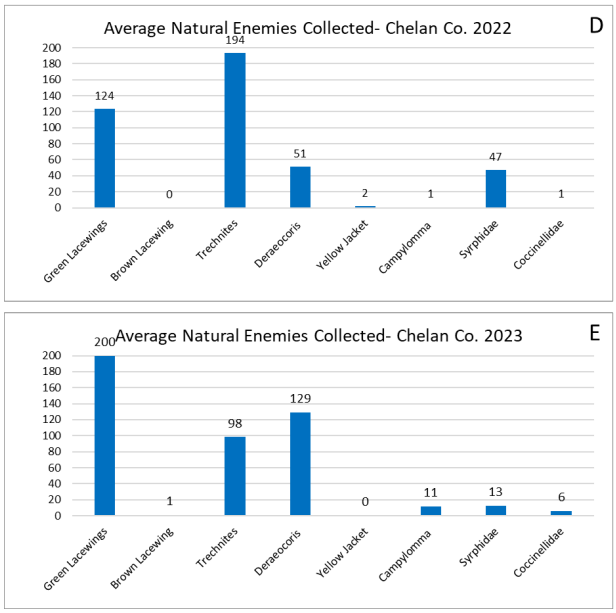



Figure 4 (D &E) Average natural enemies Chelan CO in 2022 (D) and 2023 (E).

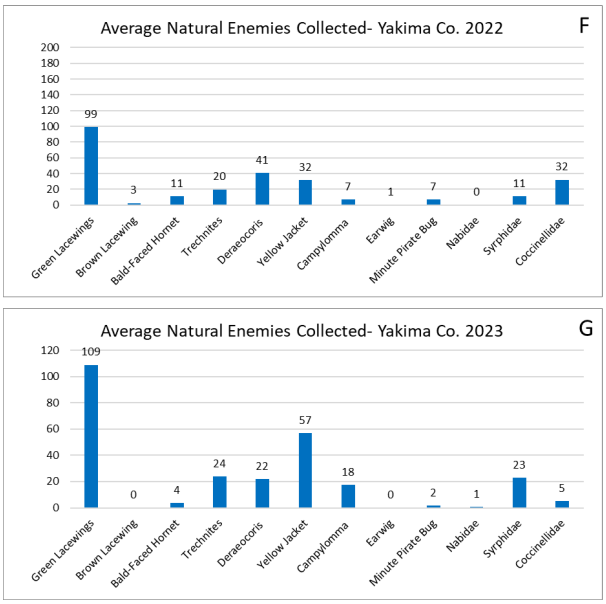



Figure 5 (F & G) Average number of natural enemies collected Yakima Co. in 2022 (F), 2023 (G).

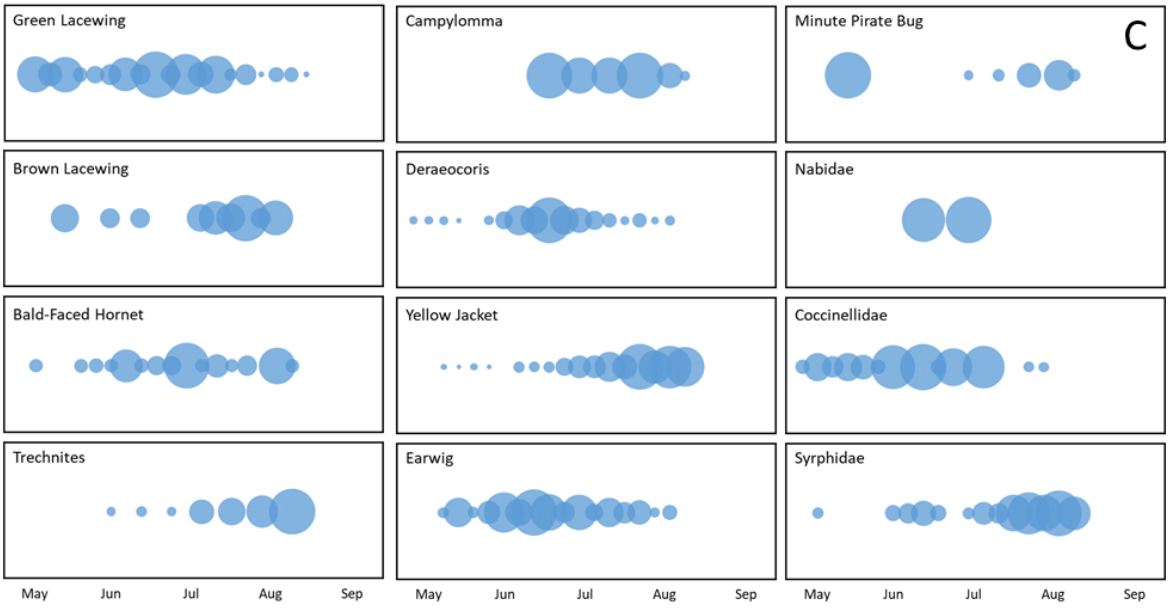



Figure 6. The relative abundance of natural enemies throughout the season in Hood River illustrates the timing of natural enemy occurrence.

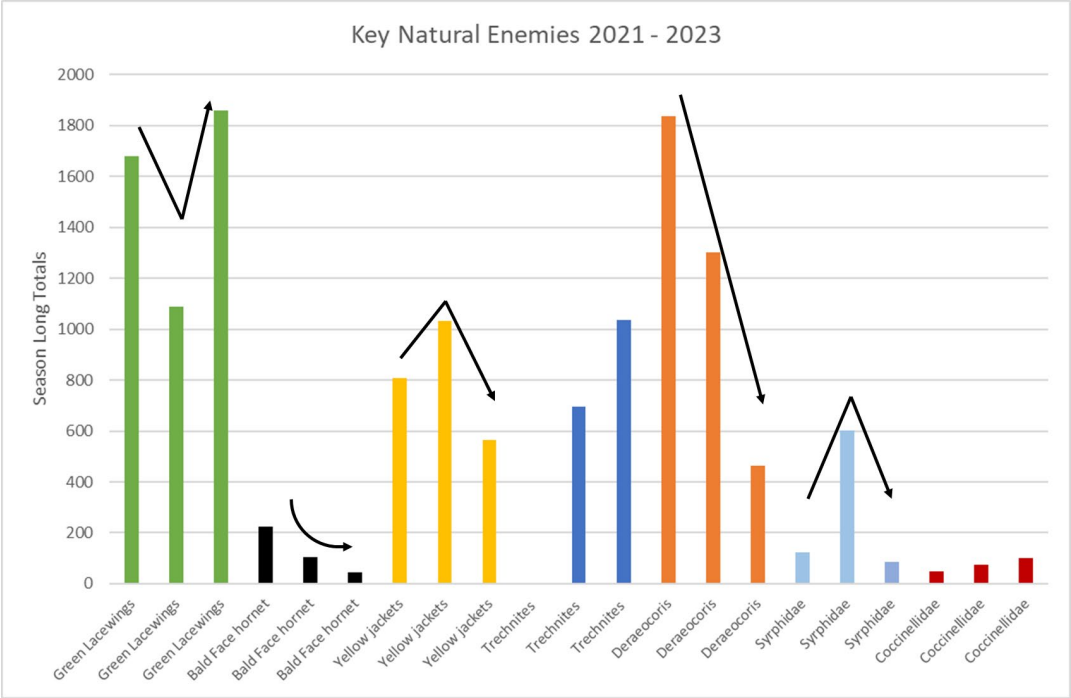



Figure 7. Natural enemies season-long totals over three years. Over the three-year period of this research pear psylla numbers (not shown) for the region increased every year.

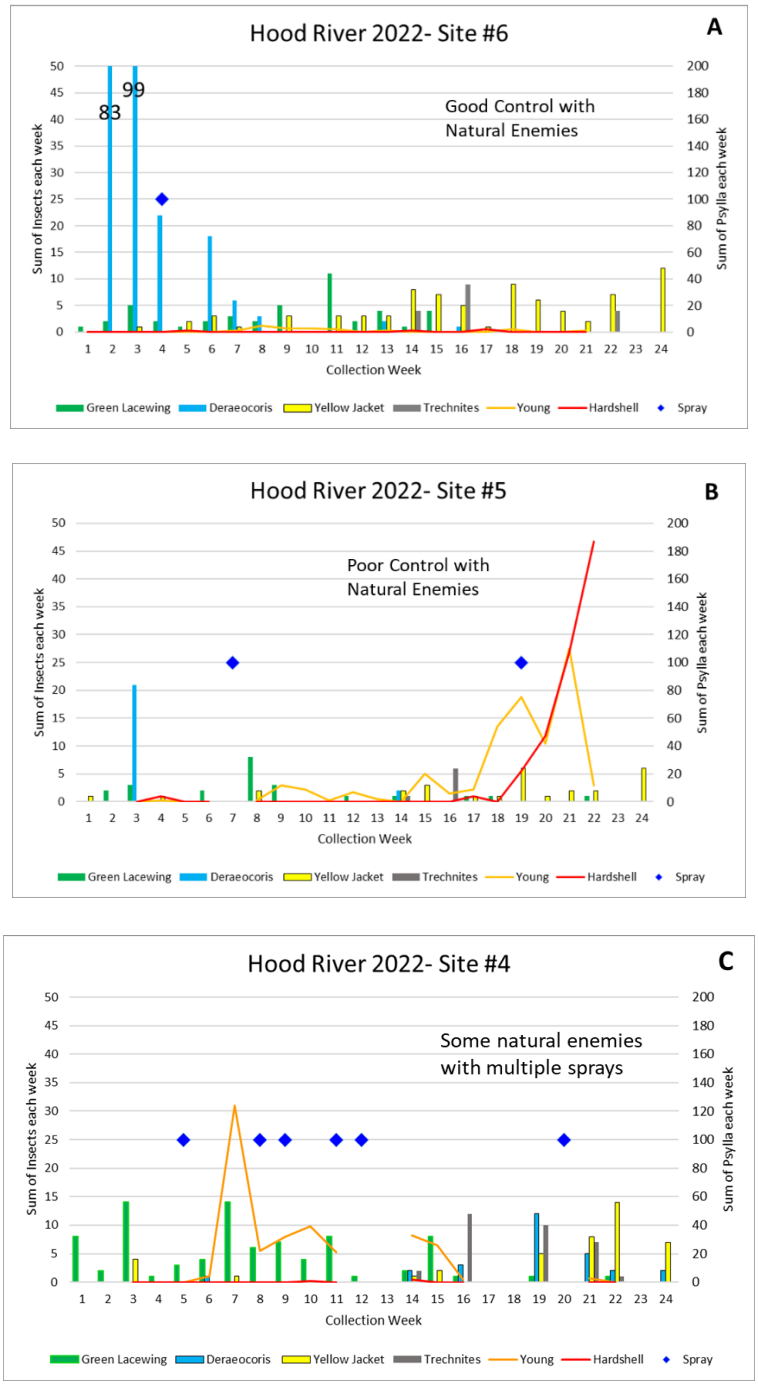



Figure 8. Representative orchards showing season long catch. Counts of natural enemies, young pear psylla nymphs (young), and mature psylla nymphs (hard-shell) at select sites in Hood River Co. Figure A shows ideal natural enemy control and low psylla and minimal pesticide sprays. Figure B shows minimal pesticide sprays but a lack of natural enemy control, and end of season increase in psylla population. And Figure C shows insufficient natural enemy control, multiple pesticide applications, and low (overall) psylla populations.

**References**

Booth, S.R. (1992). The Potential of endemic natural enemies to suppress pear psylla, Cacopsylla pyricola Forster, in the Hood River Valley, Oregon. Corallis, OR: Oreong State University Dissertation.

Brunner, J. F. (1975) Economic injury level of the pear psylla, Psylla pyricola Forster, and a discrete time model of a pear psylla-predator interaction. Wenatchee, WA: Washington State University.

Burts, E.c. (1983) Effectiveness of a soft-pesticide program on pear pests. Journal of Economic Entomology, 76, 936-941

DuPont, S. T., C. J. Strohm. (2020). Integrated pest management programmes increase natural enemies of pear psylla in Central Washington pear orchards. Journal of Applied Entomology, 144:109-122.

DuPont S. T., C. Strohm, L. Nottingham, Dalila Rendon. (2021). Evaluation of an integrated pest management program for central Washington pear orchards. Biological Control, 152; 1049-9644.

Horton, D. R. (1994) Relationship among Sampling Methods in Density Estimates of Pear Psylla (Homoptera: Psyllidae): Implications of Sex, Reproductive Maturity, and Sampling Location. Annal of the Entomological Society of America, 87, 5;1, 583-591.

Jones, V. P., D.R. Horton, N. J. Mills, T. R. Unruh, C. C. Baker, T. D. Melton, E. Milickzy, S. A. Steffan, P. W. Shearer, K. G. Amerasekare. (2016). Evaluating plant volatiles for monitoring natural enemies in apple, pear and walnut orchards. Biological Control, 102, 53-56.

Tougeron, K., C. Illtis, F. Renoz, L. Albittar, T. Hance, S. Demeter, G. J. LeGoff. (2021). Ecology and biology of the parasitoid Trechnites insidiosus and its potential for biological control of pear psyllids. Pest Management Science, DOI 10.1002/ps.6517.

Mills, N. J., E. H. Beers, P.W. Shearer, T. R. Unruh, K.G. Amarasekare. (2016) Comparative analysis of pesticide effects on natural enemies in western orchards: A synthesis of laboratory bioassay data. Biological Control, 102, 17-25. http://doi.org/10.1016/j.biocontrol.2015.05.006.

Mills, N. J., V. P. Jones, C. C. Baker, T. D. Melton, S. A. Steffan, T. R. Unruh, D. R. Horton, P. W. Shearer, K. G. Amarasekare, E. Milickzy. (2016). Using plant volatile traps to estimate the diversity of natural enemy communities in orchard ecosystems. Biological Control, 102, 66-76.

Unruh, T.R., P. Shearer, R. Hilton, J.C. Chiu. (2015). Pesticide resistance in pear psylla and identification of resistance related genes. Continuing report on project PR-14-103. Washington Tree Fruit Research Commission.

Van de Baan, H. & B. Croft. (1990). Factors influencing insecticide resistance in Psylla pyricola (Hymenoptera: Psyllidae) and susceptibility in the predator Deraeocoris brevis (Heteroptera: Miridae). Environmental Entomology, 19, 1223-1228. https://doi.org/10.1093/ee/19.5.1223.

Van de Baan, H.E., B.A. Croft, E.C. Burts. (1990). Resistance to the pyrethroid fenvalerate in pear psylla, Psylla pyricola Foerster (Homoptera: Psyllidae), in the northwestern USA. Crop Protection, 9, 185-189. https://doi.org/10.1016/0261-2194(90) 90161-Y.

**Executive Summary**

**Project title:** Calibrating current NE action thresholds with lure-baited trap catch

**Key words:** Pear psylla management, natural enemies, new lure-baited trap

**Abstract:** Pear psylla is the most important pest to control for the fresh-market pear producers. Heavy infestations can create large amounts of honeydew leading to sooty mold and russeting, and in some cases tree decline. Pear psylla develops pesticide resistance quickly, making it challenging for growers to completely suppress populations and thus psylla remains a constant threat. Natural enemies of pear psylla have been shown to provide effective free biocontrol in some growing regions, and carful integrated pest management has been shown to increase the numbers of natural enemies available and reduce psylla populations. Assessing the level of available biocontrol remains a challenge for crop consultants. Sampling currently requires extensive scouting, tapping limbs of two dozen trees across 20 acres. The objective of this research was to build on earlier research by Jones et al. (2016) to develop lure-baited monitoring traps for natural enemies of pear psylla to improve data collection and provide crop consultants with a new tool for measuring biocontrol. To do this we selected four plant volatiles that were shown to be attractive to several key natural enemies and produced lures in our lab. The four-component lure included acidic acid, methylsalicylate, 2-phenylethanol, & phenylacetaldehyde. Lures were paired with a yellow sticky card and placed in 20 orchards in Hood River and Yakima over three seasons, insect data was collected weekly and shared with stakeholders through weekly emails. Lure-baited traps reliably collected data on twelve key natural enemies of pear psylla. Lure-baited traps collected more insect data than limb-tapping and caught several species of adult (flying) insects that are not measured from limb tapping. Time required to collect data was significantly less with lure-baited traps vs. limb tapping, which is key for crop consultants. We saw that blocks with high numbers of natural enemies did see lower psylla pressure on average. Biocontrol was not always available in every block, even when pesticides were withheld. Action thresholds for individual insects are still needed but the most abundant natural enemies were green lacewings and *Deraeocoris brevis*. With the exception of green lacewings and the parasitic wasp *Trechnites insidious,* all natural enemies were at a three-year low while psylla was at a three-year high in 2023. This pattern looks similar to the classic predator-prey relationship where the predators crash the prey population, and then their numbers in turn decline from a lack of resources. If this pattern holds, we should be able to predict “good years” and “bad years” for psylla pressure. The most important natural enemy appears to be *Deraeocoris brevis.* Green lacewings can be found in similarly high numbers, but do not seem to follow the predator-prey relationship. Yellow jackets and hornets are important generalist predators but likely eat as many beneficial insects as psylla, so it is difficult to quantify their net affect. Another confounding factor is that some of these insects are moving across the landscape between blocks and are not restricted to a single orchard. Action thresholds will require more research to measure factors such as landscape level movement, total egg capacity, and number of psylla consumed per insect per day. In conjunction with this research, we added pitfall traps for spiders (because I hired someone passionate about spiders, and wanted to give him a project). In that study we found 7 families of spiders, including one new record for the state. Bi-catch from these pitfall traps included dozens of ground beetles, known to be excellent indicators of overall bio-control. These data suggest that the system is more complex and we are only measuring a small part of the system. While action thresholds have not been established at this time, crop consultants feel they have a better understanding of the amount of biocontrol available in these orchards, and have used this data to make their own management decisions. Additional funding has been applied for with WSARE so that we can continue to work on developing action thresholds.