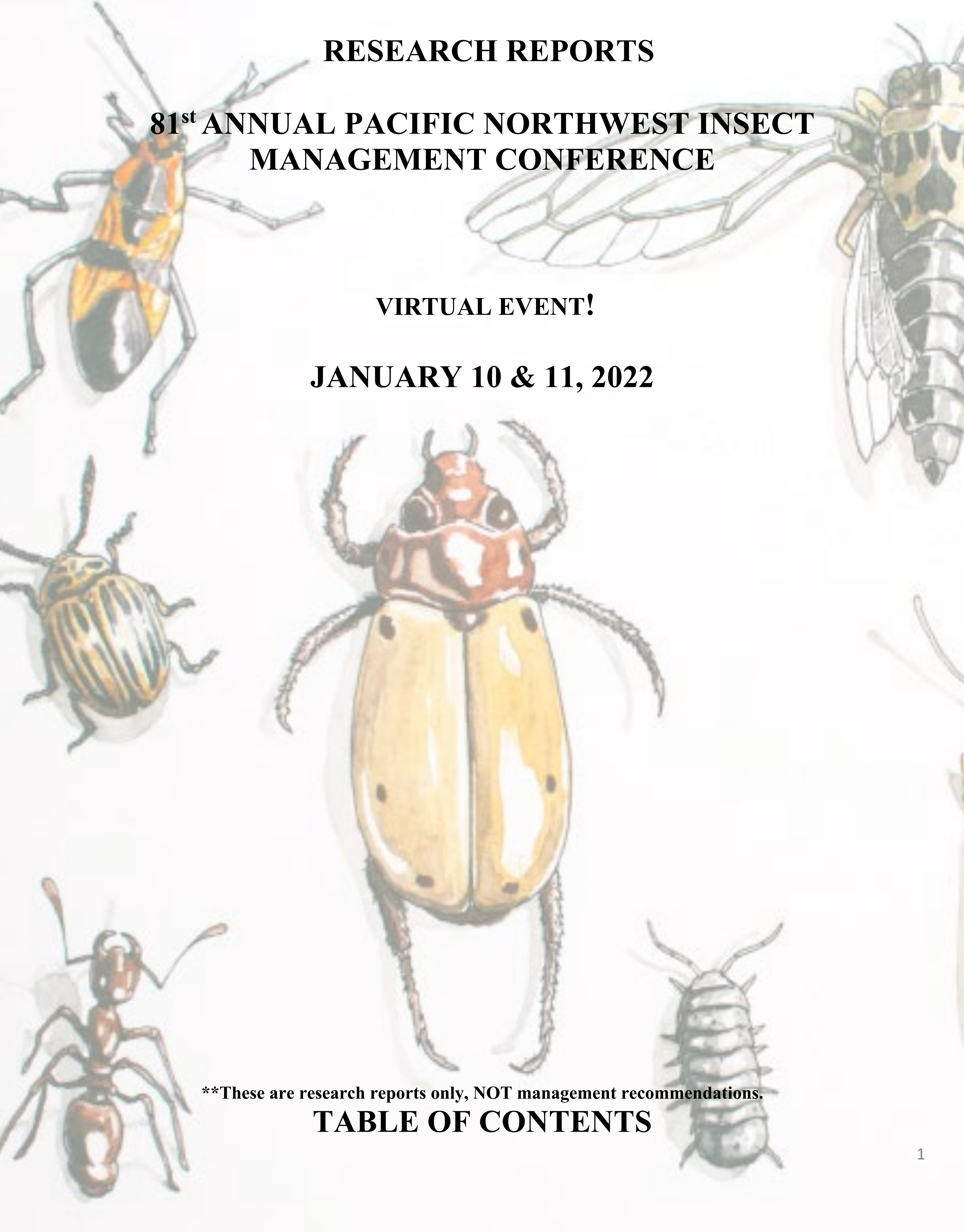

RESEARCH REPORTS

81st ANNUAL PACIFIC NORTHWEST INSECT MANAGEMENT CONFERENCE

VIRTUAL EVENT!

JANUARY 10 & 11, 2022

****These are research reports only, NOT management recommendations.**

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81st ANNUAL PACIFIC NORTHWEST INSECT MANAGEMENT CONFERENCE

January 10 & 11, 2022

PAPERS

Note: "" denotes a student paper. Students present their reports together, in a separate block of time, on Tuesday morning (see Agenda)*

SECTION I: Invasive Pests, Emerging Pests, and Hot Topics of Interest

SECTION II: Bees and Pollinators

SECTION III: Environmental Toxicology and Regulatory Issues

SECTION IV: Field Crop Pests

SECTION V: Potato Pests

SECTION VI: Small Fruits, Tree Fruits and Nuts

SECTION VII: Pests of Turf and Ornamentals

SECTION VIII: New and Current Product Development

SECTION IX: Extension & Consulting: Updates & Notes from the Field

No Submissions

AGENDA

81st ANNUAL
PACIFIC NORTHWEST INSECT MANAGEMENT CONFERENCE

January 10 & 11, 2022

(*Each presentation is allotted 15 minutes*)

MONDAY, JANUARY 10th

Sign-In	*8:00AM*
Call to Order Business Meeting *(Judges for Student Competition; Tumblebug Committee, Recognition to Sponsors)*	8:10AM
Student Presentations (8 reports)	8:30AM
Break	10:30AM
Section I (8 reports) Section II (3 reports)	10:45AM
Adjourn	12:00PM

TUESDAY, JANUARY 11th

Sign-In	*8:00AM*
Call to Order	8:10AM
Section III (2 report) Section IV (5 reports)	8:15AM
Break	10:00AM
Section V (2 reports) Section VI (2 report) Section VII (2 reports) Section VIII (1 report)	10:15AM
Final Business Meeting	11:45AM
Adjourn	12:00PM

SECTION I
Invasive Pests, Emerging Pests, and Hot Topics of Interest

Section I: Invasive Pests, Emerging Pests, and Hot Topics of Interest

Codling Moth Task Force Industry Survey Results

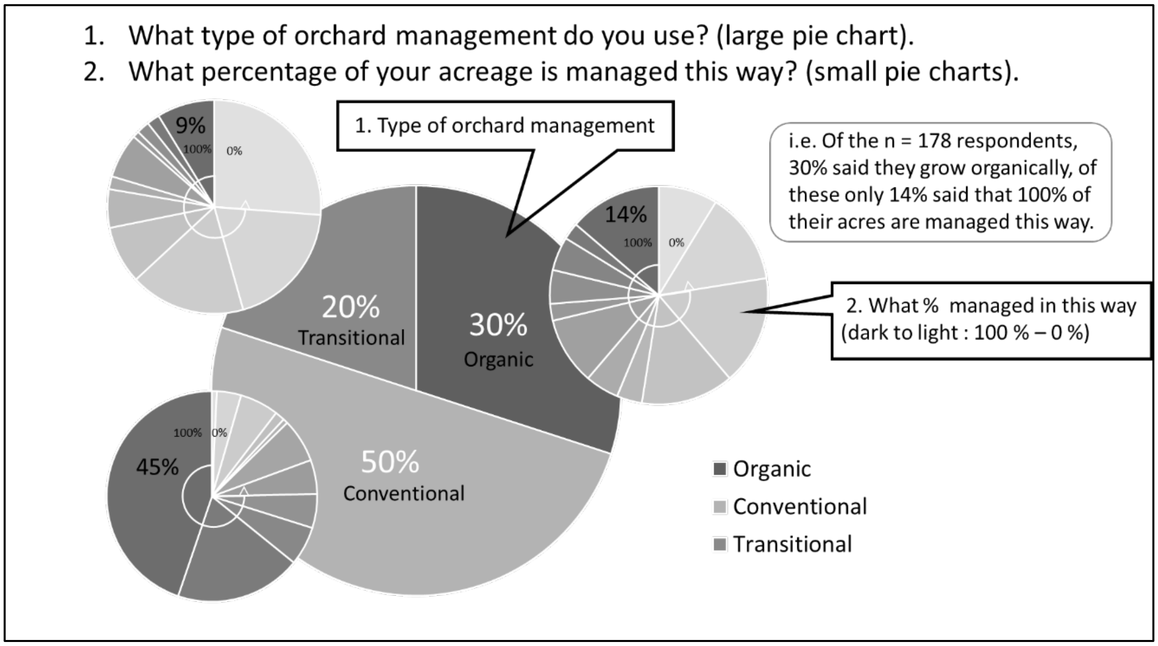
Christopher Adams[1], Elizabeth Beers[2], Louis Nottingham[2], David Epstein[3], Michael Doerr[4]

[1]Oregon State University, Mid-Columbia Agricultural Research and Extension Center, Hood River, OR;[2]Washington State University, Tree Fruit Research and Extension Center, Wenatchee, WA;[3]Northwest Horticultural Council, Yakima, WA;[4]Wilbur Ellis, Wenatchee, WA

In September 2020, the Washington Tree Fruit Research Commission (WTRFC) directed the formation of a task force to address the growing concern over codling moth management. The Task Force consists of 29 members including growers, researchers, extension specialists, crop consultants and other industry representatives. It is led by Dr. Christopher Adams, Assistant Professor of Entomology at Oregon State University, along with an executive committee including Dr. Elizabeth Beers (Washington State University), Michael Doerr (Wilbur-Ellis Co.), Dr. David Epstein (Northwest Horticultural Council), and Dr. Louis Nottingham (Washington State University).

Codling moth has been the key pest of pome fruits across the growing regions of Washington and Oregon for over a hundred years. During that time, pest management programs regularly evolved as key pesticides were phased out and new technology was incorporated. Years of successful control and low pest pressure has diminished the focus on this key pest. In recent years, reports of increased codling moth pressure are becoming more frequent. As we continue to adapt new tools and tactics, there is a need to synthesize and evaluate past and current codling moth research and management recommendations, and to communicate that information to stakeholders. The Codling Moth Task Force was created to take the lead in this issue. The Task Force aims to promote education on basic biology, monitoring, and management; identify challenges to control; keep the industry up-to-date on new research findings, both local and worldwide; and, finally, encourage novel research and extension initiatives that will provide new tactics and approaches in the future.

A first and critical step in this process is to characterize industry practices for codling moth control, with the aim of better understanding why problems are occurring. To that end, an industry-wide survey was written and circulated. We received 178 responses to this survey. Respondents were split nearly 50/50 between apple and pear. Results of survey are discussed.



1. What type of orchard management do you use? (large pie chart).
2. What percentage of your acreage is managed this way? (small pie charts).

1. Type of orchard management

i.e. Of the n = 178 respondents, 30% said they grow organically, of these only 14% said that 100% of their acres are managed this way.

2. What % managed in this way (dark to light : 100 % – 0 %)

Figure 1. Breakdown of survey responses from Tree Fruit Industry Survey when asked; 'what type of orchard management do you use?'(large pie chart) and then 'what percentage of your acreage is managed in this way?' (smaller pie charts). Of the 178 respondents 50% said they are managing their orchards 'conventionally', 30% are managing organically, and 20% are in transition from conventional to organic. When asked the follow-up question we found that only 45% of the conventional growers said 100% of their acres are conventional. Of the 30% who stated they are organic growers, only 14% of their acres are 100% organic. These data illustrate how complex and dynamic the tree fruit industry currently is, and helps to explain the challenges of managing pests under these conditions.

EXPANDING A SPATIAL MODELING PLATFORM WITH EMPHASIS ON INVASIVE INSECTS, PLANT DISEASES, AND WEEDS

Brittany Barker[1,2], Len Coop[1,2], and Theresa Crimmins[3,4]
[1]Oregon IPM Center (formerly IPPC), Oregon State University, Corvallis, OR
[2]Department of Horticulture, Oregon State University, Corvallis, OR
[3]USA National Phenology Network, Tucson, AZ
[4]School of Natural Resources and the Environment, University of Arizona, Tucson, AZ

Invasive pests present a significant threat to agricultural production in the United States, yet decision support tools that can accurately predict where and when to expect pests have not yet been fully developed and utilized. Here we present our spatial modeling platform known as DDRP (Degree-Days, Risk, and Phenological event mapping), which was designed to provide regularly updated forecasts of the potential distribution (risk of establishment) and timing of seasonal activities (phenology) of pests (Barker et al. 2020). Currently we are using DDRP to produce regularly updated (every three days) forecasts for 15 high-risk pest insects for the USDA APHIS Cooperative Agricultural Pest Survey (CAPS) program (http://uspest.org/CAPS), including emerald ash borer (*Agrilus planipennis*) and Asian longhorned beetle (*Anoplophora glabripennis*). As an example, we show forecasts for emerald ash borer (Fig. 1), which could potentially have devastating ecological and economic impacts if it invades the Pacific Northwest.

We will describe our plans to extend DDRP's capacity to model a wider range of agricultural biosecurity threats including weeds and plant pathogens and to build new models for high-priority pests including spotted lanternfly (*Lycorma delicatula*) and giant Asian hornet (*Vespa mandarinia*; Fig. 2). Model forecasts will be delivered and communicated in a range of user-friendly, readily accessible formats at the USA National Phenology Network's website to enable wide adoption. Ground-based observations collected by citizen scientists, collaborators, and other stakeholders over the course of this project will be used to validate forecasts for each target pest.

Forecasts will facilitate surveillance and management operations taking place in the right place at the right time, allowing for rapid and cost-effective detections and responses to biosecurity threats. This will reduce expenses involved with detecting and responding to invasive pests, support efforts to conserve and protect natural resources, increase sustainability of agricultural production systems, and help protect the nation's supply of food, forage, timber, and horticultural products.

References

Barker, B. S., L. Coop, T. Wepprich, F. Grevstad, and G. Cook. 2020. DDRP: real-time phenology and climatic suitability modeling of invasive insects. PLoS ONE 15:e0244005.

Acknowledgments

The development of DDRP was supported by funding from USDA-NIFA-CPPM-EIP (Extension Implementation Program), Western IPM Center, APHIS-PPQ-CPHST (Center for Plant Health Science and Technology) & CAPS, and DoD SERDP (Strategic Environmental Research and Development Program). USDA-NIFA-AFRI (Agriculture and Food Research Initiative) funds will support the planned work presented here.

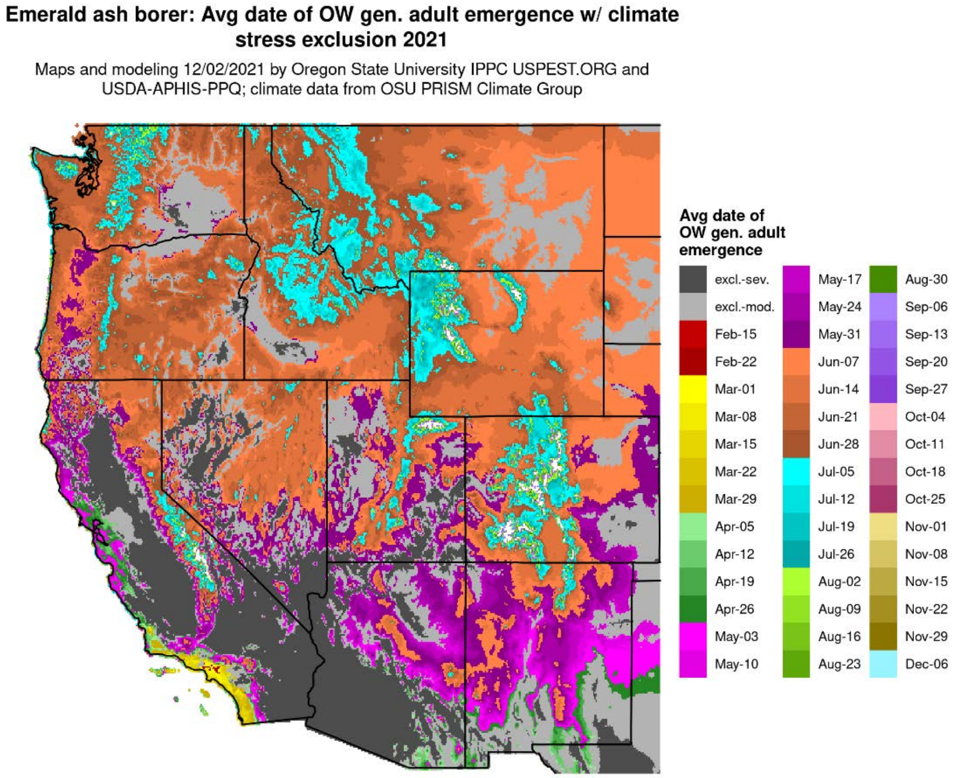


Figure 1. Pest forecast for emerald ash borer in the western U.S. in 2021 produced by DDRP, indicating the average date of emergence of overwintered (OW) adults. The potential distribution is defined as areas not excluded by severe or moderate climate stress (excl.-sev and excl.-mod, respectively). Future work will involve creating an interactive online visualization tool at the USA National Phenology Network's website to allow users to zoom, pan, and interrogate maps.

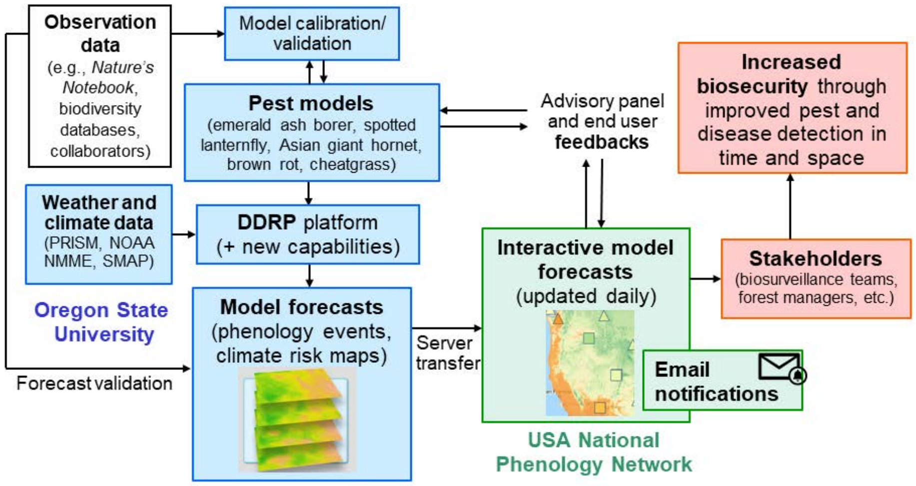


Figure 2. An overview of the information flow for planned work to extend DDRP's capabilities, build pest models, provide pest forecasts and alerts, and gather citizen science data for forecast validation. PRISM = Parameter-elevation Relationships on Independent Slopes Model, NMME = North American Multi-Model Ensemble, SMAP = Soil Moisture Active Passive.

RECEPTOR INTERFERENCE (RECEPTORI): GPCR-BASED INSECTICIDE DISCOVERY

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The discovery of new insecticides improves integrated pest management, but is usually a long high-risk process with a low probability of success. For over two decades, insect neuropeptides and their G-protein coupled receptors (GPCRs) have been considered as biological targets for insect pest control, because they are involved in many key biological processes associated with insect life stages. A key roadblock to success has been the question of how large volume chemical libraries can be efficiently screened for active compounds. New genomic and proteomic tools have advanced and facilitated the development of new approaches to insecticide discovery. A novel GPCR-based screening technology that uses millions of short peptides randomly generated by bacteriophages, and a method using an insect Sf9 cell expression system. In the first proof-of-concept using a fire ant neuropeptide and GPCR, bioactive peptides were isolated for the development of novel arthropod pest management strategies. The novel small peptides could interfere with the target GPCR-ligand functions. Therefore, we refer to this new mechanism as "receptor interference" (RECEPTORi). The GPCR-based bioactive peptide screening method offers multiple advantages. Libraries of phage-displayed peptides are inexpensive. An insect cell-based screening system rapidly leads to target specific GPCR agonists or antagonists in weeks. Delivery of bioactive peptides to target pests can be flexible, such as topical, ingestion, and plant-incorporated protectants. A variety of GPCR targets are available, thus minimizing the development of potential insecticide resistance. This report provides the first proof-of-concept for the development of novel arthropod pest management strategies using neuropeptides, and GPCRs.

A NEW “PUSH” EMAIL DELIVERY SYSTEM FOR PEST AND CROP MODELS

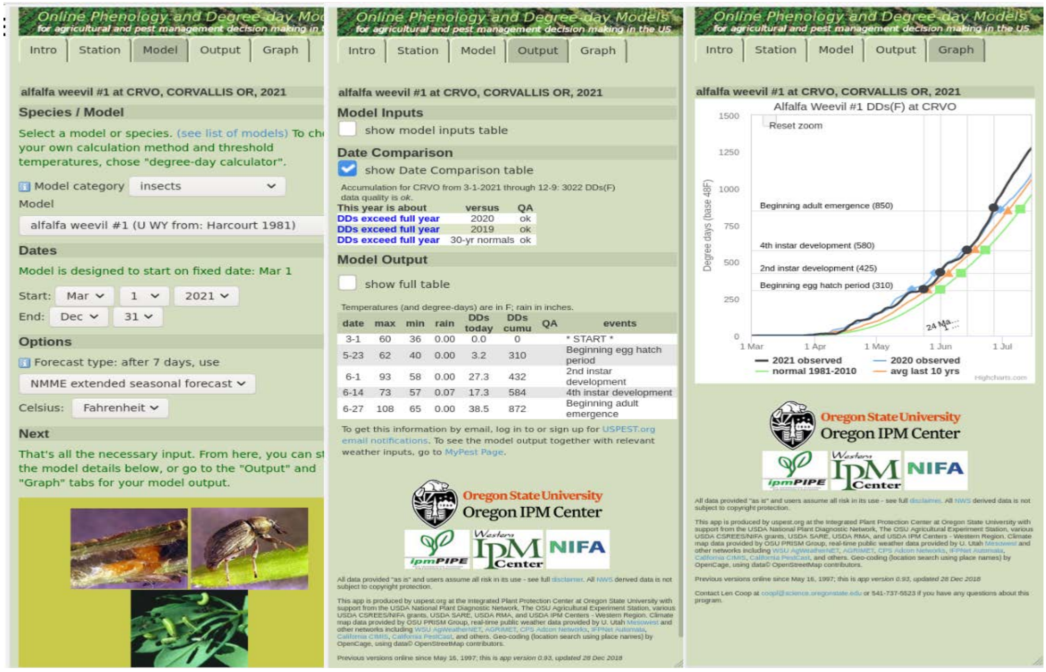
Len Coop[1,2], Chris Hedstrom[1], and Dan Upper[3]
[1]Oregon IPM Center, Oregon State University, Corvallis, OR
[2]Department of Horticulture, Oregon State University, Corvallis, OR
[3]Consulting programmer, Corvallis, OR
coopl@oregonstate.edu, chris.hedstrom@oregonstate.edu

Informed decisions of when to monitor and apply control measures for insects, weeds, and plant diseases depend upon assessment of the current stages of the crop and pest, which can vary greatly depending upon the location and how the season progresses. Phenology or development models, and plant disease infection risk models, have become commonplace tools in providing such decision support. Most models are now run via a web browser or mobile app, requiring a user to **actively** visit the site, remember settings including which weather station to use, a biofix date, and other inputs. A convenient, complementary approach is for the user to create an account with all such settings pre-configured, and then setting a schedule so that they **passively** receive model predictions in their email inbox. Over the past year, we have been updating our mobile-friendly model apps at USPEST.ORG to include “push” email delivery of model predictions. This system now totals support for 150 different models. Our main phenology modeling app, at https://uspest.org/dd/model_app, integrates 136 different phenological models, including 45 for established (IPM) insects, 27 for invasive insects, 6 for beneficial arthropods, 5 for weeds, 6 for plant diseases, 16 for agronomic crop models, and 29 for vegetable “CROPTIME project” models. In addition, we have 9 separate apps for plant disease infection risk models, including fire blight, late blight of tomato/potato, boxwood blight, apple and pear scab, grape bunch rot, cherry, grape, and hop powdery mildew, dollar spot, watermelon and muskmelon MELCAST, and Tomcast DSV. The account settings for all of these models are integrated into a single account page that is available at https://uspest.org/push. In Fig. 1, we display the main pages, separated by tabs, for alfalfa weevil as an example of the app interface. In Fig. 2, we display the main sections of the account subscription system.

This system was developed as a result of numerous feedback events including usability tests, whereby we ask a new user to run the models while providing continuous commentary on their navigation of the interface, including how they decide what settings to select, and how they try to interpret model output. A 1-minute video introduction to this new system is available here: https://www.youtube.com/watch?v=XA65WxEMkrs. We will be tracking the uptake and usage of this new “push” email system, in comparison to our older user interfaces for the models. Our goal is to increase the adoption and usefulness of these decision support tools. We hope that these updates of the modeling suite at USPEST.ORG will help in achieving this goal, by making model delivery and decision support more timely and convenient.

Acknowledgments

The development of these models and apps was supported by funding from USDA NIFA CPPM EIP (Extension Implementation Program), ARDP (Applied Research and Development Program), and Western IPM Center, APHIS PPQ, DoD SERDP, and USDA NIFA AFRI.



alfalfa weevil #1 at CRVO, CORVALLIS OR, 2021

Species / Model

Select a model or species. (see list of models) To ch… your own calculation method and threshold temperatures, chose "degree-day calculator".

Model category: insects

Model: alfalfa weevil #1 (U WY from: Harcourt 1981)

Dates

Model is designed to start on fixed date: Mar 1

Start: Mar 1 2021

End: Dec 31

Options

Forecast type: after 7 days, use NMME extended seasonal forecast

Celsius: Fahrenheit

Next

That's all the necessary input. From here, you can st… the model details below, or go to the "Output" and "Graph" tabs for your model output.

alfalfa weevil #1 at CRVO, CORVALLIS OR, 2021

Model Inputs

☐ show model inputs table

Date Comparison

☑ show Date Comparison table

Accumulation for CRVO from 3-1-2021 through 12-9: 3022 DDs(F)
data quality is *ok*.

This year is about	versus	QA
DDs exceed full year	2020	ok
DDs exceed full year	2019	ok
DDs exceed full year	30-yr normals	ok

Model Output

☐ show full table

Temperatures (and degree-days) are in F; rain in inches.

date	max	min	rain	DDs today	DDs cumu	QA	events
3-1	60	36	0.00	0.0	0		* START *
5-23	62	40	0.00	3.2	310		Beginning egg hatch period
6-1	93	58	0.00	27.3	432		2nd instar development
6-14	73	57	0.07	17.3	584		4th instar development
6-27	108	65	0.00	38.5	872		Beginning adult emergence

To get this information by email, log in to or sign up for USPEST.org email notifications. To see the model output together with relevant weather inputs, go to MyPest Page.

Oregon State University
Oregon IPM Center

All data provided "as is" and users assume all risk in its use - see full disclaimer. All NWS derived data is not subject to copyright protection.

This app is produced by uspest.org at the Integrated Plant Protection Center at Oregon State University with support from the USDA National Plant Diagnostic Network, The OSU Agricultural Experiment Station, various USDA CSREES/NIFA grants, USDA SARE, USDA RMA, and USDA IPM Centers - Western Region. Climate map data provided by OSU PRISM Group, real-time public weather data provided by U. Utah Mesowest and other networks including WSU AgWeatherNET, AGRIMET, CPS Adcon Networks, IFPNet Automata, California CIMIS, California PestCast, and others. Geo-coding (location search using place names) by OpenCage, using data© OpenStreetMap contributors.

Previous versions online since May 16, 1997; this is *app version 0.93, updated 28 Dec 2018*

alfalfa weevil #1 at CRVO, CORVALLIS OR, 2021

Oregon State University
Oregon IPM Center

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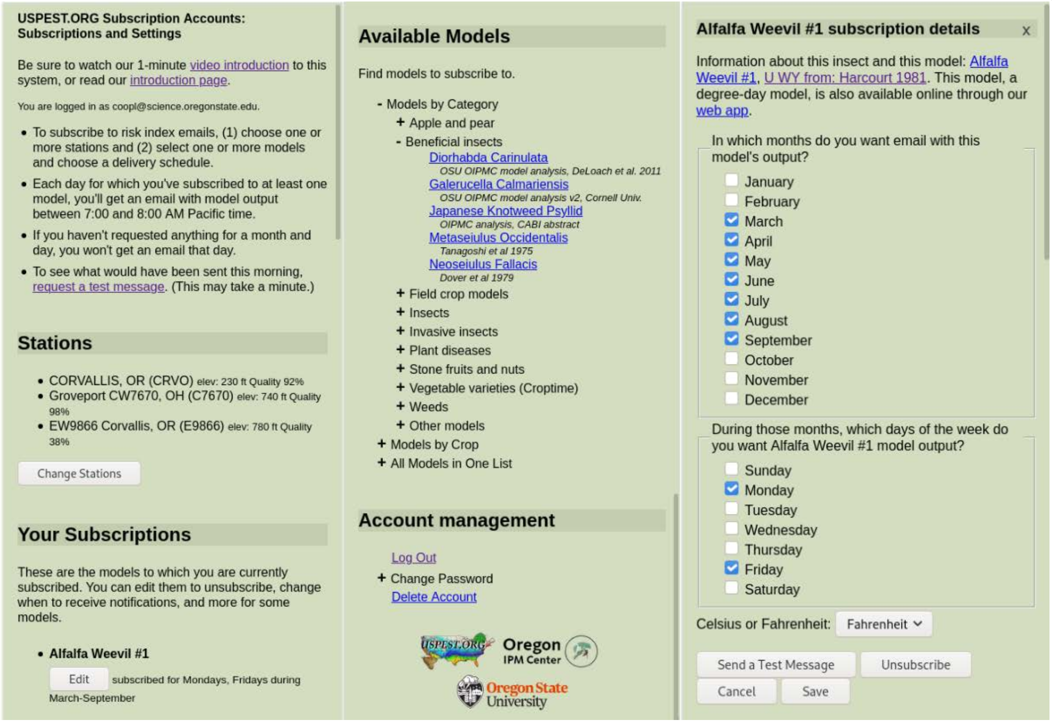
This app is produced by uspest.org at the Integrated Plant Protection Center at Oregon State University with support from the USDA National Plant Diagnostic Network, The OSU Agricultural Experiment Station, various USDA CSREES/NIFA grants, USDA SARE, USDA RMA, and USDA IPM Centers - Western Region. Climate map data provided by OSU PRISM Group, real-time public weather data provided by U. Utah Mesowest and other networks including WSU AgWeatherNET, AGRIMET, CPS Adcon Networks, IFPNet Automata, California CIMIS, California PestCast, and others. Geo-coding (location search using place names) by OpenCage, using data© OpenStreetMap contributors.

Previous versions online since May 16, 1997; this is *app version 0.93, updated 28 Dec 2018*

Contact Len Coop at coopl@science.oregonstate.edu or 541-737-5523 if you have any questions about this program.

Figure 1. Mobile-friendly model app interface for example pest, alfalfa weevil, showing model selection and settings page (left), tabular model outputs (middle), and graph output (right) showing comparison of current (2021 observed) weather vs. previous years (2019 and 2020), and 10 and 30 year average weather data. Email "push" outputs are similar to these app examples.



USPEST.ORG Subscription Accounts: Subscriptions and Settings

Be sure to watch our 1-minute video introduction to this system, or read our introduction page.

You are logged in as coopl@science.oregonstate.edu.

- To subscribe to risk index emails, (1) choose one or more stations and (2) select one or more models and choose a delivery schedule.
- Each day for which you've subscribed to at least one model, you'll get an email with model output between 7:00 and 8:00 AM Pacific time.
- If you haven't requested anything for a month and day, you won't get an email that day.
- To see what would have been sent this morning, request a test message. (This may take a minute.)

Stations

- CORVALLIS, OR (CRVO) elev: 230 ft Quality 92%
- Groveport CW7670, OH (C7670) elev: 740 ft Quality 98%
- EW9866 Corvallis, OR (E9866) elev: 780 ft Quality 38%

Your Subscriptions

These are the models to which you are currently subscribed. You can edit them to unsubscribe, change when to receive notifications, and more for some models.

- **Alfalfa Weevil #1**
  Edit subscribed for Mondays, Fridays during March-September

Available Models

Find models to subscribe to.

- Models by Category
  + Apple and pear
  - Beneficial insects
    Diorhabda Carinulata
    OSU OIPMC model analysis, DeLoach et al. 2011
    Galerucella Calmariensis
    OSU OIPMC model analysis v2, Cornell Univ.
    Japanese Knotweed Psyllid
    OIPMC analysis, CABI abstract
    Metaseiulus Occidentalis
    Tanagoshi et al 1975
    Neoseiulus Fallacis
    Dover et al 1979
  + Field crop models
  + Insects
  + Invasive insects
  + Plant diseases
  + Stone fruits and nuts
  + Vegetable varieties (Croptime)
  + Weeds
  + Other models
+ Models by Crop
+ All Models in One List

Account management

Log Out
+ Change Password
Delete Account

Alfalfa Weevil #1 subscription details

Information about this insect and this model: Alfalfa Weevil #1, U WY from: Harcourt 1981. This model, a degree-day model, is also available online through our web app.

In which months do you want email with this model's output?

☐ January
☐ February
☑ March
☑ April
☑ May
☑ June
☑ July
☑ August
☑ September
☐ October
☐ November
☐ December

During those months, which days of the week do you want Alfalfa Weevil #1 model output?

☐ Sunday
☑ Monday
☐ Tuesday
☐ Wednesday
☐ Thursday
☑ Friday
☐ Saturday

Celsius or Fahrenheit: Fahrenheit

Figure 2. Example account settings for alfalfa weevil. Left – weather stations and models selected. Middle - expandable categories for all 150 models and account management. Right – subscription settings including email schedule for this particular model. Settings may differ for other models.

Foraging behaviors of *Trissolcus japonicus*, a potential biological control agent of brown marmorated stink bug

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There is increasing use of exotic natural enemies for biological control of invasive insect pests. Prior to release, these natural enemies undergo an extended period of laboratory testing and evaluation, usually under quarantine conditions. The focus of these research is often on risk evaluation with little focus on efficacy. In many cases, initial testing is very artificial and lacking in ecological complexity which might be key to understanding interactions in the field after release. Incorporating ecological and behavioral studies in biological control agent evaluations can help us gain insight into key characteristics which might impact success of biological control programs. This report reflects on the current progress in understanding the ecology of the samurai wasp, *Trissolcus japonicus*, and what ecological conditions might impact the efficacy and risk of this wasp as a biological control agent.

In collaboration with Dr. Paul Abram, we examined the relationships between *T. japonicus* age, egg load, and locomotor activity. Female wasps emerge with only a small portion of their maximum egg load available, with more eggs maturing as they age. Locomotor activity of females increases in parallel with egg maturation, with both reaching their peak around day six. Following this result, we compared the foraging efficiency of young (1-day old) and old (7-day old) wasps in a small cage (24.5x24.5x63 cm), containing a bean plant with a single egg mass. We found that older wasps were nearly twice as likely to find the egg mass in the foraging period and did so much quicker on average that young wasps that did find the egg mass (Figure 1). These results indicate that laboratory tests and field releases may benefit from using females that are at least 7-days old, as young wasps may not demonstrate full activity patterns.

Next, we explored some of the cues involved in host finding for *T. japonicus.* Using cage arenas, we tested preference and foraging efficiency of wasps given a choice between a sentinel egg mass (on filter paper attached to the leaf) or an egg mass laid directly on the plant. Plants with eggs also contained feeding damage and walking cues, which recent research has indicated are used by *T. japonicus* in foraging (Boyle et al. 2020, Malek et al. 2021). Wasps were video recorded to determine efficiency and initial host encounter in case both eggs were parasitized. We found that *T. japonicus* had no preference for either egg mass type and the efficiency of searching was equivalent regardless of which egg was eventually attacked. From this, it appears that *T. japonicus* may not make strong use of semiochemicals for egg location, at least within the range tested. To explore this further, we also performed choice tests between native stink bug eggs (*Banasa dimidiata*) and brown marmorated stink bug using the same set up. However, even in these tests, wasps had no preference between the two host options and foraging efficiency and exploitation of hosts was similar for both egg species. Overall, *T. japonicus* consistently exploited the first egg mass encountered, regardless of differences in cues present or quality of host species. We hypothesize that this parasitoid may be using non-chemical cues (such as vision) as a primary means to locate hosts. Furthermore, our results suggest that *T. japonicus* has a low perception of host availability in the environment and has high acceptance for hosts when encountered. Nontarget species are likely to be accepted if they are encountered first, even if the generally preferred brown marmorated hosts are available nearby. Further work exploring these alternate cues and foraging strategies by *T. japonicus* are ongoing.

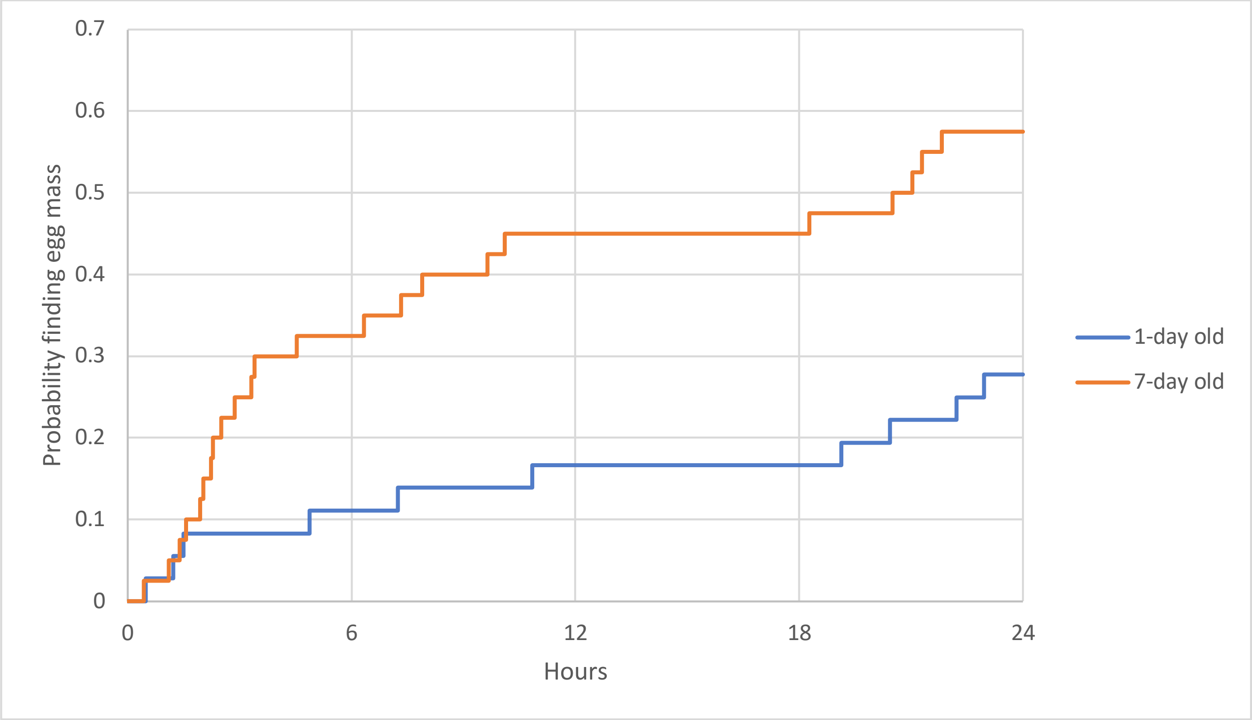

Figure 1. Effects of *T. japonicus* age on foraging efficiency.

MASS-REARING AND REDISTRIBUTION OF *TRISSOLCUS JAPONICUS* IN OREGON

Max Ragozzino and Jessica Rendon

Oregon Department of Agriculture, Insect Pest Prevention and Management

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Max.Ragozzino@oda.oregon.gov, Jessica.Rendon@oda.oregon.gov

Mass-rearing of natural enemies is essential for the biological control of an invasive insect pest. Oregon department of agriculture has utilized existing and novel methods of mass rearing brown marmorated stink bug (BMSB), *Halyomorpha halys,* as a host resource for its associated parasitoid, the samurai wasp, *Trissolcus japonicus*. Over the last two years, ODA has established a colony, mass-reared and released 17,415 adult parasitic wasps across Oregon (Figure 1).

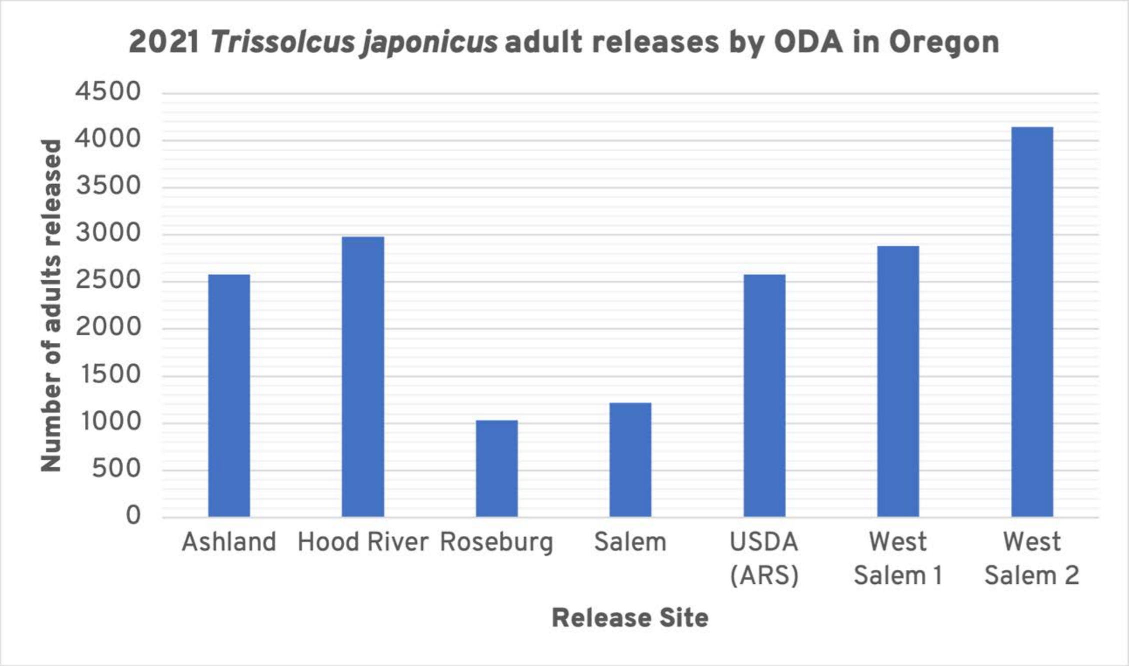

Figure 1. Field releases of adult *Trissolcus japonicus* in Oregon. Releases primarily occurred on refugia adjacent to crops susceptible to BMSB between May and September 2021.

Brown marmorated stink bug is an economically important pest of a wide variety of crops within Oregon including hazelnuts, tree fruits, vegetables, and other high-value crops. Initially detected in Portland, Oregon in 2004, it is now widespread across Oregon. According to OSUs BMSB reporting tool, ODA and USDA field surveys, BSMB populations are concentrated in the Willamette valley.

In 2016 an advantageous population of the *T. japonicus* was discovered in Portland, Oregon. The samurai wasp, *Trissolcus japonicus*, was considered as biological control options and is being studied under quarantine. However, advantageous populations were discovered in Beltsville, MD (2014), before releases were approved. Due to the presence of advantageous populations, and following discussions with USDA-APHIS, ODA determined that redistribution of *T. japonicus* within Oregon would be acceptable. Since then, Oregon State University, and Oregon Department of Agriculture (ODA) have reared and redistributed *T. japonicus* across the state in an effort to manage BMSB.

In 2020, with the help of the Wiman lab at OSU, colonies of BMSB and *T. japonicus* were established at the ODA Southwest Oregon field office. As of fall 2021, ODA has released 17,415 adult *T. japonicus* across Oregon and reared over 70,000 BMSB eggs for parasitoid rearing, colony reproduction, sentinel egg masses, for to researchers at OSU, USDA and Utah State University.

Brown marmorated stink bug adults were kept in various sized mesh and vinyl rearing cages (Bioquip Popup Rearing & Observation Cage, 1466CB, 1466AV; Bugdorm 6E610) containing two to four 4–8-week-old potted bush bean plants. To perpetuate the colony, BMSB eggs were allowed to hatch on the foliage of the bush bean plants. Plants with 1st to 2nd instar BMSB were removed and placed in a new mesh cage. All BMSB cages were fed a diet of primarily green beans and snap peas, supplemented with carrots, apples, shelled unsalted sunflower seeds, unsalted almonds, and organic jelly beans (Imperfect Foods). Food was observed daily and replaced as necessary. Adult oviposition cages were observed daily, and egg masses were removed by applying light pressure on the opposite side of the substrate.

Trissolcus japonicus rearing containers consisted of a pint soup cup, with a clear plastic petri dish friction fit inside the top of the cup. Adult wasps were provided with honey as a food source. Honey was streaked onto the inside of the cup once per week using a #2 insect pin. Parasitoid adults were kept in rearing containers containing 50 to 400 adults, and were assumed gravid 48 hours after emergence. Parasitoids were chilled at -18ºC for between 90 and 120 seconds to prevent flight, then aspirated, and placed in a new honey-streaked rearing cup. Fresh (<48 hour old) BMSB eggs were provided at a 1:10 parasitoid: host ratio every 7 days. Initially, rearing cups were limited to 20 adult wasps and 200 fresh eggs. By the end of 2021, up to 40 adult wasps and 400 fresh eggs were set up per rearing cup, successfully. Parasitoids were removed from rearing containers 24 hours prior to release. All releases occurred between May and early September 2021.

Field sites were selected based on the following criteria: 1) An abundance of BMSB, or crop loss due to BMSB damage, 2) minimal application of neonicotinoids and pyrethroids to prevent parasitoid mortality (Lowenstein et al. 2019), and 3) a presence of natural refugia. Field sites were varied. We released adult *T. japonicus* at five commercial growers, including pear and hazelnut orchards, as well as vineyards. Additionally, we released at one backyard orchard adjacent to commercial orchards, the ODA Southwest Oregon field office, and a woodlot with heavy BMSB presence. In Spring 2022, field sites will be surveyed for overwintering success, and early signs of establishment.

References:

David M Lowenstein, Heather Andrews, Anthony Mugica, Nik G Wiman, Sensitivity of the Egg Parasitoid Trissolcus japonicus (Hymenoptera: Scelionidae) to Field and Laboratory-Applied Insecticide Residue, Journal of Economic Entomology, Volume 112, Issue 5, October 2019, Pages 2077–2084, https://doi.org/10.1093/jee/toz127

OREGON DEPARTMENT OF AGRICULTURE INVASIVE INSECT SURVEYS: UPDATES FROM THE 2021 SEASON

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Every year, the Oregon Department of Agriculture's Insect Pest Prevention and Management (IPPM) program conducts statewide surveys for a variety of invasive pests with the goal of detecting and eradicating any introductions before populations become established. This report provides an update of IPPM's survey activities over the 2021 season.

In 2021, IPPM surveyed for 57 invasive target species. Of these taxa, there are a few towards which the majority of effort is aimed: the Japanese beetle (*Popillia japonica*), *Lymantria dispar dispar*, and *Lymantria dispar asiatica.* Statewide, there were 12,662 traps placed for *P. japonica*, 7,252 *L. dispar asiatica* traps, and 3,946 *L. dispar dispar* traps in 2021. These trap numbers include detection traps as well as delimitation traps placed in response to positive catches. It is worth noting that, although there are separate surveys targeting each *L. dispar* subspecies, the traps and lures are identical and so are effective at trapping both.

This year, there were 3,656 *P. japonica* caught in traps. All but one of these beetles was caught within the infested area in and around Beaverton, OR. The remaining detection occurred in Albany, OR. Add-on traps placed in the immediate area following this detection yielded no additional catches, and a delimitation trapping grid centered around the catch site will be placed in 2022. Only a single *Lymantria dispar dispar* specimen was caught in 2021 very near the OR/WA border outside Walla Walla, WA. Add-on traps following this detection resulted in no additional moth catches. In 2022, a delimitation trapping scheme will be centered around the catch site; IPPM will conduct the survey for the portion of the delimitation in OR, and the Washington State Department of Agriculture will conduct the delimitation for the portion that lies across the border in WA.

Numerous other specialty surveys are conducted by IPPM annually. Recent notable detections include the Houdini fly, *Cacoxenus indagator* and the granulate ambrosia beetle, *Xylosandrus crassiusculus* (both in 2020), as well as the vine mealy bug, *Planococcus ficus*, and the honey locust borer, *Agrilus difficilis* in 2021.

The Oregon Department of Agriculture will continue a robust invasive arthropod monitoring program in 2022, responding to these positive detections and surveying for new introductions in an effort to protect the state from the establishment of harmful invasive species.

LIGHT BROWN APPLE MOTH ERADICATION IN OREGON

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The light brown apple moth (LBAM, *Epiphyas postvittana*) is an exotic pest that feeds on a wide range of fruit crops and other plants. The first LBAM found in Oregon was caught in 2010 at a commercial nursery in Polk County as part of a USDA-APHIS funded, national LBAM survey following detection of the pest in California in 2006. Three years of delimitation trapping found no additional moths. However, in 2015, two more LBAMs were caught at the same nursery and in an adjacent orchard. The 2015 detections were again trap delimited and in 2016 three additional moths were detected. All six of the detections were within an approximately one square mile, agricultural area of Polk County and centered on nursery and orchard properties (the core). Oregon is the only state in the continental US, besides California, where LBAM has been found.

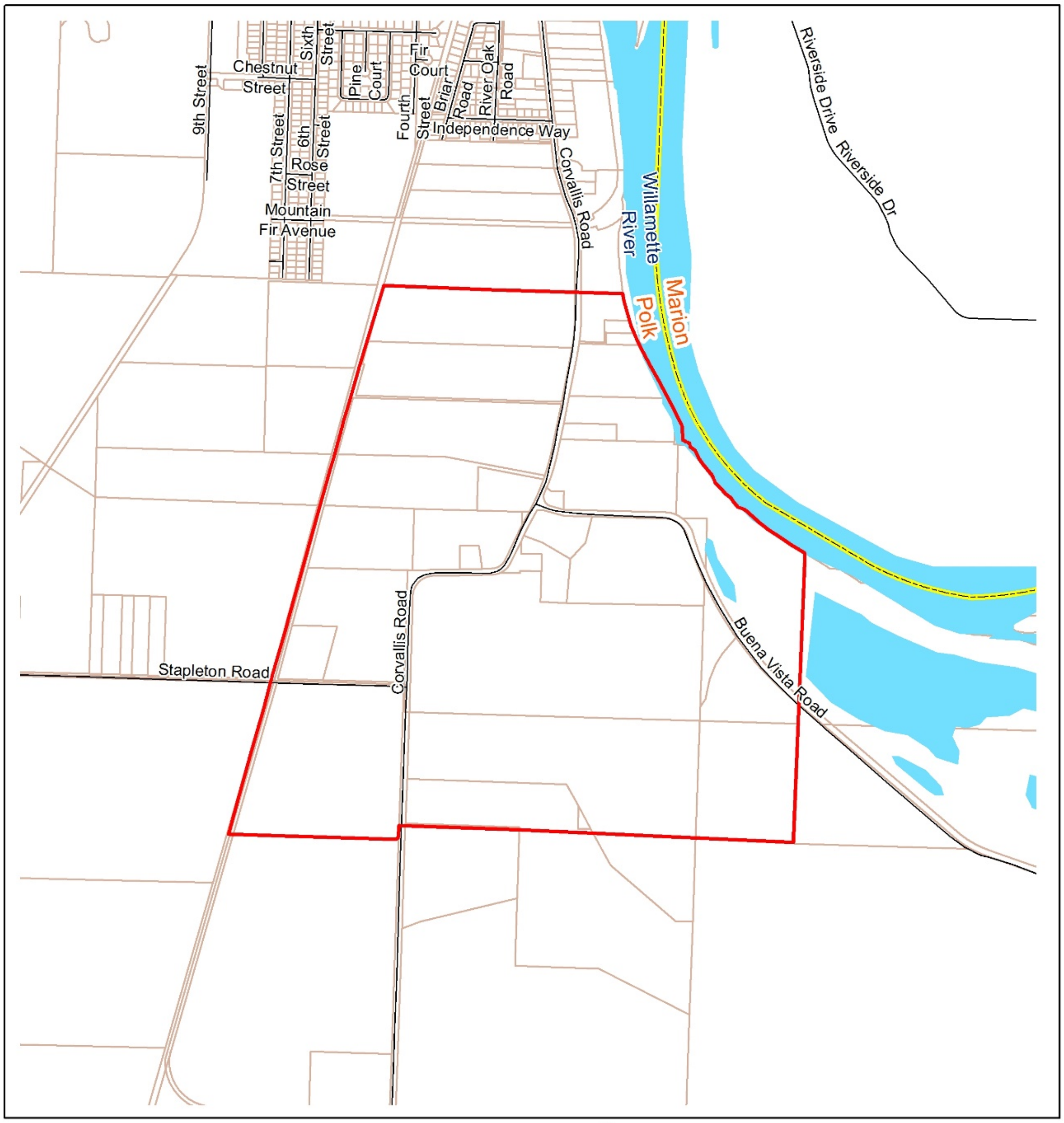
IPPM first attempted eradication in 2016 by using species specific mating disruption (MD) pheromone product (SPLAT LBAM HD Organic, ISCA Technologies) covering about 37 acres within the core area. This material was applied by hand to tree trunks, wooden stakes, and fence posts using a caulking gun. The three moths collected in 2016 indicated that the two MD applications made in May and July were ineffective.

The goal of eradicating the LBAM population while it was still small was attempted again in 2017 using aerial applications of the MD pheromone (2x, 8 weeks apart) targeting the adult flight period and an organic formulation of *Bacillus thuringiensis kurstaki* (Btk, Valent Biosciences) (3x, appx. 1 week apart) which targeted young larvae that may have been present. The ODA contracted with Al's Flying Service (AFS) in Michigan to apply the products to a 510 acre treatment area (TA), encompassing the 2016 treatment area and positive trap catch sites.

A portion of the 2017 delimitation traps were placed within the 510 acre MD TA where the trap effectiveness was questioned, since the MD product could potentially mask the trap lures, resulting in male moths not finding the traps. Trap catch of known, common, non-target moth species inside the TA was indeed very low during 2017, supporting the idea that MD treatment was effective. To partially counter the reduced effectiveness of the pheromone traps, we used UV light traps inside the TA since they have the ability to catch moths, particularly females, regardless of semiochemical use.

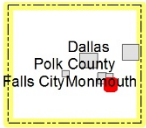
In 2018, IPPM placed 193 delimitation traps within the same area as traps placed in 2017 (see map). Also, the recently developed 4-component LBAM pheromone lure, that was shown in studies to be even more attractive to male LBAM than the 2-component lure, and provided by the USDA-ARS Otis laboratory in Buzzards Bay, MA, was used again in 2017. The 2018 traps were considered effective since the MD product had degraded and dissipated. Pheromone traps were placed from April through mid-October. This was also the second year we used UV light traps in the delimitation.

Delimitation trapping with pheromone and UV traps continued in 2019, and again with pheromone traps only in 2020. All samples were negative and LBAM is considered eradicated in that Polk County location. Since then we have found single moth detections in two new counties, Douglas in 2018 and Multnomah in 2020, but all delimitation traps have not caught any additional moths. We will trap Multnomah again in 2022. USDA plans to deregulate LBAM as a pest of national concern.



2017 LBAM Proposed Treatment Area
Independence, Polk County

Proposed Treatment Acres: 510



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Miles

Oregon Department of Agriculture
635 Capitol St NE
Salem, OR 97301-2532

IPPM
Insect Pest Prevention & Management

Prepared By: kschwarz
Printing Date: May 15, 2017
Projection Information:
Name: NAD 1983 OR Statewide Lambert Ft
Projection: Lambert Conformal Conic
Datum: North American 1983
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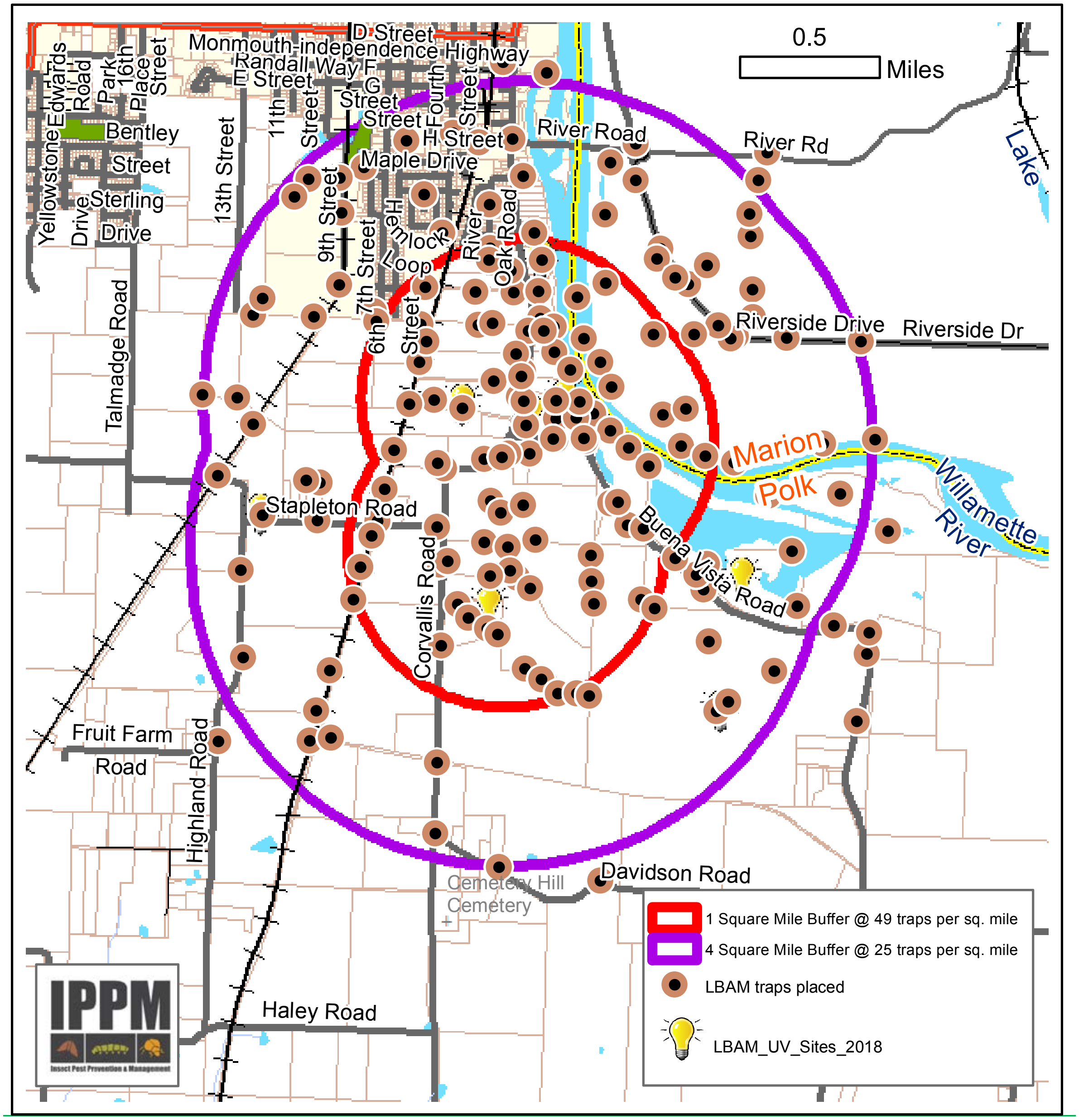
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Sterling
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9th Street
7th Street
6th
Street
Maple Drive
Hemlock
Loop
River
Oak Road
River Road
River Rd
Lake
Riverside Drive
Riverside Dr
Marion
Polk
Willamette
River
Talmadge Road
Stapleton Road
Corvallis Road
Buena Vista Road
Fruit Farm
Road
Highland Road
Davidson Road
Cemetery Hill
Cemetery
Haley Road
IPPM
Insect Pest Prevention & Management
1 Square Mile Buffer @ 49 traps per sq. mile
4 Square Mile Buffer @ 25 traps per sq. mile
LBAM traps placed
LBAM_UV_Sites_2018

Establishment of the samurai wasp (*Trissolcus japonicus*), a biological control agent of the brown marmorated stink bug, in Oregon

Claire Donahoo[1], David Lowenstein[2], Richard Hilton[3], Chris Adams[4], Heather Andrews[5], and Nik Wiman[5]

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The brown marmorated stink bug, *Halyomorpha halys*, is a polyphagous and invasive pest that has caused millions of dollars of economic damage in US specialty crops and is an increasing problem to the specialty crop industry in the Pacific Northwest. An effective control method is the use of broad-spectrum insecticides, but these may be destructive to integrated pest management (IPM) programs already in place. In the home range of *H. halys*, the samurai wasp, *Trissolcus japonicus*, is known to be an efficient egg parasitoid of the pest, with parasitism rates as high as 90%. As of 2021, Oregon State University has redistributed this adventive agent at 39 sites across four ecoregions throughout the state of Oregon. Between 2016 and 2021, we also placed yellow sticky cards and/or sentinel egg masses of *H. halys* at these release sites the year of release and each year following to assess establishment of *T. japonicus* populations in urban, agricultural, and riparian habitats. Including non-release sites for monitoring *T. japonicus*, we have set up sticky cards at 120 sites across five ecoregions in Oregon. Additionally, we collected wild egg masses of *H. halys* at both release and non-release sites and assessed their parasitism by *T. japonicus*. Here, we present our state-wide monitoring efforts and the establishment of this biological control agent in Oregon.

Data from Historic Museum Specimens Improves Understanding of Flatheaded Borer Pests

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Chrysobothris mali Horn (Pacific flatheaded borer) and *Chrysobothris femorata* Olivier (flatheaded apple tree borer) are native, Buprestid wood-boring beetles of economic importance on the West Coast of North America. Both species use a wide range of woody deciduous host plants during reproduction including shade, fruit, and nut trees (Burke 1929, Fenton 1942). In recent years, rapidly expanding high-value tree crop acreage in the west and record drought conditions have caused a resurgence of flatheaded borer damage (Wiman et al. 2019). Flatheaded borers often target trees that are drought or transplant stressed, leading us to believe that their economic impacts may increase as climate change induced droughts become more prevalent on the West Coast (Burke 1929, Fenton 1942, Xu et al. 2019).

Though flatheaded borers have become economically impactful pests, very little is known about their distribution, life history, and host plant use, particularly in the Pacific Northwest. We began our exploration of *C. mali* and *C. femorata* biology in the west by examining historic specimens in four major western arthropod museums: the California Academy of Sciences (CASC), M.T. James Museum (MTJM) at Washington State University, Oregon State Arthropod Collection (OSAC) at Oregon State University, and the William F. Barr (WFBM) Museum at University of Idaho.

Label data and morphological measurements were collected from all preserved *Chrysobothris mali* and *C. femorata* specimens housed in OSAC, MTJM, and WFMB. To supplement this data, a database of *C. femorata* and *C. mali* specimen label data from CASC collection was downloaded from Global Biodiversity Information Facility (GBIF; gbif.org).

Label information was collected from 519 *Chryobothris mali* specimens, 99 of these were female and 147 were male. Label data was collected from 355 *Chrysobothris femorata* specimens with 148 females and 148 males. Specimens in the four collections were field collected between 1905 and 2009, with a median collection year of 1951. There was a notable gap in collection effort between the 1980's and current day. The median collection year for the WFB museum was drastically elevated due to the sampling efforts of Frank M. Beer and William F. Barr who contributed 139 and 43 specimens respectively (Figure 1).

Mean morphological measurements taken from 296 *C. femorata* and 246 *C. mali* specimens were significantly different in all categories (head width, the elytral length, and the overall body length at their widest points (paired t-test P <0.0000)). These results indicate that *C. femorata* is larger than *C. mali.* Comparisons of the sexes within each species revealed that males are smaller on average than females (paired t-test P <0.0001; figure not included).

Dates collected from the labels of 293 *C. femorata* and 246 *C. mali* specimens allowed us to obtain an estimate of each species' phenology. The data was split at the 40th parallel to examine phenology changes due to climate and photoperiod differences between the southern and northern latitudes (Figure 2). In the north, *C. mali* is active between mid-April and mid-August, with peaks occurring in June and July. Below the 40th parallel, *C. mali* remained active at approximately the same times, but peak activity occurred in May and June. Above the 40th parallel, *C. femorata* was present from mid-March to August, with most collections occurring in June and July. In the more southern latitudes, *C. femorata* was collected consistently between February and September.

Collection location information was available for 311 *C. femorata* and 466 *C. mali* specimens. This data was used to create the only comprehensive map of *C. femorata* and *C. mali* distributions in the West (Figure 3). In California, *Chrysobothris spp.* were collected throughout the state with high sampling effort in the Central Valley and in southern California. In Oregon, most sampling occurred east of the Coast Range and west of the Cascades. Only two *C. mali* individuals were collected in Washington state, whereas 27 *C. femorata* were collected throughout the state. *Chrysobothris mali*'s range extended to the Rocky Mountains in central Colorado, while *Chrysobothris femorata* was found throughout the United States (Figure 3). Montana and Idaho are new state records for *C. mali*.

Both species were associated with a total of 64 plant taxa, though they were only reared from 9 plant species. Plant associations were indicated by the collector as: "on", "flying to", or collected via "beating". *Chrysobothris femorata* was associated with 10 plant families, 16 genera, and 26 species (Figure 4). *Chrysobothris mali* was associated with 9 plant families, 16 genera, and 23 species (Figure 4). New host records were found for both species and are indicated in red boxes in Figure 4. The plant associations of the two species did not overlap often; out of the 64 associated plant taxa, only six associations were shared between the species (Figure 4). Both species were associated with *Salix spp.* (willows), *Salix lasiandra* (shining willow), *Prunus spp.* (stone fruits), *Malus domestica* (apple), *Prunus avium* (sweet cherry), and *Platanus racemose* (western sycamore). Previous research with these species in western states indicates that *C. femorata* and *C. mali* both attack walnuts, hazelnuts, and other fruit trees (Wiman et al. 2019, Rijal 2020, Archeampong et al. 2016) . However, *C. mali* is thought to be the principal damage causing agent in this region (Burke 1929, Wiman et al. 2019).

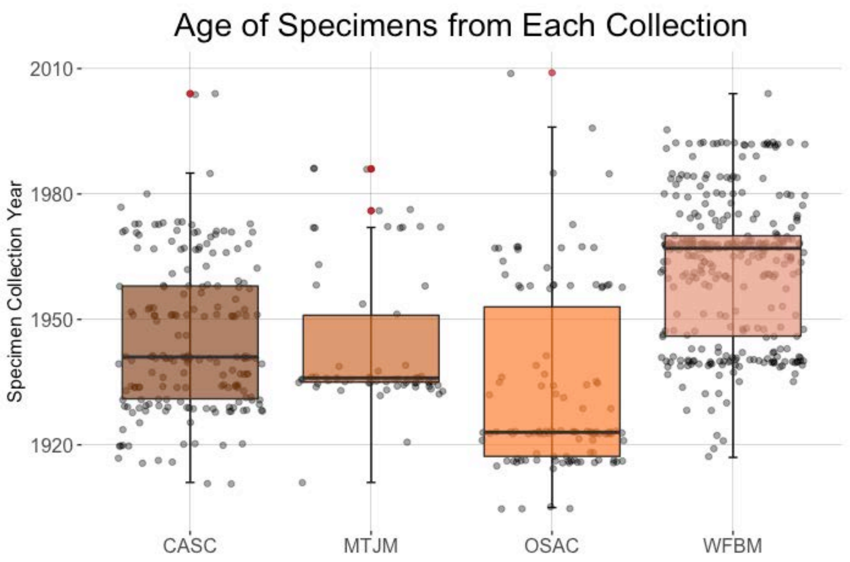

Figure 1: The distributions of specimen collection years for each natural history museum. California Academy of Science (CASC); M. T. James Museum (MTJM); Oregon State Arthropod Collection (OSAC); William F. Barr Museum (WFBM).

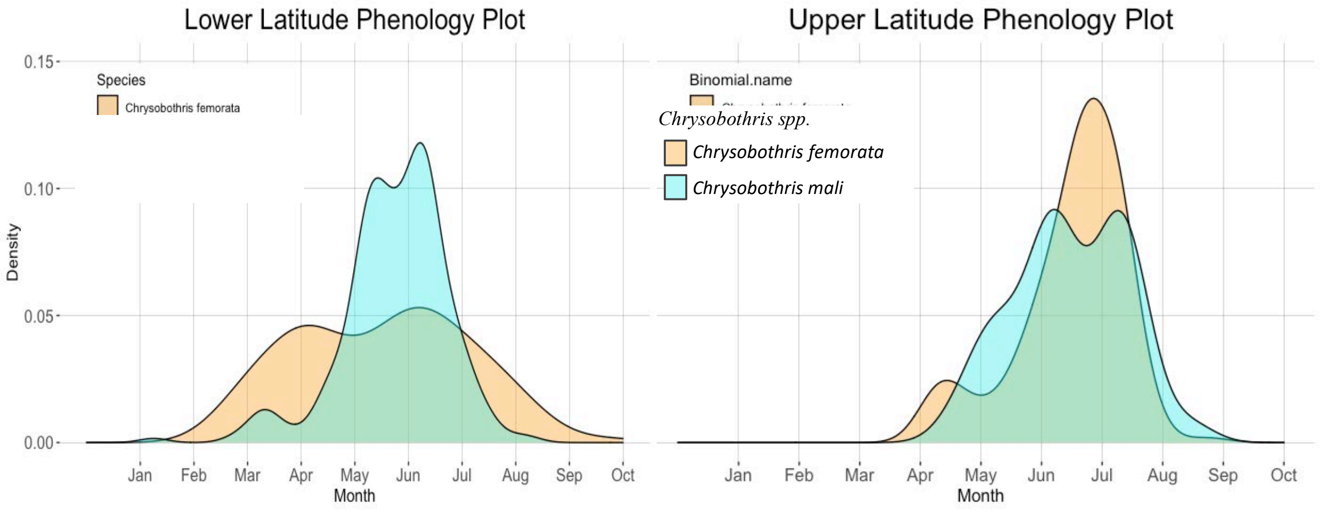

Figure 2: Phenology curves obtained from the collection dates of the museum specimens. *Chrysobothris femorata* is in orange and *C. mali* is in blue.

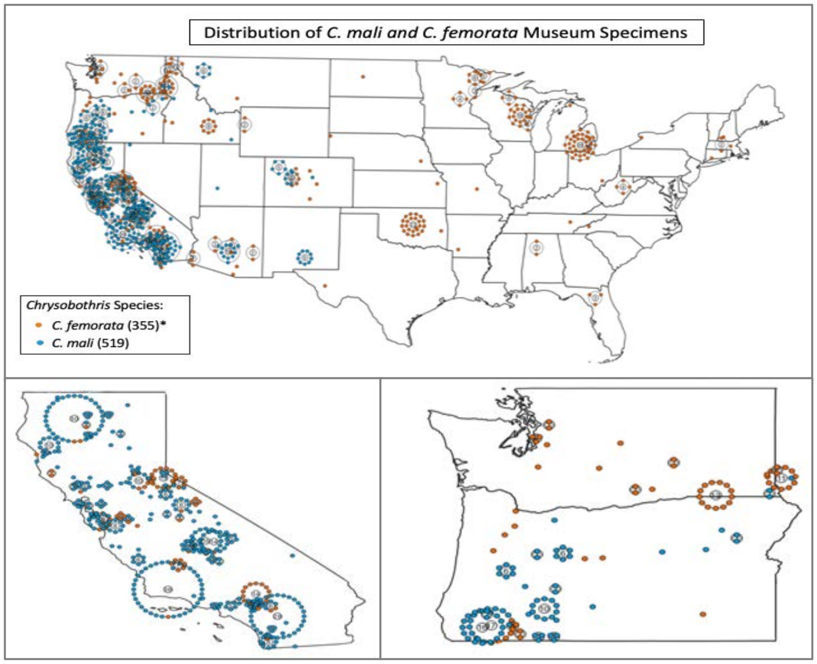

Figure 3: The only comprehensive maps of *C. femorata* and *C. mali* distributions in the United States. *C. femorata*'s eastern range is not complete in this figure, as we only used western collections in this analysis. *Chrysobothris femorata* is shown in orange, while *C. mali* is in blue. Dot rings indicate the number of specimens collected at a single location in the center of the circle.

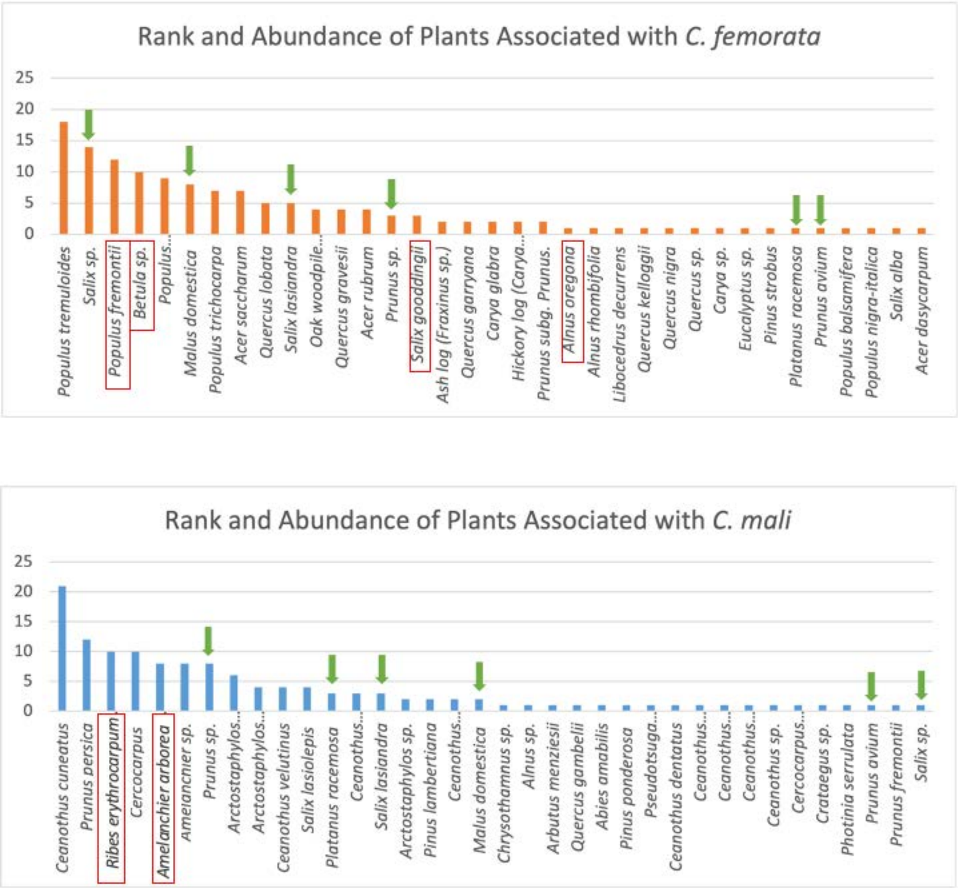

Figure 4: Rank and abundance histograms of the various plant species associated with each taxon. Green arrows indicate plant taxa that are utilized by both species. Red boxes indicate new host records for each species.

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SECTION II
Bees and Pollinators

Evaluating the efficacy and safety of oxalic acid vaporization method to control a honey bee pest *Varroa destructor*

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Beekeepers around the world have faced the challenges of controlling Varroa destructor which is a devastating parasitic mite of the honey bee *Apis mellifera*. Oxalic acid (OA) is a natural chemical that has been used by beekeepers to control Varroa mite. Recently, the vaporization method of OA has been gaining popularity among beekeepers. There are only a few studies that have investigated the efficacy and safety of the oxalic acid vaporization method in controlling Varroa mites by testing three different doses of oxalic acid. We also assessed any potential negative impacts on brood and adult bees.

At the start of the experiment, we performed colony evaluations by estimating the number of bees and broods in each experimental colony. At the same time,(August 2nd, 2021), the alcohol wash method was used to estimate the percentage of Varroa mites in each colony. The experiment continued for three weeks. We had four treatment groups; 1g, 2g, 4g OA per brood chamber, and a control. Each treatment had eight hives in the same apiary located in the Lewis Brown Farm in Corvallis/OR. Three OA applications were applied one week apart and the following parameters were measured: a) mite infestation with the alcohol wash and sticky board methods. b) Number of frames of bees and c) Number of frames of brood. At the end of the experiment, queens from all experimental hives were collected to analyze any damage to their appendages and reproductive fitness. During the three-week experiment, the mite that fell on the sticky boards were also counted every day and the sticky boards were replaced with new ones.

The oxalic acid was vaporized within the honey bee hive for 2-4 min. using special equipment with the power of a 12V battery. After application, the hive entrance and all cracks around the hive were closed with a wet towel to prevent escape of OA vapors from the hives. Another issue that was taken into consideration was the use of protective equipment such as gloves and respirators throughout the treatment.

Data analysis for this study is still in progress. Preliminary analysis suggests that 4g oxalic acid has greater efficacy than other treatments (2g and 1g).

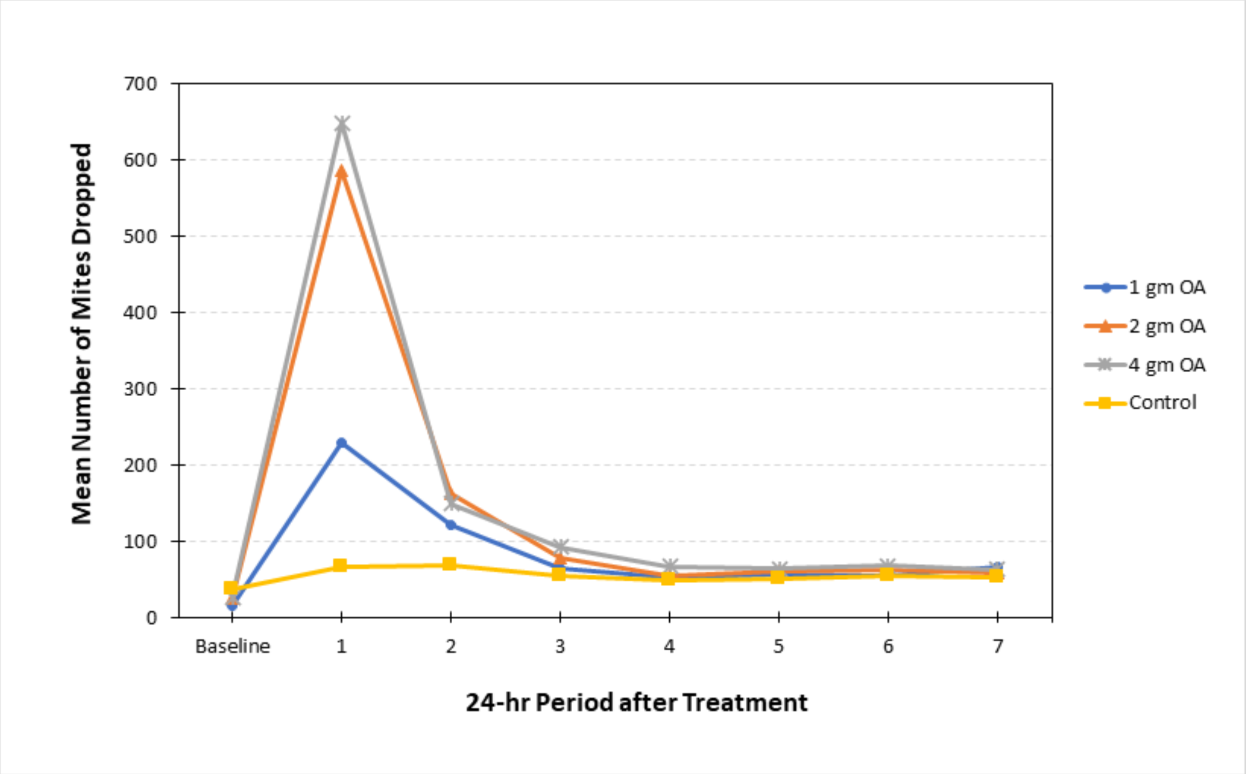

Figure 1. Mean number of mites falling on the sticky boards during a seven-day period for each of the four treatments (ag, 2g, 3, OA, and control)

HONEY BEE AND NATIVE BEE VISITATION IN SWEET CHERRY ORCHARDS

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Introduction

Food and seed production relies on the pollinating force of European honey bee, *Apis mellifera* L., colonies to facilitate fruit and seed set in a diverse range of crops. Yet, colonies in agricultural environments may stray from the crop and forage on wild plants and other nearby food sources[1]. This leads to a complex pesticide risk profile that includes the products applied to the crop and the potential for honey bees to be exposed to chemicals applied to other attractive plants within their foraging radius[2,3].

When a diverse pollen sample is tested for pesticides, it is difficult to ascertain where the chemicals originated in the landscape[4,5]. Pollen samples collected from honey bee colonies are a composite of plant species. Therefore, while a test of the composite sample provides a wholistic view of the honey bee's pesticide exposure over a given period, it does not allow scientists and land managers to identify high-risk areas of the landscape[3].

Furthermore, the European honey bee, *Apis mellifera* L., is commonly used as a surrogate to understand pesticide risk to all bees[6], yet, honey bees have different life history and foraging behavior than most bees native to North America[7]. Native bees are primarily solitary ground and stem nesters supplying larvae with individual pollen provisions rather than collecting resources for a eusocial colony[7,8]. One key assumption in the current pesticide risk model is that, despite differences in forage preferences and behavior[8], all bees in agriculture are exposed to the same level of pesticide risk. One key assumption in the current pesticide risk model is that, despite differences in forage preferences and behavior[8], all bees in agriculture are exposed to the same level of pesticide risk. We tested the assumption that native bees and honey bees share similar pesticide exposure patterns in cherry production in The Dalles, Oregon.

In this study, we investigate pesticide risk to honey bees in four pollinated crops of Oregon from March to August of 2020; sweet cherry (The Dalles and the Willamette Valley). In total, twelve sweet cherry fields were monitored for pesticides to understand pesticide risk to honey bee colonies moving through these pollination systems. Samples, collected at peak and late bloom were analyzed for over 250 pesticide residues. We then sorted composite pollen samples into each species and identified the major plant species within each color of pollen[9,10]. These sorted samples were then tested again for pesticides and compared to the original composite test, allowing us to identify species of plants which disproportionately contribute pesticide risk to the composite sample.

Results and Discussion

This study compares pesticide risk of honey bees and native bees by examining pollen forage overlap in sweet cherry orchards (both cherry itself and blooming understory) and native oak habitat. Twelve commercial cherry orchards and six native oak fragments were assessed for honey bee and native bee presence in The Dalles, OR. Four carrot fields and two cover crop plots were assessed for honey bee and native bee presence in Madras, OR.

We estimated exposure by comparing the bee communities and pesticide residues associated with each habitat block. Native bees were surveyed via net collection and honey bees were counted with a clicker in timed walking surveys. This provides a visitation rate of bees per minute.

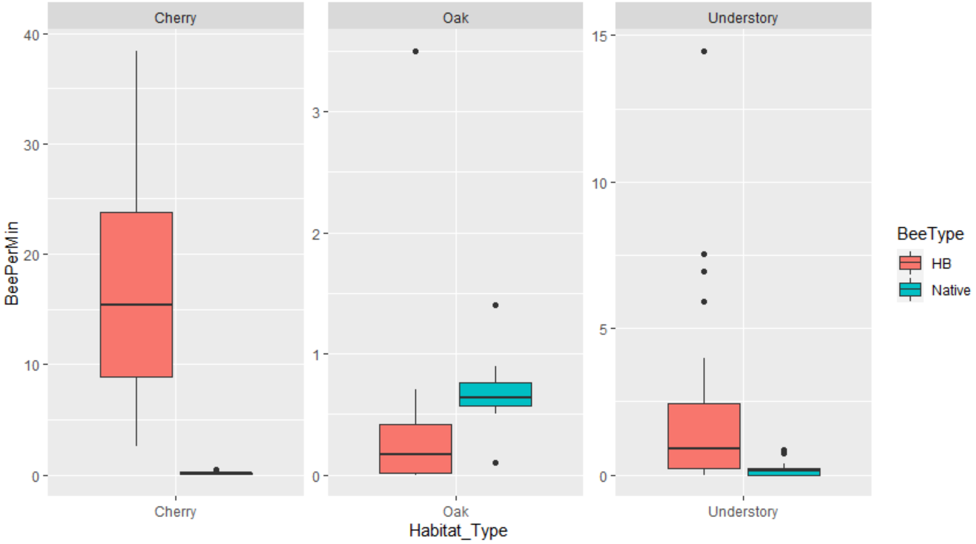
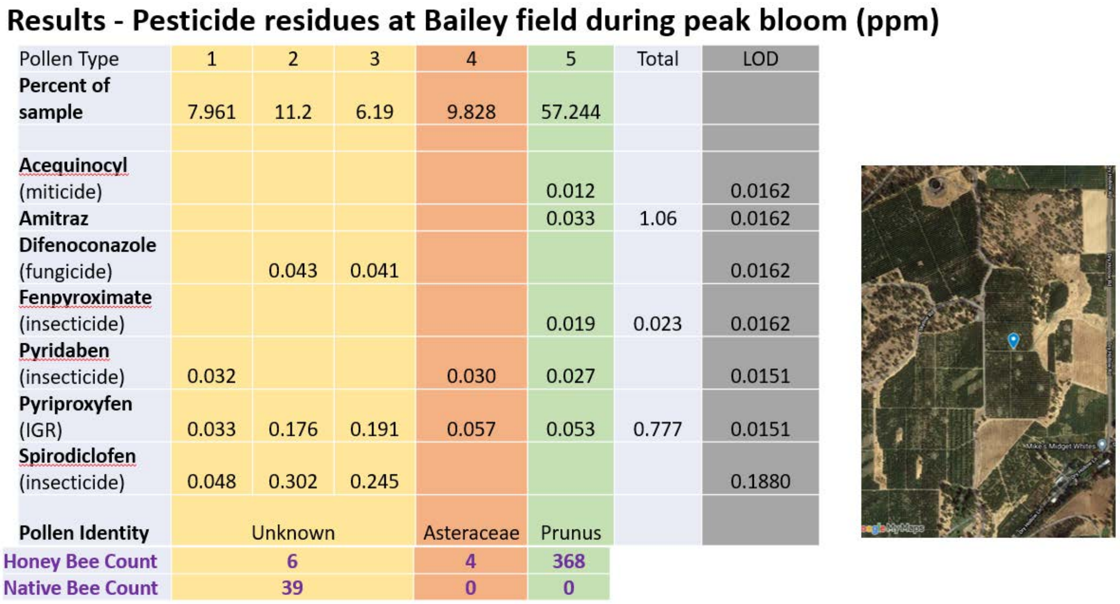


Figure 1. *A box and whisker plot showing the visitation rate (bees per minute) of flowers in each landcover class in The Dalles, OR sweet cherry production and surrounding oak habitat.*

Preliminary analysis shows that honey bees and native bees are using landcover classes differently and visiting floral resources in them at different rates. Interestingly, this difference in floral visitation also leads to a difference in pesticide exposure profiles.



Results - Pesticide residues at Bailey field during peak bloom (ppm)

Pollen Type	1	2	3	4	5	Total	LOD
Percent of sample	7.961	11.2	6.19	9.828	57.244		
Acequinocyl (miticide)					0.012		0.0162
Amitraz					0.033	1.06	0.0162
Difenoconazole (fungicide)		0.043	0.041				0.0162
Fenpyroximate (insecticide)					0.019	0.023	0.0162
Pyridaben (insecticide)	0.032			0.030	0.027		0.0151
Pyriproxyfen (IGR)	0.033	0.176	0.191	0.057	0.053	0.777	0.0151
Spirodiclofen (insecticide)	0.048	0.302	0.245				0.1880
Pollen Identity	Unknown			Asteraceae	Prunus		
Honey Bee Count	6			4	368		
Native Bee Count	39			0	0		

Figure 2. *A table showing native bee and honey bee presence by habitat in Bailey Field during peak bloom and the associated pesticide residue profiles of each pollen source.*

These differences in pesticide residue profiles and floral visitation rates indicate that the exposure model for honey bees and native bees is not the same. Pesticide hazard to honey bees may originate from direct spray applications. Pesticide hazard to native bees may originate from pesticide drift onto non-target plant species. Future work will identifying native bee species, and repeating this work on the 2021 data set.

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IMPACTS OF STEROL-BIOSYNTHESIS INHIBITORY FUNGICIDES ON HONEY BEE TISSUE PHYTOSTEROLS

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Introduction

Pesticides have often been considered as one of the primary factors for global bee declines, with impairments ranging from physiological, morphological and behavioral, affecting both individual bees and the overall colony health (Frazier et al. 2008; Winfree et al. 2009; Chakrabarti et al. 2015; Chakrabarti et al. 2019a). Honey bee hive matrices like pollen and wax have been shown to contain significant pesticide residues (Mullin et al. 2010; Pettis et al. 2013), including several fungicides. One such group of fungicides is the sterol biosynthesis inhibitory (SBI) fungicides. SBI fungicides include chemical groups such as imidazoles, triazoles and piperidines. Metconazole (MTZ) and propiconazole (PPZ) are commonly used SBI fungicides and have been reported in wax, pollen and bee samples from North American apiaries (Mullin et al. 2010; Long and Krupke 2016).

All insects, including bees, are sterol auxotrophs (Carvalho et al. 2010), essentially indicating that they have lost the sterol biosynthesis pathways and are dependent on their food sources for dietary intake of required sterols. Sterols, on the other hand, are a critical micronutrient as they are the precursors to insect molting hormones and form the basis of various cell membrane molecular components (Behmer and Nes 2003). Hence it is crucial to investigate the indirect impacts of SBI fungicide exposures on bees by assessing these impacts on bee tissue phytosterol concentrations. The present study is novel and explores the impacts of SBI fungicides on honey bee tissue phytosterols for the first time. In addition, the impacts of additional pollen supplementation (as pollens contain phytosterols (Chakrabarti et al. 2019b)) on the phytosterol profiles of treated honey bees have also been studied.

In this study, honey bees in laboratory were exposed to MTZ and PPZ through their diets, with or without pollen supplementation. All honey bees received 40% sugar syrup. This study was conducted for three weeks.

Results and Discussion

Survival was significantly different between the experimental groups at the end of three weeks with honey bees surviving the longest in the groups as follows: pollen control > sugar syrup control > PPZ+Pollen > MTZ+Pollen > PPZ+MTZ+Pollen > MTZ > PPZ > PPZ+MTZ. Targeted lipidomics was conducted based on existing methods (Chakrabarti et al. 2019b) the phytosterol profile of the honey bee tissues was found to be significantly altered on exposure to SBI fungicides. Figure 1 shows a generalized total ion chromatograph of the phytosterol analysis using targeted lipidomics approach.

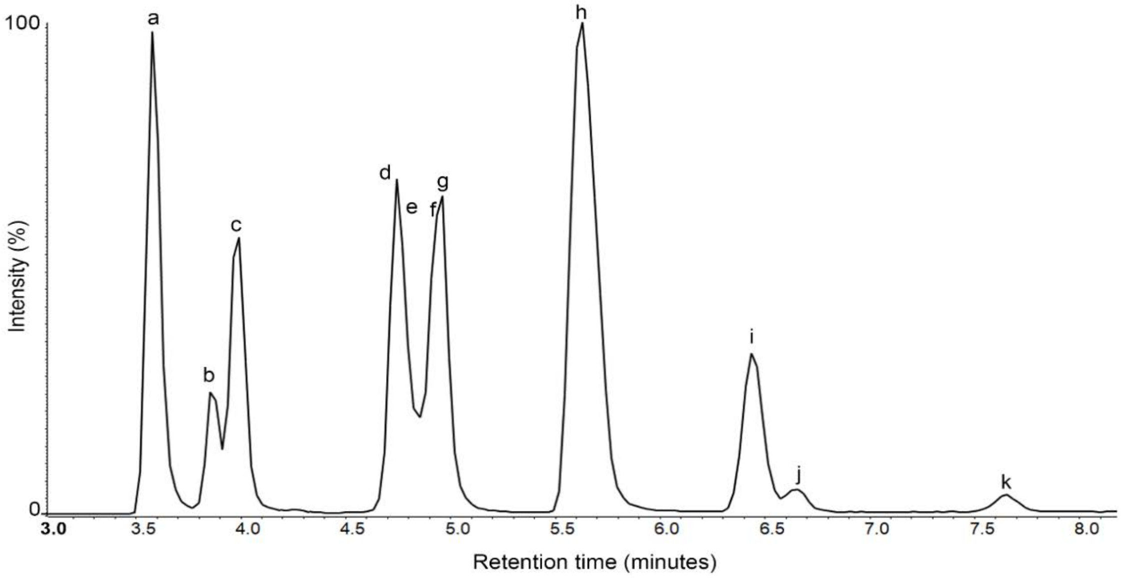

Figure 1: Total ion chromatograph of a representative sterol standard mix (75µm). The sterol peaks identified are as follows: (a) Desmosterol; (b) Ergosterol; (c) 24-methylenecholesterol; (d) Stigmasterol; (e) Brassicasterol; (f) Δ5-avenasterol; (g) Cholesterol; (h) Campesterol; (i) β-sitosterol; (j) Campestanol; (k) Sitostanol. A targeted lipidomics was conducted for quantifying phytosterols at the Oregon State University Mass Spectrometry Center. Figure reproduced from Chakrabarti et al. 2019b.

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NATIVES AND NATIVARS: UNDERSTANDING POLLINATOR PREFERENCE FOR NATIVE PLANTS AND THEIR CULTIVATED COUNTERPARTS IN THE PACIFIC NORTHWEST

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Global insect declines and the plight of pollinators has been well documented and broadcasted throughout both scientific and non-scientific media streams. When gardeners and other community members ask what they can do to support pollinator conservation, planting a pollinator garden is often included among the list of actionable items. Although well-intended, the success of pollinator gardens may be limited, depending on the management practices and the palette of plants a gardener selects.

Exotic plants, for example, have documented negative impacts on the abundance of both generalist and specialist insect herbivores (Tallamy *et al*., 2009; Burghardt *et al*., 2010) and may further interrupt typical plant-insect interactions through host shifts, new plant associations, or evolutionary traps which result in poor larval development or high larval mortality (Sunny *et al*., 2015). Many pollinating insects, including bees, are generalists that will forage across a broad array of plants (Matteson and Langellotto, 2011; Langellotto, 2017). However, observational studies suggest that gardens with more native plants may have higher bee visitation (Fukase & Simons, 2015;) diversity (Hostetler & McIntyre, 2001) or abundance (Pardee & Philpott, 2014).

Indeed, garden plant palettes that are dominated by exotic plants may not be the best choices for pollinator conservation gardens. However, many native plants are not broadly available on the retail market, or else do not fit into industry production practices or meet consumer standards for ornamental plants. Whether or not native cultivars (i.e. plants that have been bred from native plants for ornamental gardens and landscapes) represent a good compromise between industry production practices, consumer expectations, and pollinator benefits, has yet to be thoroughly explored.

Only 13.4% of plants sold in the United States are reported as “native” (Hall *et al.,* 2011). However, not all of these plants are *true* natives. In fact, the majority of them are likely native cultivars (Wilde et al., 2015; Coombs & Gilchrest, 2017). Many native cultivars available in the horticultural market have been bred or selected for ornamental qualities, such as changes in flower and/or foliage size and color, architecture, as well as resistant traits (e.g. drought, disease) (Wilde *et al*., 2015; White *et al.,* 2018). Though researchers suggest that selections in native plant breeding should focus on the goal of maintaining ecological function, many ornamental characteristics are achieved by changing genes, multiplying genes, or through selection for function loss in particular genes (Wilde *et al*., 2015). Thus far, research seeking to evaluate pollinator preference for native cultivars compared to wild types has yielded mixed results, which confirms a need for further research (White, 2016; Ricker, 2019).

Here, we will report on two years of research comparing bee visitation to 7 genera of Oregon native plants and one to three associated cultivars (Table 1). This study is ongoing, and takes place at Oregon State University’s Oak Creek Center for Urban Horticulture in Corvallis, Oregon. The goals of this research are to identify if there is a difference in bee preference for wild type natives or cultivars, in addition to understanding what floral traits are impacted by the plant breeding process. We hypothesize that pollinator preference for native status (natives or cultivars) will vary by plant genus group, and that changes to plant traits (via breeding) may be associated with increased or decreased bee visitation. In this report, we will focus on bee visitation documented across two years of field observations.

Table 1. **List of Study Plants**

Native Species	Native Cultivar 1	Native Cultivar 2	Native Cultivar 3
Yarrow *Achillea millefolium*	‘Calistoga’	‘Salmon Beauty’	‘Moonshine’
Western Red Columbine *Aquilegia formosa*	*A.* x ‘XeraTones’	n/a	n/a
Great Camas *Camassia leichtlinii*	‘Caerulea Blue Heaven’	‘Sacajawea’	n/a
Farewell-to-spring *Clarkia amoena*	‘Aurora’	‘Dwarf White’	‘Scarlet’
California poppy *Eschscholzia californica*	‘California Mikado’	‘California White’	‘Purple Gleam’
Baby Blue Eyes *Nemophila menziesii*	‘Penny Black’	‘Snow White’	n/a
Douglas Aster *Symphyotrichum subspicatum*	‘Sauvie Sky’	‘Sauvie Snow’	n/a

Methods

In November of 2019, two 3x30m rows were tilled, mulched, and labelled in preparation for the study. The garden layout was established following the criteria for a randomized complete block design, and guided by work from White (2016) and Rollings and Goulson (2019). Five replicates (1m^2 plots) of each plant type were established across the four garden beds at OCCUH, with each individual plant type at least one meter away from another replicate. Each plant type was seeded or planted based on nursery recommendations to achieve full plot coverage. The plots receive regular maintenance during the field season and off-season, including watering and weeding as needed.

Our field seasons spanned the primary growing season for plants in the study (April – September) in both 2020 and 2021. Each week, we censused open blooms in each plot. Once a plot reached at least 25% bloom coverage, we conducted 5-minute observations of all pollinators visiting a plot. During peak bloom (~50% or greater bloom coverage), we conducted pollinator and bloom counts twice a week. Observations were limited to days with favorable weather conditions (temperature $\geq$60^{o}F, wind speed less than 3.5 m/s, and cloud cover <50%) between 09:00 and 16:00 PST.

For our 5-minute pollinator observations, an observer watched a plot and sight-identified any insect activity on the study plants (e.g. foraging, basking, nectar-robbing). If an insect left the observation area and later returned, it was considered a new individual. Butterflies were identified to the species level, bee species were grouped into morphospecies: honeybees (*Apis mellifera*), orange bumblebees (such as *Bombus melanopygus*), bumblebees (e.g. *Bombus vosnesenskii*), black bees (e.g. *Halictus ligatus*), green bees (e.g. *Agapostemon virescens*), long horned bees *(Melissodes sp.* and *Eucera sp.)*, leafcutter bees (all Megachilidae), and other bees (e.g. *Nomada sp.*). Flies were identified as members of the Syrphidae family or not, and all other insects were identified to taxonomic order.

Table 2. Significant Results of post hoc Tukey Test

Year	Comparison	Ratio	Standard Error	*P* Value
2020	Native *Clarkia* – 'Aurora'	3.7254	0.63733	<.0001
2020	Native *Clarkia* – 'Dwarf White'	2.4437	0.37371	<.0001
2020	Native *Achillea* – 'Calistoga'	4.1477	1.42756	.0063
2021	Native *Clarkia* – 'Aurora'	2.3454	0.42674	0.0006
2021	Native *Clarkia* – 'Dwarf White'	2.3090	0.35722	<.0001
2021	Native *Clarkia* – 'Scarlet'	2.5034	0.39386	<.0001
2021	Native *Achillea* – 'Moonshine'	2.7884	0.58386	.0002
2021	Native *Achillea* – 'Salmon Beauty'	3.5893	1.03739	.0022
2021	Native *Eschscholzia* – 'Purple Gleam'	2.4399	0.42405	.0001

Preliminary Findings

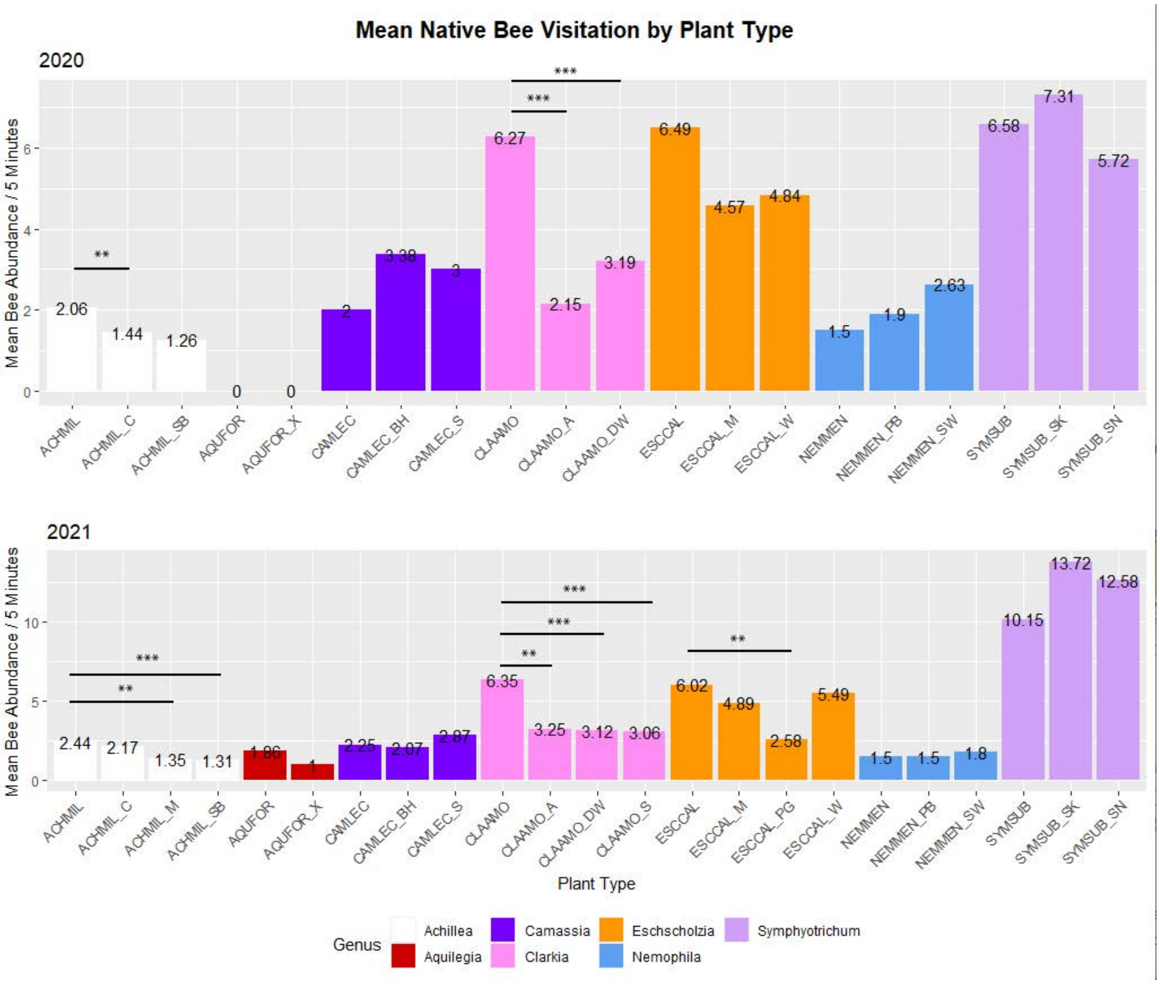
In 2020 we conducted pollinator observations on 28 different dates, allowing us to observe 6,238 interactions between pollinators and our study plants. In 2021 we observed our plots on 33 different dates, documenting 6,225 interactions. Here we will report only on 2 years of observations of foraging native bees. Thus, this report excludes honeybees, *Apis mellifera*, and the non-native wool-carder bee, *Anthidium manicatum*, and excludes non-foraging activity, such as resting, mating, or basking.

Year 1 (2020) was the first year of establishment for the plants in our study, which resulted in a shortened or minimal bloom for some of our perennials (e.g. *Aquilegia formosa* and its cultivar 'XeraTones' in addition to the native *Camassia leichtlinii*). This limited bloom may explain some of the variation in mean abundance of foraging native bees during our 5-minute observation periods (Figure 1). The annual plant baby blue eyes (*Nemophila menziesii*) does not tolerate clay soils, which also likely limited its bloom and overall success.

Across both 2020 and 2021 there is no clear preference for native plants or cultivars across all our seven groups of study plants (Figure 1). Type II analyses of variances (ANOVAs) were conducted on binomial regression models in order to understand the relationship between foraging native bee abundance and individual plant types. The 2020 (F=741.75, d.f.(18, 996) , p= <0.0001) and 2021 (F=1786.64, d.f.(21, 964) , p= <0.0001) found plant type to be a significant predictor of the variance in foraging native bee abundance. A post-hoc Tukey test found significant differences between plant types at $p < 0.05$ in both 2020 and 2021 (Table 2). The native annual *Clarkia amoena* received greater visitation in both 2020 and 2021 than its cultivars, and the same is true for *Eschscholzia californica* and *Achillea millefolium*, though only some of those differences were statistically significant (Figure 1 & Table 2).

Native plant species selection was guided by a 2017-2019 study of Oregon native plants; selected natives were found to be highly attractive (e.g. *Symphyotrichum subspicatum, Eschscholzia californica, Clarkia amoena*), moderately attractive (e.g. *Achillea millefolium, Nemophila menziesii*), and less attractive (e.g. *Camassia leichtlinii, Aquilegia formosa*) to pollinators (Anderson, in prep.). We included plants exhibiting low and moderate levels of attractiveness to see how selection for specific plant traits (e.g. color or bloom size) might increase or decrease pollinator visits to nativars. Based on the observation data, it does not seem like the cultivars possess traits that make them drastically more attractive to native bees, although is possible they actually possess traits that decrease their mean visitation rates.

Figure 1. Mean Foraging Native Bee Abundance per 5 Minute Observation. Plants are color-coded according to genus, and named following a 6-letter naming convention; e.g. *Achillea millefolium* = ACHMIL, and its cultivar 'Calistoga' = ACHMIL_C. The number of each bar is the mean abundance of foraging native bees across all observation periods in 2020 (top chart) and 2021 (bottom chart). Asterisks denote statistically significant differences between natives and cultivars within genus groups, based on a post hoc Tukey test, where $p \leq 0.05$ = *, $p \leq .005$ = **, and $p \leq .0005$ = ***.



Moving Forward

Over two years we have tracked pollinator preference (visitation, relative abundance, diversity) to each of our 23 plant types and have additionally collected and measure various floral traits in attempts to quantify morphological and nutritional differences within genus groups. As this research is ongoing, we do not yet have all the data to conduct our final analyses. Our final field season will occur in 2022, after which we will be able to share more information about pollinator preference and floral trait differences. Floral trait information will span from flower size, plot bloom density, pollen nutrition, color measurements, and ultraviolet photographs.

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EFFECT OF ERYTHRITOL, A PROSPECTIVE HUMAN-SAFE INSECTICIDE FOR *DROSOPHILA SUZUKII*, ON HONEYBEE (*APIS MELLIFERA)* VISITATION AND BROOD SURVIVAL

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Drosophila suzukii (Matsumura) (Diptera: Drosophilidae), commonly referred to as spotted-wing drosophila, is a problematic pest from Asia that attacks a wide range of small fruits. Erythritol, a non-nutritive sugar, is safe for human consumption but insecticidal to spotted-wing drosophila and is being developed as a human-safe insecticide for berry and cherry crops. Bees most often visit crops while in bloom, while the erythritol spray would be applied post-bloom, minimizing exposure to pollinators while maximizing risk to spotted-wing drosophila. Understanding the effect of erythritol on *Apis mellifera* is important to commercialize our formulations as honeybees have been observed visiting erythritol-treated bushes during recent field trials. During field trials, we observed visitation frequency at sprayed bushes at various distances to honeybee hives and found that honeybee visitation was similar among all treatments which would indicate that they are not considerably lured toward the sugar sprays. In Choi et al. (2019), the effect of erythritol consumption by adult honeybees was explored through a laboratory cage-incubation study. Erythritol-fed bee survivorship was comparable to sucrose-fed control bees. Although results showed no toxicity to adults, toxicity to developing brood was previously unknown was accessed here by dripping our erythritol formulations into honeybee brood cells, imitating an unrealistic level of exposure to developing larvae. We found no detriment from both of our formulations in comparison to our control, distilled water. Overall, our results show that our two erythritol formulations cause minimal non-target damage to honeybees.

SECTION III

Environmental Toxicology and Regulatory Issues

RESULTS FROM THE PESTICIDE STEWARDSHIP PARTNERSHIP PROGRAM—IMIDACLOPRID AND OTHER INSECTICIDE DETECTIONS FROM STREAMS IN OREGON.

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The State of Oregon initiated the Pesticide Stewardship Partnership (PSP) program in response to the detection in 1999 of problematic levels of organophosphate insecticides in the Hood River watershed. Over time the PSP program has expanded and currently operates in nine watersheds throughout Oregon (Figure 1). These areas are being sampled for pesticides on a regular basis to determine what the key issues are and what research or outreach is needed to address any problems that are being observed. The pesticide detection database amassed by the PSP program over the last two decades provides valuable information on changes in pesticide-use practices. While the vast majority of the pesticide detections have been herbicides, insecticides have generally been the compounds of greatest concern as their established benchmark levels for impacting aquatic life are usually much lower than for herbicides or fungicides.

Sampling for imidacloprid as part of the PSP testing protocol was started in 2008 and, presently, imidacloprid is the insecticide that is detected most frequently. The detection limit for imidacloprid is higher than the current aquatic life benchmark level thereby making any detection of imidacloprid above the established benchmark. In 2020, imidacloprid was responsible for over half of the statewide detections above the aquatic life benchmark level, out of 469 samples, there were 82 pesticide detections above the aquatic life benchmark, 64 were insecticides and 45 of those were imidacloprid detections. Over the period starting in 2009, the first full year of sampling for imidacloprid, to the present, the frequency of imidacloprid detections statewide has ranged between 3.9% and 13.9% annually. In each of those years, imidacloprid has been the pesticide with the highest number of detections above the aquatic life benchmark level. Additionally, the concentration of imidacloprid being detected has been trending upward (Figure 2).

Other pesticides which are often detected at levels above or near the aquatic life benchmarks include three organophosphates: chlorpyrifos, malathion, and diazinon (Figure 3). Carbaryl, a carbamate, is the second most detected insecticide overall but is not often detected at levels above or approaching the benchmark. Pyrethroid insecticides are extremely toxic to fish and aquatic invertebrates but detection is relatively infrequent due to their low solubility and high level of adherence to soil particles. However, when sediments are sampled then pyrethroids are found more frequently.

The PSP data set does have a number of limitations. The sampling sites change over time and the sampling is directed to find problems. Sites or watersheds which have few or no pesticide detections are generally dropped after a few years. For example, the entire South Umpqua PSP (see Figure 1) was terminated after 2019 due to a lack of significant pesticide detections. Despite the fact that the list of materials being sampled has expanded over time and currently consists of 196 analytes, a major limitation is that many materials, especially newer materials, are not sampled for, even though in some crops they may be the primary materials being used. Only two neonicotinoids: imidacloprid and acetamiprid, and three pyrethroids: bifenthrin, fenvalerate, and permethrin, are part of the current testing regime. No testing is being done for any diamides or spinosyns even though insecticides in those groups are heavily used in a number of cropping systems. However, it is expected that the material list will continue to be expanded in the future.

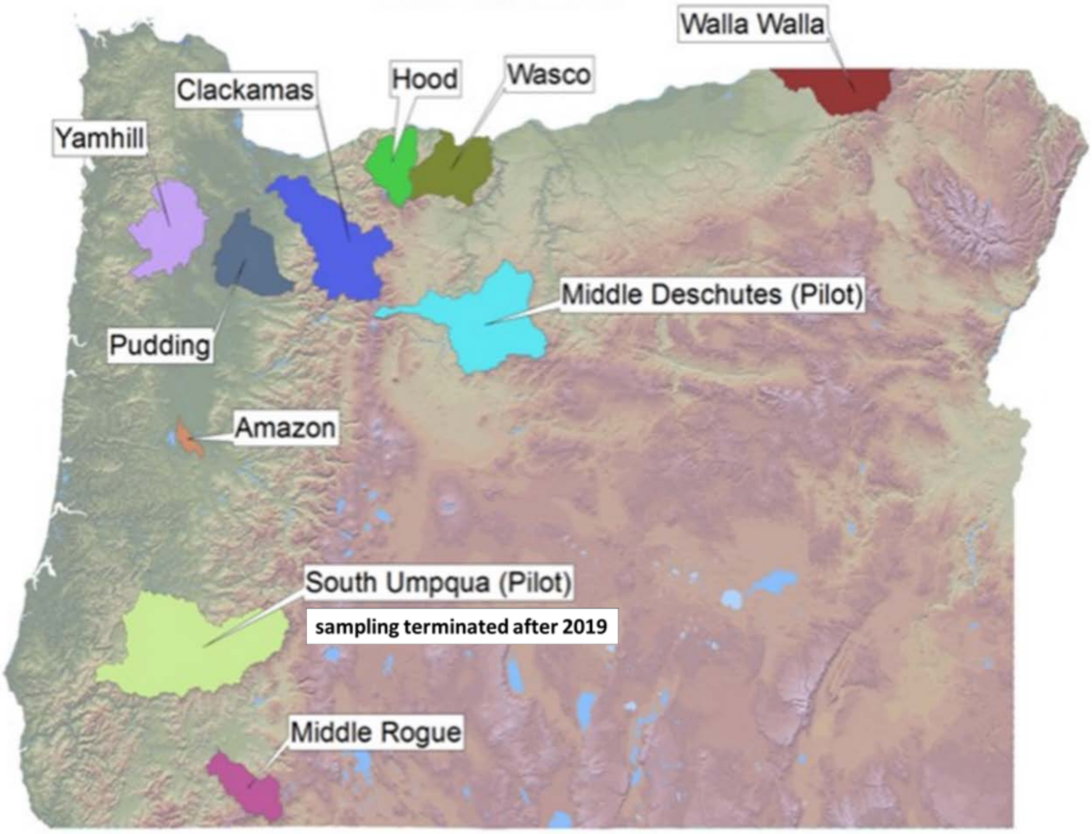

Figure 1. Watersheds in the PSP program, where sampling of streams for pesticides is being conducted.

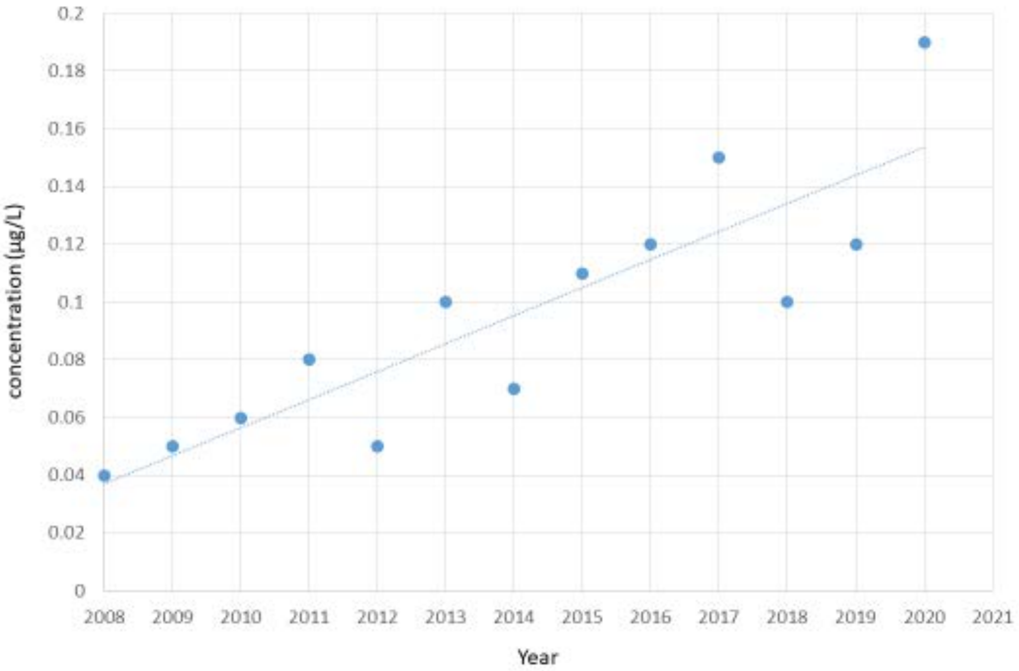

Figure 2. Average concentration (µg/L) of an imidacloprid detection per year (2008-2020).

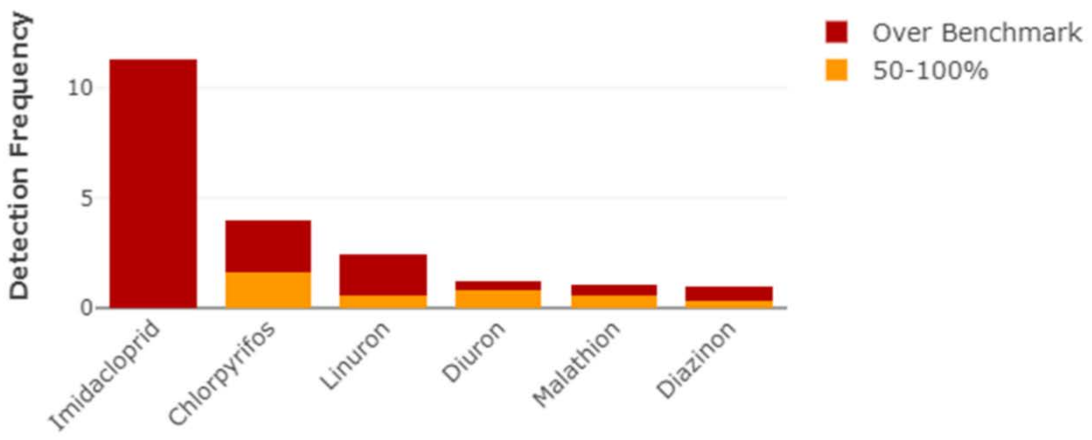

Figure 3. For the sampling period 2016 to 2020, these are the six pesticides which were most frequently detected at a level above 50% of the established aquatic benchmark.

SURVEY RESULTS ASSESSING CRITICAL USES OF CHLORPYRIFOS IN OREGON

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We surveyed Oregon specialty crop producers in February 2021 using an online Qualtrics survey to assess grower uses of chlorpyrifos and interest in IPM strategies. There were 106 respondents, of which 64% were growers. While the survey primarily targeted grass seed, clover seed, onion and cherry producers, responses were provided for over 30 specialty crops. 86% of respondents identified as conventional producers, with 66% of respondents reporting that they apply chlorpyrifos annually to their crops. The top two reasons cited for use of chlorpyrifos were efficacy for the pest being targeted, and lack of available alternatives to control the pest.

As expected for a broad spectrum insecticide, respondents identified a wide range of pests they currently use chlorpyrifos to control, including piercing/sucking insects (aphids, scale), soil dwelling insects (maggots, symphylans, cutworms), and foliar pests (armyworms, webworms, weevils). The three pests cited most frequently were maggots, symphylans and cutworms.

97% of respondents reported using some type of IPM strategy before applying chlorpyrifos, with 89% of respondents reporting that they monitor or scout for pests for applying chlorpyrifos. 68% of respondents reported waiting until they reached an action threshold before applying chlorpyrifos. Only 12% of respondents reported using non-chemical IPM strategies before applying chlorpyrifos.

SECTION IV
Field Crop Pests

Section IV: Field Crop Pests
Student competition

GEOCORIS PUNCTIPES (SAY) FEEDING PREFERENCE USING POTATO PESTS

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Introduction

Biocontrol agents can be an effective addition to integrated pest management programs. Additionally, they can help reduce the use of biocidal agrochemicals. Generalist biocontrol agents provide broad spectrum control in field conditions; however, predator feeding preferences can influence this broad-spectrum dynamic in ways that are prey species specific. This trophic interaction can suppress the overall efficacy of an agent who feeds disproportionately on a pest that is less damaging but more abundant or better preferred by the predator. Under this context, the Manly-Chesson preference index can be used to determine β as an estimate of predator preference by comparing the ratio of capture rate to encounter rate for two prey types (Chesson, 1978).

Geocoris spp. are well known generalist biocontrol agents and they predate in pests like *Myzus persicae* Sulzer and Lygus spp., both pests of potato. In the lower Columbia Basin, *Geocoris punctipes* Say and *Geocoris pallens* Stäl are common species. Both species have shown prior preferences towards species of the Aphididae family, despite aphids being relatively poor sources of nutrition (Cohen, 1989; Eubanks, et al., 1999; Eubanks, et al., 2000; Koss, et al., 2004).

Our study evaluated the predator-prey interactions for two seasonally distinct *G. punctipes* populations, spring and summer, exposed to field collected Lygus spp., and *M. persicae* reared under laboratory conditions.

Materials and Methods

Geocoris punctipes was collected in the field from *Kochia scoparia*, *Malva neglecta*, and *Chenopodium spp*. in eastern Oregon using a sweep net. Individuals were collected with an aspirator and placed in a small glass vial where they were starved for 24 hr.

Myzus persicae was acquired courtesy of Dr. Luis Canas (Ohio State University). Insects were shipped overnight on broccoli leaves for each seasonal cohort.

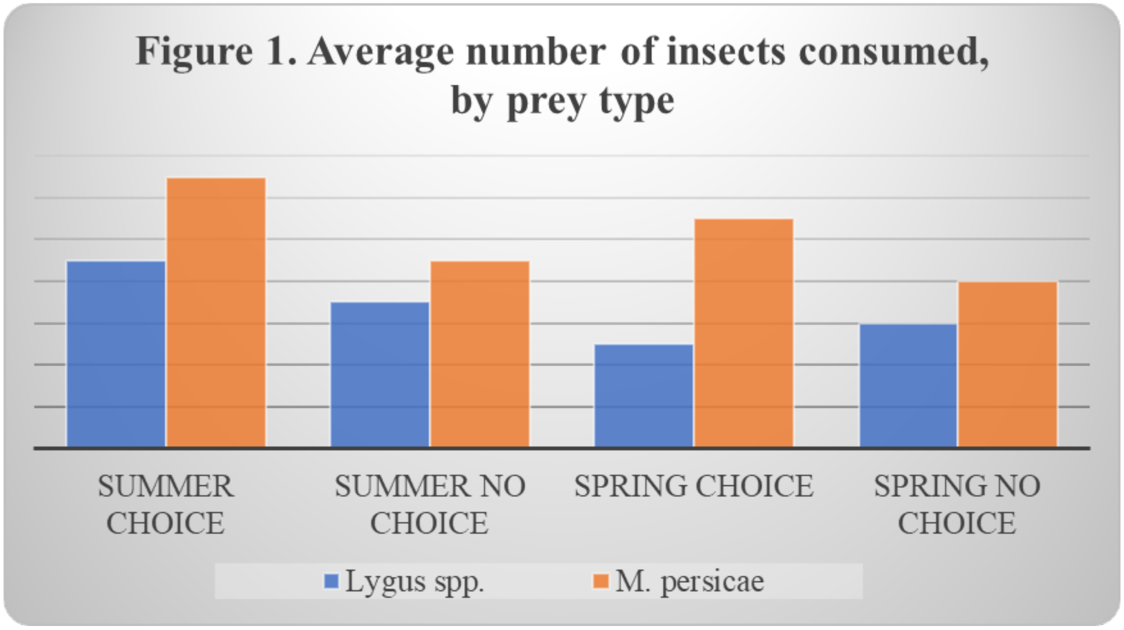
Lygus bugs were collected from *K. scoparia*, *M. neglecta*, and *Chenopodium spp*. in areas bordering recently cut alfalfa using an inverted leaf blower. Contents of the leaf blower were dumped onto a beat sheet in the field to allow for the winged adult lygus to naturally exclude themselves. Individual lygus nymphs were collected with an aspirator and placed 15 a piece in a 50 ml nonsterile tube.

No choice and choice trials were conducted using spring and summer populations in late May and late August, respectively. No choice trials consisted of a testing area which included a potato leaflet wrapped in moistened cotton inside of a petri dish. No choice trials were conducted with 15 of either *M. persicae* or *Lygus* spp nymphs along with 1 *G. punctipes* adult. Choice trials were conducted in similar testing set up with 15 each *M. persicae* and Lygus spp. nymphs along with 1 *G. punctipes* adult. Each trial was replicated 10 times and a control trial containing no predator was replicated 5 times for both choice and no choice models. Predation was determined after 24 hrs under stereomicroscope.

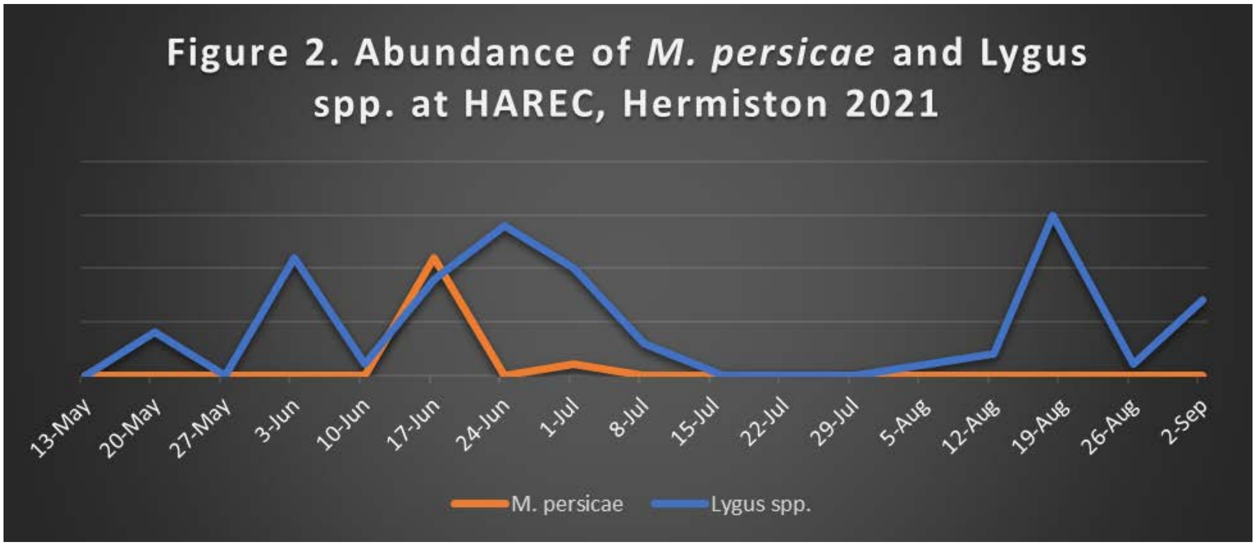
Results and Discussion

The no choice trials showed no significant difference in predation when prey was offered individually. This indicates that *G. punctipes* will consume roughly the same amount of either species when not given an alternative. Prior studies reported similar levels of aphid consumption in 24 hours by individual Geocoris (Rondon, et al., 2004).

In the choice study, both, spring and summer populations of *G. punctipes,* fed preferentially on *M. persicae*. This preference, however, was reduced in the summer population. Interestingly, feeding was overall increased in the summer population.



Prior studies have also found that *G. punctipes* has preferential feeding behavior towards aphids when compared with eggs of other species (Eubanks, et al., 2000; Koss, et al., 2004). Eubanks, et al 2000 proposed mobility as the primary factor in prey selection for Geocoris comparing non mobile eggs with mobile aphids. Our study evaluated two mobile prey types although mobility was not tested. Empirical observations suggest Lygus spp. are more mobile than *M. persicae* but the significance of this difference has not been properly researched. Based on observations we can deduce that mobility alone is not the sole driver of *G. punctipes* prey selection. If it where the more mobile prey would be expected to be more heavily predated. In terms of predator-prey interactions, mobility can both alert a predator to the presence of the prey through visual or mechanical cues (e.g. vibrations carried through a leaf) or help the prey evade capture if it is more mobile than its predator or alternative prey types. Thus, future studies will focus on prey mobility and its association to predator perception, and vicariously encounter and capture rate. Under these assumptions, prey motility could erroneously influence determination of preference using Manly's β when making comparisons with mobile and non-mobile species. While perception of the prey likely influences a predator encountering the prey, prey abundance is the principal driver of encounter rate. Prey abundance can change throughout the season based on species specific diel cycles and environmental conditions. The abundance of *M. persicae* in the Lower Columbia Basin has been studied and shown to vary dramatically in short intervals of time in relation to a number of abiotic factors (Klein, 2016). Recent data for *M. persicae* and Lygus spp. abundance near the collection site is shown in Figure 2.



Changes in the encounter rate for one prey type will lead to higher instances of predation regardless of preference. Each instance of predation works to form a search image which influences what prey signals a predator responds to (Yumiko, et al., 2009). It is possible that the decrease in *M. persicae* preference observed in the summer population is at least partially due to the summer population having developed a search image under field conditions with relatively higher encounter rates for Lygus spp.

Further studies will better differentiating predator perception from prey handling as described in Rondon, et al 2004 and accounting for relative prey mobility could be achieved through digital monitoring and video tracking. Search images can be standardized through controlled diets in laboratory conditions. These modifications to the experiment would aid in elucidating the role prey mobility has in Geocoris prey selection and enable us to quantitatively evaluate how search images differ temporally and between populations.

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UTILIZATING TRAP CROPS TO CONTROL CABBAGE MAGGOT

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Cabbage maggot, *Delia radicum* (L.) (Diptera: Anthomyiidae) is a devastating insect pest that affects brassica cropping systems within the Pacific Northwest and world-wide. Chemical control methods are typically used for management; however, many commonly used insecticides, such as chlorpyrifos, are being phased out, highlighting the need for the discovery of alternative control methods.

One promising control method is trap cropping. This method involves planting a trap crop that lures an insect pest away from the cash crop, preventing damage to the cash crop. The success of this method hinges upon the identification of suitable trap crops that are more desirable to the cabbage maggot flies than the cash crop. A field trial was conducted to evaluate the effectiveness of three different turnip varieties as trap crops for a rutabaga cash crop. Sticky traps were deployed to monitor pest pressure within the respective crops, and plant samples were collected for damage assessment. Overall, flies were present in both crops and damage to both trap crop and cash crop was observed.

INVESTIGATING OPTIONS FOR SEED CORN MAGGOT IN VEGETABLES

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The seed corn maggot complex (Diptera: *Delia platura* and *D. florilega*) is a perplexing challenge. Related pests *D. radicum* and *D. antigua* have known and narrow host ranges of crucifers and alliums. Conversely, seed corn and bean seed maggot can be primary pests on a wide variety of crops including legumes, cucurbits, brassicas, and grains, and also have association as secondary invaders, feeding on decomposing tissue. Monitoring activity of adult flies with passive traps is labor intensive and developmental phenology of seed corn maggot in the Pacific Northwest is not well understood. Current management relies on seed treatments, but options are limited for both conventional and organic growers, depending on the cropping system.

Two trials were conducted at the Oregon State Vegetable Research Farm near Corvallis, OR. Seeds of snap bean var. Pierroton were treated with spinosad (*Entrust* @ 0.125 mg ai/seed and *Tracer* @ 0.25 mg ai/seed). Trials were planted on May 5 and May 18, 2021. Prior to planting, fresh dairy manure was vigorously rototilled into the soil at a rate of ~5 tons/A fresh wt. Seeds were planted with a hand-push belt planter with 2 rows per plot, then blood meal applied over the seed row at 2 cups per 20 row ft in a 2-inch band. Plots were replicated four times. Three additional trials were conducted in grower fields that included prepared seeds as described above as well as Syngenta seeds treated with a different formulation of spinosad (*Regard*). Single rows were planted in 20 to 25 ft plots with 3 or 4 replications in a randomized block design. Manure and blood meal were not used in on-farm trials.

Snap bean emergence was counted in the entire plot and vigor rated. Stand counts were made before the trifoliate leaf expanded in a 1 m length of row with poor emergence, then seedlings counted and excavated to assess damage and presence of root maggots.

Seed corn maggot injury to snap beans was highly variable within sites and season. Only one of the sites (Keizer, OR.) had sufficient maggot damage to reliably evaluate insecticide seed treatment efficacy (Table 1). However, inconsistent effects among treatments leaves questions about spinosad efficacy; possibly due to formulation, seed size, or other factors not yet known. Pierroton is a very small seeded variety and emergence is often poor compared to other varieties. We have noted in the past that Pierroton emergence is often hampered by seed corn maggot, even when seed is commercially treated with thiamethoxam. Perhaps seed surface area of Pierroton is so much smaller than other varieties that the amount of insecticide applied is insufficient to suppress or control SCM. Of all the situations tested in these studies, larger seeded varieties appeared to most responsive to spinosad seed treatments.

Table 1. Seed treatments and evaluated parameters at the Keizer, OR. site, snap beans.

	Cultivar/Source of seed treatment	Seed treatment/ insecticide	Rate	Stand	No. seedlings	Snake heads	All maggot-damaged seeds or seedlings	Maggots visible on roots	Stunting (29-Jun)
				no./plot (200 seeded)	*---------- No./1 m of row in area with poor stand -------*				*%*
1	Pierroton/IR-4	Nontreated[a]	-	57	9.0	0.7	3.0	0.7	30
2	Pierroton/IR-4	Entrust[a]	0.125 mg ai/seed	38	4.7	1.3	2.3	0.0	43
3	Pierroton/IR-4	Tracer[a]	0.25 mg ai/seed	77	8.3	1.3	2.7	0.7	17
4	Pierroton/Syn	Regard	0.15 mg ai/seed	74	7.0	1.3	4.7	0.0	17
5	Pierroton/Syn	Nontreated	-	35	7.0	2.3	4.7	2.3	77
6	Pierroton/Syn	Regard	0.15 mg ai/seed	76	10.3	1.0	3.7	0.0	0
7	Pierroton/Syn	Untreated[a]	-	86	10.3	4.0	7.0	3.7	50
8	Pierroton/Syn	Capture LFR[a]	16 oz/A, 4 inch band over row	110	10.0	0.7	2.7	0.3	23
9	SB4734/Syn	Nontreated	-	44	6.7	1.7	5.0	1.0	60
10	SB4734/Syn	Nontreated	-	52	6.7	1.3	4.7	2.0	40
11	SB4734/Syn	Regard	0.15 mg ai/seed	72	9.0	0.7	2.0	0.3	8
12	Rogue/Syn	Nontreated	-	104	13.7	2.7	7.0	4.3	20
13	Rogue/Syn	Regard	0.15 mg ai/seed	97	9.3	0.7	4.0	0.7	8
14	Huntingdon/Syn	972[b]		169	22.3	2.3	3.0	0.0	10
15	Huntingdon/Syn	333[c]		166	20.7	1.3	4.3	1.7	28
16	Huntingdon/Syn	972 + spinosad (Regard) @ 0.15 mg/seed		167	17.0	0.0	1.3	0.0	8
17	Outlaw/Syn	972[b]		170	15.3	1.3	2.7	0.0	5
18	Outlaw/Syn	333[c]		169	19.3	0.3	0.3	0.0	13
19	Outlaw/Syn	972 + spinosad (Regard) @ 0.15 mg/seed		170	20.3	0.7	0.7	0.3	23
	ANOVA (Pr>F)			0.001	0.001	0.5	0.04	0.13	0.002
	FPLSD (0.05)			28	7.3	ns	3.7	2.9	2.9

[a] Seed also treated with fungicide

[b] 972 = Captan, 2.5 fluid oz; thiram 2.0 fl oz.; mefenoxam 0.45 fluid oz.; **thiamethoxam 1.28 fluid oz**.; streptomycin 0.3 oz/A; sedaxane (fungicide) 0.08 fl oz, all applied at rate specified/100 lbs of seed.

[c] 333 = Captan, 2.5 fluid oz; thiram 2.0 fl oz.; mefenoxam 0.45 fluid oz.; **thiamethoxam 1.28 fluid oz**.; streptomycin 0.3 oz, all applied at rate specified/100 lbs of seed.

FLIGHT PHENOLOGY AND SPATIAL DISTRIBUTION OF RED CLOVER CASEBEARER POPULATIONS IN OREGON

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The red clover casebearer moth, *Coleophora deauratella*, is an invasive pest in red clover production systems in western Oregon. Native to Europe and Asia, *C. deauratella* was introduced to Canada in 1991 and first sighted in Oregon in 2011. Although *C. deauratella* is considered a secondary pest in Oregon, significant reductions in seed yield from larval feeding have been recorded in Canada, and high moth populations have become more frequent in select regions across the Willamette Valley. This study aims to further understand the temporal and spatial dynamics of *C. deauratella* populations in western Oregon to improve management plans for this pest.

We deployed an attract-based trap network in commercial red clover fields (n = 59 total sites) to monitor male *C. deauratella* populations in red clover across the Willamette Valley for five years (2013, 2014, 2018, 2020, 2021). Traps consisted of a sex pheromone lure inside one green universal bucket trap per field site placed >30 m within fields and positioned at canopy height. Traps were checked weekly from late May to early August.

Trap catch with male moths was used as a proxy to model flight phenology for *C. deauratella* populations using publically available climate data. Potential landscape effects on the spatial distribution of *C. deauratella* abundance were also analyzed. Temporal and spatial predictors of *C. deauratella* populations presented in this study provide practical implications for managing this pest in red clover production systems in western Oregon.

Alfalfa weevil (Coleoptera: Curculionidae) resistance to lambda-cyhalothrin in the western region of the United States

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Forage alfalfa (*Medicago sativa* L) is an important agricultural component of the western region and the third most valuable exported row crop in the United States. Alfalfa weevil (*Hypera postica* Gyllenhal (Coleoptera: Curculionidae)) is an economically damaging insect pest of alfalfa, causing 10-15% yield loss annually.

Chemical control is often the only option available to producers to protect yield. Pyrethroid active ingredients are frequently used because of their efficacy, and cost effectiveness for the control of alfalfa weevil. Thus, the loss of all pyrethroids would be a major challenge to alfalfa producers. Alfalfa producers have reported pyrethroid resistant alfalfa weevils in Alberta Canada (2015), Scott Valley California (2016), and Big Horn County Montana (2019). In 2021, Big Horn County Montana producer reports were the first confirmed documentation of alfalfa weevil lambda-cyhalothrin (type II pyrethroid) resistance.

In 2020 and in 2021, sixty-five populations with unknown resistance to lambda-cyhalothrin were assayed in Arizona, California, Montana, Washington, and Wyoming. Highly resistant populations to lambda-cyhalothrin were found in every state evaluated. However, some populations never reached 50% mortality even at the highest concentration tested (3.30µg/$cm^2{}_{2020}$; 10.0µg/$cm^2{}_{2021}$). Indicating that populations with high lambda-cyhalothrin resistance are present across the western region of the United States. Interestingly, susceptible populations were found in every state included in this study as well, with the concentration causing 50% mortality (LC_{50}) ranging from 0.01 to 0.30µg/cm^2. This emerging issue highlights the need to develop insecticide resistance management strategies to prevent the complete loss of efficacy for pyrethroids amongst resistant populations.

EVALUATING INSECTICIDES FOR CLOVER SEED WEEVIL CONTROL

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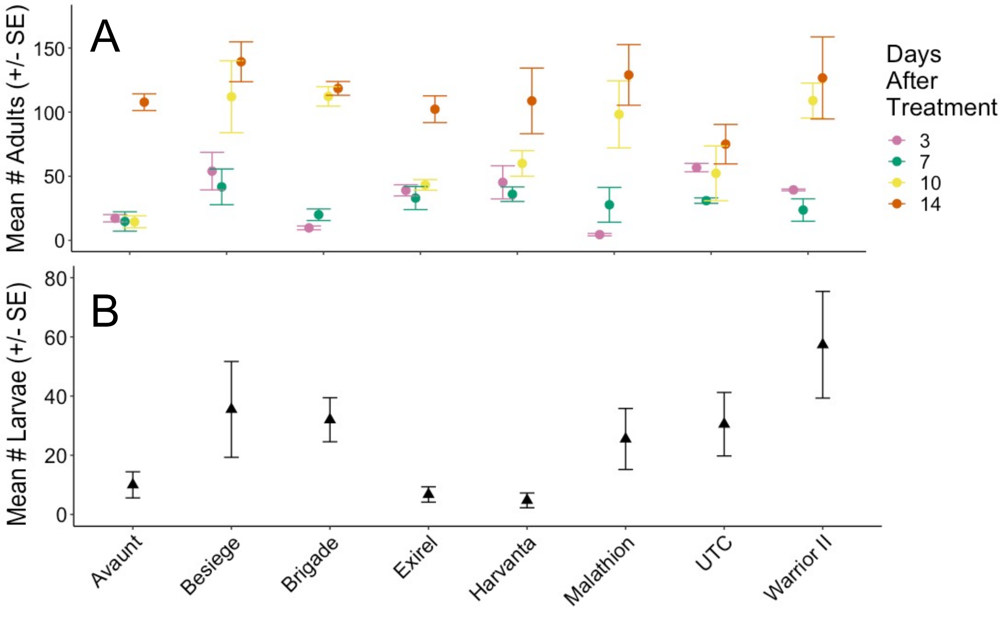
The clover seed weevil, *Tychius picirostris*, is an important pest in the Willamette Valley. Growers traditionally treat with Brigade, however, Brigade no longer provides satisfactory control of the weevil. A grower survey conducted in 2020 identified clover seed weevil control as the number one priority for insect research.

Here, we compare seven insecticides—Avaunt eVo, Besiege, Brigade 2EC, Exirel, Harvanta 50SL, Malathion 8 Aquamul, and Warrior II—for clover seed weevil control in white clover (*Trifolium repens*). We used a randomized complete block design with 4m x 9m plots, treatments replicated four times (exception: Warrior II had 3 replications), and a single spray application on 15-Jun-2021. Adult weevils were sampled 3, 7, 10, and 14 days after treatment (DAT), and larval were sampled 14 DAT.

Avaunt, Brigade, and Malathion suppressed adult weevil density 3 DAT compared with untreated plots (Figure 1A). However, other than the Avaunt 10 DAT sample, adult weevil densities for all other treatments did not differ from untreated plots. The larval sample means were statistically different, though result interpretation is complex; Avaunt, Exirel and Harvanta plots trended toward lower larval density than other plots, though none of the treatments contained statistically fewer larvae than the untreated check (Figure 1B). There was no clear relationship between adult and larval density when compared within treatments, i.e., low numbers of larvae in the Harvanta and Exirel treatments did not equate with low numbers in the corresponding adult samples. More research is needed to better understand sublethal effects and other ecological consequences of these chemistries. This design allowed us to evaluate immediate and prolonged effects of seven labeled insecticides on adult weevils, while also raising the question: Is adult weevil sampling a valid indicator of pesticide efficacy and/or weevil infestation levels, or is larval sampling a more representative approach?

Figure 1



Efficacy Evaluation of Yellow and Brown Mustard Concentrated Extract Against Sugar beet wireworm, *Limonius californicus* (Coleoptera: Elateridae), in Wheat

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1- Introduction

For the past two decades, cereal production in the Pacific Northwest (PNW) and Intermountain regions of the US has been threatened by the re-emergence of a damaging pest, known as “wireworm”. Wireworms are the larval stage of click beetles (Coleptera: Elateridae). They are subterranean herbivores, which feed on a wide range of cultivated and non-cultivated host plants. They can cause serious damage by feeding on seed, and seedling roots and underground stems. Failed germination, seedling wilt and stunt growth, and seedling death are examples of their damage at the plant scale. Depending on species and environmental conditions (e.g., soil temperature, moisture and food availability), wireworm can remain in the soil for up to a decade.

Historically, wireworms were controlled by highly toxic broad-spectrum organochlorine insecticides. The use of those insecticides is no longer allowed in the U.S., due to their human health and environmental risks. The long larval developmental stage, their cryptic subterranean habitat, and the wide host range make wireworms a difficult pest to control. Despite the availability of some insecticides, identifying effective alternative and sustainable control approaches are needed for developing region-specific IPM strategies to minimize wireworm damage.

Planting mustard as a cover crop (green manure soil incorporation) has been proposed as a measure to reduce weeds, pathogens and arthropod pests in the soil. There are several species mustard, which are known for their biocidal effects on weeds, pathogens and arthropod pests, due to their glucosinolate contents. In the yellow mustard, *Sinapis alba*, sinalbin is a major glucosinolate compound that mostly have herbicidal effects when hydrolyzed in the presence of moisture. Whereas the brown mustard, *Brassica juncea*, primarily contains sinigrin which is when hydrolyzed shown to be effective against soil-borne pests such as nematodes and, to some degree, wireworms.

In the present study, we are comparing the efficacy of yellow and brown mustard applications as green manure (both plant tissue and seed meal incorporation) against the sugar beet wireworm, *Limonious californicus*. Sugar beet wireworm is the most damaging wireworm species in the Pacific Northwest region. As a component of this study for the first time, we are also examining efficacy of a newly marketed concentrated seed meal extract of *B. juncea* against wireworms. All evaluations are being conducted in both field and greenhouse.

2- Research summary

In a series of greenhouse assays, we evaluated the effects of soil-incorporated yellow and brown mustard plants (Fig.1), seed meal and concentrated seed meal extract of each of two plant species against sugar beet wireworm. There was a total of 13 treatments (listed in Fig.4) with 10 replicates per treatment, in each of the two time-blocks. Each replicate consisted of a small pot (4×4×5 inch) filled with potting soil and containing a single sugar beet wireworm (Fig. 1-3). After incorporating copped plants or applying each product into the soil, pots were covered with plastic and sealed with parafilm for 24 hours (Fig. 2). Wheat was planted 14 days after application (Fig.3). Wireworm mortality, plant damage and emergence success were assessed 60 days after the applications.

Fig. 1. Canola, brown and yellow mustrad plants chapped and mixed with soil.

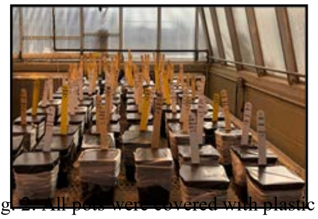


Fig. 2. All pots were covered with plastic bag and parafilm after incorporating mustard green manure, seed meal and concentrated seed meal extract.

Fig. 3. Wheat was planted on pots after treatment application

Our results showed significant variation among treatments (generalized linear mixed model: F= 2.23, df = 12, 192, *p* = 0.012) (Fig. 4). The brown mustard concentrated extracts, applied at the rates of 3.3 and 4.5 t/ha, achieved 56.25% and 64.28% wireworm mortality, respectively, which was significantly higher than the nontreated control (6.25%). Yellow mustard seed meal and concentrated seed meal extract were not effective in reducing wireworms. Germination rate was not significantly different among treatments (P > 0.05; not presented). Seed meal concentrated extract from brown mustard appears to be a promising product in reducing wireworm numbers in the greenhouse.

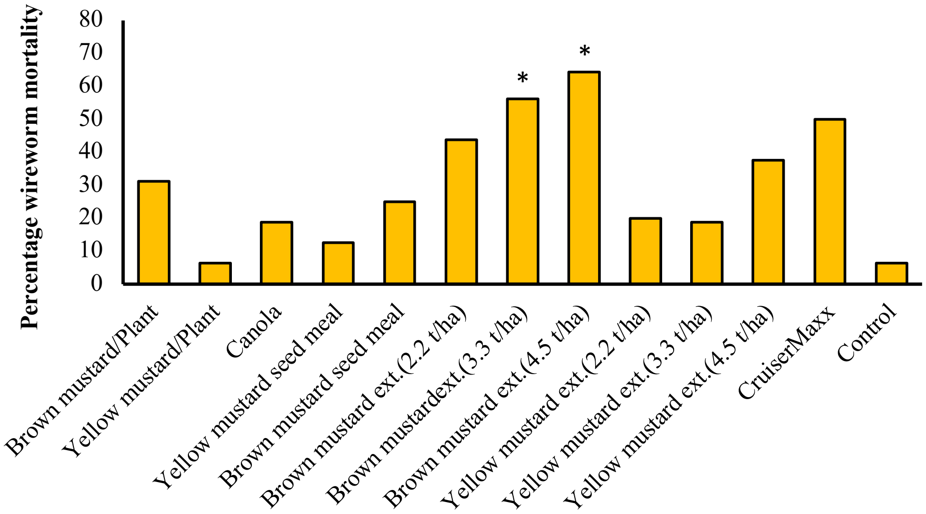
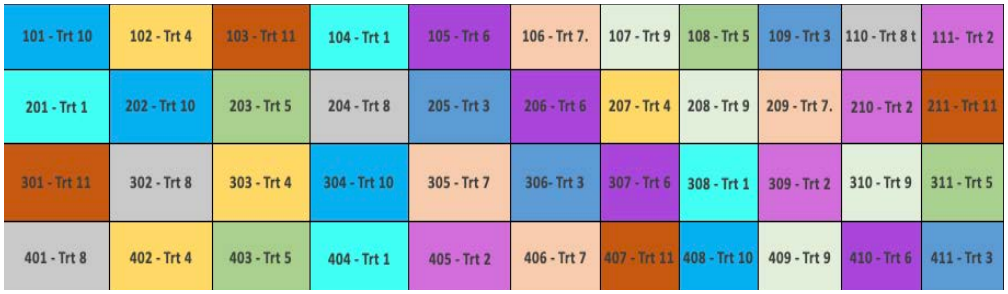


Fig. 4. Percentage mortality caused by each treatment in sugar beet wireworm. *B. juncea* concentrated seed meal extract at the rates of 3.3 and 4.5 t/ha caused significantly higher mortality in wireworm compared to non-treated control. A total of 13 treatments in two time blocks evaluated including; 1) yellow mustard soil- incorporated plant; 2) brown mustard soil-incorporated plant; 3) canola soil-incorporated plant as control; 4) yellow mustard (defatted seed meal); 5) brown mustard (defatted seed meal); 6) brown mustard (concentrated extract 2.2 t/ha); 7) brown mustard (concentrated extract 3.3 t/ha); 8) brown mustard (concentrated extract 4.5 t/ha); 9) yellow mustard (concentrated extract 2.2 t/ha); 10) yellow mustard (concentrated extract 3.3 t/ha); 11) yellow mustard (concentrated extract 4.5 t/ha); 12) neonicotinoid seed treatment (Cruiser Maxx); 13) non-treated control. Asterisks indicate treatments that are significantly different than the non-treated control.

To evaluate the effect of mustard plants and their products on wireworm population in cereal fields, three heavily infested cereal fields in southern and northern Idaho have been selected. A total of 11 treatments with four plot-replicates per treatment are planned for each location (listed in Fig. 5). Canola (as a control), yellow mustard and brown mustard were planted in early September 2021 and disk-incorporated in early November. The yellow and brown mustard seed meals, and brown mustard concentrated seed meal extract were applied and incorporated into the soil in November (Fig. 6), within two hours of soil surface application. All plots will be planted with spring wheat in 2022. Wireworm numbers were estimated in each plot before planting by using solar bait traps and will be monitored again prior to our spring planting. Wireworm numbers and plant stand counts will be used to determine the effectiveness of our treatments in relation to nontreated controls.



101 - Trt 10	102 - Trt 4	103 - Trt 11	104 - Trt 1	105 - Trt 6	106 - Trt 7.	107 - Trt 9	108 - Trt 5	109 - Trt 3	110 - Trt 8 t	111- Trt 2
201 - Trt 1	202 - Trt 10	203 - Trt 5	204 - Trt 8	205 - Trt 3	206 - Trt 6	207 - Trt 4	208 - Trt 9	209 - Trt 7.	210 - Trt 2	211 - Trt 11
301 - Trt 11	302 - Trt 8	303 - Trt 4	304 - Trt 10	305 - Trt 7	306- Trt 3	307 - Trt 6	308 - Trt 1	309 - Trt 2	310 - Trt 9	311 - Trt 5
401 - Trt 8	402 - Trt 4	403 - Trt 5	404 - Trt 1	405 - Trt 2	406 - Trt 7	407 - Trt 11	408 - Trt 10	409 - Trt 9	410 - Trt 6	411 - Trt 3

Fig. 5. An example of a plot map from our 2021-22 field trails. Treatments include: 1)Winter fallow followed by CruiserMaxx-treated spring wheat; 2) winter fallow followed by non-treated spring wheat; 3) brown mustard (*Brassica juncea*) followed by non-treated spring wheat; 4) yellow mustard (*Sinapis alba*) followed by non-treated spring wheat; 5) canola (*Brassica napus*) followed by non-treated spring wheat; 6) brown mustard seed meal at the rate of 8.9 t/ha followed by non-treated spring wheat; 7) yellow mustard seed meal at the rate of 8.9 t/ha followed by non-treated spring wheat; 8) brown mustard concentrated seed meal extract at the rate of 4.5 t/ha followed by non-treated spring wheat; 9) winter fallow followed by brown mustard concentrated seed meal extract at the rate of 4.5 t/ha; 10) Winter fallow followed by Teraxxa-treated spring wheat; 11) brown mustard concentrated seed meal extract at the rate of 4.5 t/ha followed by brown mustard concentrated seed meal extract at the rate of 4.5 t/ha at planting

Fig. 6. Brown mustard concentrated seed meal extract preparation and application in experimental plots.

This research is being conducted in collaborations with our regional wheat producers Roy Patten (University of Idaho), Hans Hayden (ID), Wayne Westberg (ID), Gordon Gallup (ID) and Mark Greene (WA). This work is supported by the USDA-NIFA- Western SARE, projects GW20-206 (greenhouse) and SW21-922 (field), and Idaho Wheat and Barley Commissions. The concentrated seed meal extracts for field trials were provided by MustGrow Biologics Corp., Saskatoon, Canada.

NATIVE STRAINS OF ENTOMOPATHOGENIC NEMATODES AS POTENTIAL BIOCONTROL AGENTS FOR SUBTERRANEAN SOD WEBWORM, *CHRYSTOTEUCHIA TOPIARA* (ZELLER) IN OREGON GRASS SEED PRODUCTION SYSTEMS

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The larvae of cranberry girdler or subterranean sod webworm *Chrysoteuchia topiaria* Zeller (Lepidoptera: Crambidae) inflict damage to the plant roots leading to poor fall regrowth and ultimately reducing yields in cool-season perennial grass seed production systems (Anderson and Salisbury 2021). As a soil-dwelling insect species, larvae are continuously exposed to a wide range of subterranean pathogenic organisms such as entomopathogenic nematodes (EPNs). Identifying native EPNs and determining their impact on this pest would contribute to the development of biological control of *C. topiaria*. The main aim of this study was to determine the occurrence of EPN species in commercial grass seed fields in OR and to assess if the native EPN strains can act as potential biocontrol agents.

Soil samples were collected during a field surveys at biweekly intervals during March-May 2021 from 22 commercial grass seed fields (tall fescue, fine fescue, perennial ryegrass, or orchardgrass) in western Oregon with a history of sod webworm infestation. These samples were collected from five random points within the field (Sandhi et al. 2020) at approximately 4-6 inches deep. These samples were made into composite samples in the laboratory following an EPN isolation procedure. EPNs were extracted from the soil using the insect-baiting techniques as described in Orozco et al. (2014). For baiting, five final instar larvae of wax worms, *Galleria mellonella* Linnaeus (Lepidoptera: Pyralidae), were placed in each plastic deli container consisting of composite soil samples. The containers with *G. mellonella* larvae were kept in the dark room with an ambient temperature for about a week. These containers were checked daily for any signs of EPN infection (such as discoloration of host cadaver) in *larvae*. Infected larvae were removed from the container, rinsed with water, and placed in modified White traps (Orozco et al. 2014) until EPN emergence. White traps were incubated at room temperature (~22°C) and observed daily for infective juvenile (IJ) emergence. Once IJs emerge from the cadavers, they were collected from the White traps every two days with a pipette, washed 2-3 times, and suspended in fresh tap water. The collected IJs were stored at 8-10°C in 20 mL falcon tubes and used within 10 days of collection.

Out of 88 composite samples (440 single point samples) collected during four sampling dates, nematodes were recovered from only 25% of samples during the isolation process. These samples were subjected to molecular analyses for identification. Re-culturing or mass production was possible with three different nematode isolates later identified in the molecular studies indicating that likely not all samples were entomopathogenic and some were free-living nematodes.

DNA of nematode species were extracted using the DNA extraction protocol (DNAeasy Blood and Tissue Kit), then the PCR was preformed to amplify Cox1 region (Kanzaki and Futai 2002), and targeted products were subjected to electrophoresis using 1% agarose gel. PCR products were cleaned up using Invitrogen PCR quick clean-up kits. Samples were sent for direct sequencing at the OSU Center for Genome Research and Biocomputing. DNA sequences were aligned, and consensus sequences were made using Geneious software and Blastn searches were performed using NCBI GenBank database for species identification.

The three culturable Oregon isolates identified in this study fell into three major groups (Table 1). Oregon-WV-1 and Oregon-WV-2 isolates were up to 91.6% and 100% identical to the EPN species in genus *Steinernema* and *Oscheius* respectively. Infectivity trials using the three native OR isolates and commercial EPN products containing *Heterorhabditis bacteriophora. Steinernema carpocapsae*, and *S. feltiae* against black cutworm larvae were conducted according to the methods described in (Yuksel and Canhilal 2018). Attempts were made to rear a lab colony of *C. topiaria* but were unsuccessful. Therefore, we used a lab reared colony of black cutworm, *Agrotis ipsilon* as an alternative host in infectivity trials. Preliminary results in infectivity trials were promising (data not presented here) indicating comparable virulence of local EPN strains to the commercial EPN products used. This study is the first to report the occurrence of native EPN species in commercial grass seed and warrants their further testing as a potential biocontrol agent of *C. topiara* and different other subterranean insect pests in grass seed production systems.

Table 1. BLASTn results of the sequence identity of the isolates found in the current study.

EPN isolate identified in the current study	Nematode associates and corresponding region in BLASTn analyses	GenBank Accession	Identity (%)
Oregon-WV-1	*Steinernema* sp. 1 FDL-2017 mitochondrial partial COI gene	LT963444	91.6
Oregon-WV-2	*Oscheius tipulae* isolate CEW1 mitochondrion region	CP059034	100
Oregon-WV-3	Unidentified nematode isolate N6734 cytochrome oxidase subunit 1 (cox1) gene	MK754228	100

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Yuksel E. and Canhilal R. 2018. Evaluation of local isolates of entomopathogenic nematodes for the management of black cutworm, *Agrotis ipsilon* Hufnagel (Lepidoptera: Noctuidae). *Egyptian Journal of Biological Pest Control* 28: 1-7.

SECTION V
Potato Pests

16 YEARS TRAPPING POTATO PESTS IN EASTERN OREGON

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Aphids, Psyllids, Beet Leafhoppers, and Potato Tuber moths are some of the primary pests of concern to potato growers in the lower Columbia Basin and eastern Oregon. The OSU-HAREC IAEP program has been monitoring potato pests for the last 16-years, however, the core program started over 40 years ago. The IAEP services 37 traps in Umatilla and Morrow counties; the program also helps the sampling effort in Union and Baker counties adding 25 traps to a total of 62 traps. The monitoring program creates an area-wide alert system that helps producers stay informed regarding pest incidence in/or near their operations and tracking population dynamics as the growing season progresses. The system has improved over the years by integrating the use of information technology and responding to new insect pest species. Although we still drive over 220 miles in Umatilla/Morrow and 210 in Union/Baker placing and replacing yellow buckets for aphids, delta pheromone traps for potato tuber moths, and yellow sticky cards for psyllids or leafhoppers, efforts have been made to modernized the system using systems like Trapview or drones which we won't discussed on this report at this time.

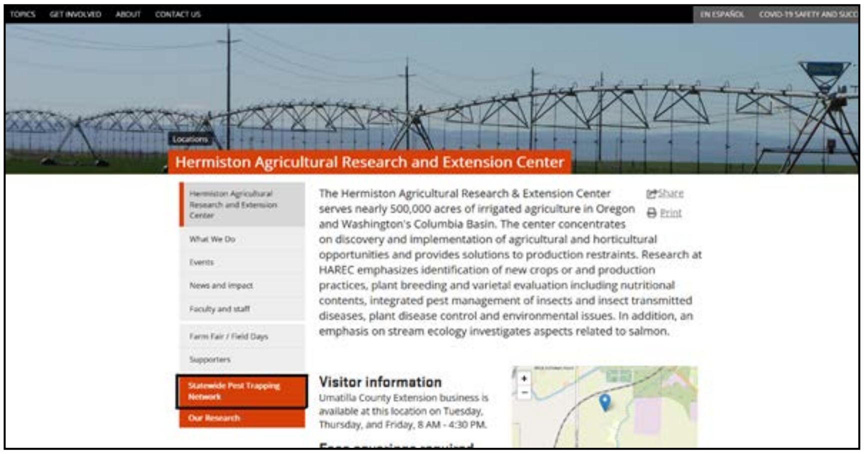
In all locations, trapping occurs during the summer; traps are replaced weekly and brought back to the laboratory where insects are counted, tabulated, and data reported online. Thanks to a collaboration with Anderson Geographic Inc, currently we have the capability to develop population dynamic curves for each pest for each location. We emphasize that our purpose in running our trap route is to function as an early detection tool and information should only supplement growers existing scouting programs. How can you access our online information?

Step 1. Click our main website https://extension.oregonstate.edu/harec

Step 2. Click Statewide Pest Trapping Network

Click **Find Trap** tab (at bottom) to open map and find traps near your farm. Enter an address if desired. Map zoom is limited to protect privacy.

Click **View Chart** tab (at bottom) to open the pest count chart. Note chart depicts **mean # insects per day** (not raw count per week) in order to standardize for trap visitation intervals. The vertical axis height adjusts based on charted data.

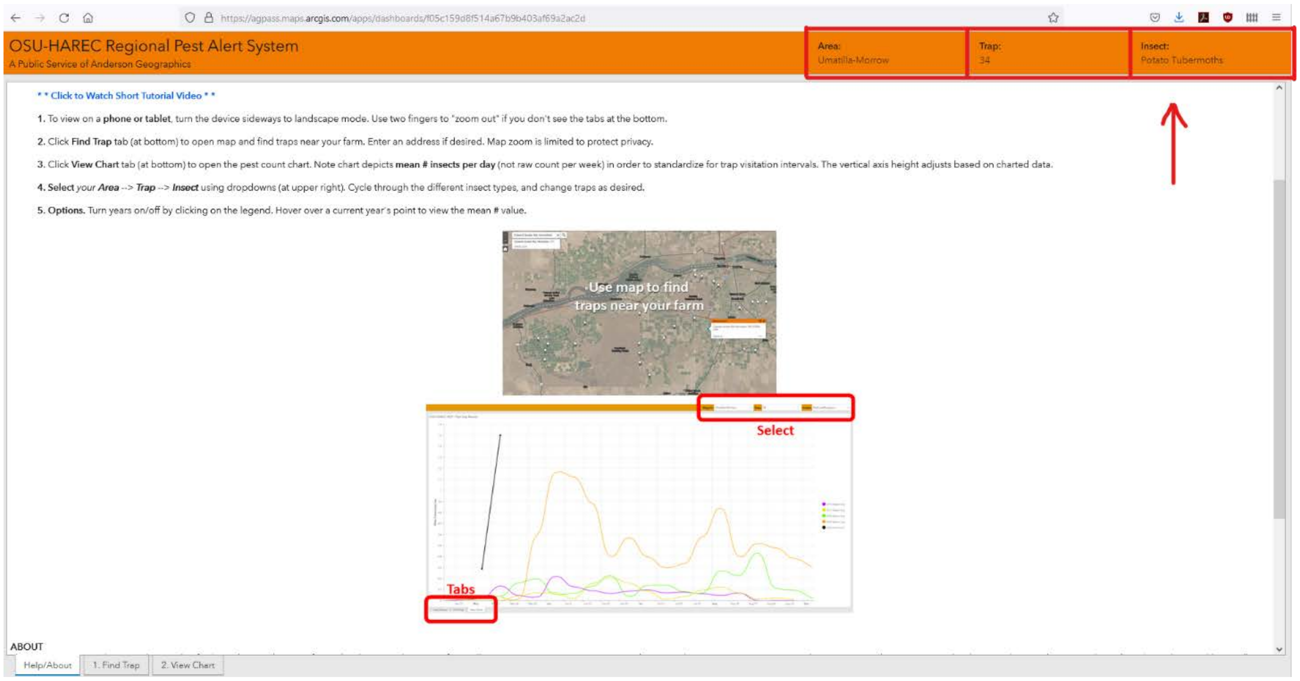


The Hermiston Agricultural Research & Extension Center serves nearly 500,000 acres of irrigated agriculture in Oregon and Washington's Columbia Basin. The center concentrates on discovery and implementation of agricultural and horticultural opportunities and provides solutions to production restraints. Research at HAREC emphasizes identification of new crops or and production practices, plant breeding and varietal evaluation including nutritional contents, integrated pest management of insects and insect transmitted diseases, plant disease control and environmental issues. In addition, an emphasis on stream ecology investigates aspects related to salmon.

Visitor information

Umatilla County Extension business is available at this location on Tuesday, Thursday, and Friday, 8 AM - 4:30 PM.

Step 3. Select *your* ***Area*** --> ***Trap*** --> ***Insect*** using dropdowns (at upper right). Cycle through the different insect types, and change traps as desired.

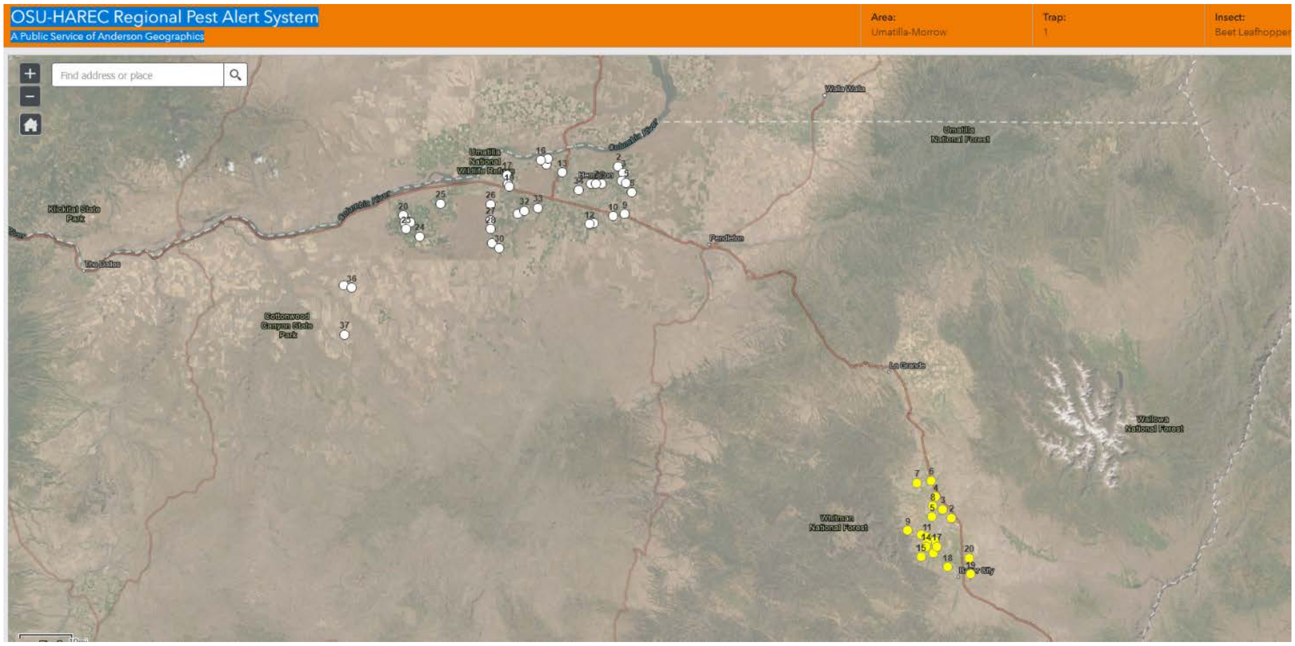


OSU-HAREC Regional Pest Alert System
A Public Service of Anderson Geographics

Area: Umatilla-Morrow
Trap: 34
Insect: Potato Tubermoths

* * Click to Watch Short Tutorial Video * *

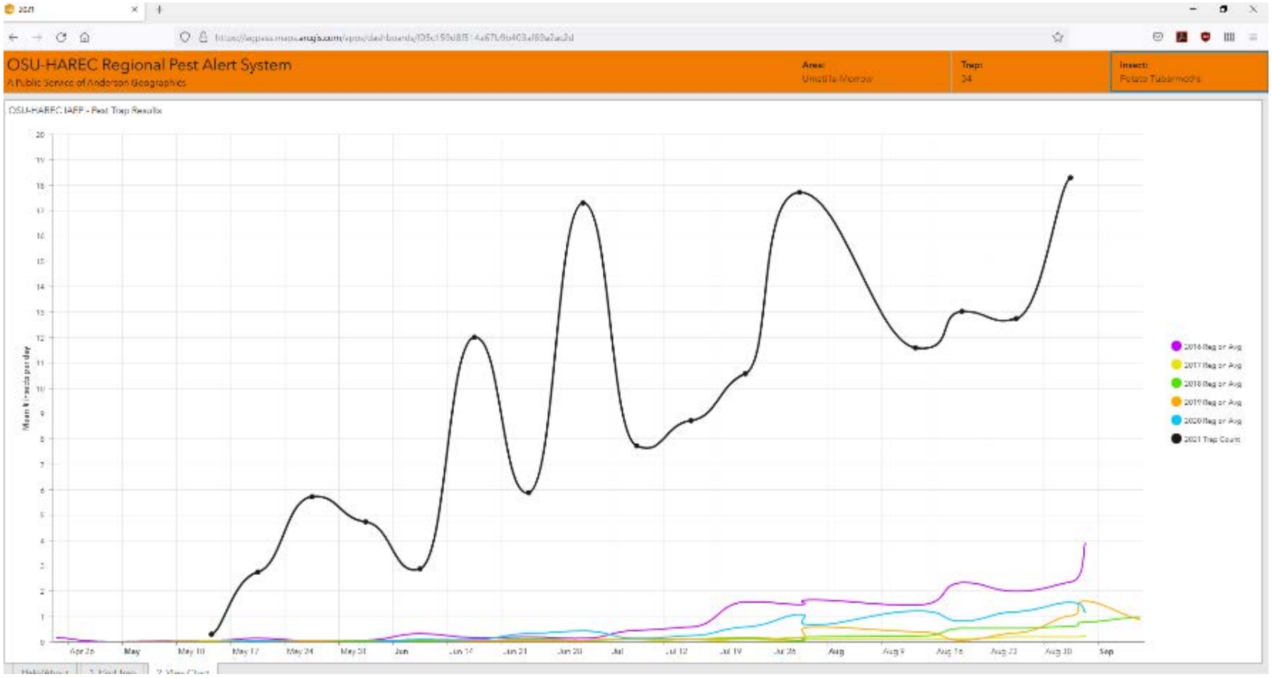
1. To view on a **phone or tablet**, turn the device sideways to landscape mode. Use two fingers to "zoom out" if you don't see the tabs at the bottom.
2. Click **Find Trap** tab (at bottom) to open map and find traps near your farm. Enter an address if desired. Map zoom is limited to protect privacy.
3. Click **View Chart** tab (at bottom) to open the pest count chart. Note chart depicts **mean # insects per day** (not raw count per week) in order to standardize for trap visitation intervals. The vertical axis height adjusts based on charted data.
4. **Select** *your* ***Area*** --> ***Trap*** --> ***Insect*** using dropdowns (at upper right). Cycle through the different insect types, and change traps as desired.
5. **Options.** Turn years on/off by clicking on the legend. Hover over a current year's point to view the mean # value.



OSU-HAREC Regional Pest Alert System
A Public Service of Anderson Geographics

Area: Umatilla-Morrow
Trap: 1
Insect: Beet Leafhopper

Step 4. A population dynamic curve is presented detailing several years of data. **Options.** Turn years on/off by clicking on the legend. Hover over a current year's point to view the mean # value.



For more detail, watch this short

video https://www.youtube.com/watch?v=FHkTLibSjss

For more information contact Silvia Rondon @ silvia.rondon@oregonstate.edu

BREEDING FOR RESISTANCE TO CONTROL THE COLORADO POTATO BEETLE IN THE COLUMBIA BASIN

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The Colorado potato beetle, *Leptinotarsa decemlineata* Say (Coleoptera: Chrysomelidae), is one of the most harmful and persistent insect pests of potato (*Solanum tuberosum* L.). *Leptinotarsa decemlineata* has developed resistance to more than 50 different insecticides mode of actions representing nearly all insecticidal modes of actions. Current efforts are focusing on finding new genetic material to be incorporated in potato breeding programs.

In 2020 and 2021, a field study was conducted at the OSU Hermiston Agricultural Research and Extension Center, in Hermiston OR. The field experiment was set up as a randomized complete block design with four replications per variety/clone. The following varieties/clones were exposed to natural infestations of *L. decemlineata*. The varieties were: $F_1$4085, Echo Russet, Payette Russet, Castle Russet, Dakota Diamond, Clearwater Russet, Russet Norkotah, Alturas Russet, Russet Burbank, and Shepody. Two blocks were planted side by side; each block with all treatments treated with or without a neonicotinoid at planting. Weekly, the total number of *L. decemlineata* egg masses, larvae, and adults were counted; plant defoliation (%) was also estimated; all plots were taken to yield.

Based on percentage of defoliation, in the neonicotinoid-applied block, Echo Russet and Payette Russet, showed better response against *L. decemlineata* compared to Russet Norkotah and Alturas Russet; in the no-neonicotinoid-applied block, Echo Russet and Clearwater responded better than $F_1$4085 and Russet Norkotah. Interestingly, although Russet Norkotah and $F_1$4085 presented the highest defoliation rate, they presented high yields compared to other varieties in this experiment.

CAN WE PREDICT PEST INCIDENCE IN POTATOES?

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Several hemipterans are well-known potato pests either causing direct foliage damage or vectoring plant pathogens. For example, *Circulifer tenellus* (Fam. Cicadellidae) is the only known vector of the beet leafhopper transmitted virescence agent (BLTVA) that causes purple top disease. *Myzus persicae* and *Macrosiphum euphorbiae* (Fam. Aphididae) are the most significant aphids found in potatoes since they are effective vectors of viruses such as *Potato virus Y* (PVY) and *Potato leaf roll virus* (PLRV). *Lygus* spp. (Fam. Miridae) are considered emerging pests in the Columbia Basin because of their ability to feed on stems and flowers, blocking phloem movement and causing early desiccation of plants.

Pests are influenced by environmental factors that can drive population dynamics and contribute to their establishment. Degree-days models based on temperature analysis have been developed as a way to measure the movement of pests in the agroecosystem in response to accumulated daily temperatures. Host plant phenology can also contribute to determining pests' establishment. Thus, in this study, we monitored the seasonal population dynamics of *C. tenellus*, *Lygus* spp., *M. persicae,* and *M. euphorbiae* weekly throughout several potato growing seasons in commercial fields located in the lower Columbia Basin in Oregon. In each potato field, *C. tenellus* and *Lygus* spp. adults were monitored using yellow sticky cards, while aphids were sampled using yellow buckets. Daily temperatures were obtained from the AgriMet weather stations closest to each sampled field. Most of the potato fields monitored were late-season Ranger Russets.

Using a multi-year dataset, we developed phenology models of each pest based on temperature (accumulated degree-days, DD) and potato growing stage (potato days, PD). To predict seasonal population growth, the total emergence percentage of insects captured over the season was regressed on accumulated DD and PD, respectively.

Circulifer tenellus and *Lygus* spp. are the first ones to colonize potato fields, with 90% of cumulative catch by 2,823 and 1,776 DD, respectively. In contrast, *M. persicae* and *M. euphorbiae* populations increased more gradually throughout the season. Potato days-mediated population growth models suggest that 50% of the populations of *C. tenellus*, *Lygus* spp., and *M. persicae* can be collected at the potato tuber growth stage, while 50% of the *M. euphorbiae* population at the tuber initiation stage. Our results will help producers improve hemipteran potato pests' management.

Reference Cited

Oppedisano T., G. Shrestha, S. Anderson, D. I. Thompson, and S. I. Rondon. 2021. Predicting phenology of four major hemipteran pests to enhance integrated pest management programs in potatoes in the lower Columbia Basin. *Journal of Economic Entomology* (in press).

SECTION VI
Small Fruit, Tree fruits and Nuts

Section VI: Biological control/orchards

Population Dynamics of Aphids and Natural Enemies in PNW Hazelnuts

Tatum Keyes, Heather Andrews, Mathew Pederson, Nik Wiman

Oregon State University, North Willamette Research and Extension Center, Aurora, OR

Two species of aphid affect production of hazelnut worldwide. Filbert aphid, (*Myzocallis coryli* Goetze), which mainly feeds on leaf veins, and hazelnut aphid (*Corylobium avellanae* Schrank), which transitions from leaves and petioles to husks and peduncles early in the growing season. Severe infestations of filbert aphid are known to reduce kernel fill, affecting yields and sooty mold forms on honeydew, impacting overall photosynthetic capacity of trees. In the 1980's, the importation and release of *Trioxys pallidus* (Haliday) (Hymenoptera: Aphididae) against filbert aphid initiated a highly successful classical biological control program that is still in place, but is less relied upon. While there was some excellent work done on the filbert aphid and its natural enemies in the 1980s era, the hazelnut industry has since gone through some major transitions and changes, including the arrival of hazelnut aphid and a transition to new varieties. More growers are spraying aphids and there is a need to re-examine aphid phenology, population dynamics and biological control. Few growers and managers are aware of any aphid biological controls besides *T. pallidus.* Thus, the purpose of this research is to re-examine aphid community dynamics in the modern hazelnut production system and document natural enemies. Beginning in 2020, we began weekly, season-long sampling at two untreated hazelnut orchards in the northern Willamette Valley for aphids and natural enemies on both leaves and shoots. Aphids were identified and classified by life stage. To fully determine the extent of parasitism by *T. pallidus*, samples were held in cups in the lab for an additional week to note further development of mummies. This report focuses primarily on the natural enemy dynamics.

In 2020, which was a relatively typical season in line with historic environmental norms for the Willamette Valley, there was a clear early peak in filbert aphid abundance in mid-May, followed by a population decline, few aphids during the hottest part of the growing season, and some population recovery at the very end of the season when the cool weather returned. (Fig. 1). Filbert aphid populations were consistently higher than hazelnut aphid populations throughout the season. By contrast, in 2021, which was an unusually hot and dry summer, aphid populations remained extremely low throughout the growing season, and rebounded considerably at the end of the season (Fig. 2).

Fig. 1. Abundance of aphids in two hazelnut orchards sampled weekly in the Willamette Valley in 2020.

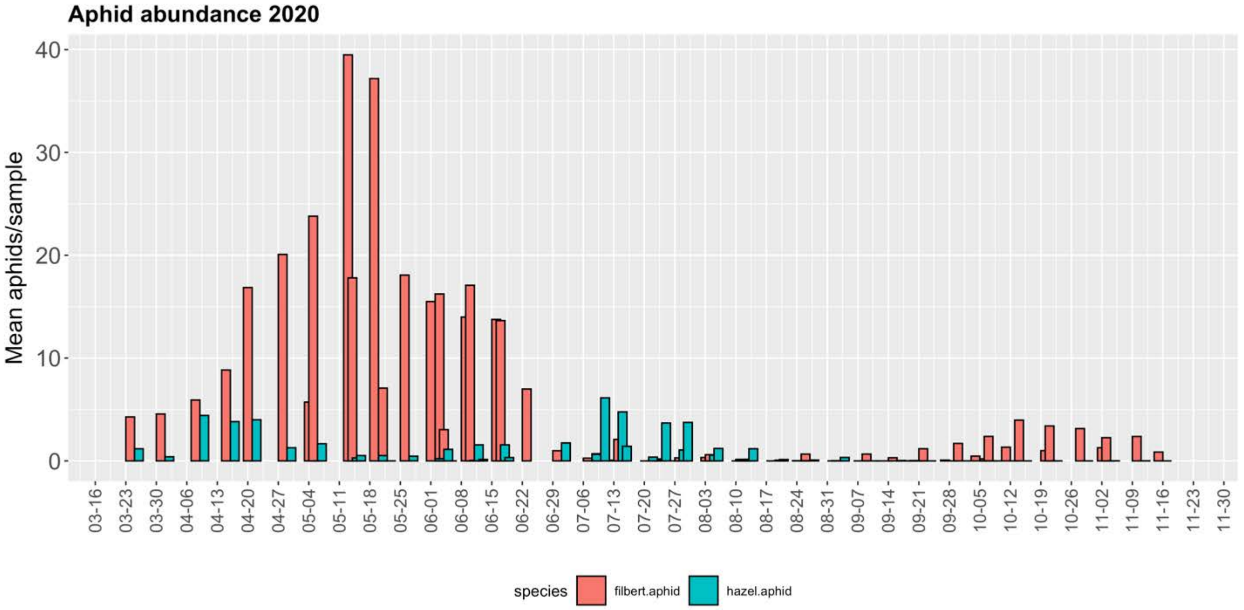
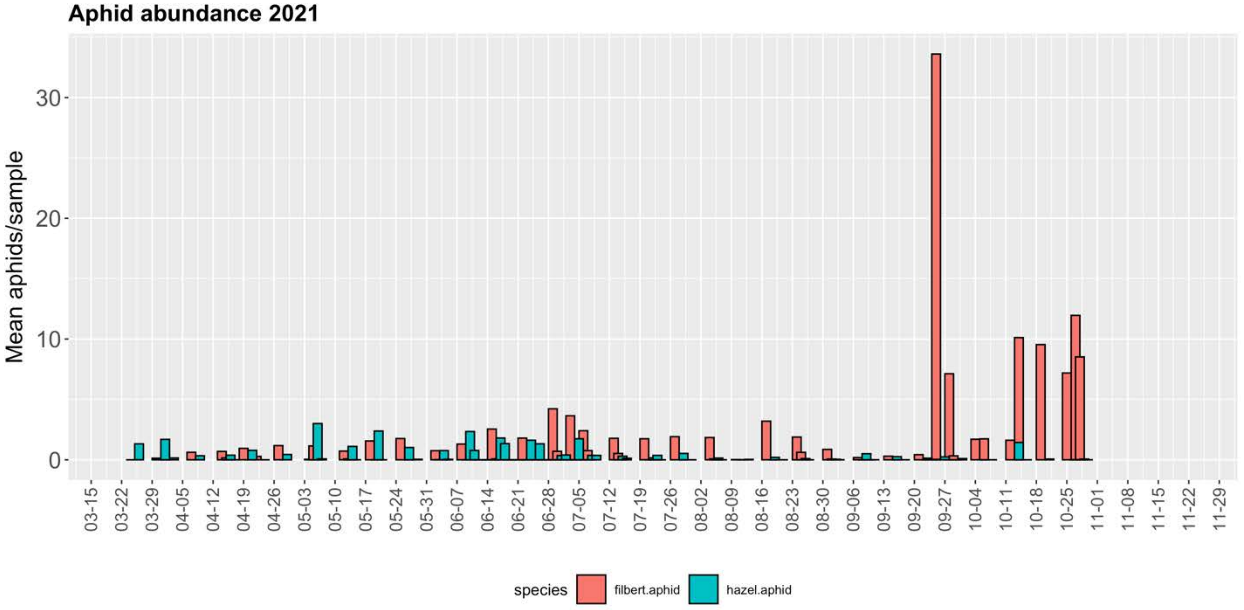


Fig. 2. Abundance of aphids in two hazelnut orchards sampled weekly in the Willamette Valley in 2021.



In general, parasitism by *T. pallidus* caused the most mortality on aphid populations in both years as demonstrated by the presence of mummies, but the phenological patterns were different in the two seasons. In 2020, which was year with much higher aphid populations, the abundance of mummies peaked mid-season in July, lagging behind peak populations of filbert aphid (Fig 3). In 2021, which was a growing season with unprecedented heat and very low aphid populations, parasitism peaked early on in late May, and other natural enemies were more abundant in samples, including spiders and lacewings (Fig. 4). However, in general, natural enemy activity was much lower in 2021 given that aphid populations were also much lower. It is important to note, that in both seasons, activity of T. *pallidus* was delayed from the onset of aphid population increase, which has been previously documented in the literature. Thus, growers must use restraint when considering treating aphids in the early season to take advantage of biological control.

Fig. 1. Natural enemy abundance and diversity in 2020 on unsprayed hazelnuts in the northern Willamette, Valley, OR.

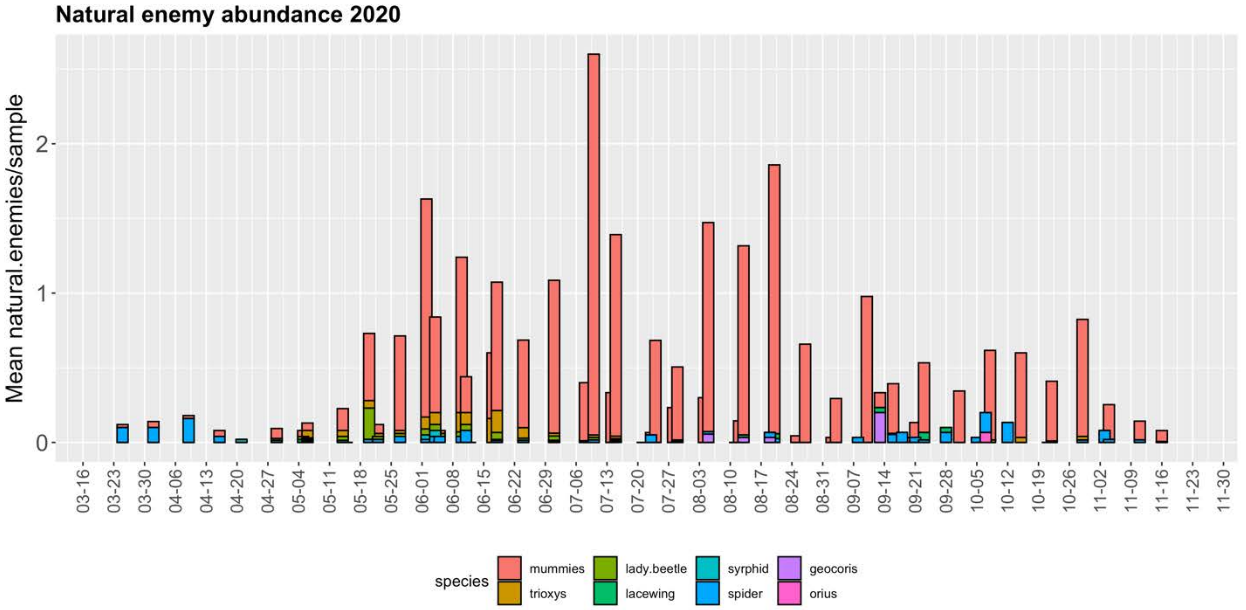
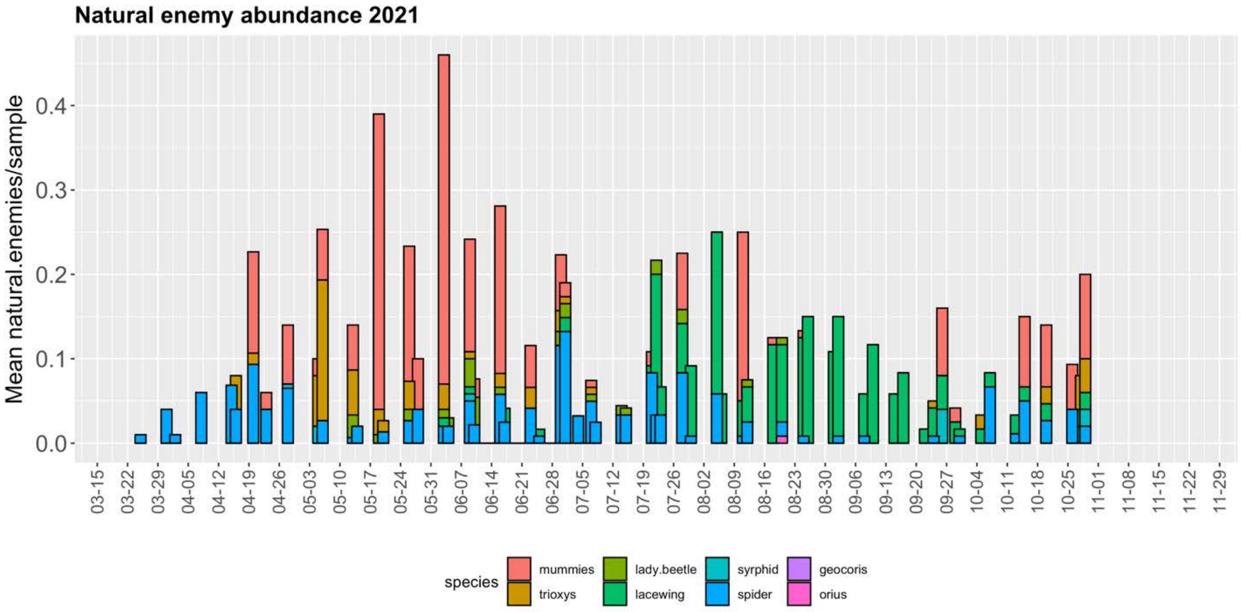


Fig. 2. Natural enemy abundance and diversity in 2021 on unsprayed hazelnuts in the northern Willamette, Valley, OR.



Enhanced monitoring for *Drosophila suzukii* in Oregon's sweet and blush cherries

Matthew Pedersen, Heather Andrews, Tatum Keyes, and Nik Wiman

Oregon State University North Willamette Research and Extension Center, Aurora, OR

Since 2009 spotted wing drosophila (SWD), *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae), has established as an economically significant pest of soft-skinned fruit crops in Oregon. The widespread establishment of *D. suzukii* has prompted regional and national efforts to improve pest control and monitoring strategies. While effective, standard liquid bait traps have not been widely adopted by growers, and there remain important knowledge gaps on how trap captures relate to crop damage. Our goal was to assess monitoring tools for improved management of *D. suzukii* in dark sweet and blush cherries using experimental dry traps in two Willamette Valley cherry orchards.

Sticky traps were deployed at two young sweet cherry orchards, which included a low elevation site composed of mixed varieties (Site 1), and a high elevation site composed of primarily 'Sweetheart'(Site 2) in Oregon's Willamette Valley. Traps were placed in a randomized complete block design and included Trecé broad-spectrum, Trecé high-specificity, and AlphaScents *D. suzukii* specific lures. Both orchards remained untreated for *D. suzukii* during the entire trial.

Drosophila suzukii began showing up on traps by mid-June, and trap captures peaked in mid-July. Captures dropped off drastically following a heatwave in July. Traps baited with Trece broad-spectrum lures had the greatest *D. suzukii* and total by-catch, though the Trece high-specificity infrequently produced a substantial by-catch as well (**Fig.1**).

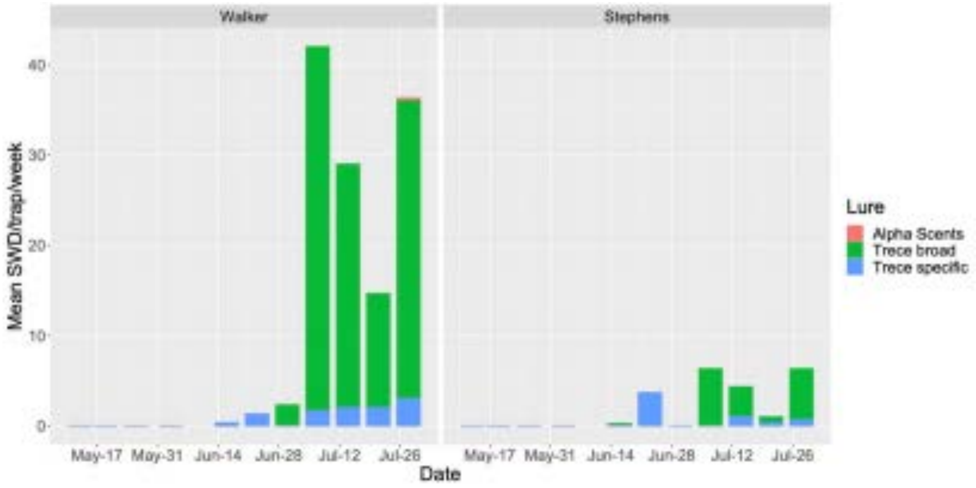


Figure 1. *Drosophila suzukii* captures on sticky card traps at the two research sites.

There was a strong correlation between male and female *D. suzukii* captured on the broad-spectrum traps, suggesting that the number of females could be accurately estimated based upon the number of males captured (Fig. 2). Since males are easier to identify, this could drastically save time when checking traps.

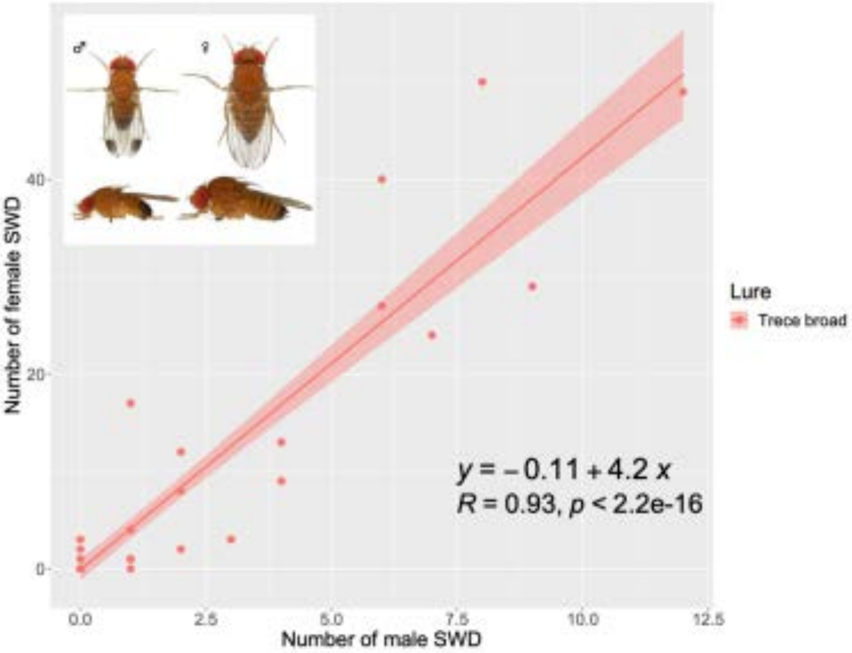


Figure 2. The number of male *D. suzukii* was predictive of the number of females captured on Trece broad-spectrum traps.

This trial was part of a nationwide collaboration with several other labs studying *D. suzukii* captured in dry and liquid traps baited with three different commercially available lures. Trapping took place primarily in blueberries. In general, trap capture trendss were similar to our findingsrs, with Trece broad-spectrum baited traps capturing more bycatch compared with the high specificity lure (Fig. 3).

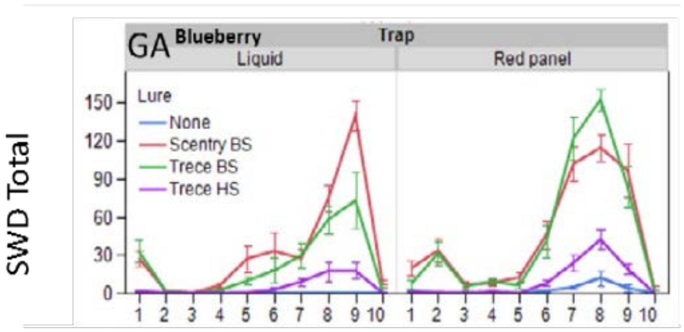


Figure 3. Trap captures in liquid and red panel traps placed in blueberries and baited with Trece and another commercially available lure. ¶

From Cesar Rodriguez-Saona et al. 2021, unpublished.

SECTION VII
Pests of Turf and Ornamentals

SUMMARY OF THE INTEGRATED PEST MANAGEMENT STRATEGIC PLAN FOR OREGON NURSERIES

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IPM Strategic Planning fosters collaboration and consensus among industry stakeholders, including farmers, researchers, and regulators. These living documents identify the critical pest management needs and concerns of agricultural industries. The comprehensive guides include production and industry overviews, key pests by growing stages, and critical research, educational and regulatory needs.

Our initial planning meeting with the Northwest Nursery Crops Research Center at USDA-ARS in Corvallis took place on January 19, 2021. Chris Hedstrom met with Drs. Jana Lee, Jerry Weiland, Nik Grunwald and Carolyn Scagel to discuss the scope of the project, methods of recruiting participants, brainstorming a list of key workgroup participants from industry, research, and extension, and to determine a project timeline based on the industry's production schedules. As the definition of "nursery" is broad compared to other industries for which we've produced IPMSP, it was determined to limit the definition of nursery to include primarily container and field grown ornamental woody perennials.

Efforts to recruit workgroup collaborators from industry, research, and Extension we began in late spring 2021 by PI Chris Hedstrom following the completion of the industry shipping season. Industry contacts primarily consisted of members of the Oregon Association of Nurseries research committee. Other contacts were those identified through meetings with Oregon State Extension agents and researchers working on nursery related projects, consisting of faculty currently of the Horticulture Department and OSU's North Willamette Research and Experiment Center in Aurora, OR. From these efforts, we identified over 45 workgroup members and received commitments to participate from 27, representing industry, government, and university research and outreach. Based on the responses and participants, the decision was made to include ornamental shade and fruit trees and greenhouse annual production for this IPMSP.

Questionnaires were emailed and interviews were conducted with the workgroup about their integrated pest management strategies for insects, weeds, diseases. Participants completed tables identifying their key pests and management activities for a calendar year, as well as relevant field or industry activities also occurring (e.g. shipping to retail, receiving new plant materials). Information about their specific needs for integrated pest management solutions regarding research, education and regulation was also captured.

Because of the restrictions on travel and concerns of Covid-19, a virtual workgroup meeting was held via Zoom with 18 project participants. For past IMPSPs, these workgroup meetings have been held in person and take place over the course of a day. The virtual format for this meeting limited to 3.5 hours, with activities such as ranking the critical IPM needs done via Qualtrics survey following the meeting. The focus of the virtual meeting was primarily to verify the data from the surveys, add or remove key pests, identify emerging threats, and to identify any additional critical IPM needs.

The report is still in a draft form to be reviewed by the workgroup and published by OSU Extension publications so these results should be regarding as preliminary. However, some of the critical IPM issues for the nursery industry regarding IPM were as follows:

Education

- Education about the relationship between clean plants, scouting, sprays and beneficials
- Education about BMPs or IPM practices for likely new or invasive pests (Japanese beetle, spotted lanternfly) to reduce disruption of IPM management plans
- Education about implementation of beneficial insects (natural enemies)

Research

- Research into western flower thrips management
- Research into aphid (multiple species) management
- Development of action thresholds for ornamental production systems

Regulation

- Clarification of rules on shipping and quarantine
- Simplify finding rules, restrictions, and guidelines, or collect industry rules to a central place

Multiple integrated pest management strategies are currently utilized for all aspects of production. Some have reported a significant or total reduction in applications for pesticides for some insect pests. However, these is still a dependence on pesticides for weeds, where the primary methods of management reported was pre-emergent herbicides. We also found the same situation for pathogens where the primary method of management for nearly all pathogens was fungicides. However, there were also multiple integrated pest management strategies that were identified to prevent diseases before they became a problem.

The full document is expected to be published by in the first quarter of 2022 through Oregon State University Extension Publications. *This project was funded by the Northwest Nursery Crop Research Center, USDA-ARS Horticultural Crops Research Center, Corvallis, OR.*

METHYL SALICYLATE FOR PEST CONTROL IN NURSERIES

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Methyl salicylate (MeSA) is an herbivore-induced plant volatile widely tested for attracting natural enemies for pest control. MeSA is commercially sold as slow-release lures or as a spray. While MeSA application has enhanced natural enemies in numerous food crops, its ability to reduce pests for crop protection is not as frequently demonstrated. Our first objective was to test MeSA lures in ornamental fields where few studies have been done, and monitor natural enemies, pests, and crop protection. A two-year study in spruce container yards revealed more aphid parasitoids (*Pseudopraon* sp.), fewer aphids (*Mindarus obliquus*) on shoot tips, and less shoot tip damage in MeSA plots during the first year. A two-year study in red maple fields revealed more predatory lady beetles and rove beetles, and parasitic Ceraphronidae, Diapriidae, and Chalcidoidea in one or both years with MeSA. Fewer pest thrips were also captured in MeSA plots, though it is not clear whether this was due to enhanced predation or reduced colonization. Maple growth as measured by stem diameter change did not differ with MeSA use. A two-year study examining predation on sentinel *Halyomorpha haly*s eggs in various mature ornamental stock blocks found no increase in predation except for one month, though green lacewings, lady beetles, and predatory thrips occurred more in MeSA plots in the first year. While MeSA is expected to enhance biological control by herding in natural enemies, the impacts that applied volatiles have on predator efficiency is unknown. Thus, our second objective examined how volatile presence would impact feeding rates. Adult carabid *Pterostichus melanarius*, adult coccinellids *Coccinella septempunctata* and *Harmonia axyridis*, and larval lacewing *Chrysoperla rufilabris* consumed their prey at similar rates in the presence/absence of MeSA when food was presented directly, or when foraging in a small outdoor soil arena or leaflet with aphids.

Paper submitted to Frontiers Ecology and Evolution, in revision 12/2021

SECTION VIII
New & Current Product Development

Early season insecticide applications for selective control of aphids in PNW hazelnuts

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Filbert aphid (*Myzocallis coryli* Goetze) was a major problem for hazelnut growers until the European parasitoid *Trioxys pallidus* (Haliday) was introduced in the 1980s. The parasitoid flourished in the PNW climate, and most growers stopped spraying aphids after the classical biological control program was established. Since then, new pest species including the hazelnut aphid (*Corylobium avellanae* Schrank) and brown marmorated stink bug (*Halyomorpha halys* (Stal)) have been introduced, resulting in increased insecticide applications, and therefore complicating biological control of *T. pallidus*. Now there appears to be some resurgence of aphids with populations far exceeding damage thresholds in many orchards, and more growers are treating aphids. Damaging populations of aphids have a cumulative effect on hazelnut trees, leading to reduced photosynthetic activity and reduced ratio of kernel to shell (crackout).

We tested new selective and soft chemistries against aphids and we assessed activity of aphid natural enemies in two orchards in the early spring of 2021. One orchard was selected near Gervais (Site 1) and the other near Keizer, OR (Site 2). Both orchards had cv. 'Jefferson', and were in early production years. We applied treatments to both orchards on April 1, 2021 at bud break. Sprays were applied with a spray wand fitted with a solid cone diffuser and D8 nozzle attached to a hose reel. Spray solution was mixed in 6 gal stainless steel canisters (Cornelius kegs) which were pressurized and maintained at 100 psi with an air compressor (Rigid 4.5 gal air compressor) powered by a gas generator (Honda 2,300-W). All spray equipment was fitted to the cargo area of our Kawasaki Mule. Trees received approximately 0.80 and 0.50 gal of spray with a 100 gal/acre water dilution at Site 1 and Site 2, respectively, which provided excellent coverage. Treatments, rates and adjuvants applied are provided in Table 1.

Product name	Active Ingredient	EPA No.	Rate per ac	Adjuv.	Rate per ac
Control	water	--	--	R-11	0.25%
Superior Spray Oil 440	Petroleum distillates	2935-546	2 gal	R-11	0.25%
Rango	Cold-pressed neem oil	88760	1.25% v/v	R-11	0.25%
Aza-Direct	Azadirachtin	71908-1-10163	1.5 pints	R-11	0.25%
Admire Pro	Imidacloprid	264-827	14 oz	R-11	0.25%

Table 1. Treatments and rates for the early season aphid control trial.

In a randomized block design, we applied treatments to single trees across 4 orchard rows, with two untreated trees as buffer between treated trees within a treated row, and a untreated row as a buffer between treated rows. There were 4 trees treated per treatment. We collected 10 random buds from each treated tree and counted the number of live (moving) aphids and natural enemies on the bud/leaflet surface under magnification 7, 14 and 19 days after treatment.

All products resulted in significant reduction in live aphids 7 days after treatment (figs. 1 and 2).

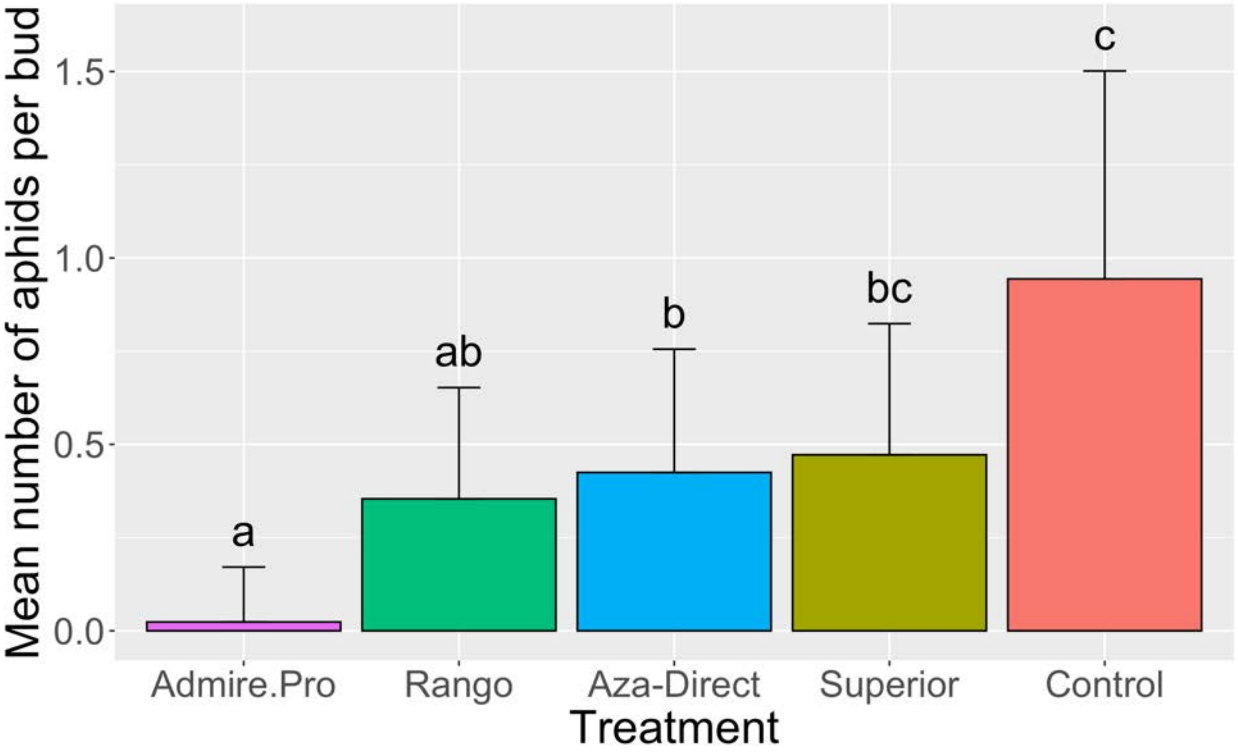

Figure 1. Mean number of live aphids per bud 7 days after treatment at Site 1

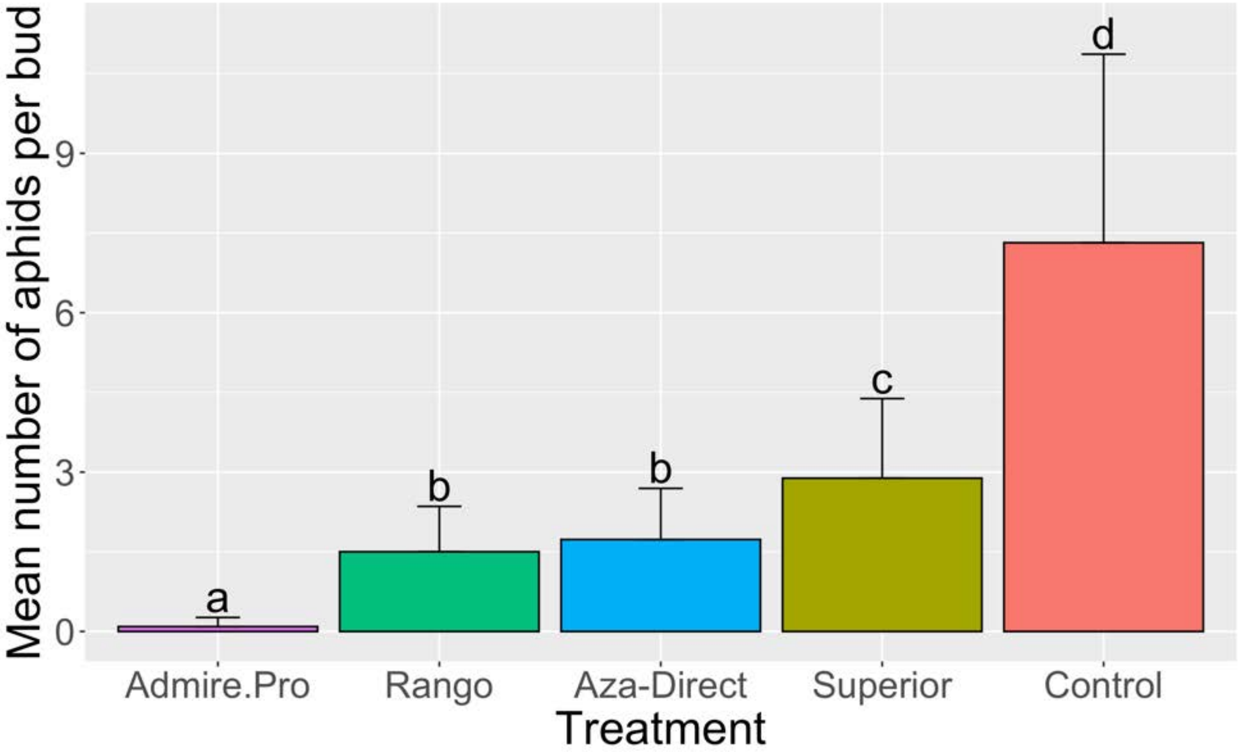

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Figure 2. Mean number of live aphids per bud 7 days after treatment at Site 2.

Control with all products continued to persist 14 days following the initial application (figs. 3 and 4).

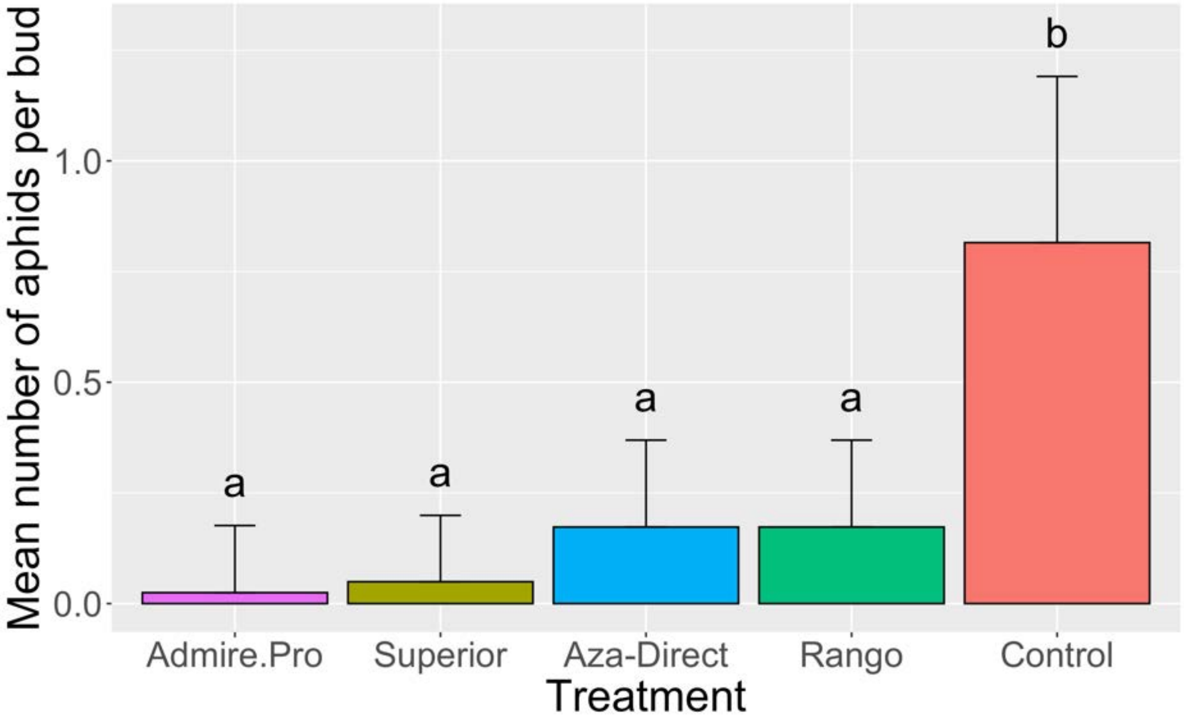

Figure 3. Mean number of live aphids per bud 14 days after treatment at Site 1.

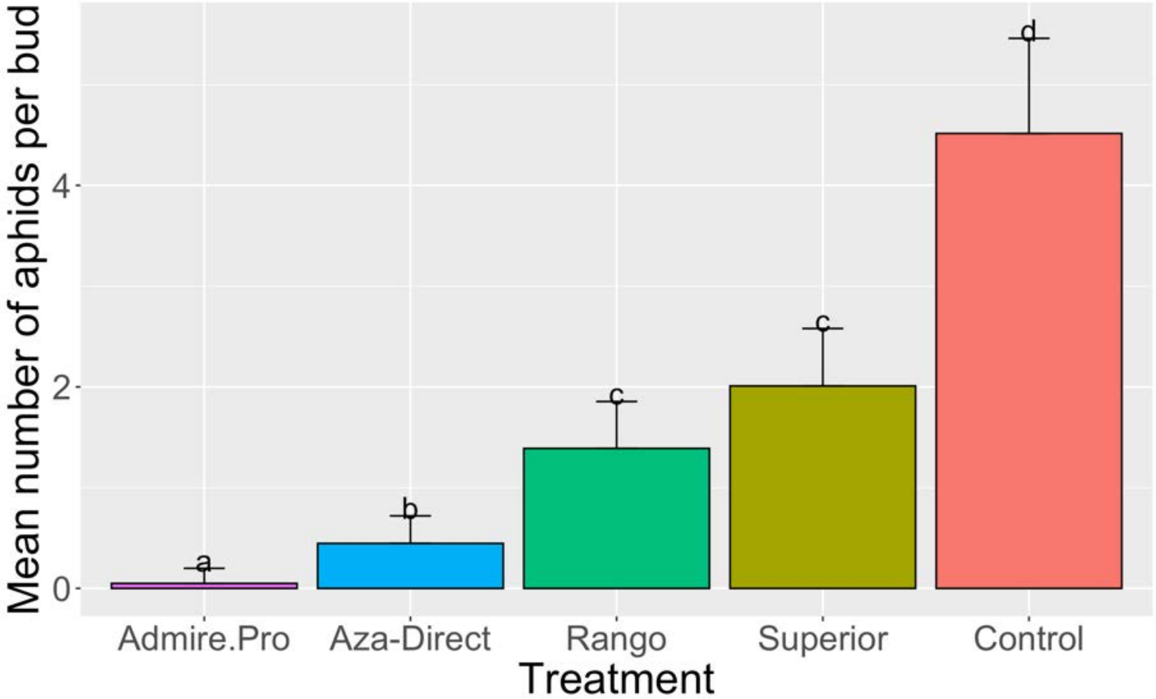

Figure 4. Mean number of live aphids per bud 14 days after treatment at Site 2.

Aphid populations dropped significantly 19 days after treatment, and no statistically significant differences could be found between any treatments. At this time, more natural enemies were also showing up in our samples, and the presence of additional natural enemies could have been the main reason for low aphid pressure.

These results indicate that there are a number of products, including those that are OMRI certified, that could effectively reduce aphid pressure early in the season before many natural enemies emerge from overwintering sites. Although not included in the analysis, we did note that there were quite a few predatory mites present across all treatments at the beginning of this trial, and most of these were alive. In addition to effectively reducing aphid populations, the presence of live predators across all of our treatments indicates that adverse effects to natural enemy populations could be minimized by early applications of these insecticides.

Superior Spray Oil 440 is often used in organic fruit orchards to control pests such as mites and thrips, or as an adjuvant to improve efficacy of other products. There is concern that trees could be burned with oil sprays and this risk rises dramatically when temperatures exceed 90F. Early spring applications will avoid this upper temperature extreme. It is also important to avoid any combination with sulfur, and oil should not be applied to trees that have been sprayed with sulfur for at least 30 days. Sulfur is commonly applied to hazelnuts during the dormant season to control other pests such as bud mite and some diseases, so it is important for growers to exercise caution when alternating between these products.

Another concern growers may have is that oil sprays would adversely affect hazelnut pollination, which takes place during the winter. Our products were applied in early spring. While flower buds are still present, they're typically in the spider stage, which is past pollination but not yet at fertilization. Therefore, pollination would not be adversely affected by oil sprays.

Keywords: *Myzocallis coryli, Trioxys pallidus, Corylobium avellanae , Halyomorpha halys,* hazelnut, aphids

SECTION IX
Extension & Consulting: Updates and Notes from the Field

(No Submissions)