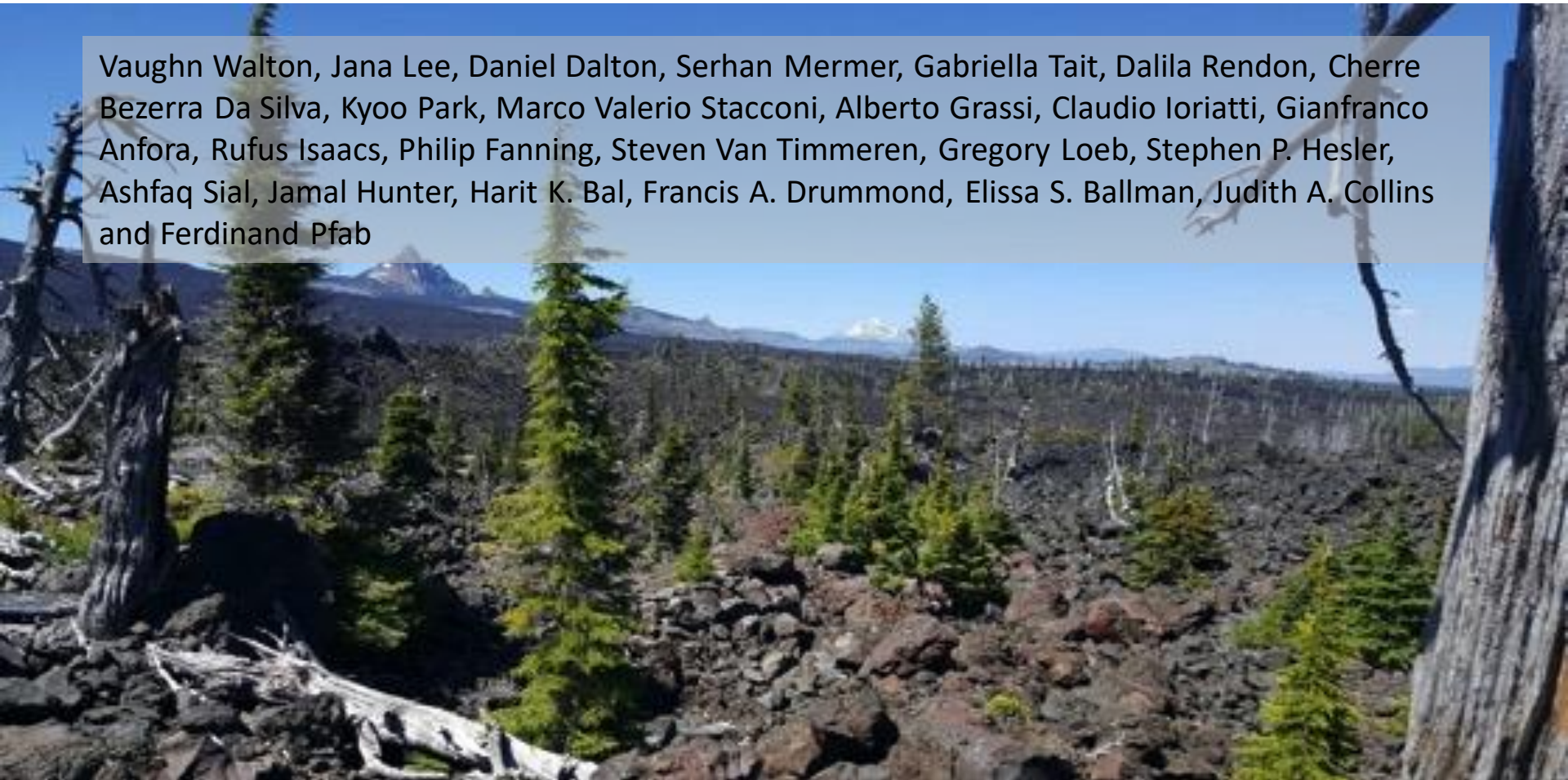




Drosophila suzukii (SWD): Perspectives on management



Vaughn Walton, Jana Lee, Daniel Dalton, Serhan Mermer, Gabriella Tait, Dalila Rendon, Cherre Bezerra Da Silva, Kyoo Park, Marco Valerio Stacconi, Alberto Grassi, Claudio Ioriatti, Gianfranco Anfora, Rufus Isaacs, Philip Fanning, Steven Van Timmeren, Gregory Loeb, Stephen P. Hesler, Ashfaq Sial, Jamal Hunter, Harit K. Bal, Francis A. Drummond, Elissa S. Ballman, Judith A. Collins and Ferdinand Pfab

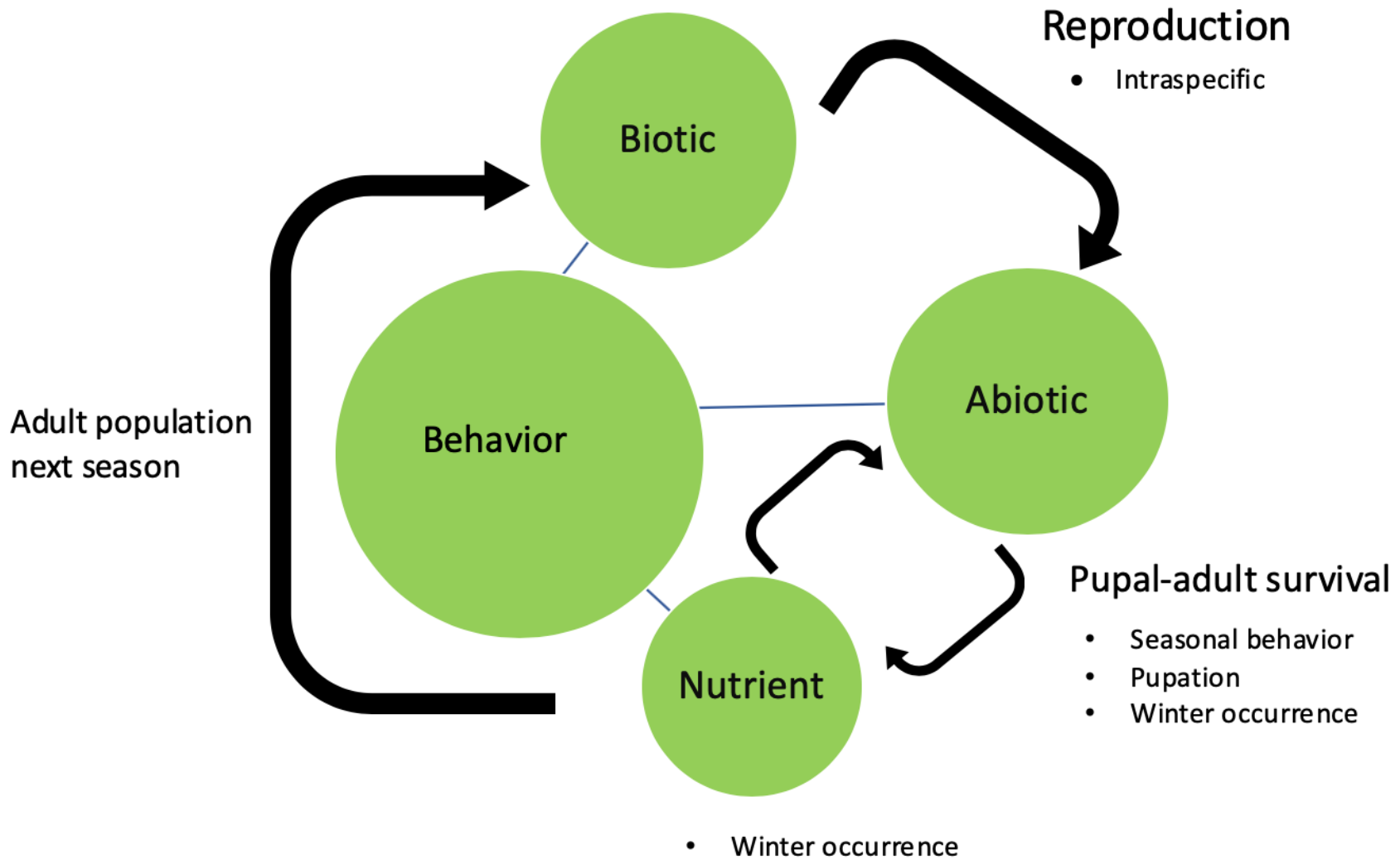
*vaughn.walton@oregonstate.edu

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Avosani, from Tait et al 2021

Landscape effects and SWD invasiveness

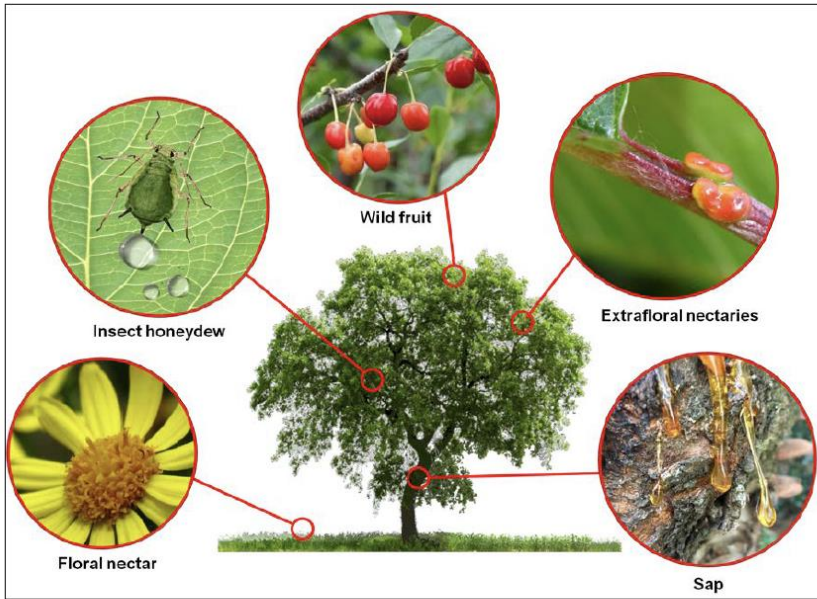


Illustration: Marco Rossi-Stacconi, © Oregon State University

Figure 1. SWD can benefit from sugars and other environmental resources provided by many plants.

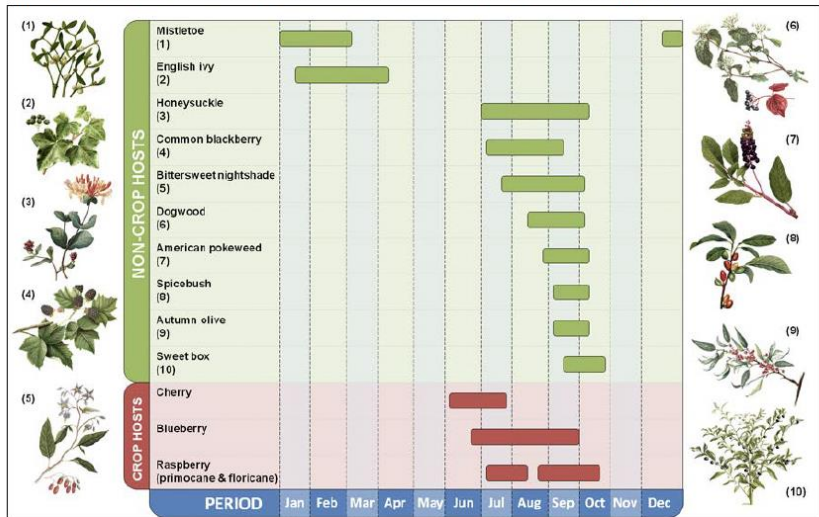


Illustration: Marco Rossi-Stacconi, © Oregon State University

Figure 2. Berry ripening calendar of noncrop (green) and crop hosts species (red) used by SWD for egg laying in Oregon.

OSU Extension service EM9264, 2019. Adapted from Lee et al. 2015. Infestation of wild and ornamental noncrop fruits by *Drosophila suzukii* (Diptera: Drosophilidae). *Annals of the Entomological Society of America* 108:117–129.

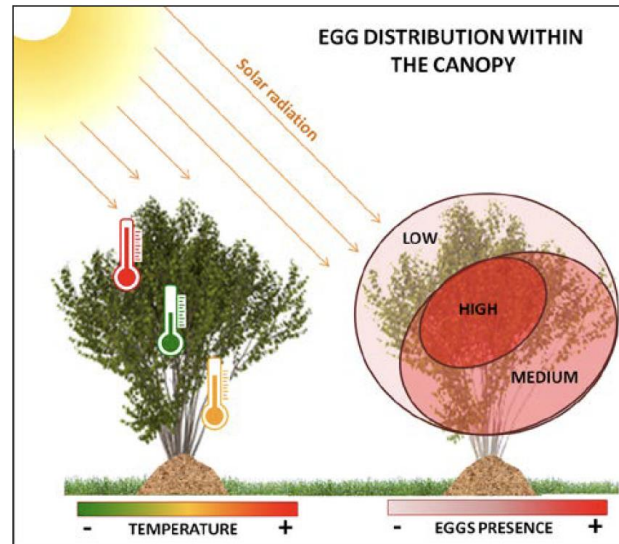


Illustration: Marco Rossi-Stacconi, © Oregon State University

Figure 3. Temperature and sunlight differences within the canopy affect the distribution pattern of eggs by SWD. Because lower temperatures and higher relative humidity are more suitable for SWD survival, flies prefer shaded fruits and fruits in more dense portions of the canopy for egg laying.

How fruit characters affect SWD susceptibility

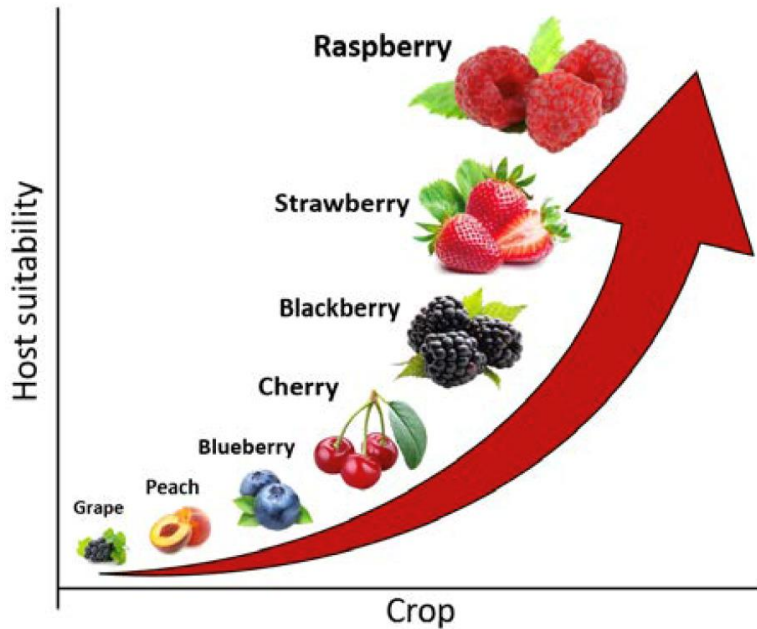


Illustration: Marco Rossi-Stacconi, © Oregon State University

Figure 1. Susceptibility ranking of fruits based on aroma preference, egg-laying performance and reproductive success of SWD (after: Bellamy et al. 2013).

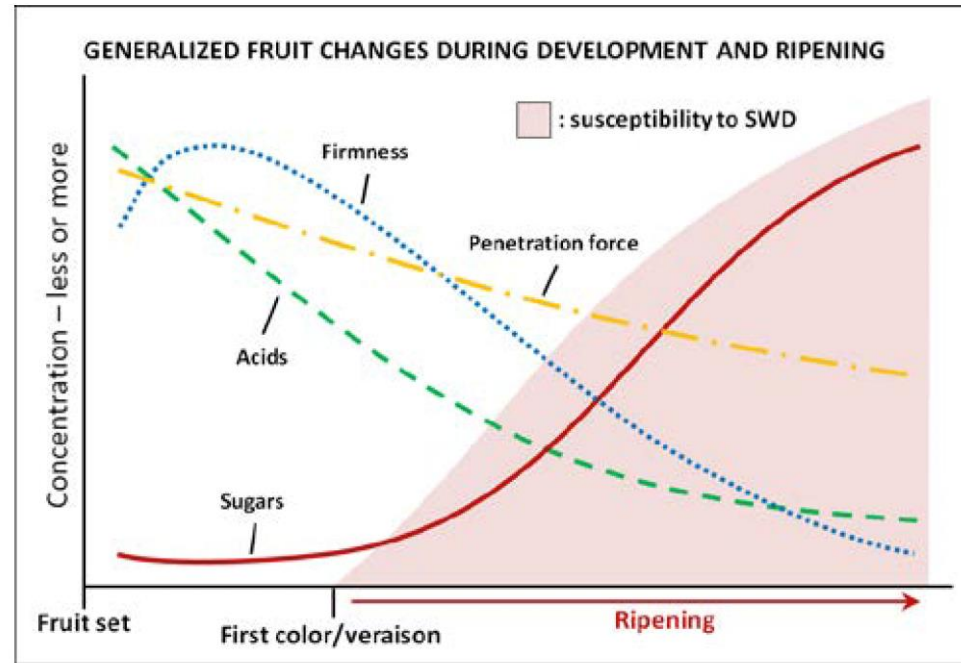


Illustration: Marco Rossi-Stacconi, © Oregon State University

Figure 2. Fruit susceptibility to spotted-wing drosophila associated with changes of physical and chemical features (adapted from Lee et al. 2016).

OSU Extension service EM9264, 2019. Lee et al. 2015. Infestation of wild and ornamental noncrop fruits by *Drosophila suzukii* (Diptera: Drosophilidae). *Annals of the Entomological Society of America* 108:117–129.

D. suzukii and winter survival

male

2 mm

female

2 mm

summer

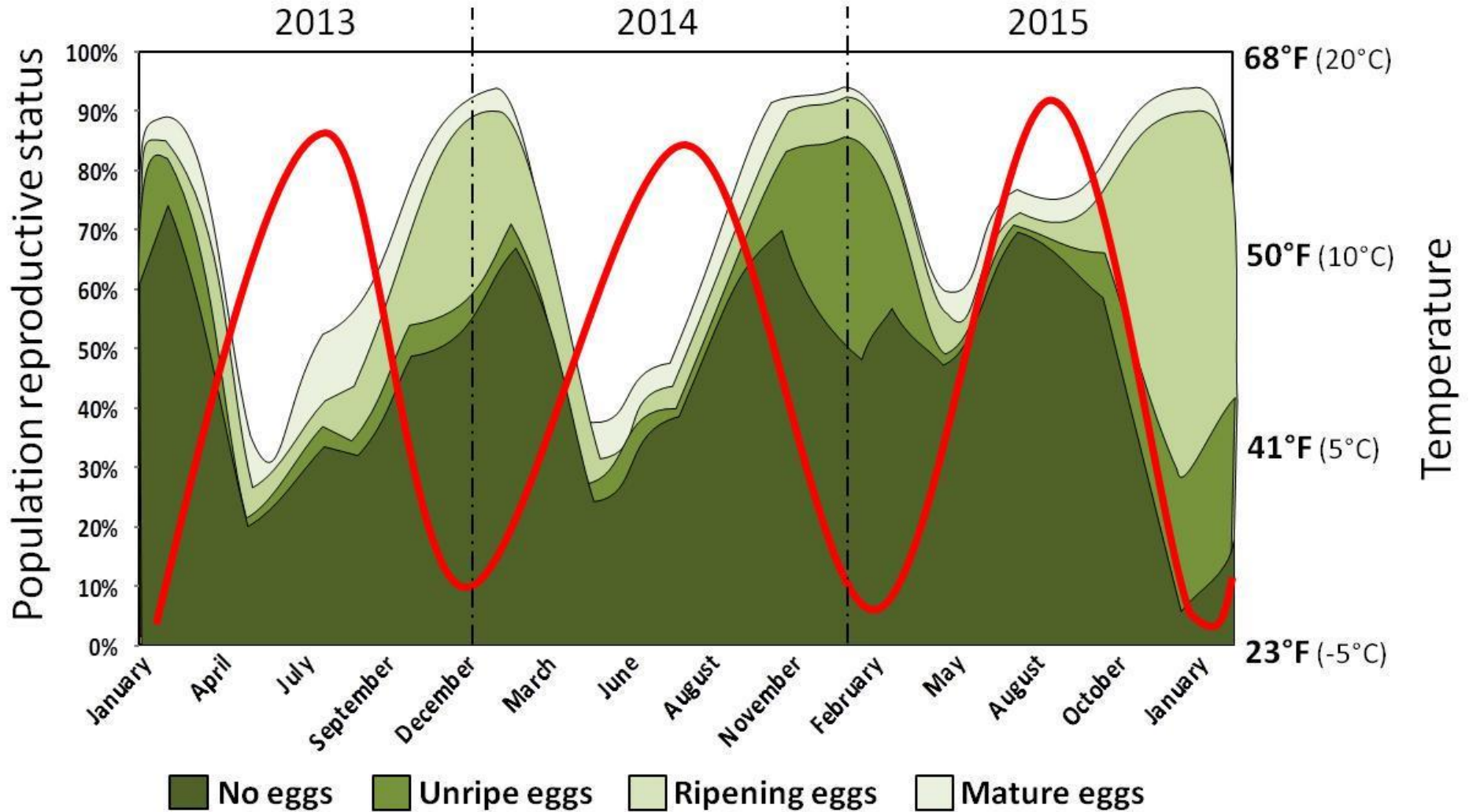


winter



How seasons affect SWD

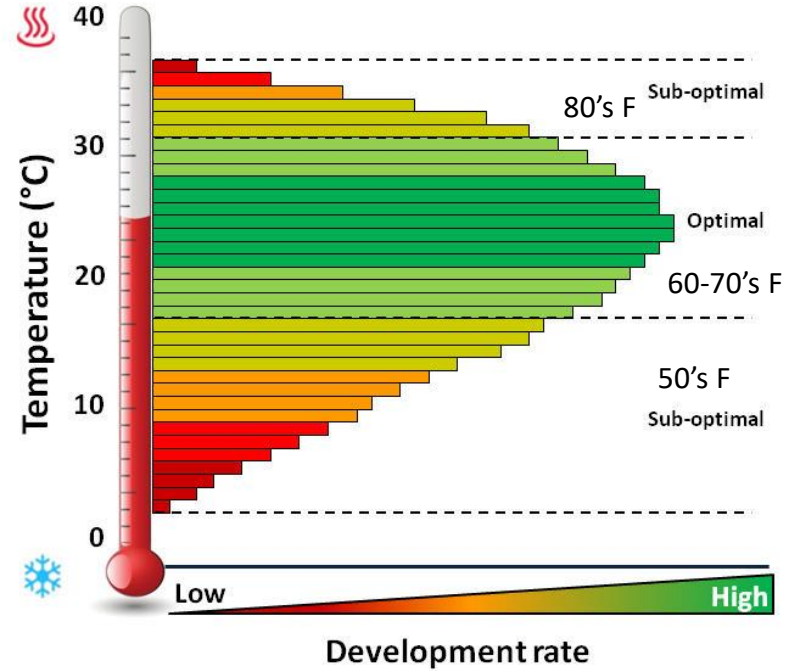
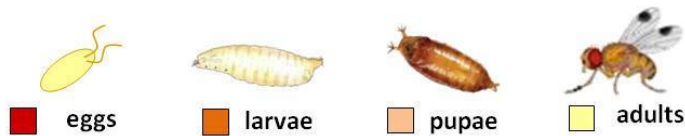
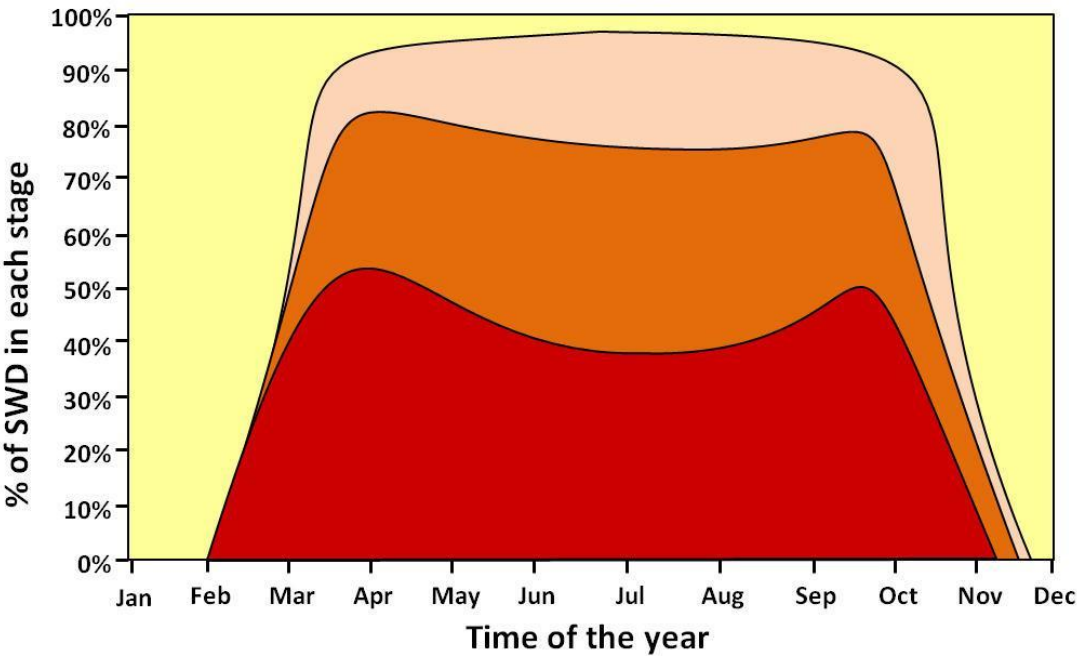
(OSU Extension service, EM 9261)



Grassi et al 2018, Tochen et al 2014, Wiman et al 2016, Walton et al 2019

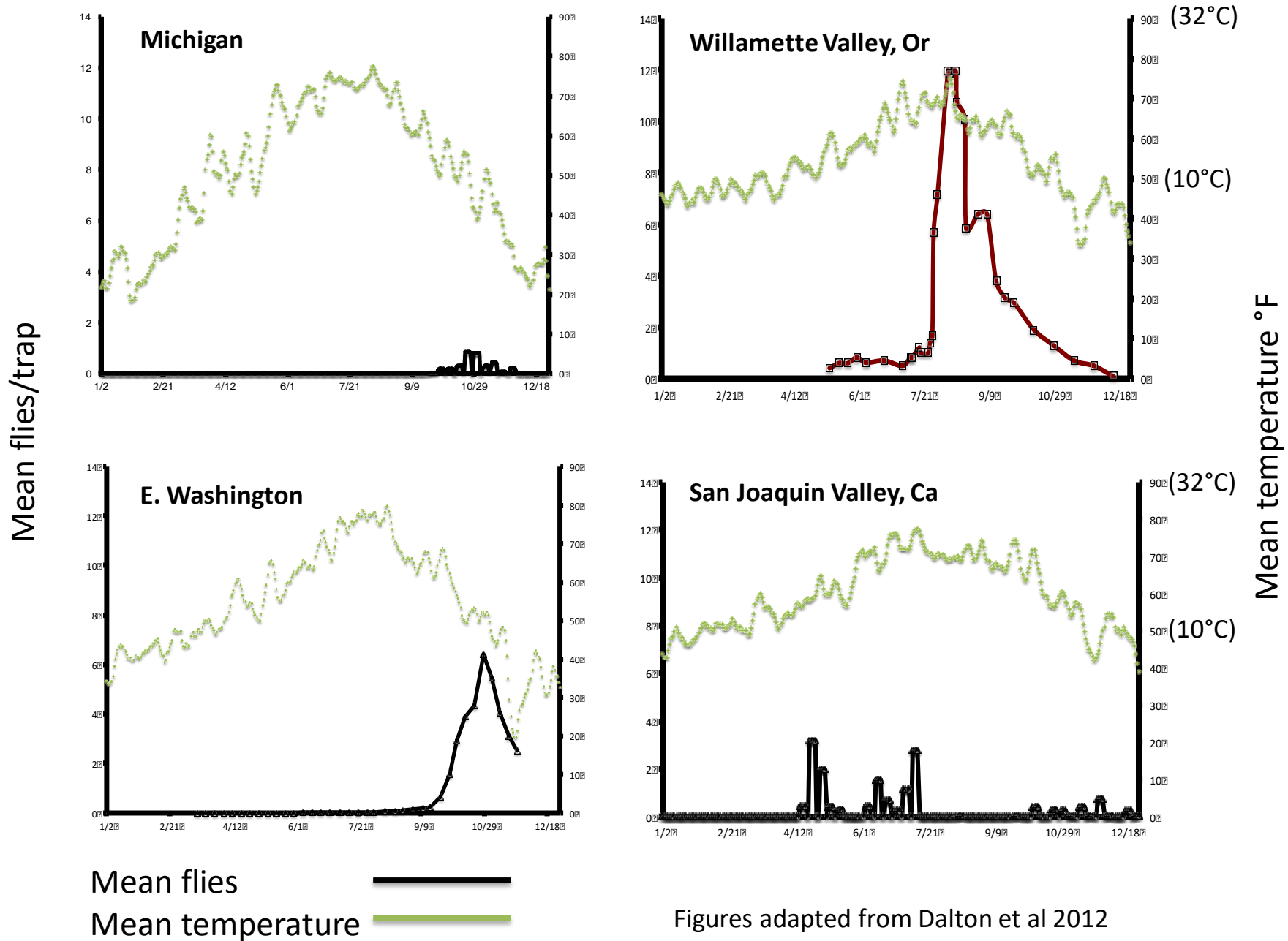
How seasons affect SWD

(OSU Extension Service, EM 9261)



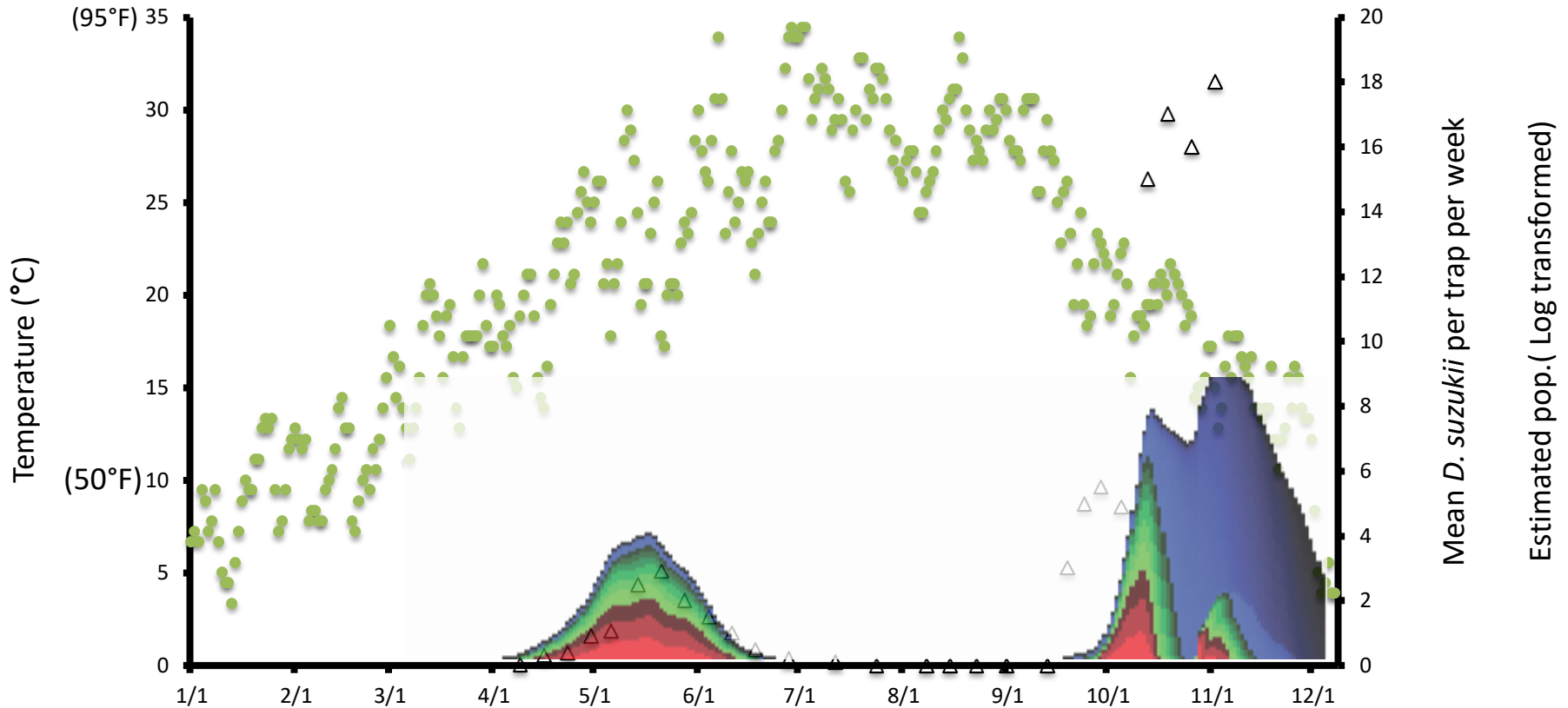
Grassi et al 2018, Tochen et al 2014, Wiman et al 2016, Walton et al 2019

Differences in seasonal phenology



Figures adapted from Dalton et al 2012

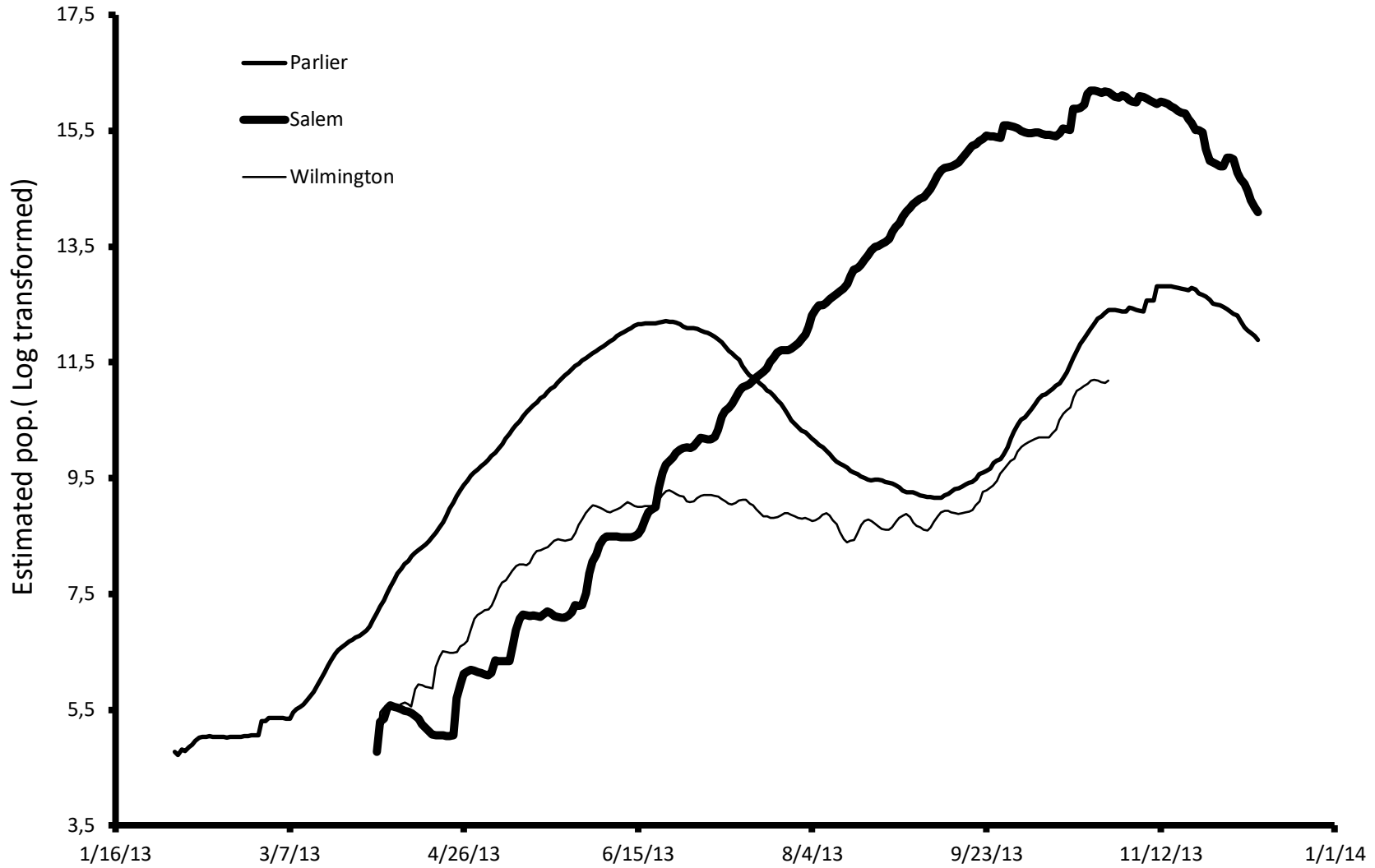
SWD population model – Regional differences

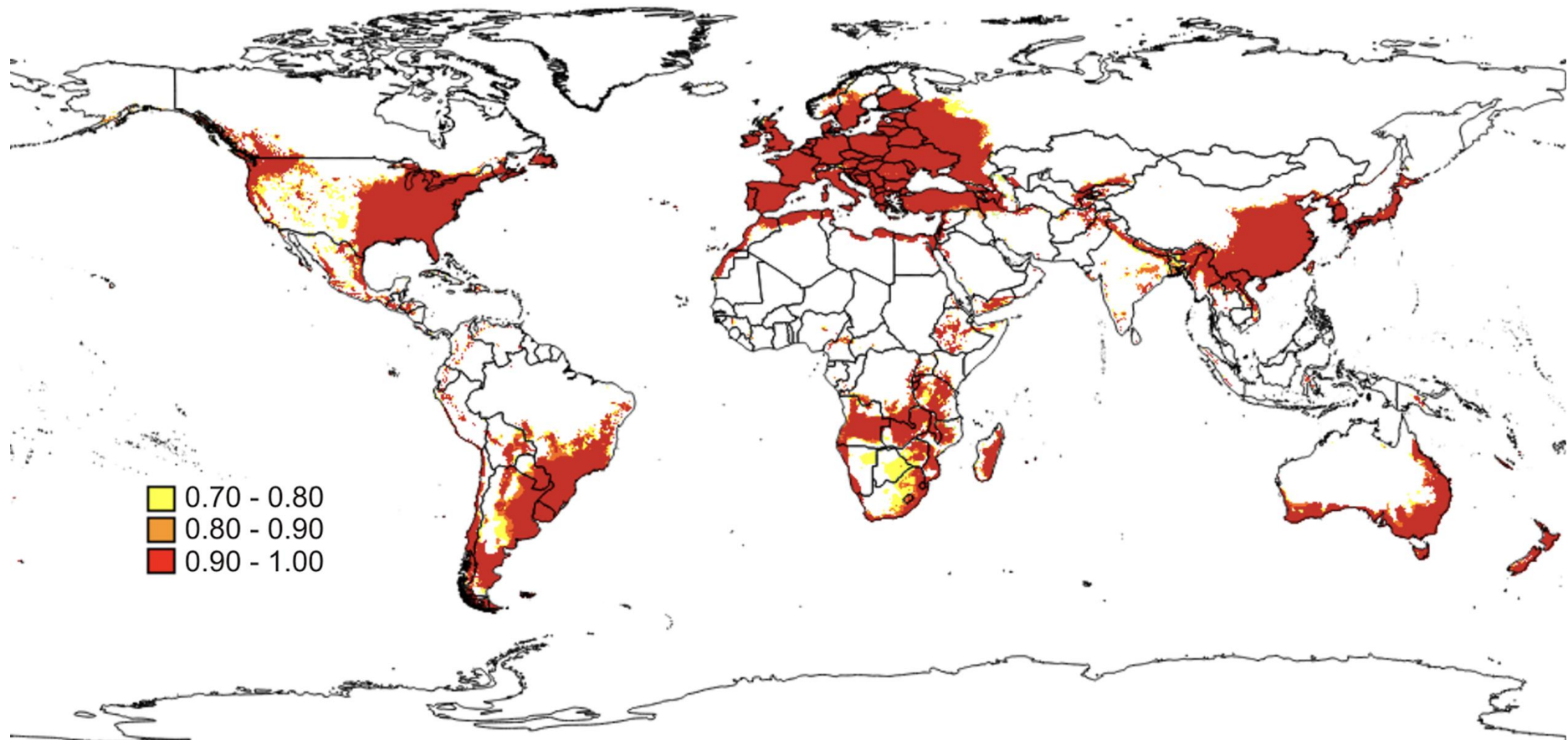


Adapted from Wiman et al. 2014. Integrating temperature-dependent life table data into a matrix projection model for *Drosophila suzukii* population estimation



SWD population model – Regional differences





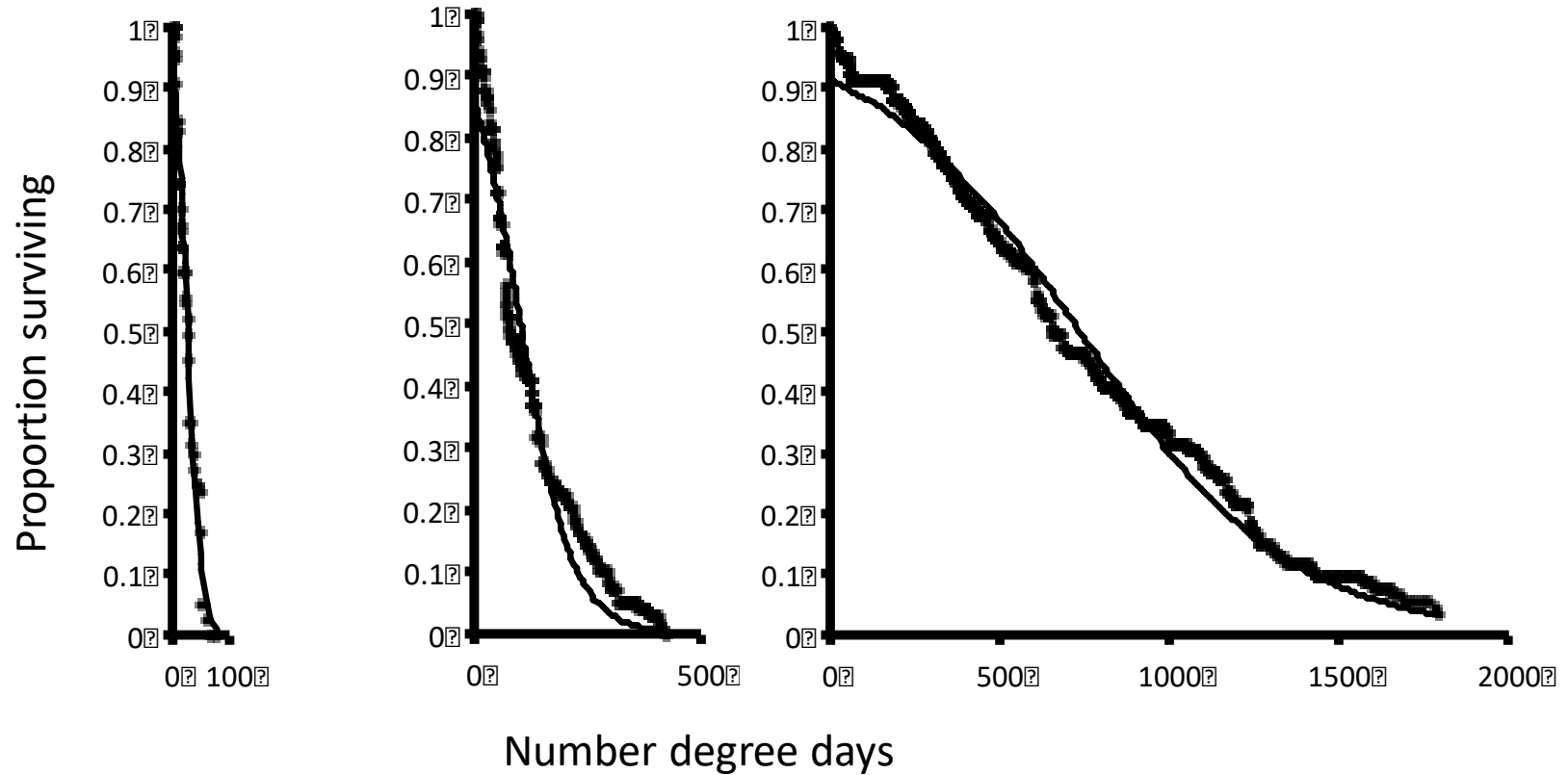
Dos Santos et al. 2017

D. sukuzii overwintering success, impact of diet

no food

50% protein: 50% sugar

100% sugar

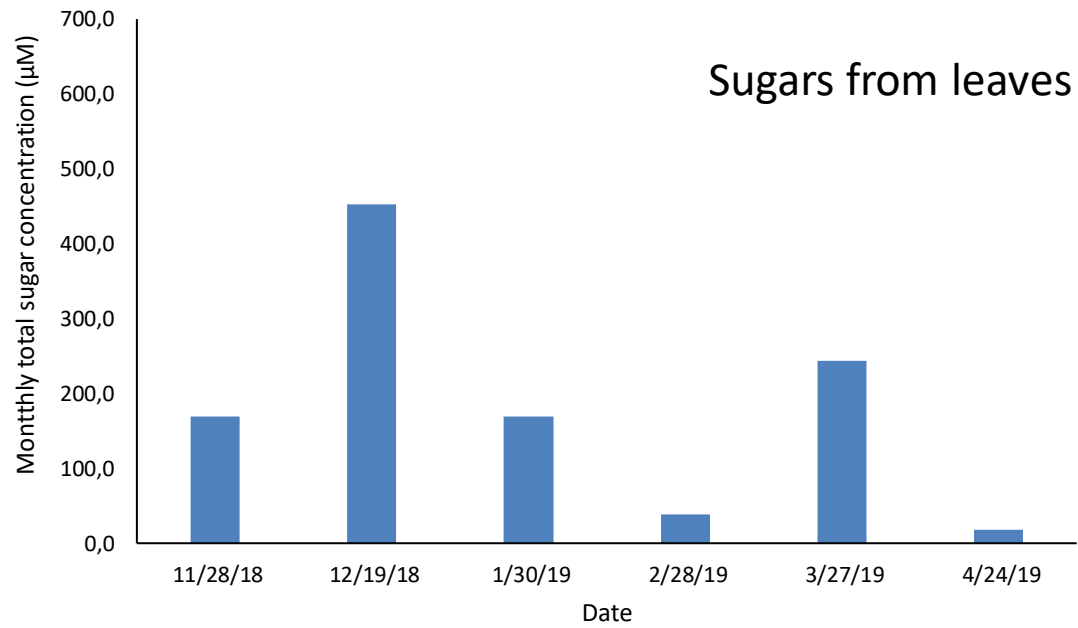
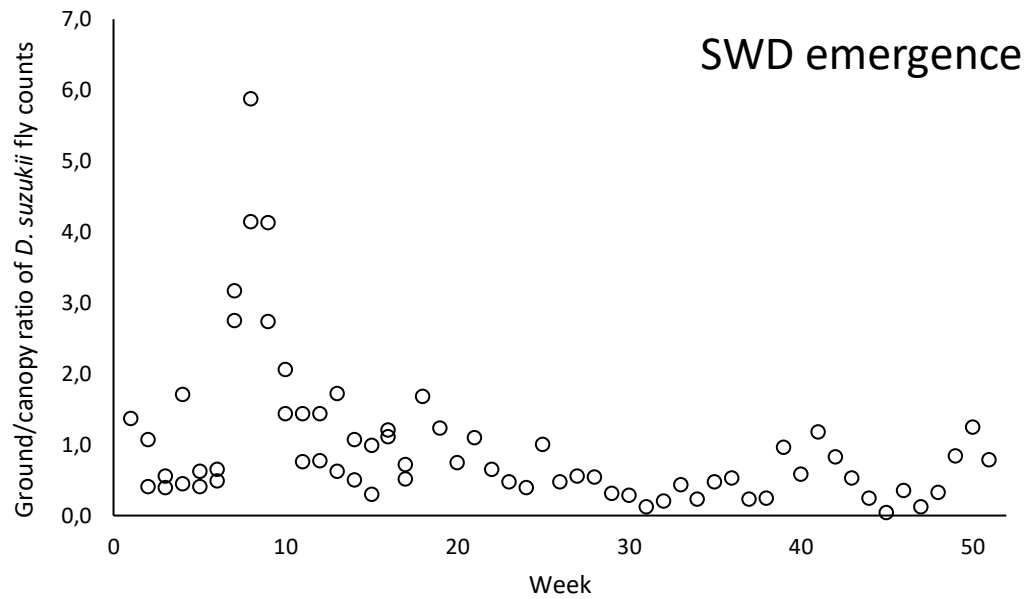


SWD needs sugar and likely need to feed constantly during overwintering

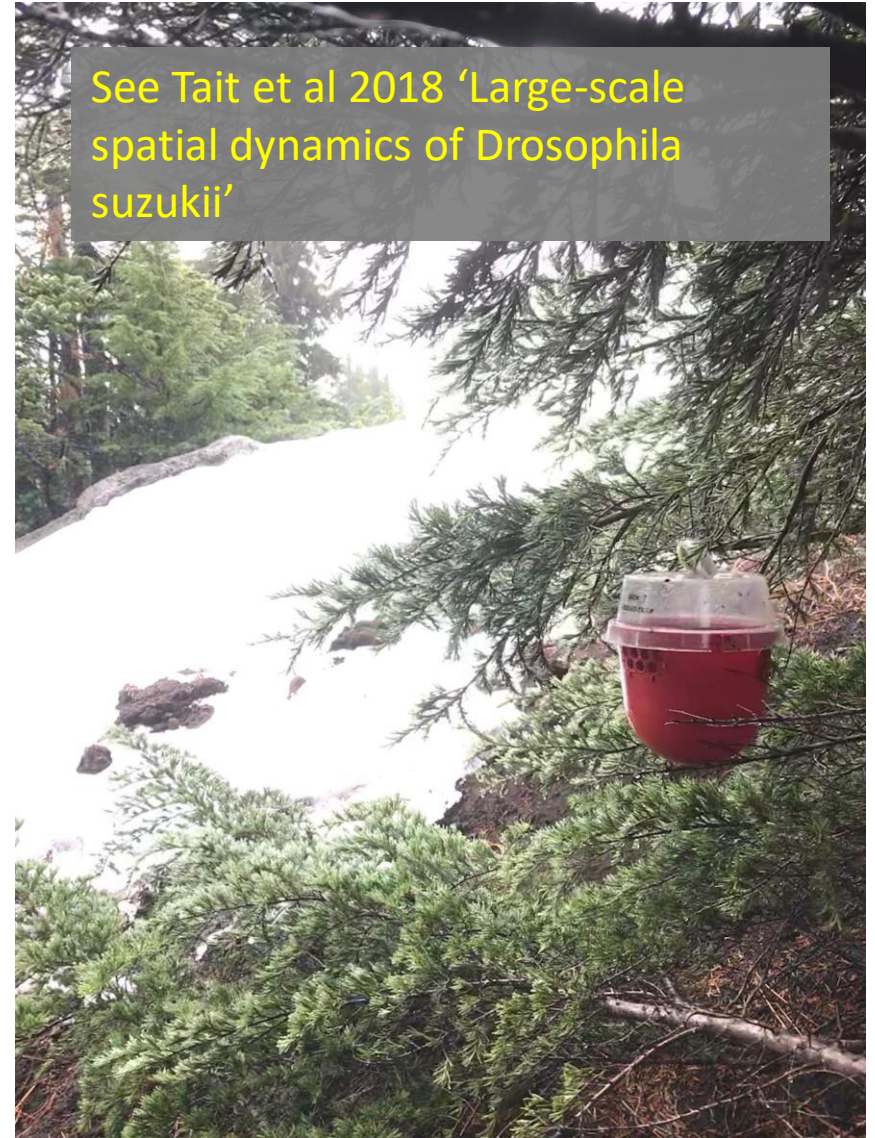
Rendon et al. Journal of Insect Science 2018.



Park, PhD
thesis, OSU
2020



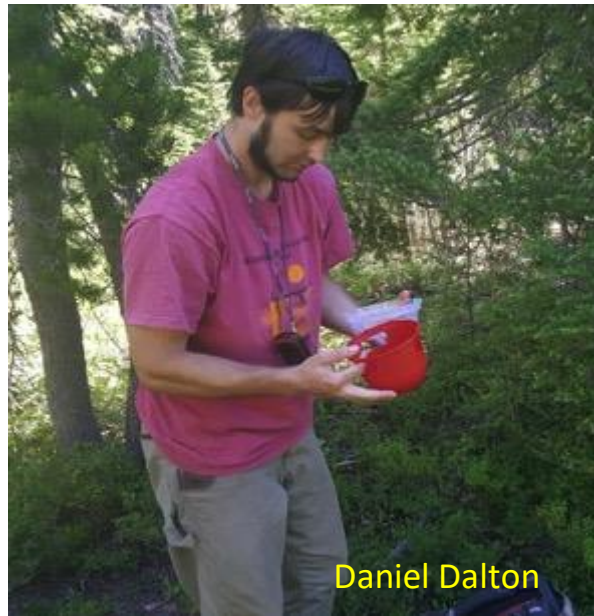
Modeling SWD population dynamics: Insights into biology and management



See Tait et al 2018 'Large-scale spatial dynamics of *Drosophila suzukii*'

Long distance movement and sources of SWD

Spatial and Elevation study: Willamette Valley, Hood River and Sisters Wilderness, OR



Daniel Dalton



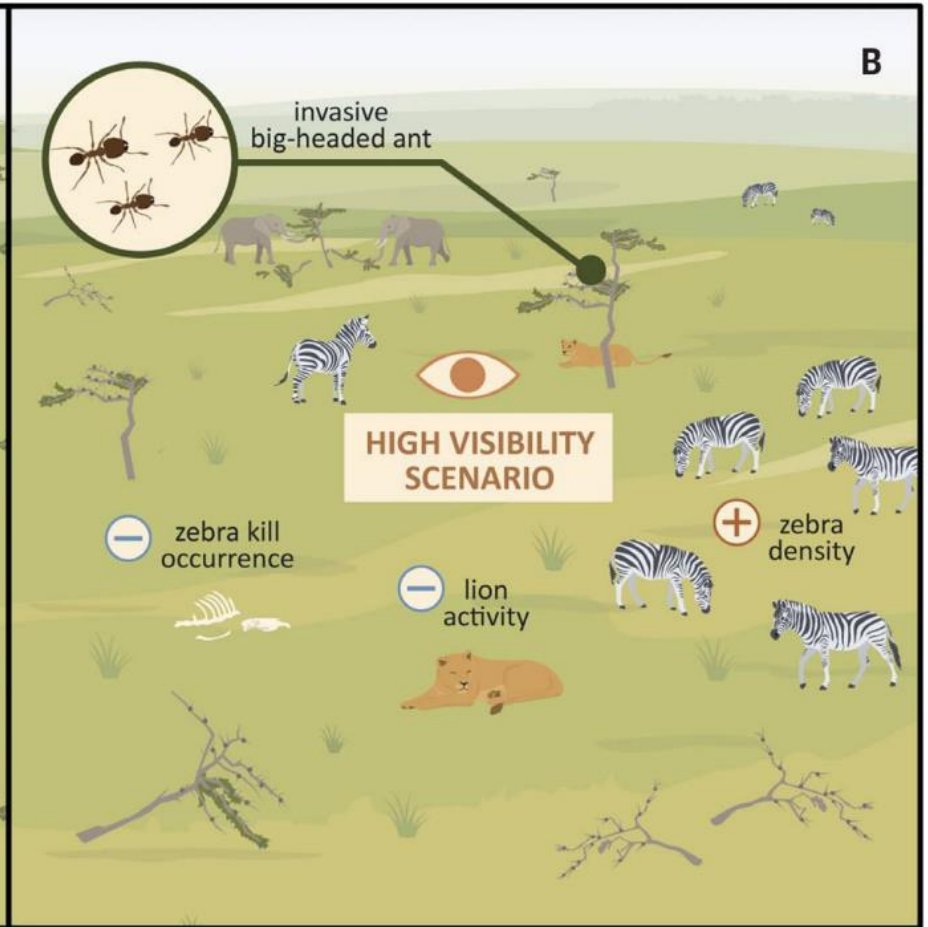
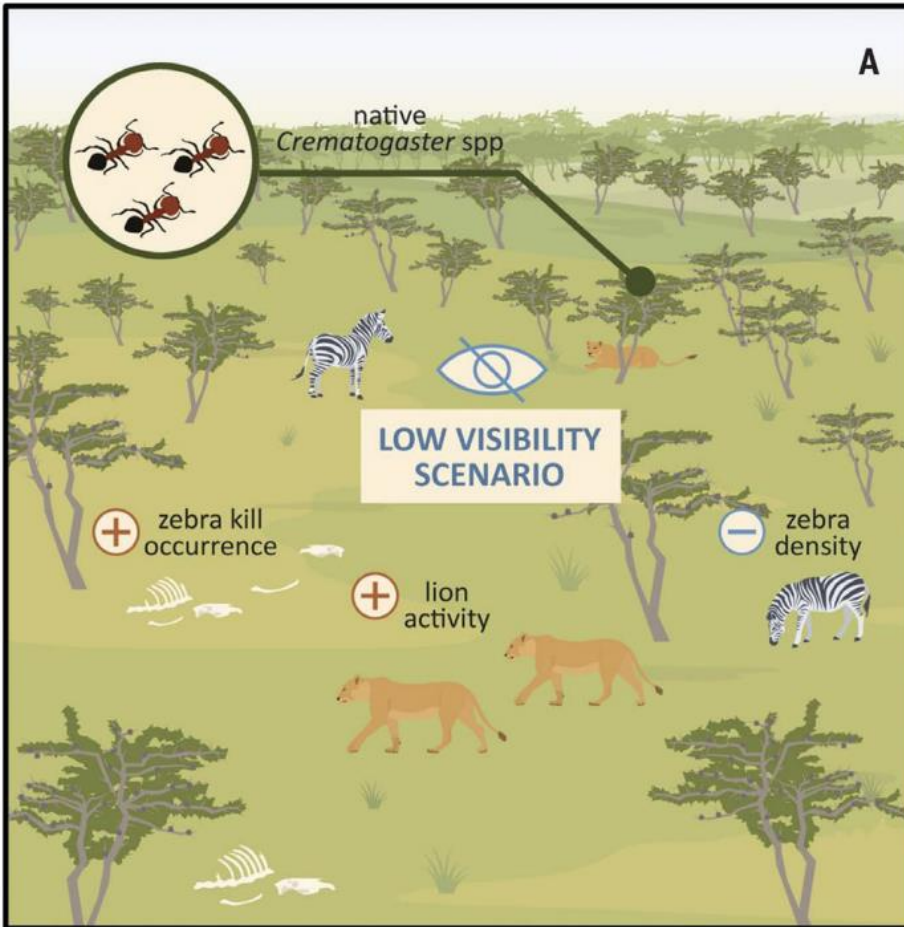
Dalila Rendon

Place traps in crop and surrounding vegetation
Most flies are caught in surrounding vegetation
Trap every week.



Lions in Kenya's Ol Pejeta Conservancy have changed their hunting habits in the past few decades, a study says. (Victoria Zero)

Kamaru et al 2024



FACTORS AFFECTING SWD ENVIRONMENT SUITABILITY

- 1 – Irrigation type
- 2 – Presence of weed mat
- 3 – Pruning intensity
- 4 - Surrounding vegetation

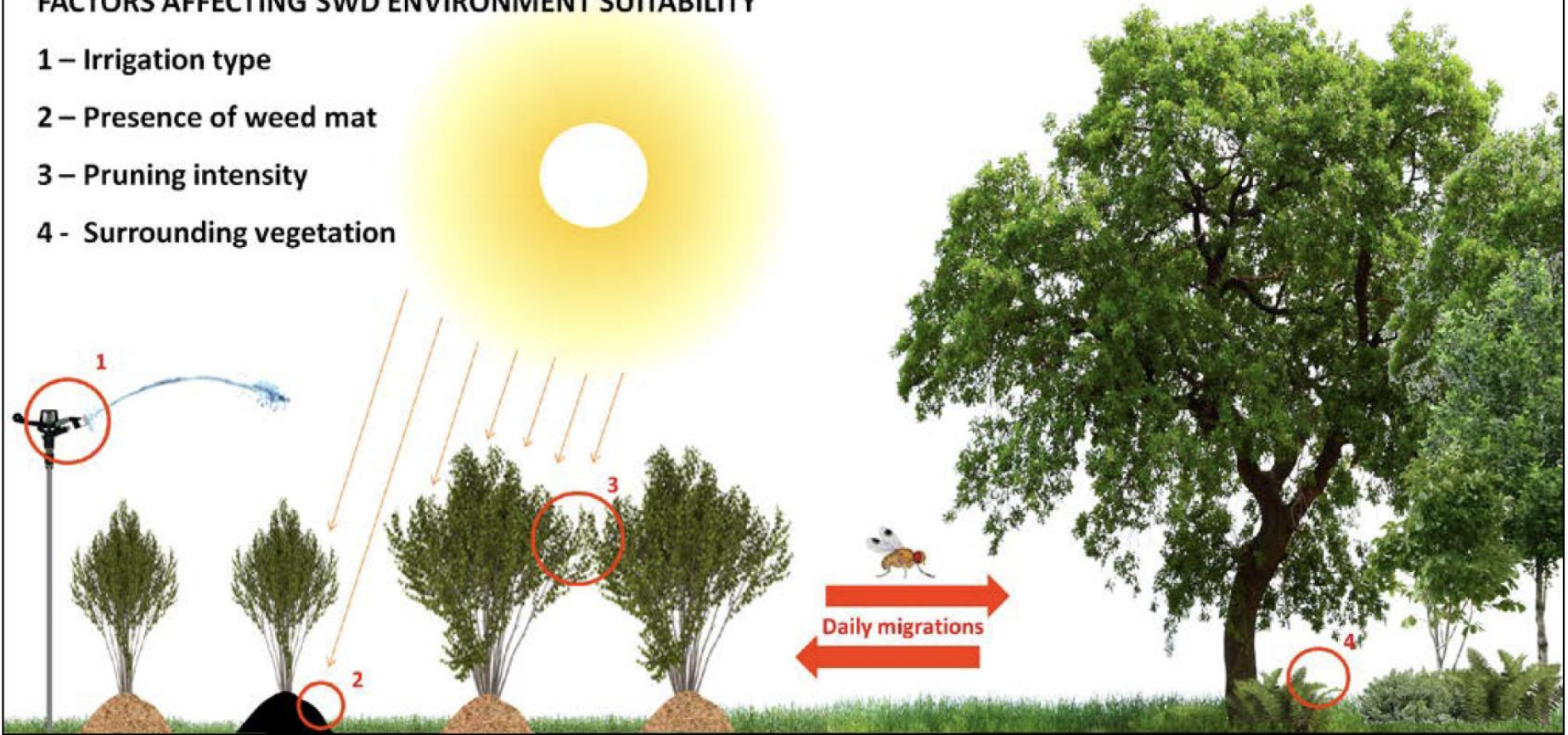


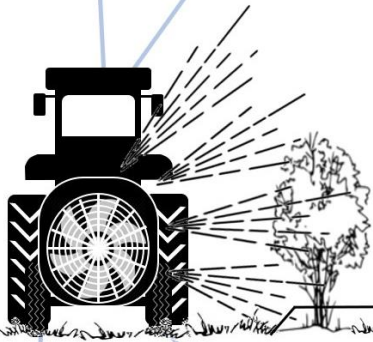
Illustration: Marco Rossi-Stacconi, © Oregon State University

Rendon et al 2019, EM 9262, OSU Extension Service

CHEMICAL PRACTICES

NON-NUTRITIVE SUGARS
(Roubos *et al.* 2019)

ADJUVANTS
(Ruobos *et al.* 2019)



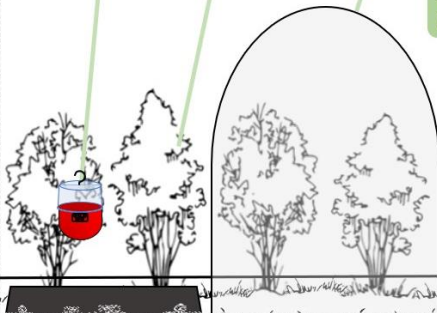
ORGANIC: pyrethrin and
spinosyn classes
(Sarkar *et al.* 2020)

CONVENTIONAL:
organophosphates,
pyrethroids and spinosyn
classes (Disi *et al.* 2020)

CULTURAL PRACTICES

FOLIAR CALCIUM FERTILIZERS
(Lee *et al.* 2016)

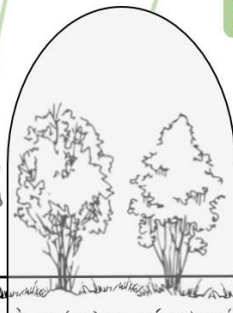
MASS TRAPPING
(Grassi *et al.* 2014)



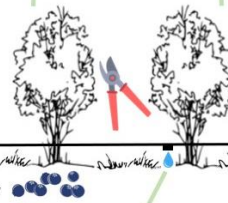
WEEDMATS
(Rendon *et al.* 2020)

FRUIT REMOVAL and SANITATION
(Bal *et al.* 2017)

PROTECTIVE COVERINGS
(Stockton *et al.* 2020)



PRUNING and MULCHING
(Rendon *et al.* 2020)

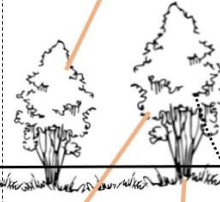


DRIP IRRIGATION
(Follet *et al.* 2014)

MICROORGANISMS: fungi, bacteria, viruses, microsporidia
(Yousef *et al.* 2018; Fanning *et al.* 2017; Carrau *et al.* 2018;
Biganski *et al.* 2020; Hamby & Becher 2016)

BIOLOGICAL PRACTICES

NATURAL ENEMIES:
parasitoids and predators
(Biondi *et al.* 2020; Woltz
and Lee 2017)



NEMATODES
(Foye & Steffan 2020)

DEVELOPMENTAL DISRUPTION

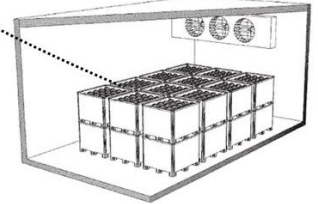
- SIT (Kruger *et al.* 2018)
- RNA interference (Murphy *et al.* 2016)
- CRISPR/Cas9 (Yan *et al.* 2020)



Post-harvest treatments



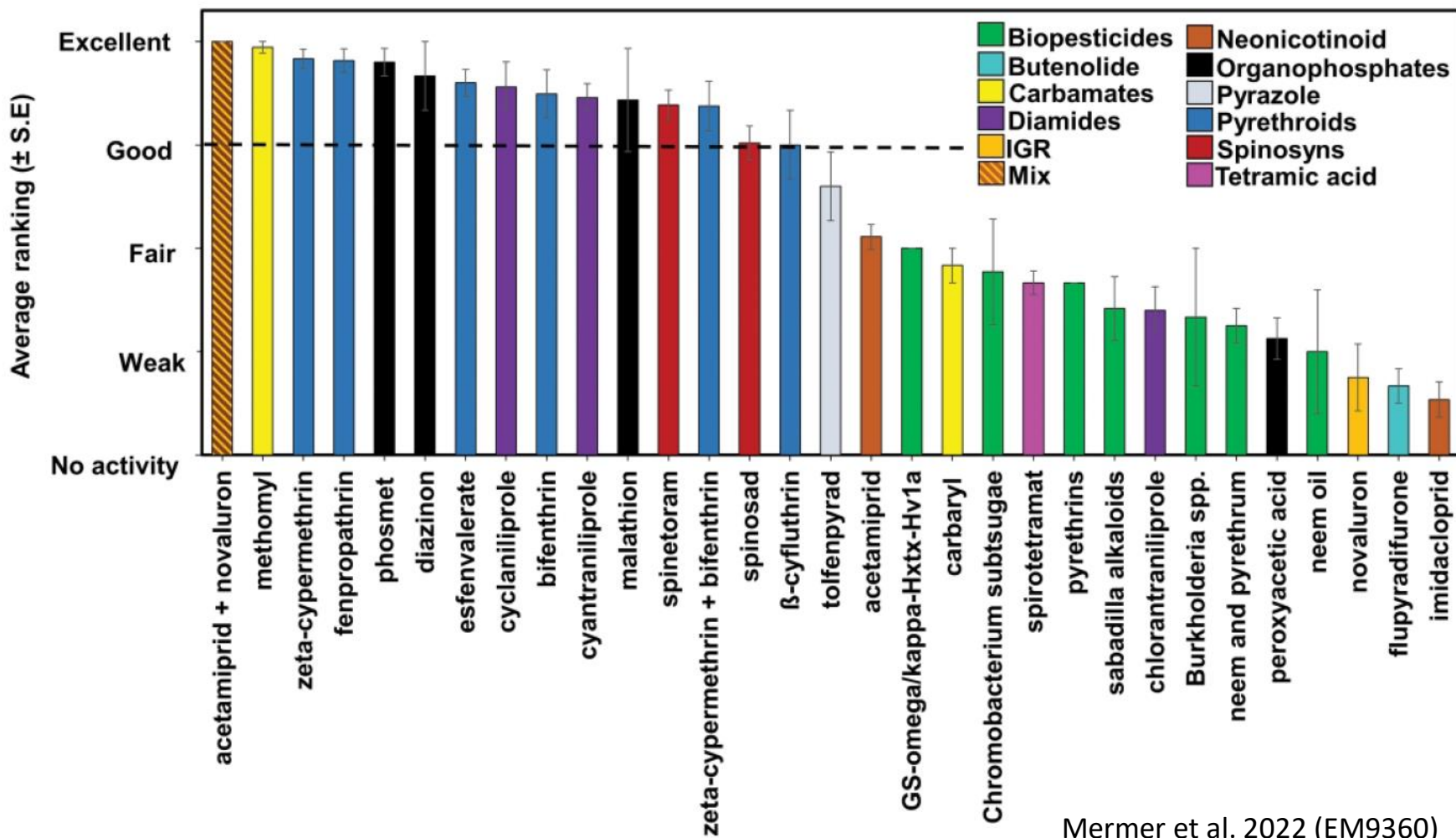
REFRIGERATION / IRRADIATION (Kraft *et al.* 2020)



Rossi-Stacconi, from Tait *et al.* 2021

Relative ranking of insecticide efficacy and insecticidal class

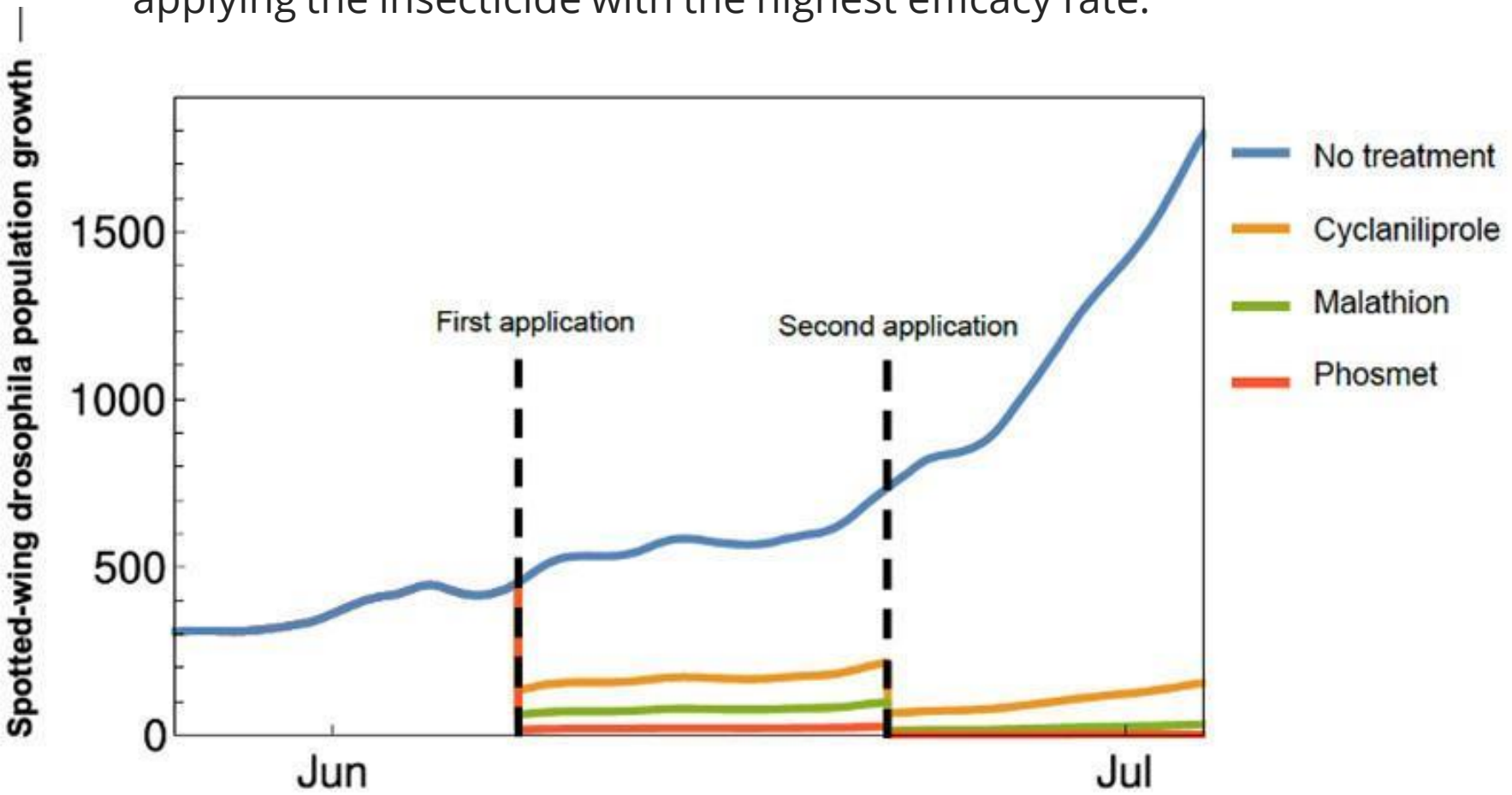
(indicated by color code) of insecticides commonly used to control spotted-wing drosophila. Insecticides are color-coded by insecticidal class.



Chemical control of *D. suzukii*

Insecticide (Active ingredient)	Percent mortality				Relative mortality ranking	Average mortality of all stages	PHI* (day)	
	Egg	Larvae	Pupa	Adult				
Imidan 70 WP (phosmet)	91	92	>99	99	High	95	3	
Lannate (methomyl)	84	77	100	99	High	90	3	
Delegate (spinetoram)	84	81	99	95	High	89	3	
Entrust (spinosad)	83	76	>99	95	High	88	3	
Malathion 8F (malathion)	85	72	98	90	Medium	86	1	
Assail (acetamiprid)	80	78	90	90	Medium	84	1	
Exirel (cyantraniliprole)	73	69	95	95	Medium	83	3	
Danitol 2.4 (fenpropathrin)	63	67	95	95	Medium	80	3	
Mustang Maxx (zeta-cypermethrin)	52	60	99	>99	Medium	77	1	
Harvanta 50 SL (cyclaniliprole)	67	71	70	70	Low	69	1	Mermer et al. 2022 (EM9360)

Drosophila suzukii seasonal population growth (blue line) and relative efficacy of two seasonal insecticidal application regimes (dotted lines). The highest level of control is likely obtained by first applying the insecticide with the highest efficacy rate.

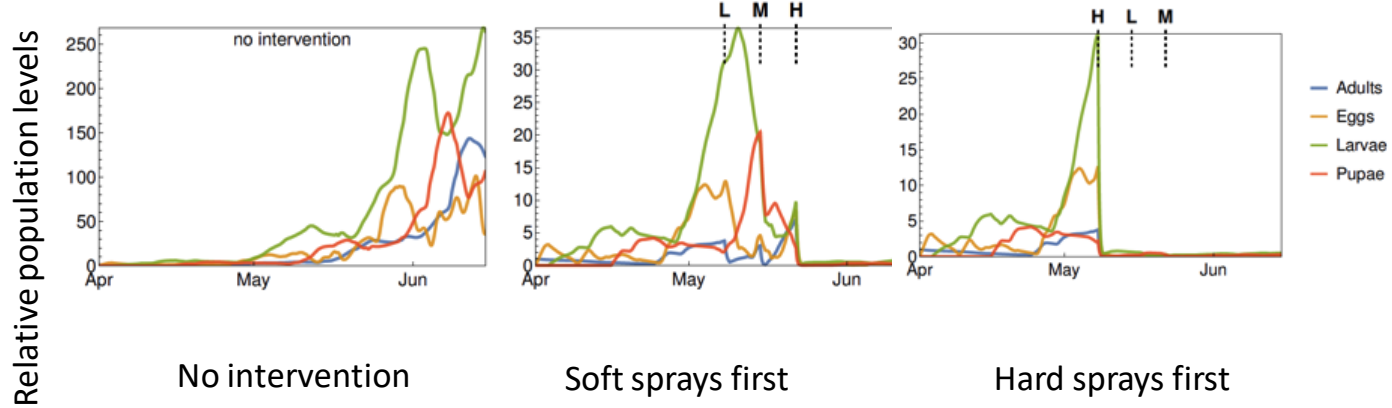




Chemical control of *D. suzukii*: Population estimations

Wilmington, NC temperatures

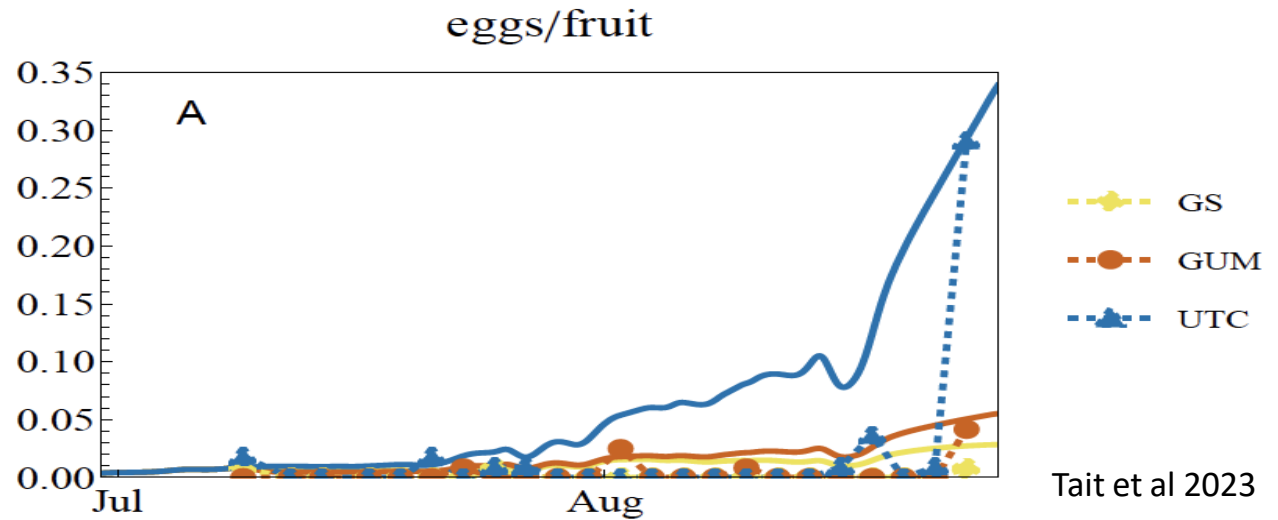
Mortalities: Low= 12, Mid = 64, High = 98



Hard sprays applied early in the season will result in lower population levels

Mermer et al. 2022. Impact of timing of insecticide sprays on *D. suzukii* life stage and populations

A modeling perspective based on a ~50% egg reduction using Decoy: Real data



Grower adoption of sustainable tools and reduction of pesticide use:

Decoy™ Food-grade gum

Lasts 3 weeks

As attractive as fruit

Not applied directly onto fruit

Minimum Risk Insecticide

EPA - SECTION 2(ee) USE RECOMMENDATION

Section 2(ee) of FIFRA allow that a pesticide may be:

- Applied at any dosage, concentration, or frequency less than that specified on the label (unless the label specifically prohibits such an application).
- Applied against any target pest not specified on the label (unless EPA has required that the pesticide may be used only for the specified pests).
- Applied by any method not prohibited by the label (unless the label specifically states the pesticide may be applied only by the methods specified on the label). Examples of methods include aerial, ground and airblast.

Bait Sprays e.g. Combi-Protec



BAIT SPRAY

20-40 l spray volume / ha

2.5- 5.0 gal Spray Volume/acre

minimized insecticide use

3 – 10% of standard rates

minimized residues of actives

3-8% coverage of plant canopy

fast application



FULL COVERAGE APPLICATION

100-1000l spray volume / ha

20 – 100l gal spray volume / acre

up to 50% less insecticide use

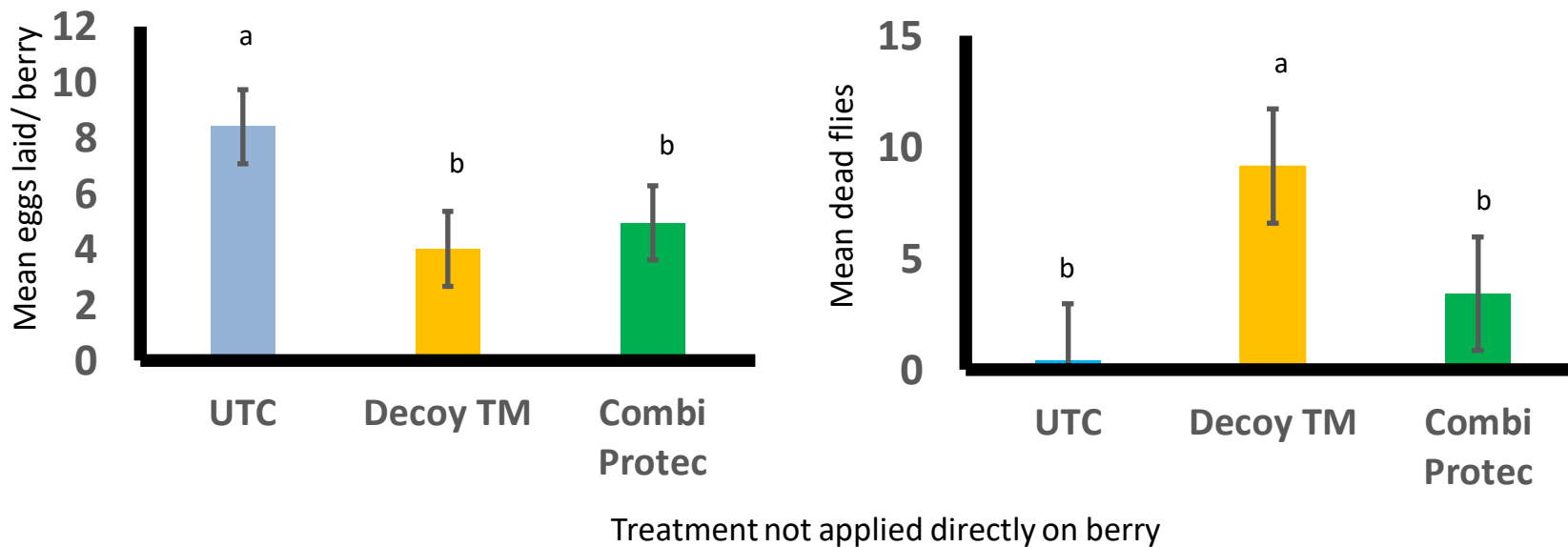
by equal efficacy

Reduces effectiveness loss due to washing off by rain

possible use of fungicides

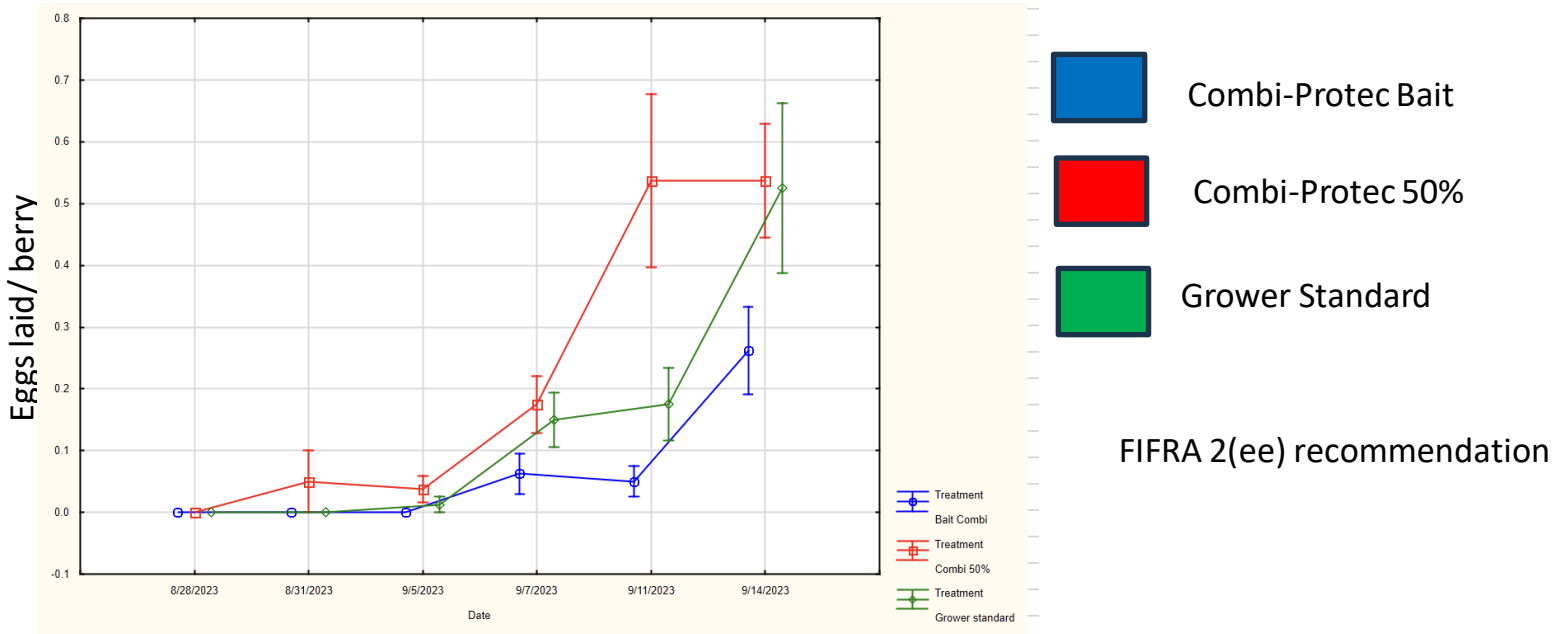
in tank mix

Laboratory trials in actively ventilated arenas over 24 hrs



Molokwu et al in prep; 7 replicates, ANOVA analysis, sig. dif. separated by Tukey's HSD

Open-field trials 5-acre plots, Jefferson Oregon, Legacy blueberry 2023



Not replicated, 12 collections/plot, collected
~27 times 2 times/week

Molokwu et al in prep.

Summary

- Every component of the system can result in significant outcomes
- Surrounding vegetation important
- We should focus on reducing damage to berries
- Cultural techniques reduces SWD
- Behavioral management and A&K
- The best chemical control does not result in 100% SWD control
- Lower trap counts \neq lower crop damage

Qualtrics
presenter
survey <30
seconds



Thank you



Funding for research was provided by the Oregon Blueberry Commission and United States Department of Agriculture National Institute for Food and Agriculture award #2010-51181-21167, #2015-51181-24252, USDA OREI #2014-51300-22238, USDA CRIS 5358-22000-037-00D, USDA NWCSFR, On Target Spray Systems, Jacto. We thank the Oregon State Blueberry Commission, the Washington State Blueberry Commission, the Washington State Red Raspberry Commission, the Washington State Strawberry Commission, the Washington State Commission on Pesticide Registration, Project GREEN, and the Michigan State Horticultural Society. We thank the California Cherry Board and USDA APHIS (Farm Bill, fund 14-8130-0463) for partial funding of this study. . In Italy, this work was partly funded by the Autonomous Province of Trento (Italy), Research funds for Grandi Progetti, Project LExEM (Laboratory of excellence for epidemiology and modeling, <http://www.lexem.eu>). Antonio Biondi received funding from the People Programme (Marie Curie Actions) of the European Union's Seventh Framework Programme FP7/2007-2013/under REA grant agreement 318246 and from the Italian Ministry of Education, University and Research (PRIN project GEISCA, 2010CXXHJE_004). Molly Albrecht provided assistance with *D. suzukii* dissections.

Linda Brewer, Dave Bryla, Gabriella Boyer, Jessica Buser