Enhancing Biocontrol with perimeter plantings

Habitat Modification
(for orchard pest biocontrol)

In orchard -same irrigation – direct sprays

- Ground covers :1) pollen/nectar, 2) alternative prey/hosts, 3) overwintering habitat
- Mulch: 1) overwintering habitat

Near orchard -same irrigation - **No sprays**

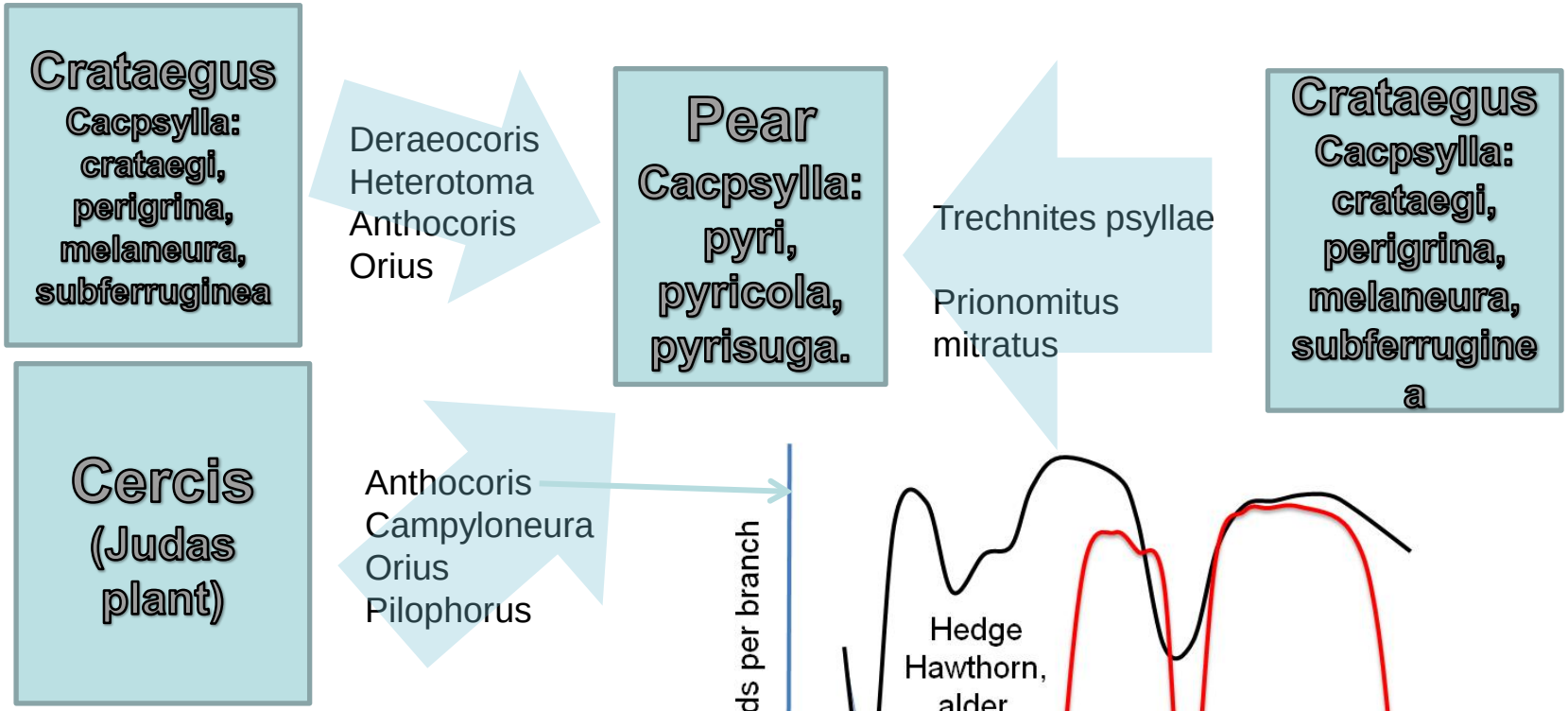
- Ground covers, shrubs, hedges, trees :1) pollen/nectar, 2) alternative prey/hosts, 3) overwintering habitat
- Bat house and bird houses 1) seasonal habitat

Underlying approach

- Increase general biodiversity (many papers, no enduring success)
- Bioengineering of key species (few papers, no enduring success

Major Examples Biological Engineering in perennial deciduous crops

Hedgerows: Significant traditional use of hedgerows in Europe
diverse shrubs/trees form a living fence on field margins.
Hedge rows for pear psylla produce early season prey and overwintering hosts for predators and parasitoids, respectively.



Nguyen, T. X., Delvare, G. & Bouyjou, B. 1984. Biocénose des Psylles du Poirier (*Psylla pyri L. et Psylla pyrisuga Förster) dans la région toulousaine. In : Colloque Lutte Intégrée contre les Psylles du Poirier, Toulouse, 27, 28, 29.9.1983. Bulletin OILB/SROP, 5 VII 1984 : 191-197.*

Petru Scutareanu et al. 1999 Ecological Entomology 24, 354-362

Anagrus on leafhoppers

studies in California, New York, and Europe

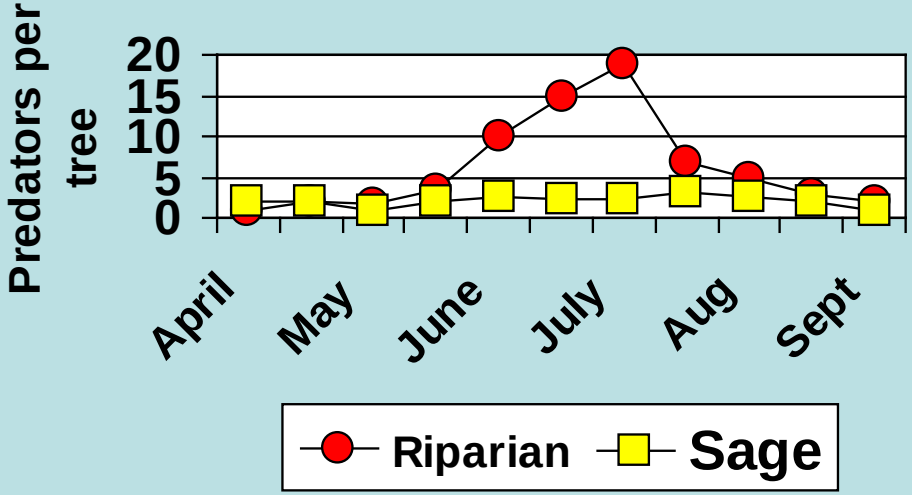
"Because grape leafhoppers overwinter as adults, and Anagrus species overwinter in host eggs, Anagrus species must rely on alternate host insects that overwinter as diapausing eggs in perennial plants" ….. Ex. L. William et al. 2000

- Prune Trees provisioning vineyards in California
  - Leafhopper eggs on prunes are attacked by Anagrus in fall and wasps colonize vineyards in spring
  - Increase in parasitism and capture of marked Anagrus was seen 50-100 meters from prunes trees in early spring . Anagrus becomes very abundant by summer and parasitism becomes very high even without prunes
- Wood lots provisioning vineyards in New York
  - Roughly same trend: more Anagrus were captured and egg parasitism was higher on border vines than on vines farther inside the vineyard; differences largely disappear as the season continues

Colonization of potted trees

Riparian	Sage
Rose	Lupine
Cottonwood	Sage
Willow	Bitterbrush

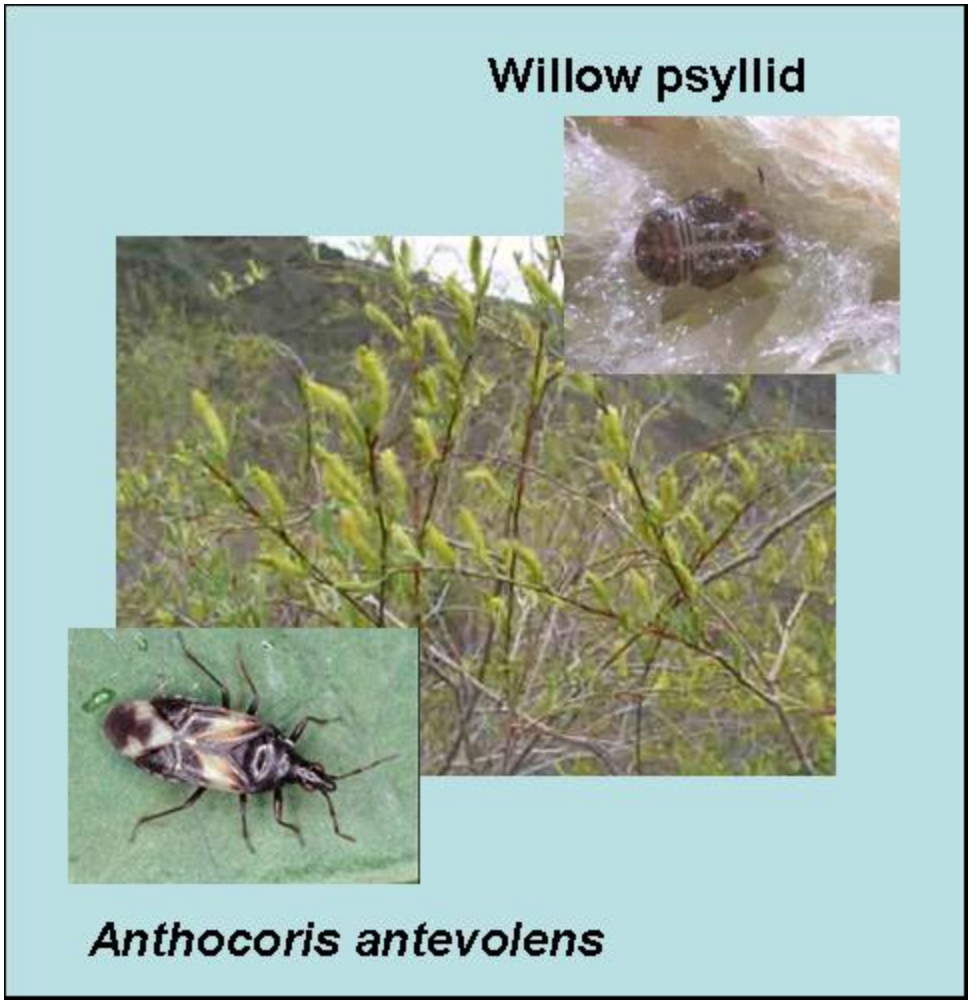
(From Rathman and Brunner)



	Riparian	Sage
Mites	20%	0
Spiders	18%	65%
Beetles	5%	12%
Flies	27%	0
True bugs	10%	17%
Lacewings	20%	6%

Grower perceptions: biocontrol is more extensive in orchards next to rivers or riparian habitats.

Dave Horton's research on *Anthocoris* and other psylla predators show they are influenced by habitat elements



Inventory of Alder

(Gene Miliczky Dave Horton)

Alder:

- **Rapid growth**
- **Nitrogen fixer**
- **Lots of good bugs**
  - **Spiders, ladybeetles, lacewings and bugs**
- **No bad actors**

Poplar windbreak

Alder

Leaf rollers in apples, pears & cherries

- *Choristoneura rosaceana,* OBLR, and *Pandemis limitata,* PLR
  - damage more than 25% of a a crop
- One or two pesticide used for LR
- Organic growers use Bt and Entrust but the latter is disruptive
- There is a diverse fauna of parasitoids that attack LRs which varies from region to region, but their capacity to control leafroller populations is unreliable

Oblique banded leafroller

The key players: *Colpoclypeus florus*

- Discovered in WA in 1992
  - Collected in Italy and released into Ontario Canada in 1968
  - In Europe, *C. florus* is the most important parasite of leafrollers in tree fruits
  - Both in Europe and here it shows **very low** parasitism of the spring (overwintering) leafroller larvae

Colpoclypeus florus attacking OBLR

***Colpoclypeus florus* larvae on OBLR**

The alternative host: *Ancylis comptana*

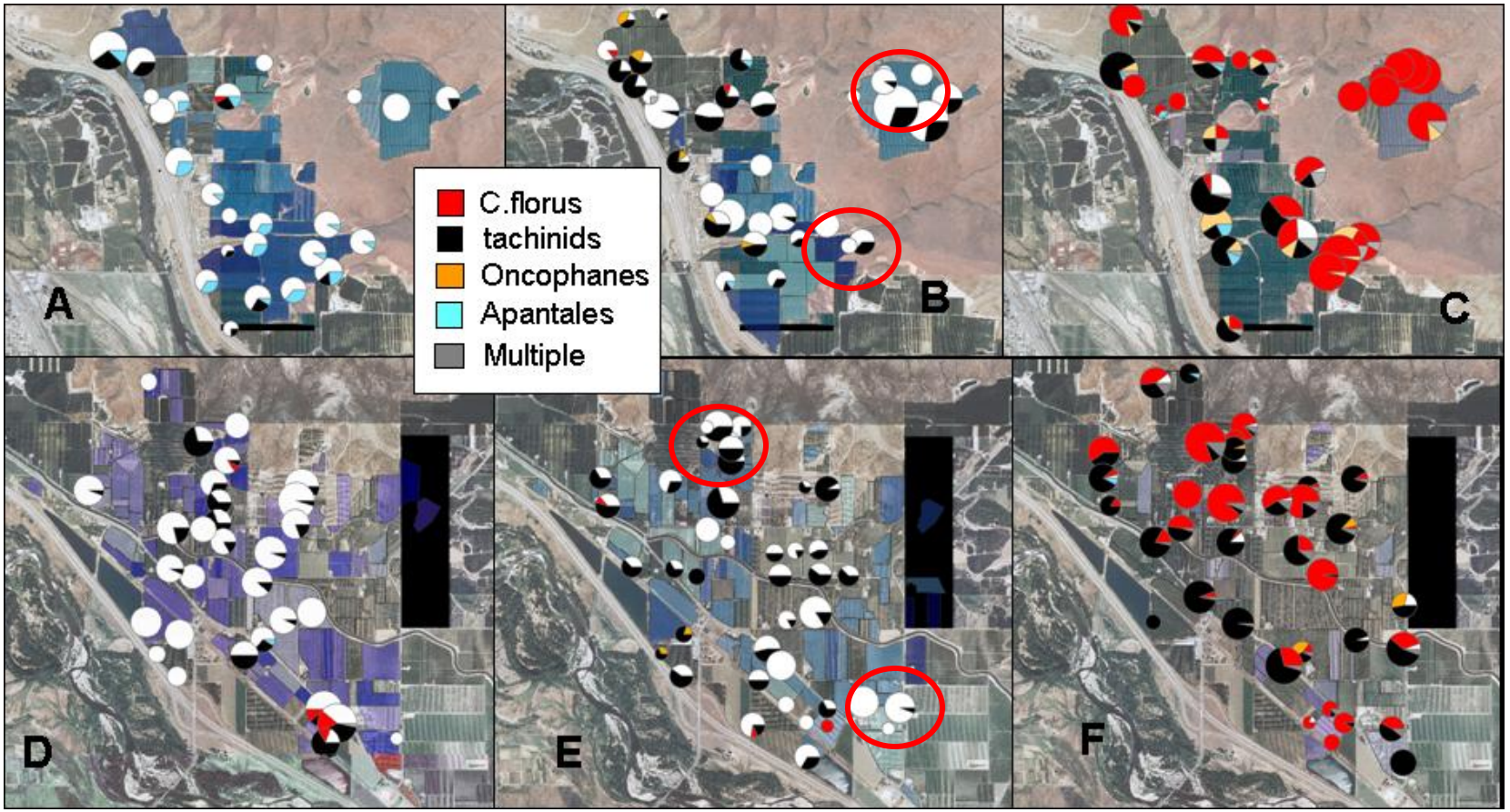
- Bob Pfannenstiel found that *C. florus* overwintered on *Ancylis comptana* (Strawberry leaf roller SLR) on wild rose, *Rosa woodsii*
- SLR prefers strawberry as a host but is found on roses both here and in the eastern USA and Europe.
- SLR overwinters as mature larva and is a good size for an overwintering host for *C. florus,* **in contrast to our pest leafrollers which overwinter as small larvae.**

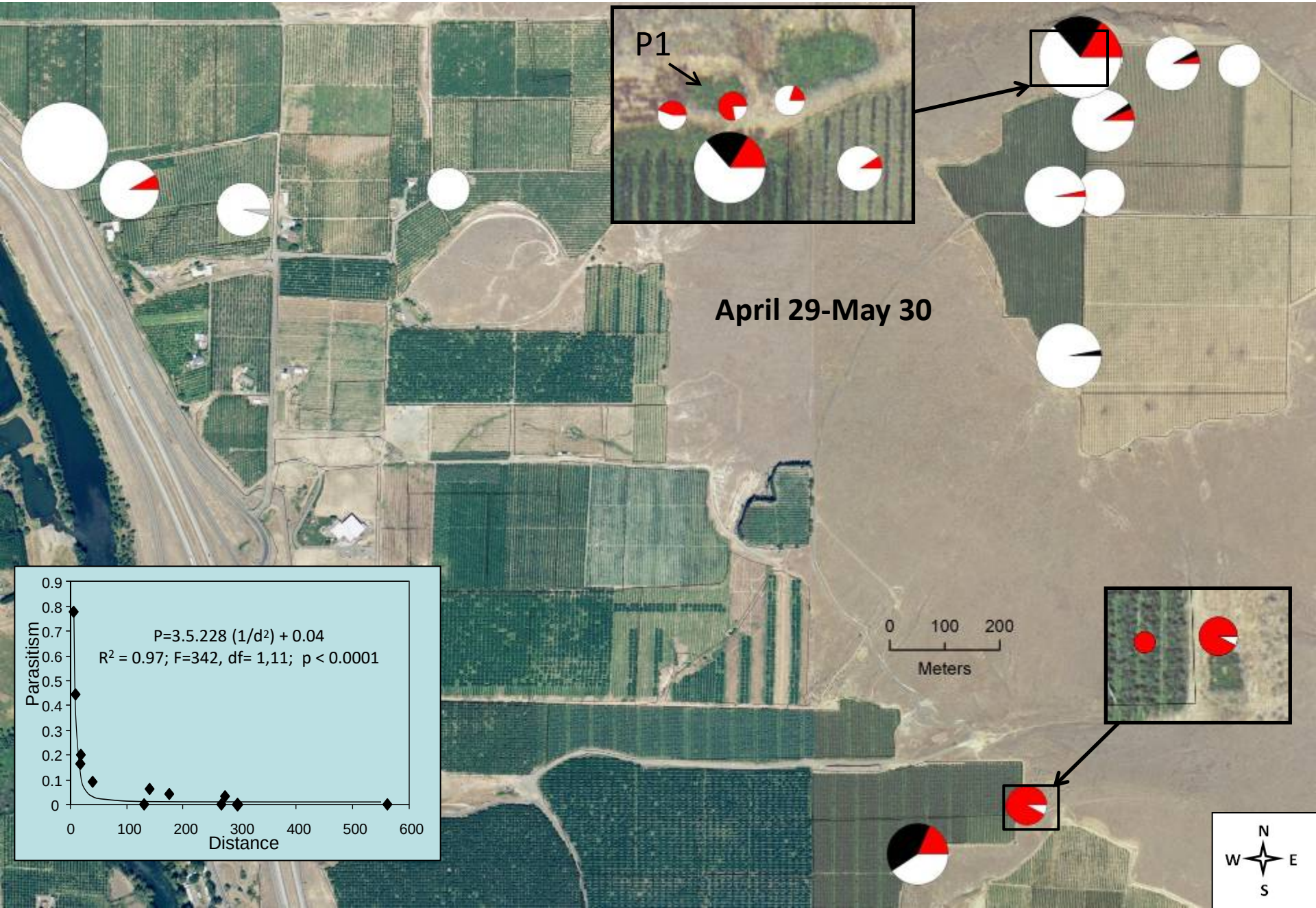
Can we plant roses and strawberry near to orchards to enhance spring parasitism

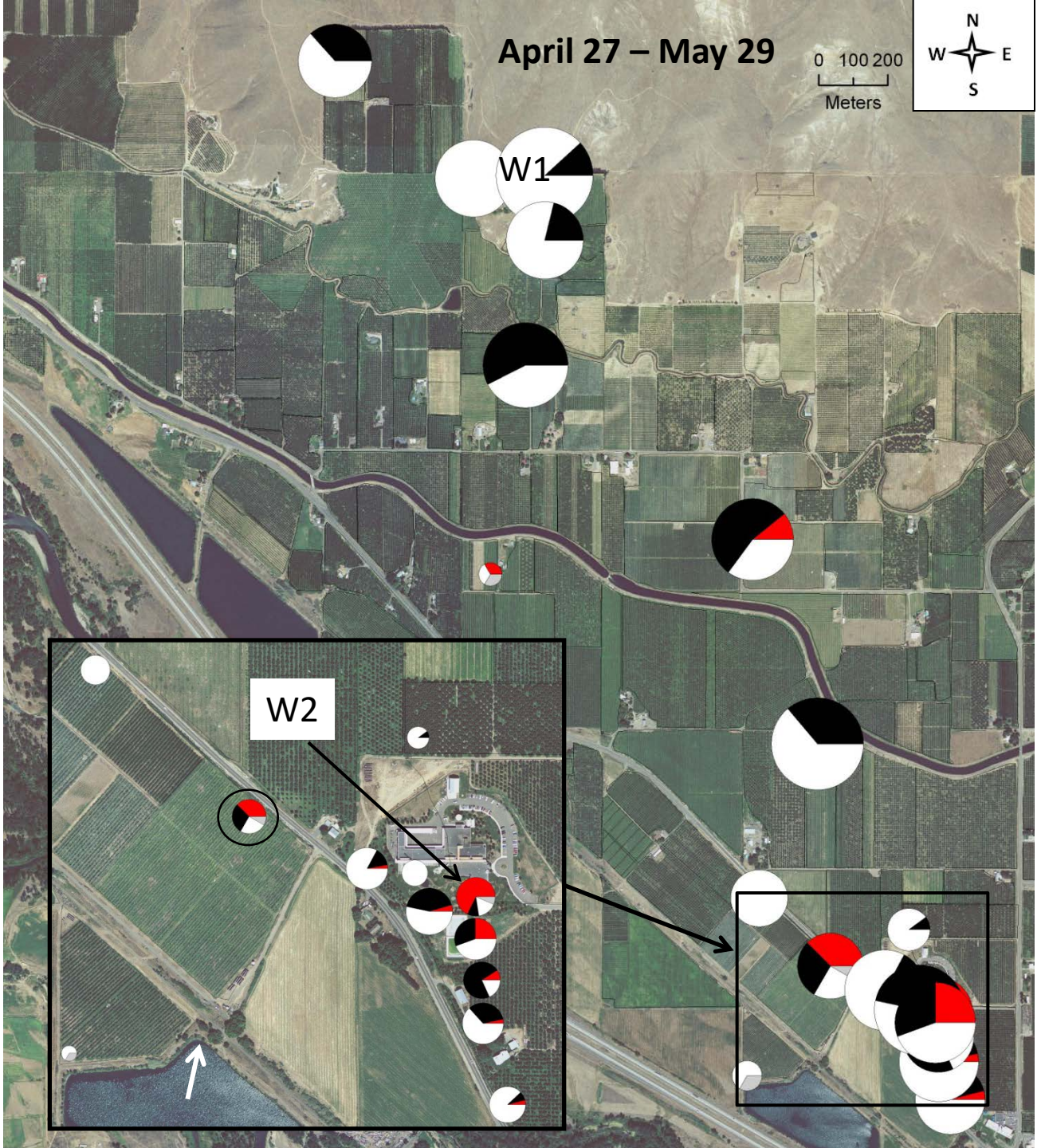
- Studied parasitism of *C. florus* in orchards near naturally occurring rose patches (it was generally high --- not shown)
- We evaluated parasitism in a 800 ha landscape area in the Yakima Valley
- We planted rose and strawberry gardens in the landscape and observed the results

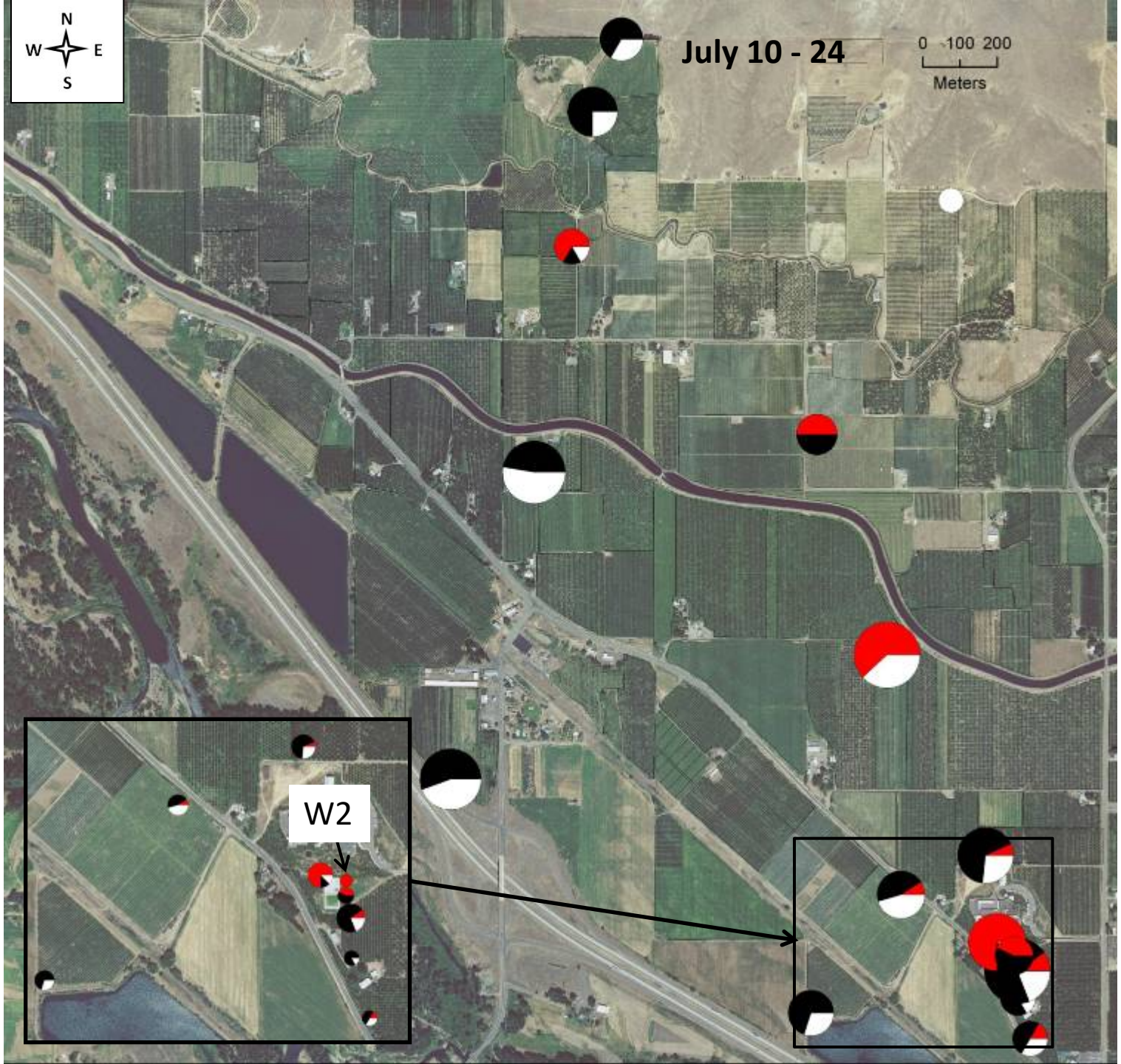

PLATH ORCHARD
UPPER PLATH
10-22-03

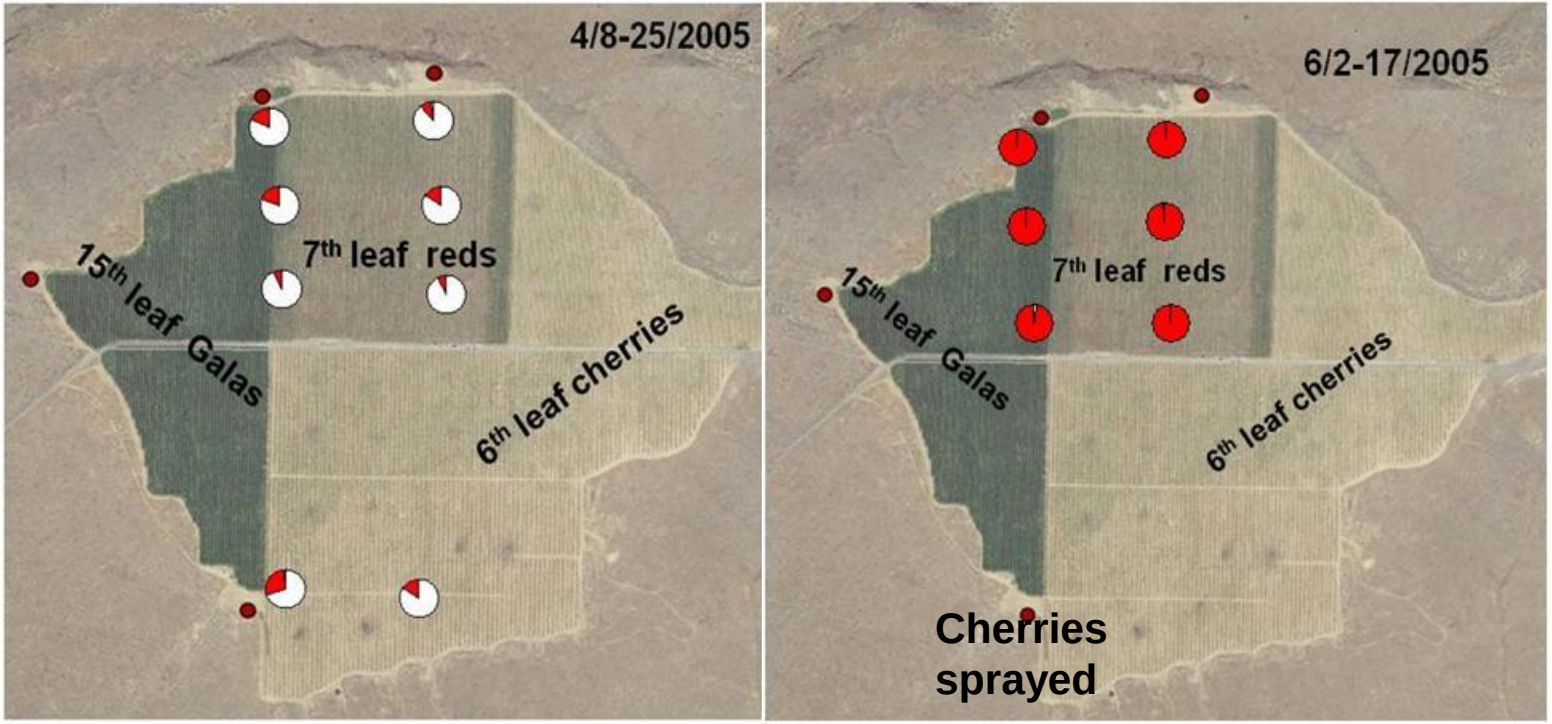
2000



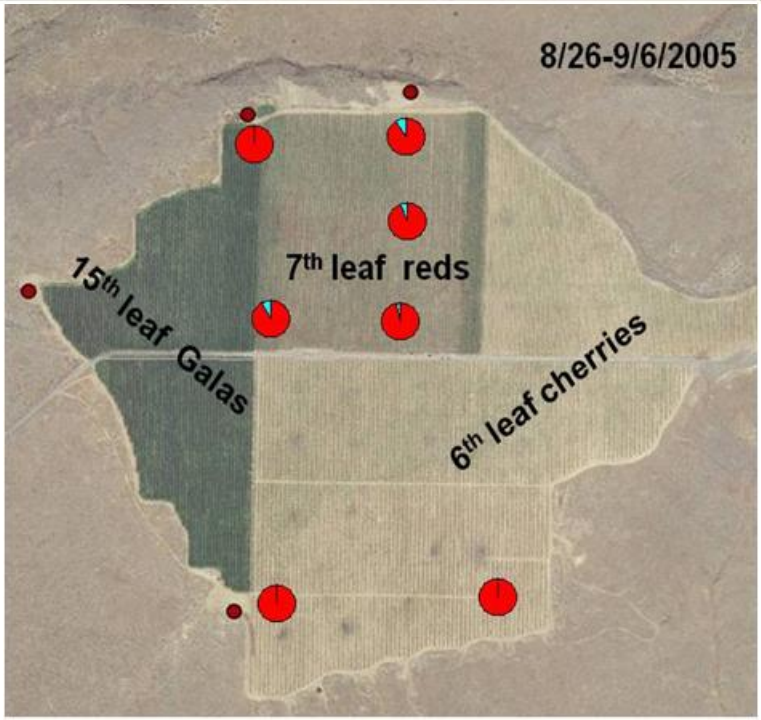

P1
April 29-May 30
0 100 200
Meters
N
W
E
S
Parasitism
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
P=3.5.228 (1/d²) + 0.04
R² = 0.97; F=342, df= 1,11; p < 0.0001
0 100 200 300 400 500 600
Distance

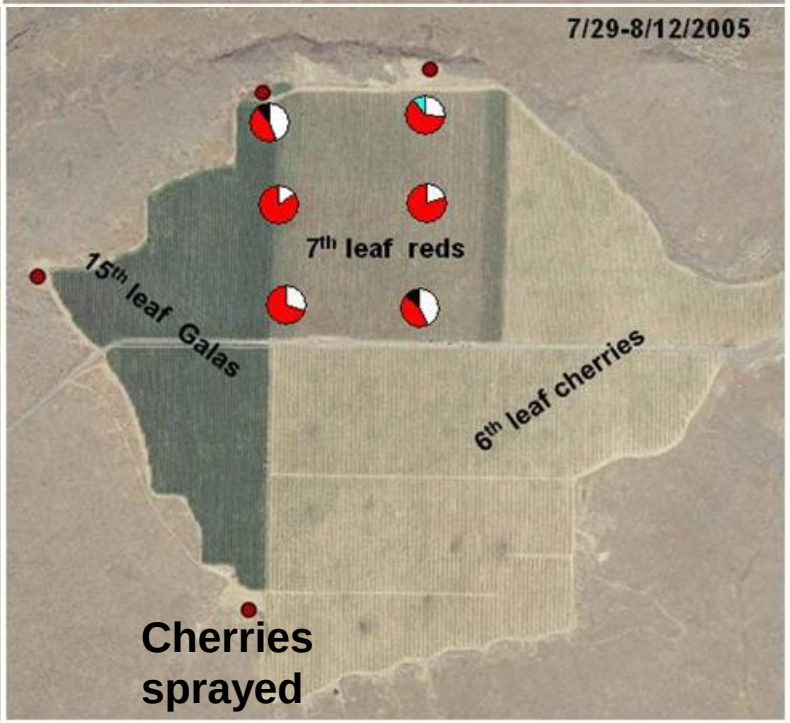

April 27 – May 29
0 100 200
Meters
N
W
E
S
W1
W2


N
W
E
S
July 10 - 24
0 100 200
Meters
W2

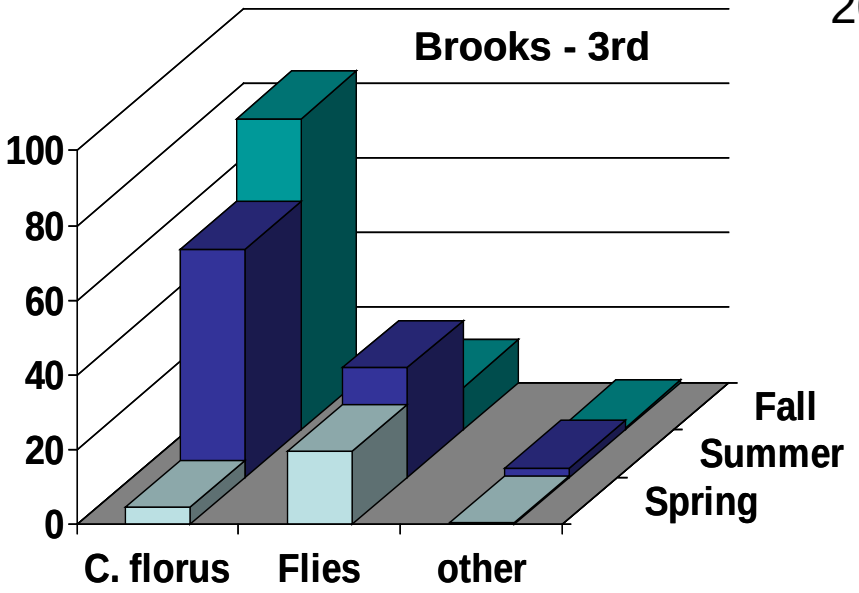

4/8-25/2005
7th leaf reds
15th leaf Galas
6th leaf cherries

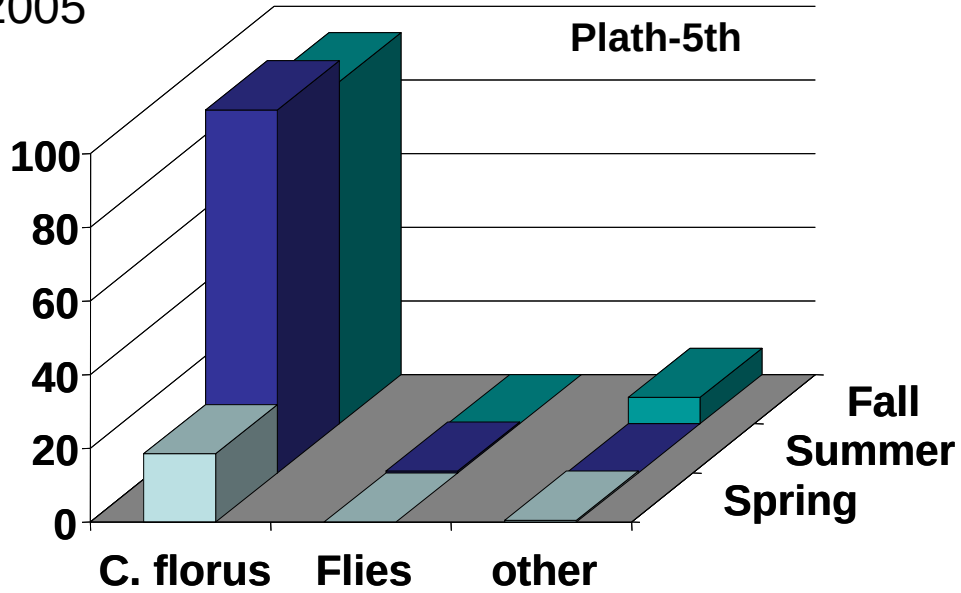
6/2-17/2005
7th leaf reds
15th leaf Galas
6th leaf cherries
Cherries sprayed

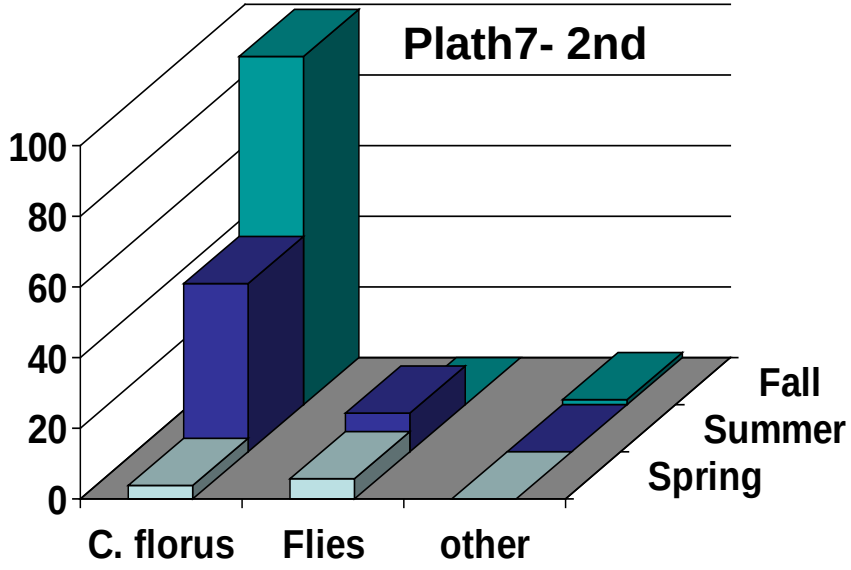

8/26-9/6/2005
7th leaf reds
15th leaf Galas
6th leaf cherries

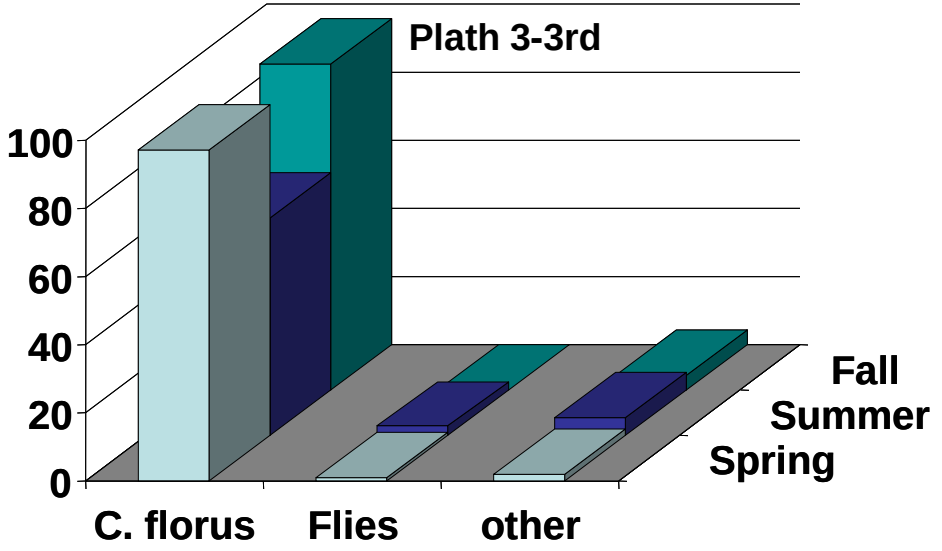

7/29-8/12/2005
7th leaf reds
15th leaf Galas
6th leaf cherries
Cherries sprayed

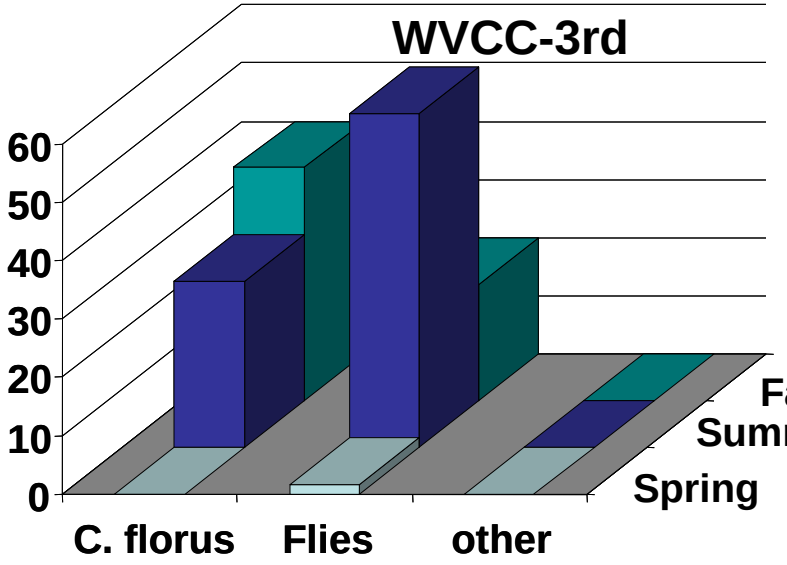
2005

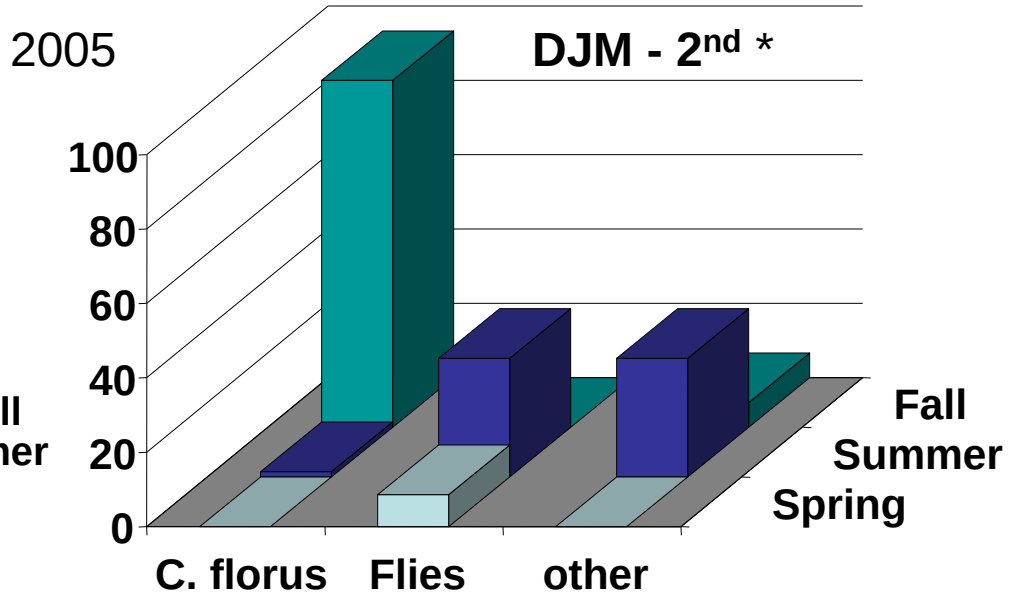

Brooks - 3rd
100
80
60
40
20
0
C. florus
Flies
other
Fall
Summer
Spring

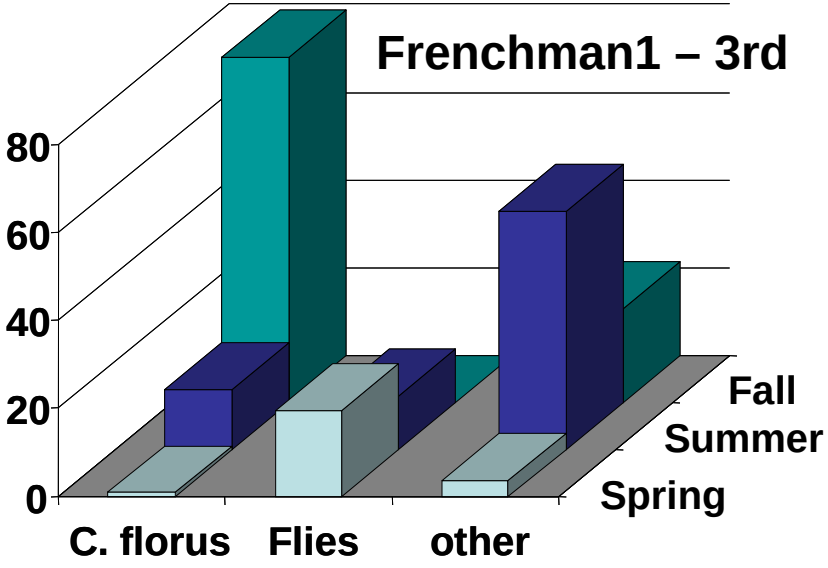

Plath-5th
100
80
60
40
20
0
C. florus
Flies
other
Fall
Summer
Spring

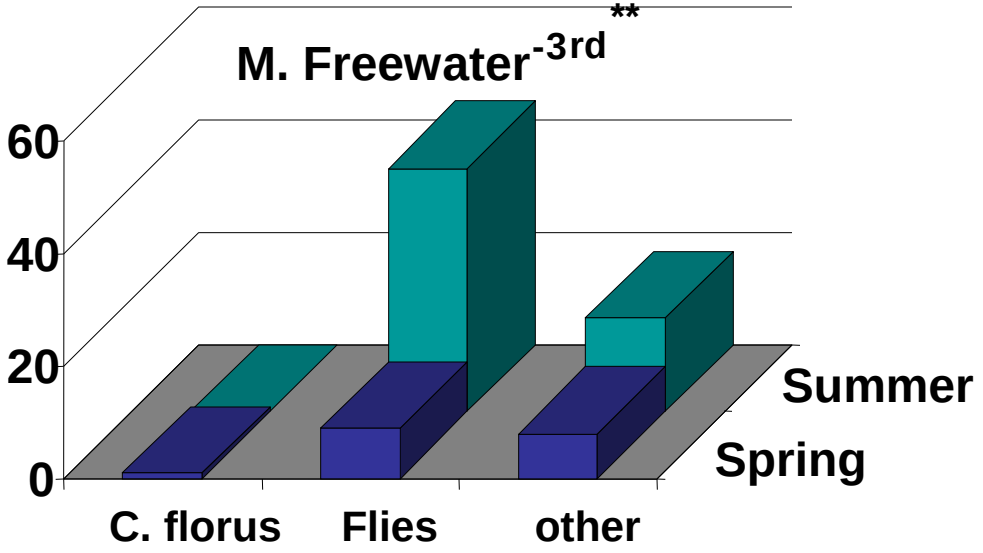

Plath7- 2nd
100
80
60
40
20
0
C. florus
Flies
other
Fall
Summer
Spring

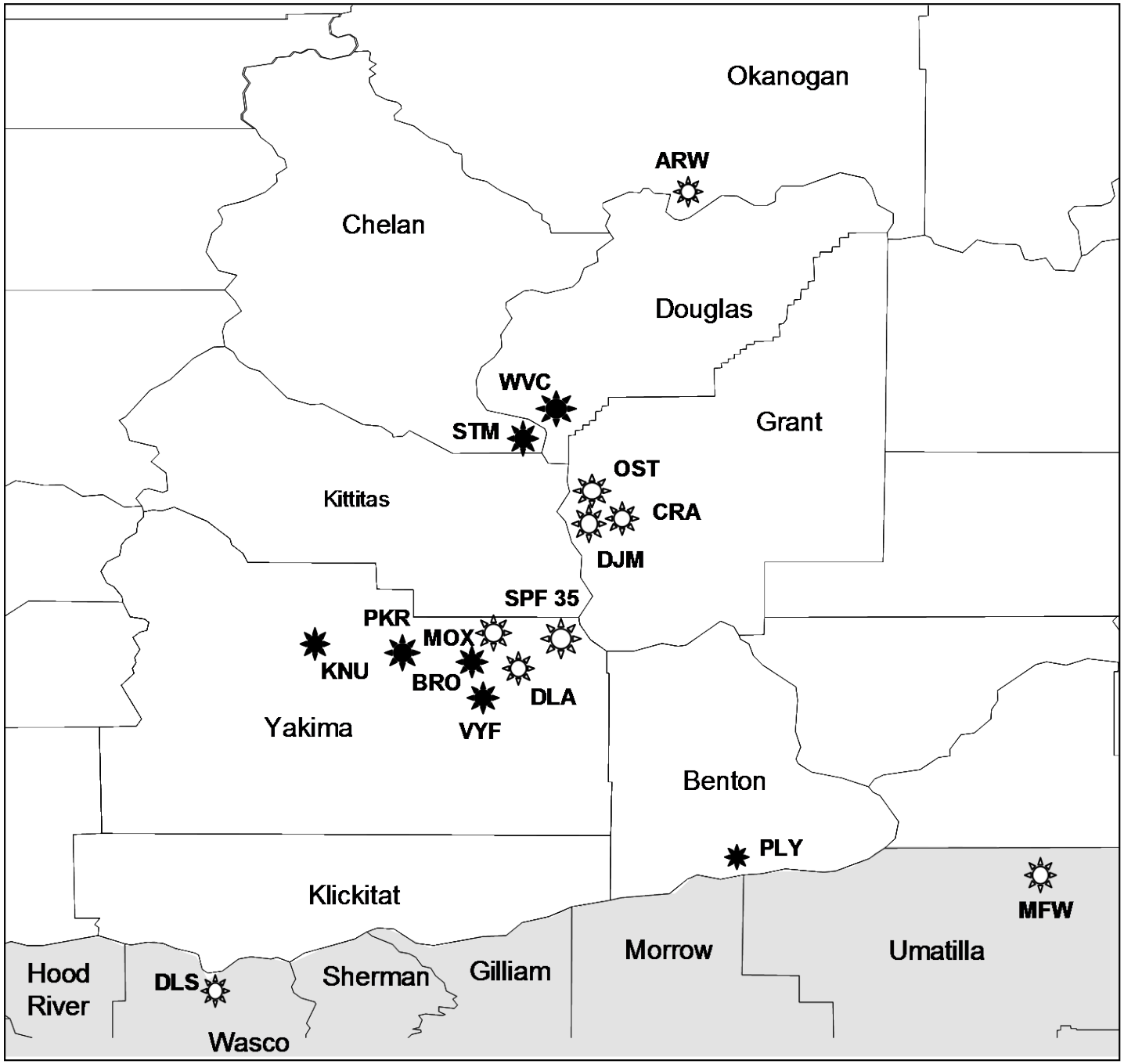

Plath 3-3rd
100
80
60
40
20
0
C. florus
Flies
other
Fall
Summer
Spring


WVCC-3rd
60
50
40
30
20
10
0
C. florus
Flies
other
Fall
Summer
Spring


2005
DJM - 2nd *
100
80
60
40
20
0
C. florus
Flies
other
Fall
Summer
Spring


Frenchman1 – 3rd
80
60
40
20
0
C. florus
Flies
other
Fall
Summer
Spring

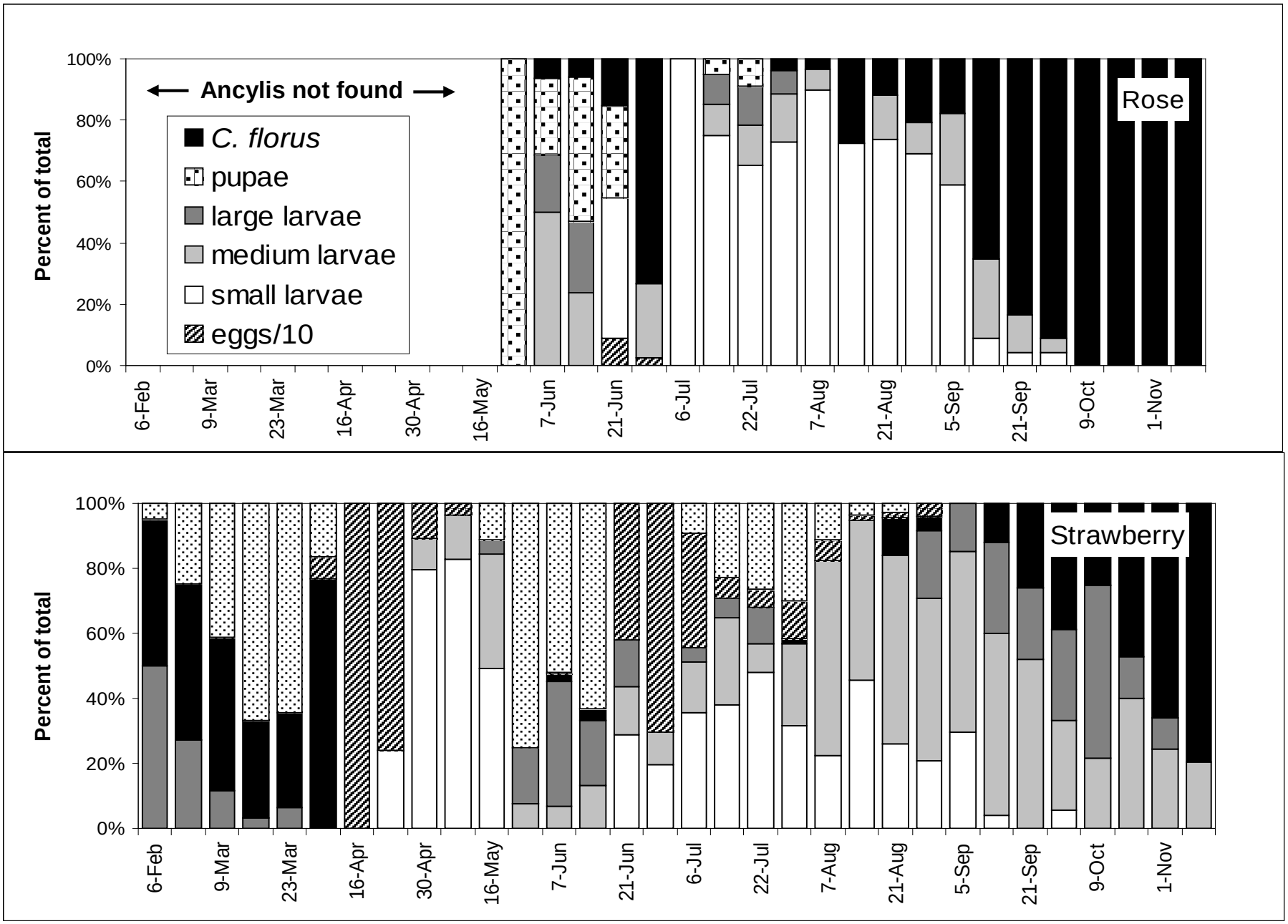

M. Freewater -3rd **
60
40
20
0
C. florus
Flies
other
Summer
Spring


Okanogan
ARW
Chelan
Douglas
WVC
STM
Grant
OST
Kittitas
CRA
DJM
SPF 35
PKR
MOX
KNU
BRO
DLA
VYF
Yakima
Benton
PLY
Klickitat
MFW
Morrow
Umatilla
Hood River
DLS
Sherman
Gilliam
Wasco

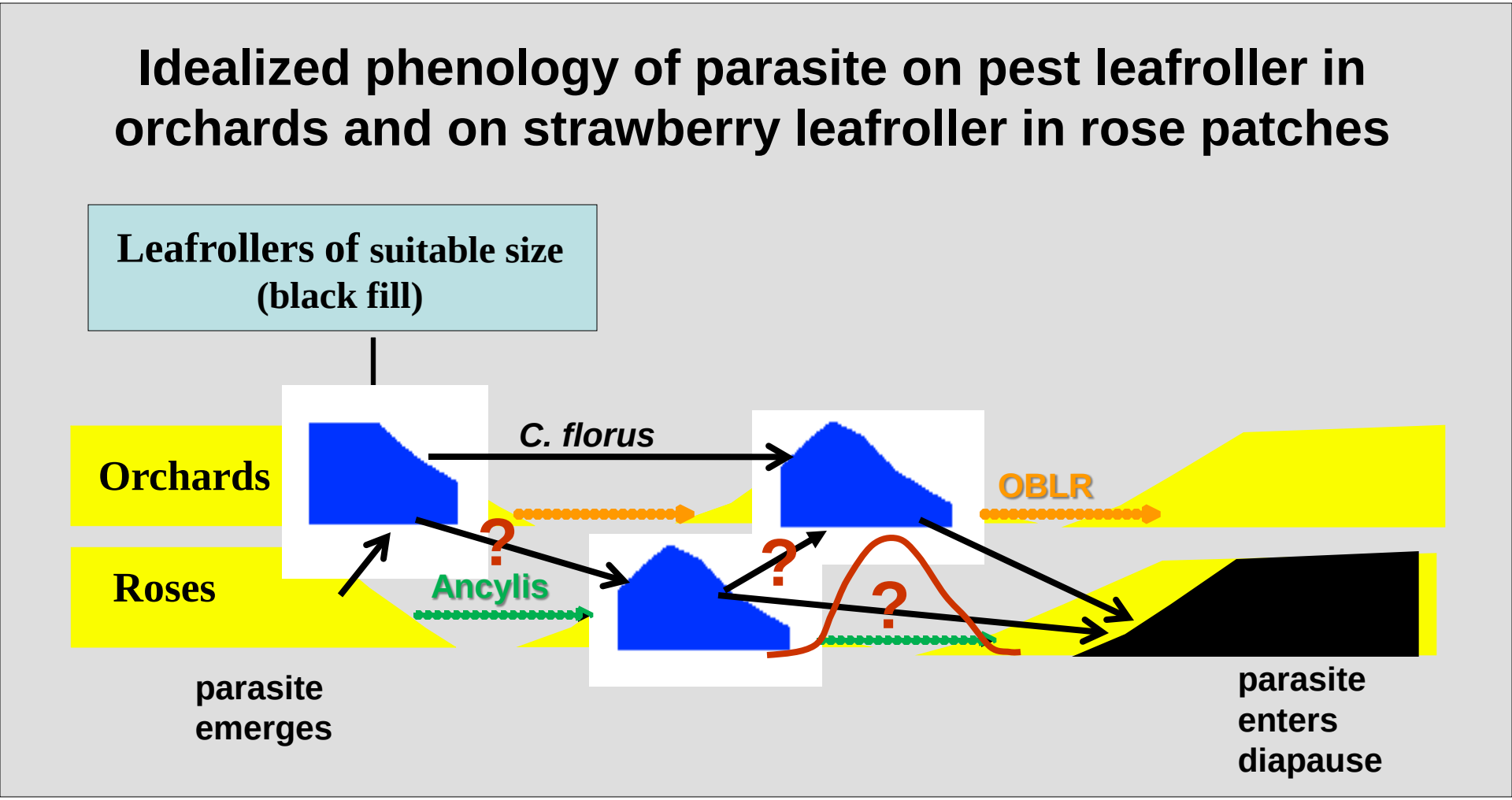
Planted garden effect - summary

- Adding and infesting rose/strawberry gardens with *A. comptana* increased parasitism by *C. florus* of pest leafrollers adjacent to 3 of the 4 gardens planted in late 2000
- Parasitism by *C. florus* continued to be observed near garden areas through 2006
- Growers planted gardens throughout Washington in consultation with me and continue to do so on their own

So what is happening in the gardens?
How well can they serve this role of provisioning wasps to control leafrollers in orchards?


Rose
Strawberry
Percent of total
100%
80%
60%
40%
20%
0%
Ancylis not found
C. florus
pupae
large larvae
medium larvae
small larvae
eggs/10
6-Feb
9-Mar
23-Mar
16-Apr
30-Apr
16-May
7-Jun
21-Jun
6-Jul
22-Jul
7-Aug
21-Aug
5-Sep
21-Sep
9-Oct
1-Nov

If a garden is only roses it is likely there will be 2 or more generations of *Ancylis* depending on exposure. *Ancylis* on roses are attacked by *C florus* in June but not in strawberries probably due to the height preference of *C. florus*. This and very high parasitism in roses suggests both roses and strawberries should be used in gardens



Conclusions rose gardens

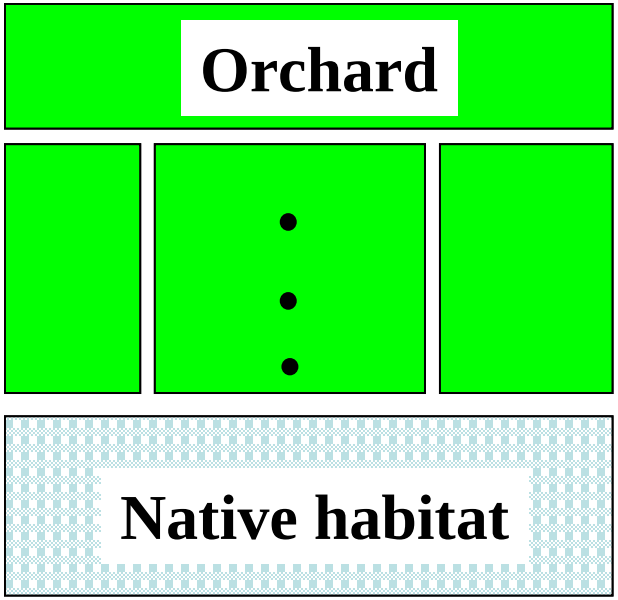
- Parasitism by *C. florus* can often be enhanced by establishing rose/strawberry gardens that support *Ancylis comptana*
- Relatively small gardens can have a large effect
- Understanding how to make this alternate host persist is one key to success

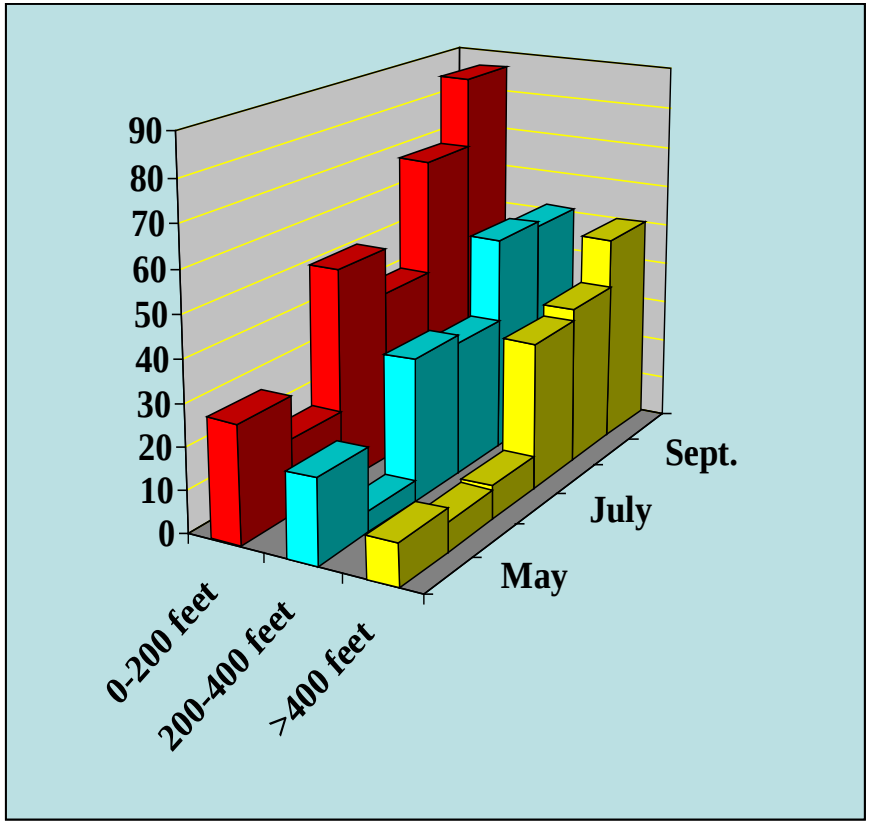
Growers continue to plant gardens on their own

  - Over 50 in the last 5 years

- Both roses and strawberries should be used and separated from one another
- Other plants may support overwintering hosts of other leafroller parasitoids, such as the tachinid complex

Colonization of orchards: Distance effects



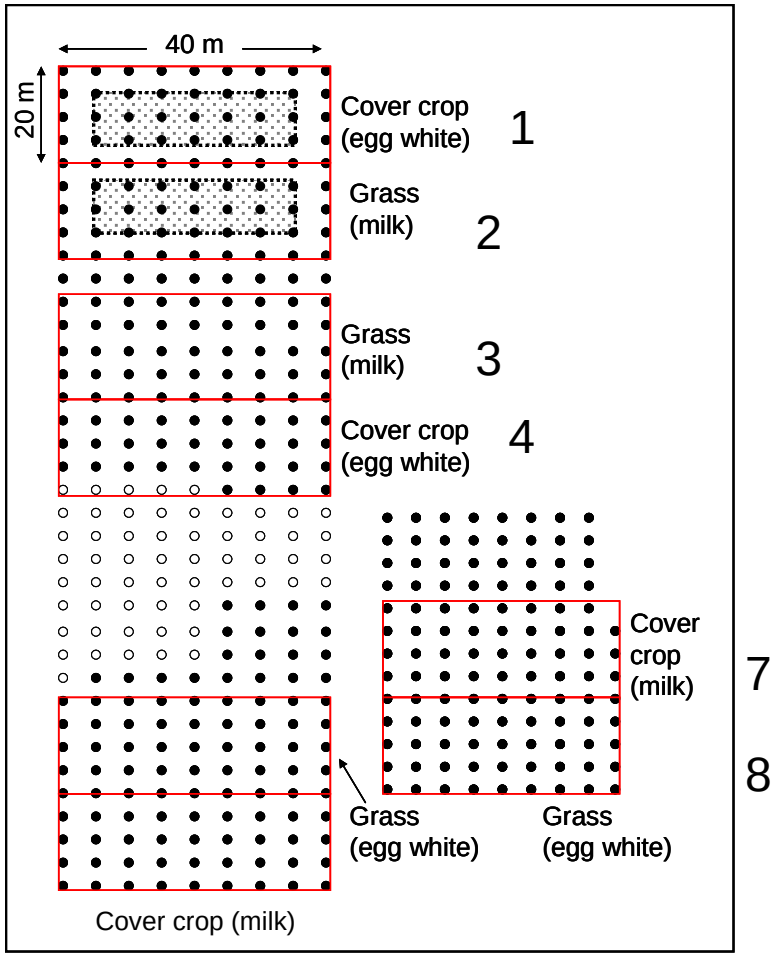


Quantifying biological control of pear psylla in a cover crop system

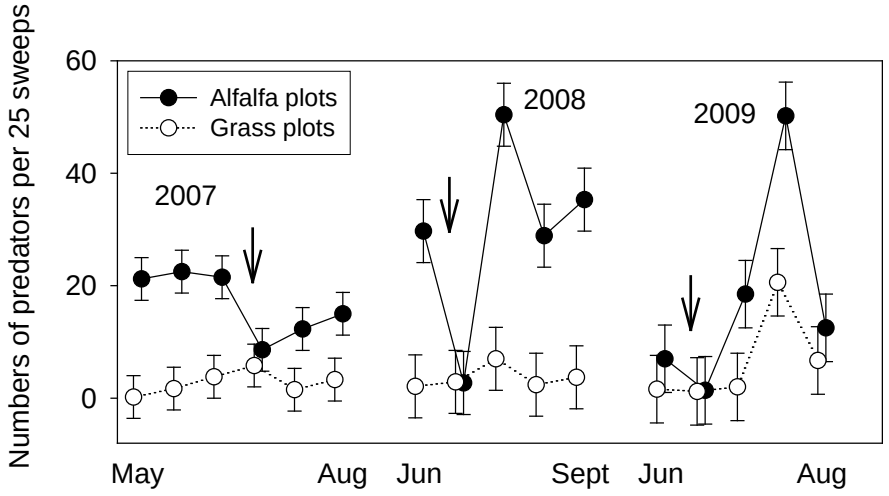
David Horton, Tom Unruh, Vince Jones

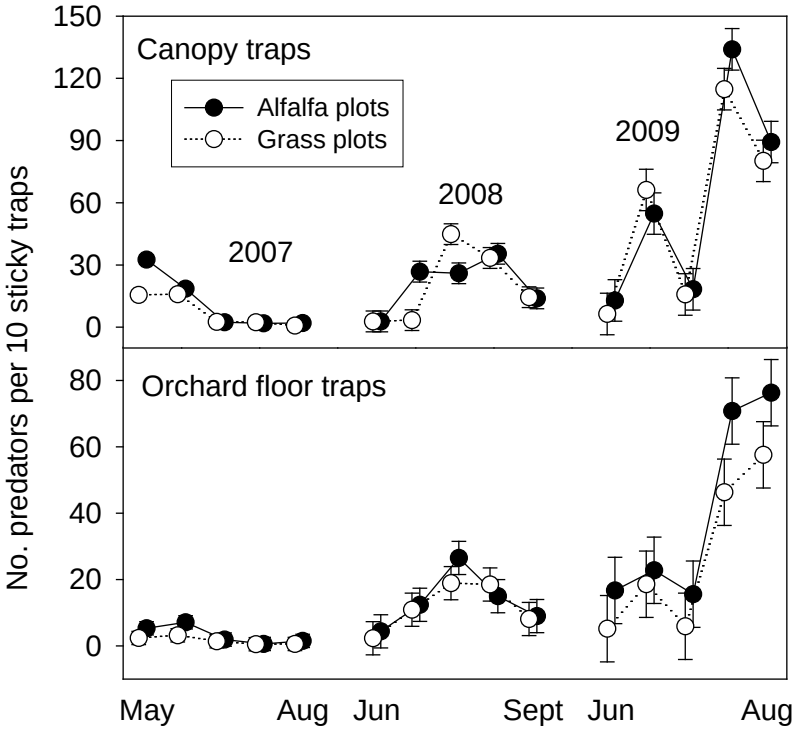
1. Test whether an alfalfa cover crop leads to improved biological control of pear psylla
2. Estimate movement rates of predators from alfalfa into tree canopy
3. Determine whether switch in habitat accompanied by switch in diet to attack target pest (psylla)
4. Determine whether cover crop leads to increased levels foliar nitrogen in pear trees

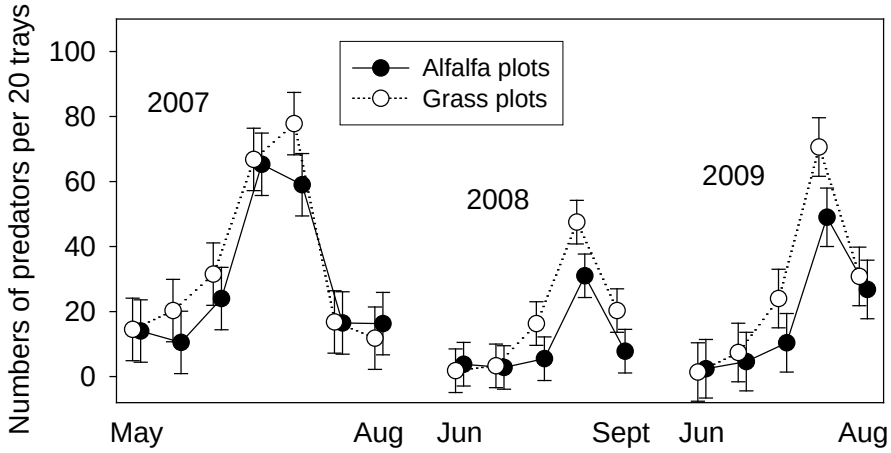
Moxee site


40 m
20 m
Cover crop
(egg white)
1
Grass
(milk)
2
Grass
(milk)
3
Cover crop
(egg white)
4
Cover
crop
(milk)
7
5
8
6
Grass
(egg white)
Grass
(egg white)
Cover crop (milk)

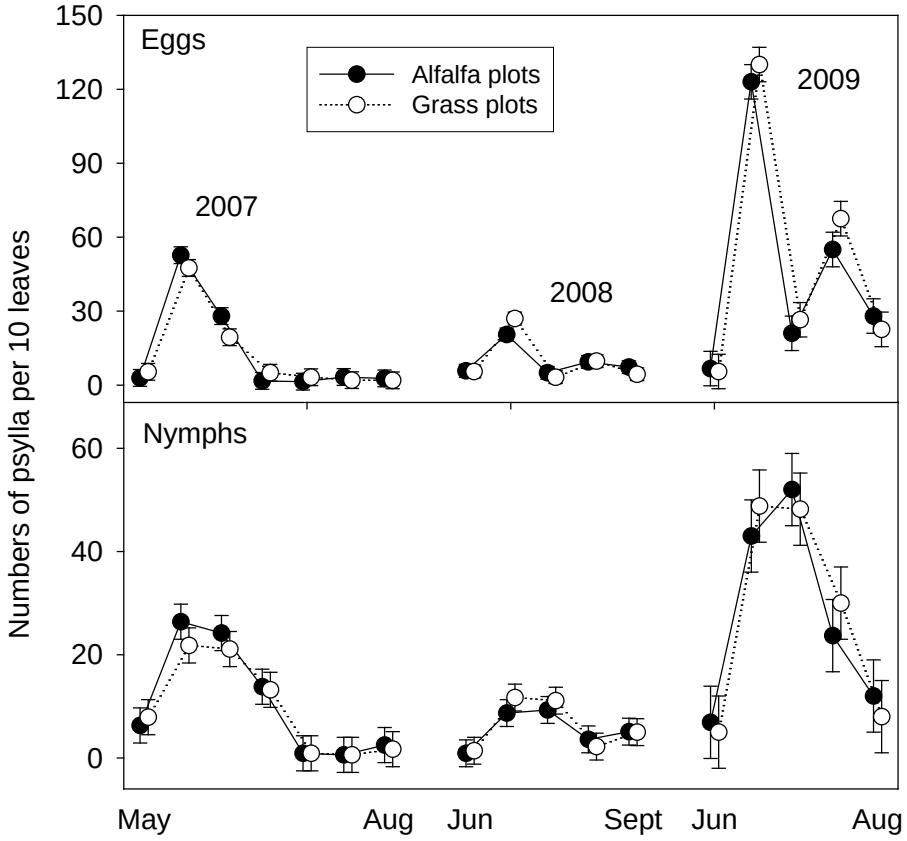
Predator counts

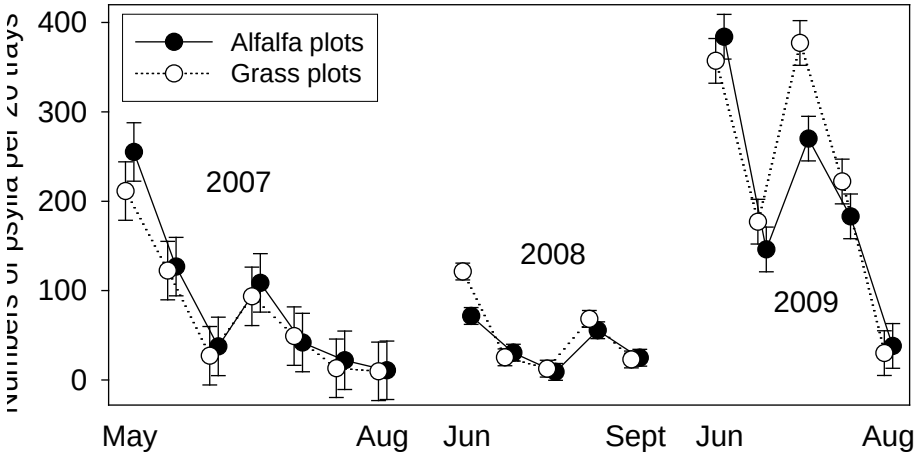






Psylla numbers

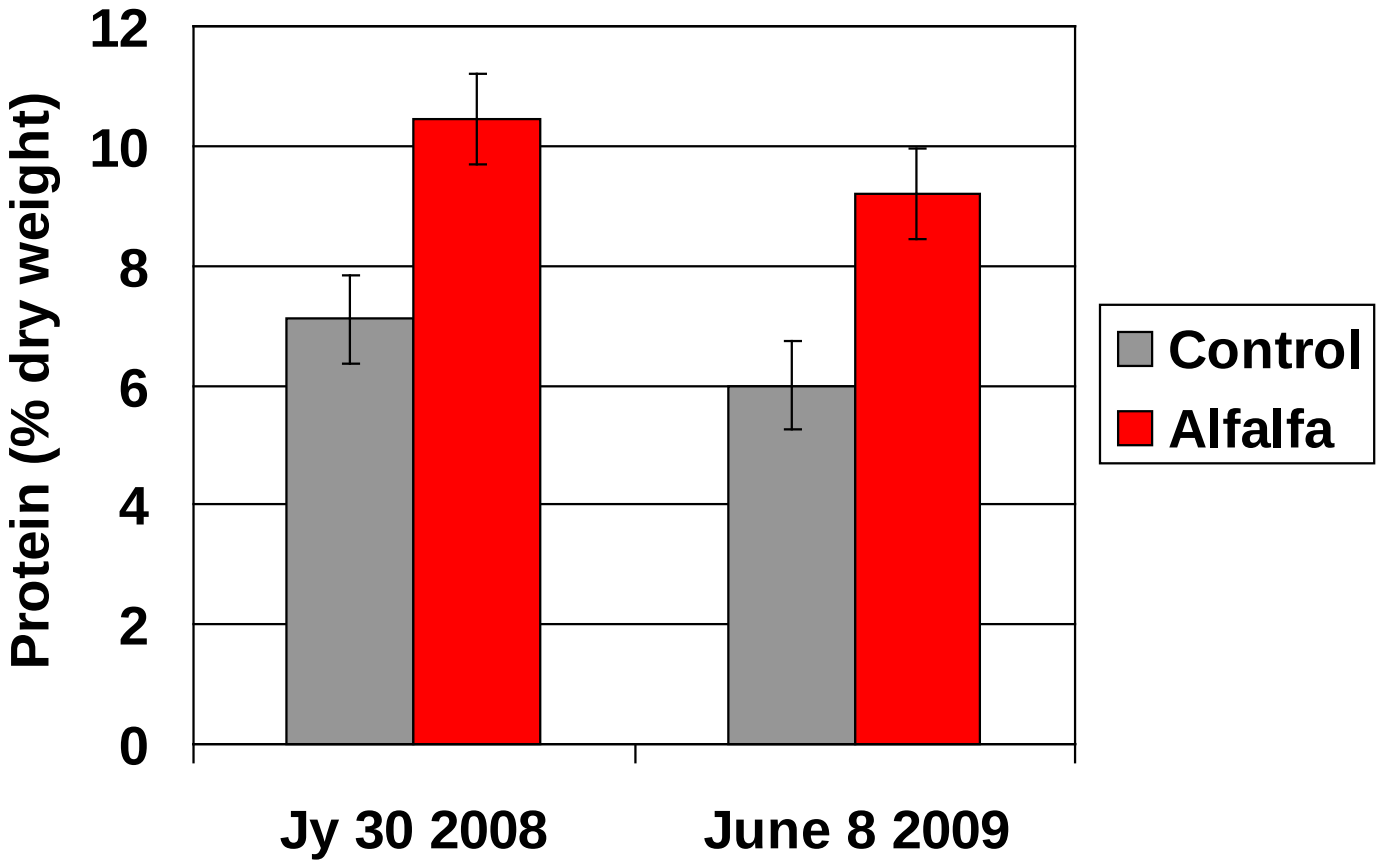




Movement studies (Captured in trees)

	June 2009		August 2009	
	Alfalfa	Control	Alfalfa	Control
TRUE BUGS				
Anthocoris	1/28 (3.6)	0/8 (0)	4/71 (5.6)	8/101 (7.9)
Deraeocoris	5/127 (3.9)	0/93 (0)	12/85 (14.1)	4/81 (4.9)
Orius	0/4 (0)	0/5 (0)	0/2 (0)	0/3 (0)
Nabis	--	--	1/1 (100)	--
TOTAL	6/159 (3.8)	0/106 (0)	17/159 (10.7)	12/185 (6.5)
LACEWINGS				
Hemerobius	0/1 (0)	0/1 (0)	0/1 (0)	--
Eremochrysa	4/31 (12.9)	5/23 (21.7)	18/48 (37.5)	5/16 (31.3)
C. plorabunda	6/17 (35.3)	1/17 (5.9)	5/35 (14.3)	5/14 (35.7)
C. nigricornis	1/1 (100)	0/3 (0)	5/23 (21.7)	0/3 (0)
C. coloradensis	0/1 (0)	1/10 (10.0)	--	--
TOTAL	11/51 (21.6)	7/54(13.0)	28/107 (26.2)	10/33 (30.3)
LADYBIRD BEETLES				
Hippodamia	0/1 (0)	0/1 (0)	6/27 (22.2)	8/42 (19.0)
Stethorus	0/2 (0)	0/1 (0)	1/5 (20.0)	0/12 (0)
C. transversoguttata	--	0/1 (0)	--	--
Harmonia	--	--	2/6 (33.3)	3/17 (17.6)
Chilocorus	--	--	0/1 (0)	1/6 (16.7)
Hyperaspis	--	--	14/65 (21.5)	0/5 (0)
C. septempunctata	--	--	2/8 (25.0)	1/6 (16.7)
unknown	--	--	0/1 (0)	0/4 (0)
TOTAL	0/3 (0)	0/3 (0)	25/113 (22.1)	13/102 (12.7)
SPIDERS	11/99 (11.1)	1/76 (1.3)	5/84 (5.9)	5/68 (7.4)

Leaf nitrogen results



Speculation: why no effects on psylla densities?

- *Deraeocoris* and *Anthocoris* (tree dwellers) blur effects of other species
- Species shown to move from alfalfa to tree may not be psylla predators (ELISA)

species	N	species	%comm
Anthocoris	591	75.3%	15.1%
BLW	24	66.7%	0.5%
Deraeocoris	777	65.3%	17.2%
Forficula	37	10.8%	0.1%
Eremochrysa	158	14.6%	0.8%
Chrysop	125	64.0%	2.7%
Geo	1	0.0%	0.0%
Coccinelids	300	41.5%	4.2%
Lygus	12	8.3%	0.0%
Nabid	1	0.0%	0.0%
Orius	16	75.0%	0.4%
Spider	891	26.9%	8.1%
Steth	21	9.5%	0.1%
	2654		49.2%

General conclusions: ground cover

Alfalfa cover crop leads to improved biological control of pear psylla? NO!

Movement rates of predators from alfalfa into tree canopy? Very modest!

Change in habitat associated with change in diet (from aphid on ground to psylla in trees)

Cover crop leads to increased levels foliar nitrogen in pear trees? Yes!!!

What other systems should we use?

Control of other 2nd pests may be enhanced by putting other riparian habitat plants adjacent to our orchards

- Aphid complex, pear psylla, mealybug, and again leafrollers
- Ground cover failure don't forget predator behavior

- Other simple plant/insect communities or habitats may also enhance our pollinators
  - Pollinators>>>>>Gene
- Which plants should we avoid?
  - Hosts of apple maggot, cherry fruitfly, spotted wing Drosophila, others