Who's eating who?

Evaluating predators and parasitoids and the influence of the farm-scape using protein-marking and gut content analysis

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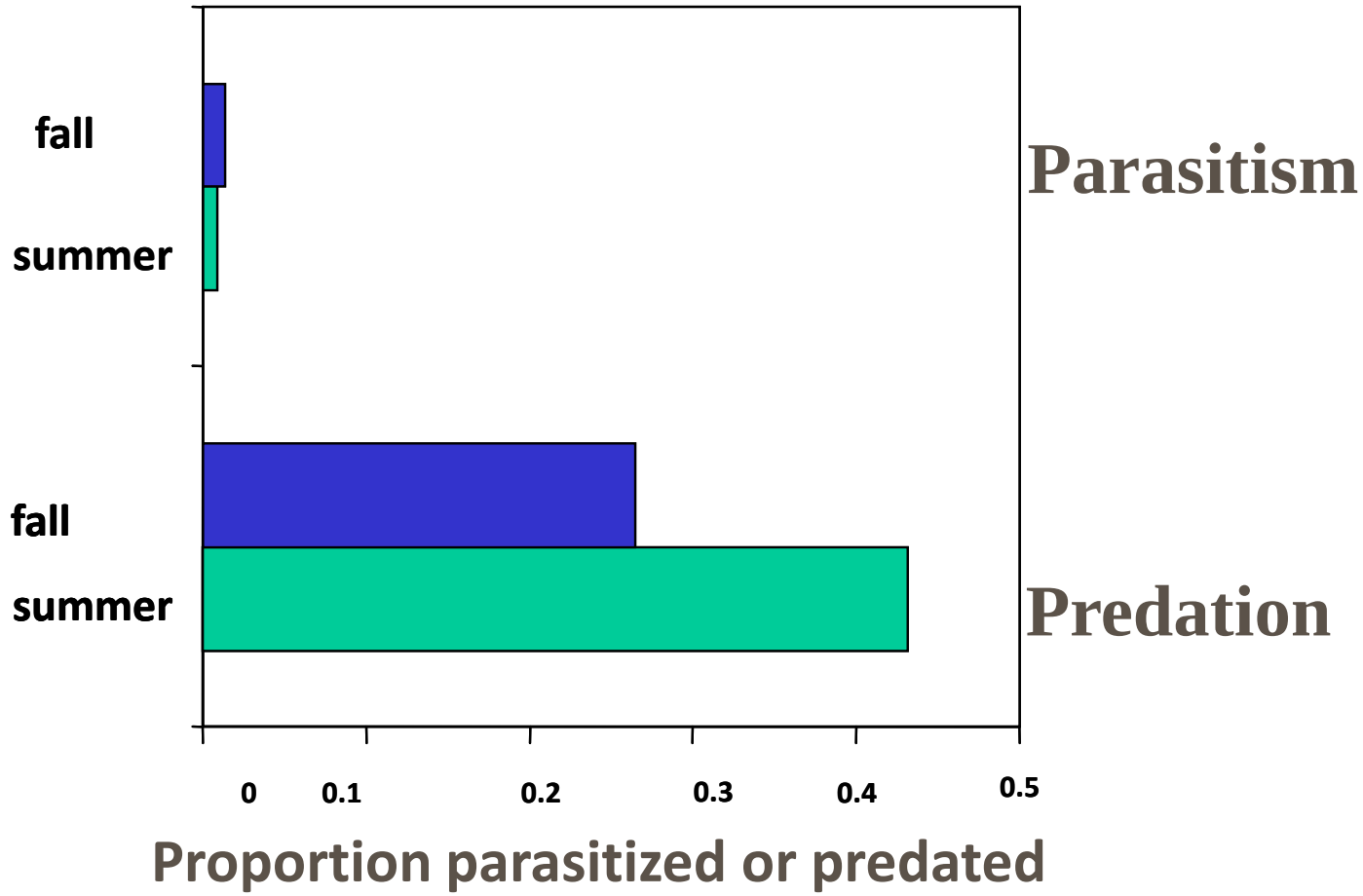
Outline

- Predators of codling moth, psylla, aphids: what little we know
  - **Canopy residents –or- opportunists from groundcovers**
    - **Do opportunists do much good?**
  - **Overwinter in orchard –or- colonize in spring from outside**
    - **What proportion of each predator species overwinter in orchards?**
  - **Periods of activity**
    - **What is timing of appearance and activity in orchards?**
- How do we tell?
  - 1. *Detailed sampling studies for phenology and position*
  - 2. **Marking to demonstrate inter-habitat movements**
  - 3. **Gut content analysis to demonstrate use of key prey**
- Speculate how we can evaluate and enhance resource services in the farm-scape with these tools
  - **Sources of predators, parasitoids, and pollinators**

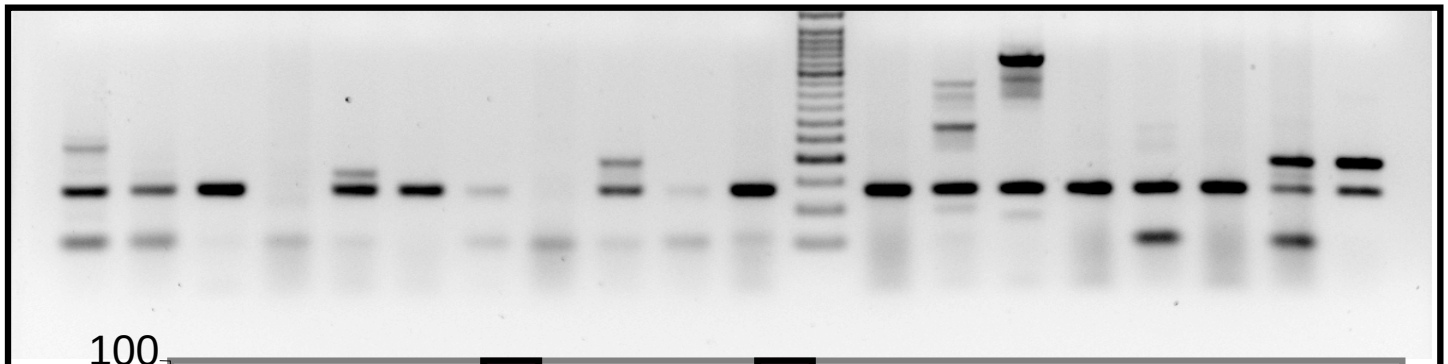
Predation and parasitism of cocooned codling moth larvae in several commercial orchards

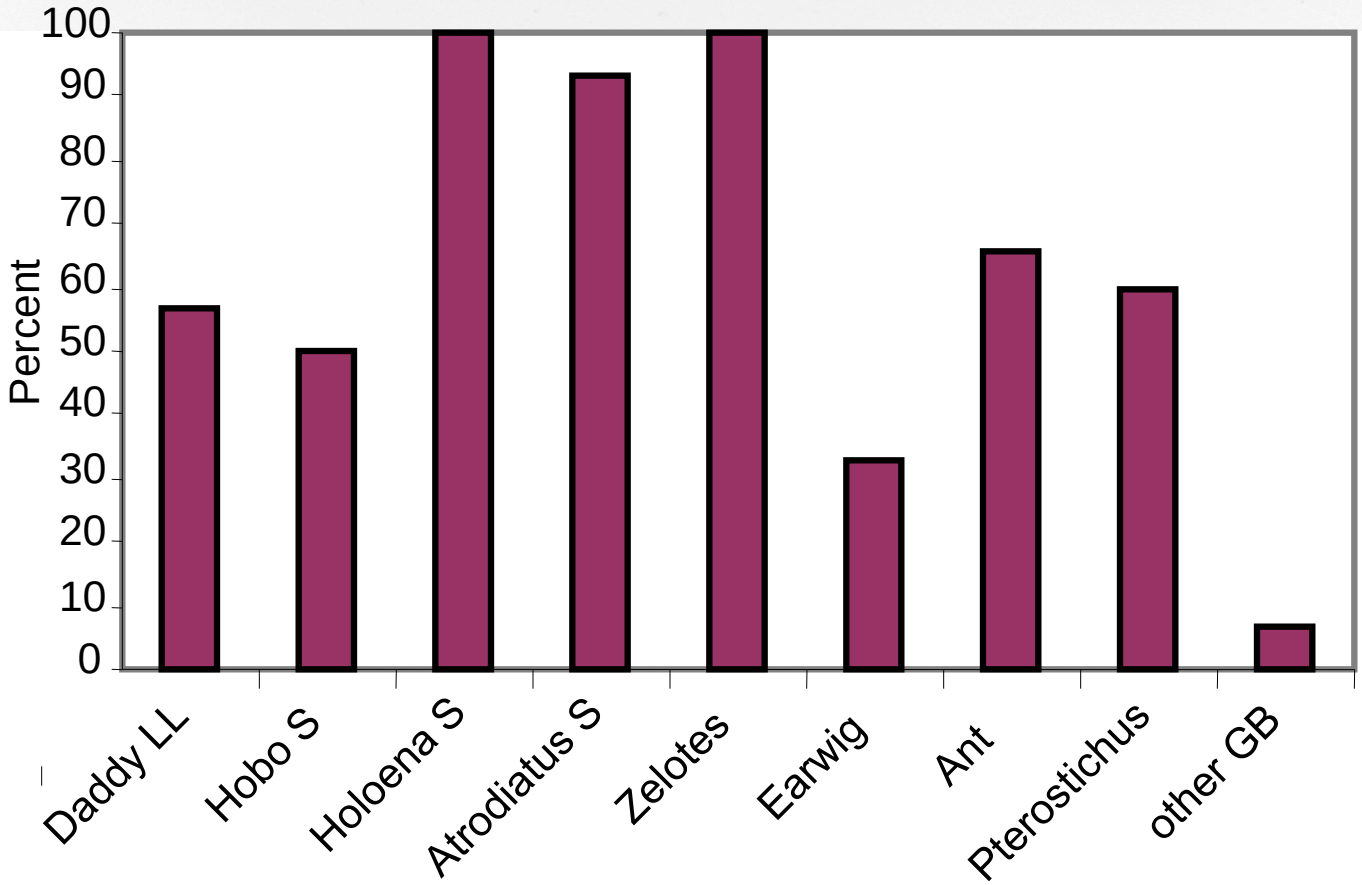


Predators and parasitoids of CM in literature

Its low density & cryptic life makes predation studies truly challenging

	effective habitat	phenology	Stage attacked
Birds	Canopy & ground	S S F	L. mobile larvae in and out of fruit and cocoons
rodents	ground	S S F	L. mobile larvae -- cocoons
ground beetles	ground	S S F	L. mobile larvae -- cocoons?
Sm. bugs	canopy	? S F	Eggs, s. larvae
Lrg. bugs	C & ?	? S F	l. larvae
ants	C & G	S S F	All imm stages outside of fruit
earwigs	C & ?	? S F	All imm stages outside of fruit
spiders	C & ?	? S F	All stages outside of fruit
Ascogaster	C	S S	egg
Mastrus	C & G	S ? F	Cocooned larvae





Percentage positive for Cm in late summer

Habitat manipulations

Understory plants in orchards (examples)

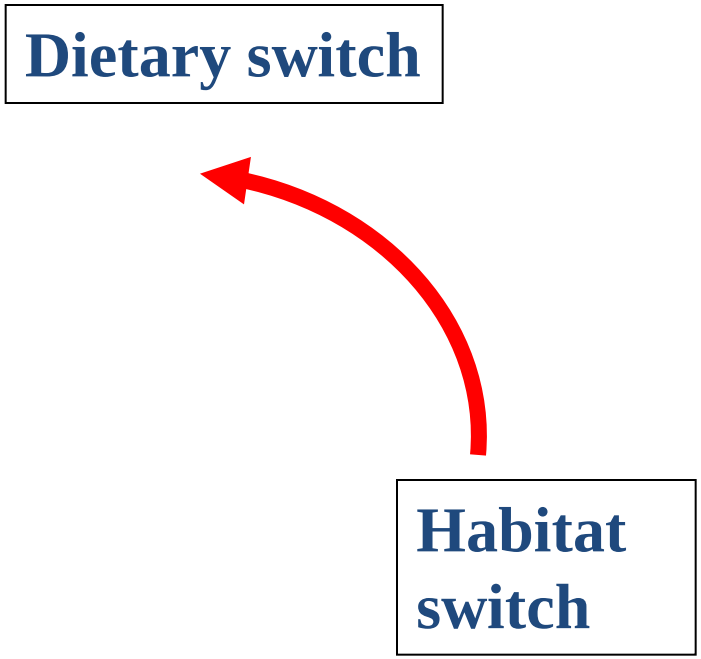
- **Pecans (GA): pecan aphid and convergent ladybeetle (cover crop of hairy vetch) - - increased numbers of ladybeetle in canopy**

  Tedders (1983)

- **Citrus (China): citrus red mite and predatory mites (conservation of weed *Ageratum*) - - used on 135,000 ha of citrus**

  Liang and Huang (1994)

It seems logical



Pest control benefits rarely shown conclusively

- **Poorly designed studies (replication)**
- **Pest data often not taken**
- **Poor understanding of habitat and dietary switching**

Can habitat switching of predators from groundcover into trees improve psylla control in pears?

- Often inferred from presence in both habitats

Mostly tree canopy

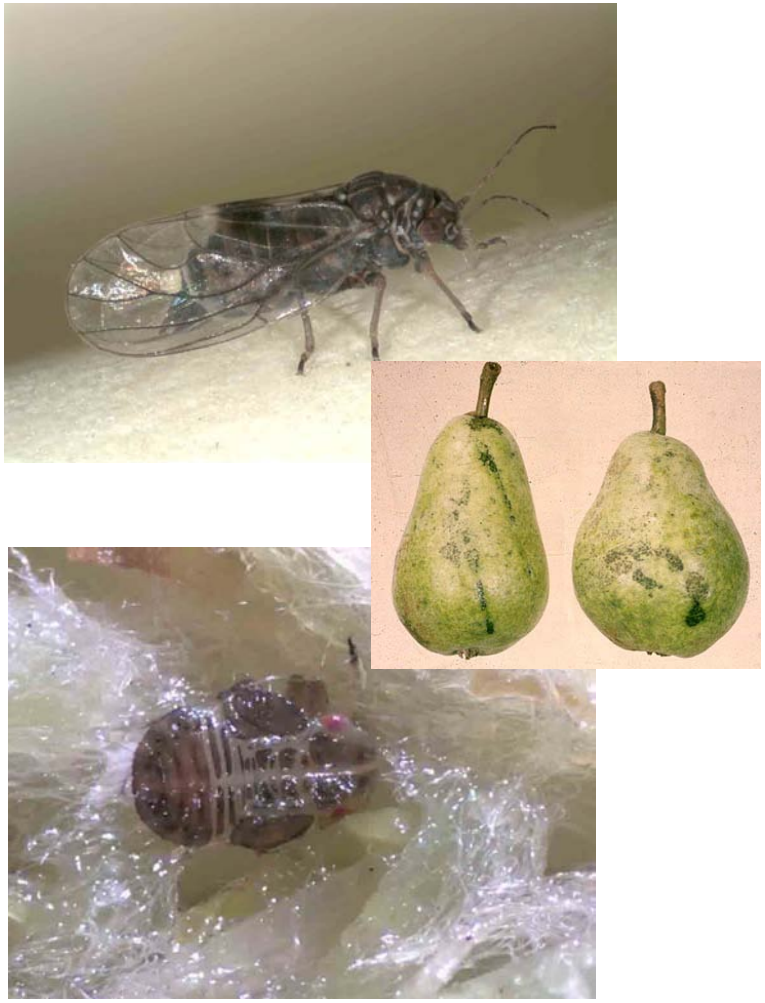
Tree canopy and ground cover

Mostly ground cover

Objectives

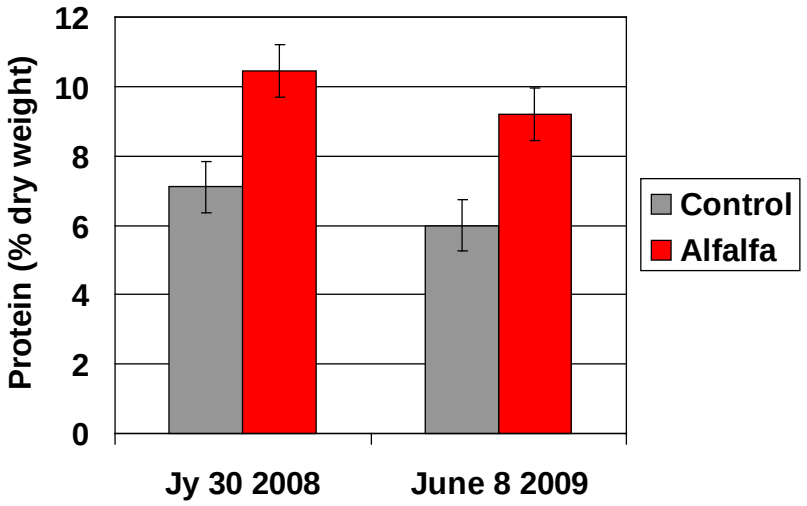
Horton, Jones and Unruh

- Can we use a cover crop to improve biological control of a difficult pest in pears?
- Organic pears: nitrogen problems (legume cover crop?)
  - Tradeoff: psylla loves N

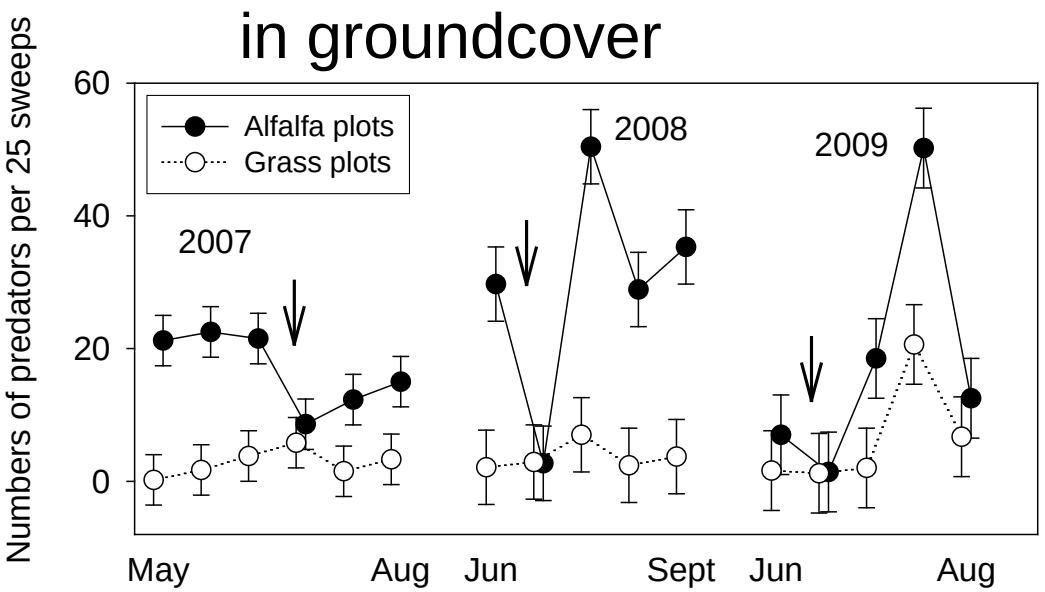


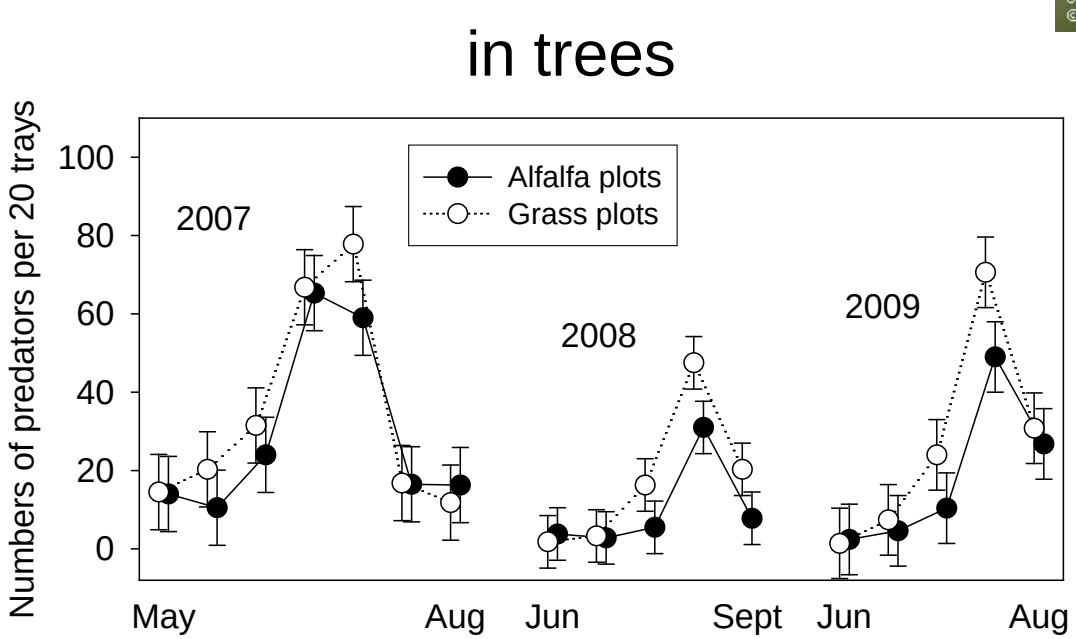
Methods

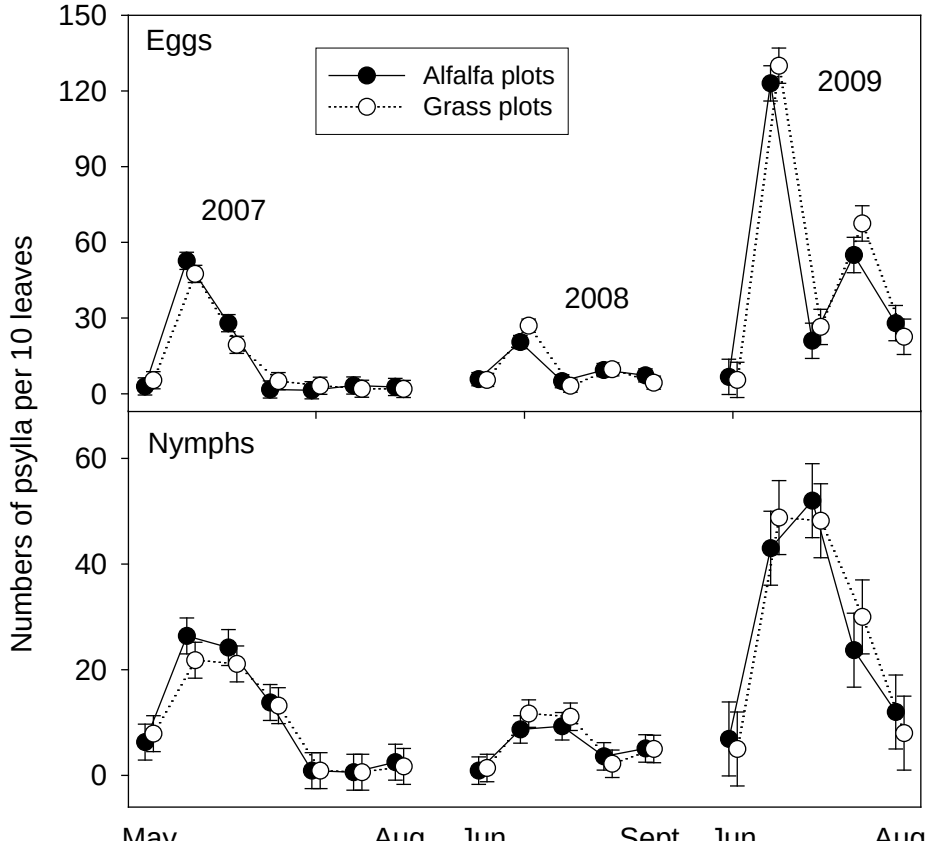
- Four orchards
  - 1 “experimental”; 3 commercial organic
  - Alfalfa cover crop
- Monitored psylla densities and predator densities
  - Sweep nets, beat trays, leaf samples
- Nitrogen levels in pear foliage
- Movement (marker)
- Diet (gut contents)

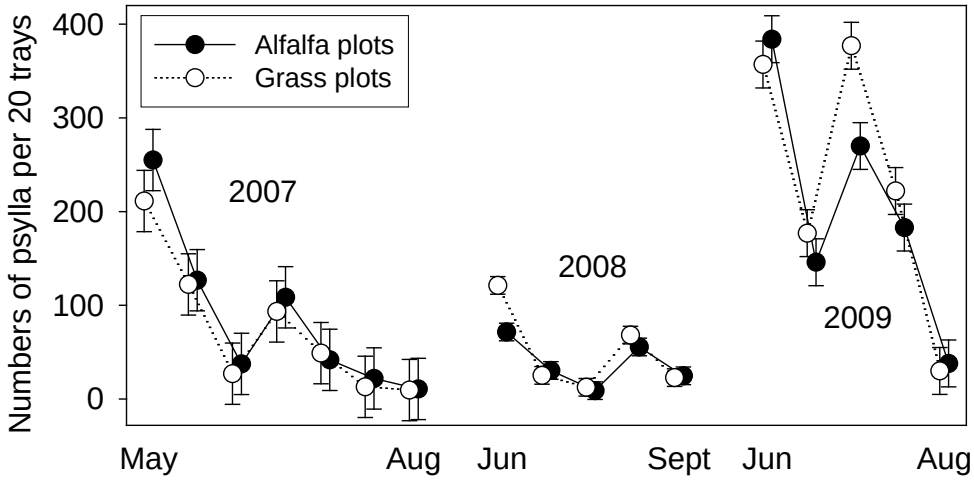


Predator counts









Psylla numbers

The point is there are little almost no differences in pest density

New technology

New marker technology for monitoring movement

(Jones et al. 2006, Horton et al. 2008, Hagler et al. 2010)

Table 3. Percentage of insects from cover crop and tree habitats found to be carrying the marker, 2005 and 2006 data combined

	Cover crop		Tree	
TAXON	N	% positive	N	% positive
HETEROPTERA	1287	93.6	465	19.6
Anthocoris tomentosus	11	100.0	121	31.4
Deraeocoris brevis	60	96.7	326	15.0
Orius tristicolor	867	95.0	10	20.0
Nabis sp.	55	100.0	4	25.0
Geocoris spp.	294	87.1	4	25.0
CHRYSOPIDAE	31	90.3	109	11.9
Chrysoperla plorabunda	15	93.3	57	12.3
Eremochrysa sp.	7	85.7	47	10.6
Chrysopa nigricornis	0	--	3	33.3
Chrysopa oculata	8	87.5	0	--
Chrysopa coloradensis	1	100.0	2	0.0
COCCINELLIDAE	120	99.2	83	8.4
Hippodamia convergens	74	98.6	5	20.0
Coccinella transversoguttata	15	100.0	10	10.0
Coccinella septempunctata	21	100.0	26	7.7
Hyperaspis *lateralis*	10	100.0	7	0.0
Harmonia axyridis	0	--	35	8.6
TOTAL	1438	93.9	657	16.9

Adult insects only were assayed (tree and cover crop specimens); data for immature insects are provided in Table 4. N = numbers assayed.

Habitat switching?

(# marked in ground cover / # examined from tree)

	Preference for tree	Preference for cover crop	Habitat generalist
Anthocoris	13/208 (6.3%)		
Deraeocoris	21/386 (5.4%)		
C. nigricornis	6/30 (20.0%)		
Harmonia	5/23 (21.7%)		
Orius		0/6 (0%)	
Nabis		1/1 (100%)	
Hippodamia		14/71 (19.7%)	
Eremochrysa			32/118 (27.1%)
C. plorabunda			17/83 (20.5%)
C. coloradensis			1/11 (9.1%)
Hyperaspis			14/70 (20.0%)
C. septempunctata			3/14 (21.4%)
TOTALS	45/645 (7.0%)	15/86 (17.4%)	67/297 (22.6%)

(2) What about dietary switching?

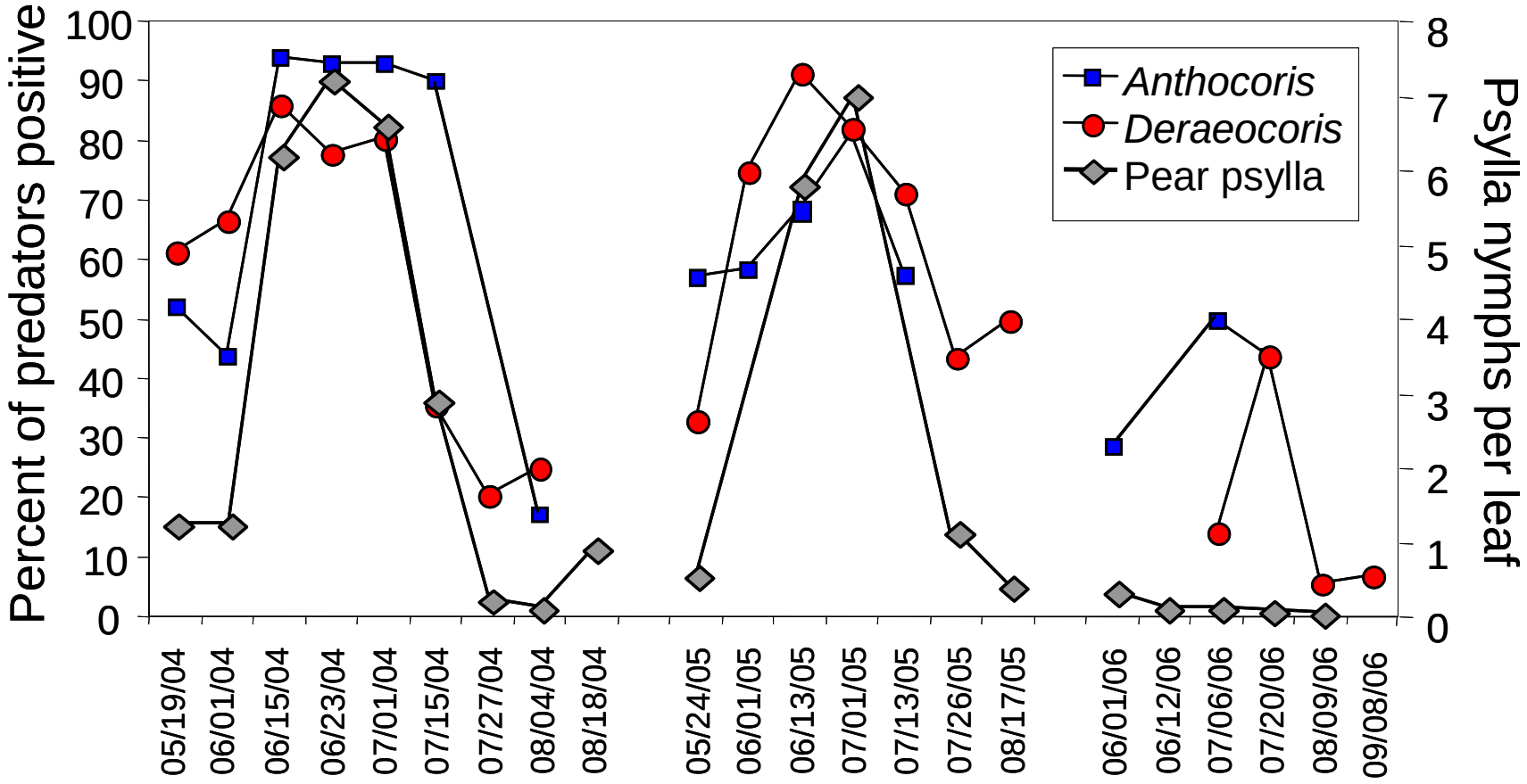
- "Generalist" predators: how generalized?
  - Laboratory trials unlikely to reflect field behavior

- Predators eat the evidence (thus, difficult to quantify diets in field)

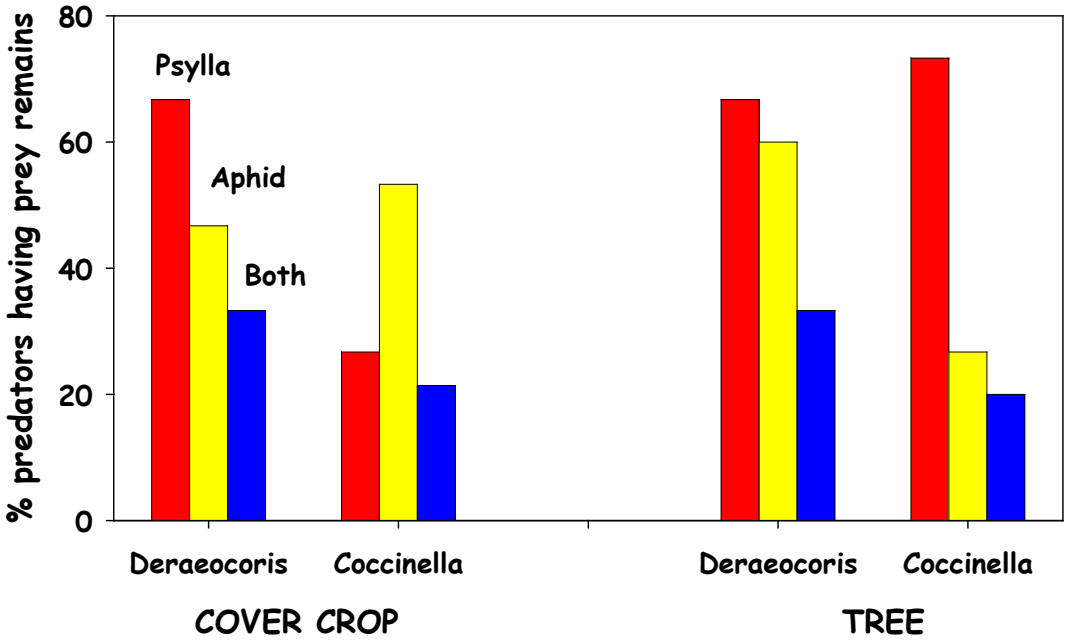
New technology

Molecular methods for assessing gut contents of predators: psylla and pea aphid

(Unruh et al. 2008 & unpubl.)

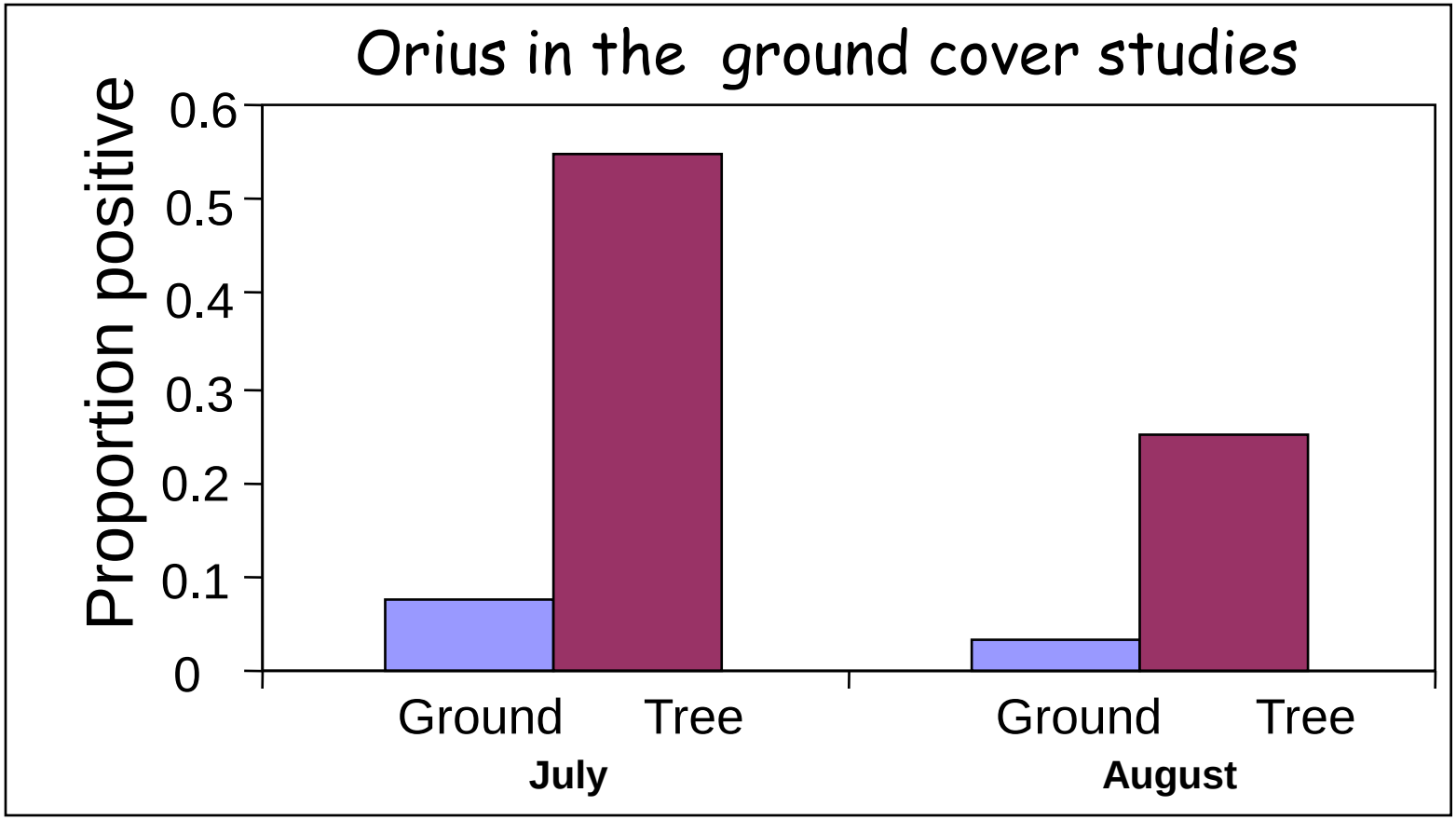


Dietary switching?



Deraeocoris is frequently moving between tree and ground

C7 is moving less, switching to dominant prey, and maybe digesting more rapidly


Orius in the ground cover studies
Proportion positive
0.6
0.5
0.4
0.3
0.2
0.1
0
Ground
Tree
Ground
Tree
July
August

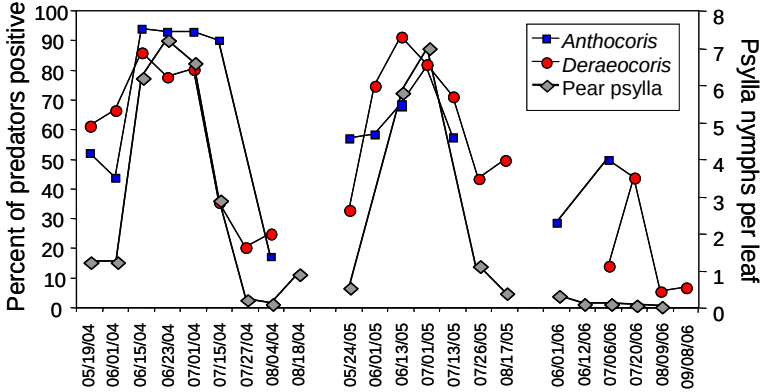
Summary of results

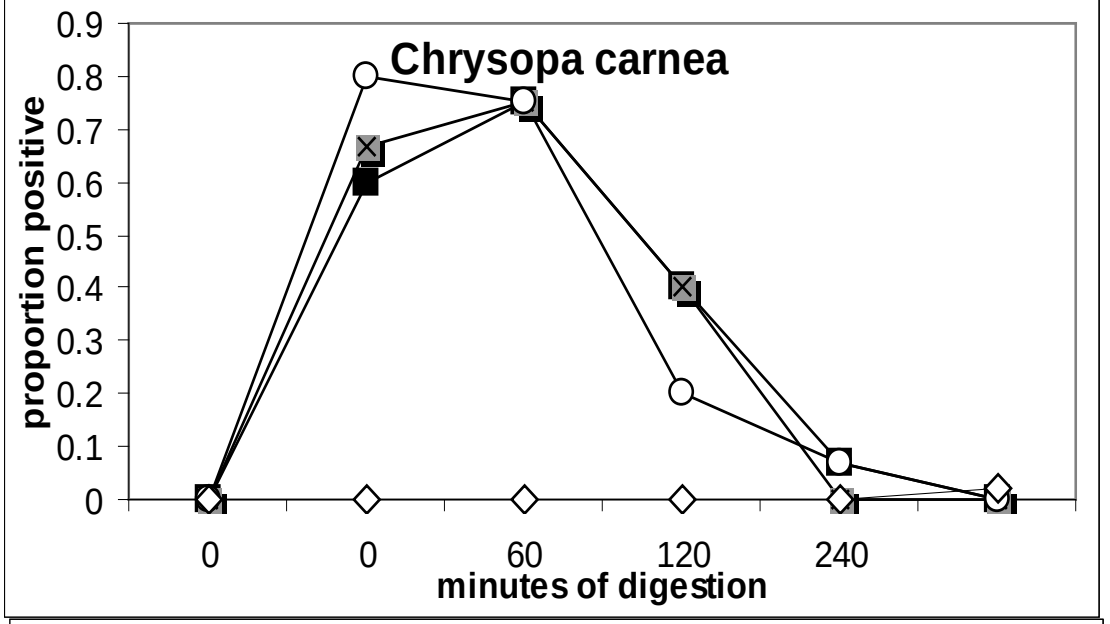
- Substantial build-up of generalist predators in alfalfa cover crop
- Demonstrated movement between habitats by several predator species (colonization of tree from cover crop)
- Demonstrated switching of diet between aphid (cover crop) and psylla (target pest)

Why no effects of cover crop on psylla densities?

Possible explanations

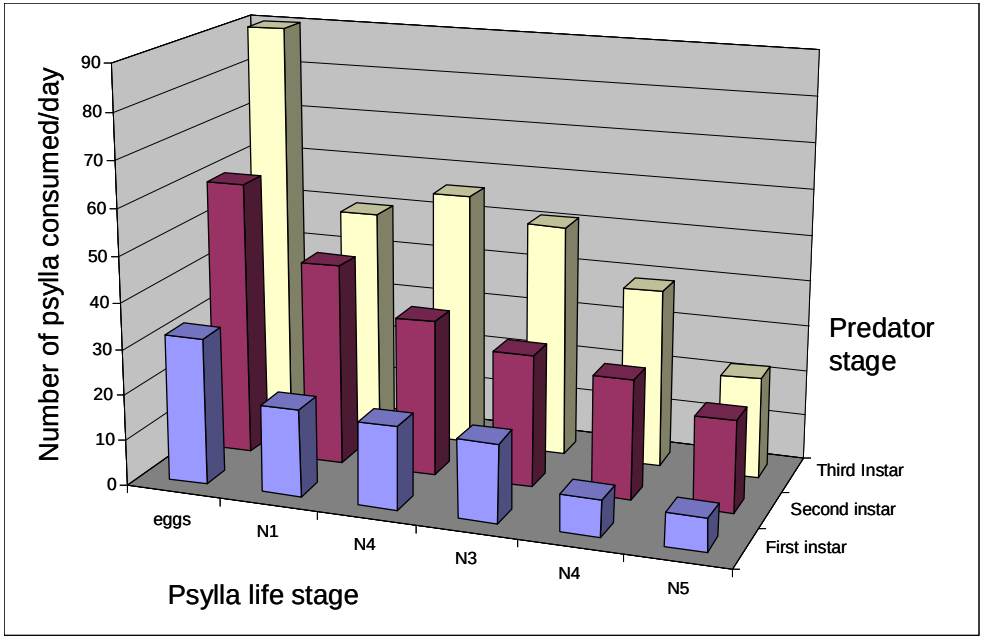
1. Two species (*Anthocoris* and *Deraeocoris*) "blur" effects
   - ❑ Probably our two most important psylla predators
   - ❑ Numerically dominant in tree canopy (often 80%)
   - ❑ But, primarily tree dwellers, little affected by cover crop
2. Some common predators in cover crop that move between habitats may not feed extensively on psylla
   - ❑ *Hyperaspis* (scale insects, mealybug)
   - ❑ *Eremochrysa* (unknown biology)
   - ❑ Aphid predators (lacewings, ladybeetles): need gut contents work





GCA does not give predation rate because both number of prey consumed and time since feeding are unknown

What the preds eat in the lab per day may be a dramatic overestimate of feeding rate in nature



Chrysoperla plorabunda

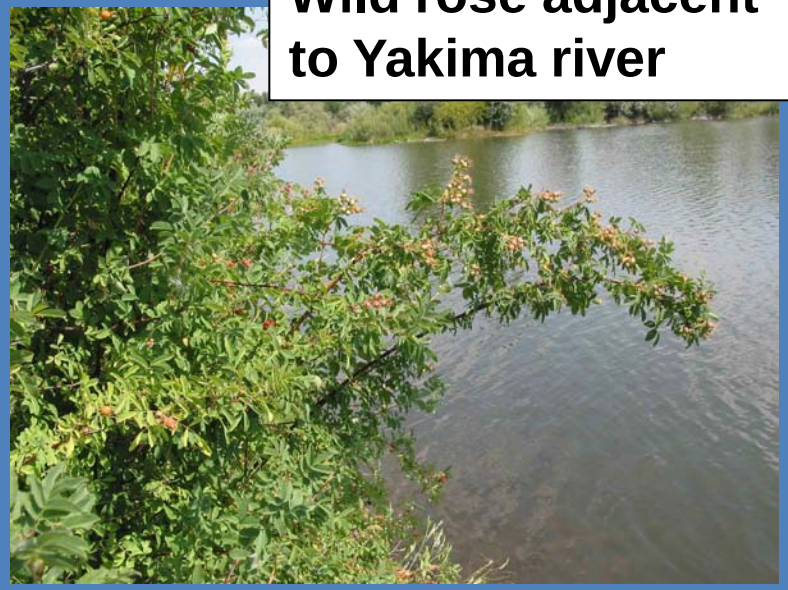
These tools can help us evaluate the potential for enhancing conservation biological control by habitat manipulation

- Objective: provide alternative resources to natural enemies of pests → eventual colonization of crop by those natural enemies
- Applicable in both organic and conventional agricultural systems
- Orchards:
  - Hedge rows (orchard perimeter)
  - Cover crops (orchard floor)

Wild rose and leafrollers (T. Unruh)

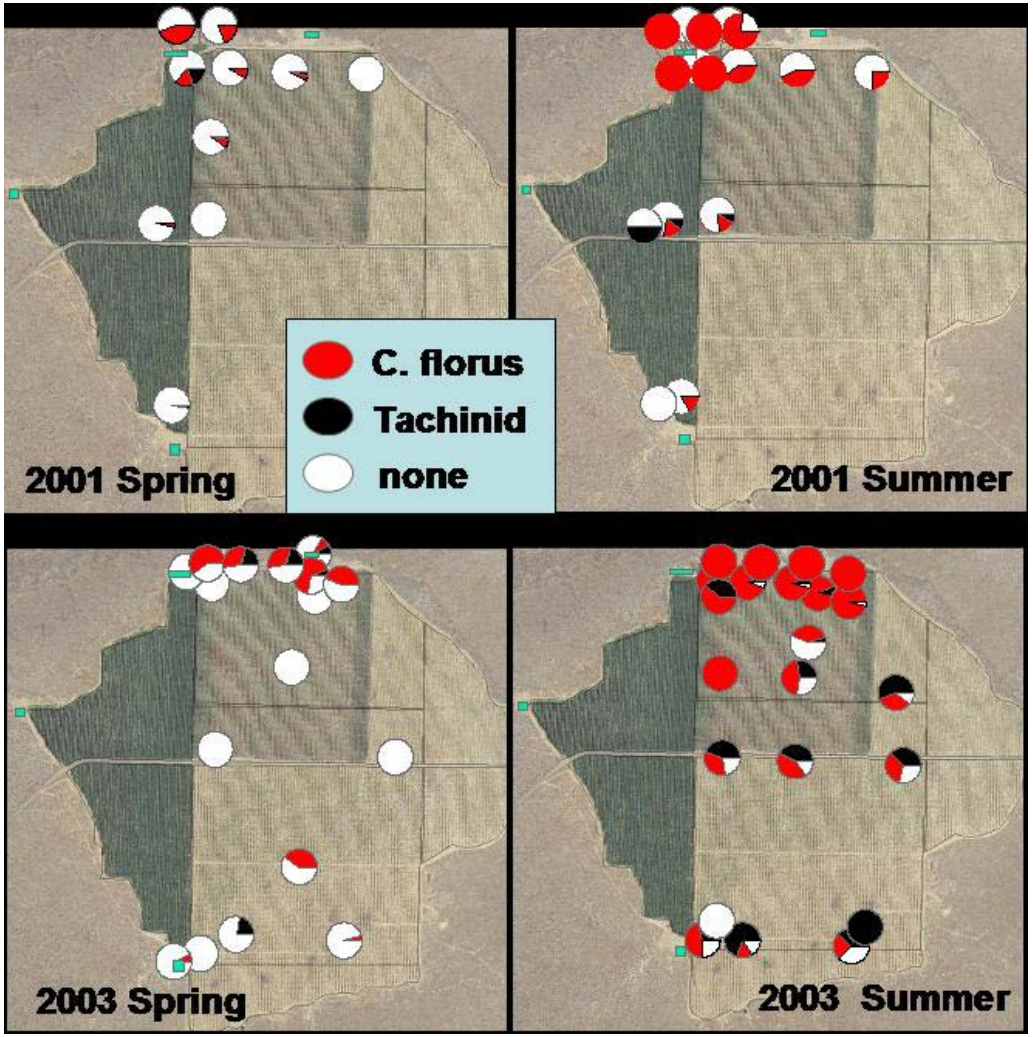
Leafroller pests in orchards:
- **Oblique-banded**
- ***Pandemis***

Wild rose adjacent to Yakima river



- No parasitism of pest leafrollers by *C. florus* in 1999 and 2000

- Gardens planted and infested in 2000



Where to now?

1. Different target pest? (scale insects and mealybug – *Hyperaspis*)
2. Different crop? (apple – aphid pests)
3. Manipulation of cover crop (2010)
   - ❑ Mowing trial to push predators into tree
     - Methods:
       - Use egg marker to assess whether mowing leads to jump in #'s of marked predators in tree canopy
       - Low RPM rotary mower, deposit of clippings near tree

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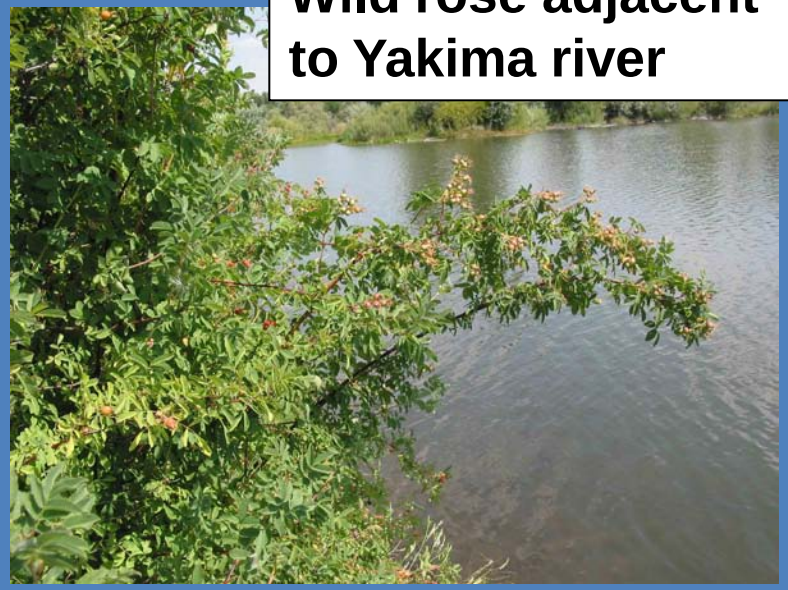

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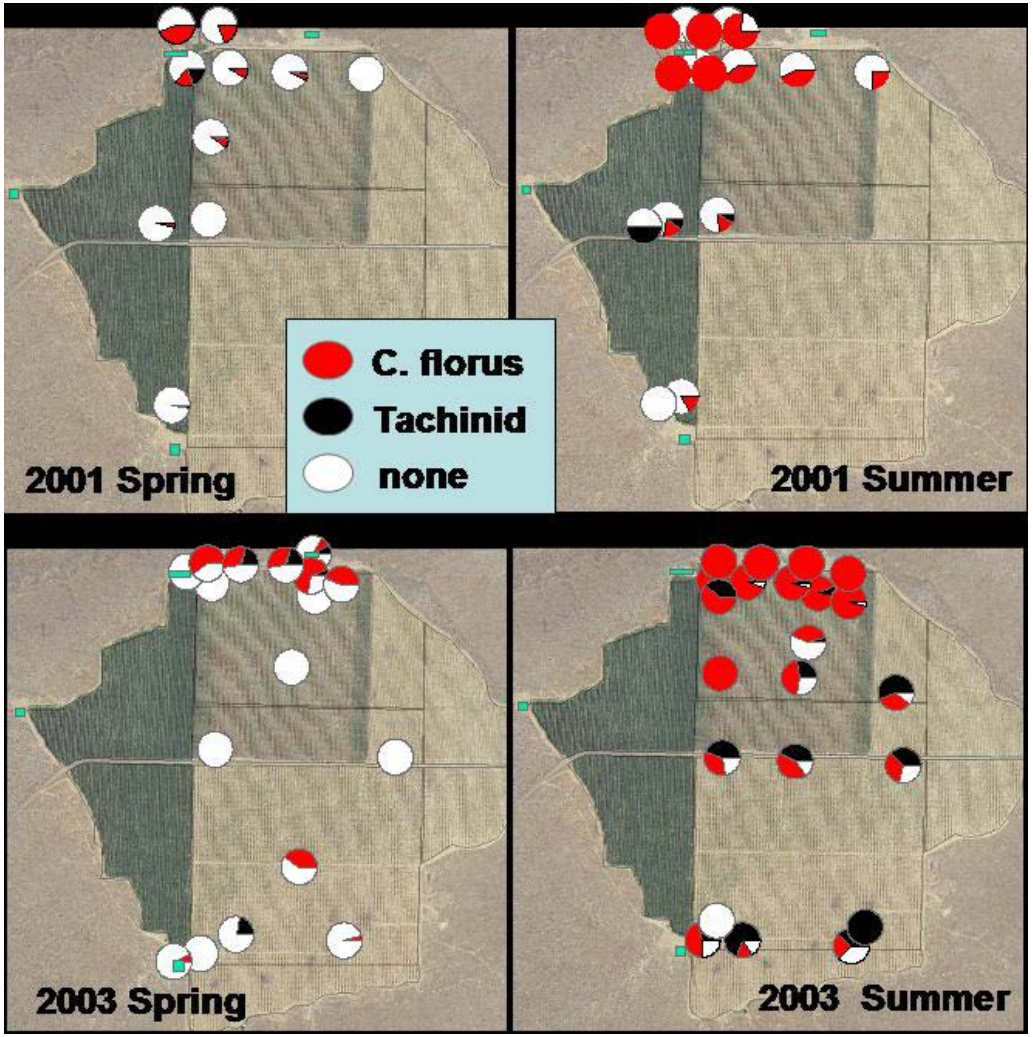
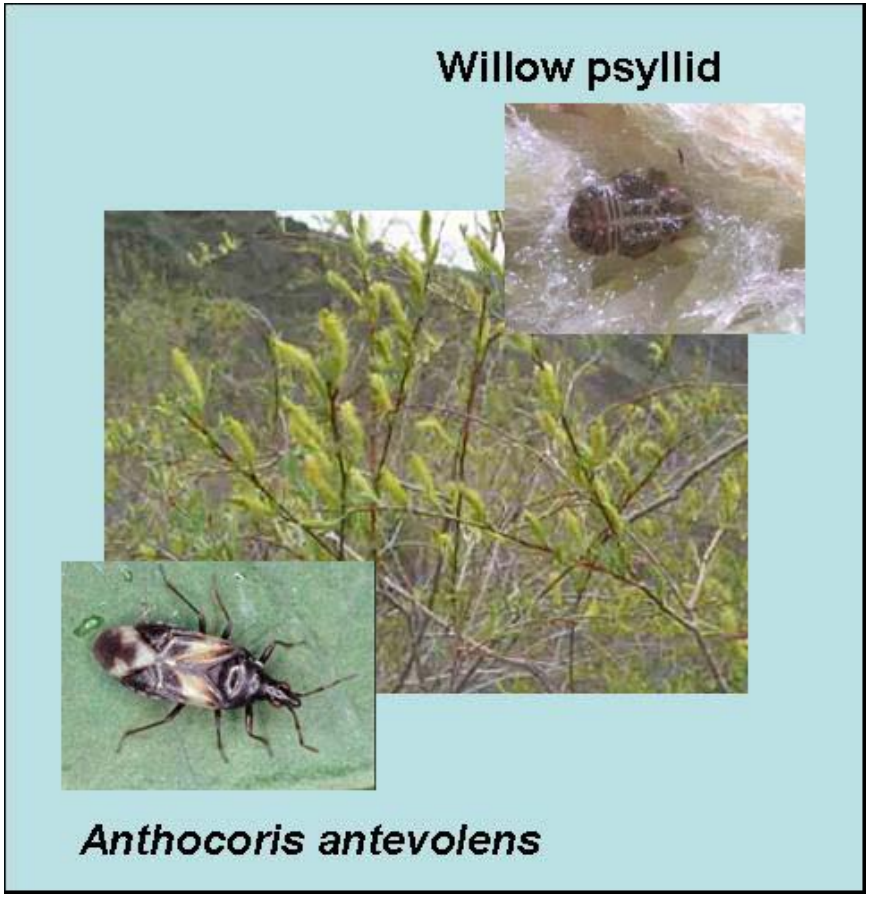
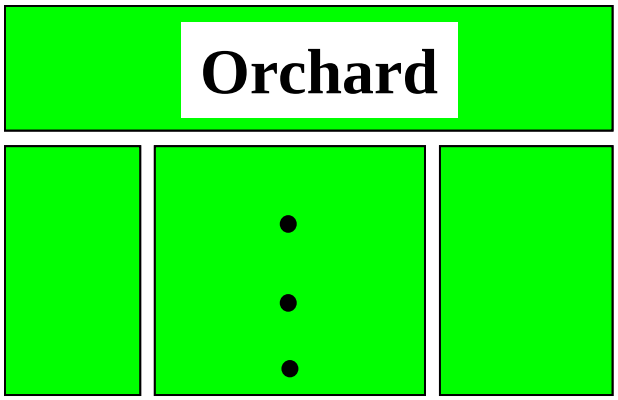


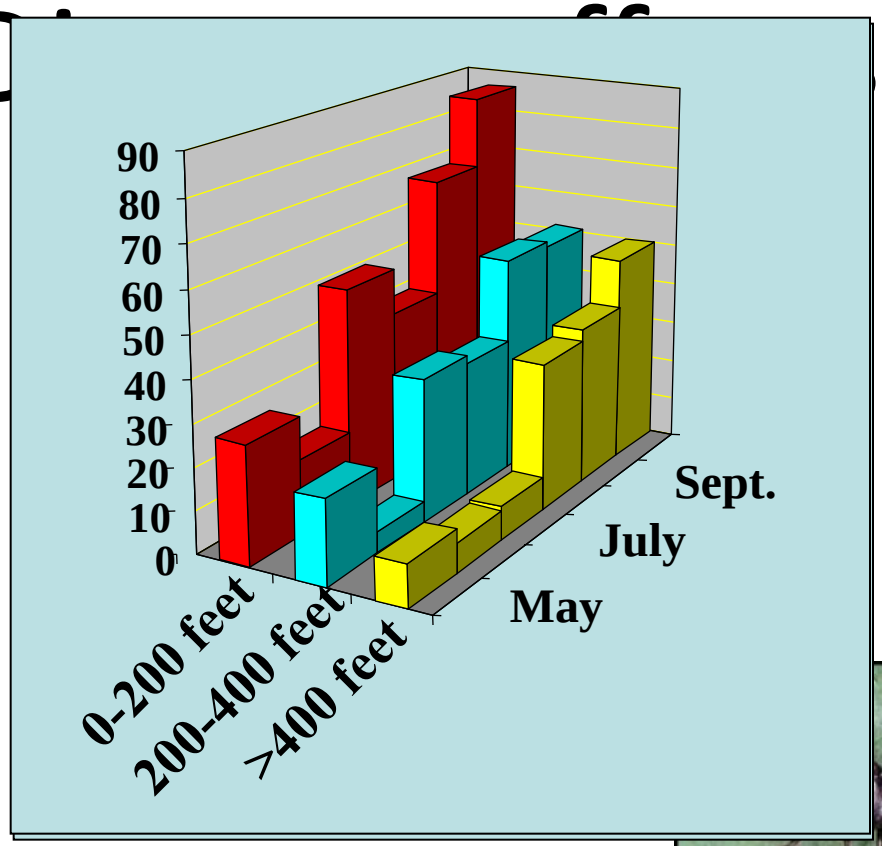
Growers already see that BC is higher for blocks next to riparian habitats.

Dave's research shows *Anthocoris* and other psylla predators use native riparian habitats in spring



Colonization of orchards:





Broader Conclusions

- Riparian plant species can export beneficial arthropods to orchards
- Several sage-steppe species also important exporters of beneficials but abundance of these plants is usually low
- We've shown that some benefits can be captured from a companion planting = roses
- The rose experience suggests that these manipulations should be engineered but for predators
  - Bloom time
  - Host high densities of nonpest aphids, psyllids, leafrollers
  - Management friendly
- We want to test alder, bitterbrush, xeric-adapted willows and others

The application of new technology in farmscape studies …… connecting the dots

- Mark habitats producing predators neat to orchards and document their arrival in orchards from that source
- Demonstrate said predators are consuming target pest in orchards

Old technology is critical

- Need to match phenologies of natural enemies we wish to enhance with the need for greater pest control in orchards
- Need to greatly enhance our natural history knowledge of the beneficial fauna in the non-orchard landscape and in the ground cover