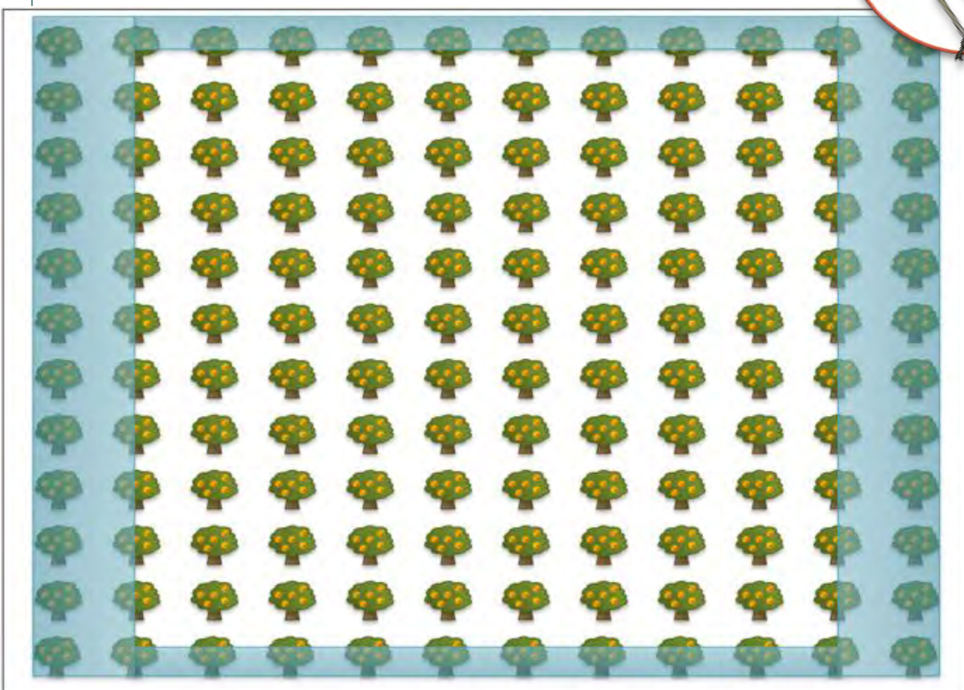
Objective 3. Develop management tools and strategies that are compatible with biological control and informed by risk from landscape factors.

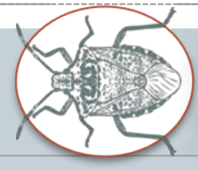



T. Leskey

Informed Management from Landscape Factors with Minimal Risk

- **3.a Develop decision support tools to assess BMSB abundance and to mitigate damage**
- **3b. Identify effective uses of insecticides that minimize impacts on natural enemies**
- **3c. Spatially-focused management or habitat manipulation**
- **3d. Integrate IPM tools across landscapes**

Informed Management from Landscape Factors with Minimal Risk



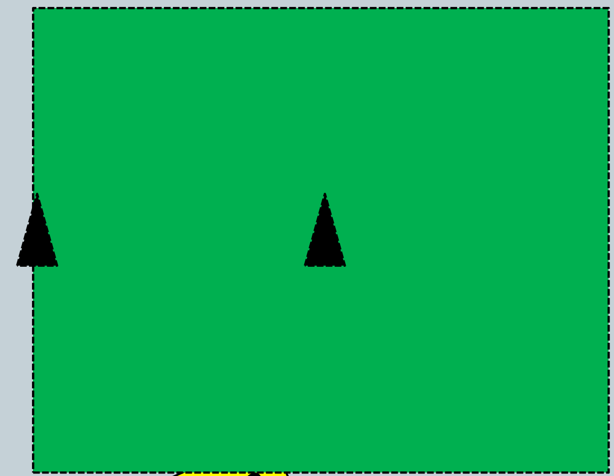
- **3a. Develop decision support tools to assess BMSB abundance and to mitigate damage**
  - **Optimize trap design**
    - Develop user-friends, cost efficient, sensitive and crop-specific pheromone based monitoring for surveillance and decisions support
  - **Relationship between captures in traps and crop injury**
    - Develop trap-based decision support tools

Can traps be used to monitor presence and activity of BMSB on tomato farms?

- In 2014 and 2015, VT monitored numerous commercial tomato fields in PA, DE, NC and VA
- BMSB was found in 75% of the >50 fields sampled.
- Peak trap catch occurred in Aug and early Sept.
- Trap catch exceeded 10 BMSB per trap per week during peak movement in 39% of fields sampled.

Can we use biological information provided by trap captures to guide management decisions?

- Apple blocks monitored with two baited traps (10 mg pheromone + 66 mg synergist). Traps checked weekly.
- When captures of adults in either trap reached a set threshold, the block was treated with BMSB material (ARM).
- Block treated again 7-d later. Threshold was then reset.



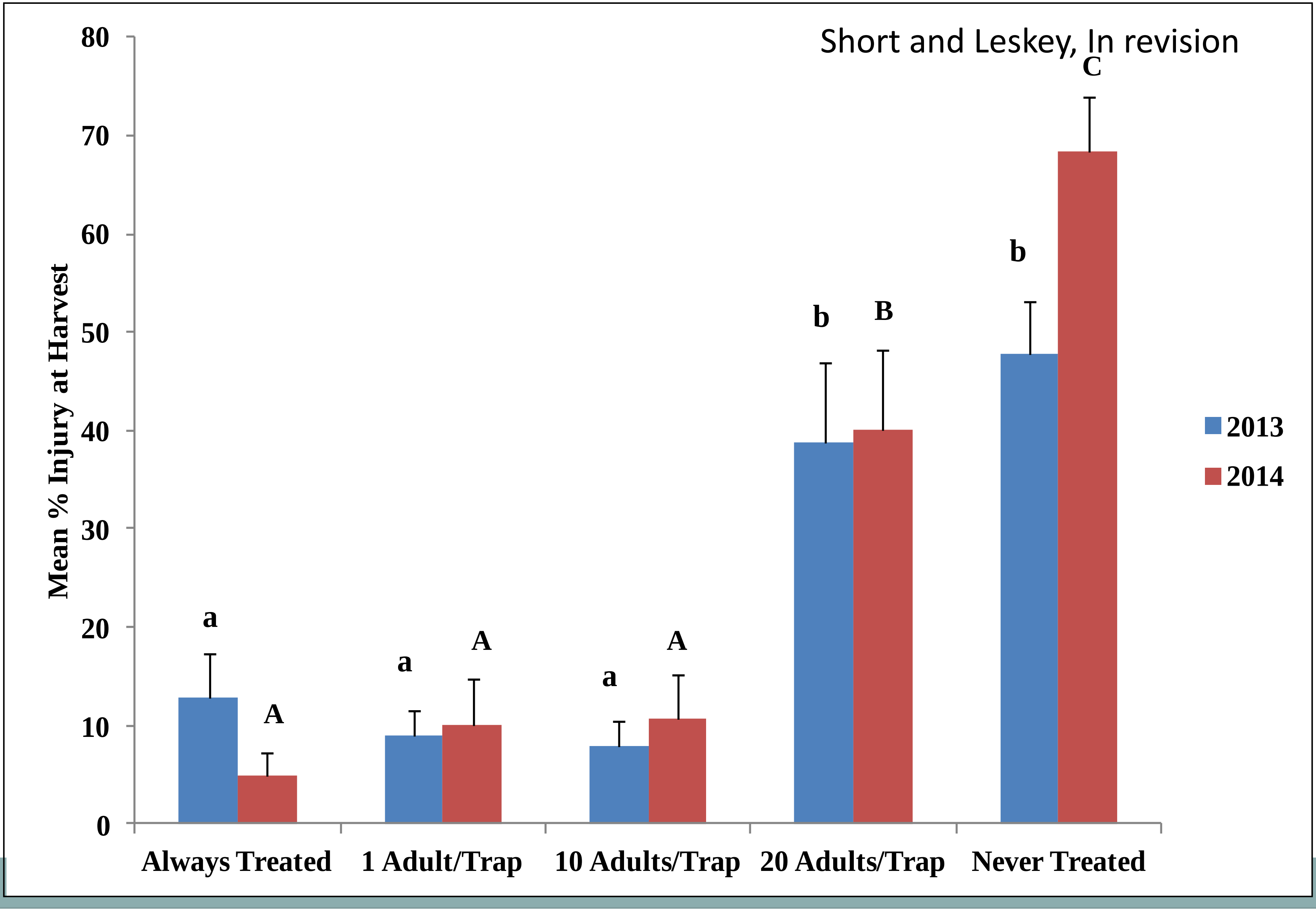
Treatment Regimes

Sprays Triggered at:
1) 1 Adult / Trap
2) 10 Adults / Trap
3) 20 Adults / Trap

4) Treated Every 7 d

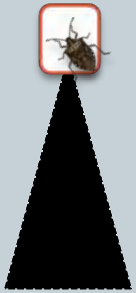
5) No Spray (Control)

BMSB Injury at Harvest



Next Steps

- Change to trap design
- Expand evaluation of threshold in apple
- Two years of work in peaches evaluating population response to traps
  - Continue in peaches
  - Expand to other specialty crops



- Tomato and pepper will evaluate using sticky card traps on stakes to develop a threshold-based program
  - Compare a threshold-based to conventional program

3b. Identify effective uses of insecticides that minimize impacts on natural enemies

- **Evaluate new materials and threat of resistance**
  - Develop based response of different populations
- **Impact of insecticides on natural enemies**
  - Natural enemy toxicity will become available

- **Currently-used insecticides (pyrethroids & neonics) are:**

  1. disruptive to IPM-programs
  2. can lead to 2º pest outbreaks
  3. are often not compatible with pollinator protection plans

Previous Insecticide Testing

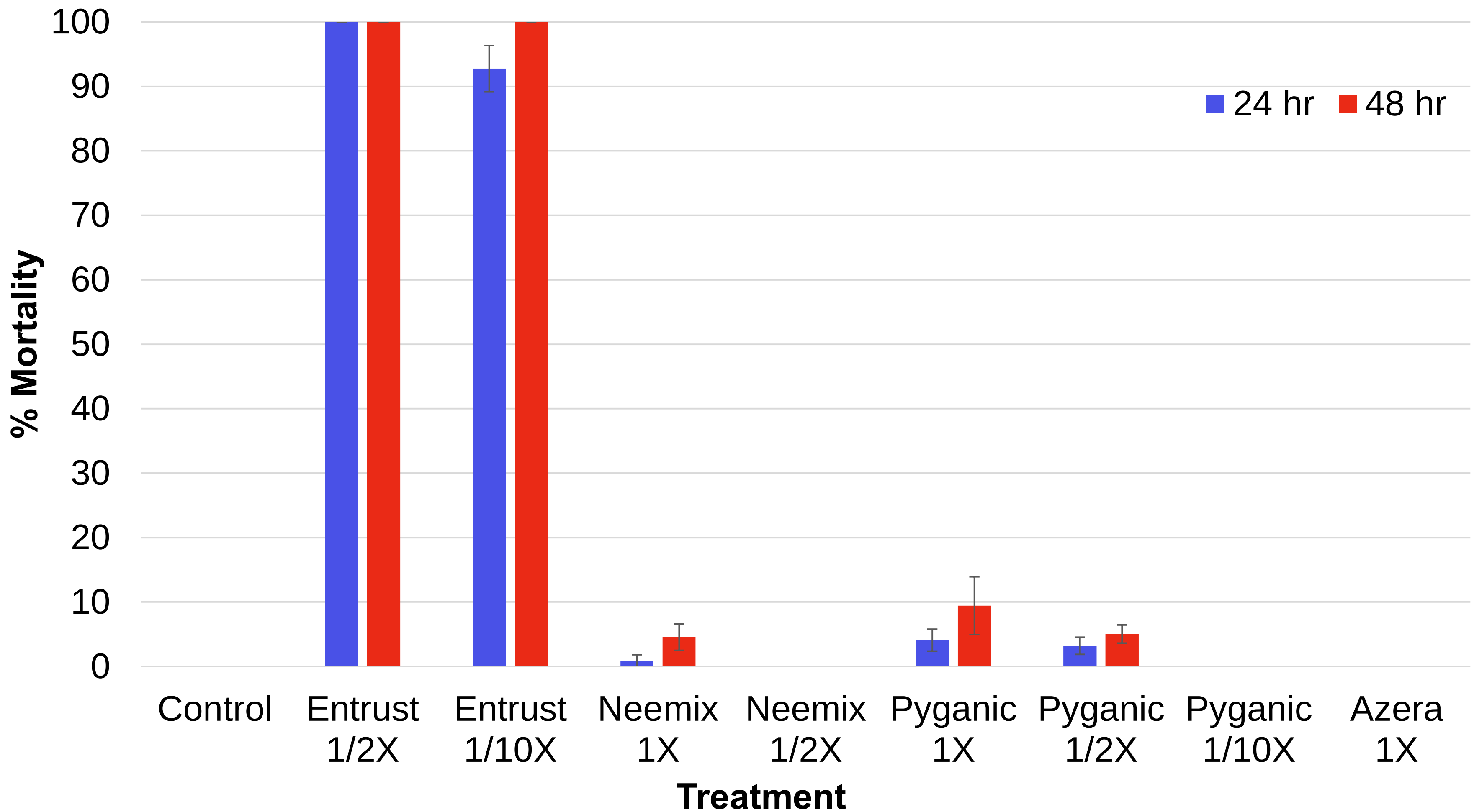
- Laboratory screening
  - Feeding mortality
  - Contact mortality
  - Behavioral changes
- Field testing
  - New products
  - Expansion of approved labels
  - Toxicity of residues
  - Season-long protection

BMSB Laboratory-Based Testing Lethality Index

Active Ingredient	Trade Name	Lethality Index	Active Ingredient	Trade Name	Lethality Index
Chlorpyrifos/Gamma-Cyhalothrin	Cobalt	**95.4**	Oxamyl	Vydate	**46.8**
Dimethoate	Cygon	**93.3**	MBI-203	MBI-203	**43.4**
Malathion	Malathion	**92.5**	Esfenvalerate	Asana	**43.3**
Bifenthrin	Brigade	**91.5**	Imidacloprid	Provado	**40.0**
Endosulfan	Thionex	**90.4**	Tolfenpyrad SC	Tolfenpyrad SC	**36.5**
Methidathion	Supracide	**90.4**	MBI-205	MBI-205	**35.7**
Methomyl	Lannate	**90.1**	Tolfenpyrad EC	Tolfenpyrad EC	**33.3**
Chlorpyrifos	Lorsban	**89.0**	Pyrifluquinazon	Pyrifluquinazon	**28.3**
Acephate	Orthene	**87.5**	Kaolin Clay	Surround	**23.1**
Fenpropathrin	Danitol	**78.3**	Diazinon	Diazinon	**20.4**
Permethrin	Permethrin	**77.1**	Phosmet	Imidan	**20.0**
Azinphosmethyl	Guthion	**71.3**	Acetamiprid	Assail	**18.8**
Dinotefuran	Safari	**67.3**	Thiacloprid	Calypso	**18.3**
Kaolin Clay/Thiamethoxam	Particle Delivery	**66.7**	Abamectin	Agri-Mek	**16.3**
Formetanate HCl	Carzol	**63.5**	Indoxacarb	Avaunt	**11.3**
Gamma-Cyhalothrin	Proaxis	**59.0**	Spirotetramat	Movento	**9.8**
Zinc Dimethyldithiocarbamate	Ziram	**57.5**	Carbaryl	Sevin	**9.2**
Thiamethoxam	Actara	**56.3**	Water	Control 6	**9.2**
Clothianidin	Clutch	**55.6**	Flonicamid	Beleaf	**7.7**
Beta-Cyfluthrin	Baythroid	**54.8**	Water	Control 2	**6.9**
Lambda-Cyhalothrin	Warrior	**52.9**	Water	Control 3	**6.3**
Zeta-Cypermethrin	Mustang Max	**52.1**	Water	Control 5	**6.0**
Cyfluthrin	Tombstone	**49.0**	Water	Control 4	**4.2**
MBI-206	MBI-206	**48.4**	Cyantraniliprole	Cyazypyr	**1.7**

Lee et al 2012.; Nielsen et al. 2009; Kuhar (many); Krawczyk

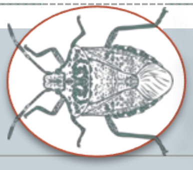
Anastatus reduvii substrate bioassay



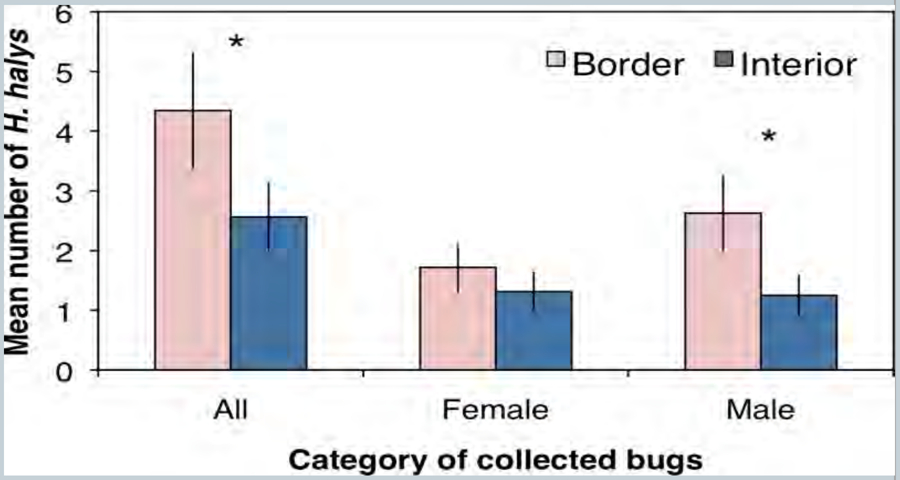
Next steps

- Evaluate new insecticides
  - Mixtures
  - Chitin biosynthesis inhibitors, novel diamides, and hemipteran-specific
- Collect baseline studies in the laboratory for insecticide resistance
- Evaluate insecticide impacts against *Trissolcus japonicus*

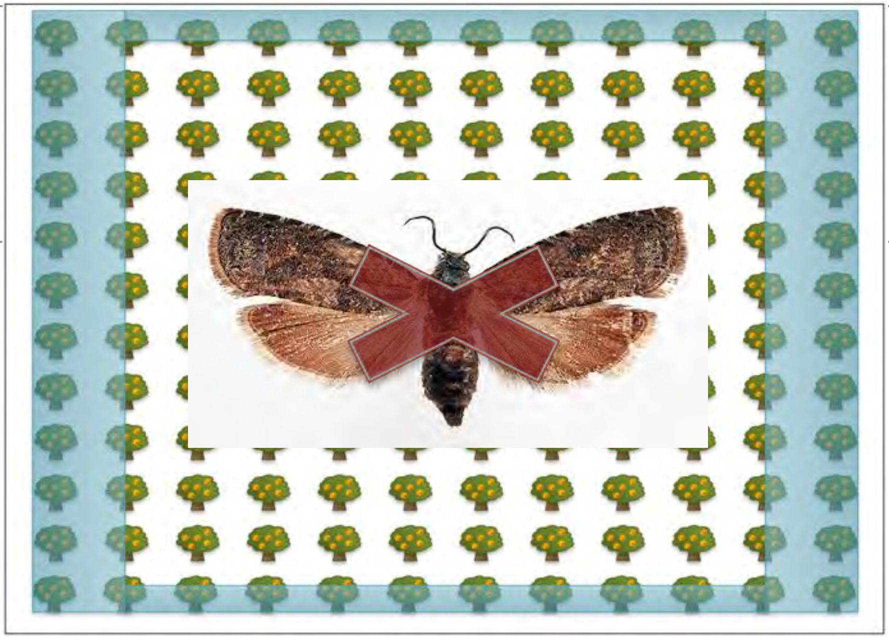
3c. Spatially-focused management or habitat manipulation

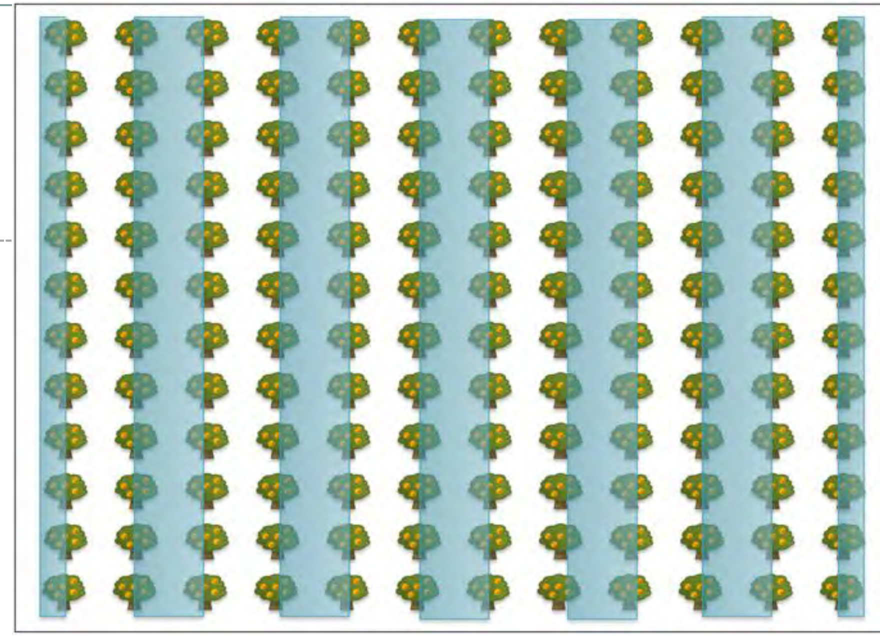


- **Impact of behaviorally-based management on BMSB and natural enemies**
  - Reduce insecticide inputs as much as 75%
    1. Border sprays
    2. Attract & Kill
- **Refine trap crop utilization**
  - Improve trap crop system
- **Conserve natural enemies**
  - Conservation tillage
  - Insectary strips

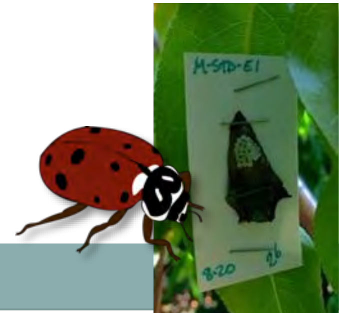


Blaauw et al. 2016 Peer J

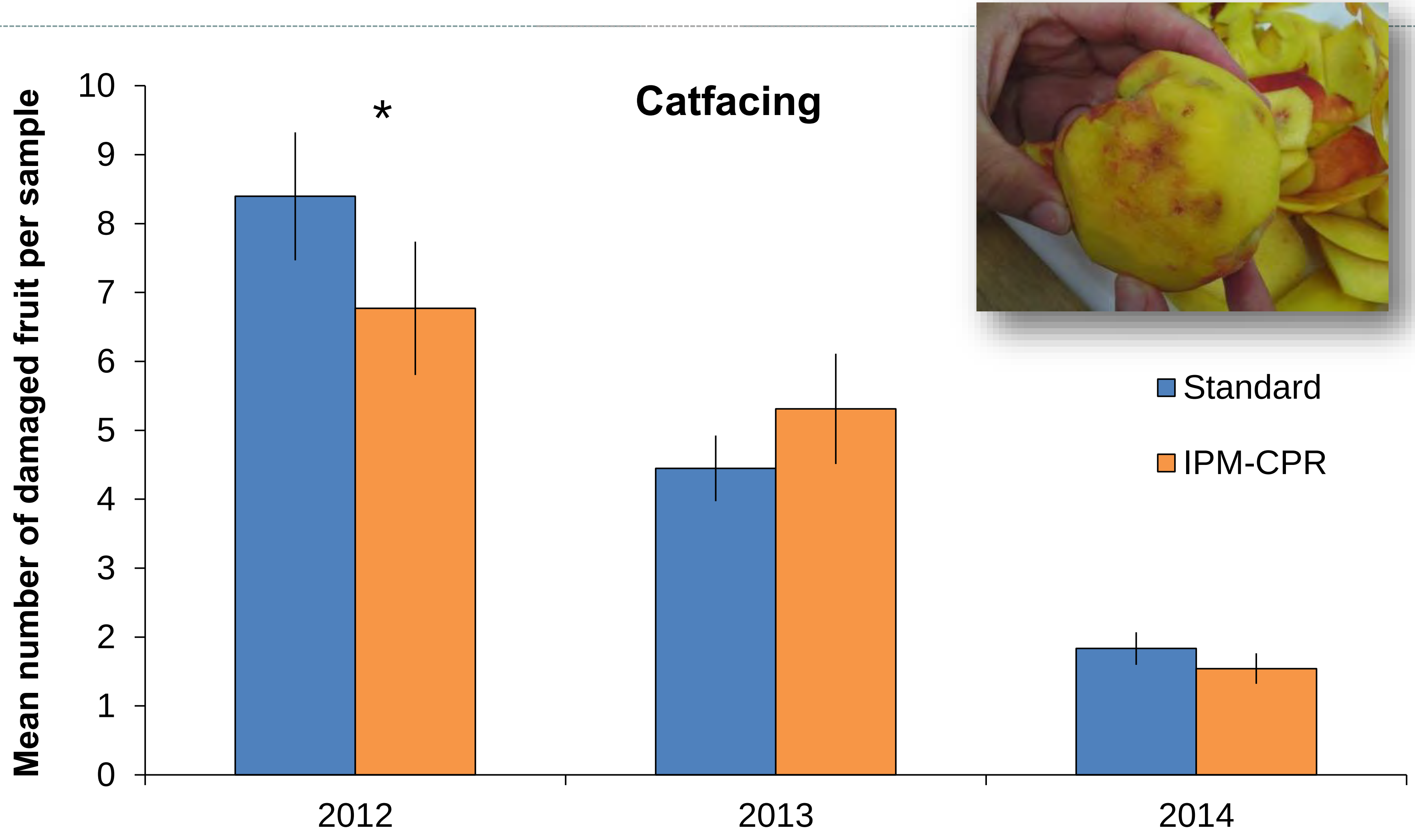




- 17 sampling sites
- Visual sampling for BMSB, catfacing injury, moth injury
- Sweep net for *Lygus sp*.
- Harvested 50 fruit per sample (850 fruit/block)
- 3 farms
- 3 years



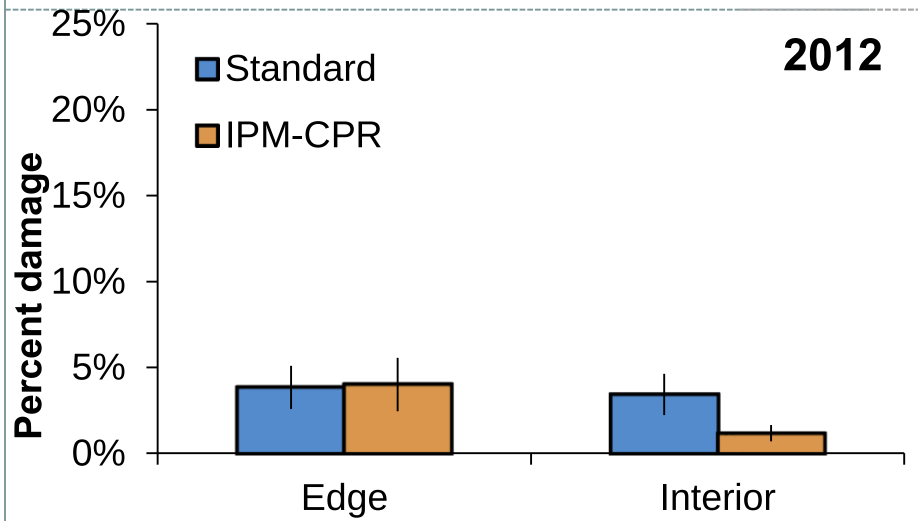
Peach Damage at Harvest

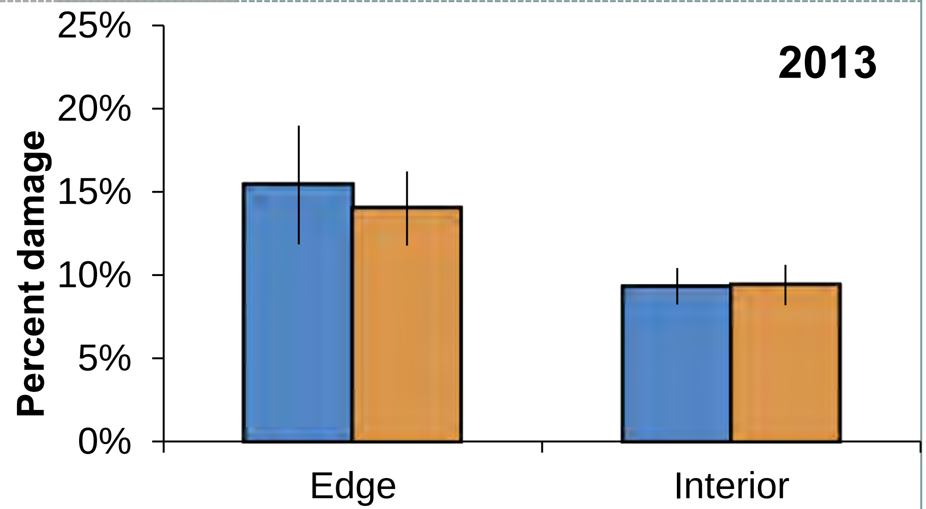


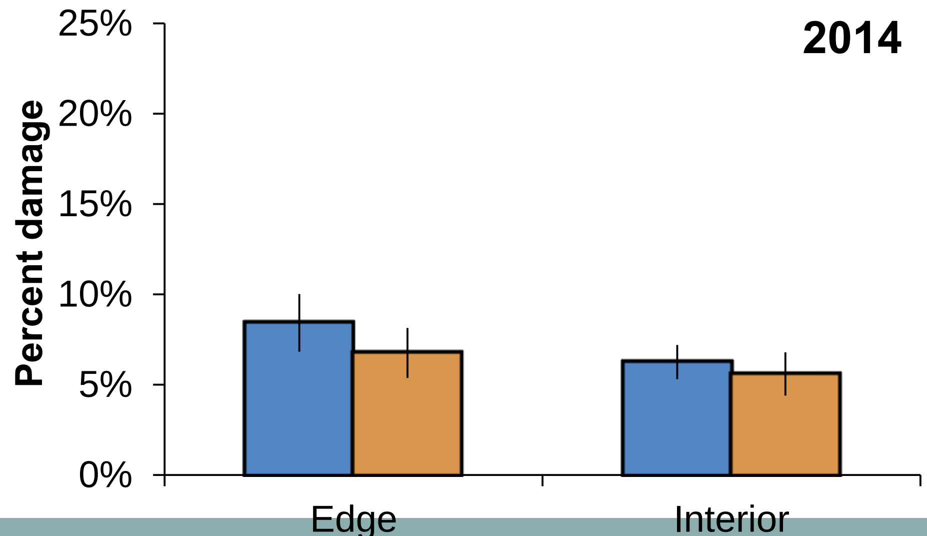
Blaauw, Polk, and Nielsen. 2014 *Pest Management Science*

Catfacing Injury at Harvest in Peach

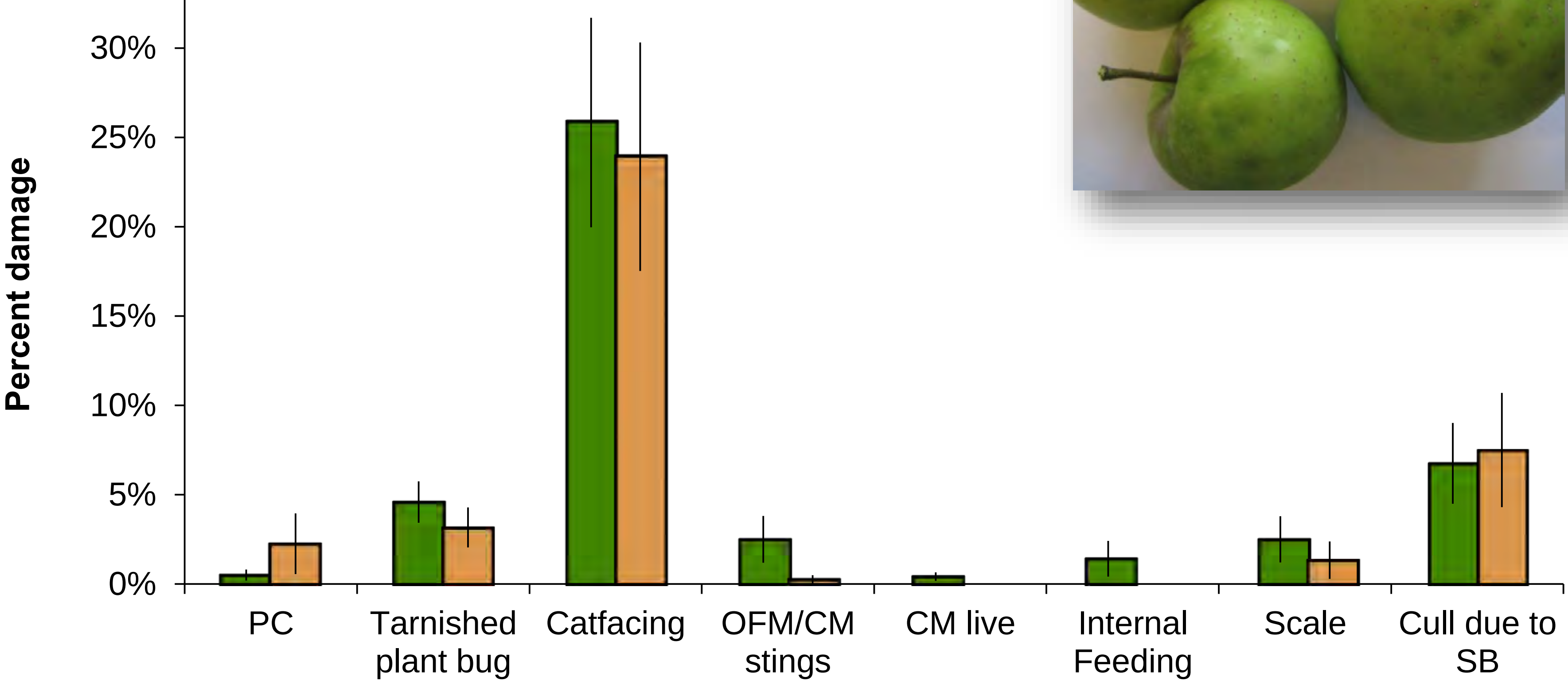
Peaches



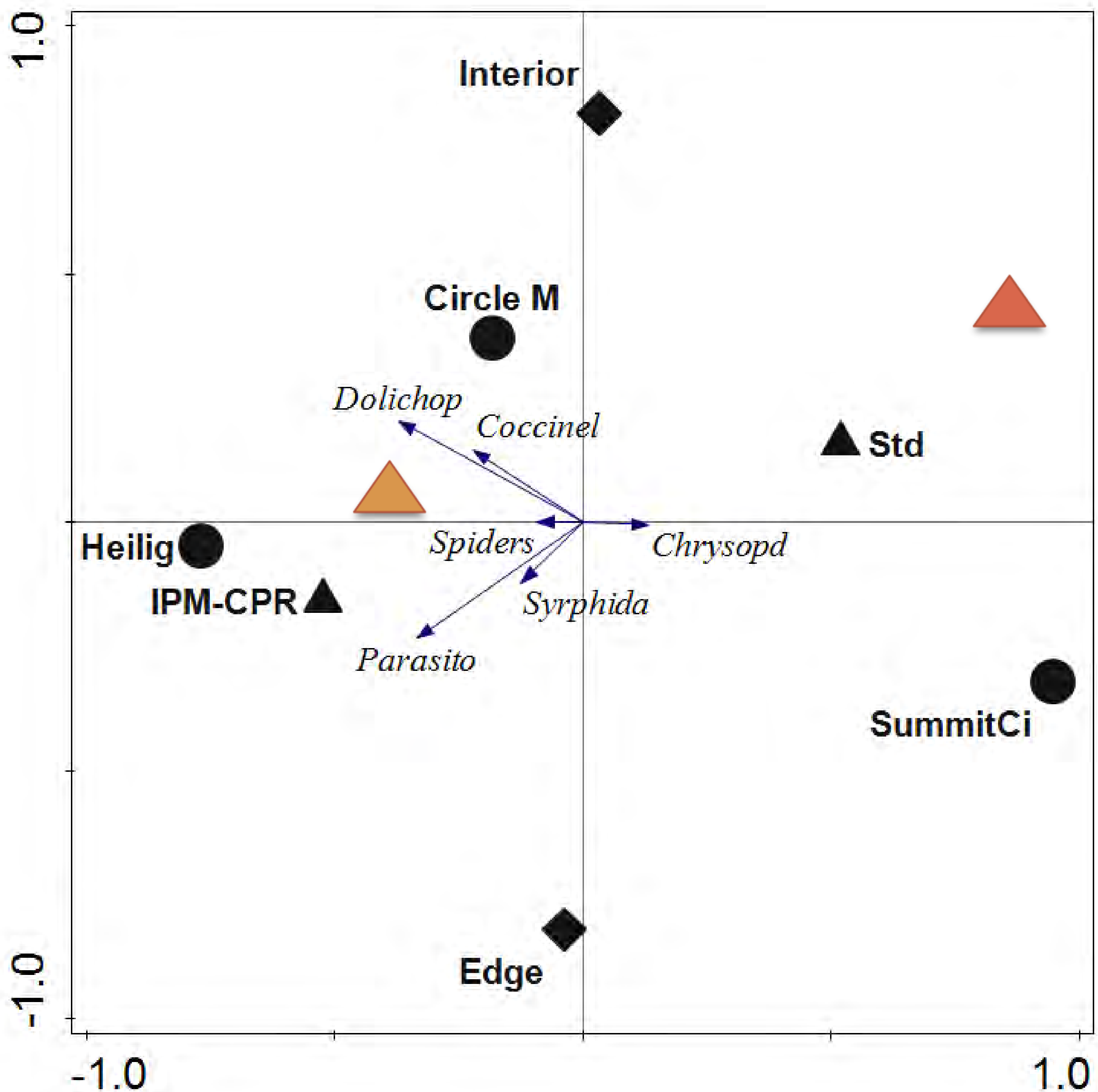




Apple Damage at Harvest 2014

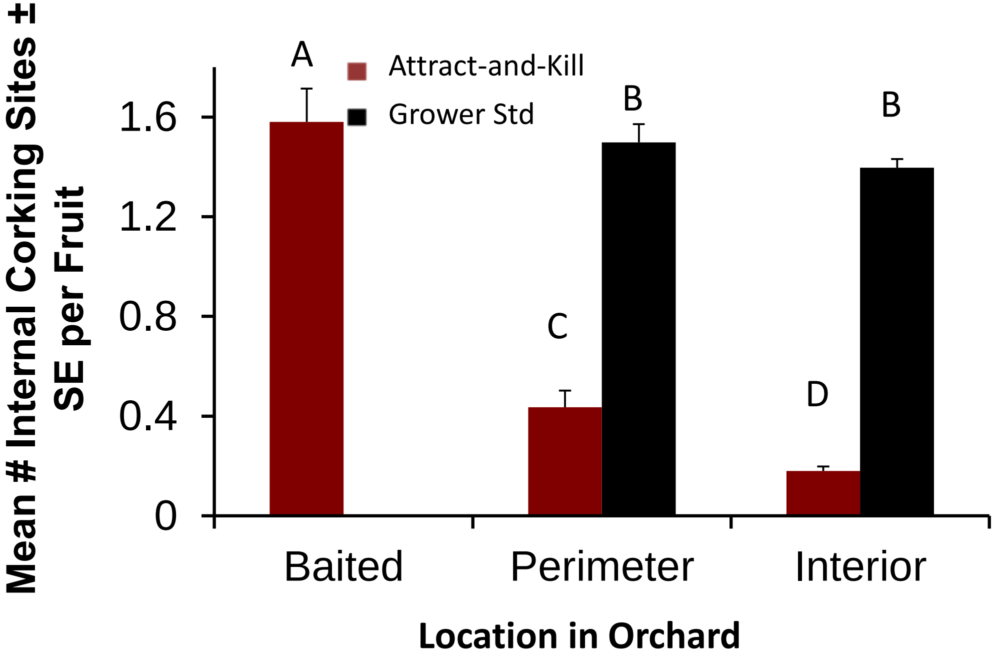


Impact on natural enemies



- Two independent measurements show that border sprays conserve natural enemies and predation
- Similar results in apple
- Work continuing in apple and peach on a broader geographic basis

Attract-and-Kill for BMSB



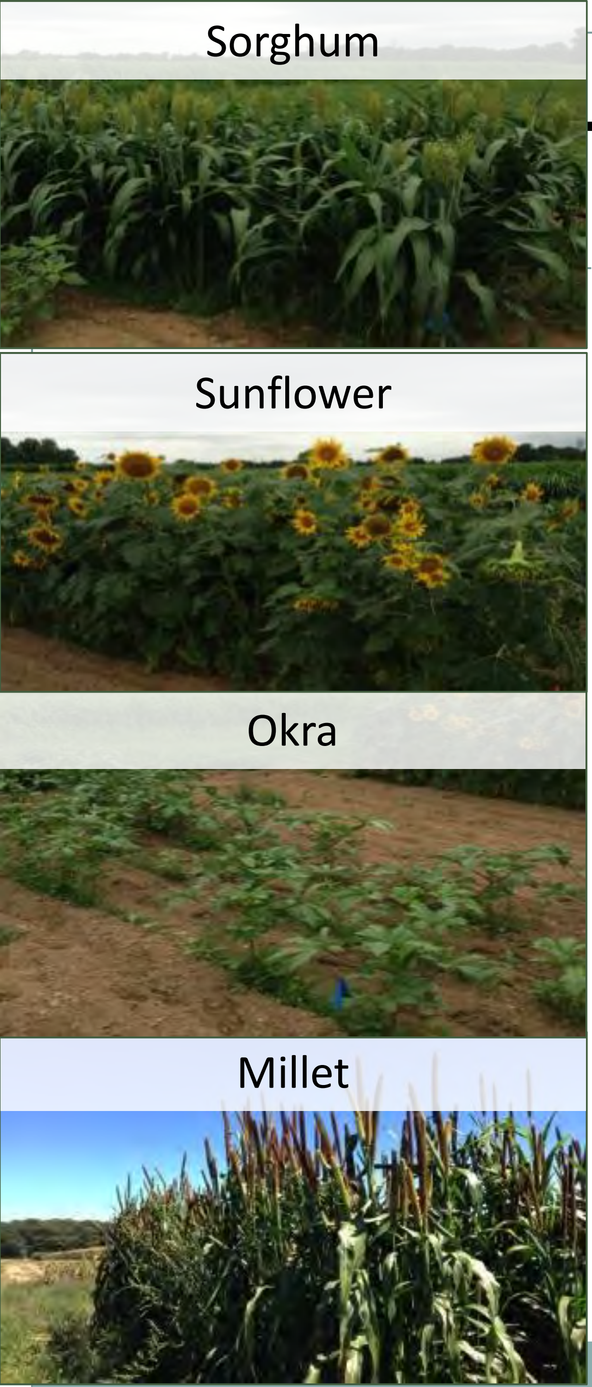
Morrison et al. 2016 J Pest Sci

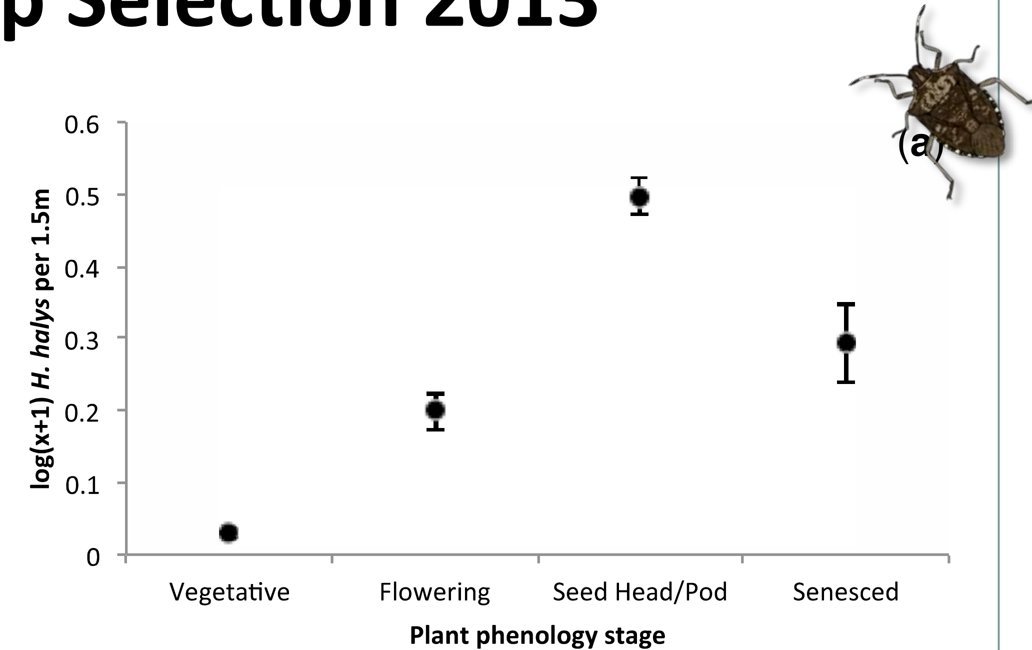
Next Steps

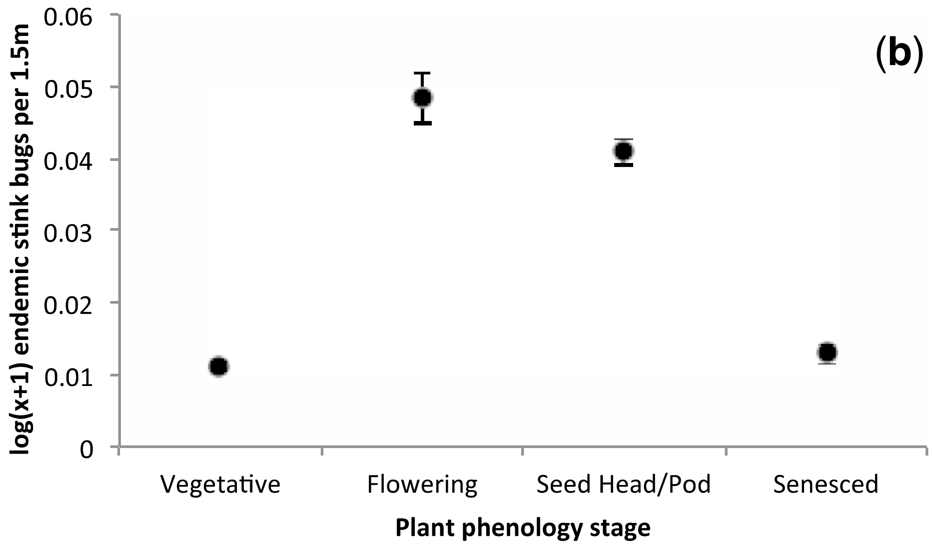
- Incorporate threshold and/or improved decision support tools for initiation of sprays
- Determine appropriate size of

either border sprays or attract and kill sites
  - Barrier screening in transition zone between woods and apple (PSU and Cornell)
  - Expand investigation in other crops
    - Deltamethrin treated netting in peppers
- Understand importance of landscape features that influence BMSB densities
  - Field crops are not included in SCRI but are an important component of the landscape

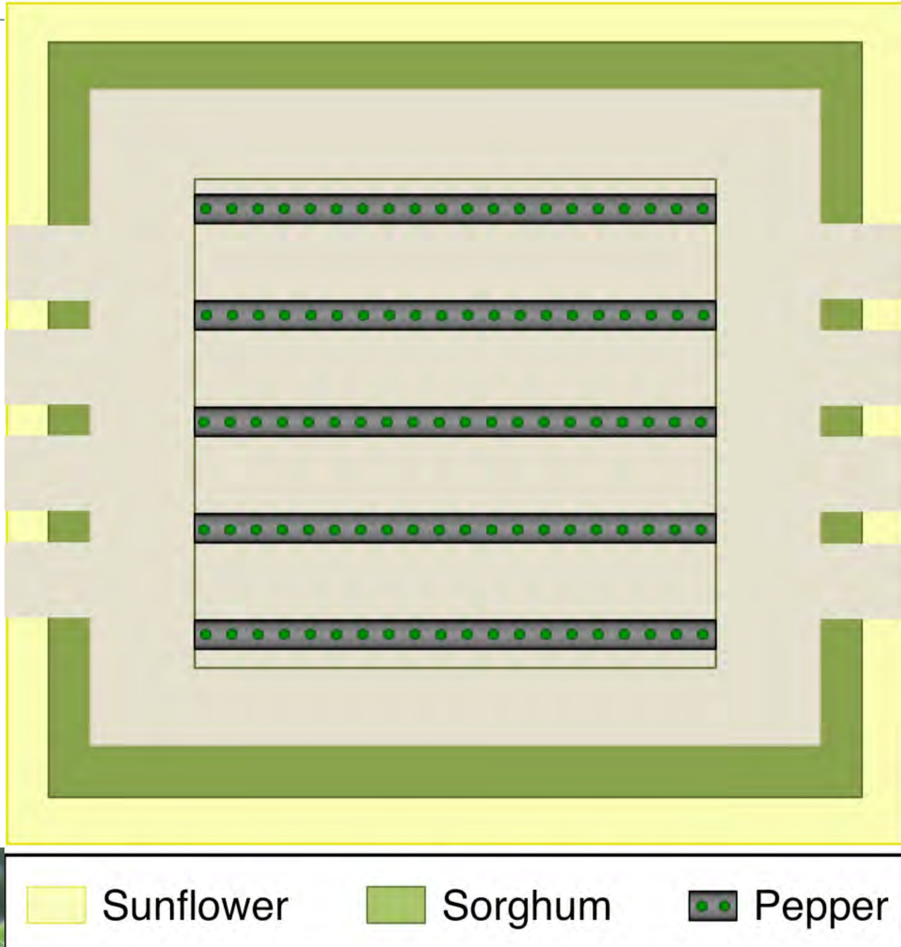
Trap Crop Selection 2013

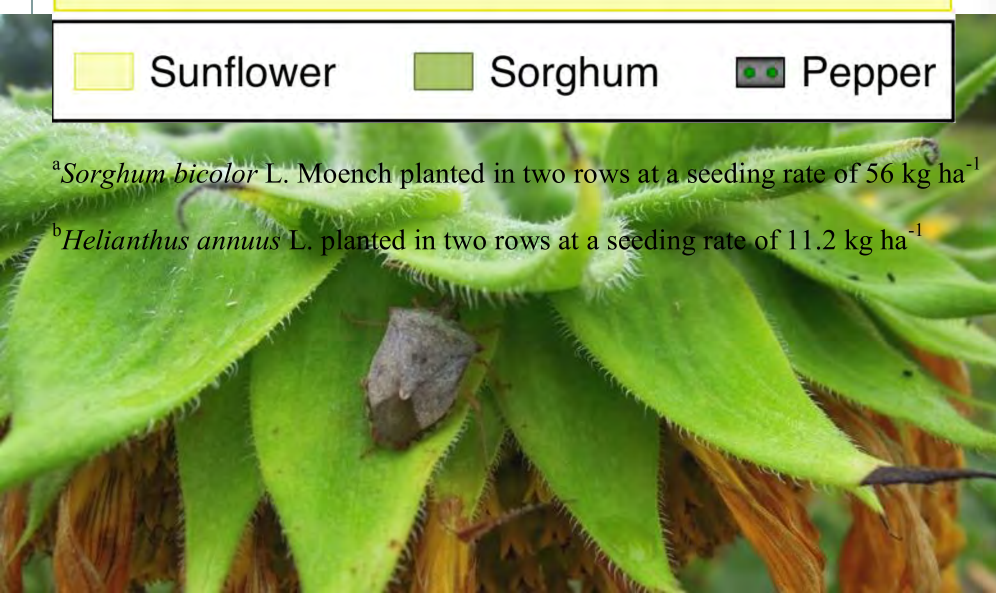






Nielsen et al. *Env. Entomol. 2016*





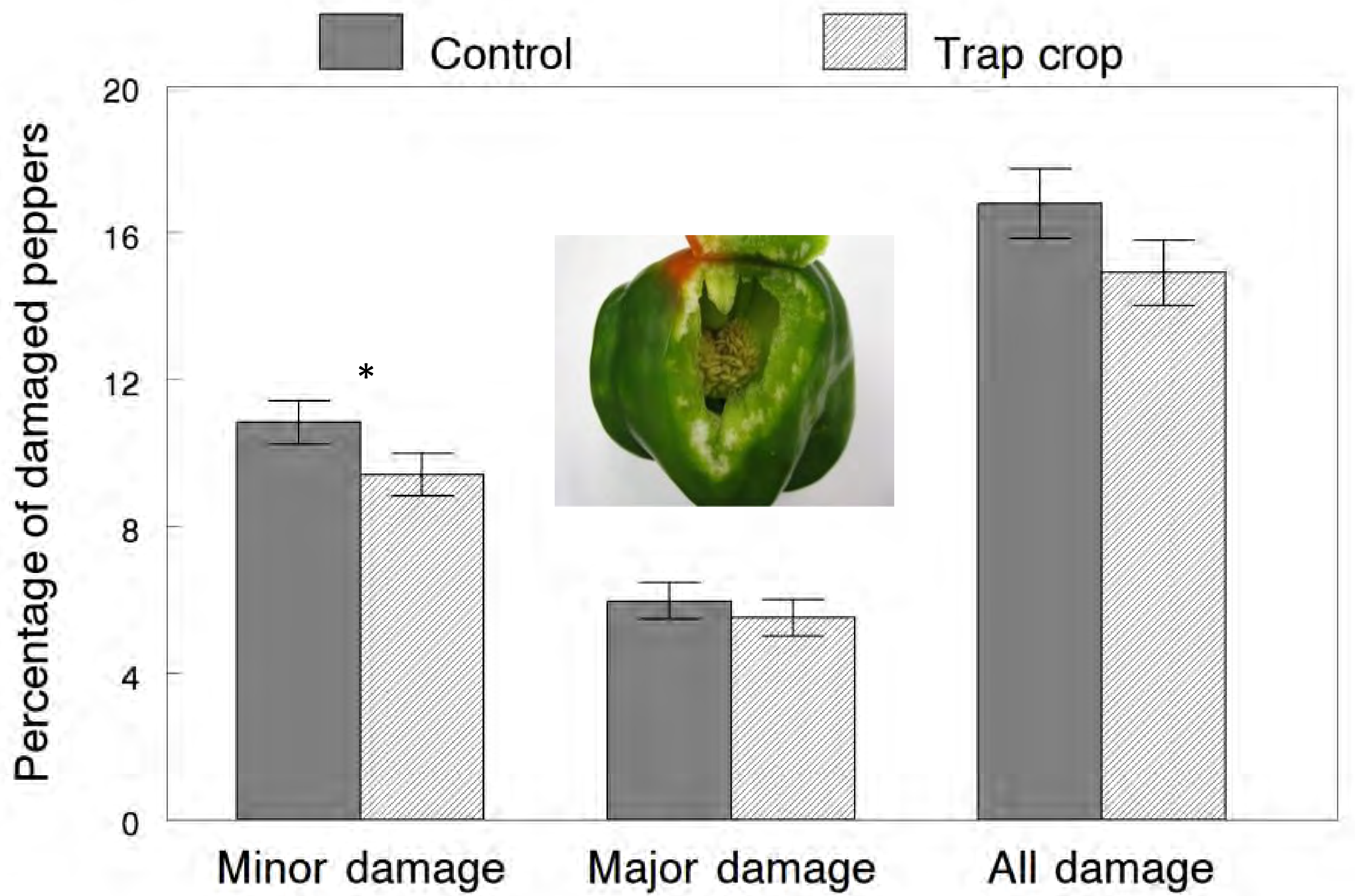
[a]*Sorghum bicolor* L. Moench planted in two rows at a seeding rate of 56 kg ha^{-1}

[b]*Helianthus annuus* L. planted in two rows at a seeding rate of 11.2 kg ha^{-1}

pepper planting. The asterisk above mean comparisons indicates statistically significant diffe

and trap crop treatment ($P < 0.05$).

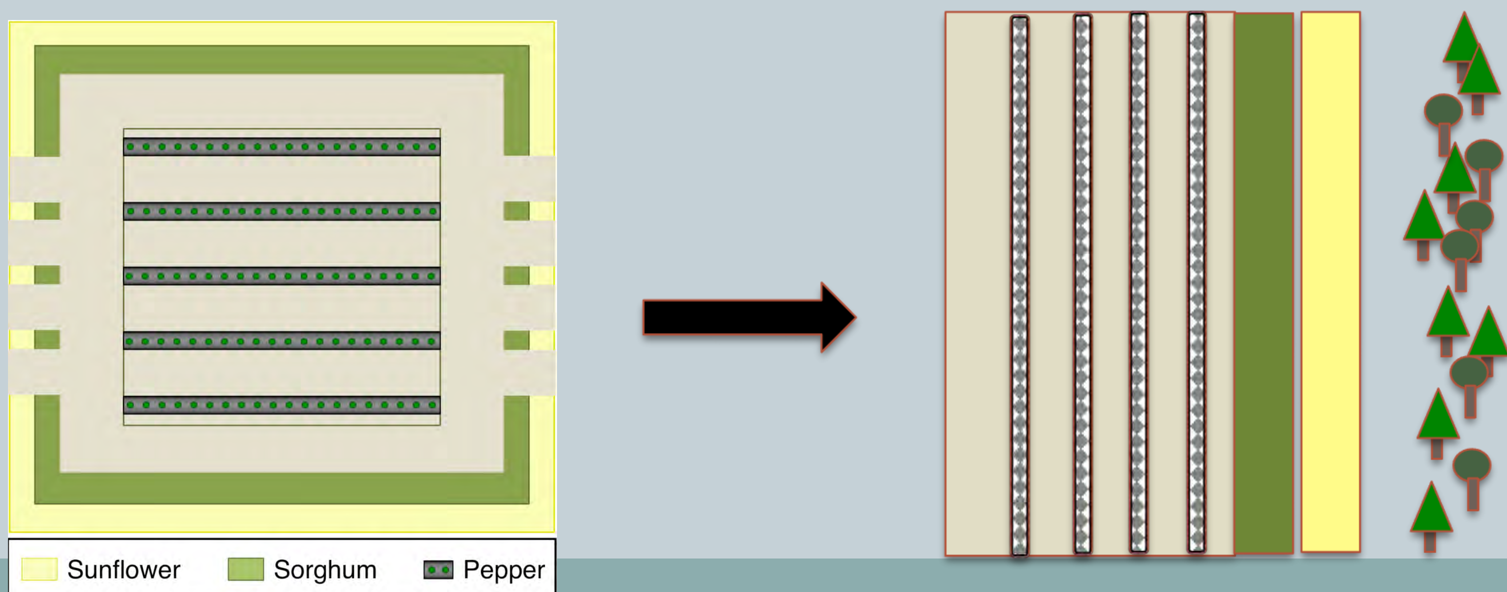
Multi-State Trial



Areas for improvement

- Know that the trap crop attracted and retained BMSB for ~1 week (Blaauw et al. *In revision*)
- Trap crop fully surrounded cash crop
- Increase relative area of trap crop and spatial location

Figure 1. Schematic depicting one experimental field plot containing five rows of 'Aristotle' bell peppers (100 plants/plot) in black plastic surrounded by polyculture trap crop border comprised of an interior sorghum[a] strip and an exterior sunflower[b] strip. The aisles between crop rows were maintained open for ease of access and equipment usage for mowing.



[a]*Sorghum bicolor* L. Moench planted in two rows at a seeding rate of 56 kg ha^{-1}

Insectary Plantings





- Native wildflowers
  - Higher predation by sucking predators than rye control plots
- Determine biological control with partridge pea companion plantings in corn
  - No difference in parasitism observed
  - No difference in injury to corn

Next steps

- **Conserve natural enemies**
  - Crop scale: Conservation tillage in vegetable crops
    - Measure parasitoid overwintering survival through emergence traps
  - Insectary strips
    - Annual crops: partridge pea + edamame
    - Perennial: flower mixes
    - Measure impact of parasitism through wild and sentinel egg masses

3d. Integrate IPM tools across landscapes

- Next year!