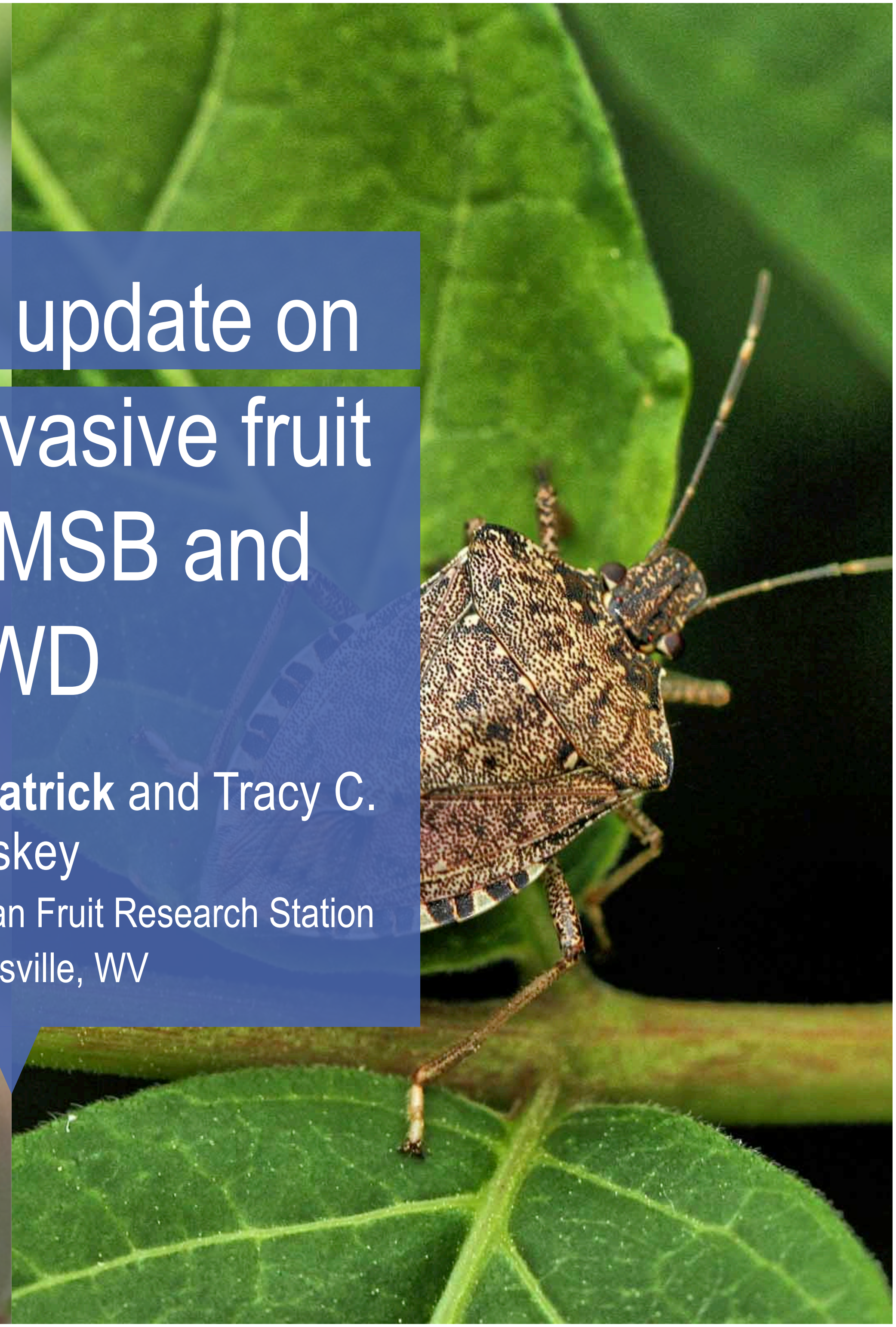

Research update on two key invasive fruit pests: BMSB and SWD

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SWD Research Update

SWD Non-nutritive sugars project

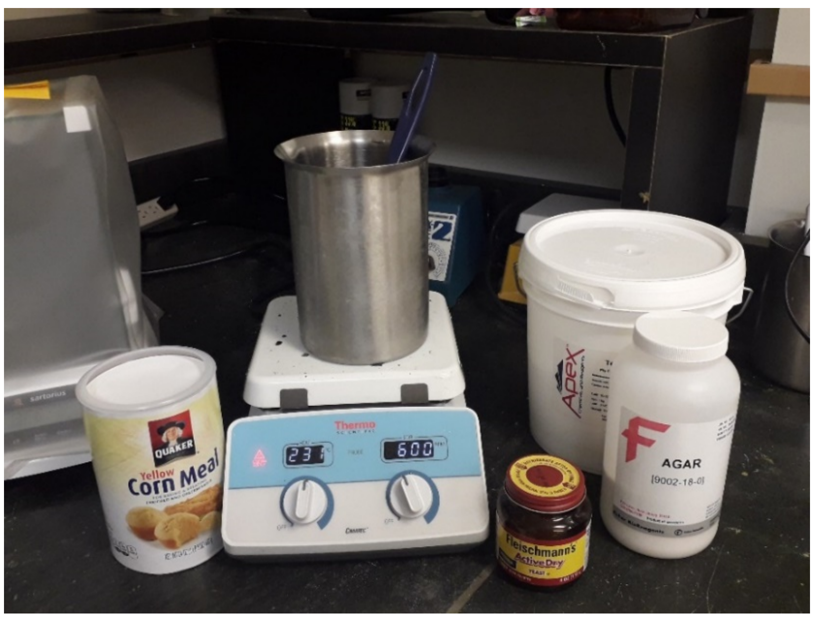
Project led by Post-doc Laura Nixon, PhD

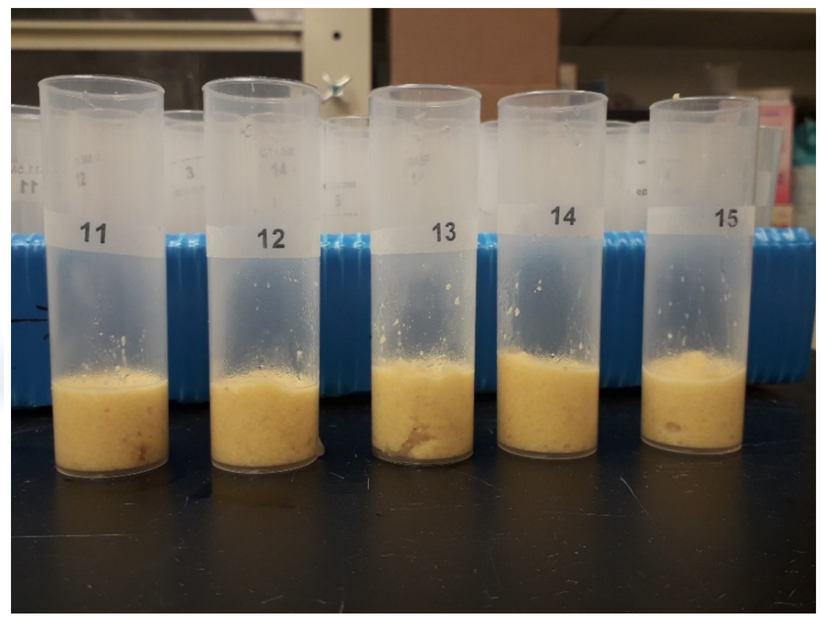
Can we use non-nutritive sugars to replace toxicants?

- Major components of artificial sugars include stevia, erythritol, dextrose, sucralose, saccharin, and aspartame
- Do non-nutritive sugars have same level of toxicity as insecticide?
- Can non-nutritive sugars significantly reduce survivorship of SWD?

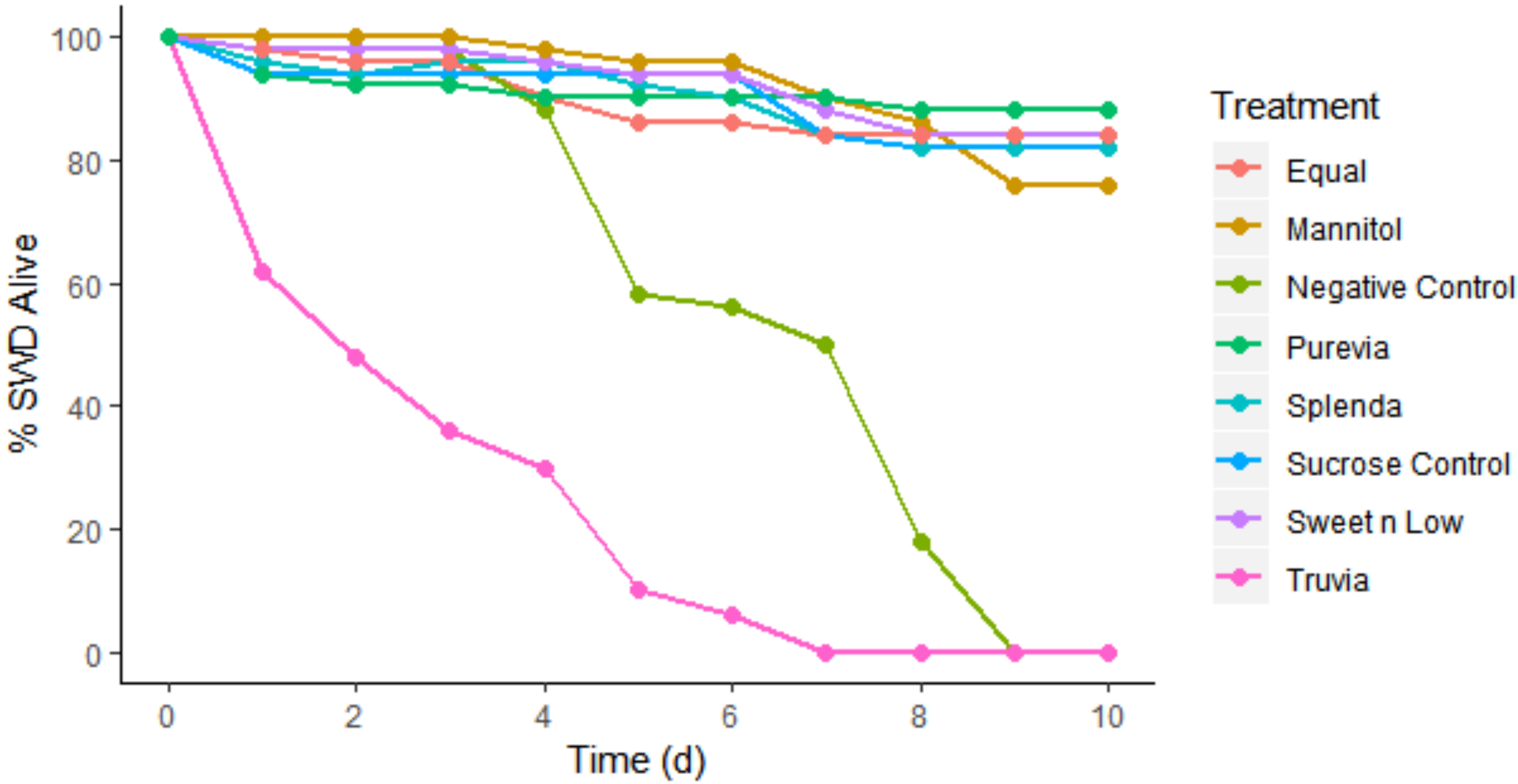
Replacing Sugar in SWD Diet

- Prepared Drosophila diet with nutritive sugar component removed
- Replaced sucrose with non-nutritive sugar treatment
- Positive control: sucrose, negative control: water
- Filled Drosophila tubes with 3 cm of diet, and placed 10 adult flies (0-48 hrs old) into each (5 tubes/50 flies per treatment)
- Counted survivorship of each tube daily for 10 days



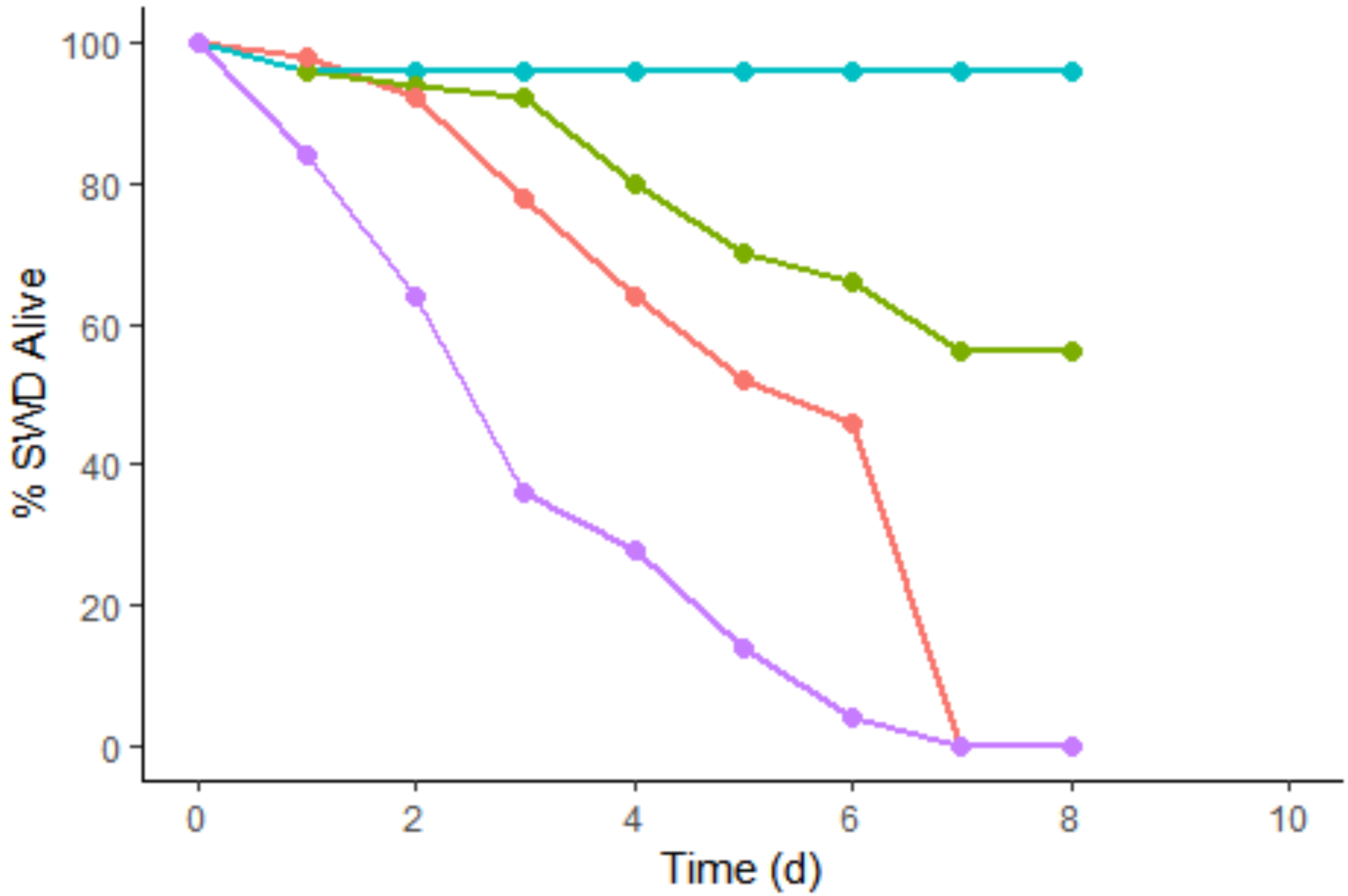


Which commercially available sugars will be toxic to SWD?



- Diet with Truvia added in killed SWD significantly faster than all other diets, including the negative control (water) diet

Truvia (erythritol) is toxic to SWD



- Erythritol (a sugar alcohol) is the major component in Truvia
- Kills flies faster than the negative control
- Suggests the erythritol is poisoning rather than starving them

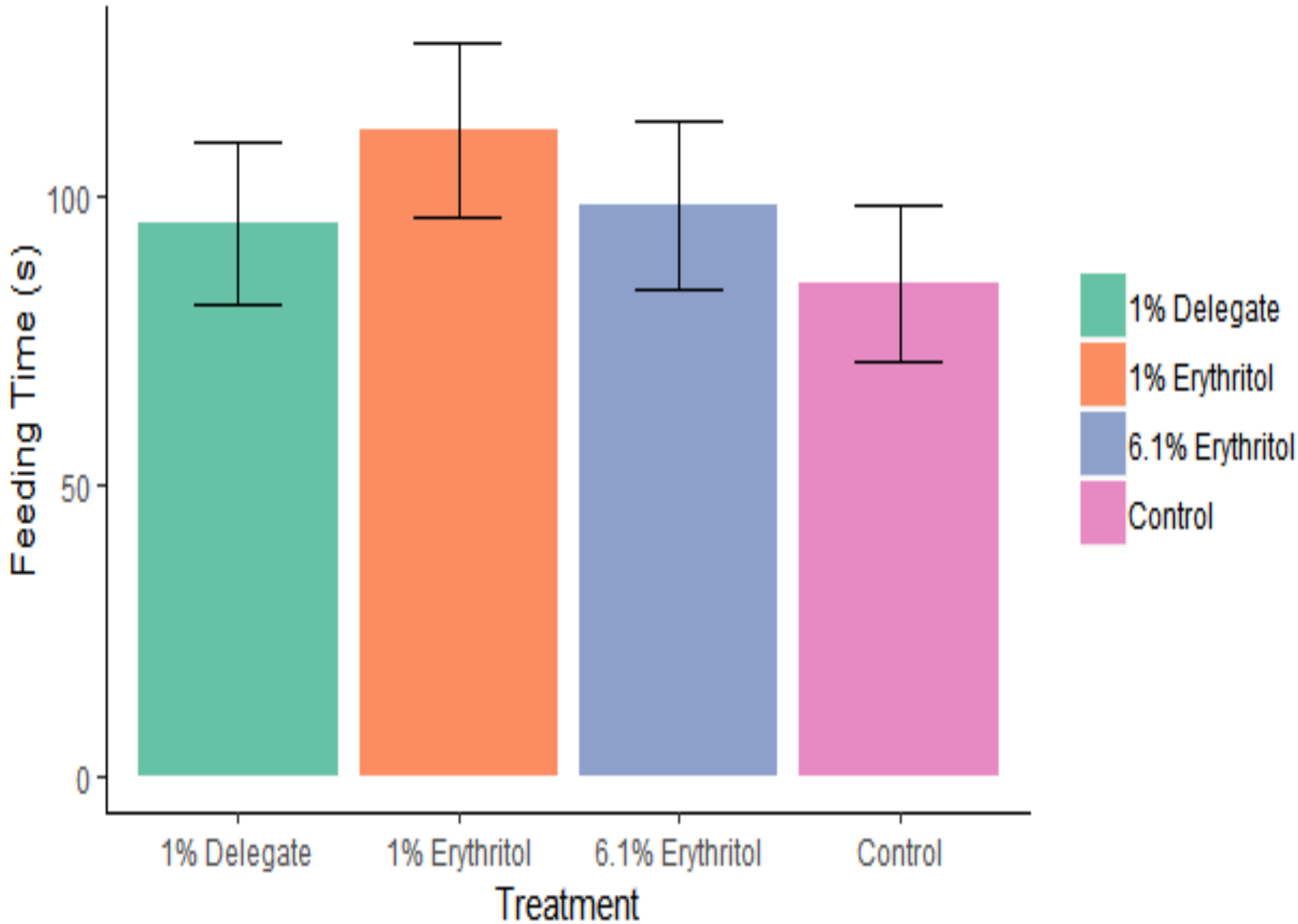
Killing Agent Lethality for SWD

- Evaluate lethality of attracticidal spheres with non-nutritive sugars as toxicant for SWD
- Cap contains a feeding stimulant (sugar) and toxicant
- Exploits environmental moisture (rain and dew) to continuously renew toxicant on sphere surface
- Toxicant not washed away with first rain even or heavy morning dew

Compressed cap of soluble feeding stimulant, wax carrier, and toxicant

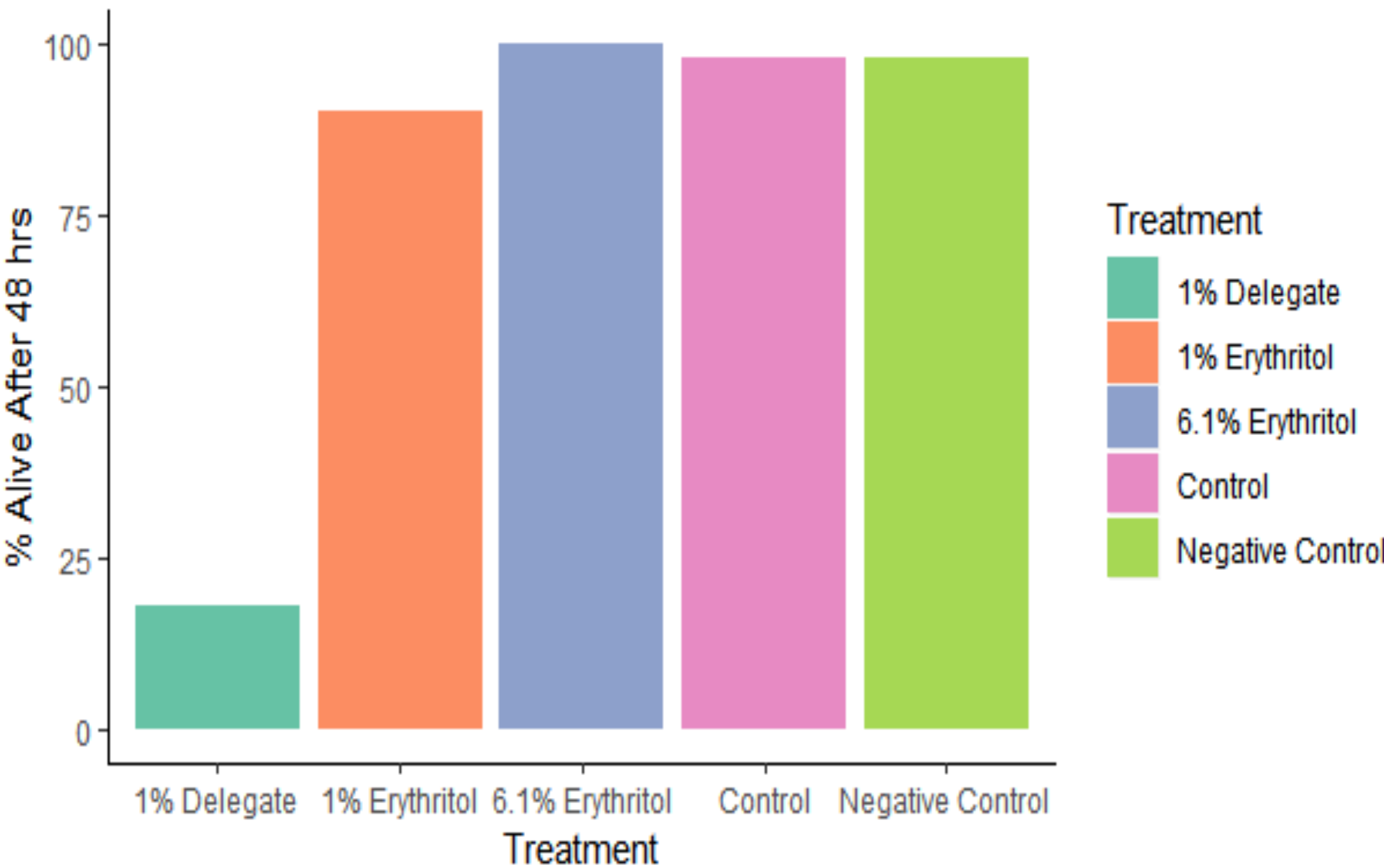
Visually integrated cap and sphere body, non-persistent toxicant bound in expendable cap

SWD feeding from attracticidal spheres dosed with Erythritol



- ➢ When SWD were allowed to feed for 5 minutes, there were no significant differences in feeding times among Erythritol, insecticide, and sucrose solution

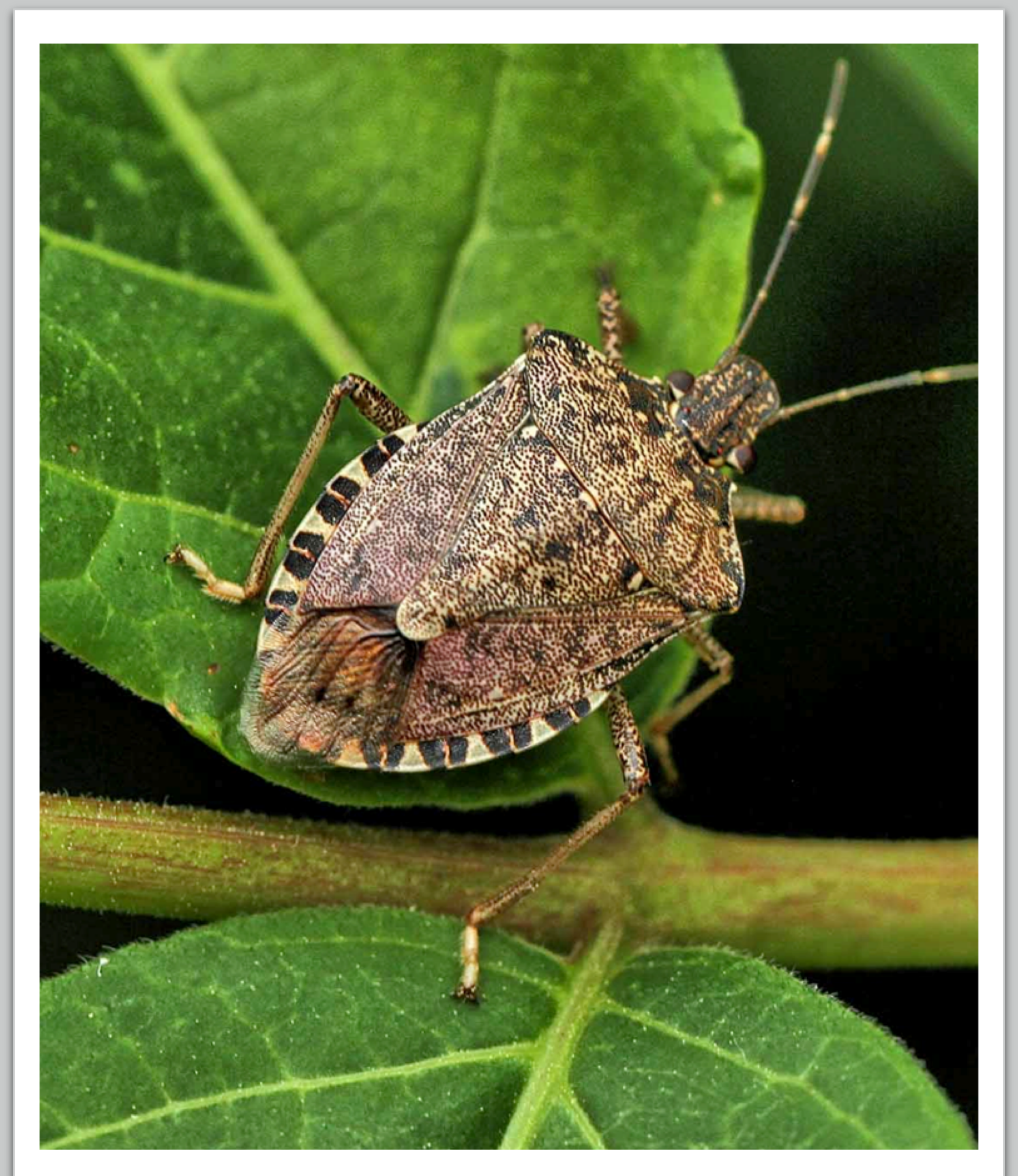
Survivorship of SWD after feeding from attracticidal sphere for 5 minutes



- Only 1% solution of Delegate showed a significant decrease in SWD survival

Tentative Conclusions

- Erythritol is toxic when included in SWD diet
- Diet including Erythritol kills SWD faster than sugar-free diets
- Suggests Erythritol is poisoning rather than starving the flies
- Erythritol appears to be non-toxic when available for short durations
- When incorporated into attracticidal spheres, no significant decrease in survival; only delegate showed significant decrease in survival



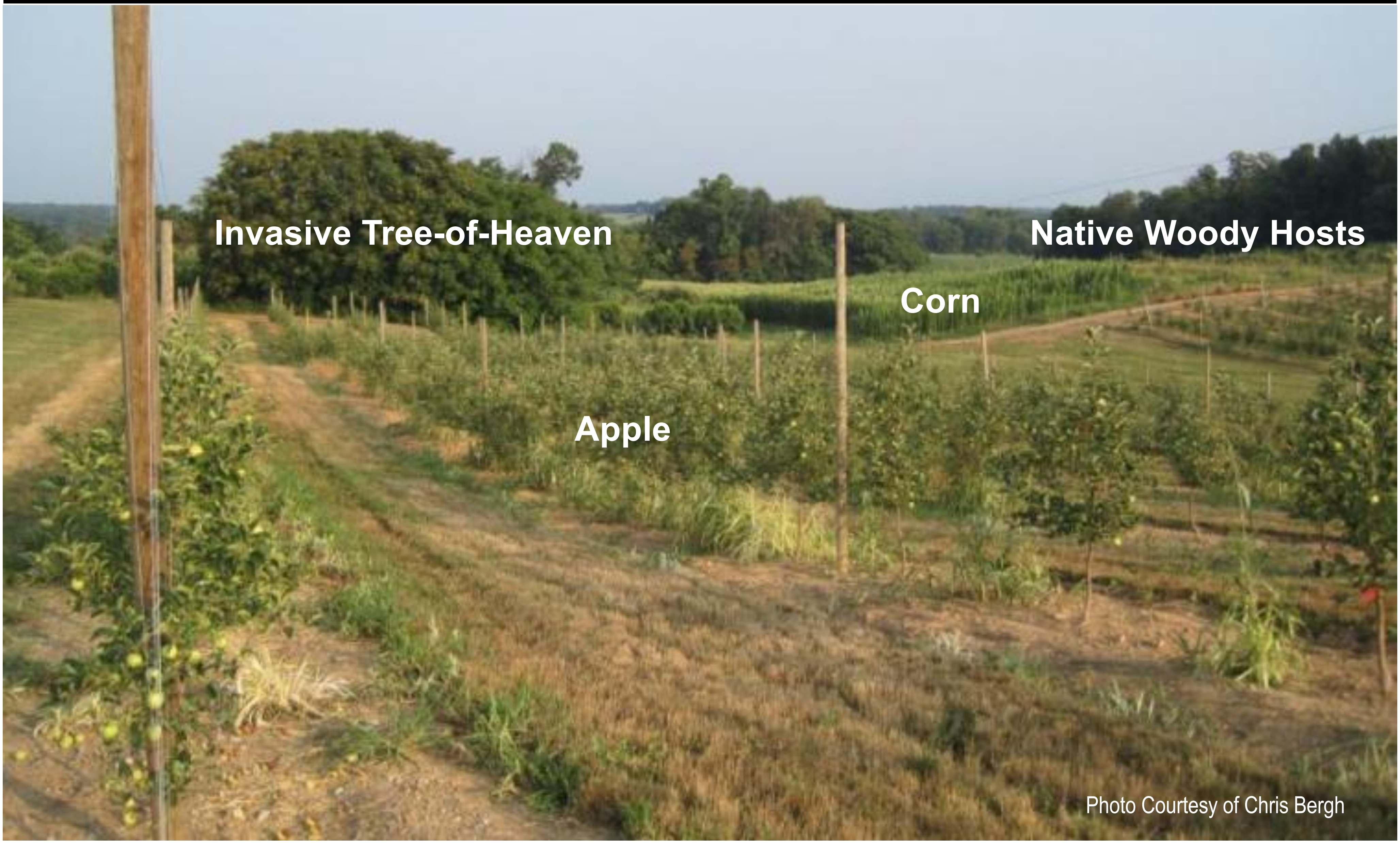
BMSB Research Update

History of BMSB in the United States

1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013 - Present

- **1998:** First suspected specimens collected in Allentown, PA
- **2001:** First properly identified specimen in the USA. Collected in Allentown, PA
- **2003:** First confirmed MD specimen
- **2004–2007:** Continued spread and localized reports of injury in Allentown, PA area
- **2008:** First widespread reports of late season injury in tree fruit in Mid-Atlantic
- **2009:** Serious late season injury in tree fruit in Mid-Atlantic
- **2010:** Severe crop injury and serious nuisance problems throughout the mid-Atlantic.
- **2011:** Aggressive chemically-based management. Late-season populations down in most locations, higher than others.
- **2012:** Secondary pest problems become common in east and increasing populations in west and southeast
- **2013 - Present:** Rebuilding IPM and mitigating risk

Landscape-Level Threat To Crops



Can We Develop Reliable Pheromone-Based Monitoring Tools?

- Tools that provide **accurate** measurements of presence, abundance, and seasonal activity of BMSB

- Inexpensive
- Easy to deploy

- Established thresholds so growers can make informed management decisions and reduce damage levels

Two Approaches To Establishing Thresholds

Retrospective Approach: Establishing Correlations Between Trap Captures and Damage

- We found this approach to be problematic
- Many factors that affect captures and damage at harvest
- Non-uniformity among growers (timing and materials) used for spray applications against BMSB and other pests, and delay in injury symptoms appearing leads to a lack of discernable relationship between trap captures and injury

Forward-Driven Approach: Using Set Thresholds To Drive Spray Applications

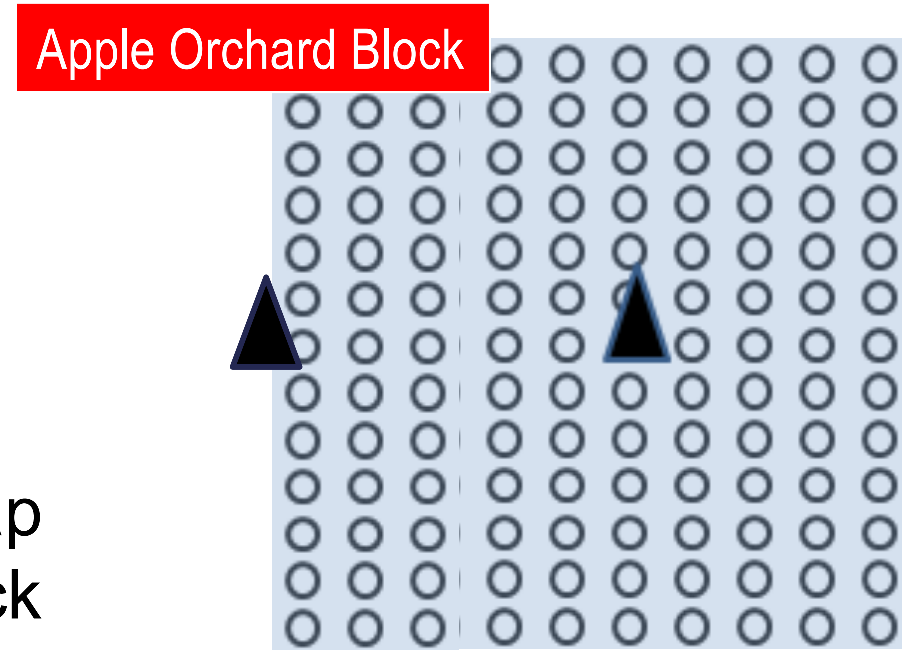
- This approach establishes that the only sprays applied against BMSB will be triggered by experimental thresholds
- This increases uniformity and enables us to determine if the number of sprays applied at a time indicated by trap captures (based on a set threshold) reduced damage at harvest

Forward-Driven Approach: Establishing A Threshold for Apple

- Apple blocks monitored with two black pyramid traps baited with pheromone lures; traps checked weekly

- When adult captures in either trap reached a set threshold, the block was treated with BMSB material (ARM) and block treated again 7-d later. Threshold was then reset

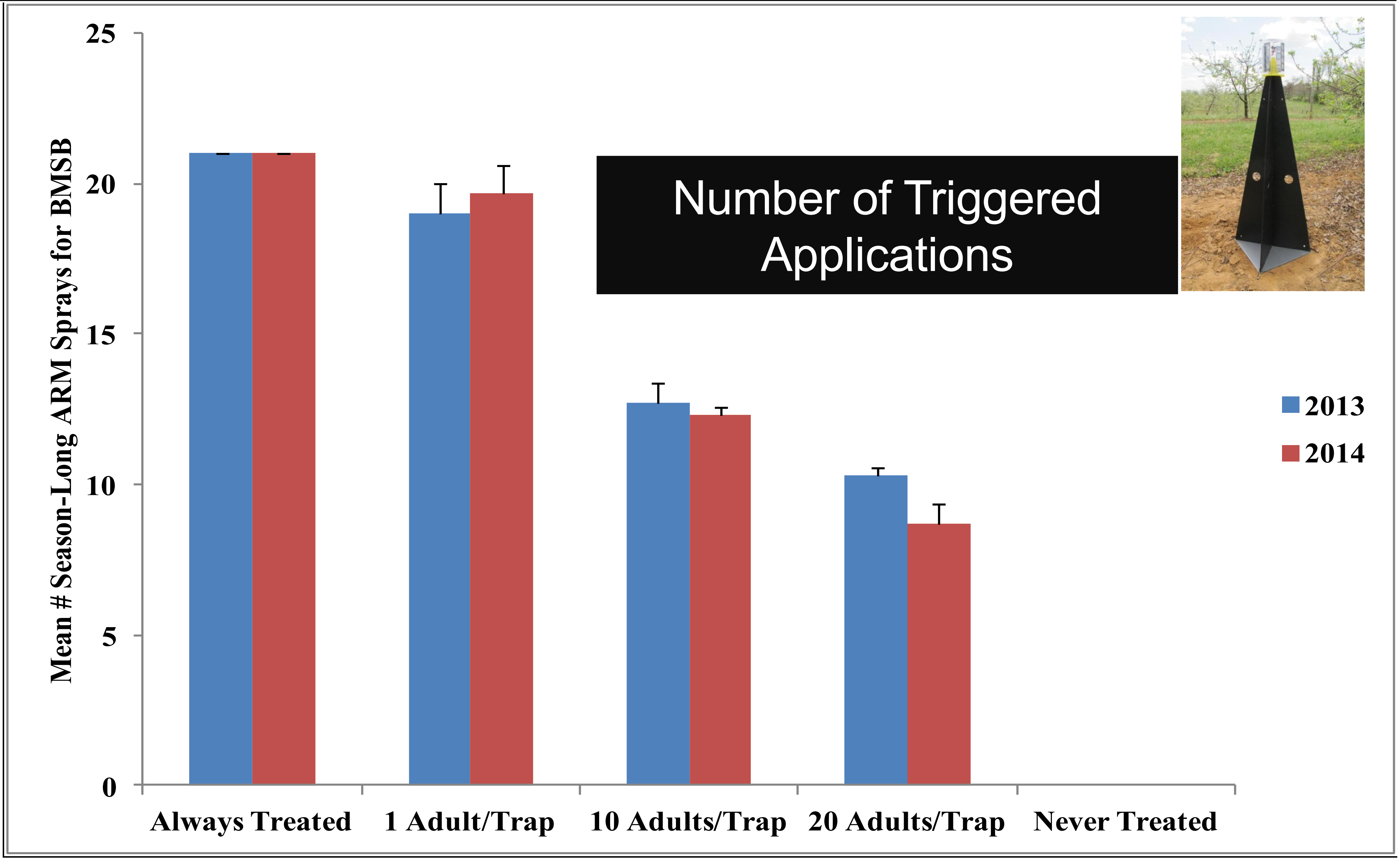
- This approach enabled the sprays to drive the results against BMSB



Experimental Treatments

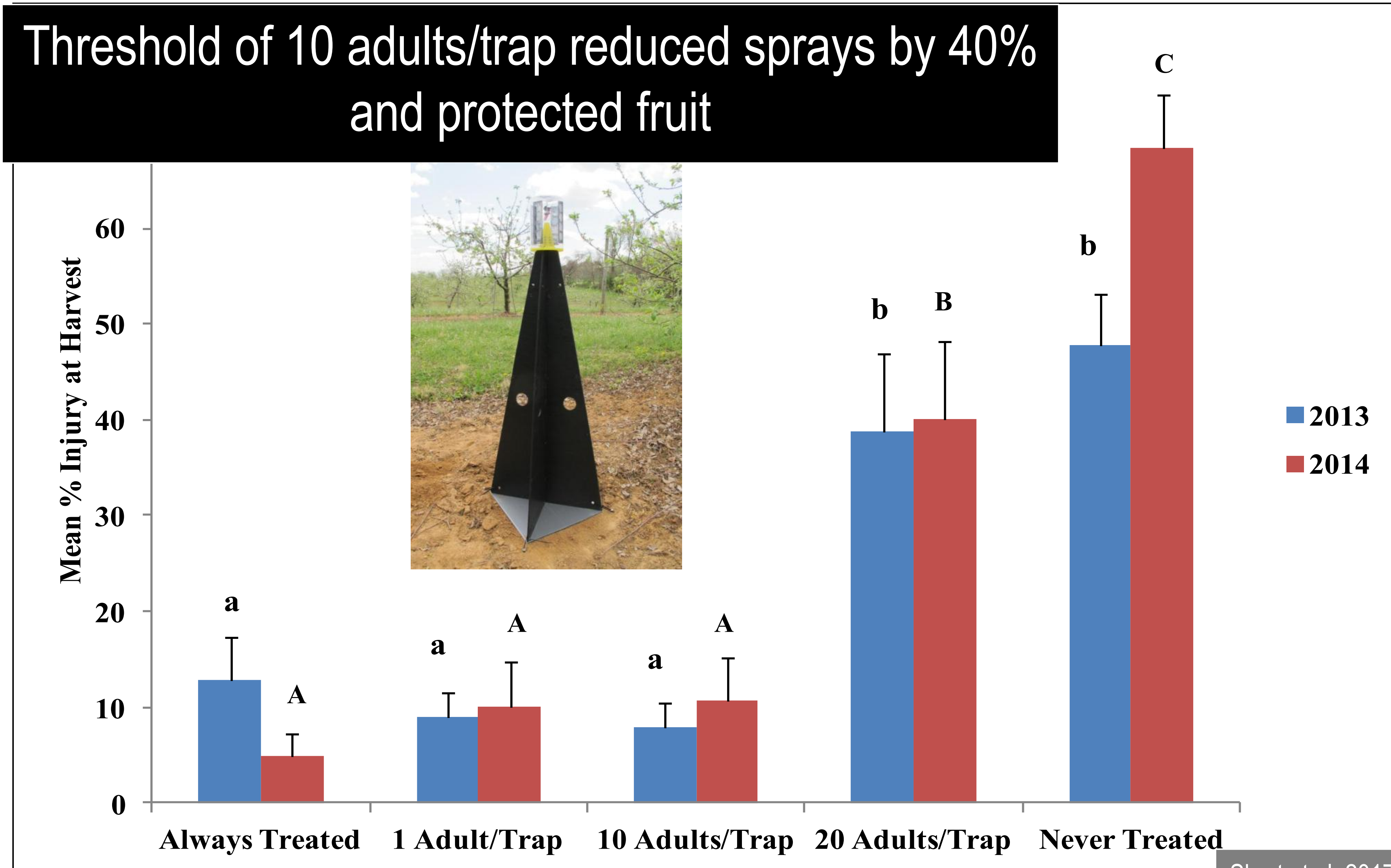
1) 1 Adult / Trap
2) 10 Adults / Trap
3) 20 Adults / Trap
4) Treated Every 7 d
5) No Spray (Control)

Season-Long Insecticide Applications Made Against BMSB Triggered By Trap Captures



Need for and Timing of Applications Against BMSB

Threshold of 10 adults/trap reduced sprays by 40% and protected fruit



Short et al. 2017

Can We Improve our Trapping System?

- What is the most sensitive and **cost-effective trap** design and lure formulation?
- Easy to deploy and use?
- Can we **detect low** populations?
- Can we **detect nymphal presence** with simplified designs?
- What is the size of the **area** sampled by the trap?

Targeted Study of Two Trap Designs

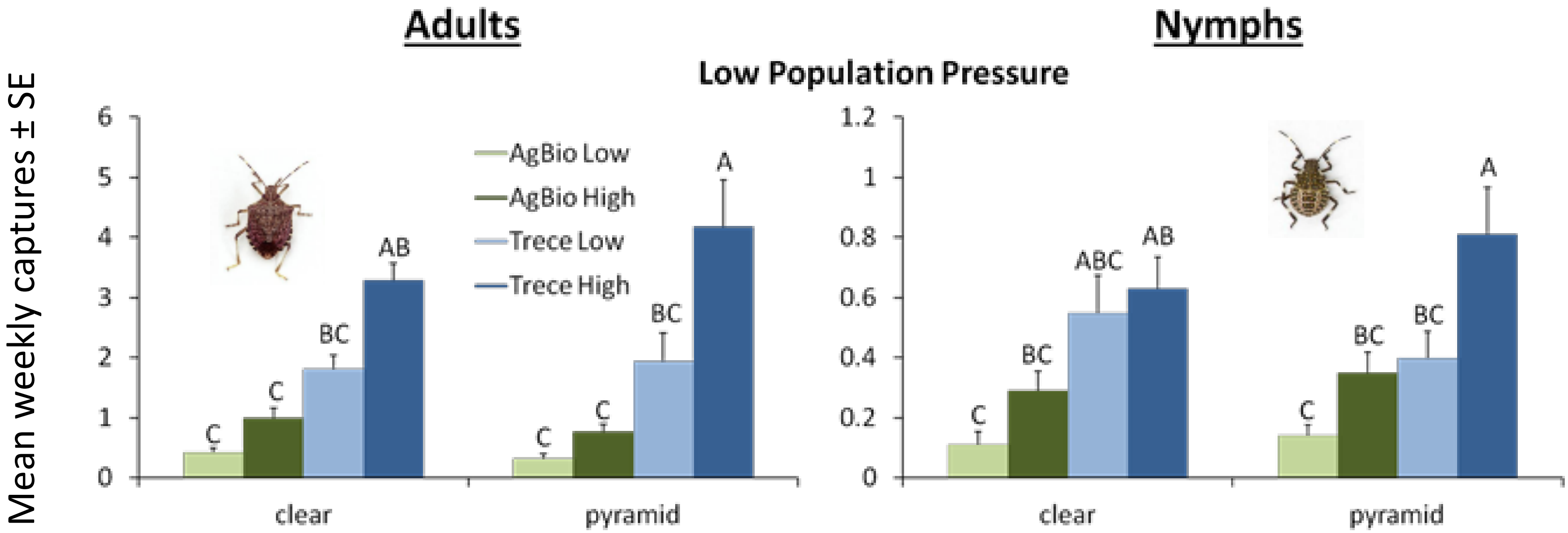
Similarities

- Ground Deployed
- Upright Visual Stimulus

Differences

- Capture Mechanism
- Retention Mechanism/ Killing Agent

- **Trece** and **AgBio** Lures
  - Low: Monitoring dose (1x) (5mg PHER/50 mg MDT)
  - High: Surveillance dose (4x) (20 mg PHER/200 mg MDT)
- Season-long captures of adults and nymphs at 12 sites in the mid-Atlantic



- Trece lure outperformed AgBio lure
- Captures with clear sticky traps statistically similar to pyramid traps
- All traps detected low density BMSB populations
- Nymphs detected with both trap designs

Sensitive Trap-Based Monitoring System

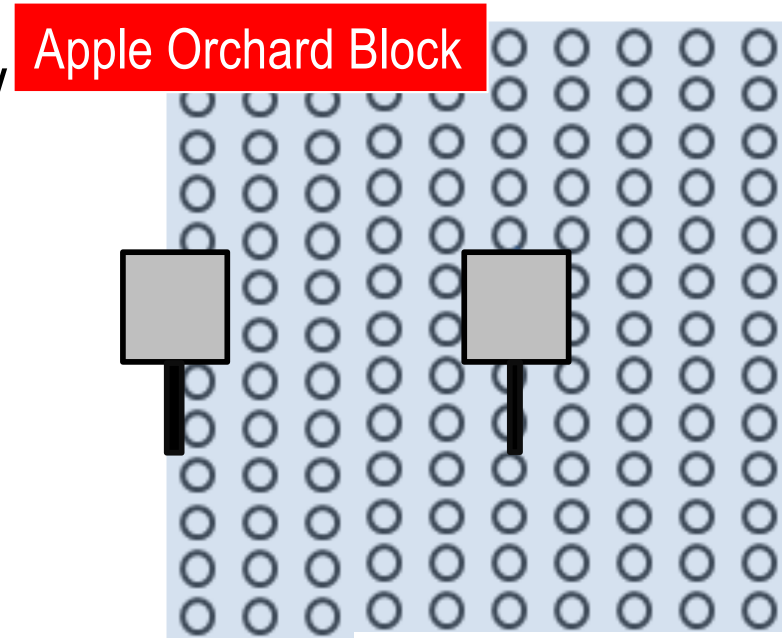
- Capture **adults** and **nymphs** at low, moderate or high population levels
- Trap is **less expensive** and easier to deploy than Black Pyramid Traps
- Trece monitoring lures are long-lasting (12 weeks) and sensitive

Forward-Driven Approach: Establishing A Threshold for Apple with Clear Sticky Traps

- Apple blocks monitored with two clear sticky panels baited with Trece Dual Lures
- Black pyramid trap standard included
- Traps checked weekly

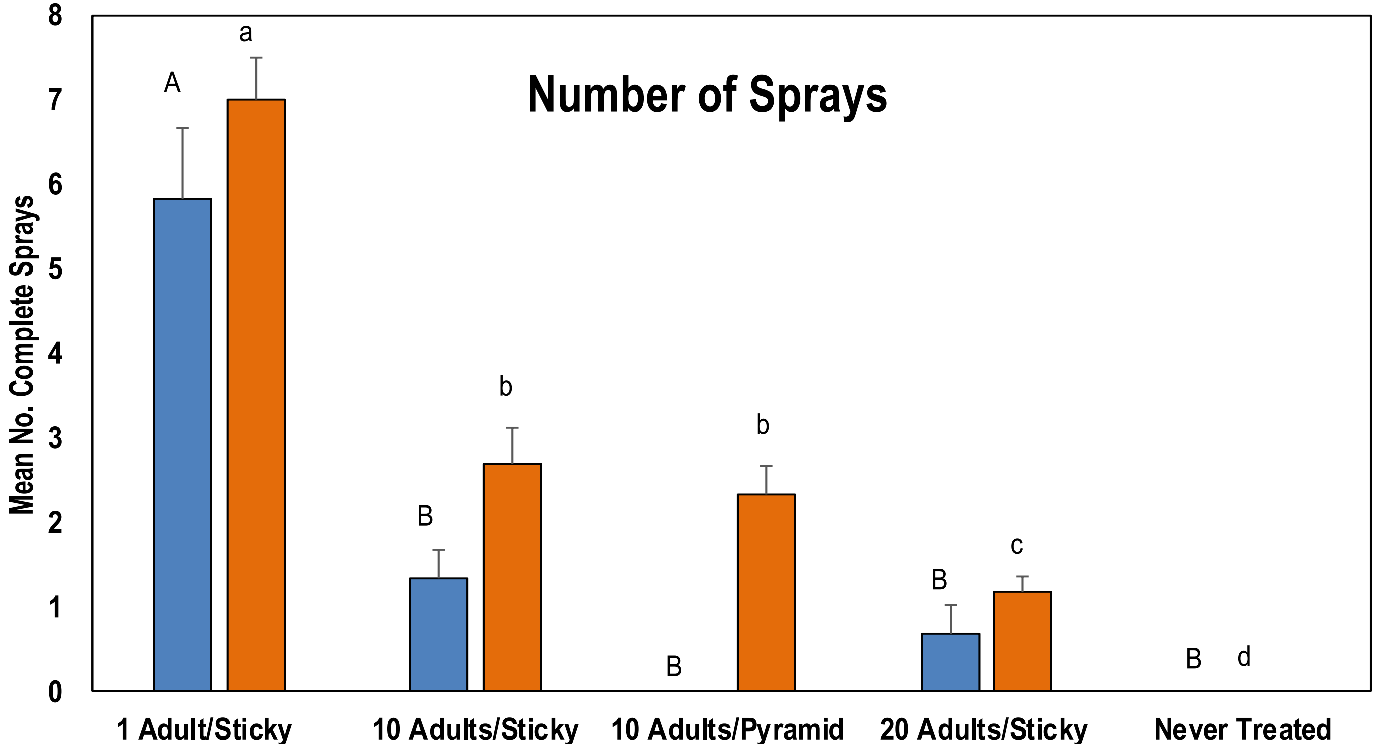
- When adult captures in either trap reached a set threshold, the block was treated with BMSB material (ARM). Block treated again 7-d later and threshold reset

- This approach enabled the sprays to drive the results against BMSB

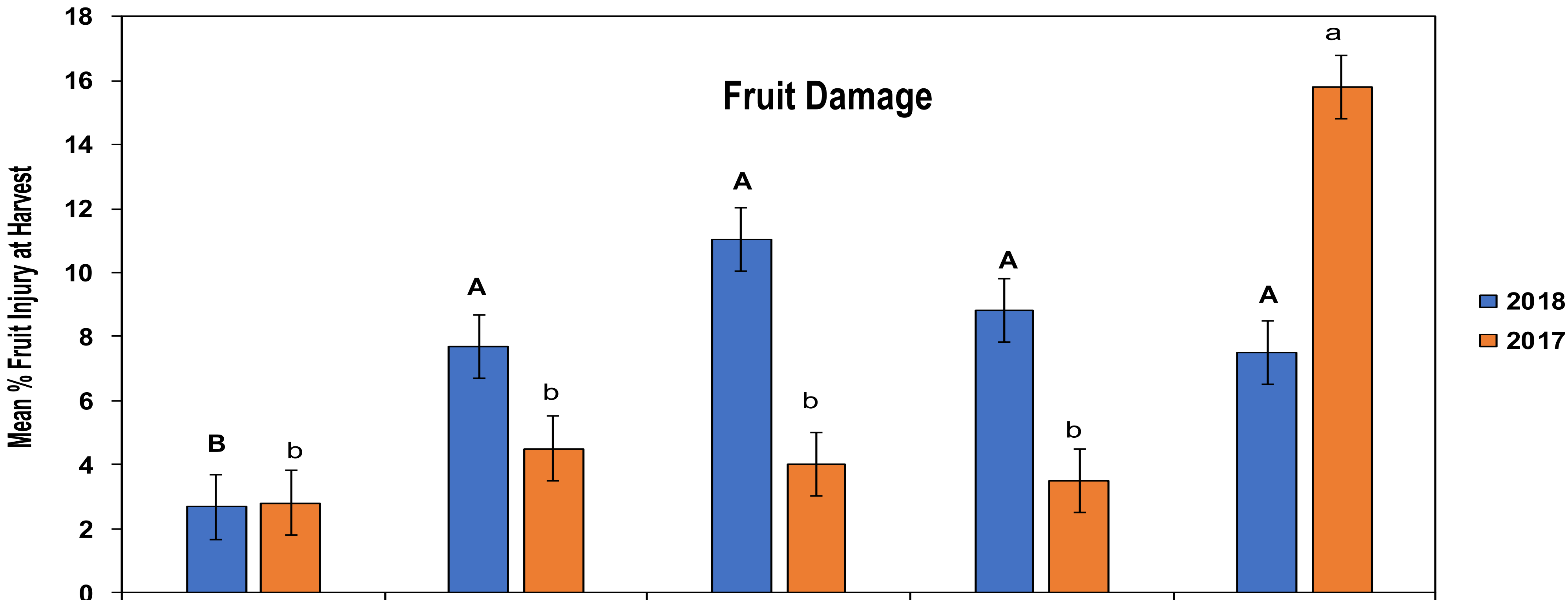


Experimental Treatments

1) 1 Adult / Trap
2) 10 Adults / Trap
3) 20 Adults / Trap
4) Treated Every 7 d
5) No Spray (Control)



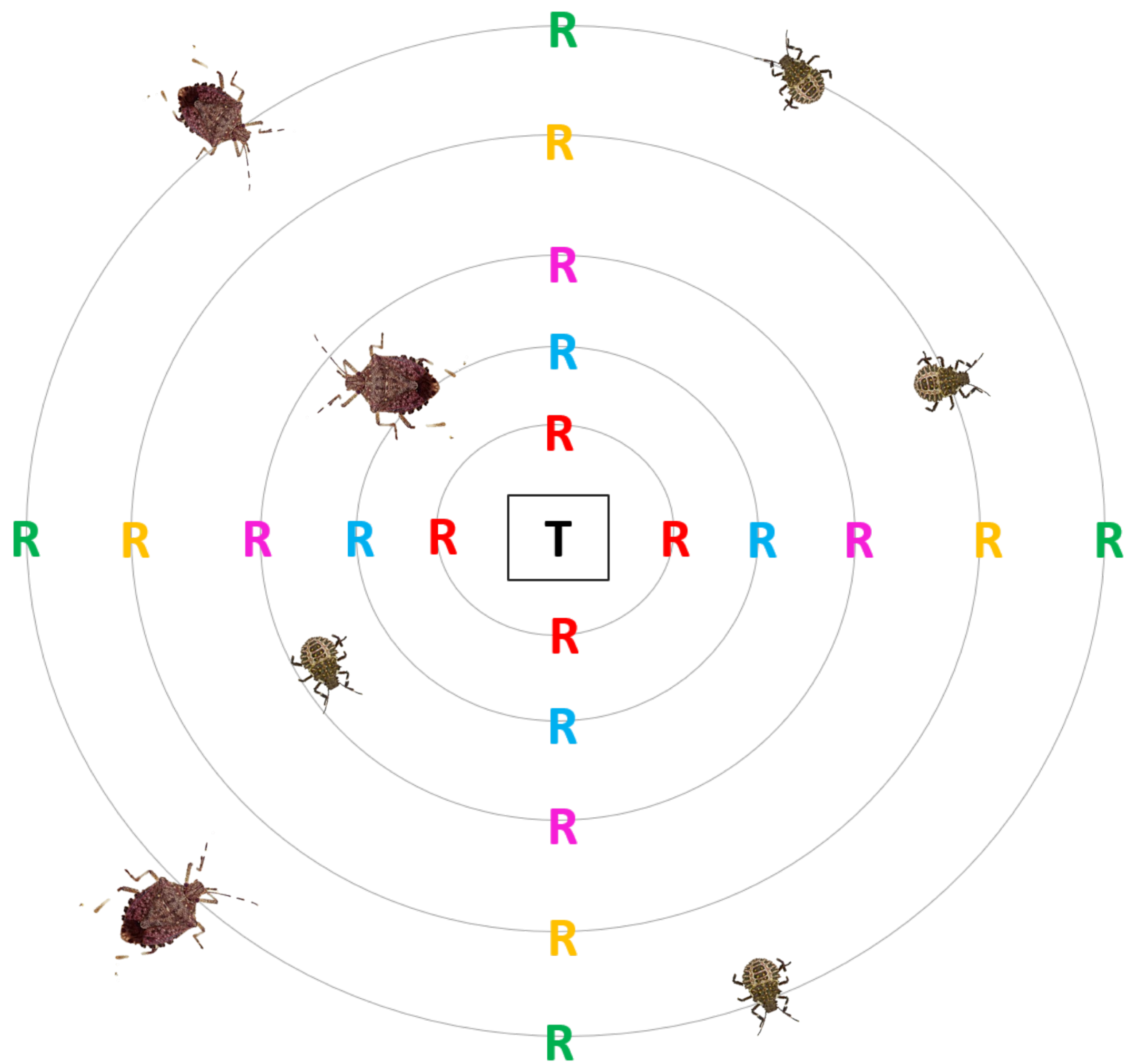
- Threshold of **1 adult/sticky trap** resulted in significant reductions in injury
- *Used a threshold of 4 adults/sticky trap in commercial orchards with good success



2019 Plans: Establishing A Threshold for Apple Using Clear Sticky Traps

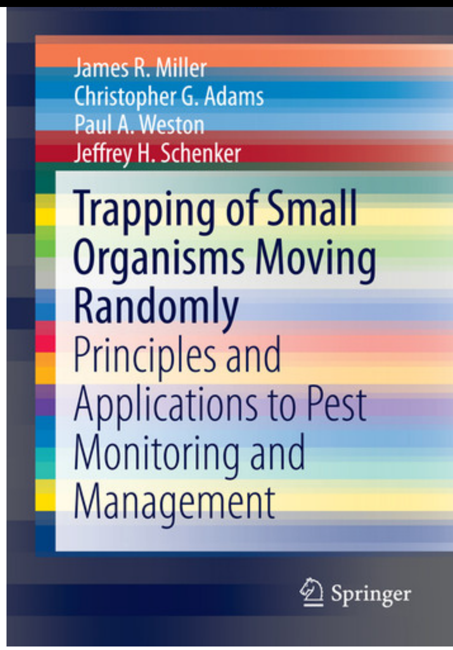
- More work needed to establish accurate threshold
- The following threshold treatments will be evaluated in apple orchards using clear sticky traps baited with Trece Dual Lures
  - 1 adults/sticky trap
  - 4 adults/sticky trap
  - 10 adults/sticky trap
  - Always sprayed (positive control)
  - Never sprayed (negative control)

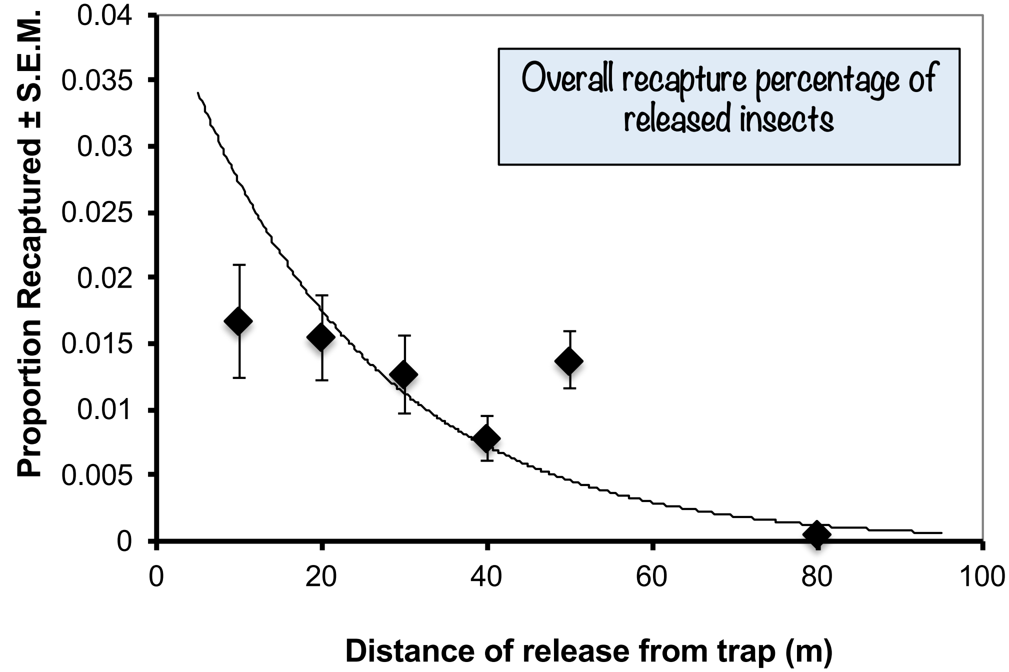
What is the dispersal capacity of BMSB adults and nymphs?

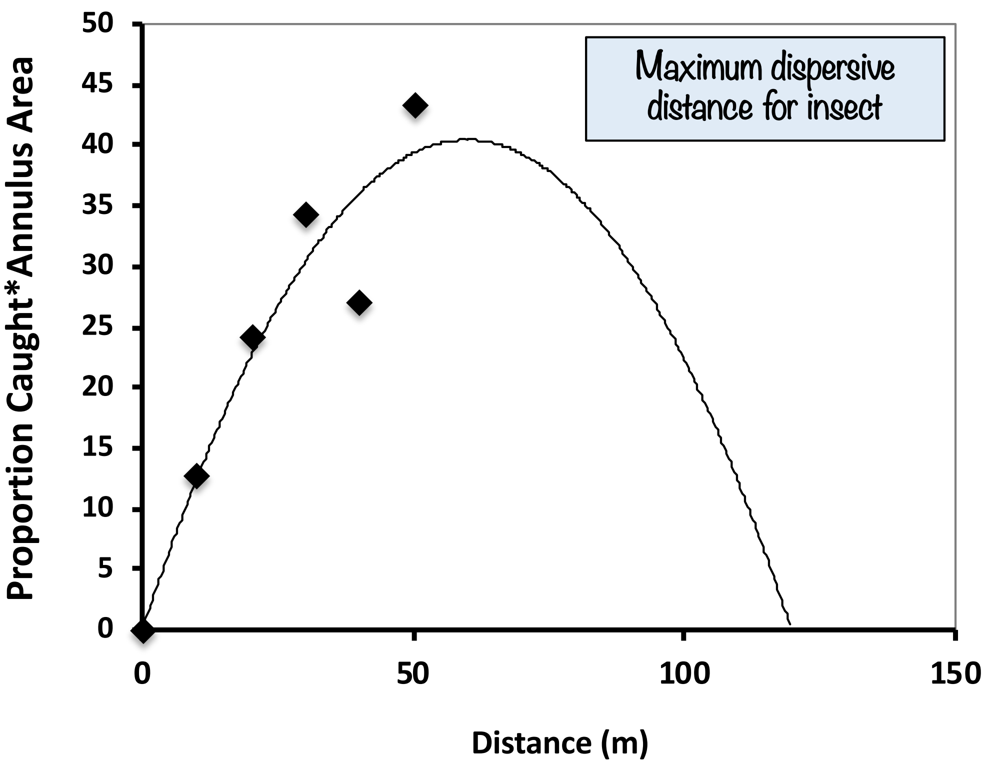


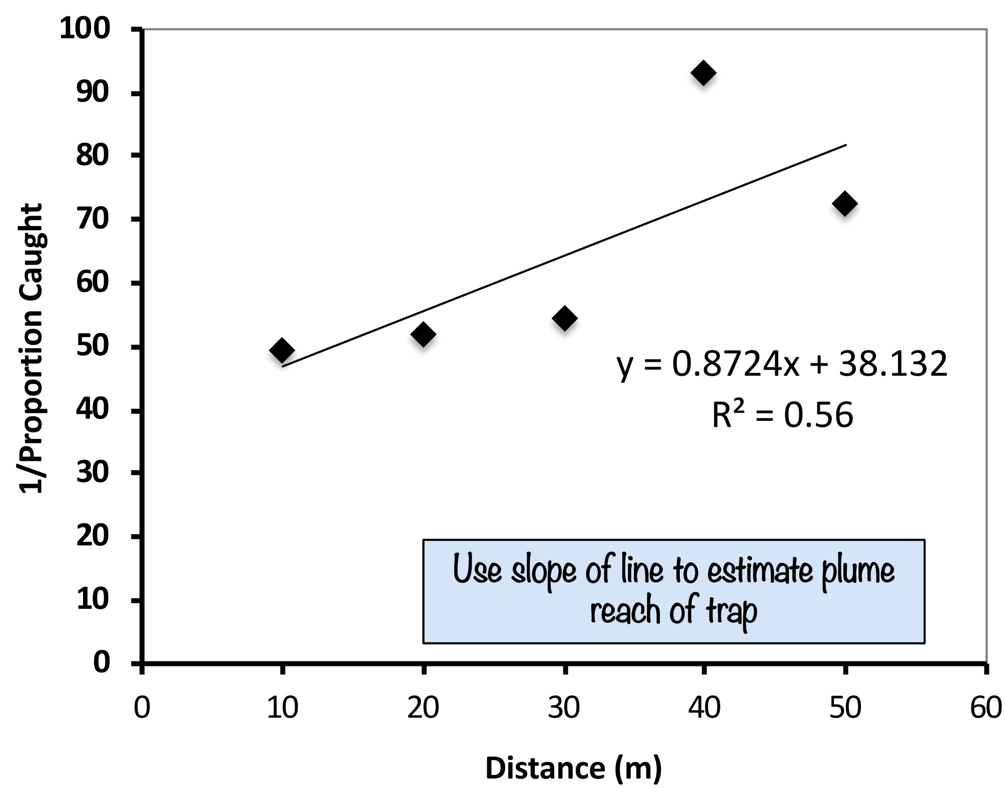
Single trap, multiple release method

Trapping Theory

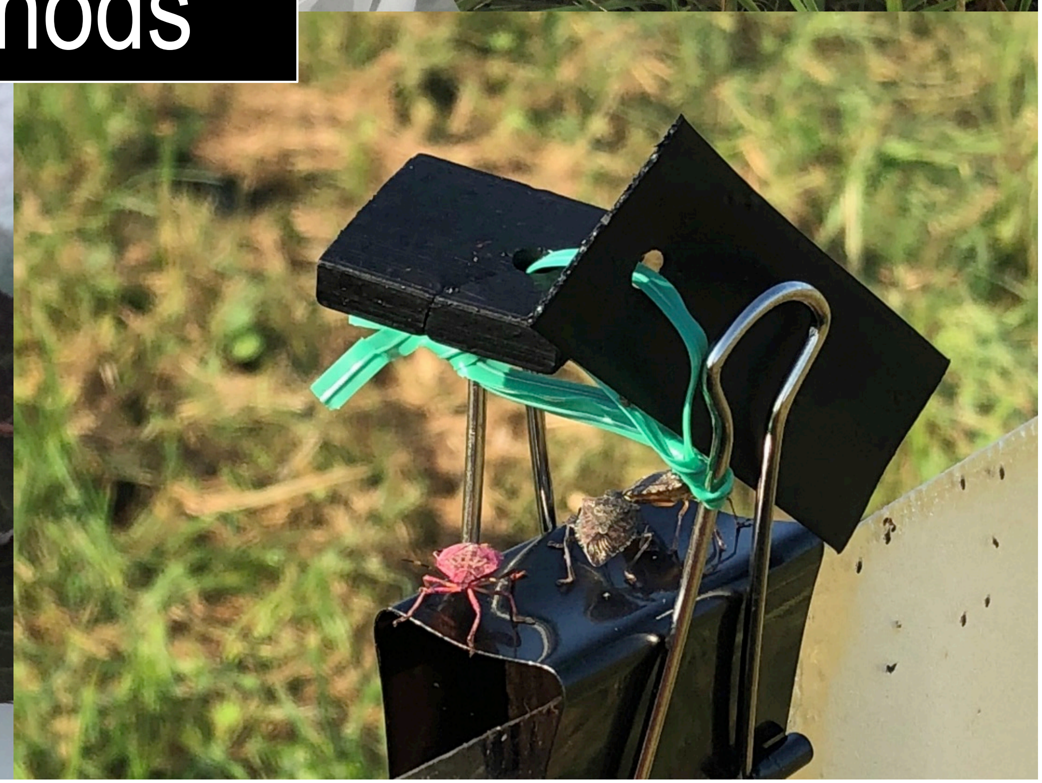


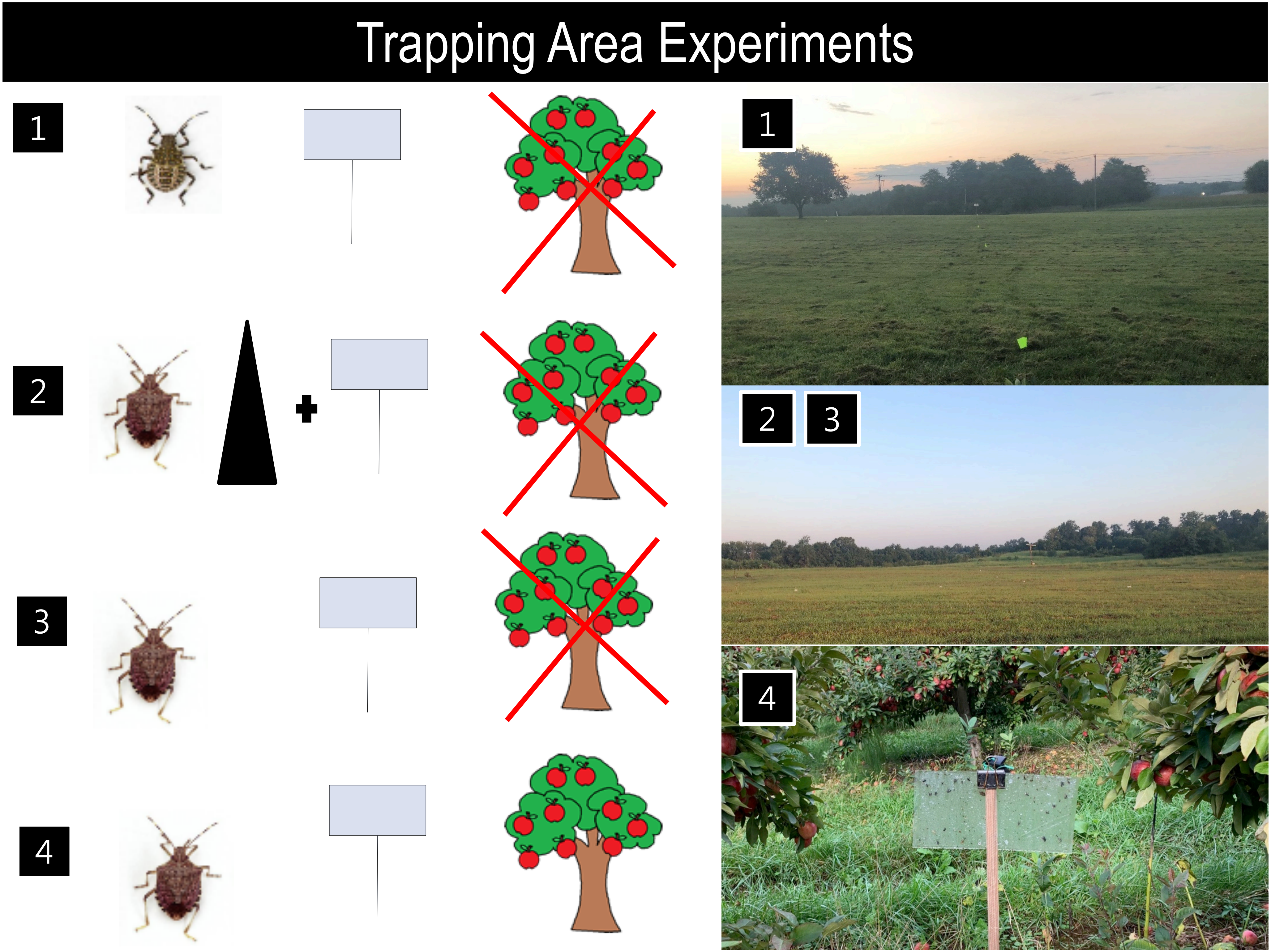






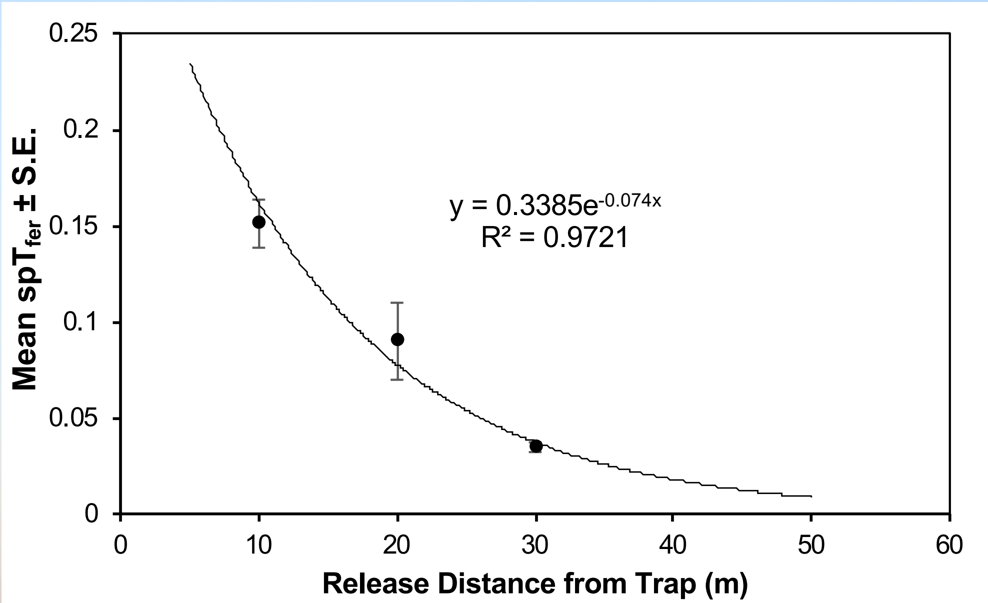
Methods

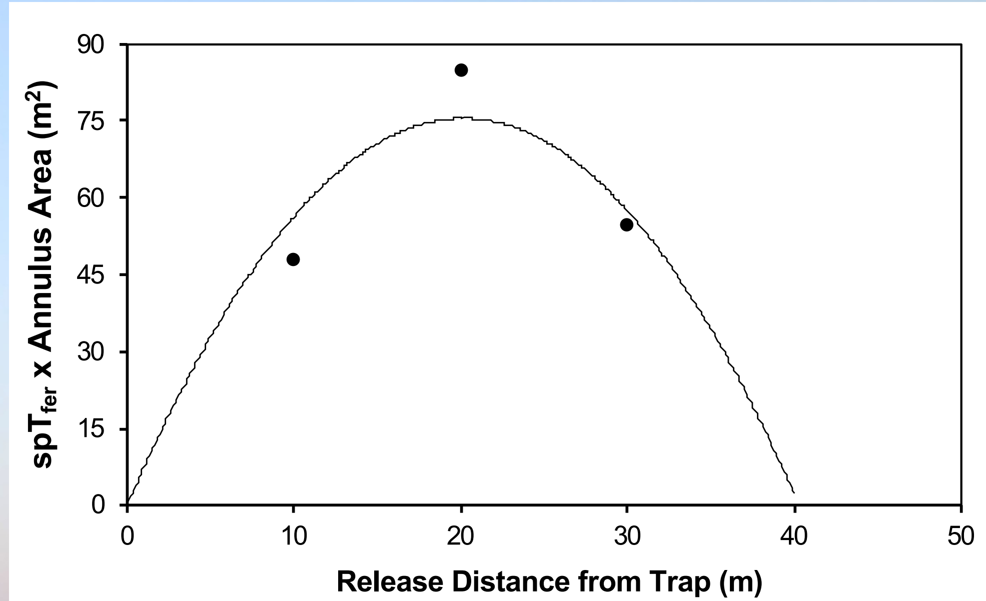


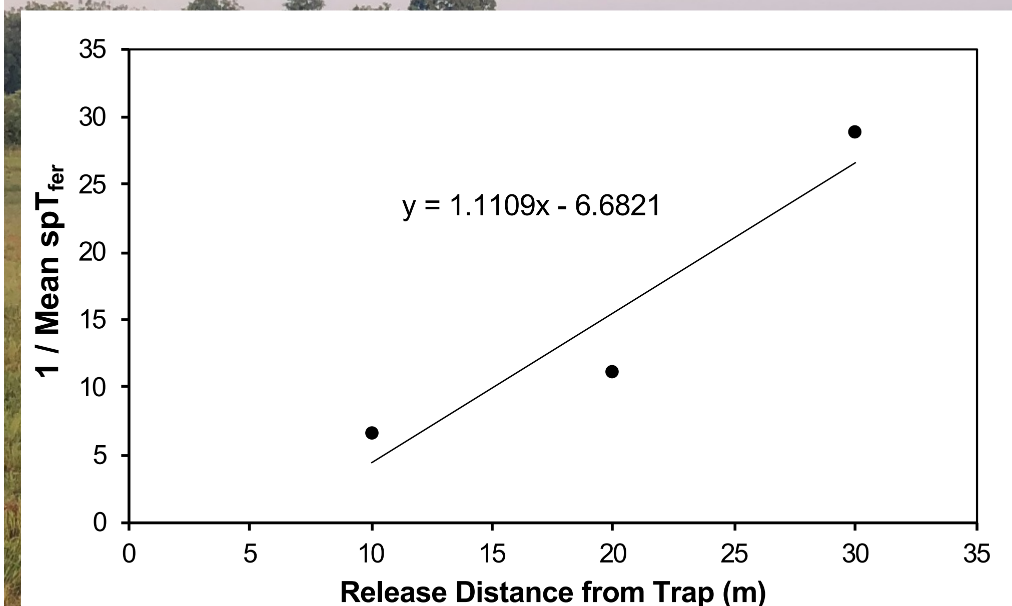


Trapping Area Experiments
1
2
3
4
1
2
3
4

Nymphal Trapping Area Results







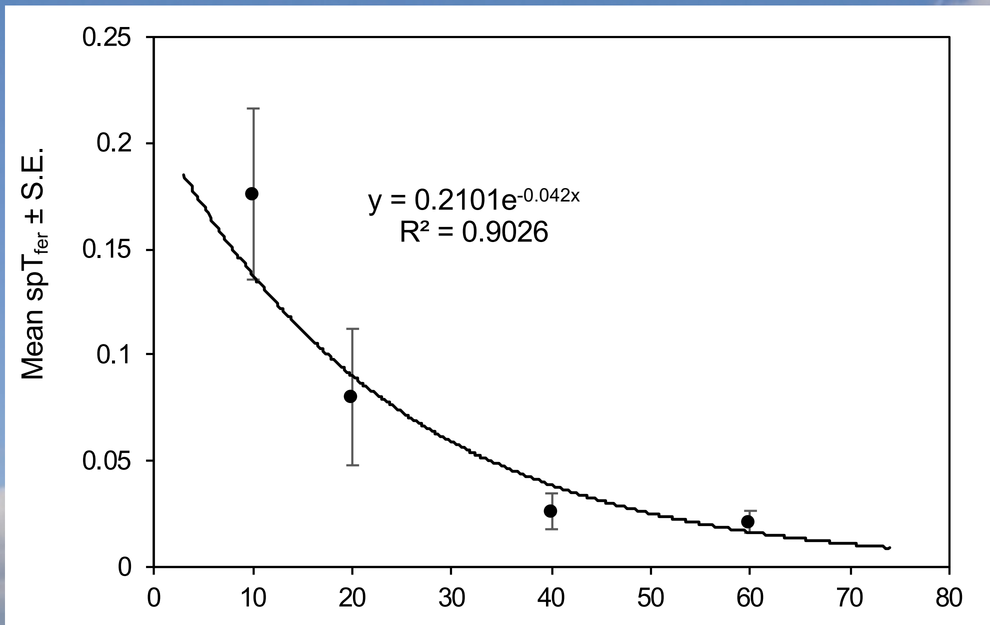
Nymphal Mark-Recapture Results

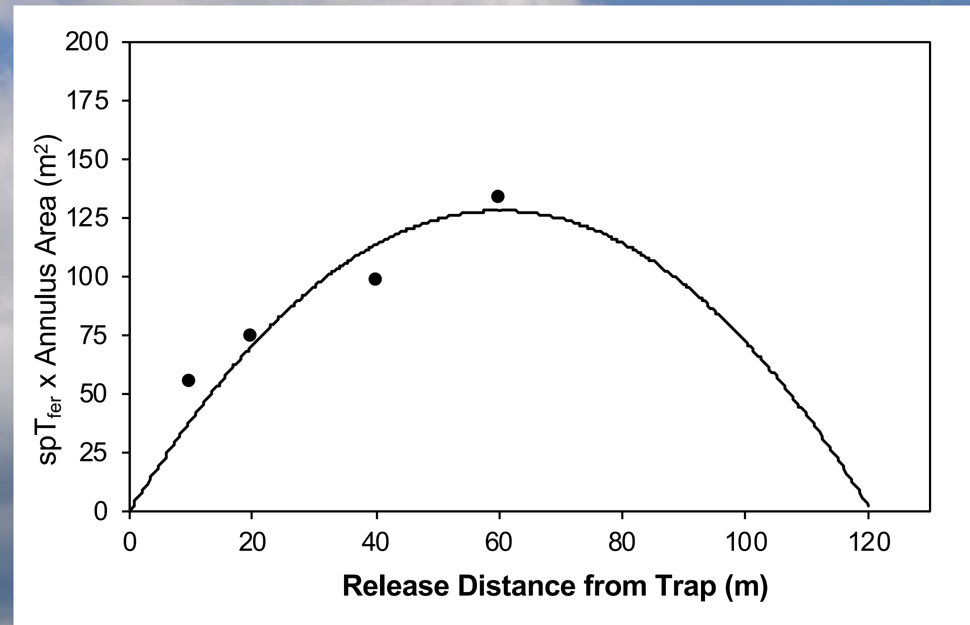
- Recapture 6.6% of released nymphs
- Maximum Dispersive Distance ~40 m
- Plume Reach < 3 m

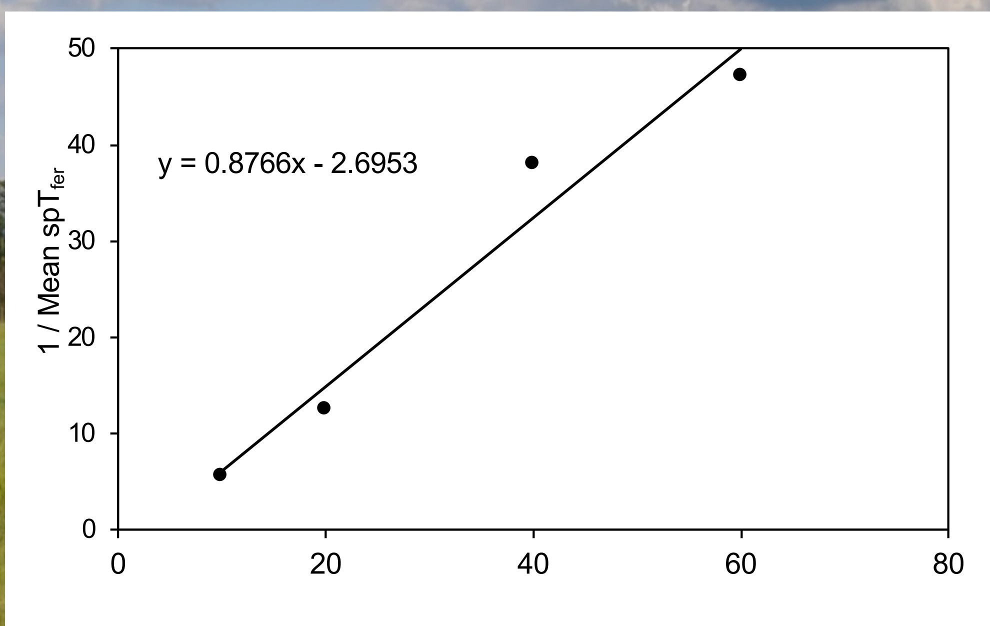
- Trapping Radius = 43 m

- Trapping Area = 0.58 ha

Adult Open Field (with Pyramids) Results



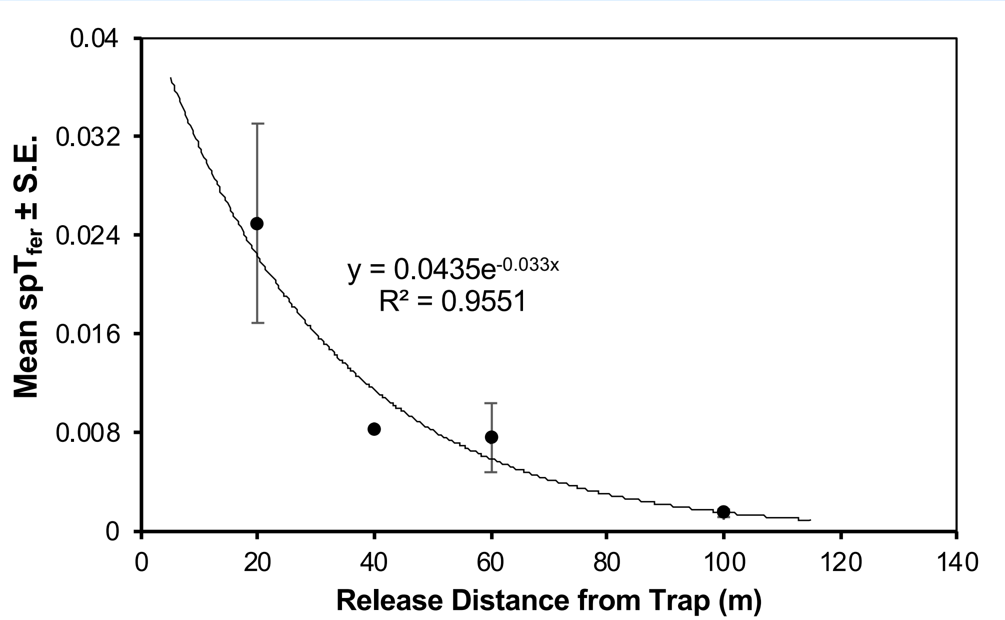


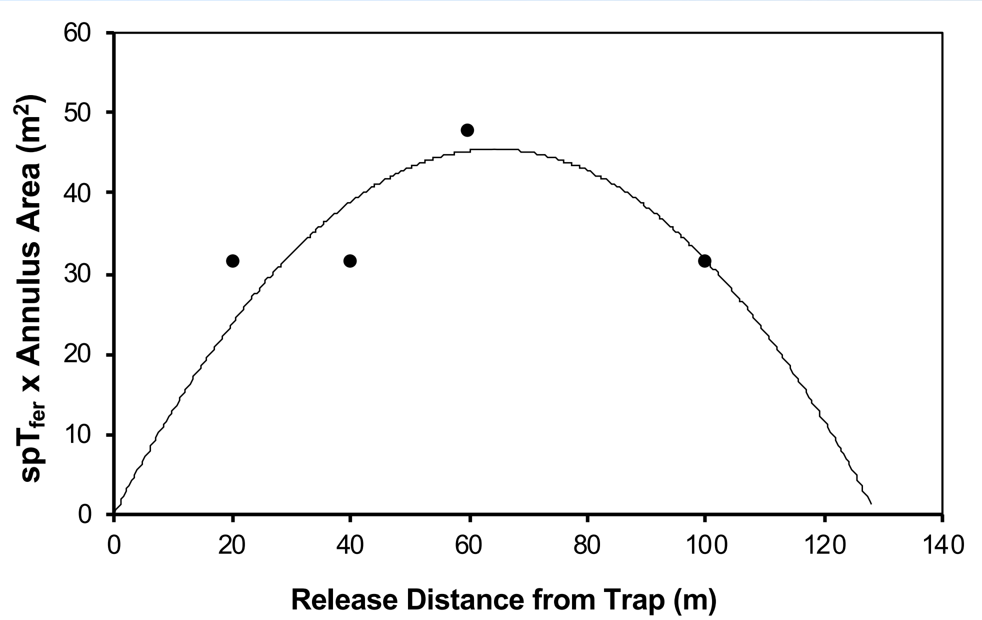


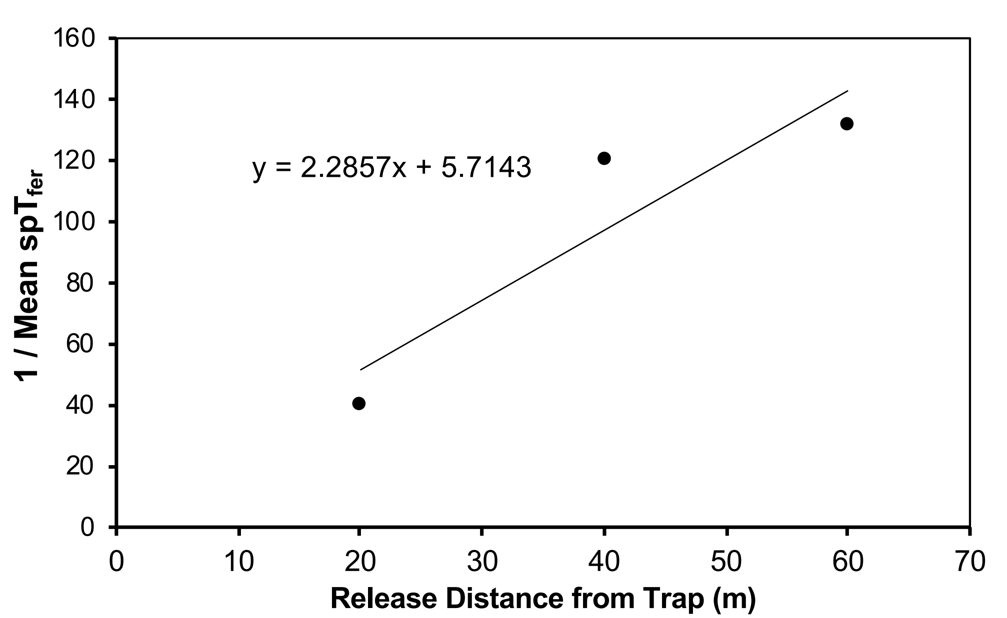
Preliminary Adult Mark-Recapture Open Field

- Overall Recapture Rate: 3.23%
- Max Dispersive Distance ~120 m
- Plume Reach < 3 m
- Trapping Radius = 123 m
- Trapping Area = 4.83 ha

Adult Open Field Trapping Area Results



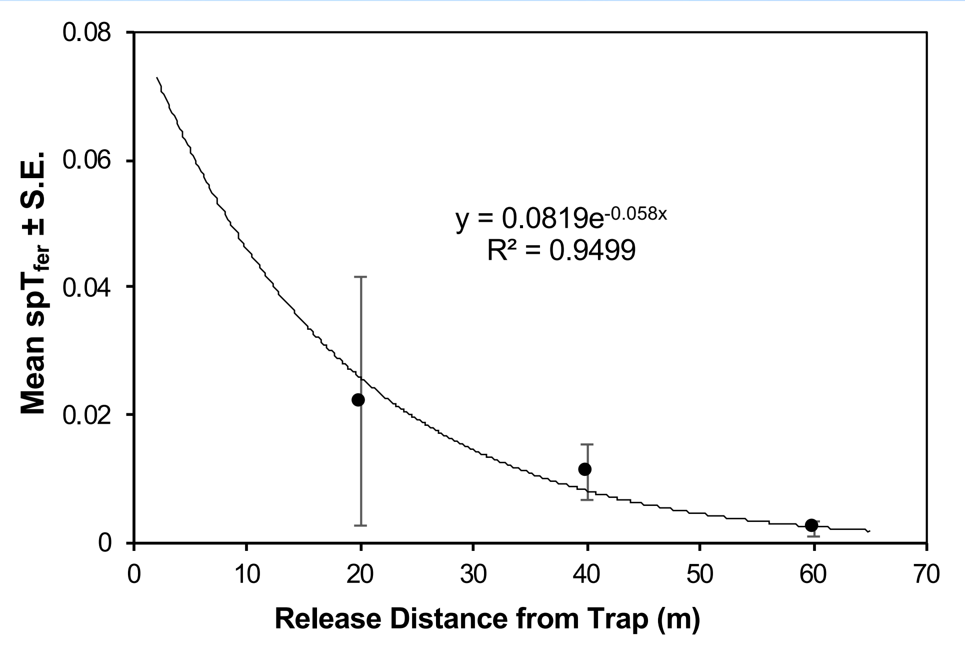


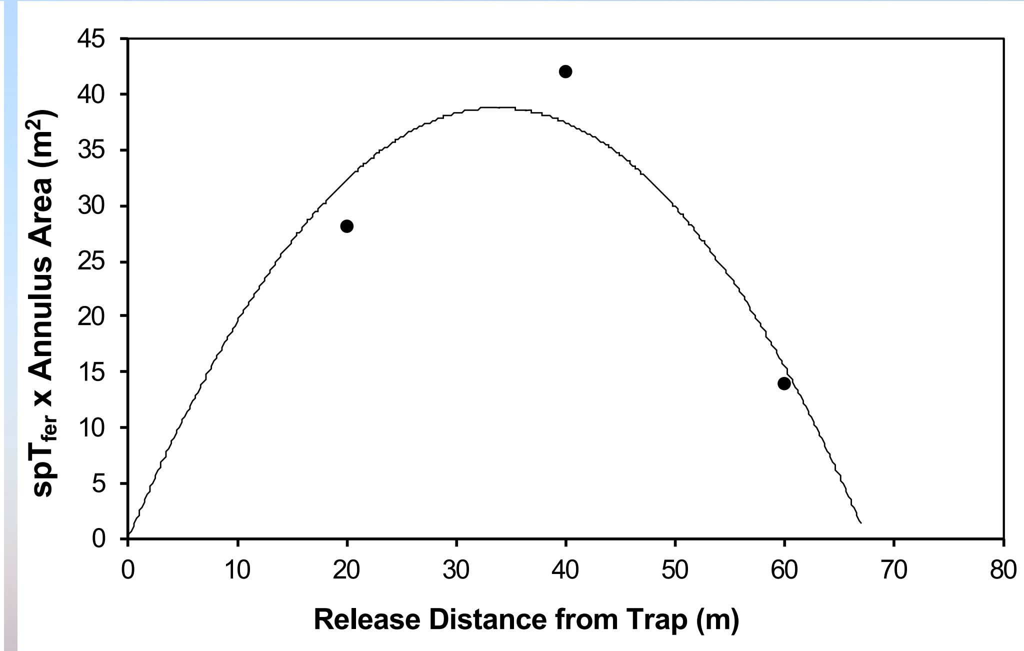


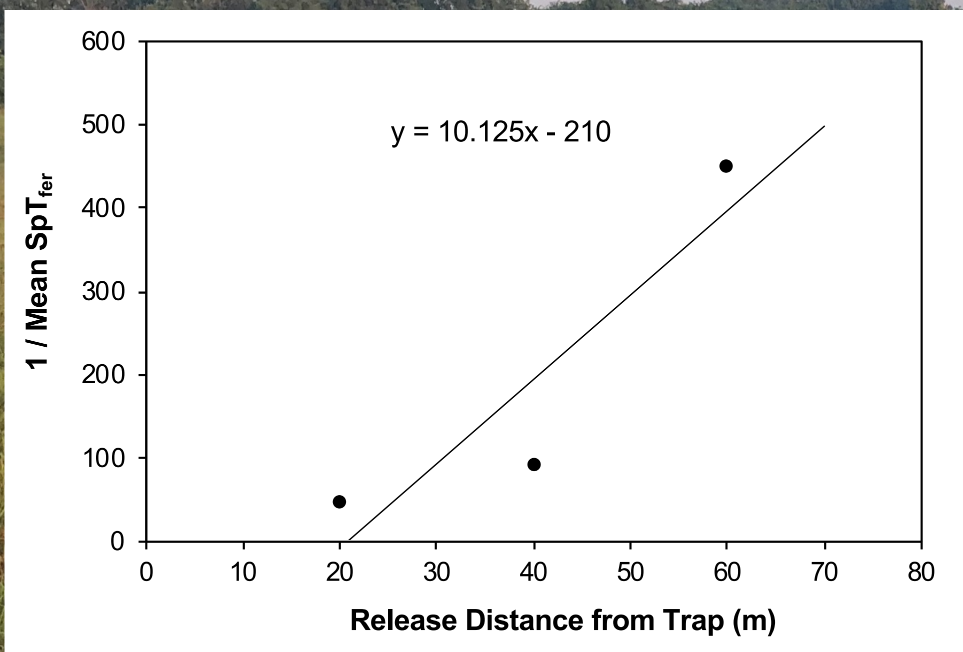
Adults Mark-Recapture Open Field

- Recapture 0.6% of released BMSB
- Max Dispersive Distance ~130 m
- Plume Reach < 3 m
- Trapping Radius = 133 m
- Trapping Area = 5.56 ha

Adult Apple Block Trapping Area Results







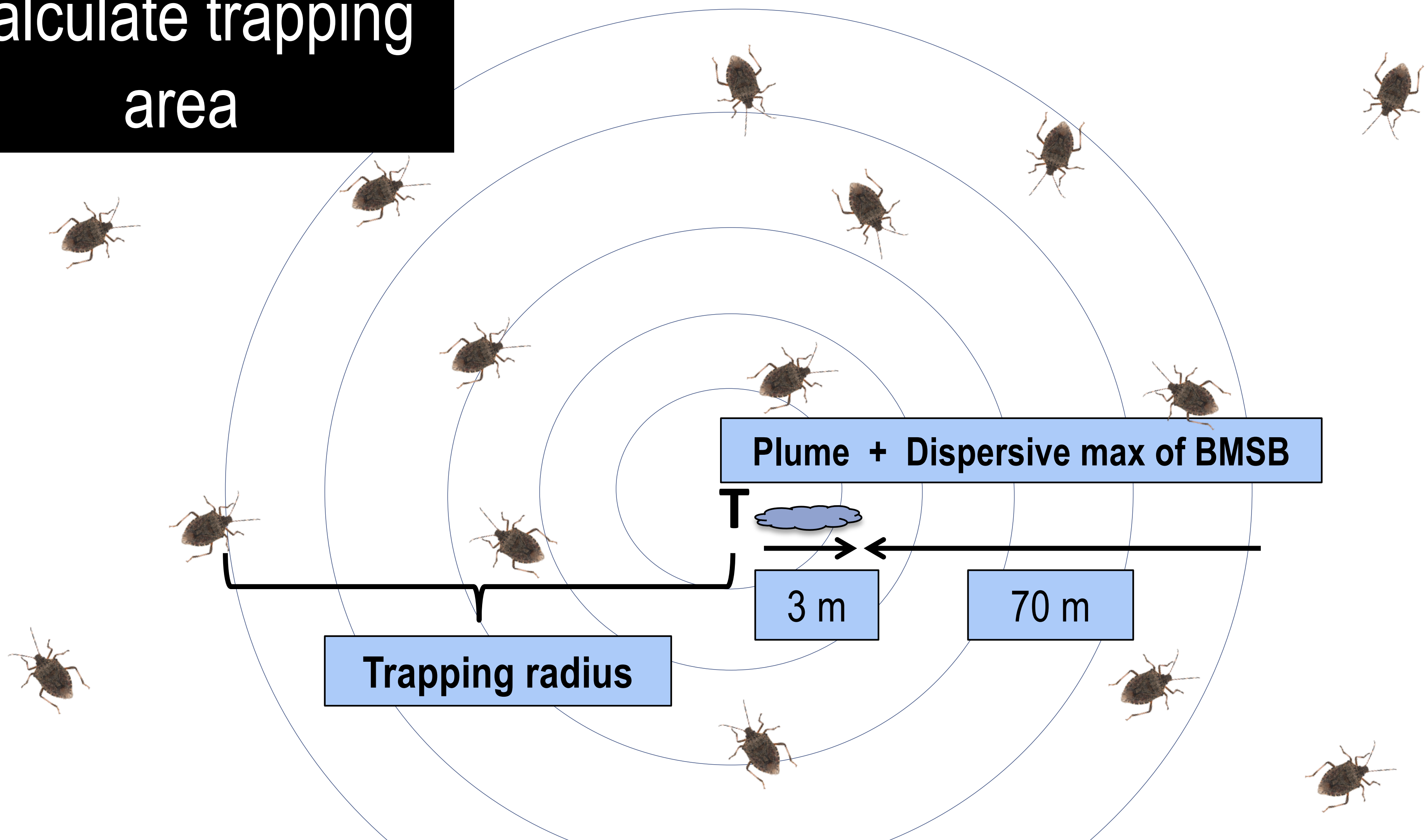
Adults Mark-Recapture Apple Block Edge

- Recapture 1.1% of released BMSB
- Maximum Dispersive Distance ~70 m
- Plume Reach < 3 m

- Trapping Radius = 73 m

- Trapping Area = 1.67 ha

Calculate trapping area



Trapping radius = 70 m + 3 m = 73 m

Trapping area = $\pi * 73^2 = 16{,}742^2$ m

4.14 acres = 1.67 hectares

Results For Sticky Panel Trap Baited with Trécé Monitoring Lure

Life Stage	Experiment	Percent Recaptured	Plume Reach	Maximum Dispersal Distance	Trapping Area
Adults 	Open Field With Pyramid Traps	3.2%	< 3 m	120 m	4.83 ha
	Open Field	0.6%	< 3 m	130 m	5.56 ha
	Apple Orchard	1.1%	< 3 m	65 m	1.67 ha
Nymphs 	Open Field	6.6%	< 3 m	40 m	0.58 ha

•Adult trapping area in an open field is ~ 5 ha

•Adult trapping area in an apple orchard is reduced to 1.67 ha

•Nymphal trapping area is ~0.6 ha; will likely decrease in a host crop

•Strong behavioral association with host plants that influences response to trap and increases retention time

•More replication needed in apple orchards and other host crops such as peach, vegetables and field crops to further estimate accurate trapping areas

Kirkpatrick et al. in prep.

Conclusions and Next Steps

- Non-nutritive sugars for SWD control
  - ***Erythritol is toxic, but not for short durations of feeding***
  - ***Evaluate erythritol+sugar for attracticidal spheres***

- Forward-driven approach to develop management thresholds in apple for BMSB:
  - ***Pyramid traps: 10 adults/trap protected fruit***
  - ***Clear sticky traps: 1 adult/trap or 10 adult/trap depending on year***
  - ***Future:*** **EVALUATE 1, 4, and 10 adults/trap with always or never sprayed to establish accurate threshold for clear sticky traps**

- BMSB adults and nymphs are capable of long range dispersal
  - ***Estimate of trapping area of ~2 ha for clear sticky traps in apple with one trap placed about every 40 m on apple orchard edge and interior***
  - ***Additional work needed in apples and other crops***

- Trapping Area for BMSB changes in the environment in which it is presented
  - ***Impact of other host plants/vulnerable crops on trapping area?***

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Stop BMSB

Thanks!

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