Population dynamics of insect pests in mills and impact of aerosol treatments

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Integrated Pest Management Programs in Food Facilities

- Sanitation
- Structural Modification
- Exclusion
- Stock Rotation
- Temperature Management
- Insecticides
  - Crack and Crevice
  - Surface
  - Aerosol
  - Fumigant

Introduction

- Integrated pest management (IPM) programs can reduce need to perform a fumigation or heat treatment
  - Reducing population growth rates
  - Reducing carrying capacity of a facility
- Aerosol reduced risk insecticide use is increasing in food facilities
- What impact do aerosol insecticide applications have as part of an IPM program on pest populations in food facilities?

Why Aerosols Might Not Have an Impact

- Do notpenetrate into hidden areas where populations are typically located
- Only a small proportion of the population, typically adults, is out and directly exposed to aerosol treatment
- Limited residual activity for many insecticides when applied as an aerosol
- Mortality of exposed adults can have a minimal impact on total population in hidden refugia

Why Aerosols Might Have an Impact

- Insect Growth Regulators (IGR) have good residual activity – increase exposure time
- Good coverage of all surfaces within a space – increase chance of contact
- Cumulative impact of repeated exposure to aerosols and build-up of residual IGR could cause greater impact on populations
- Combined impact with other IPM tactics such as sanitation and timing of fumigation

Approach

- Bioassays can be used, but don't show impact on resident population
- Compare insect captures in facilities over time with and without the regular use of aerosol insecticide programs
- Challenges
  - Pest populations can change over time for reasons other than treatment
  - Difficult to hold other factors constant and only change aerosol treatment
  - No true replication

Examples of Aerosol Insecticides

- Insecticides commonly used in food industry
  - Synergized pyrethrins
  - Pyrethroids
  - Insect growth regulators (IGR)
  - Dichlorvos (DDVP)
- Different application systems and formulations
- Can mix compounds during application – typically IGR with another insecticide to get immediate knockdown and longer term residual control

Aerosol Insecticides Combination Evaluated in these Case Studies

- Synergized Pyrethrins
  - 1% and 3% formulations (Entech Fog-10 and Fog-30)
- Methoprene (Diacon II)
- Applied at labeled rates in combination using an aerosol application system
- Typically 2-4 week treatment intervals

Pheromone Trapping Program to Estimate Pest Populations

Tribolium castaneum – red flour beetle

Case Study #1

Flour Mill #1: 55 traps

Flour Mill #2: 32 traps

Case Study #2

Rice Mill: 36 traps

Case Study #1

Wheat Flour Mill

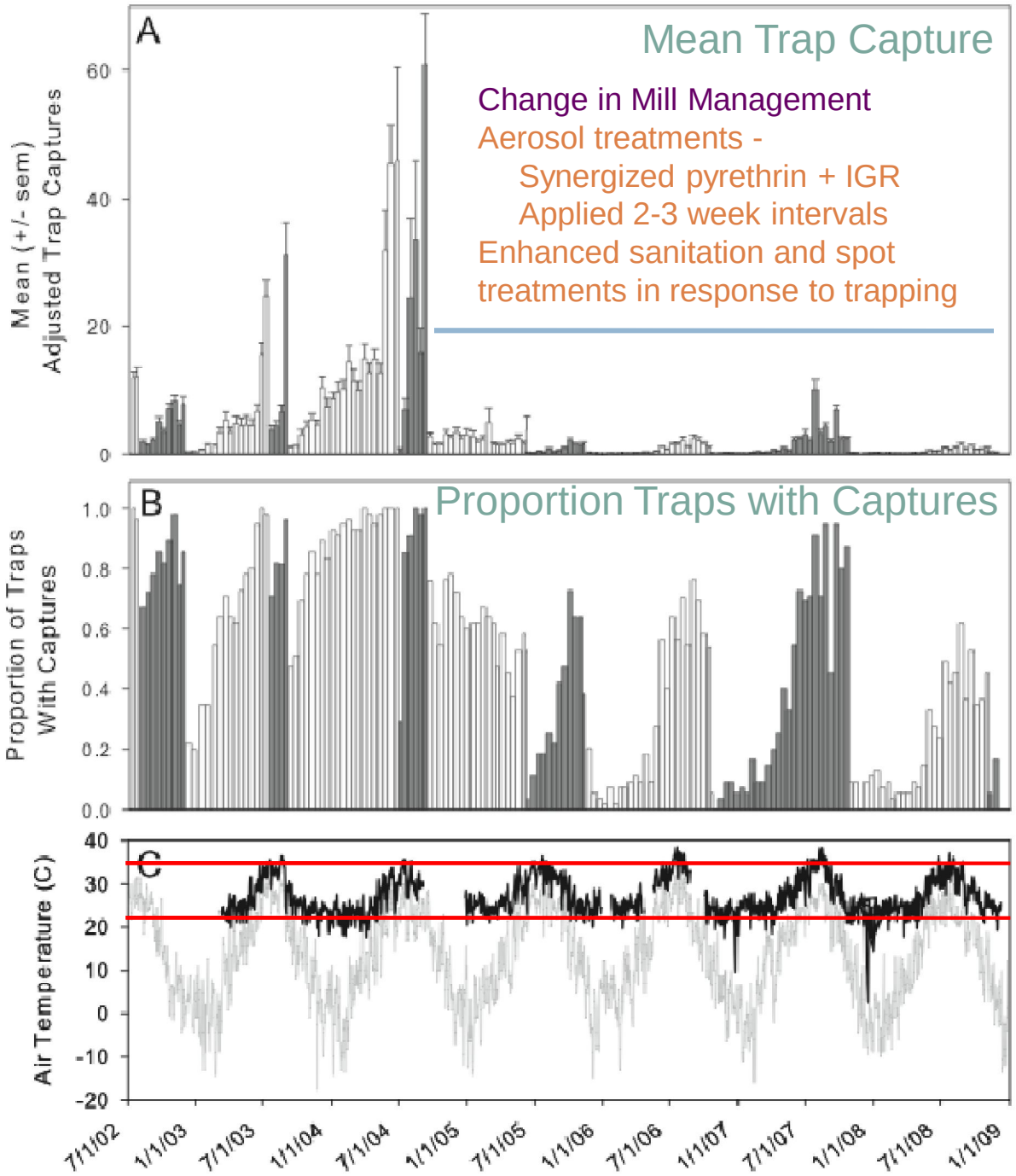
Mill #1

Mean number captured in traps: 4.5 ± 0.7 beetles/ trap/monitoring period

Change in mean number captured between monitoring periods without fumigation: 45 ± 9% increase

Mean percent of traps with captures: 49 ± 3 % of traps with one or more RFB

Change in percent of traps with captures between monitoring periods without fumigation: 18 ± 5% increase



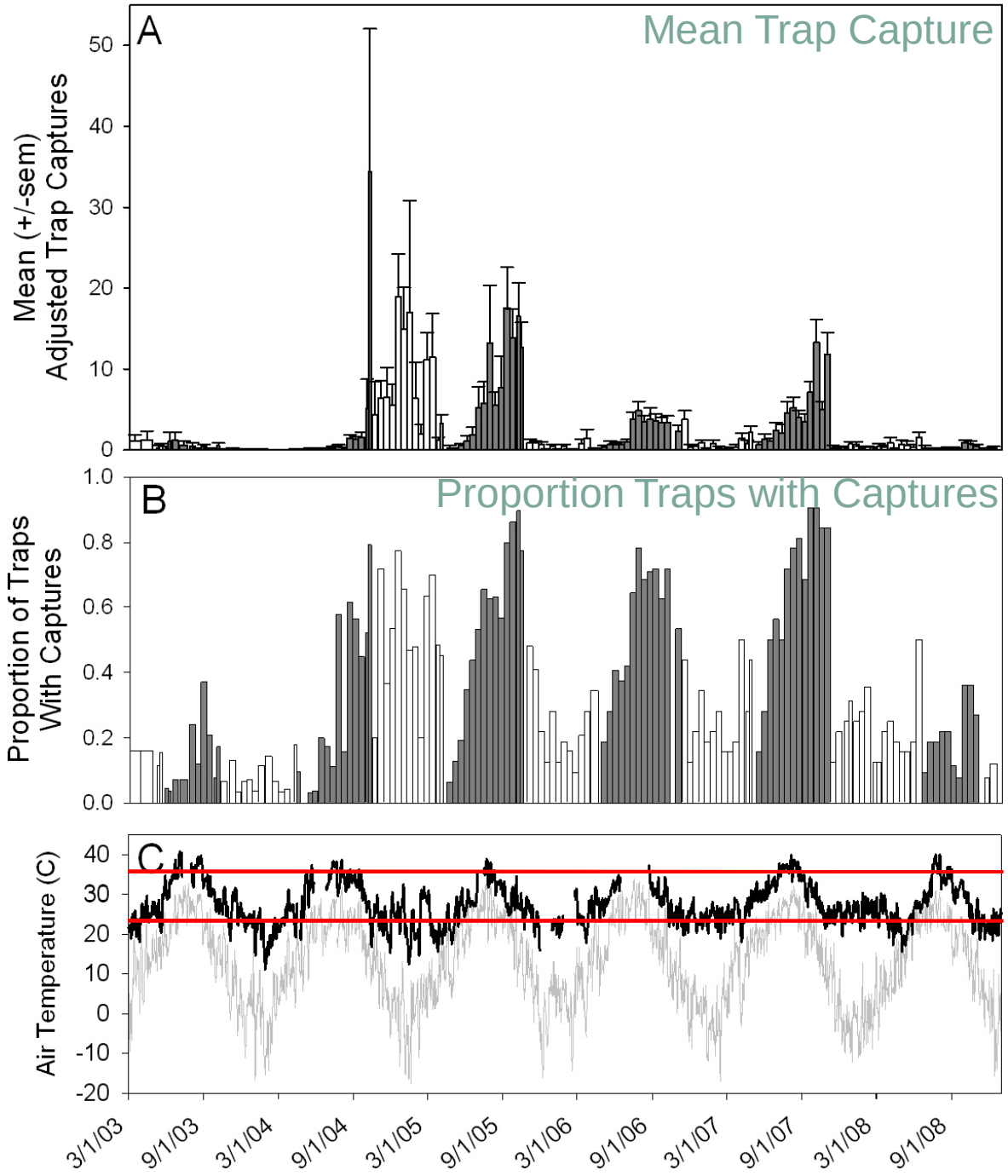
Mill #2

Mean number captured in traps: 2.6 ± 0.4 beetles/ trap/monitoring period

Change in mean number captured between monitoring periods without fumigation: 62 ± 14% increase

Mean percent of traps with captures: 33 ± 2 % of traps with one or more RFB

Change in percent of traps with captures between monitoring periods without fumigation: 32 ± 8% increase



Fumigation Efficacy – Initial Reduction in Beetle Captures

- Two mills did not differ from each other in reduction in trap capture after fumigation
- **84.6±4.6% reduction in beetles/trap/period (n=23 fumigations)**
  - 11.4±3.5 beetles/trap/period immediately before fumigation
  - 0.8±0.2 beetles/trap/period immediately after fumigation
  - Only 3 fumigations had no captures immediately after fumigation

Fumigation Efficacy – Initial Reduction in Beetle Captures

- Two mills did not differ from each other in reduction in proportion of traps with captures after fumigation
- **70.9±5.1% reduction in proportion of traps with captures (n=23 fumigations)**
  - 58±7% of traps had captures immediately before fumigation
  - 20±5% of traps had captures immediately after fumigation

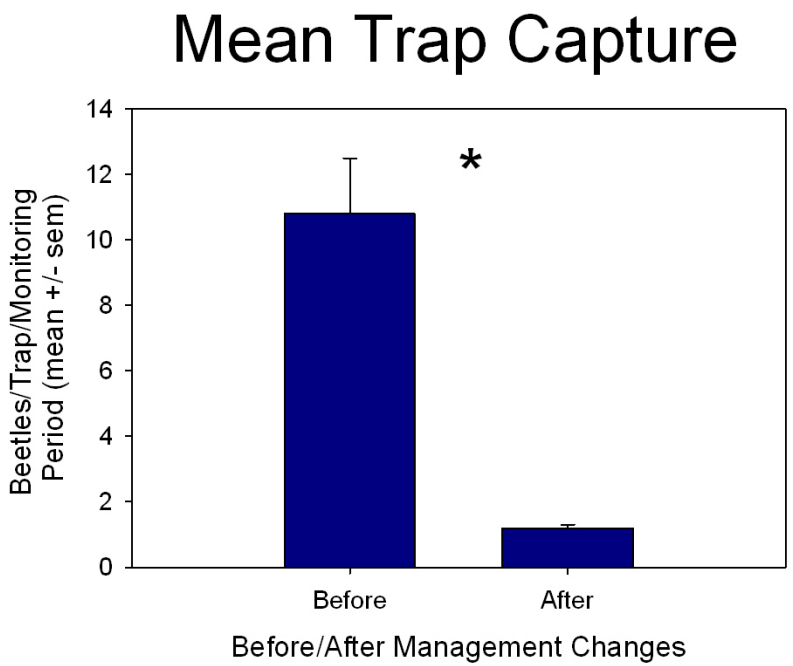
Difference Between Mills Before and After Changes at Mill #1

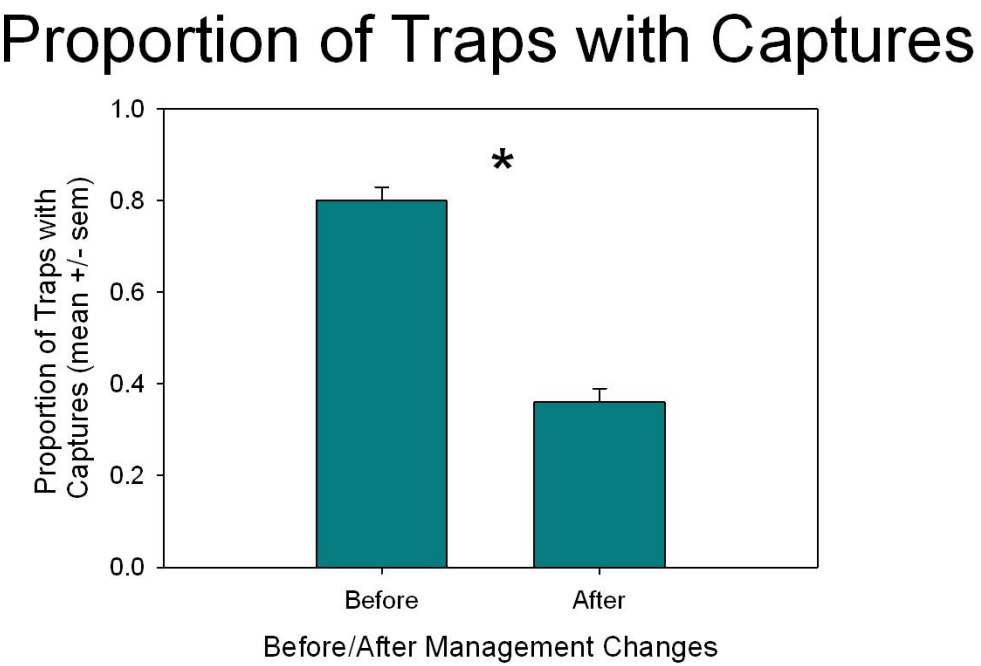
Mean Number of Beetles Captured

	Period Before	Period After
Mill #1	12.7±2.1	1.2±0.2
Mill #2	1.4±0.8	3.1±0.4

All combinations were significantly different:
Mann-Whitney Ranked Sum Test ($P<0.05$)

Before and After Comparison: Mean Beetle Captures

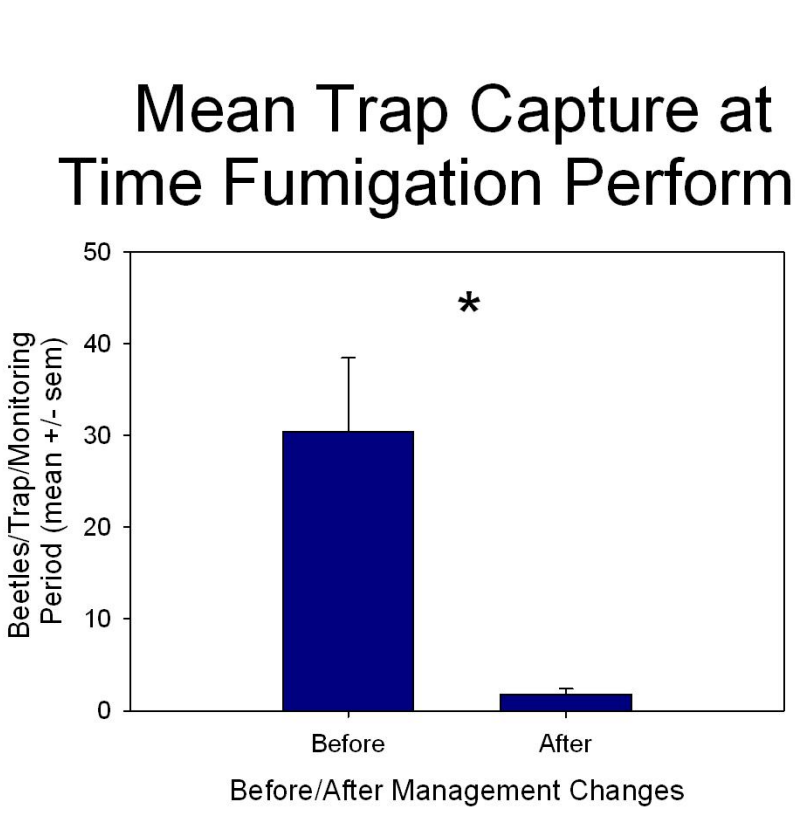




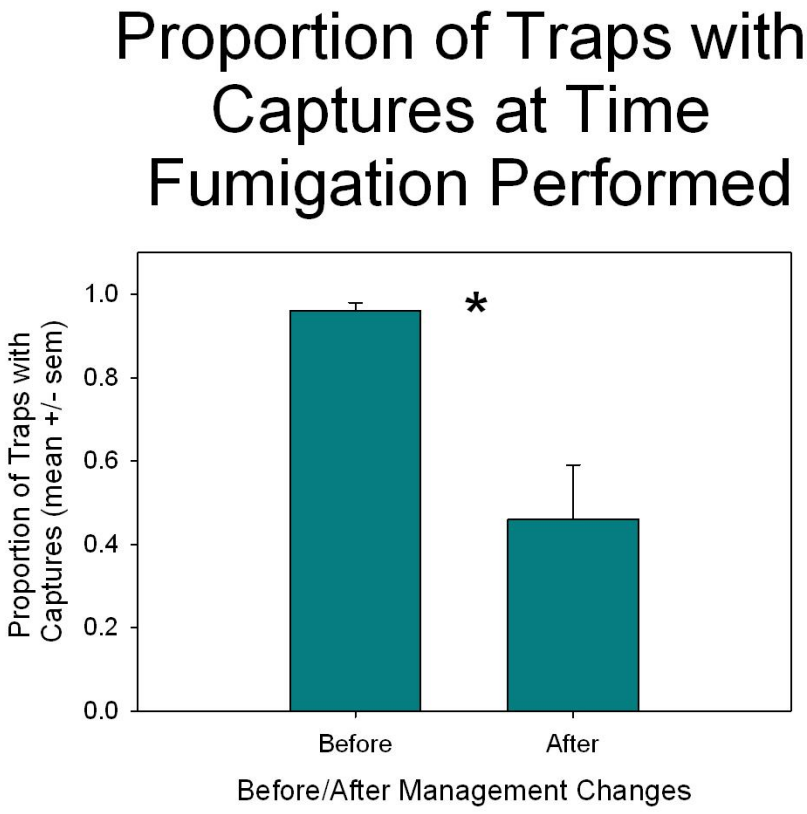
GLM: $F_{1,166}$=64.91, P<0.0001

GLM: $F_{1,166}$=111.27, P<0.0001

Before and After Comparison: Beetle Captures Before Fumigation



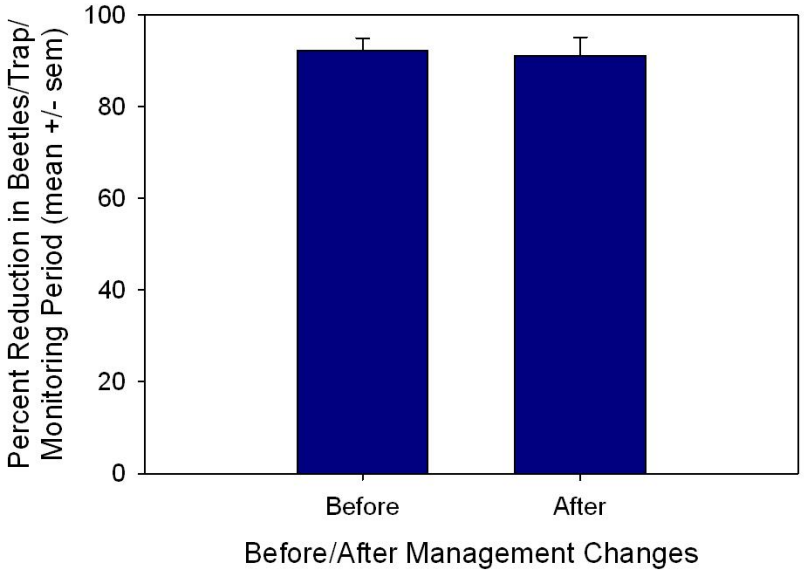
GLM: $F_{1,9}$=9.71, P=0.0124



GLM: $F_{1,9}$=17.05, P=0.0026

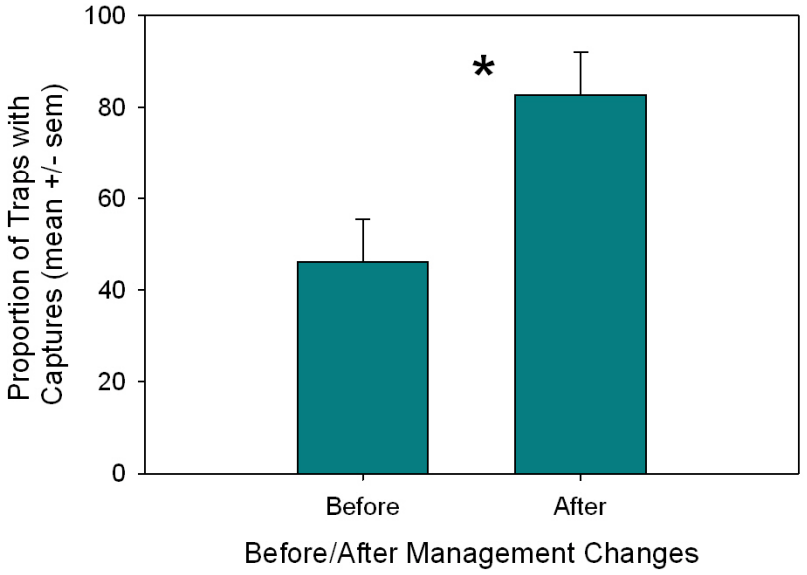
Before and After Comparison: Percent Reduction After Fumigation

Percent Reduction in Mean Trap Capture Following Fumigation



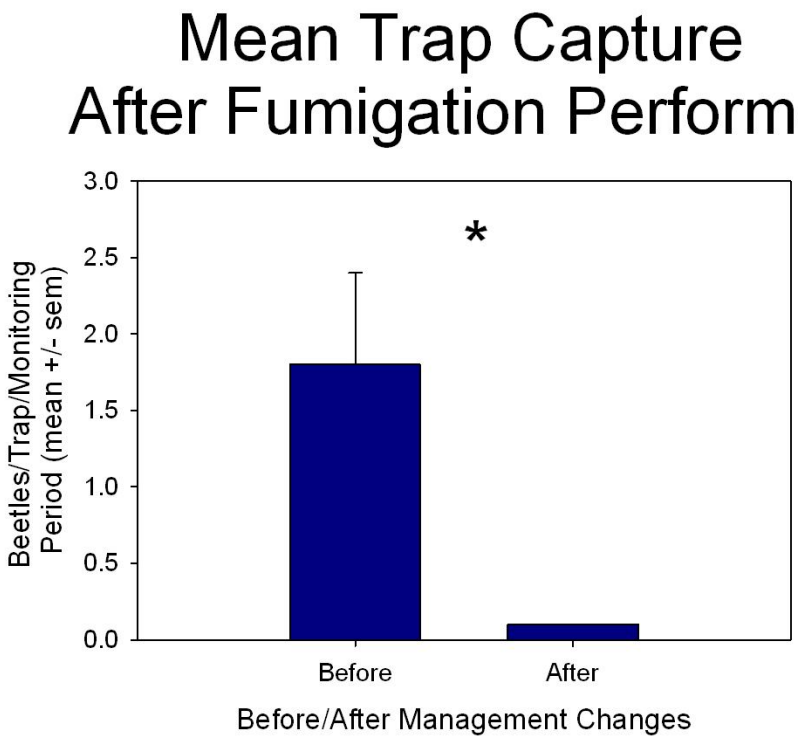
GLM: $F_{1,9}=0.04$, P=0.8438

Percent Reduction in Proportion of Traps with Captures at Time Fumigation Performed

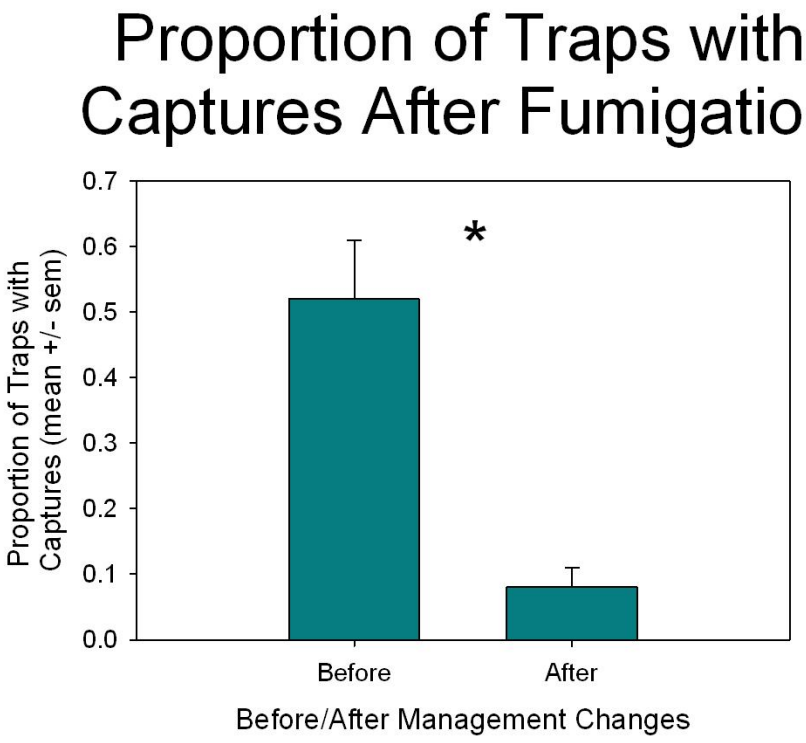


GLM: $F_{1,9}=7.59$, P=0.0223

Before and After Comparison: Beetle Captures After Fumigation



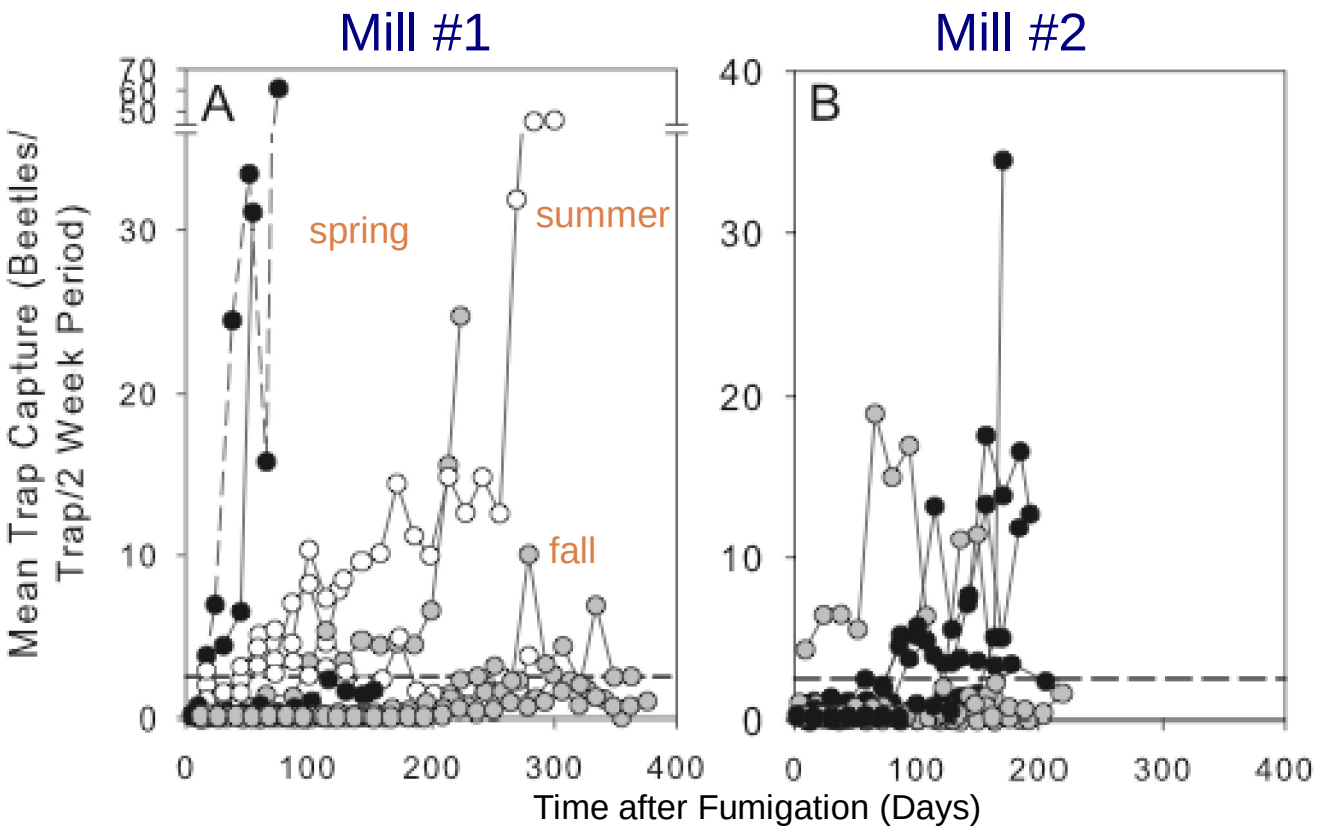
GLM: $F_{1,9}$=7.07, P=0.0261



GLM: $F_{1,9}$=17.07, P=0.0026

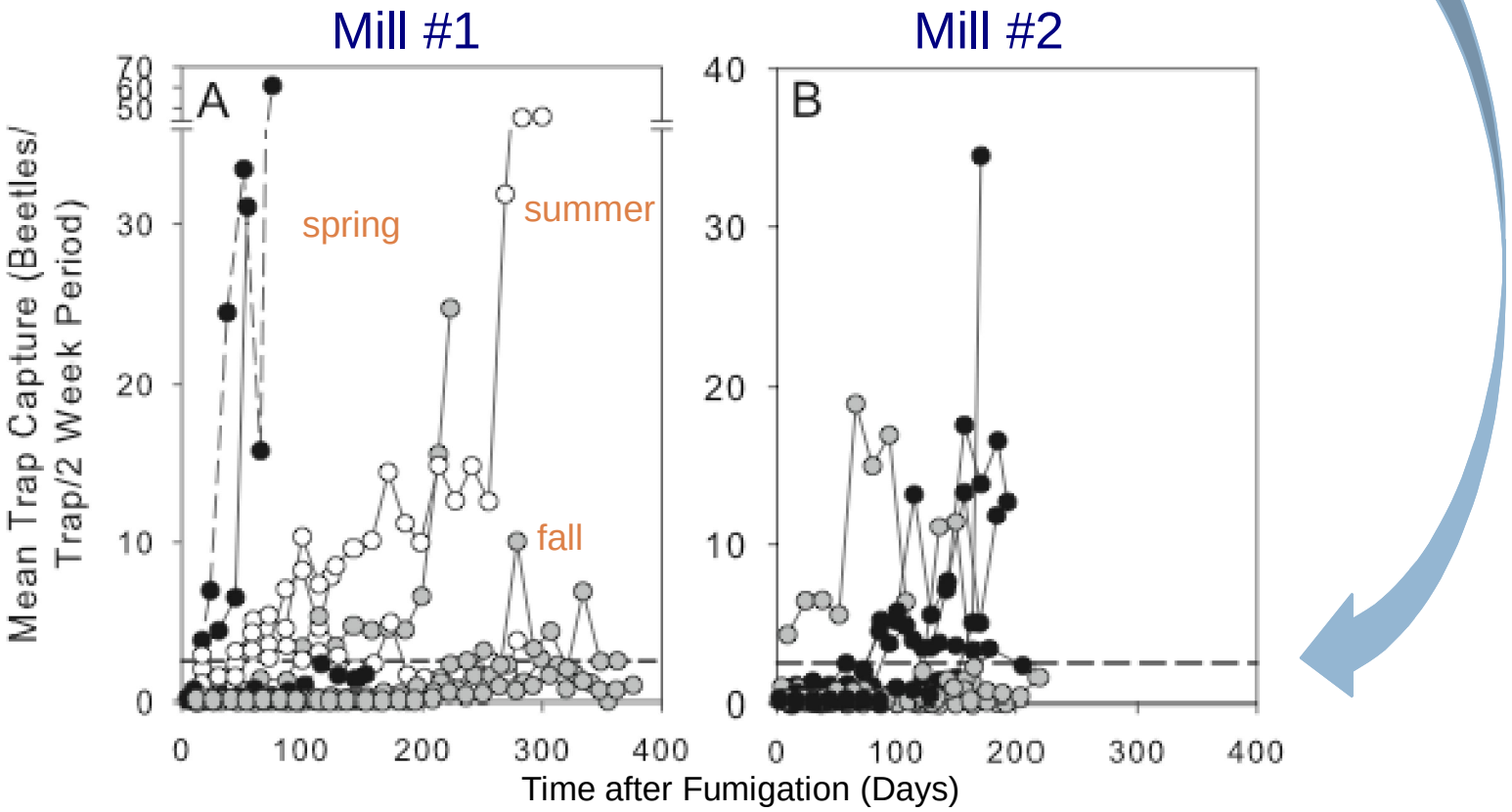
Fumigation Efficacy – Rebound in Beetle Captures

- Rebound in mean trap capture after fumigation was highly variable

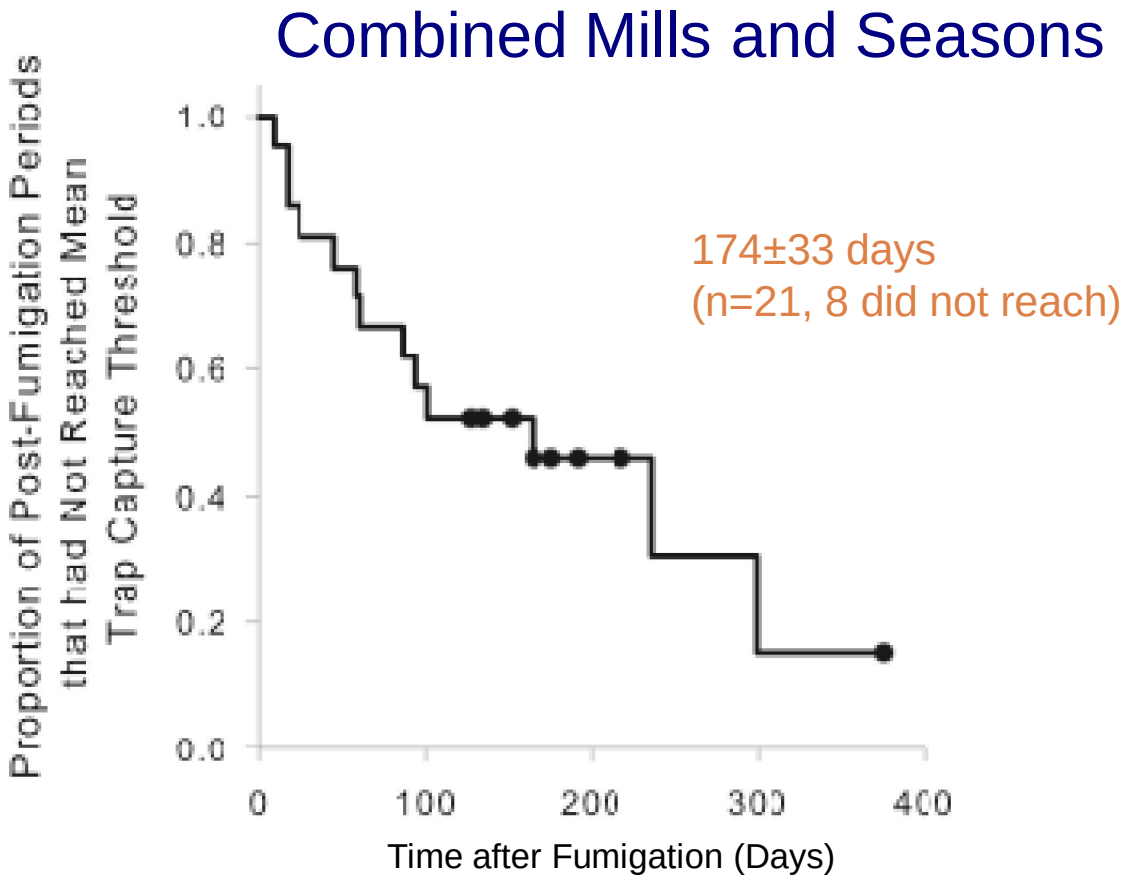


Fumigation Efficacy – Rebound in Beetle Captures

- Developed threshold value to compare rebound rates – 2.5 beetles/trap/2 wk period (= median trap capture prior to fumigation)



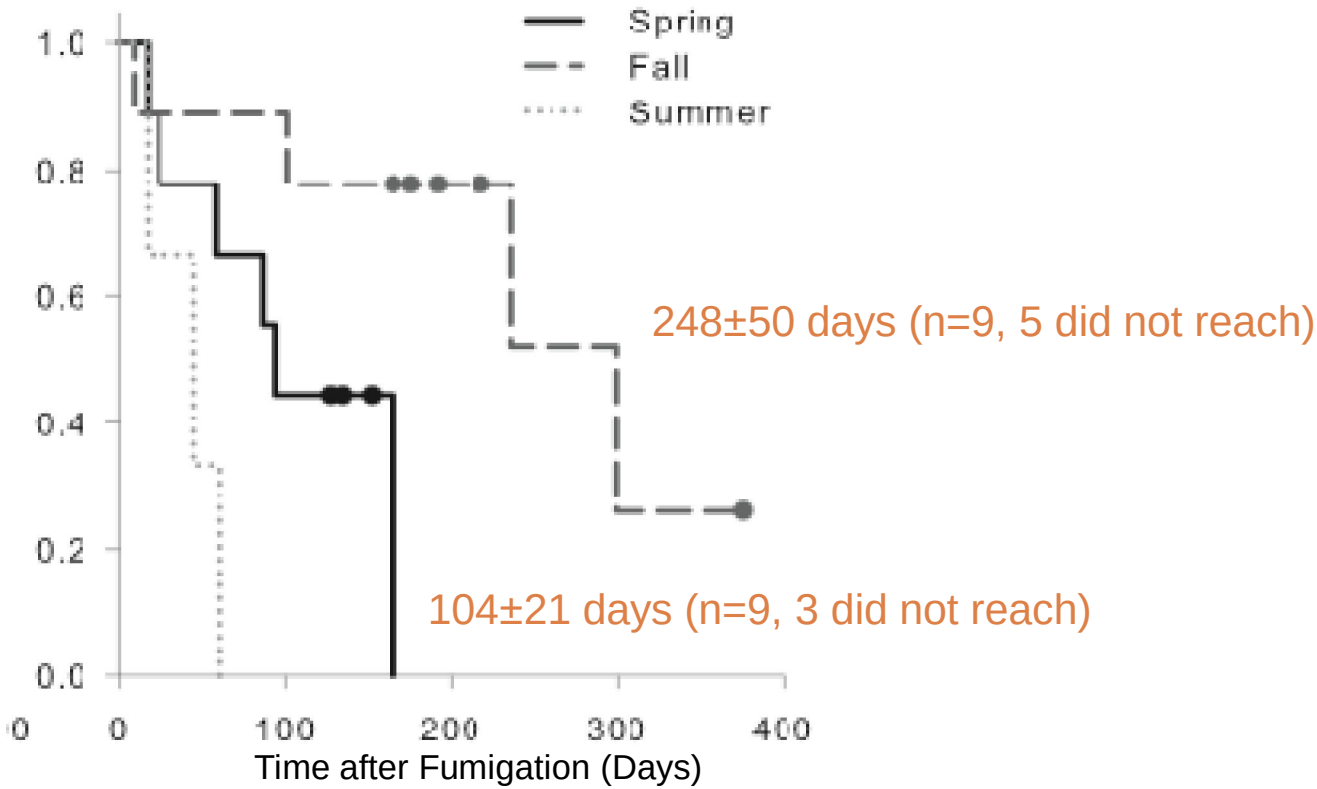
Fumigation Efficacy – Rebound in Trap Captures



Fumigation Efficacy – Rebound in Beetle Captures

- Significant effect of season on rebound to mean beetle capture threshold

Sorted by Season

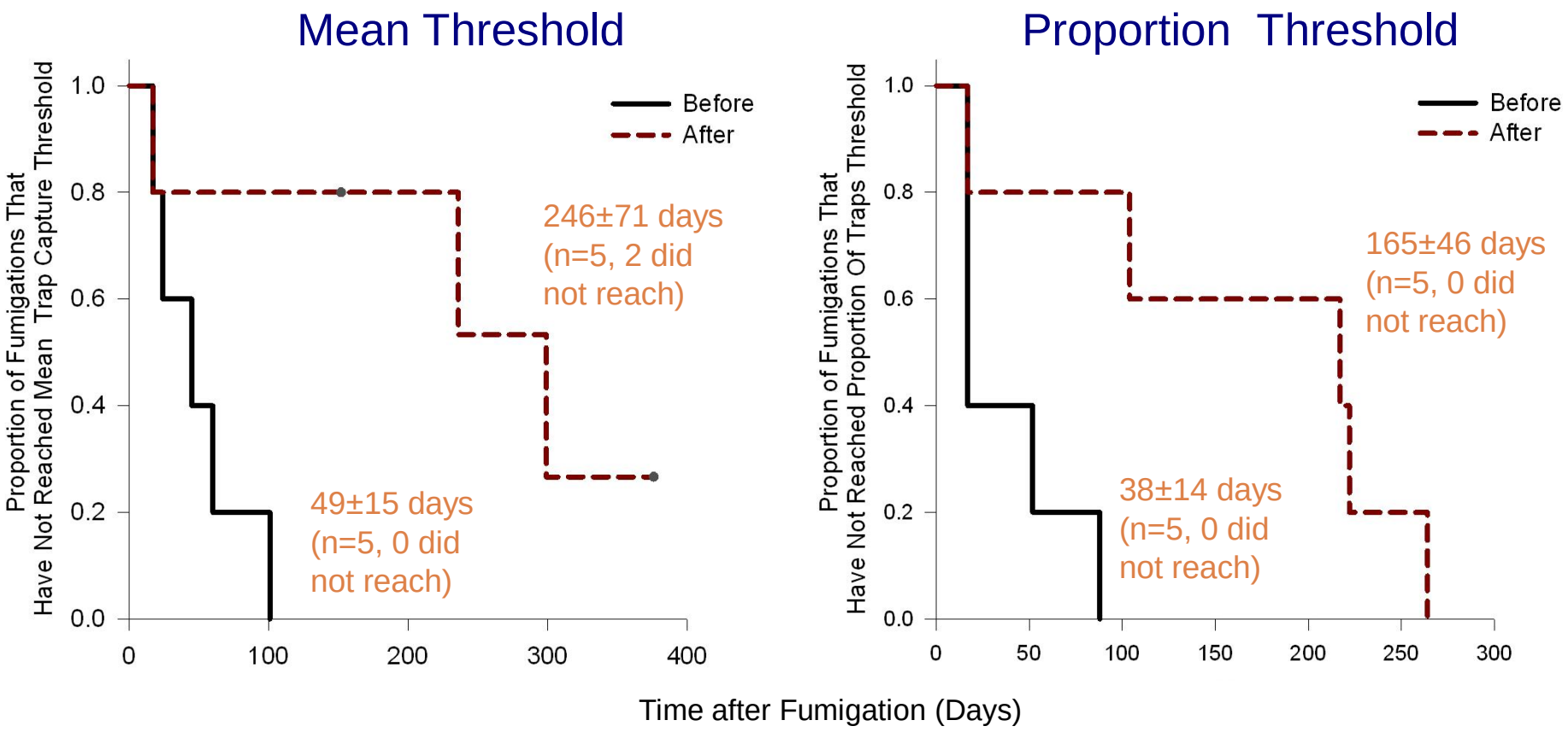


248±50 days (n=9, 5 did not reach)

104±21 days (n=9, 3 did not reach)

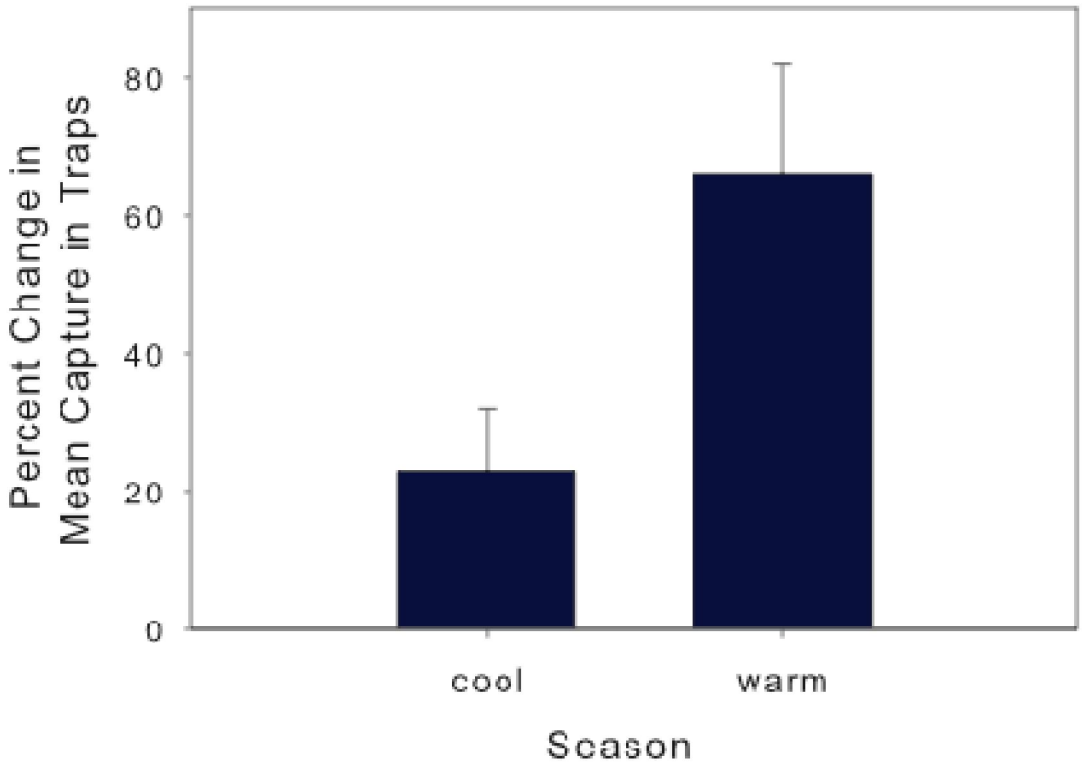
Fumigation Efficacy – Rebound in Beetle Captures

- Significant effect of change in management on rebound



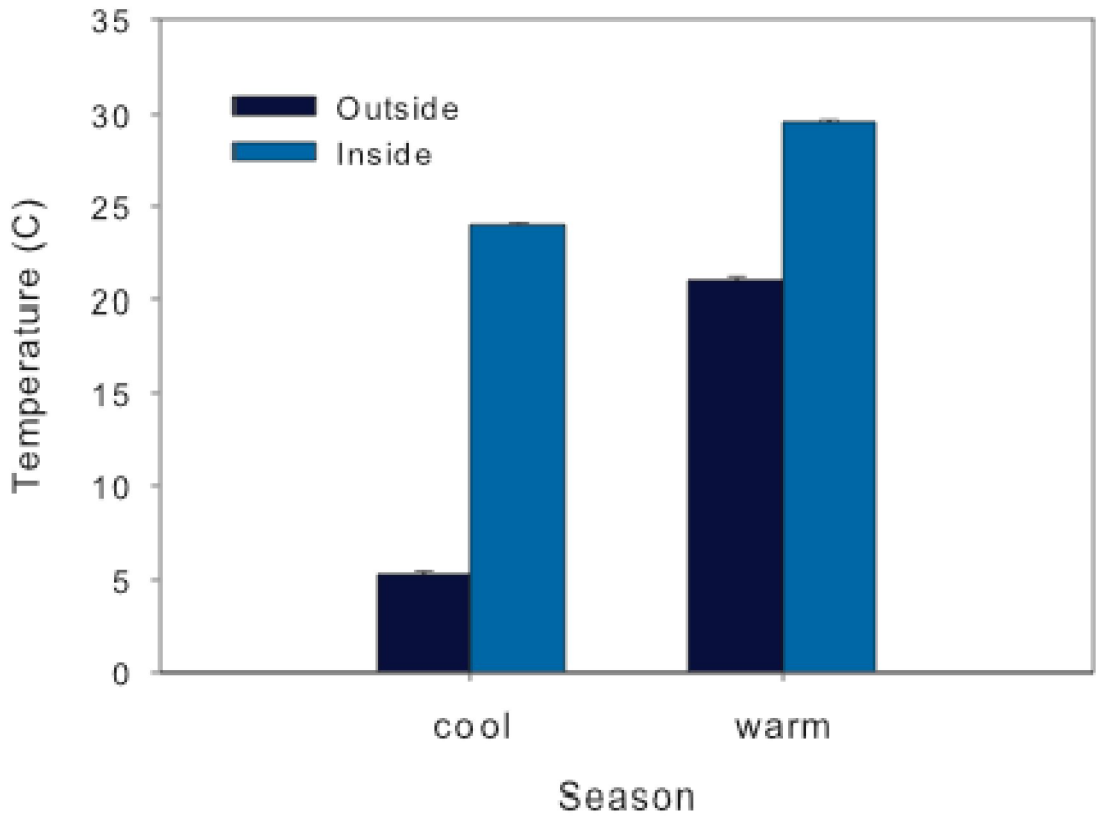
Change in Beetle Captures Between Sequential Monitoring Periods

- Overall model (GLM) for mean trap captures (season and before/after management change) was significant
  - Season was a significant factor
  - Change in management not significant
  - Interaction not significant



Air Temperature Differences Between Seasons

- Both inside and outside temperatures differed significantly between seasons
- Impacts both population growth rate inside and immigration from outside sources

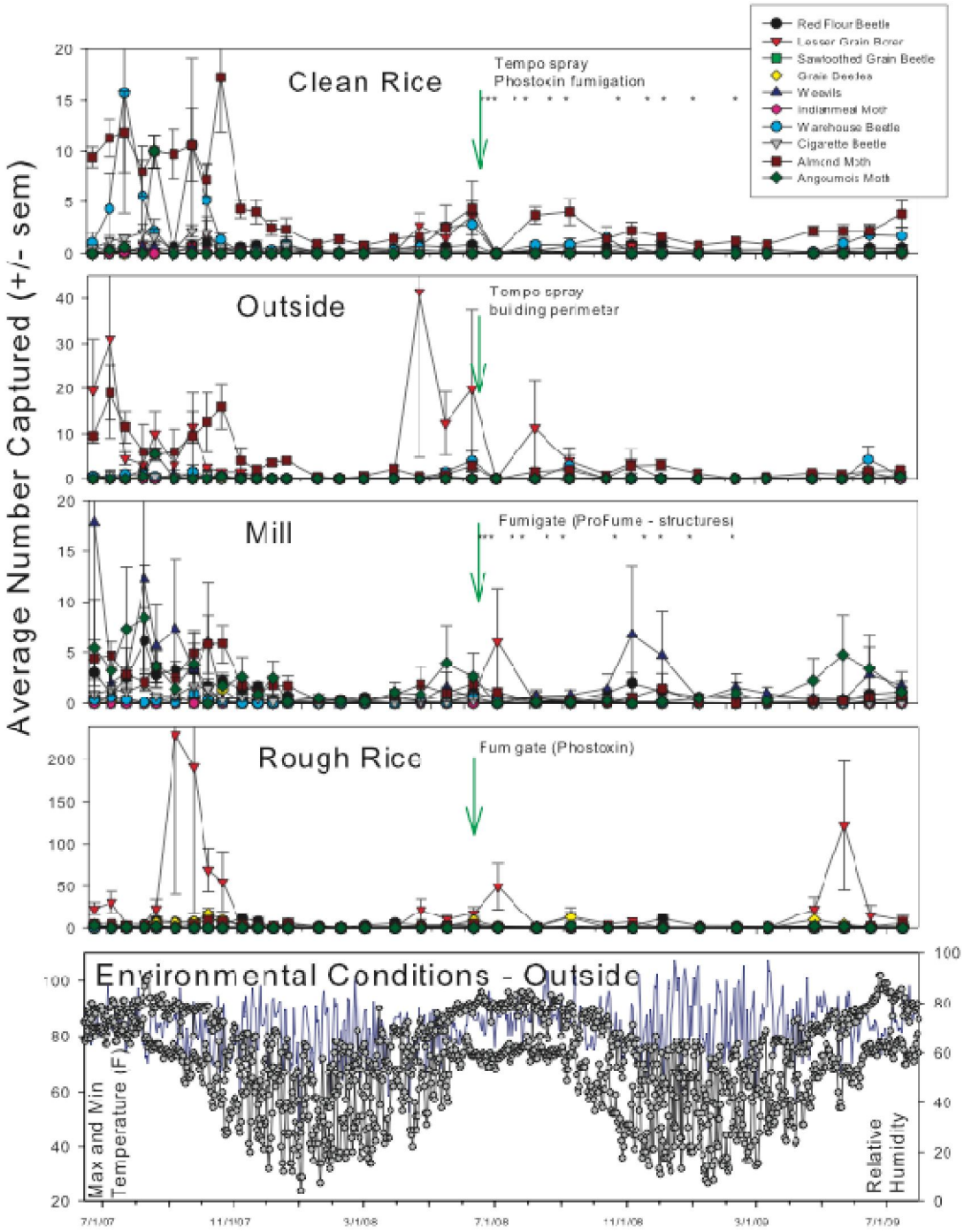


Case Study #2

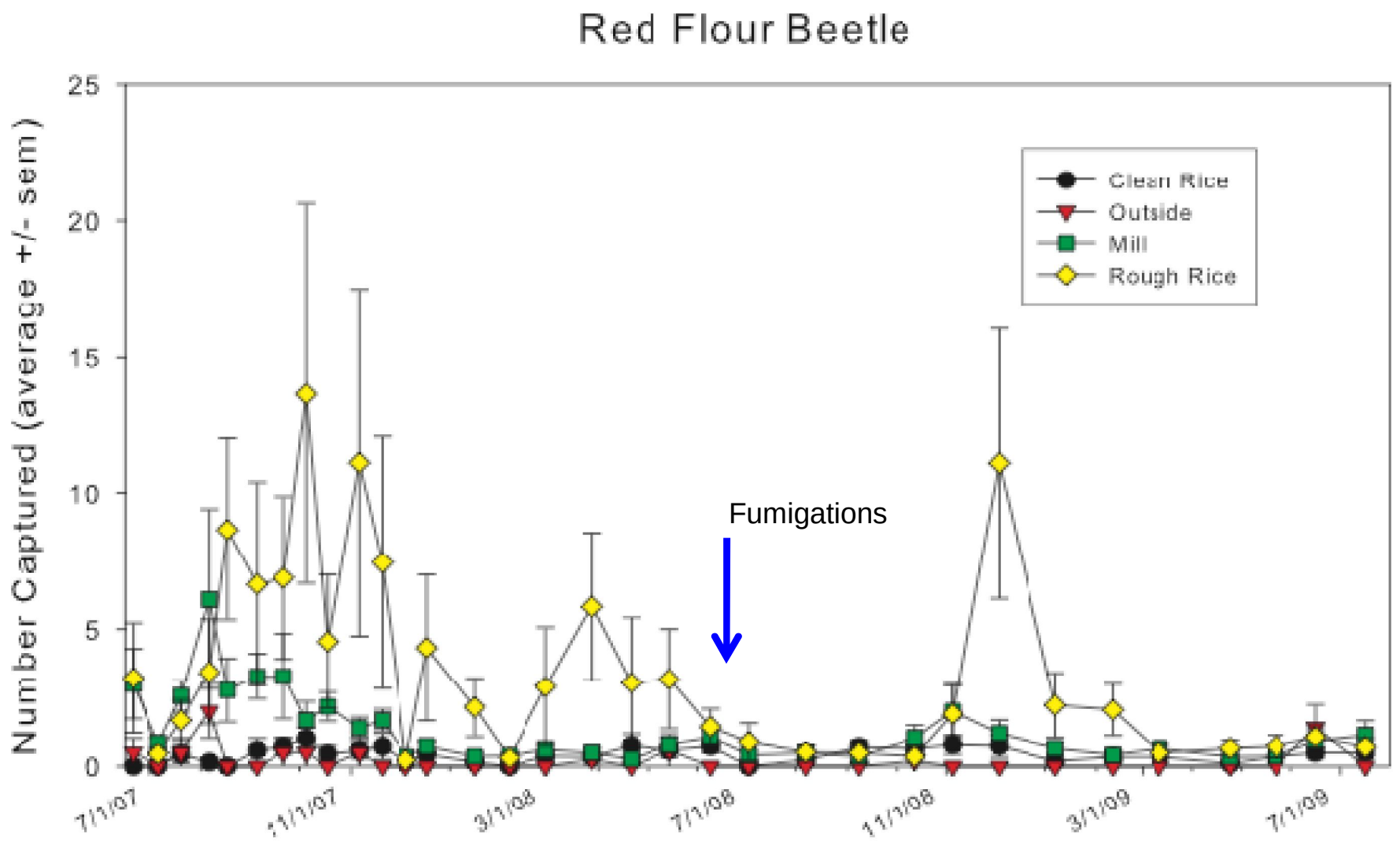
Rice Mill

Rice Mill

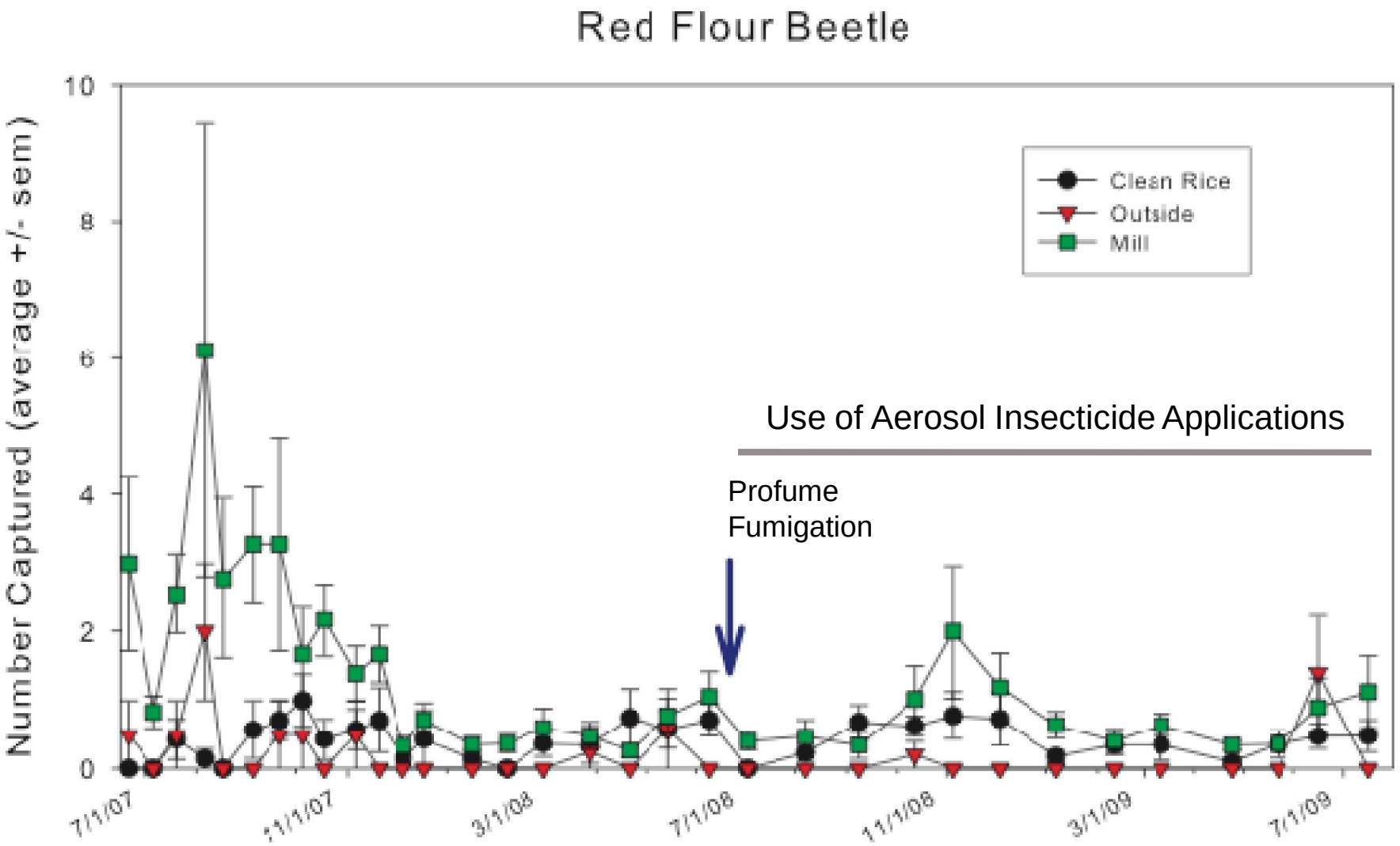
- Different zones at mill
- Range of stored-product species captured at the facility
- One year of monitoring before and one year afterward



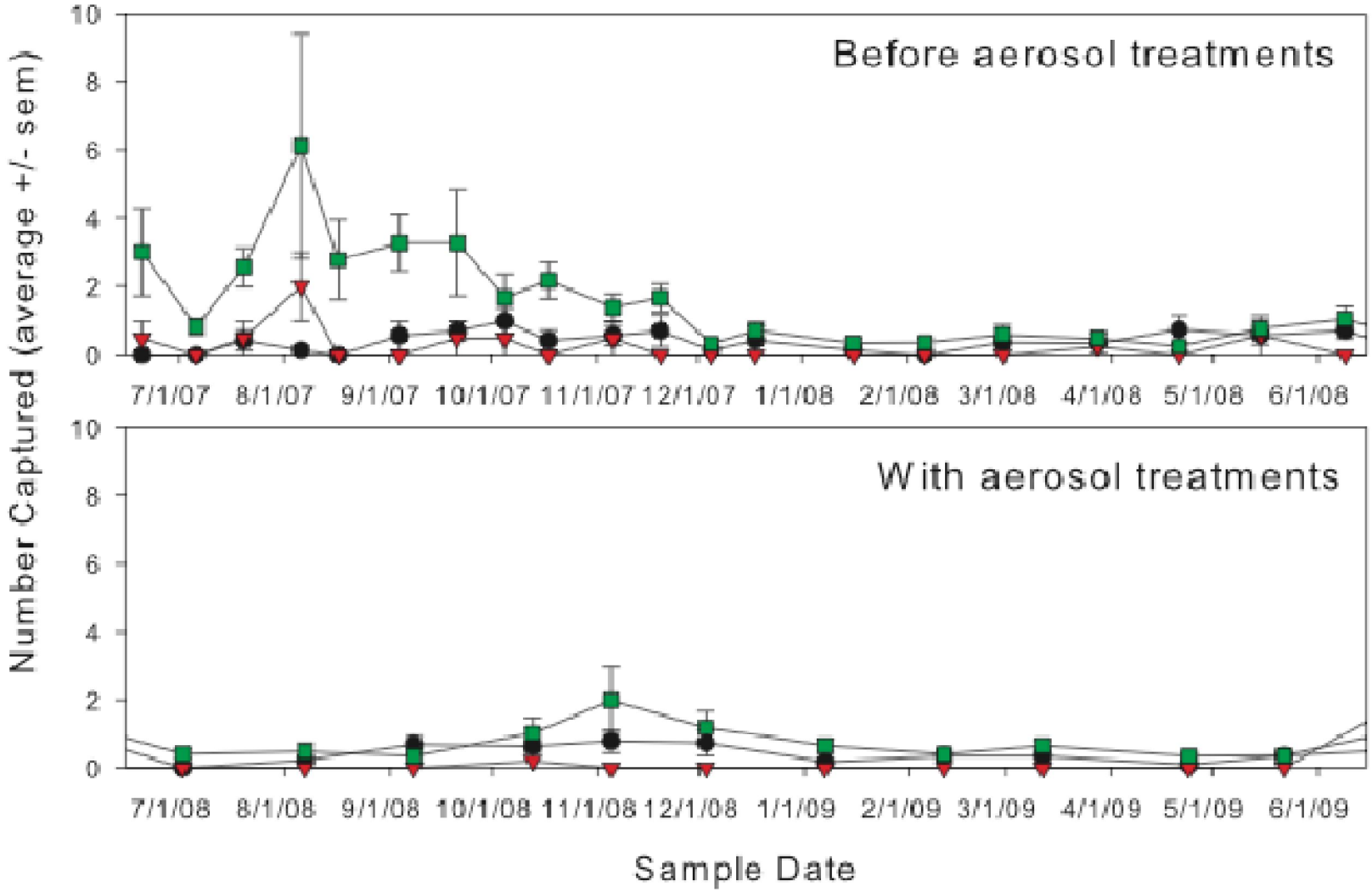
Trends in Red Flour Beetle Captures: Whole Facility



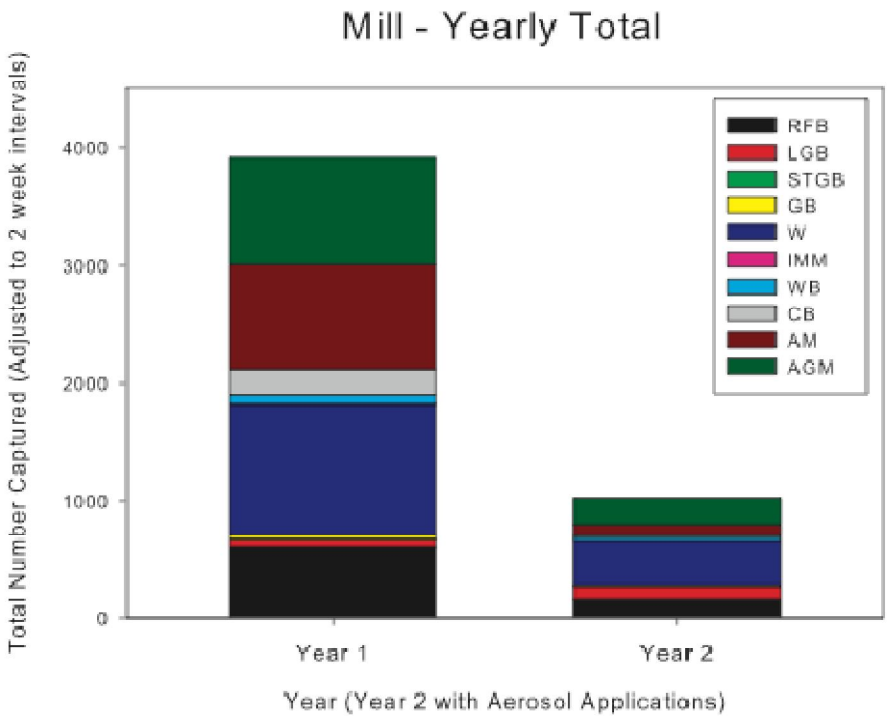
Trends in Red Flour Beetle Captures: Aerosol Treated Zones

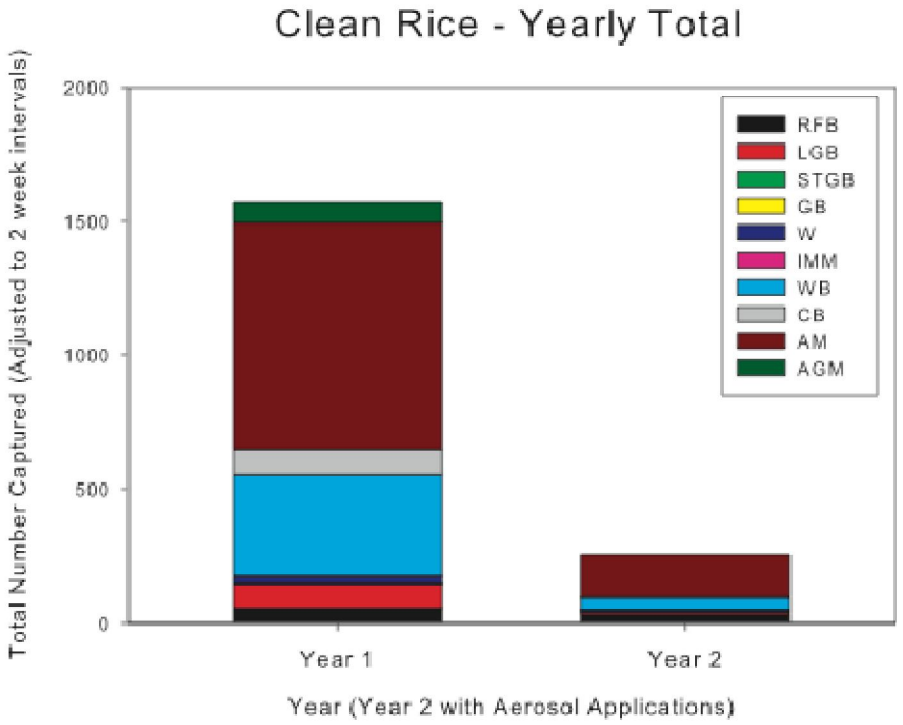


Trends in Red Flour Beetle Captures: Before and After

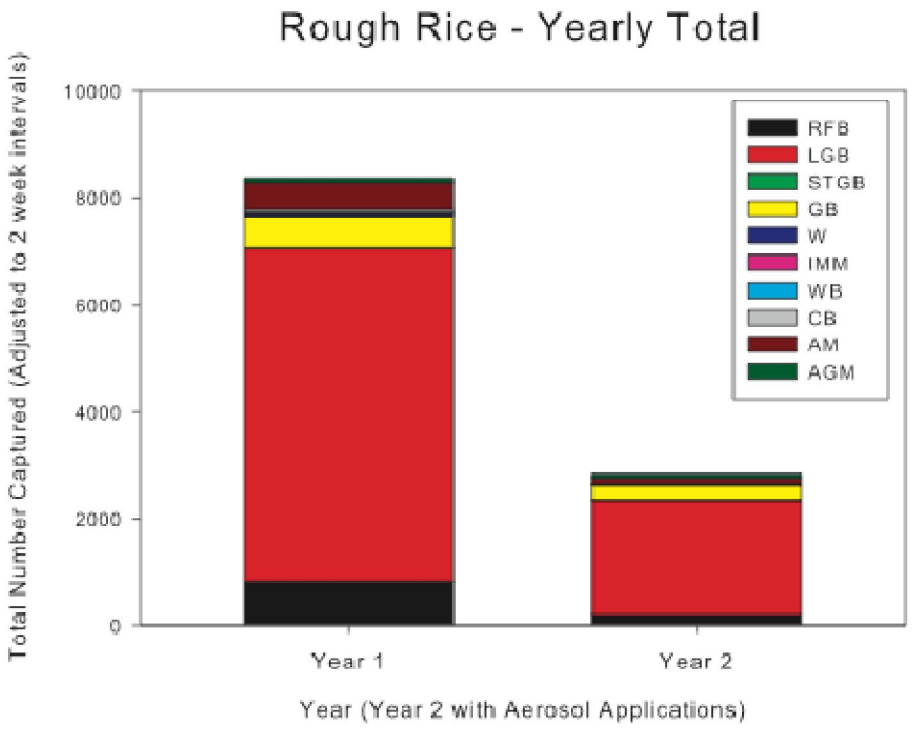


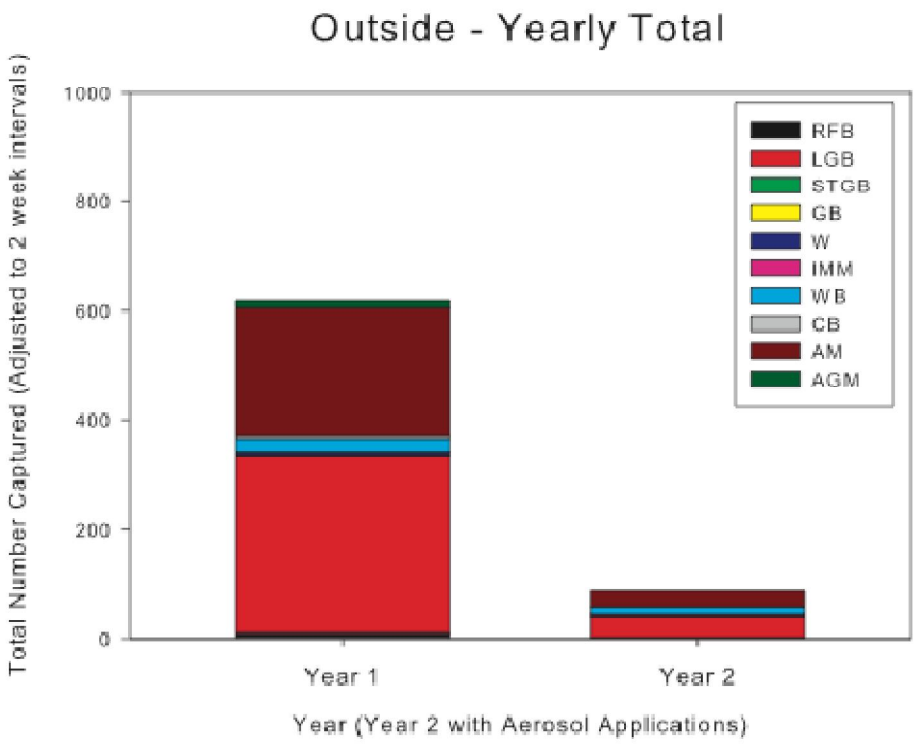
Aerosol Treated Areas





Non-Treated Areas





Evaluation of Results to Date

- Decline in beetle captures during periods when aerosol system was used, but degree of impact is confounded by other factors
- Case Study #1 confounded with other management changes and potential seasonal impacts, but showed how combined IPM approach can impact populations
- Case Study #2 also had declines in non-treated areas and in other non-target species
- As add other locations and longer periods of time can better correlate impact with treatment

Questions

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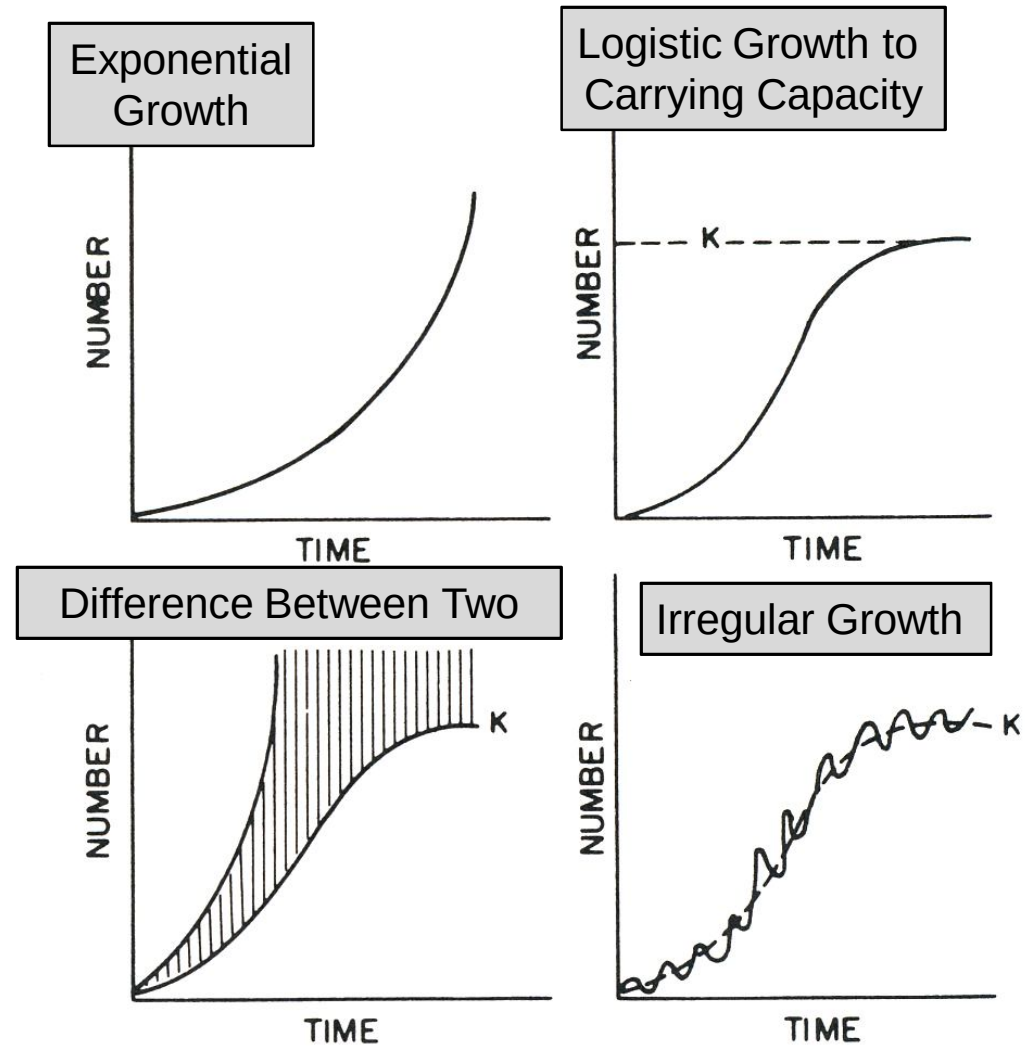
Population Growth

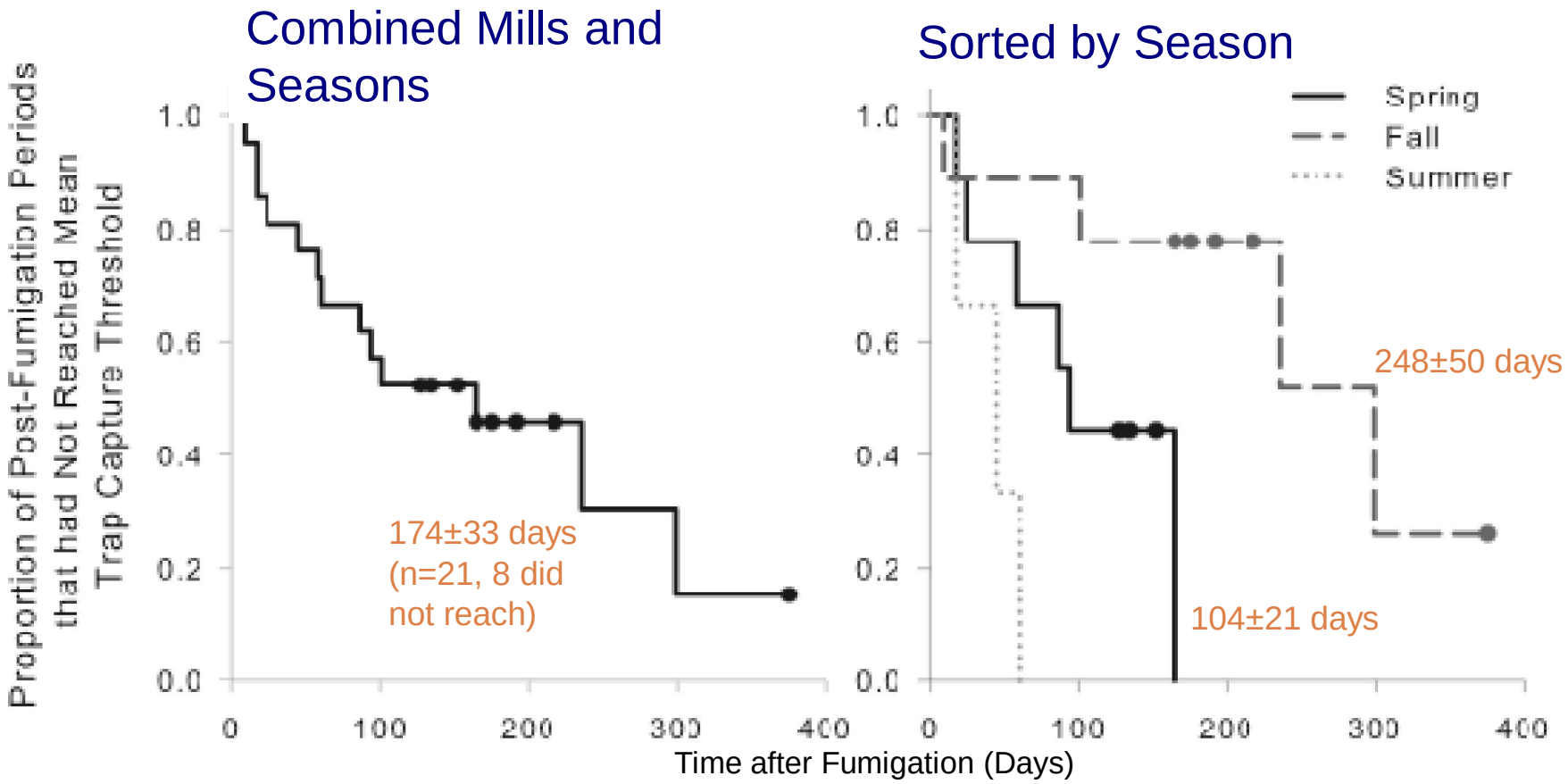


from Price (1984)

- Exponential growth: population increases by a constant factor
- Logistic growth: factor decreases as approach maximum number (K)
- Difference between two due to competition
- Management goal: reduce carrying capacity (K) and growth rate

Fumigation Efficacy – Rebound in Trap Captures

- Significant effect of season on rebound to mean trap capture threshold



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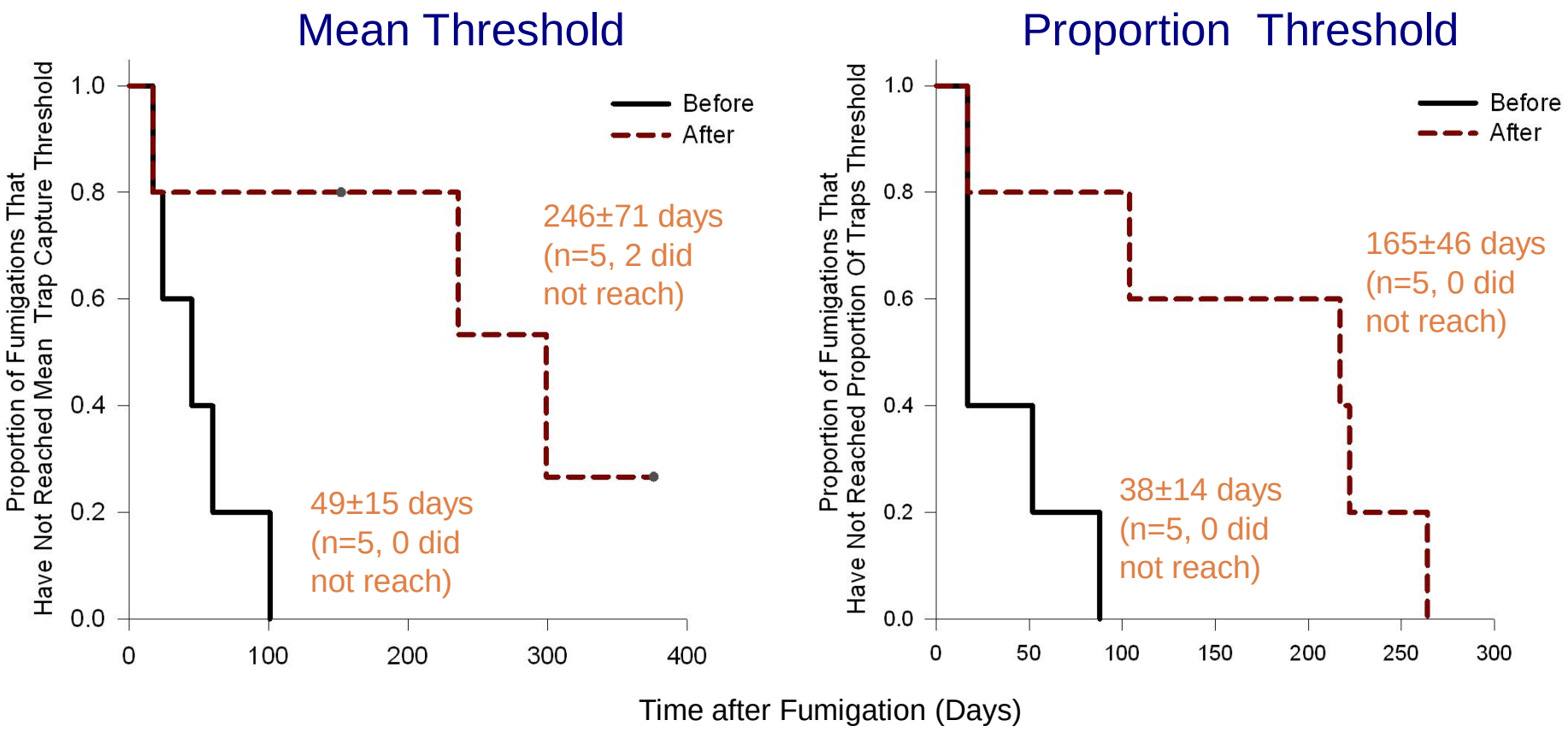
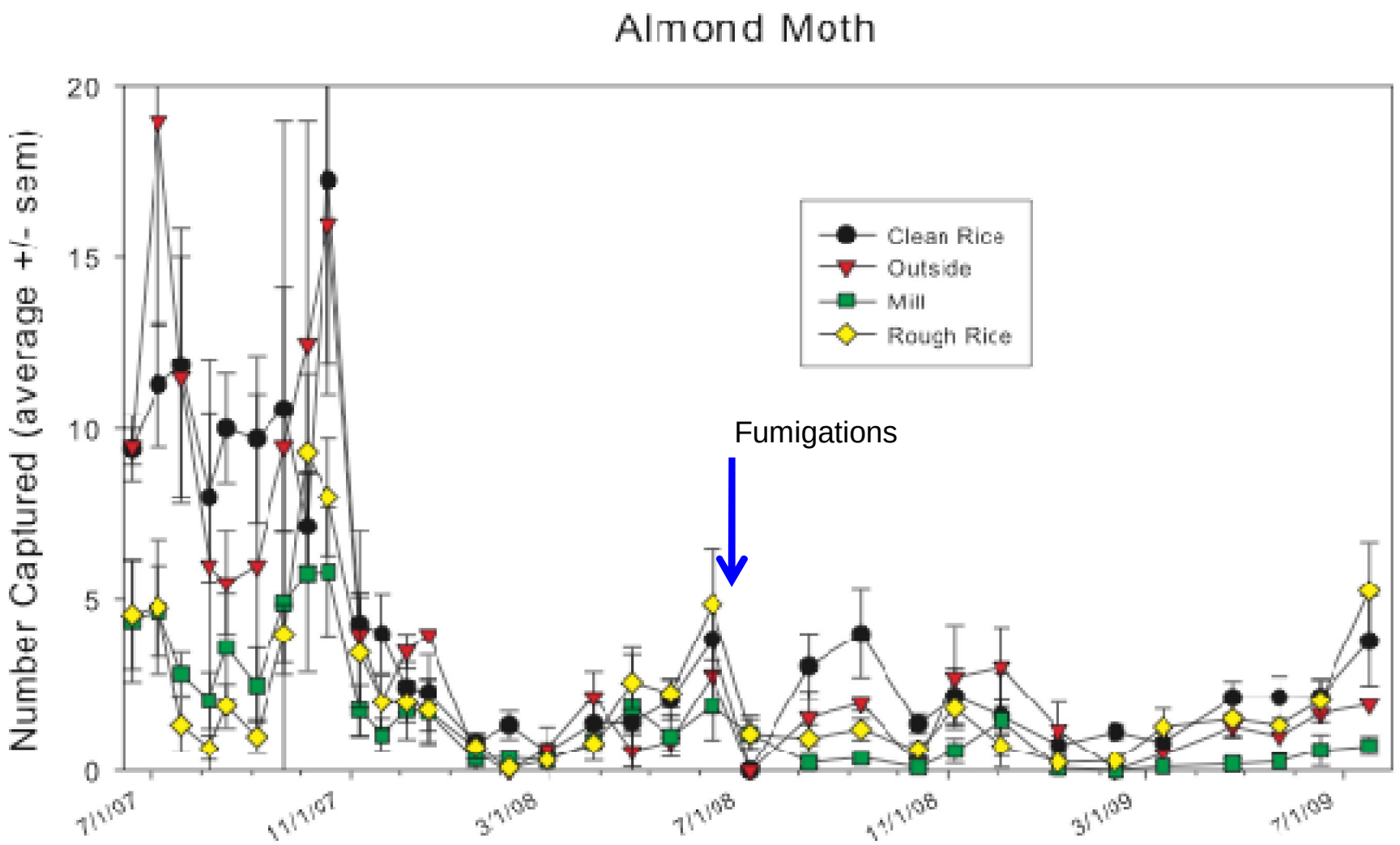


Trends in Almond Moth Captures: Whole Facility



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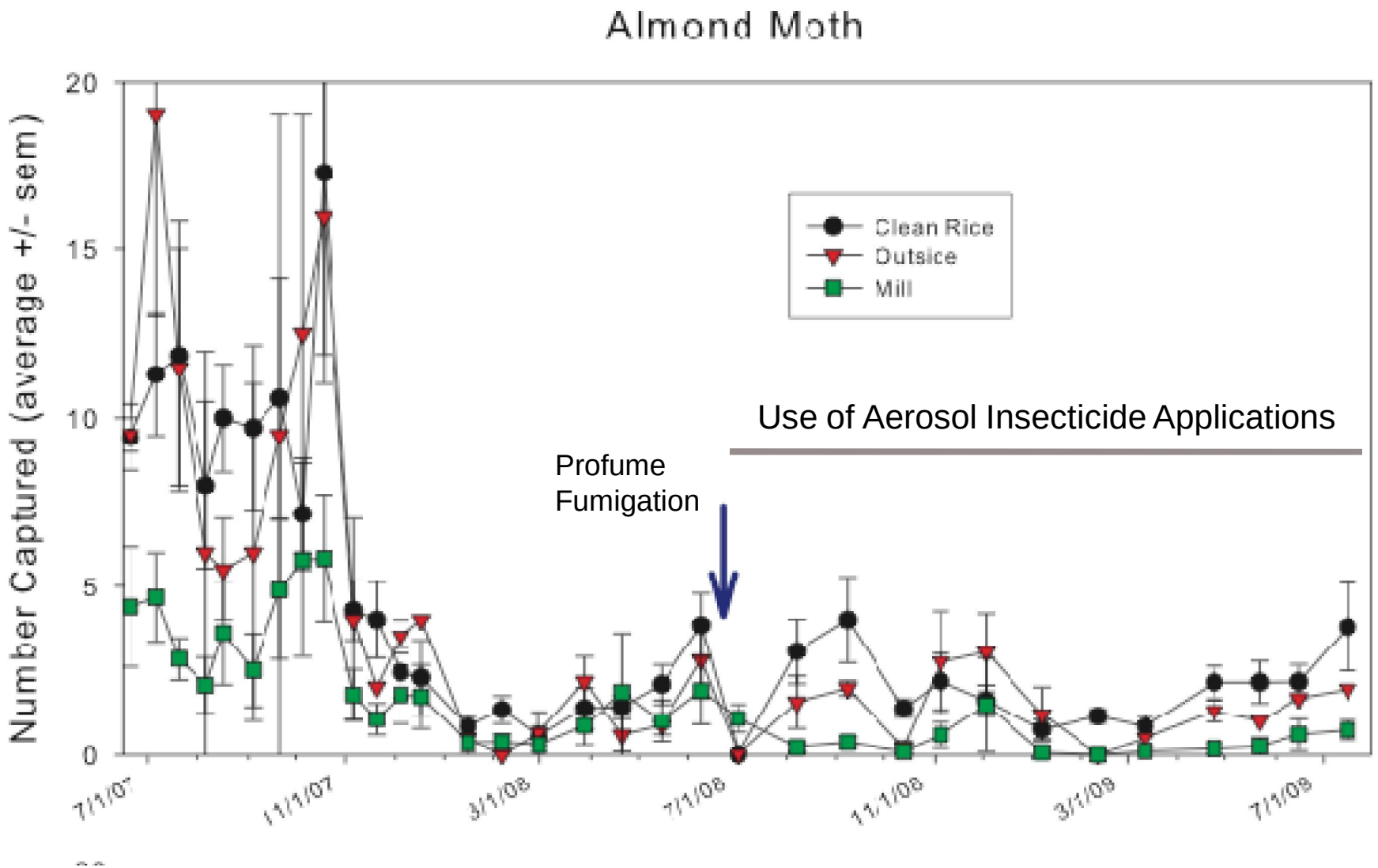

Trends in Almond Moth Captures: Before and After