



Monitoring and Assessing Treatment Efficacy: US Perspective

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Introduction

- Ultimate goal of structural treatments is to manage pest populations
- Structural treatments do not happen in isolation – they are part of a broader long-term pest management program
- In evaluating alternatives to methyl bromide, need to know how both methyl bromide and alternatives impact populations

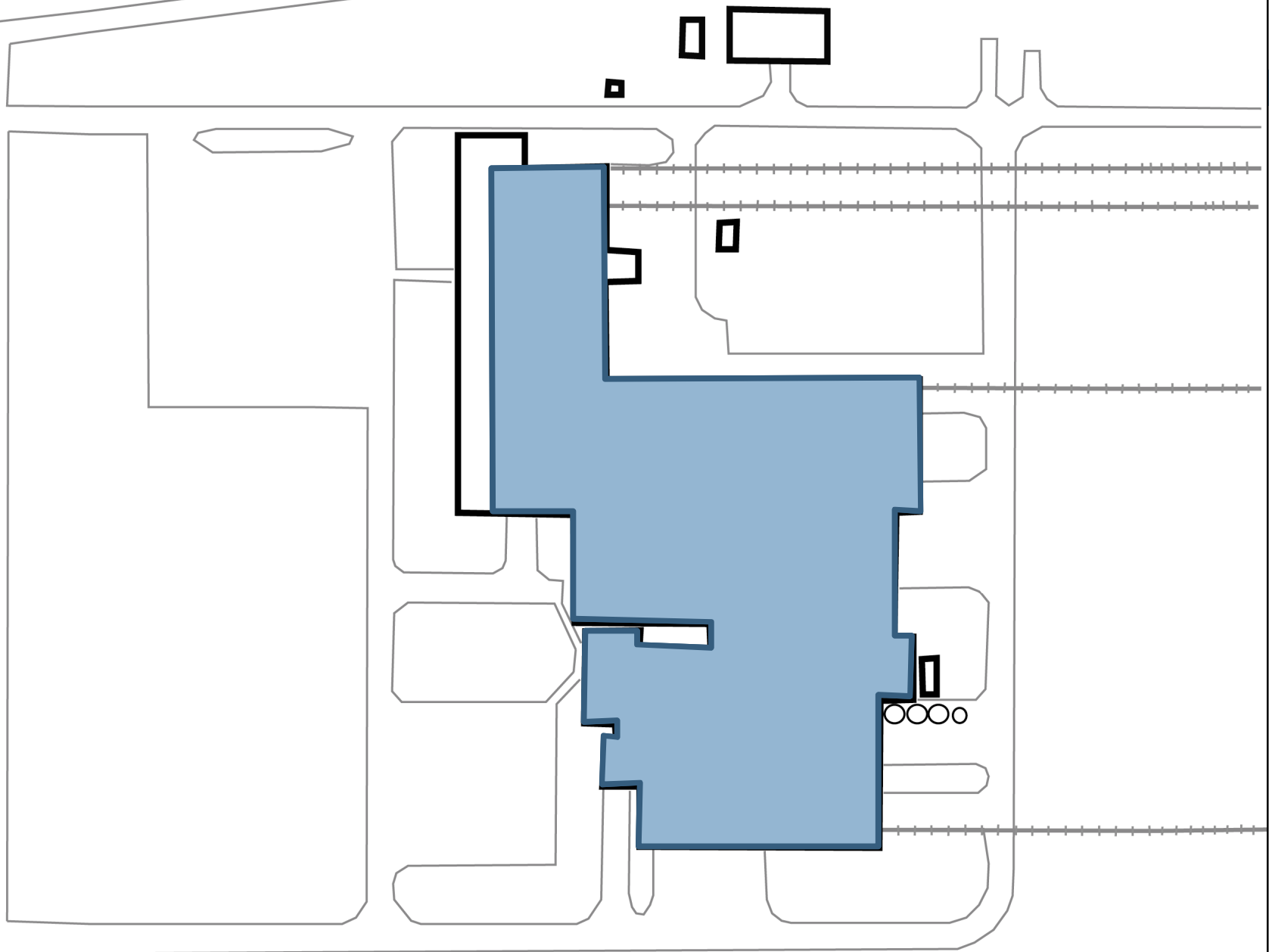


Questions

- What is the pest population level and does it warrant a structural treatment?
- What are the short- and long-term (rebound) impacts of treatments on pest populations?
- What factors contribute to efficacy and can these be managed to improve short- and long-term efficacy?



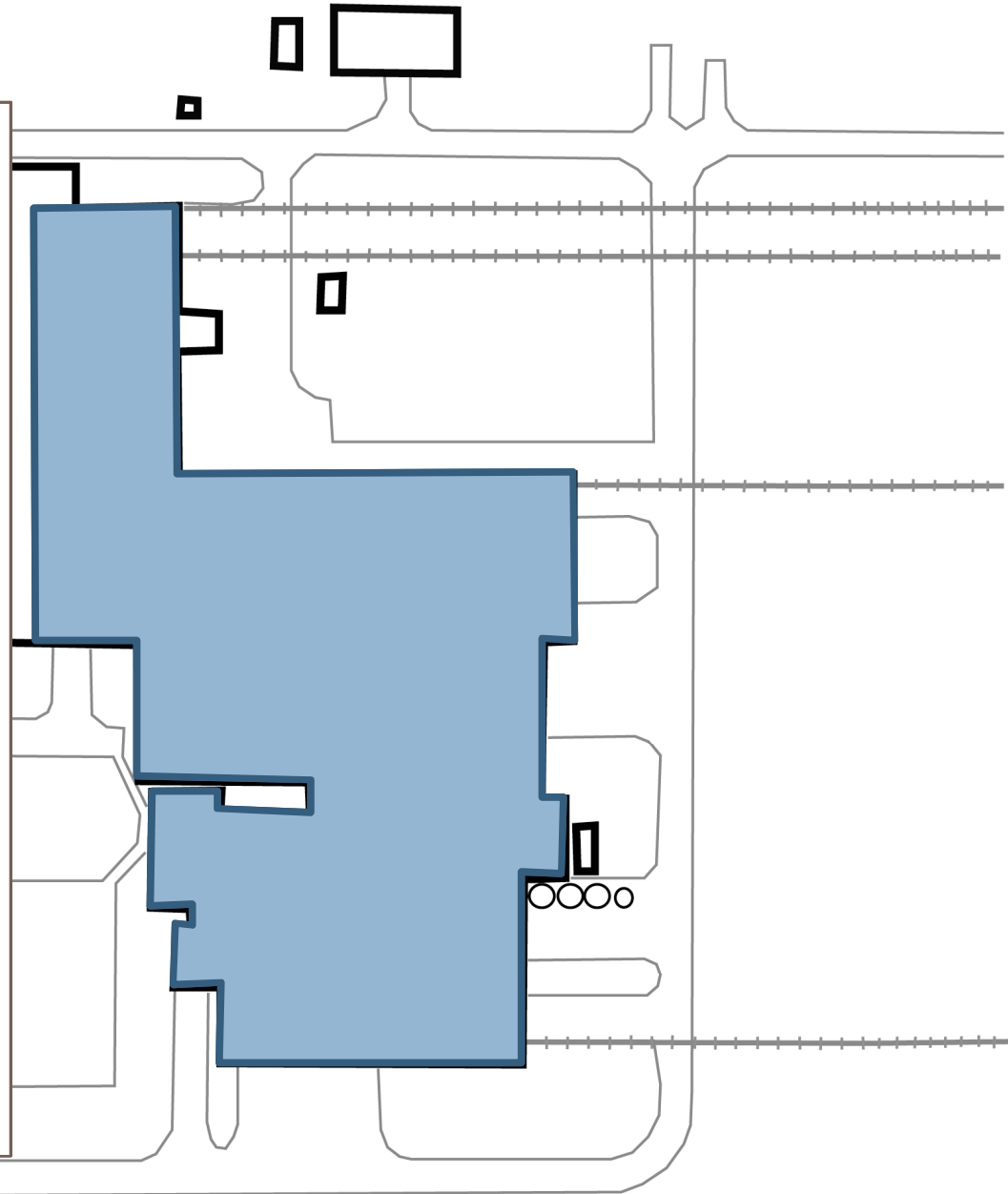
FUMIGATION/HEAT EFFICACY



FUMIGATION/HEAT EFFICACY

Short-Term Pest Reduction

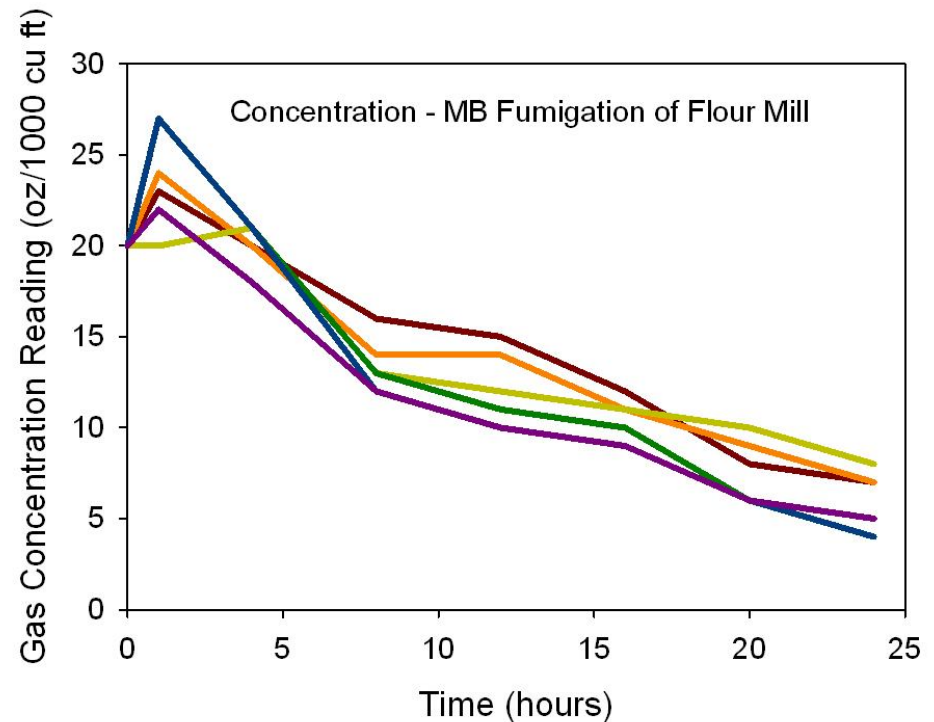
- Technical Factors
 - Type
 - Gas concentration or temperature/time
 - Distribution
- Biological Factors
 - Life stages present
 - Susceptibility
 - Mobility
 - Density & distribution
 - Mortality in different subpopulations



FUMIGATION/HEAT EFFICACY

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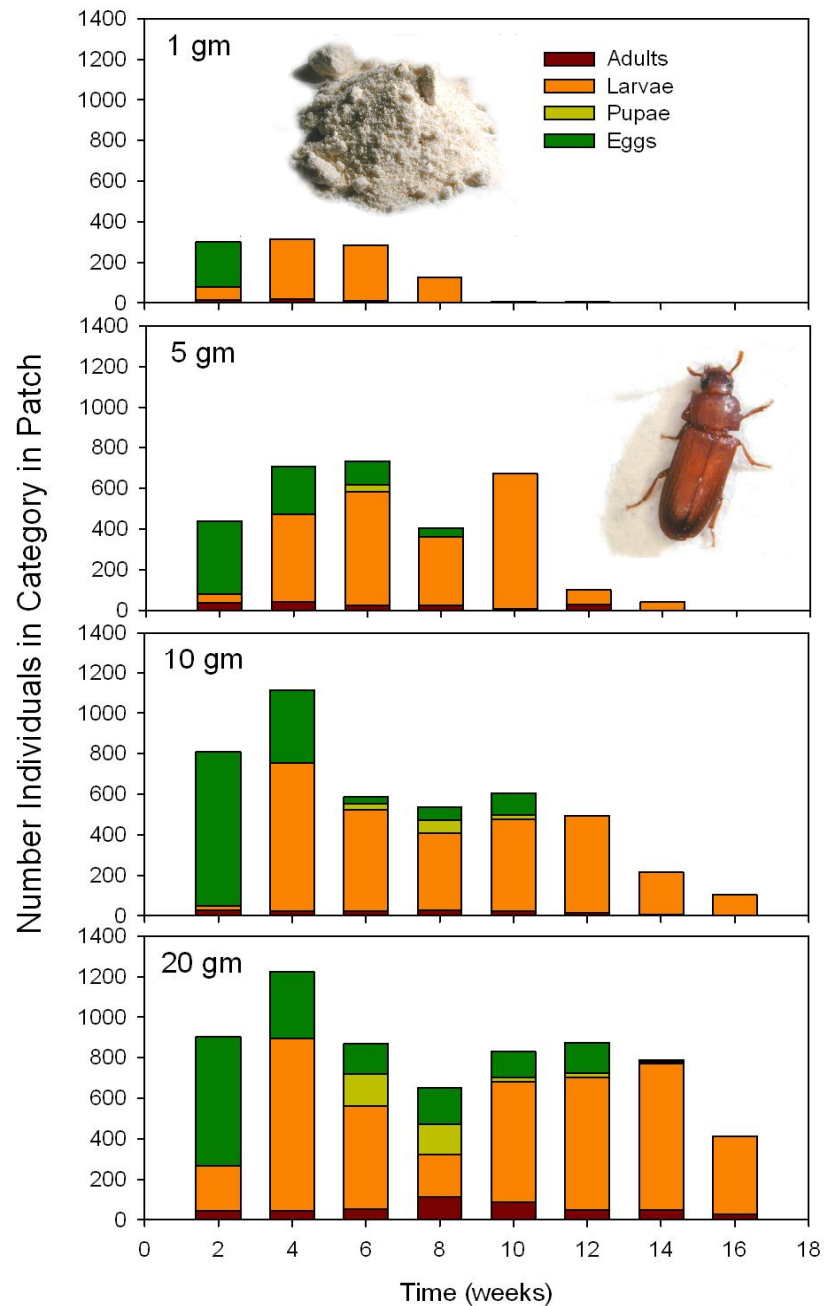
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FUMIGATION/HEAT EF

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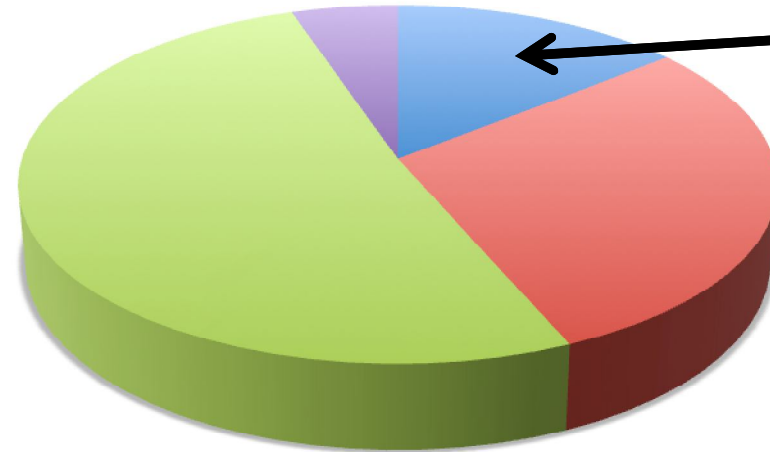
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- Adults
- Eggs
- Larvae
- Pupae

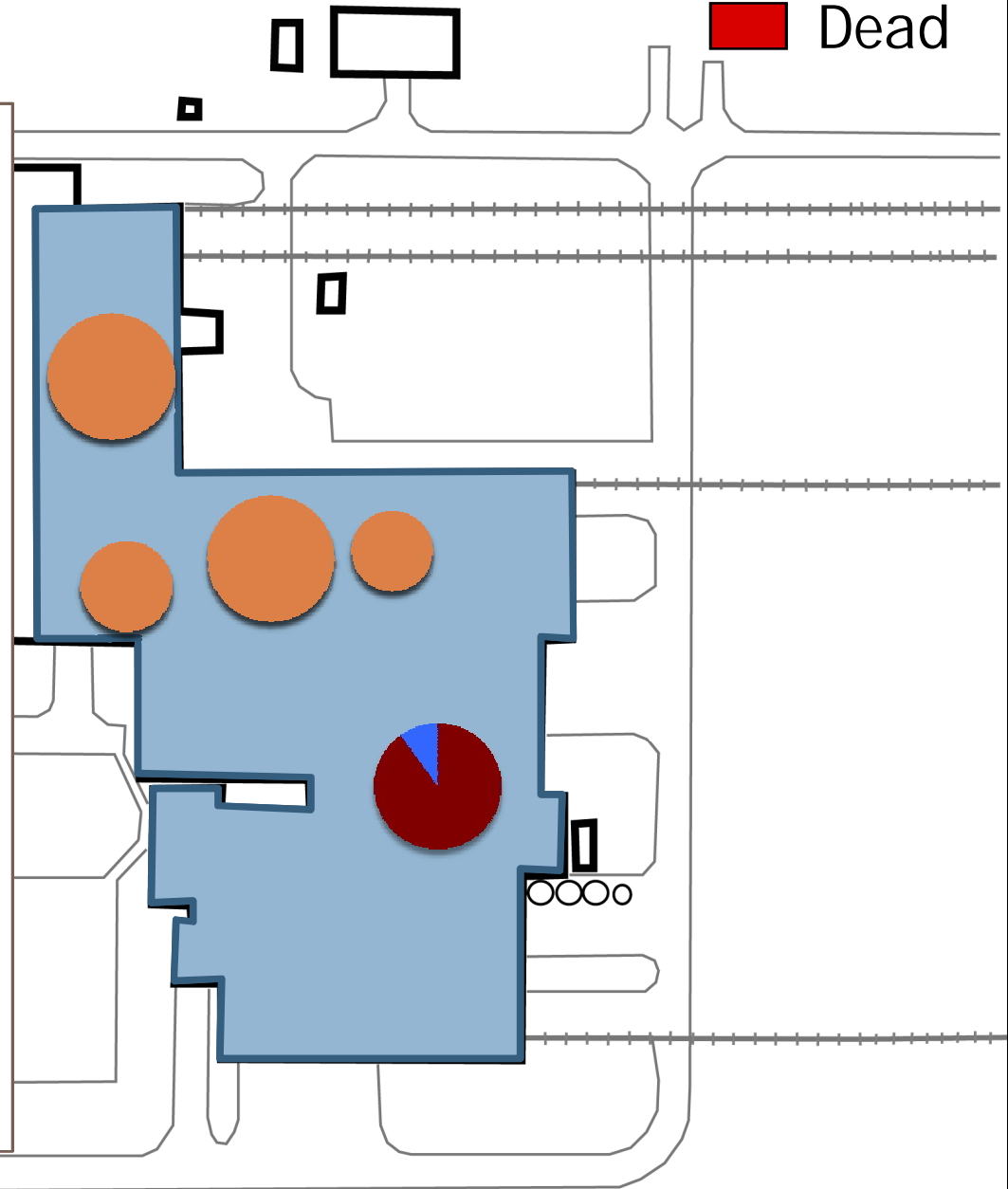


FUMIGATION/HEAT EFFICACY

■ Alive
■ Dead

Short-Term Pest Reduction

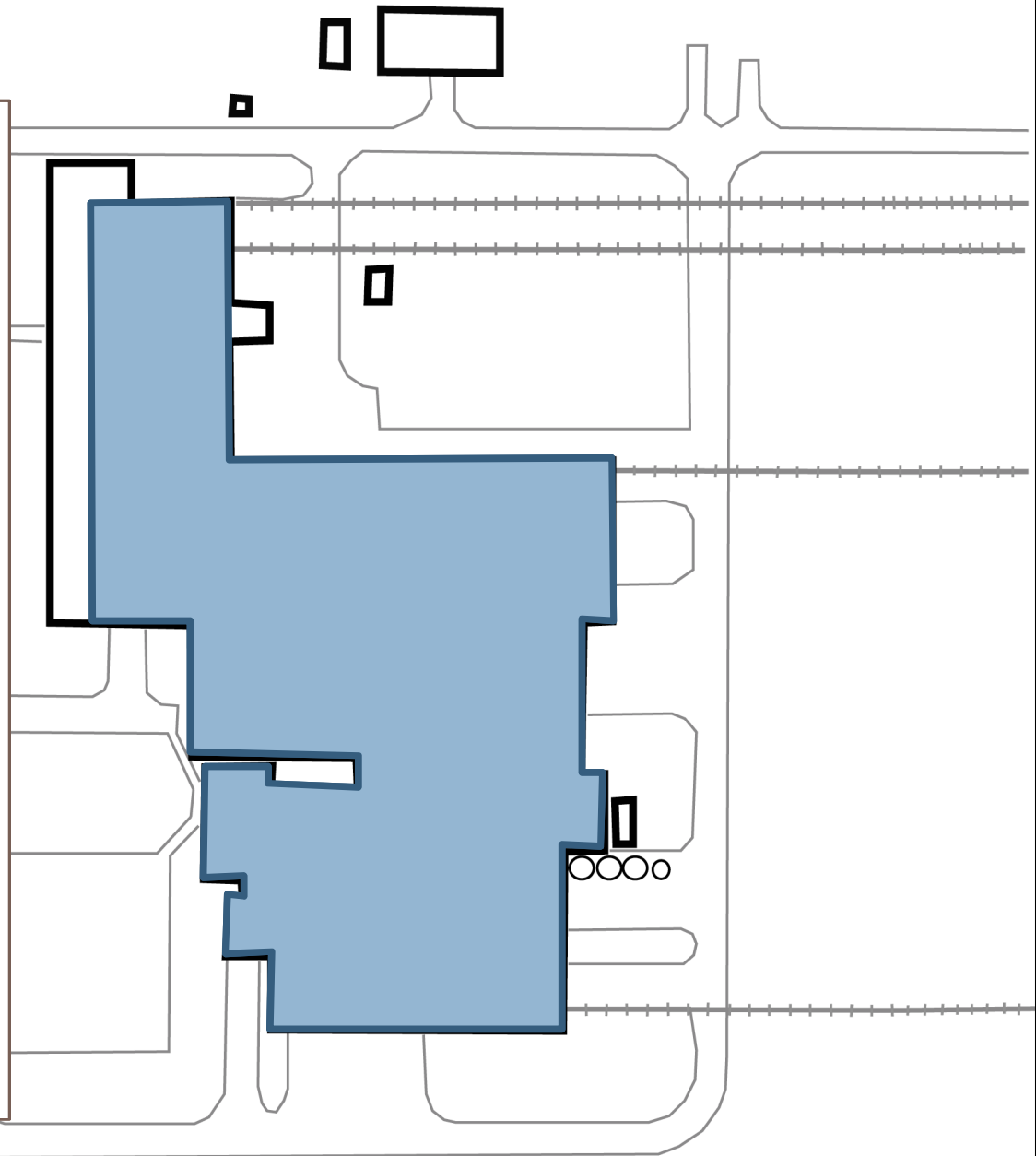
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FUMIGATION/HEAT EFFICACY

Pest Population Rebound

- Survival
- Immigration rate from untreated areas
 - Human activities
 - Pest behavior
- Environmental Conditions (e.g., temperature)
 - Population growth rate
 - Immigration rate
- Management tactics

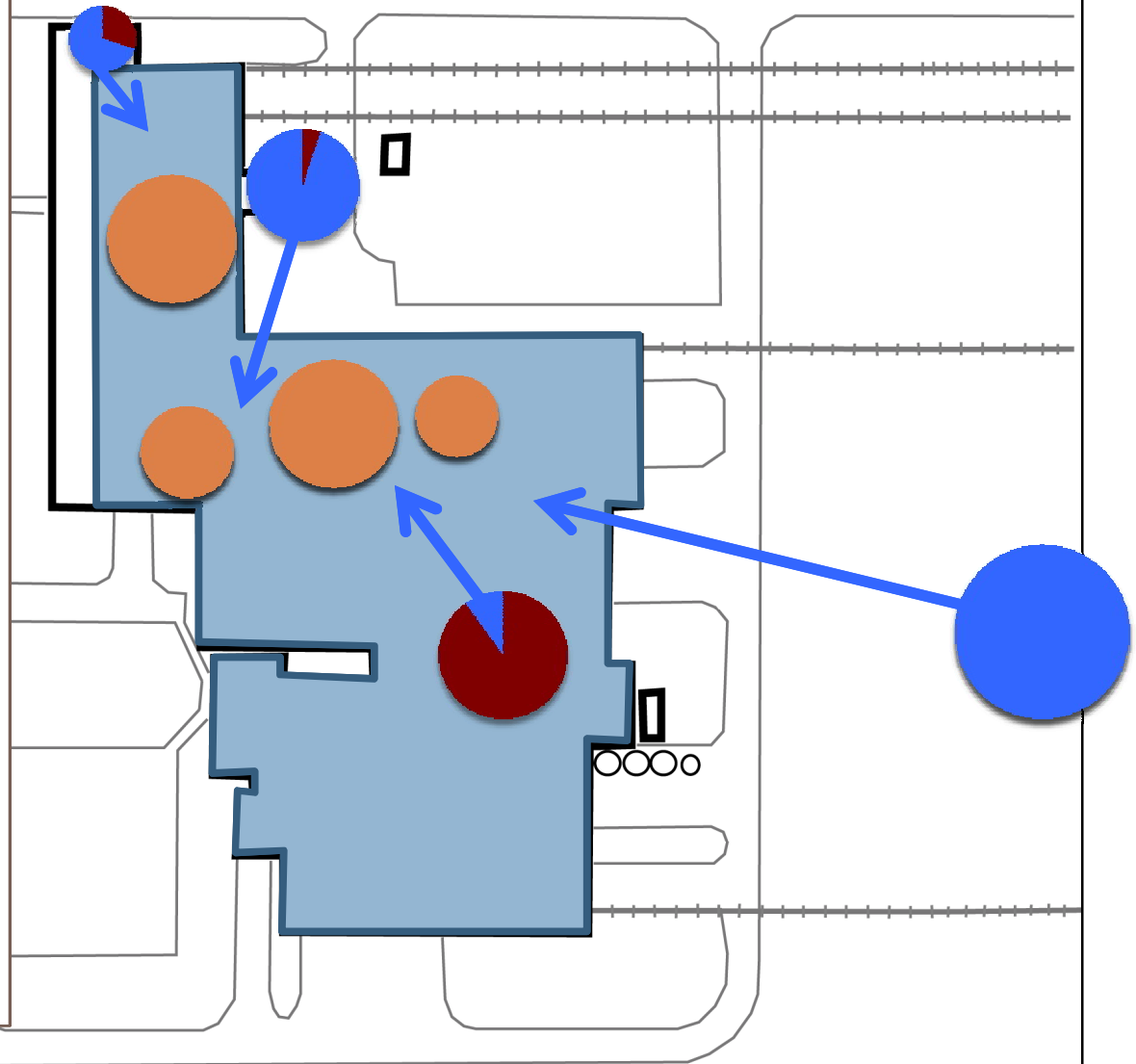


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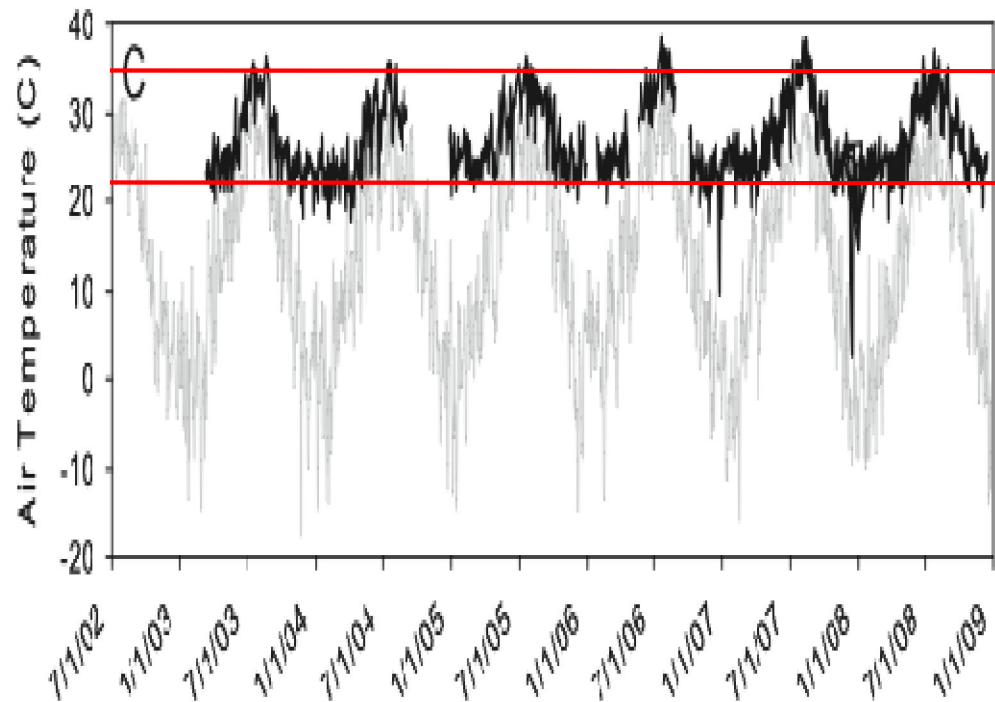
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FUMIGATION/HEAT EFFICACY

Pest Population Rebound

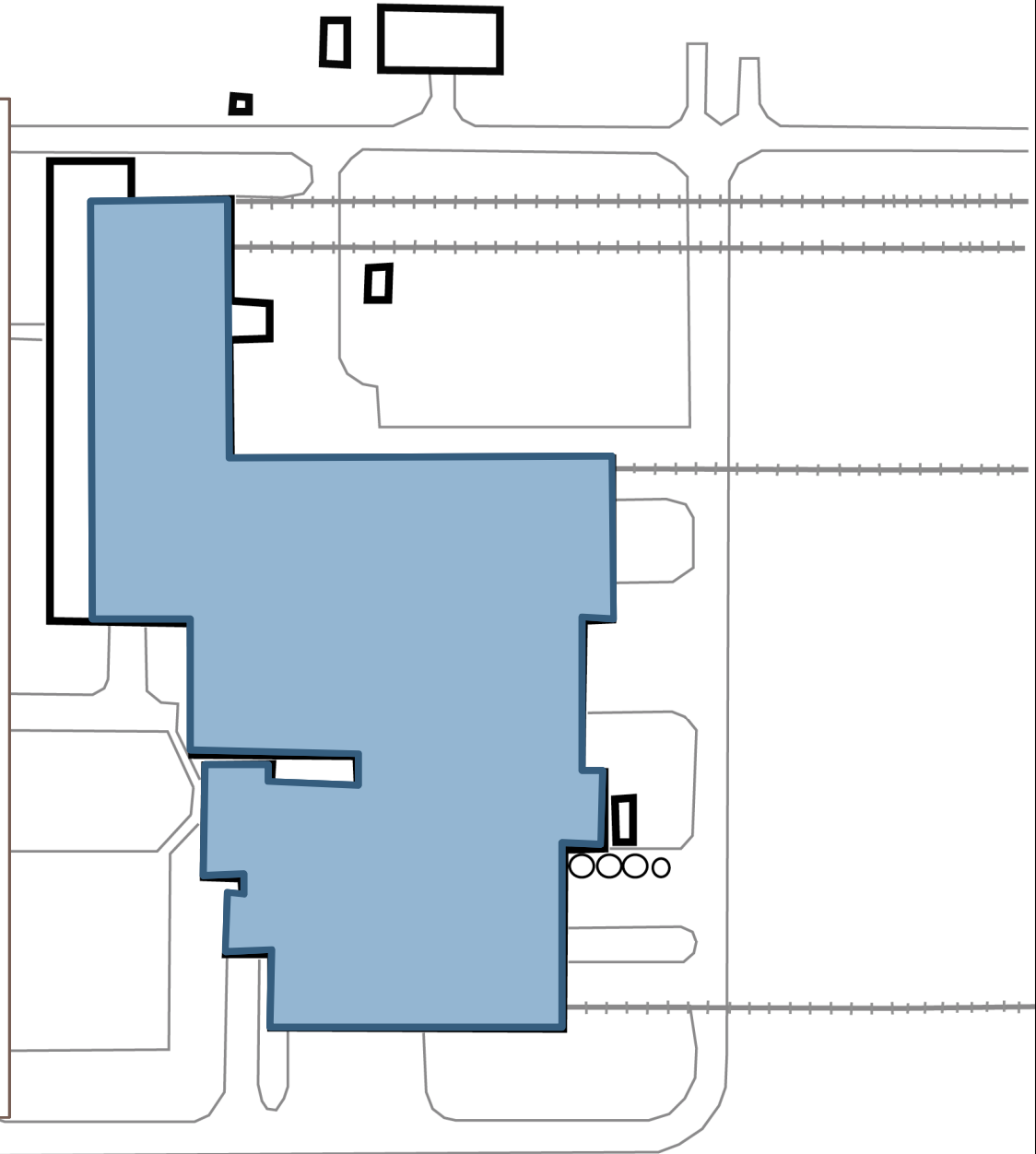
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FUMIGATION/HEAT EFFICACY

Pest Population Rebound

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- Environmental Conditions (e.g., temperature)
 - Population growth rate
 - Immigration rate
- **Management tactics**



Before Structural Treatment



After Structural Treatment



Methods to Evaluate Efficacy

- Sentinel insects/bioassays
 - ▣ Accurate measure of mortality due to treatment
 - ▣ Labor and time intensive to perform well
 - ▣ Difficult to place in all locations where resident pests can occur



Methods to Evaluate Efficacy

- Inspection and sampling
 - ▣ Important part of IPM program at facility
 - ▣ Mortality after treatment
 - Heat treatments drive insects from refugia
 - Number of dead insects and actual population levels not always related
 - ▣ Difficult to quantify, standardize, and compare trends over time



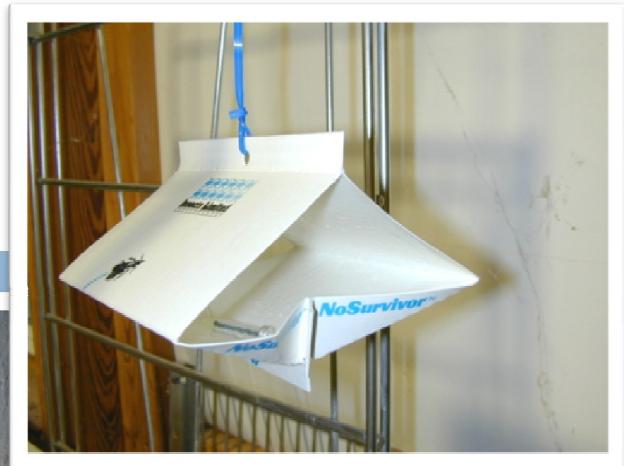
Methods to Evaluate Efficacy

- Sifter tailings (mills)
 - Measures actual of infestation of product stream
 - Can be quantified and trends determined
 - Delayed detection of structural infestations
 - Limited number of sampling points limits ability to identify sources



Methods to Evaluate Efficacy

- Trapping - pheromones, food attractants, and passive traps
 - ▣ Can detect at low pest densities and be used to identify sources
 - ▣ Can be quantified and standardized to id trends
 - ▣ Relationship to pest infestation level difficult to determine



Evaluating Fumigation Efficacy in Two Flour Mills

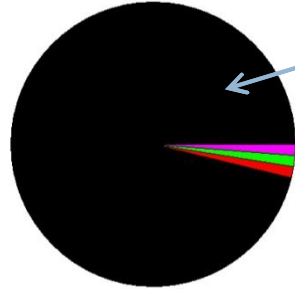
- Difficult to compare efficacy among fumigations because of variation among locations, season, pest populations, other management tactics, etc.
- Long term monitoring datasets (~6 yrs) from two locations provides a unique opportunity
- **Flour Mill #1: 10 structural fumigations:** 8 methyl bromide (1.25 to 1.5 lb/1000 ft³) and 2 sulfuryl fluoride fumigations (low rate – 2 lb/1000 ft³ and high rate – 6.9 lb/1000 ft³)
- **Flour Mill #2: 11 structural fumigations:** all methyl bromide (1.5 lb/1000 ft³)

Species Diversity: Mill #1



Mill and Warehouse
1/7/03 - 1/21/03

Winter

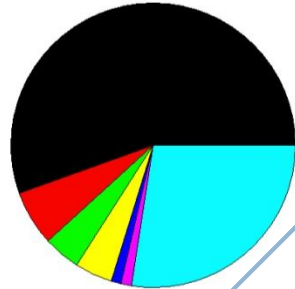


red flour beetle



Mill and Warehouse
6/3/03 - 6/17/03

Spring

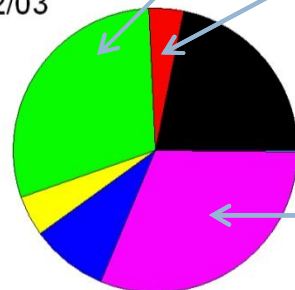


hairy fungus beetle



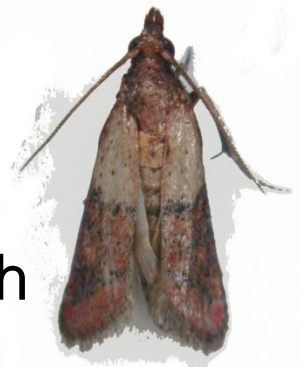
Mill and Warehouse
7/29/03 - 8/12/03

Summer

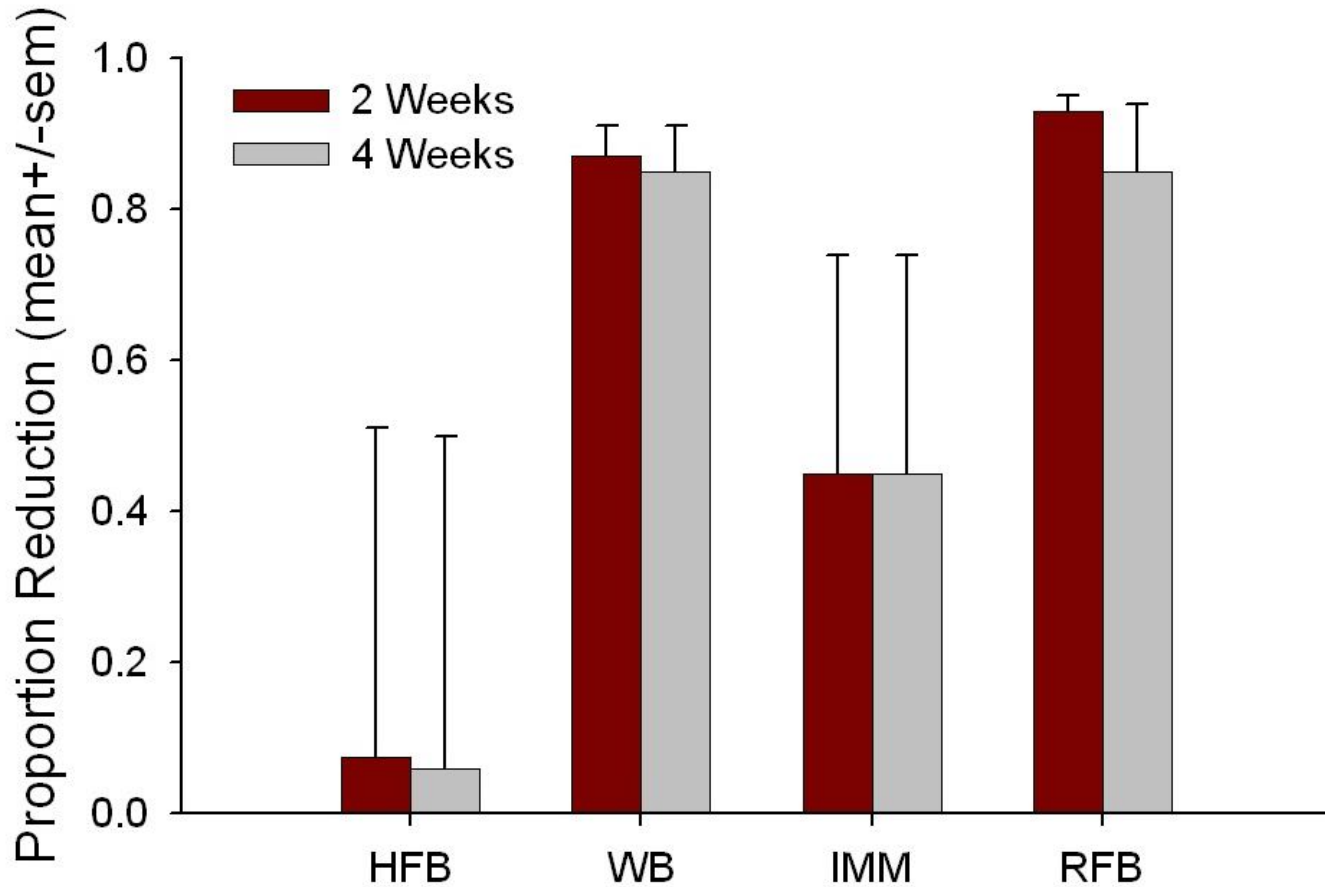


warehouse beetle

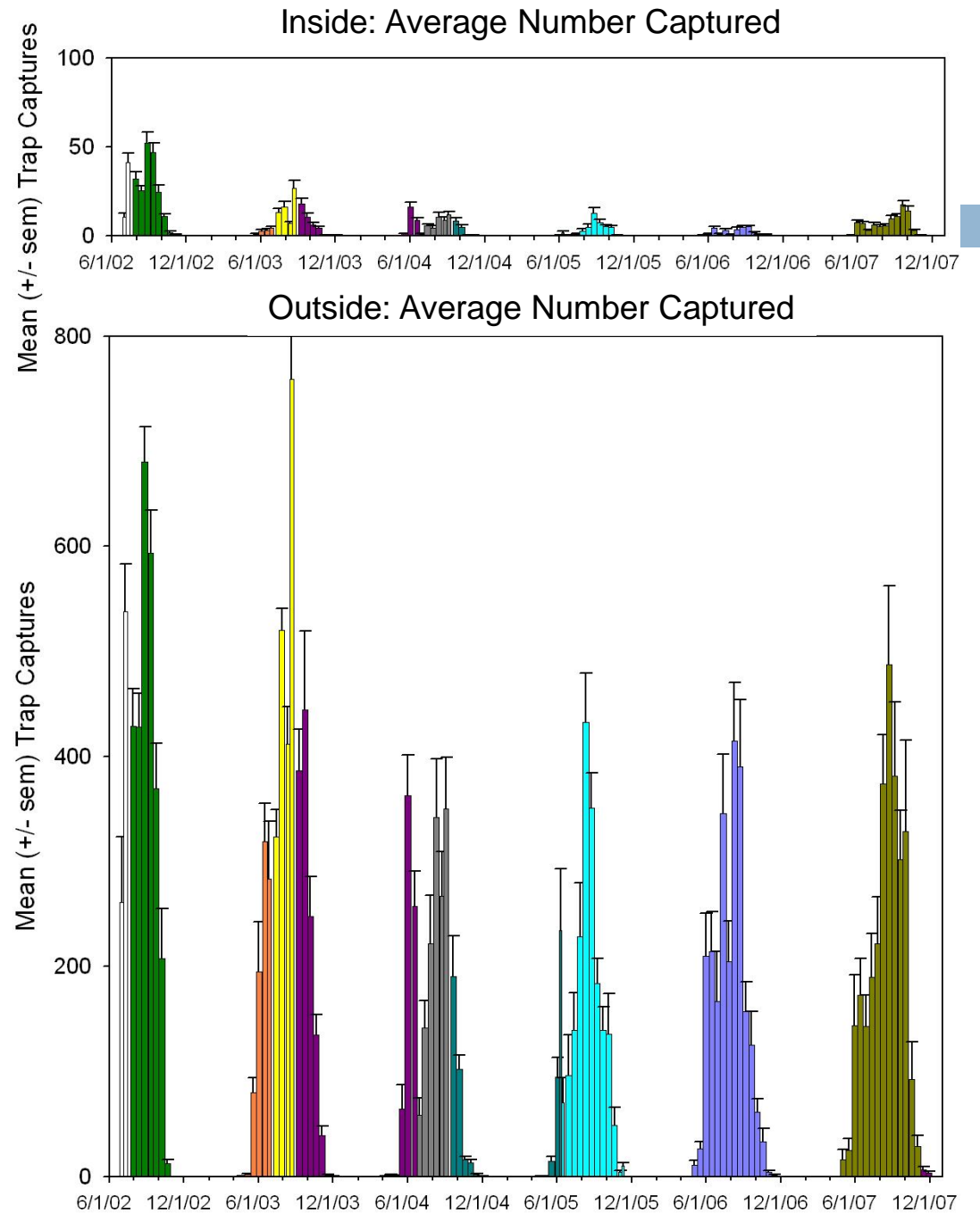
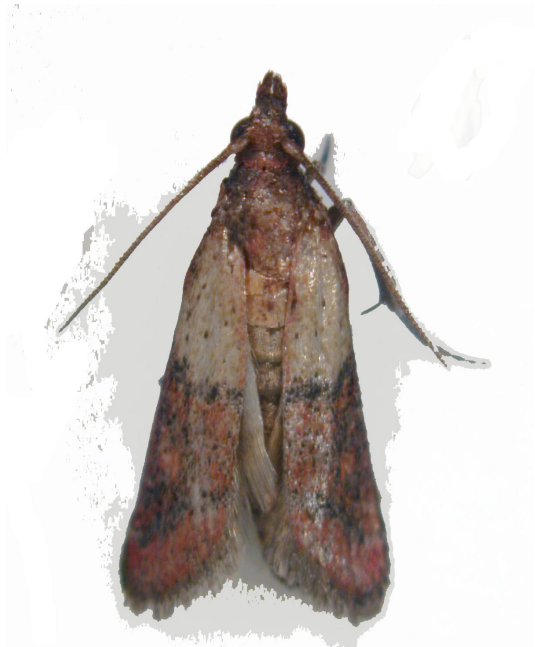
Indianmeal moth



Differences in Response to Fumigation



Plodia interpunctella Indianmeal moth



Pheromone Trapping Program

Tribolium castaneum –
red flour beetle



Mill #1: 55 traps
Mill #2: 32 traps

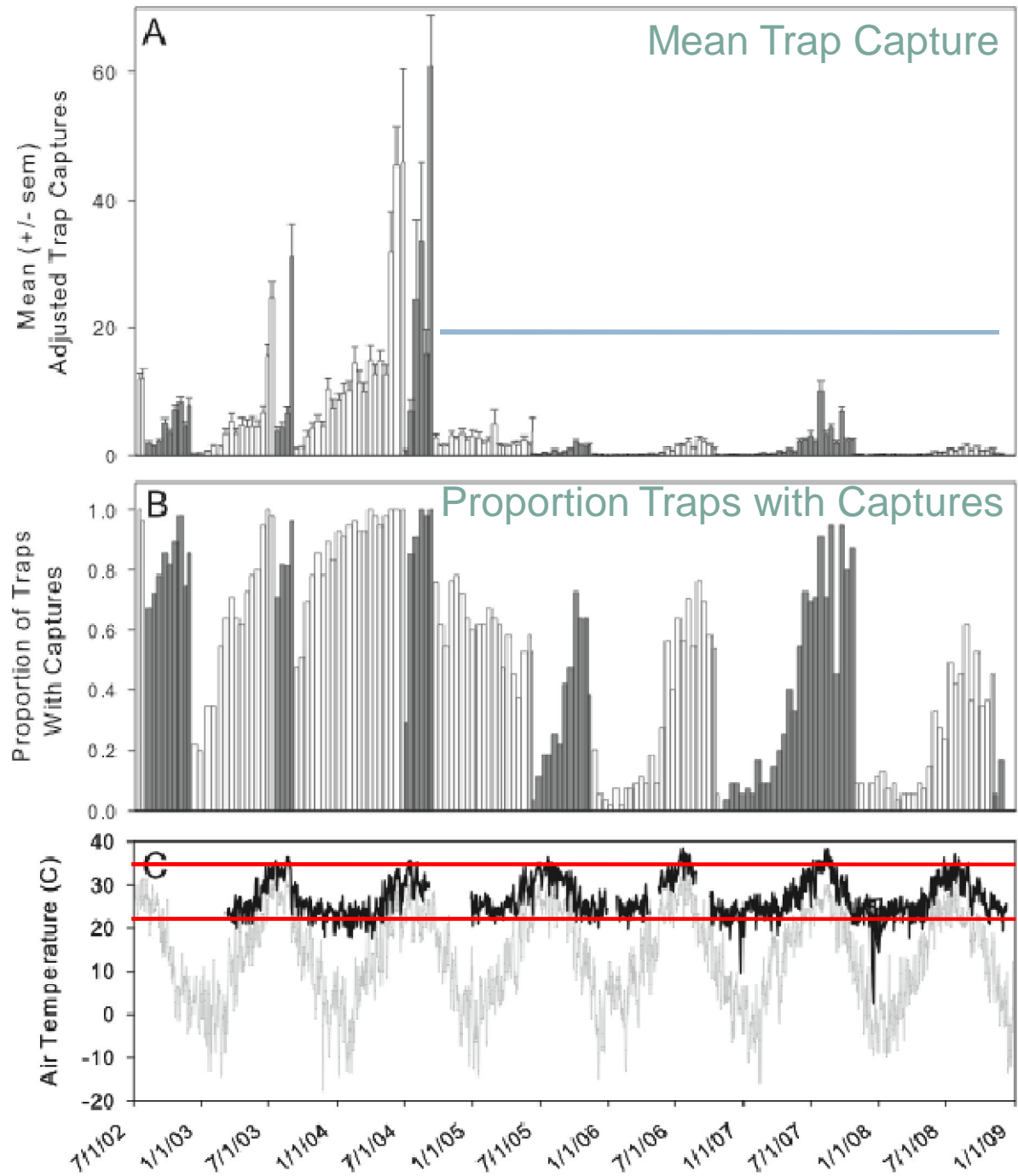
Mill #1

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

Change in mean number
captured between
monitoring periods
without fumigation:
 $45 \pm 9\%$ increase

Mean percent of traps
with captures: $49 \pm 3\%$
of traps with one or more
RFB

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



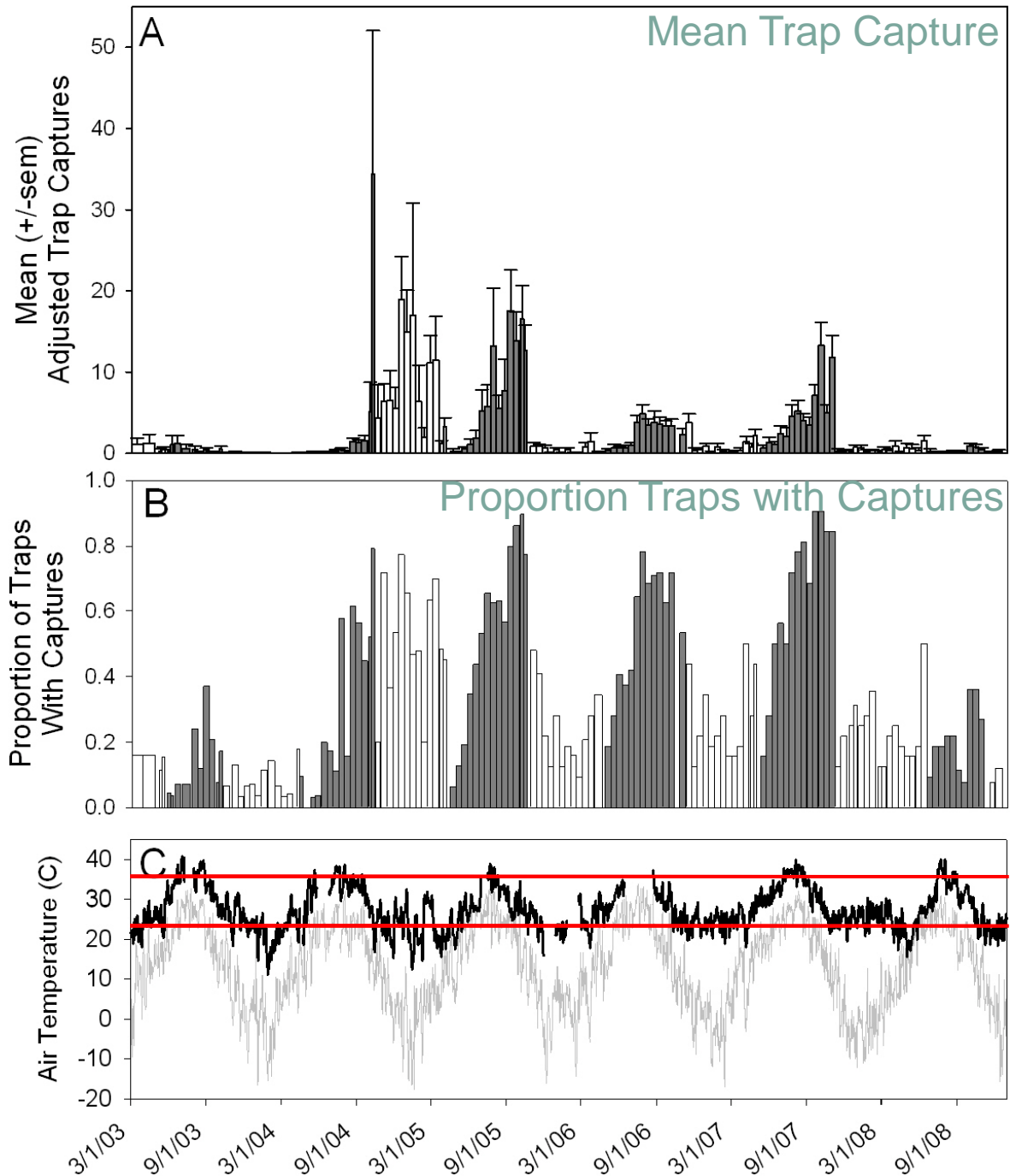
Mill #2

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

Change in mean number
captured between
monitoring periods
without fumigation:
 $62 \pm 14\%$ increase

Mean percent of traps
with captures: $33 \pm 2\%$
of traps with one or more
RFB

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



Fumigation Efficacy – Initial Reduction in Trap Captures

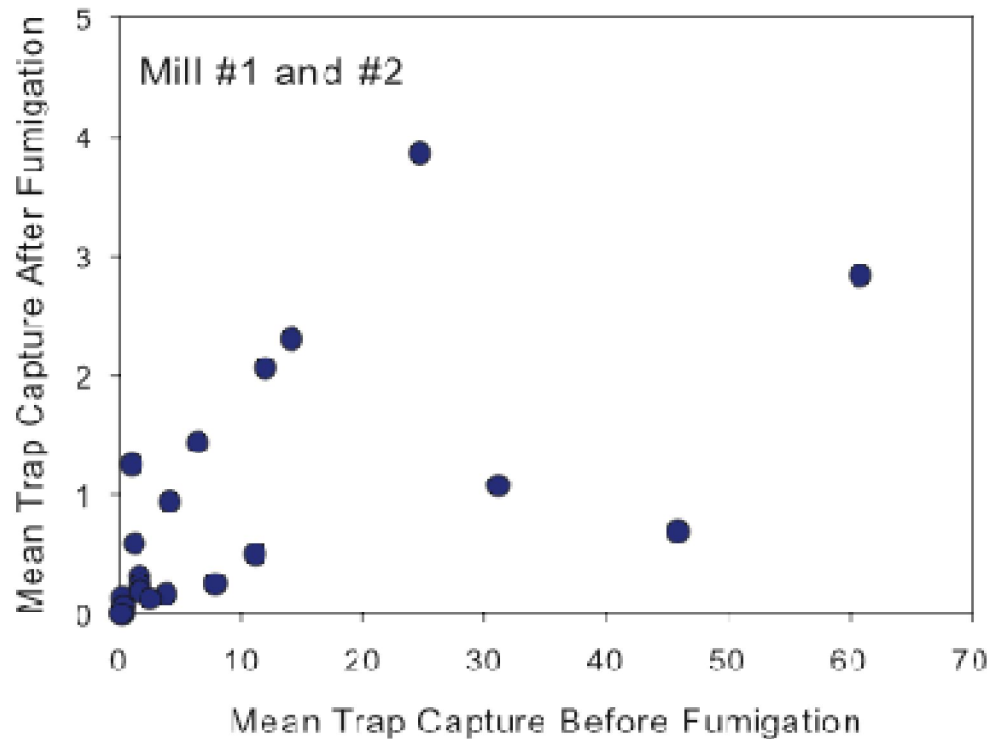
- Two mills did not differ from each other in reduction in trap capture after fumigation
- **84.6 ± 4.6% reduction in beetles/trap/period (n=23 fumigations)**
 - ▣ 11.4 ± 3.5 beetles/trap/period immediately before fumigation
 - ▣ 0.8 ± 0.2 beetles/trap/period immediately after fumigation
 - ▣ Only 3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

Fumigation Efficacy – Initial Reduction in Trap 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

Fumigation Efficacy – Initial Reduction in Trap Captures

- Significant positive correlations between before and after fumigation trap captures: the greater the number captured or proportion of traps with captures before fumigation the greater the mean number captured or proportion of traps with captures after fumigation



Seasonal Effects on Fumigation Efficacy – Initial Reduction in Traps

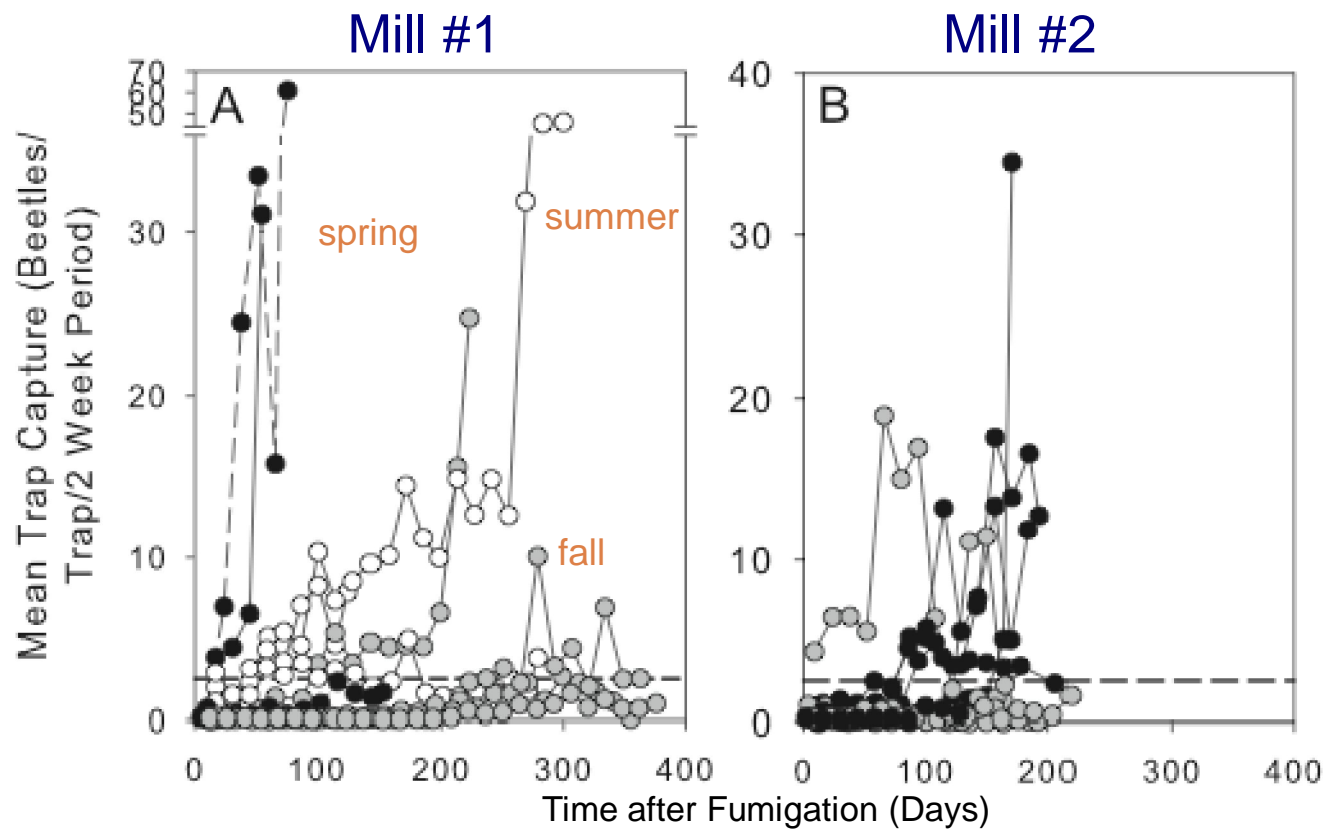
- Spring (April-June)(3 fumigations at mill #1 and 6 fumigations at mill #2)
- Fall (Oct-Dec) (4 fumigations at mill #1 and 5 fumigations at mill #2)
- Outside temperatures were lower during fall ($12 \pm 2^{\circ}$ C) than during spring ($19 \pm 1^{\circ}$ C) fumigations
- Inside temperatures did not differ between spring ($25 \pm 1^{\circ}$ C) and fall ($24 \pm 1^{\circ}$ C) fumigations

Seasonal Effects on Fumigation Efficacy – Initial Reduction in Traps

- No difference between spring and fall fumigations in:
 - ▣ Reduction in mean number captured
 - ▣ Reduction in proportion of traps with captures
 - ▣ Mean number of beetles captured immediately after fumigation
 - ▣ Proportion of traps with captures immediately after fumigation

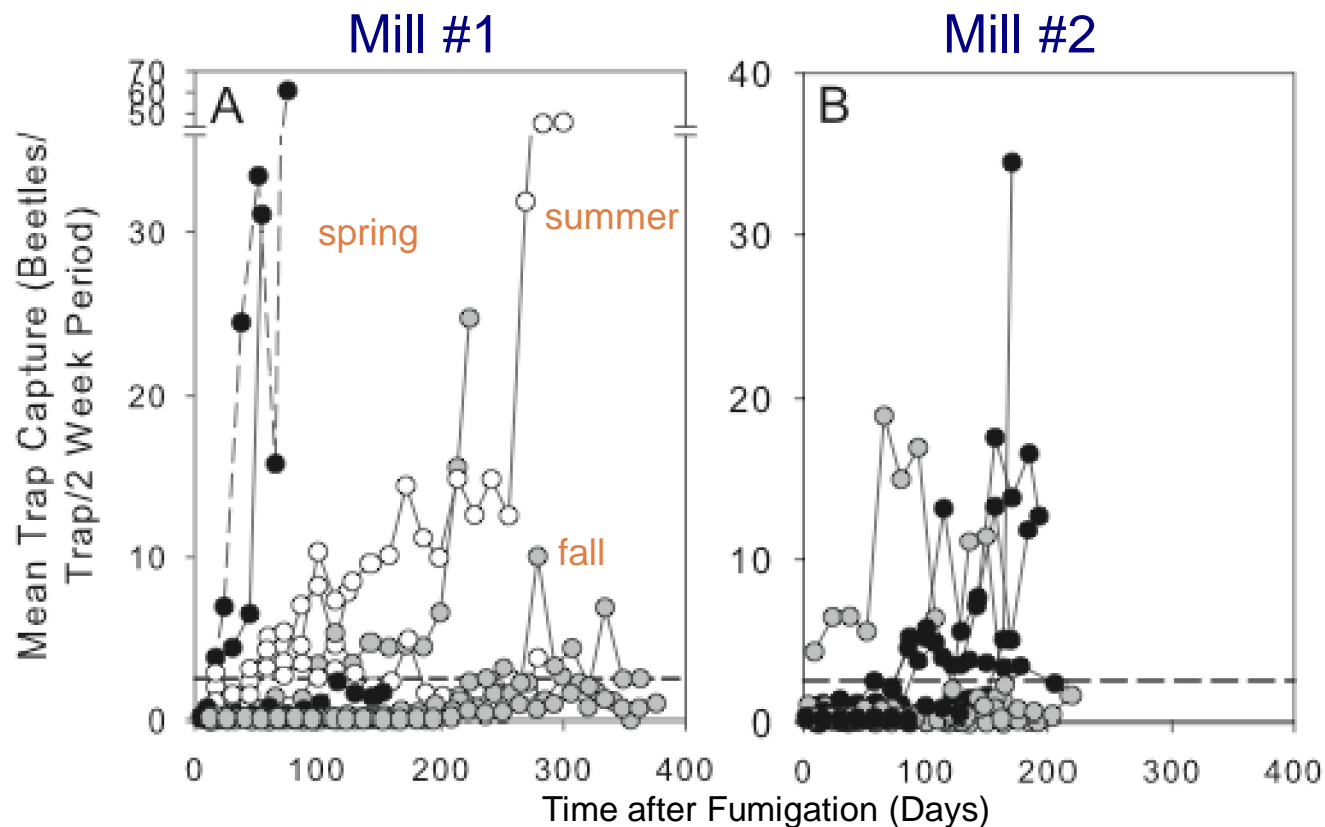
Fumigation Efficacy – Rebound in Trap Captures

- Rebound in mean trap capture after fumigation was highly variable



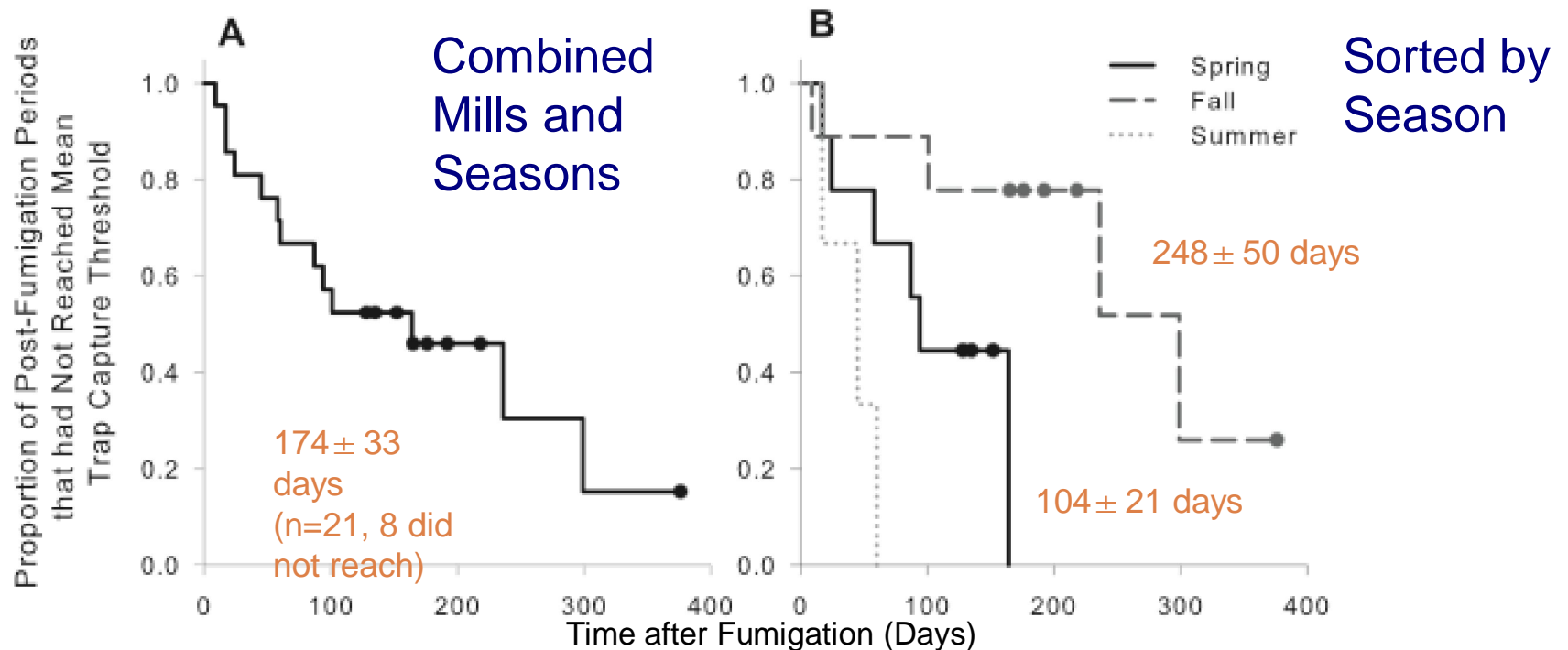
Fumigation Efficacy – Rebound in Trap Captures

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



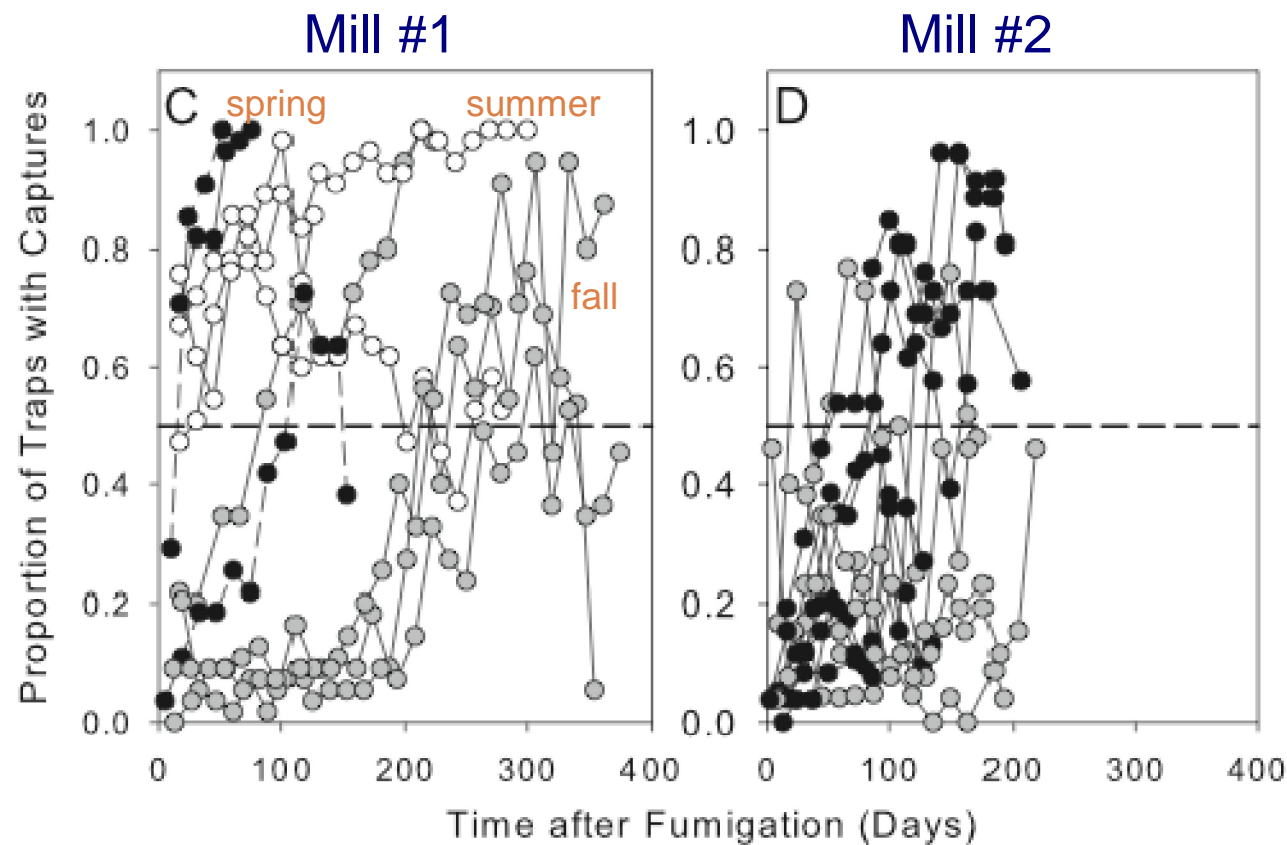
Fumigation Efficacy – Rebound in Trap Captures

- Threshold for comparative purposes, does not necessarily represent an economic threshold
- Significant effect of season on rebound to mean trap capture threshold



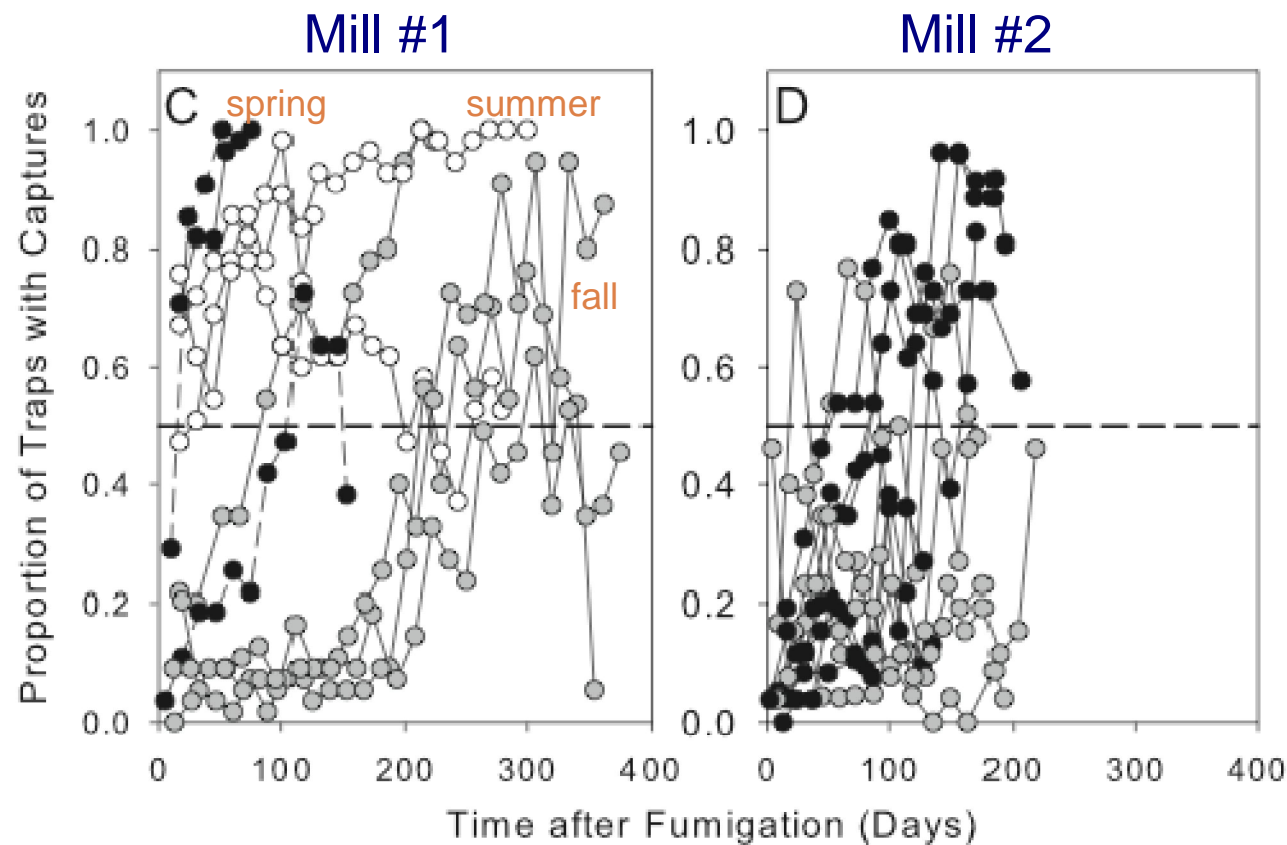
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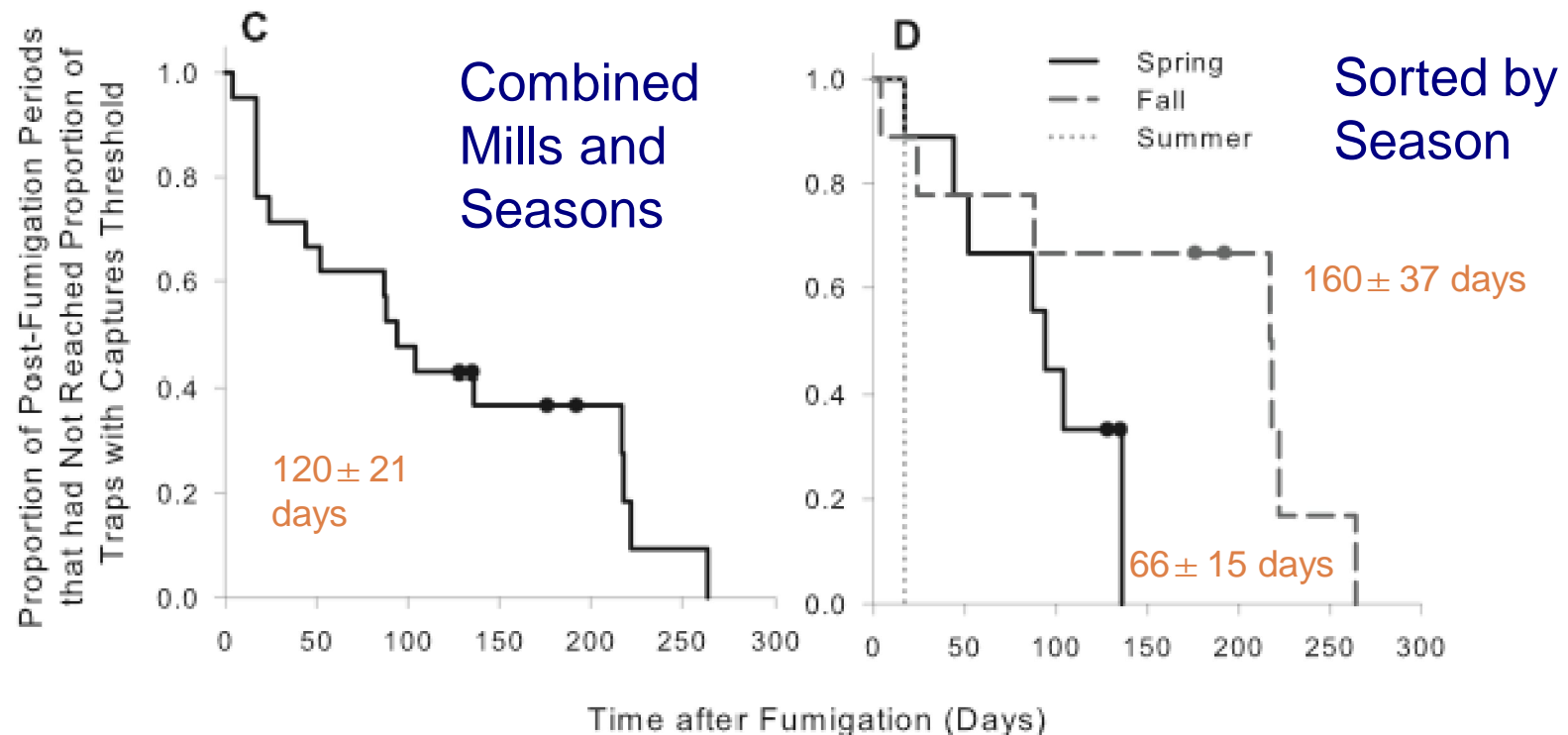
Fumigation Efficacy – Rebound in Trap Captures

- Developed threshold value to compare rebound rates – 50% of traps with captures of one or more beetles (= median trap capture prior to fumigation)

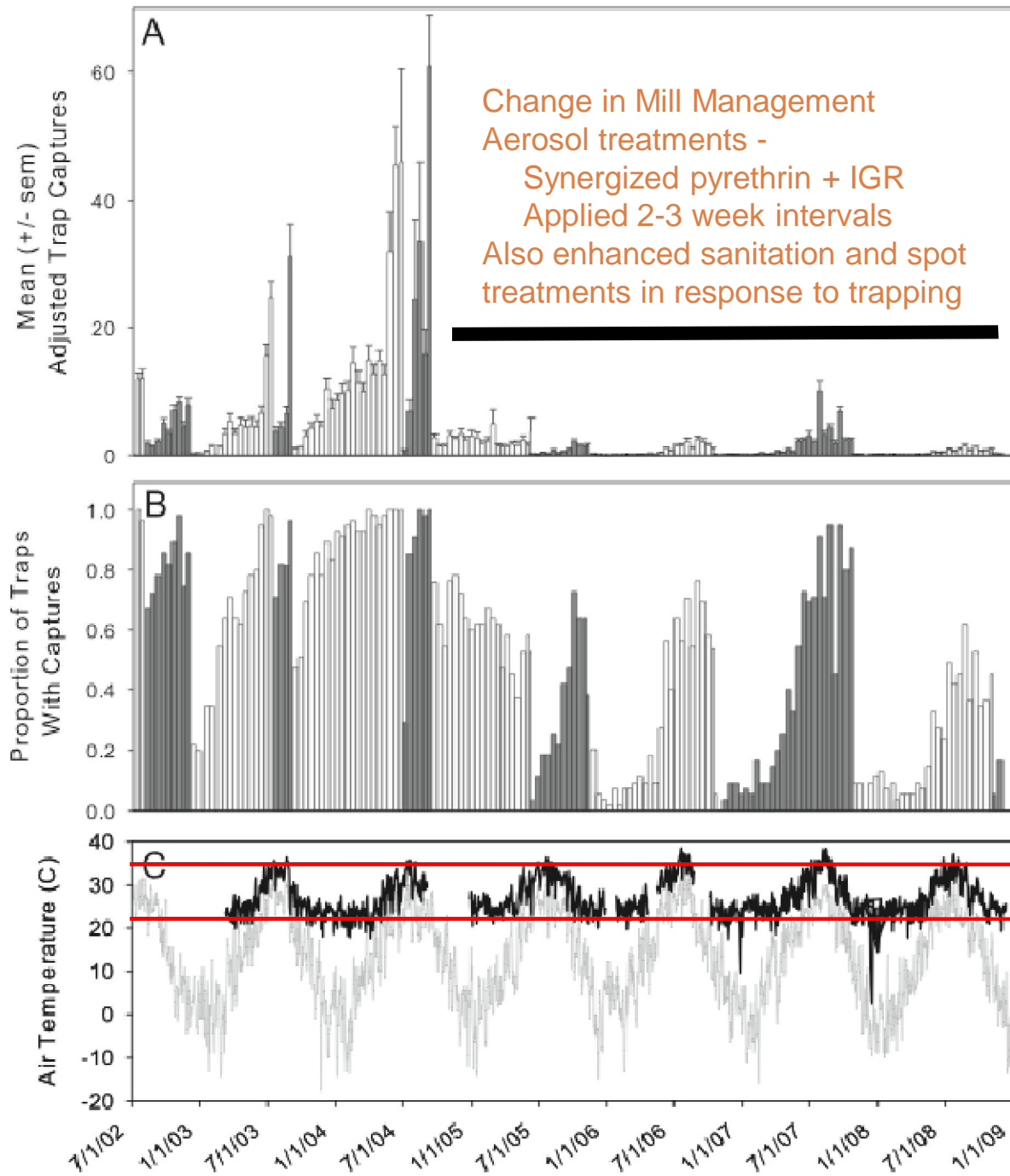


Fumigation Efficacy – Rebound in Trap Captures

- Threshold for comparative purposes, does not necessarily represent an economic threshold
- Season did not significantly effect rebound to proportion of traps with captures threshold

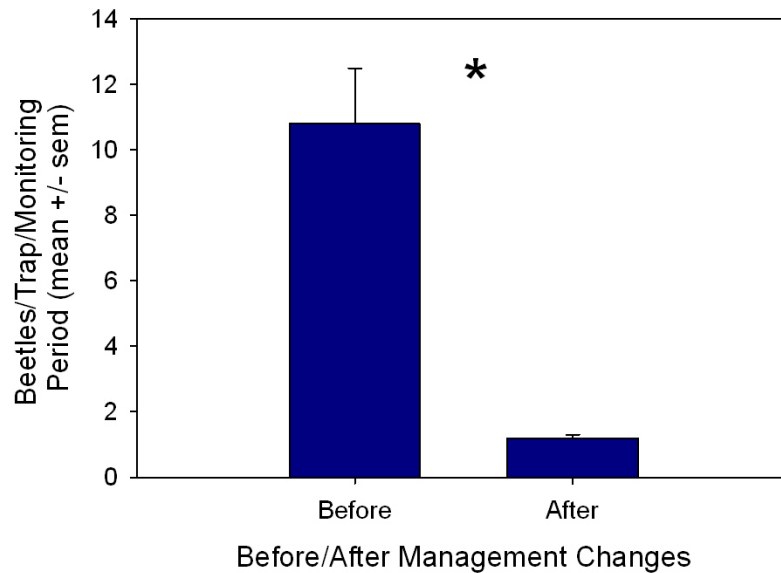


Managing Rebound Rate (Mill #1)



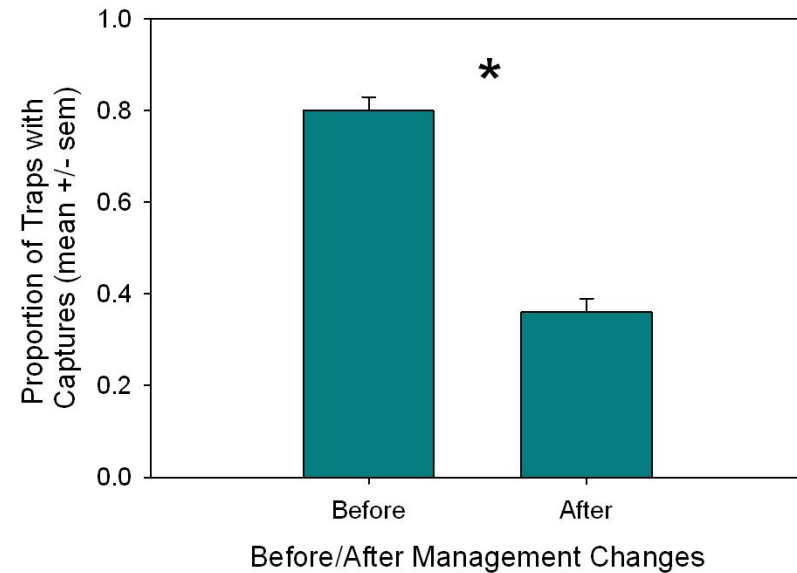
Before and After Comparison: Mean Trap Captures

Mean Trap Capture



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

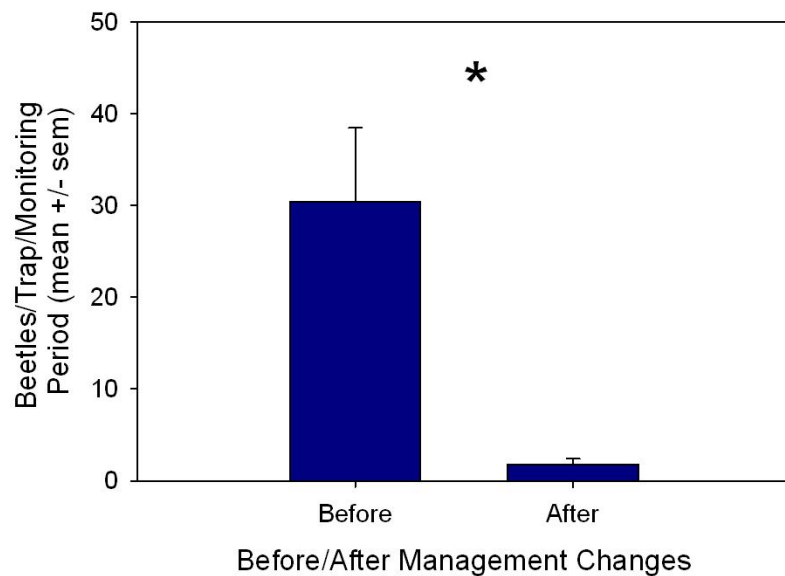
Proportion of Traps with Captures



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

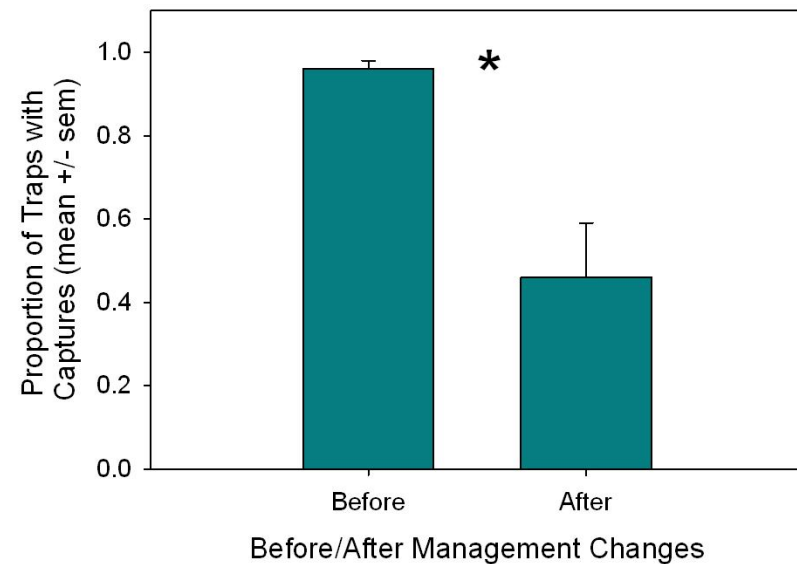
Before and After Comparison: Trap Captures Before Fumigation

Mean Trap Capture at Time Fumigation Performed



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

Proportion of Traps with Captures at Time Fumigation Performed

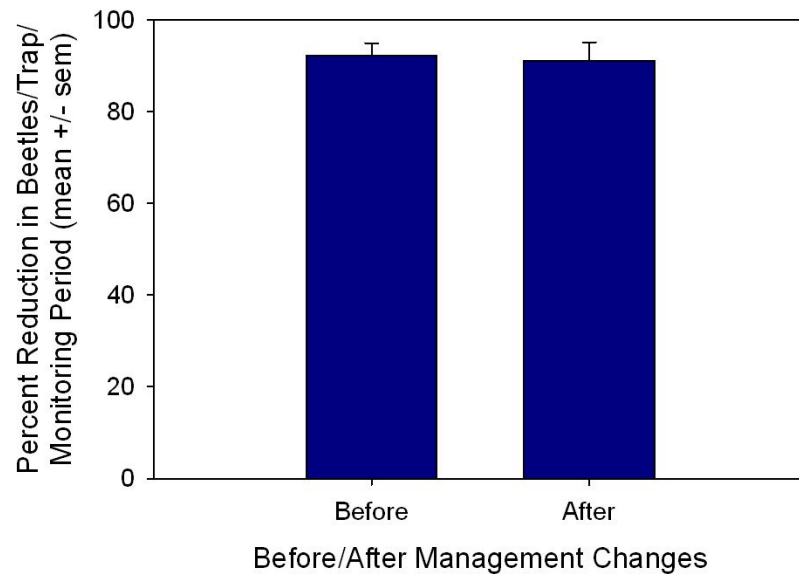


GLM: $F_{1,9}=17.05$, $P=0.0026$

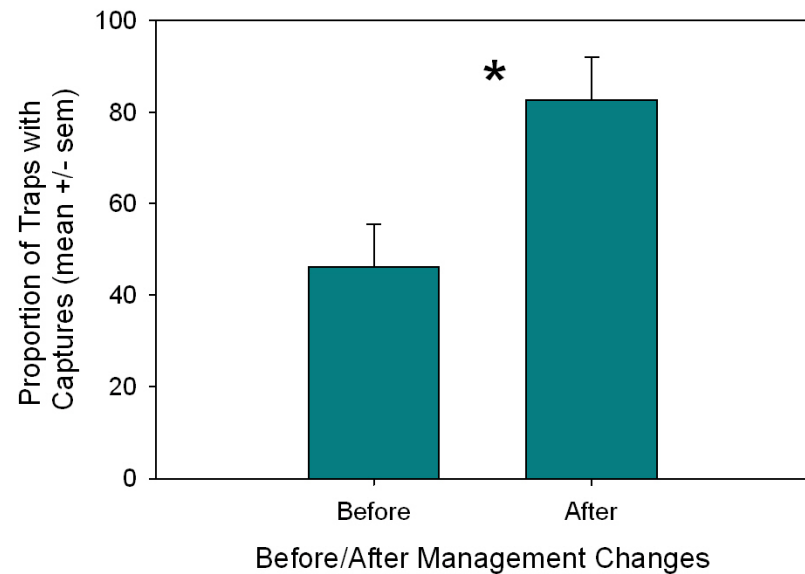
Before and After Comparison: Percent Reduction After Fumigation

Percent Reduction in Mean Trap Capture Following Fumigation

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



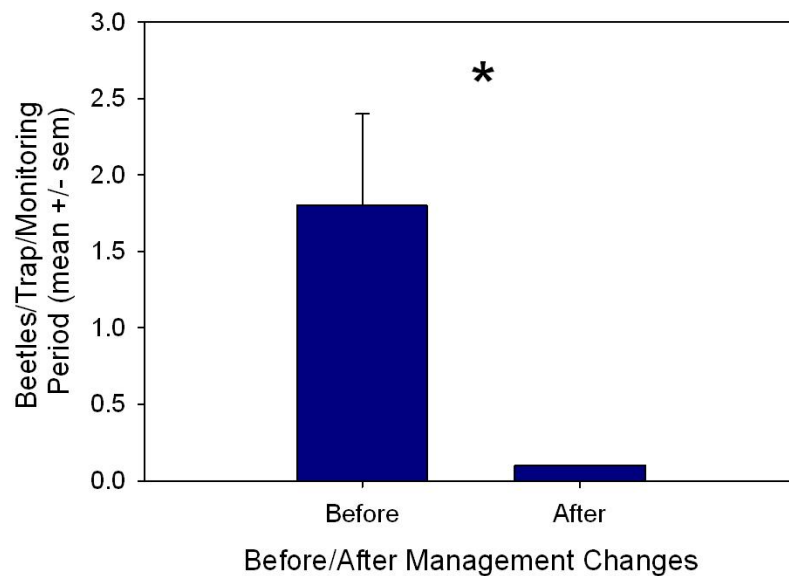
GLM: $F_{1,9}=0.04$, $P=0.8438$



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

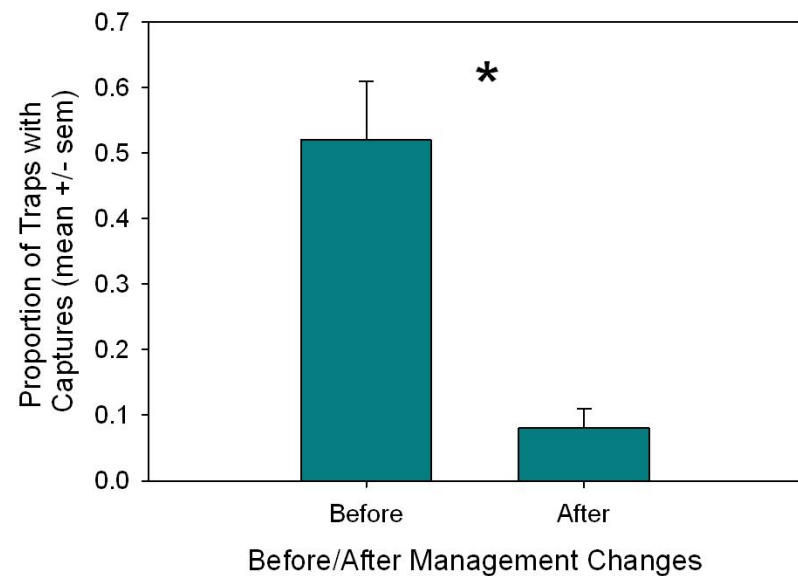
Before and After Comparison: Trap Captures After Fumigation

Mean Trap Capture After Fumigation Performed



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

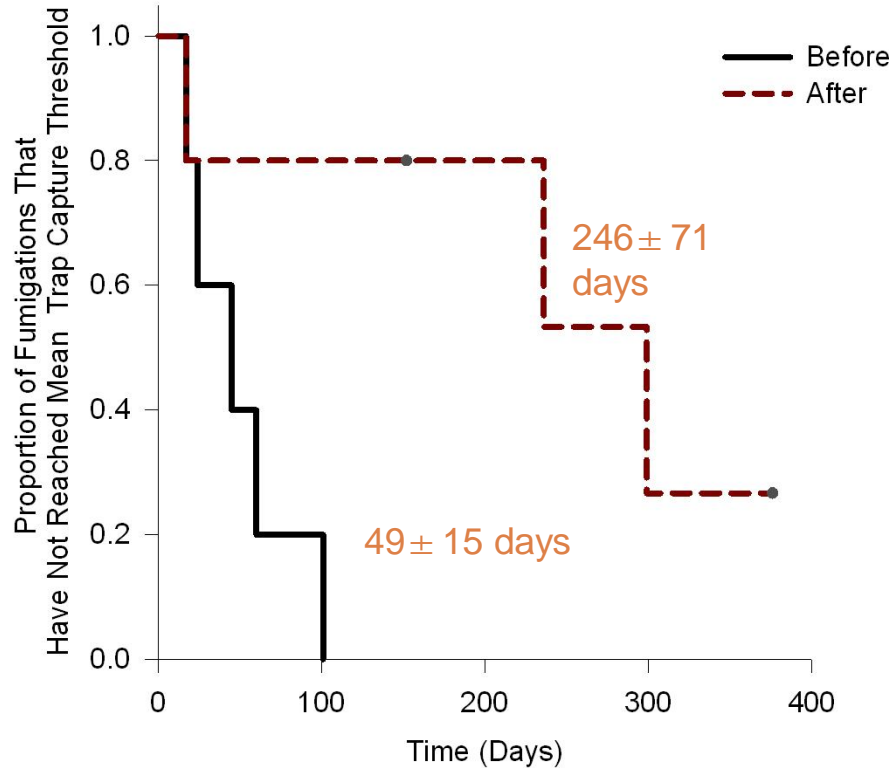
Proportion of Traps with Captures After Fumigation



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

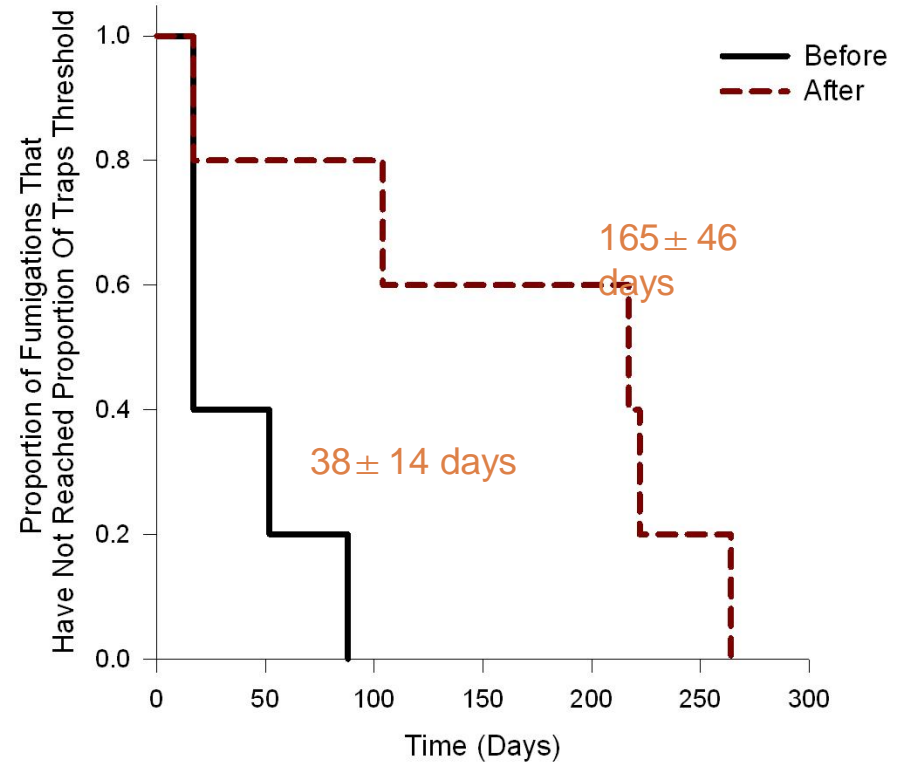
Change In Rebound Rate

Mean Trap Capture



Log Rank: $r=4.874$, d.f.=1, $P=0.027$

Proportion of Traps with Captures



Log Rank: $r=5.801$, d.f.=1, $P=0.016$

Conclusions and Questions



Acknowledgements:

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