Invasion Biology:
Science and Policy

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Invasive Species Summit
Vancouver, BC 11/10/18

Invasion Databases:
Scientific Goldmines

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Surveillance Program Data

1. Protection—biosecurity
2. Understanding—science

Cost for Detecting One Adult Fly in California

- Annual surveillance costs = $20 million
- 60-year cost = >>$1 billion
- Number adult tephritids captured > 5,500

Cost/fly:
$180,000/fly
Invasion Databases

Port Information Network (PIN)
Global Eradication and Response Database (GERDA)

- Species/date (B. dorsalis; Sept, 1974)
- Location (San Diego)
- Infestation size (81,000 ha)
- Management decisions (eradicate)
- Cost ($2.2 million)
- Control tools (bait spray)

Oriental Fruit Fly Detection Database

9/21/76 Culver City 32.743 -117.099

Date City precise location
Hanging Offense

“He analyzed the fruit fly data”

Oriental Fruit Fly Detections in U.S.
Potential Oriental Fruit Fly Distribution

Oriental Fruit Fly Detections

No Oriental Fruit Fly Detections
Oriental Fruit Fly Detections in California (1960-2018)

California Oriental Fruit Fly Invasion

- 2018
- 1987
- 1983
- 2000’s
- 1960
- 1970
Detections every year for 50 straight years

Los Angeles Basin

250 km (150 miles)
Oriental Fruit Fly Cumulative Detections (1960-2018)

Oriental Fruit Fly Detections (1960-2018)
Oriental Fruit Fly Detections (1960-2018)

Los Angeles Basin

39 years (detections 300 m apart)
QUESTION #1:
Why have oriental fruit fly outbreaks been occurring annually for the past 50 years in California and only one other state?

ANSWER:
Because this fruit fly is permanently established in the state.
**QUESTION #2:**

What is the probability of a first outbreak in a randomly-chosen 100 km$^2$ (10 x 10 km) grid cell in state?
California Divided into 10 x 10 km grids

Total grids = 4,353
Infested grids = 166
% infested = 3.8%

Bay Area
Los Angeles; San Diego

QUESTION #3:
What is the probability of a second and subsequent outbreaks?
Conditional Probability of Oriental Fruit Fly Outbreaks

Number of Outbreaks

Probability

0 1 2 3 4 5 6 7 8 9 10

0 20 40 60 80 100

4% 53% 81% 82% ≈ 80%

QUESTION #4:
What is the distribution of outbreak risk in the state?
QUESTION #5:
What does capture of a single fly mean?

ANSWER:
Ominous sign—100 % probability of eventual outbreak
Mediterranean Fruit Fly
Los Angeles Basin

Single fly (1982)—Non-actionable

Single fly (1984)—non-actionable

Single fly (1986)—non-actionable

Mediterranean Fruit Fly
Los Angeles Basin History of Outbreaks (1987-2009)

Outbreaks 1987-1994
QUESTION #6:
What does zero capture mean?

ANSWERS:
1. **Meaningful** if never captured a fly in region
2. **Less meaningful** if captured fly previously in region

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### Oriental Fruit Fly Outbreak Interval in LA Basin

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1 yr</th>
<th>2 yrs</th>
<th>3 yrs</th>
<th>4 yrs</th>
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<tr>
<td>grid</td>
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<td>12%</td>
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<td>8%</td>
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QUESTION #7:
How concerned should grower be in located just outside regulated area?

ANSWER:
Very concerned in both immediate and longer term
Regulated Areas

Policy Implications
## Science informed policy

<table>
<thead>
<tr>
<th>Current</th>
<th>Informed</th>
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</thead>
<tbody>
<tr>
<td>1. 100% eradication success</td>
<td>Low-level population</td>
</tr>
<tr>
<td>2. One fly non-actionable</td>
<td>One fly actionable</td>
</tr>
<tr>
<td>3. Three generation no detection rule</td>
<td>Maintain program</td>
</tr>
<tr>
<td>4. Post-program complete re-set</td>
<td>High vigilance</td>
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<tr>
<td>5. No risk information for growers</td>
<td>Risk information available</td>
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### Why is eradication so difficult?
Spatial Redundancy in Pest Invasions

100 grids

Post-treatment:

95% grid-level treatment efficiency

99% probability region still infested

Spatial Redundancy in Pest Invasions

100 grids

Post-treatment:

99% grid-level treatment efficiency

63% probability region still infested
Probability of Eradication (E)

\[ E = 1 - s^n \]

Number of spatial units
Efficiency fraction

Basic principle of eradication:

As pest distribution increases *arithmetically*,
the difficulty of eradication increases
*geometrically.*
Extension of principle:

If pest distribution increases *geometrically*, the difficulty of eradication increases *supergeometrically*.

Closing thoughts:

- Databases—e.g., Agriculture Data Act of 2018
- Eradication—re. cancer staging
- Invasion science—closer to policy
- Micro-demography—small populations
- Policy forum—Science Magazine
Thank you