Making Sense of Absence: A Bayesian Framework.

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August 29, 2017
Importance of determining pest absence

- Gaining and maintaining market access to trade with other countries without additional phytosanitary measures.
- Determining when we are confident that a pest has been eliminated from an area post-control.
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- Gaining and maintaining market access to trade with other countries without additional phytosanitary measures.
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NB: what’s the difference?
Inference from Ignorance.
\[ \alpha = 1 - (1 - p)^N \] (1)
Cannon (2002)

\[ \alpha = 1 - (1 - S \times p)^N \]
What Can Possibly Go Wrong?

Species status

- Present
  - Detected: True presence
  - Undetected: False negative

- Absent
  - Detected: False positive
  - Undetected: True absence
We need two things:

1. A prior estimate of the probability of occurrence, and
2. An estimate of the sensitivity of the surveillance system to detect the pest.

Probability of absence, given no detections

\[ p_a = \frac{\Pr(\text{Prior non-occurrence})}{\Pr(\text{Prior non-occurrence}) + \Pr(\text{Failed detection}) \times \Pr(\text{Prior occurrence})} \]
Case study: Mediterranean fruit fly

Source: Katja Schulz - Washington, D.C., USA
**Medfly**

- *Ceratitis capitata*

- Major quarantine pest world-wide

- Highly polyphagous *known to feed on over 300 horticultural species*

- Countries with established populations face significant trade barriers

- $4.8B of Australia’s $6.9B horticultural industry is FF-sensitive.

Source: Gail Hampshire - Cradley, Malvern, UK
Medfly trap sensitivity

Source
- Cunningham & Couey, 1986
- Lance & Gates, 1994
- Manoukis et al., 2015

Location
- Orchard
- Residential
### Medfly trap sensitivity

<table>
<thead>
<tr>
<th>Study</th>
<th>Estimate [95% CI]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cunningham and Couey, 1986</td>
<td>0.035 [0.024, 0.045]</td>
</tr>
<tr>
<td>Lance and Gates, 1994</td>
<td>0.028 [0.017, 0.039]</td>
</tr>
<tr>
<td>Manoukis et al., 2015</td>
<td>0.019 [0.014, 0.025]</td>
</tr>
</tbody>
</table>

**RE Model**  \( I^2 = 70.6\% \)

<table>
<thead>
<tr>
<th>Estimate of trap attractiveness</th>
<th>0.010</th>
<th>0.020</th>
<th>0.030</th>
<th>0.040</th>
<th>0.050</th>
</tr>
</thead>
<tbody>
<tr>
<td>RE Model</td>
<td>0.026 [0.017, 0.036]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Prior belief a pest is present in a cell will likely depend on three things:

- An arrival rate (*How likely is it to arrive?*)
- Climatic suitability (*Is the local climate suitable?*)
- Availability of hosts (*Is there available food?*)
And he quoth ...
And he quoth ...

- Let the prior for arrival be 0.3.
- Let the prior for each cell be 0.01.
And he quoth ...

- Let the prior for arrival be 0.3.
- Let the prior for each cell be 0.01.

And the 200 m. trap sensitivity be 0.0005, and let’s use a candidate allocation of traps to cells.
detection_rate <- 0.0005  # Effectiveness / sensitivity
area_prior <- 0.3        # Arrival rate (80 years)
n_cells <- 120           # Number of cells within state
n_flies <- 1             # Trigger
super_pop <- 20          # Design prevalence

prob_absence(detection_rate, area_prior, n_cells, n_flies, super_pop, n_effort = rep(0, 120), aggregate = TRUE)
## [1] 0.7

prob_absence(detection_rate, area_prior, n_cells, n_flies, super_pop, n_effort = cell.grid, aggregate = TRUE)
## [1] 0.7160708
```r
prob_absence(detection_rate, area_prior, n_cells,
             n_flies, super_pop, n_effort = rep(0, 120),
             aggregate = TRUE)

## [1] 0.7

prob_absence(detection_rate, area_prior, n_cells,
             n_flies, super_pop, n_effort = rep(25, 120),
             aggregate = TRUE)

## [1] 0.7574084
```
```
super_pop <- 50

prob_absence(detection_rate, area_prior, n_cells, 
             n_flies, super_pop, n_effort = rep(0, 120),
             aggregate = TRUE)

## [1] 0.7

prob_absence(detection_rate, area_prior, n_cells, 
             n_flies, super_pop, n_effort = rep(25, 120),
             aggregate = TRUE)

## [1] 0.8261191
```
Caveats — beware the black swan.
Questions?

The Imperative
Inference from Ignorance
Case Study: MedFly
Caveats
Questions?

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INVASIVE SPECIES
Risk Assessment and Management
EDITED BY ANDREW ROBINSON, TERRY WALSHE, MARK BURGMAN AND MIKE NUNN