Vector Infestation Control

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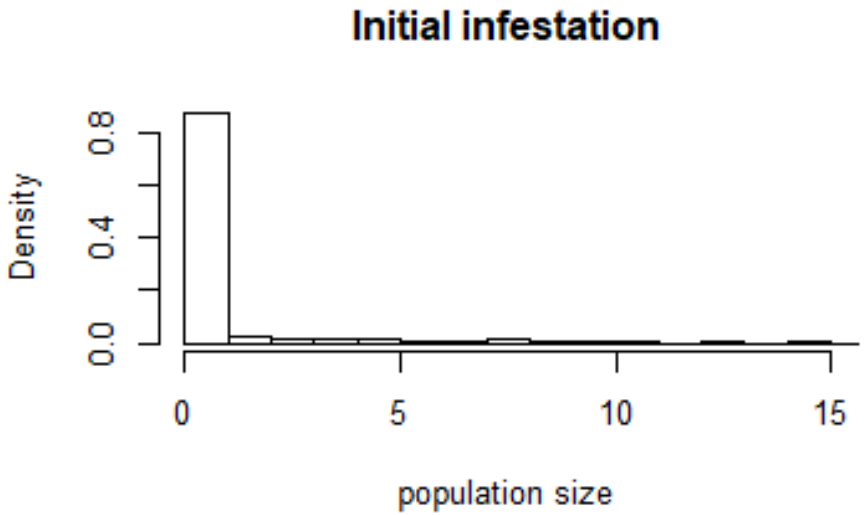
Introduction

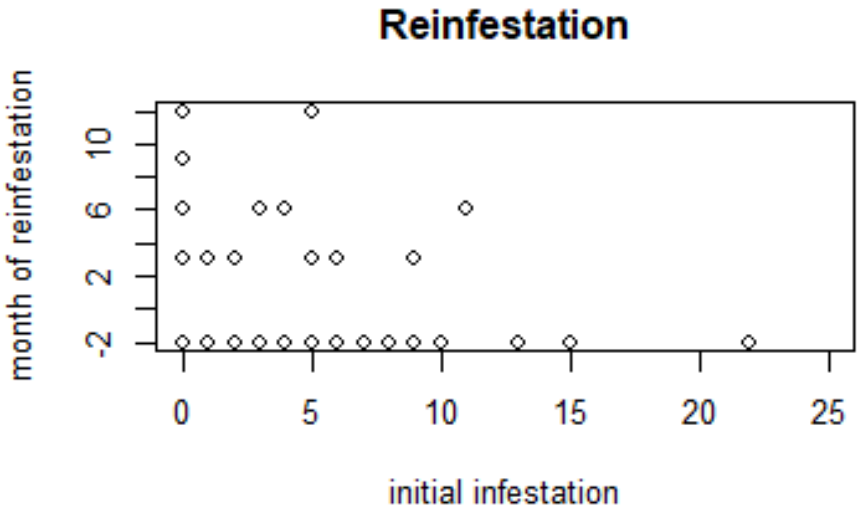
- Triatomines (nasty bugs) carry infectious diseases
- Re-infest sprayed homes

Aims

- Understand the dynamics of this re-infestation
- Understand methods which can be used to control the population

Data Analysis

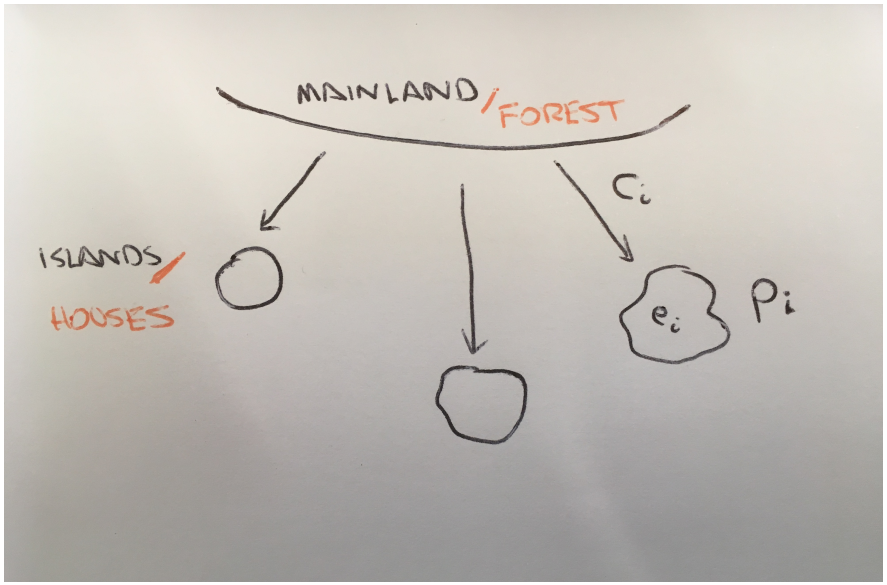




Population Models

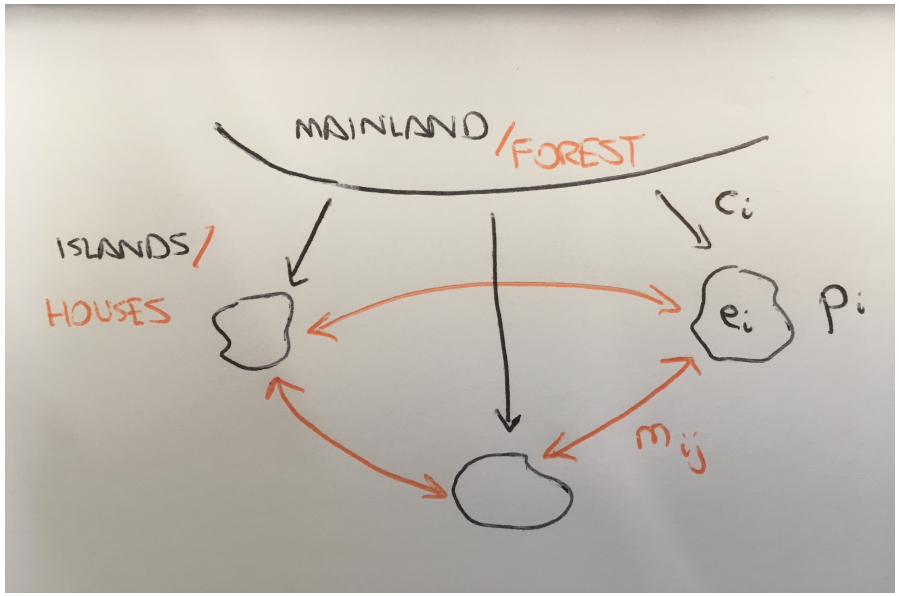
Island Biogeography Model

$$\frac{dP}{dt} = c(1 - P) - eP$$

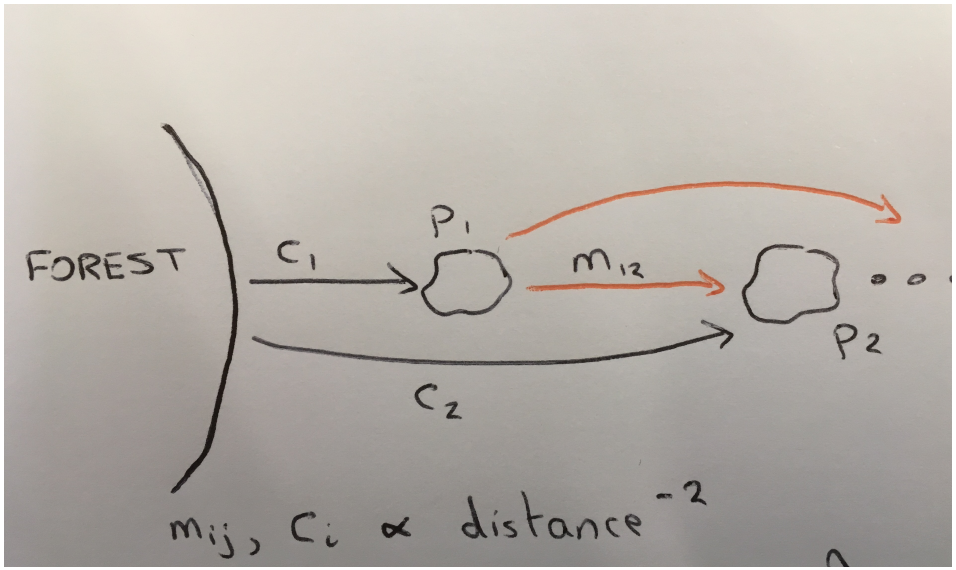


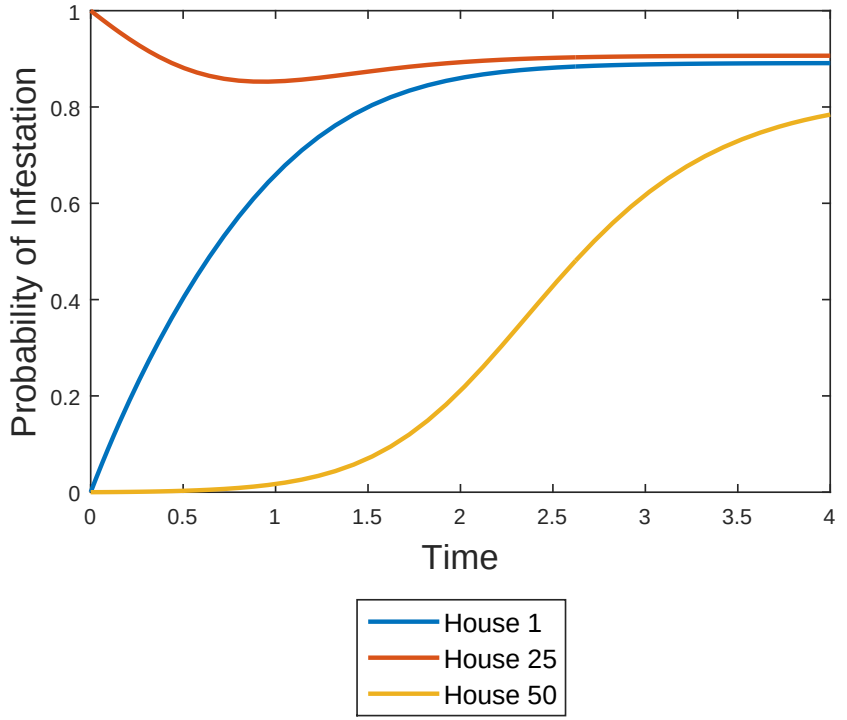
Island Migration

$$\frac{dP_i}{dt} = c_i(1 - P_i) - eP_i + \sum_j m_{ji}(1 - P_i)P_j$$



Example


FOREST
c_1
P_1
m_{12}
P_2
c_2
$m_{ij}, c_i \propto \text{distance}^{-2}$

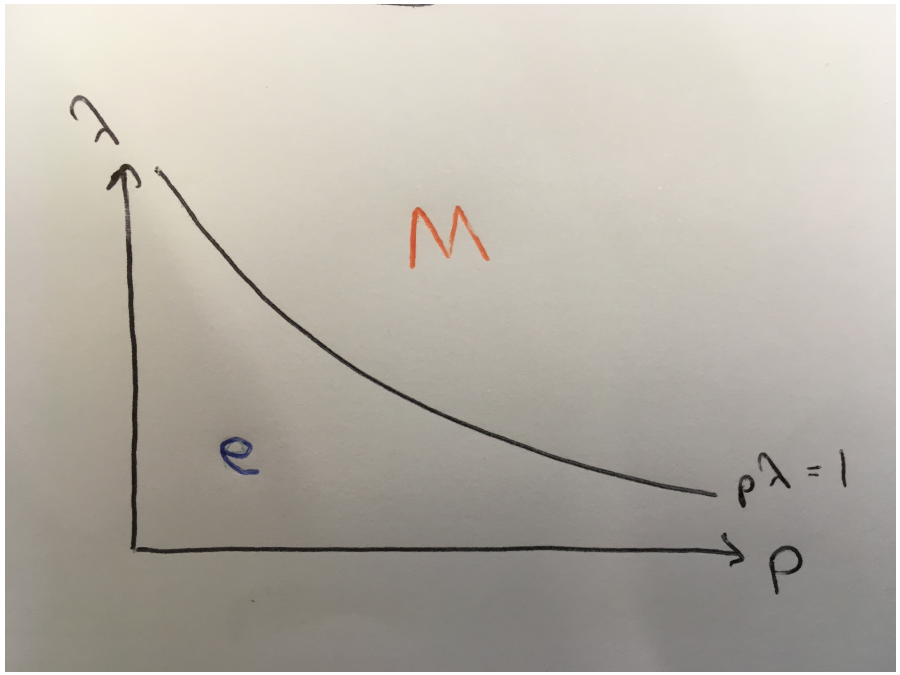

Probability of Infestation
Time
0
0.2
0.4
0.6
0.8
1
0
0.5
1
1.5
2
2.5
3
3.5
4
House 1
House 25
House 50

Control

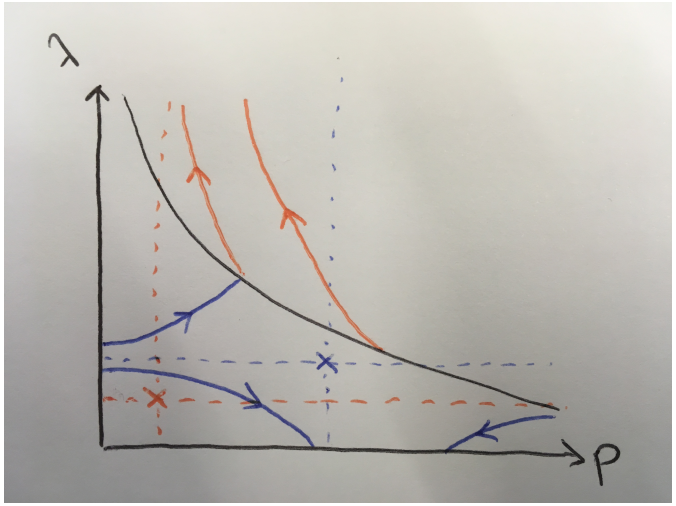
- One island - incorporate control into extinction term
- Hamiltonian:

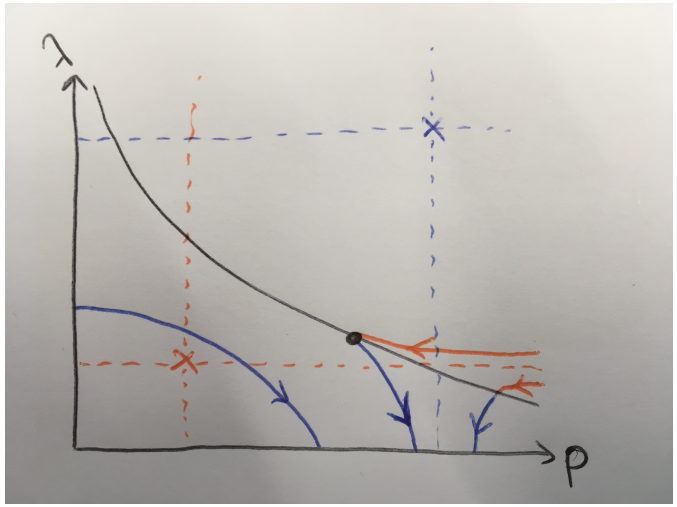
$$\mathcal{H}(p, \lambda) = u + \gamma p + \lambda \left[d(1 - p) - up \right]$$

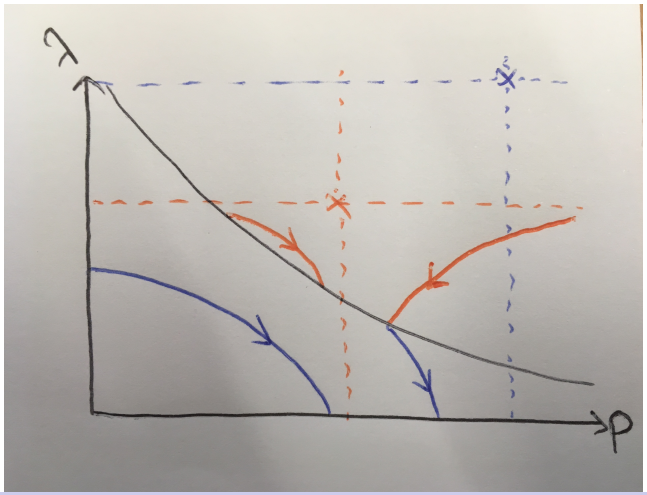
- Contour plot for $\mathcal{H}$



Control



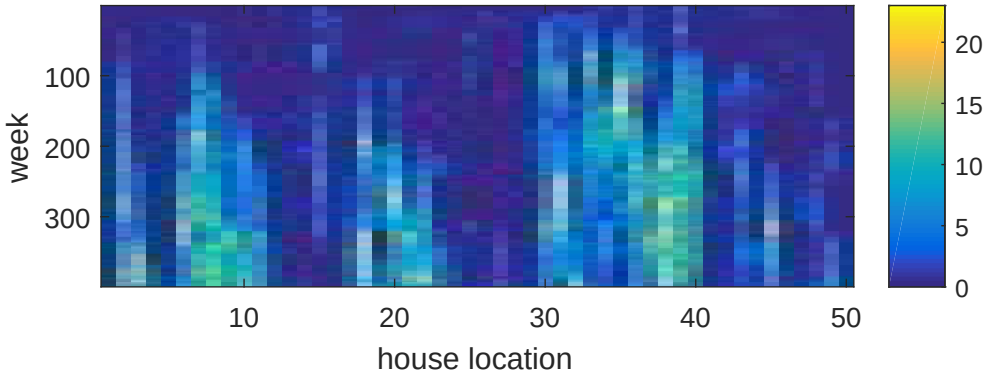


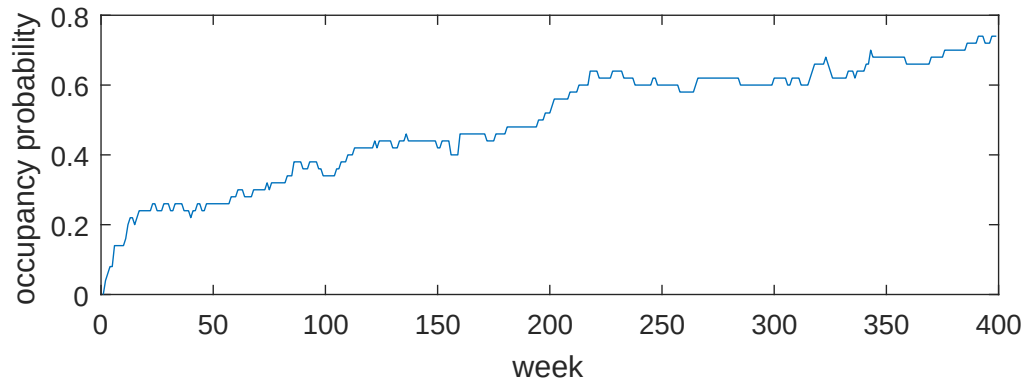


- Contours are hyperbolae - placement of centres is key
- Follow contours to find optimal control
- No cycles $\Longrightarrow$ no periodic spraying

Population Model

$$\begin{aligned}\frac{\mathrm{d}N_i}{\mathrm{d}t} &= \left(\alpha_1 - \alpha_2 N_i\right) N_i \\ &\quad - \left(\mu_1 + \mu_2 N_i\right) N_i \\ &\quad - g\left(N_i\right) N_i \\ &\quad + \frac{\eta}{\bar{N}} f\left(N_i\right) \\ &\quad + \sum_{k=i\pm 1} \frac{N_k}{2} g\left(N_k\right) f\left(N_i\right)\end{aligned}$$





Conclusions and Further Work

Islands:

- Island Migration is simplistic
- Don't get control behaviour that is expected
- Review biological model

Population Density:

- Working with N_i instead of P_i is more compatible with data
- Should be investigated further
- Need more data to infer parameters

Thanks For Listening!