IBM **Research**
Australia

Weather Driven Psyllid Movement Within and Between Citrus Orchards

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Background

- Huanglongbing (HLB) is a disease that affects citrus plants, commonly called “citrus greening”
- HLB is caused by the bacterium *Candidatus Liberibacter asiaticus*
- The bacteria is transmitted between trees and orchards via two psyllid species, with one depicted in Figure 1
- HLB ultimately kills the tree, but takes years and includes significant asymptomatic infection periods
- The symptomatic period of HLB infection includes lopsided fruits with colour inversion and less juice
- **HLB is estimated to have cost the Florida citrus industry $9.1B**

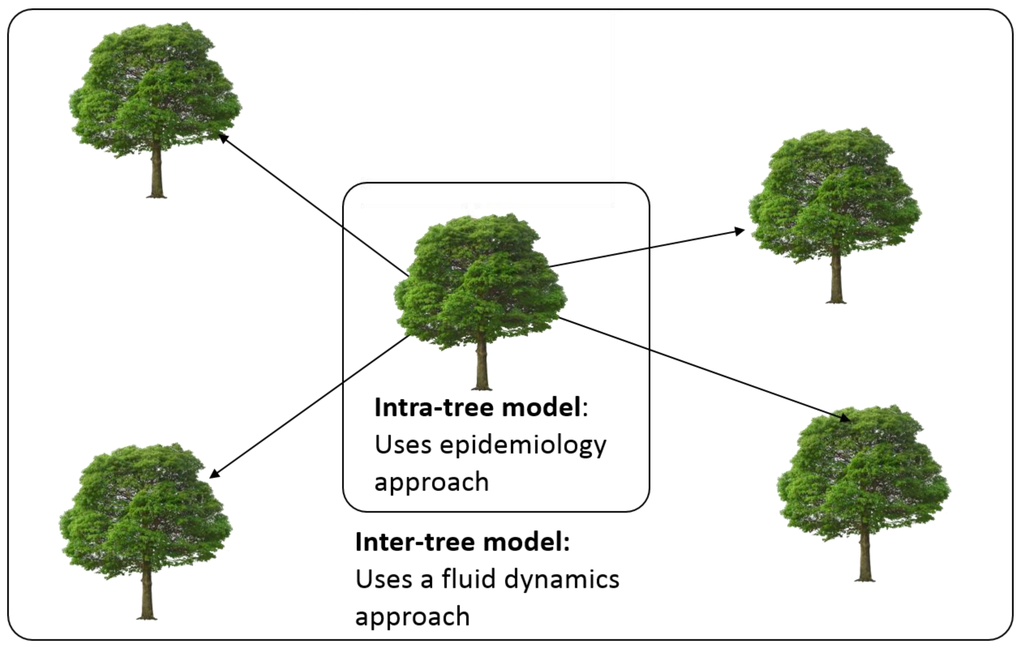
Study

Our goal is to understand how wind and temperature affects HLB Spread. To this end, we

- combined high resolution historical simulations of weather with psyllid trap data [1]
- developed a mathematical model of the psyllid lifecycle and dispersal
- conducted a sensitivity analysis of the model to identify key parameters to enable optimisation of control strategies

Model

The mathematical model is divided into the sub-problems of intra- and inter- tree dynamics.
The system of equations is solved on a structured grid using a second-order finite difference method for the diffusive term, and a first-order upwind finite difference method for the advection term.



Weather effects

Aspects of psyllid growth and movement are effected by weather

- death rate of eggs
- death rate of adults
- rate of oviposition
- rate of dislodgement
- movement speed and direction

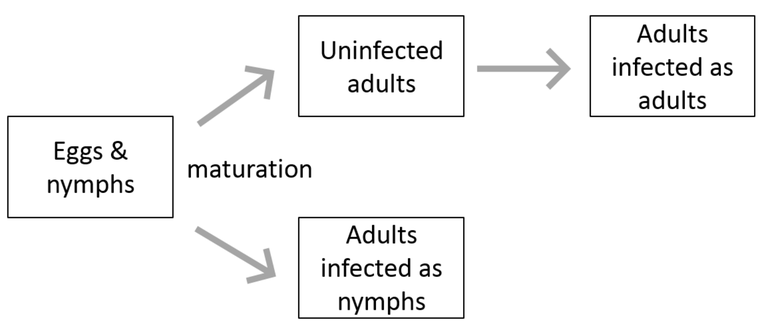
Weather variables:

- temperature
- wind speed
- wind direction

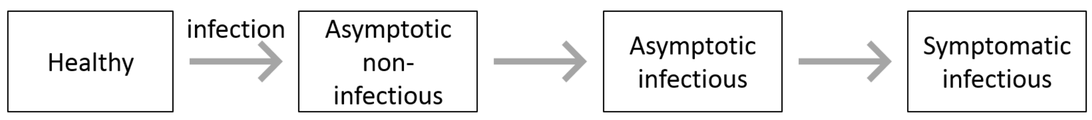
Fig. 1: Psyllids

Intra-tree Model

Psyllid lifecycle and HLB infection progression

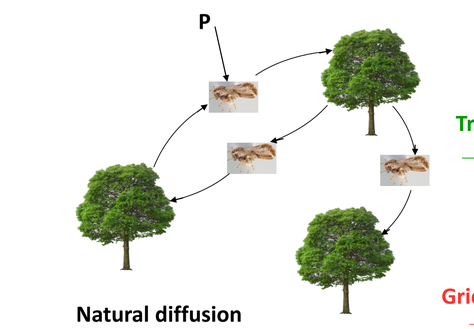


Flush (new tree growth) HLB progression



Inter-tree Model

- **P: number of adult flying psyllids**



$$\frac{d\mathbf{P}}{dt} = D_{iff}\nabla^2\mathbf{P} - a\vec{\mathbf{v}}\cdot\nabla\mathbf{P} - \delta_a\mathbf{P}.$$

Wind effects

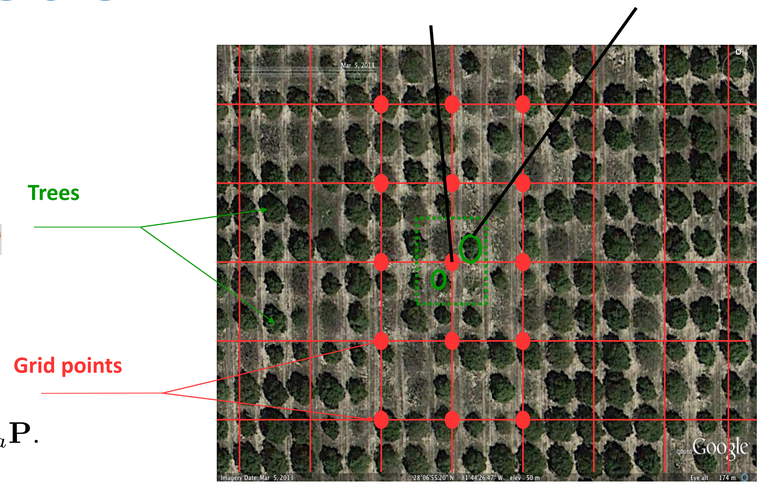


Fig. 2: Inter-tree model

Sensitivity analysis

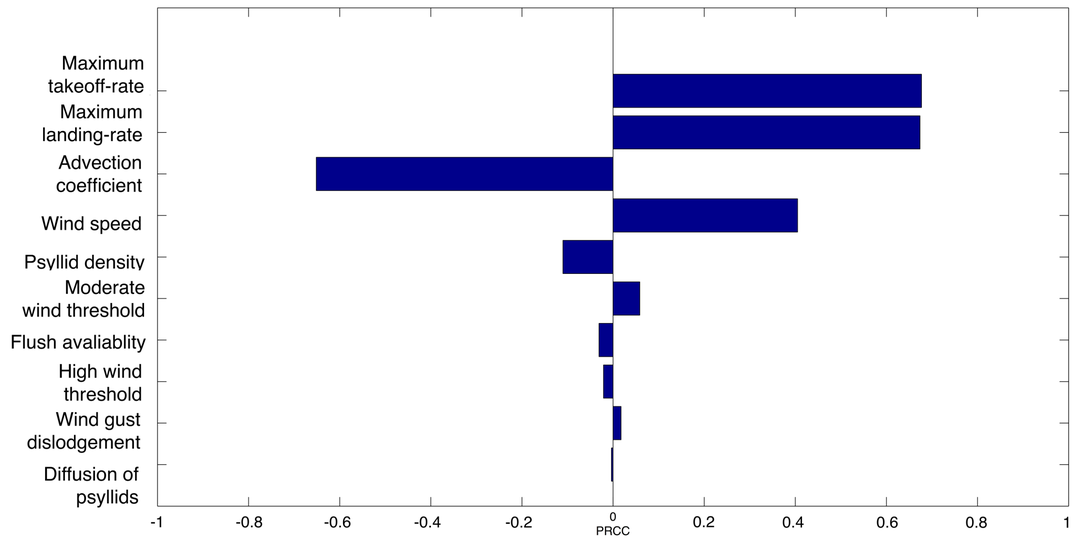


Fig. 4: Sensitivity analysis of model parameters on the spread of marked psyllids from a point of release, using a combination of Latin hypercube sampling and partial rank correlation coefficient (PRCC) multivariate analysis.

Conclusion

- Our mathematical model enables the examination of weather effects on psyllid and hence HLB spread.
- The sensitivity analysis suggests that wind speed is a key contributor to HLB spread.

References:
[1] Rosenblum 2015, Seasonal Movement Patterns and Long-Range Dispersal of Asian Citrus Psyllid in Florida Citrus, J. Econ. Entomol. 108(1): 3–10
[2] Chiyaka et al. 2012, Modeling huanglongbing transmission within a citrus tree. PNAS, 109(30):12213–12218

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