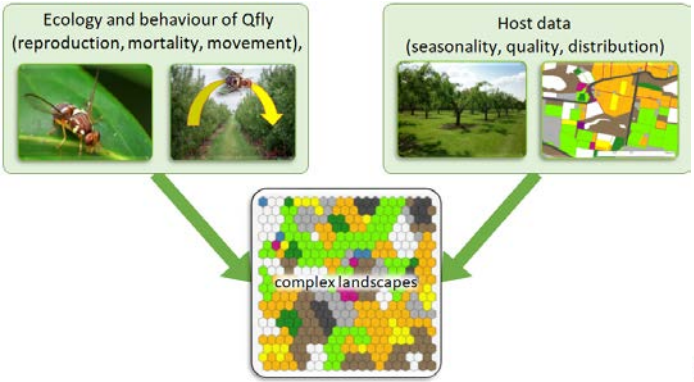
Area-wide management of Qfly: insights from spatial modelling

Hazel Parry, CSIRO

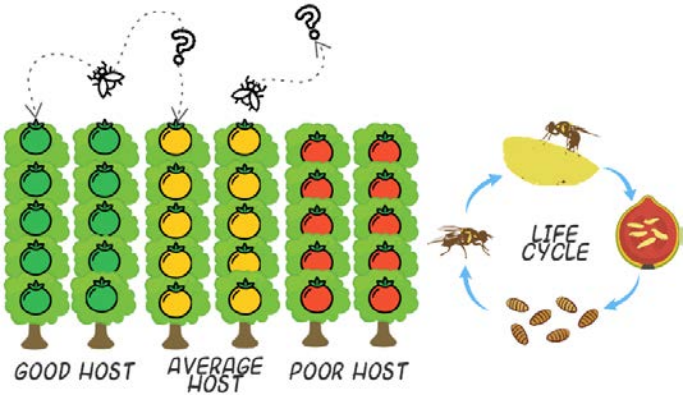
https://area-wide-management.com.au/

A tale of three models….

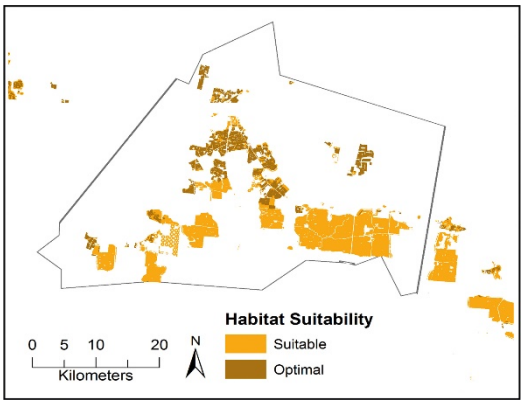
Spatially-explicit population dynamic model



Mechanistic foraging model



Habitat suitability model

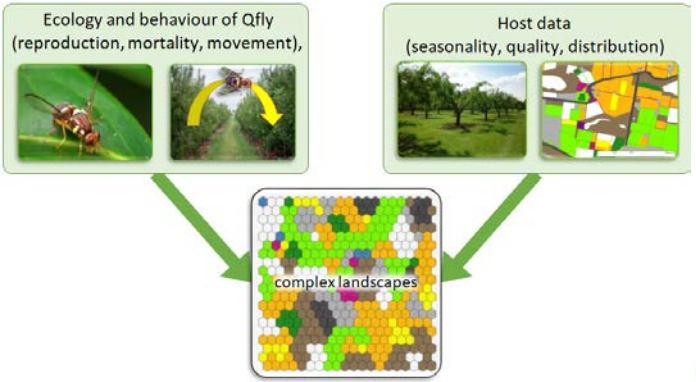


Model properties

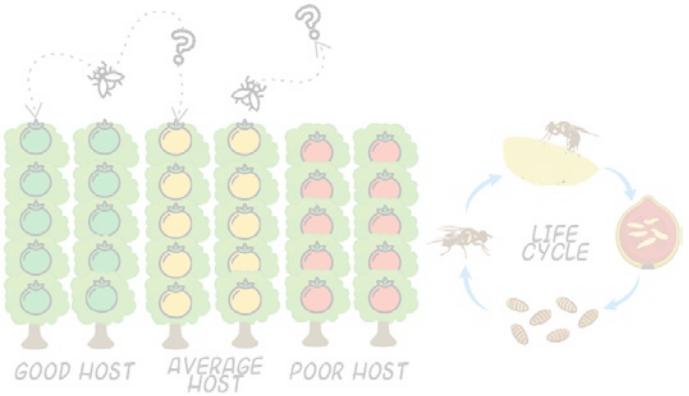
1) *Landscape and scale*
2) *Population dynamics*
3) *Dispersal*

Model insights

Spatially-explicit population dynamic model



Mechanistic foraging model



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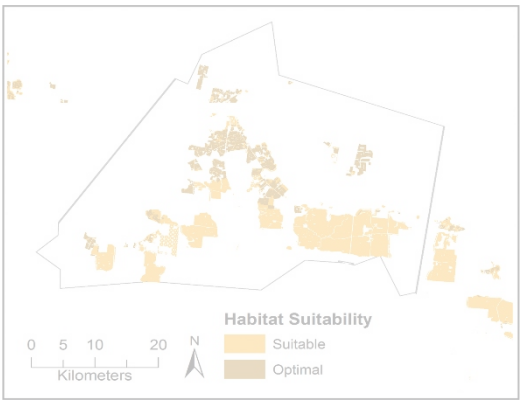

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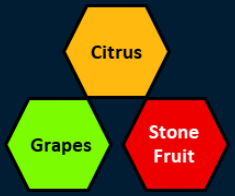
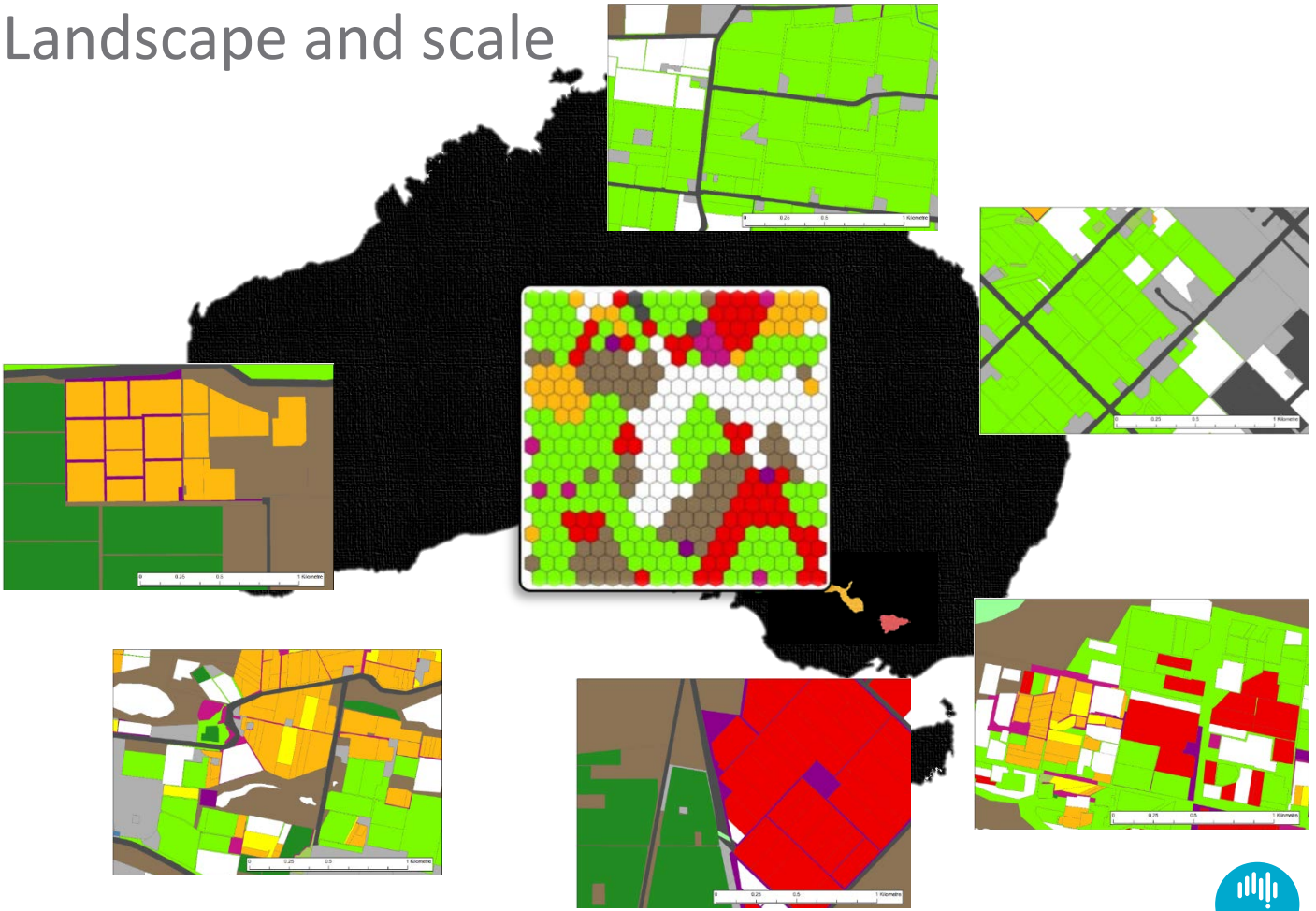
Spatially-explicit population dynamic model properties



1) *Landscape and scale*

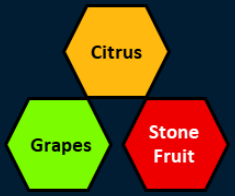
- *Single commodity per 1 ha cell*
- *Commodities vary by host quality and seasonality*

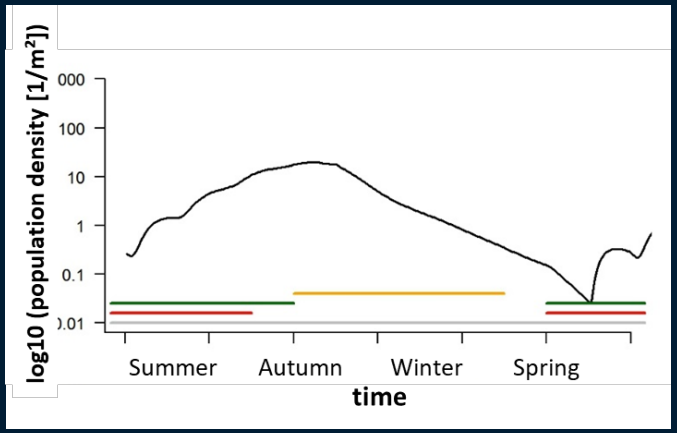
Landscape and scale



Schwarzmueller F. et al. (2017) Spatially-explicit modelling of ecological processes in complex agricultural landscapes: connecting 'artificial' landscapes with 'reality' ModSim 2017 https://doi.org/10.36334/modsim.2017.G8.schwarzmueller

Spatially-explicit population dynamic model properties





1) *Landscape and scale*

- *Single commodity per 1 ha cell*
- *Commodities vary by host quality and seasonality*

2) *Population dynamics*

- *Stage-structured approach with two stages: adults and juveniles*
- *Host quality affects reproduction, development and survival*

3) *Dispersal*

Mechanistic cellular automata:

1. Directed movement
2. Undirected movement
3. Constant emigration
4. Triggered emigration

Schwarzmueller, Schellhorn, Parry (2019) *Resource landscapes and movement strategy shape Queensland Fruit Fly population dynamics.* Landscape Ecology 34

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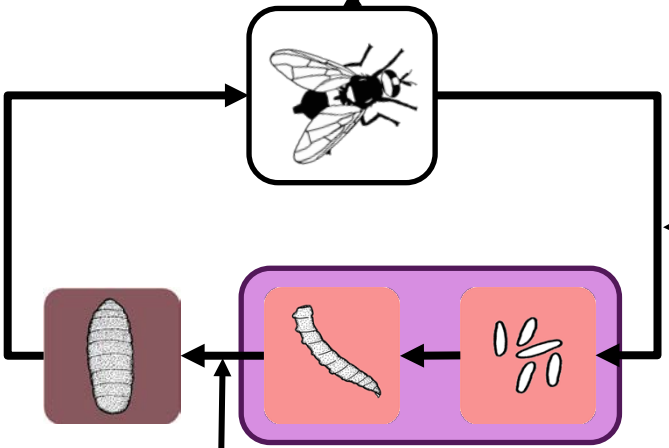
Management

protein based lure & kill



Male Annihilation Technique

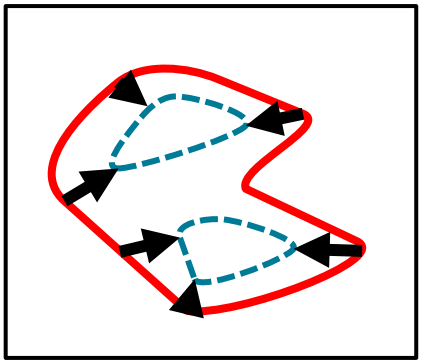
Orchard Sanitation

BMP

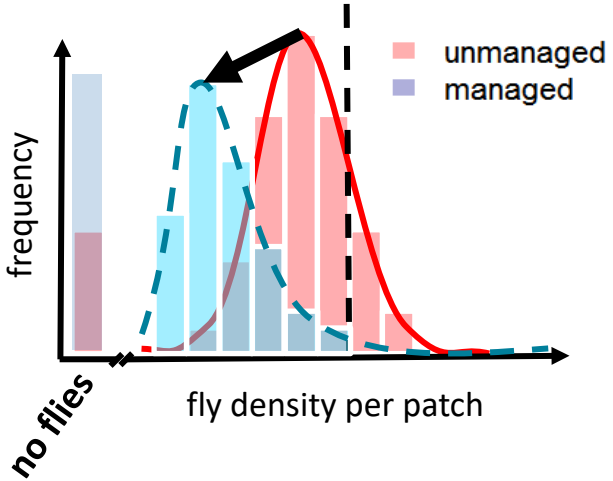
How to assess ‘management effectiveness’?

Area reduced

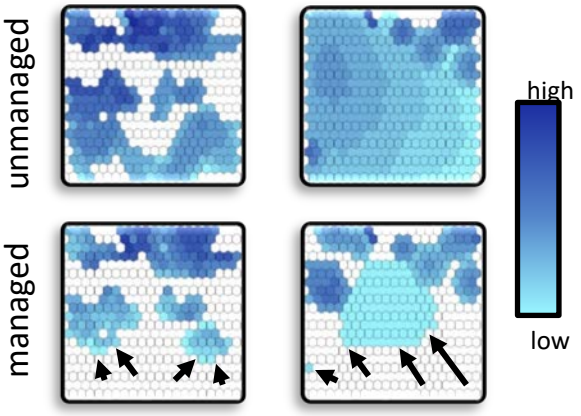
affected area

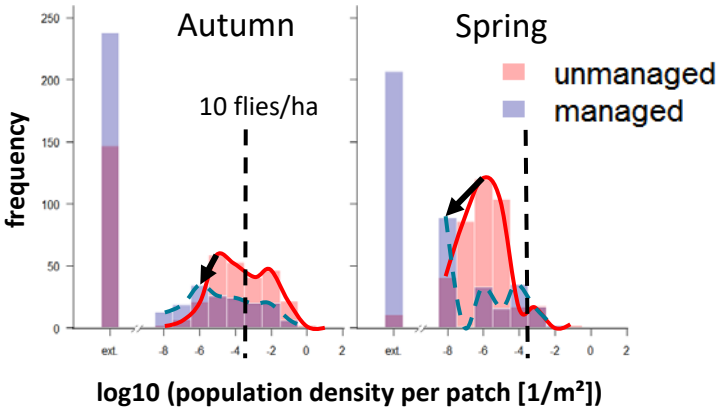


Population reduced



Management effectiveness - BMP60

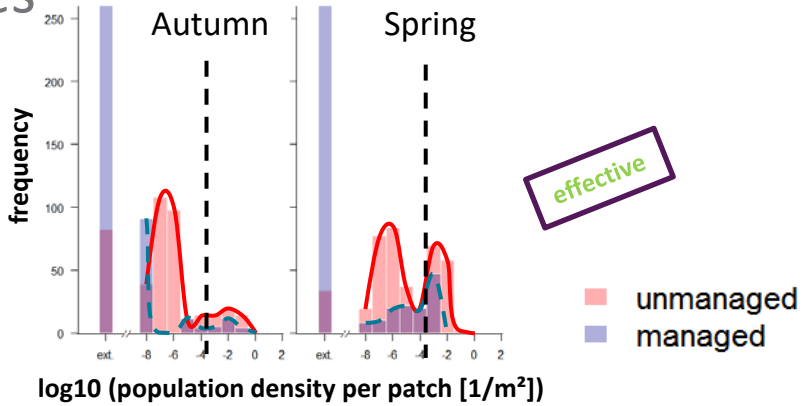


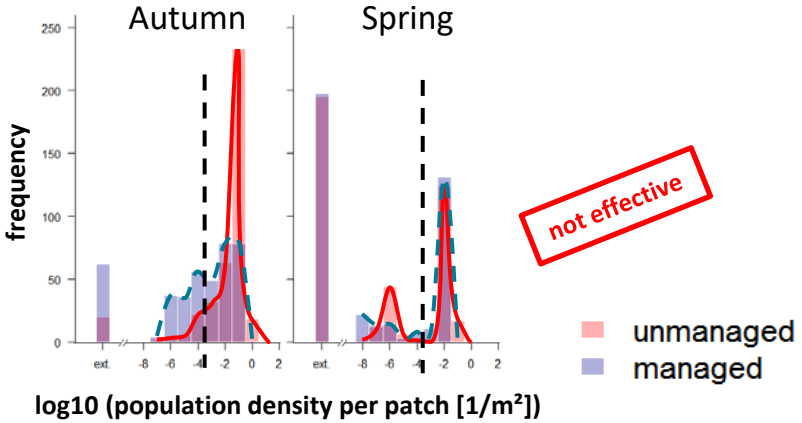


Heterogeneity in landscapes → heterogeneity in management outcomes

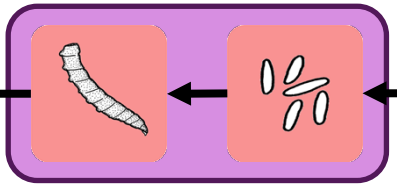
Rural citrus and grapes

Grapes in an urban setting



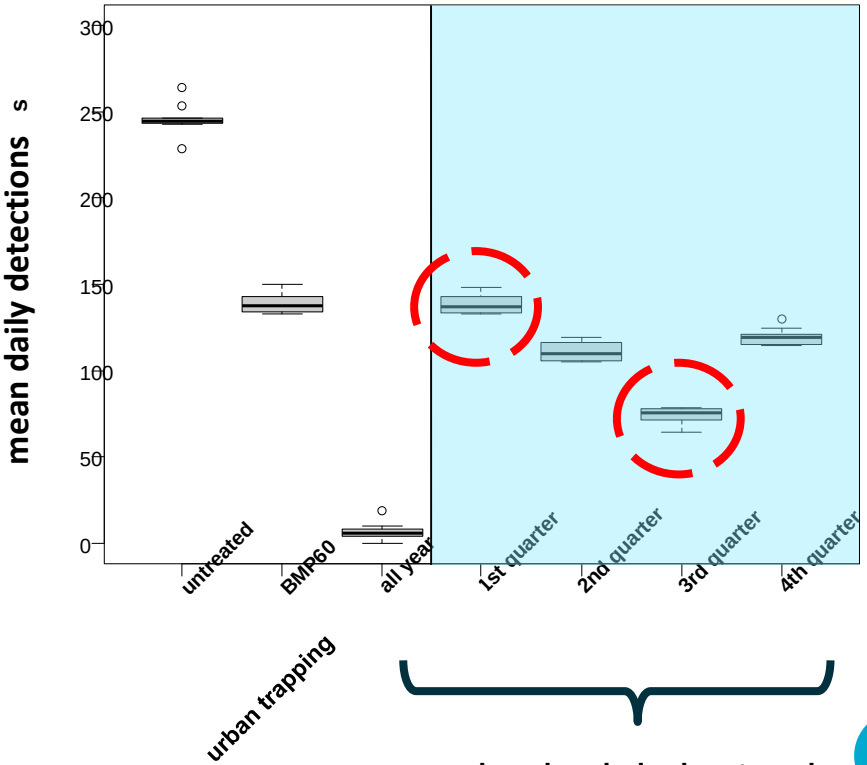


Management



SITplus

Management - urban trapping -

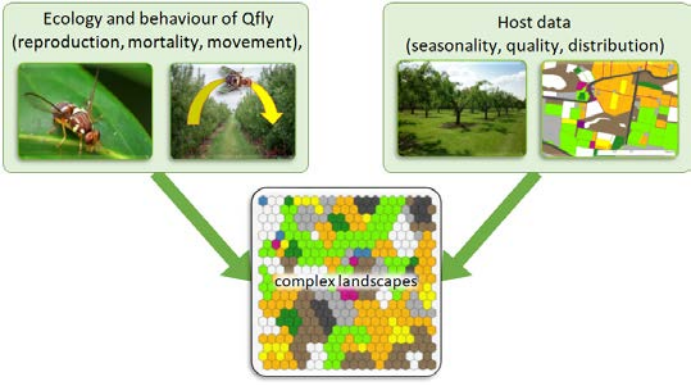


Recommendations / Guidelines

Good chance of getting on top of the problem with a large enough number of growers adopting BMP (60% +)

You have a good chance of success only if you get urban residents involved, especially in spring (3rd quarter)

Spatially-explicit population dynamic model insights

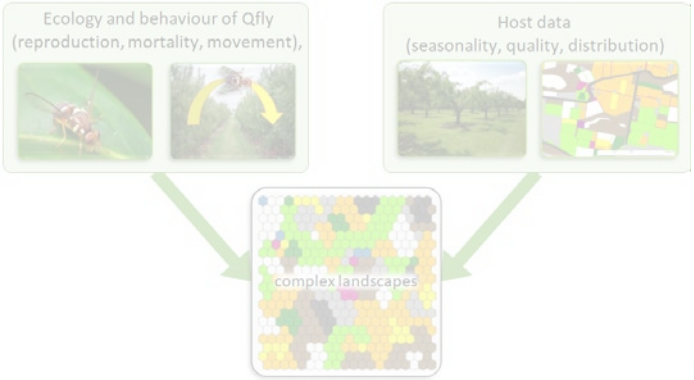


The design, implementation and evaluation of area-wide management programs needs to take into account:

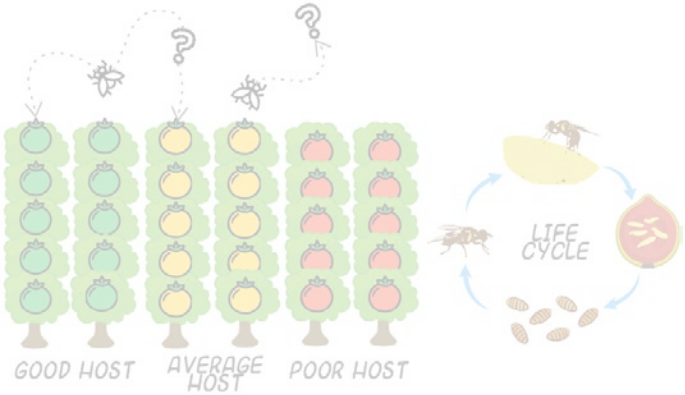
- Existing management practices and context
- the level of engagement in the programme
- landscape complexity

Schwarzmueller, Reynolds, Schellhorn, Parry (in prep) *Ecological modelling to design area-wide management of a mobile insect pest: how, where and when to manage.* Journal of Applied Ecology

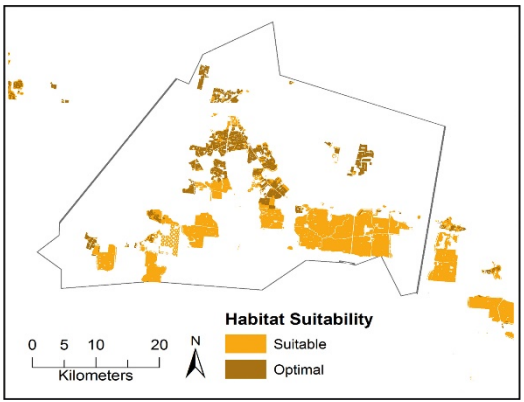
Spatially-explicit population dynamic model



Mechanistic foraging model



Habitat suitability model



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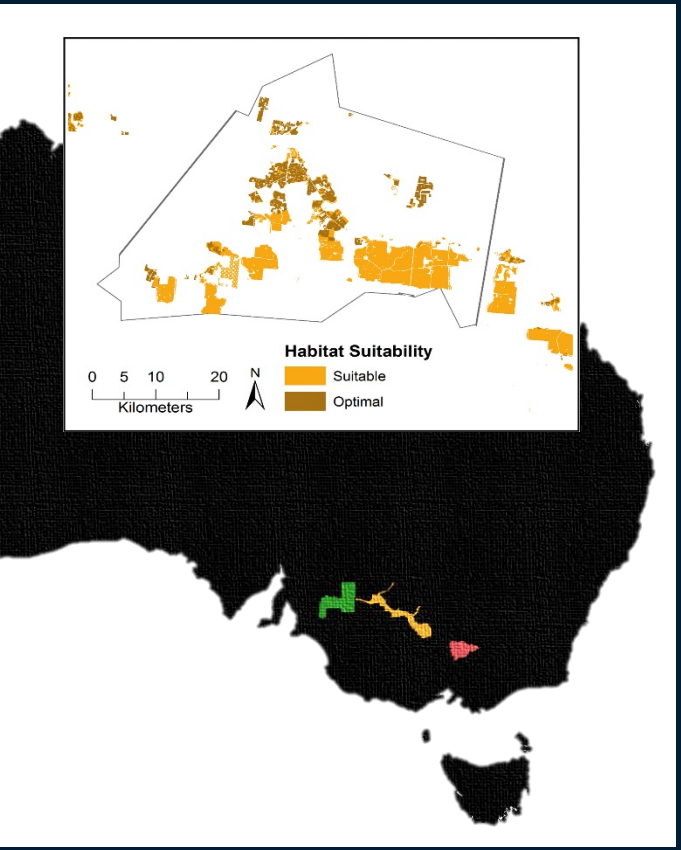
Habitat suitability model properties



1) Landscape and scale

Riverland, Sunraysia and Goulburn Valley, all located within the former Fruit Fly Exclusion Zone (FFEZ)

Crop survey and land use data (ground-truthed)

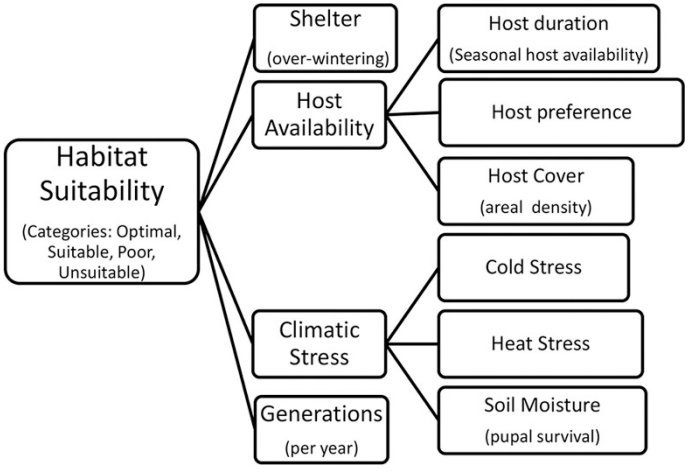
2) Population dynamics

Climate determines number of generations per year, cold and heat stress

3) Dispersal

Expert opinion: relatively limited local dispersal (~200 m) by B. tryoni - implemented as a moving window to reflect influence of nearby habitat on suitability

Habitat suitability model insights



- Multiple factors determine habitat suitability (not just climate)
- Suitable habitat is largely constrained to commercial, peri-urban and urban areas in SE Australia.
- Some within-region variation where cold-stress and land use plays a part.

Van Klinken, Murray et al. (2019) *Scale-appropriate spatial modelling to support area-wide management of a polyphagous fruit fly (Diptera: Tephritidae)* Annals of Applied Biology 175 (3)

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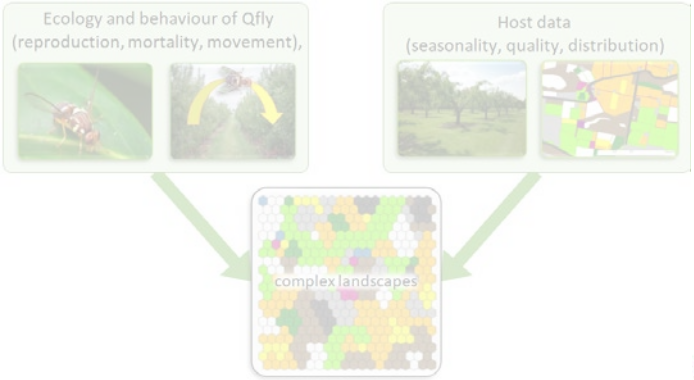
Spatially-explicit population dynamic model



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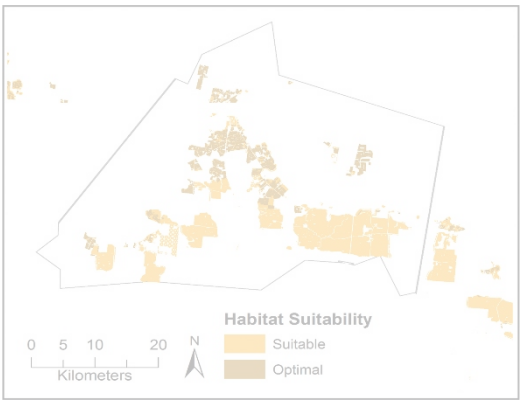

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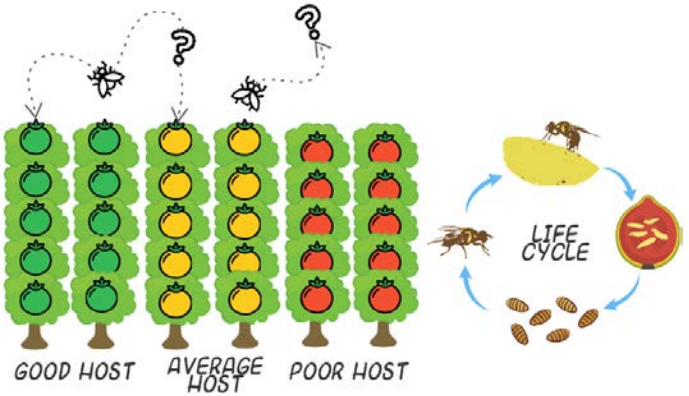

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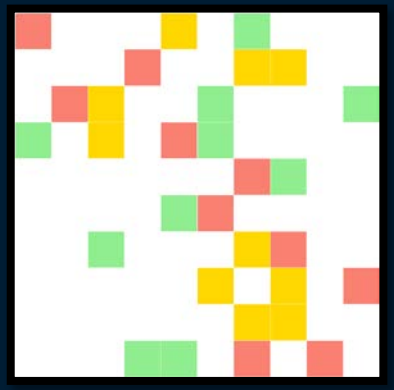
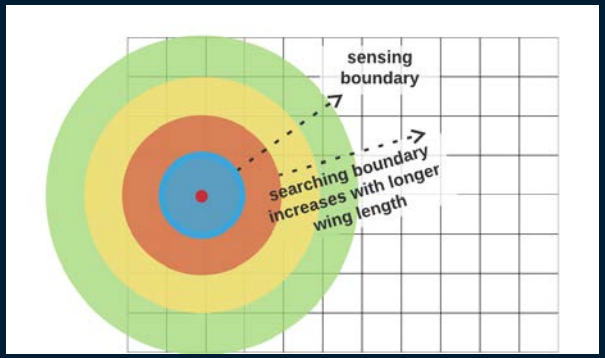
Mechanistic foraging model properties



Four tree types:

- Good
- Average
- Poor
- Non host



1) Landscape and scale

- *A tree is a 5x5m cell*
- *Proportion and aggregation of four types of fruit trees*

2) Population dynamics

- *Cohort-based model for juvenile stages*
- *Agent-based model for adult stages*
- *Incorporates effect of host tree type*

3) Dispersal

Mechanistic:

a) Optimal foraging

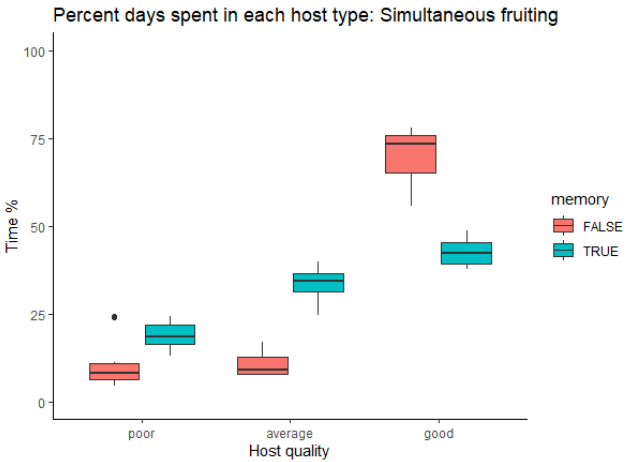
b) Experience and memory

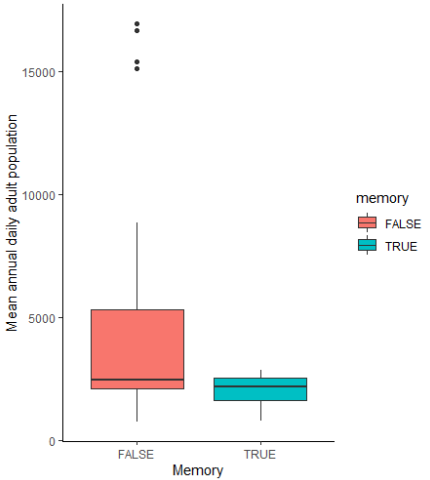
Wing length (emergent from host type)

Directed movement

Triggered emigration

Mechanistic foraging model insights:
Memory results in relatively low populations affiliated with poorer hosts





+ Influence of:
- landscape structure
- host quality
- timing of host availability

+ explore management scenarios: e.g. trap crop, removal of feral trees, crop hygiene

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Summary

- Context is important when considering Area-wide Management (AWM)
- Models can help identify where/when AWM is likely to be successful
- Models can improve our understanding of Qfly behaviour, population dynamics and distribution
- Models can consider the effectiveness of novel management approaches (SIT, trap crops etc)
- Models can be integrated with real-time observation data to provide calibrated, context-specific, management recommendations relevant to growers/decision-makers

Thank you

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I acknowledge the researchers, project team, growers, and community stakeholders who have all contributed to the work presented here.