A PRAGMATIC FRAMEWORK FOR MAPPING ESTABLISHMENT POTENTIAL OF PLANT PESTS

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Who am I?

Research Fellow within the Centre of Excellence for Biosecurity Risk Analysis (CEBRA)

- Plant pest risk mapping for early detection;
- Estimating country exposure to new threats;
- Using surveillance data to estimate likelihoods of pest/disease absence

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Developing pragmatic maps of establishment likelihood for plant pests

Technical Report for CEBRA project 170607

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November 3, 2020

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Using `edmaps` & `Zonation` to inform multi-pest early-detection surveillance designs

Technical Report for CEBRA project 20121001

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August 2, 2021

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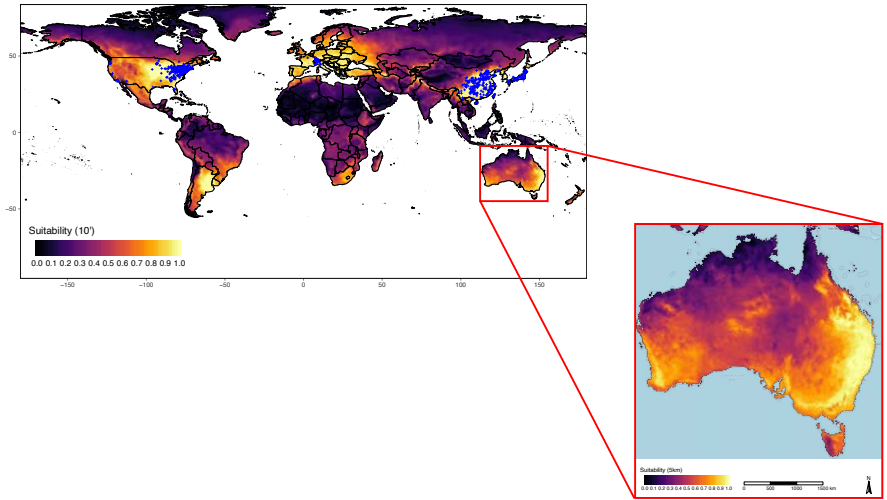
The purpose:

*"To develop a **general** and **pragmatic** framework for creating maps of pest establishment potential for the purposes of informing where to prioritise finite **early detection** surveillance resources for exotic **plant pests & diseases**"*

Common approaches

Climate suitability models



Common approaches

Pathway analysis/interception models

Pathway/interception models

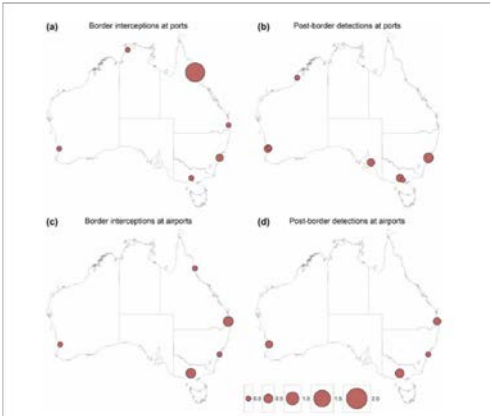
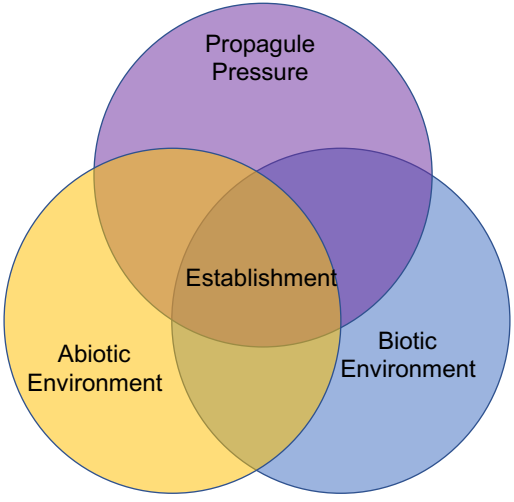


Figure 5. Number of border interceptions (a, c) and post-border detections (b, d) of *Duttaphrynus melanostictus* at maritime shipping ports and airports from 1986–2013 (log10 scale). Also shown in (b) are two individuals detected in the wild (Lang Lang and Middle Swan, VIC).

From Tingley et al. 2018 (Ecography)

Barriers to pest establishment

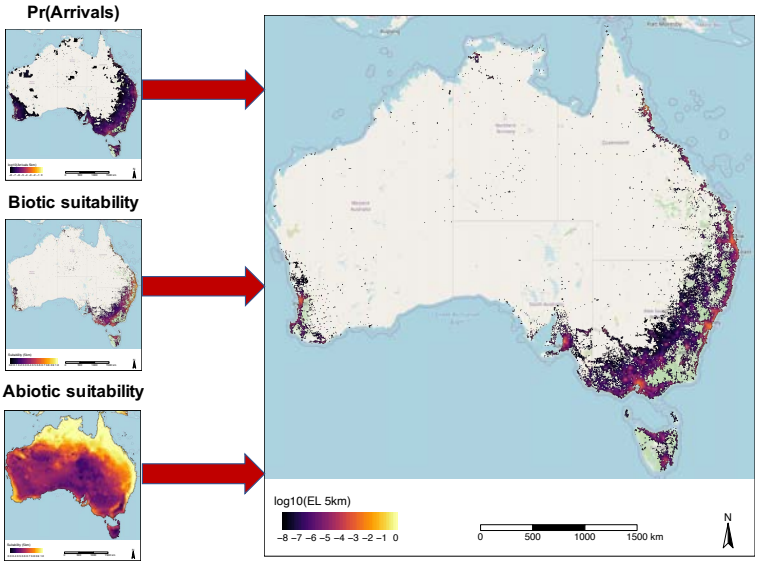


Adapted from Catford *et al.* 2009

A need for pragmatism

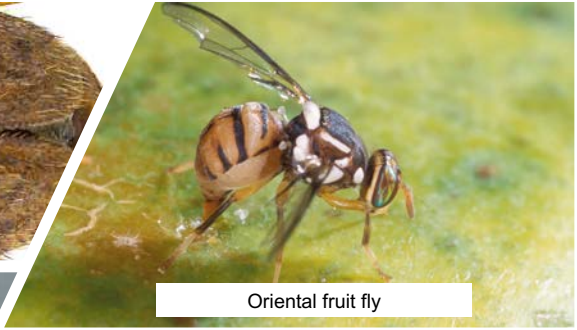
- We have imperfect and incomplete data
- Must make the most of the data we do have!
- Need to rely on assumptions and *rules of thumb*
  - These should be grounded in common sense
- Get the foundations right and then add complexity as data becomes available

The framework



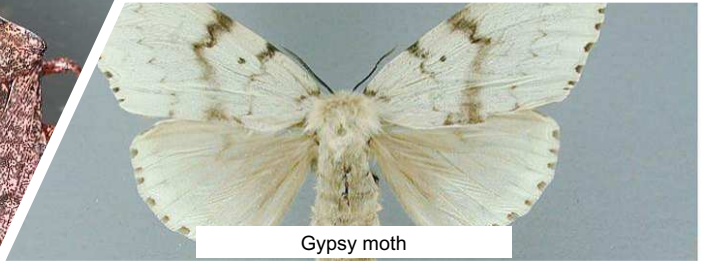
Four case study pests

Khapra beetle



Oriental fruit fly

Brown marmorated stink bug



Gypsy moth

Recently applied to expanded list of priority

- 4 exotic fruit flies
- Gypsy Moth
- Khapra beetle
- Brown marmorated Stink Bug (BMSB)
- 2 Sawyer beetles
- Bee mites
  - Asian honey bee
- Xylella
  - 4 insect vectors & plant cuttings
- Citrus Canker
- HLB disease
  - Asiatic & African citrus psyllids

The framework: Pathways


Imported fertilizer


Imported machinery

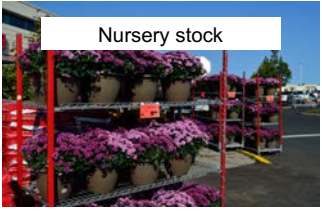
International mail


Shipping containers


International vessels

Air passengers
(Tourists & Returning residents)


Imported food


Nursery stock

The framework: Post-border movements of goods

Pathways units were distributed post-border using a number of *rules of thumb* and the following data:

- Human population density
- Distance from international airport
- Tourist accommodation (ABS)
- Distance from marine port
- Fertiliser usage statistics (ABS)
- Port container discharge numbers (BITRE)
- Container destination data (ABS)

Pathway inputs

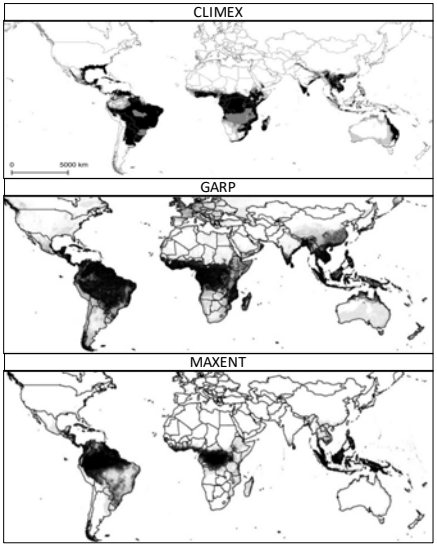
Threat	Pathway	N events (yr^1) (95% CI)	Pr(Viability) (95% CI)
Pest X	Mail	0.1, 10	0.0001, 0.00001
Pest X	Air passengers	1, 20	0.01, 0.1
Pest X	Imported machinery	10,100	0.001, 0.01

Informed by:

- Border interception data
- Expert elicitation
- Risk-Return Resource Allocation model (RRRA)

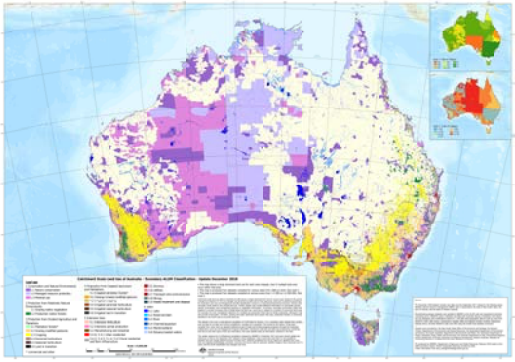
Abiotic suitability

- Many approaches
  - Different assumptions
  - Different data requirements
  - Different outputs
    (*not all are comparable amongst species*)
- Fraught with inappropriate use
- Truth is unknown
- No single best method

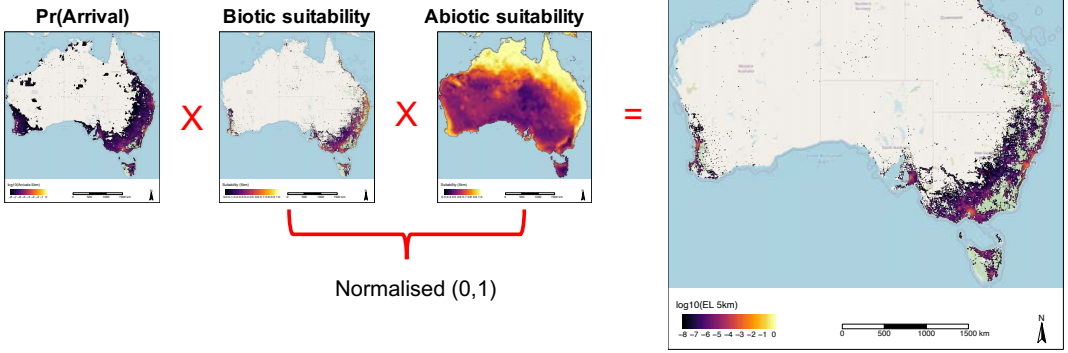


Biotic suitability

- Australian Land Use and Management (ALUM) raster
  - 100 + landuse types
- National Vegetation Information System (NVIS)
  - 98 vegetation types
- NDVI/Fractional vegetation cover
- Native host distributions



Establishment potential



Simplifying the workflow with the edmaps R package

Package 'edmaps'

August 11, 2020

Type Package

Title Estimate Likelihood of Pest Establishment

Version 1.4.0

Maintainer James Camac <james.camac@gmail.com>

Description This package combines spatial environmental data (e.g. distance from airports/marine ports, distribution of pest habitat/hosts) with biosecurity leakage rates (e.g. expert-elicited) to generate maps of the likelihood of pest establishment across the landscape. Final outputs include raster datasets (GTiff) indicating establishment likelihood across the area of interest, as well as interactive (html) and static (pdf) versions of these maps.

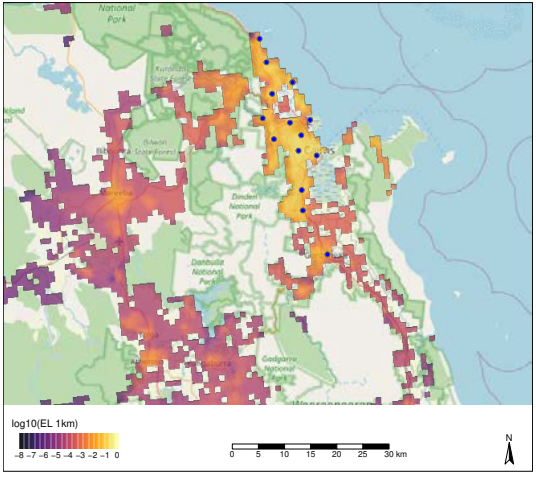
Depends R (>= 4.0)

SystemRequirements Java (>= 1.5), JRI, GNU make

EcoCommons

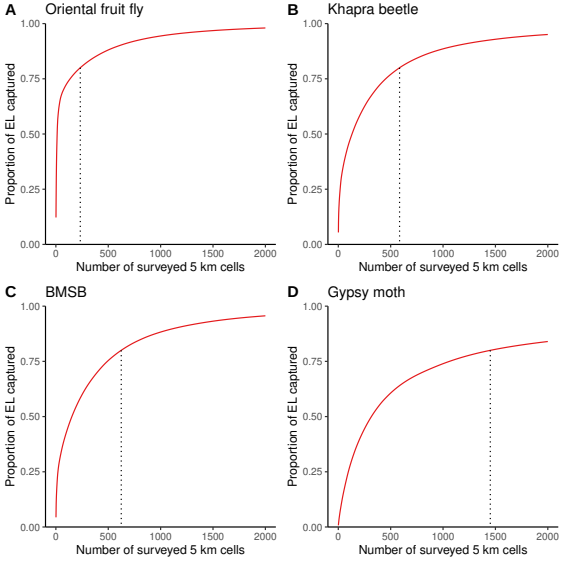
How can these maps can be used?

- Determine where to place early detection surveillance



Methyl Eugenol around Cairns

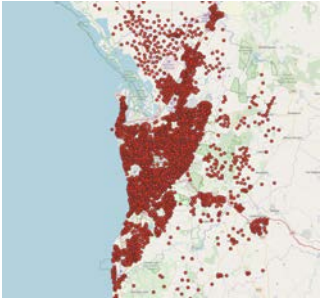
Examine how well existing surveillance captures establishment potential



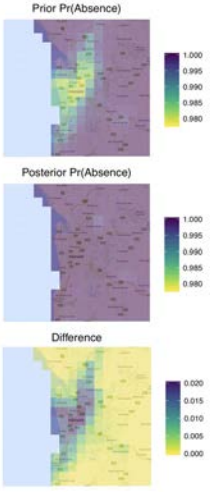
Estimate probabilities of absence

- Use maps as prior belief of presence
- Estimate probabilities of absence using Bayes theorem

Accounts for geographic barriers that are otherwise not included



Capilure traps in and around Adelaide

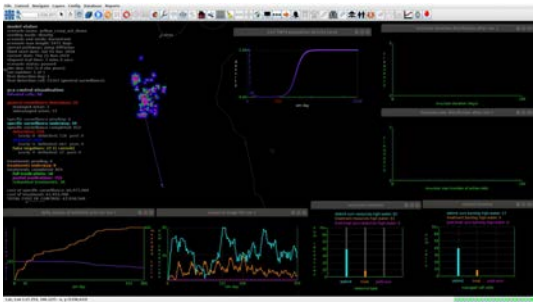


Camac *et al.* 2019

Integrate with spread & demographic models

Initial incursions will occur relative to establishment potential

- More realistic spread model simulations
- Improved response preparation

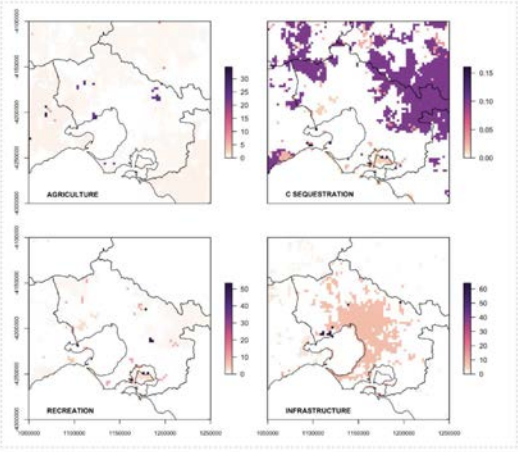


(Bradhurst *et al.* 2021)

Develop true risk maps

Combine with maps of susceptible *agricultural*, *environmental* and *recreational* values

- $Risk = Likelihood \times Consequence$
- Allow allocation of resources according to risk
- Better pest prioritisation



Dodd et al. 2020 (value report)

Develop multi-threat surveillance programs

- Create establishment maps for a suite of threats
- Prioritize surveillance to shared areas of high establishment potential
- Consolidate surveillance resources