Biosecurity COMMONS

Introduction to Biosecurity Commons

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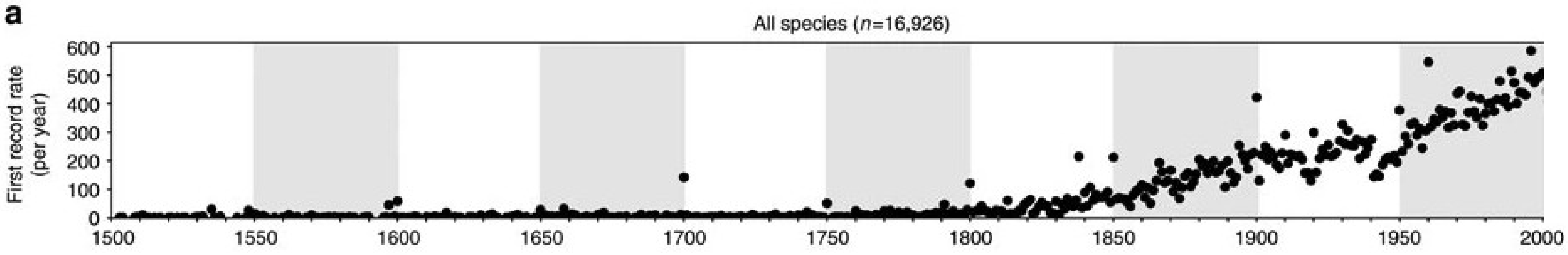
Acknowledgement of country

We acknowledge the traditional custodians of the land on which we work, learn and live, and pay respect to Elders past, present and future. We also extend that respect to all Aboriginal and Torres Strait Islanders.

Biosecurity risk is increasing globally



- Increasing global human movement
- Increasing trade
- Changes in species distributions

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AUS Pest Check®

Data and science informed risk management

- Better data harnessing capabilities
- Better screening/surveillance tech
- Better community awareness

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$$\sum_{i=1}^{n} x_i \leq B.$$

The objective is to minimize the expected total incursion management costs:

$$T(\mathbf{x}) = \sum_{i=1}^{n} p_i \{c_i^D [1 - \exp(-\lambda_i x_i)] + c_i^U \exp(-\lambda_i x_i)\}$$
$$= \sum_{i=1}^{n} p_i c_i^D + \sum_{i=1}^{n} (c_i^U - c_i^D) p_i \exp(-\lambda_i x_i), \quad (3)$$

which is the expected incursion management cost for a site (given in eqn 1) summed over all sites $i = 1, 2, \ldots, n$. The surveillance costs x_i must be measured in the same units as the budget B, and the expected incursion management costs c_i^U and c_i^D must be measured in the same units as each other; however, incursion management costs need not be measured in the same units as surveillance costs (Table 1).

The second expression of the expected incursion management costs divides it into two parts. The first part is the expected minimum cost of control, which would be incurred if all invaders were detected, where the expectation is taken with respect to the probability of invader presence. The second part is the additional control cost incurred by a failure to detect one or more incursions, given the surveillance allocation $\mathbf{x} = \{x_1, x_2, \ldots, x_n\}$.

We are limited to altering the surveillance allocation $\mathbf{x}$, so minimizing $T(\mathbf{x})$ is equivalent to minimizing

$$U(\mathbf{x}) = \sum_{i=1}^{n} (c_i^U - c_i^D) p_i \exp(-\lambda_i x_i) \quad (4)$$

We use the Kuhn–Tucker conditions (Winston 1994; p. 691–692) to find candidate solutions for the optimal surveillance allocation (see Appendix S1). It is optimal to prioritize sites $i = 1, 2, \ldots, n$ in descending order of $(c_i^U - c_i^D) p_i \lambda_i$, and invest in the top k sites, for some value of k yet to be determined. Thus, without loss of generality, we label our n sites in this order of priority. We are likely to include sites with a high probability of invasive species presence (p_i), high additional control costs when undetected $(c_i^U - c_i^D)$, and/or effective surveillance (high λ_i).

The optimal allocation of budget B is

$$x_i^* = \begin{cases} \frac{\ln[(c_i^U - c_i^D) p_i \lambda_i]}{\lambda_i} + \frac{\bar{\lambda}_K}{\lambda_i}\left[\frac{B}{k} - \bar{x}_K\right], & i = 1, 2, \ldots, k \\ 0, & i = k+1, k+2, \ldots, n, \end{cases} \quad (5)$$

where

$$\bar{\lambda}_K = \frac{k}{\sum_{j=1}^{k} \lambda_j^{-1}} \text{ and } \bar{x}_K = \frac{1}{k} \sum_{j=1}^{k} \frac{\ln\left[(c_j^U - c_j^D) p_j \lambda_j\right]}{\lambda_j}, \quad (6)$$

and sites $i = 1, 2, \ldots, k$ receive positive surveillance investment. The term $\bar{\lambda}_K$ is the harmonic mean of the $\{\lambda_j\}$, or the average surveillance efficacy. The arithmetic mean $\bar{x}_K$ is the average unconstrained-optimal allocation across sites 1 to k (see eqn 2).

The form of the solution is similar to the unconstrained problem (eqn 2), but the site allocation is moderated by the budget B and the investment efficiency at this site i relative to the other sites 1 to k. The term B/k is the funding that each site would be allocated if surveillance dollars were allocated equally to all sites and $\bar{x}_K$ is the average funding we would hope to allocate to each site if we were not constrained by the budget. Thus, the difference between them will be negative when the budget falls short of the ideal surveillance investment, and the surveillance allocated to the site will be reduced from the ideal unlimited-resource level. Multiplying by $\bar{\lambda}_K/\lambda_i$ tailors this reduction according to the surveillance efficacy at the particular site i relative to the other sites. Thus, sites where surveillance is highly effective will not have their funding allocation reduced as substantially as those where surveillance is ineffective. If the budget exceeds the ideal surveillance investment then the second term in the sum (eqn 5) is positive. All sites receive at least their optimal unlimited-resource surveillance allocation, and sites where the surveillance method is relatively ineffective receive the largest boost in surveillance.

Furthermore, the number of sites included (k) must satisfy

$$(c_k^U - c_k^D) p_k \lambda_k > \exp\left[\bar{\lambda}_K \left(\bar{x}_K - \frac{B}{k}\right)\right] > (c_{k+1}^U - c_{k+1}^D) p_{k+1} \lambda_{k+1} \quad (7)$$

(see Appendix S1). Then the total expected control impact is

$$U(\mathbf{x}^*) = \sum_{i=1}^{n} (c_i^U - c_i^D) p_i \exp(-\lambda_i x_i^*)$$
$$= \frac{k}{\bar{\lambda}_K} \exp\left(\bar{\lambda}_K \left[\bar{x}_K - \frac{B}{k}\right]\right) + \sum_{i=k+1}^{n} (c_i^U - c_i^D) p_i \quad (8)$$

We still do not know the precise number of sites k that are allocated positive surveillance funding, because there may be more than one k that satisfies eqn 7. To find the optimal funding allocation amongst n sites subject to a budget, we:

(1) set a priority list by labelling sites 1, 2, …, n such that they are in descending order of $(c_i^U - c_i^D) p_i \lambda_i$;

What is missing?

Standardised tools for investigating biosecurity questions

- Limited access to cutting-edge tools
- National inconsistencies in application
- Limited sharing of risk analytics
- Sub-optimal outcomes

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A platform for modelling and analysing biosecurity risk and response

cebra
Centre of Excellence for Biosecurity Risk Analysis

THE UNIVERSITY OF MELBOURNE

Griffith UNIVERSITY

Australian Government
Department of Agriculture, Fisheries and Forestry

ARDC
Australian Research Data Commons

NCRIS
National Research Infrastructure for Australia
An Australian Government Initiative

Atlas of Living Australia
ala.org.au

AUSVEG

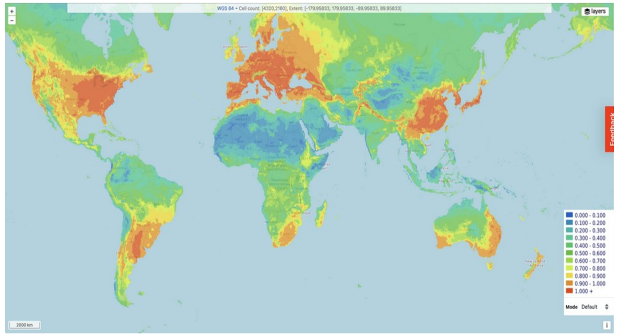
Queensland Government

Forest & Wood Products Australia

EcoCommons

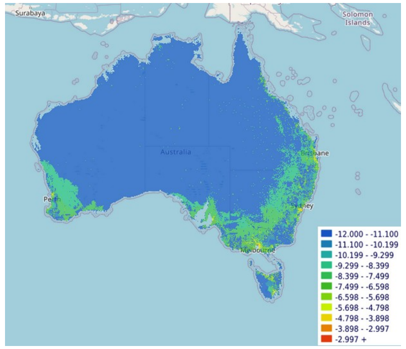
What is Biosecurity Commons?

Linked workflows



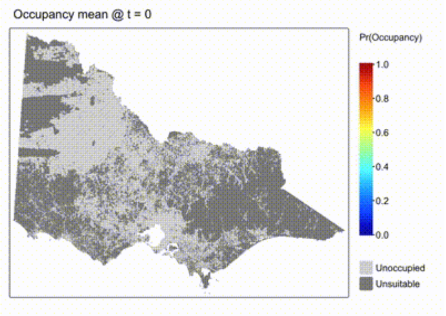
Species Distribution Modelling

Species Distribution Modelling.



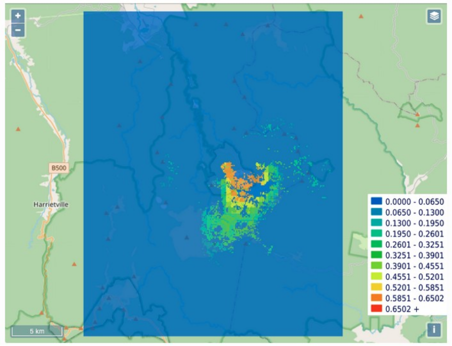
Risk Mapping

Biosecurity Risk Mapping



Population Spread Modelling

Create visual outputs and analytics of the potential spread of invasive species.



Surveillance Design

Surveillance Design.

iterations	confidence
1	0.649350649350649
2	0.774233508826262
3	0.863957755921566
4	0.921633027552699
5	0.956099265768694

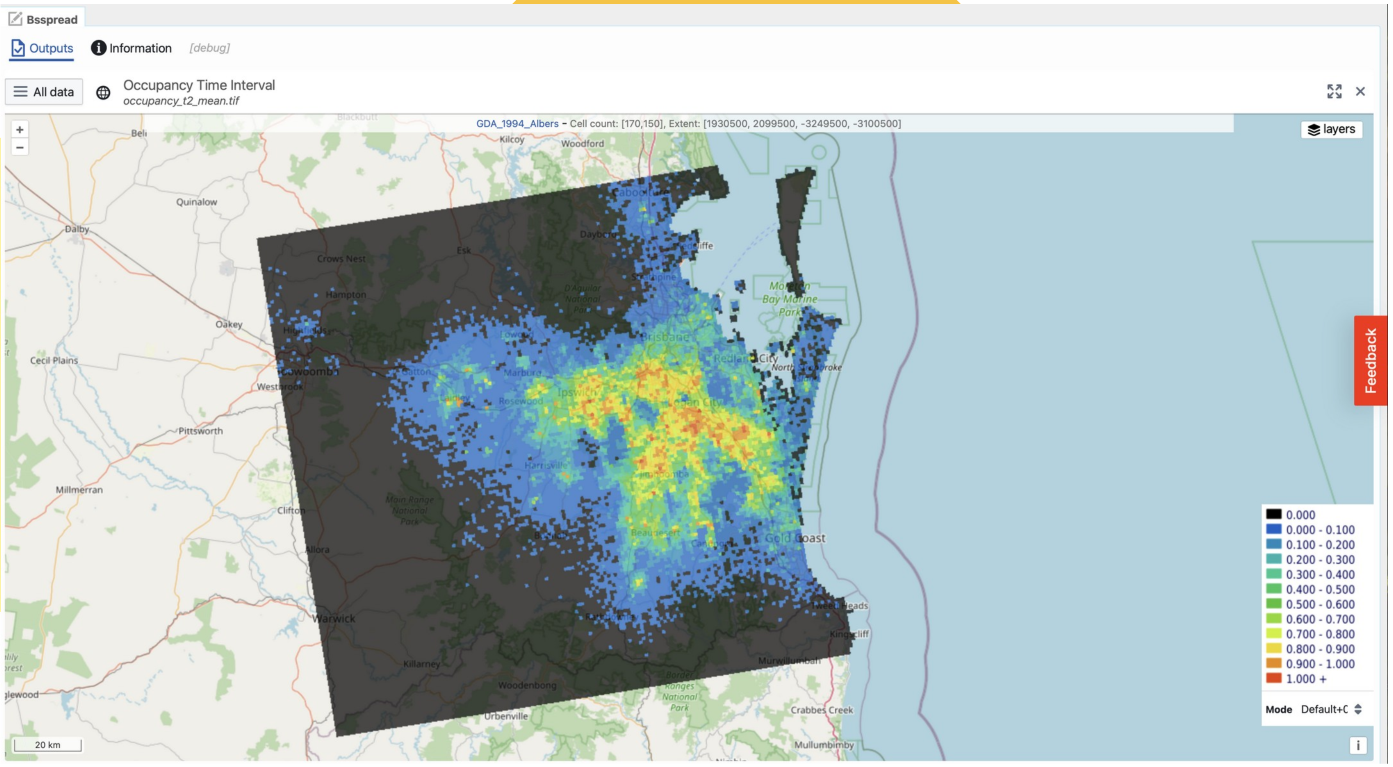
Proof of Freedom

Proof of Freedom.

Who are our intended users?

Governments	Industry and environmental groups	Universities and research centers
		
Biosecurity operations and policy	Risk management asset protection	Tool developers and training next generation

How did we build it and engage with users?



Case study: Predicting the spread of Red Imported Fire Ant in and around Brisbane

Multi-prong approach:

- Online user requirement workshops
- Develop ‘real-world’ case studies
- Conferences, live demos, training
- YouTube, social media, newsletters

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Case studies
(Local and state government, VegWatch and FWPA)


RIFA
(QDAF)


MedFly
(AGVIC)


Parkinsonia
(NSW DPI)


Buffel Grass
(Landscape SA)


Yellow Crazy Ants
(QDAF & LGAs)


Potato Cyst Nematode
(TAS NRE)


Leafminers


Brown Marmorated Stink Bug


Tomato potato psyllid


Zebra chip, CLso


Tomato mottle mosaic virus (ToMMV)


Japanese sawyer beetle


Giant Pine Scale


Brown spot needle blight


Myrtle Rust (exotic strains)

For the animal health audience...

HASTE project

- Enhancing Models for Rapid Decision-Support in Emergency Animal Disease Outbreaks

- Aims to improve Australia's biosecurity response to rapidly emerging animal disease threats