Modelling invasive species arrival and establishment

Dean Paini  |  Principal Research Scientist
September, 2017
How does my science protect plant health?

- Invasive species modelling
  - Who could invade?
  - How could they invade?
  - What will be their impact?
Invasion

Arrival  Establishment  Impact
Invasion

Arrival  Establishment  Impact
Arrival

Natural

Human-mediated
Natural - Wind

**TAPPAS**: tool for assessing pest and pathogen airborne spread

Rieks van Klinken, Peter Durr, Kerryne Graham

Access computationally complex and diverging models with “easy-to-use” interfaces will change the way biosecurity surveillance is undertaken and prioritized.
Welcome to TAPPAS v1.0

TAPPAS (Tool for Assessing Pest and Pathogen Aerial Spread) is an online software tool developed to enable biosecurity managers and scientists to run sophisticated scenarios of long-distance spread from their browsers. It is an essential biosecurity tool for preparing and responding to wind-borne threats.

News

What is happening in the TAPPAS project?


26 November 2015

TAPPAS v1.0 is released. Thank you to all of you from many organisations that have made this possible. TAPPAS is an enabling tool with the potential for diverse application. We encourage you to explore the full potential of TAPPAS. Don’t hesitate to contact us with ideas for collaboration, application and improvement. As TAPPAS is undergoing a staged release it is currently not available for commercial use, and outputs are not to be published, without prior consent.

June 2015

The first development sprint of TAPPAS are currently underway. Feedback from the user acceptance testing surveys have driven the remaining development tasks.

ACCESS-Regional Current Conditions

PROJECT PARTNERS

INTERSECT
Create a new simulation

Define Location

Define location

Select by interactive map

Select by a single area. Area is based on a predefined grid and selects the centroids of the grid. (Limits to 5000 grid locations)
Risk Map
Conclusions

• Some functionality need to improve
  • Incorporate climatic conditions in the air column

• Potential....
Human Mediated (Transport Networks)
Globalisation
Source: adapted from Drewry Shipping Consultants.
Shipping network (Great Lakes District)

All ports = 5 steps

Keller et al 2011 Div & Dist
Network theory and invasive species

The role of global trade and transport network topology in the human-mediated dispersal of alien species

Abstract
More people and goods are moving further and more frequently via many different trade and transport networks under current trends of globalisation. These networks can play a major role in the unintended introduction of exotic species to new locations. With the continuing rise in global trade, more research attention is being focused on the role of networks in the spread of invasive
Conclusions

• Increased globalisation = faster spread = more potential invasive species (poorly adapted to transport vectors)

• Monitor hubs = reduced spread
Influence maximization in complex networks through optimal percolation

Flaviano Morone¹ & Hernán A. Makse¹
Tourists/travellers
Tourist networks (Stephen Cordwell)

- New Zealand
- Analyse tourist networks
DiNeMo (Disease Networks Mobility)

- CSIRO group (Raja Jurdak)
- Fusion of data for human movement and disease modelling
- Social media (twitter), call data, public transport, airline movement, tourist data, etc
- Australian tourist data (international and domestic) – Kewei Zhang
Entropy and predictability

\[ S_i^{unc} = -\sum_{j=1}^{N_i} p_i(j) \log_2 p_i(j) \]
Entropy and predictability

\[ S_i^{\text{unc}} = - \sum_{j=1}^{N_i} p_i(j) \log_2 p_i(j) \]
Entropy and predictability

$$S_i^{unc} = - \sum_{j=1}^{N_i} p_i(j) \log_2 p_i(j)$$
Entropy and predictability

\[ S_i^{\text{unc}} = -\sum_{j=1}^{N_i} p_i(j) \log_2 p_i(j) \]
Invasion

Arrival

Establishment

Impact
Invasion

Arrival  Establishment  Impact
Establishment

species modelling (CLIMEX)
multi-species modelling (SOM)
Invasive Pest Assemblages (IPA)

Region A

Region B

= high likelihood
Predicting Invasive Fungal Pathogens Using Invasive Pest Assemblages: Testing Model Predictions in a Virtual World

Dean R. Paini$^{1,2}$*, Felix J. J. A. Bianchi$^{3,2}$*, Tobin D. Northfield$^{4,5}$, Paul J. De Barro$^{2,3}$

Threat of invasive pests from within national borders

Dean R. Paini$^{1,2}$, Susan P. Worner$^{3,2}$, David C. Cook$^{3,2}$, Paul J. De Barro$^{2,5}$ & Matthew B. Thomas$^{2,6}$
Invasion

Arrival  Establishment  Impact
Invasion

Arrival  Establishment  Impact
PRAFHIS (Pathways and Risk Assessment Framework for High Impact Species)

• Kylie Ireland & Kylie Crampton
Invasion

Arrival  Establishment  Impact
## Invasion

<table>
<thead>
<tr>
<th>Arrival</th>
<th>Establishment</th>
<th>Impact</th>
</tr>
</thead>
</table>

Global threat to agriculture from invasive species

Dean R. Paini\textsuperscript{a,b,1}, Andy W. Sheppard\textsuperscript{a}, David C. Cook\textsuperscript{c,d}, Paul J. De Barro\textsuperscript{e}, Susan P. Worner\textsuperscript{f}, and Matthew B. Thomas\textsuperscript{g,h}

\textsuperscript{a}Commonwealth Scientific and Industrial Research Organization, Canberra, ACT 2601, Australia; \textsuperscript{b}Plant Biosecurity Cooperative Research Centre, Bruce, ACT 2617, Australia; \textsuperscript{c}Department of Agriculture and Food, Western Australia, Bunbury, WA 6230, Australia; \textsuperscript{d}School of Agricultural and Resource Economics, The University of Western Australia, Crawley, WA 6009, Australia; \textsuperscript{e}Commonwealth Scientific and Industrial Research Organization, Brisbane, QLD 4001, Australia; \textsuperscript{f}Bio-Protection Research Centre, Lincoln University, Lincoln 7647, New Zealand; \textsuperscript{g}Department of Entomology, Penn State University, State College, PA 16802; and \textsuperscript{h}Center for Infectious Disease Dynamics, Penn State University, State College, PA 16802

Edited by Harold A. Mooney, Stanford University, Stanford, CA, and approved April 28, 2016 (received for review February 13, 2016)

Invasive species present significant threats to global agriculture, although how the magnitude and distribution of the threats vary of each country’s annual mean (2000–2009) importation (in millions of US dollars) from each trading partner as a proportion of
Data

- Distribution data 1,300 species (CABI CPC)
- Direction of Trade data (IMF)
- Agricultural productivity (FAO)
- Host use data (CABI CPC)
- Impact % (CABI CPC)
For each threatened country

- What crops do they grow?
- What are the pests of this crop?
- Is the pest in the threatened country?
- Which countries is this pest found?
- How much does the threatened country trade with those countries? ARRIVAL INDEX
- If it can arrive, is it likely to establish? ESTABLISHMENT INDEX
- What will it’s impact be (%%)?
- How much is the crop worth?
- RINSE AND REPEAT...
- Total invasion cost from all species that could invade a threatened country
Assumption

• GDP reflects
  • Diversity of the economy
  • Investment in:
    – border biosecurity
    – post-border interventions and control
    – post establishment management practices

TIC

GDP
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<tr>
<th>Rank</th>
<th>Country</th>
<th>TIC$_t$ (millions US$)</th>
<th>mean GDP</th>
<th>proportion of GDP</th>
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<tr>
<td>1</td>
<td>Malawi*</td>
<td>$1,071</td>
<td>$3,000</td>
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<td>$978</td>
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<td>$513</td>
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<td>$60,967</td>
<td>0.0922</td>
</tr>
</tbody>
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Acknowledgements

• Rieks Van Klinken, Peter Durr, Kerryne Graham (TAPPAS)
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Thank you

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Arrival = trade data

Forecasting Biological Invasions with Increasing International Trade

JONATHAN M. LEVINE* AND CARLA M. D’ANTONIO†

Exploring associations between international trade and environmental factors with establishment patterns of exotic Scolytinae

Lorenzo Marini · Robert A. Haack · Robert J. Rabaglia · Edoardo Petrucco Toffolo · Andrea Battisti · Massimo Faccoli