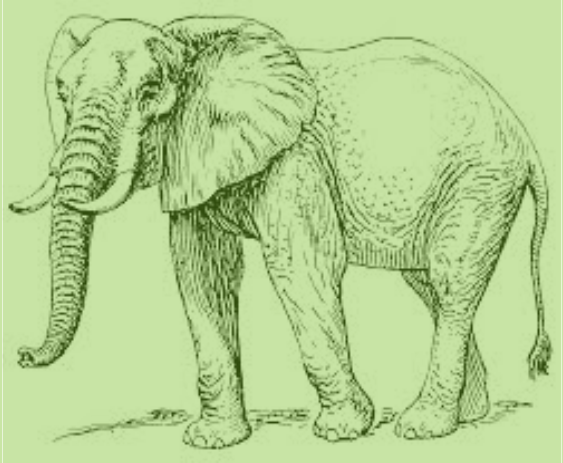

Respecting critical assumptions of probability & statistics during pest risk modelling

How did the elephant in the room grow so big?

Darren Kriticos and Peter Caley

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Contention

1. Modern computer technology and datasets have allowed us to generate pest risk models that are intuitively appealing, and frequently baffling and misleading
2. Many of these models do not respect the critical assumptions of probability
3. The complexity and “realism” of these analyses are attractive and persuasive, deflecting critical scrutiny
4. Biosecurity managers are not well-equipped to critically evaluate complex statistical models

Outline

- Examples
  - Spread modelling
  - Combining conditional probabilities
  - SDM Probabilities
- Risk assessment and perception
- Thoughts on why we make these mistakes

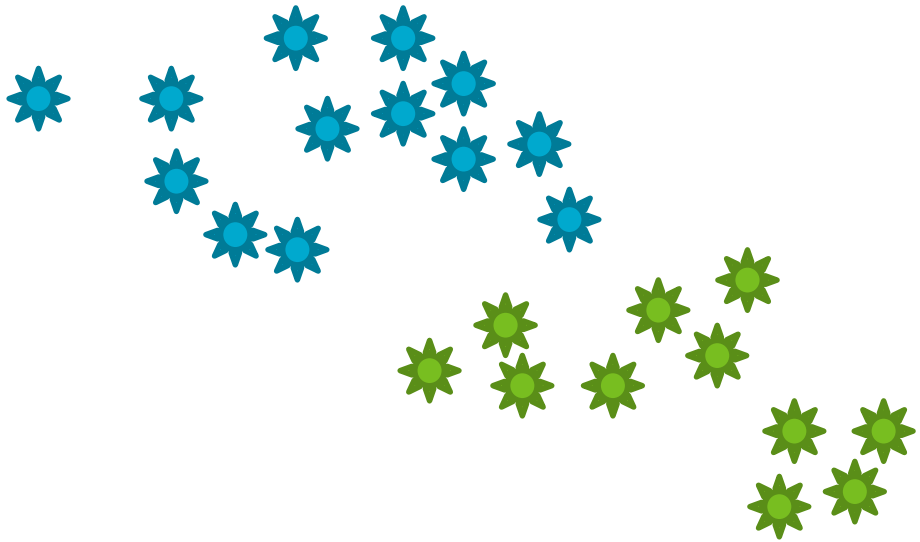
Spread Modelling

Critical Pest Risk Questions for Spread Modelling

- What ***sort*** of spread pattern will the pest have?
  - Informs heuristics for incursion management
- What is the ***rate*** at which impacts will accrue?
  - Informs the economic discount rate in cost benefit analyses

Stochastic spread modelling

- Markov chain of discrete conditional probabilities of effective dispersal

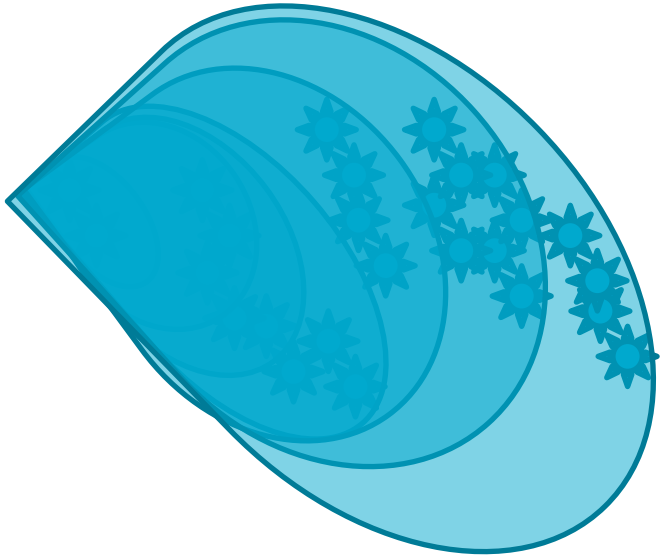


- Good for management learnings
  - Population growth rate
  - Rate of generation of satellites
- But, it is poorly predictive beyond a few timesteps
  - Not so good for PRA applications

Pest spread is a dynamic stochastic process

- No two invasions are the same!
  - Melbourne & Hastings (2009)
- Initialisation is a highly sensitive factor
  - Where does the invasion start?
- Even small random effects compound over time
  - Chaos butterfly

Running multiple realisations and collapsing the results into a "probability surface"



- Portrays what would happen if there were many repeated invasions
- Incongruous with the way real invasions behave
- Poor specificity
- Assumed initialisation
- The model of convenience dominates the perception
- Can misinform the allocation of resources for *incursion management*

Pre-border risk assessment

- Use a simpler model of spread rate e.g. logistic
- Apply this to the assets at risk in a sensitivity framework
  - Accumulate impacts in a time sequence based on area occupied over time
  - Apply discount rate to the annual impacts
  - Maximum ~30 years
- Method included in PRATIQUE spread modelling package

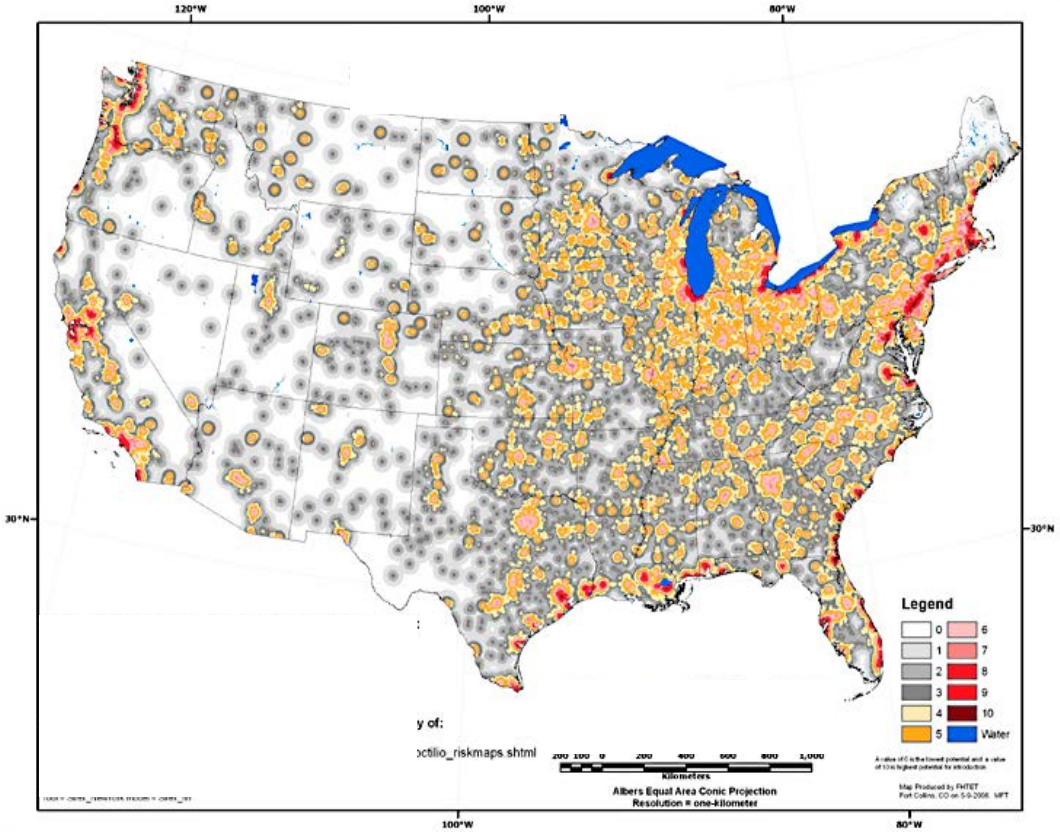
Compounding Arrival and Spread

Compounding arrival establishment and spread

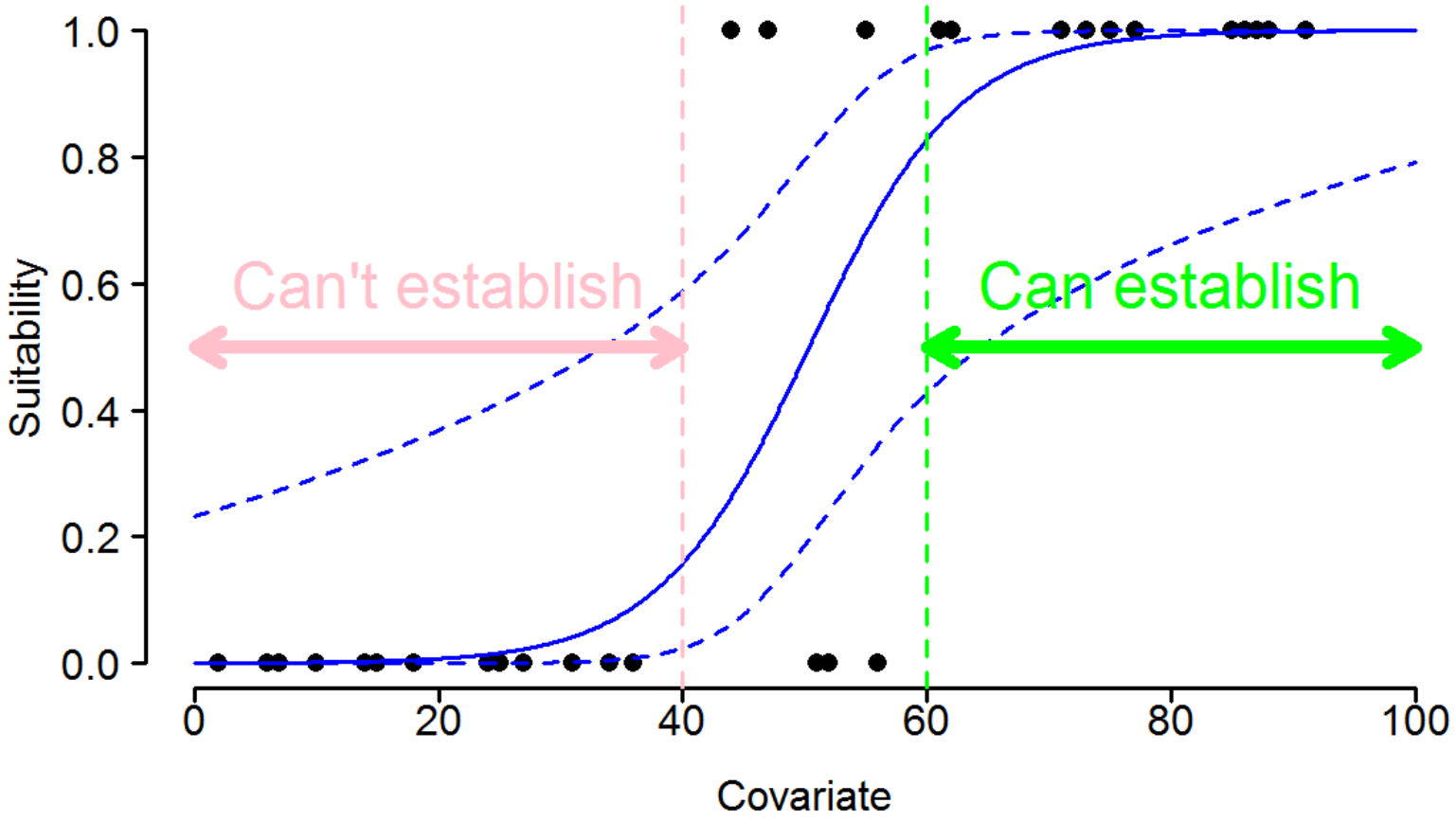
- Arrival, establishment and spread are distinct, *conditional* processes
- Arrival depends on transport
- Establishment depends on Arrival, and suitability of habitat for population growth
- Spread depends on Arrival, Establishment and suitability of habitat for population growth away from the establishment site and a means of spreading

Intuitive Assumptions are not Axioms

- Propagule pressure = ∫(trade volume)
- Establishment rate = ∫(propagule pressure, habitat suitability)
- ∴Establishment risk = ∫(trade volume, habitat suitability)
- From this we might surmise that most IAS establishment events are associated with the port with the greatest trade volumes
- Are these ***assumptions*** true?
- Difficult to tease out due to survivorship bias and inappropriate datasets (no accounting for collection effort)


120°W
100°W
80°W
30°N
30°N
100°W
80°W
Legend
0
1
2
3
4
5
6
7
8
9
10
Water
Kilometers
Albers Equal Area Conic Projection
Resolution = one-kilometer

SDM Probabilities


Can't establish
Can establish
Suitability
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
Covariate

Interpreting habitat suitability “measures”

- The proportion of cells expected to be permanently suitable
  - Suitability is permanent but spatially stochastic given covariates
- The proportion of time cells are suitable
  - Suitability is temporally stochastic (transient)
- *p* represents your belief that it is suitable
  - The cell is either permanently suitable or not
- The cell may or may not be suitable
  - Suitability depends on an unmeasured variable
- When assessing risk of entry, establishment & spread, these interpretations matter …

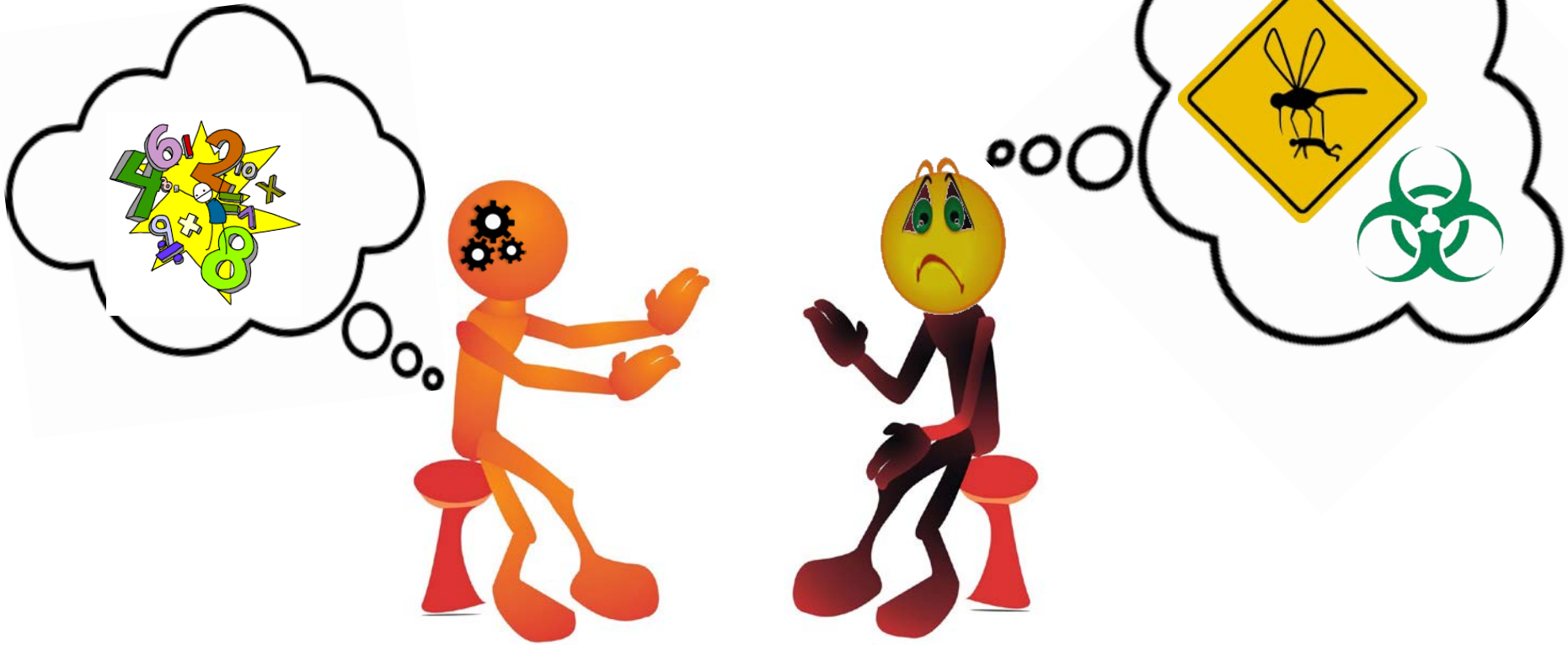
Risk Assessment and Perception

- Pest Risk Assessment aims to **inform decision-makers** about risks posed by pests
- Risk Assessment
  - *The determination of quantitative (or qualitative) estimate of risk related to a well-defined situation and a recognized threat*
- Risk Perception
  - *The **subjective** judgement that people make about the characteristics and severity of a **risk***
- Decisions are guided by the ***perception*** of the risks

Humans are really very poor at perceiving risk accurately

- Rely on heuristics, leading to biases
  - Base rate neglect
  - Gamblers fallacy
  - Illusion of validity
    - Confirmation bias
    - What you see is all there is
- Availability
  - More realistically imagined events perceived as more probable
- Anchoring and Adjustment
  - Start with known example and adjust (insufficiently)

Risk Communication



Conclusions

- Analysts should pay more attention to probability theory
- Test the assumption about establishments being associated with trade volumes
- Express probabilities in terms of natural frequencies with respect to a certain reference class
  - E.g., on average, for every 1000 shipping containers arriving into port x, there will be y unwanted alien species.
  - Avoid expressing scalar indices as proportions or probabilities

S.E.P. – Someone Else’s Problem field

Any object around which an S.E.P. is applied will cease to be noticed, because any problems one may have understanding it (and therefore accepting its existence) become Somebody Else's. An object becomes not so much invisible as unnoticed.

Douglas Adams

Thank You

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