Effect of landscape structure on invasive spread: a spatially explicit perspective

International Pest Risk Research Group

Fort Collins, NC, 25-28 August 2015

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Acknowledgements

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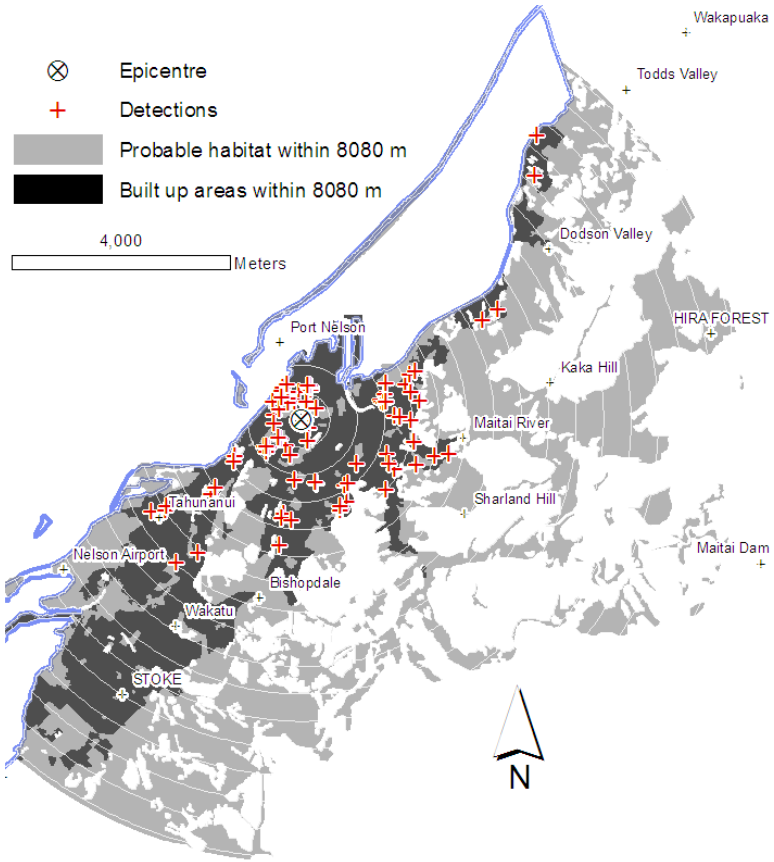
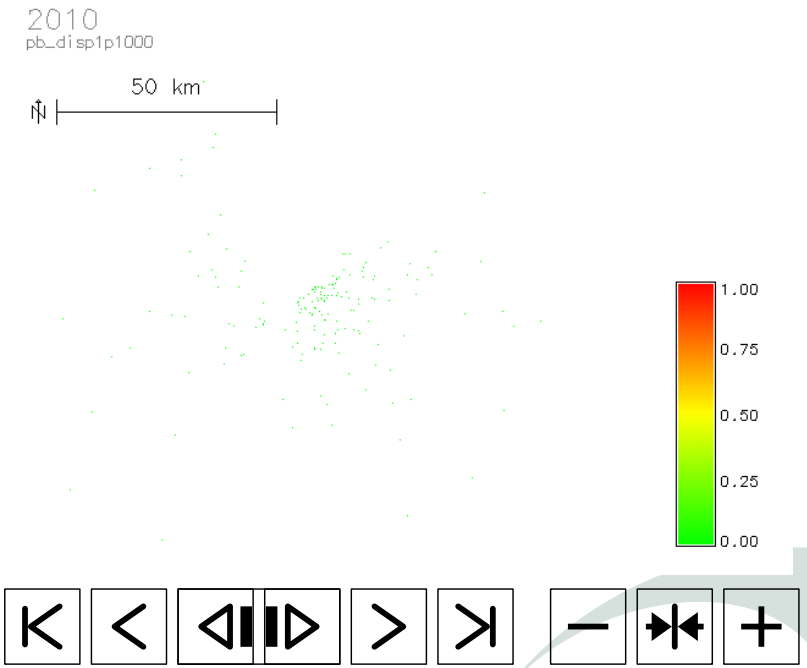
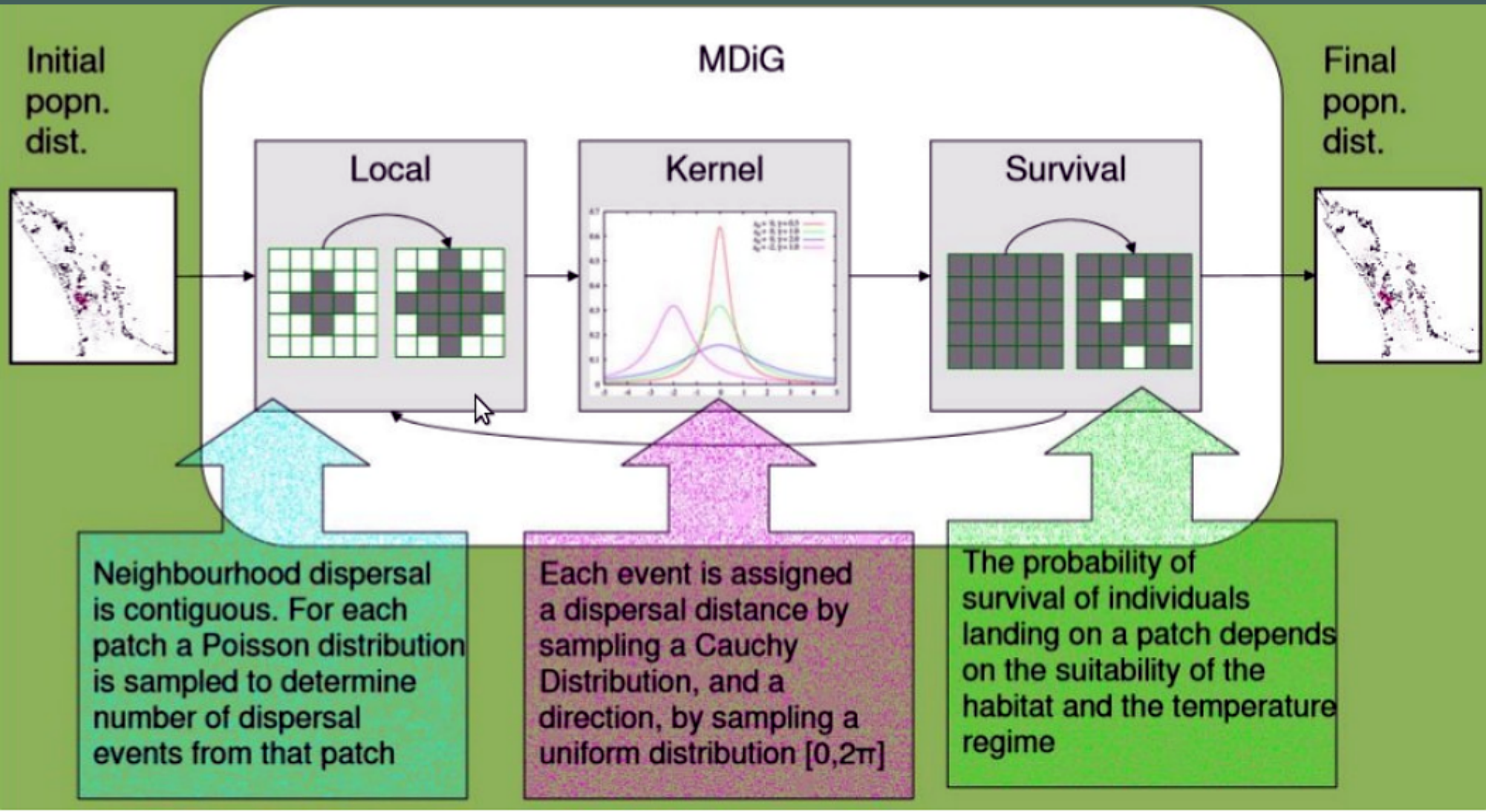
Spatio-temporal dynamics of spread





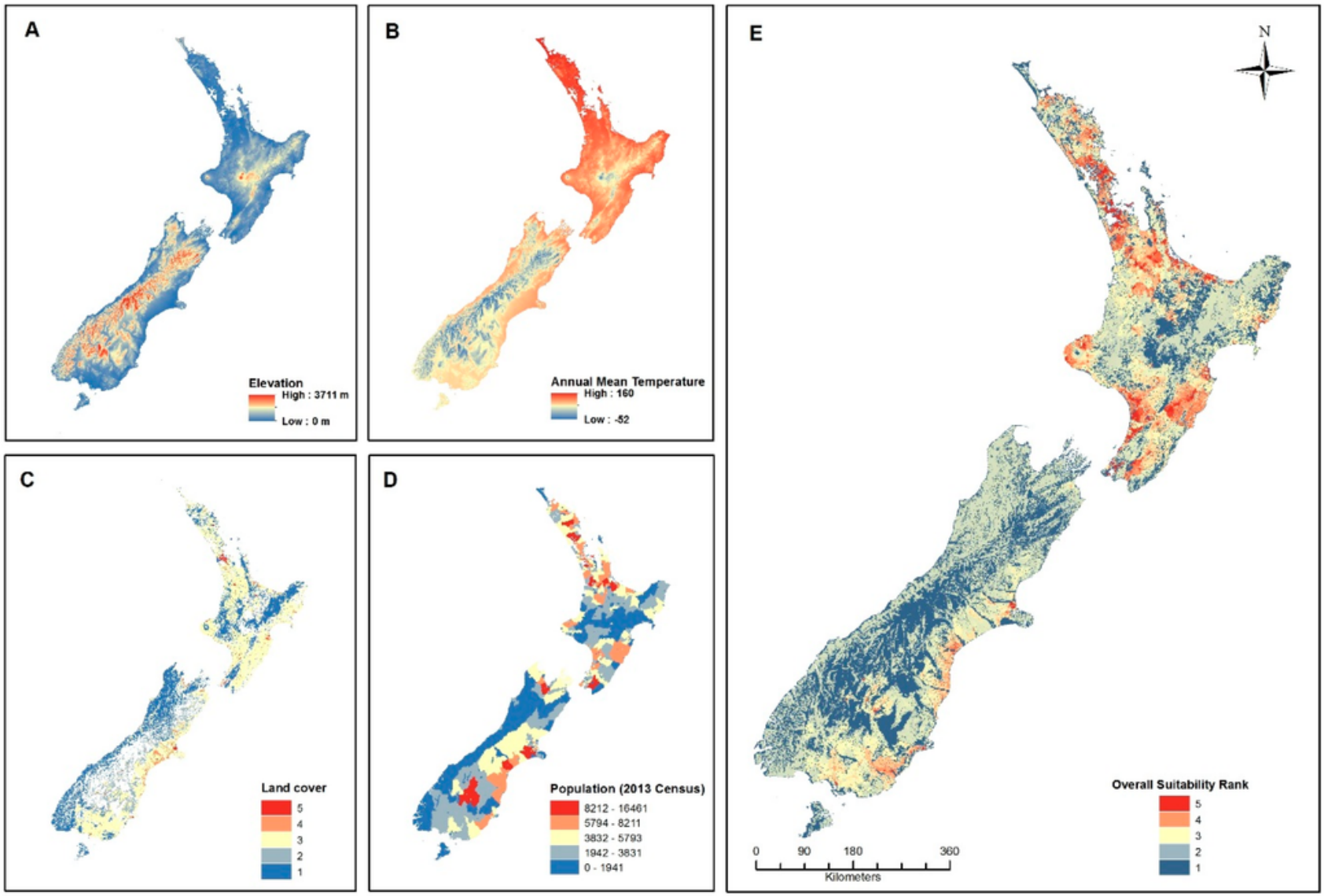
Senay et al. (2014) *B3 Conference*, Wellington, New Zealand

General dispersal framework



Pitt et al., *Ecol Appl* (2009) - `https://github.com/ferrouswheel/mdig`

General dispersal framework



Theoretical background

Species life history traits

Propagule pressure

Abiotic interactions and resource distribution

Heterogeneous spatial distribution of invasive species

Lockwood, *Wiley* (2013)

Landscape structure shaping the process of invasion

Research question

How abiotic variables and resource distribution influence establishment success and spread of invasive insects?

With, *Conservation Biology* (2002)

What do we already know?

- Urban landscape promote alien species establishment and spread (White et al. 2010)
- Urban forest, with large ratio of edge to interior habitat, are prime prime pathways from urban to natural area (Martin et al. 2009)
- Simplification of landscape increases the concentration of resources that are available to invasive pests (Robledo-Arnuncio et al. 2014)

but

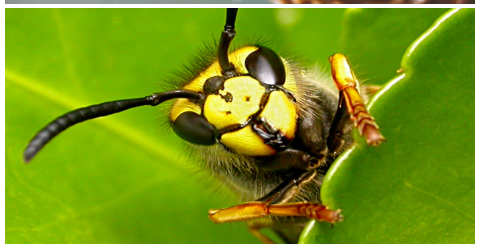
- Small gradient of habitat complexity (e.g. patch shape, interpatch connectivity, habitat corridors or habitat aggregation)
- Insufficient or null replications across habitat
- Global synthesis of the effect of landscape structure on pest spread?

Linking landscape structure to population dynamics

Modelling environmental suitability

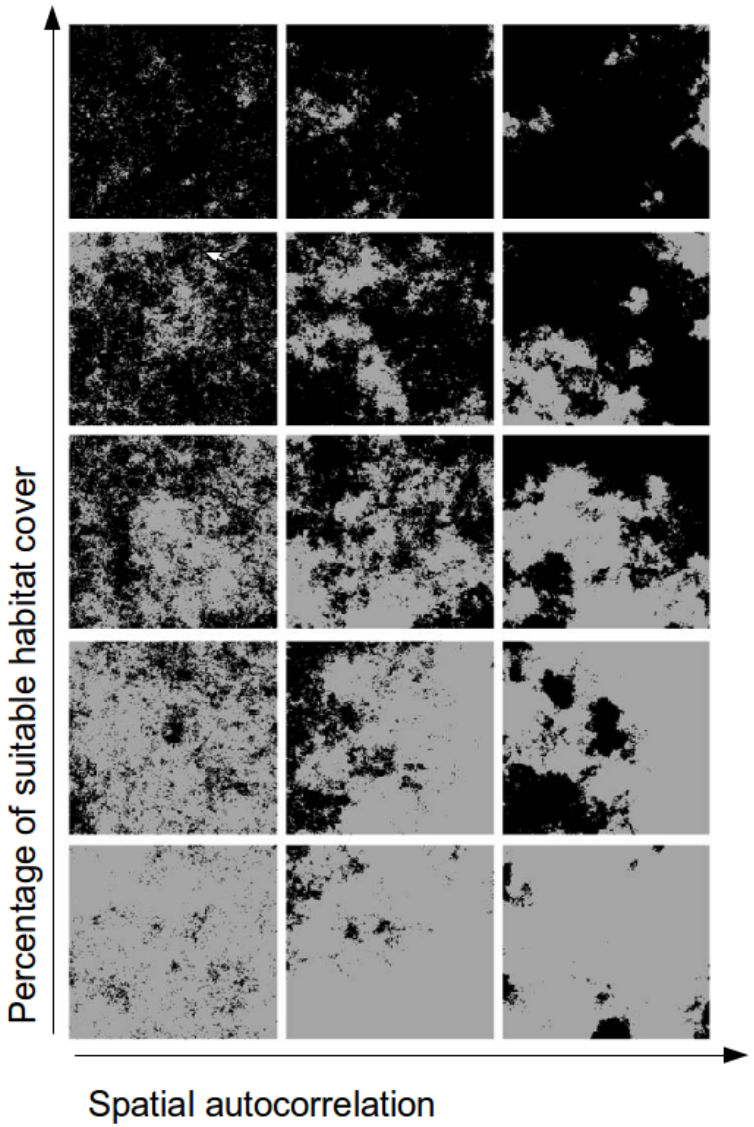
Landscape metrics

Modelling population dynamics



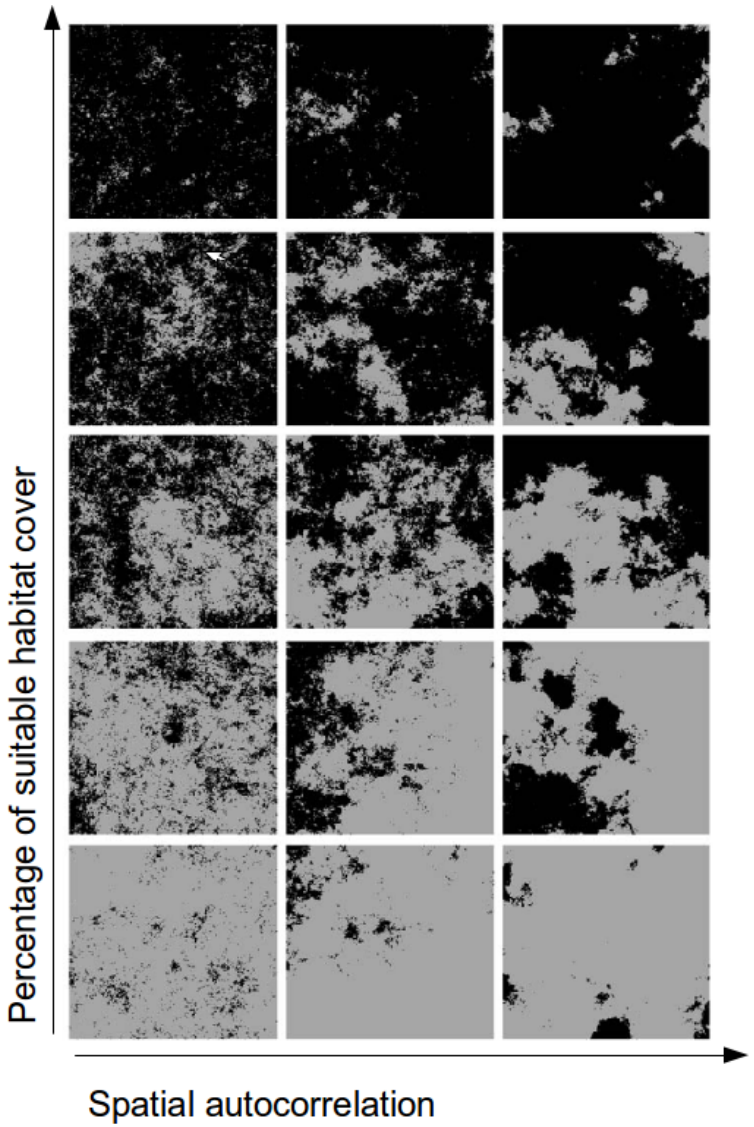
Lustig et al., *13th International Conference Autonomous Agents and Multiagent Systems, AAMAS* (2014)

Generating and quantifying landscape patterns



McGarigal et al., *FRAGSTATS v4*, (2012) and Gardner, *Springer-Verlag, New York* (1999)

Generating and quantifying landscape patterns



Context

e.g. Distance to nearest suitable patch

Shape/complexity

e.g. Perimeter/ratio

Habitat size

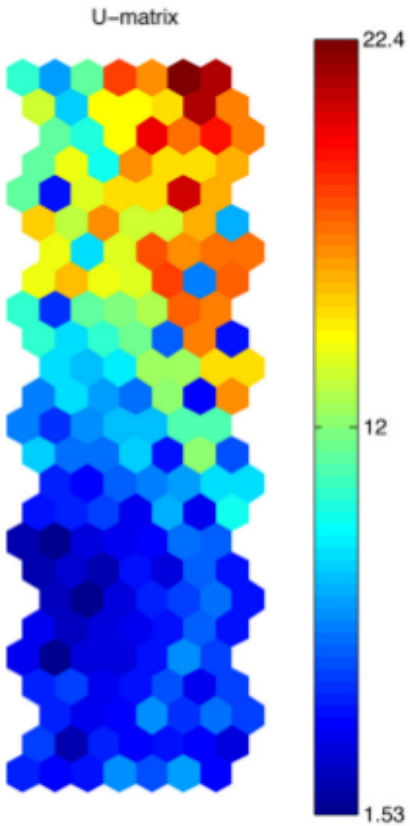
e.g. Suitable area

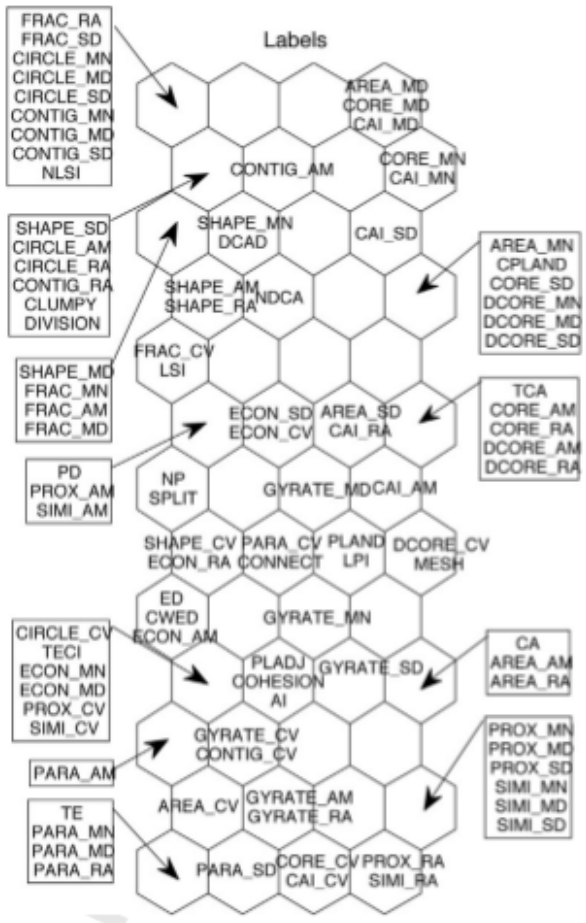
Habitat boundary

e.g. Edge density

McGarigal et al., *FRAGSTATS v4*, (2012) and Gardner, *Springer-Verlag, New York* (1999)

Better understanding landscape metrics





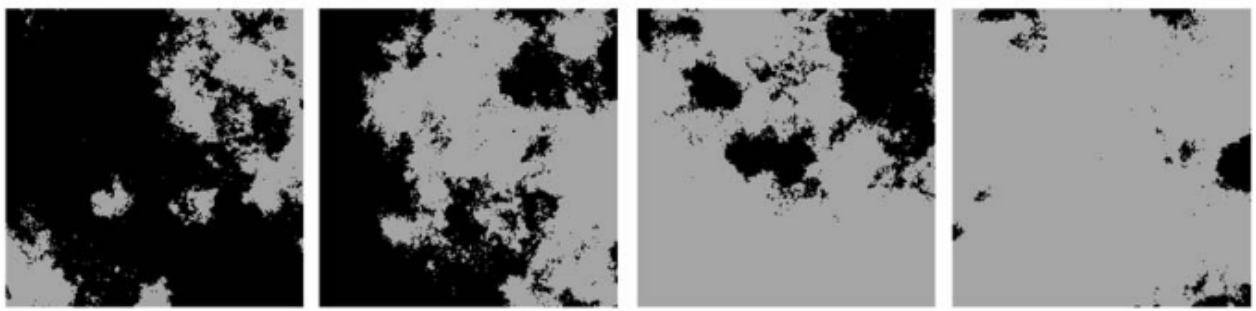
Lustig et al., *Ecological Indicators* (2014)

Effect of spatial pattern on the process of invasion

Local dispersal

Long dispersal

Rate of increase



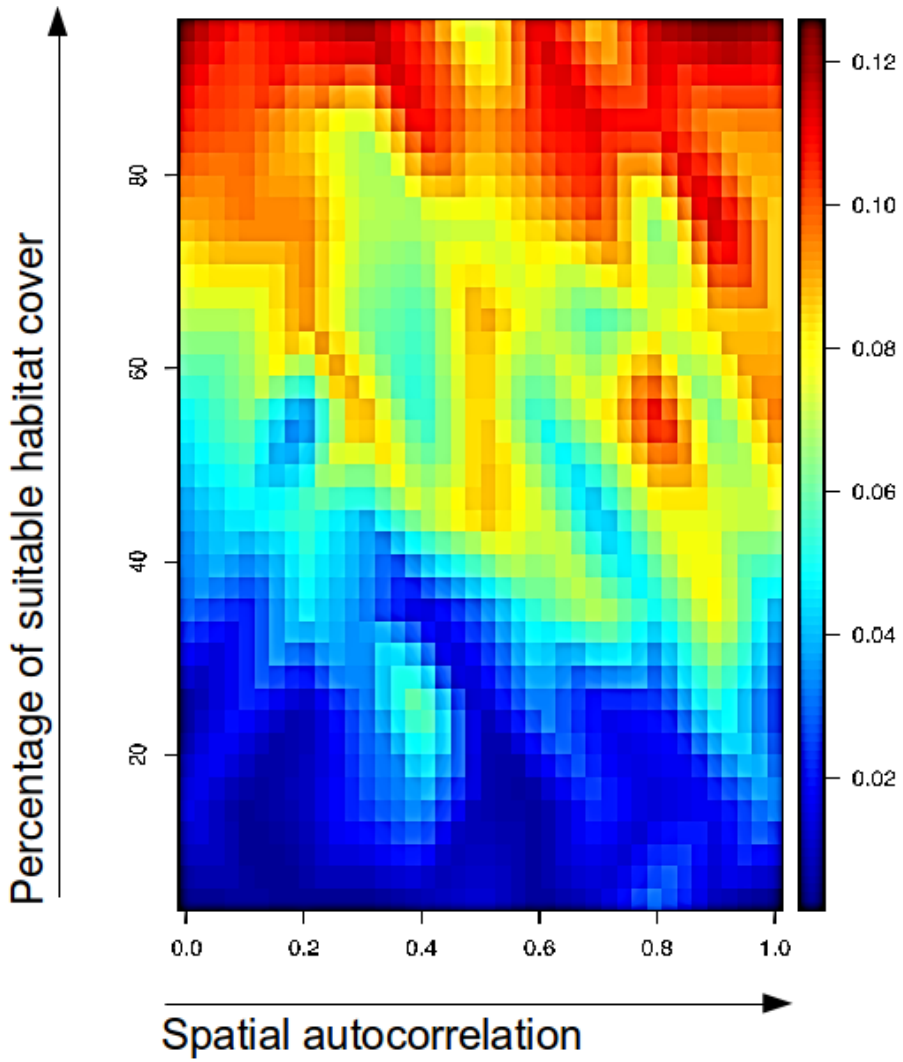
Landscape

metrics

Probability of establishment and spread

Modular Dispersal in GIS - `https://github.com/ferrouswheel/mdig`

Dispersal success as a function of spatial pattern



Role of landscape composition and configuration

- **Population density**
  - Landscape composition 27 ± 0.7 %
  - Aggregation index 10 ± 5 %
- **Occupied area**
  - Landscape composition 14 ± 4 %
  - Edge effect 11 ± 2 %
  - Clumpiness 39 ± 4 %
- **Rate of spread**
  - Landscape composition 68 ± 4 %
- **Dispersal distance**
  - Landscape composition 98 ± 4 %
  - Edge effect 12 ± 2 %
  - Aggregation index 23 ± 2 %

Conclusion and future directions

Future directions

- Relative effect of spatial pattern, dispersal abilities, and propagule pressure on dispersal success
- Source of variation in the models

In a longer term

- Quickly assessing the spread risk of any invasive insects arriving in New Zealand (and USA!)
- Assessing and communicating about map uncertainty
- Developing specific model of spread (life strategies,directional dispersal, etc.)
- Testing management strategies

Thank you for your attention

Mathematics is biology's next microscope, only better. Conversely, mathematics will benefit increasingly from its involvement with biology.

- Joel E. Cohen