Optimizing the surveillance of crop pests through network models

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Optimal Surveillance

(what's the best way to look for something you don't want to find)

Crop Pests

- Result in negative impacts
  - Food safety
  - Trade
  - Market access
  - Sustainability of plant industries

Surveillance

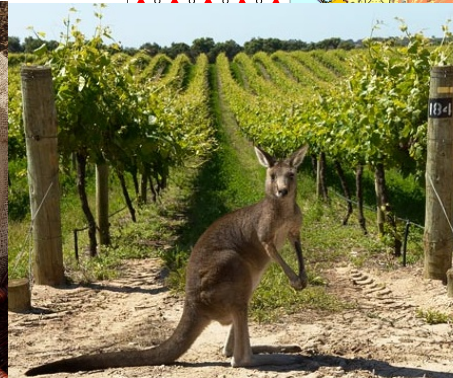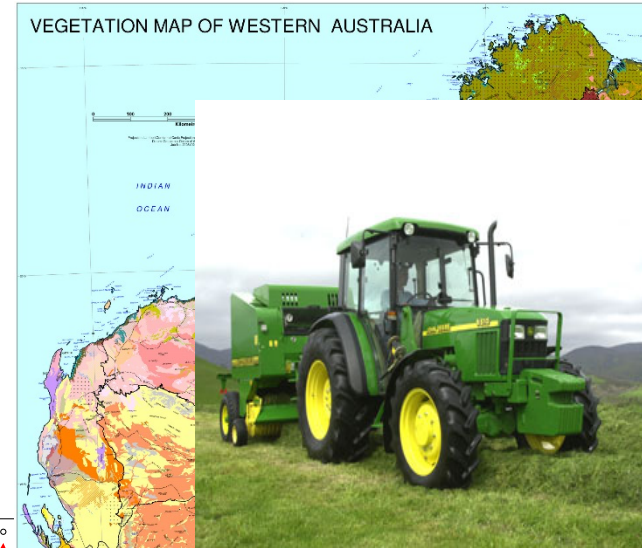- Early detection for rapid and effective response

- Delineating the extent of an incursion
- Proving area freedom to protect trade

- Inform management of established pests

Optimization

- Number, location, frequency
  - Movement, different or new technologies
  - Cost

- Structural arrangement of the landscape

- Dispersal potential of the species
  - Vectors?

Case Studies

Phylloxera and Grape Industry Board of South Australia, http://www.phylloxera.com.au/bio-security/phylloxera/

Andrew Taylor, www.agric.wa.gov.au/potatoes/potato-cyst-nematode-western-australia

Sonya Broughton, https://www.agric.wa.gov.au/citrus/fruit-fly-western-australia

Grape phylloxera,

Daktulosphaira vitifoliae Fitch

Potato-cyst nematode,

Globodera rostochiensis
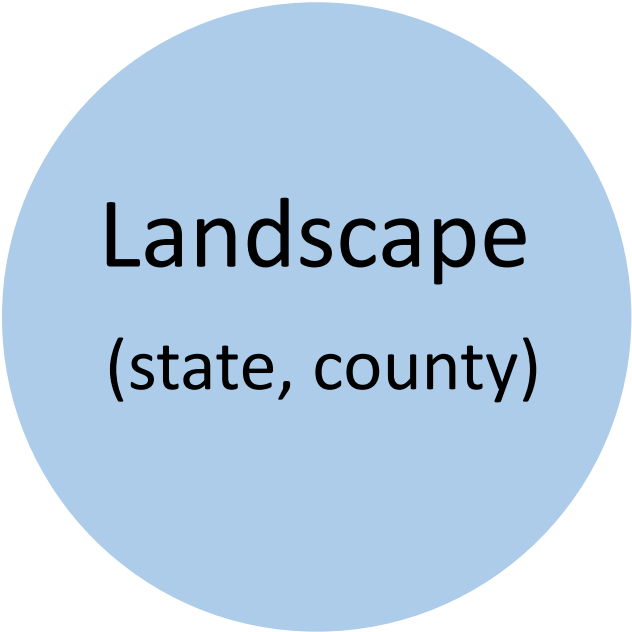
Mediterranean fruit fly,

Ceratitis capitata

Networks and Crop Pests

- Improved management and surveillance of disease in livestock and nursery plants
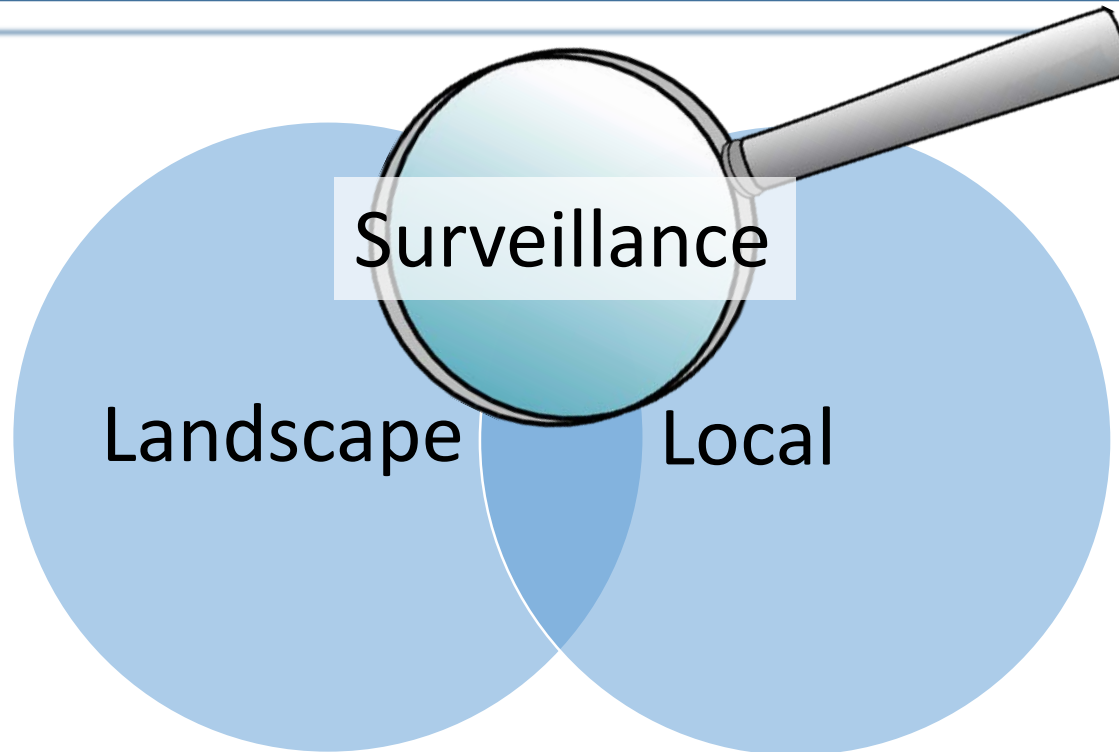- Difficult in crop systems

Landscape
(state, county)

Local
(within farm)

What are we doing different?

- Simulating spread at the landscape (area-area) and local (field-field) scales
- + Surveillance strategies over the network

Aims

- Produce **risk** maps and estimate link **transfer probabilities**

- Provide tools to prioritize surveillance to achieve **optimal** and **cost** effective **strategies**

Potato-cyst nematode (PCN)

Solanacea family hosts

rotation, resistant cultivars
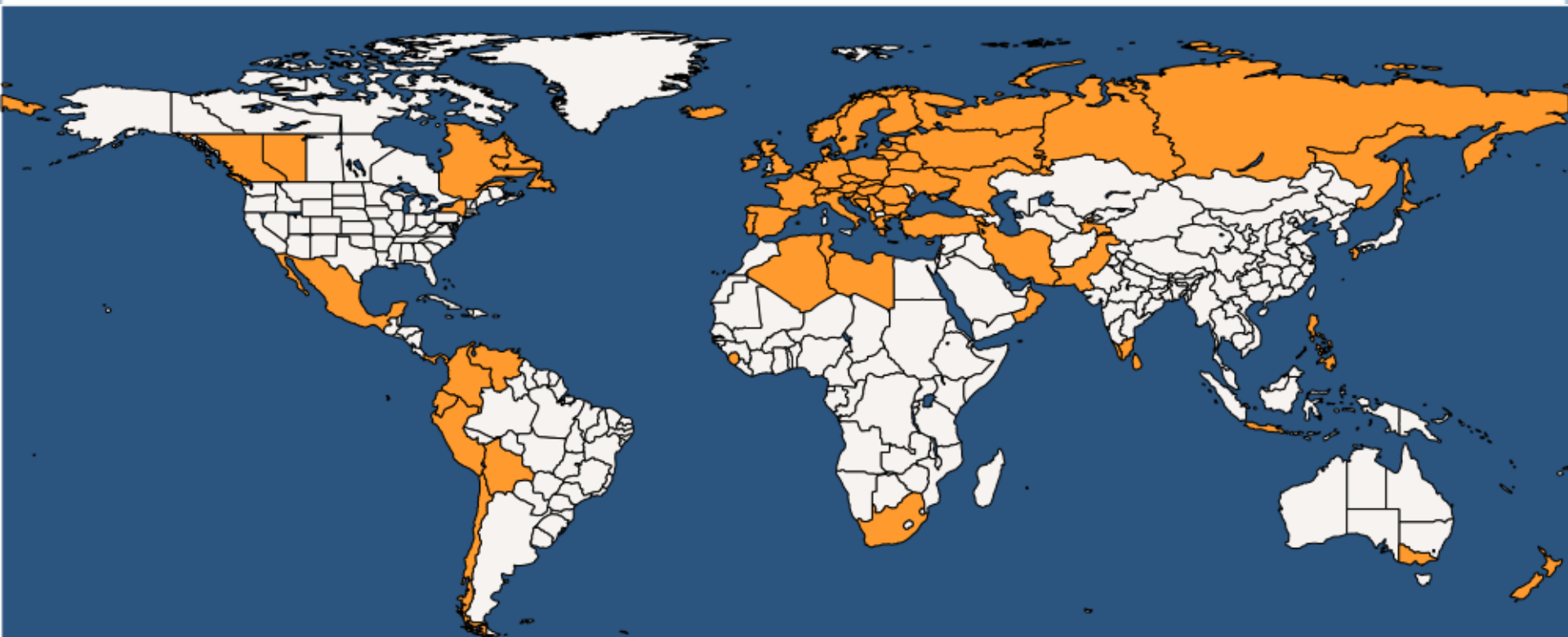
≤ 0.5 mm

Limited dispersal

100-500 eggs

PCN;
Andrew Taylor, www.agric.wa.gov.au/potatoes/potato-cyst-nematode-western-australia

1-2 generations/ potato crop

Live 20-30 years w/o host

PCN - World Distribution

Globodera rostochiensis (HETDRO)

2015-03-13
(c) EPPO http://www.eppo.int

Australia

Potatoes Grown
No
Yes

Infested Areas

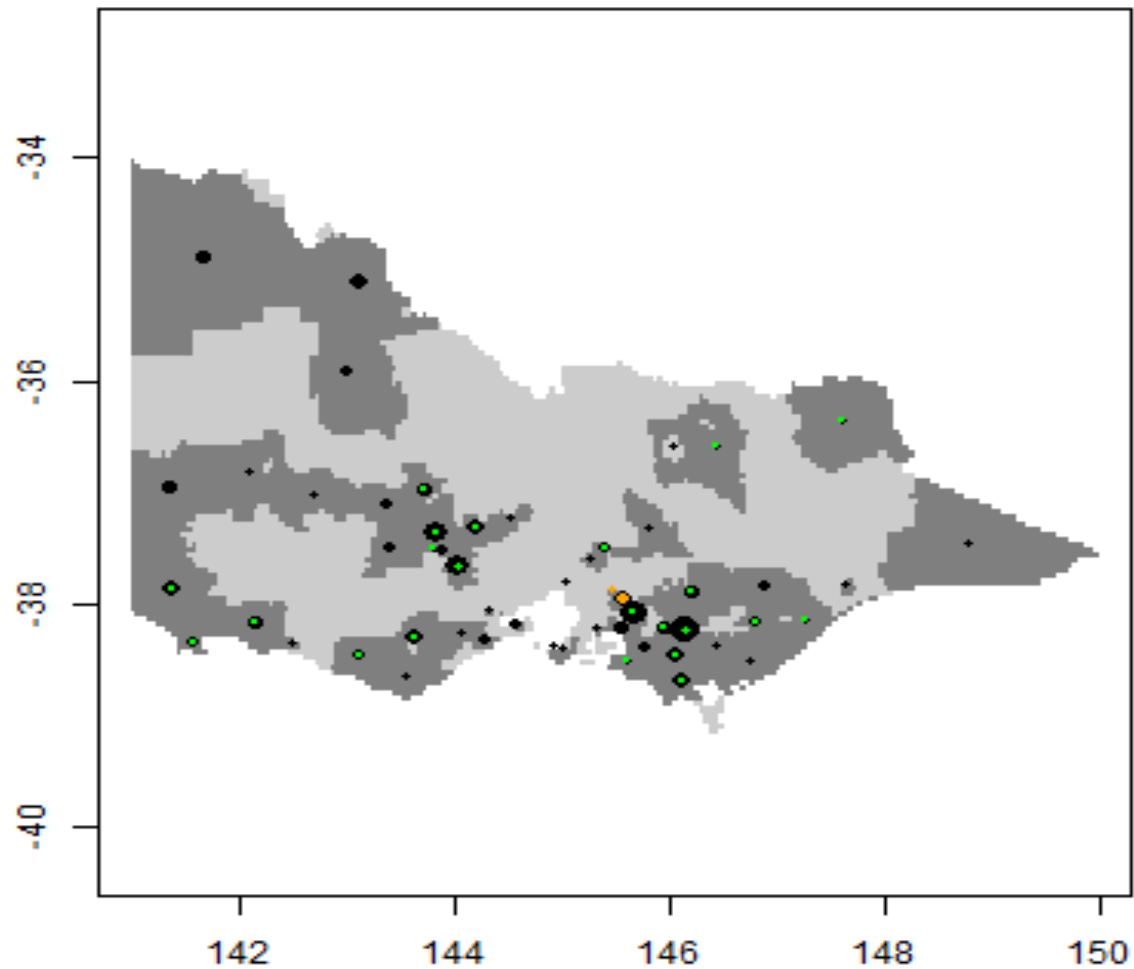0 40 80 160 Kilometers
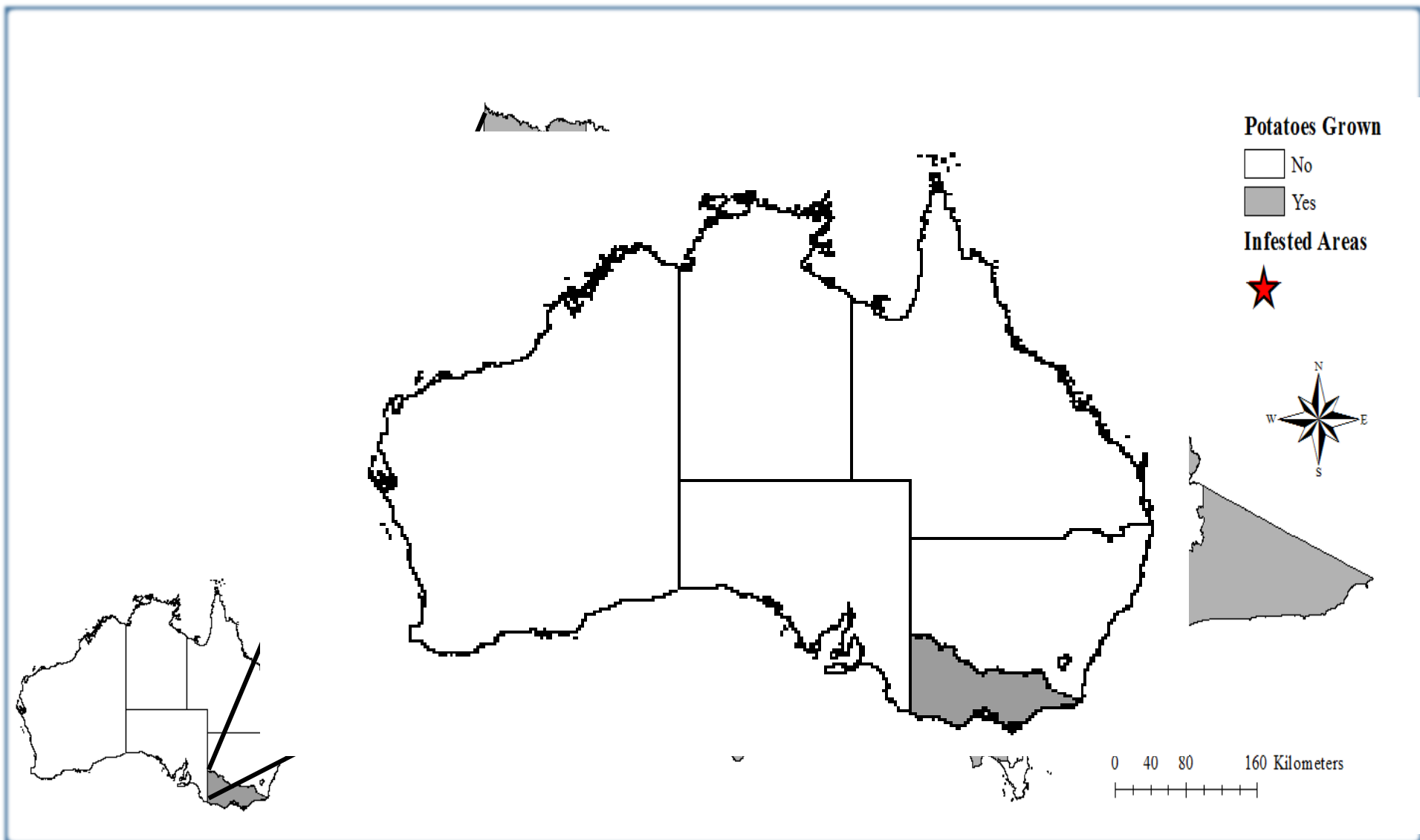
Network – Potato Production

- Areas
  - Fields
- Movement
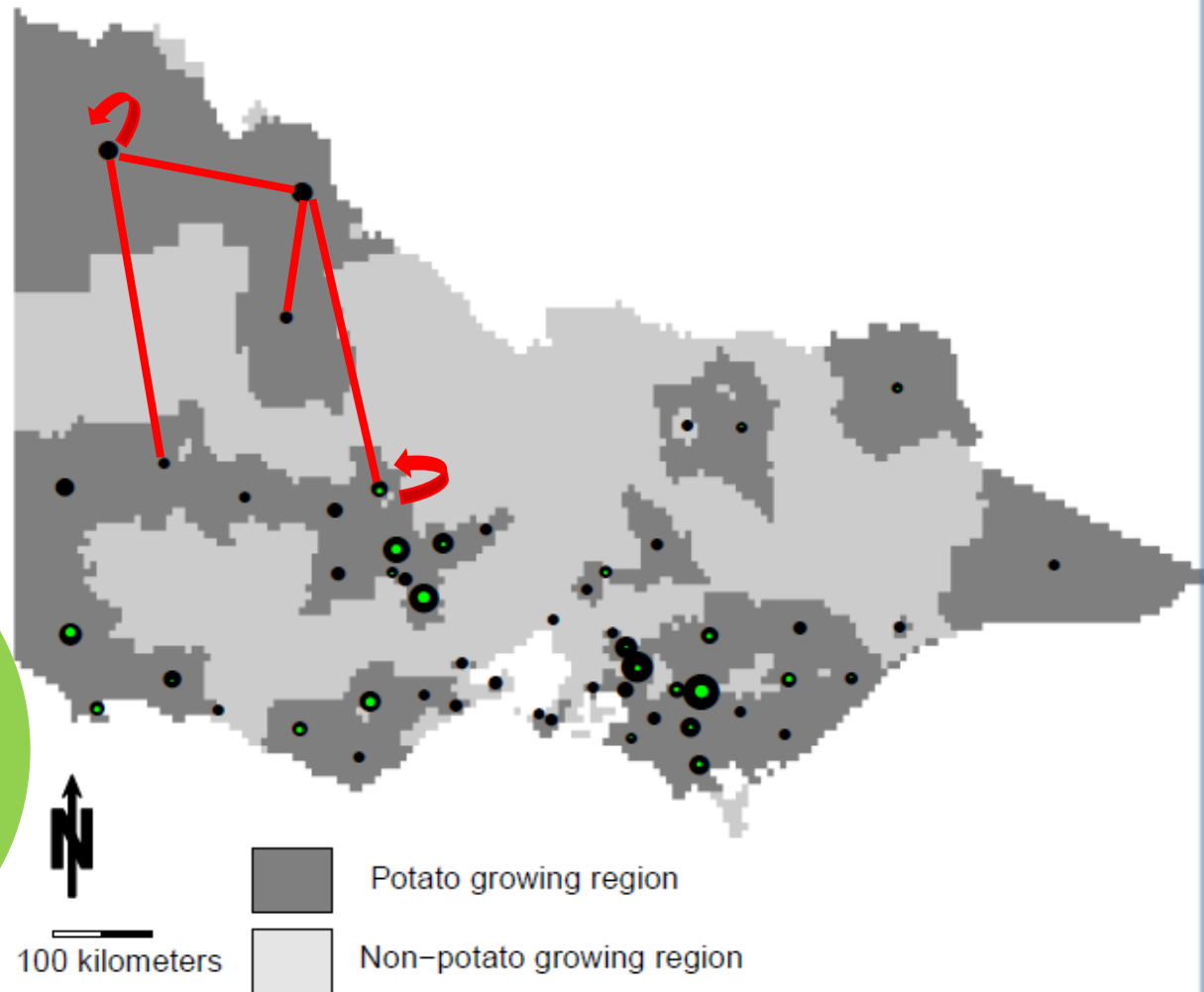
PCN Spread Simulations

Year: 1

Surveillance Strategies

Quarantine - Field

- Random
- Sequential
- Distance based
- Network based

Quarantine - Area

- Distance based
- Network based

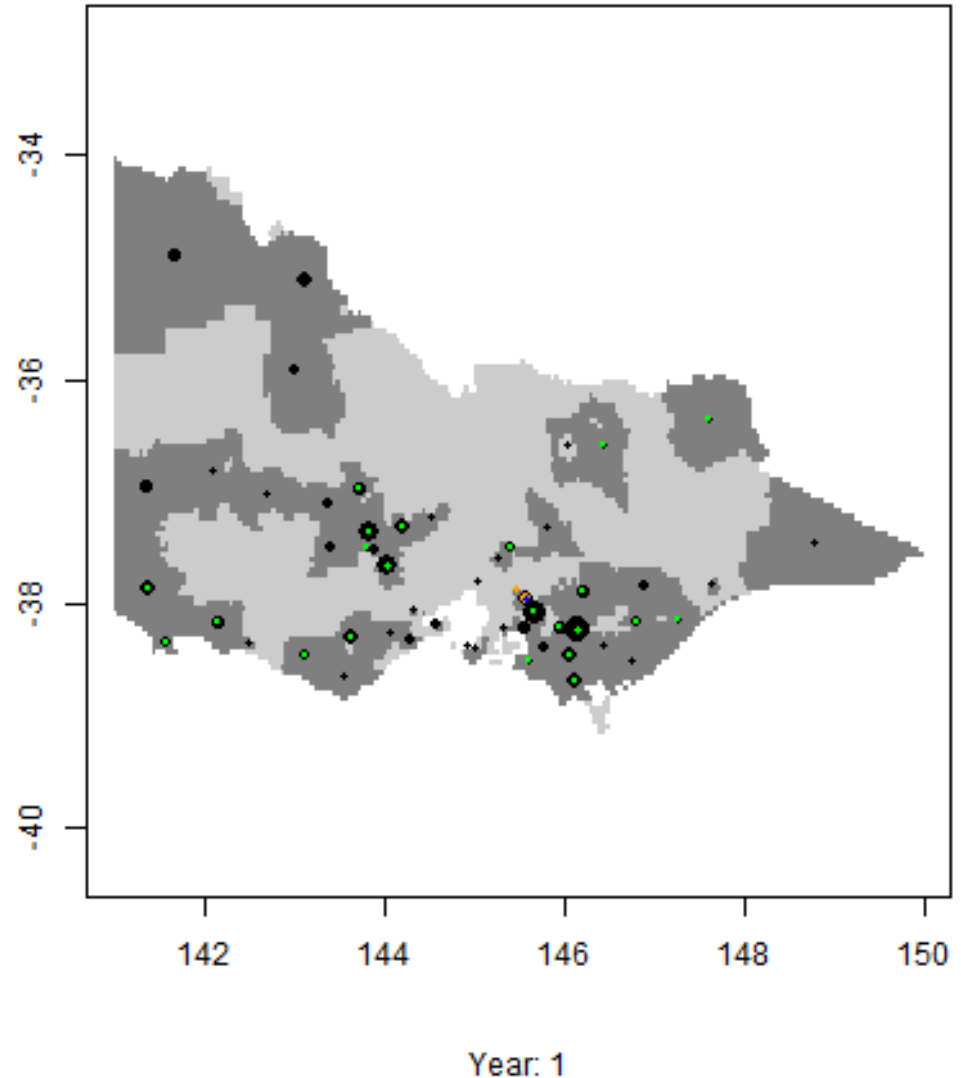https://www.agric.wa.gov.au/potatoes/area-freedom-potato-cyst-nematode

Surveillance Strategies

Targeted

- Infested areas and surrounding areas
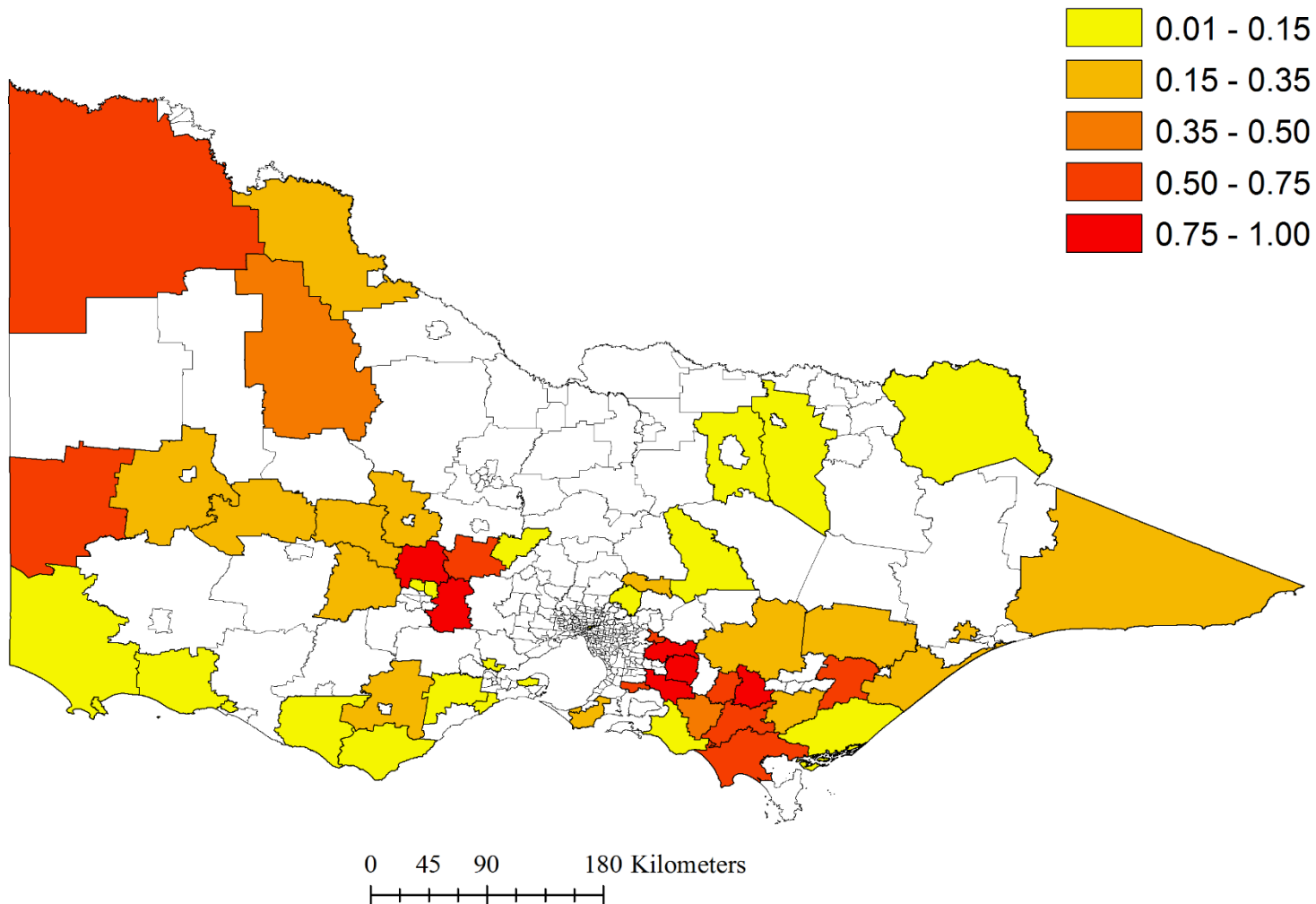
- Infested areas and the periphery of the region

. Hammeraas: http://www.bioforsk.no/ikbViewer/page/bioforsk/aktivitetskalender/aktivitet?p_document

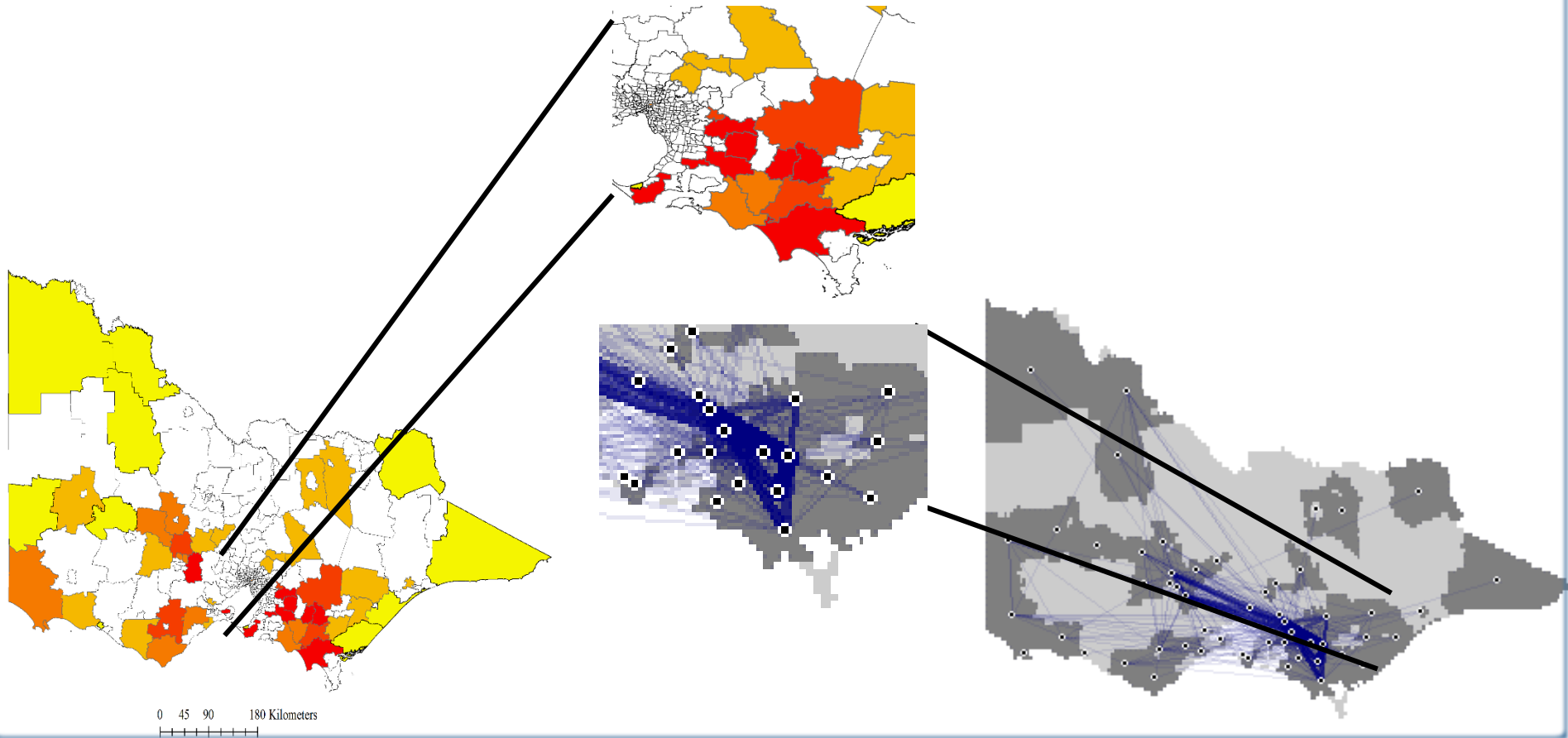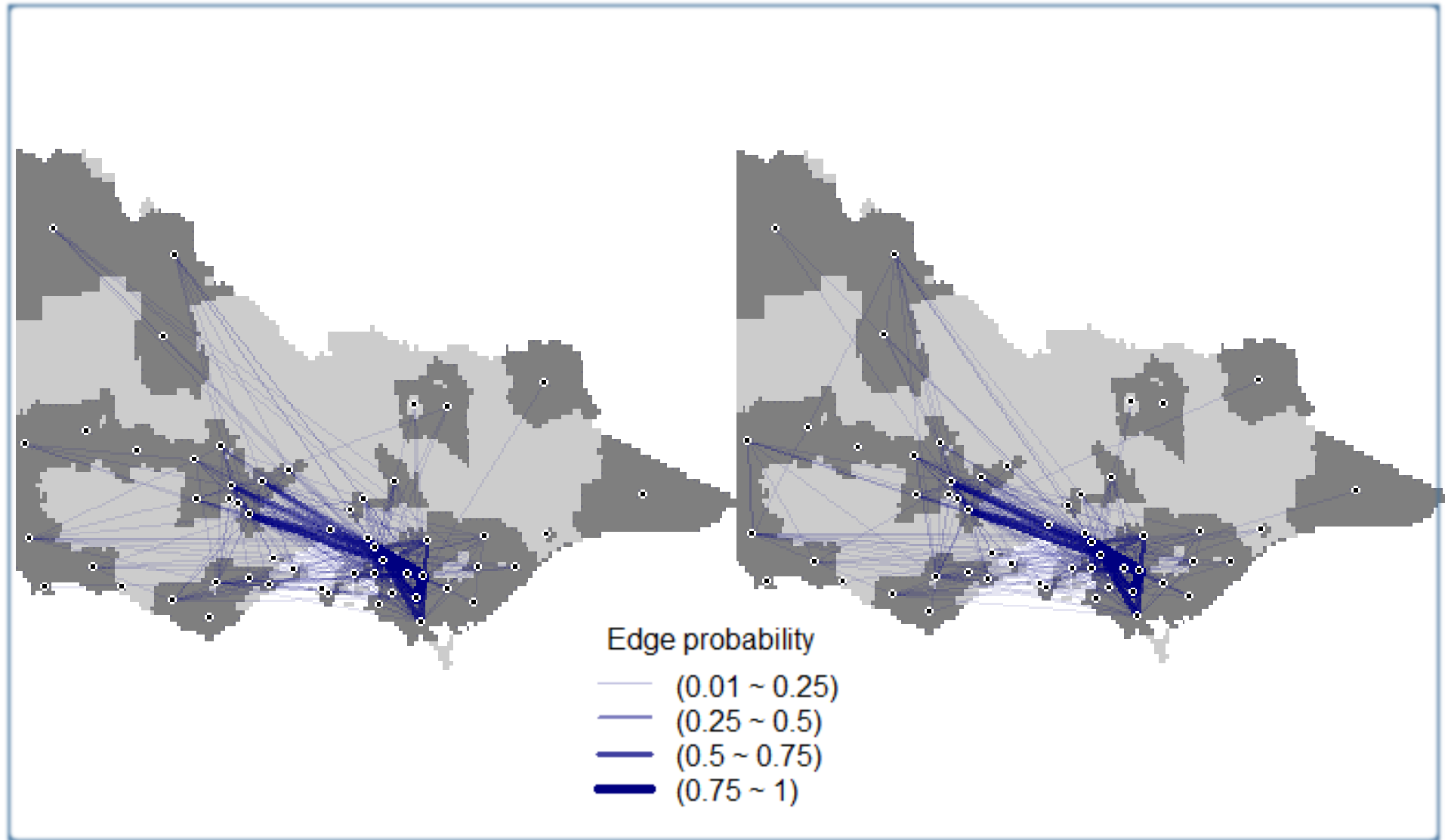# Spread + Surveillance

- Surveillance in detected areas

Infested   Detected

Year: 1

Probability of Infestation

Legend:
- 0.01 - 0.15
- 0.15 - 0.35
- 0.35 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00

0   45   90   180 Kilometers

Metrics

- Highly connected nodes ➜ feedback to surveillance

Random

Network based

Edge probability

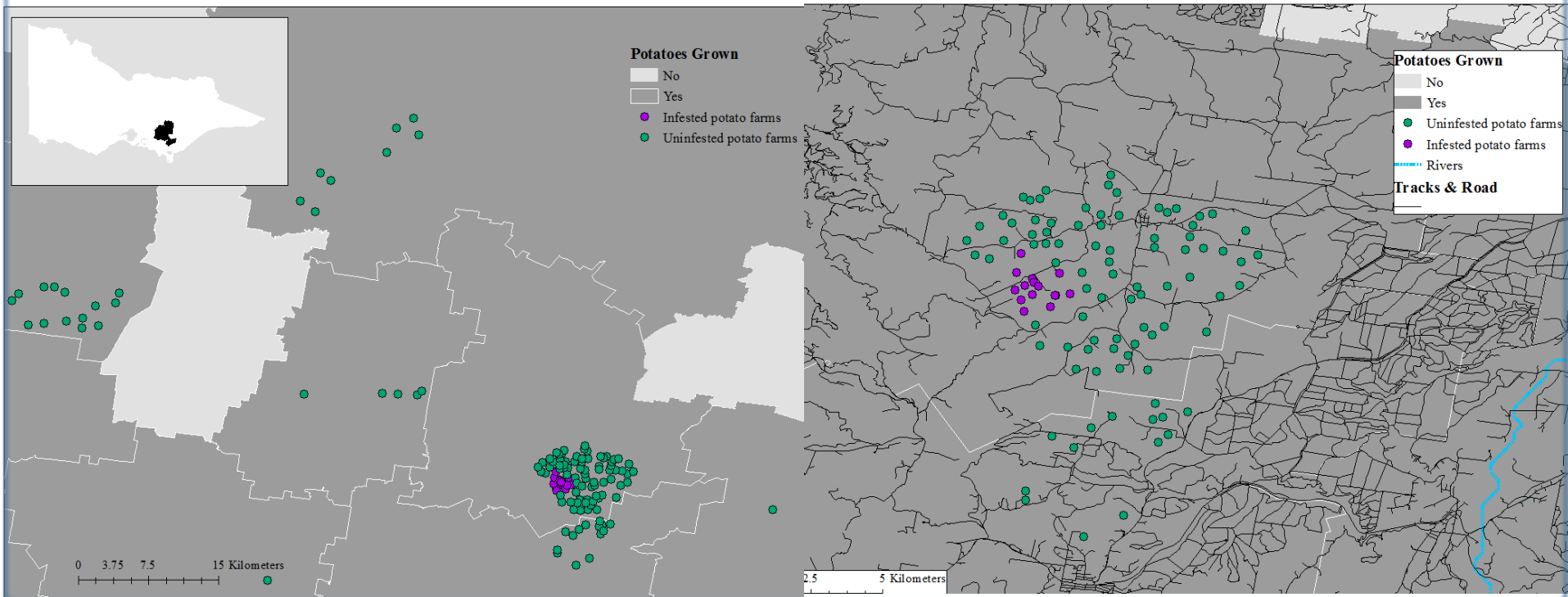(0.01 ~ 0.25)
(0.25 ~ 0.5)
(0.5 ~ 0.75)
(0.75 ~ 1)

Output

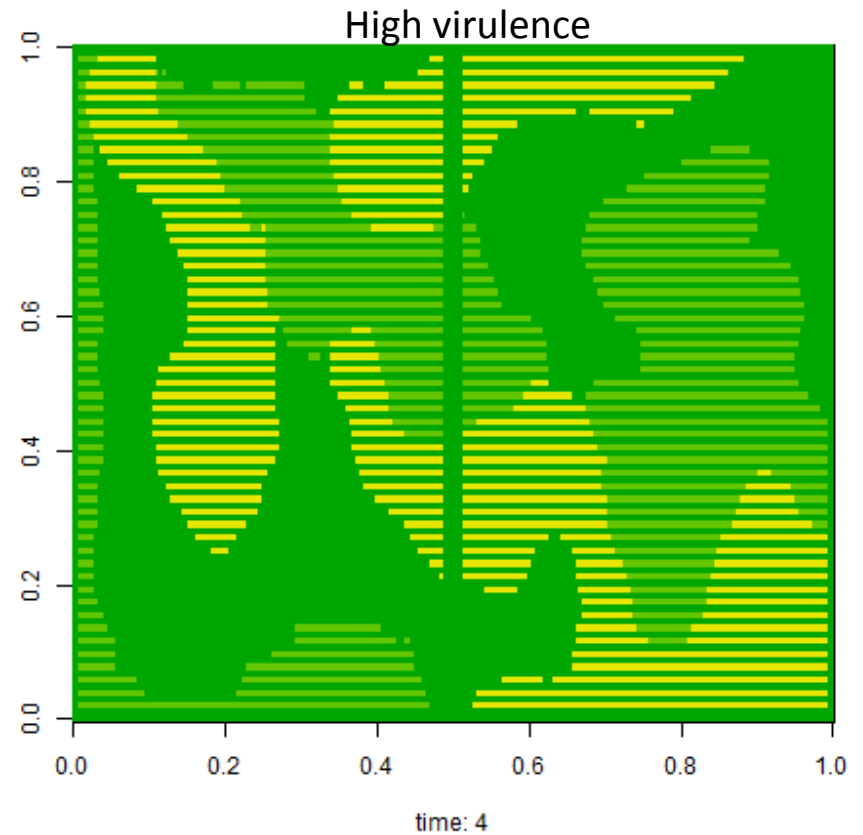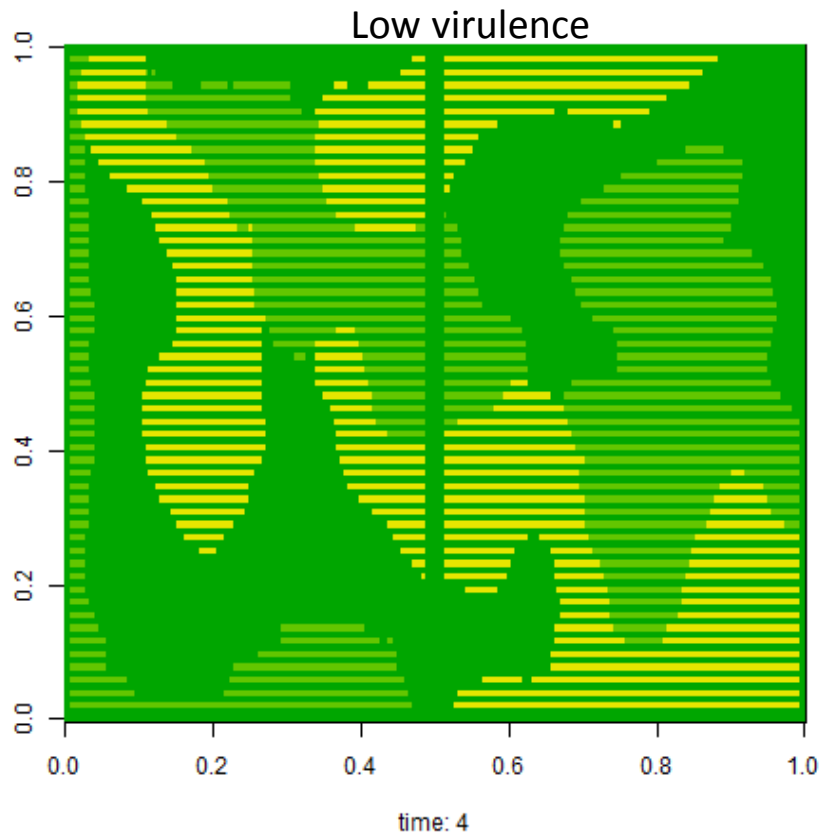- Detection vs infestation
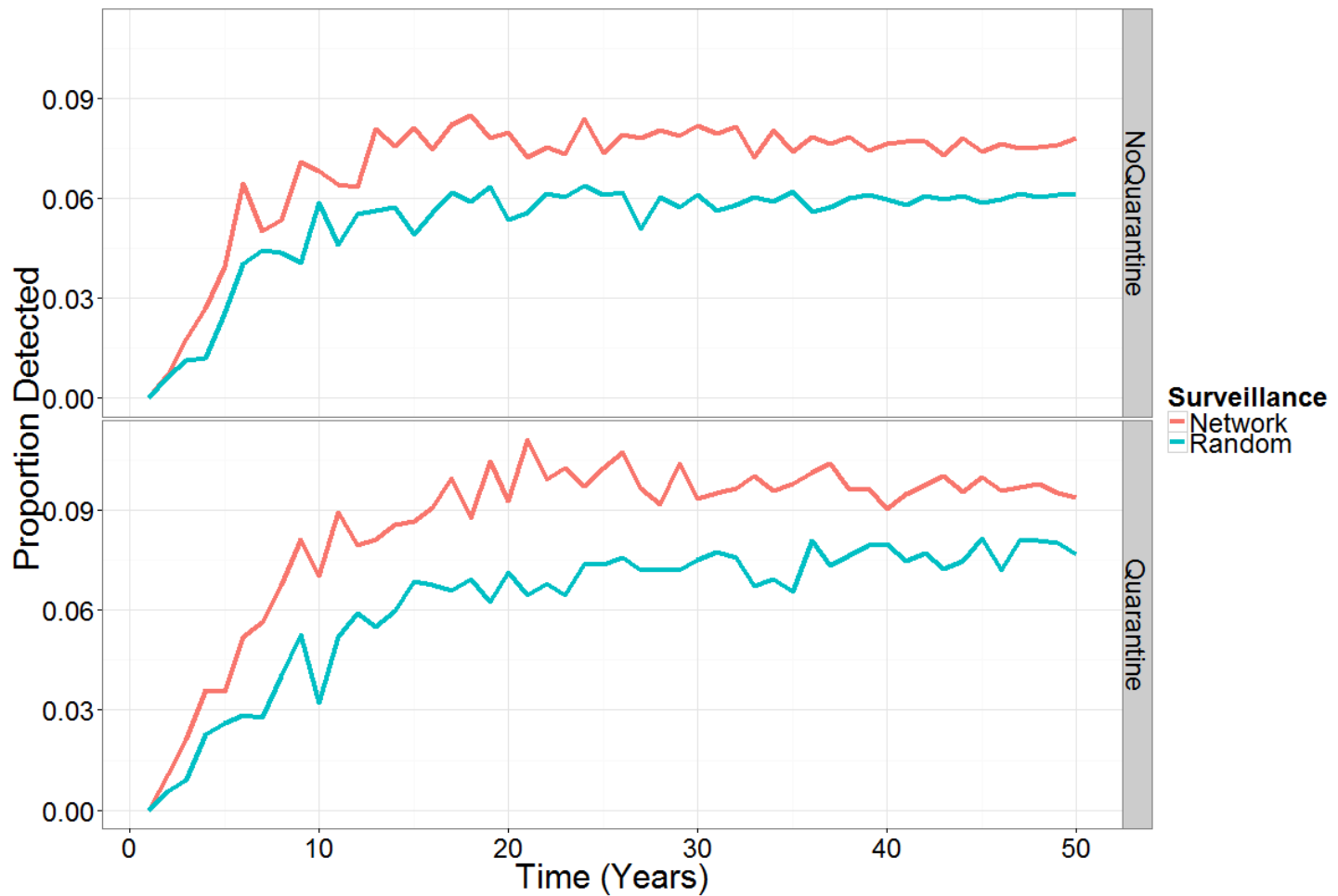
Conclusions

- PCN
  - Quarantine is essential to slowing spread
  - Focussed surveillance (distance or network based) may improve standard surveillance

- Network analyses + crop pest surveillance?
  - Data availability
  - Improve with detailed data?
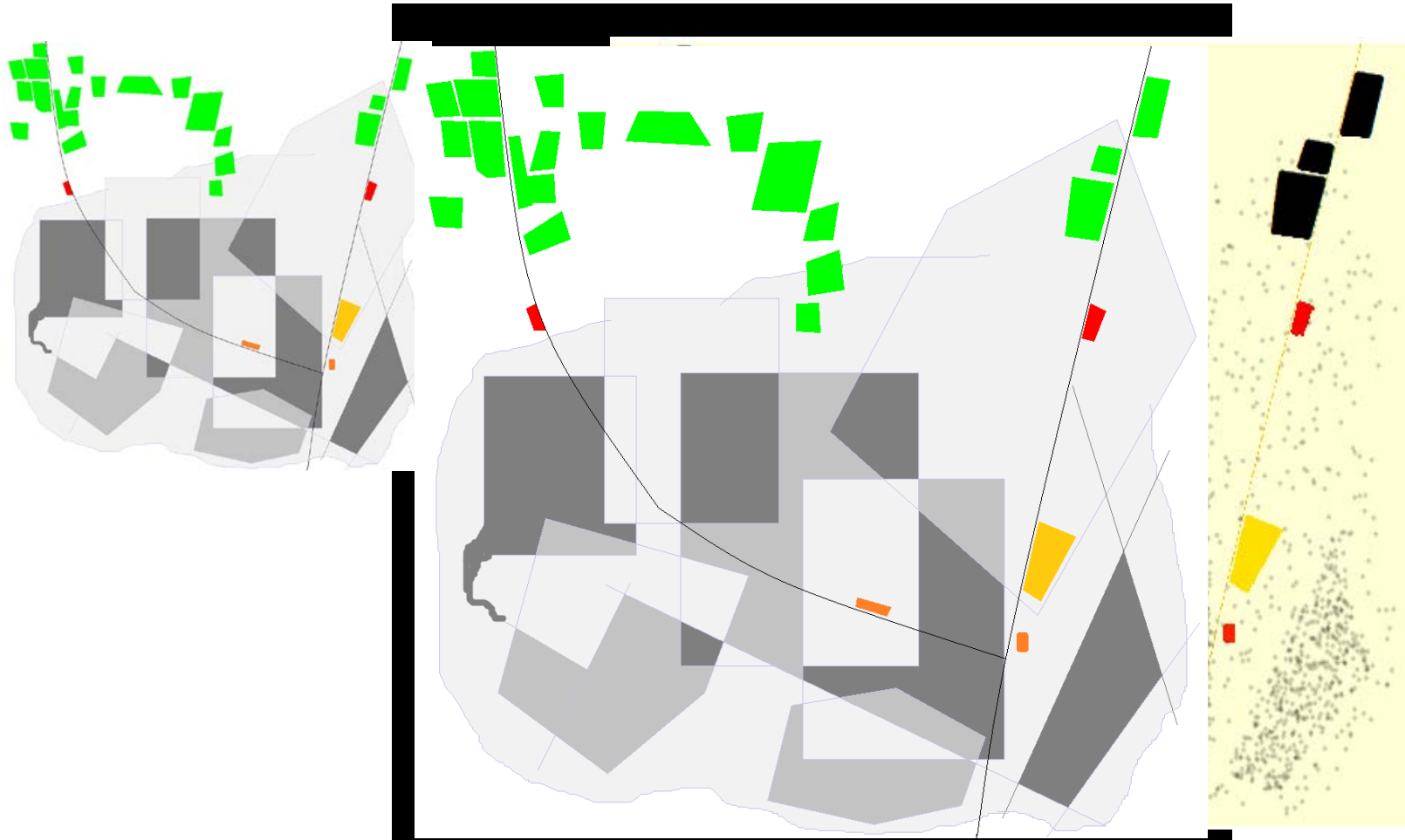   - Computational issues

Next Steps

- Detailed local spread
  - Individual farm locations; roads; waterways; linked properties

Grape Phylloxera

Mediterranean Fruit Fly

Thanks!