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

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)

- Solanaceae family hosts
- ≤ 0.5 mm
- 100-500 eggs
- Limited dispersal
- 1-2 generations/potato crop
- Live 20-30 years w/o host
- Rotation, resistant cultivars
PCN - World Distribution

Globodera rostochiensis (HETDRO)

(c) EPPO http://www.eppo.int
Network – Potato Production

- Areas
  - Fields
- Movement

Fresh

Seed

Map showing potato growing regions and non-potato growing regions.
PCN Spread Simulations
Surveillance Strategies

Quarantine - Field
- Random
- Sequential
- Distance based
- Network based

Quarantine - Area
- Distance based
- Network based

Targeted

• Infested areas and surrounding areas
• Infested areas and the periphery of the region
Spread + Surveillance

- Surveillance in detected areas
• Highly connected nodes ➔ feedback to surveillance
• 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

Low virulence

High virulence
Mediterranean Fruit Fly
Thanks!