Towards an Integrated Network-based Approach to Modeling the Dynamics of Invasive Plant Pests

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Background

Globally, invasive alien species pose a growing threat to native ecosystems, health, food security and economic stability.

Problem

The dynamics of biological invasions, particularly pests and pathogens associated with agricultural crops, are influenced not only by biological and climatic factors, but also human-centric activities such as trade, travel, supply chains, agricultural practices, etc. How do we model such a complex phenomenon?

Challenges

Modeling invasive species dynamics requires
- expertise from various disciplines
- integrating data of different types and from multiple sources; incomplete and noisy
- integrating models that represent all possible pathways of spread
- more complex the model, the harder it is to calibrate, verify and validate

Our approach

We envision a modeling paradigm for building realistic models of spread
- Includes both ecological and anthropogenic factors
- Data-driven
- A multi-resolution causal model
- Multi-layered network based approach

Case study

The framework is presented in the context of a representative pest, the South American tomato leafminer.

Goals

What is this approach intended to achieve? How is it different from existing methods?
- Provide causal explanations: possible pathways of entry, reasons for spread
- Enable studying various policies: farm level interventions to trade restrictions
- Guide economic impact assessment

The South American tomato leafminer *Tuta absoluta*

- A devastating tomato pest
- Found in packaging material, and survives harsh winters and summers in greenhouses
- 50-100% crop loss
- Attacks other plants in the Solonese family: potato, eggplant, pepper, tobacco.
- Health costs: In Spain, in the first year of introduction, pesticides were applied 15 times per season.
- Financial costs: When *T. absoluta* invades rest of the world, the tomato pest management cost will go up by $500 M per year.
- Societal costs: In West Africa alone, more than 500,000 farmers make their living by growing tomatoes.

Leveraging diverse data types

- geographic distribution of crop production
- biology of the pest, host
- climate
- import, export
- domestic logistics
- market prices
- surveys

Computational problems of interest

This approach has the potential to raise new questions which could be of interest to the data mining community. Also, several well-studied research topics can be revisited from the perspective of plant disease epidemiology. Some examples are as follows:

- network inference
- community detection
- optimal quarantining
- optimal placement of traps
- link prediction