Predicting Regional Invasion Dynamic Processes (PRIDE)

A Functional trait based, multi-scale research framework

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Macrosystems Biology
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1. Motivation

- Invasive species have significant ecologic and economic impacts
- Knowledge of macroscale invasion patterns and processes are limited, and support for many long-standing invasion hypotheses is declining due to:
  1) A single or limited species approach fails to capture the cross-taxonomic, trait-based generality and interactions
  2) Few studies have considered the interplays among all three ***invasion components*** (invader, recipient system, drivers)
  3) Neglecting complexities such as scale dependence, within and cross-scale interactions, emergences, and path-dependence to understand macrosystem patterns and processes
- Understanding the trait- and scale-dependency of invasion processes is critical to formulate novel invasion theories

2. Project Goal

To advance invasion theories using a trait-based, scale-dependent macrosystem invasion biology framework to:

- Improve mechanistic understanding and predictions of macroscale invasion
- Facilitate informed and proactive invasion management

3. Research Framework (Fig. 1)

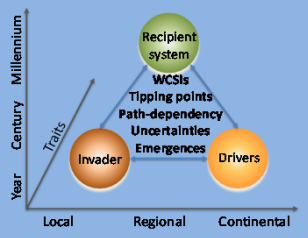


Fig. 1 Our trait-based, scale-dependent macrosystem invasion biology framework, which considers the complex within- and cross-scale interactions (WCSIs) among invader, recipient system, and socioeconomic drivers; the non-linear behavior and tipping points of key factors, path-dependency, and uncertainties in invasion process; and the emergence of large scale patterns from small scale patterns and processes.

4. Research Progress

4.1 Regional Databases

Invader	Recipient system
Plant traits [a]	Native plant traits [b]
Plant richness [a]	Native plant richness [b]
Bird richness [b]	Native bird richness [b]
Insect richness [a]	Native plant phylogeny [b]
Native ranges [b]	Bioclimatic data [a]
Historic plant distr.[b]	Physiographic data [a]
Invasion Drivers	
Disturbance (natural and human caused) [b]	
Land use / change (historical and future) [b]	
Network/transportation (ports, railroads, highways, postal routes) [b]	
Population (1790-2010) [b]	
Economic activity (Manufactures, Carload Waybill, etc.) [b]	

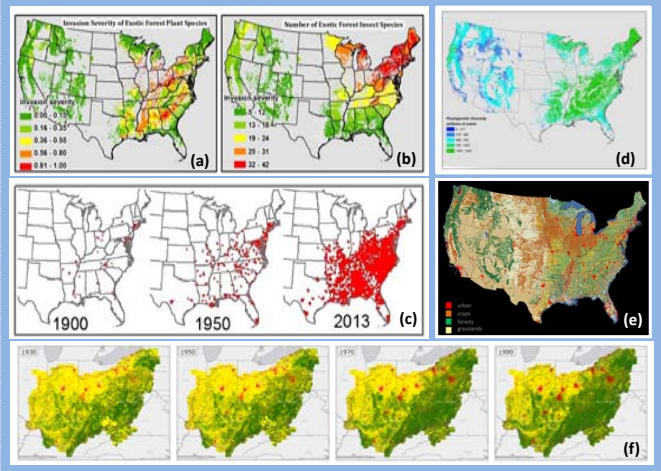
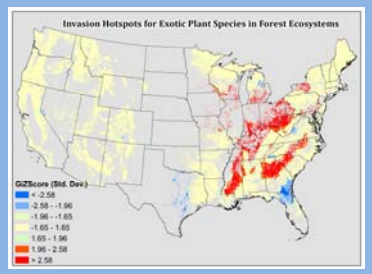


Fig. 2 Examples of region-wide databases: (a) invasive forest plants, (b) invasive forest insects, (c) temporal progression of invasive plant species from herbarium records (e.g. *Lonicera japonica*), (d) phylogenetic diversity of native tree communities, (e) land use and land cover, and (f) temporal changes in land use and land cover (e.g. Ohio River valley).

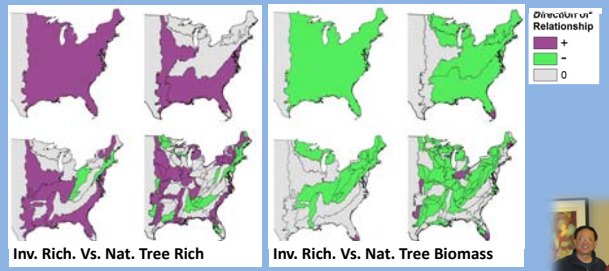
5. Key Results

5.1 Macroscale Patterns

- Greater invasion in Eastern vs. Western U.S.
- Strong relationship between invasion intensity and human land-use legacies at regional to national scales (e.g., Midwest, Piedmont)
- Pockets of low invasion still occur throughout the Eastern U.S.

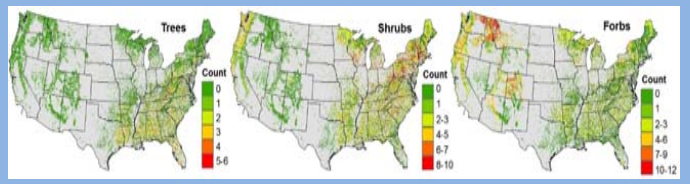


5.2 Scale Dependency



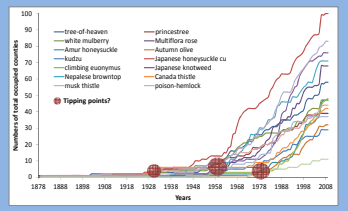
- The directions of associations between invasive plants richness and native tree richness (left) and native tree biomass (right) changes as spatial scale decreases.

5.3 Traits Dependency



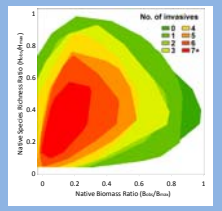
- Functionally similar invaders exhibit similar regional invasion patterns

5.4 Non-linearity



- Invasion spread is a non-linear process
- Correlation was found between major social events and invasion spread

5.5 Pattern Emergence



- Higher native biomass and richness ratios results in lower invasion
- Biomass plays a more important role in reducing invasion potential than richness

6. Future Directions (Phase II)

6.1 Research Questions and Hypotheses

Q1. Are some regions more vulnerable to invasion than others, and what cross- and within-taxonomic generalizations can be made about these patterns?

H1: Functionally similar invaders (regardless of taxonomic classification) exhibit similar historical and contemporary regional invasion patterns

Q2. What are the underlying processes that lead to the emergence of the spatiotemporal invasion patterns identified in Q1, and can we identify the key within- and cross-scale interactions and thresholds/tipping points in invasion processes?

H2: Ecosystem resistance to invasion is strongly impacted by within- and cross-scale interactions among biotic and abiotic factors.

H3: There exist tipping points where small spatiotemporal scale drivers are negated by larger scale drivers and vice versa