Spatial-Dynamic Processes & Environmental/NR Economics

SHaPE Seminar · 28 October 2008

Outline

• Spatial analysis in Environmental & NR Econ
• Wilen’s AAEA Fellows Lecture
  – Big picture:
    • Concepts—diffusion/dispersal processes, nature of space
    • Role for economic analysis

• Spatial analysis as an extension of my current research
Spatial Analysis in Env. & NR Econ

- Limited to date...low-hanging fruit in abundance?
- Hedonic property value literature most developed
- Spatial management of renewable resources
  - Optimization-based analysis
  - Limited empirical work to date

“Spatial-Dynamic” Problems

- “…process generates potentially predictable patterns that evolve over space an time.”
- Sea level rise from global warming essentially “exogenous” b/c biophysical forces already in play
- “Endogenous” processes are influenced by individual decisions at points in space-time
  - Forest fire spread as example
Economic and Policy Questions

• Not just inherently interesting systems...

• Predictive questions:
  – How will sea level rise affect people in low-lying areas?
  – Homeowner behavioral reactions to prospect of fire

• Prescriptive/normative questions:
  – Can we influence (control) this process?
  – Can we mitigate impacts?

S-D Processes Link Economic Actors

• Bio-invasions
  – Influenced by both endogenous and exogenous factors

• Metapopulations
  – Discrete subpopulations (“patches”) that are connected/interact
  – “Patch-specific factors” + systemwide connectivity

• Human and animal disease
  – The global pattern of flu cases and countries’ seasonal dynamic patterns
  – Global public goods
Why are these interesting problems?

1. Problems of this kind seem to be becoming more prevalent
   - Role of globalization (?)

2. “Knowledge explosion” about spatial processes in the sciences
   - Remote sensing, GIS, computational advances
   - “hard sciences” are paying attention...economists not so much

Facets of Spatial-Dynamics

- Diffusion/dispersal process
  - Fick's Law: “spatial diffusion at location X is proportional to the spatial gradient at X”

- Nature of space
  - Boundaries—biophysical reasons, habitat quality, geopolitical
  - Geometry—featureless plain, corridor
  - Heterogeneity—landscape = mosaic of human uses; targeting

Figure 1. Special spatial modeling issues
Diffusion/Dispersal Processes

\[
\frac{\partial C(X, t)}{\partial t} = \frac{\partial}{\partial X} \left[ D \frac{\partial C(X, t)}{\partial X} \right] = D \frac{\partial^2 C}{\partial X^2}.
\]

\(C\) = concentration  
\(X\) = location  
\(t\) = time  
\(D\) = diffusion coefficient (rate of spatial flow)

“...particles will flow from high to low density areas...initial concentration spreads over space and time”

Challenges

- PDEs not familiar to most resource economists
- Variety of diffusion models—varying levels of complexity
- Two ways to build understanding  
  - Construct numerical models of complex systems  
  - Start w/ simple models, add detail as we go
Economic Example: Bio-invasion

Geometry: corridor of fixed width

\( V \) = velocity of spread along length of corridor

Control costs incurred at each period influence velocity

\[ \min \int_0^T [\text{Damages} + \text{Control Costs}] e^{-\lambda t} \Delta t \]

Wilen’s Summarizing Points

• Generally optimal to initiate control actions at key places and points in time
  – Bio-invasion ex: early intensive control near invasion site

• “spillover benefits” from “keystone agents” go uncompensated, so “under-control”

• Local scale negotiation most likely in the presence of transaction costs, but benefits extend far beyond
Why do I care?

• Metapop. dynamics + Behavioral dynamics = Jointly-determined economic and natural systems
  – Livestock disease management work

• Is space important for
  – policy (mechanism) design?
  – markets for environmental goods and services?