Space: The Final Frontier in Resource Economics Comments on Smith, Wilen and Sanchirico

Stephen Polasky
University of Minnesota

Role of Space in Environmental and Resource Economics

- Classic resource economics problem formulation: optimal use of resource over time ("when")
- Biophysical processes happen in space: "where" matters as well as "when"
- As SWS point out – resource economics has not paid proper to attention to "where" questions

Spatial Models in Economics

- Long history of spatial modeling
  - Urban economics models: “where” development occurs across space is central issue. Solve for equilibrium land rents as a function of distance from central business district
  - von-Thunen models of the frontier development
  - Economic geography – transport costs & where to locate firms

Spatial Models in Economics: Some Recent Applications

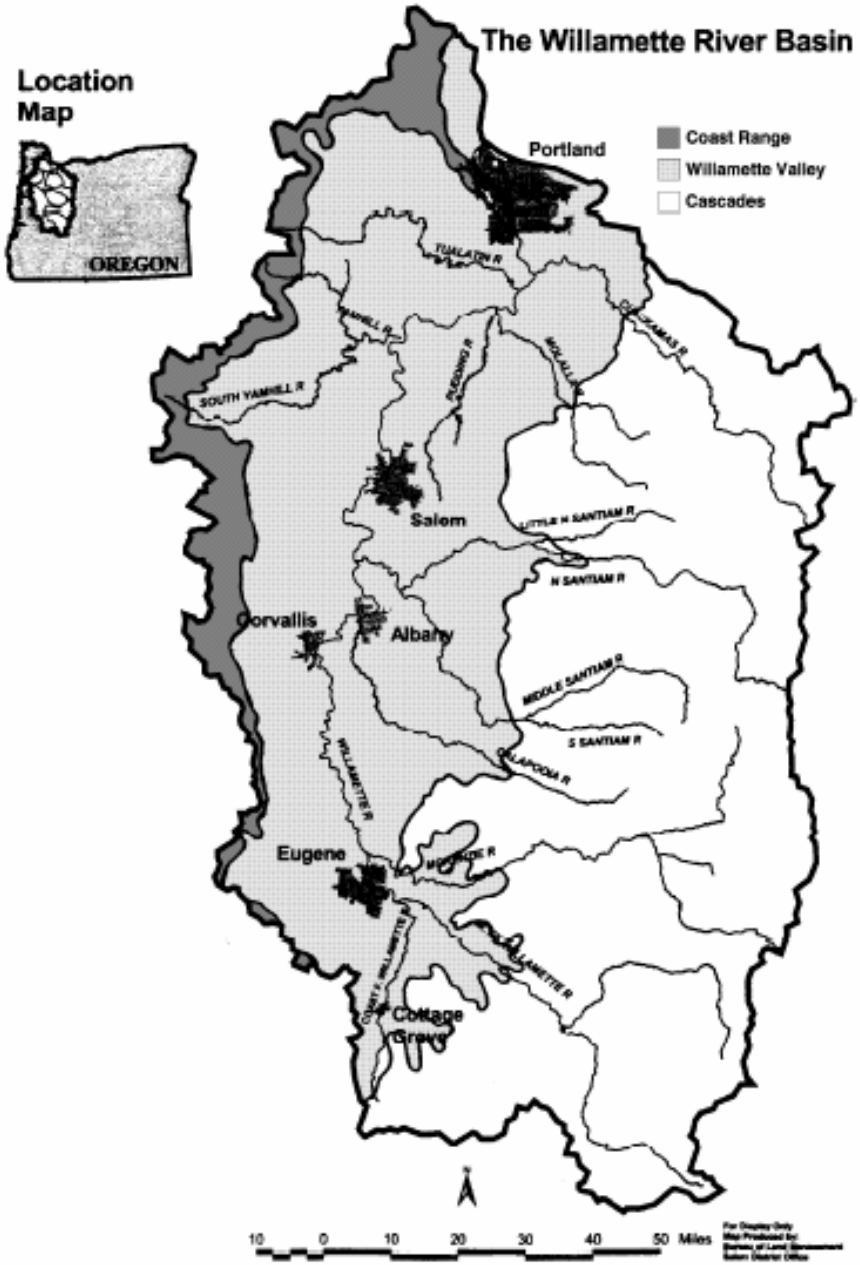
- Spatial agglomeration models (trade, urban-regional economics)
- Interactions in local land use decisions (Bockstael, Irwin and others)
- Integrated economic and biophysical modeling
  - Water quality/quantity models
  - Air quality models
  - Habitat/species conservation models
- And many other examples…

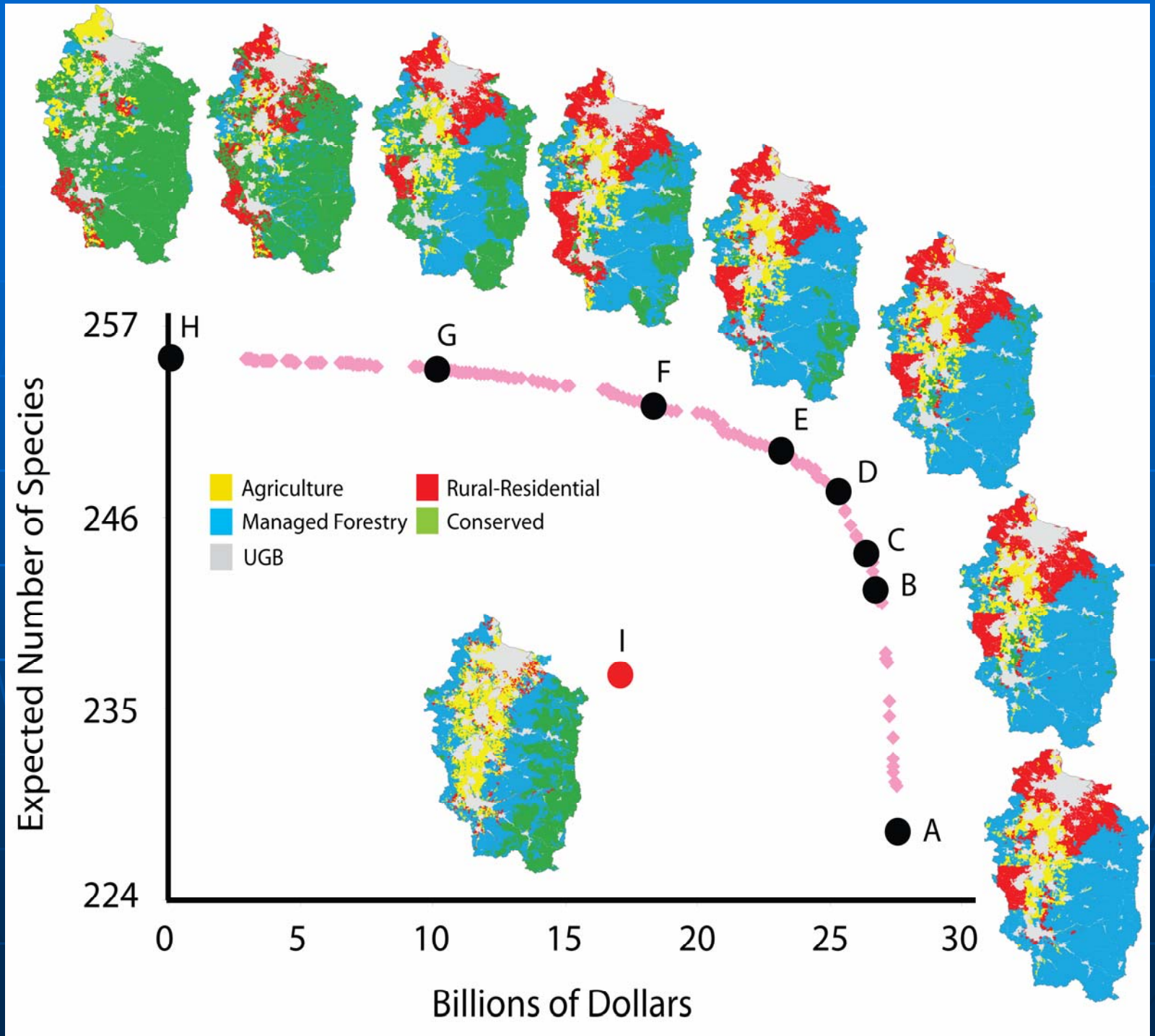
Where to Put Things: Spatial Land Management with Biological and Economic Objectives

Polasky, Nelson, Camm, Csuti, Fackler, Lonsdorf, White, Garber-Yonts, Haight Kagan, Montgomery, Starfield, & Tobalske

Land Uses and Objectives

- Consider 9 land uses in the Willamette Basin
  - row-crop agriculture
  - orchard/vineyard
  - Pasture
  - grass seed
  - 45-year rotation managed forestry
  - rural-residential development
  - conservation to create the dominant potential natural vegetation in the parcel
  - conservation to recreate conditions at the time of European settlement in the parcel
  - conservation to maintain 1990 land cover conditions in the parcel
- Objective: maximize species persistence on landscape (267 terrestrial vertebrate) for a given economic return
  - Production possibilities frontier


The Willamette River Basin
Location Map
OREGON
Portland
Coast Range
Willamette Valley
Cascades
TUALATIN R
YAMHILL R
SOUTH YAMHILL R
PUDDING R
MOLALLA R
CLACKAMAS R
Salem
LITTLE N SANTIAM R
N SANTIAM R
Corvallis
Albany
MIDDLE SANTIAM R
S SANTIAM R
CALAPOOIA R
WILLAMETTE R
Eugene
McKENZIE R
COAST FK WILLAMETTE R
MAIN WILLAMETTE R
Cottage Grove
10 0 10 20 30 40 50 Miles


Expected Number of Species
257
246
235
224
0
5
10
15
20
25
30
Billions of Dollars
H
G
F
E
D
C
B
I
A
Agriculture
Rural-Residential
Managed Forestry
Conserved
UGB

Added Dimensions from Spatial Analysis

- Adding space complicates the analysis
- Does adding space result in new insights?
  - Produce nice maps
  - Much policy relevant work depends on being able to say where things should happen
  - However, do we get qualitatively different results?
- What are the new insights from spatial models that we cannot get from non-spatial models?

Outline of Remaining Comments

- Theory
- Empirics
- Policy and management

Theory

- Why is incorporating space into resource economics models difficult ?
- Space by itself is not necessarily difficult (e.g., standard urban economics model)
- Resource economics: inherently dynamic. Typically interested in use of resource through time
- Spatial resource model must incorporate both integration over space and time
  - Presents technical challenges (e.g., partial differential equations rather than ordinary differential equations)

Modeling Approach: Continuous Diffusion Process

- Limited analytical results
  - Fisher Reaction-Diffusion Equation: density dependent growth at every place and simple diffusion across space
  - "This equation is impossible to solve in closed form…"
- If we use continuous diffusion processes for resource economics applications, we will need to move to numerical analysis
  - Standard approach in natural sciences dealing with spatial-dynamic processes
- Continuous diffusion process is appropriate for modeling certain processes such as spread of biological population or pollutant through an aquifer
- But not universally applicable: only one of a range of spatial models that may be of interest

Modeling Approaches:
Alternatives to Continuous Diffusion

- Discrete models
  - Metapopulation dynamics with discrete sites
  - Patch models of Sanchirico and Wilen (used for empirical application)
- Accurately modeling links across space – what is the mechanism?
  - Economic: price effects (e.g., leakage effects in carbon markets)
  - Biophysical
    - Non-linear (threshold responses)
    - Complementarity (e.g., species overlap in reserve site selection)

Summary

- Wide range of possible models and issues
  - Beyond harvest models
  - Pattern of development or other spatial issues...
- Need more applications on a broader set of spatial topics
- SWS: “Task will then be to synthesize and generalize conclusions...”
- I agree – what are the most important set of conclusions derived from spatial analysis?

Empirics

- Most novel part of the paper
- Some cases where it is difficult to observe underlying biophysical model
- SWS ask: “Can we observe human users of spatial-dynamic marine system and infer anything about the underlying biological structure generating their behavior?”

Empirics

- Random utility model of site choice
- Schaefer harvest function
- Use this to estimate structural parameters of the “true” biological relationships (intrinsic growth rate, diffusion coefficients...)

Empirics

- Are we likely to get better estimates of biophysical structure (diffusion, growth…) by direct observation or inferring from economic behavior?
- Direct observation – capture-recapture study, models of currents and larval dispersal…
- Indirect inference: fisheries log books are valuable source of data, but must have accurate economic model
  - Does the Schaefer model fit?
  - Errors in log book entries?

Summary

- Nice extension of the non-spatial work using catch-per-unit-effort to make inference about the size of the biological resource stock
  - Clever use of aggregate data in first stage and individual data in second stage to estimate economic and biological parameters
- Simple version of the model – numerous important extensions to consider
- Application to real fisheries:
  - What complications need to be incorporated?
  - How well does method work?

Policy and Management

- Connections between actions in one place to consequences elsewhere
  - Physical consequences:
  - Economic consequences: Example “leakage” in carbon markets
- New phenomena
  - Spatial differentiation of activities
    - Multiple site harvest model: possibility of closing some sites (biological reserves)

Policy and Management

- Combining spatial issues with dynamics
  - Increasing returns to scale
    - Biological – core areas
    - Economic – agglomeration economies
  - Sequential decision-making –
    - Likely to generate history-dependent outcomes
- What are optimal policy and management in such cases?
- We truly are on a frontier that should be explored further