GIS, Spatial Analysis and Maps: Essential Tools for the New Urban Scholar’s Toolbox?

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Introduction

- Geospatial data sources have become widely available
- Huge amount of data available online that can be related to these geospatial sources
- Many new analytical methods have been proposed
- These new methods and data sources provide numerous opportunities to advance social science theory and/or empirical work

Geographic Information

- Information about places on Earth’s surface
- Knowledge about where something is
- Knowledge about what is at a given location (at a given time?)
- Tells us “what is where when”

Geospatial Data Sources

- Points
- Grids
- Vectors
- Maps
- Imagery

Collaborators

- Alyce Belonis
- Jed Fehrenbach
- Bill Fulton
- Craig Knoblock
- Christina Li
- Travis Longcore
- Christine Ryan
- Cyrus Shahabi
- Jennifer Wolch
- Yan Xu

Outline

- Geospatial Data Sources
- Spatial Social Science
- Urban Applications
  - Urban Growth Modeling
  - Distribution of Green Cover
  - Role / Value of Nature’s Services
  - Park Equity Mapping
- Discussion and Future Work
Geospatial Data Sources

- Points
- Grids
- Vectors
- Maps
- Imagery

Semi-structured Data Sources

- Property tax records
- Telephone books
- Transit schedules

Geospatial data sources have become widely available
Huge amount of data available online that can be related to these geospatial sources

What is a GIS?

- One of several Geographic Information Technologies
- Others include –
  - Global Positioning Systems
  - Remote Sensing platforms
  - Electronic measurement and monitoring systems
  - Various types, forms of computer models
- You would know when a computer was being used for GIS because the data stored in it would include maps and images

Spatial Analysis

- Many established techniques
  - Buffers
  - Overlays
  - Terrain analysis
  - Network analysis
- New developments
  - Cellular automata
  - New forms of statistical analysis, including geographically weighted regression
  - Kriging and several other related geostatistical techniques
**Visualization**

Weighted area of 10,727 commercial parcels in Columbus, Ohio, used to generate this opportunity density surface.

*Slide courtesy of Mei-Po Kwan, Ohio State University*

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**Visualization (2)**

Diagram shows space-time paths of African-American women in Portland Activity-Travel Survey (Oregon, 1994-95) dataset.

*Slide courtesy of Mei-Po Kwan, Ohio State University*

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**Urban Growth Modeling**

- Used California Urban and Biodiversity Assessment (CURBA) model developed by John Landis and colleagues at University of California-Berkeley
- Model incorporates an Urban Growth Sub-model and a Policy Simulation and Evaluation Sub-model
- Model makes use of ArcView, SAS, and FRAGSTATS

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**Ventura County**

- Unique approach to growth
  - “Guidelines for Orderly Development” and Spheres of Influence
  - Williamson Act
  - Save Open Space and Agricultural Resources (SOAR) boundaries enacted from 1995 to 2000
- Most of 756,400 residents in 2000 spread among ten cities
- Nearly 20% of county and 70% of land inside city limits was developed in 2000

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**Ventura County (2)**

- Northern two-thirds of county is part of Los Padres National Forest
- Open space / conversation efforts in south-eastern part of county focus on Santa Monica Mountains National Recreation Area
- County leads nation in lemon production and produces large quantities of other fruits and vegetables

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**Research Questions**

- How is the spatial pattern of growth likely to vary under different local policy constraints if population is increased by 25% in next 15-30 years?
- How sensitive are farmland and natural vegetation cover types to these urban growth patterns?
Urban Growth Sub-Model

- Utilized series of multinomial logit regression models to explain past land use change in terms of several site-specific variables derived from GIS data layers, such that ...
  \[ Y = f(X_1, X_2, X_3, \text{etc.}) \]
  where \( Y \) = land use change from 1986 to 2000 and \( X_1, X_2, X_3, \text{etc.} \) are explanatory variables derived from series of ArcView GIS themes
- Site variables included land cover, political status, slope, distance to nearest freeway, percentage of neighboring cells that are urbanized, etc.

Policy Scenarios

- No Constraints
  - Growth permitted anywhere except for designated open space & parks
- Environmental / Farmland Protection
  - Growth prohibited on environmentally sensitive lands (i.e. steep slopes, wetlands, floodplains), farmland, designated open space & parkland
- Compact Growth
- Compact Growth / Farmland Protection
- Compact Growth / Environmental Protection
- Full Constraints
  - Growth prohibited outside SOAR boundaries and on environmentally sensitive lands, farmland, designated open space & parkland inside these boundaries

Urban Growth by Political Unit

<table>
<thead>
<tr>
<th>Political Units</th>
<th>Available land</th>
<th>Land Conversion Predicted Under Different Scenarios</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>#1</td>
<td>#2</td>
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<tr>
<td>Camarillo</td>
<td>2,890</td>
<td>240</td>
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<tr>
<td>Fillmore</td>
<td>635</td>
<td>20</td>
</tr>
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<td>Moorpark</td>
<td>2,660</td>
<td>700</td>
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<td>Ojai</td>
<td>425</td>
<td>15</td>
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<td>Oxnard</td>
<td>4,175</td>
<td>795</td>
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<td>Port Hueneme</td>
<td>55</td>
<td>5</td>
</tr>
<tr>
<td>Santa Paula</td>
<td>660</td>
<td>10</td>
</tr>
<tr>
<td>Simi Valley</td>
<td>8,010</td>
<td>5</td>
</tr>
<tr>
<td>Thousand Oaks</td>
<td>14,205</td>
<td>68</td>
</tr>
<tr>
<td>Ventura</td>
<td>1,965</td>
<td>90</td>
</tr>
<tr>
<td>County</td>
<td>414,710</td>
<td>2,275</td>
</tr>
<tr>
<td>Totals</td>
<td>450,330</td>
<td>25,215</td>
</tr>
</tbody>
</table>

Scenario #1

Scenario #3
Scenario #6

GAP Analysis Data

- Urban and agricultural land uses utilized 14 and 25% of the study area, respectively in 2000.
- Three sets of plant communities covered nearly 60% of the study area:
  - Venturan coastal sage (187,775 acres; 42%)
  - Six chaparral species (47,325 acres; 10%)
  - Non-native grasses (31,895 acres; 7%)
- Final 2% covered by various coastal and riparian forest and woodland cover types.

Vegetation Impacts

- Scenario #1:
  - 20 of 25 cover classes would suffer losses
  - Largest losses in relative terms would be dealt to farmland (15%), permanently flooded lacustrine habitat (15%), non-native grassland (7%), orchards & vineyards (6%), and Diegan coastal sage scrub (6%)
- Scenario #3:
  - 15 of 25 cover classes would suffer losses
  - Largest losses in relative terms would be dealt to coastal sage-chaparral scrub (40%), southern willow forest (13%), chamise chaparral (9%), non-native grassland (7%), and sandy areas (6%)

Implications

- Different urban growth policies would produce very different spatial patterns of growth in Ventura County in next 20-30 years.
- Different scenarios trade off varying proportions of farmland and natural vegetation cover to accommodate new growth.
- Enforcement of SOAR boundaries as urban growth limits would consume nearly two-thirds of potentially developable land and compromise future growth beyond 25% envisaged in this study unless densities are increased.

Distribution of Green Cover

- Parks, open space, and green vegetation are fundamental to livability of cities.
- A large and healthy green cover provides several of nature’s services:
  - Cooling and shading, carbon sequestration, air pollution removal, noise suppression, reductions in urban storm runoff, etc.
- Current study used two LANDSAT Thematic Mapper images (1/03) and Normalized Difference Vegetation Index (NDVI) to describe distribution of green cover in Los Angeles County.

NDVI

- Calculated from LANDSAT TM images using Band 4 (infrared wavelengths) and Band 3 (red wavelengths).
- These wavelengths measure amount of chlorophyll present at land surface.
- Computed values of NDVI range from -1 (few green plants present) to +1 (large numbers of green plants present).
- Final maps included 12,602,675 pixels measuring 28.5 m on a side.
Implications

- NDVI maps point to large variations in green cover – function of climate and land use, population density, and household income.
- Tendency for higher greenness values to be associated with wealthiest cities exacerbates environmental inequities because these areas also boast plentiful parks and greenbelts.
- Need creative strategies to reduce these inequities – utilizing vacant lots, alleys, under-utilized school sites, public or utility owned property, unnecessarily wide streets, riverbeds, etc.

Role / Value of Nature’s Services

- Citygreen software – ArcView extension distributed by American Forests.
- Calculates economic benefits of green cover for:
  - Carbon storage and sequestration
  - Air pollutant removal
  - Stormwater runoff reduction
  - Energy conservation
  - Wildlife habitat provision

Vermont / Hollywood Study Area

- Citygreen Sample Sites

- Hollywood (C)
- Sunset (C)
- Santa Monica (R)
- LACC (I)
- Virgil (I)
- Vermont (C)
**Study Area Metrics**

- 1,380 acres
- 50,000 residents
- 19,500 housing units (50% built before 1959)
- Current land uses
  - Residential
  - Business commercial
  - Institutional
- Very little green space

**ArcView Themes**

- Acquired digital orthophoto
- Built series of ArcView themes representing trees, grass, shrubs, buildings, etc.

**ArcView Themes (2)**

- Verified land cover types in field and collected additional plant attribute data

**CITYgreen Features / Attributes**

- TREE ID
- AREA
- PERIMETER
- PUB or PRIV
- SPECIES
- DIA (inch)
- TREE HEIGHT CLASS
- GROUND COVER:
  - SHRUB, GRASS, PAVED, SOIL, OR MULCH

**Sample Site Cover Statistics**

<table>
<thead>
<tr>
<th>Site</th>
<th>Area (acres)</th>
<th>Trees</th>
<th>Grass</th>
<th>Shrubs</th>
<th>Buildings</th>
<th>Paved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial</td>
<td>13.6</td>
<td>1.8%</td>
<td>2.7%</td>
<td>0.6%</td>
<td>30.0%</td>
<td>65.9%</td>
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<tr>
<td>Institutional</td>
<td>15.6</td>
<td>8.8%</td>
<td>13.1%</td>
<td>1.1%</td>
<td>26.7%</td>
<td>55.2%</td>
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<tr>
<td>Residential</td>
<td>17.3</td>
<td>7.2%</td>
<td>15.1%</td>
<td>3.4%</td>
<td>33.3%</td>
<td>45.0%</td>
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<tr>
<td>Sacramento</td>
<td>8.0%</td>
<td>11.5%</td>
<td>N/A</td>
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**Projected Benefits of Green Cover**

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Implications

- Must use valuation models like CITYgreen carefully – since relationships and parameters were derived from data for other parts of country
- CITYgreen works better in suburban settings than in established urban core areas like the one considered here
- CO₂ and other pollutants removed by trees and grass in study area equivalent to quantity produced by 500 automobiles

Discussion

- Could have described many different applications using these and similar types of analytical methods
  - GIS serves as a powerful and convenient framework for integration of disparate data sets
  - GIS supports a variety of spatially explicit analytical methods and models
  - GIS utilizes maps and other types of visual displays for communicating knowledge about processes, patterns, etc. operating in real world

Future Work

- Build a general framework for integrating geospatial and online data sources rapidly, automatically, and accurately
  - This work is funded by NSF and leverages a large number and variety of existing data sources to cope with unspecified events that could happen at any time in any place
  - Use these new spatial social methods to answer series of important questions
    - How settlement patterns and voting behavior have changed across Europe and North America during the past 20 years?
    - How various trends and policies influence the transfer of risk and hazards across space and time?
    - How environmental, social and behavioral variables interact to influence health behaviors and outcomes?