GIS in the City: A GISer's Guide to Advancing Policy and Practice

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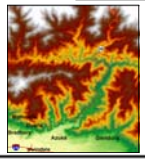
30 June, 2005

Introduction

- Digital geospatial data sources are now widely available
- Vast quantities of data available online that can be related to these geospatial sources
- Many new analytical methods and models have been proposed
- Provides numerous opportunities to advance social science theory and/or empirical work

Outline

- Spatial Social Science
- New Methods and Models
- New Data Sources
- Urban Applications (Projects)
  - Urban Growth Modeling
  - Role / Value of Nature's Services
  - Green Visions Plan Project
- Conclusions / Future Prospects



Collaborators

- Urban Growth Modeling
  - Bill Fulton, Christine Ryan, Jennifer Wolch, & Yan Xu
- Estimating the Value of Nature's Services
  - Ning Chen, Andy Lipkis, Travis Longcore, & Christina Li
- Green Visions Plan Project
  - Jason Byrne, Hong Chen, Ning Chen, Joe Devinny, Martin Kammerer, Christine Lam, Travis Longcore, Diego Martino, Thao Nguyen, Christine Ryan, Jaime Sayre, Mona Seymour, Jingfen Sheng, Jennifer Swift, Zarija Tatalovic & Jennifer Wolch

Spatial Social Science

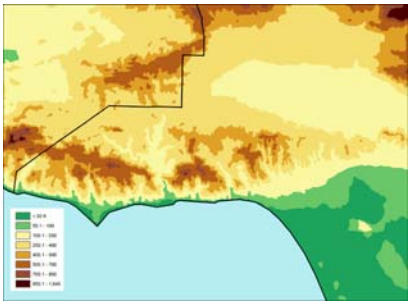
- Tremendous interest in spatial organization of the social, the economic, the political, and the cultural – key domains of social science – as exemplified by work of the Center for Spatially Integrated Social Science
- Thinking spatially – the "new" social science:
  - Urban studies
  - Business and social networks
  - Social and economic inequality
  - Environmental and climate change
  - Health and disease
  - Criminal justice
  - Community studies and grassroots organizations

Spatial Analysis and Modeling

- Interested in measuring and/or predicting context or neighborhood effects, spatial interaction, spatial externalities, using geography as a proxy, etc.
- Spatial analysis consists of three key components (after Anselin 2002):
  - Visualization – showing interesting patterns
  - Exploratory Spatial Data Analysis (ESDA) – finding interesting patterns
  - Spatial modeling, regression, etc. – explaining interesting patterns
- Needs various forms of georeferenced data as well as distance and accessibility measures

Geospatial Data Sources

- Points
- Grids
- Vectors
- Maps
- Imagery



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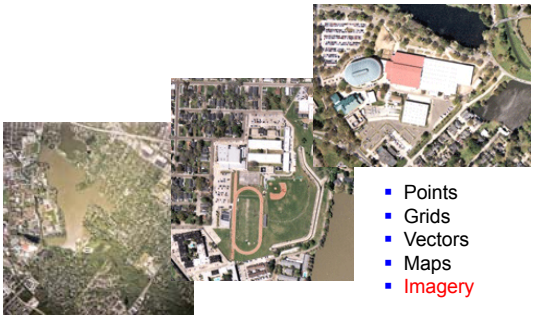


- Points
- Grids
- Vectors
- Maps
- Imagery

Semi-structured Data Sources

- Property tax records
- Telephone books
- Transit schedules

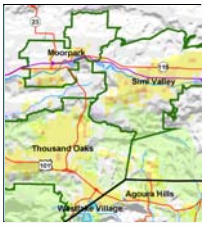
- Geospatial data sources have become widely available
- Huge amount of data available online that can be related to these geospatial sources

Urban Growth Modeling

- California Urban and Biodiversity Assessment (CURBA) model developed by John Landis and colleagues at University of California-Berkeley
- Incorporates Urban Growth and Policy Simulation and Evaluation sub-models
- Uses ArcView, SAS, and FRAGSTATS

Ventura County, California

- 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 10 cities
- 20% of county and 70% of land inside city limits was developed in 2000



Ventura County (2)

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

Research Questions

- How is 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?

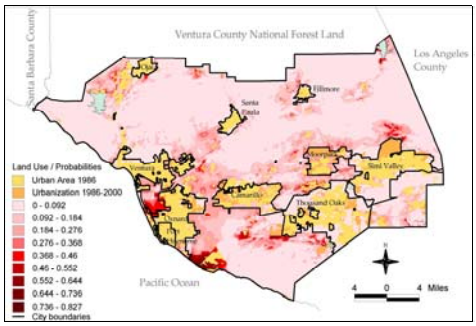
Urban Growth Sub-Model

- 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(X1, X2, X3, etc.)

  where Y = land use change from 1986 to 2000, X1, X2, and X3 are explanatory site 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.

Urbanization Probability Grid



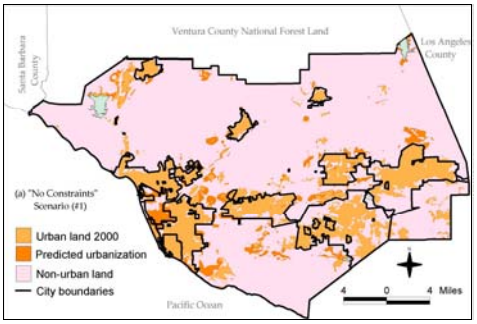
Policy Scenarios

- 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

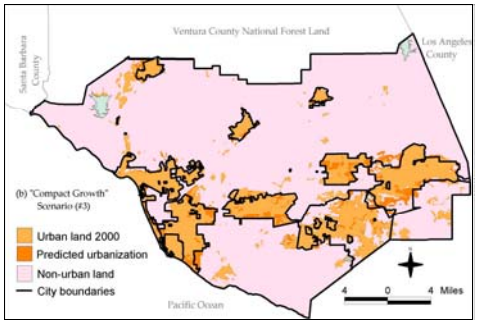
Urban Growth by Political Unit

Political Units	Available land	Land Conversion Predicted Under Different Scenarios					
		#1	#2	#3	#4	#5	#6
Camarillo	2,890	240	195	2,565	700	2,065	420
Fillmore	635	20	20	220	185	235	125
Moorpark	2,600	700	1,730	2,405	2,330	2,175	2,095
Ojai	425	15	0	270	295	320	240
Oxnard	4,175	795	290	2,455	565	2,385	495
Port Hueneme	55	5	5	55	55	5	5
Santa Paula	660	10	5	310	410	170	60
Simi Valley	8,010	5	130	4,455	6,385	4,195	4,145
Thousand Oaks	14,205	60	215	3,965	5,515	4,695	4,695
Ventura	1,965	90	10	735	790	550	270
County	414,710	23,275	23,380	8,245	8,660	9,225	6,355
Totals	450,330	25,215	25,980	25,680	25,890	26,020	18,905

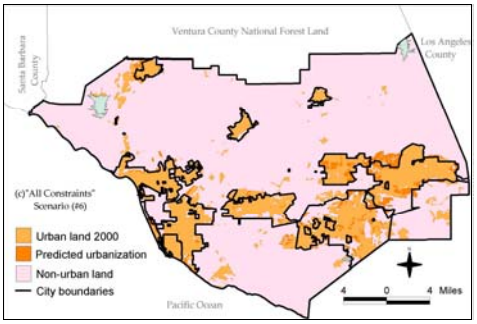
Scenario #1



Scenario #3

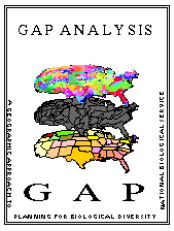


Scenario #6



GAP Analysis Data

- Urban and agricultural land uses utilized 14 and 25% of study area, respectively in 2000
- Three sets of plant communities covered nearly 60% of 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 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 dealt to coastal sage-chaparral scrub (40%), southern willow forest (13%), chamise chaparral (9%), non-native grassland (7%), and sandy areas (6%)

Project Conclusions

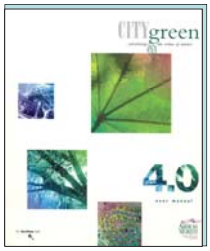
- Different urban growth policies would produce very different spatial patterns of growth in Ventura County in next 20-30 years
- Different scenarios trade off varying proportions of farmland and natural vegetation cover to accommodate new growth
- Enforcement of SOAR boundaries would consume nearly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

GIS Implications

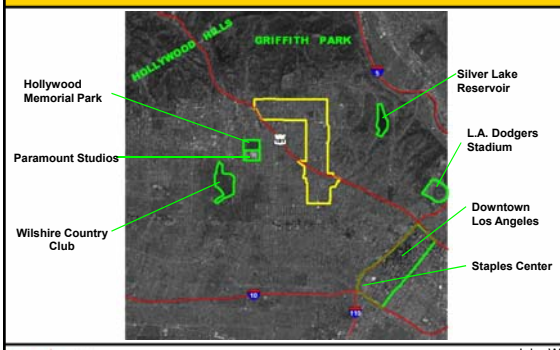
- Data Currency Issues
  - Especially acute given rapid rates of urbanization in Southern California
- Other Data Quality Problems
  - Cf. FMMP and GAP land use / land cover data datasets
- Geographic Extents and Units of Analysis
  - CURBA model used in this project could not automatically handle policy variations in different parts of landscape
- Collaborative Opportunities
  - Data sharing is sometimes tricky
  - Be careful what you wish for

Role / Value of Nature's Services

- Used CITYgreen (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

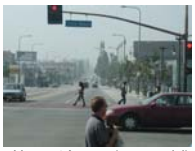


Vermont / Hollywood Study Area



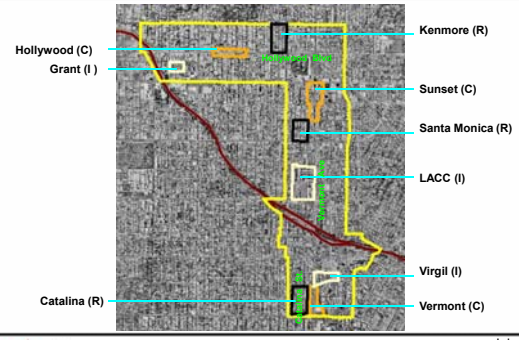
Study Area Metrics

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


Vermont Avenue (commercial)

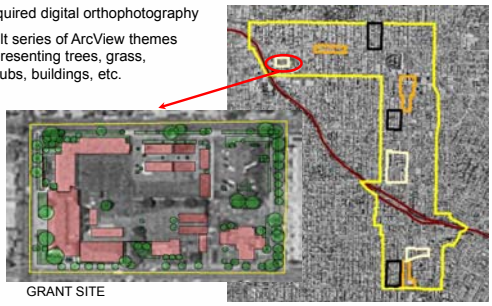

Catalina Street (residential)

CITYgreen Sample Sites



ArcView Themes

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

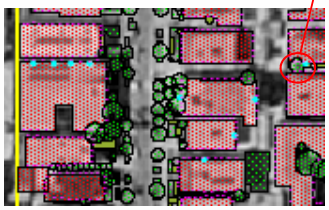

GRANT SITE

ArcView Themes (2)

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


CATALINA SITE

CITYgreen Features / Attributes



TREE ID	1
AREA	2.31
PERIMETER	5.39
PUB or PRIV	V
SPECIES	SUC
DIAMETER (inch)	4
DIAMETER CLASS	1
HEIGHT CLASS	1
HEALTH CLASS	4
GROUND COVER: SHRUB, GRASS, PAVED, SOIL, OR MULCH	GRASS

Sample Site Cover Statistics

Site	Area (acres)	Trees	Grass	Shrubs	Buildings	Paved
Commercial	**13.6**	**1.8%**	**2.7%**	**0.6%**	**30.0%**	**65.9%**
Institutional	**15.6**	**8.8%**	**13.1%**	**1.1%**	**26.7%**	**55.2%**
Residential	**17.3**	**7.2%**	**15.1%**	**3.4%**	**33.3%**	**45.0%**
Sacramento						
Commercial		**8.0%**	**11.5%**	N/A	**20.5%**	**54.0%**
Residential		**27.0%**	**7.0%**	N/A	**23.5%**	**33.5%**

Projected Benefits of Green Cover

	Pounds Removed Per Acre Per Year (lb)					Tons carbon stored ($10/t)	Economic Benefits
	O_3 ($3)	SO_2 ($2.45)	NO_2 ($6.90)	PM10 ($5.20)	CO2 ($1.50)		
Current							
Commercial	1.11	0.09	1.02	1.29	0.20	0.013	**$17.73**
Institutional	5.04	0.42	4.63	5.89	0.91	0.021	**$80.31**
Residential	4.49	0.37	4.12	5.24	0.81	0.053	**$78.81**
Scenario 1							
Commercial	3.26	0.27	2.99	3.80	0.59	0.025	**$51.97**
Institutional	8.26	0.69	7.58	9.64	1.50	0.080	**$131.95**
Residential	7.21	0.60	6.62	8.42	1.31	0.085	**$115.38**
Scenario 2							
Commercial	8.85	0.74	8.13	10.34	1.60	0.104	**$141.83**
Institutional	11.53	0.96	10.59	13.47	2.09	0.116	**$184.35**
Residential	10.33	0.86	9.48	12.06	1.87	0.122	**$165.25**

Project Conclusions

- CO_2 and other pollutants removed by trees and grass in study area equivalent to that produced by 500 automobiles
- Must use valuation models like CITYgreen carefully – relationships and parameters derived with data from other parts of country
- CITYgreen works better in suburban settings than established urban core (like study area)

GIS Implications

- This work illustrates the value of combining GIS analysis, modeling, and fieldwork
- Must choose and use models carefully – a recent paper was rejected because two reviewers concluded that CITYgreen is not a “peer-reviewed” model
- Subsequent work recognizes this flaw – takes energy savings from shade trees calculated with CITYgreen and TREES models and compares predictions with energy consumption data in two LA neighborhoods

Green Visions Plan

- Legacy of piecemeal planning
- Population growth
- Regulatory/governance context
- Public health challenges
- Environmental justice considerations
- Changing views of urban nature
- Funding opportunities

Project Goals

- Identify and assess opportunities for:
  - Habitat conservation / restoration
  - Promotion / restoration of watershed health
  - Park/open space acquisition and development
- Create GIS planning tools and data sets
- Assess alternative approaches to database architecture, management, public access, and storage

Green Visions Plan Area

Phase I Products

- Creation of Plan Library
- Creation of Clickable Web-based Map
- Geospatial Data Scan
- Preparation of Metadata Catalogue Design and Website for Distributing Geospatial Datasets
- Preparation of Green Visions Planning Framework (Phase II Work Tasks)

Phase II Products

- A Plan Book with –
  - Schematic Landscape Plan for Recreational Parks & Open Space
  - Early Notice Maps for Habitat Conservation/Restoration
  - Generalized Multi-Use Facilities Plan for Watershed Health
  - Model Ordinances to Enhance Local Ecosystems and Watersheds
- Multiple Public Access GIS Tools and Geospatial Data Sets
- Website with Links to Stakeholder Organizations, Public Agencies, etc.
  - www.greenvisionsplan.net

Habitat Conservation

Not your ordinary conservation plan

Multiple Species Approach

- Choose 30-40 focal species
  - Broad taxonomic and life history breadth
  - Include rare and endangered species
  - Include indicators of sensitive habitats
- Develop natural history profile and geographic incidence information
- Prioritize areas based on representation of focal species

Representation Approach

- "Noah's Ark" of vegetation types
- Develop historic vegetation map from existing sources and topoclimatic classification
- Rank vegetation types by rarity and percent lost (including those 100% destroyed)
- Assign parcels value for representing rare habitats

Umbrella Species Approach

- Apply reserve design principles for large carnivores — "Missing Linkages"
  - Connectivity
  - Minimum area
- Urban twist
  - Connectivity for lower trophic levels as stepping stones

Major Missing Linkages Identified

Urban Matrix Approach

- Model ordinances
  - Fuel modification, lighting, human/wildlife conflicts, tree trimming, etc.
- Local Nature Parks
  - Target migratory birds and other mobile organisms
  - Percolation theory

What's Different?

- Species reintroduction vs. preservation
- Restoration
- Multi-scale conservation
- Basic ecological processes disrupted
  - Must work within constraints
  - Re-engineering of natural processes necessary where possible
- Little things count

Sample Output

Data Requirements

- Vegetation
- Soils
- Topography
- Wildlife (especially focal species)
- Land Use
- Hydrology
- Climate
- Disturbances

National Hydrography Dataset

Multiple Use Approach

- Restored sites simultaneously serve to restore ecosystems, treat/infiltrate storm water, provide recreation, etc.

Broadous School Sun Valley

GIS Tools

Approach

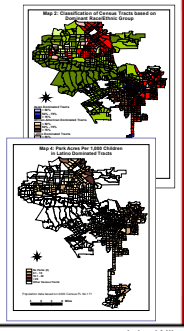
- Develop customized maps and products that serve tasks and audiences at hand
- Provide flexible data-rich, parcel-level scorecards for decision support
- Propose strategies for managing Green Visions Plan geospatial data

Sample Habitat Scorecard

Number of endangered species	0
Number of threatened species	0
Presence of recovery area for endangered species	No
Presence of recovery area for threatened species	No
Presence of habitat for focal species	Yes
Restoration potential for focal species	Yes
Identification as part of landscape linkage	No
Identification as part of local linkage	Yes
Identification as part of "stepping stone" linkage	No
Presence of rare vegetation/wetland type	Yes
Presence of vegetation type not represented in public lands	No
Presence of unique hydrological feature (e.g., vernal pool)	Yes
Measures of connectivity (% natural habitat within certain radii)	6%
Measures of natural hydrological function	Moderate
Measures of natural fire regime	Low

Conclusions

- We need to think big and yet most times act incrementally
  - "Growth Visioning" Workshops sponsored by USC Lusk Center for Real Estate
  - Green Visions Plan park asset inventory being undertaken this summer
- We need to identify the things that GIS can do best and focus on them
- Data quality is a pervasive problem and is likely to remain so for many years to come
  - National Hydrology Dataset



Future Work / Prospects

- We need to be nimble …
  - How might we use GIS to measure the benefits and costs accompanying environmental perturbation (change) – for example, how has the flood hazard been altered during the past century and what is likely to happen in next century?
- Place-Based Decision Support for Spatial and Temporal Transference of Risk and Hazards
  - This project examines how various trends and policies influence transfer of risk and hazards across space and time
- GIS can improve our knowledge of the social, the economic, the political, and the cultural