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

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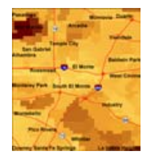
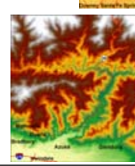
Introduction

- 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

Outline

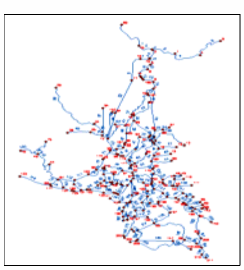
- Geospatial Data Sources
- Spatial Social Science
- Urban Applications
  - Urban Growth Modeling
  - Distribution of Green Cover
  - Role / Value of Nature's Services
  - Park Equity Mapping
- Discussion and Future Work





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

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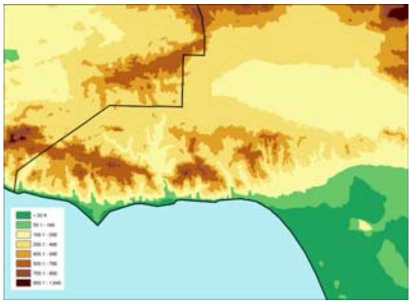

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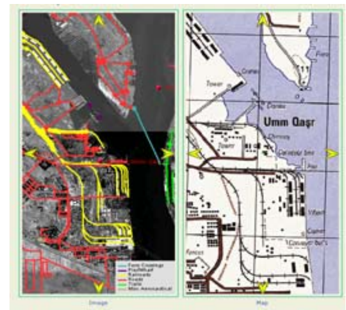
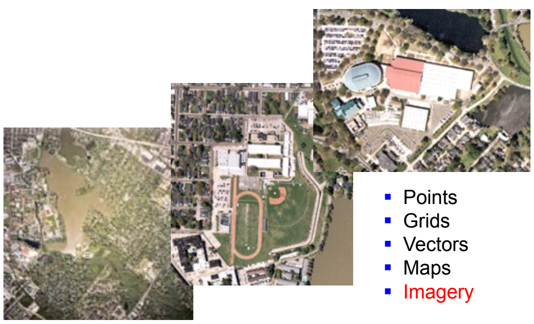


Geospatial Data Sources



- Points
- Grids
- Vectors
- Maps
- Imagery

Semi-structured Data Sources

- Property tax records
- Telephone books
- Transit schedules

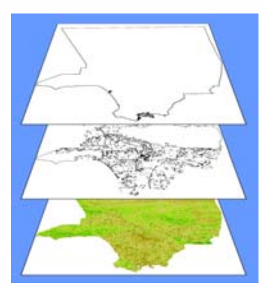
- Geospatial data sources have become widely available
- Huge amount of data available online that can be related to these geospatial sources

What is a GIS?

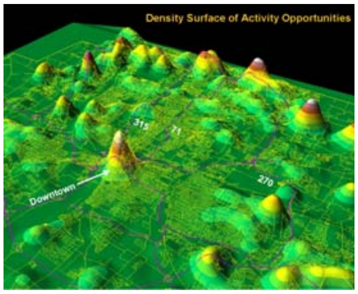
- One of several Geographic Information Technologies
- Others include –
  - Global Positioning Systems
  - Remote Sensing platforms
  - Electronic measurement and monitoring systems
  - Various types, forms of computer models
- You would know when a computer was being used for GIS because the data stored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

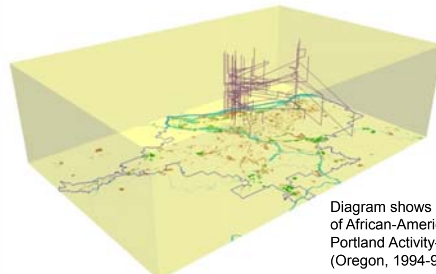

Diagram shows space-time paths of African-American women in Portland Activity-Travel Survey (Oregon, 1994-95) dataset

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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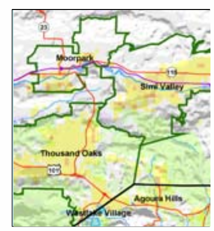
Ventura County

- 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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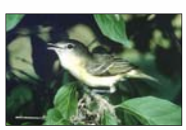
Ventura County (2)

- 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?

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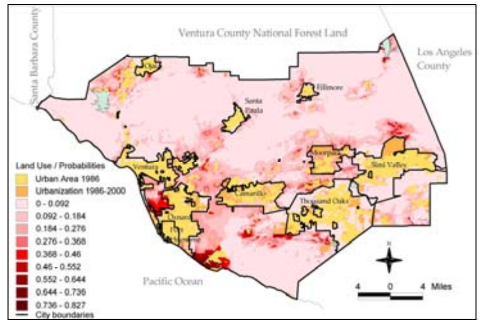
Urban Growth Sub-Model

- 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 and X1, X2, X3, 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.

Urbanization Probability Grid



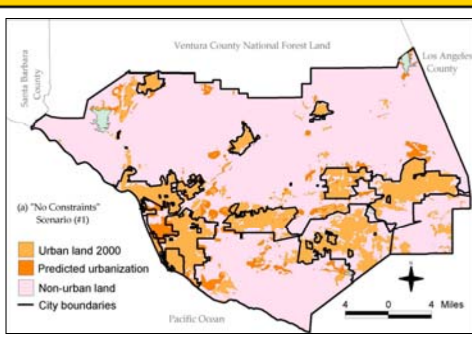
Policy Scenarios

- 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

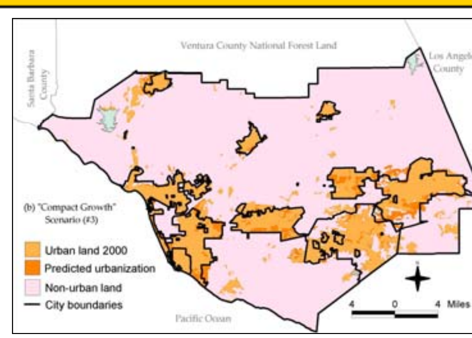
Urban Growth by Political Unit

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

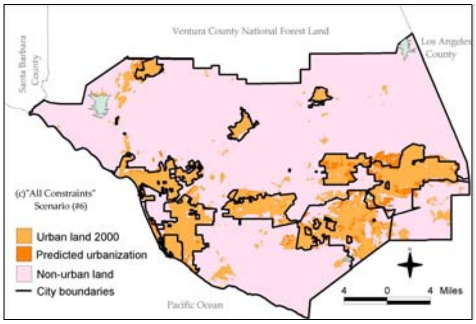
Scenario #1



Scenario #3

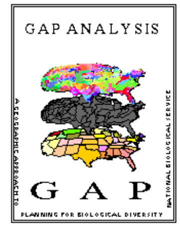


Scenario #6



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 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

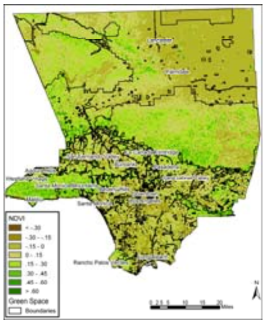
Distribution of Green Cover

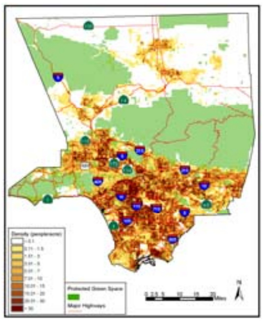
- Parks, open space, and green vegetation are fundamental to livability of cities
- A large and healthy green cover provides several of nature's services
  - Cooling and shading, carbon sequestration, air pollution removal, noise suppression, reductions in urban storm runoff, etc.
- Current study used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

NDVI

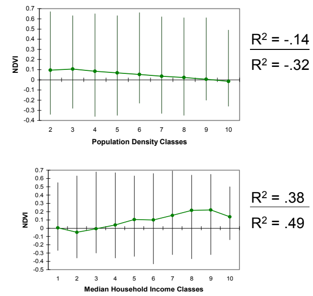
- Calculated from LANDSAT TM images using Band 4 (infrared wavelengths) and Band 3 (red wavelengths)
- These wavelengths measure amount of chlorophyll present at land surface
- Computed values of NDVI range from -1 (few green plants present) to +1 (large numbers of green plants present)
- Final maps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

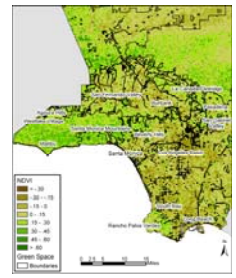
NDVI / Population Density





NDVI, Density, and Income





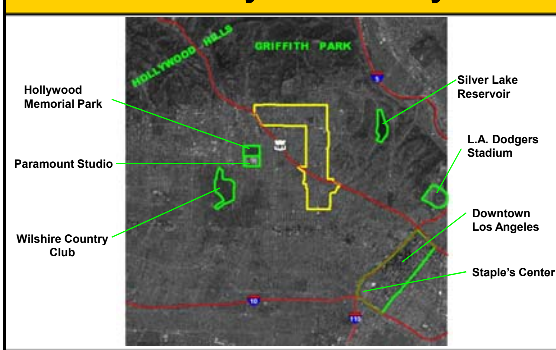
Implications

- 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.

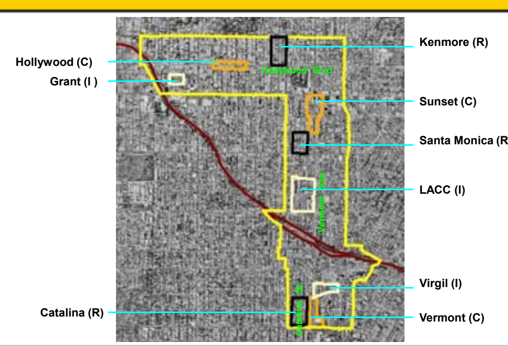
Role / Value of Nature's Services

- This project used 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

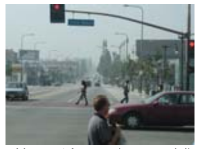


CITYgreen Sample Sites



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



Vermont Avenue (commercial)

Catalina Street (residential)

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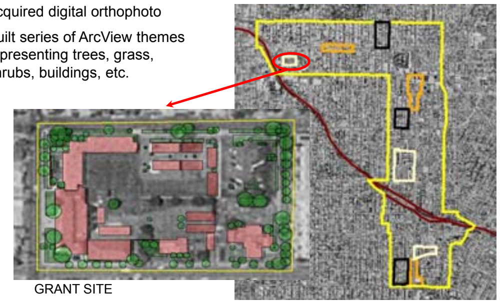
ArcView Themes

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



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ArcView Themes (2)

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

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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

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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%

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Projected Benefits of Green Cover

	Pounds Removed Per Acre Per Year (lb)					Tons carbon stored ($10/t)	Annual Savings
	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

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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
- CO_2 and other pollutants removed by trees and grass in study area equivalent to quantity produced by 500 automobiles

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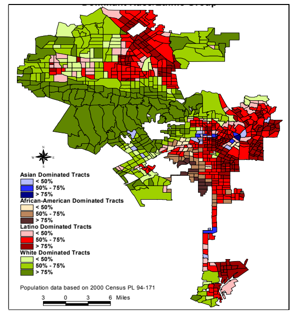
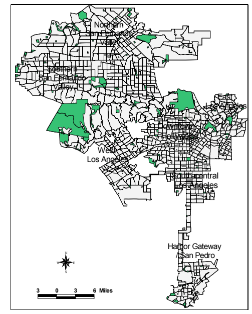
Park Equity Mapping





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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

Green Visions Plan Area

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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?

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