An Introduction to Geospatial Analysis for Health Disparities Research

Justin Stoler, PhD, MPH, CPH
Department of Geography
Department of Public Health Sciences
Abess Center for Ecosystem Science & Policy

The Health Geographics Lab: miami.edu/healthgeo

Agenda

Introduction to Geospatial Analysis (me)

Audience Group Activity (you)

Group Discussion (we)

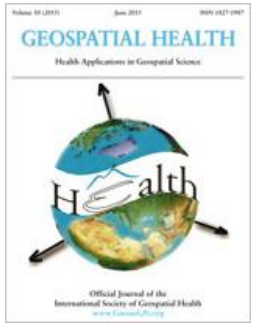
Motivation

The number of tools and data sources for geographic analysis has been exploding.

Most disciplines have re-discovered spatial thinking and spatial analysis (the natural sciences are furthest along).

Spatial analysis in public health has been mainstream for a while.

International Journal of Health Geographics



IMGS | 2017
Angers | France
17TH INTERNATIONAL MEDICAL GEOGRAPHY SYMPOSIUM

AAG
AMERICAN ASSOCIATION of GEOGRAPHERS

(300+ pp Special Issue: Geographies of Health)
2012 Vol 102 No 5

MEDICINE

Science AAAS

Spatial Turn in Health Research

Douglas B. Richardson,[1] Nora D. Volkow,[2] Mei-Po Kwan,[3] Robert M. Kaplan,[4]
Michael F. Goodchild,[5] Robert T. Croyle[6]

APHA
AMERICAN PUBLIC HEALTH ASSOCIATION
For science. For action. For health.

HEALTHOGRAPHY

APHA 142nd ANNUAL MEETING & EXPO
NOVEMBER 15–19, 2014 | NEW ORLEANS, LA

UM Communities Using GIS

Civil Engineering

Ecosystem Science & Policy

RSMAS

Master of Public Administration

Sociology and Criminology

Biology's Coastal Ecology Lab

Office of Civic and Community Engagement

Center for Computational Sciences…

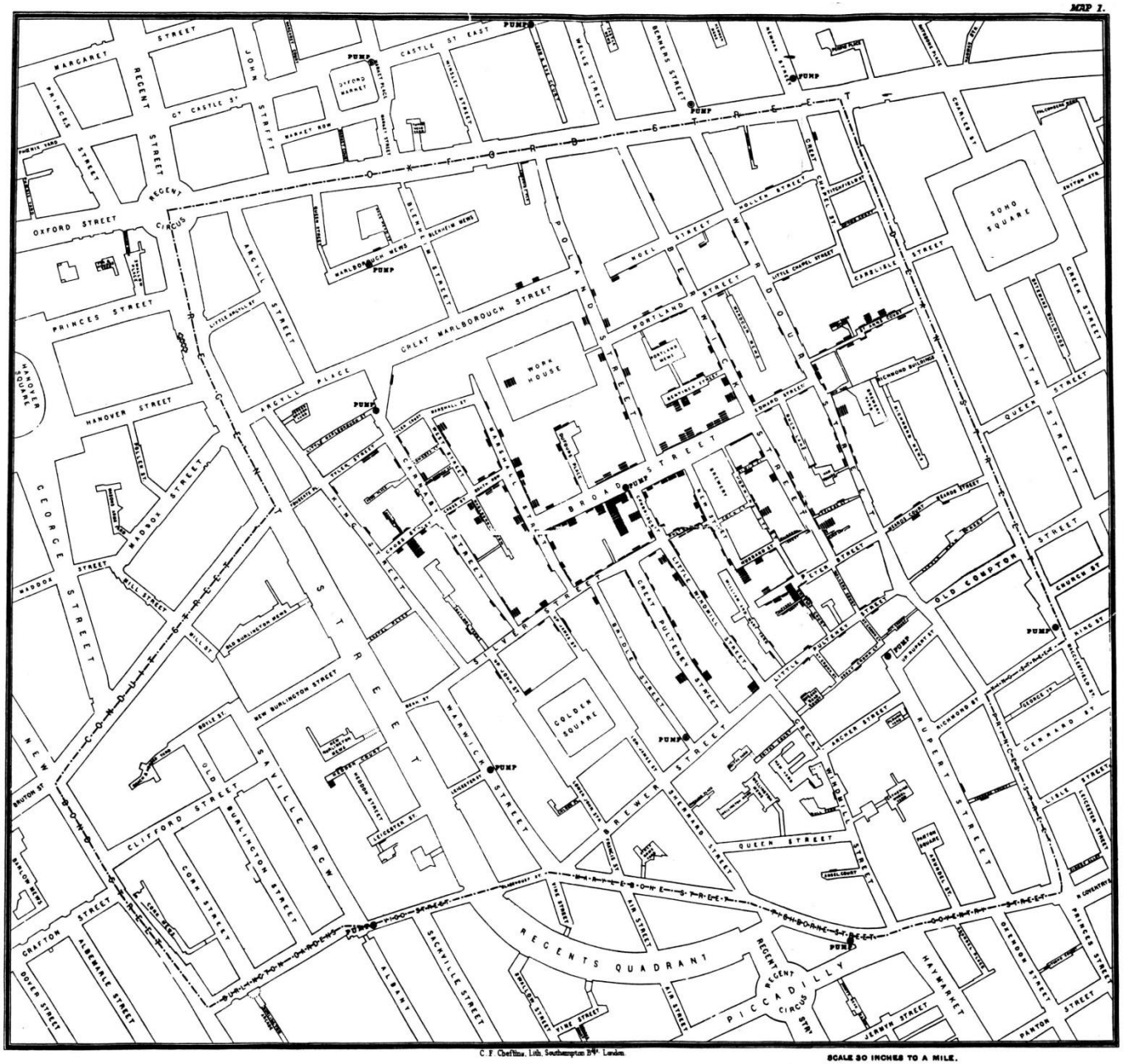
On Airs, Waters, and Places

Whoever wishes to investigate medicine properly, should proceed thus: …consider the seasons of the year, and what effects each of them produces… Then the winds, …such as are peculiar to each locality. We must also consider the qualities of the waters, for as they differ from one another in taste and weight… In the same manner, when one comes into a city, he ought to consider its situation, how it lies as to the winds and the rising of the sun… the waters which the inhabitants use, whether they be marshy and soft, or hard and running from elevated and rocky situations, and deficient in water, or wooded and well watered, and whether it lies in a hollow, confined situation, or is elevated and cold; and the mode in which the inhabitants live, and what are their pursuits…

From these things he must proceed to investigate everything else.

-Hippocrates (c. 400 BC)

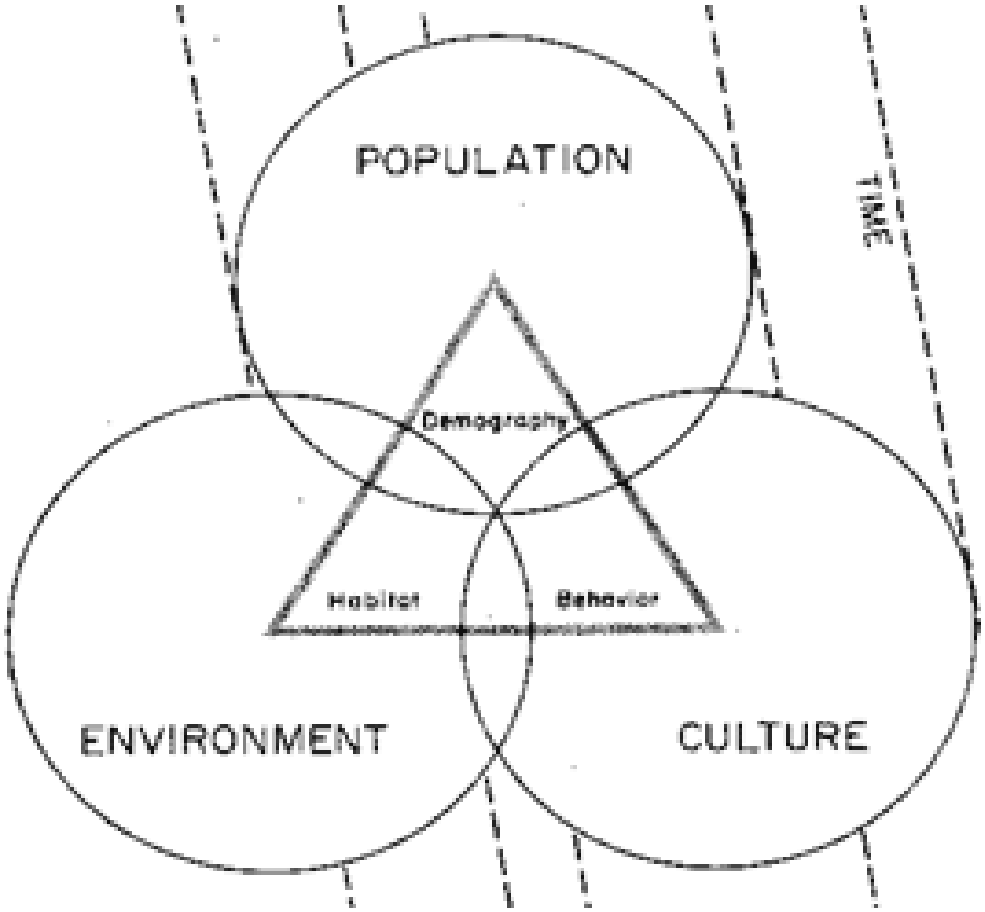
Westeros
— and the —
Free Cities
THE SHIVERING SEA
THE NARROW SEA
THE RILLS
BARROWLANDS
THE NECK
THE FLINT CLIFFS
THE BITE
THE FINGERS
IRON ISLANDS
IRONMAN'S BAY
VALE of ARRYN
BAY of CRABS
BLACKWATER BAY
FAIRISLE
GOLD ROAD
LORATH BAY
HILLS of NORVOS
ANDALOS
VELVET HILLS
THE FLATLANDS
FOREST of QOHOR


MAP 1.
BROAD STREET
GREAT MARLBOROUGH STREET
OXFORD STREET
REGENT STREET
REGENTS QUADRANT
PICCADILLY
GOLDEN SQUARE
SOHO SQUARE
WORK HOUSE
PUMP
C. F. Cheffins, Lith. Southampton Bldgs. London.
SCALE 30 INCHES TO A MILE.

Modern Medical Geography

- The emergence of a systematic interest in medical geography can be dated from the first report of the commission on Medical Geography (ecology) of Health and Disease to the International Geographical Union in 1952
    - geographic pathology, medical ecology, medical topography, geographical epidemiology, geomedicine
- More recently: health geography, spatial epidemiology, etc.

Triangle of Human Ecology



Melinda Meade: Medical Geography and Human Ecology, 1977

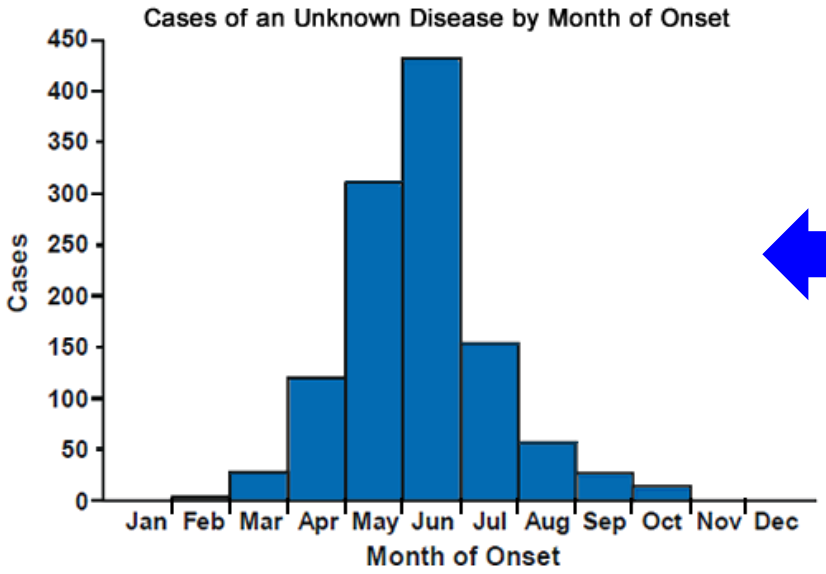
Fast Forward to Today

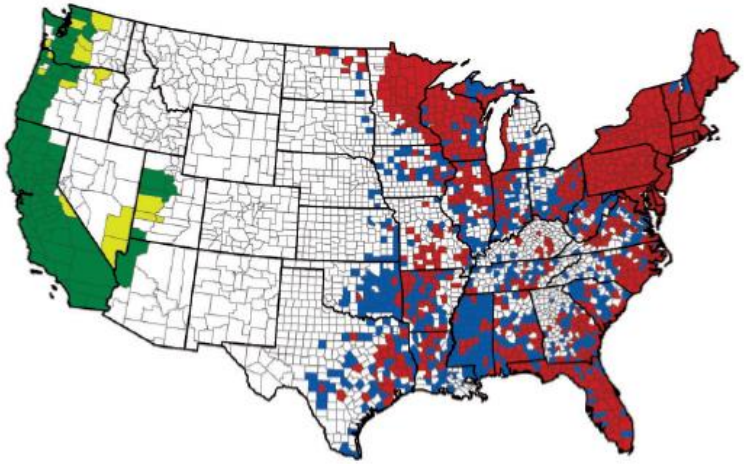
Explosive growth in Health Geography due to:

- emerging and reemerging infectious diseases in a globalizing world
- increase in degenerative diseases due to "Westernization" and population aging
- maturity of GIS, leading to increased scientific analysis of spatial patterns of disease and health risks

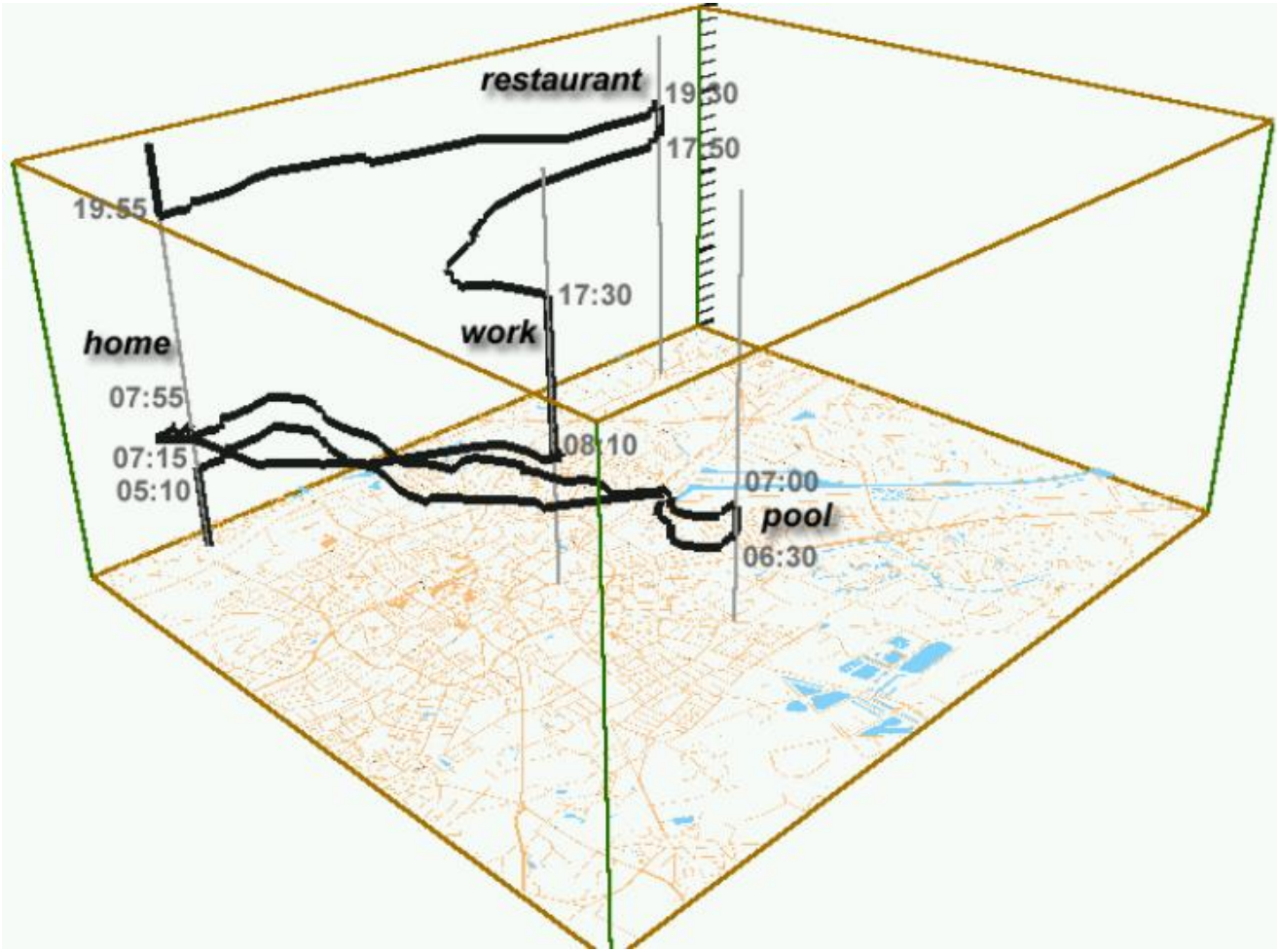
Epidemiology Defined

"The study of the determinants, distribution, and control of disease and other health factors."





The Holy Grail: The Space-Time Cube



Interest in a Spatial Perspective

Driven by:

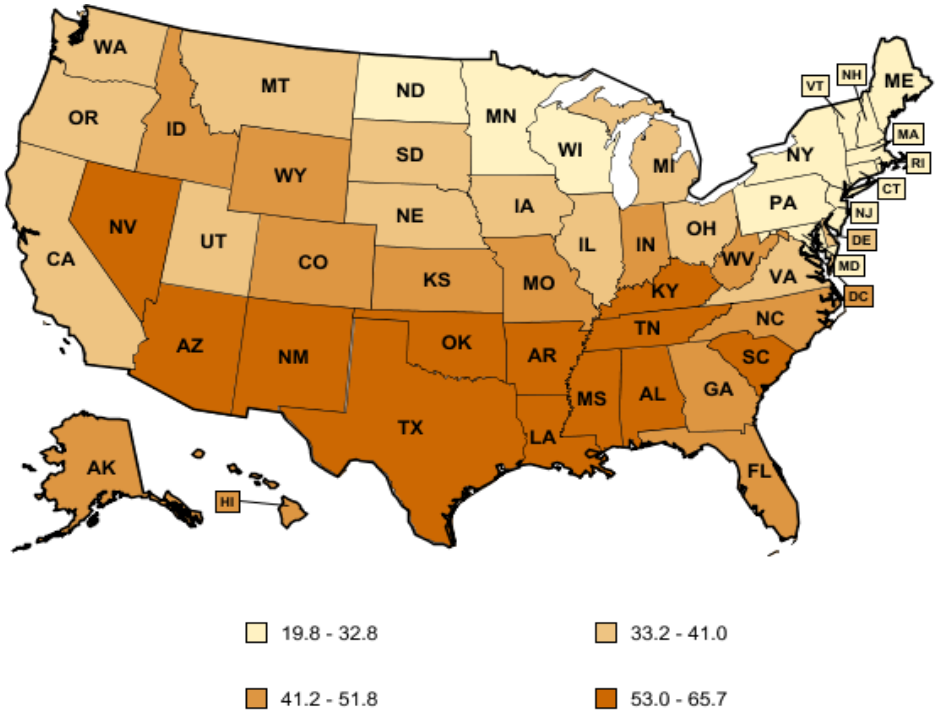
a) the ready availability of very different kinds of geo-referenced data

b) the tools to visualize and analyze them:
   - geographic information systems (GIS)
   - spatial analysis
   - spatial statistics

Geographic Information Science

	Teen Birth Rate per 1,000
United States	41.5
Alabama	53.0
Alaska	46.8
Arizona	56.2
Arkansas	61.8
California	38.4
Colorado	42.5
Connecticut	22.9
Delaware	40.4
District of Columbia	50.9
Florida	42.8
Georgia	51.8
Hawaii	42.1
Idaho	41.2
Illinois	38.1
Indiana	43.7
Iowa	33.9
Kansas	45.6
Kentucky	55.6
Louisiana	54.1

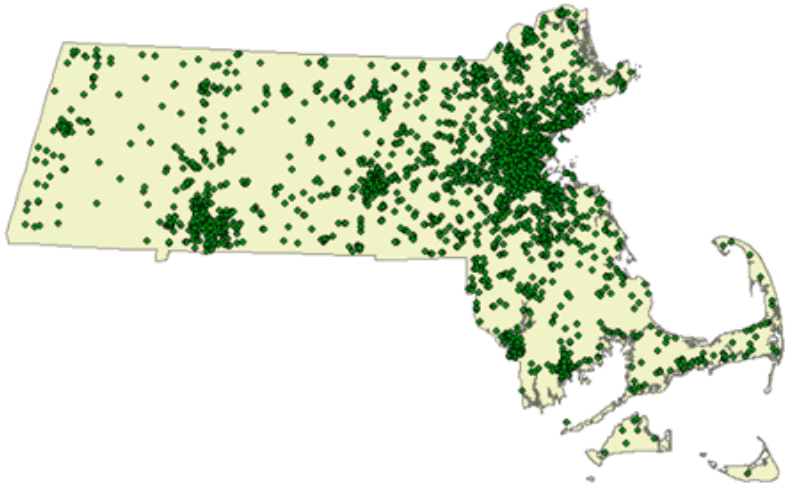
← summary statistic

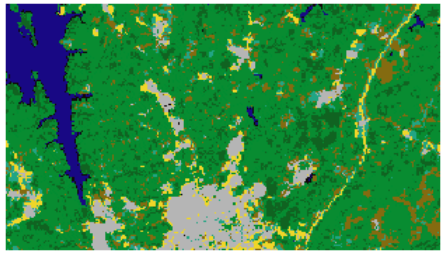


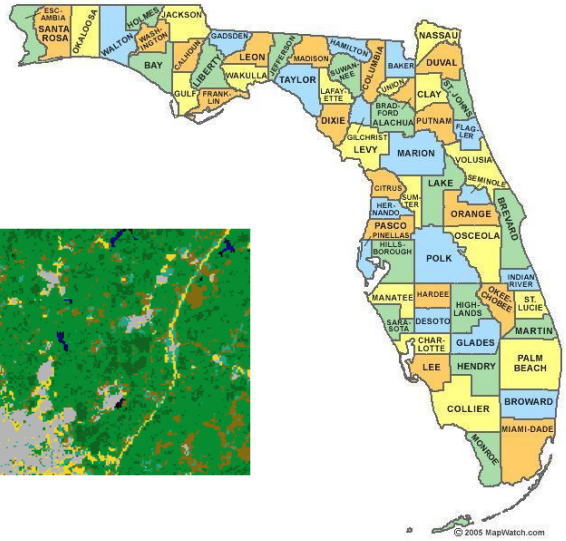
What is Spatial Data?

Simply any data with explicit or inherent location

- x-y coordinates
- linked to some areal region







What is Spatial Data?

Geographic (spatial) data have unique features

- location = ID variable
- absolute and relative location
- scale/aggregation
- spatial embeddedness (networks, hierarchies)
- spatial autocorrelation

Ignoring these unique features limits analytical potential and can also introduce problems.

Why Spatial Data?

The ability to analyze, over space and time:

locations

quantities

densities

changes

connections

what's inside

what's nearby

Representations of Geographic Data

Two methods of representing geographic data in digital format:

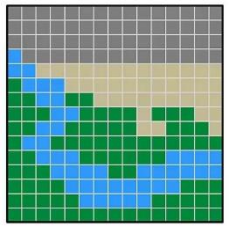
Vector (features):

- point: to record location in a 2-dimensional space
- lines: between two points (directions and length)
- polygons: closed vectors (area, centroids, and perimeter)

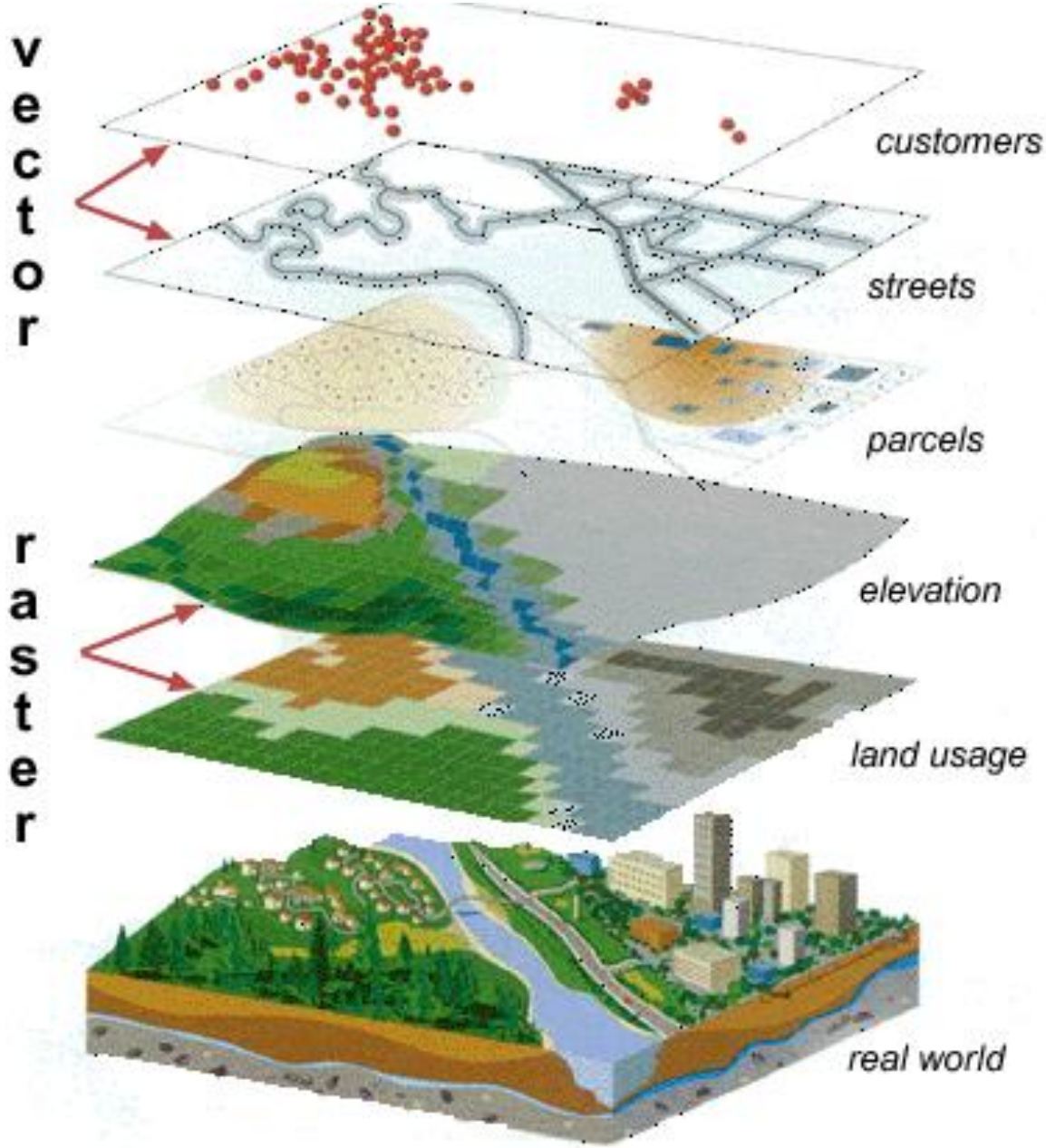
VECTOR

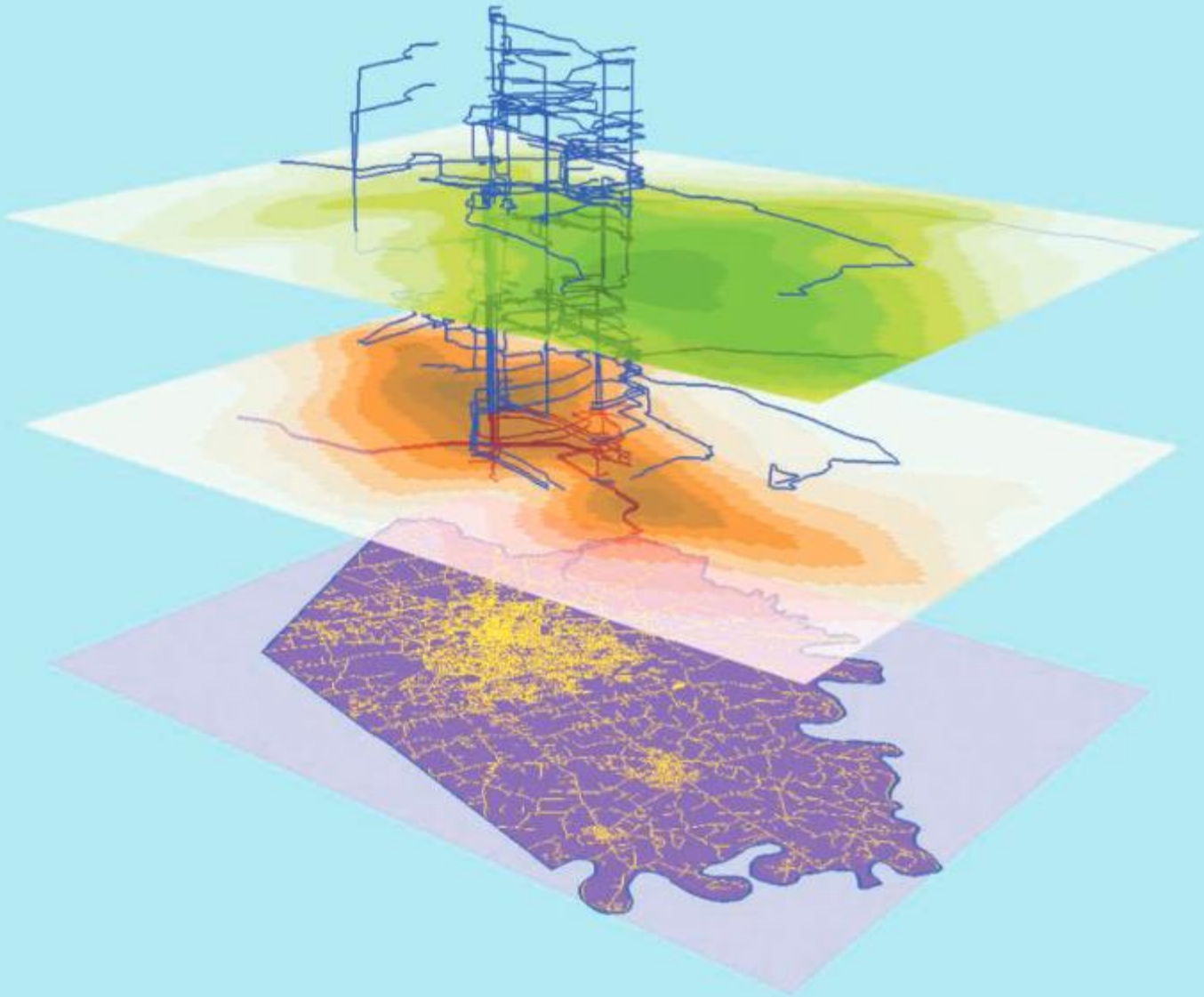
Raster (surfaces):

- use a fixed grid and record information about each element on the grid (satellite images, aerial photos, etc.)



RASTER


vector
raster
customers
streets
parcels
elevation
land usage
real world


Risk factor concentration 2
Risk factor concentration 1
Spatial extent of study area

“Everyday” Geographical Objects

Points

households, health clinics, schools, retail outlets, crimes, bus stops, parks, neighborhood institutions and/or community assets, resources and risks…
OR… individuals (or other objects that can move)…

Lines

roads and transportation routes, rivers, pathways, social connections, infrastructure…

Areas (Polygons)

census units, ZIP codes, counties, states, provinces, school districts, police precincts, service areas, activity spaces, neighborhoods, watersheds…

Surfaces

weather, topography, land cover, pollution, urban-ness, risk…

“Everyday” Spatial Data Producers

Users have become producers, not just consumers, of spatial data

- Volunteered Geographic Information (VGI)
  - “Old”: Flickr, Foursquare, Google Maps, Historypin, etc.
  - “New”: mobile apps, wearable technologies
- Crowdsourcing (online posts, SMS, tweets…)
- Participatory GIS (PGIS)
  - “empowering the public and communities with GIS”

Classic GIS Applications

Businesses — site location for a new store

Urban planners — map traffic capacity and congestion

Demographers — population growth and decline

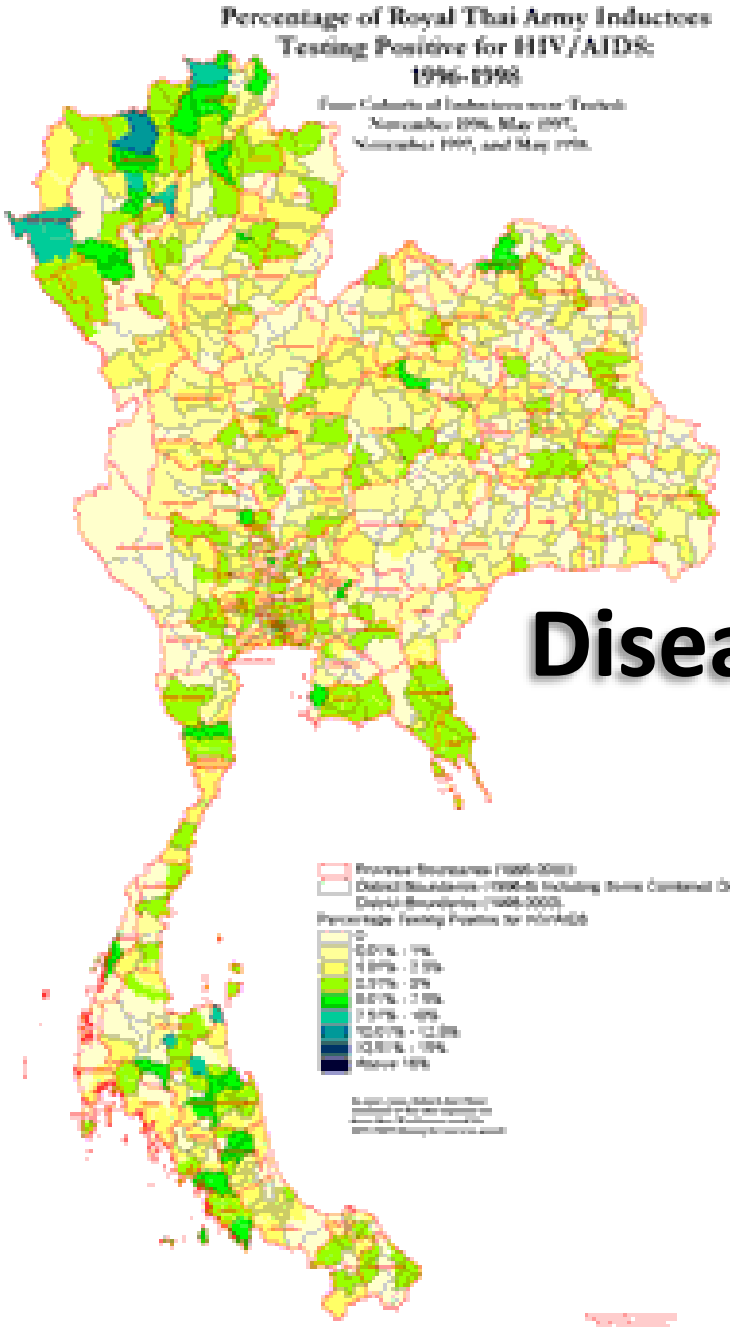
Police/firefighters — shortest route to incident

Epidemiologists — spread of disease

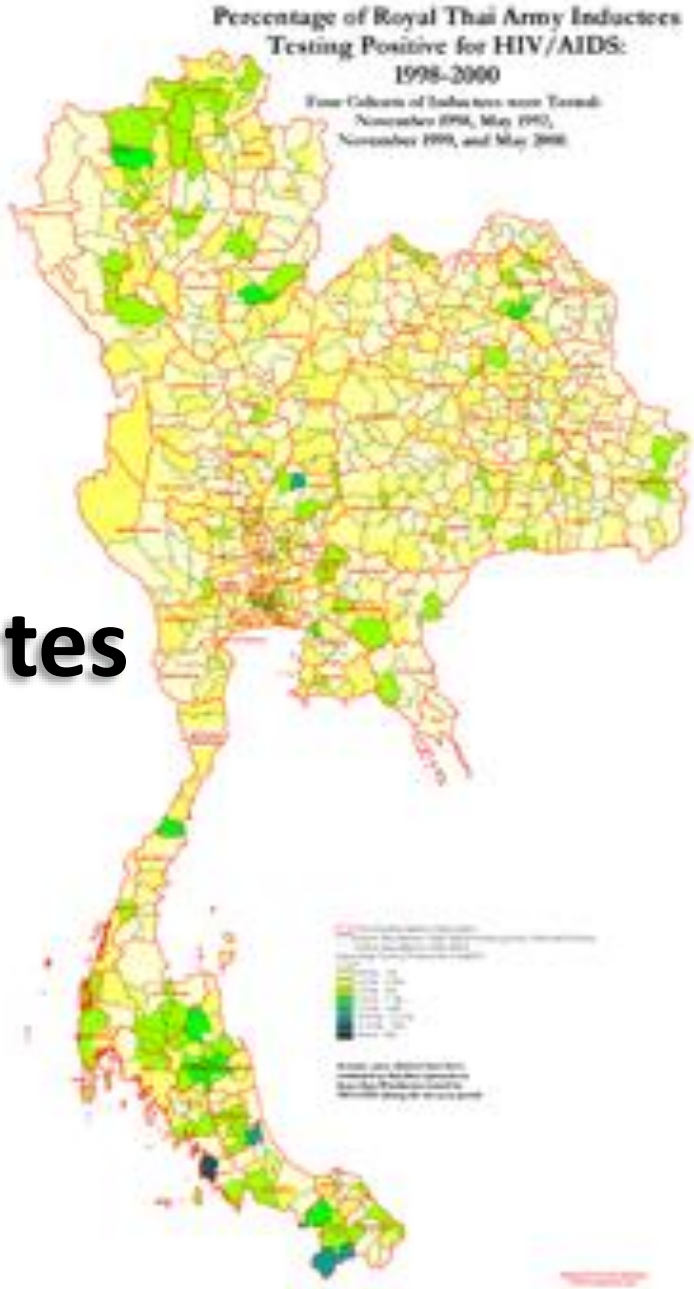
Biologists — invasive species or wildlife corridors

Public Health Applications

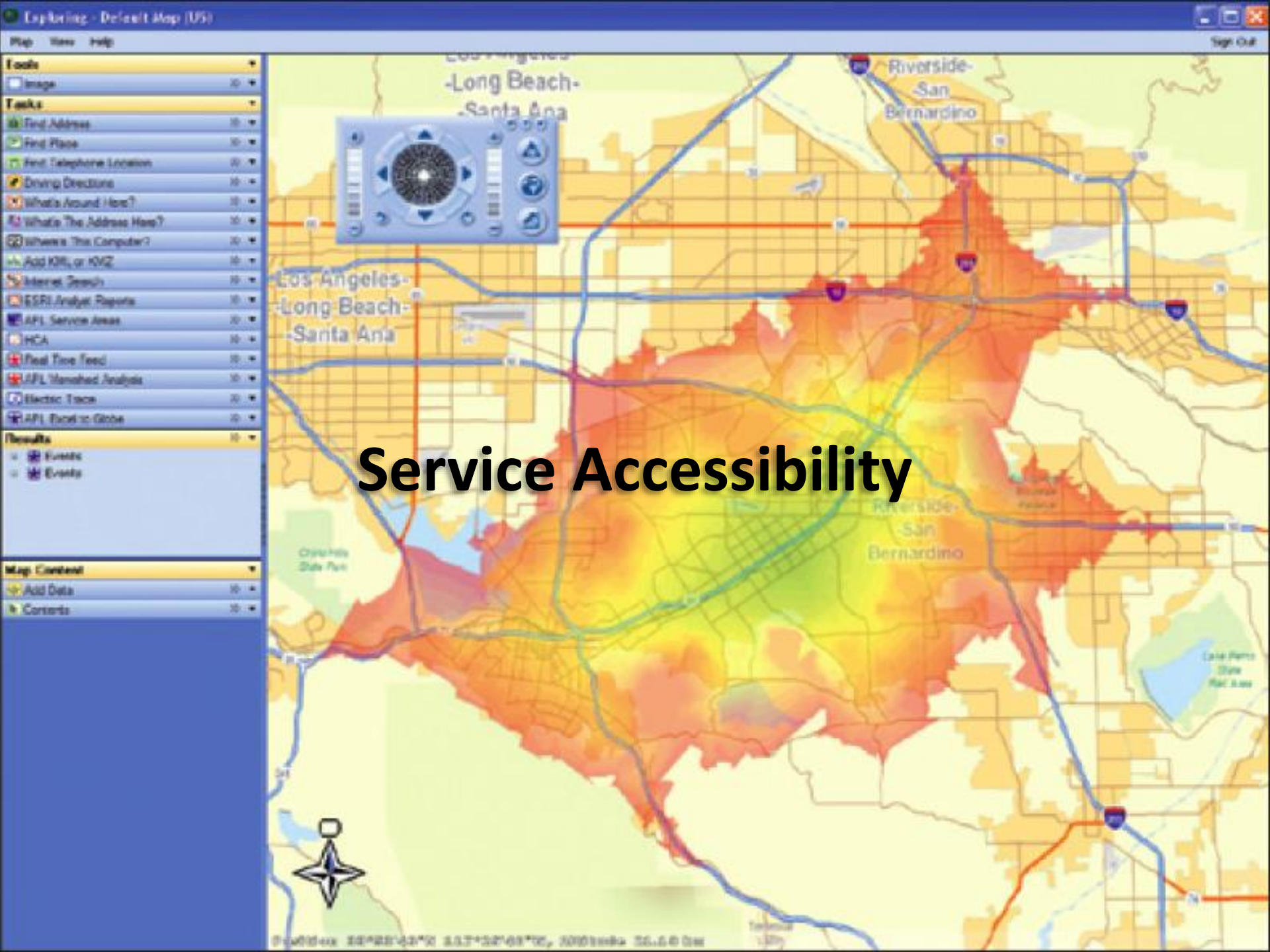
- Creating public health surveillance databases
- Mapping health data, e.g. spatial clustering of health events
- Risk and spread of infectious diseases
- Landscape ecology of vector-borne diseases
- Access to and location of health services
- Health disparities (geographic, socio-cultural, environmental)
- Ethnography of lived experiences of health care

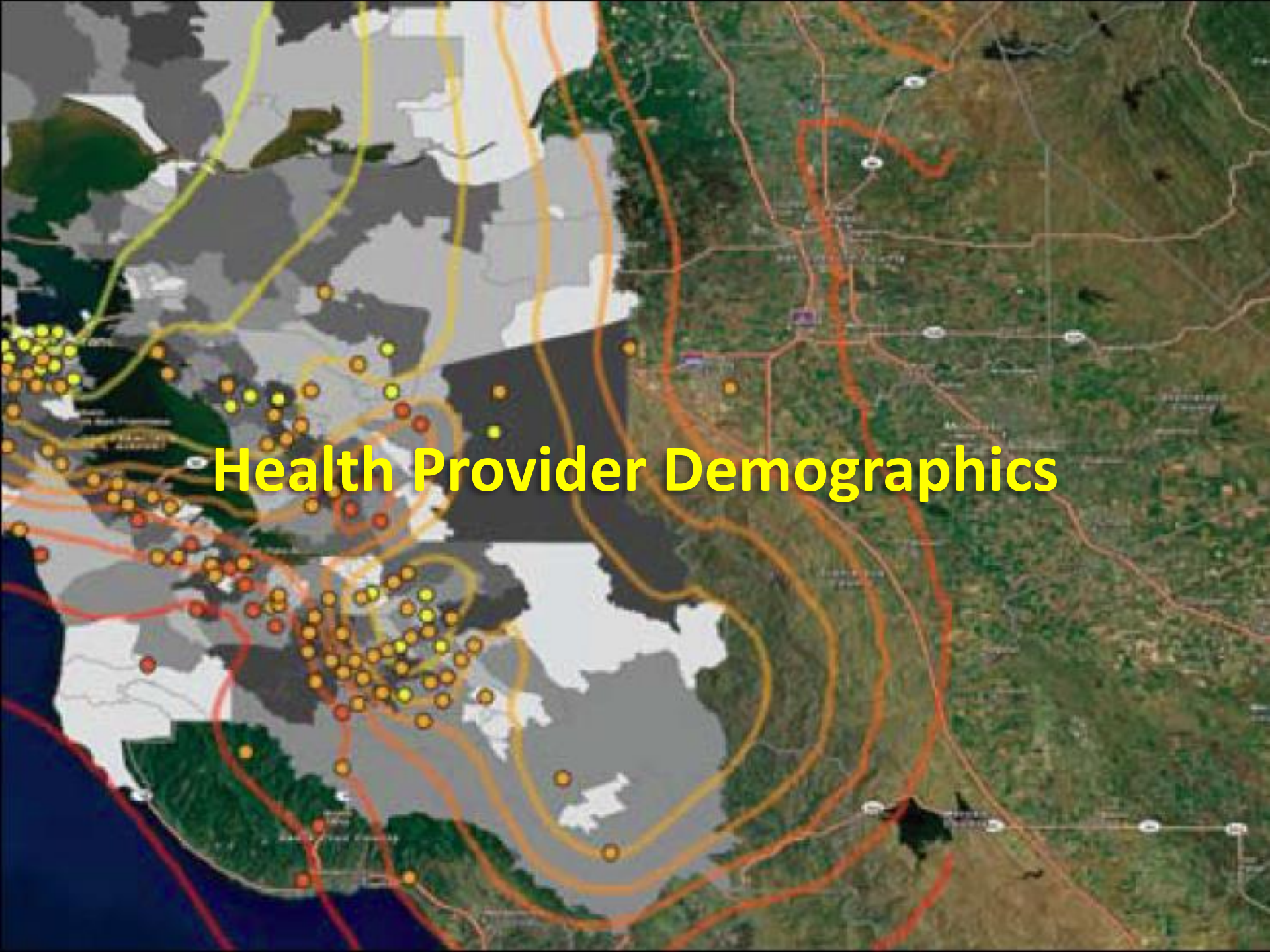


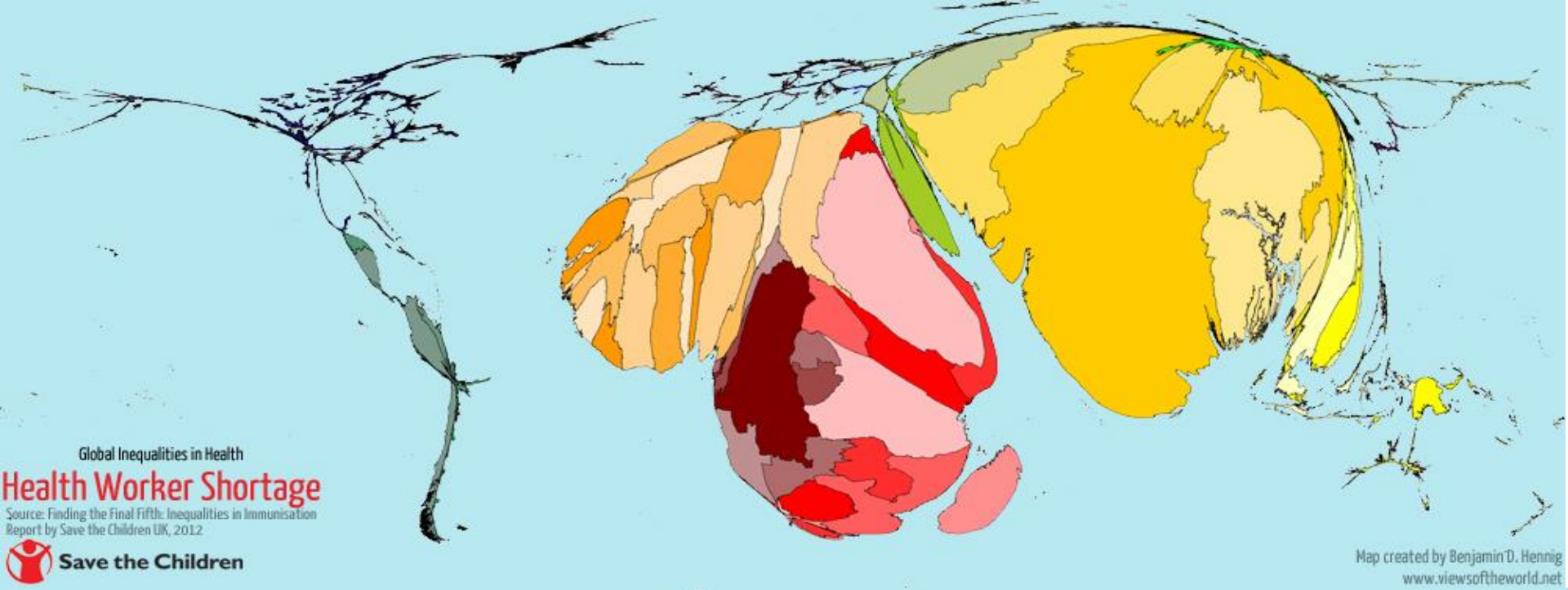
Disease rates

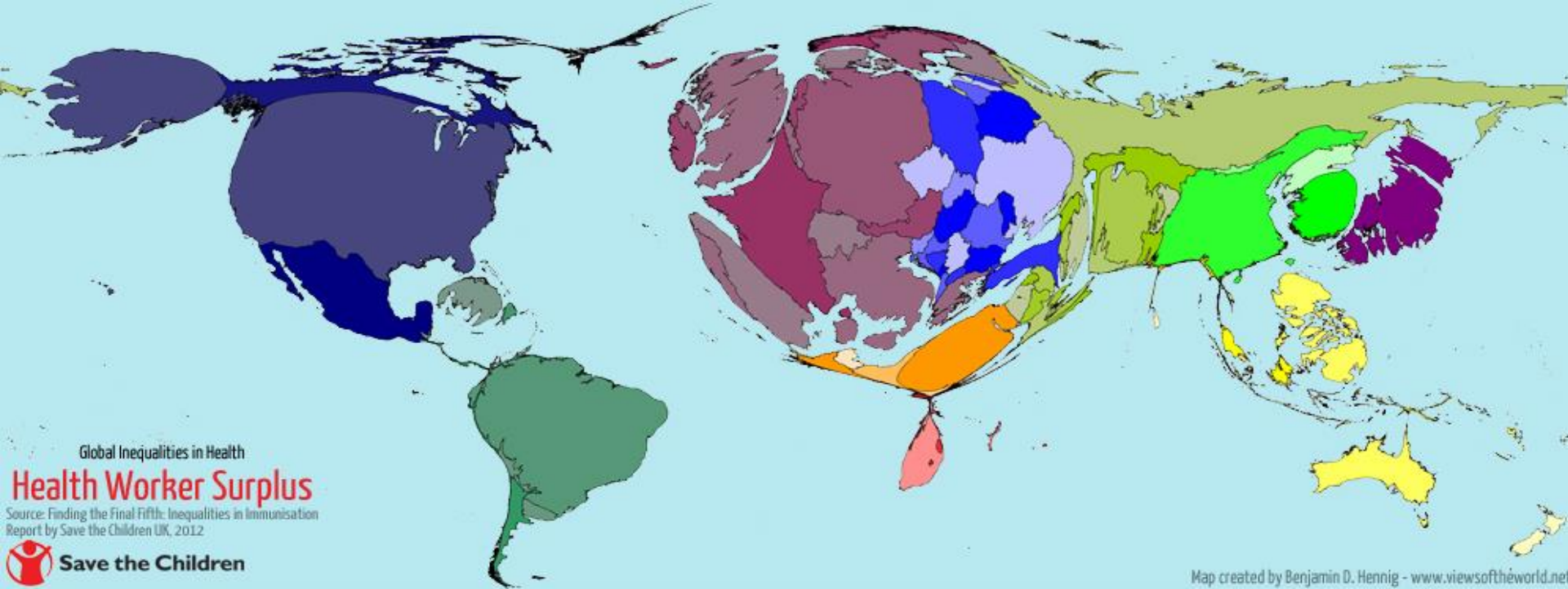


Loma Linda University Medical Center • DISCOVERIES PROJECT
Advanced Emergency Geographic Information System
Emergency services


Service Accessibility
Riverside-
San
Bernardino
Los Angeles-
Long Beach-
Santa Ana


Health Provider Demographics


Global Inequalities in Health
Health Worker Shortage
Source: Finding the Final Fifth: Inequalities in Immunisation
Report by Save the Children UK, 2012
Save the Children
Map created by Benjamin D. Hennig
www.viewsoftheworld.net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Health Worker Surplus
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Save the Children
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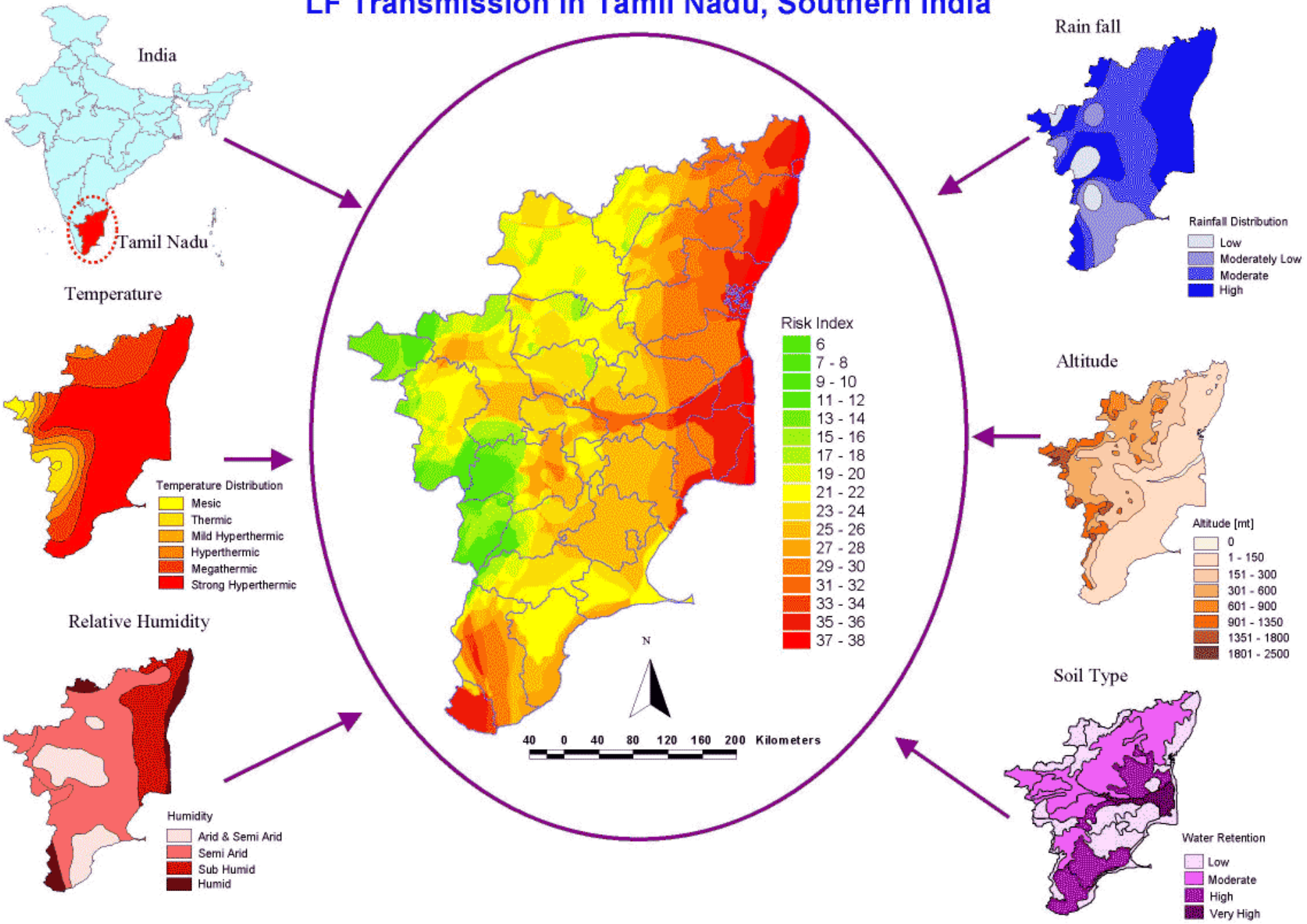
A Geo-Environmental Risk Map showing Areas Potential for LF Transmission in Tamil Nadu, Southern India



Beyond the Map… Spatial Statistics

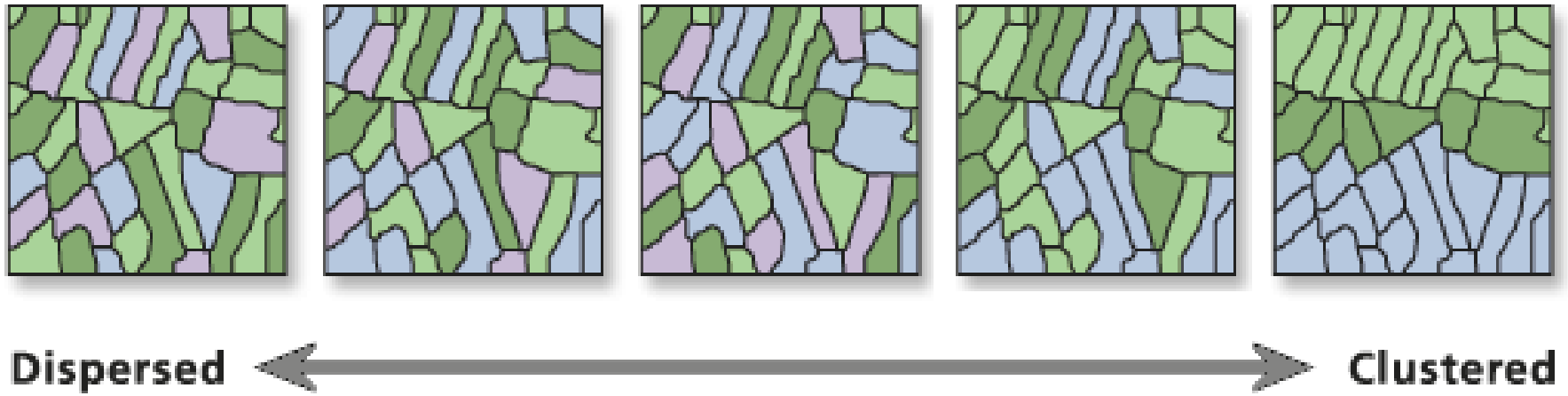
Why spatial statistics?

- Assumption of normality in the central limit theorum:
  "independent and identically distributed"

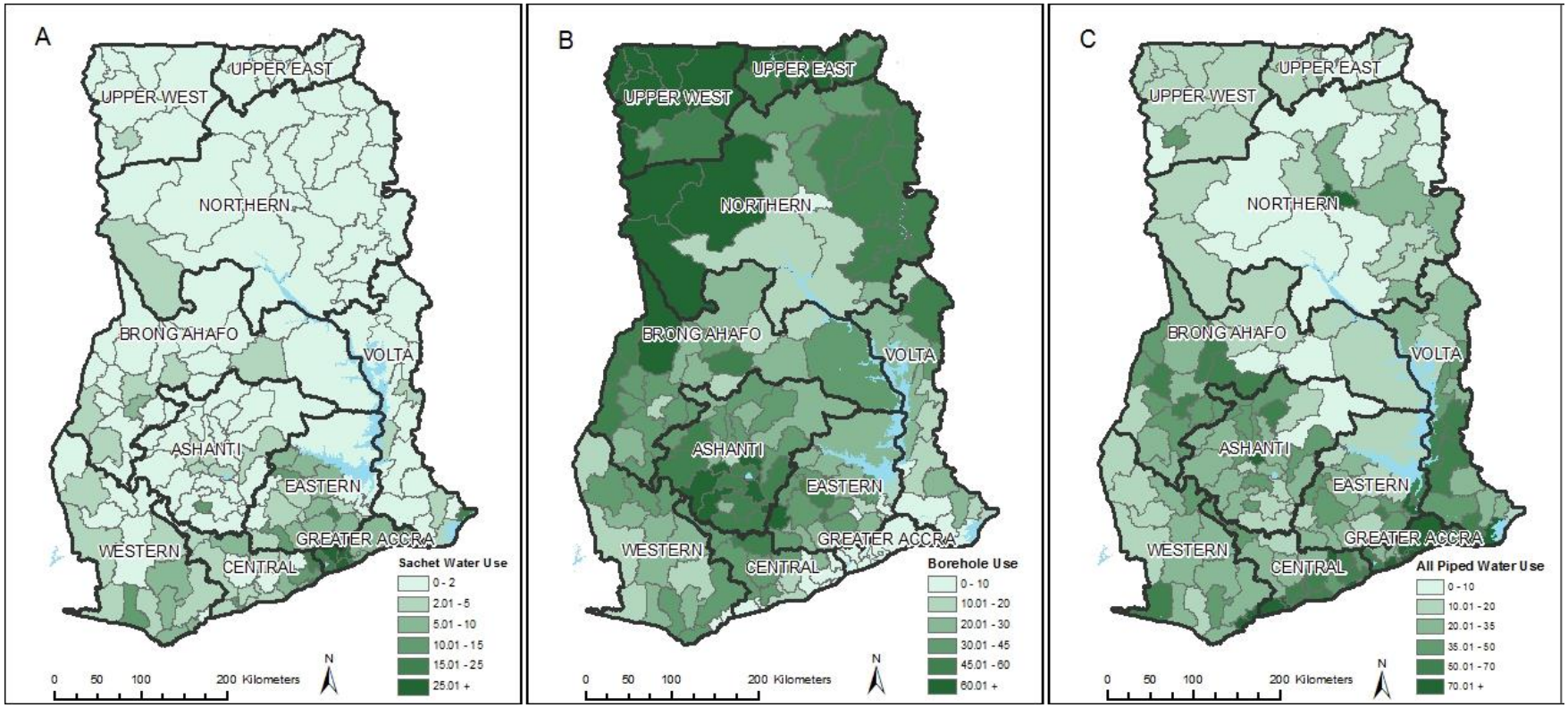
$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + \varepsilon$$

Spatial Autocorrelation

The extent to which similar values are near each other; a core principle of spatial analysis.

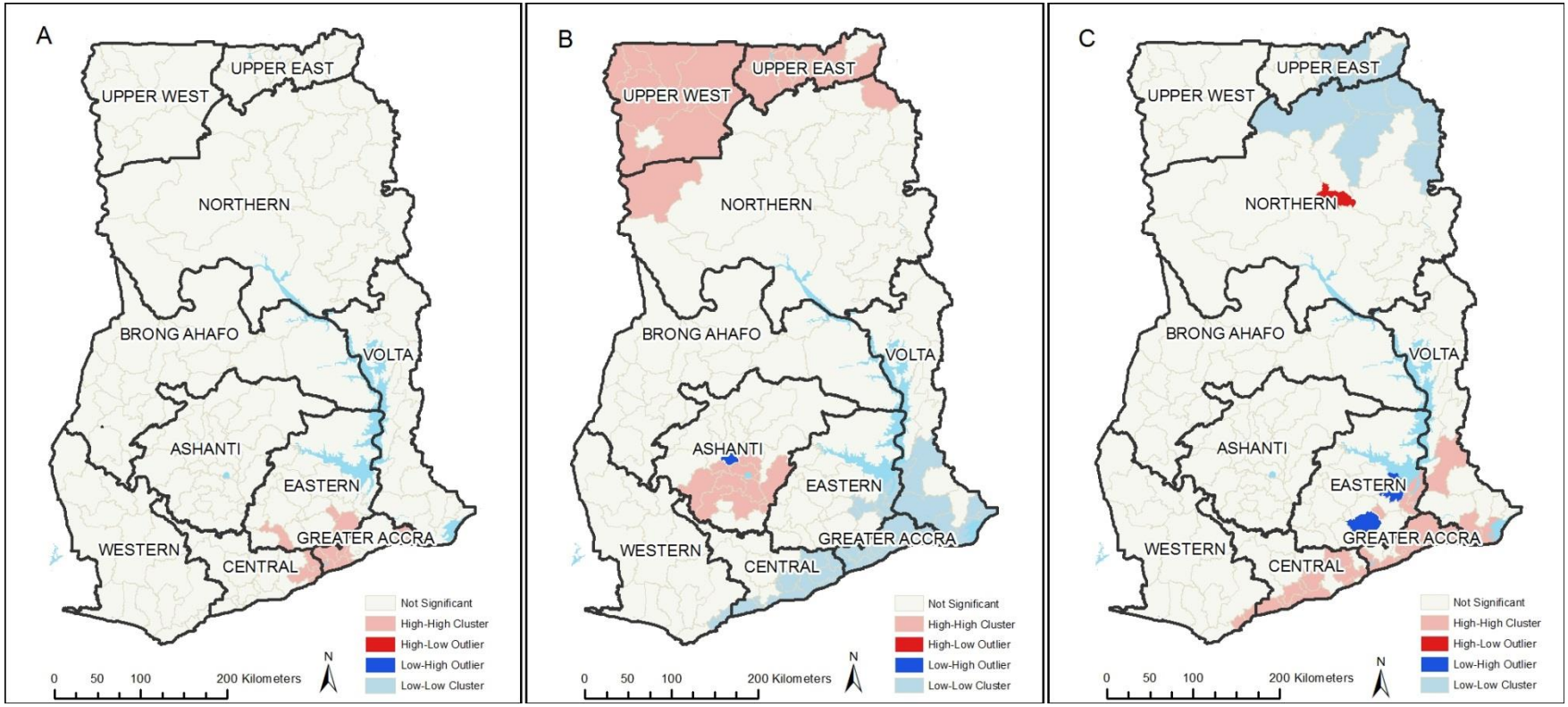


Primary drinking water sources



Sachet water Boreholes Piped water

Local cluster analysis (LISA)



Sachet water Boreholes Piped water

Predictors of sachet use

OLS Model			
Characteristic	β (se)	t-score	R^2
Sachet water			0.601
Constant	0.093 (0.03)	2.994**	
Trash collection service access (%)	0.350 (0.05)	6.704***	
Reside where born (%)	-0.100 (0.05)	-2.200*	
Internet access (%)	0.357 (0.11)	3.245**	
Distance from Accra (km)	-0.0001 (0.00)	-2.636**	

* $P < .05$; ** $P < .01$; *** $P < .001$

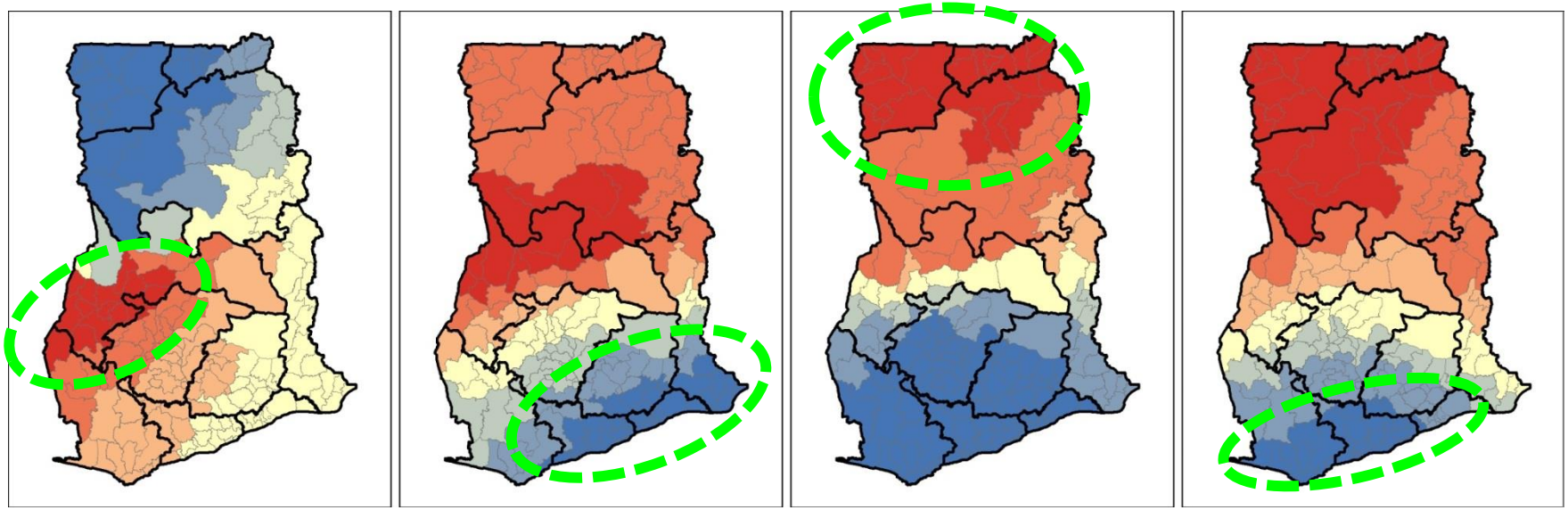
Geographically Weighted Regression (GWR) coefficients: sachet use

Trash collection (+)

Reside where born (-)

Internet access (+)

Distance to Accra (-)

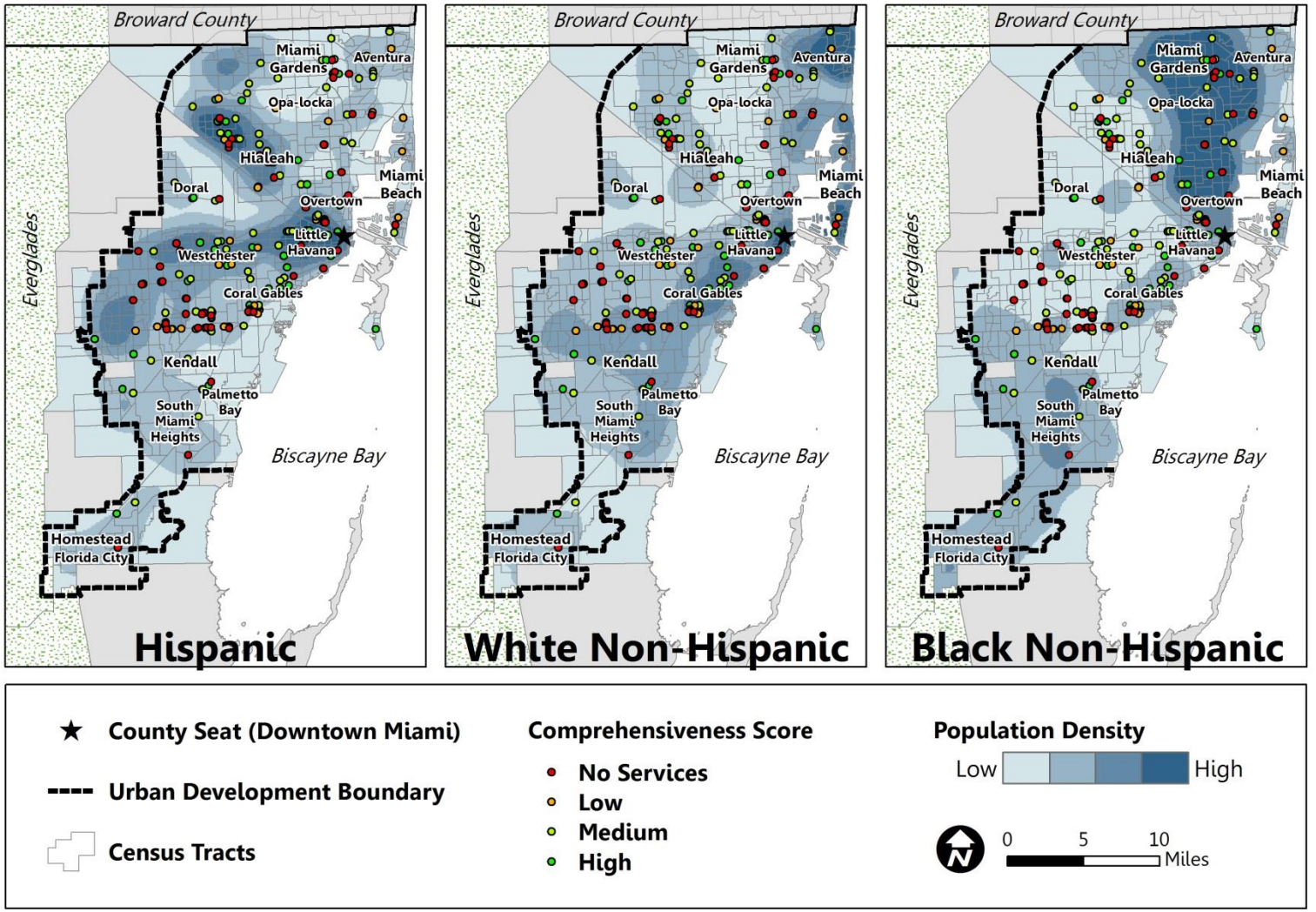


Coefficient value:

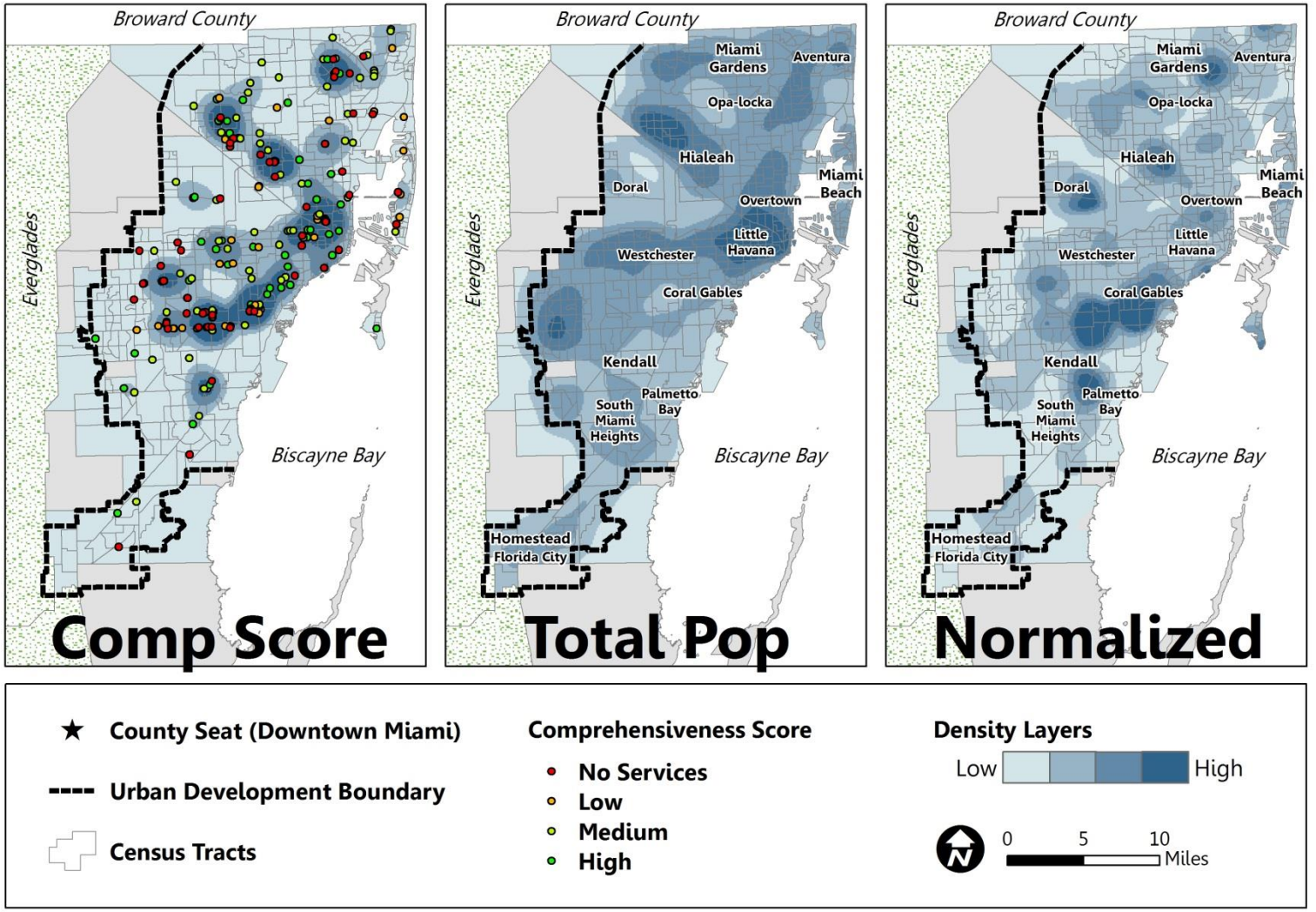
Low ⇔ High

It’s All About Health Disparities

Example: IPV services & race in MDC



Example: IPV service disparities in MDC



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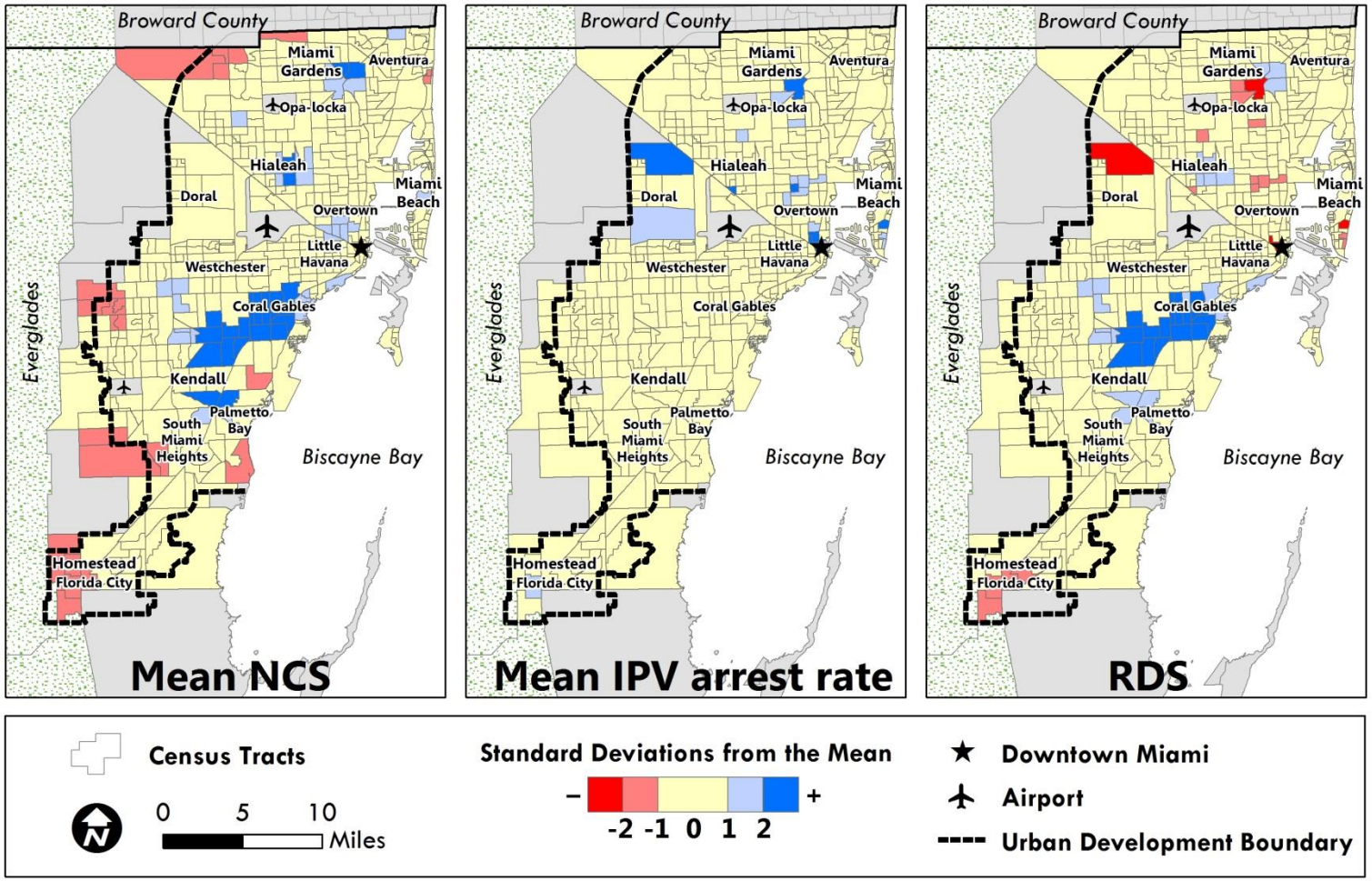
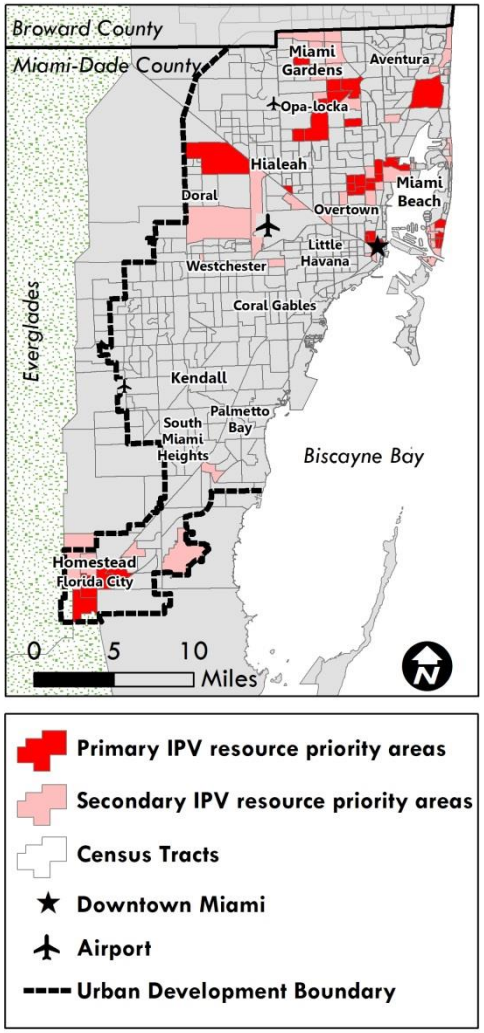
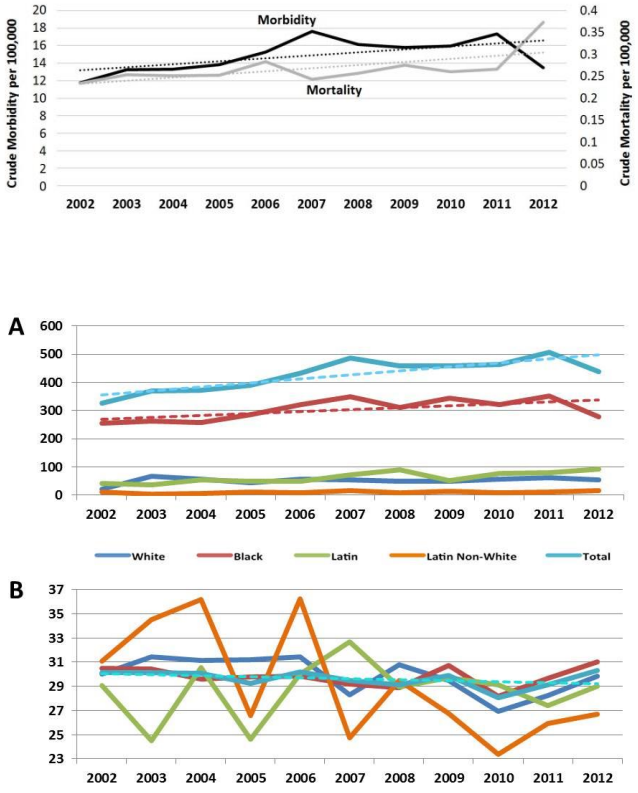
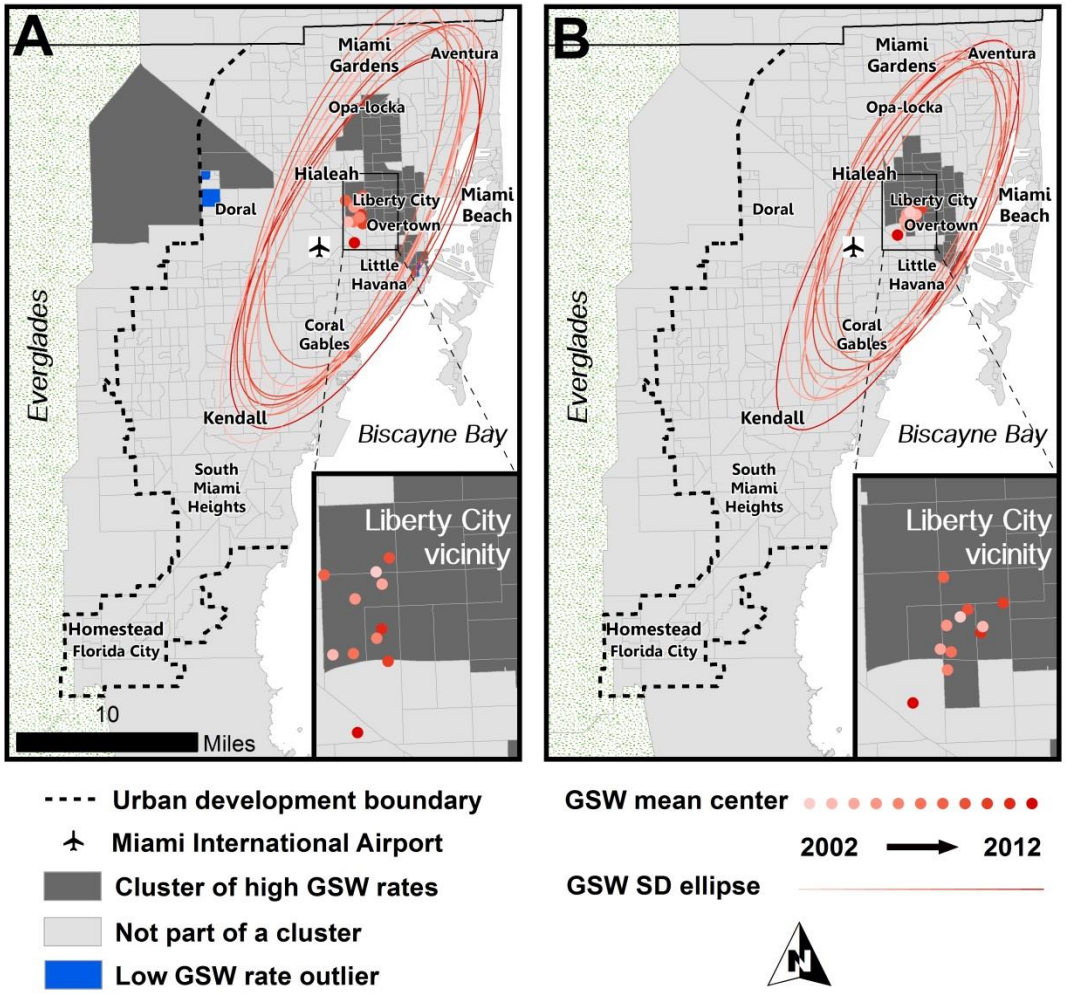


Example: IPV service disparities in MDC



Example: GSW in Miami-Dade





So… Why Geospatial Analysis?

- Visualize your data
- Generate and test new hypotheses
- Exploit the unexploited in your data

Gain a fuller understanding of health phenomena

(Oh, and funding agencies love interdisciplinarity)

Audience Group Activity

Why Spatial Data?

The ability to analyze, over space and time:

locations

quantities

densities

changes

connections

what's inside

what's nearby

Open Source Spatial Tools

- ArcGIS Online and ESRI Virtual Campus
- Google Maps and Google Earth
- SimplyMap
- Quantum GIS
- GRASS
- OpenGeoDa
- SAGA
- … and many other web map servers, spatial DBMS, and data transformation tools

Resources at UM

- ArcGIS software installed campus-wide
- GIS Resources at UM Libraries
  - Budget for data acquisition
- GIS Consultant in Richter Library's GIS lab
- Center for Computation Science (Ungar bldg)
- Development of a GIS data clearinghouse supported jointly by GEG and UM Libraries
- Health Geographics Lab: miami.edu/healthgeo

Freely Available Spatial Data

- ESRI's ArcGIS Online Map and Image Services
- Geocommons
- SimplyMap (via UM subscription)
- National Atlas
- The GIS Data Depot
- DIVA-GIS
- Libre Map Project
- AfricaMap (and other WorldMap projects)
- United Nations Environment Programme
- State and local government offices...

Innovative GIS Applications

- Crime events (DC homicides)
- Economic growth (Global MetroMonitor)
- International migration flows (Peoplemovin)
- Sports analytics (basketball shooting maps)
- Spoken Inuktitut place names (Arctic Bay Atlas)
- The London Blitzkrieg (Bomb Sight)
- Literary landscapes (Scene Changes)
- Historical soundscape of NYC (Roaring Twenties)
- Urban emotion maps (Christian Nold)
- Location-based gaming (Zombie Apolcalypse)
- Virtual tour of Coral Gables (Coral Gables Virtual History)
- Spatially reference historical maps, and more (HyperCities)

The Health Geographics Lab:

miami.edu/healthgeo

stoler@miami.edu

Minor in Social Science & Medicine

Minor in Medical Humanities