

# **Geographical Information System (GIS)**

Dr. Tarendra Lakhankar

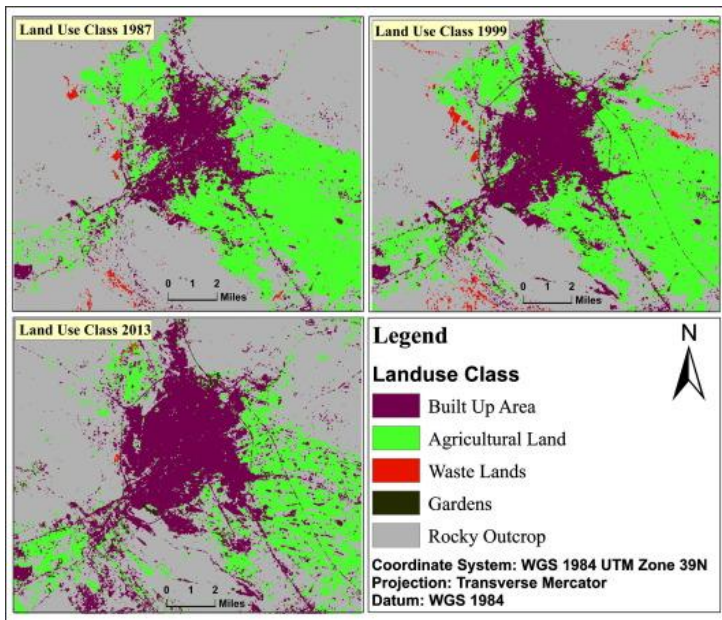
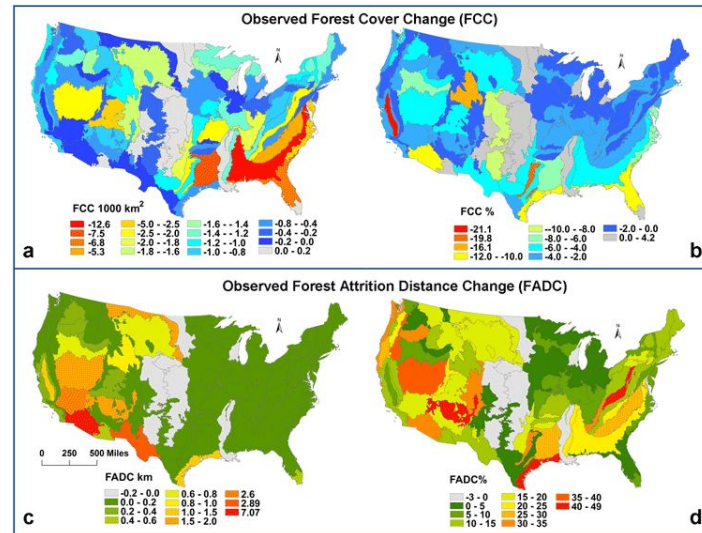
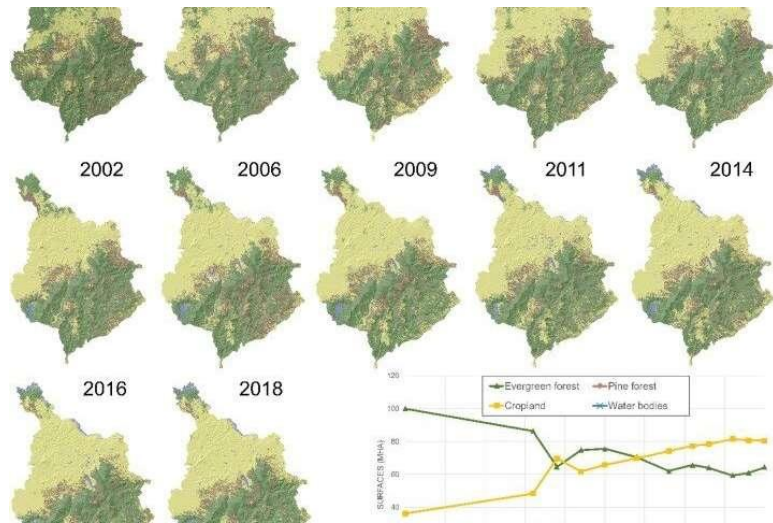
# Why make maps?

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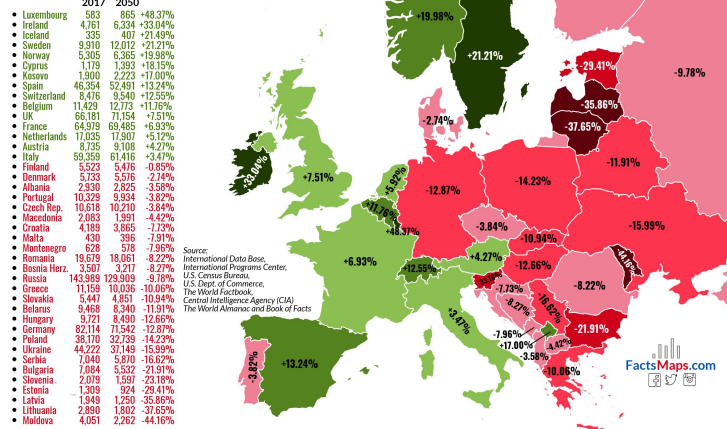
**Maps as story tellers and can used as problem solvers.**

- To represent a larger area than we can see
- To show a phenomenon or process we can't see with our eyes
- To present information concisely
- To show spatial relationships

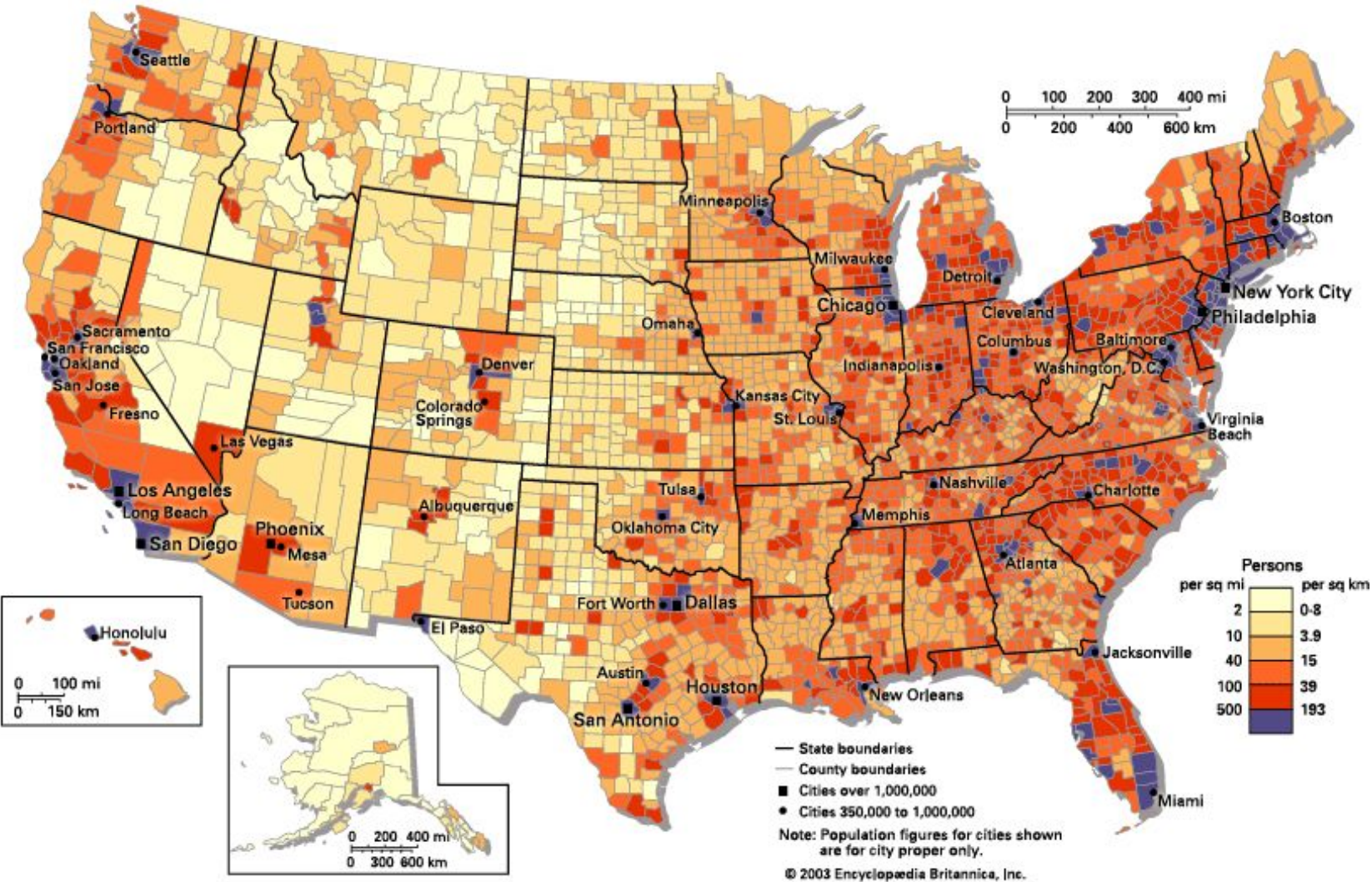
# Show what we can't see



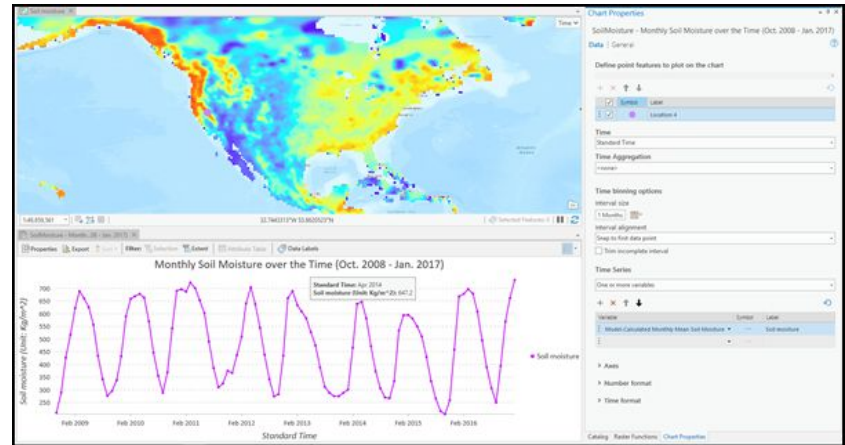
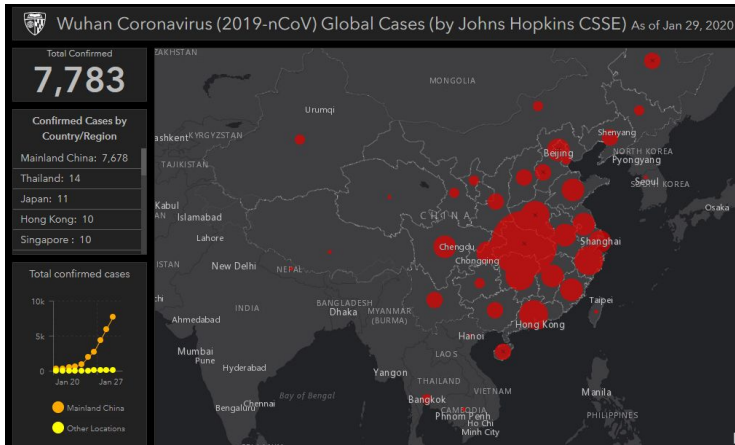
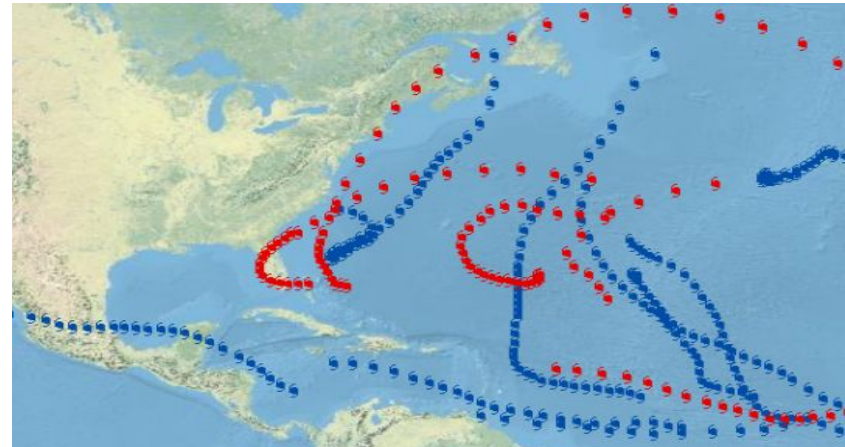
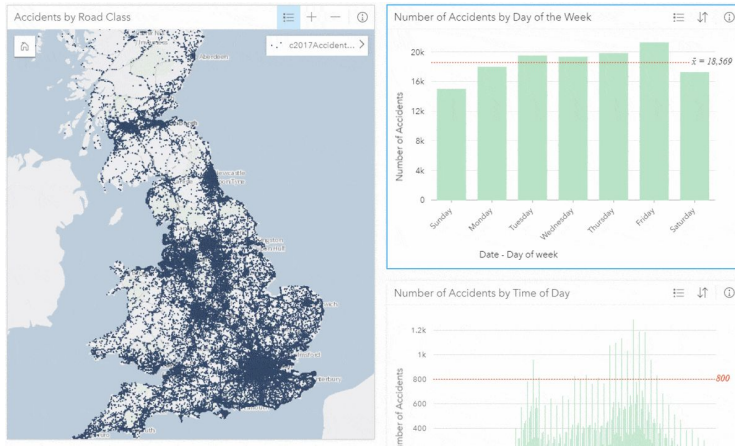
## Projected Population Change in European Countries 2017 to 2050



# Present info concisely



# Show spatial-temporal relationships

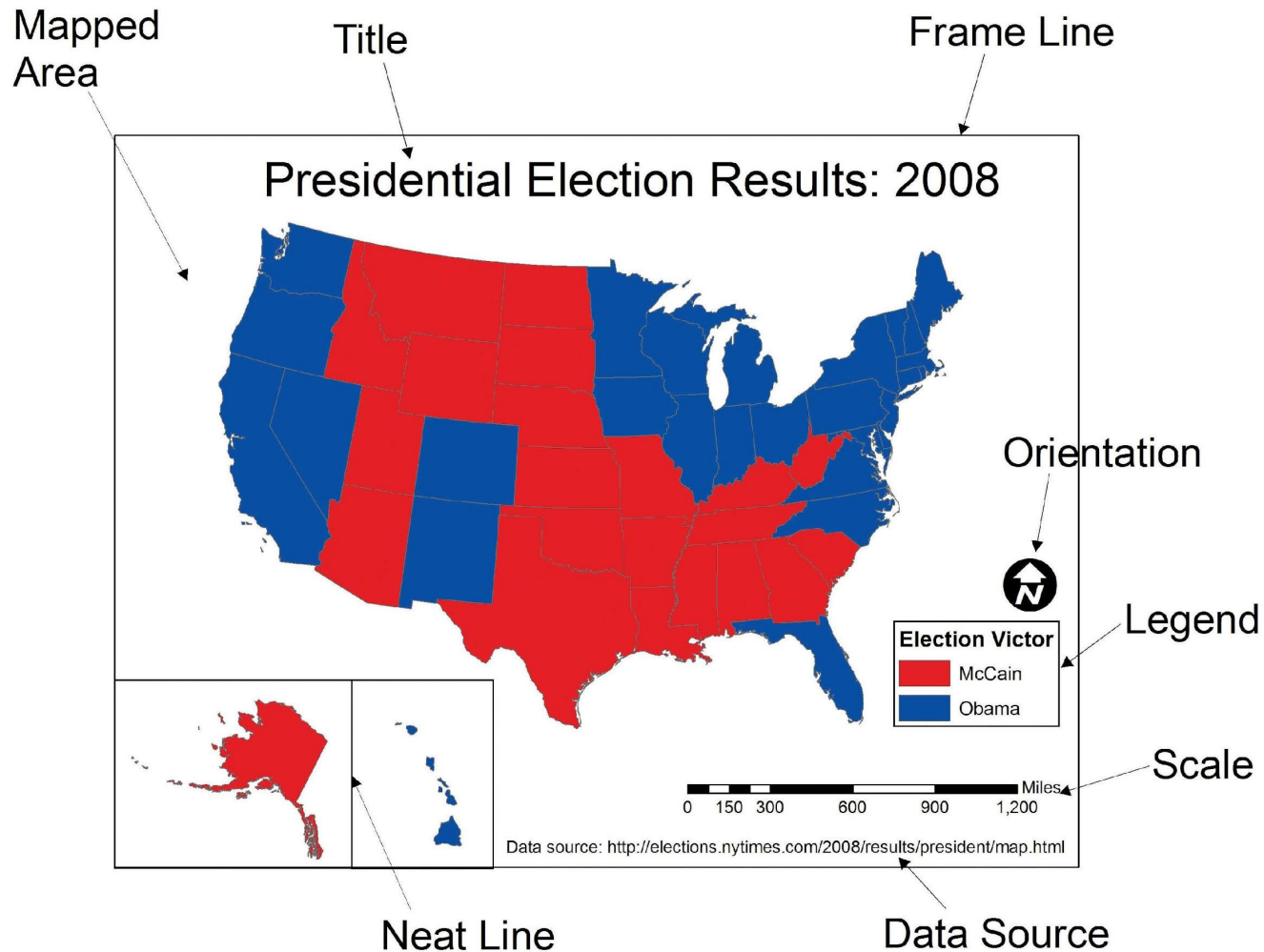


# How do we read maps?

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- Maps are selective views of reality
- Size of the map relative to reality (scale)
- What's on the map (symbolization)
- Shape of the map (projection)
- Checking map orientation (North Arrow)

# Common Map Elements



# What is a GIS?

- A GIS is a computer system that allows you to map, model, query, and analyze large quantities of data within a single database according to their location.

The screenshot displays a GIS interface. On the left is a map showing a network of roads and several green-shaded areas representing parks. On the right is a 'Select by Attributes' dialog box. The dialog box has a 'Method' dropdown set to 'Create a new selection'. Below this is a list of fields: 'OBJECTID', 'Name', 'Status', 'Reg\_Pk\_Typ', 'Jurisdic', 'Comments', 'Type', 'SHAPE\_Leng', and 'SHAPE\_Areal'. To the right of the fields is a 'Unique sample values' list. Below the fields is a 'SQL Info...' button and a 'Complete List' button. The 'SELECT \* FROM Parks\_In\_CRD WHERE' clause is entered as: 'Jurisdic' = 'District of Saanich' AND 'SHAPE\_Areal' > 500000. Below the dialog box is a table titled 'Attributes of Parks\_In\_CRD'. The table has columns: Name, Status, Reg\_Pk\_Typ, Jurisdic, Comments, Type, SHAPE\_Len, and SHAPE\_Areal. The table contains 10 rows of data. At the bottom of the interface, there is a record navigation bar showing 'Record: 390' and 'Records: 4 out of 963 Selected'.

Name	Status	Reg_Pk_Typ	Jurisdic	Comments	Type	SHAPE_Len	SHAPE_Areal
Gulf Islands National Park Reserv	Corrections Complete	N/A	Islands Trust (South Pen		Federal Park	4725.69729	532443
Cedar Hill Park	Corrections Complete	N/A	District of Saanich		Municipal Park	3620.544827	536154
Gulf Islands National Park Reserv	Corrections Complete	N/A	Islands Trust (Sitama Isl		Federal Park	8561.687966	54971
French Beach Provincial Park	Corrections Complete	N/A	Juan de Fuca Electoral A		Provincial Park	3989.957005	954025
Willy's Lagoon Regional Park	Corrections Complete	Park	District of Metchoosin		Regional Park	8456.045992	567178
Hill Hill Regional Park	Corrections Complete	Park	District of Langford/Town		Regional Park	4684.605626	607967
Seato-Sea Green/Blue Belt Land	Corrections Complete	Park Reserve	District of Sooke		Regional Park	3173.582063	605213
Mount Finlayson Provincial Park	Corrections Complete	N/A	District of Langford		Provincial Park	3331.509201	61922
Seato-Sea Green/Blue Belt Land	Corrections Complete	Park Reserve	Juan de Fuca Electoral A		Regional Park	3170.433275	627965

# Geographic primitive

$$G = f(x, y, z, t, F)$$

$x, y$  = Spatial data  
 $z$  = Elevation data  
 $t$  = time data  
 $F$  = Attribute data



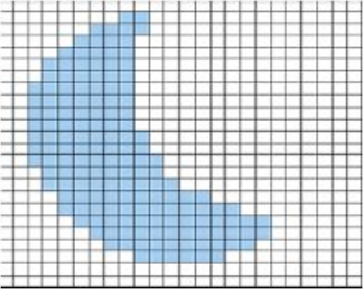
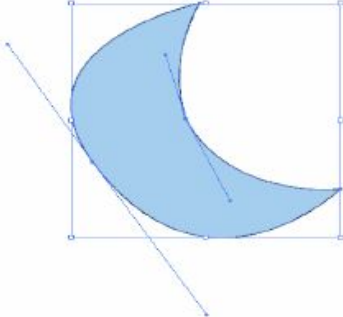
# The Feature Model

	<b>POINT</b>	<b>LINE</b>	<b>AREA</b>
<b>FEATURES</b>			

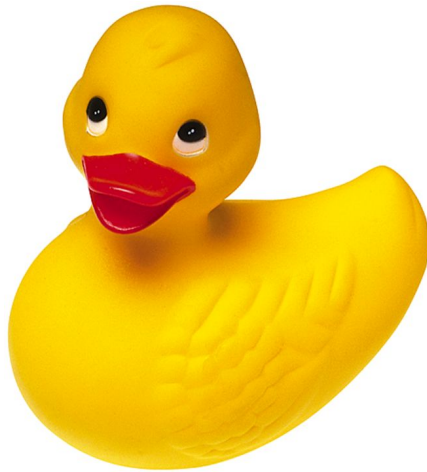
Figure 1.2 The Feature Model: Examples of a point feature (38 foot elevation bench mark), line feature (road, contours) and area features (reservoir, vegetation).

# Raster vs Vector

## Raster and Vector Graphics

Raster	Vector
	
Made up of a <u>grid</u> of pixels	Geometric shapes and lines that are defined <u>mathematically</u>
Resolution dependent	Resolution <u>independent</u>
When scaled, visual quality and sharpness is degraded	When scaled, visual quality and sharpness is <u>unaffected</u>
File size is relatively <u>large</u>	File size is relatively <u>small</u>
File Formats: <u>GIF, TIF, BMP, PSD</u>	File Formats: <u>EPS, WMF, AI</u>
Pixel-oriented	<u>Object</u> -oriented

# Zoom raster vs Vector image



100% (900 x 983 dpi)



200%



500%



100%



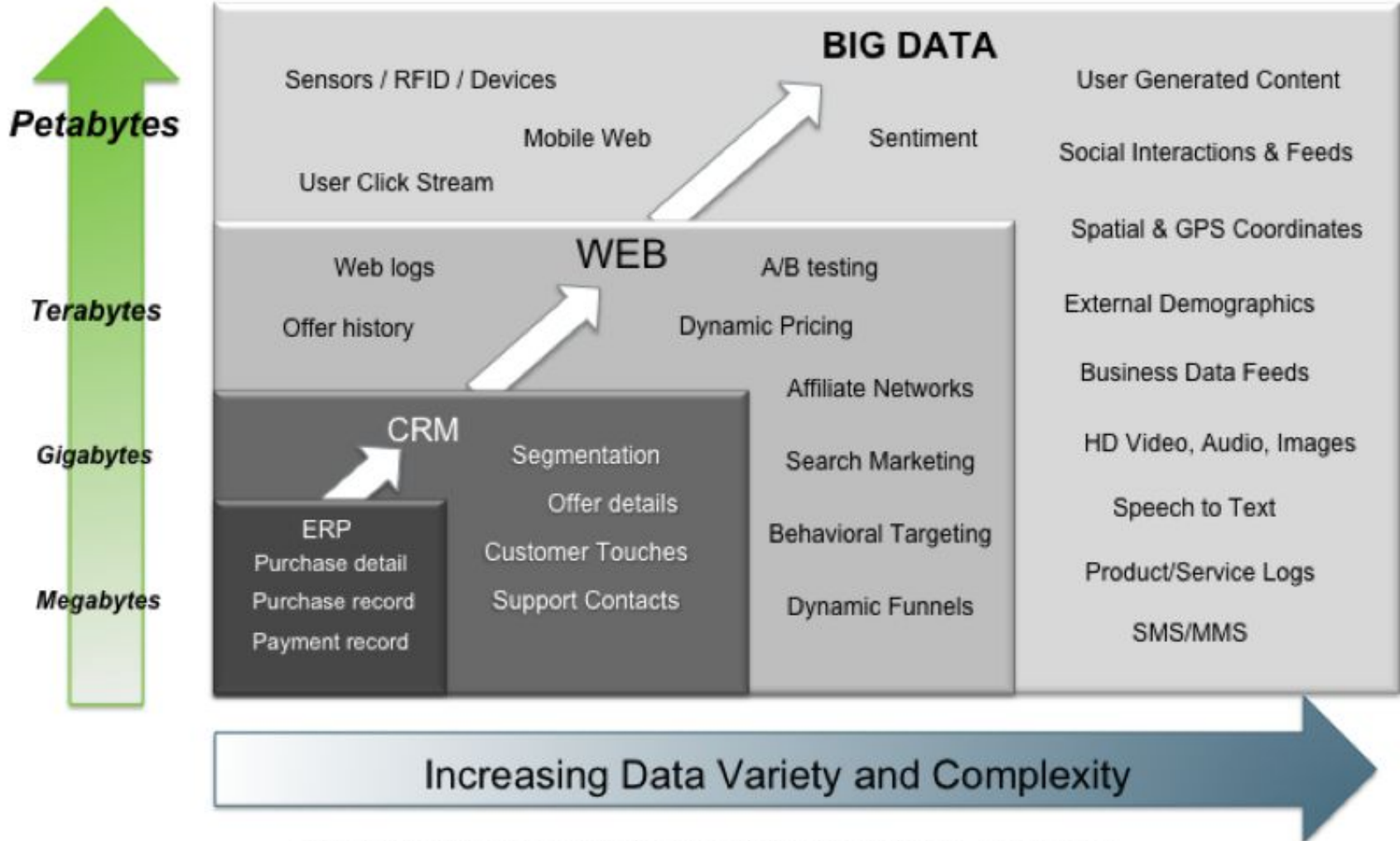
200%



500%



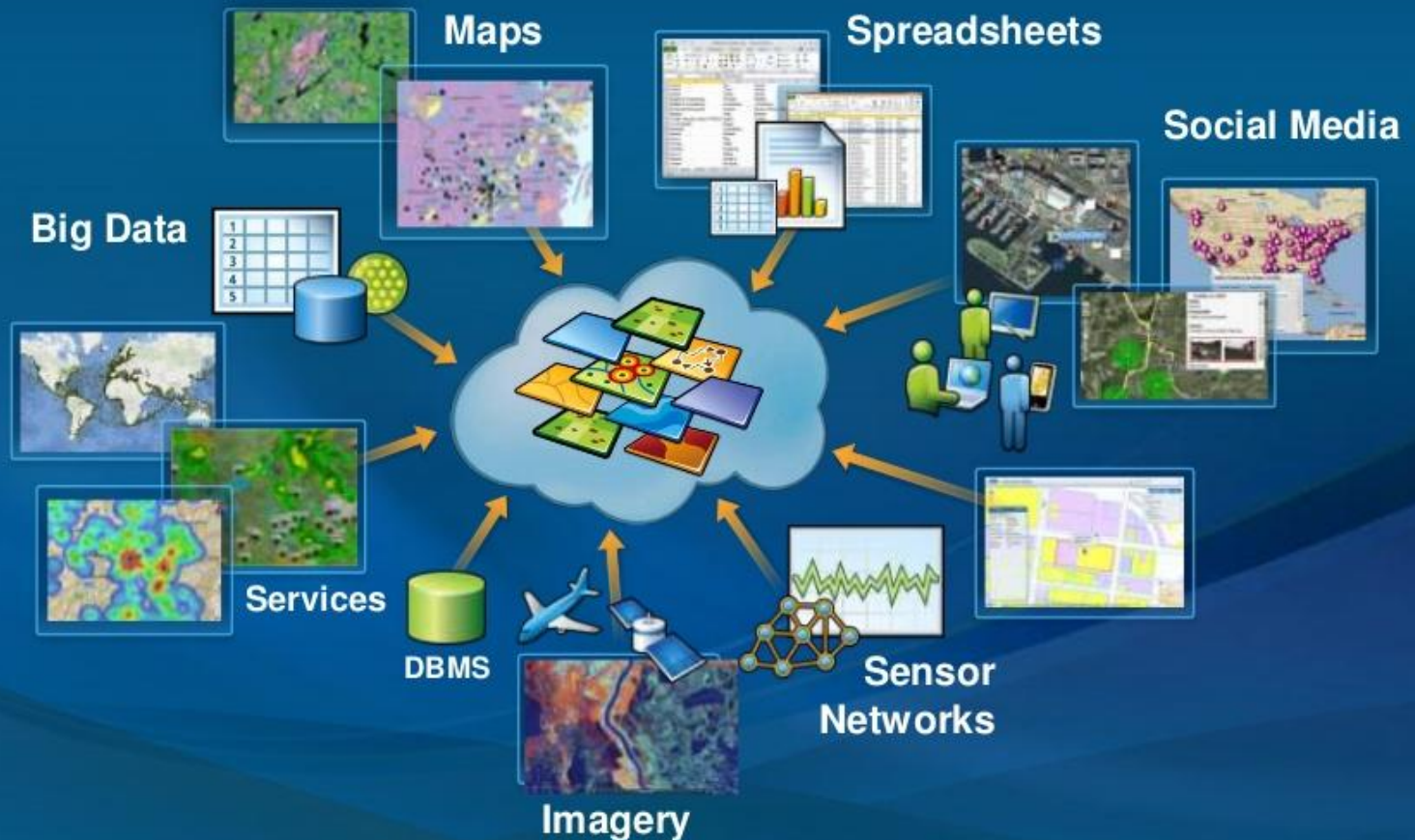
# Big Data = Transactions + Interactions + Observations



**Source:** Contents of above graphic created in partnership with Teradata, Inc.

# ArcGIS online integrates geospatial information

## Leveraging the cloud and standards



# Content

## Authoritative content

Basemaps

Reference layers

Demographic

Templates



The foundation and building blocks for making maps and apps

# What is GIS?



It's **Geographic Information System**



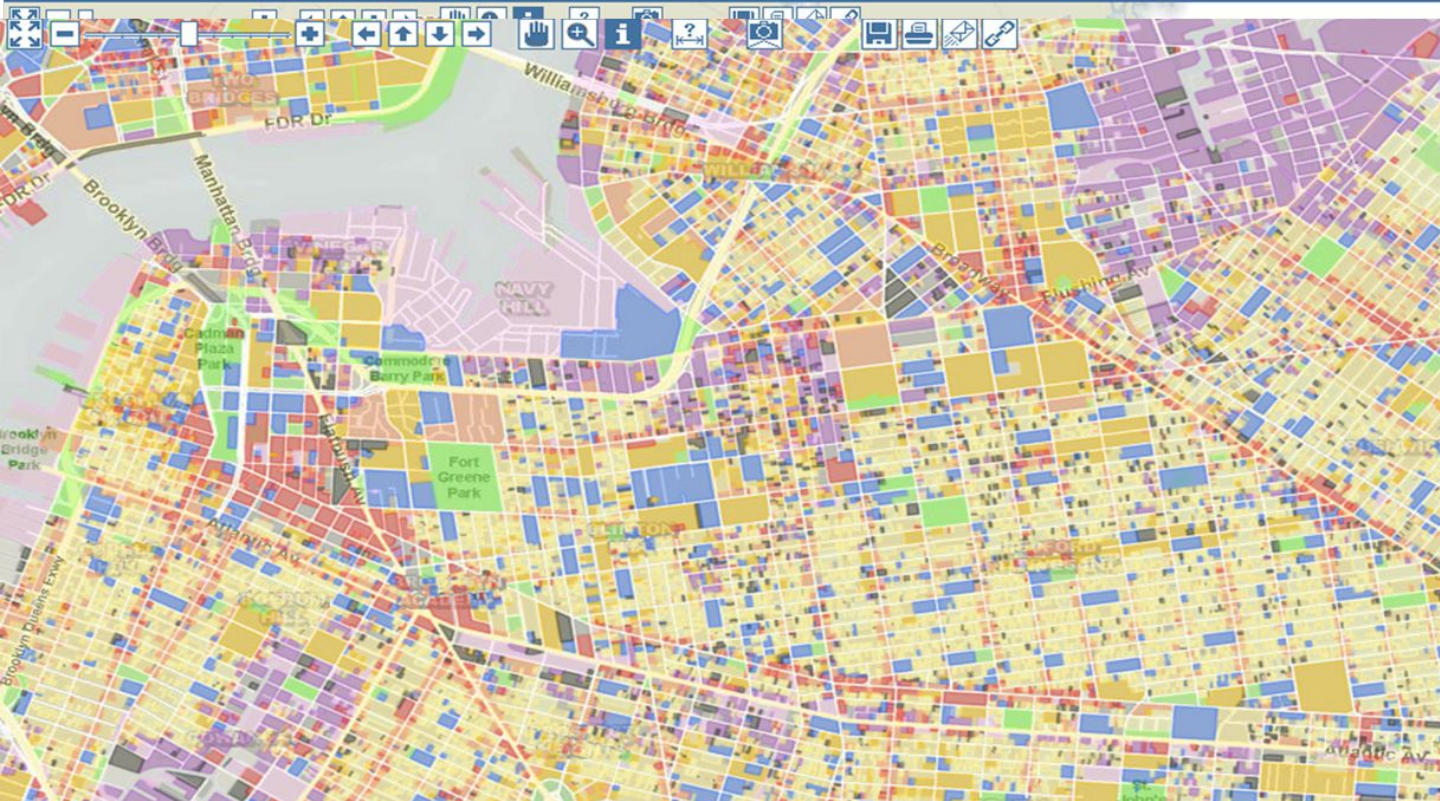
So, GIS deals with any data with geographical coordinates?

# Examples of Applied GIS

- **Urban Planning, Management & Policy**
  - Zoning, subdivision planning
  - Land acquisition
  - Economic development
  - Code enforcement
  - Housing renovation programs
  - Emergency response
  - Crime analysis
  - Tax assessment
- **Environmental Sciences**
  - Monitoring environmental risk
  - Modeling stormwater runoff
  - Management of watersheds, floodplains, wetlands, forests, aquifers
  - Environmental Impact Analysis
  - Hazardous or toxic facility siting
  - Groundwater modeling and contamination tracking
- **Political Science**
  - Redistricting
  - Analysis of election results
  - Predictive modeling
- **Civil Engineering/Utility**
  - Locating underground facilities
  - Designing alignment for freeways, transit
  - Coordination of infrastructure maintenance
- **Business**
  - Demographic Analysis
  - Market Penetration/ Share Analysis
  - Site Selection
- **Education Administration**
  - Attendance Area Maintenance
  - Enrollment Projections
  - School Bus Routing
- **Real Estate**
  - Neighborhood land prices
  - Traffic Impact Analysis
  - Determination of Highest and Best Use
- **Health Care**
  - Epidemiology
  - Needs Analysis
  - Service Inventory

A low-angle, upward-looking photograph of several modern skyscrapers with glass facades. The buildings are arranged in a circular pattern, creating a sense of height and urban density. The sky is a clear, vibrant blue with scattered, light white clouds. The overall composition is dynamic and emphasizes the scale of modern architecture.

# Urban planning and management



Search for a Location

Searched Locations

Show Zoning & Related Data on Map

- Waterfront**
- Land Use**
  - Primary Land Use
    - One & Two Family Residence
    - Multi-Family Residence (Walkup)
    - Multi-Family Residence (Elevator)
    - Mixed Residential & Commercial
    - Commercial Use
    - Industrial / Manufacturing
    - Transportation / Utility
    - Public Facilities and Institutions
    - Open Space & Recreation
    - Parking
    - Vacant Land
- Other Program Areas**
- Landmark**

# Land-use data

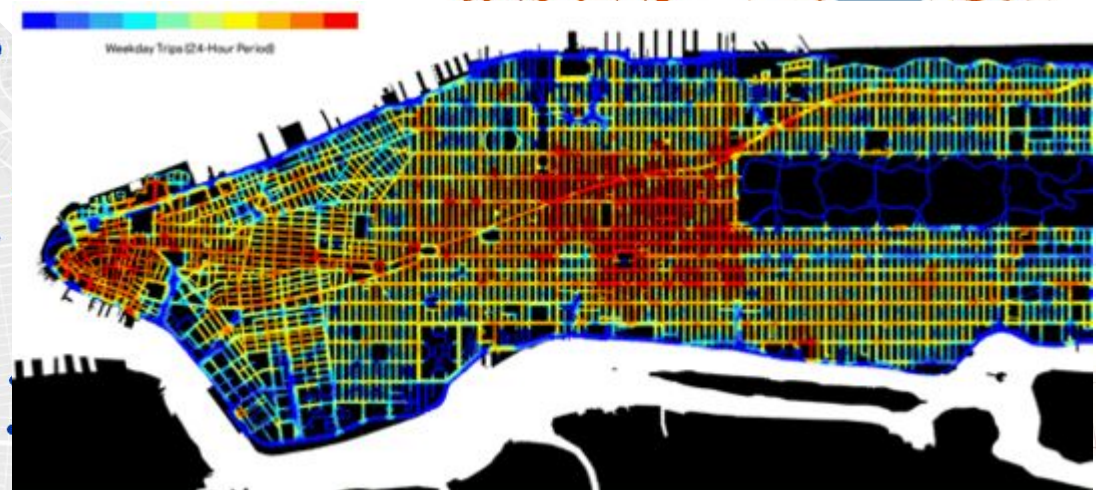
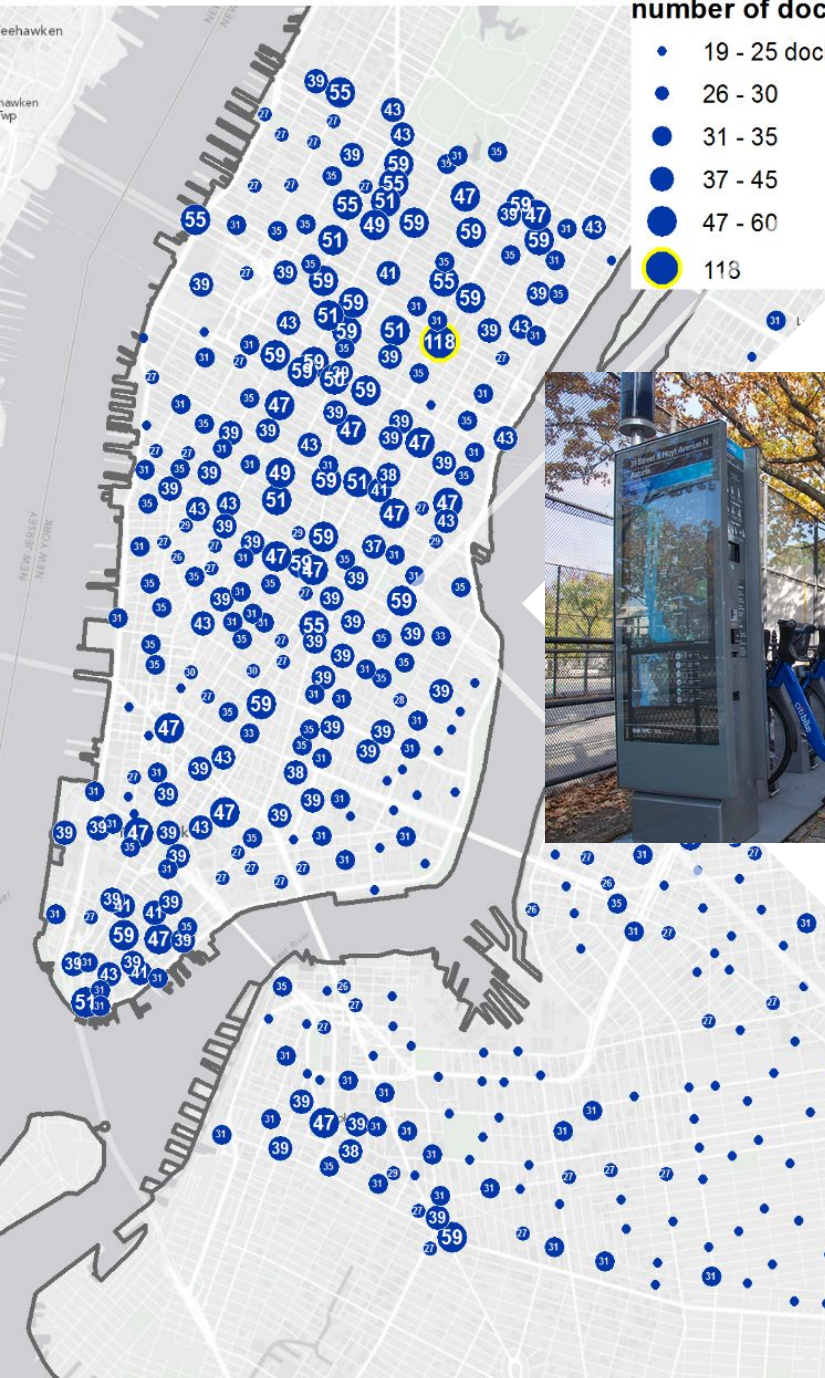
<http://maps.nyc.gov/doitt/nycitymap/>

## Proposed NYC Citi Bike Number of docks per kio

- 19 - 25 docks
- 26 - 30
- 31 - 35
- 37 - 45
- 47 - 60
- 118

## 5.5 Million Journeys at NYC Bike Share

Based on origin-destination data released by NYC Bike Share for journeys between July 2013 and February 2014. Idealised route assumed, using OpenStreetMap data.





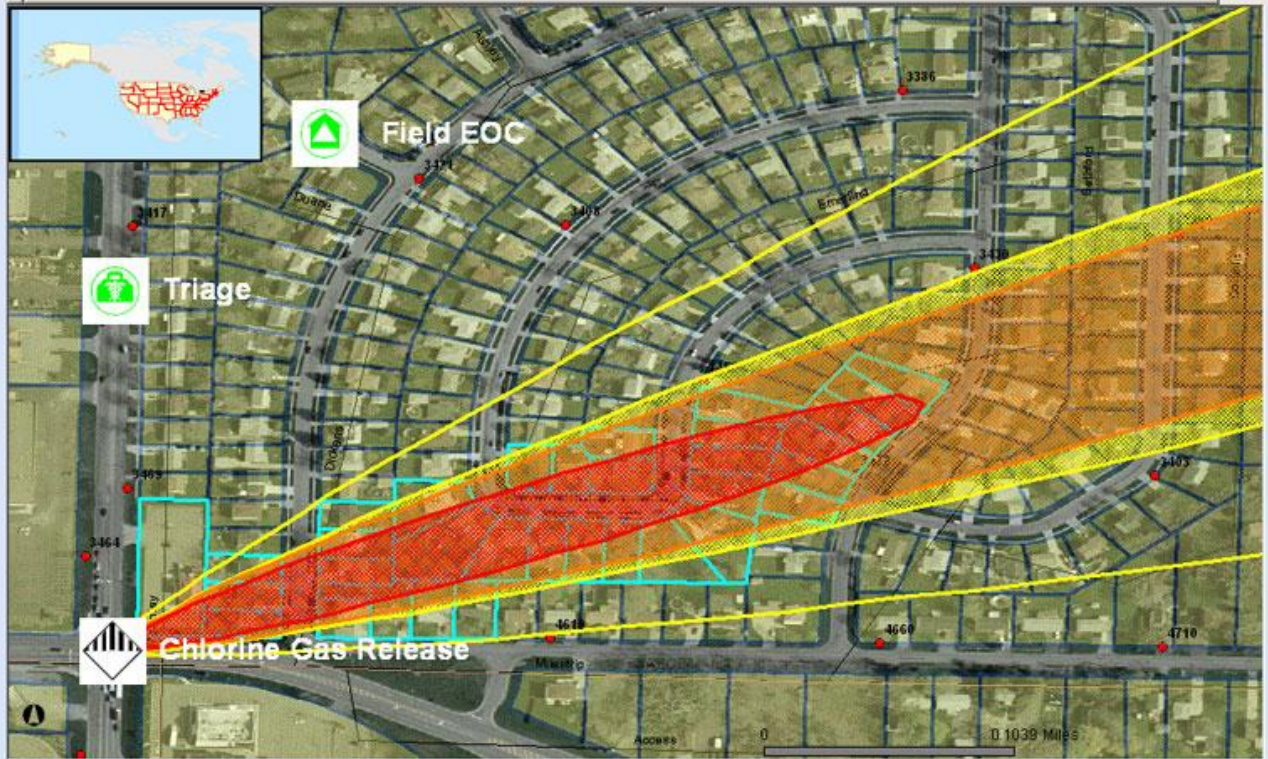
# Incident Management Mapping System

- Zoom To Region
- Address Search
- Coord. Search
- Zoom In
- Zoom Out
- Full Extent
- Pan
- Measure
- Identify
- Select by Box
- Buffer Feature
- Buffer Point
- Clear Selection
- Markup Map**
- Erase Markup
- ALOHA Plume
- Retrieve Data
- Erase Plume
- Track Assets
- Print

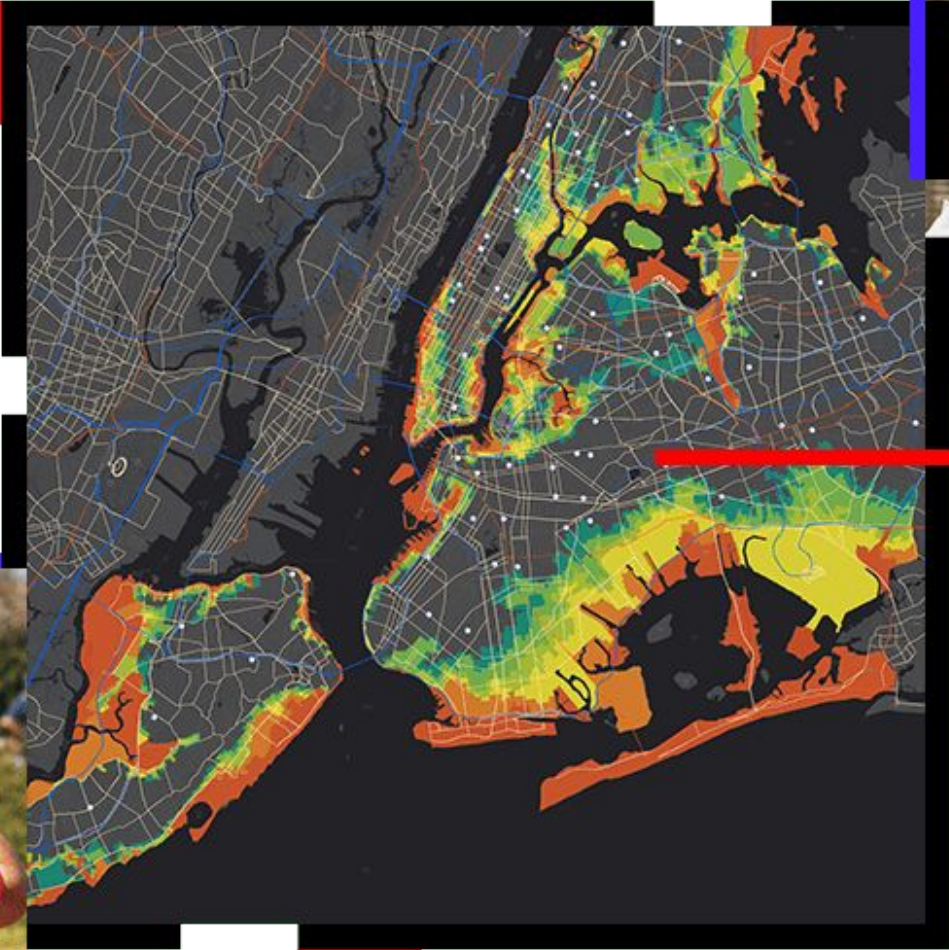
- View Layers
- View Legend
- Refresh Map

- Map Layers
  - Auto Vehicle Locator
  - Shelters
  - Pharmacies
  - Schools
  - Day Care Centers
  - Fire Hydrants
  - Parcels
  - Erie County Ortho Imagery
- Airports
  - Runways (Regional)
  - Airports (Regional)
  - Airports (Local)
  - Landing Fields (Detailed)
- Background
  - National Forests (Reg-Local)
  - US Background (National and State)
  - US Background (Regional)
  - US Background (Local)
  - Canada and Mexico Background
  - Ocean Background
- Cities (Points)
  - Large Cities (National)
  - Major Cities (State)
- City (Areas)
  - Urban Outlines (State)
  - Urban Outlines (Regional)
  - Municipal Boundaries
  - Places (Outline)
  - Urban Areas (State)

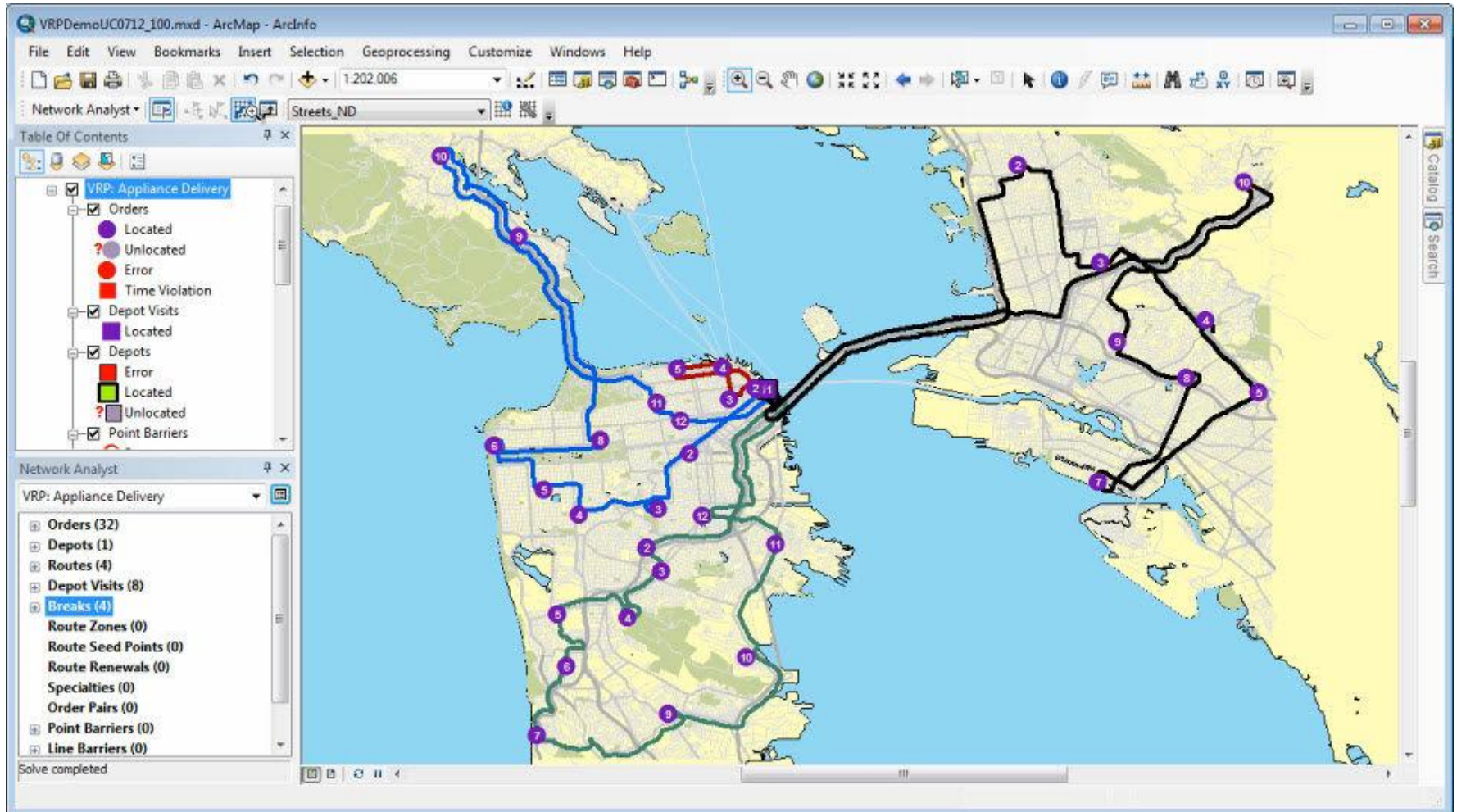
Current Map Mode: Markup Map



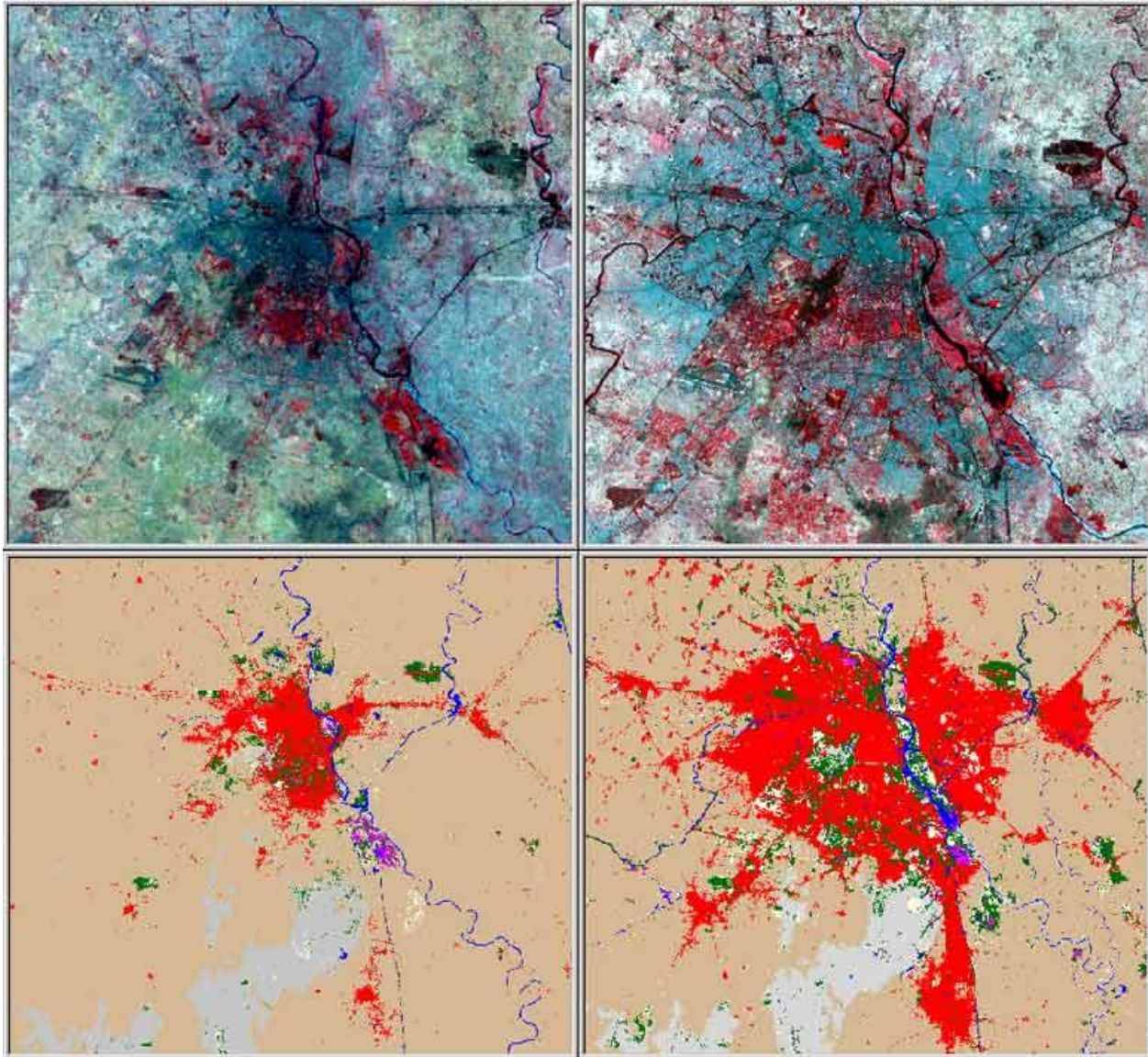
# Emergency Management



# Road Network Analysis (Appliance Delivery)



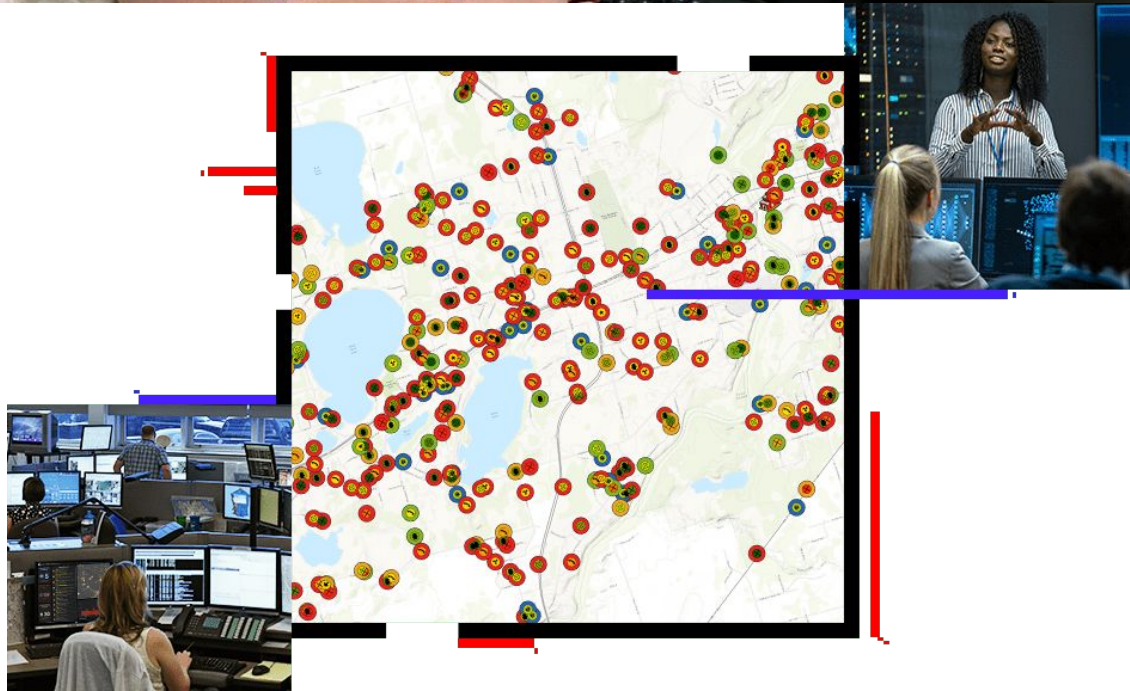
# Mapping and Compare Urban Growth





# 911 - GIS Integration

Computer-aided  
dispatch (CAD)



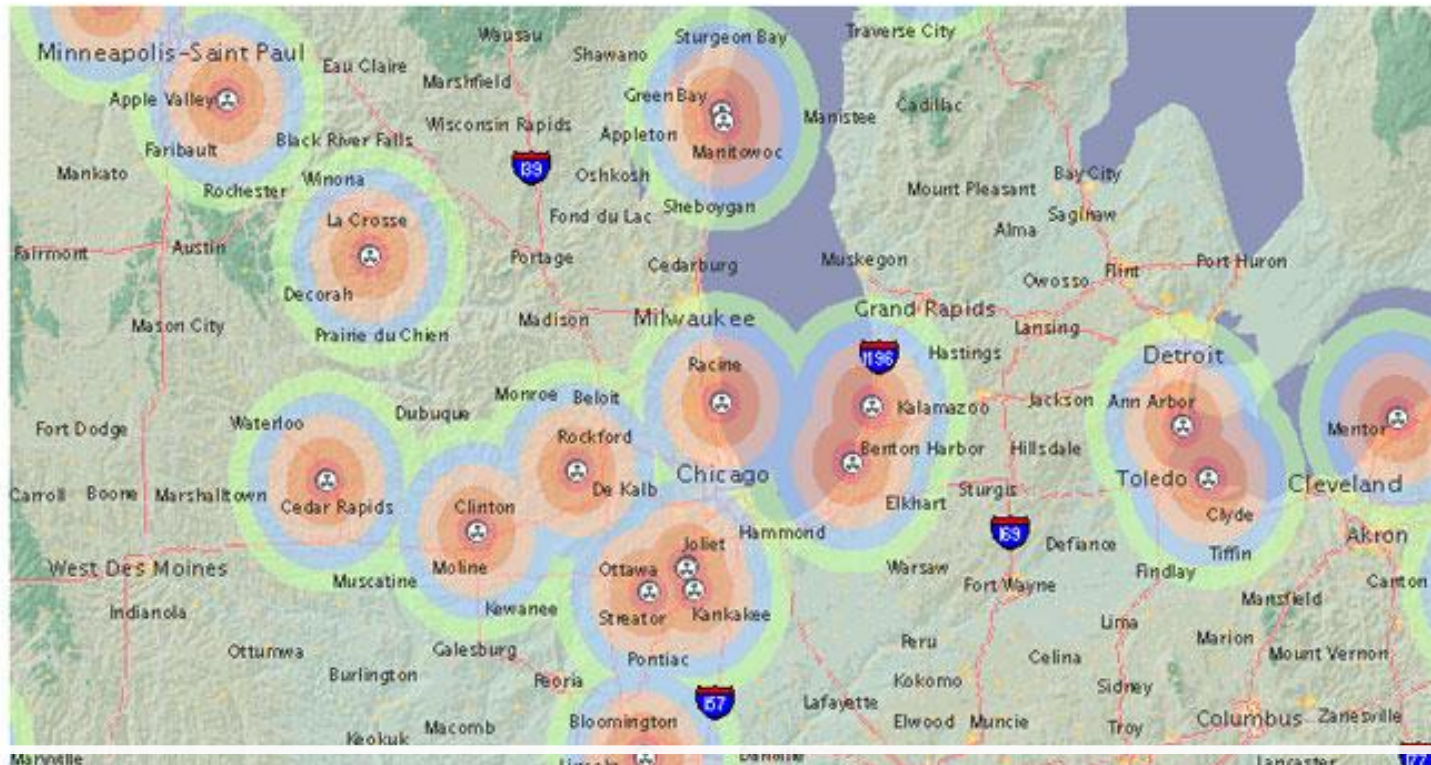




# **Environmental applications**

# Insurance & Reinsurance Industry Geographic Information System

*What is it ?* A database driven map that can overlay hazard data with policy & exposure data to quantify risk

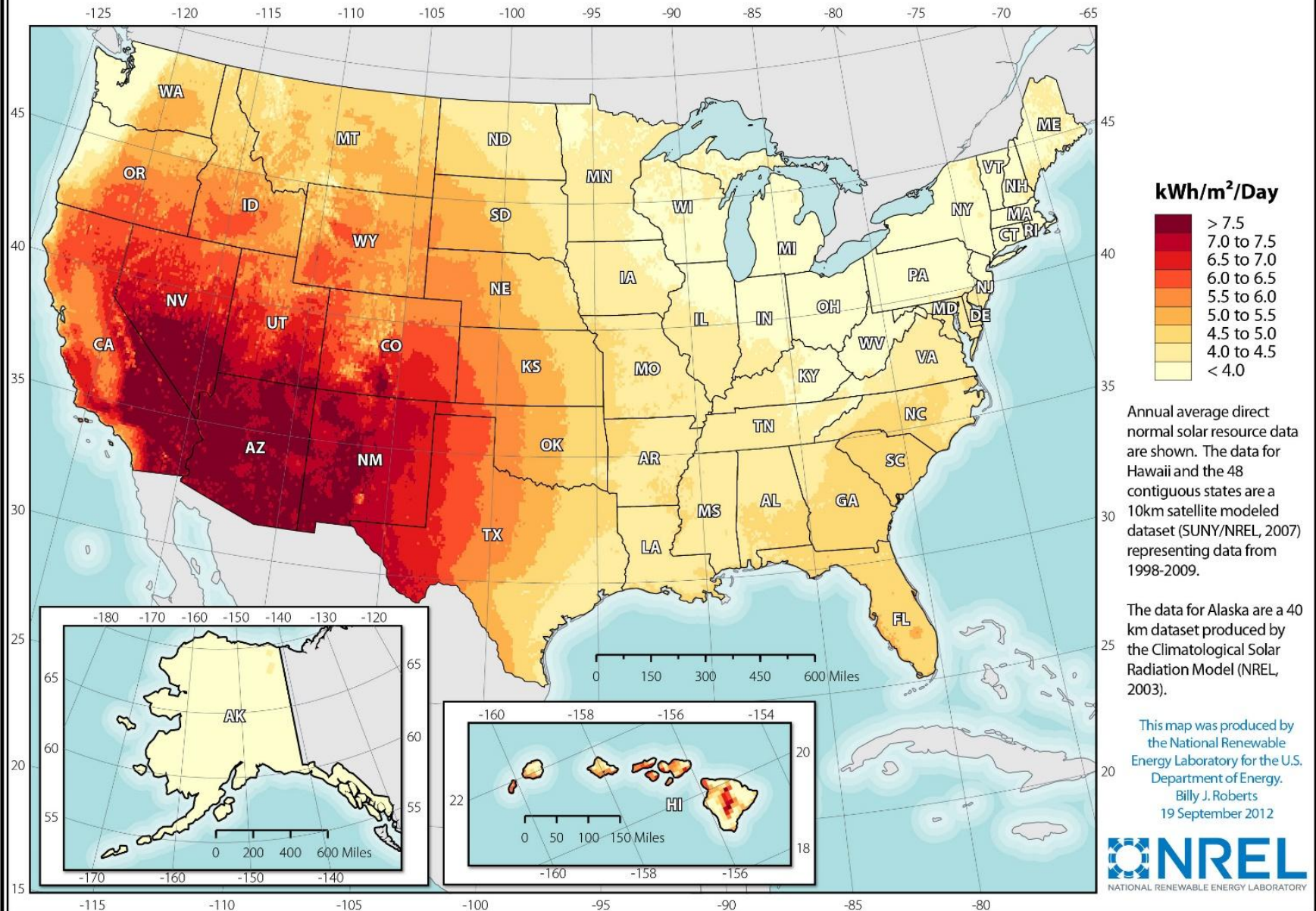


- Legend**
- Nuclear Plants
  - 10 miles (a)
  - 20 miles (b)
  - 30 miles (c)
  - 40 miles (d)
  - 50 miles (e)
  - Cities and Towns
  - Major Roads
  - Interstate Highways
  - Major Water
  - Urban Areas

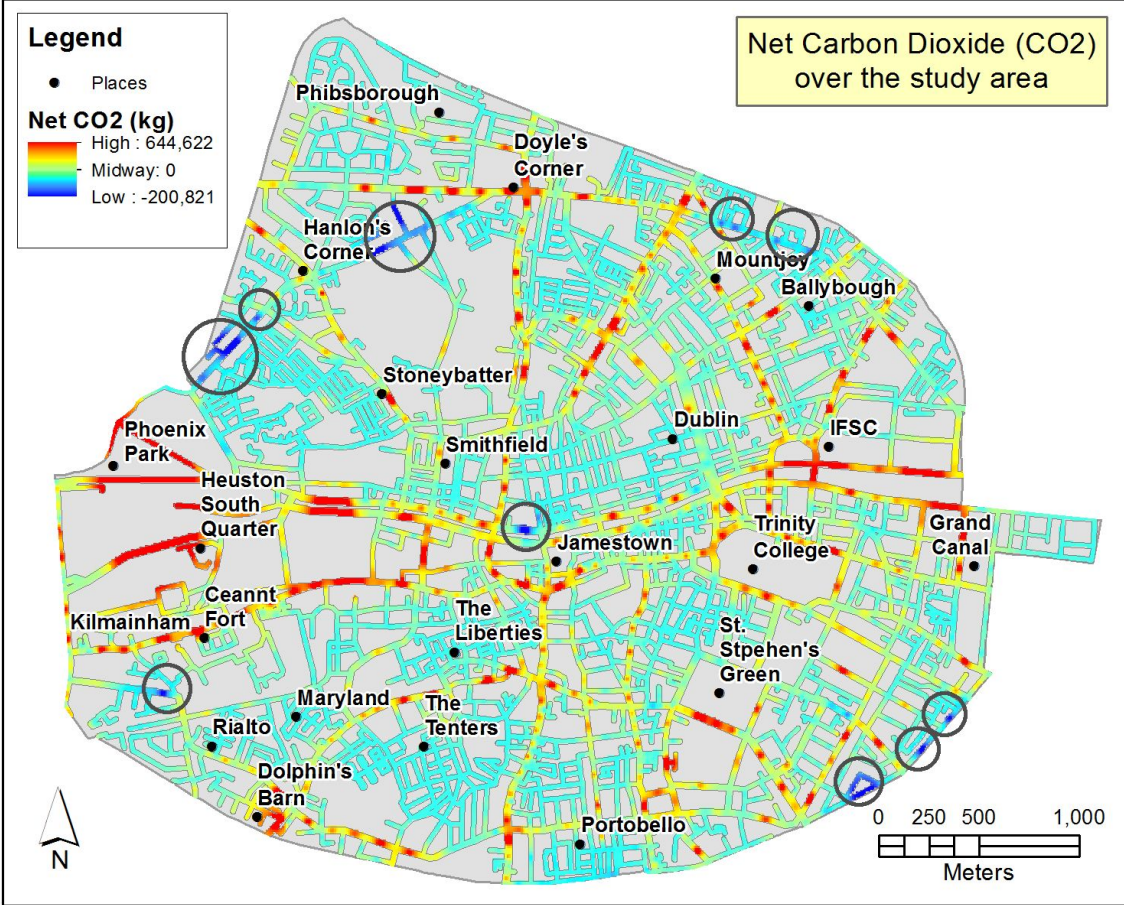


Insurance

# Concentrating Solar Resource of the United States

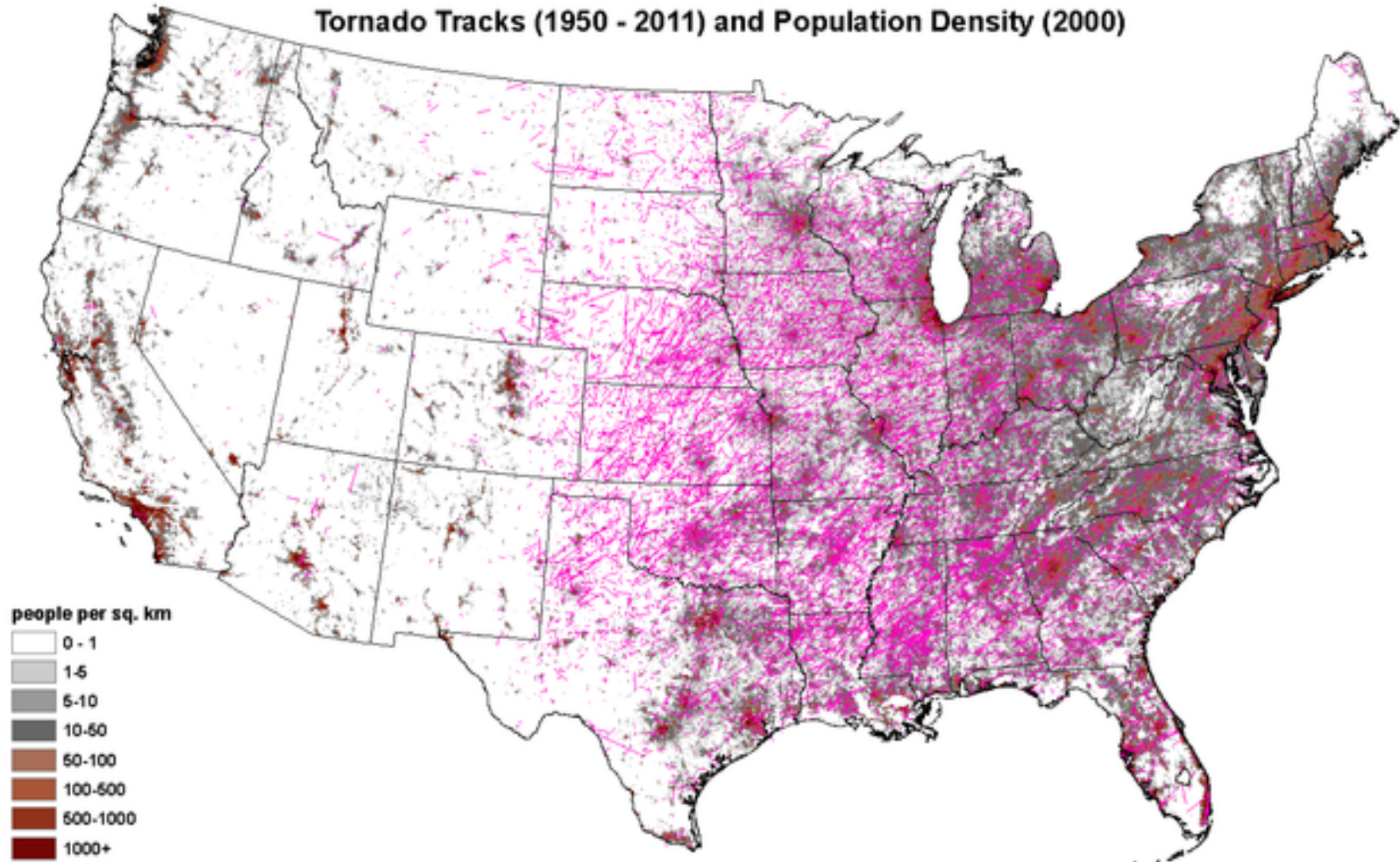


# Environmental Analysis: CO2 and Traffic Congestion





# Tornado Tracking



# Forest Fire



Task Center

Click on a task heading to activate it in the Task Center.

[Task Center tips](#)

Tasks

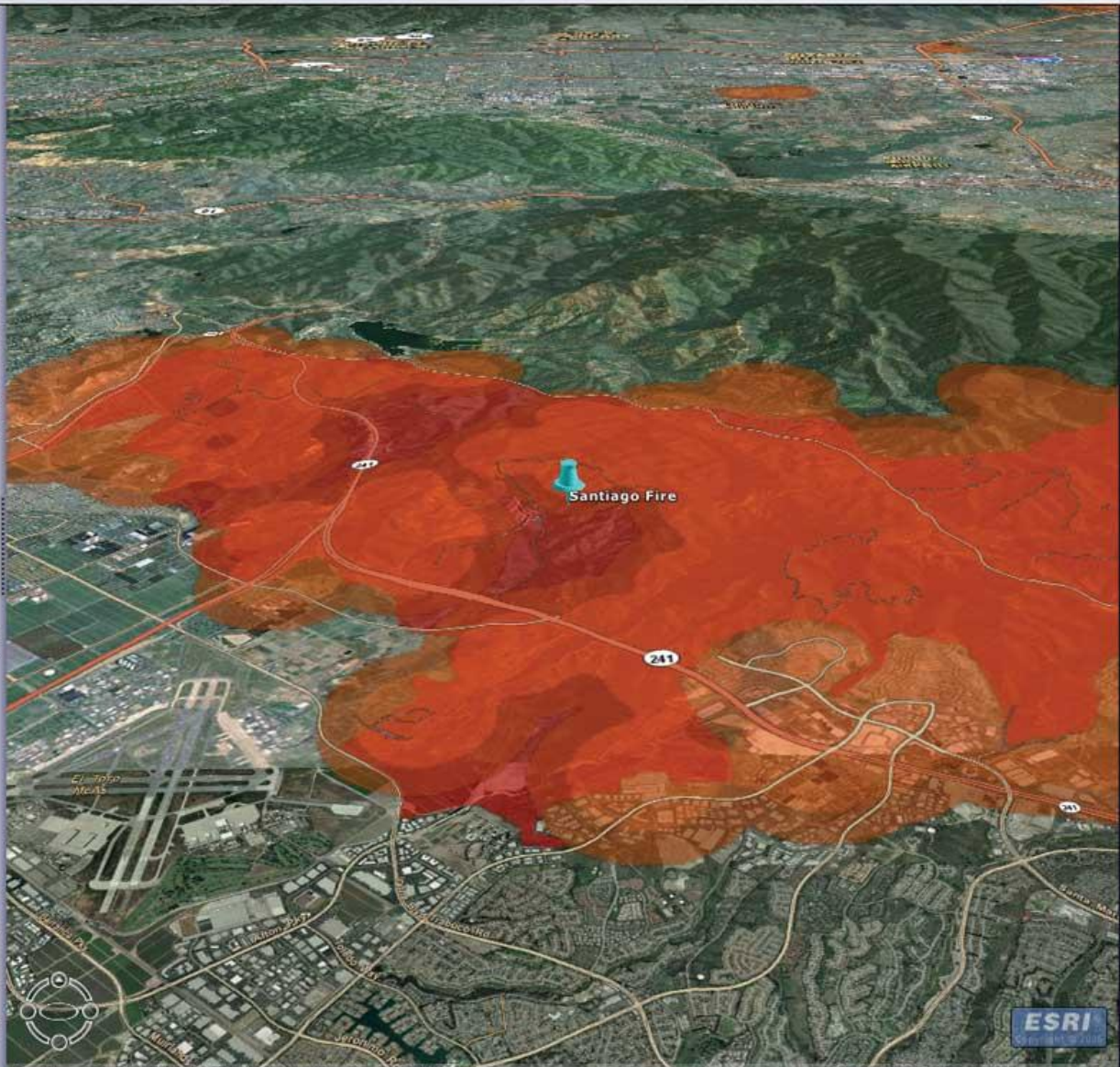
- Find Place
- Find Address
- Get Driving Directions
- What's The Address Here?
- Create Notes
- Measure
- Identify

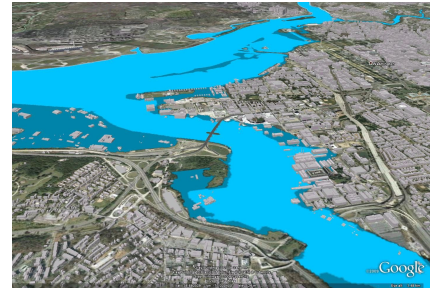
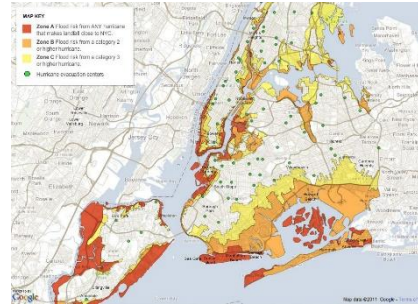
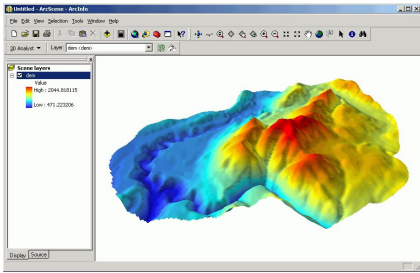
Results

- NICC / OES California Wildfires
  - www.inciweb.org
    - Slide Fire
    - Grass Valley Fire
    - Harris Fire
    - Ranch Fire
    - Rice Fire
    - Ammo Fire
    - Poomacha Fire
    - Witch Fire
    - Santiago Fire
    - Rosa Fire
    - Cajon Fire
    - Canyon Fire
    - McCoy Fire
    - Buckweed Fire
    - Magic Fire
    - Rosa Fire
    - Nightsky Fire
    - Sedgewick Fire
    - October Fire
    - Coronado Hills Fire

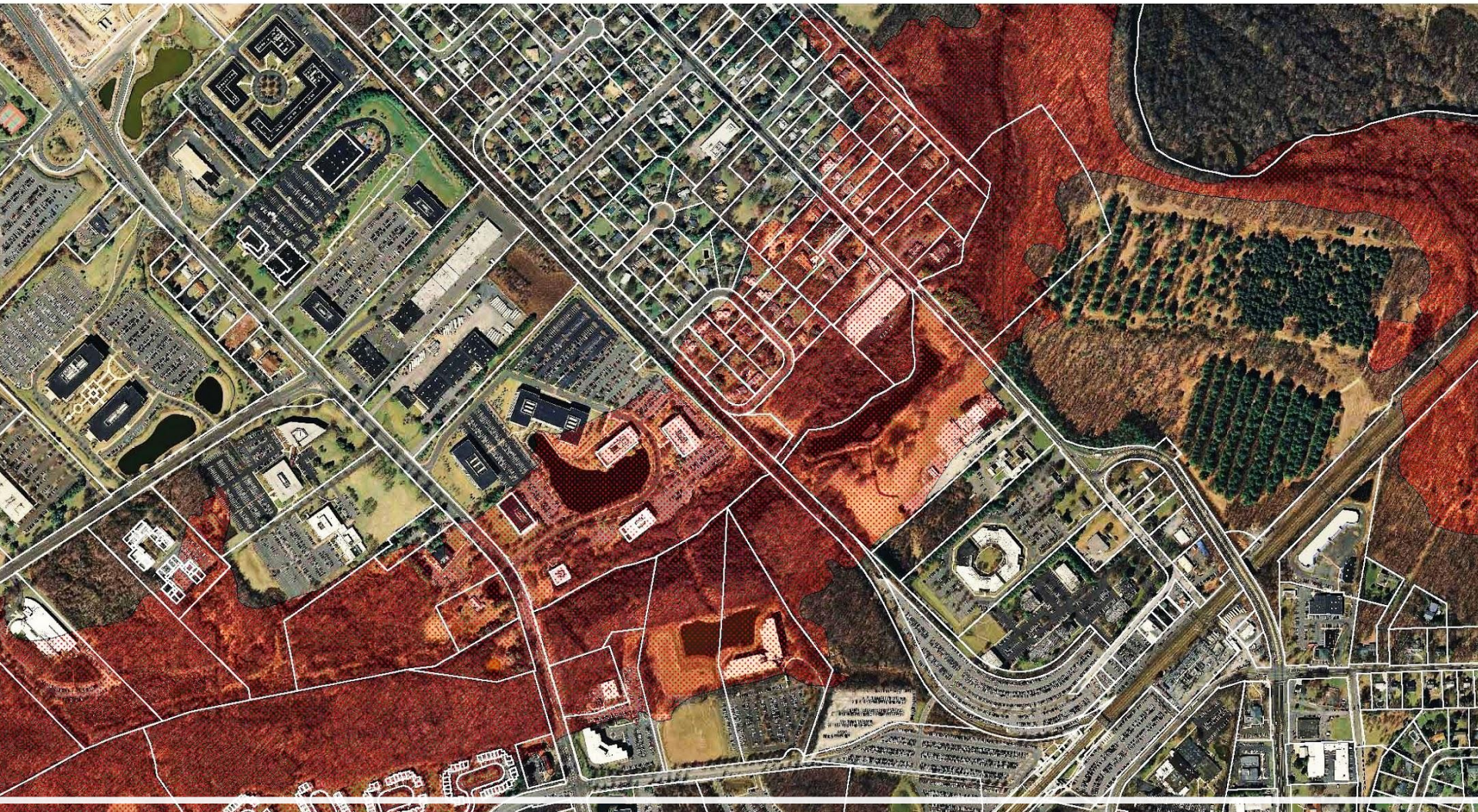
Contents

- In Range
  - Boundaries and Places
  - Transportation
  - MODIS Estimated Burn Zone
  - USGS Recent Fire Perimeters
  - US Topo Maps



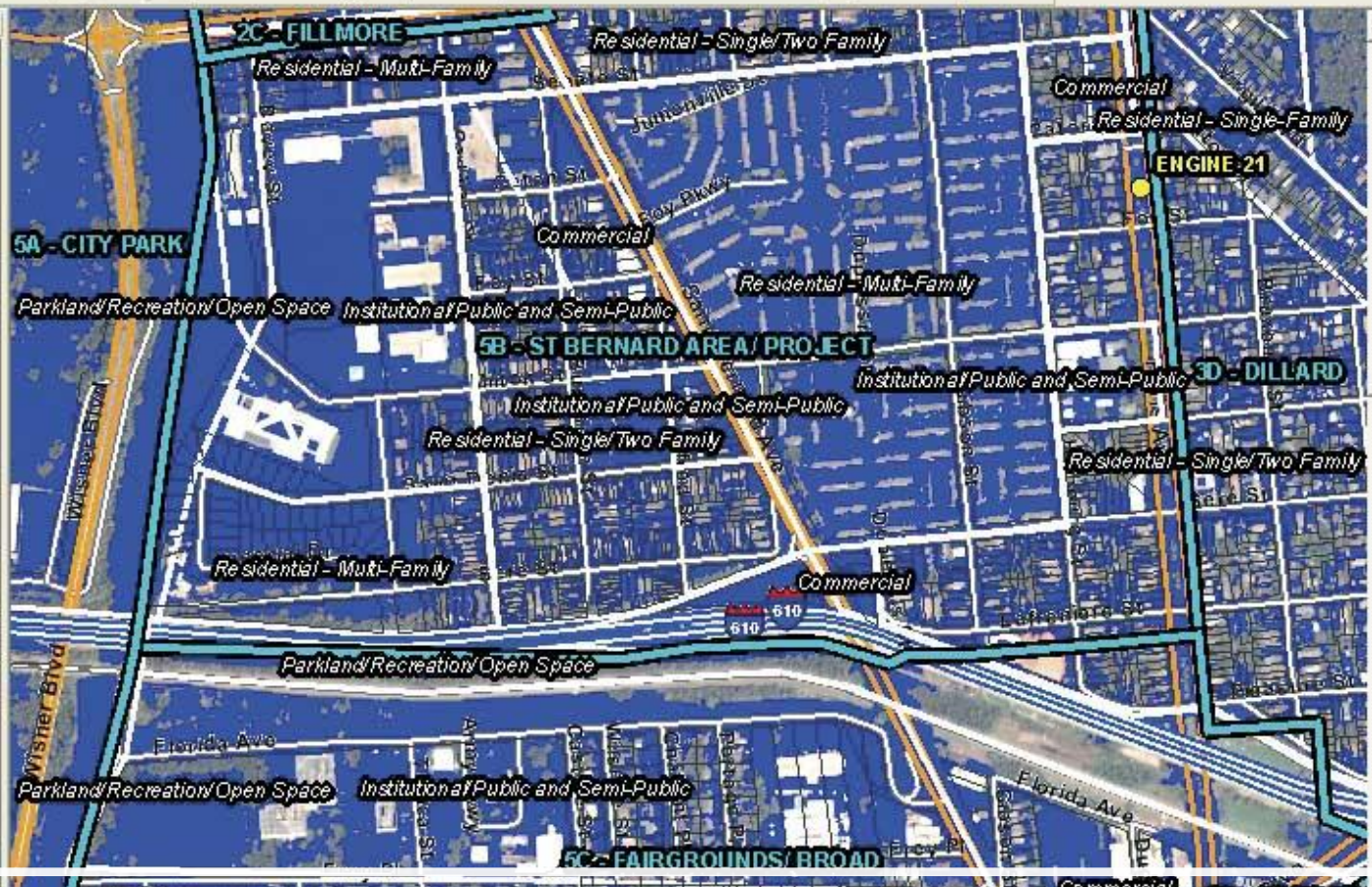


# Mapping possible Flooding Area 3D

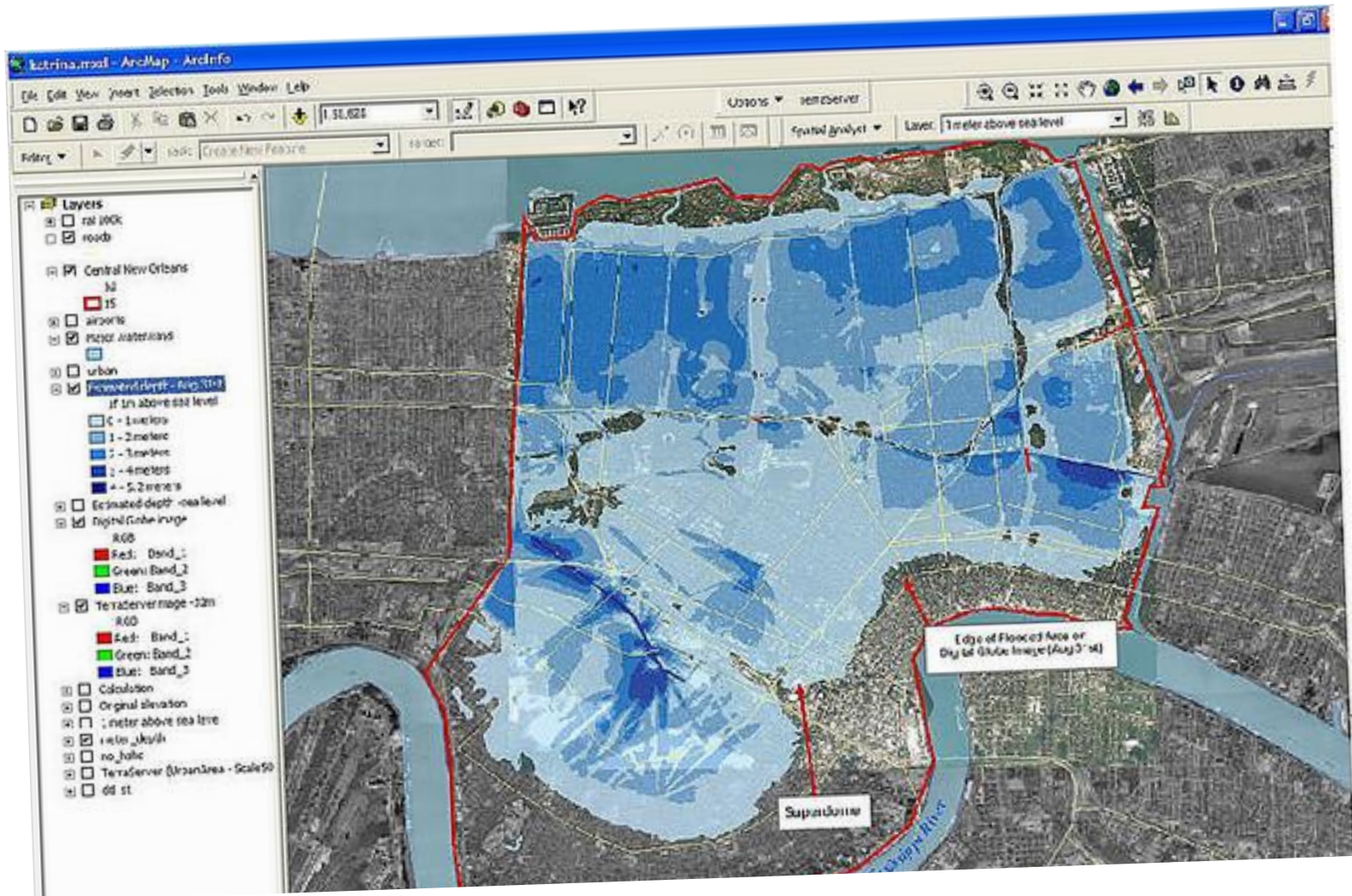


Mapping possible Flooding Area

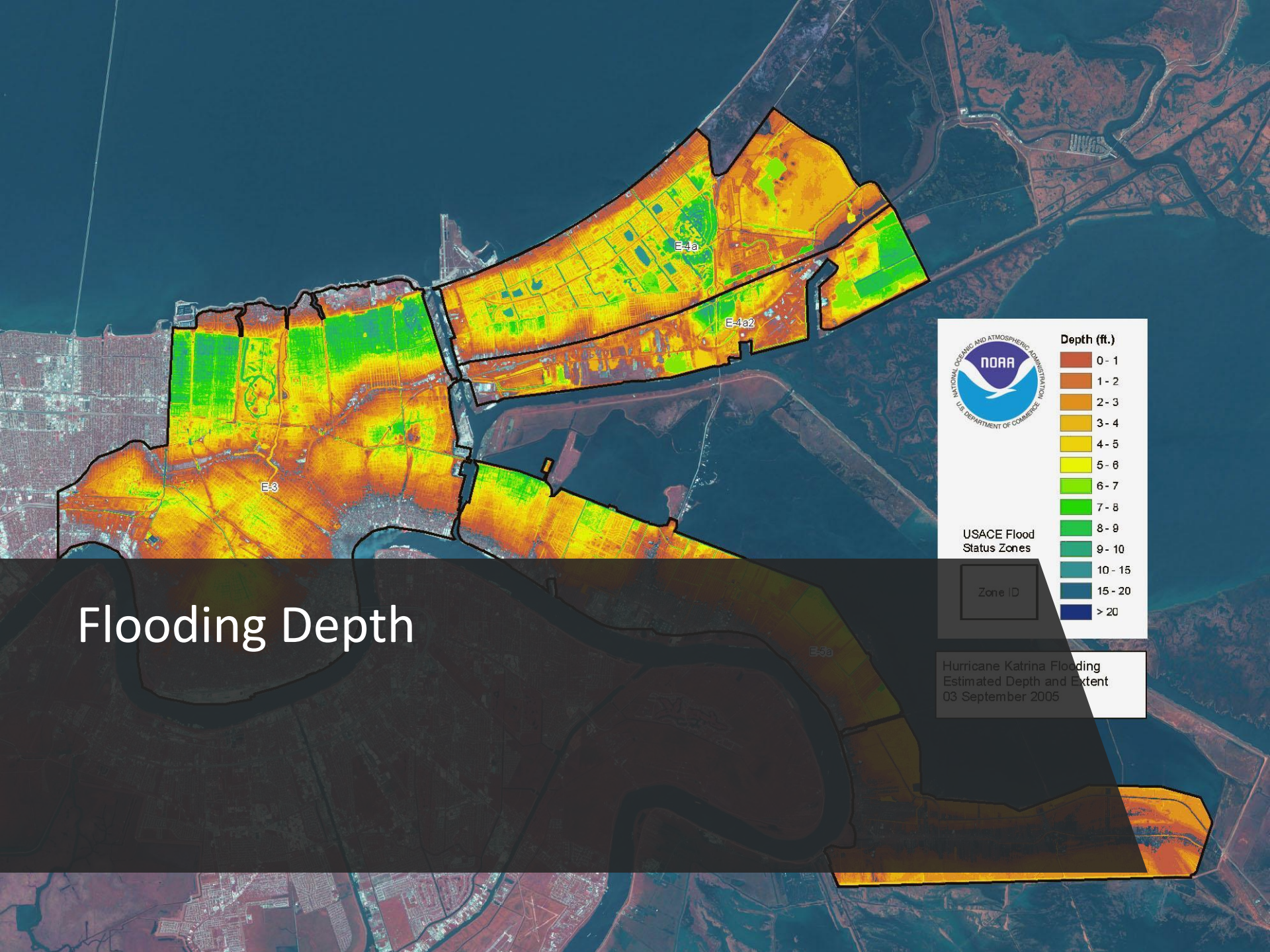
- City of New Orleans GIS
- Fire\_Stations
- Hospitals
- Police\_Stations
- Schools
- Sewer\_Nodes
- Water\_Nodes
- Buildings
- Curblines
- Railroads
- Sewer\_Lines
- Water\_Lines
- Evacuation\_Routes
- Interstates
- Major\_Roads
- Street\_Centerlines
- Evacuation\_Zones
- FEMA\_Zones
- Fire\_Zones
- Lots
- Neighborhoods
- NOPD\_Subzones

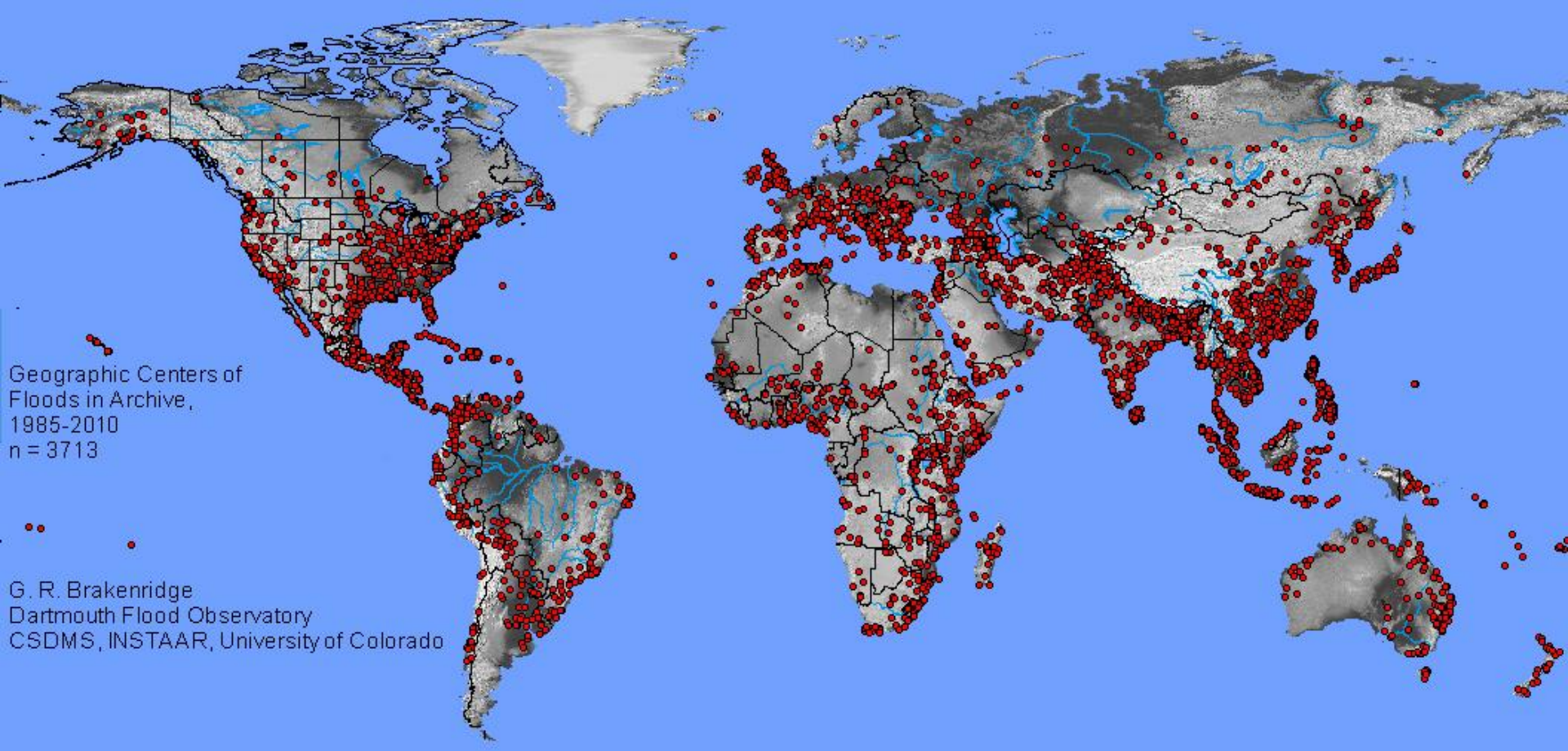


Mapping possible Flooding Area



# Flooding Depth





# Floods

Zoom In   Zoom Out   Pan   Measure   Full View   Last View   Select Parcel   LOMC   Report   Datasheet   Home

County: HONOLULU   TMK: (1)3-5-023-038   Address: 4997 KAHALA AVE   LOMC: NONE   [Clear Map](#)

Layers

Property Search

1. Select a County:

HONOLULU

2. Enter a street name to search:

KAHALA AVE

[Street Lookup](#)

OR

Enter a 9-digit Tax Map Key with no special characters (e.g. 444002032):

[Search TMK](#)

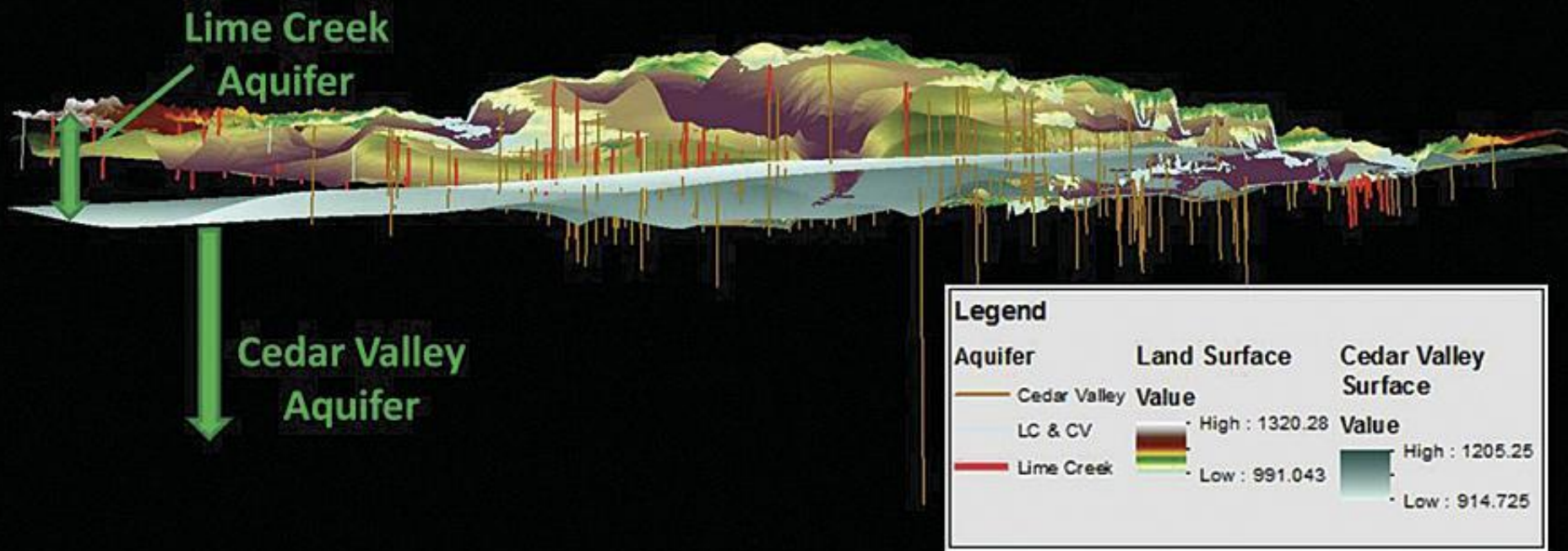
[Restart Search](#)

Map Legend  
 Letter of Map Change (LOMC)  
 Elevation Certificate  
 Flood Insurance Studies (FIS)  
 Island Number

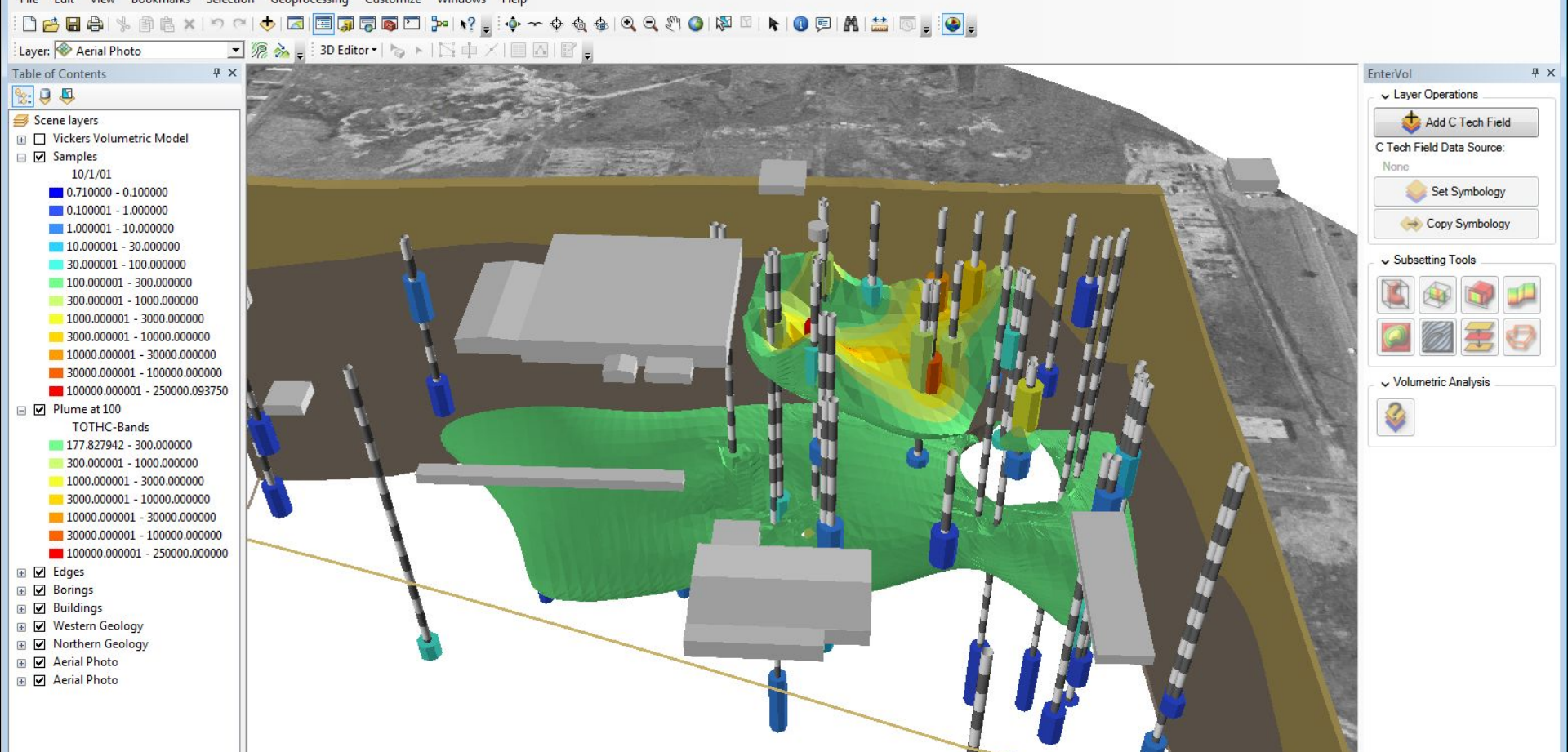
H E L P . . .

Using Toolbox Buttons  
 Property Search  
 Letter of Map Changes  
 Elevation Certificate

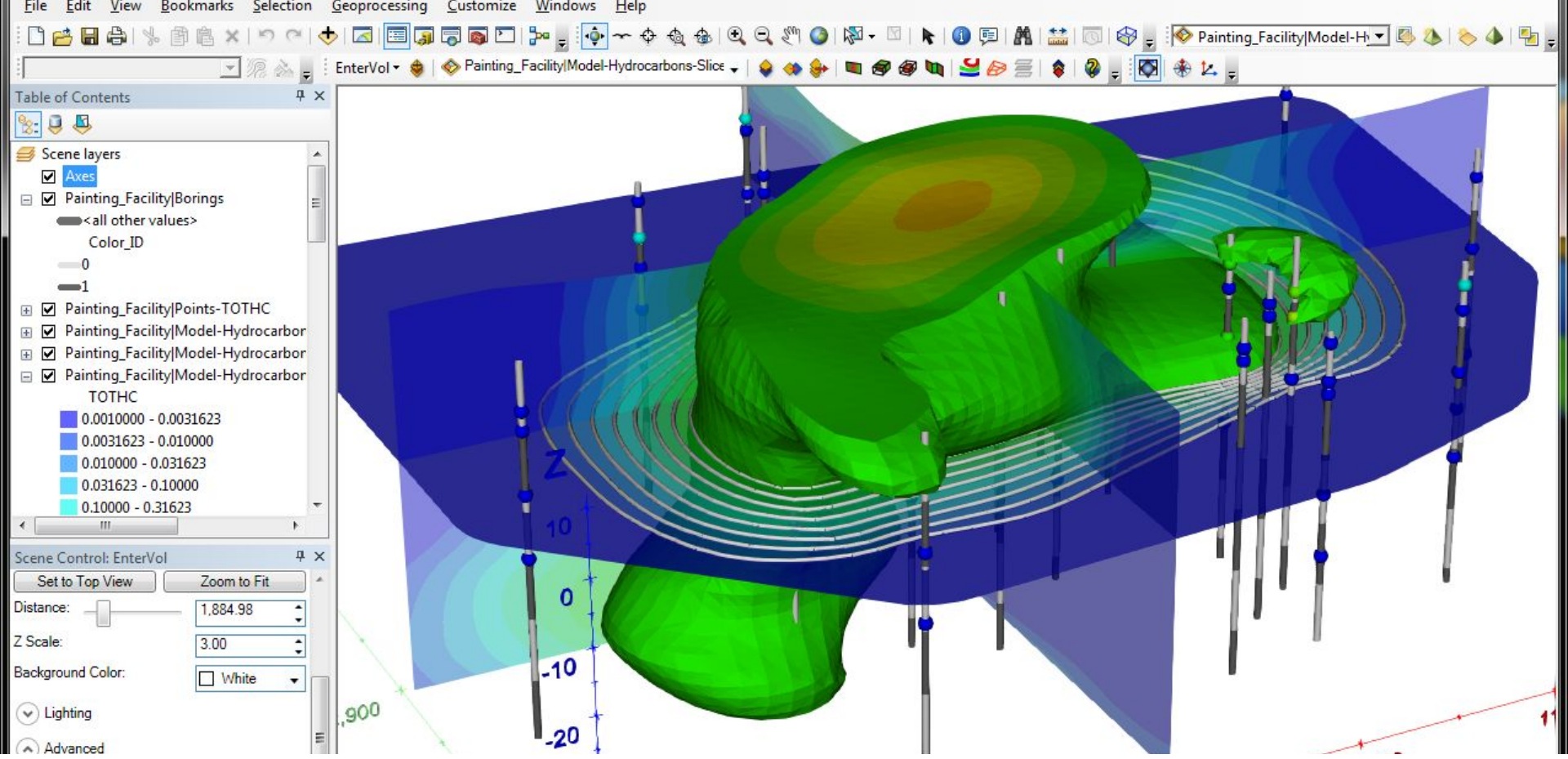
# National Flood Insurance Program



# Groundwater Contamination

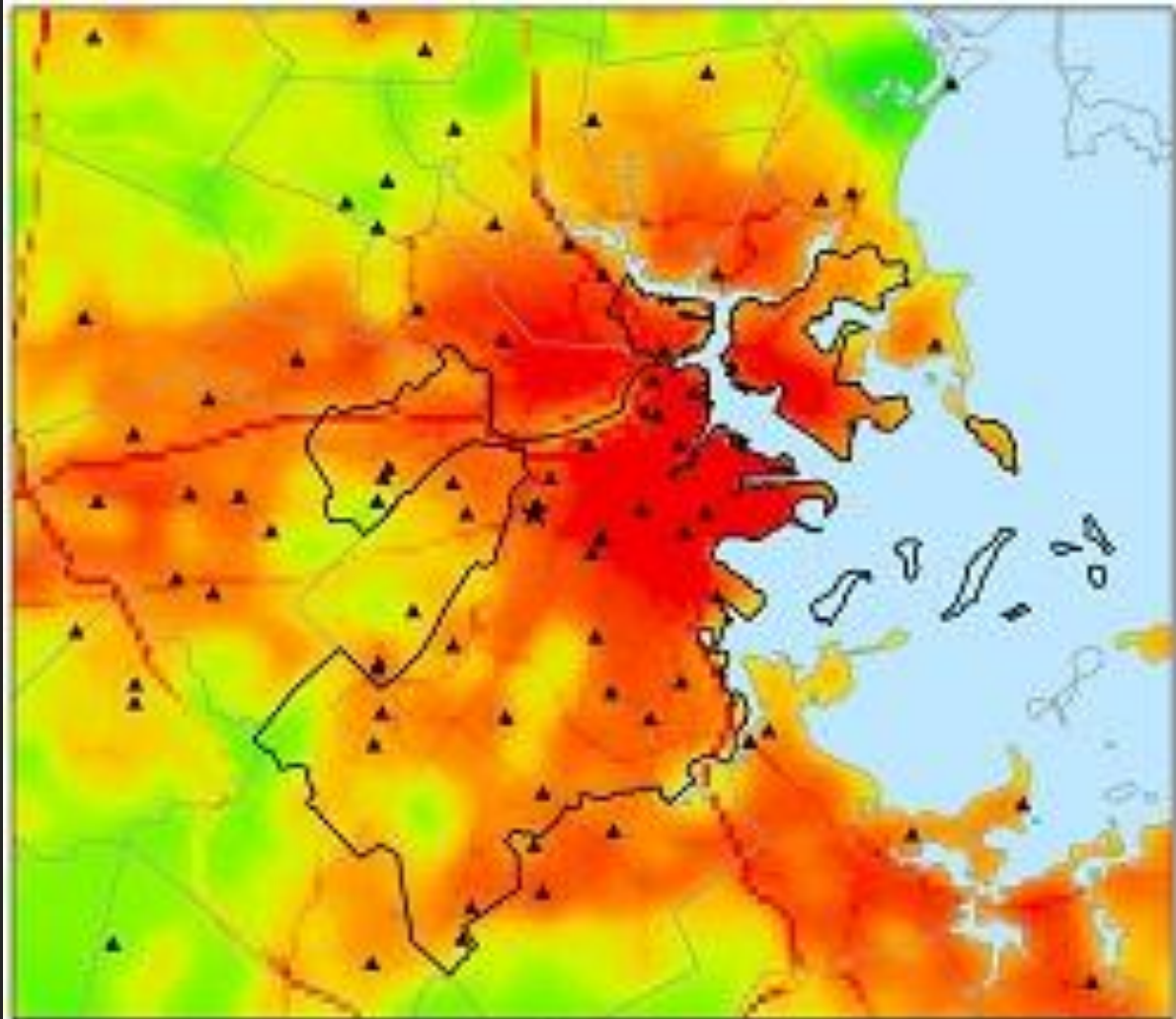


# Groundwater Contamination



# Groundwater Contamination

# Air Quality



## Legend

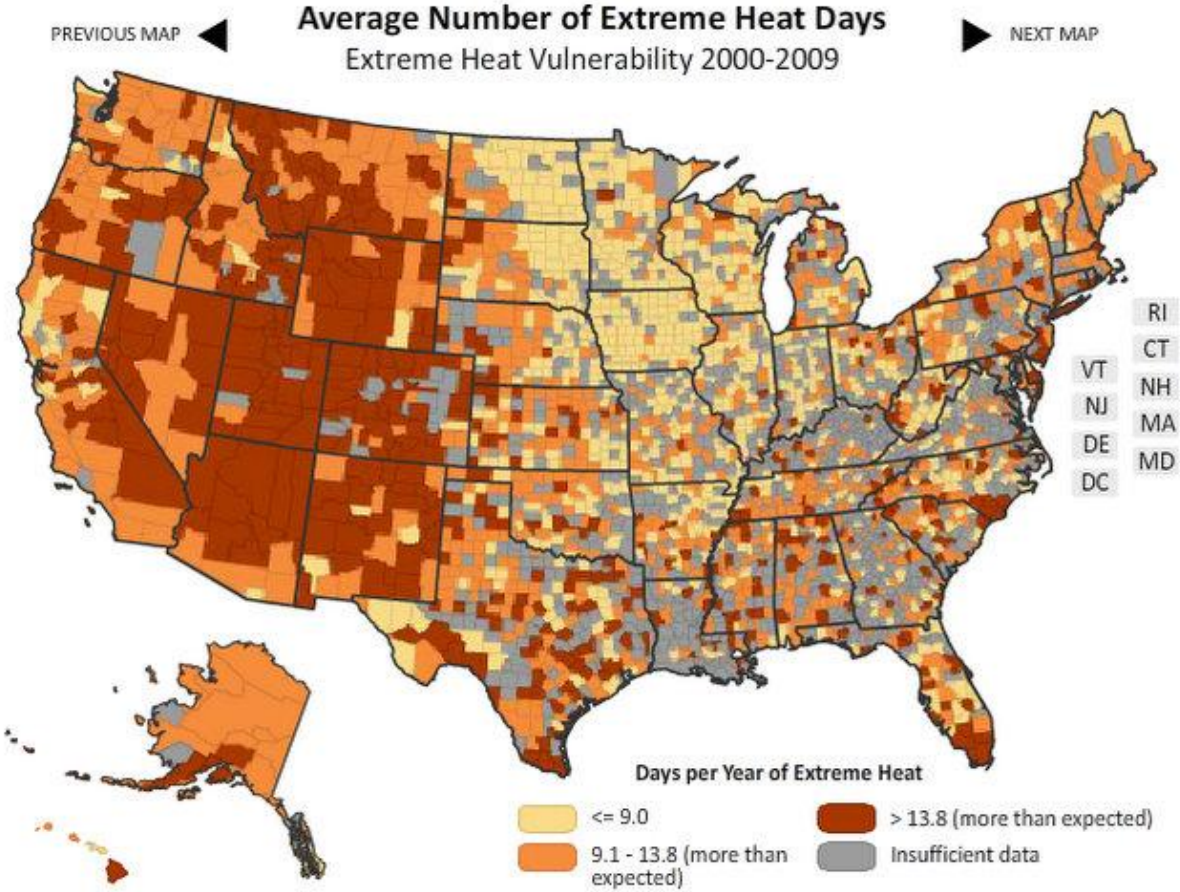
log Black Carbon

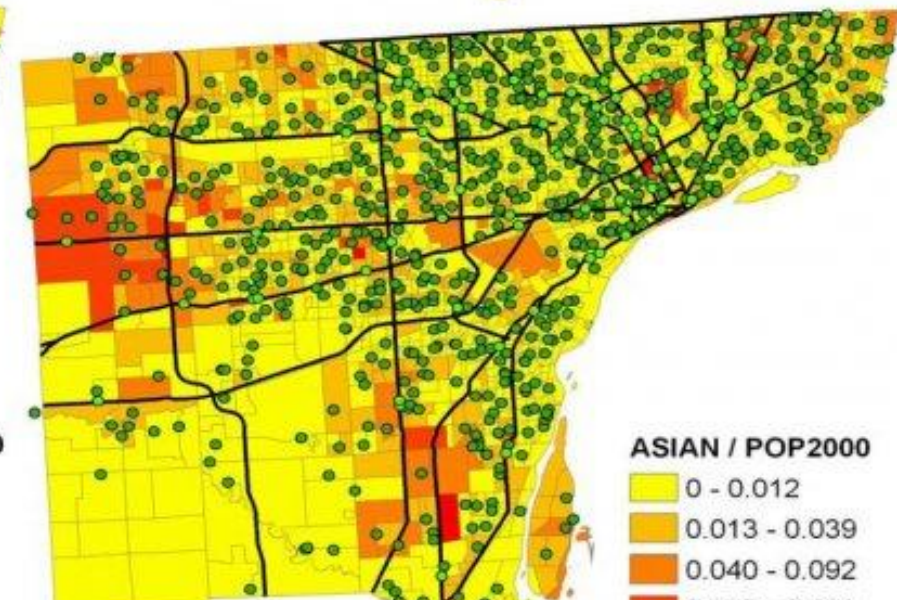
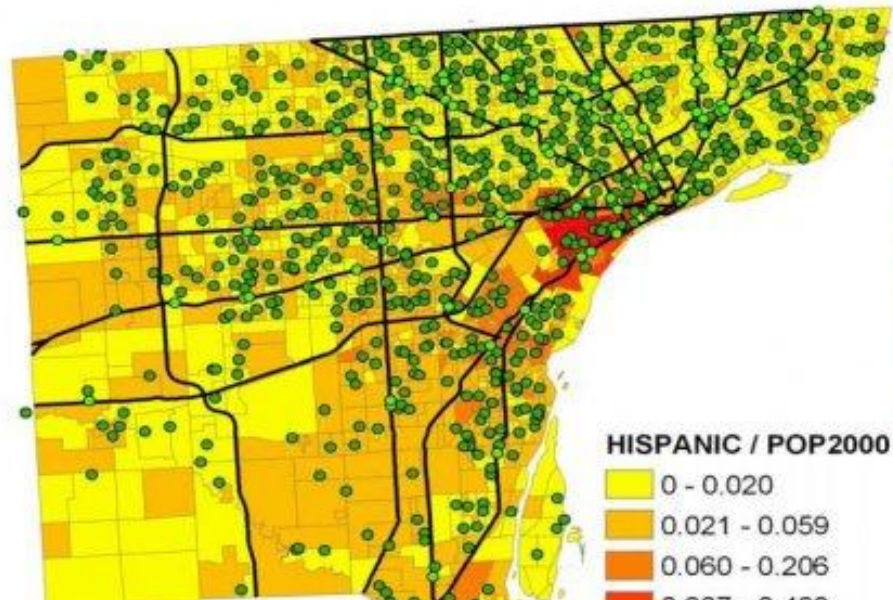
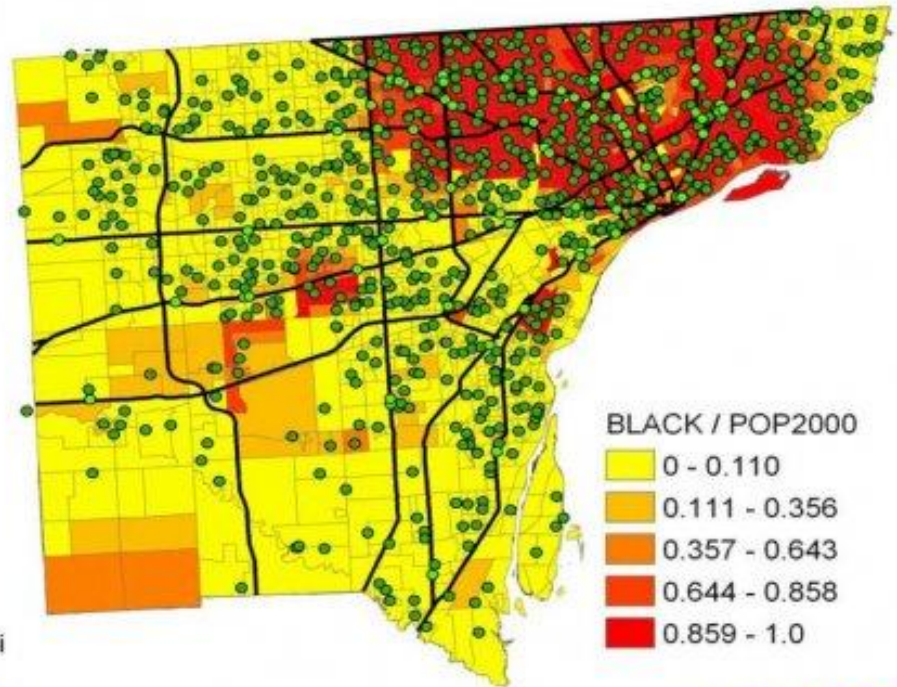
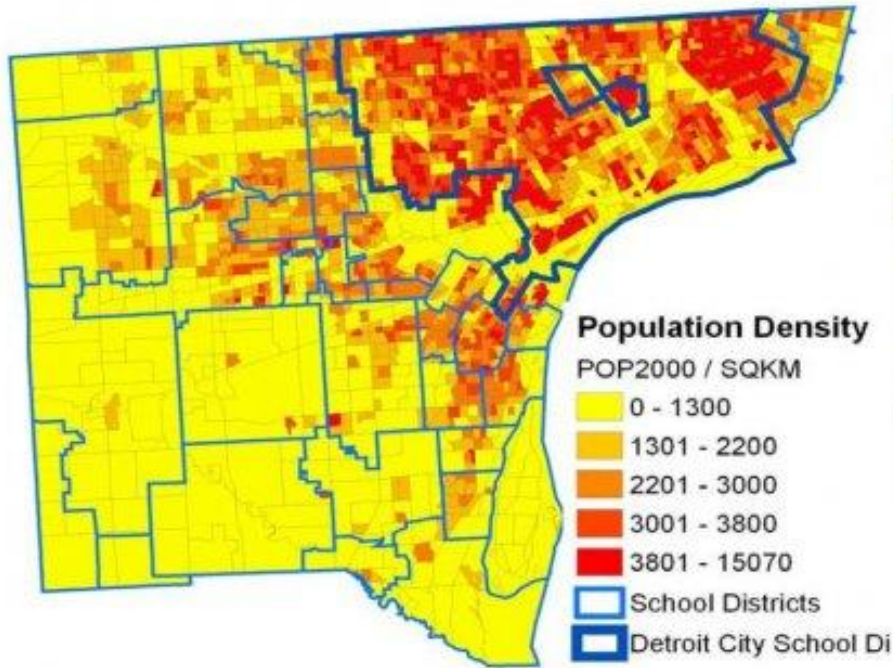


★ Country  
▲ Monitors

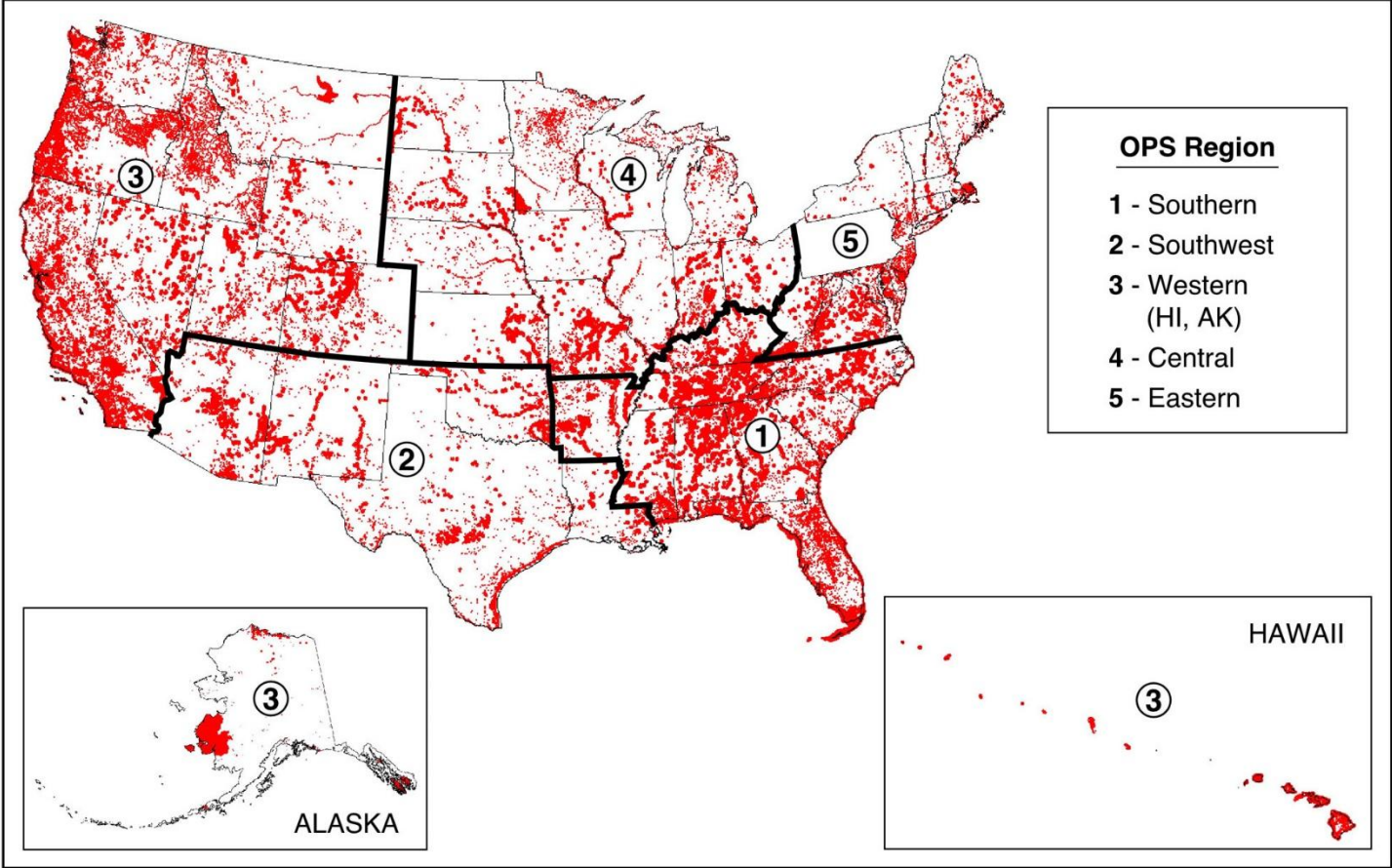


# Extreme Heat Days





# Hazardous Liquid Pipeline Accident





The background image shows a financial market data screen with various stock indices and a line graph. The text "Business" is overlaid in the center.

# Business

Index	Value	Change	Direction
OMXC25	10916.69	10847.17	Buy
OMXRG1	984.13	0.87%	Buy
OMX18	27956.04	28289.06	Buy
OMXIC8	6230.9	6230.9	Sell
OMXIS8	599.40	599.40	Buy
OMXIS18	1632.51	-0.30%	Sell
OMXIS25	1172.94	0.81%	Buy

1 in = 1.5 mi

Labeling Fast Spatial Analyst

Editor Link: Create New Feature Target:

Business Analyst Geostatistical Analyst

Targeting

Derived Analysis

New York Area Customers

Amount Spent (Single Purchase)

\$100.48 - \$148.00

\$150.00 - \$218.00

\$220.00 - \$322.50

\$324.00 - \$472.00

\$480.00 - \$740.00

\$775.00 - \$1,200.00

\$1,260.00 - \$1,920.00

\$2,208.00 - \$3,072.00

Points

Transportation Terminals

Bus

Train

Marine

Customer Prospecting by ZipCode

Huff Model Predictive Sales Analysis

\$4.05 - \$100.00

\$100.01 - \$200.00

\$200.01 - \$300.00

\$300.01 - \$400.00

\$400.01 - \$500.00

\$500.01 - \$600.00

\$600.01 - \$700.00

\$700.01 - \$800.00

\$800.01 - \$900.00

Market Penetration

Market Penetration Percent

0.01% - 0.04%

0.05% - 0.12%

0.13% - 0.23%

0.24% - 0.4%

0.41% - 0.59%

0.6% - 0.8%

0.81% - 1.14%

1.15% - 1.48%

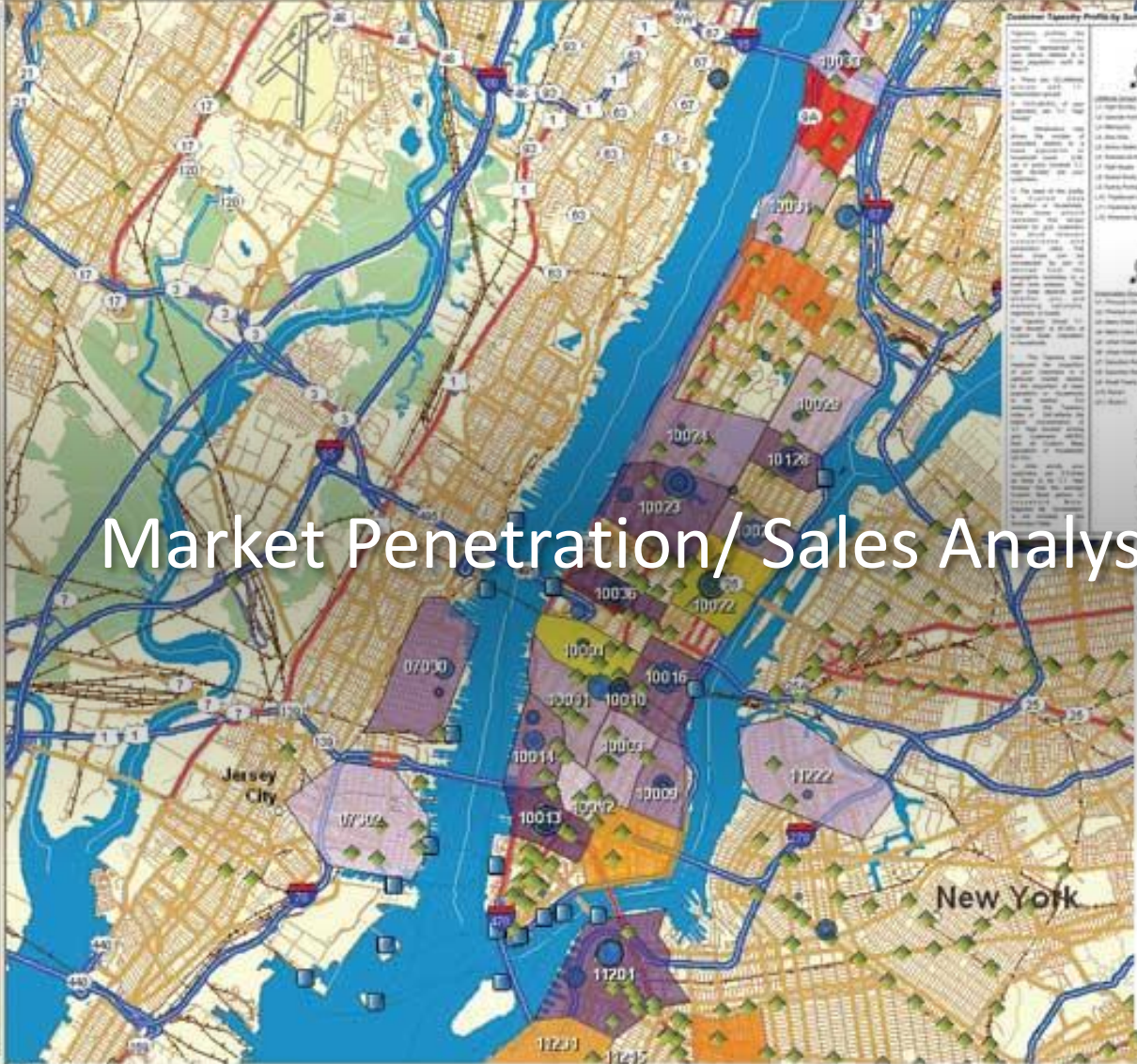
1.49% - 2.13%

2.14% - 3.55%

Business Analyst Detailed Map

Business Reference Layers

Map



# Market Penetration/Sales Analysis

Customer Segments Profile by Summary Group

Segment	Number	Mean	Std. Dev.	Min.	Max.
1	100	100	100	100	100
2	100	100	100	100	100
3	100	100	100	100	100
4	100	100	100	100	100
5	100	100	100	100	100
6	100	100	100	100	100
7	100	100	100	100	100
8	100	100	100	100	100
9	100	100	100	100	100
10	100	100	100	100	100
11	100	100	100	100	100
12	100	100	100	100	100
13	100	100	100	100	100
14	100	100	100	100	100
15	100	100	100	100	100
16	100	100	100	100	100
17	100	100	100	100	100
18	100	100	100	100	100
19	100	100	100	100	100
20	100	100	100	100	100
21	100	100	100	100	100
22	100	100	100	100	100
23	100	100	100	100	100
24	100	100	100	100	100
25	100	100	100	100	100
26	100	100	100	100	100
27	100	100	100	100	100
28	100	100	100	100	100
29	100	100	100	100	100
30	100	100	100	100	100
31	100	100	100	100	100
32	100	100	100	100	100
33	100	100	100	100	100
34	100	100	100	100	100
35	100	100	100	100	100
36	100	100	100	100	100
37	100	100	100	100	100
38	100	100	100	100	100
39	100	100	100	100	100
40	100	100	100	100	100
41	100	100	100	100	100
42	100	100	100	100	100
43	100	100	100	100	100
44	100	100	100	100	100
45	100	100	100	100	100
46	100	100	100	100	100
47	100	100	100	100	100
48	100	100	100	100	100
49	100	100	100	100	100
50	100	100	100	100	100

Core and Development Segments

Who are your target customers?

By using the Specific Profile from the previous analysis, a combination of five specific zip codes are highlighted on the map. These zip codes represent the Core and Development Segments.

Core Segments

Segments with a high percentage of your own customers are the segments that not only do not have an above average value to be a percentage of your customer base, but the segments represent highly and good market segments in your study area. These segments are those with values greater than 500.

Development Segments

Development segments are the segments that have a low percentage of your own customers but do not have an above average value. These segments represent a significant portion of customer base and are highly profitable. These segments are those with values greater than 500.

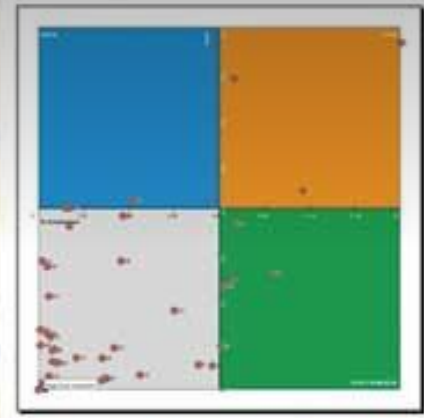
Game Plan Chart

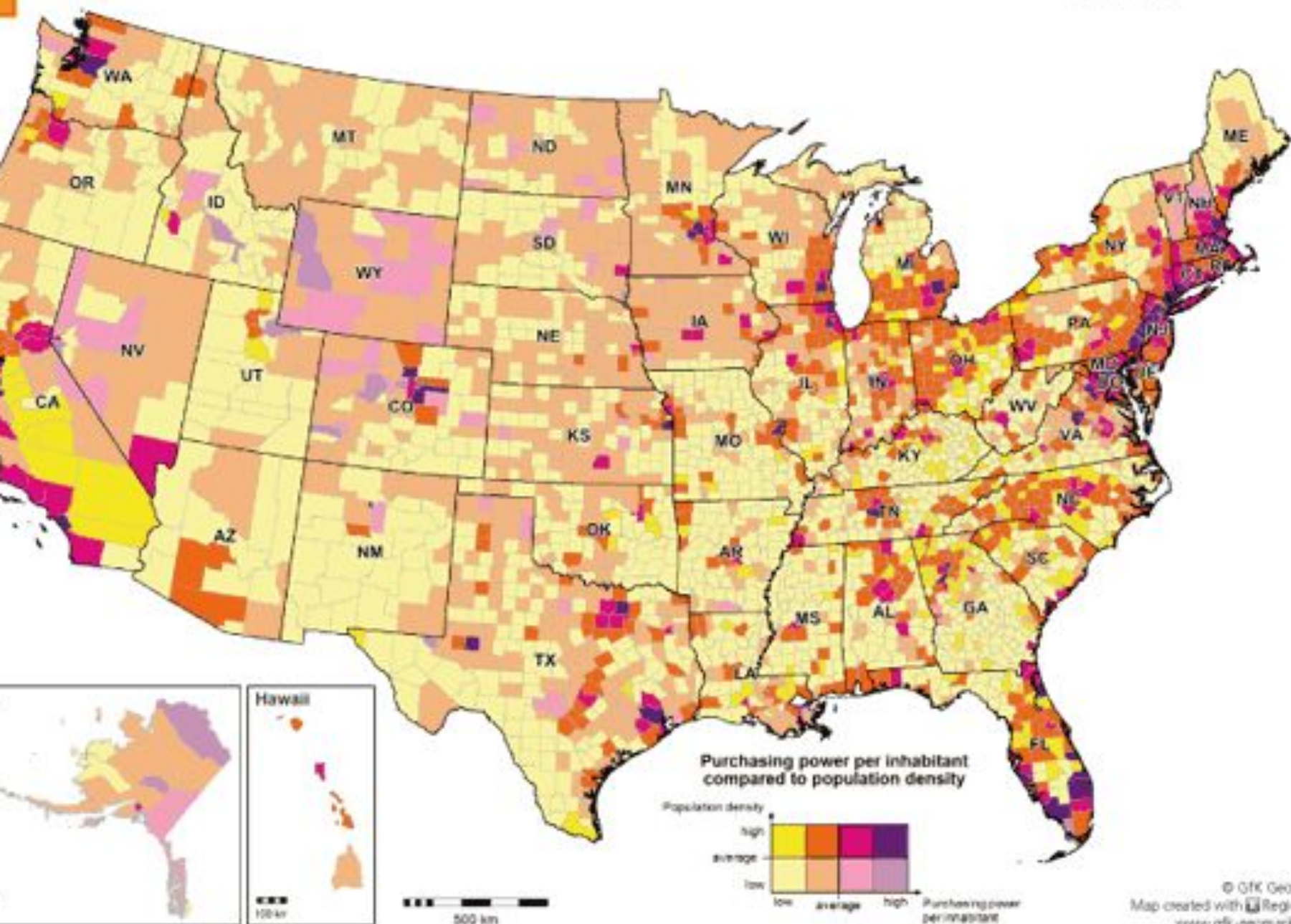
The Game Plan Chart is a visual representation of your 50 zip codes and measures the sales and financial performance of each zip code. The chart shows the sales and financial performance of each zip code and is represented by the size of the zip code.

Core Segments not only make up a large percentage of your average sales, but also represent a significant portion of all customers. Customers in this segment have a high percentage of your own customers and are represented by the size of the zip code.

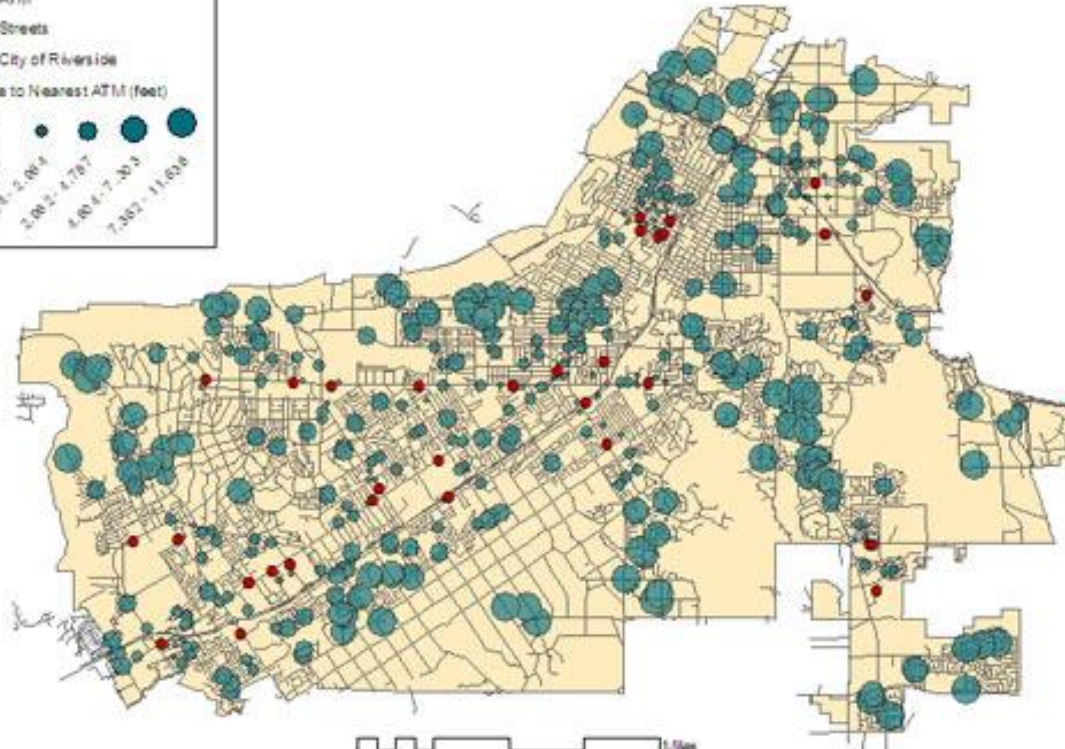
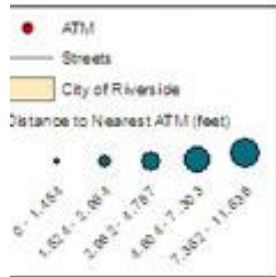
Development Segments make up a significant portion of your average sales. Development segments are those zip codes that have a high percentage of your own customers but do not have an above average value. These segments represent a significant portion of customer base and are highly profitable. These segments are those with values greater than 500.

Other Segments do not make up a significant portion of your average sales. Customers in this segment have a low percentage of your own customers and are represented by the size of the zip code.





## Proximity of ATMs to Businesses Providing Services City of Riverside, CA



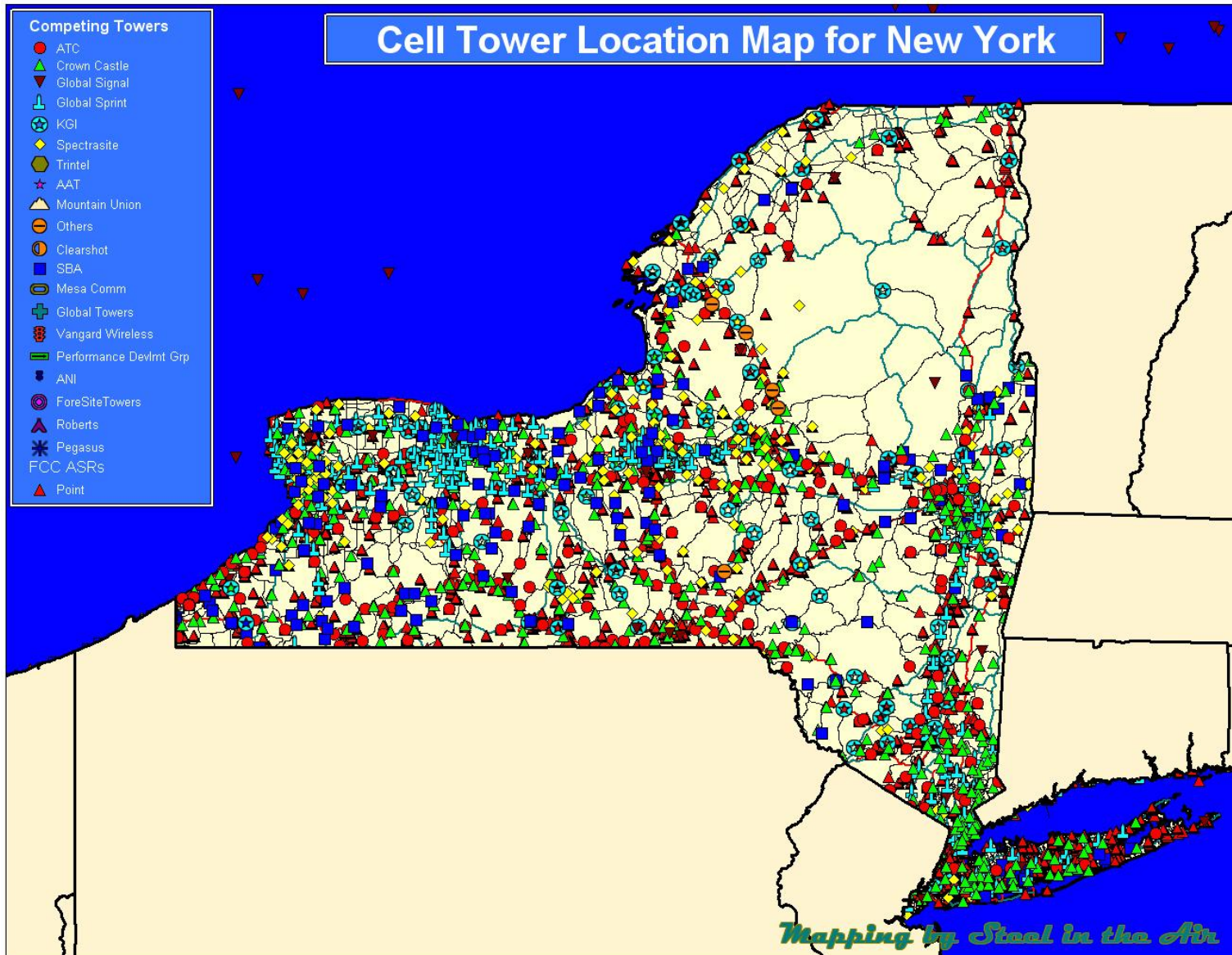
100,000

Data Source: City of Riverside, Riverside County Assessors Office, [www.co-riverside.org](http://www.co-riverside.org)  
Projection: Lambert Conformal Conic Coordinate System, State Plane, California VI, feet, Datum: NAD83

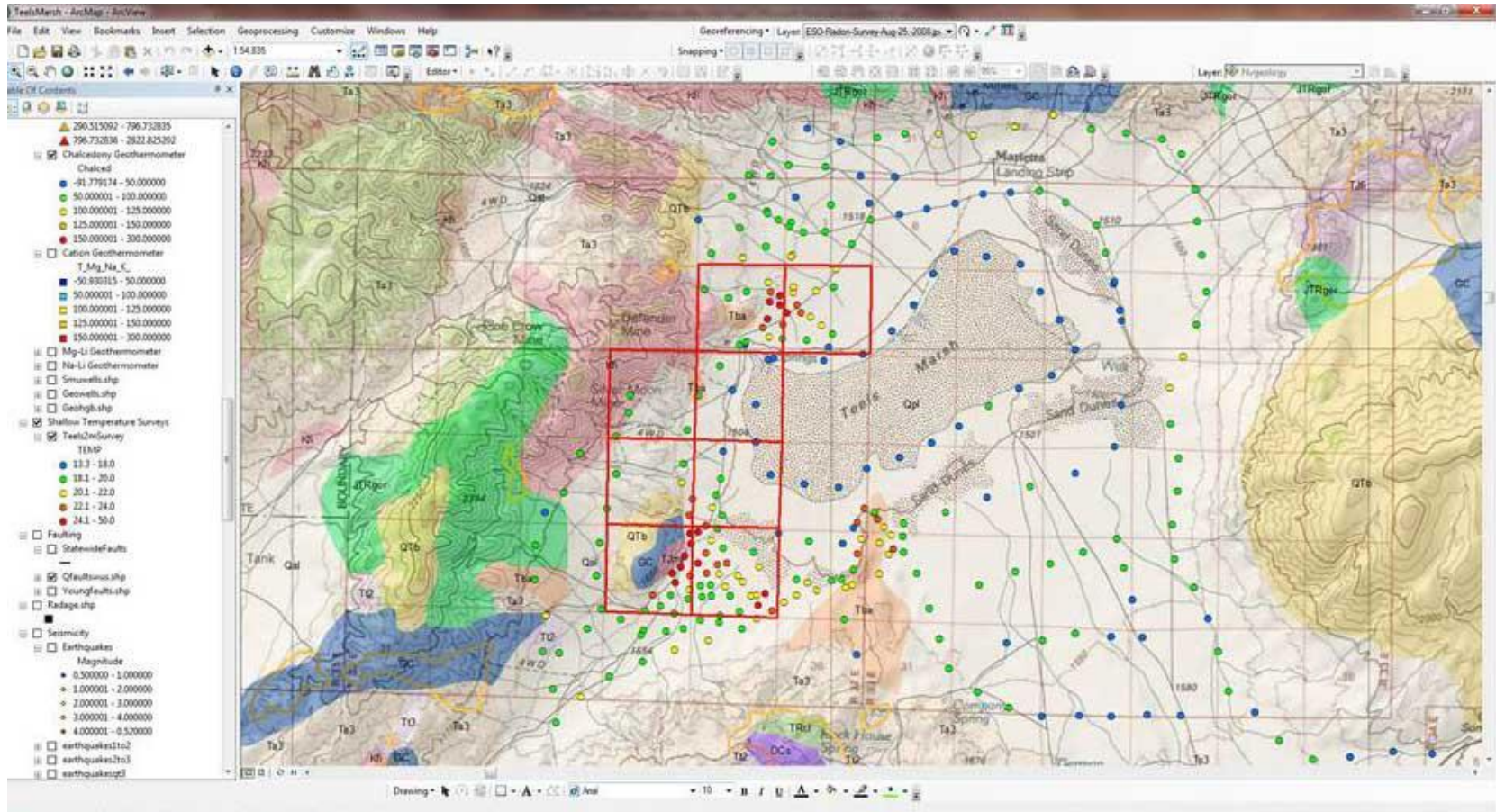
Printed 2

Identify  
Optimum  
ATM  
Locations

# Cell Towers Location



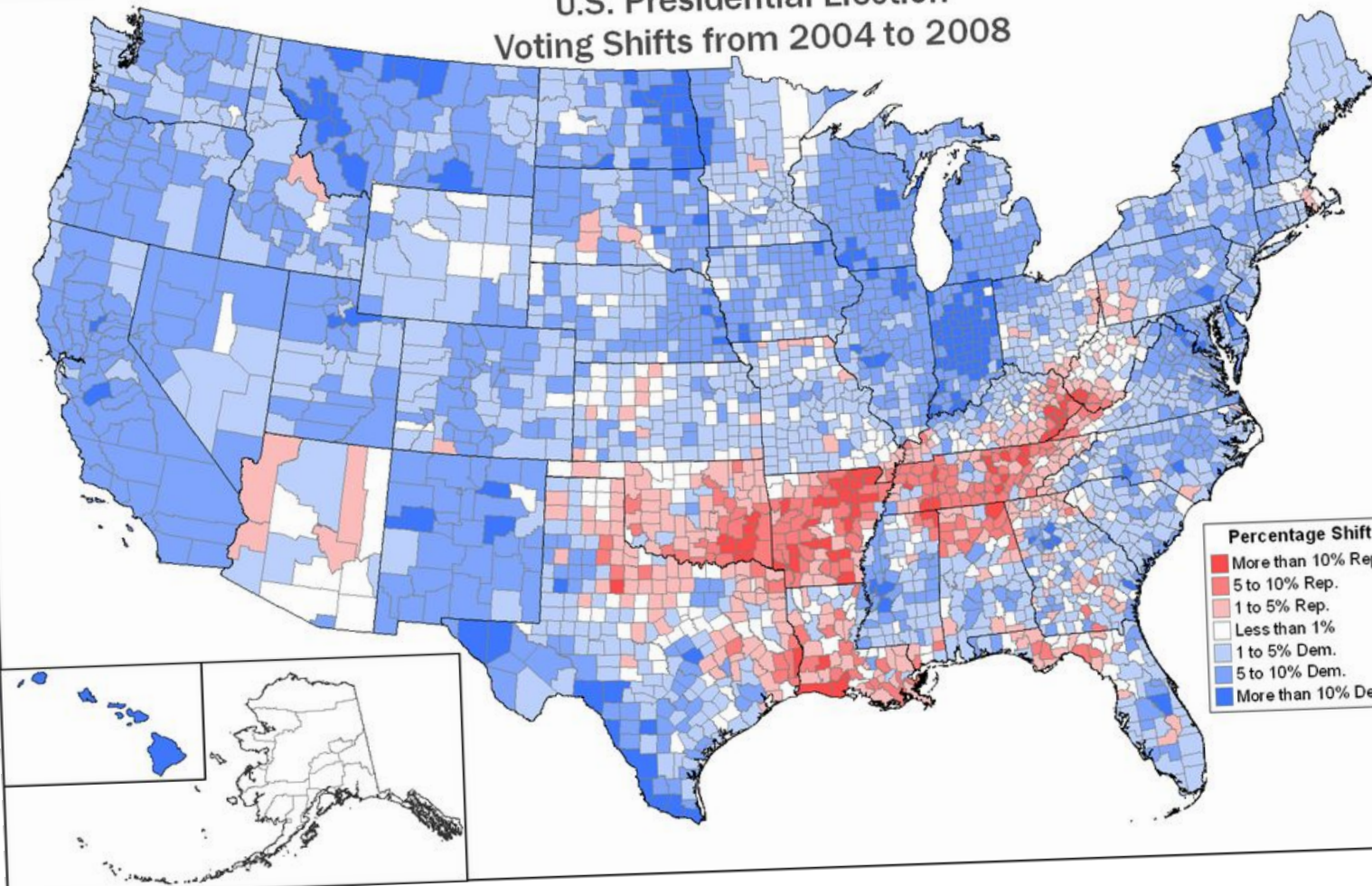
# Oil Well Drilling - finding optimum location



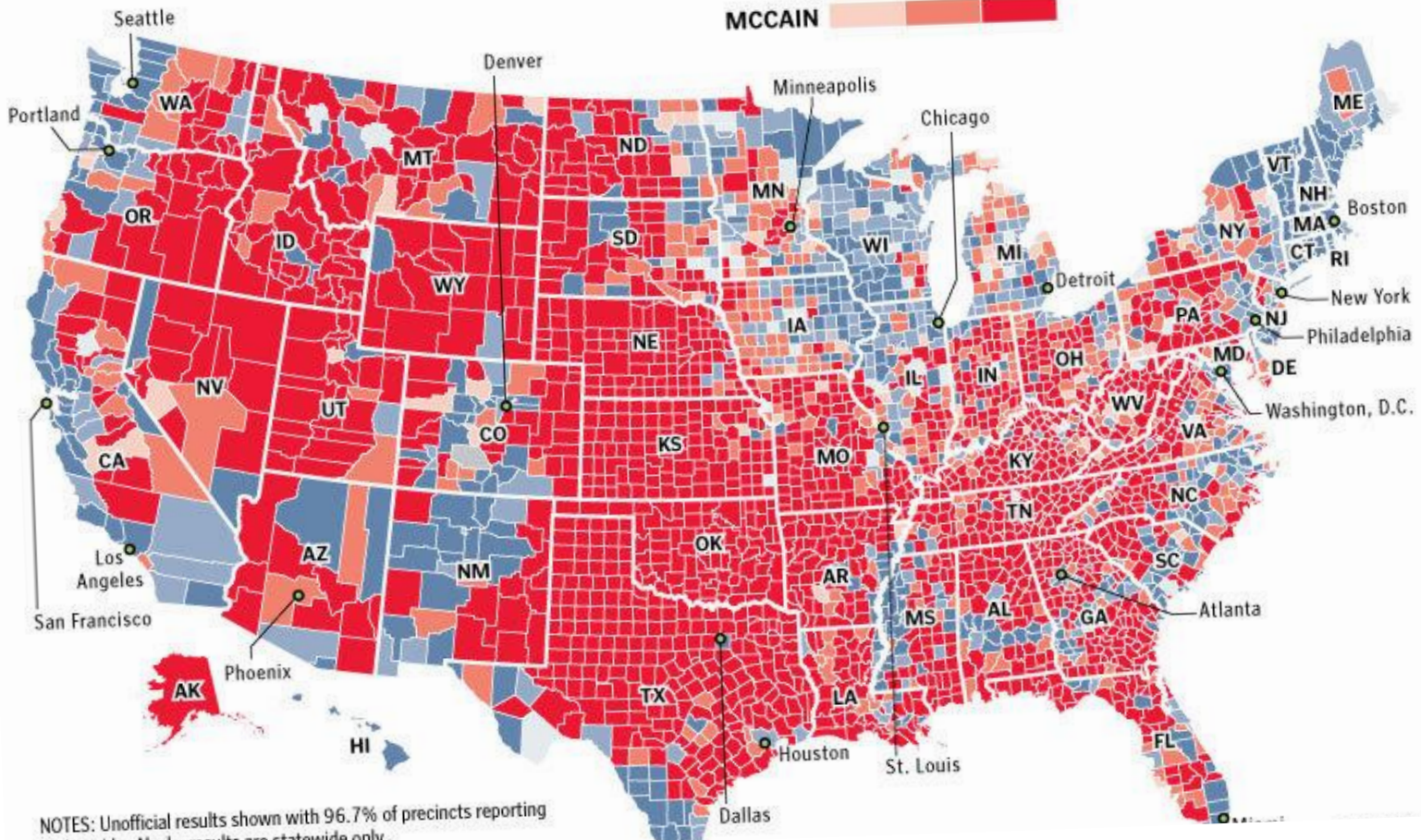
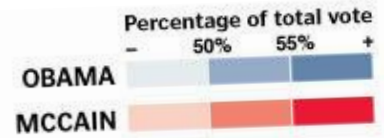


# Political Science

# U.S. Presidential Election Voting Shifts from 2004 to 2008



# President: County-by-county popular vote

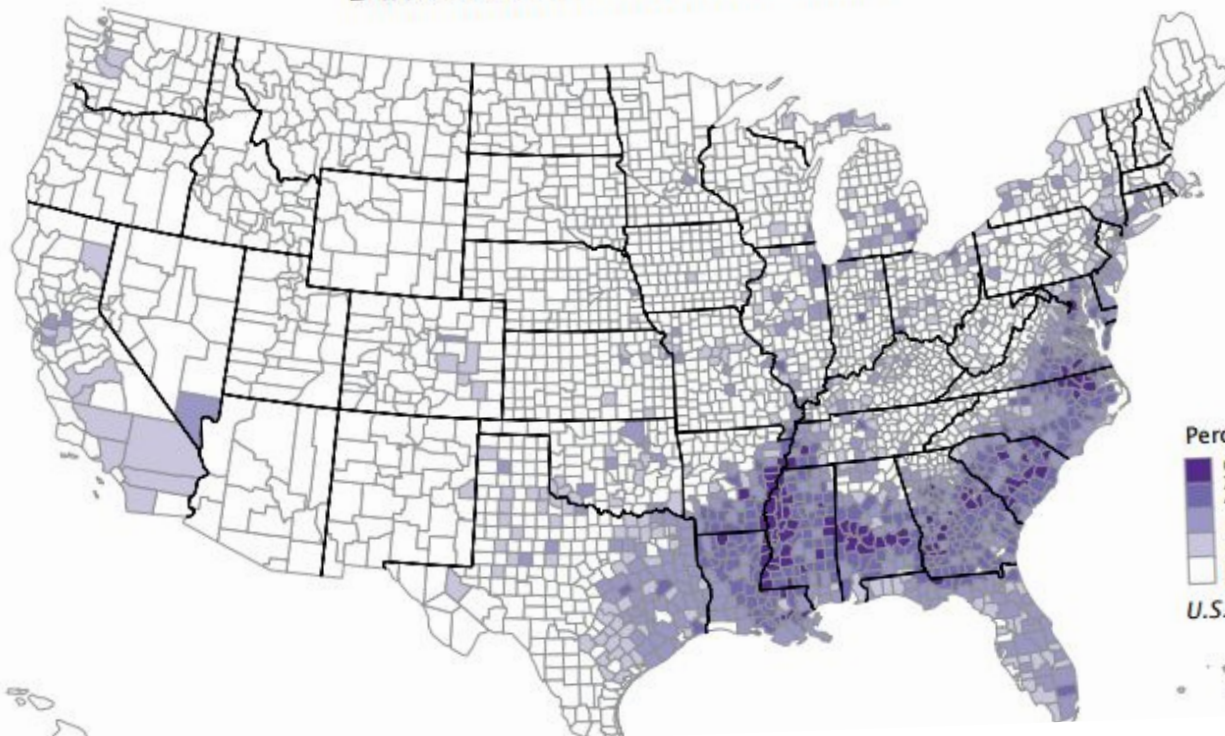


NOTES: Unofficial results shown with 96.7% of precincts reporting nationwide. Alaska results are statewide only.

## Black or African American Population as a Percent of County Population: 2010

(For information on confidentiality protection, nonsampling error, and definitions, see [www.census.gov/prod/cen2010/doc/pl94-171.pdf](http://www.census.gov/prod/cen2010/doc/pl94-171.pdf))

### Black or African American Alone



Percent

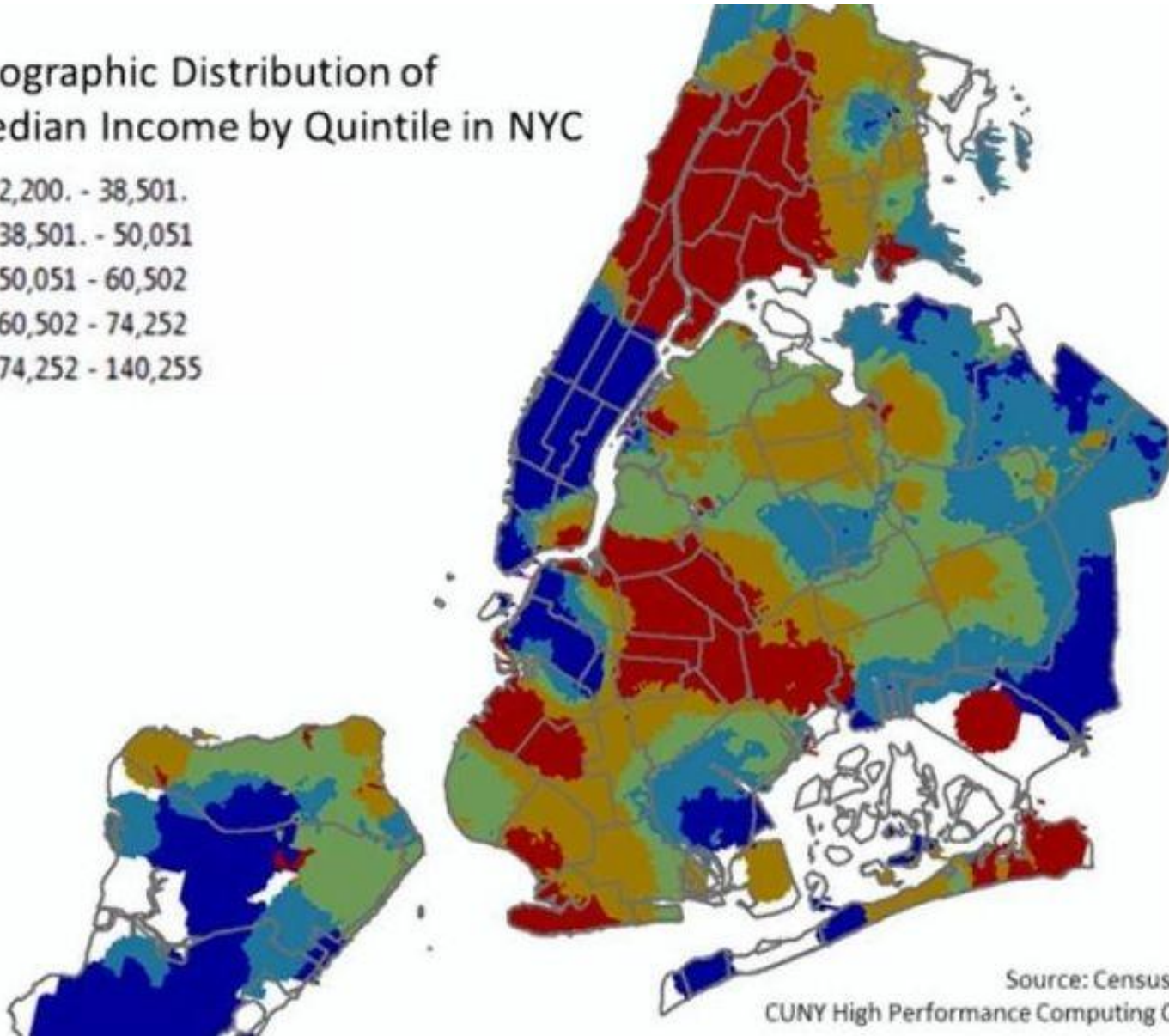
- 50.0 or more
- 25.0 to 49.9
- 10.0 to 24.9
- 5.0 to 9.9
- Less than 5.0

U.S. percent 12.6



**Real Estate**

## Geographic Distribution of Median Income by Quintile in NYC



Source: Census 2010  
CUNY High Performance Computing Center

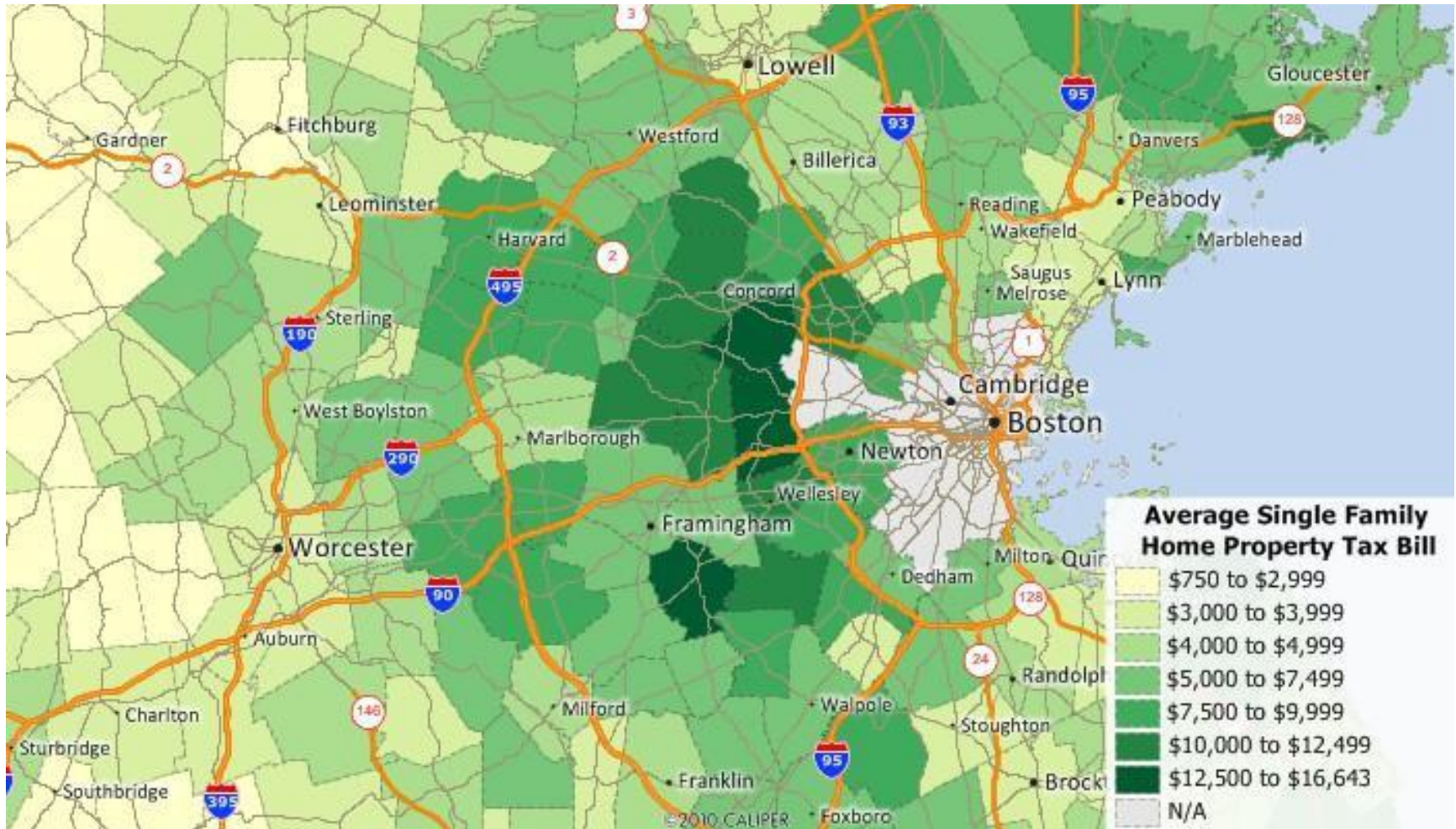
# Housing Sales Prices

Median sales price for  
California counties

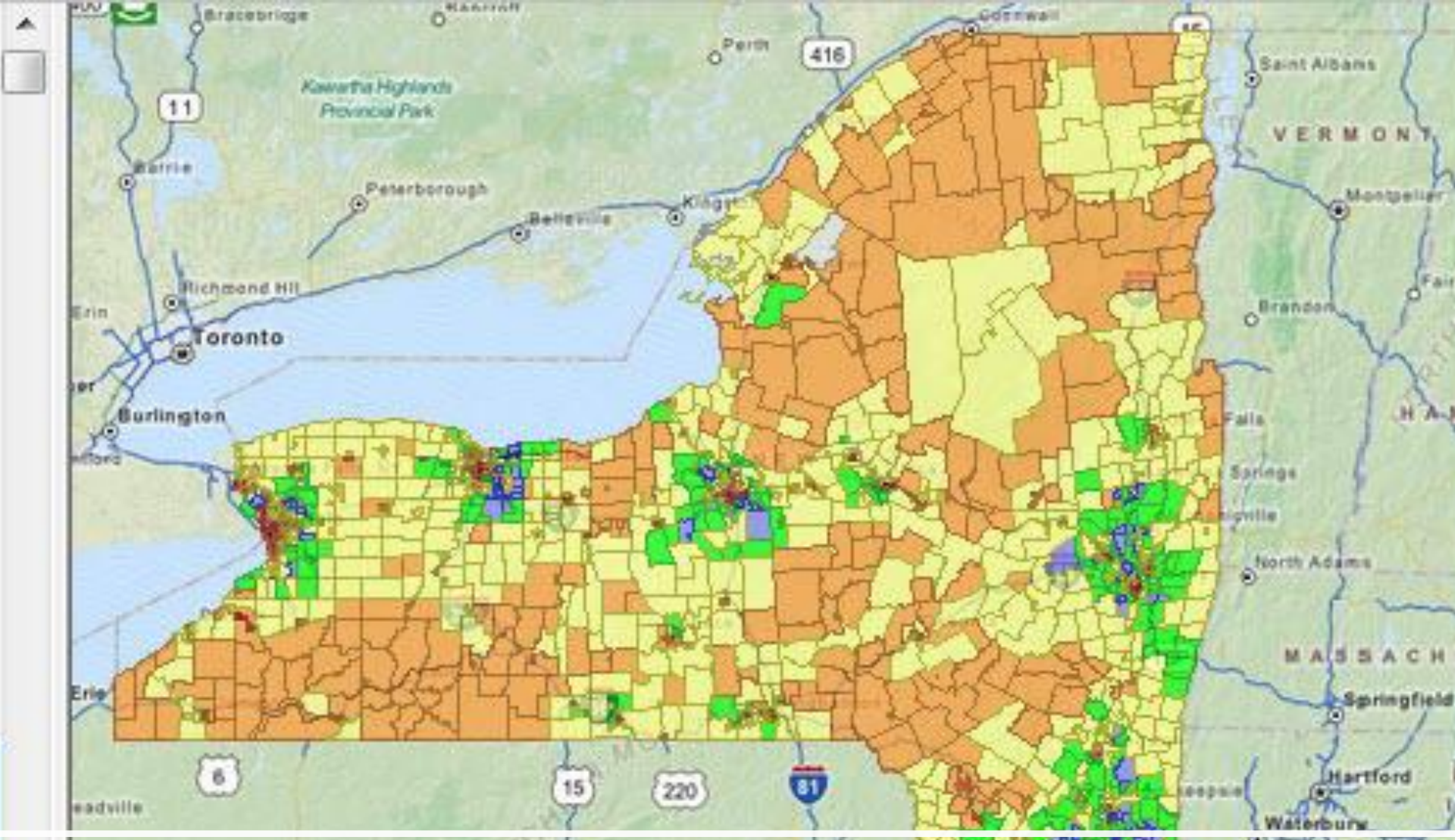
Jun - Aug '06



# Property Tax



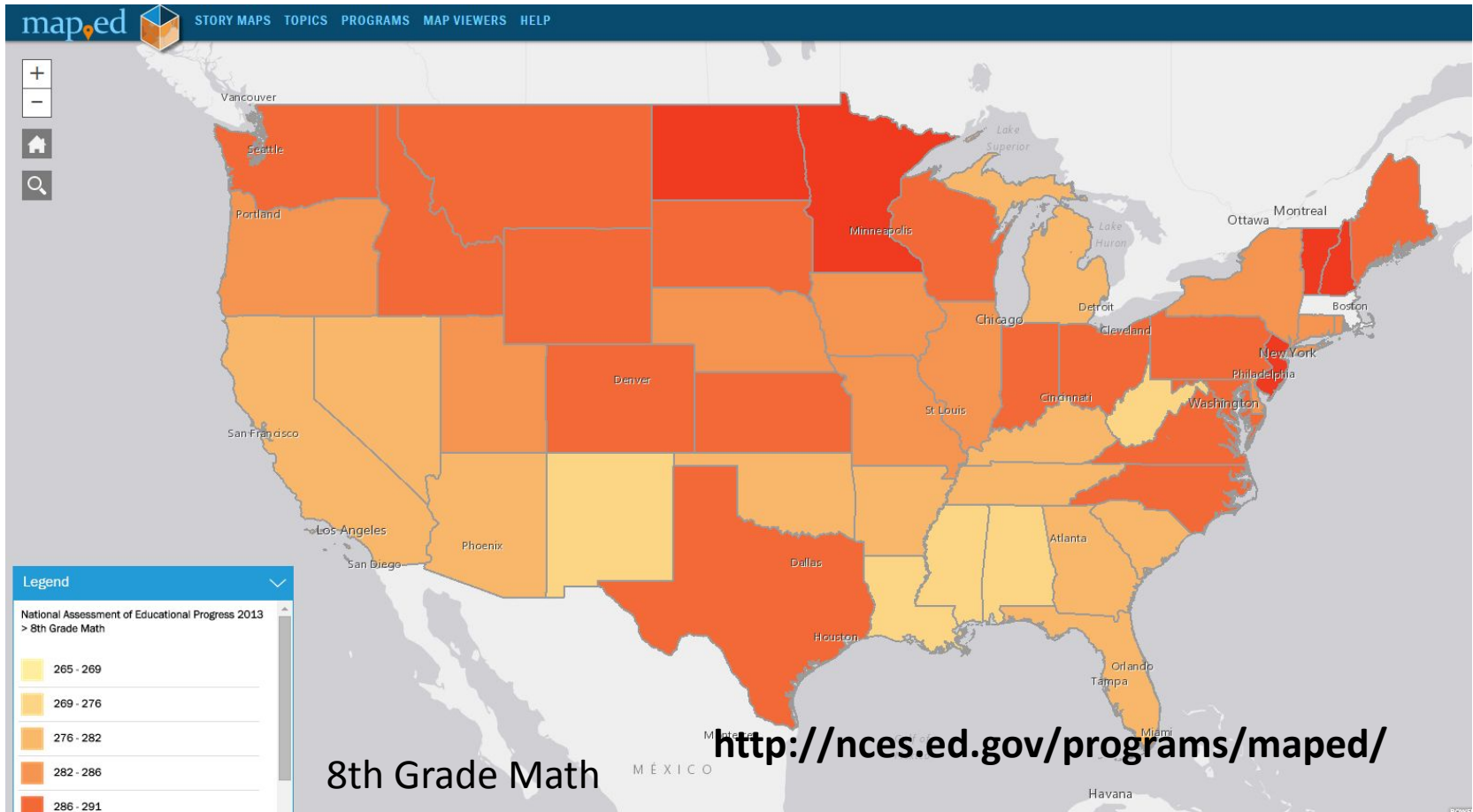
Education



## NYC Schools

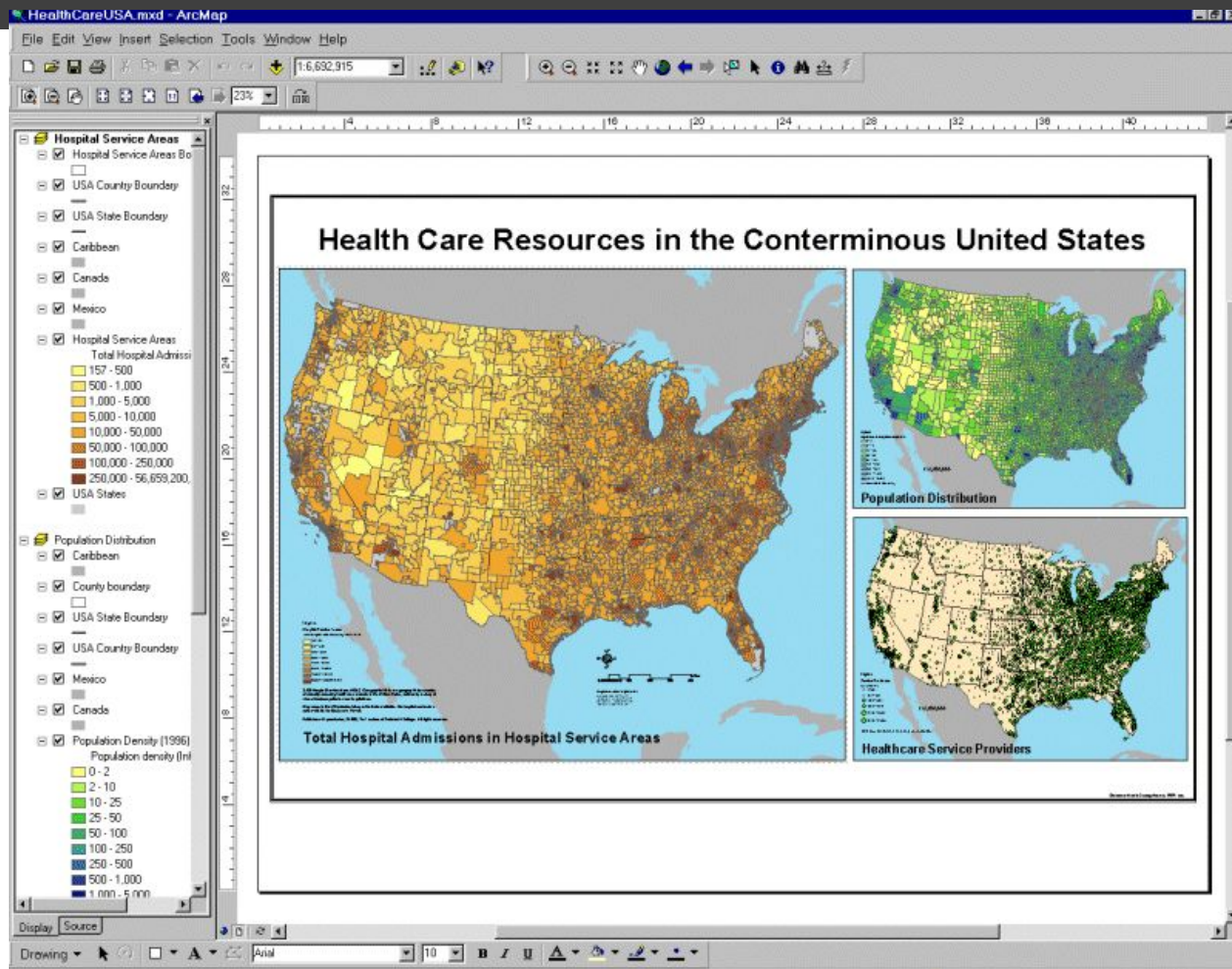


# National Assessment of Educational Progress 2013



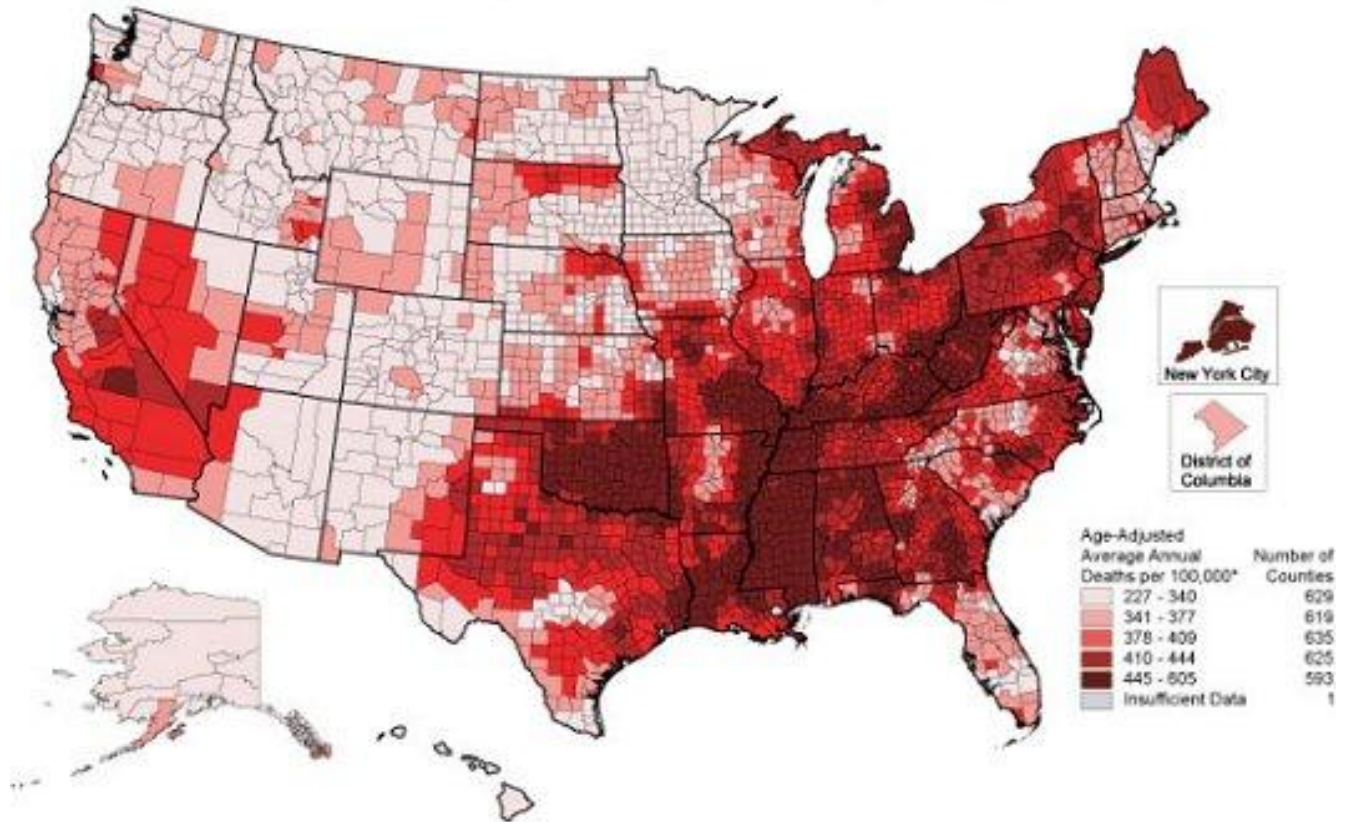
# Health Care

# Sample Health Application



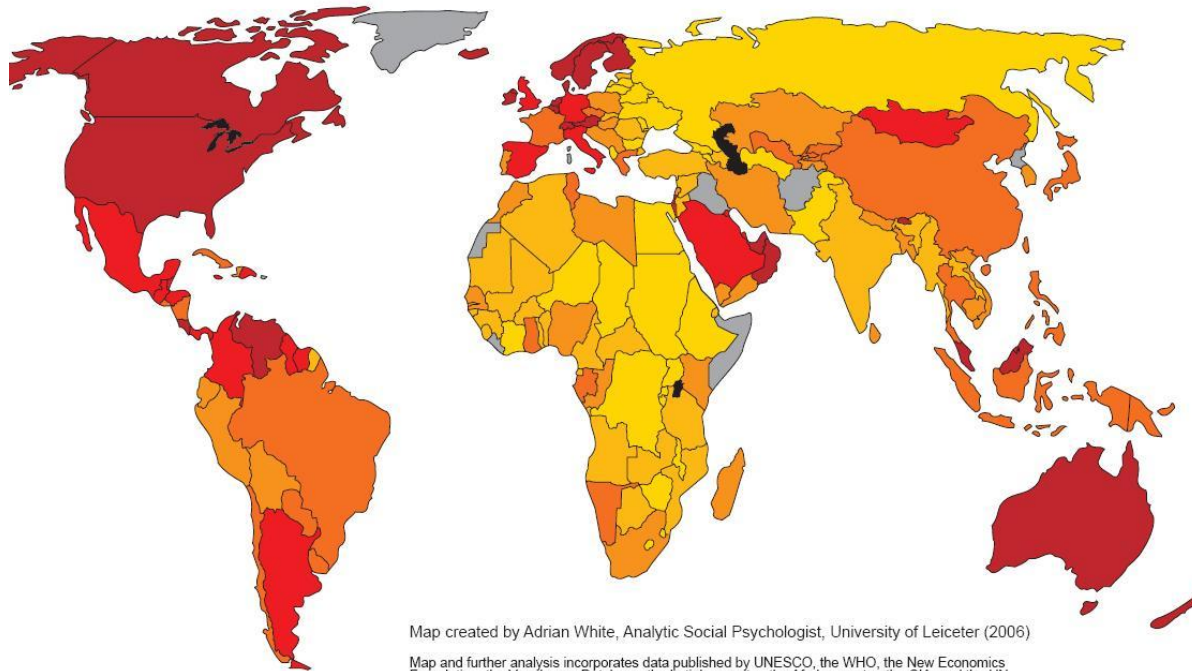
# Human Health

Heart Disease Death Rates, 2000-2004  
Adults Ages 35 Years and Older by County



# World Happiness

A Global Projection of Subjective Well-being:  
The First Published Map of World Happiness

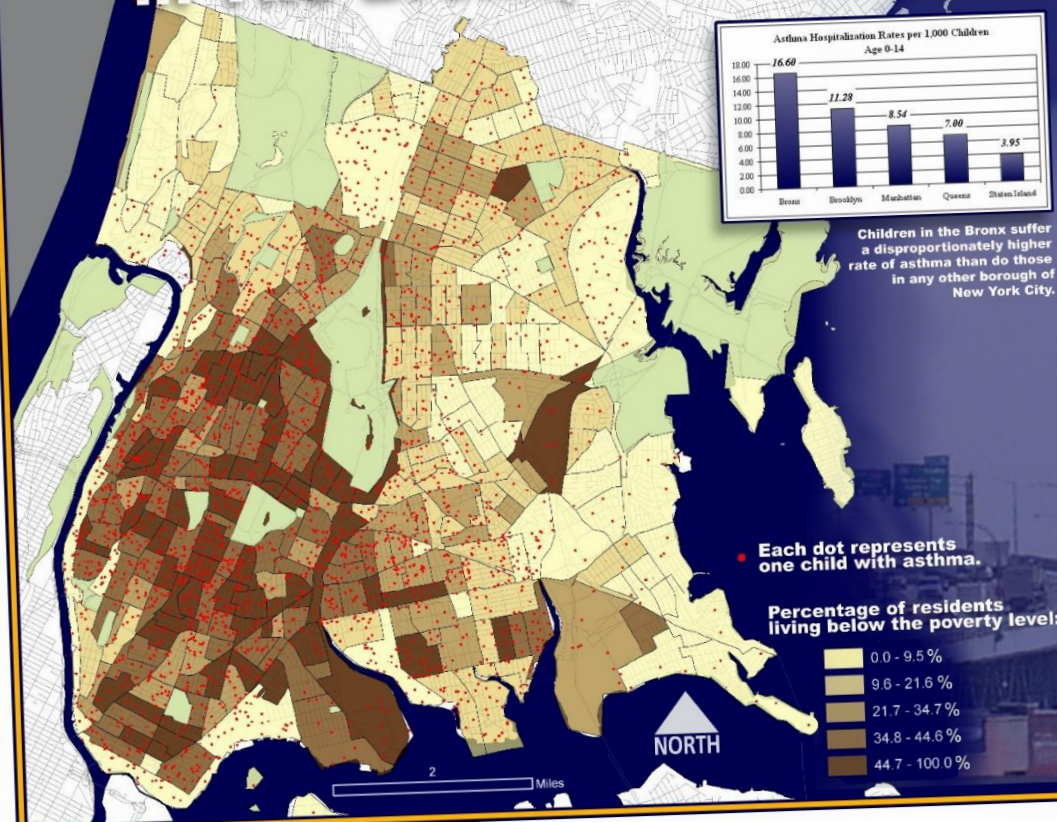


Map created by Adrian White, Analytic Social Psychologist, University of Leicester (2006)

Map and further analysis incorporates data published by UNESCO, the WHO, the New Economics Foundation, the Veenhoven Database, the Latinbarometer, the Afrobarometer, the CIA, and the UN Human Development Report.



# Childhood Asthma and Poverty in The Bronx, New York



Children in the Bronx suffer a disproportionately higher rate of asthma than do those in any other borough of New York City.



One of the poorest areas in New York City, the South Bronx has one of the highest rates of asthma among children. Heavy truck traffic is a primary contributor to the poor air quality experienced by residents of this area.

Designed and created by Brian Morgan  
 Lehman College, CUNY  
 April 2007  
 Special thanks to Dr. Juliana Maantay  
 Data sources:  
 U.S. Census, 2000;  
 NYC Department of Health and Mental Hygiene, May 2003

Guess?

