Government 1008
Introduction to Geographical Information Systems

Lecture 1: Introduction to Course and Content

Sumeeta Srinivasan

ssriniv@fas.harvard.edu or
ssrinivasan@cga.harvard.edu

Reference: Campbell and Shin; Bolstad, P; Longley, Goodchild, et al.

Outline for Today

- Course description
  - Objectives, lecture format, evaluation and project, schedule
- Course overview: What is GIS?

Course Objectives

1. An understanding of the nature of spatial data and the principles of geographic information systems as a “science”
   - GIS data structures, databases and georeferencing
   - Geographic thinking as an analytical method
   - Spatial analysis
2. Hands-on experience in using commercially available GIS software
3. Implementing a project using available data

Evaluation

- Lab exercises (7): 34%
  - 4 points each for Labs 1-4
  - 6 points each for Labs 5-7
- Mid term exam: 26%
  - Open book and notes
- Final project: 30%
- Participation (showing up, asking questions, involved in guest lectures) : 10%

Standard Format for Classes

- **Lecture (~1 hour Tuesdays)**
  - 60-75 min. lecture + case study + discussion
- **Lab exercise (2+ hours Thursdays)**
  - 10-20 min demo (optional)
  - 2-? hours (may extend beyond class times) that should be returned to the instructor the following Friday (unless otherwise specified in the schedule)
  - Instructor is available 9:30-12:30pm; 3-5pm; TF from 5-7pm

Final Project

- Project abstract by November 15th
  - Should include description of problem
  - Background research (context)
- The final project
  - Project interview scheduled Nov 1st-26th
  - Formal in-class presentation (5% of the course grade on Dec 3rd and/ or 5th) and
  - Project summary report 8-10 pages of written content (25% of the course grade by Dec 15th)

Readings

- Jonathan Campbell and Michael Shin, Essentials of Geographic Information Systems http://students.flatworldknowledge.com/course?cid=1040769&bid=463791 e-ISBN: 978-1-4533-3023-4 Or
- Bolstad, Paul, 2012, *GIS Fundamentals*, 4th Edition, (Atlas Books). ISBN 978-0-9717647-3-6

Optional:

- Longley, Paul A., Michael F. Goodchild, David J. Maguire, David W. Rhind. 2011 *Geographic Information Systems and Science*, 3rd Edition (John Wiley & Sons). ISBN 9780470721445

Other materials distributed in class or available on the web (Check links on syllabus)

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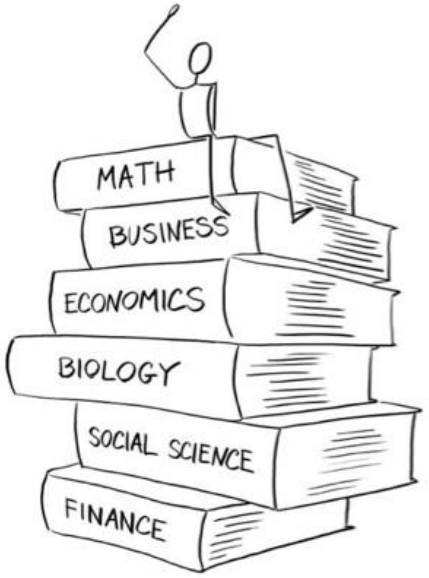


Course Schedule

1. Introduction
2. Principles of GIS
   - Nature of spatial data
   - Georeferencing
3. Techniques
   - Spatial data models
   - Spatial databases
4. Analysis
   - Visualization and cartography
   - Spatial analysis techniques
   - Spatial models and applications
5. Research, Applications and Policy

How this course fits in overall

- General Introduction to GIS
  - Methods course: not discipline dependent

- In Spring you can continue with:
  - Gov 1016 Spatial Models– More in spatial statistics and modeling
    - Assumes basic statistics background
  - Gov 1009 – Advanced Workshop –
    - No quantitative background but introductory GIS background needed

Outline

- Course description
  - Objectives, lecture format, evaluation and project, schedule
- Course overview

What is GIS?

Overview Outline

What is GIS?

- Vocabulary
- Why is geographic information different?
- What is GIS?
- History of GIS
- GIS Applications
- Social Implications
- Summary

The Vocabulary

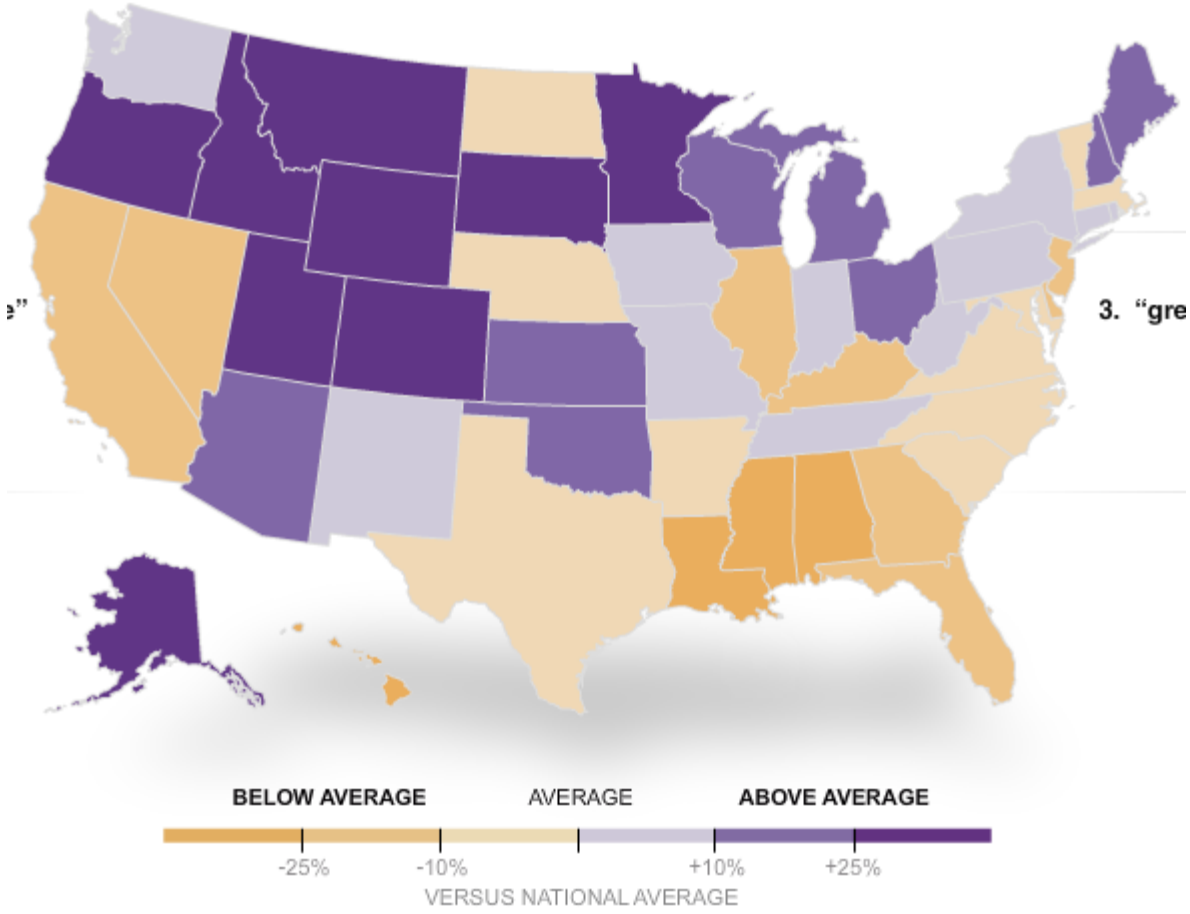
- Geographic – Earth's surface and near-surface
- Spatial – any space (including geographic)
- Geospatial – synonymous with geographic

Think of the Map

- “There were more searches originating in the western and mid-western states for pumpkin pie as compared to the west and the south.”

RANK SEARCH TERM PER 10,000 SEARCHES

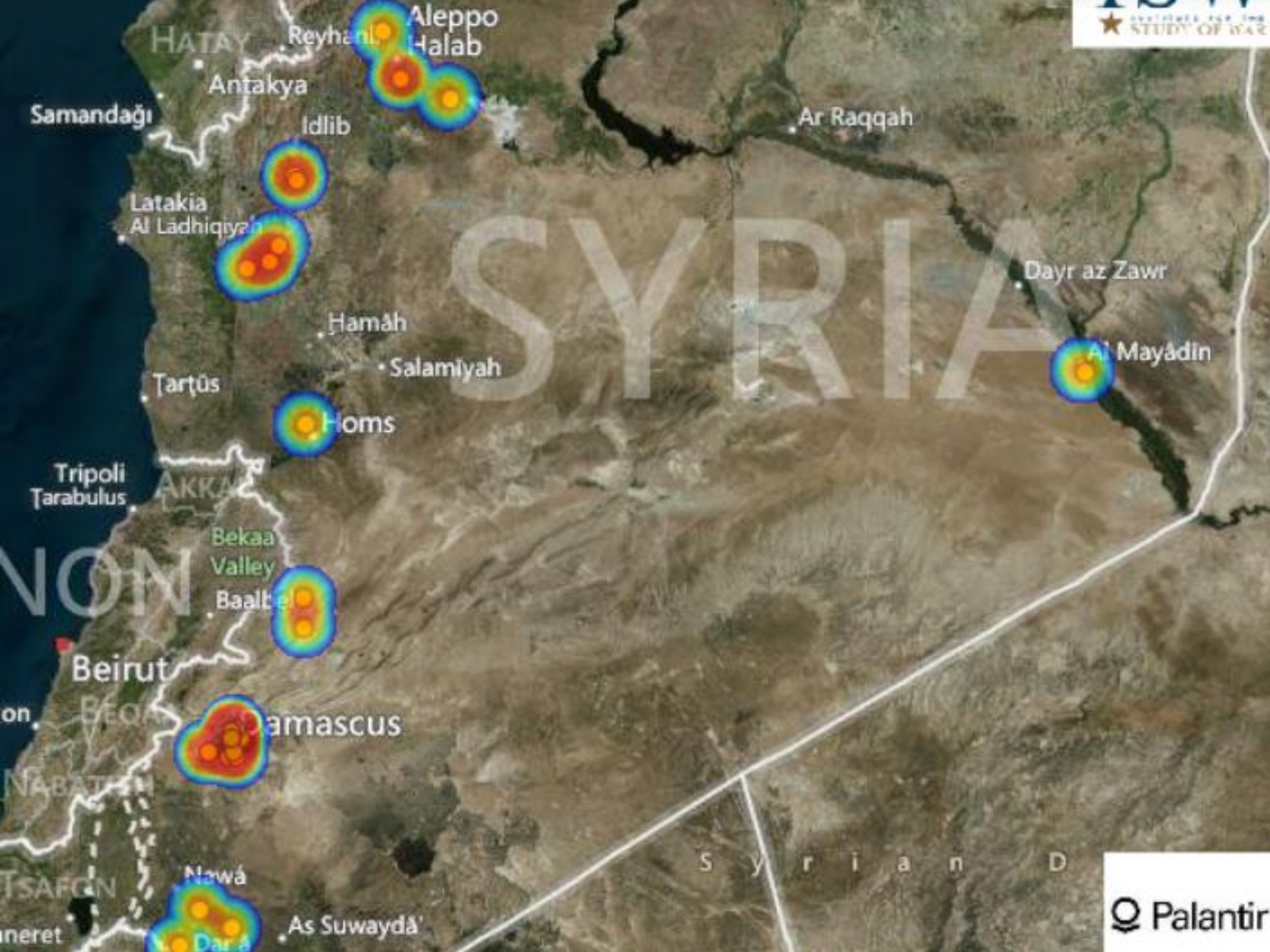
2. “pumpkin pie” 189



3. “gre

Think of the Map

- “Heavy fighting continued throughout Syria yesterday, with Damascus bearing the brunt of it. There were regime bombardments and airstrikes, but in Aleppo the rebels took the offensive, with attacks on a military checkpoint near al-Safira and a fuel center.”

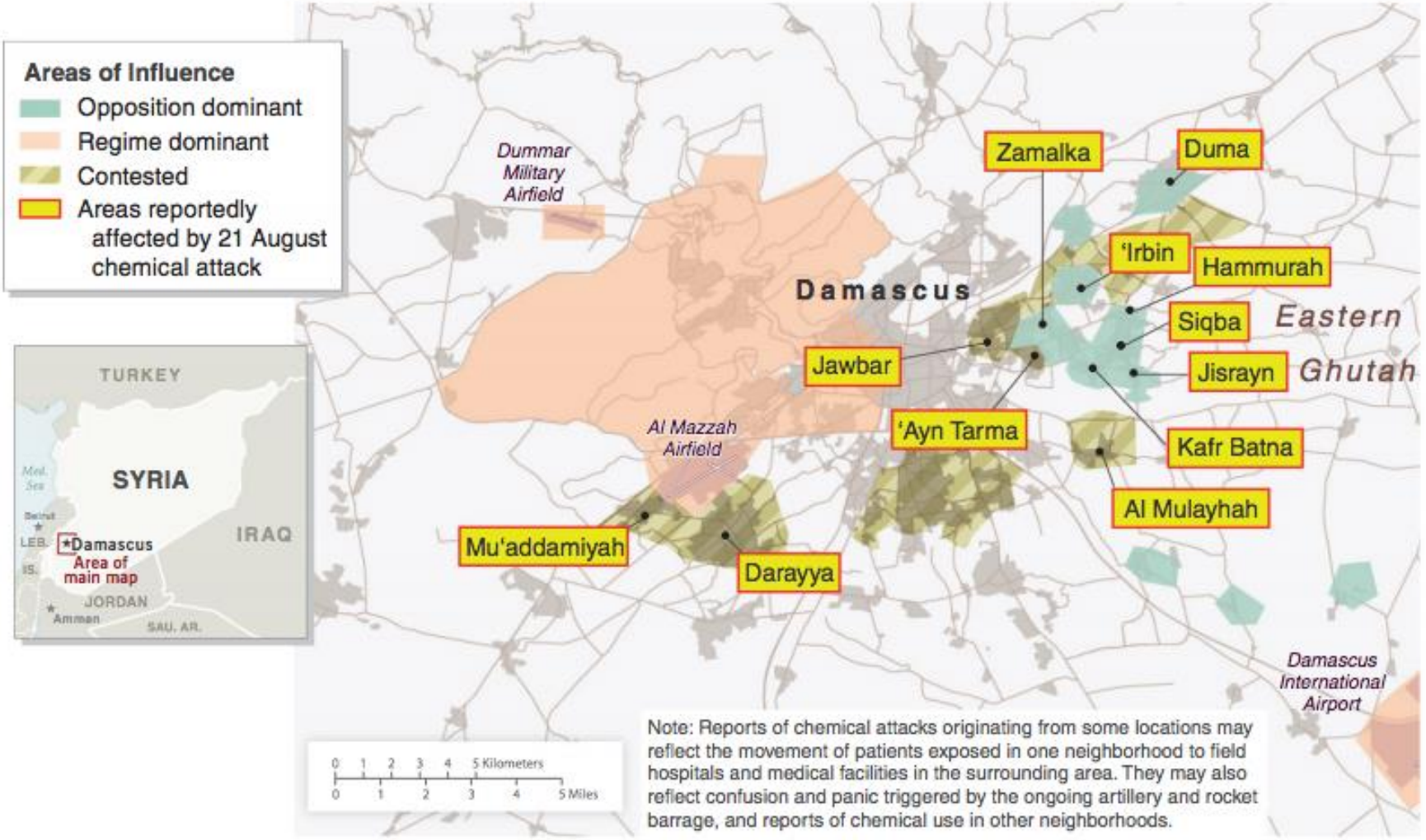

Aleppo
Halab
HATAY
Reyhanlı
Antakya
Samandağı
Idlib
Ar Raqqah
Latakia
Al Ladhiqiyah
SYRIA
Dayr az Zawr
Ḥamāh
Salamīyah
Al Mayādīn
Ṭarṭūs
Homs
Tripoli
Ṭarabulus
AKKAR
Bekaa
Valley
Baalbek
Beirut
Damascus
Nawá
As Suwaydā'
Syrian D
Palantir

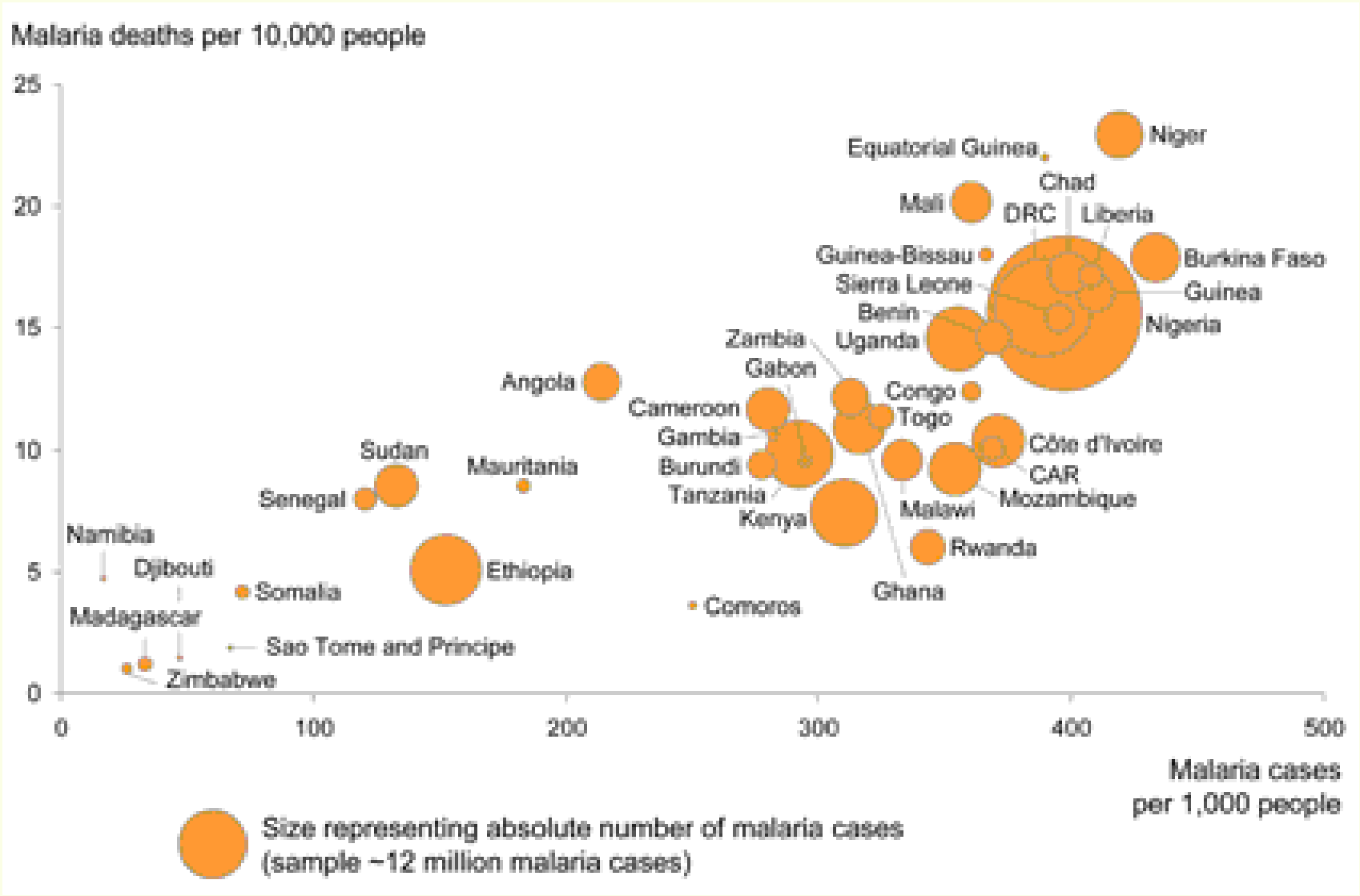
Think of the map that goes with this:

According to the report US intelligence:

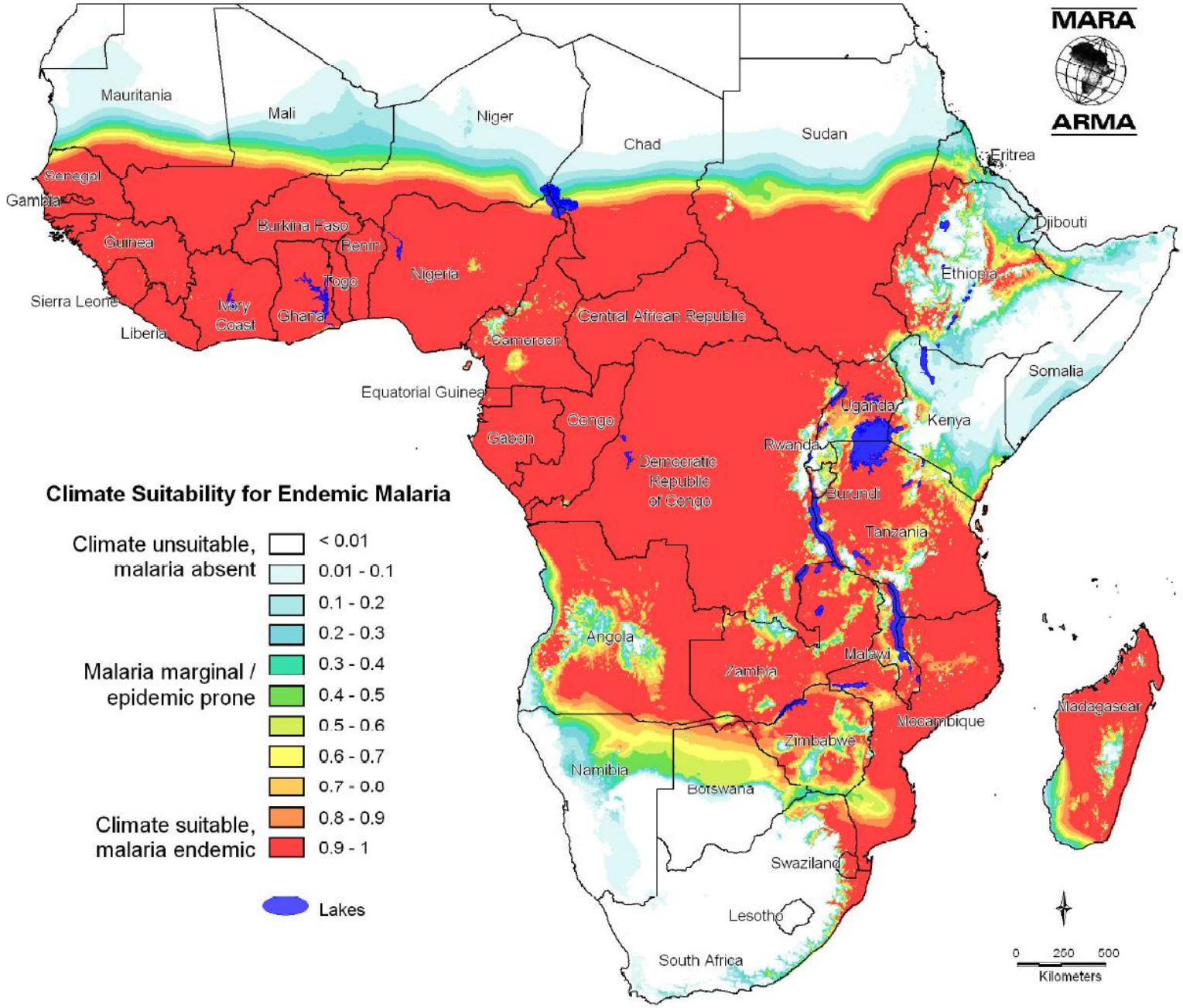
Confirmed with high confidence that the Syrian government carried out the chemical weapons attack against opposition elements in the Damascus suburbs on August 21 and that the scenario in which the opposition executed the attack is highly unlikely. Indicated the attack came from a regime-controlled area and struck neighborhoods in Damascus, including Kafr Batna, Jawbar, ‘Ayn Tarma, Darayya, and Mu’addamiyah.

Syria: Damascus Areas of Influence and Areas Reportedly Affected by 21 August Chemical Attack



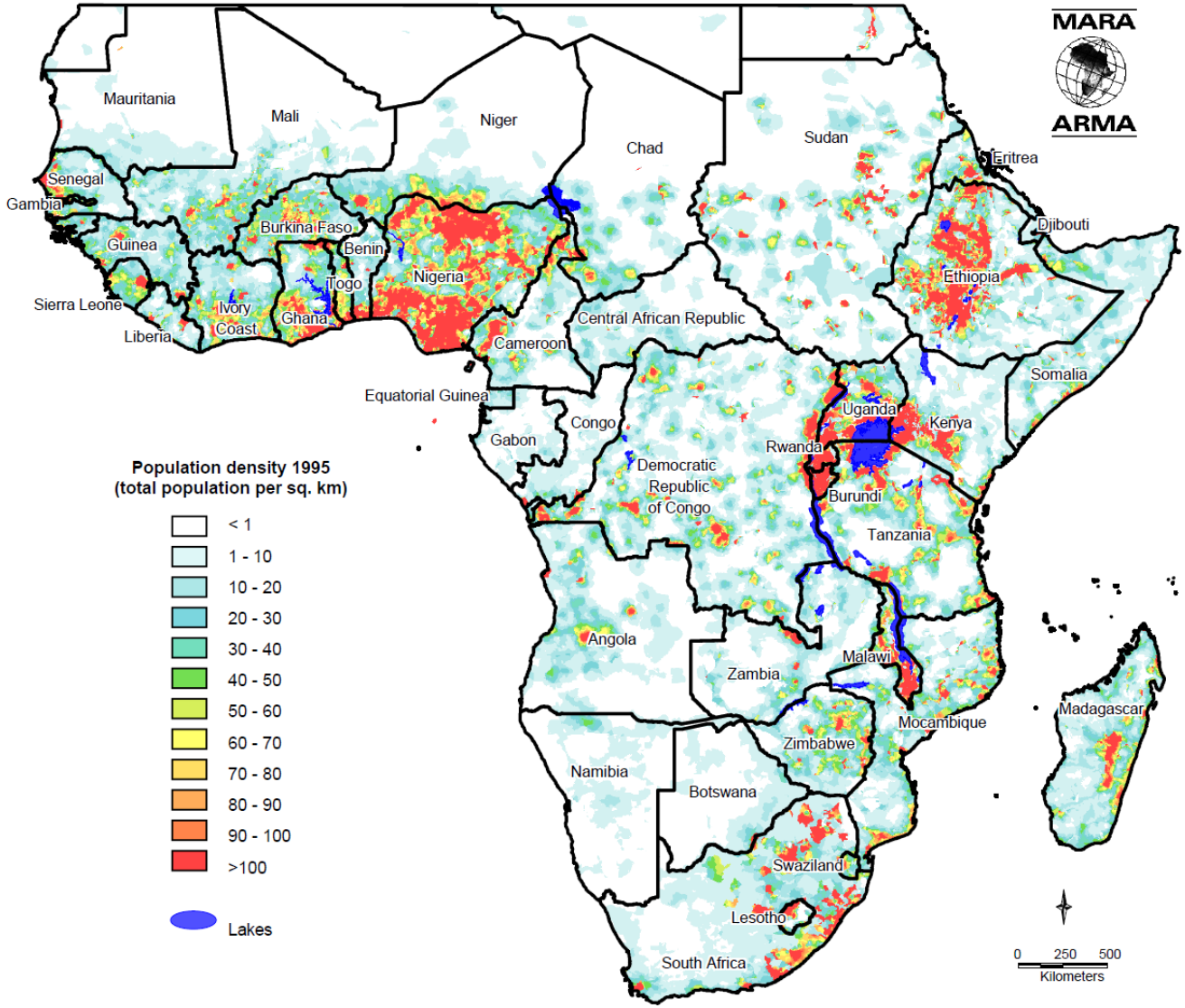


Why would a map help here?


MARA
ARMA
Mauritania
Mali
Niger
Chad
Sudan
Eritrea
Djibouti
Senegal
Gambia
Guinea
Burkina Faso
Benin
Nigeria
Togo
Ethiopia
Sierra Leone
Liberia
Ivory Coast
Ghana
Central African Republic
Cameroon
Somalia
Equatorial Guinea
Uganda
Kenya
Congo
Gabon
Rwanda
Democratic Republic of Congo
Burundi
Tanzania
Angola
Malawi
Zambia
Madagascar
Mozambique
Zimbabwe
Namibia
Botswana
Swaziland
Lesotho
South Africa
Climate Suitability for Endemic Malaria
Climate unsuitable, malaria absent
< 0.01
0.01 - 0.1
0.1 - 0.2
0.2 - 0.3
Malaria marginal / epidemic prone
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
Climate suitable, malaria endemic
0.8 - 0.9
0.9 - 1
Lakes
0 250 500
Kilometers

Is there a pattern with respect to some other variable?

Total Population Distribution 1995

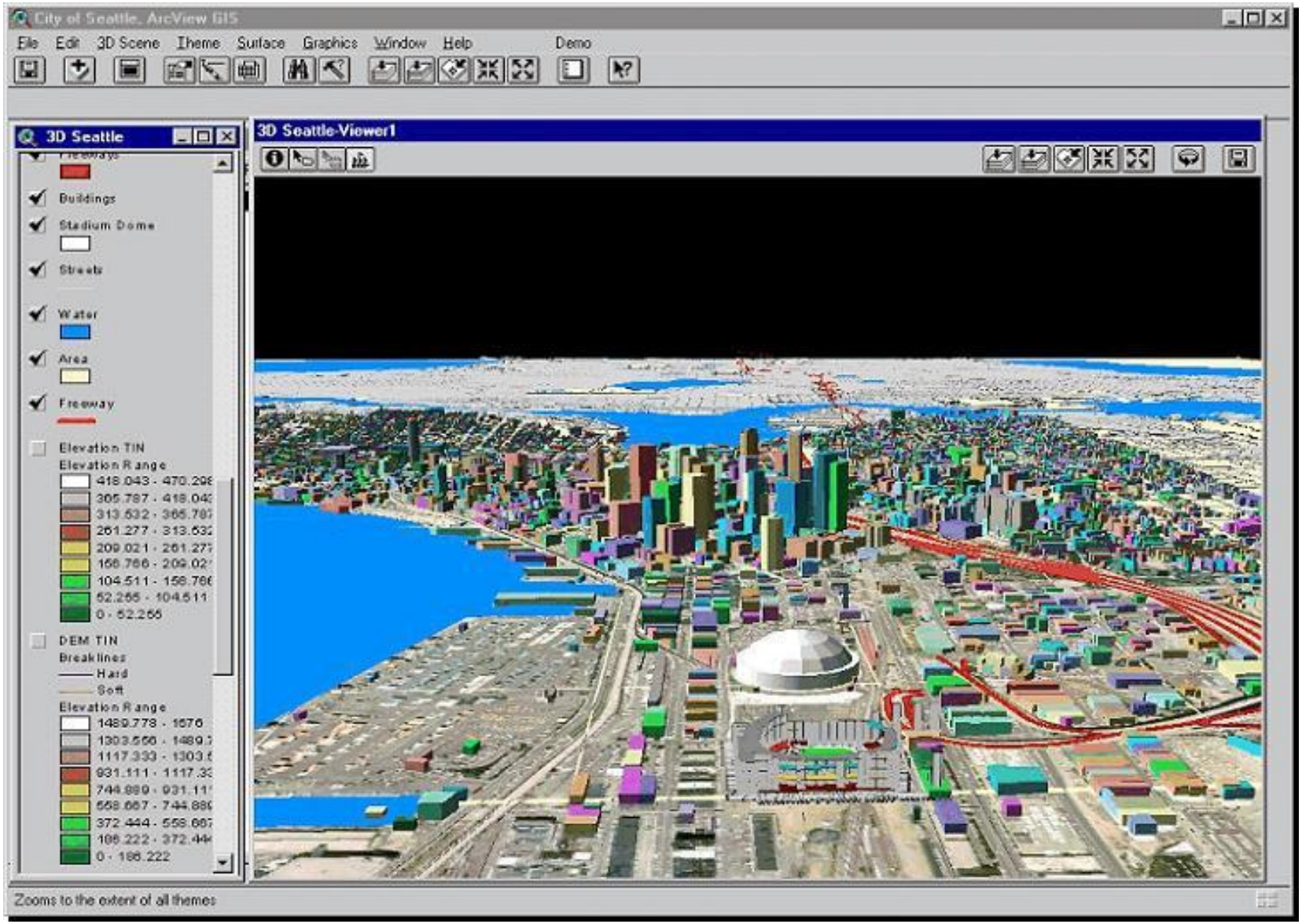


Why is geographic data different? Geographic Information:

- Has Location X, Y

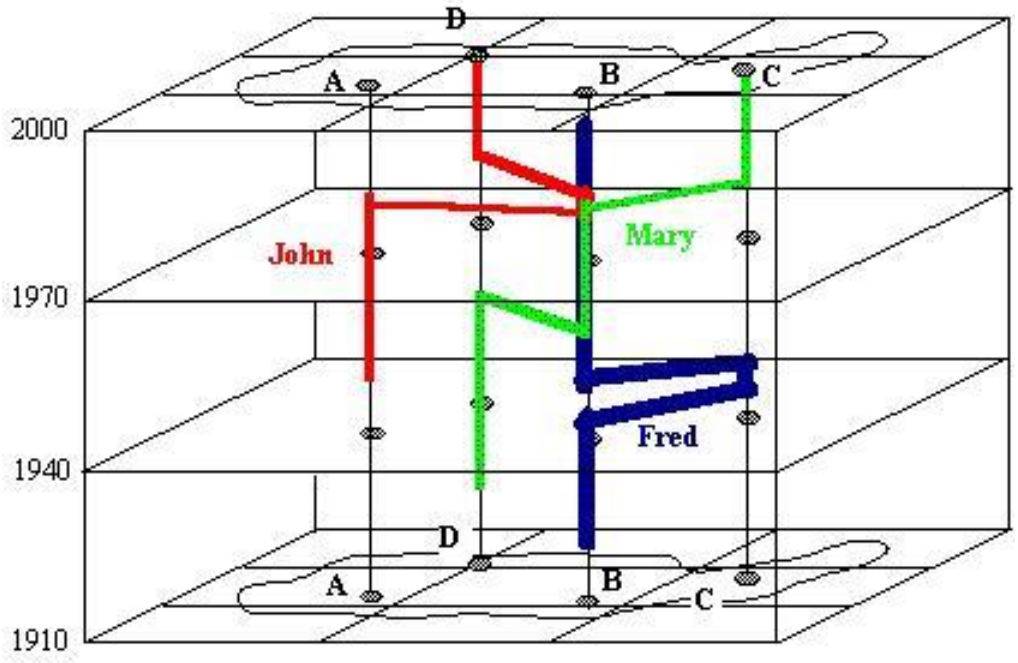
Why is geographic data different? Geographic Information:

- Has Volume X, Y, Z



Why is geographic data different? Geographic Information:

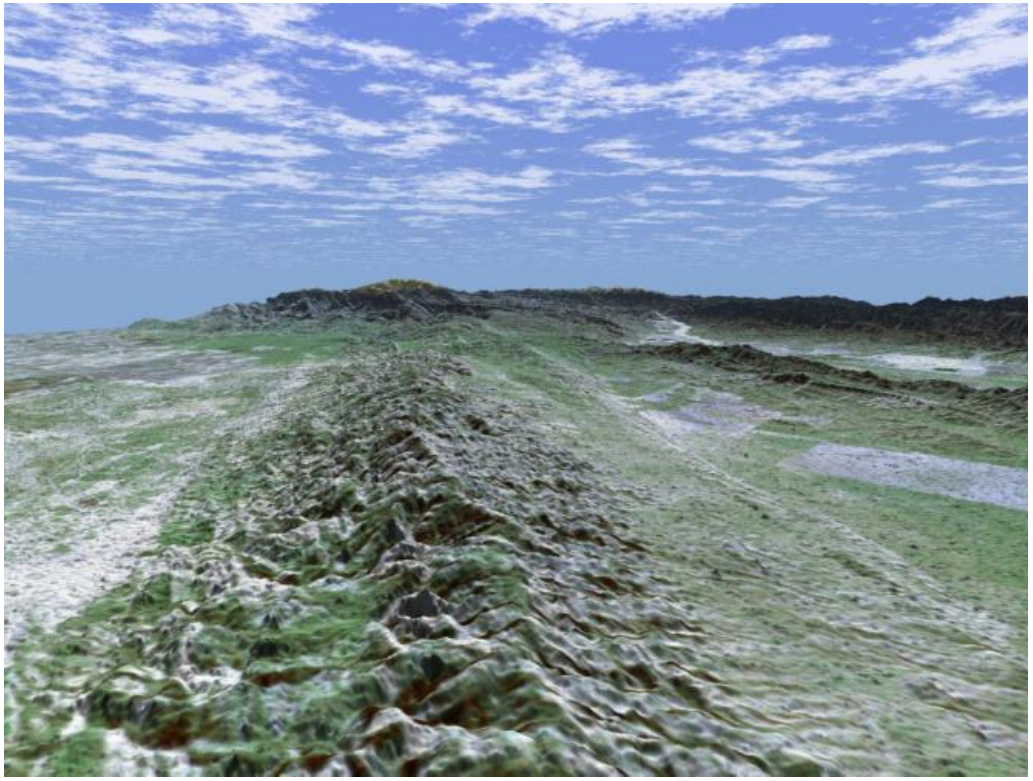
- Multidimensional X, Y, Z and T



Schematic representation of the lives of three US citizens in space (two horizontal axes) and time (vertical axis)

Geographic Information is:

- Multidimensional
- Voluminous
- Requires projection to flat surface



Phenomena conceptualized as fields. The illustration shows elevation data from the Shuttle Radar Topography Mission draped with an image from the Landsat satellite, looking SE along the San Andreas Fault in Southern California, plus a simulated sky

Geographic Information:

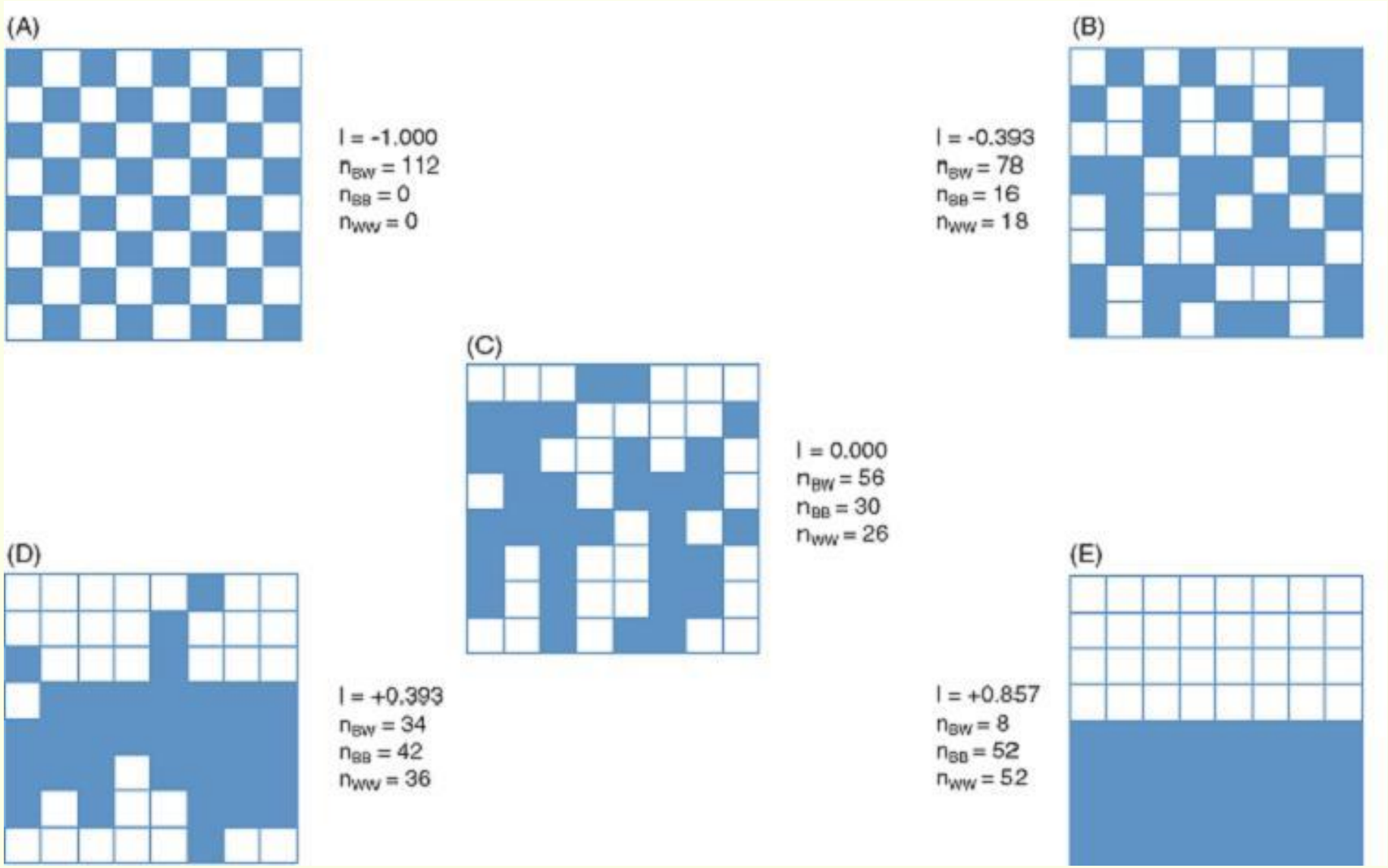
- Multidimensional
- Voluminous
- Requires projection to flat surface
- Analyses require data integration

Think of a map. What data would you need to make the map?

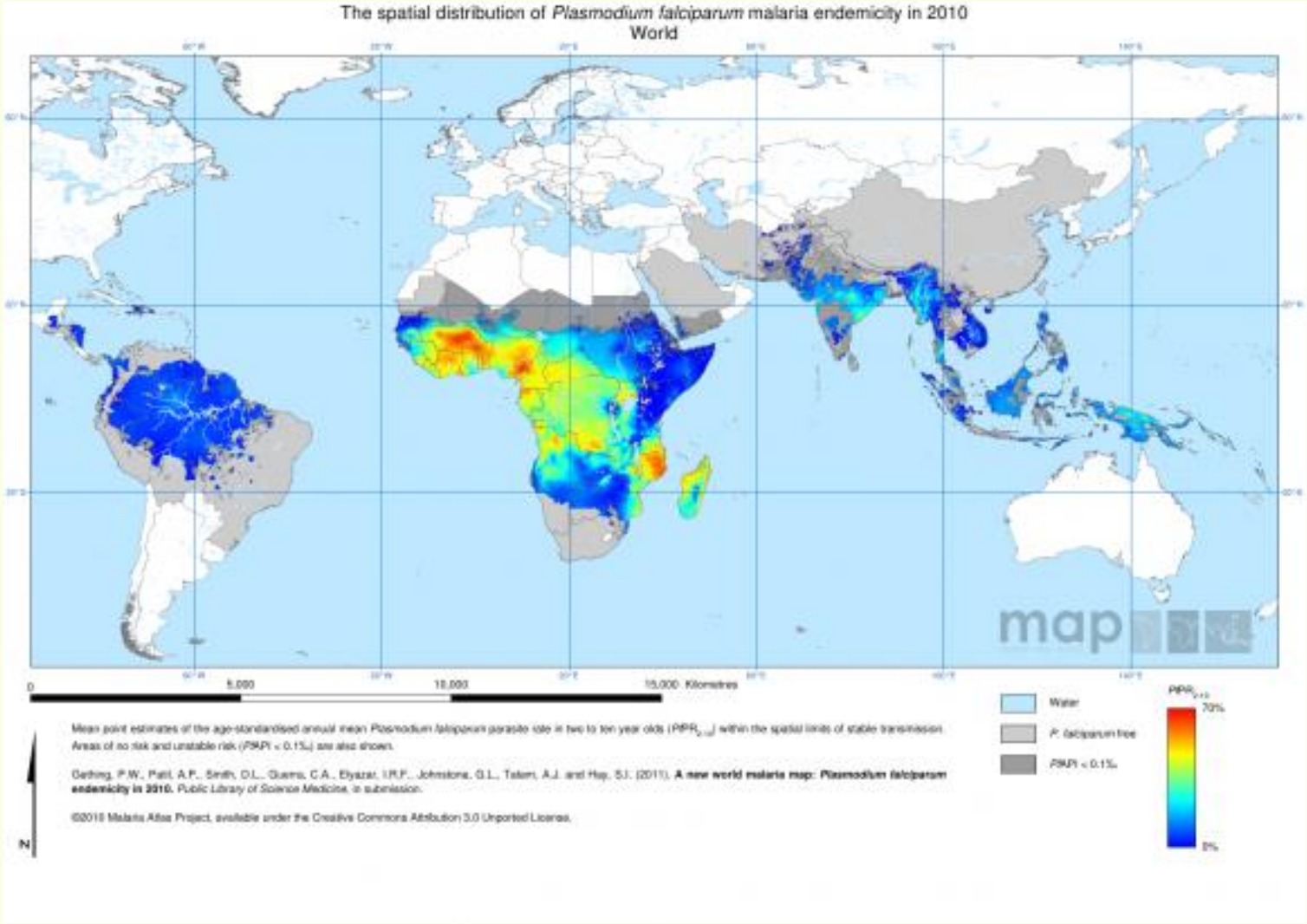
Geographic Information is:

- Multidimensional
- Voluminous
- Requires projection to flat surface
- Analysis method

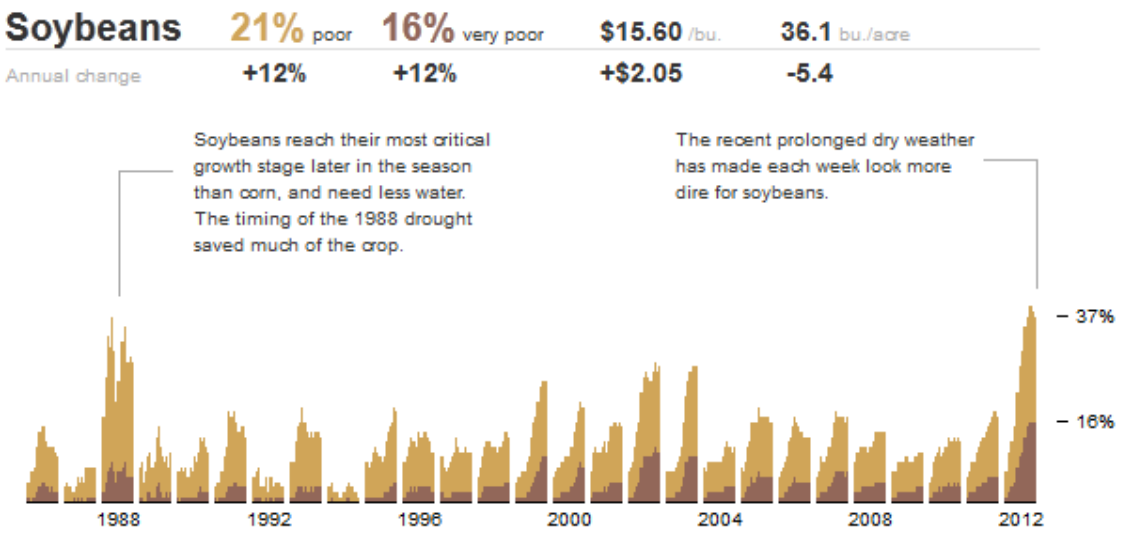
Is it clustered?

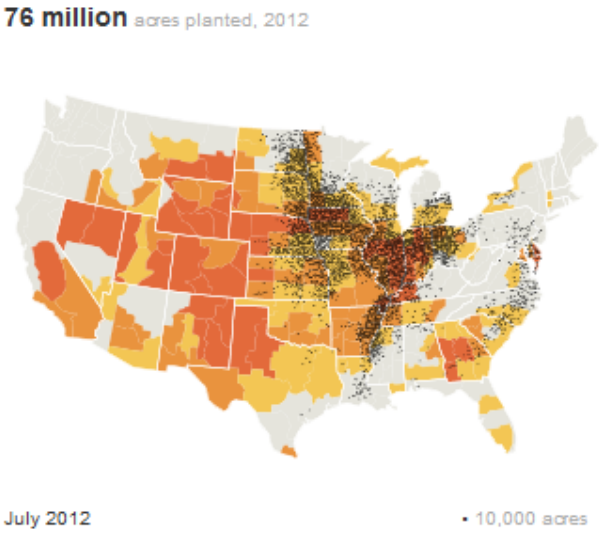


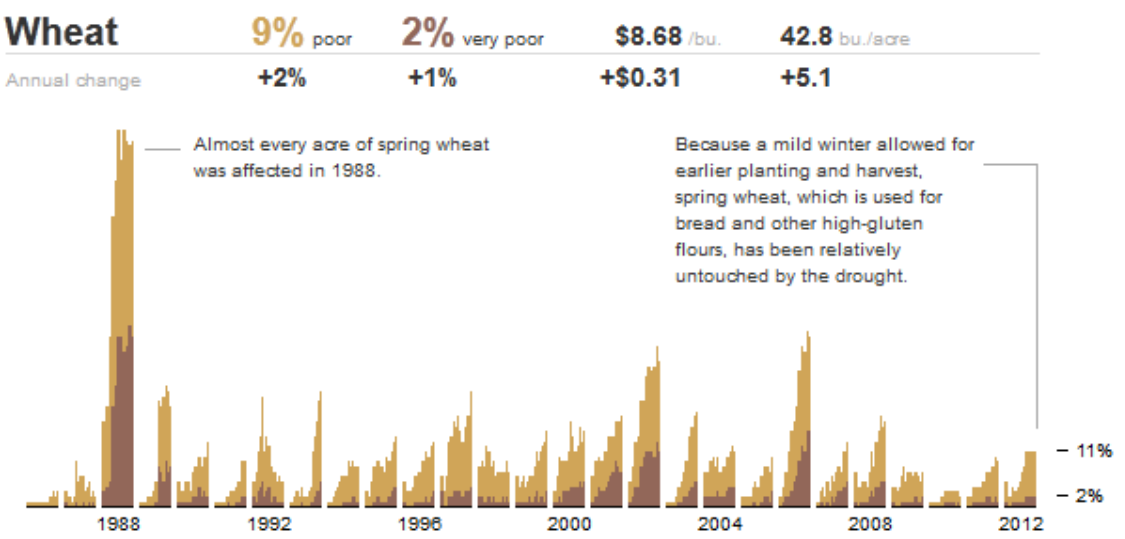
Where is it clustered? (malaria endemicity)

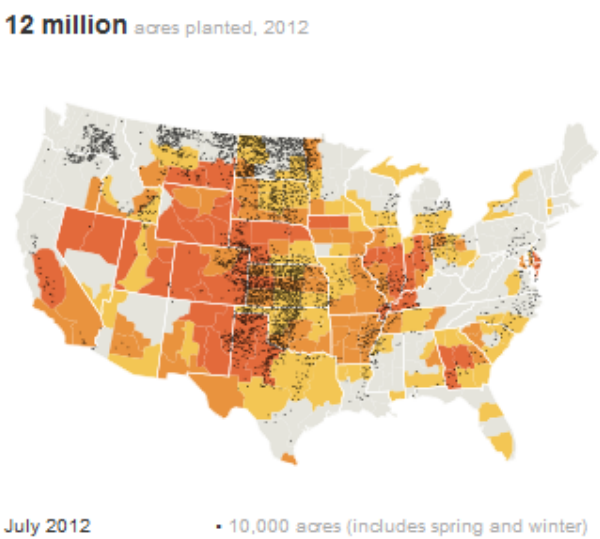


Is it clustered relative to “x” or “y” or…?

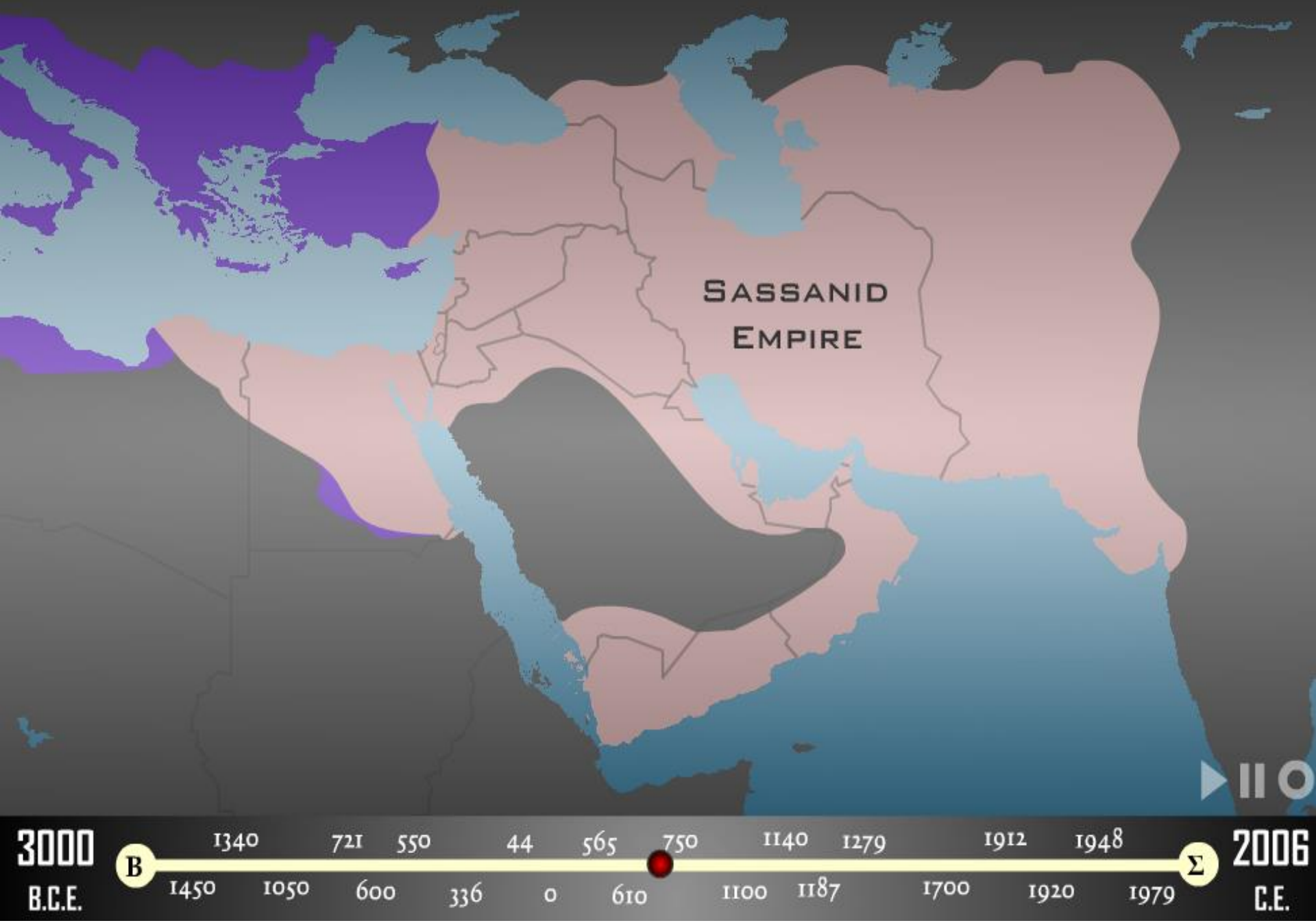








How does the clustering change over time?



http://www.mapsofwar.com/ind/imperial-history.html

3D + Time

http://www.davidrumsey.com/view/3d-gis

Geographic Information is:

- Multidimensional
- Voluminous
- Requires projection to flat surface
- Unique analysis methods
- Analyses require data integration
- Spatial data are expensive and time consuming
- Map displays require fast data retrieval

The First Census (1790)

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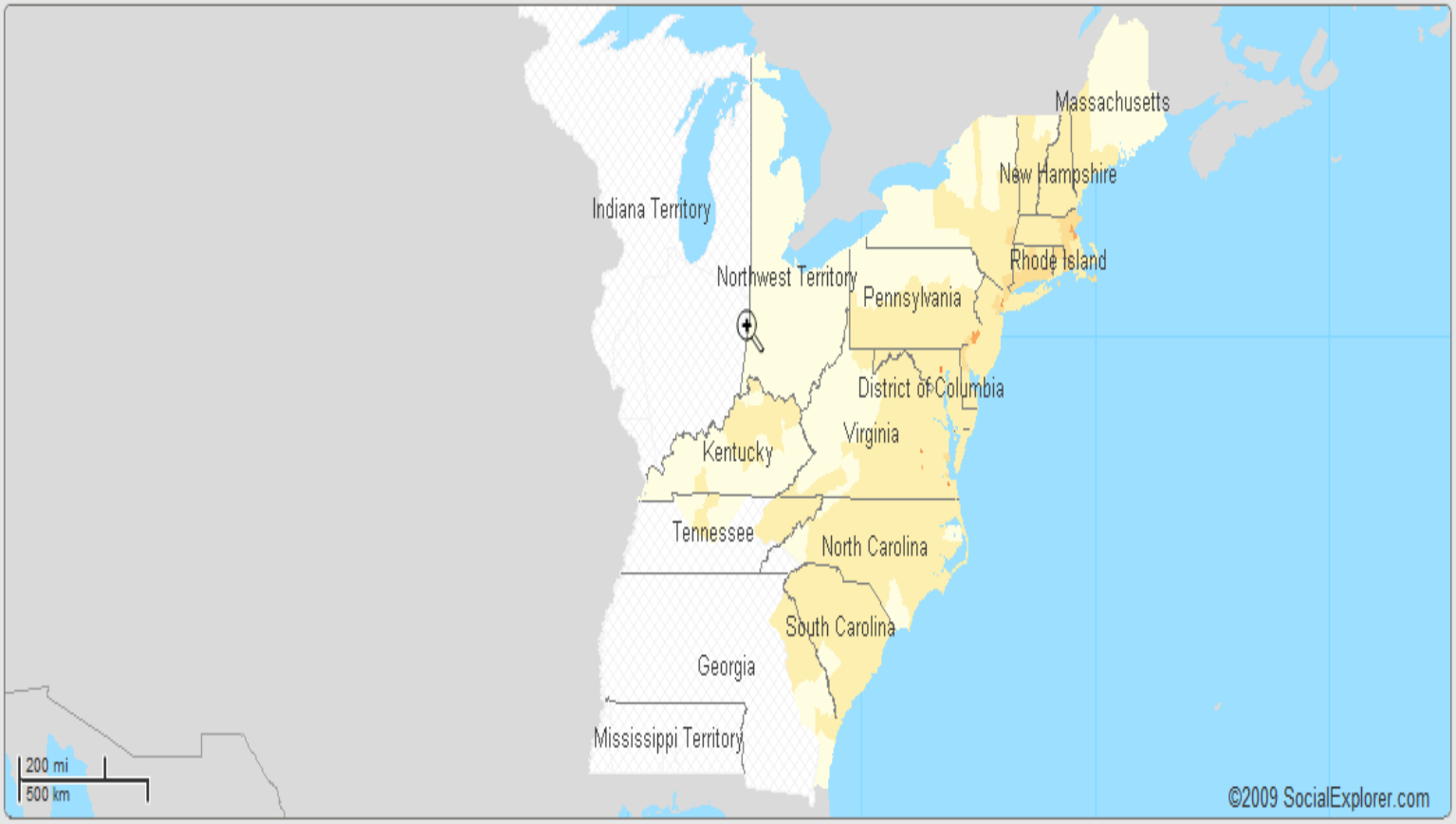

Choose a map:

1800 Census

Population

Population Density

1800 Census

Population Density

- Missing Data
- n/a (<100 base cases)
- < 5 people per sq. mile
- 5 to 50
- 50 to 200
- 200 to 500
- 500 to 1,000
- 1,000 to 2,635

State

close slideshow tool

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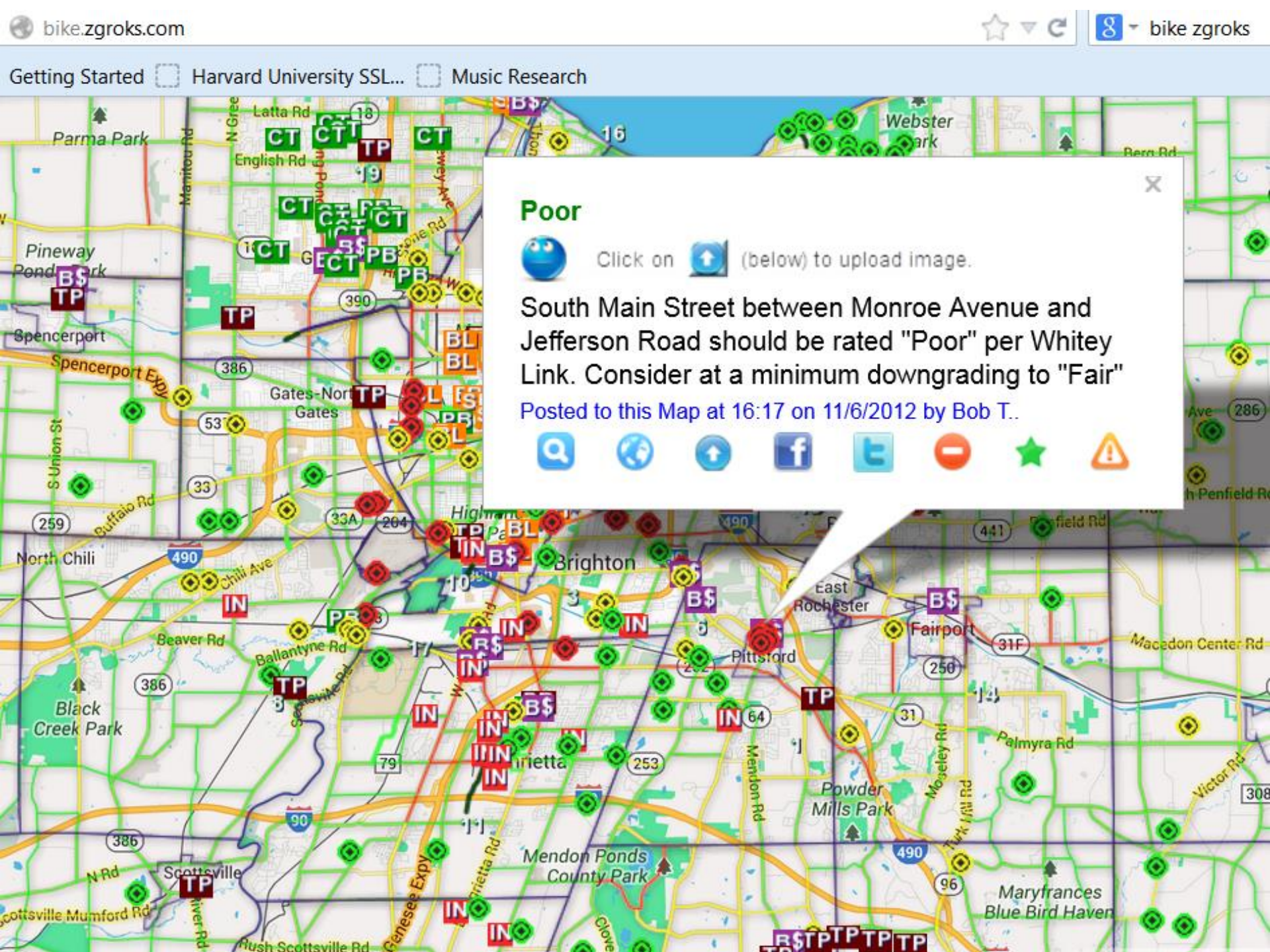
speed: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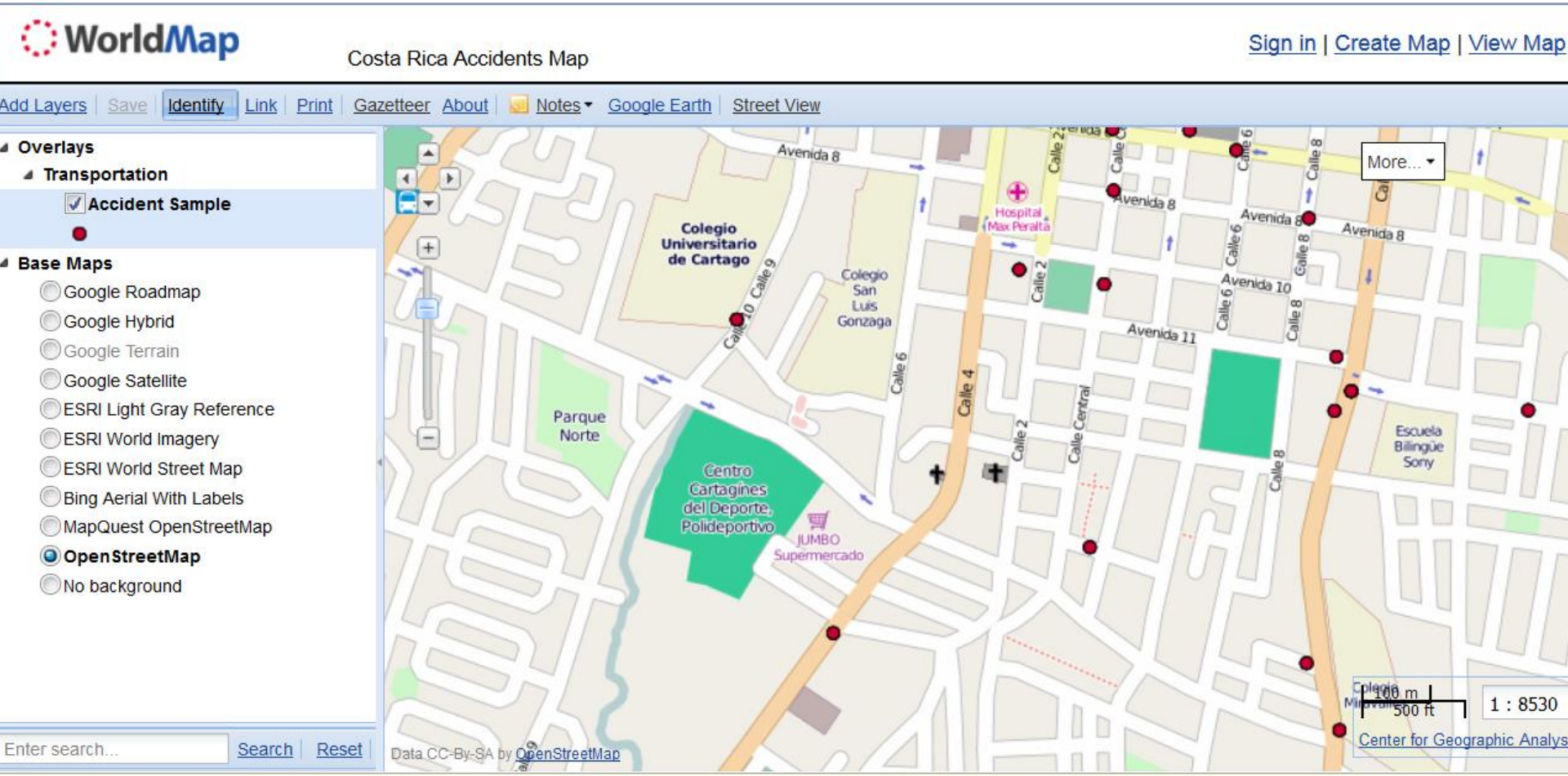
Getting Started
Harvard University SSL...
Music Research
Poor
Click on
(below) to upload image.
South Main Street between Monroe Avenue and Jefferson Road should be rated "Poor" per Whitey Link. Consider at a minimum downgrading to "Fair"
Posted to this Map at 16:17 on 11/6/2012 by Bob T..
Parma Park
Pineway Pond Park
Spencerport
Spencerport Expy
Gates-North Gates
North Chili
Brighton
East Rochester
Fairport
Pittsford
Webster
Penfield
Black Creek Park
Beaver Rd
Ballantyne Rd
Chili Ave
Buffalo Rd
S Union St
Latta Rd
English Rd
Palmyra Rd
Macedon Center Rd
Powder Mills Park
Mendon Ponds County Park
Maryfrances Blue Bird Haven
Scottsville
Scottsville Mumford Rd
Rush Scottsville Rd
Genesee Expy
Mendon Rd
Moseley Rd
Victor Rd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Costa Rica Accidents Map
Sign in | Create Map | View Map
Add Layers | Save | Identify | Link | Print | Gazetteer | About | Notes | Google Earth | Street View
Overlays
Transportation
Accident Sample
Base Maps
Google Roadmap
Google Hybrid
Google Terrain
Google Satellite
ESRI Light Gray Reference
ESRI World Imagery
ESRI World Street Map
Bing Aerial With Labels
MapQuest OpenStreetMap
OpenStreetMap
No background
Enter search...
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Reset
More...
Avenida 8
Colegio Universitario de Cartago
Colegio San Luis Gonzaga
Hospital Max Peralta
Parque Norte
Centro Cartagines del Deporte, Polideportivo
JUMBO Supermercado
Escuela Bilingüe Sony
Avenida 10
Avenida 11
Calle 4
Calle Central
100 m
500 ft
1 : 8530
Center for Geographic Analys
Data CC-By-SA by OpenStreetMap

Geographic Information

- How it looks – Form

(Look at malaria map)

- How it works – Process

(Is malaria related to climate change?)

http://www.indiaenvironmentportal.org.in/files/malaria%20and%20climate%20change.pdf

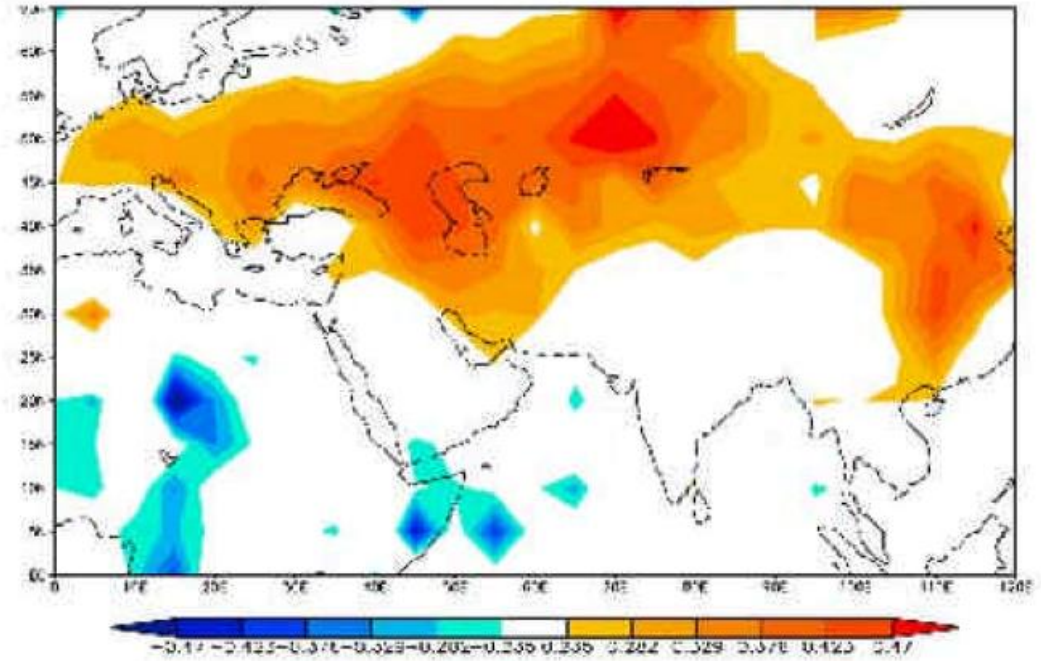

Figure 6. Northern hemispheric temperature in January is positively correlate efficient of correlation ranging between 0.2 and 0.5), and SSTs in March, April with malaria incidence (coefficient of correlation ranging between –0.47 and –0.

http://www.indiaenvironmentportal.org.in/files /malaria%20and%20climate%20change.pdf

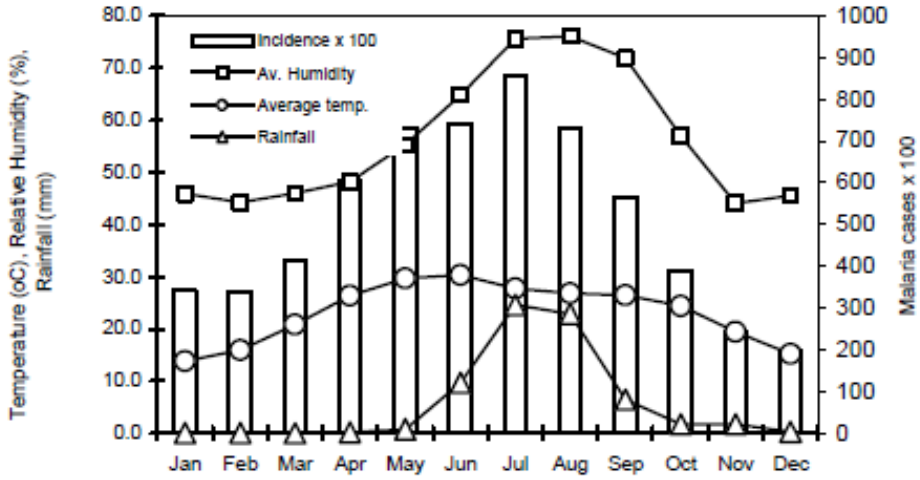

Figure 2. Trends of average monthly temperature, precipitation, relative humidity and malaria cases in India between the period 1970 and 2000.

Data, Information, Evidence, Wisdom and Knowledge

Decision-making Support Infrastructure	Ease of sharing
Wisdom	Impossible
Knowledge	Difficult
Evidence	Difficult
Information	Easy
Data	Easy

Forms of Knowledge

- Classifications - eg. what is a wetland? (established rules)
- Rule sets - eg. how wilderness can be defined based on a set of factors/ variables that can be measured
- Models - (Social Science or Physical Science) eg. how can we predict where species will be lost?

Geographic Information Systems

- Software product
- Data sets / databases
- Community of people working with geographic information and tools
- Activity of advanced science and problem solving

Geographic Information System

- Organized collection of
  - Hardware
  - Software
  - Network
  - Data
  - People
  - Procedures

Brief History of GIS

- 1960 – 70s Innovation
  - First GIS – Canada Land Inventory (CGIS)
  - DIME US Bureau of Census
  - Harvard Laboratory for Computer Graphics
  - Major vendors started (e.g. ESRI, Intergraph)
- 1980, 90s Commercialization
  - Commercial GIS software (e.g. ArcInfo), First GIS textbooks, First global data sets
- 2000 and 2010s Exploitation
  - Web, social media becomes major deliver vehicle

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http://www.casa.ucl.ac.uk/gistimeline/

Go

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GiS TiMELiNE

Developed by
GiSTiMELine Team at
Centre for Advanced Spatial Analysis

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http://www.casa.ucl.ac.uk - GIS TiME LiNE @ CASA - Mozilla...

http://www.casa.ucl.ac.uk - GIS TiM

Harvard Lab established	
Date	1964
Event description	The Harvard Lab for Computer Graphics established by Howard Fisher.The Lab was an important research centre, creating pioneering software for spatial data handling.Many of the key individuals in the GIS industry studies there. These inlcude David Sinton (Intergraph), Jack Dangermond (ESRI), Lawrie Jordan and Bruce Rado (ERDAS), Hans Koeppel and Nicos Polydorides
Event categories	Research project or activity Key person activity
Persons involved	Howard Fisher

Close window

Done

19 59

(W.Tobler)
Zoom in...]

19 63

CGIS established
[More...][Zoom in...]

established
Zoom in...]

19 64

Harvard Lab established
[More...][Zoom in...]

19 65

SYMAP
Zoom in...]

19 67

DIME developed
[More...][Zoom in...]

ECU established
[More...][Zoom in...]

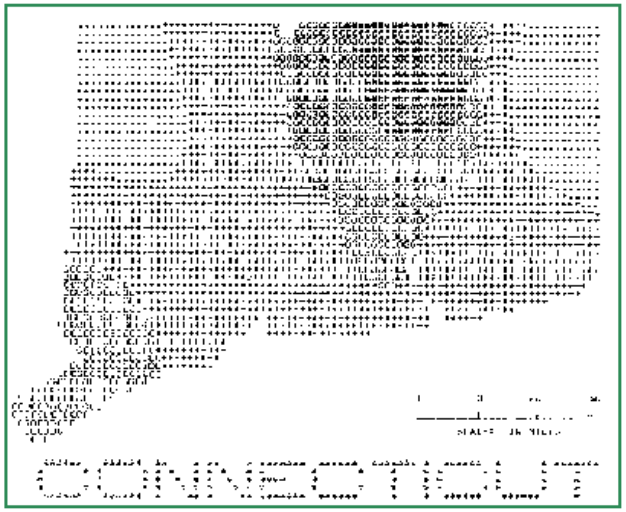
CIA Automap
[More...][Zoom in...]

19 68

Done

http://www.casa.ucl.ac.uk - GIS TiME LiNE @ CASA - Mozilla Fire...

SYMAP	
Date	1965
Event description	SYMAP (Synagraphic Mapping Sytem) - a pioneering automated computer mapping application developed byHoward Fisher at the Northwestern Technology Institute and completed in the Harvard Lab
Event categories	Research project or activity
Persons involved	Howard Fisher

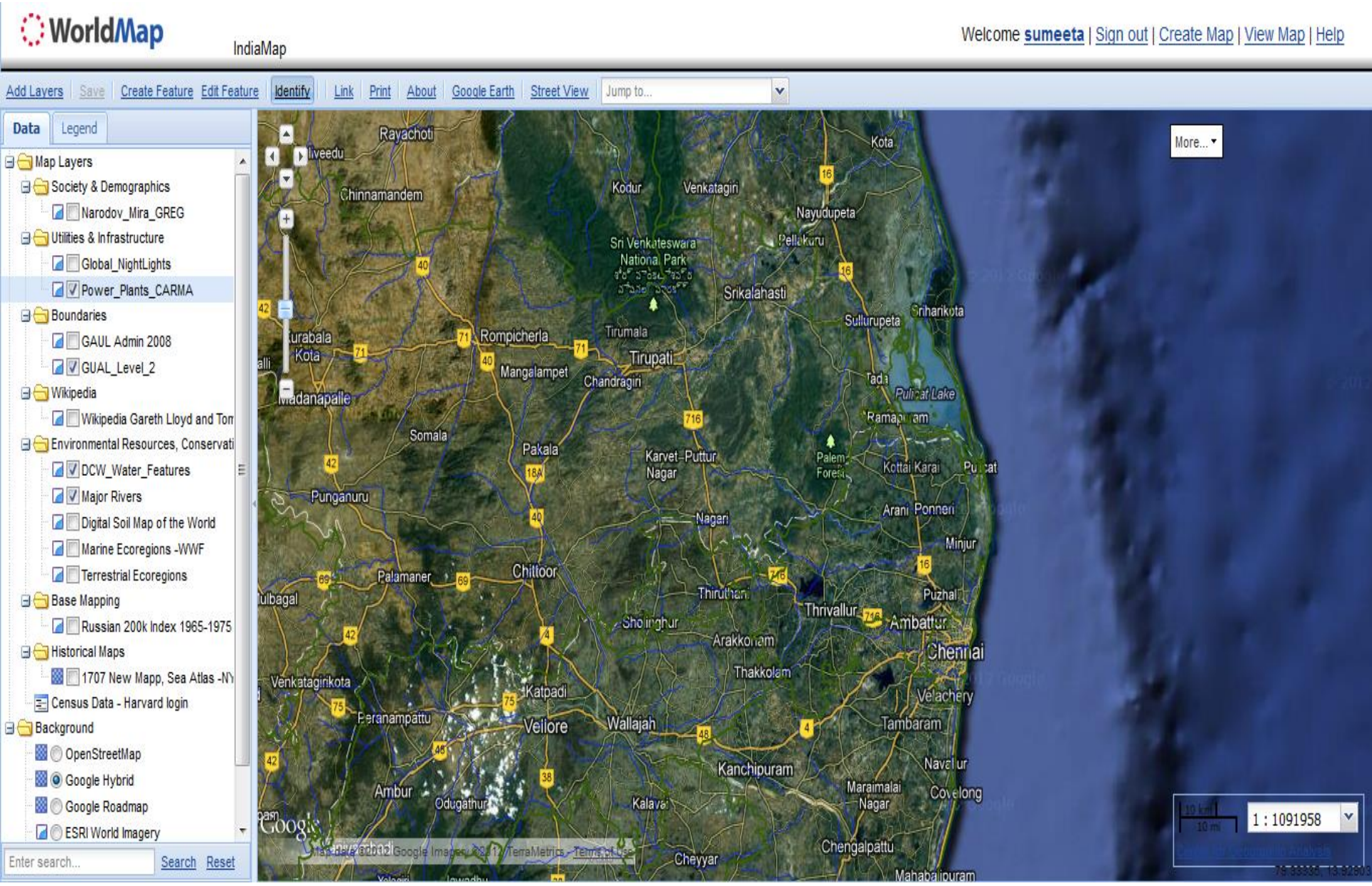


Close window

Done

Definitions of GIS

- Container of maps


WorldMap
IndiaMap
Welcome sumeeta | Sign out | Create Map | View Map | Help
Add Layers | Save | Create Feature | Edit Feature | Identify | Link | Print | About | Google Earth | Street View | Jump to...
Data | Legend
Map Layers
Society & Demographics
Narodov_Mira_GREG
Utilities & Infrastructure
Global_NightLights
Power_Plants_CARMA
Boundaries
GAUL Admin 2008
GUAL_Level_2
Wikipedia
Wikipedia Gareth Lloyd and Tom
Environmental Resources, Conservati
DCW_Water_Features
Major Rivers
Digital Soil Map of the World
Marine Ecoregions -WWF
Terrestrial Ecoregions
Base Mapping
Russian 200k Index 1965-1975
Historical Maps
1707 New Mapp, Sea Atlas -NY
Census Data - Harvard login
Background
OpenStreetMap
Google Hybrid
Google Roadmap
ESRI World Imagery
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Reset
More...
Rayachoti
Kodur
Venkatagiri
Kota
Nayudupeta
Pellakuru
Sri Venkateswara National Park
Srikalahasti
Sullurupeta
Srihari kota
Rompicherla
Tirumala
Tirupati
Mangalampet
Chandragiri
Madanapalle
Somala
Pakala
Karvet-Puttur Nagar
Palem Forest
Kottai Karai
Punganuru
Nagari
Arani
Ponneri
Minjur
Chittoor
Palamaner
Thiruthani
Thrivallur
Puzhal
Ambattur
Chennai
Arakkonam
Thakkolam
Venkatagirikota
Katpadi
Velachery
Perunampattu
Vellore
Wallajah
Tambaram
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Ambur
Odugathur
Kalavai
Maraimalai Nagar
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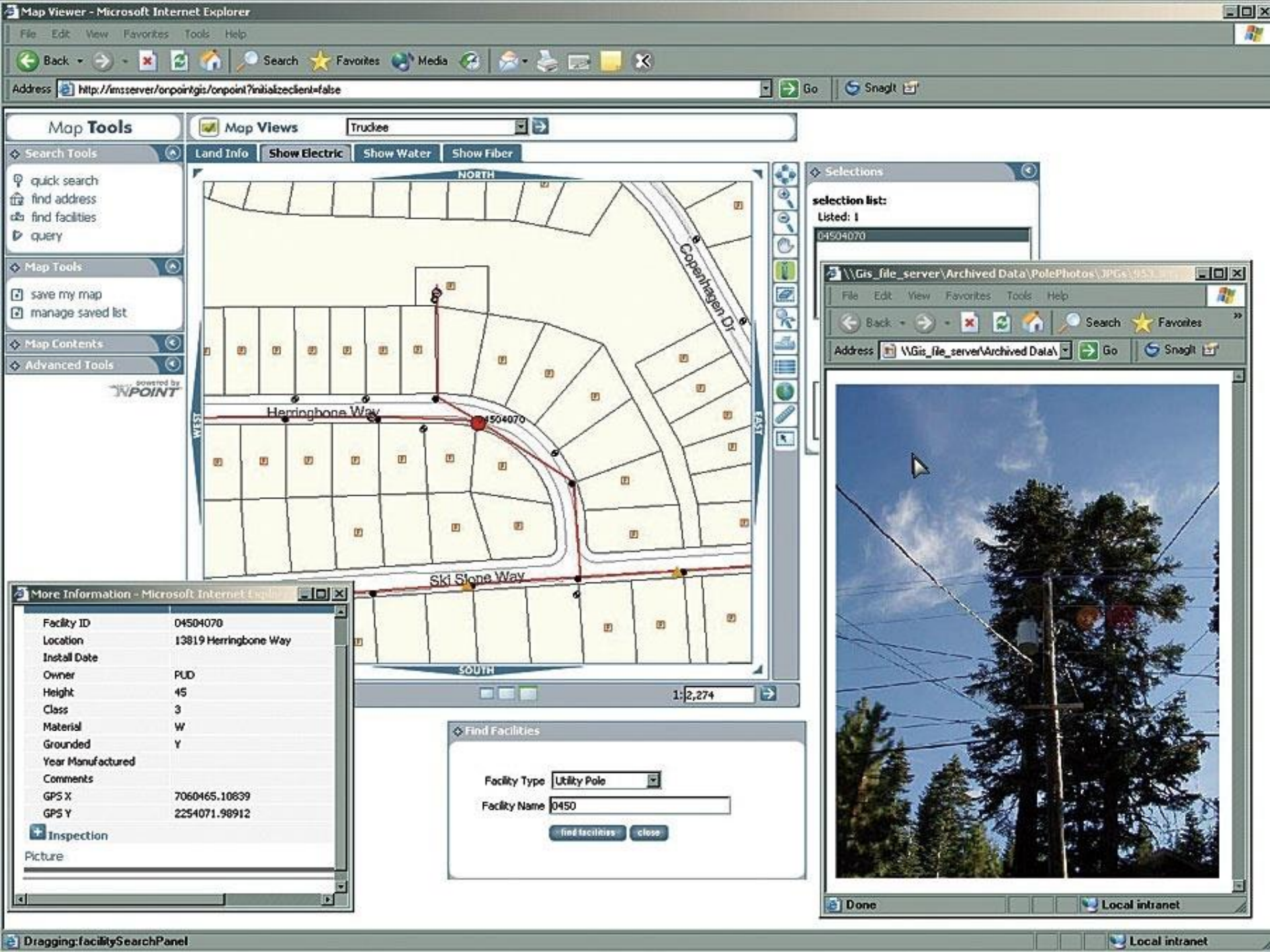
Geographic Information System

- Container of maps
- Mechanized inventory of geographically distributed features and facilities


Map Viewer - Microsoft Internet Explorer
Address http://mxserver/onpointgis/onpoint?initializeclient=false
Map Tools
Map Views
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Search Tools
quick search
find address
find facilities
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save my map
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Map Contents
Advanced Tools
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Show Water
Show Fiber
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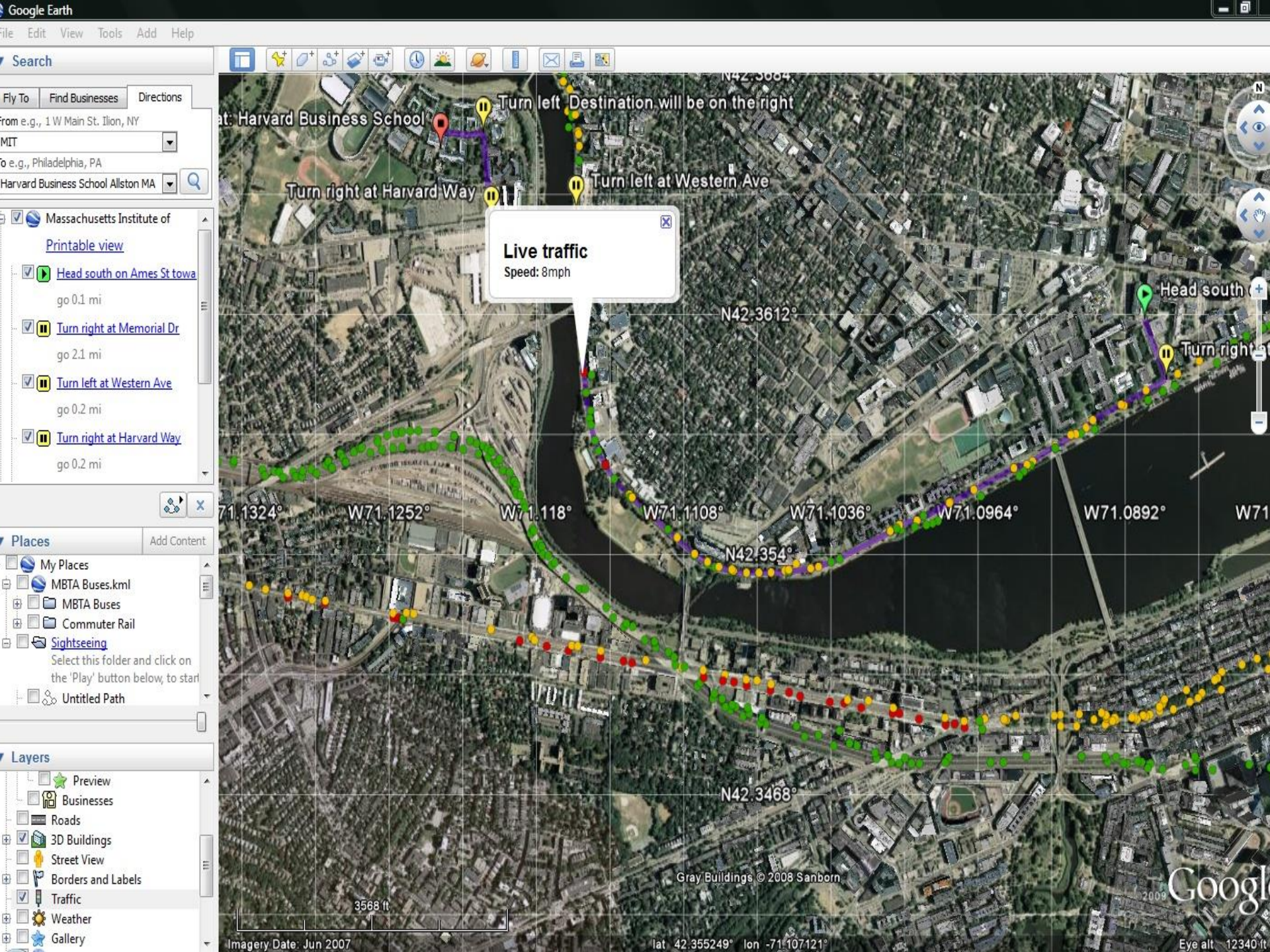
Local intranet
More Information - Microsoft Internet Explorer
Facility ID 04504070
Location 13819 Herringbone Way
Install Date
Owner PUD
Height 45
Class 3
Material W
Grounded Y
Year Manufactured
Comments
GPS X 7060465.10839
GPS Y 2254071.98912
Inspection
Picture
Find Facilities
Facility Type Utility Pole
Facility Name 0450
find facilities
close
Dragging:facilitySearchPanel
Local intranet

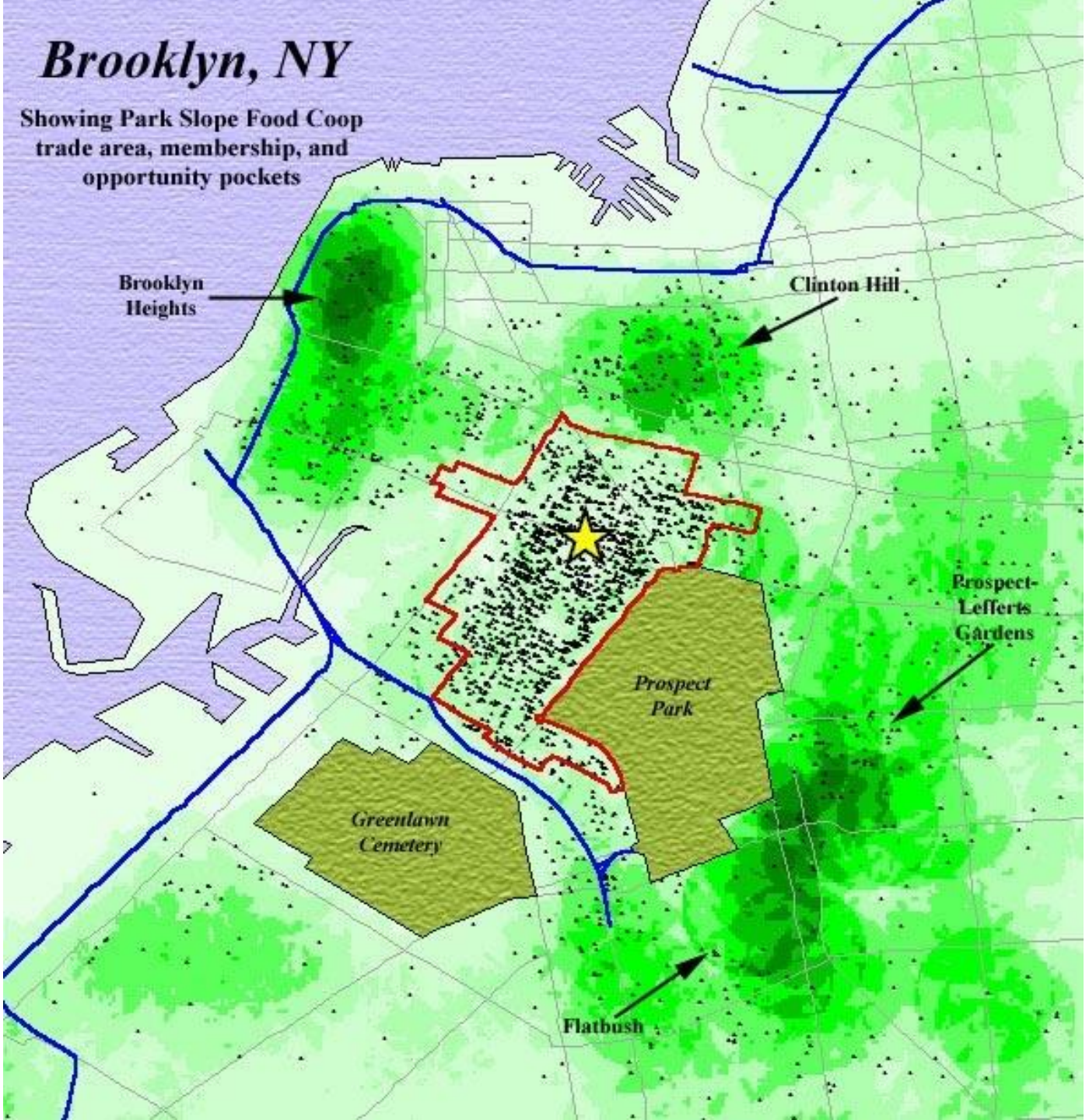
Geographic Information System

- Container of maps
- Mechanized inventory of geographically distributed features and facilities
- Computerized tools for solving geographic problems


Google Earth
File Edit View Tools Add Help
Search
Fly To
Find Businesses
Directions
From e.g., 1 W Main St. Ilion, NY
MIT
To e.g., Philadelphia, PA
Harvard Business School Allston MA
Massachusetts Institute of
Printable view
Head south on Ames St towa
go 0.1 mi
Turn right at Memorial Dr
go 2.1 mi
Turn left at Western Ave
go 0.2 mi
Turn right at Harvard Way
go 0.2 mi
Places
Add Content
My Places
MBTA Buses.kml
MBTA Buses
Commuter Rail
Sightseeing
Select this folder and click on the 'Play' button below, to start
Untitled Path
Layers
Preview
Businesses
Roads
3D Buildings
Street View
Borders and Labels
Traffic
Weather
Gallery
Harvard Business School
Turn left Destination will be on the right
Turn right at Harvard Way
Turn left at Western Ave
Live traffic
Speed: 8mph
Head south
Turn right
N42.3612°
N42.354°
N42.3468°
W71.1324°
W71.1252°
W71.118°
W71.1108°
W71.1036°
W71.0964°
W71.0892°
Gray Buildings © 2008 Sanborn
3568 ft
Imagery Date: Jun 2007
lat 42.355249° lon -71.107121°
Eye alt 12340 ft

Geographic Information System

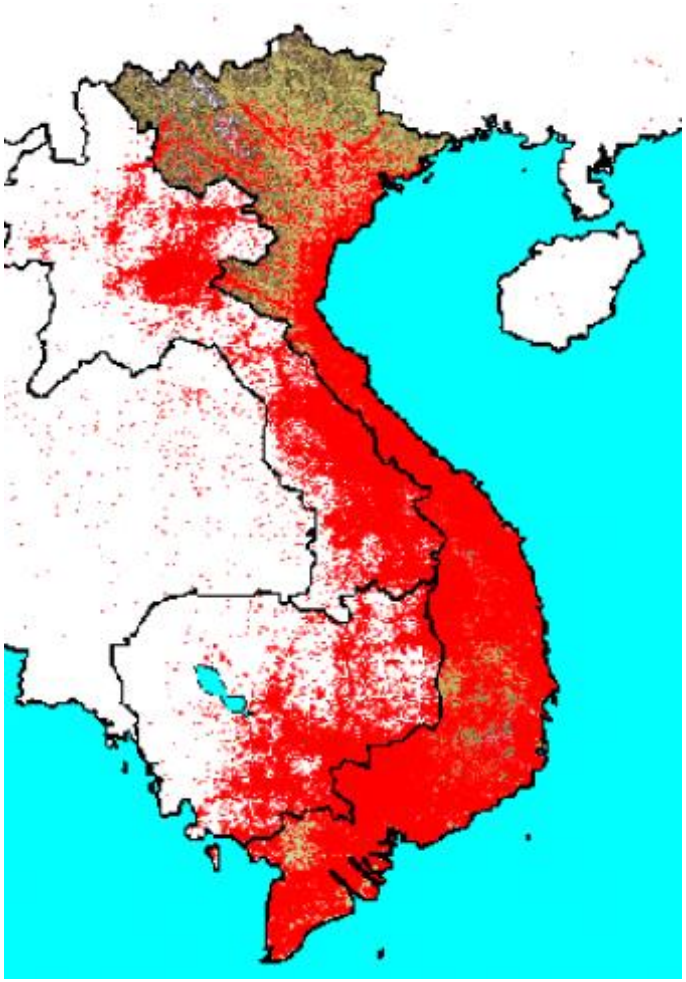
- Container of maps
- Mechanized inventory of geographically distributed features and facilities
- Computerized tools for solving geographic problems
- Spatial decision support system


Brooklyn, NY
Showing Park Slope Food Coop trade area, membership, and opportunity pockets
Brooklyn Heights
Clinton Hill
Prospect-Lefferts Gardens
Prospect Park
Greenlawn Cemetery
Flatbush

Geographic Information System

- Container of maps
- Mechanized inventory of geographically distributed features and facilities
- Computerized tools for solving geographic problems
- Spatial decision support system
- Method for revealing patterns and processes in geographic information

Vietnam Cancer Study

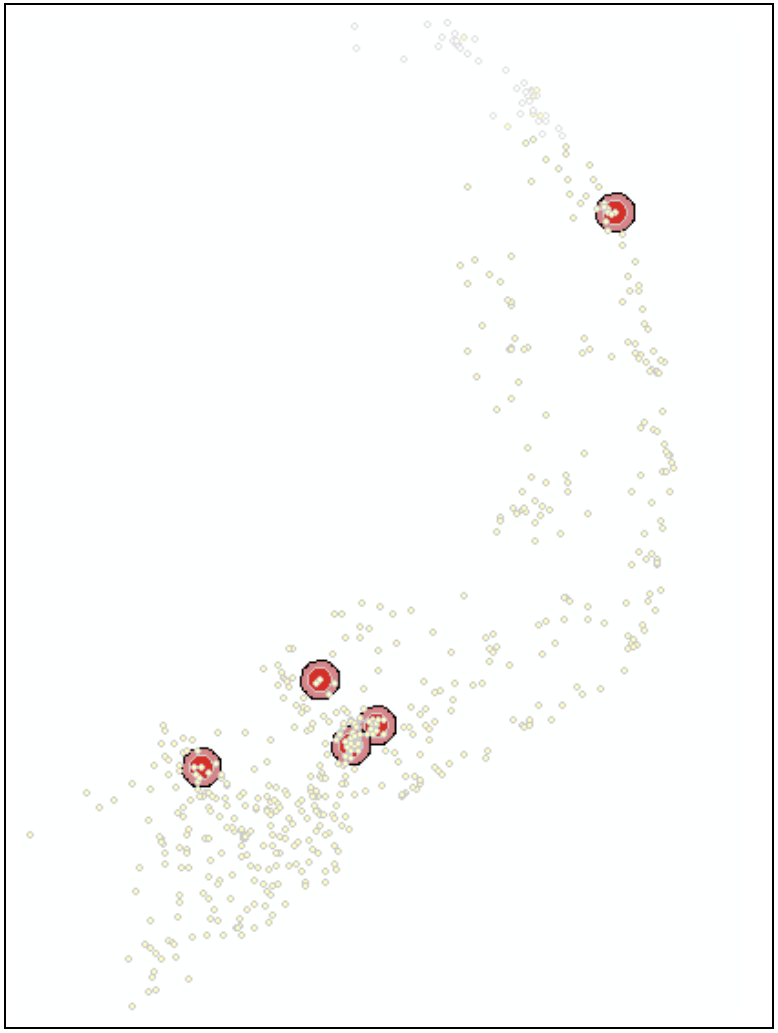


North Vietnam	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	**5.89e+01**	2.94e+01	2.01	0.04
Age sq	**4.69e-04**	6.71e-05	6.99	2.7e-12
Educ	**8.51e-01**	3.01e-01	2.82	0.00
Male	-2.33e-01	2.76e-01	-0.85	0.39
Latitude	-1.59e-01	1.24e-01	-1.28	0.20
Longitude	**-6.02e-01**	2.71e-01	-2.22	0.03
Herbcide hit within 15km	-1.87e-03	7.99e-02	-0.02	0.98
Dioxin hit within 15km	8.11e-03	1.11e-01	0.07	0.94
Bombing load	4.77e-08	4.54e-08	1.05	0.29
Elevation	-2.65e-03	1.76e-03	-1.51	0.13

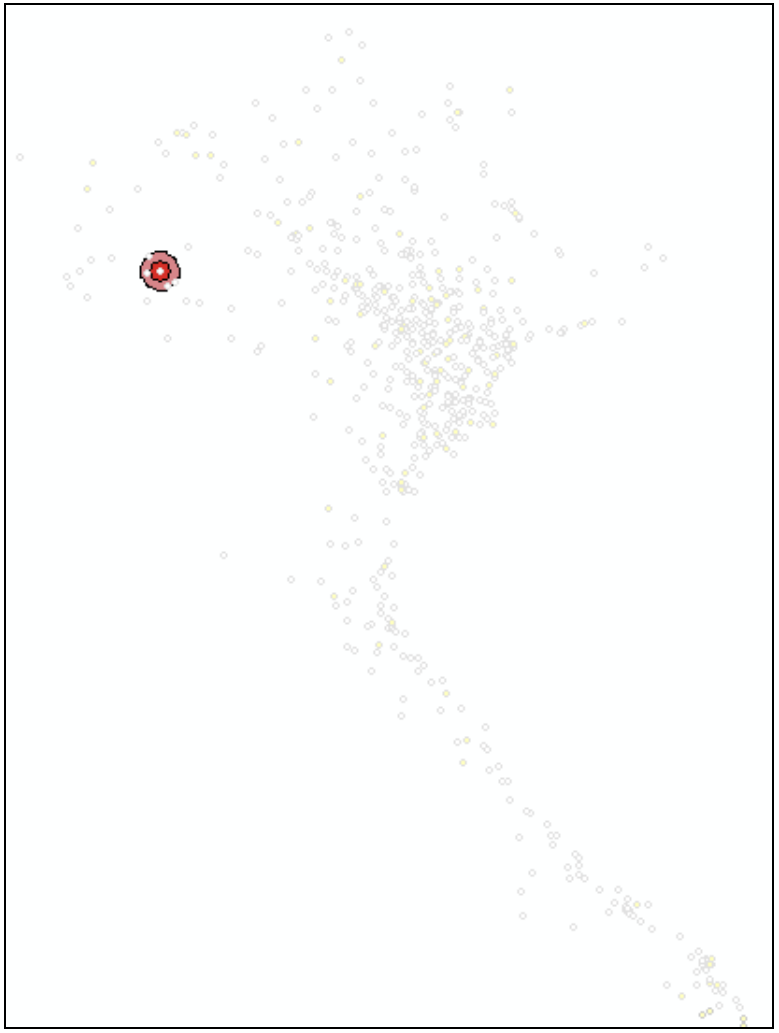
South Vietnam	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-3.05e+01	1.54e+01	-1.98	0.05
Age sq	**4.72e-04**	5.14e-05	9.18	<2e-16
Educ	3.23e-01	2.69e-01	1.20	0.23
Male	**-9.70e-01**	2.63e-01	-3.69	0.00
Latitude	**-2.43e-01**	1.24e-01	-1.96	0.05
Longitude	2.38e-01	1.54e-01	1.54	0.12
Herbicide hit within 15km	**2.71e-03**	1.21e-03	2.25	0.02
Dioxin hit within 15 km	-2.08e-03	2.97e-03	-0.70	0.48
Bombing Load	4.66e-08	4.22e-08	1.10	0.27
Elevation	2.14e-05	5.71e-04	0.04	0.97

Source: Do, T. et al, (2009)

Vietnam Cancer Study



South Vietnam



NorthVietnam

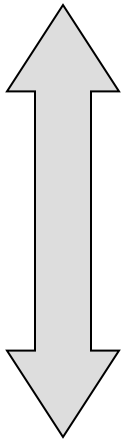
Problem Solving using GIS

Components and stages

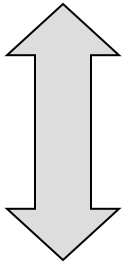
- Objective or goal - often maximize or minimize (cost, distance, time)
- Tangible (well defined reduce pollution) vs intangible - eg. quality of life, environmental impact
- Multiple objectives - eg. cost and environmental impact

Five Ms of Applied GIS

- Mapping
- Measuring
- Monitoring
- Modeling
- Managing



Gov 1008

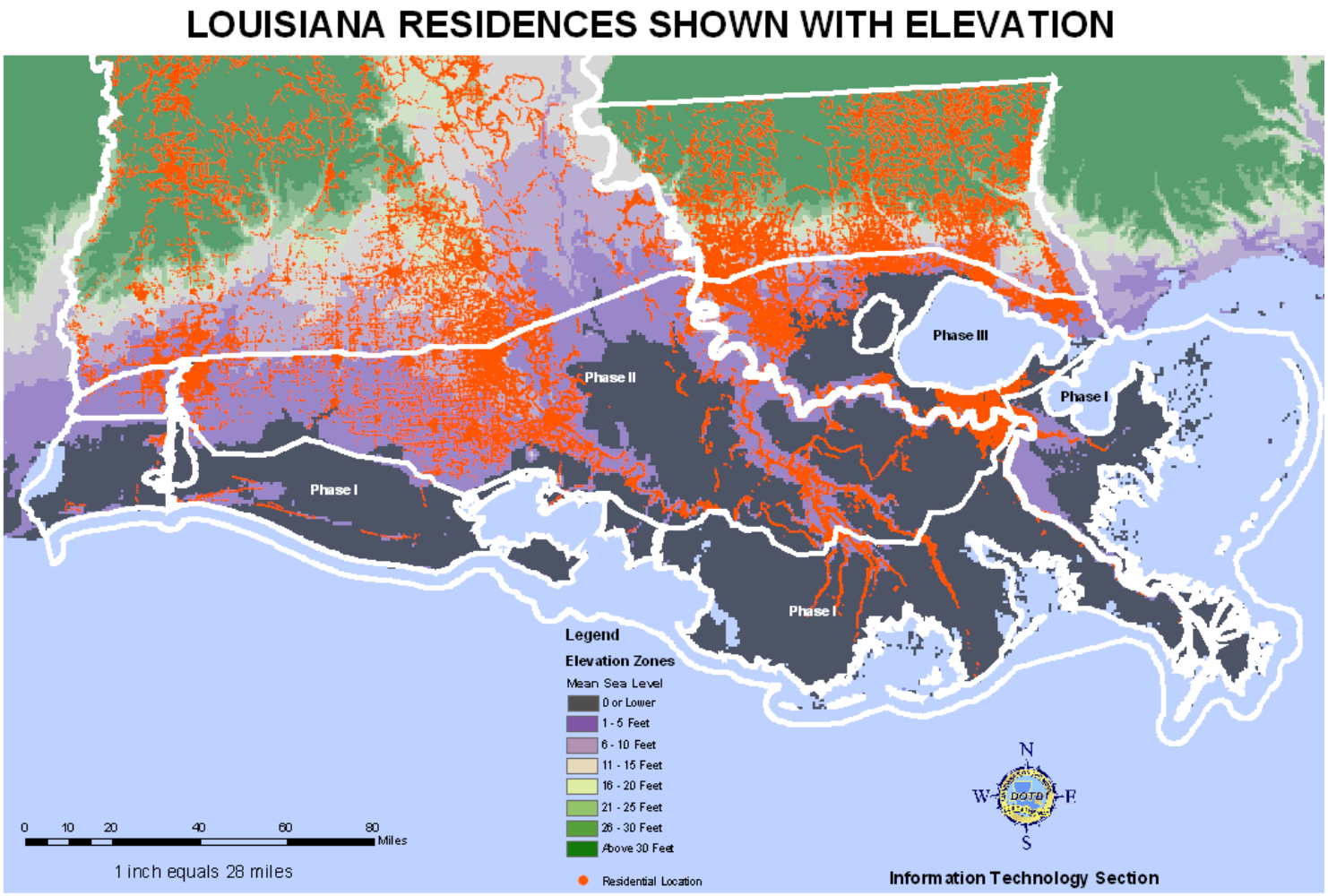


Spring courses

GIS Application

How could you use GIS to create a map that can be used to evacuate a coastal region using a hurricane/ tsunami/ cyclone forecast?

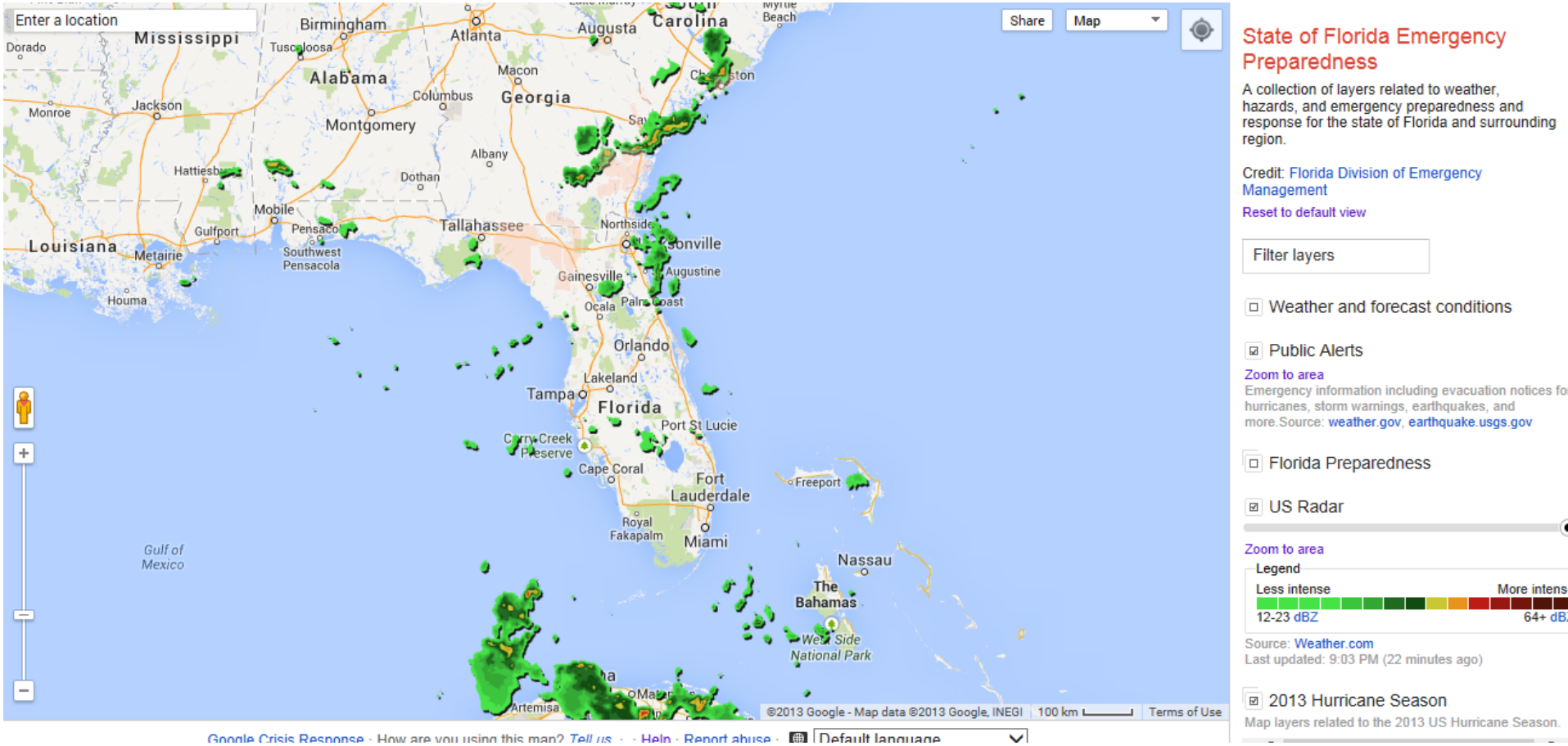
GIS Analysis to Develop a Staged Evacuation Plan



dotdgis.dotd.louisiana.gov

Hurricane Isaac

(http://www.google.org/crisismap/florida_emergency_preparedness)



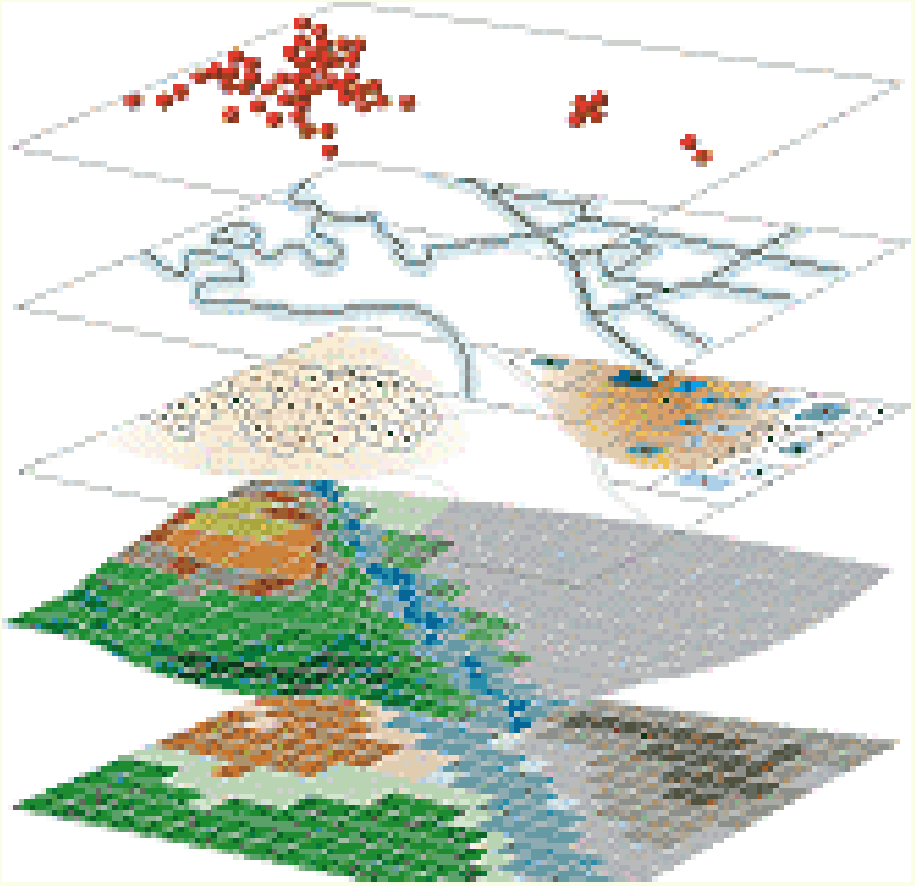
GIS for

- Mapping
- Measuring
- Monitoring
- Modeling
- Management

Spatial Analysis

Layers of data combine

- Tweets, Shelters
- Roads, rivers
- Neighborhood, county
- Elevations
- Water levels



Modeling

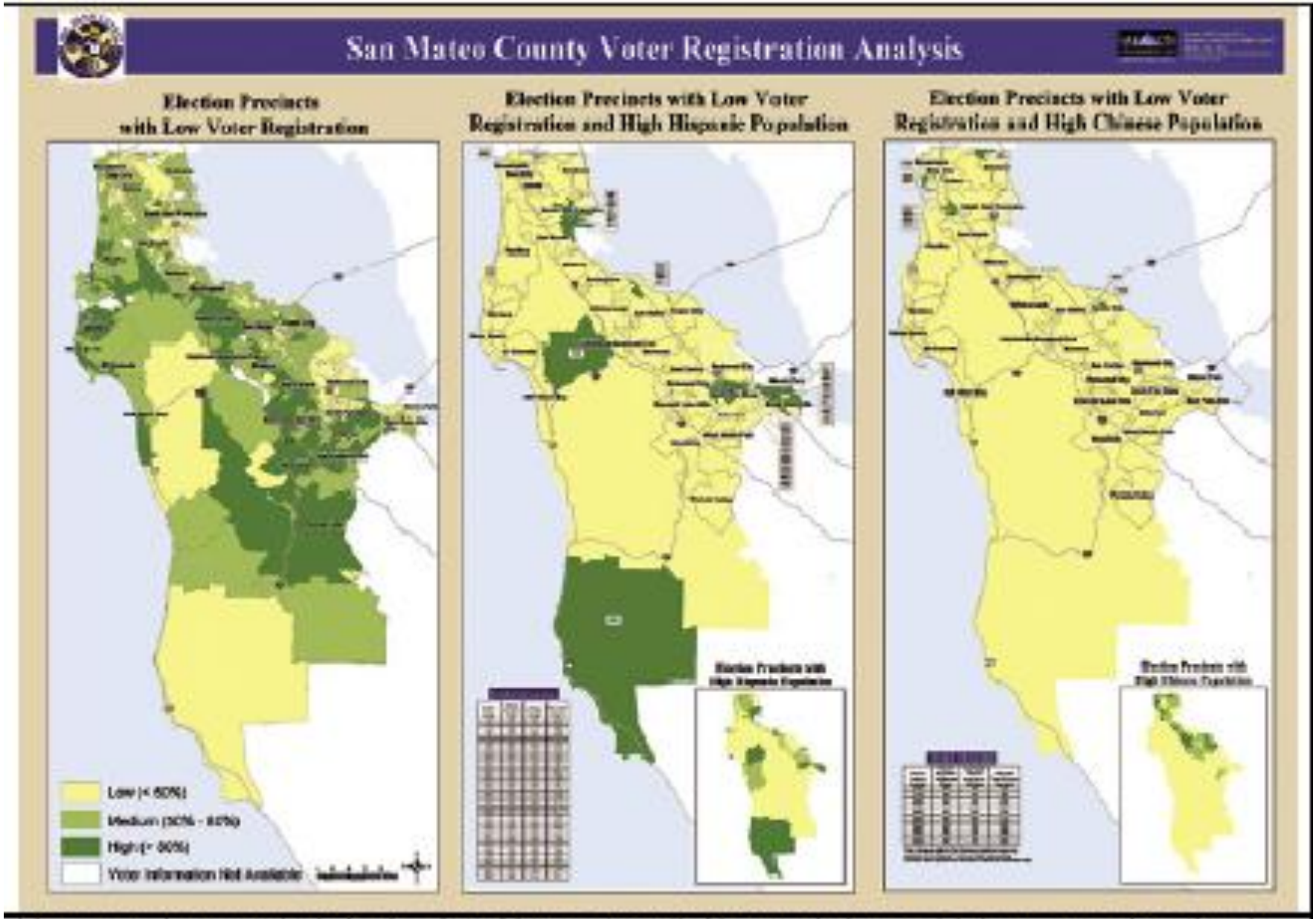
- Speed of evacuation network tools
  - Shortest path network
- Predicting path of the waters based on hydrological calculations
  - Least elevation path

Management

- GIS can be used to create effective evacuation vulnerability maps
- Model impact of bottlenecks on speed of evacuation using standard GIS tools

Social Implications of GIS

- Favors generalization, possibly at expense of minorities and individuals
- Use is not always neutral and usually data are derived from military and industrial surveillance
- Tendency to be technological rather than human need focused
- Maintains and extends the status quo of societal power structures?



Voter precinct analysis in the San Mateo area (left) reveals low to high voter registration in gradients of green. The dark green shade in these maps reveal areas with high Hispanic (center) and Chinese (right) populations that also have low voter registration. Such areas are targeted for outreach.

Growing Interest in GIS

- Applications via Internet
- Price reductions
- Greater awareness
- Improved ease of use
- Better technology
- Proliferation of data
- Commercial software packages
- Real applications
- Proven cost:benefit cases

GISystems, GIScience and GIStudies

- **GISystems**
  - Emphasis on technology and tools
- **GIScience**
  - Fundamental issues raised by the use of GIS and related technologies (eg.)
    - Spatial analysis
    - Map projections
    - Accuracy
    - Scientific visualization
- **GIStudies**
  - Systematic study of the use of geographic information

Summary

- GISSc is fundamentally a problem-solving science
- Many applications of GIS across a very wide range of areas
- Understanding the “science” behind applications will help

Thought Exercise: Think of a problem that you could solve. Think in “layers”