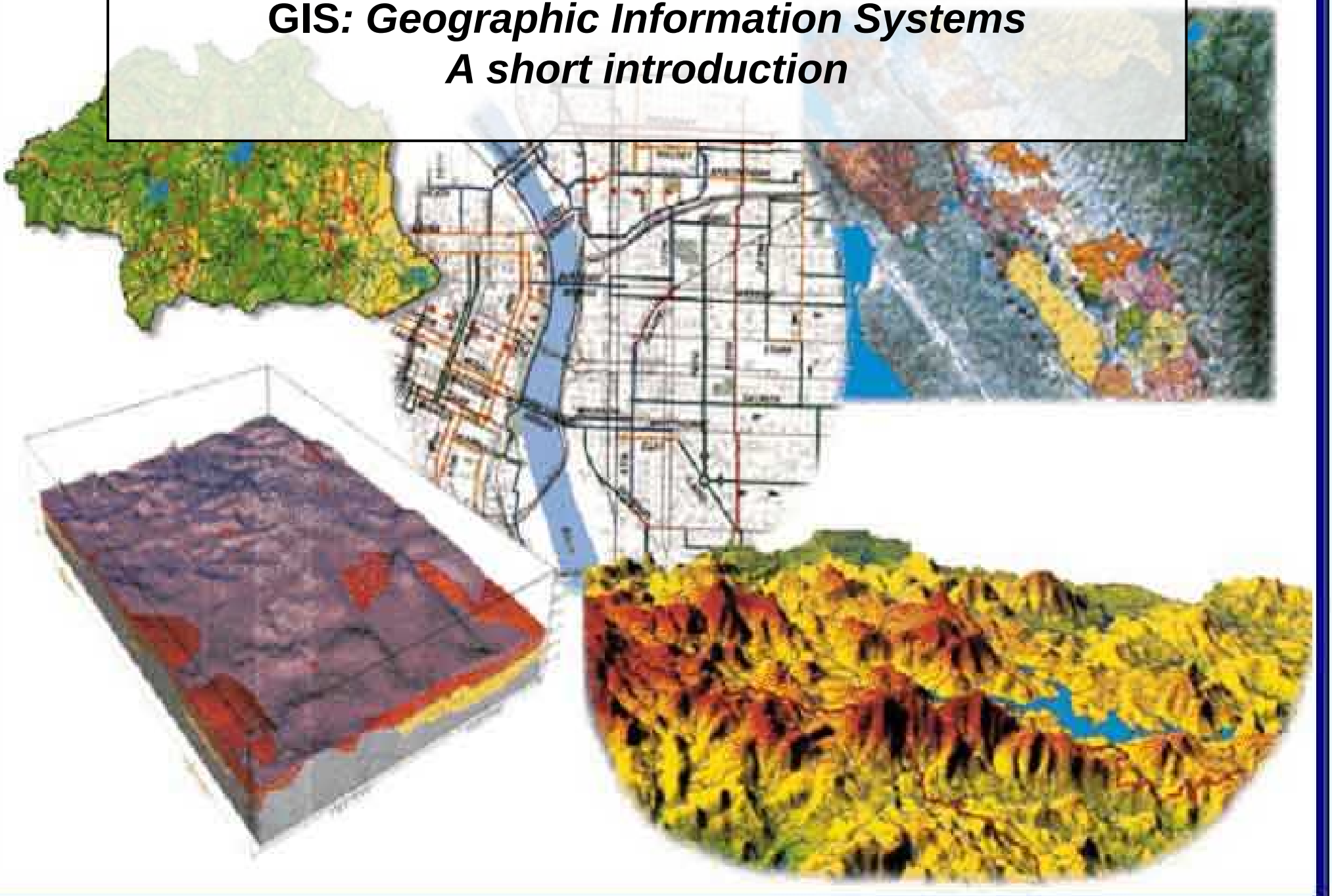
GIS*: Geographic Information Systems*
A short introduction



Outline

- The Center for Digital Scholarship
- What is GIS?
  - Data types
- GIS software and analysis
- Campus GIS resources

Center for Digital Scholarship

- Center services:
  - Text Analysis
  - Research design
  - Data management
  - Statistic analysis
  - Geographic Information Systems (GIS)

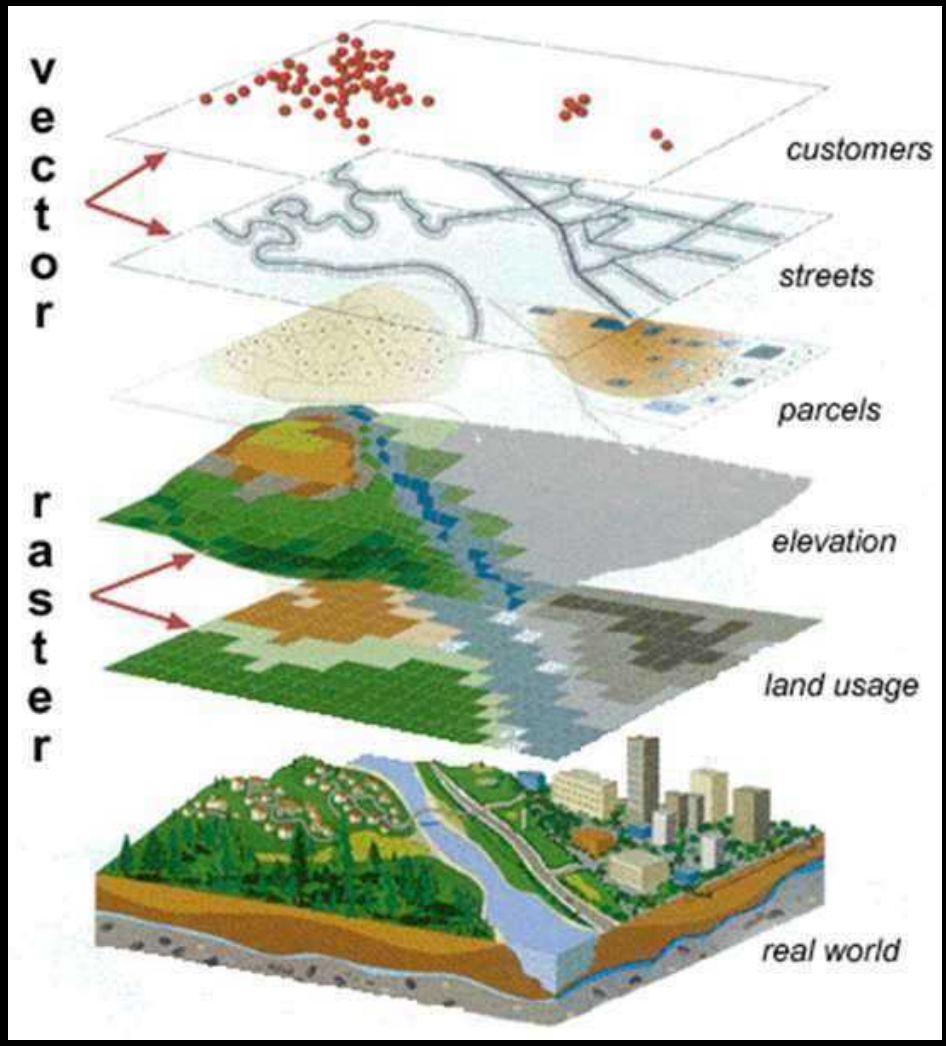
What is GIS ?

- In short: “computerized mapping software”
- Formal definition

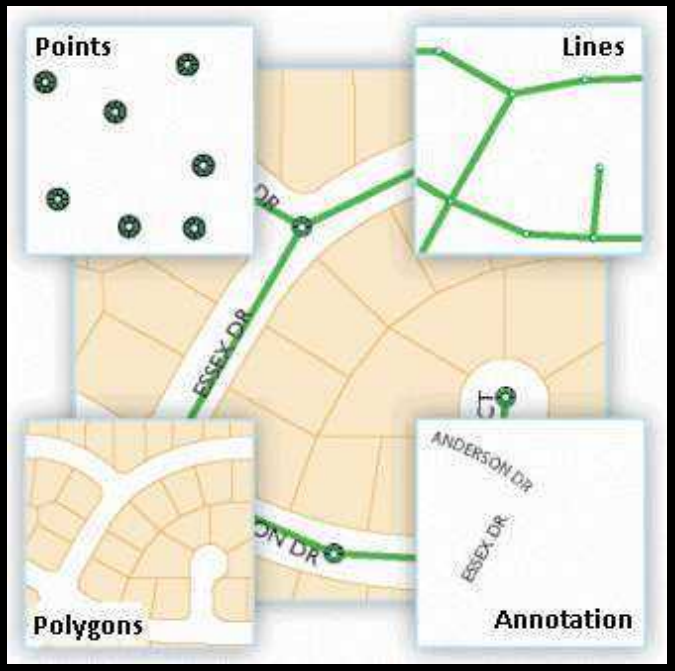
  A Geographic Information System (GIS) is a computerized database management system for capture, storage, retrieval, manipulation, analysis and display of spatial (i.e. locationally defined) data

Layers

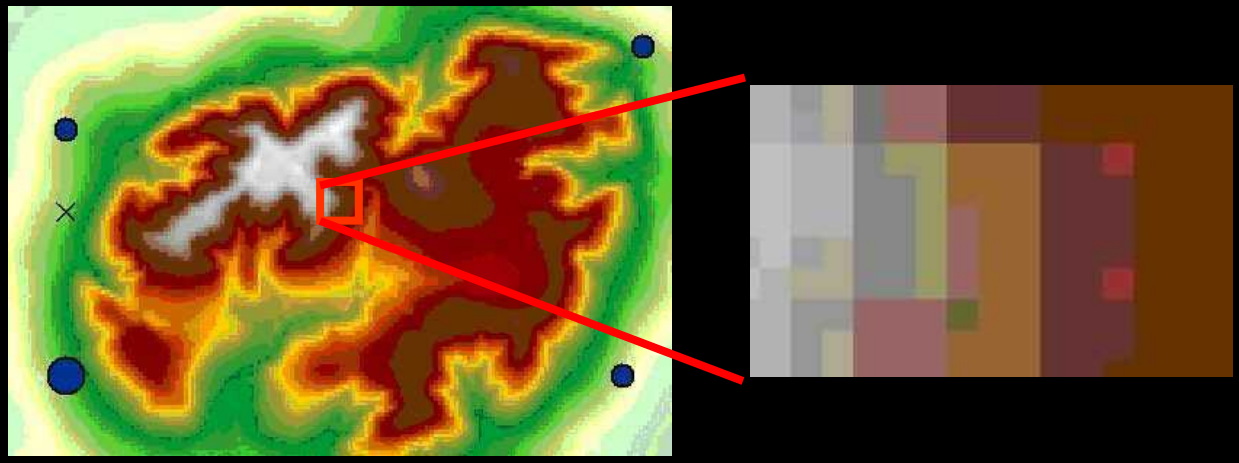
- A GIS is composed of layers of spatial information
- Can be different types of data
- Everything is referenced to a coordinate system
  - e.g. latitude / longitude



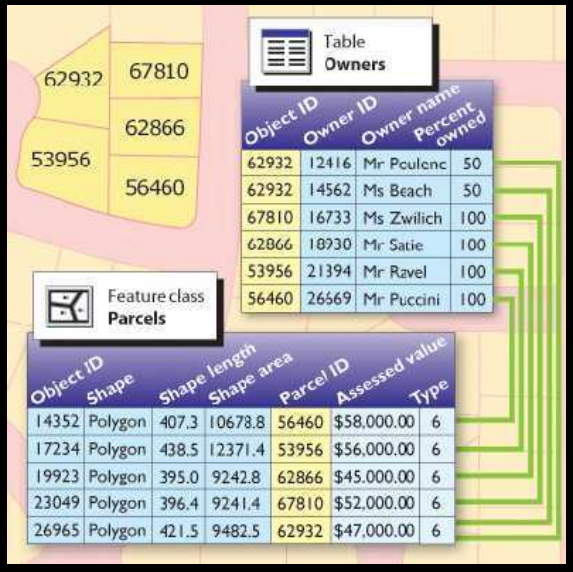
GIS digitally models the real world using:



Three types of geometry
- -Points
- -Lines
- -Areas



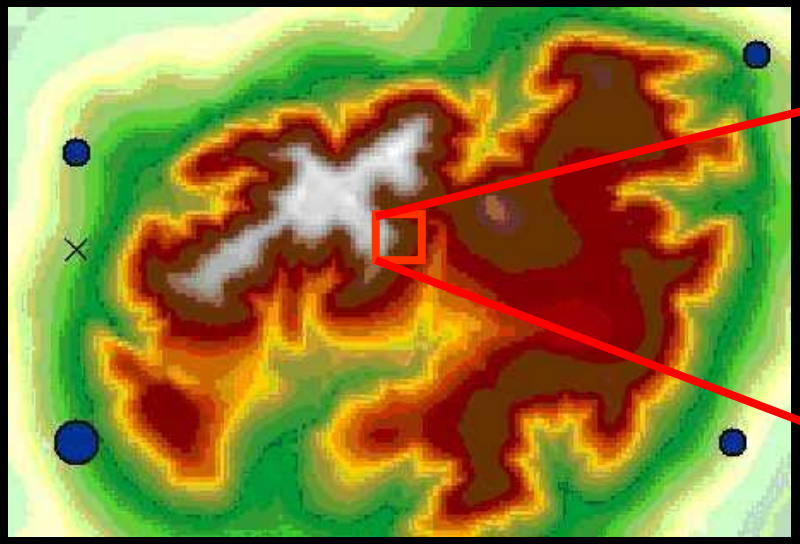
Cells in an image

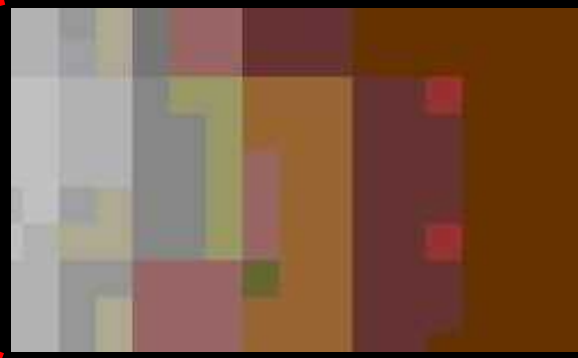


Data tables

Raster Data

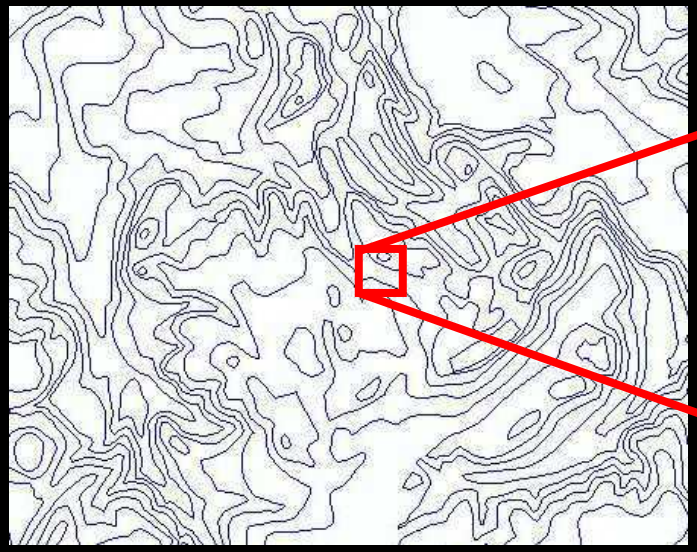
- Based on pixel

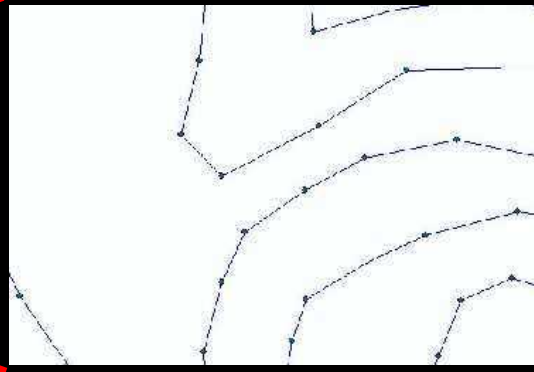




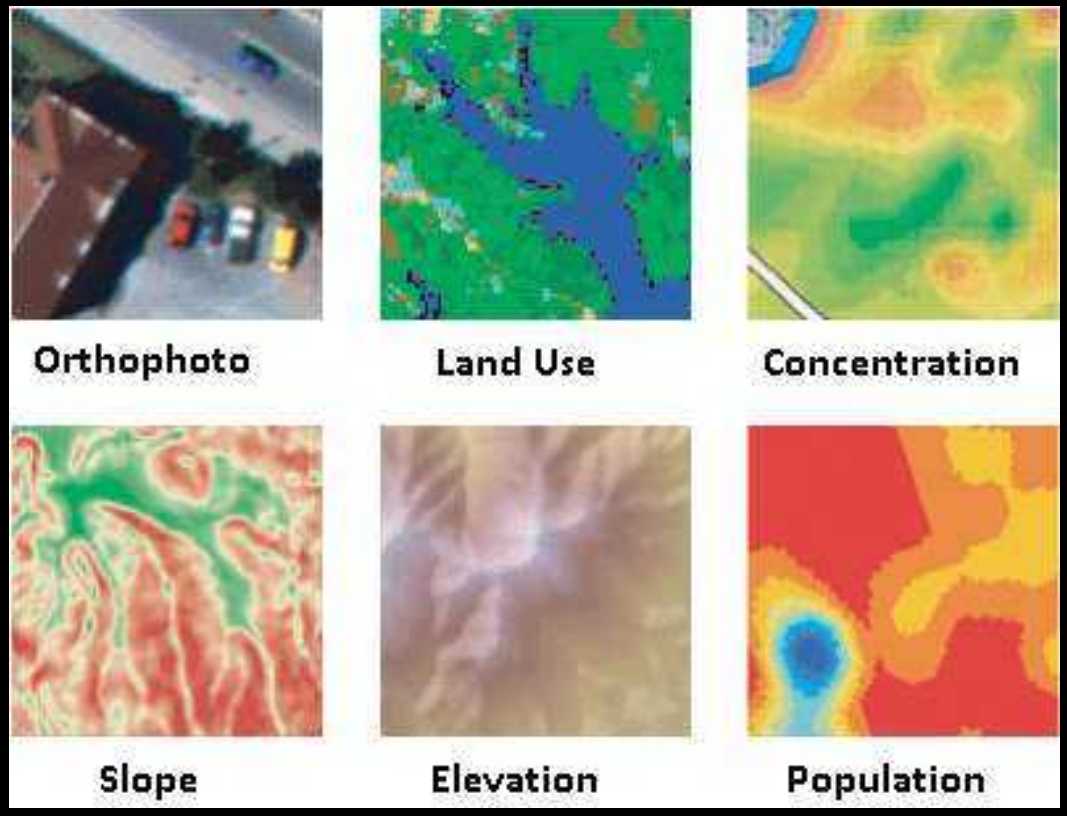
Vector Data

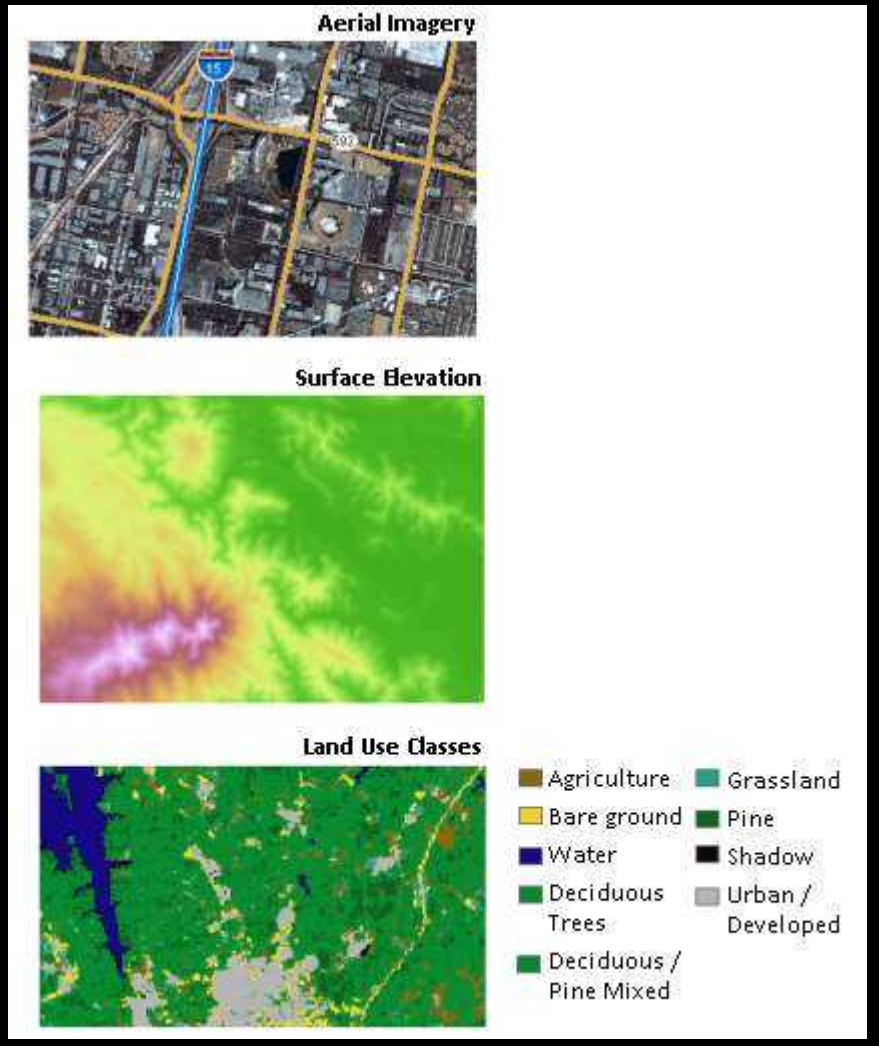
- Based on discrete points

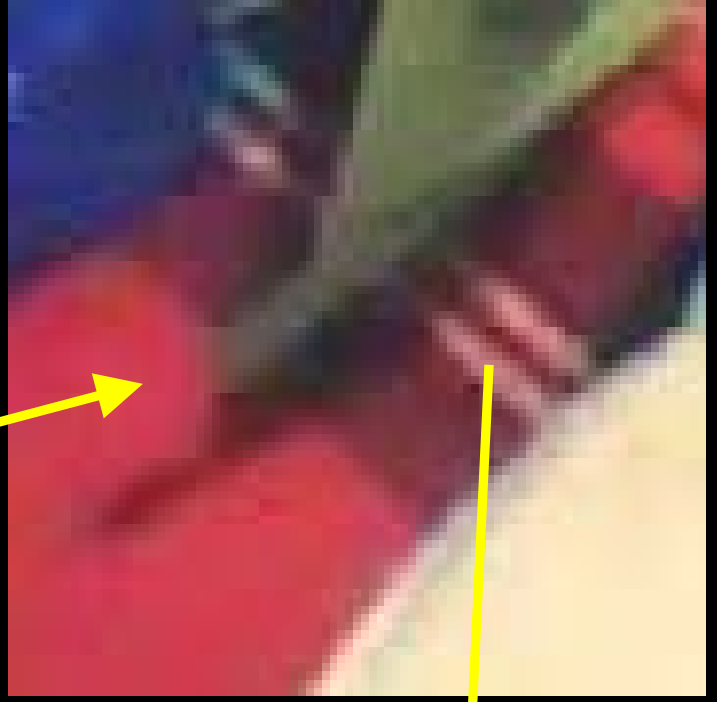


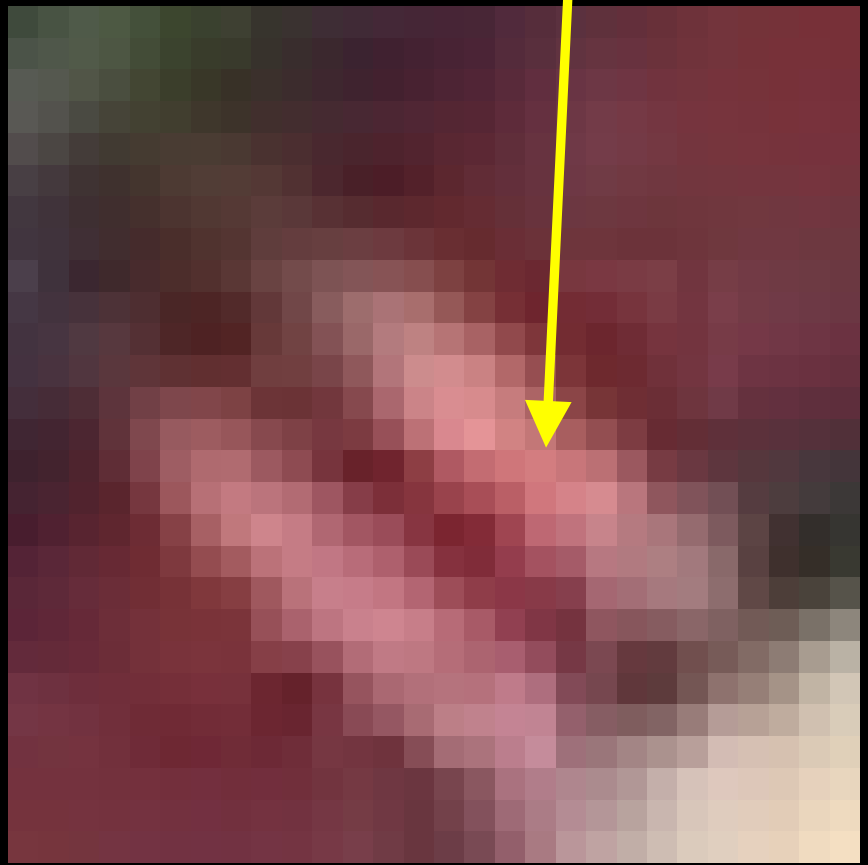


Rasters


Orthophoto
Land Use
Concentration
Slope
Elevation
Population

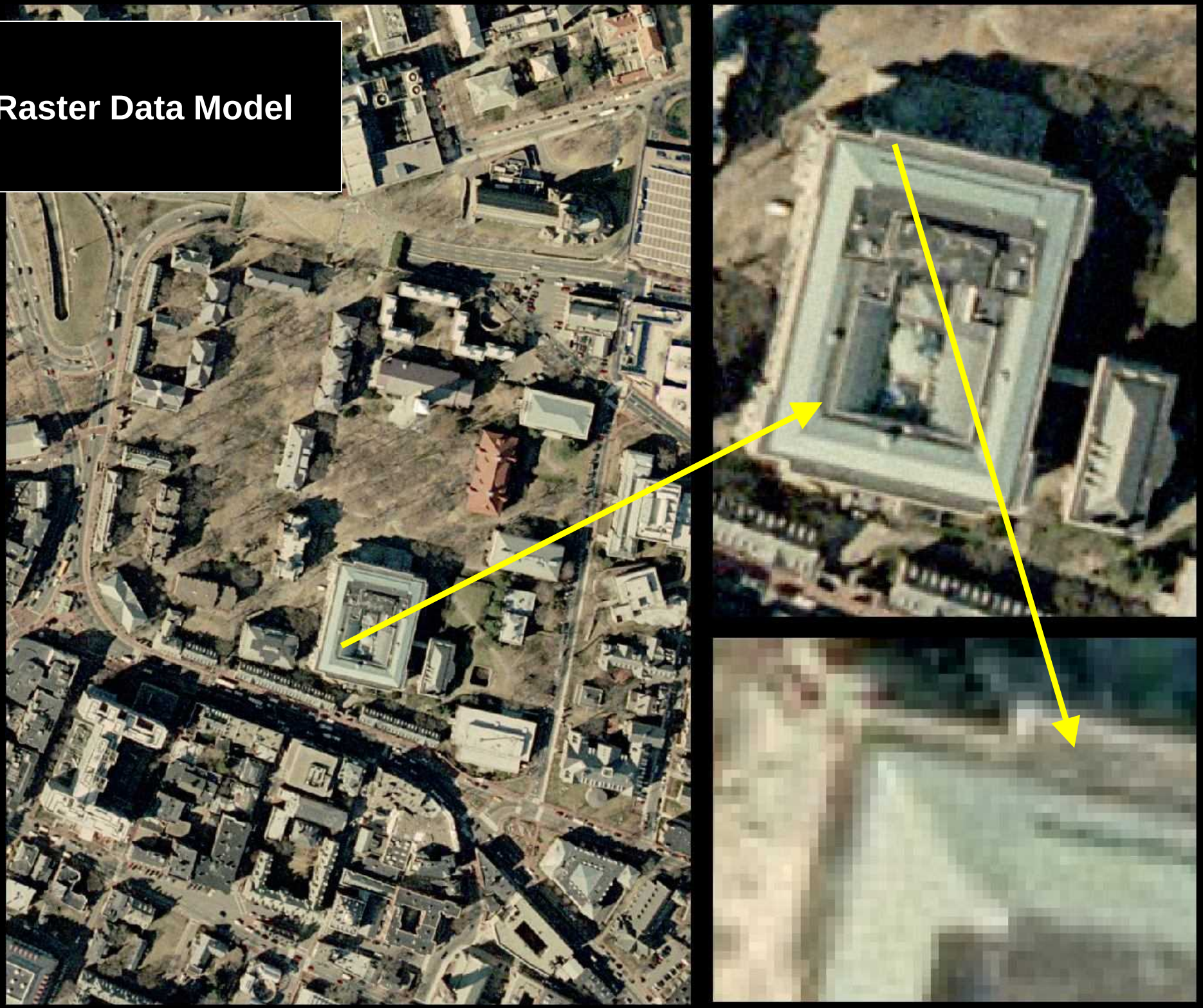

Aerial Imagery
Surface Elevation
Land Use Classes
Agriculture
Bare ground
Water
Deciduous Trees
Deciduous / Pine Mixed
Grassland
Pine
Shadow
Urban / Developed





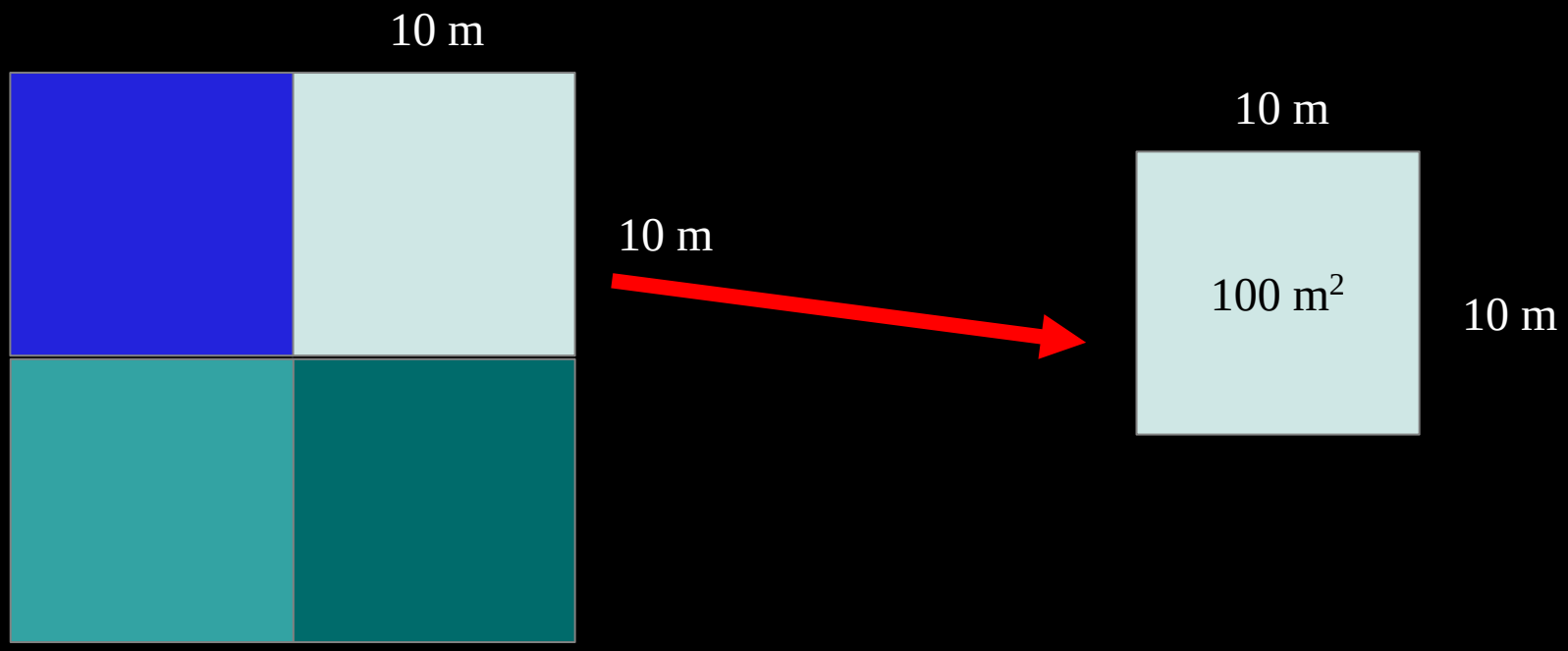
- The fundamental unit of a raster image is the pixel
- This is the same as a digital picture

Raster Data Model

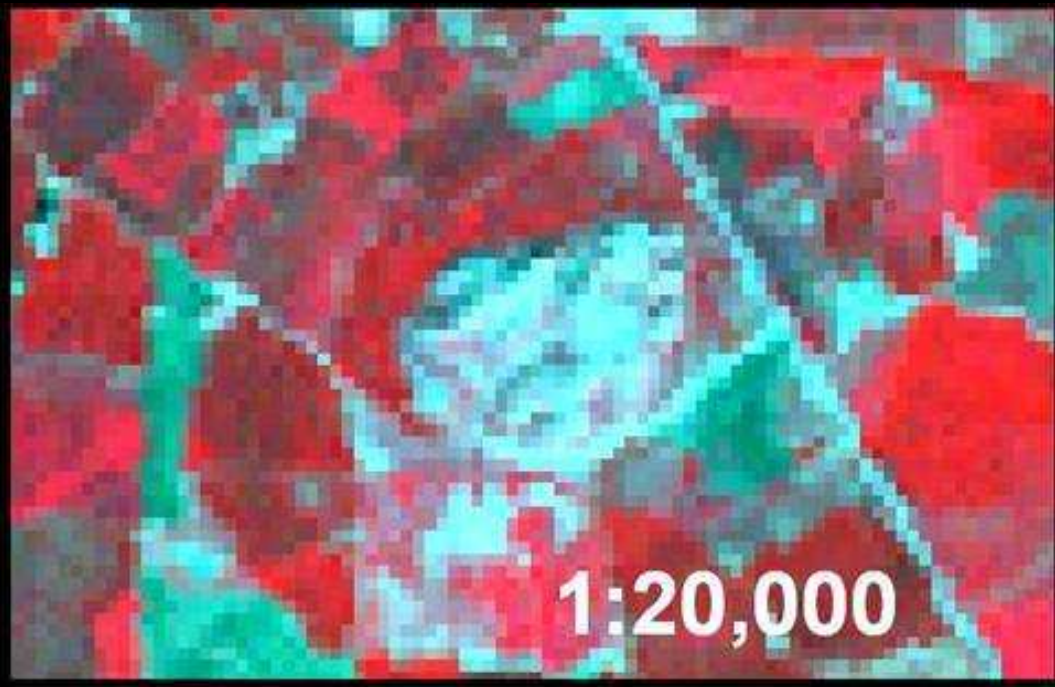


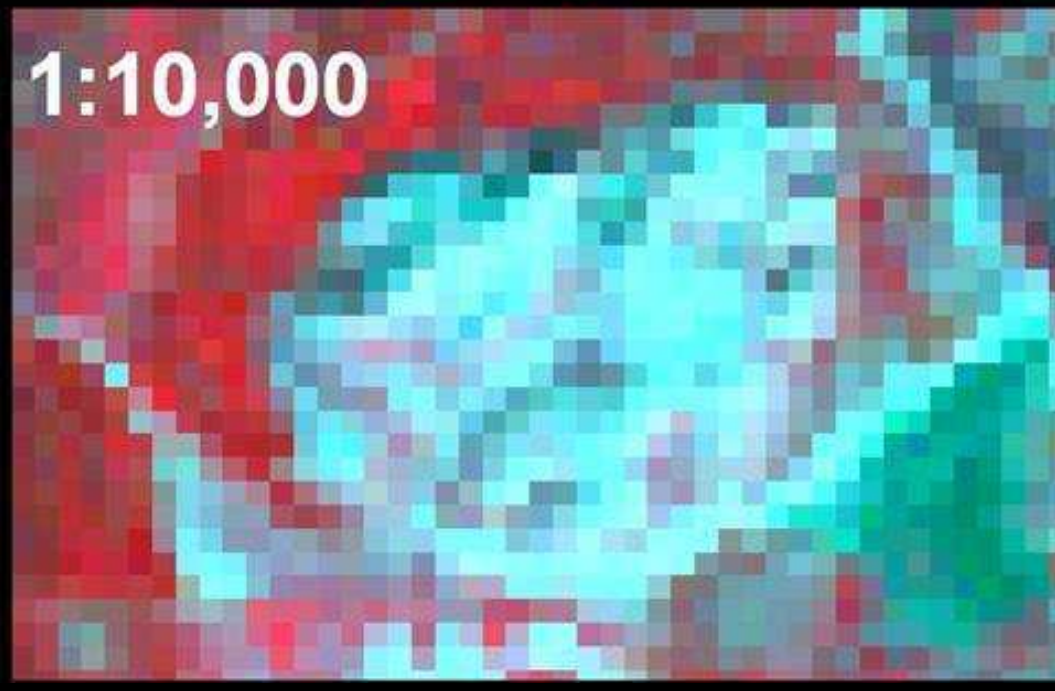
Spatial Resolution

The length, in real world measurements, of each side of a square pixel



Raster Resolution Comparison





Raster Data Model

Raster Advantages

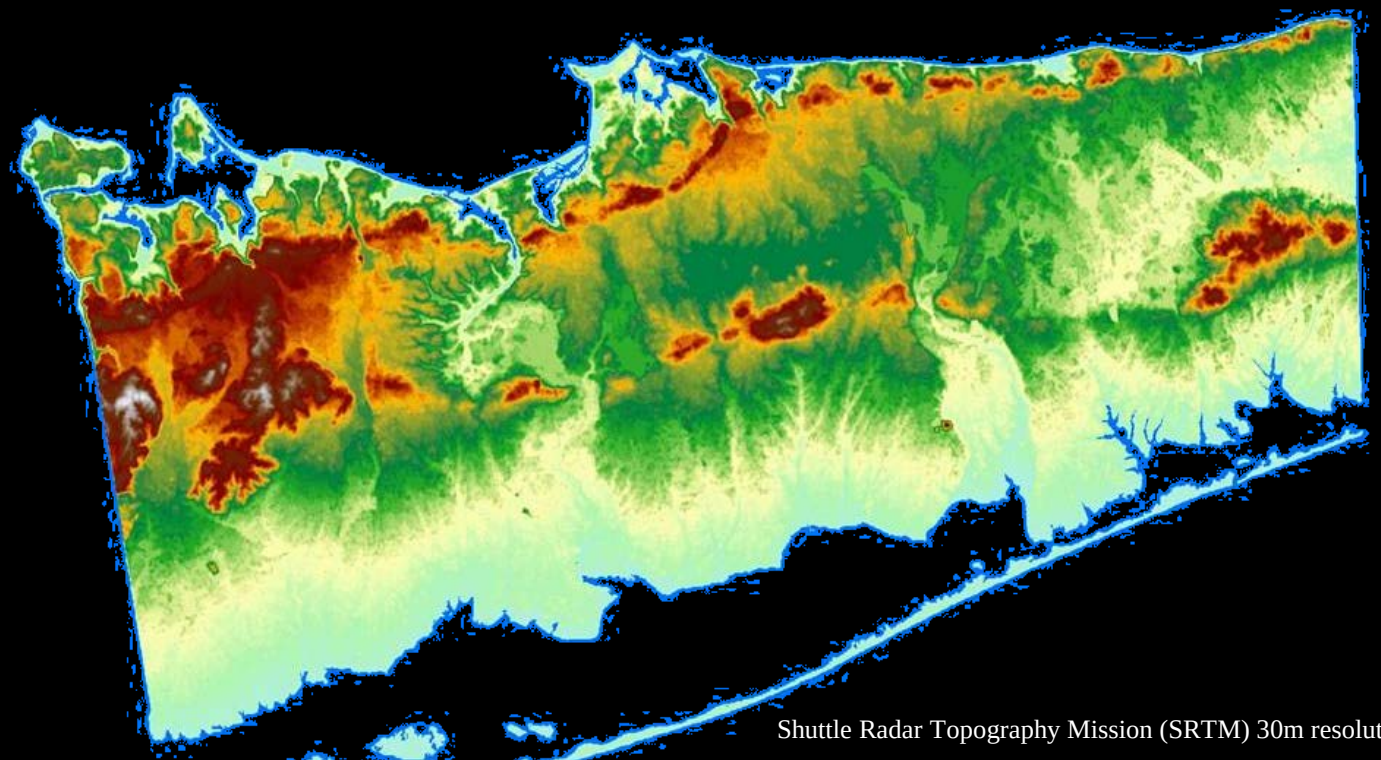
- Continuous Coverage
- Detail beyond human perception
- Easily manipulated

Raster Disadvantages

- Fixed resolution
- Large file size
- Difficult to edit individual pixels

Digital Elevation Model (DEM)

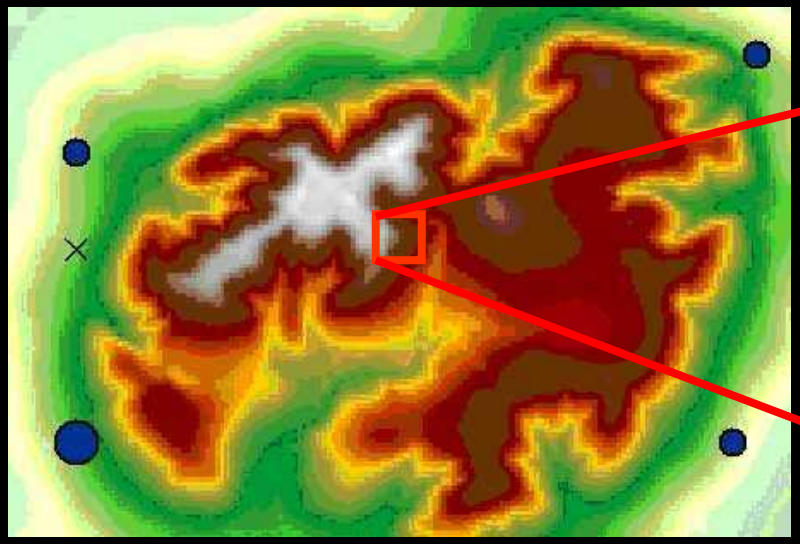
- Type of raster where the pixel value corresponds to elevation
- Used for analyzing slope, waterflow, visibility, etc.

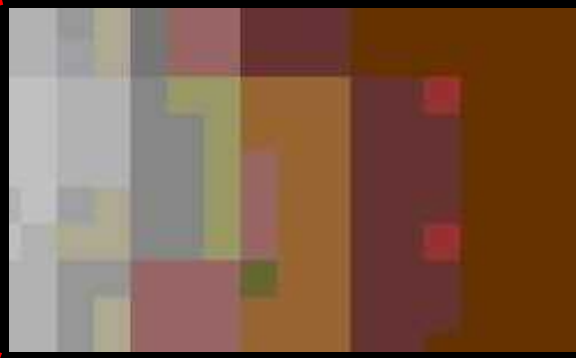


Shuttle Radar Topography Mission (SRTM) 30m resolution

Raster Data

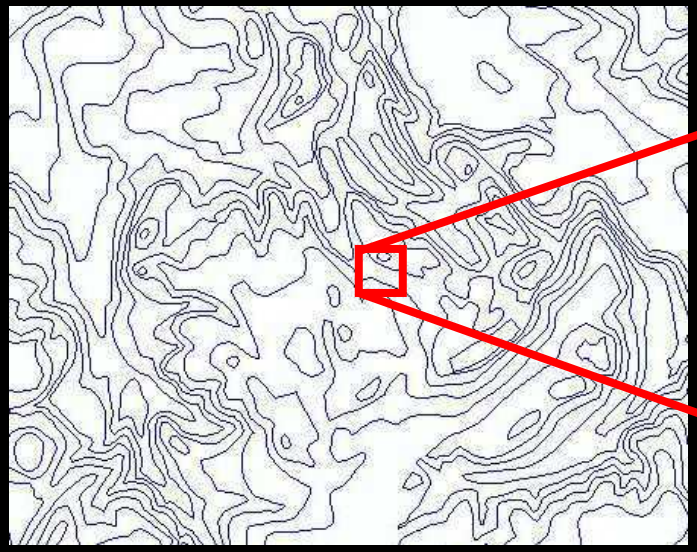
- Based on pixel

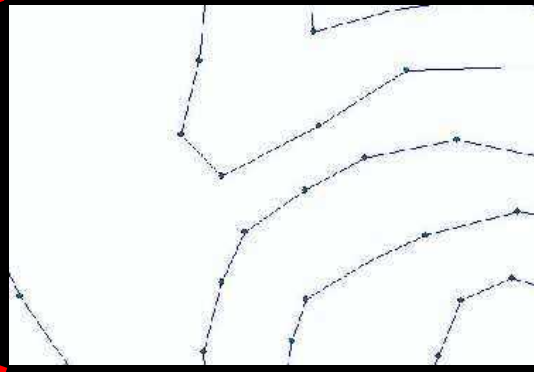




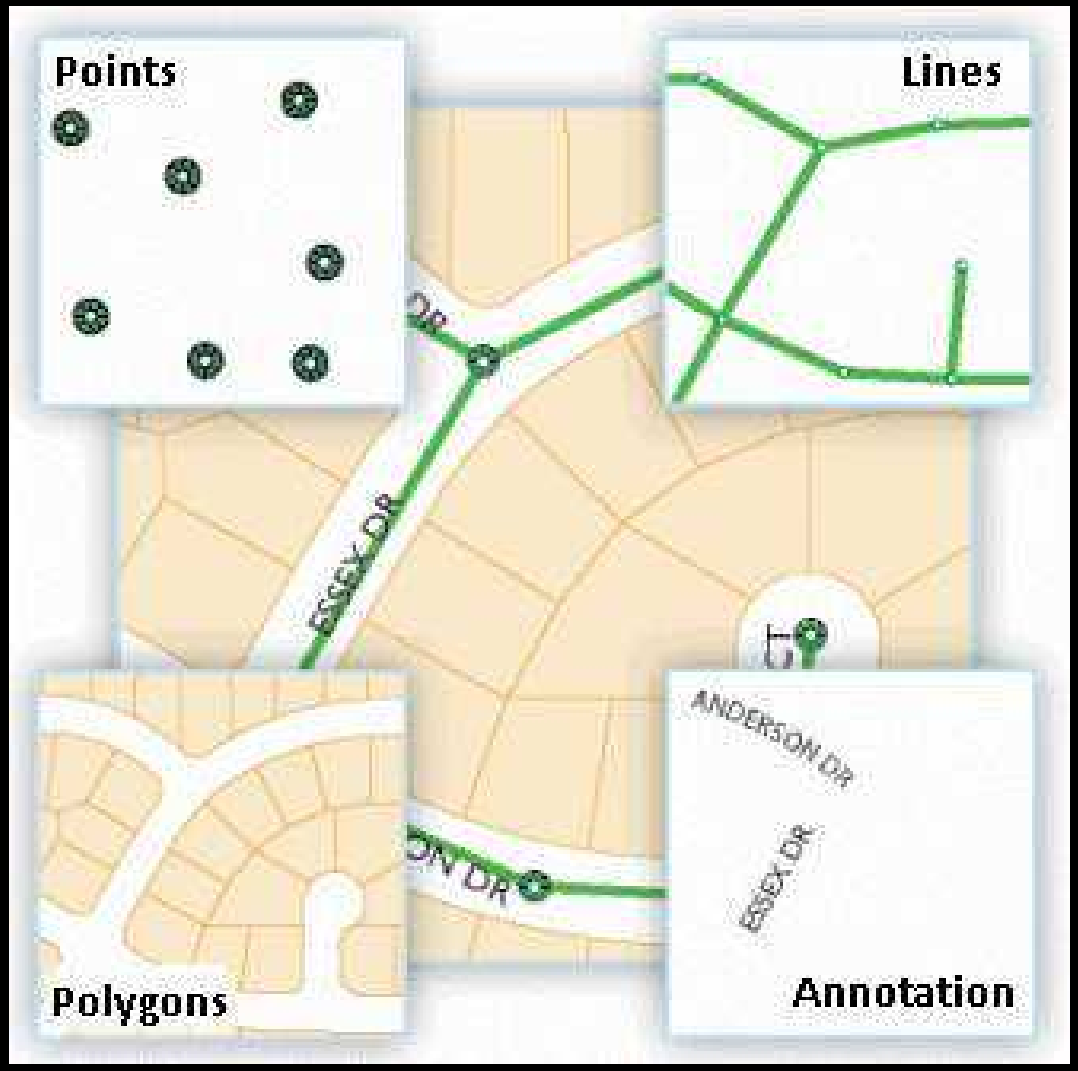
Vector Data

- Based on discrete points

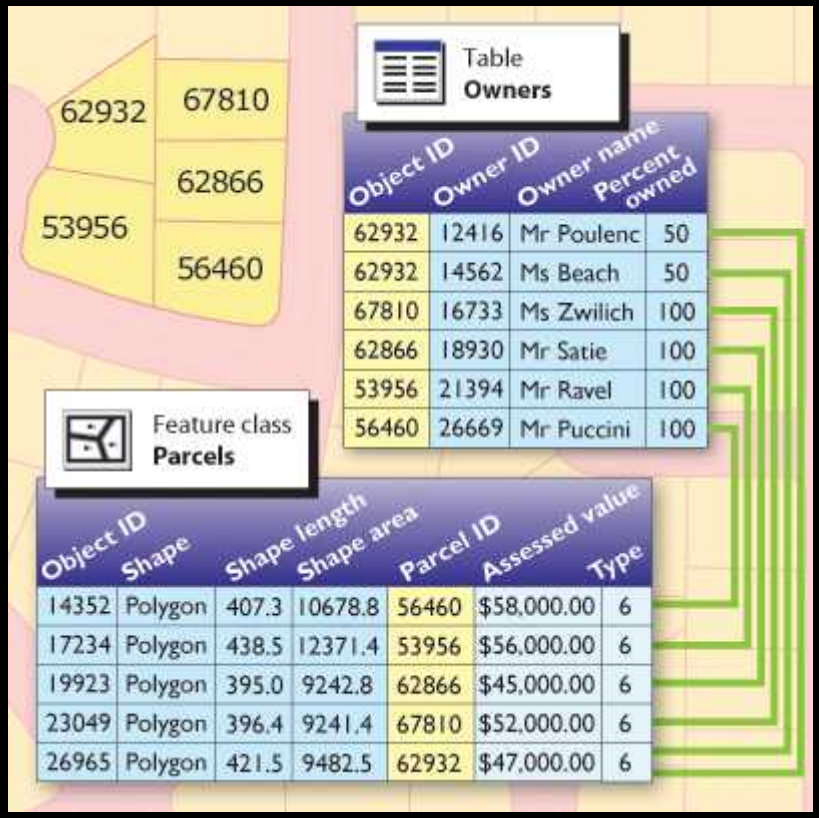




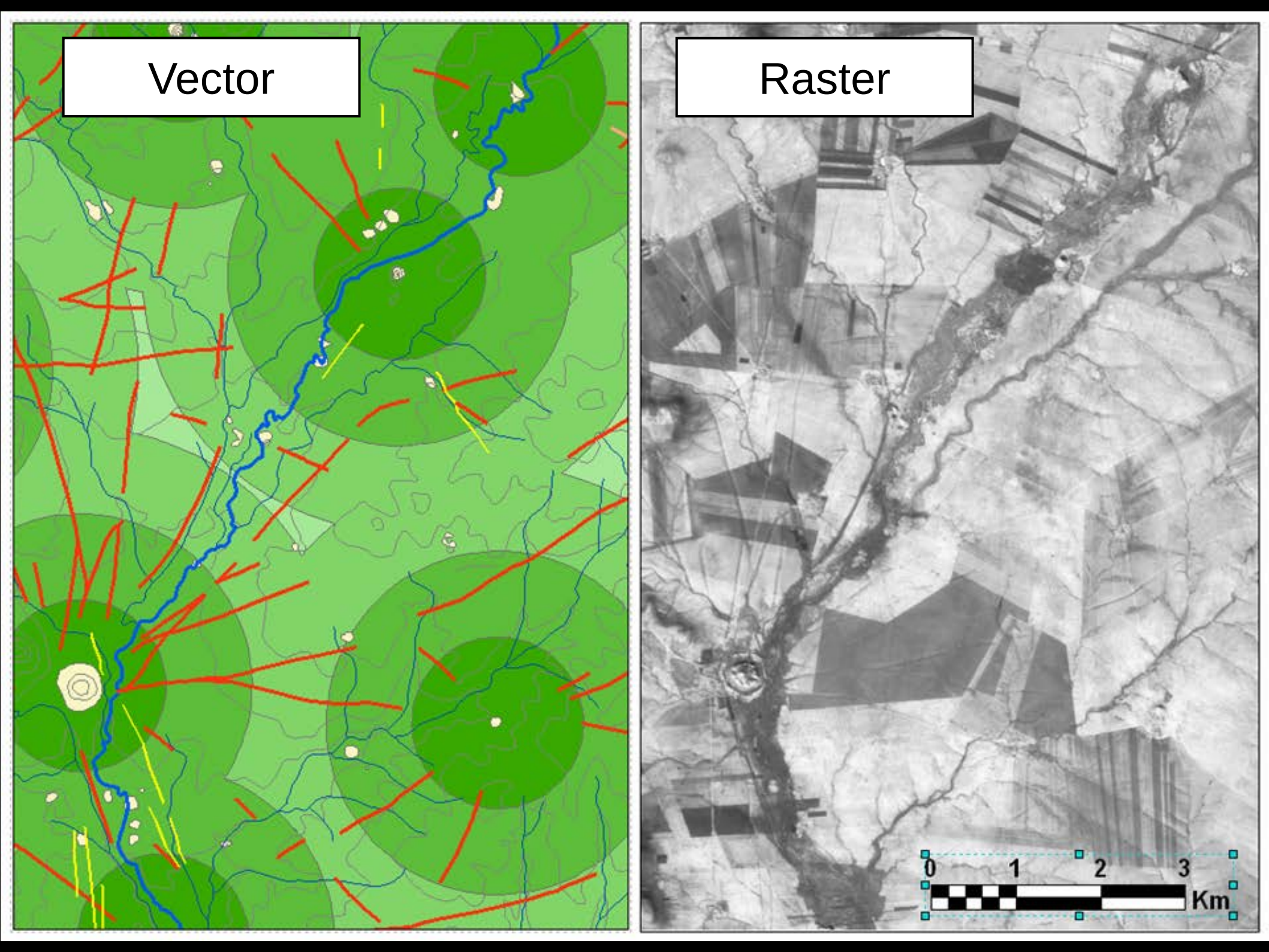
Vectors



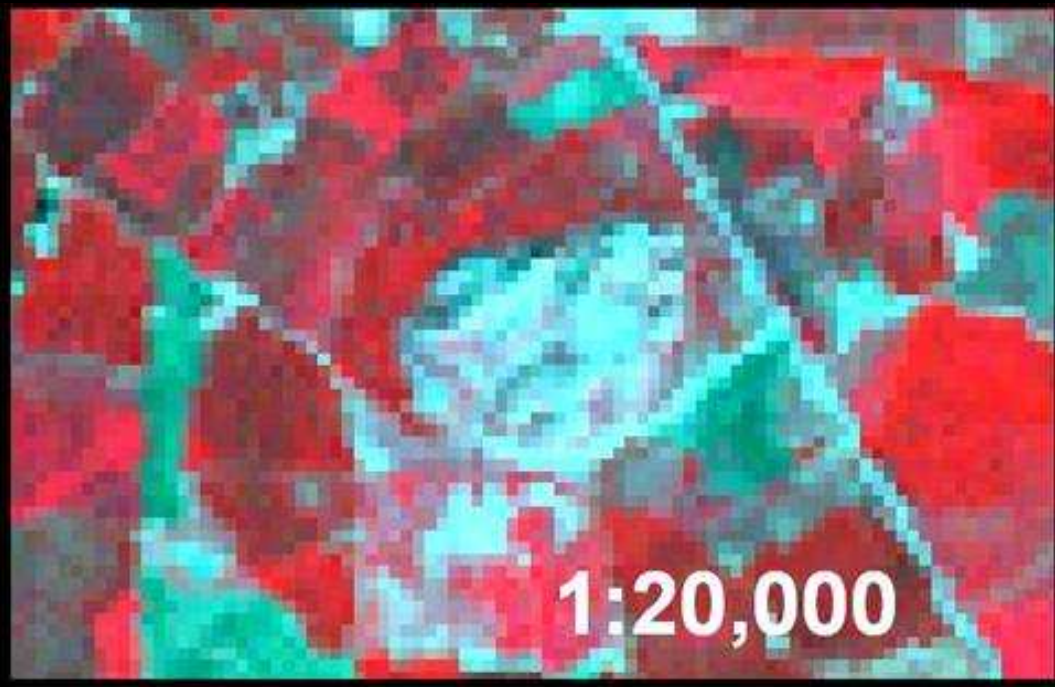
Data Types

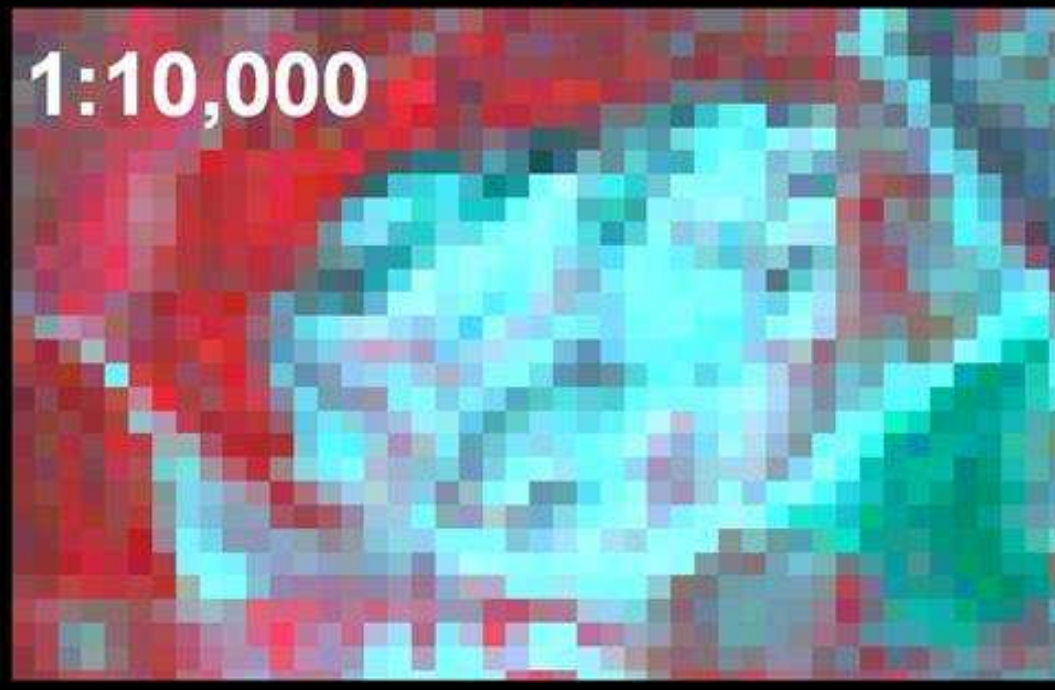


Attribute Tables

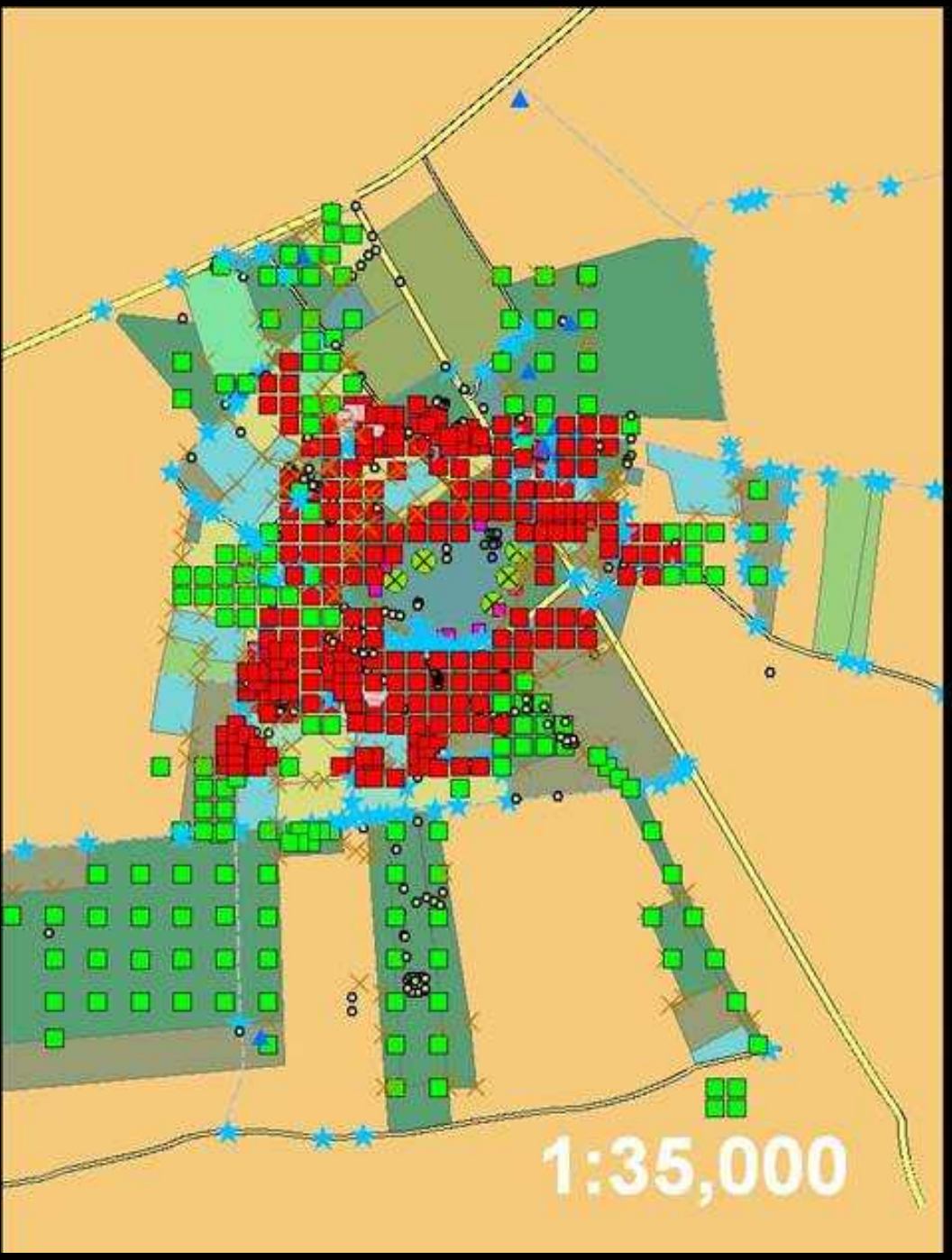

Vector
Raster
0
1
2
3
Km

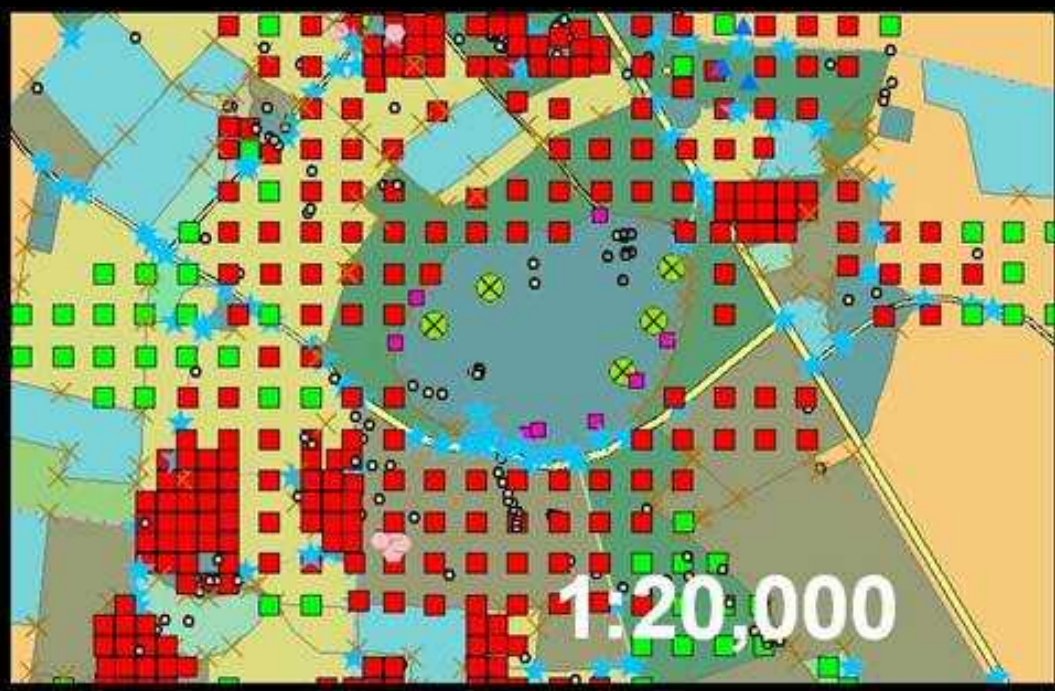
Raster Resolution Comparison

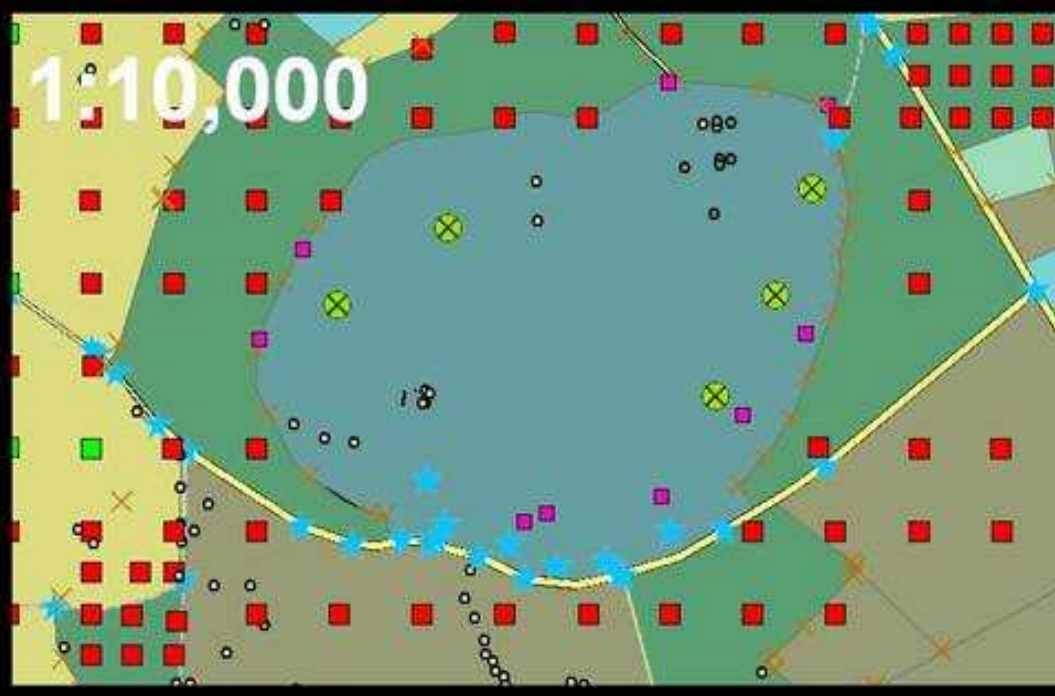




Vector Resolution Comparison







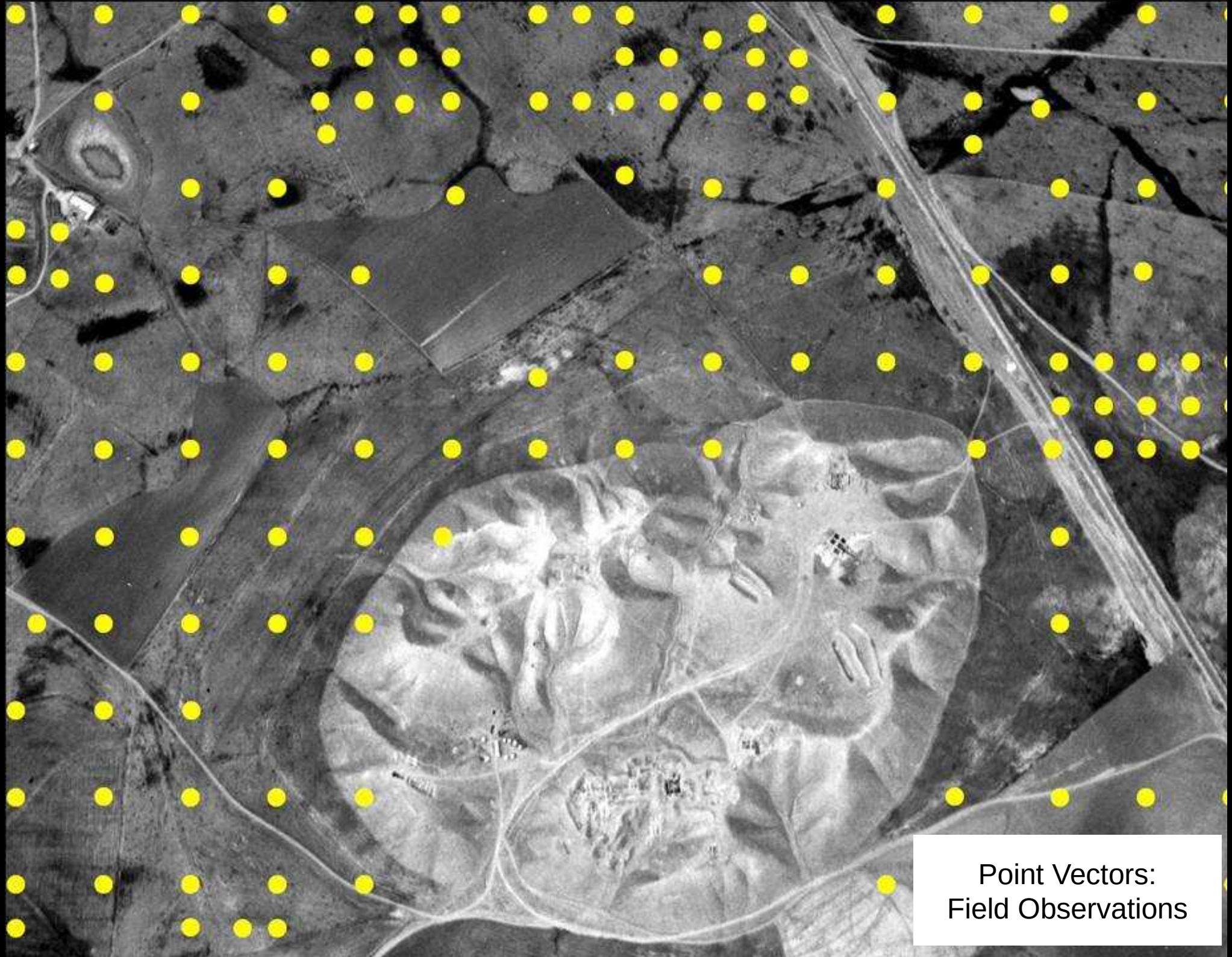
Vector vs. Raster

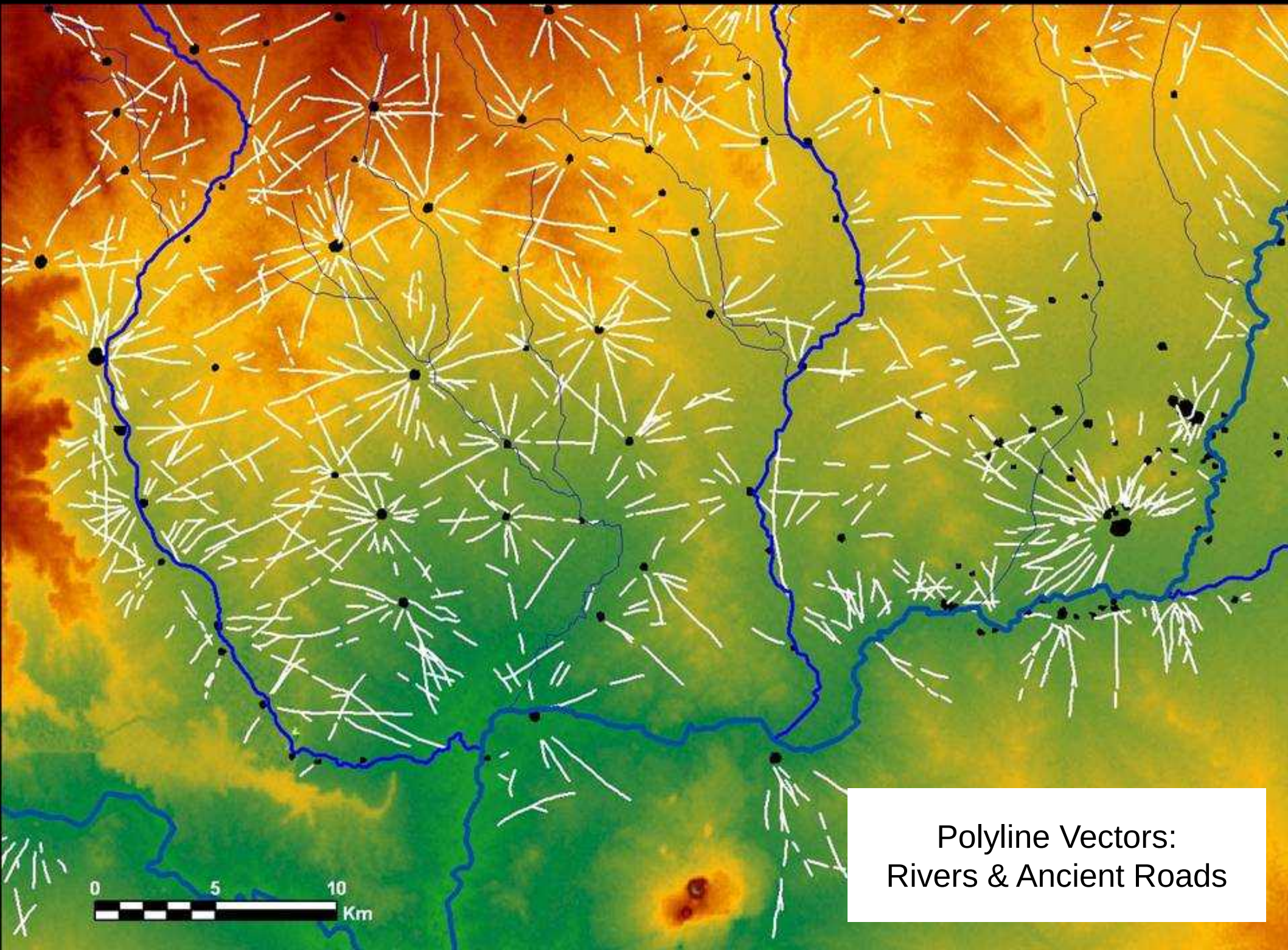
Vector Advantages

- Economical in space
- Good for discrete features
- More flexible with regard to scale

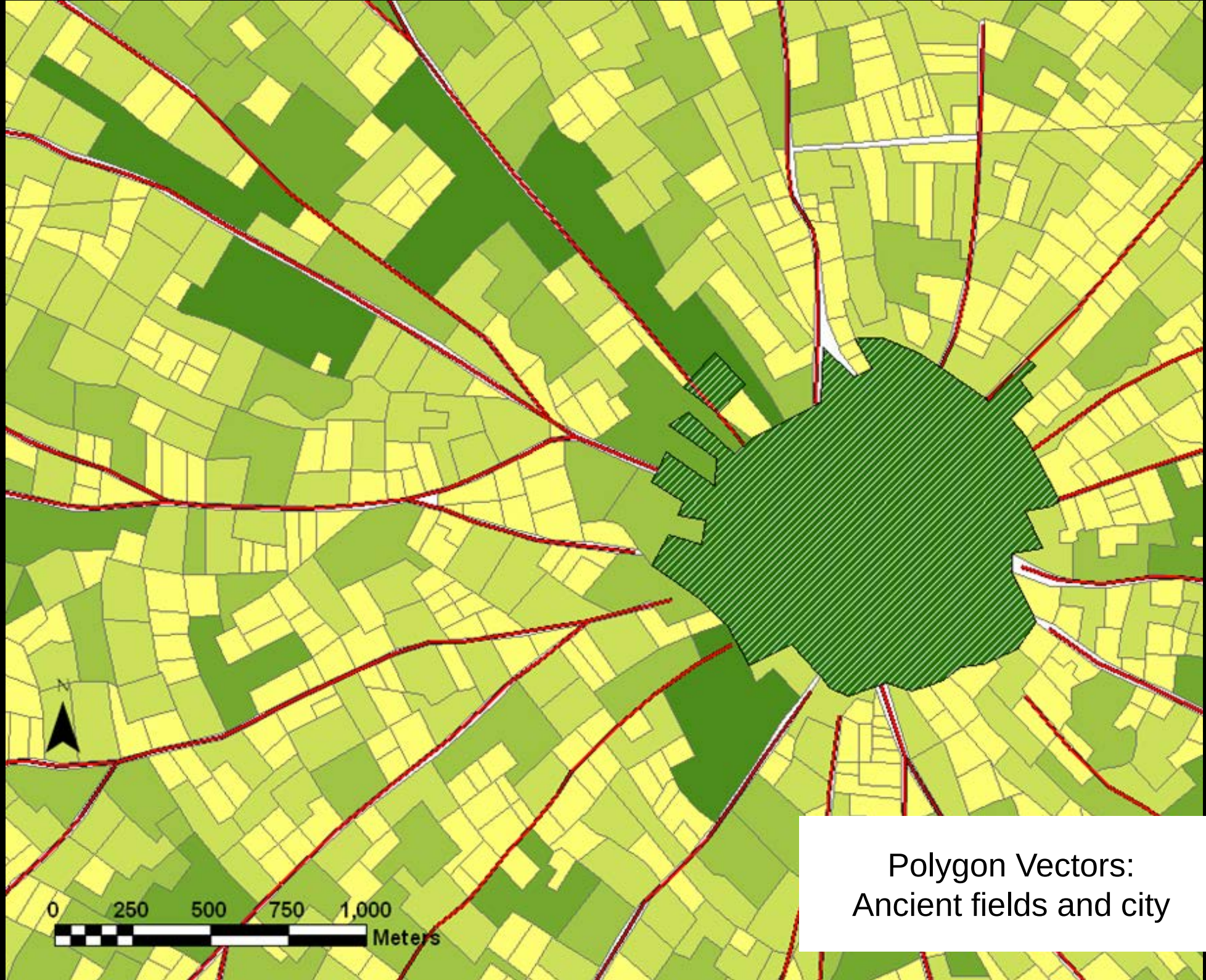
Vector Disadvantages

- More schematized version of reality
- Poorly suited for continuous phenomena

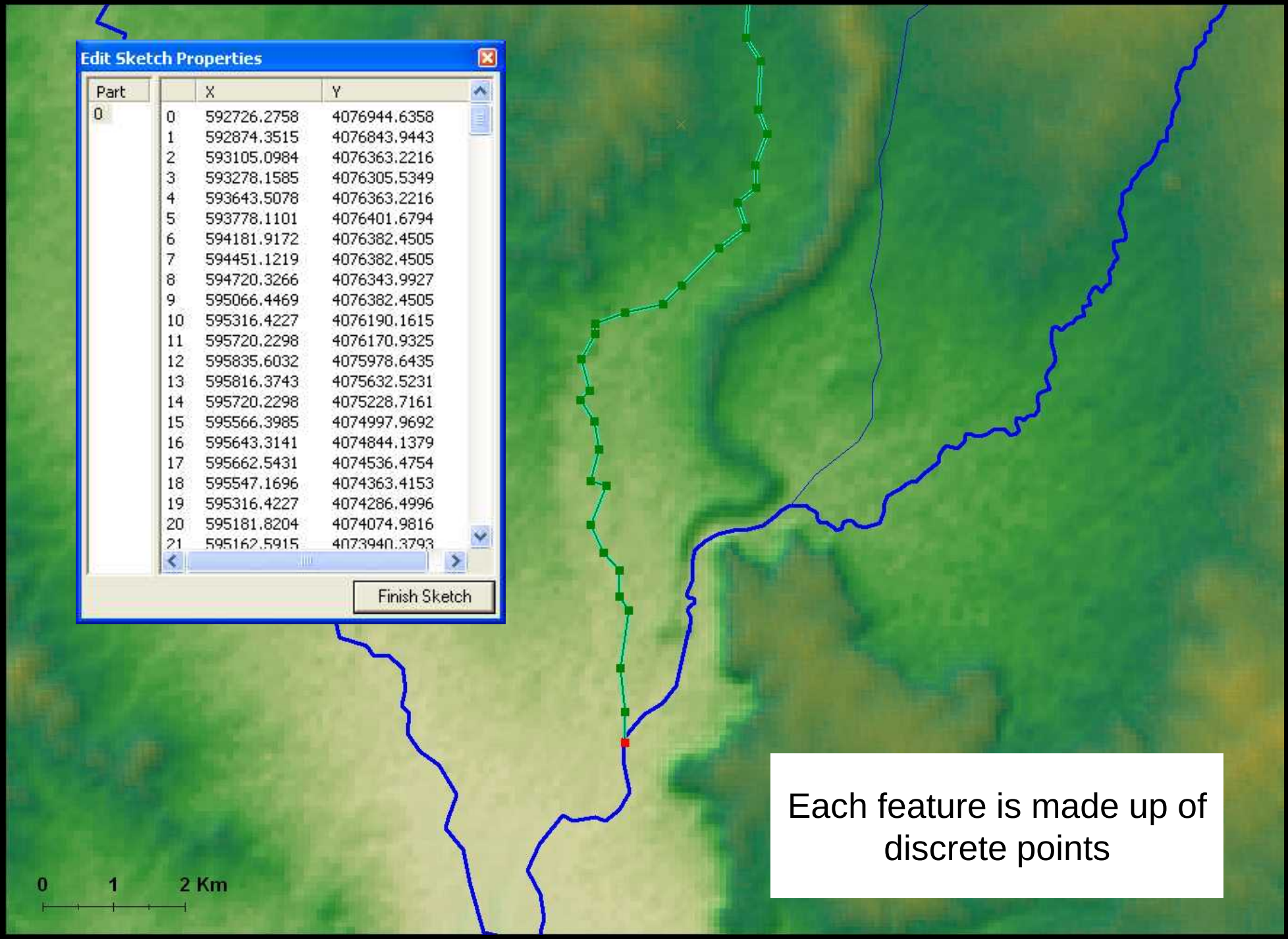

Point Vectors:
Field Observations



Polyline Vectors:
Rivers & Ancient Roads



Polygon Vectors:
Ancient fields and city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X
Y
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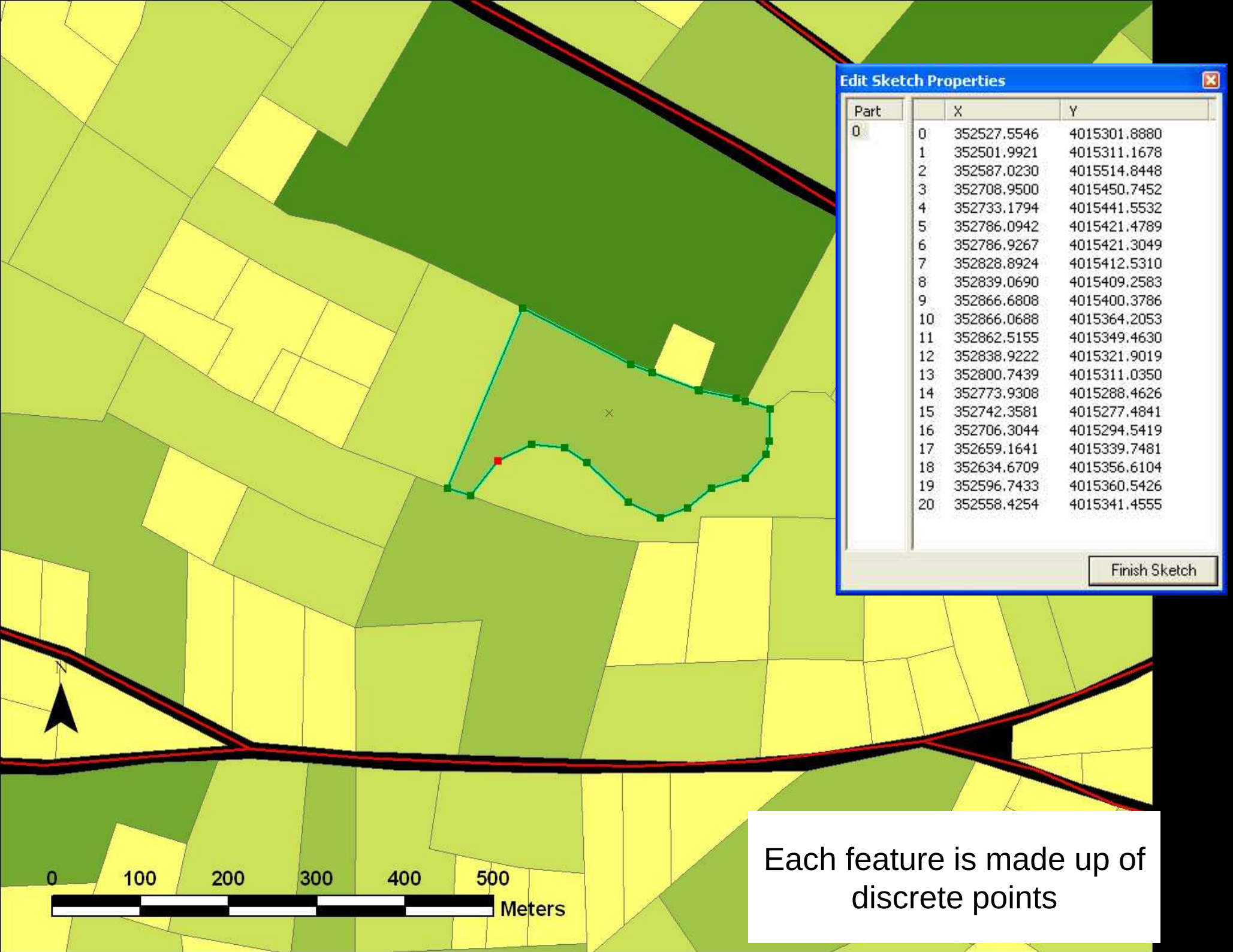
3 593278.1585 4076305.5349
4 593643.5078 4076363.2216
5 593778.1101 4076401.6794
6 594181.9172 4076382.4505
7 594451.1219 4076382.4505
8 594720.3266 4076343.9927
9 595066.4469 4076382.4505
10 595316.4227 4076190.1615
11 595720.2298 4076170.9325
12 595835.6032 4075978.6435
13 595816.3743 4075632.5231
14 595720.2298 4075228.7161
15 595566.3985 4074997.9692
16 595643.3141 4074844.1379
17 595662.5431 4074536.4754
18 595547.1696 4074363.4153
19 595316.4227 4074286.4996
20 595181.8204 4074074.9816
21 595162.5915 4073940.3793
Finish Sketch
0 1 2 Km
Each feature is made up of discrete points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X
Y
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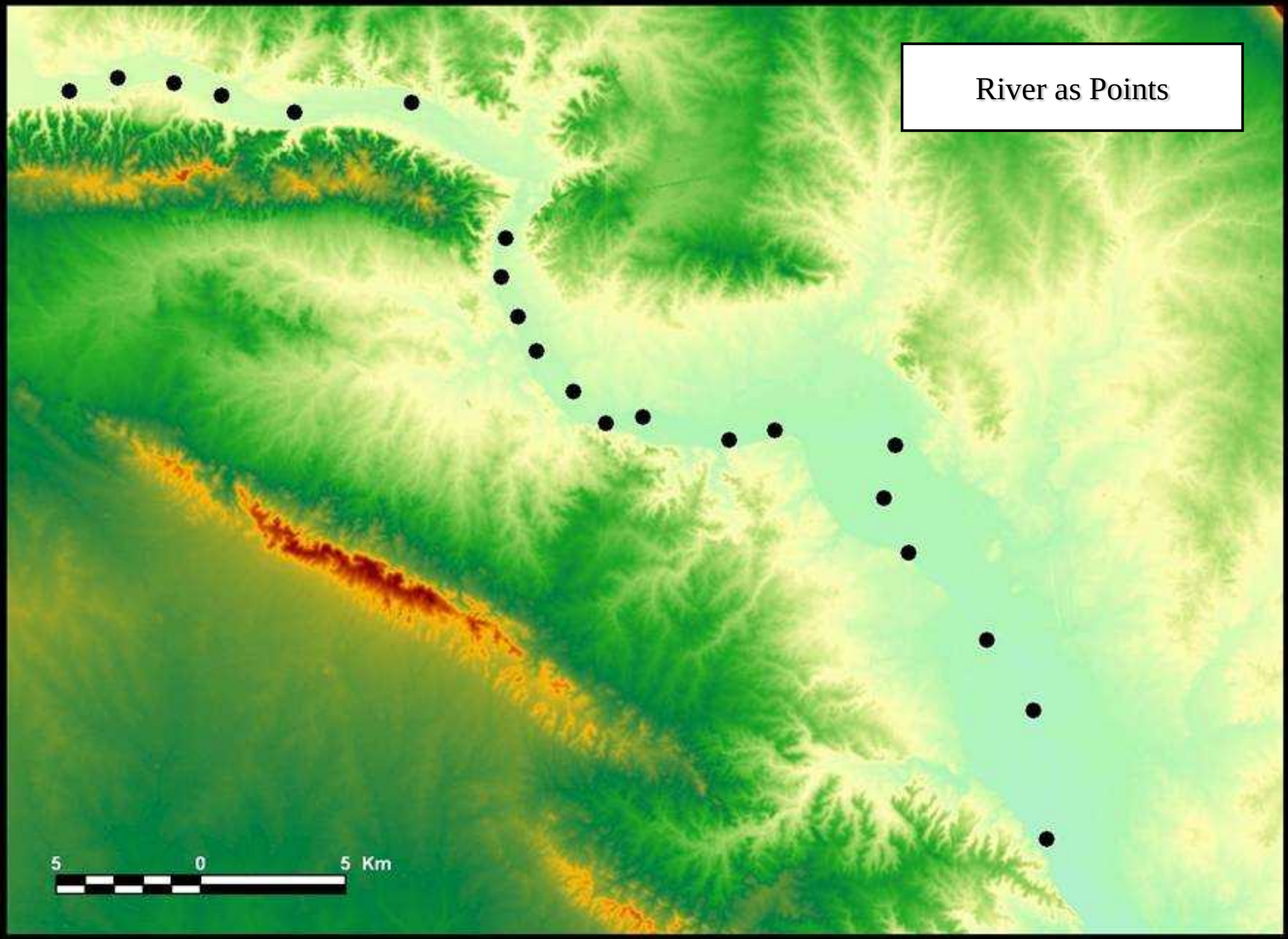
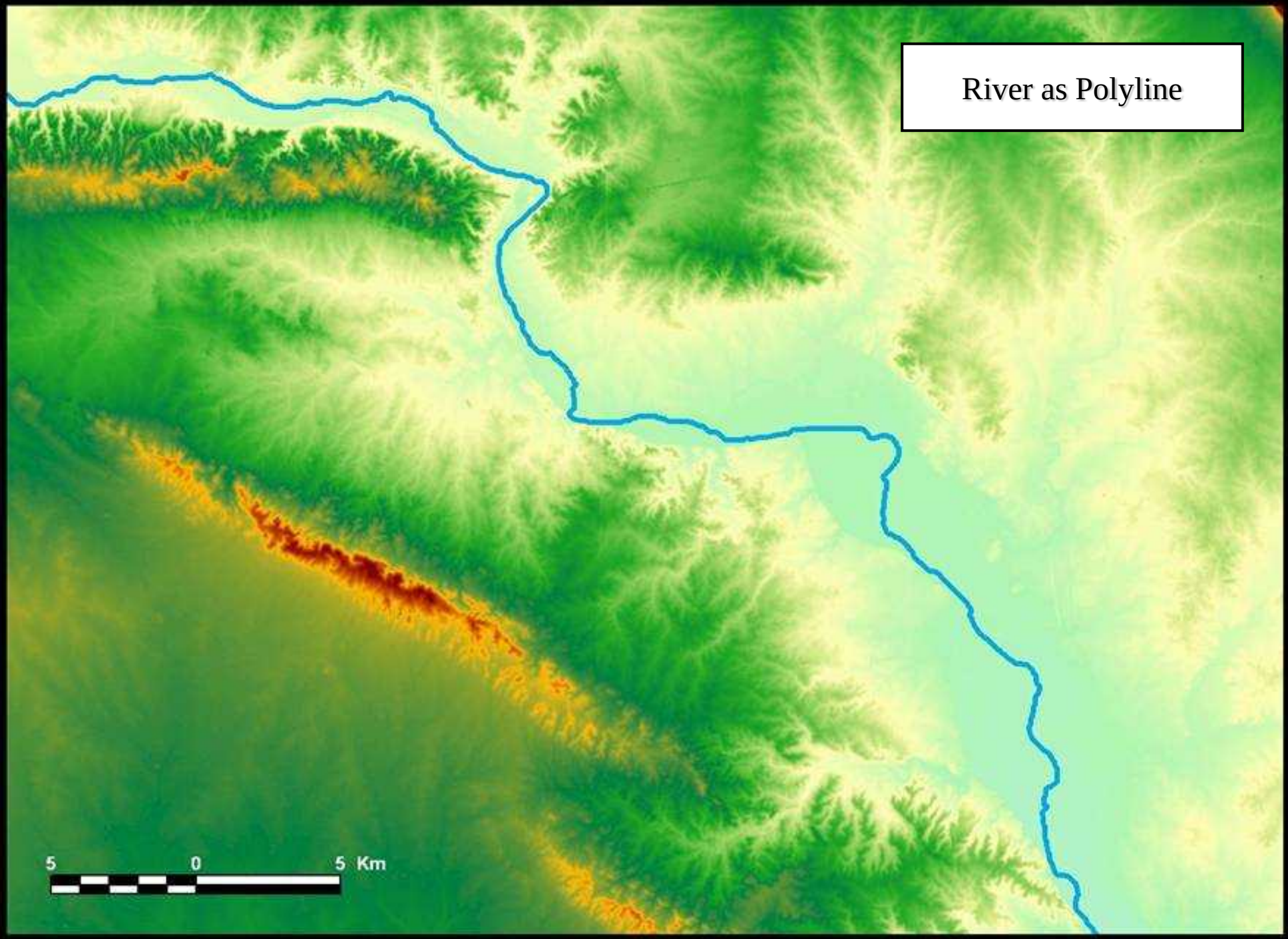
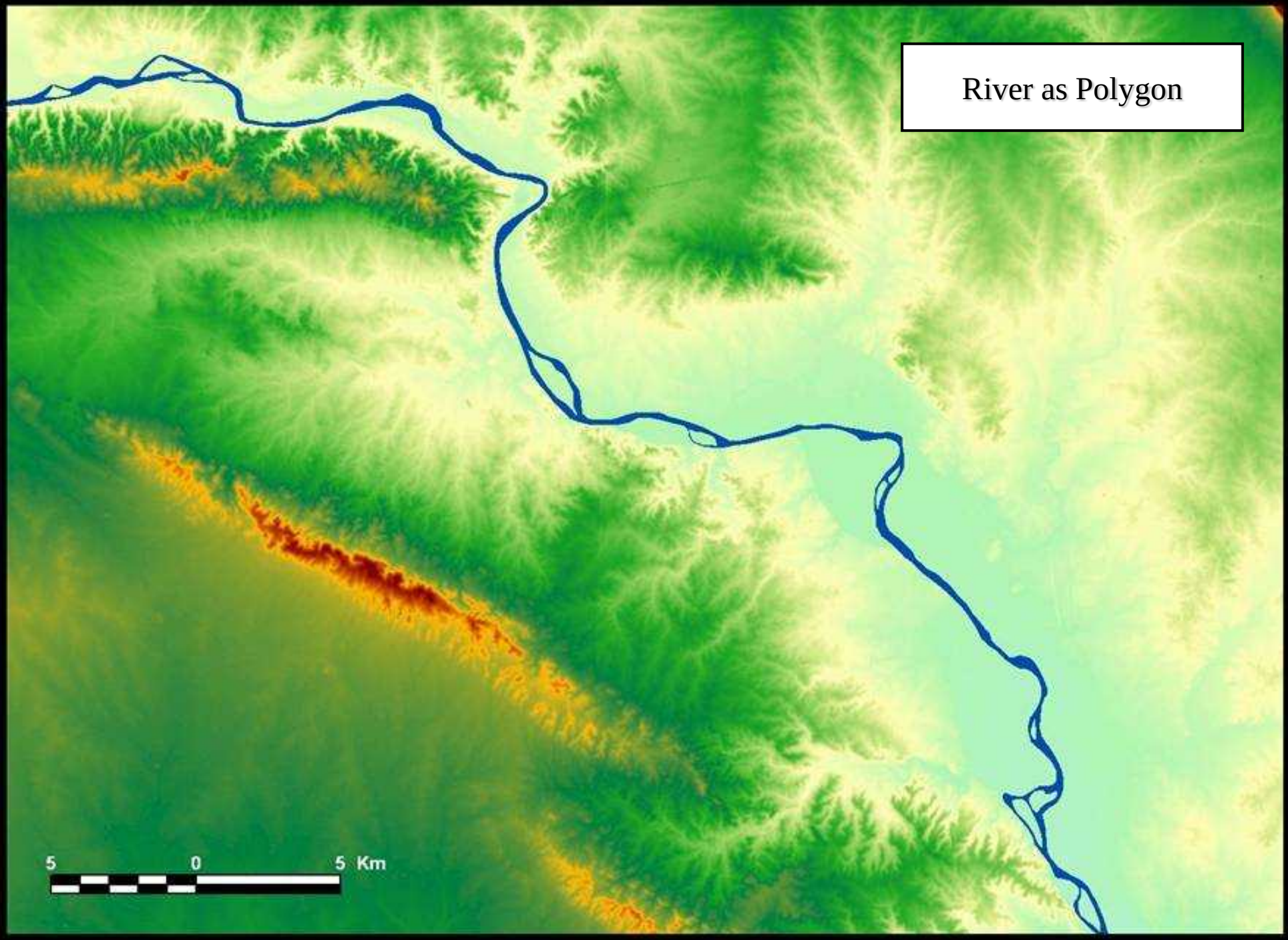
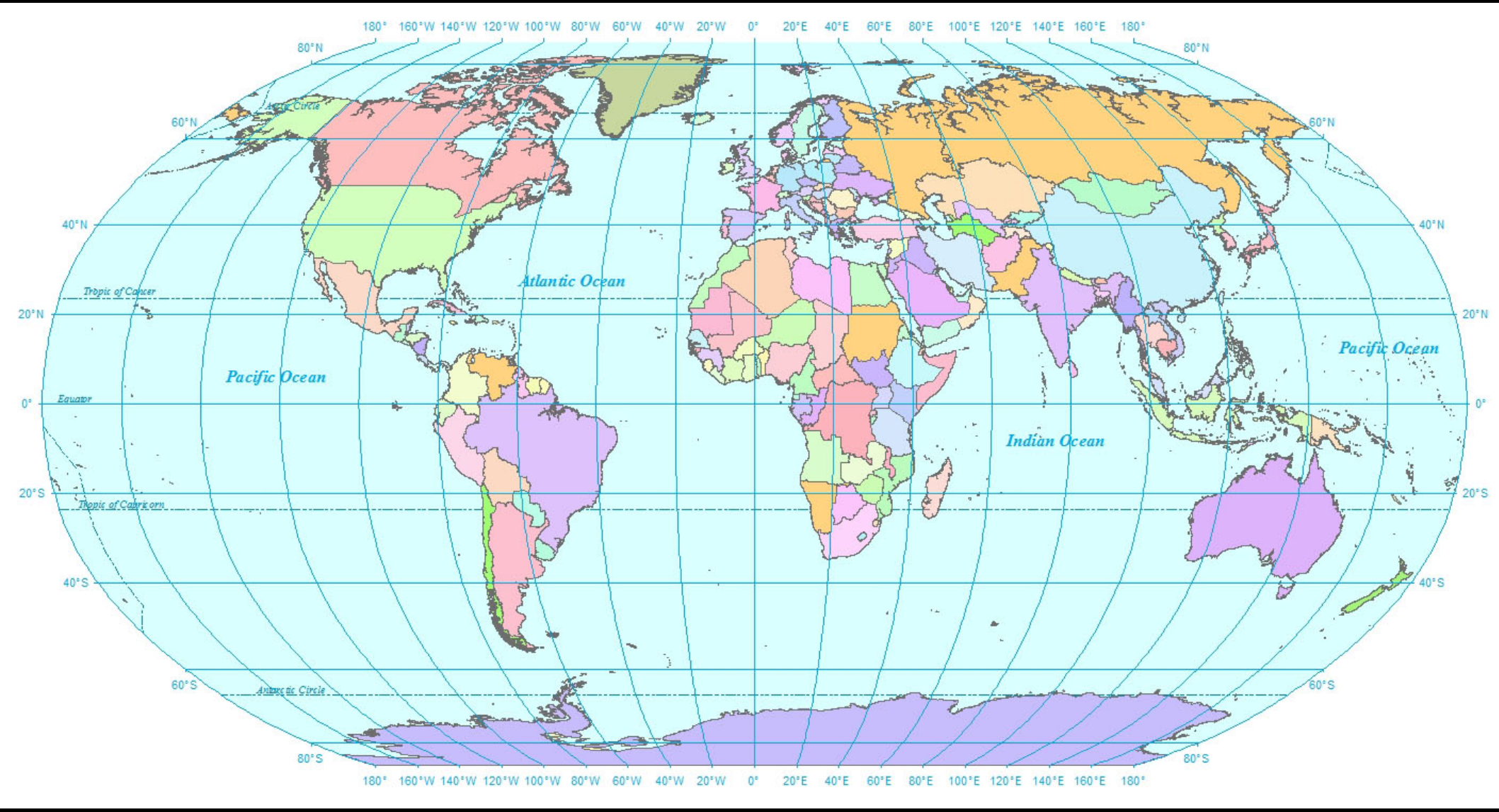
2 352587.0230 4015514.8448
3 352708.9500 4015450.7452
4 352733.1794 4015441.5532
5 352786.0942 4015421.4789
6 352786.9267 4015421.3049
7 352828.8924 4015412.5310
8 352839.0690 4015409.2583
9 352866.6808 4015400.3786
10 352866.0688 4015364.2053
11 352862.5155 4015349.4630
12 352838.9222 4015321.9019
13 352800.7439 4015311.0350
14 352773.9308 4015288.4626
15 352742.3581 4015277.4841
16 352706.3044 4015294.5419
17 352659.1641 4015339.7481
18 352634.6709 4015356.6104
19 352596.7433 4015360.5426
20 352558.4254 4015341.4555
Finish Sketch
N
0
100
200
300
400
500
Meters
Each feature is made up of discrete points


River as Points
5 0 5 Km

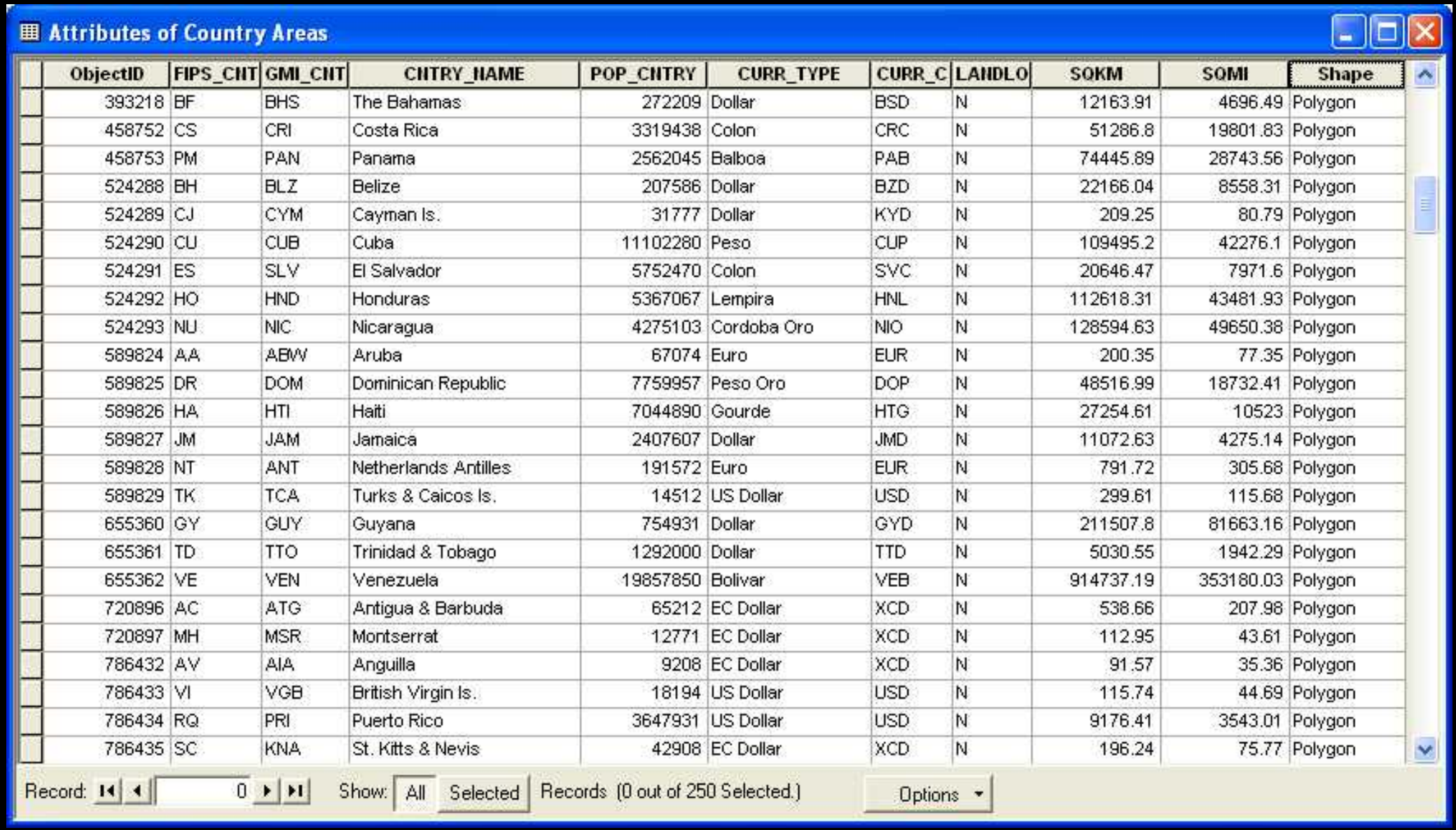

River as Polyline
5
0
5 Km


River as Polygon
5
0
5 Km

Attribute Data



Attribute Data



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458752	CS	CRI	Costa Rica	3319438	Colon	CRC	N	51286.8	19801.83	Polygon
458753	PM	PAN	Panama	2562045	Balboa	PAB	N	74445.89	28743.56	Polygon
524288	BH	BLZ	Belize	207586	Dollar	BZD	N	22166.04	8558.31	Polygon
524289	CJ	CYM	Cayman Is.	31777	Dollar	KYD	N	209.25	80.79	Polygon
524290	CU	CUB	Cuba	11102280	Peso	CUP	N	109495.2	42276.1	Polygon
524291	ES	SLV	El Salvador	5752470	Colon	SVC	N	20646.47	7971.6	Polygon
524292	HO	HND	Honduras	5367067	Lempira	HNL	N	112618.31	43481.93	Polygon
524293	NU	NIC	Nicaragua	4275103	Cordoba Oro	NIO	N	128594.63	49650.38	Polygon
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589828	NT	ANT	Netherlands Antilles	191572	Euro	EUR	N	791.72	305.68	Polygon
589829	TK	TCA	Turks & Caicos Is.	14512	US Dollar	USD	N	299.61	115.68	Polygon
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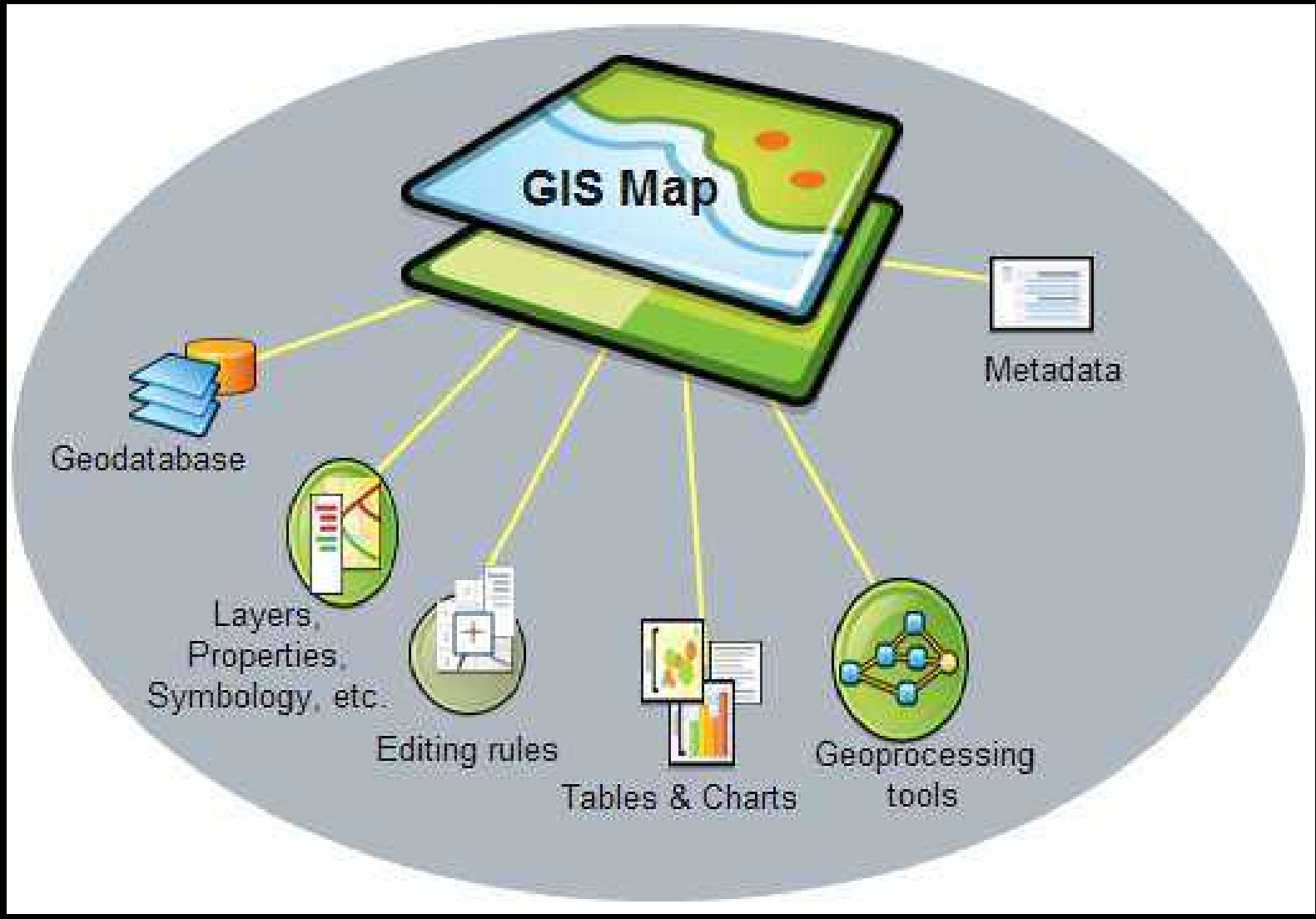
655362	VE	VEN	Venezuela	19857850	Bolivar	VEB	N	914737.19	353180.03	Polygon
720896	AC	ATG	Antigua & Barbuda	65212	EC Dollar	XCD	N	538.66	207.98	Polygon
720897	MH	MSR	Montserrat	12771	EC Dollar	XCD	N	112.95	43.61	Polygon
786432	AV	AIA	Anguilla	9208	EC Dollar	XCD	N	91.57	35.36	Polygon
786433	VI	VGB	British Virgin Is.	18194	US Dollar	USD	N	115.74	44.69	Polygon
786434	RQ	PRI	Puerto Rico	3647931	US Dollar	USD	N	9176.41	3543.01	Polygon
786435	SC	KNA	St. Kitts & Nevis	42908	EC Dollar	XCD	N	196.24	75.77	Polygon

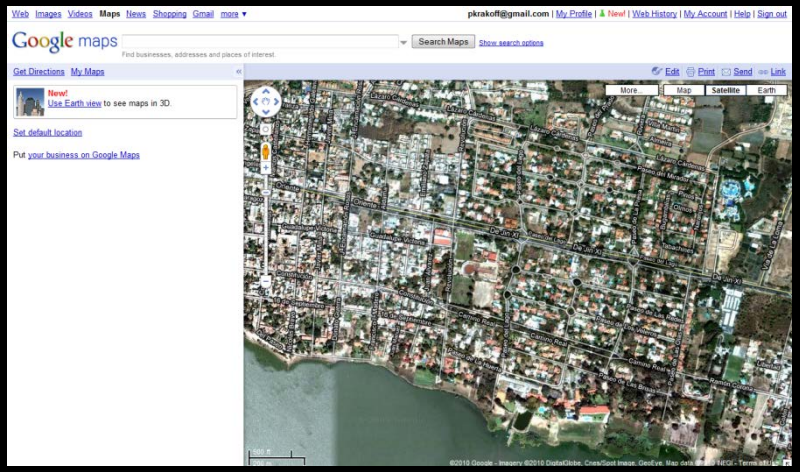
Tabular data associated with each feature

Building a GIS map

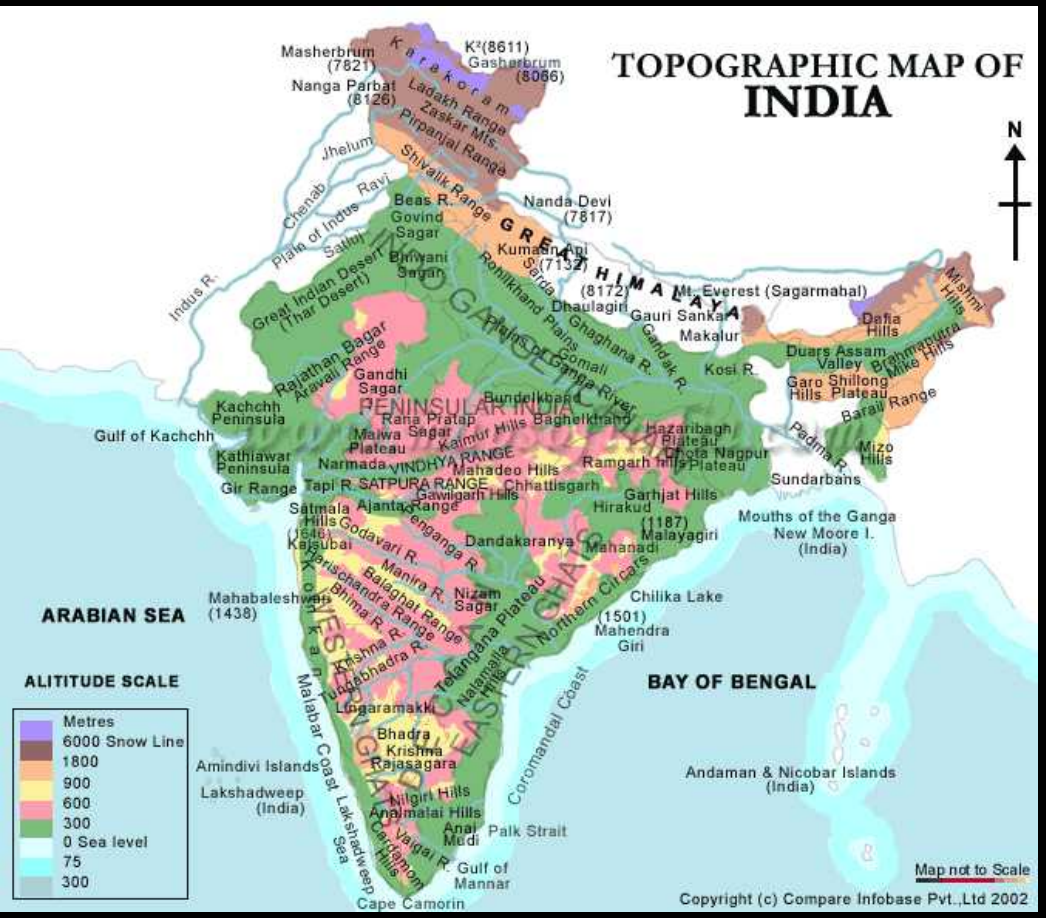


Individual data layers combine with ways of symbolizing data, charts and figures, editing rules and other tools to form a full GIS map

Not just pretty maps



- Google Maps and similar software are a type of simple GIS
- Full GIS packages usually have additional editing and analytical tools



There is very little in the GIS toolkit that cannot be done by traditional means, but it might be computationally difficult or very time consuming

What can GIS be used for?

- GIS adds “space” to research dimensions
  - Geographical significance & patterning
    - Does location make any difference?
      - Real estate, new business locations
    - Are there any patterns?
      - Migration patterns? How did the disease spread?
  - Geographical correlations and relationships
    - Are A and B in this location related?
      - Crime rate and average income
  - Prediction and predictive modeling
    - How many people will be affected by something?
    - Where are we likely to find something?

Why is GIS important?

Government

- 80% of **local government** activities estimated to be geographically based
  - plots, zoning, public works (streets, water supply, sewers), garbage collection, land ownership and valuation, public safety (fire and police)
  - natural resource management
  - highways and transportation

Businesses

  - retail site selection & customer analysis
  - logistics: vehicle tracking & routing
  - natural resource exploration
  - civil engineering and construction

Military and defense

  - Battlefield management
  - Satellite imagery interpretation

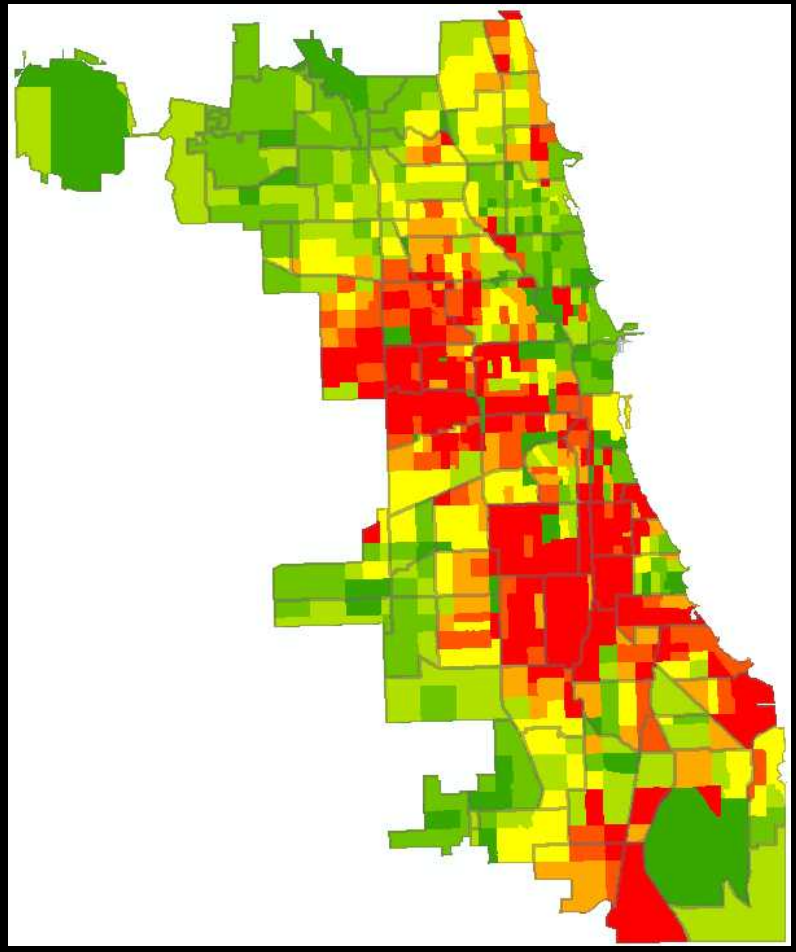
Research:

  - Hard Sciences: Geography, geology, botany, epidemiology
  - Social Sciences: Anthropology, sociology, economics, political science
  - Humanities: History, criminology

Examples of how GIS can be used

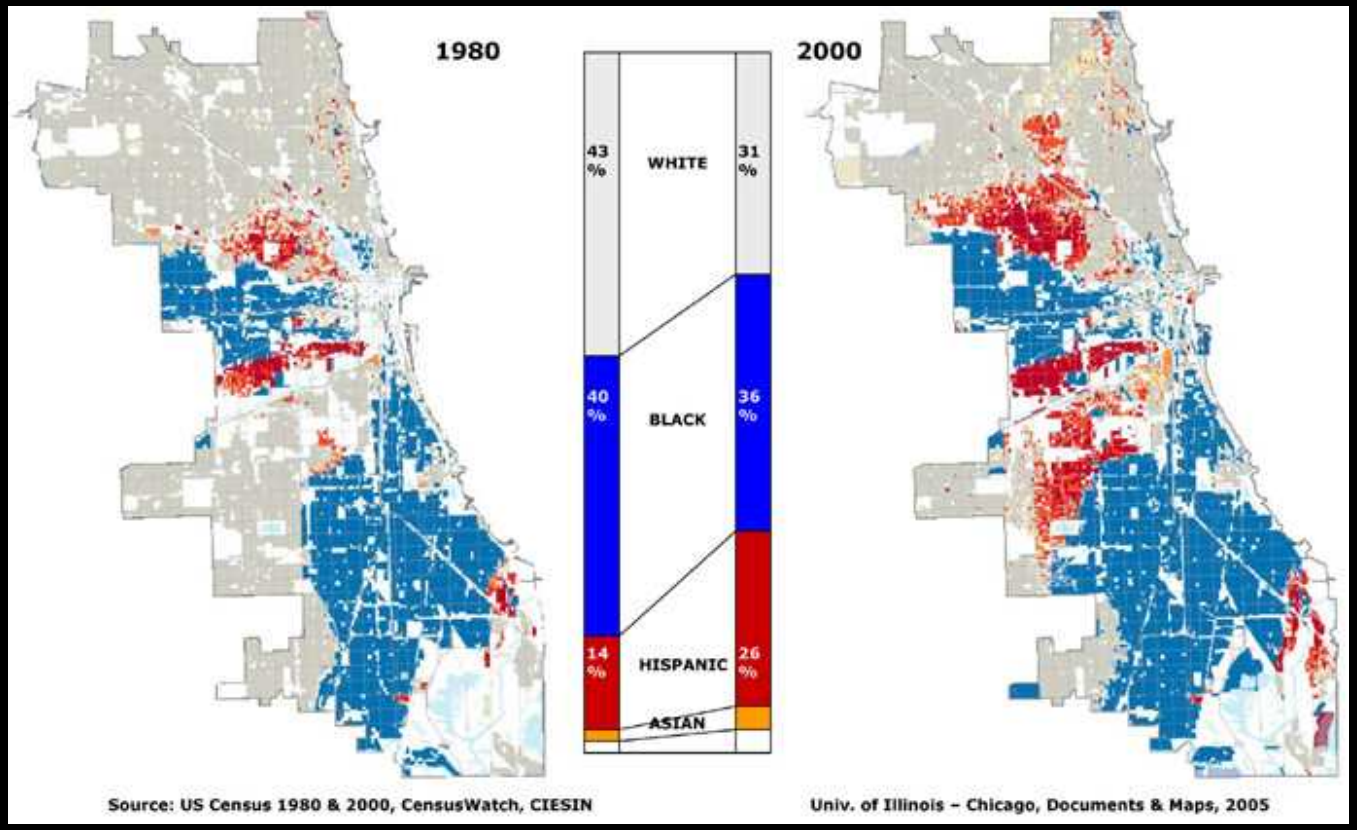
Example: Patterns

- Socio-economic
  - 2000 Census data
  - Unit – Census Tract
  - Over the community area boundaries
  - % families below poverty level



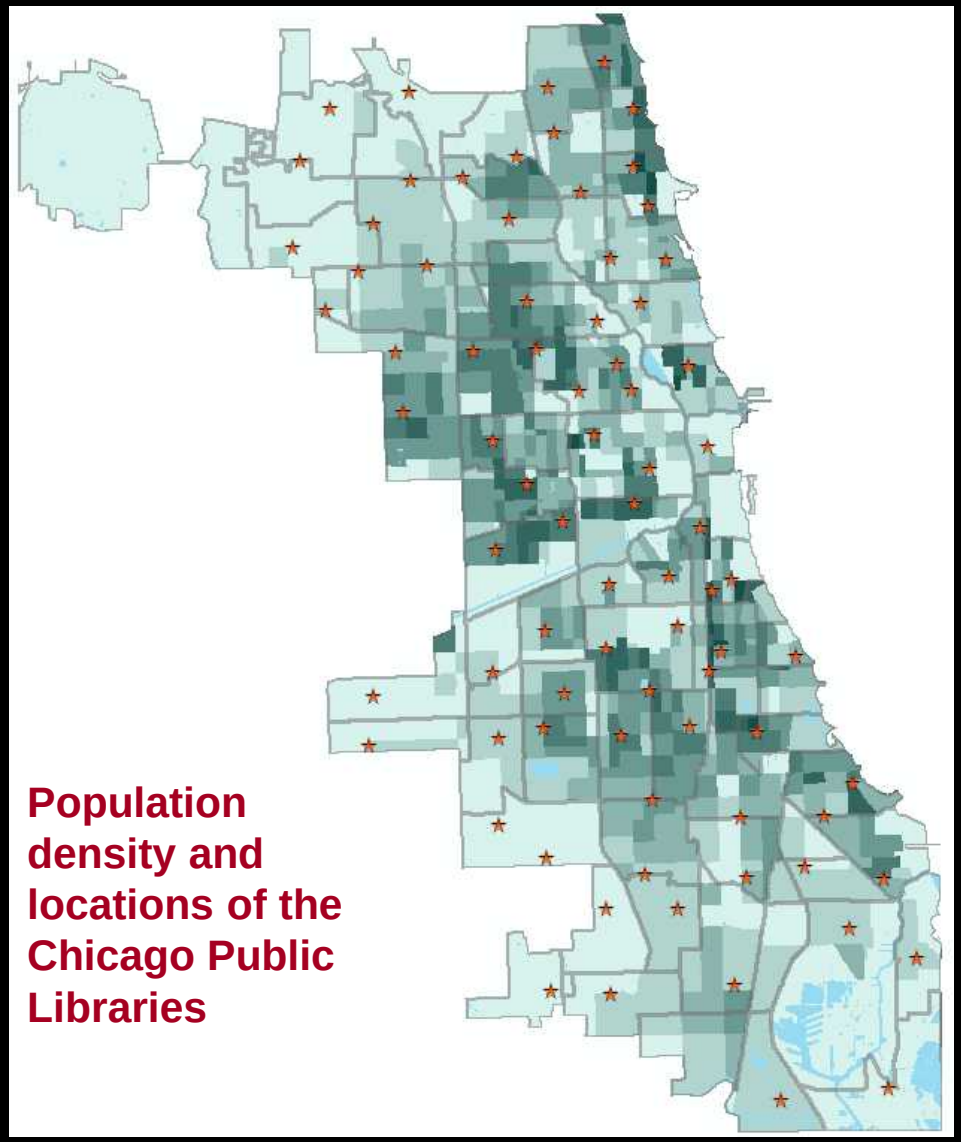
GIS Ex: Patterns – historical/trend

- Trend
  - Changes over time using historical (time-series) data



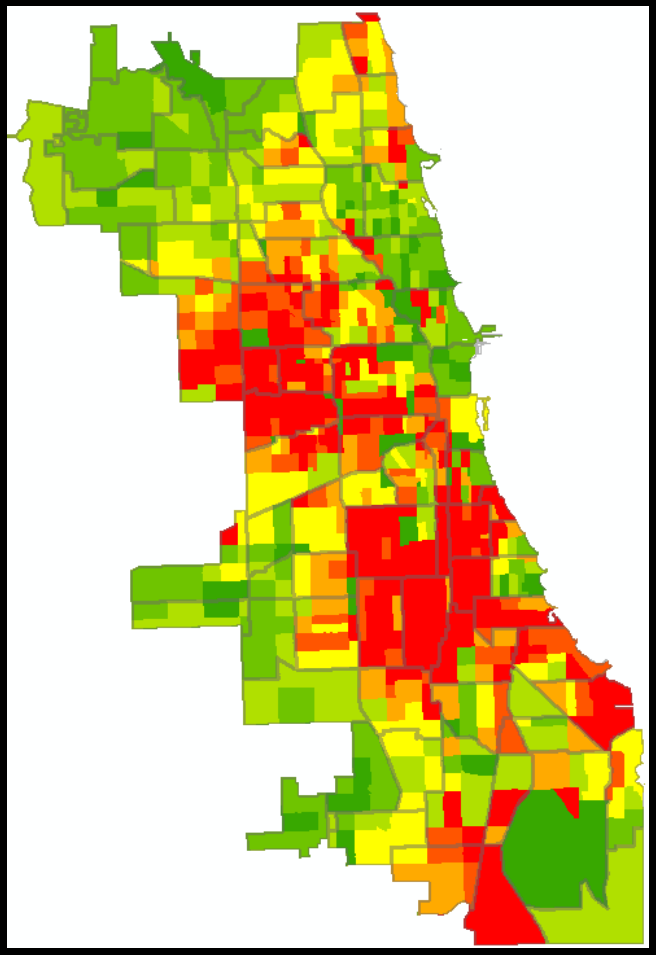
Example: Relationship

- Association
  - Demography x Libraries
  - Are there enough libraries to serve local residents?

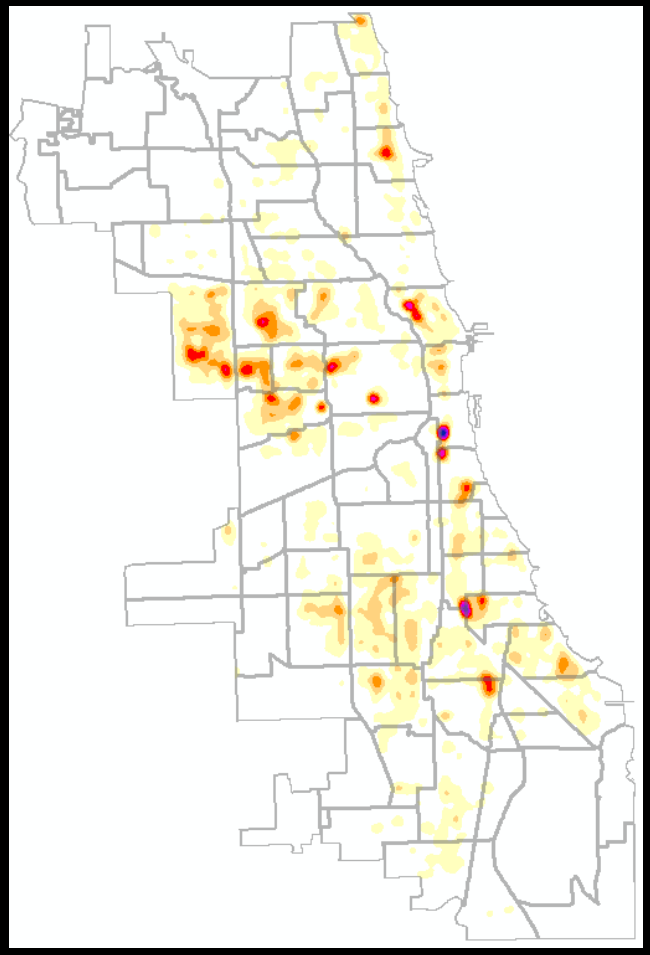


Population density and locations of the Chicago Public Libraries

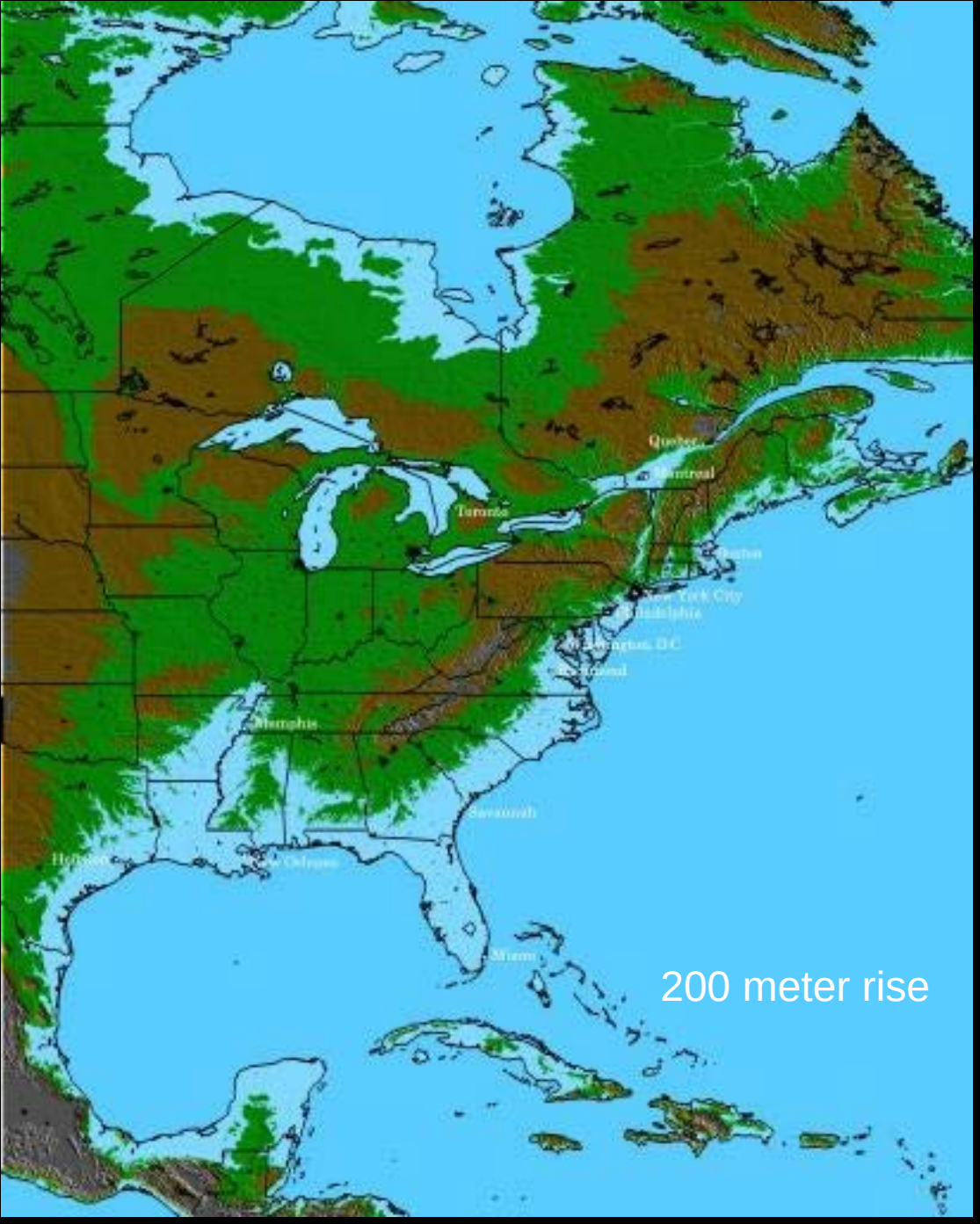
Example: Associations



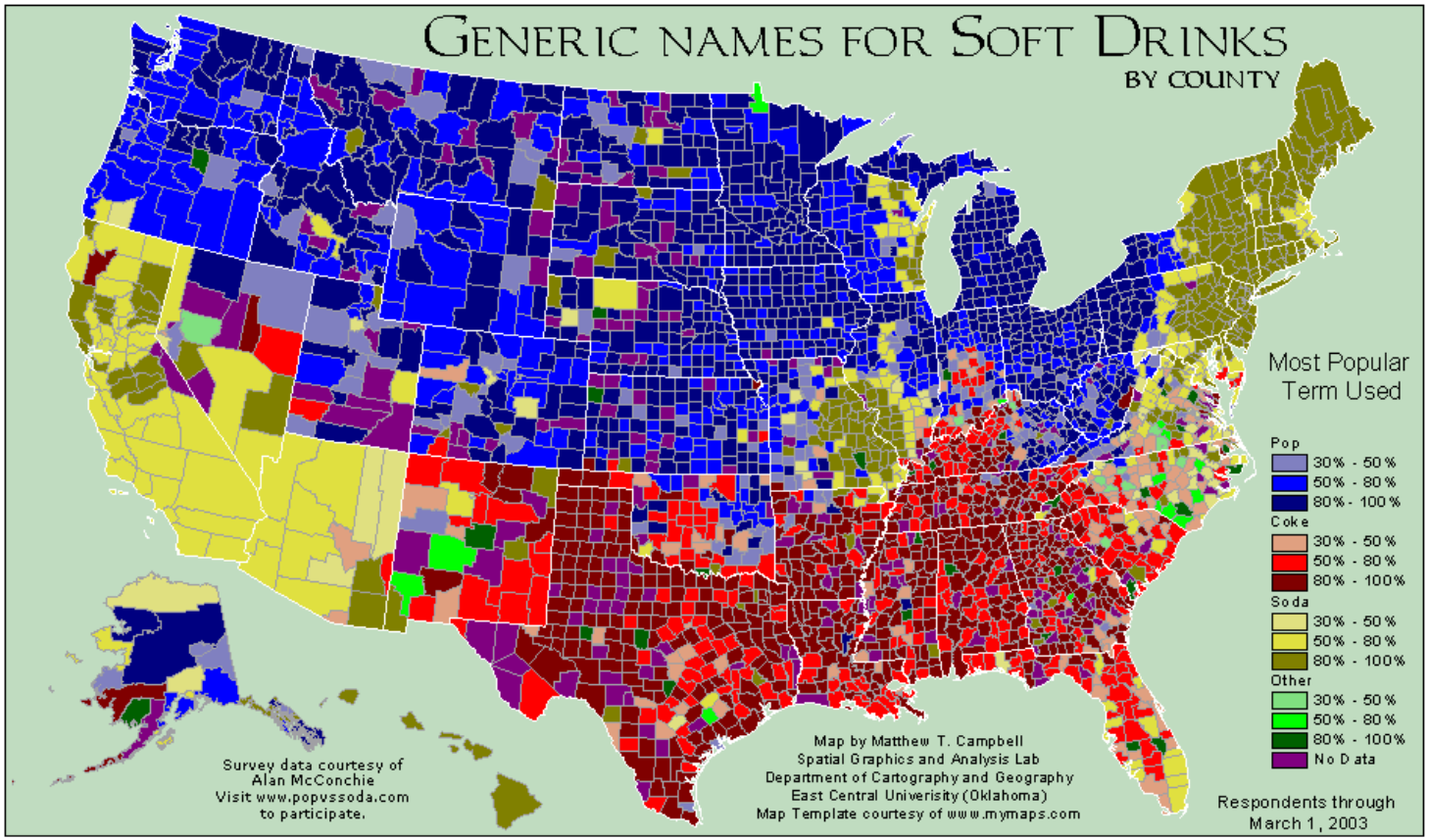
% families below poverty level



Crime hotspots

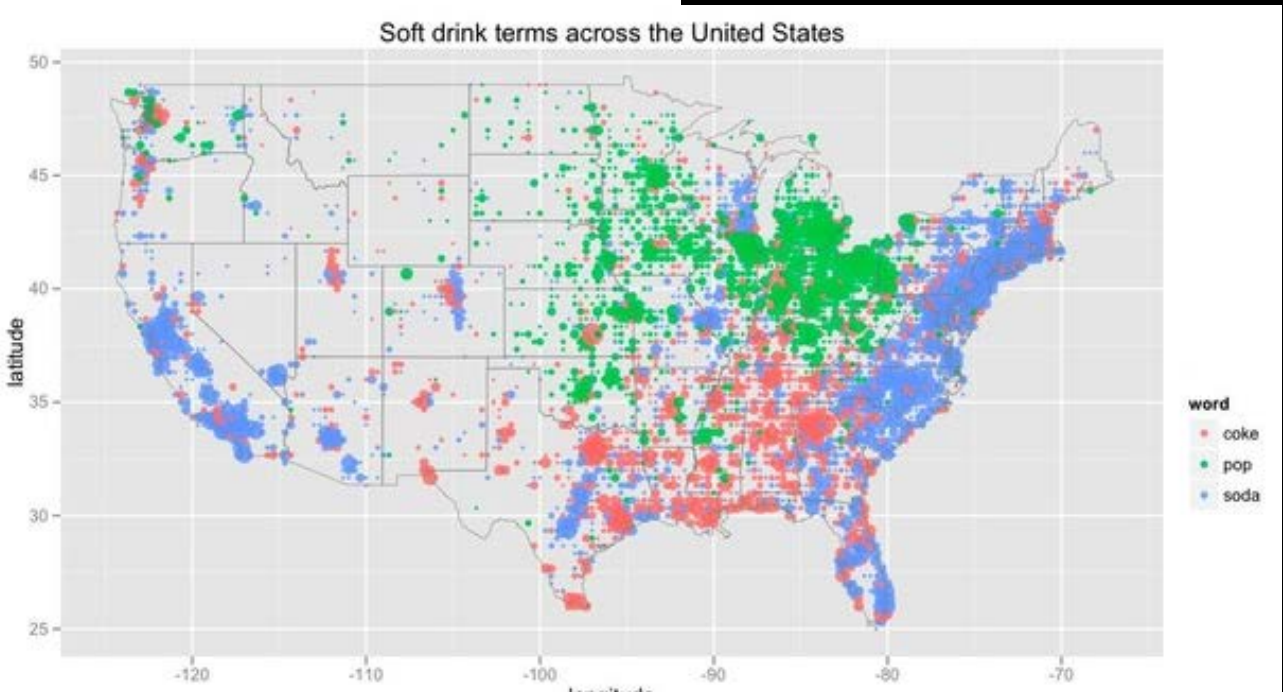


Areas impacted by sea-level rise

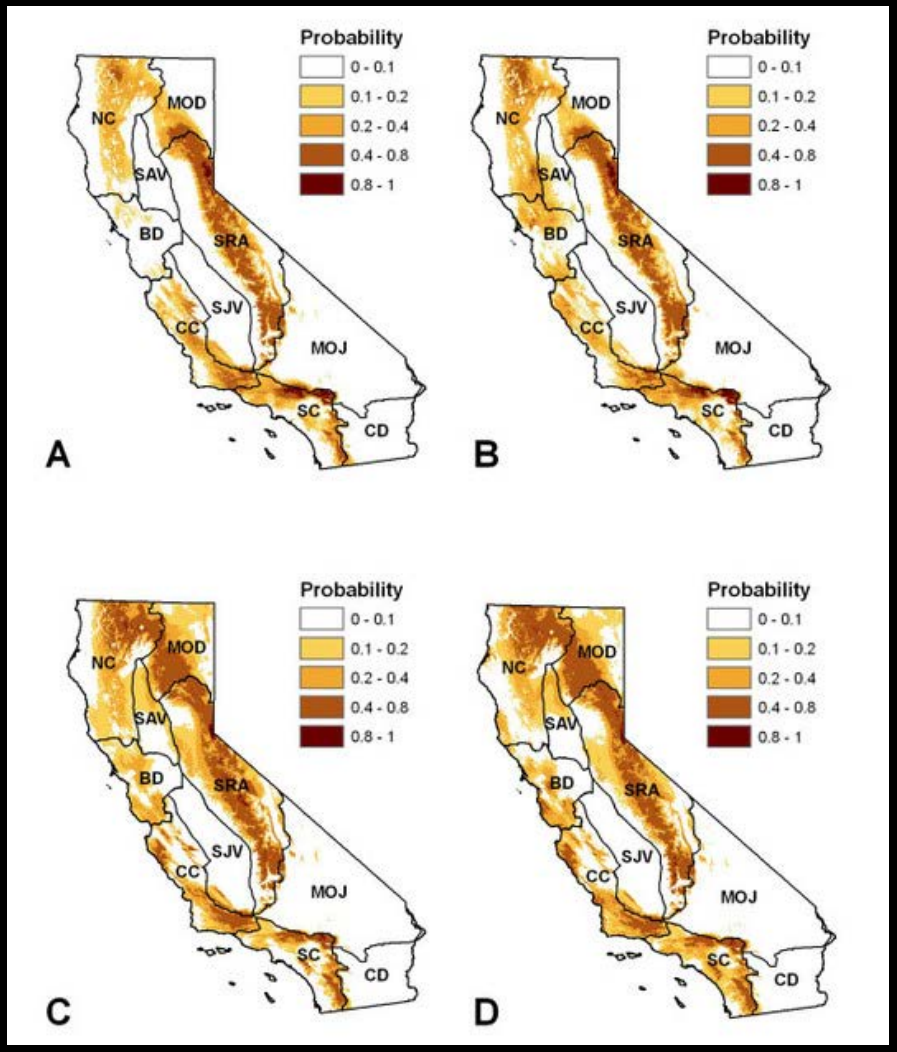


Geographers have even analyzed the distribution of generic names for soft drinks by US county

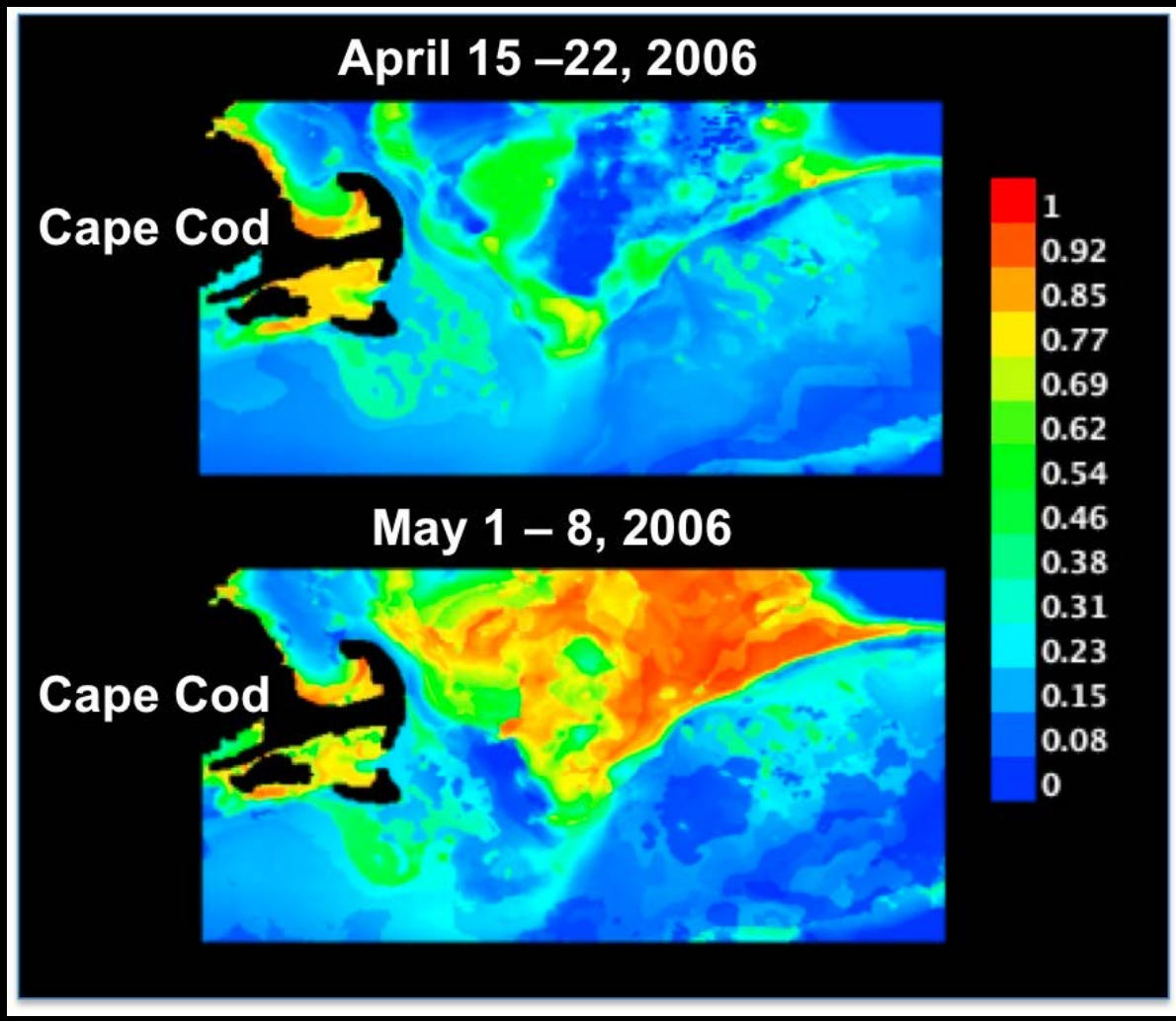
Same analysis, but done via geotagged tweets mentioning one of the key words



Predictive Modeling

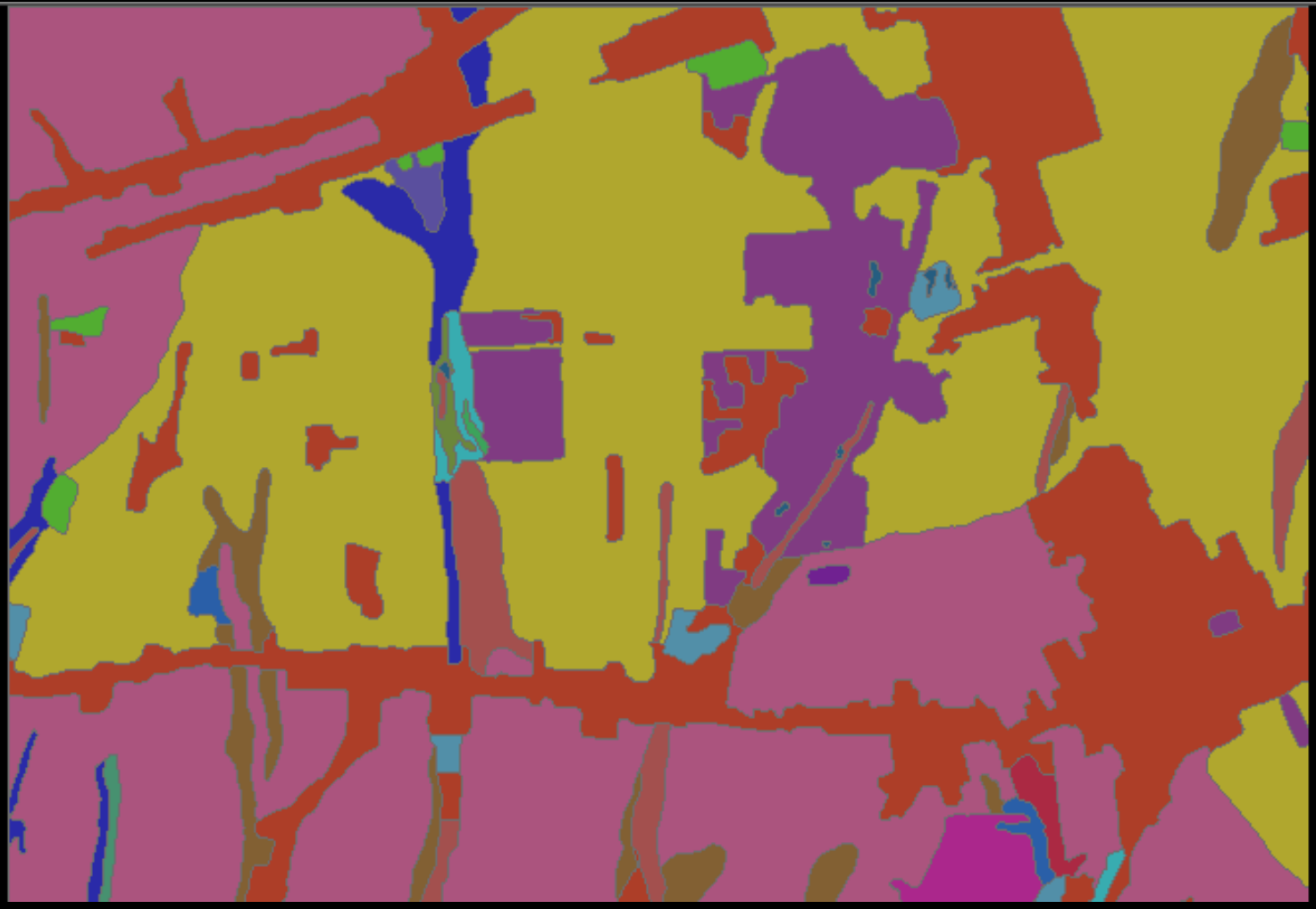


Models of plague activity in California ground squirrels
Used to identify potential plague risk areas based on future climate scenarios



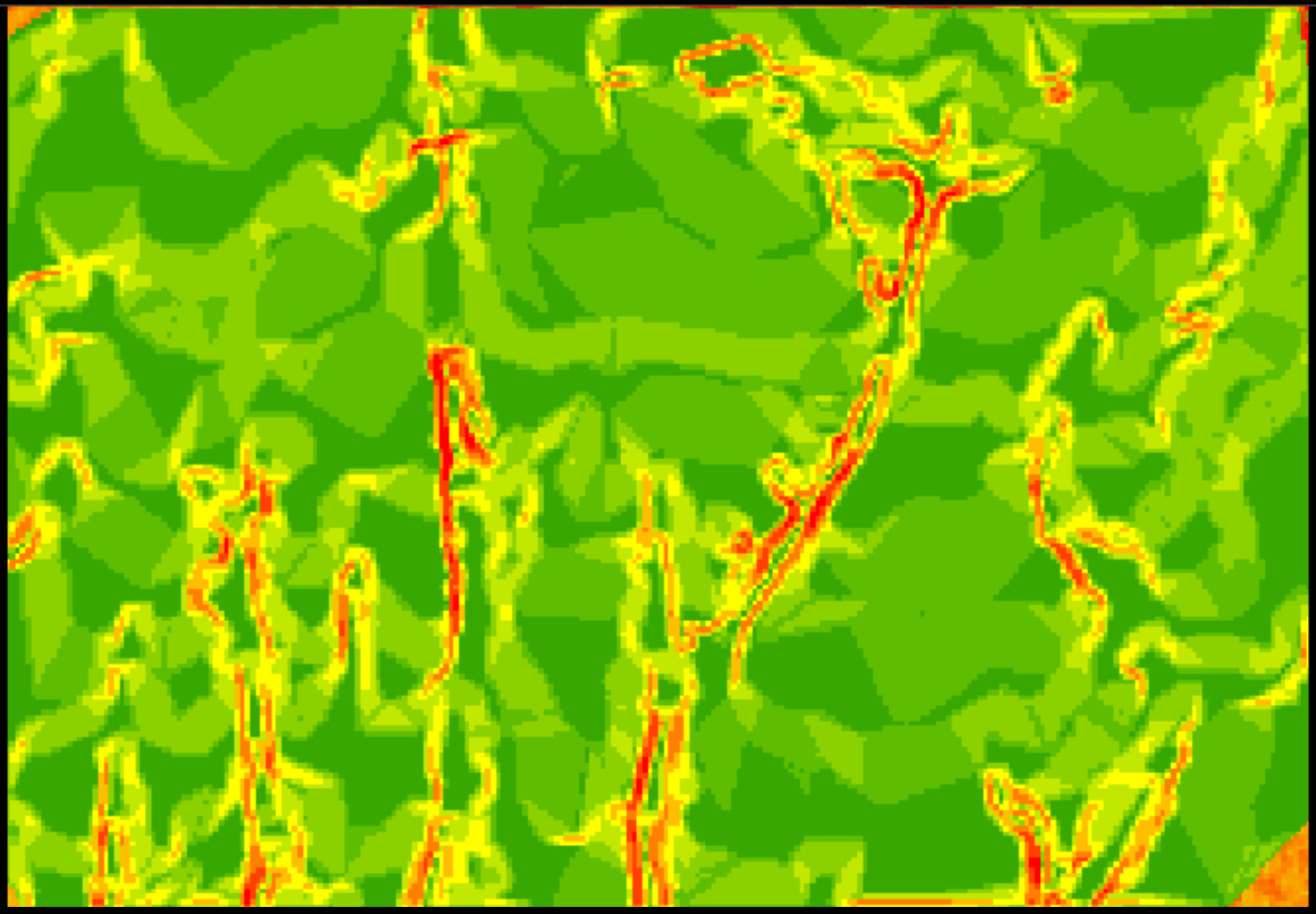
Prediction of likely right whale locations off of Cape Cod

Prediction and Modeling: Erosion Risk



Input Data 1. Soils

Prediction and Modeling: Erosion Risk



Input Data 2. Slope

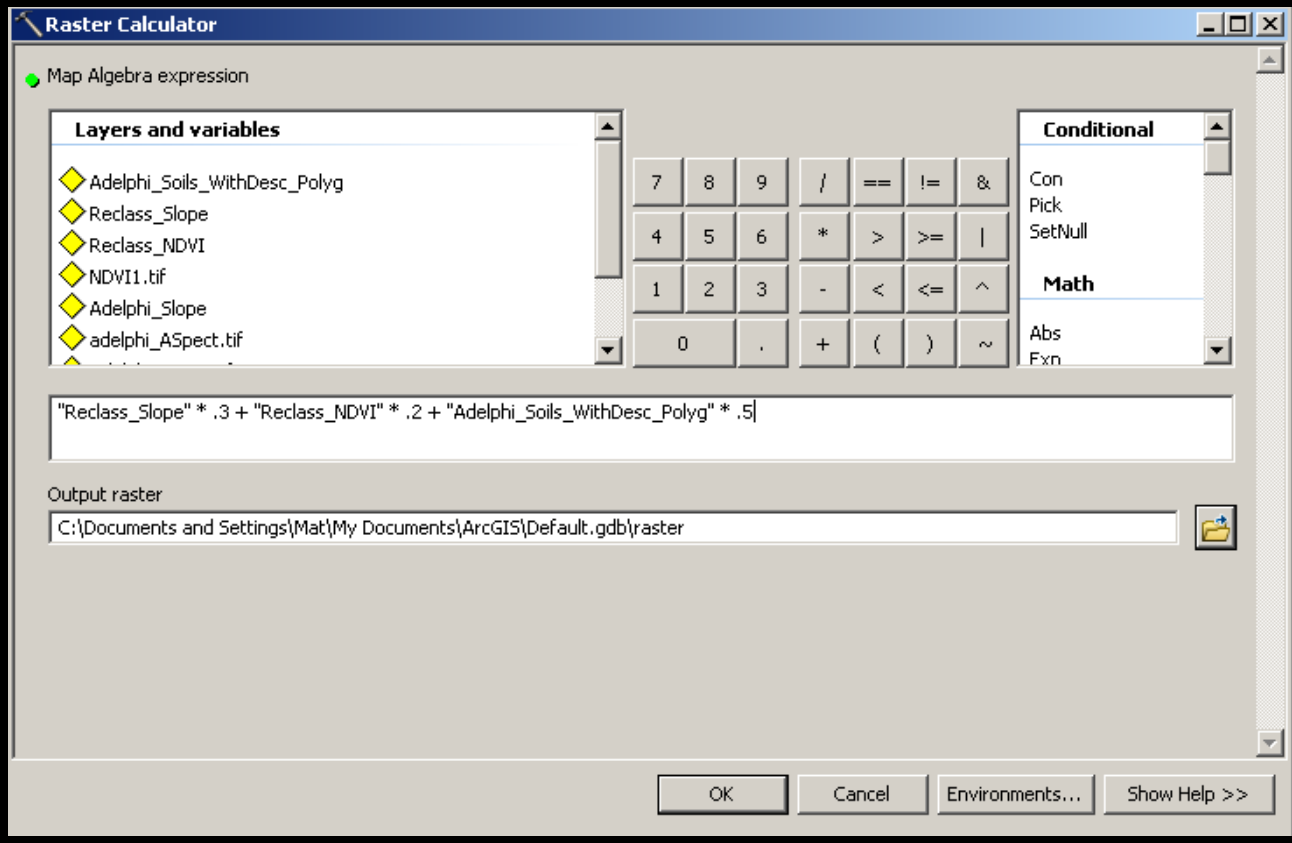
Prediction and Modeling: Erosion Risk

Input Data 3: Vegetation Density (NDVI)

Complex Calculation: Erosion Risk

Erosion risk model

30 %: Slope
20 %: Vegetation
50 %: Soils



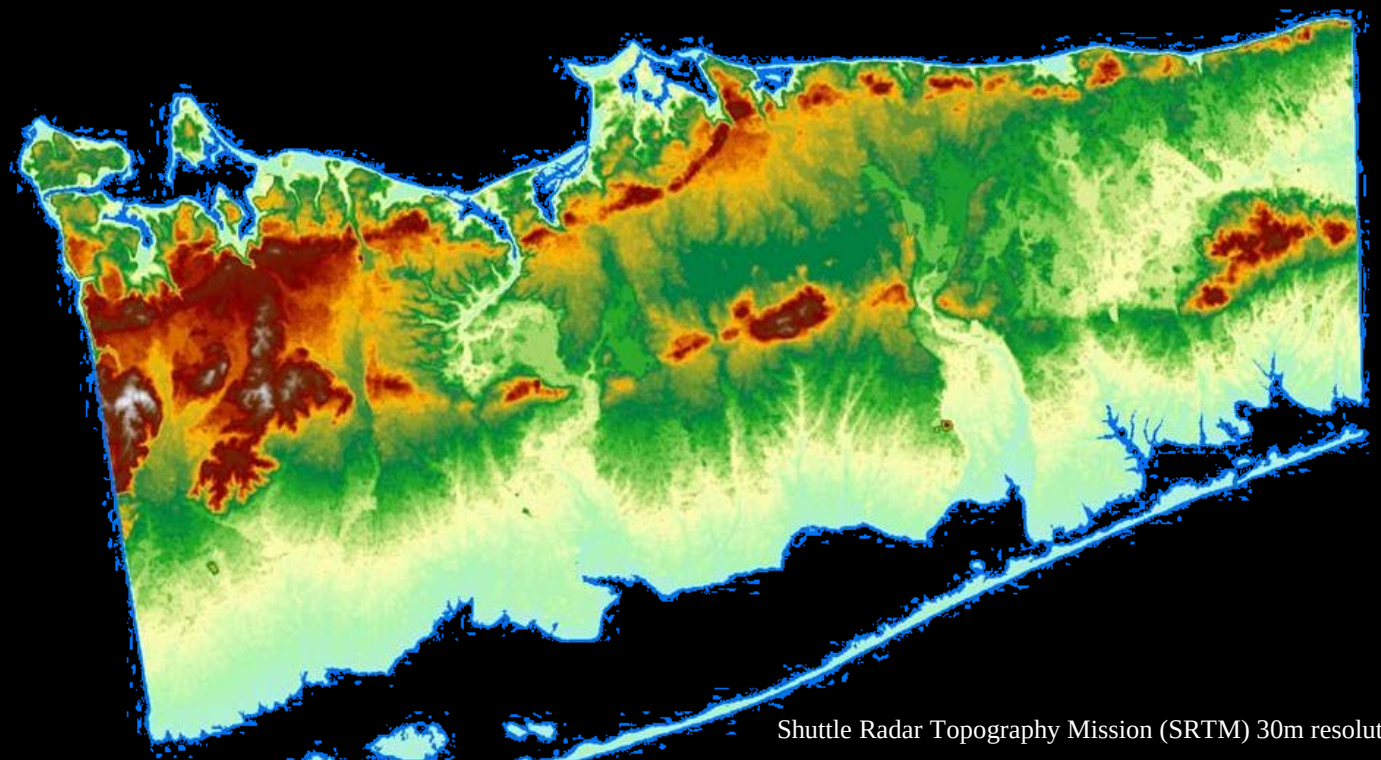
Use GIS tools to weight each factor and create a single layer representing erosion risk

Complex Calculation: Erosion Risk

Final map: Erosion risk is ranked from 1 – 10

Digital Elevation Model (DEM)

- Type of raster where the pixel value corresponds to elevation
- Used for analyzing slope, waterflow, visibility, etc.



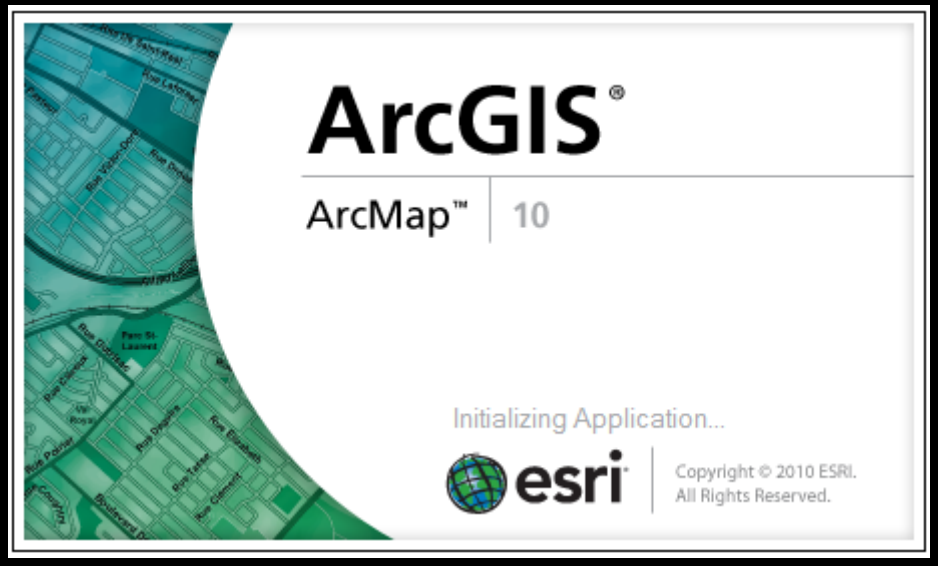
Shuttle Radar Topography Mission (SRTM) 30m resolution

GIS software and analytical tools

GIS Software

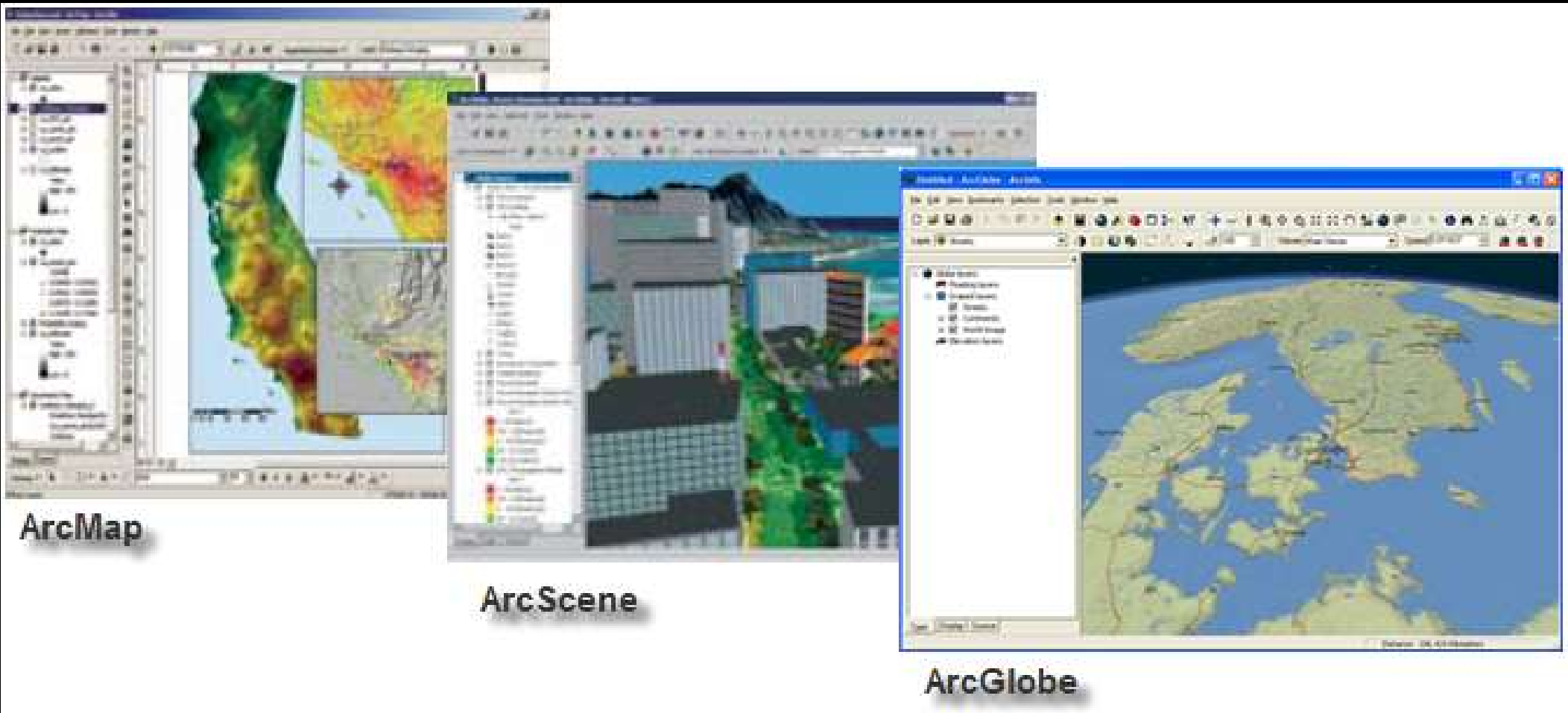
GRASS:
Open source GIS

Quantum GIS:
Open source GIS

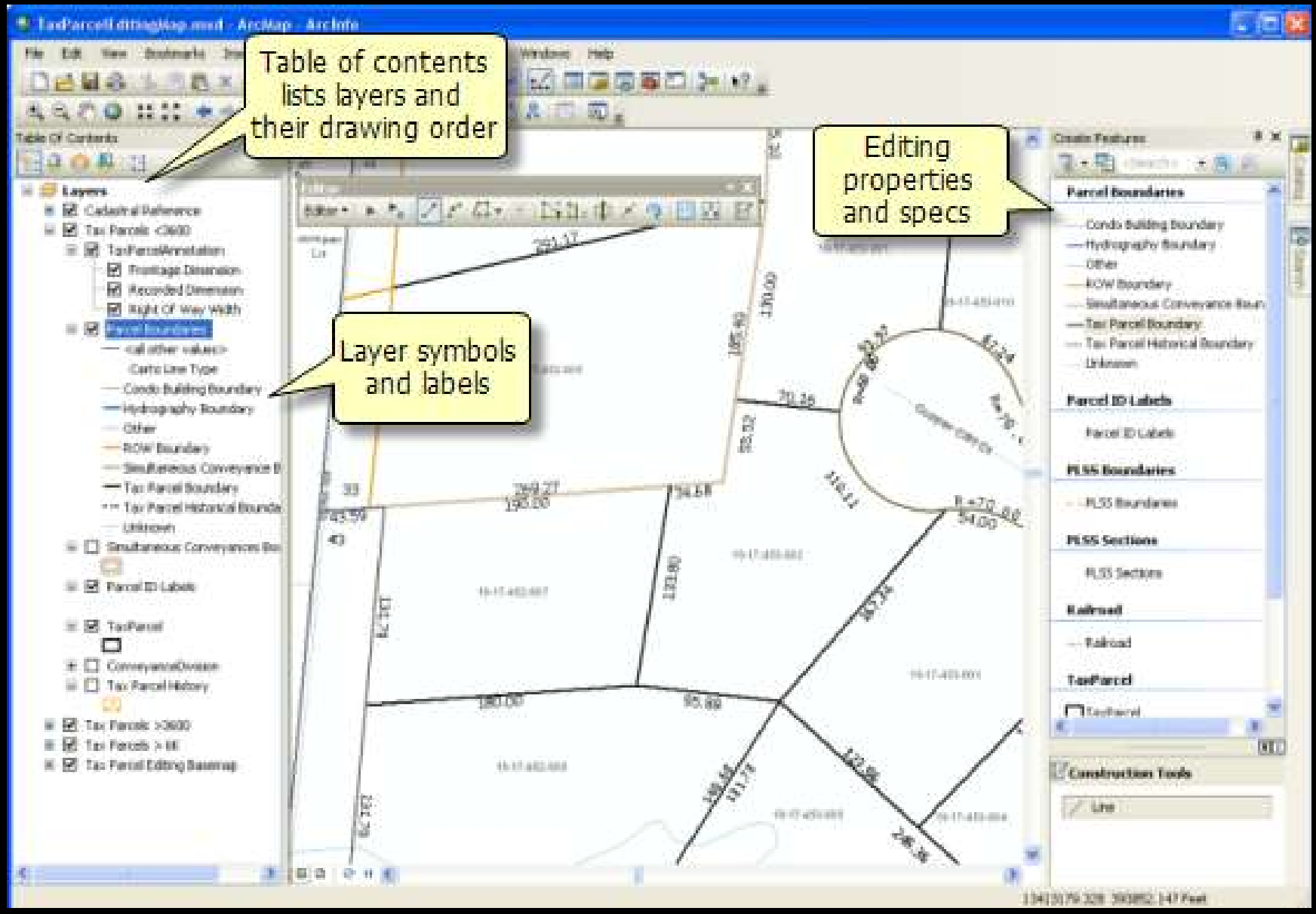


ArcInfo GIS:
Proprietary, industry standard, GIS package

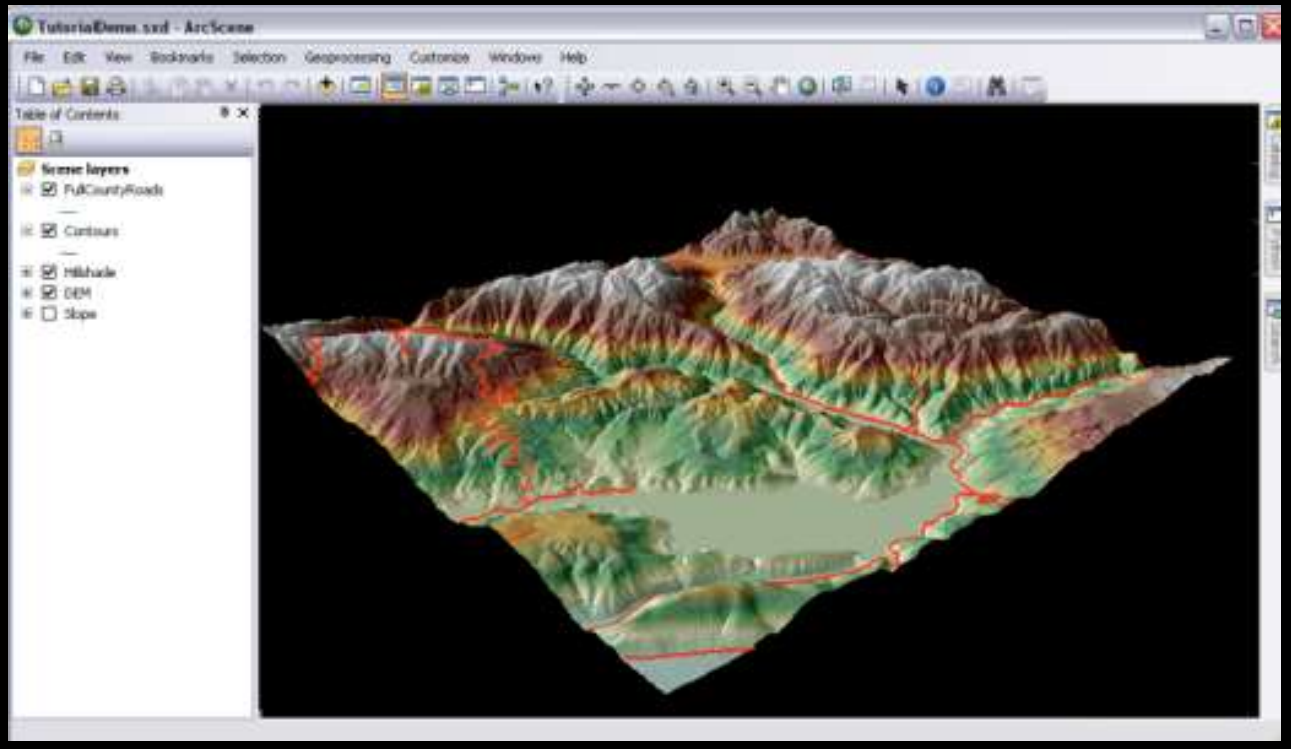
ArcGIS 10.1

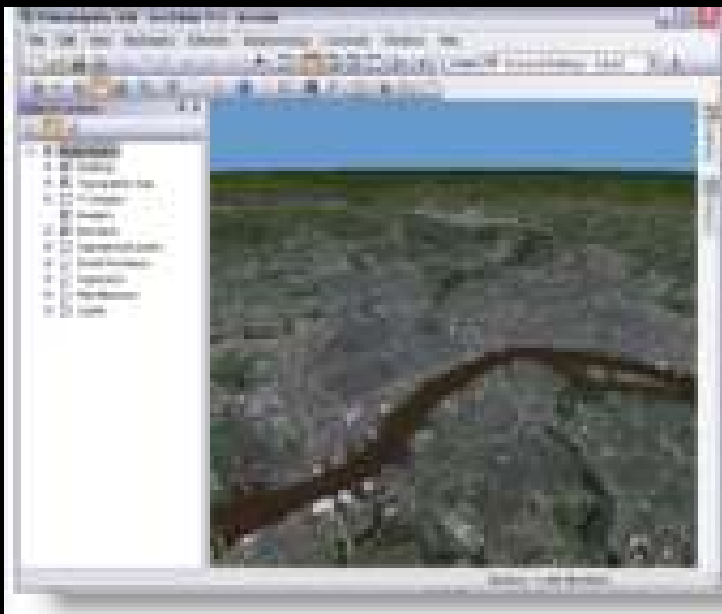


2d Visualization
ArcMap

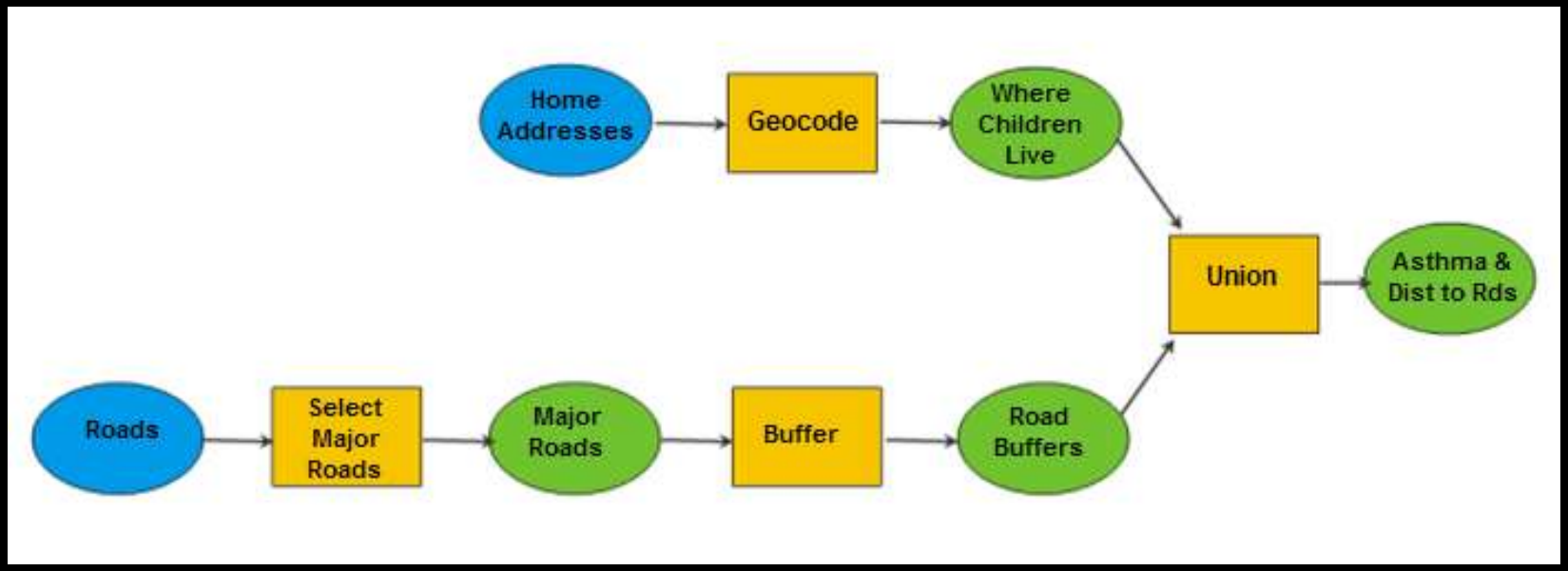


3d Visualization
ArcScene and ArcGlobe





Model building and Scripting



reproject.py - C:\Documents and Settings\Mat\Desktop\reproject.py

File Edit Format Run Options Windows Help

```
# ---------------------------------------------------------------------------
# reproject.py
# Created on: Thu Aug 19 2010 10:50:06 AM
#   (generated by ArcGIS/ModelBuilder)
# ---------------------------------------------------------------------------

# Import system modules
import sys, string, os, arcgisscripting

# Create the Geoprocessor object
gp = arcgisscripting.create()

# Load required toolboxes...
gp.AddToolbox("C:/Program Files/ArcGIS/ArcToolbox/Toolboxes/Data Management Tool


# Local variables...
output = "Y:\\OpenProjects\\Dissertation\\GISData\\DataSourceBackups\\RandyScans
inputS = "Y:\\OpenProjects\\Dissertation\\GISData\\DataSourceBackups\\RandyScans
gp.ProjectRaster_management(inputS, output, "PROJCS['WGS_1984_UTM_Zone_31N',GEOG
```

GIS resources in the library

- Center for Digital Scholarship
  - Bank of 8 computers with extensive GIS software
    - ESRI ArcGIS
    - DIVA-GIS
    - GRASS
    - Quantum GIS
    - Google Earth Professional
  - 42” sheet-feed map scanner
  - 8 baseline GPS units and 2 high-end data collectors

GIS resources in the library

- Staff
  - **Matthew Sisk (CDS)**: General GIS questions, Data acquisition and management, Satellite imagery analysis
  - **Milan Budhathoki (CRC)**: Industry GIS, Vector analysis, GIS Analysis