



GIS for Actuaries Part 1 CAS RPM 2016

Garrett Bradford
March 15, 2016

GIS for Actuaries Workshop Outline

- I. Introduction to GIS: the basics
- II. Geocoding, Uncertainty, and
GIS Data Sources
- III. Spatial Analysis and GIS Workflows

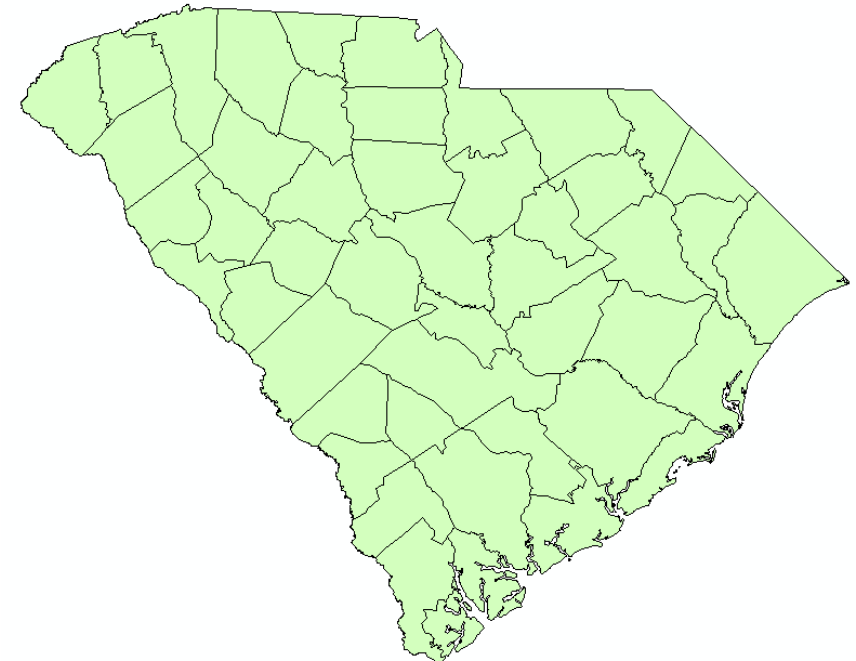
Introduction to GIS: the basics

- Science versus Systems
- GIS Applications
- Data types
- Coordinate Systems and Projections
- Data sources
- Assignment 1

Geographic Information Systems (GIS)

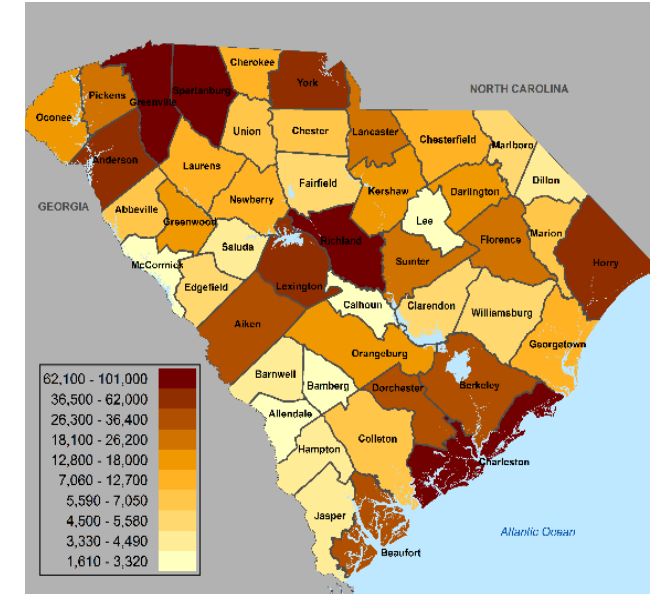
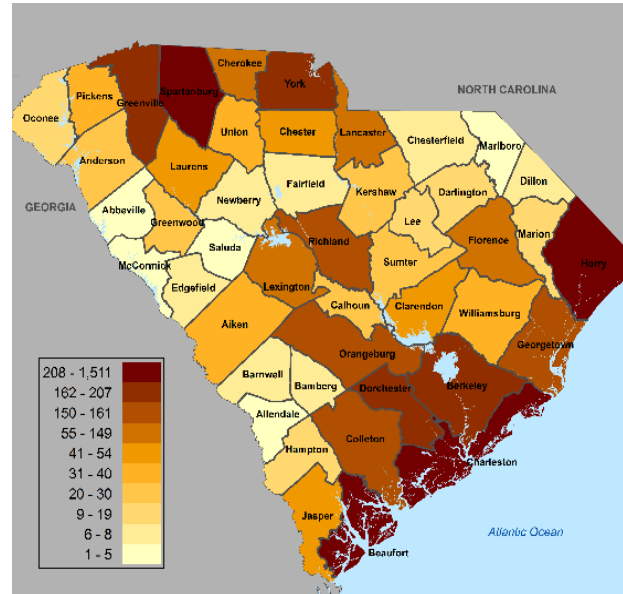
- GIScience: “the science behind the systems”
- GISystems are used to capture, store, edit, analyze, and present geographic data

OBJECTID *	county *	Owner_SF_detached	policies	quotes
1	ABBEVILLE	5859	1	19
2	AIKEN	35926	37	174
3	ALLENDALE	1610	1	14
4	ANDERSON	43918	30	141
5	BAMBERG	3125	7	56
6	BARNWELL	3911	8	29
7	BEAUFORT	36393	629	11633
8	BERKELEY	35246	198	3427
9	CALHOUN	3317	29	170
10	CHARLESTO	71596	743	11770
11	CHEROKEE	9926	146	571
12	CHESTER	7047	45	142
13	CHESTERFIE	8191	6	37
14	CLARENDON	5575	54	350



Combining actuarial data with GIS

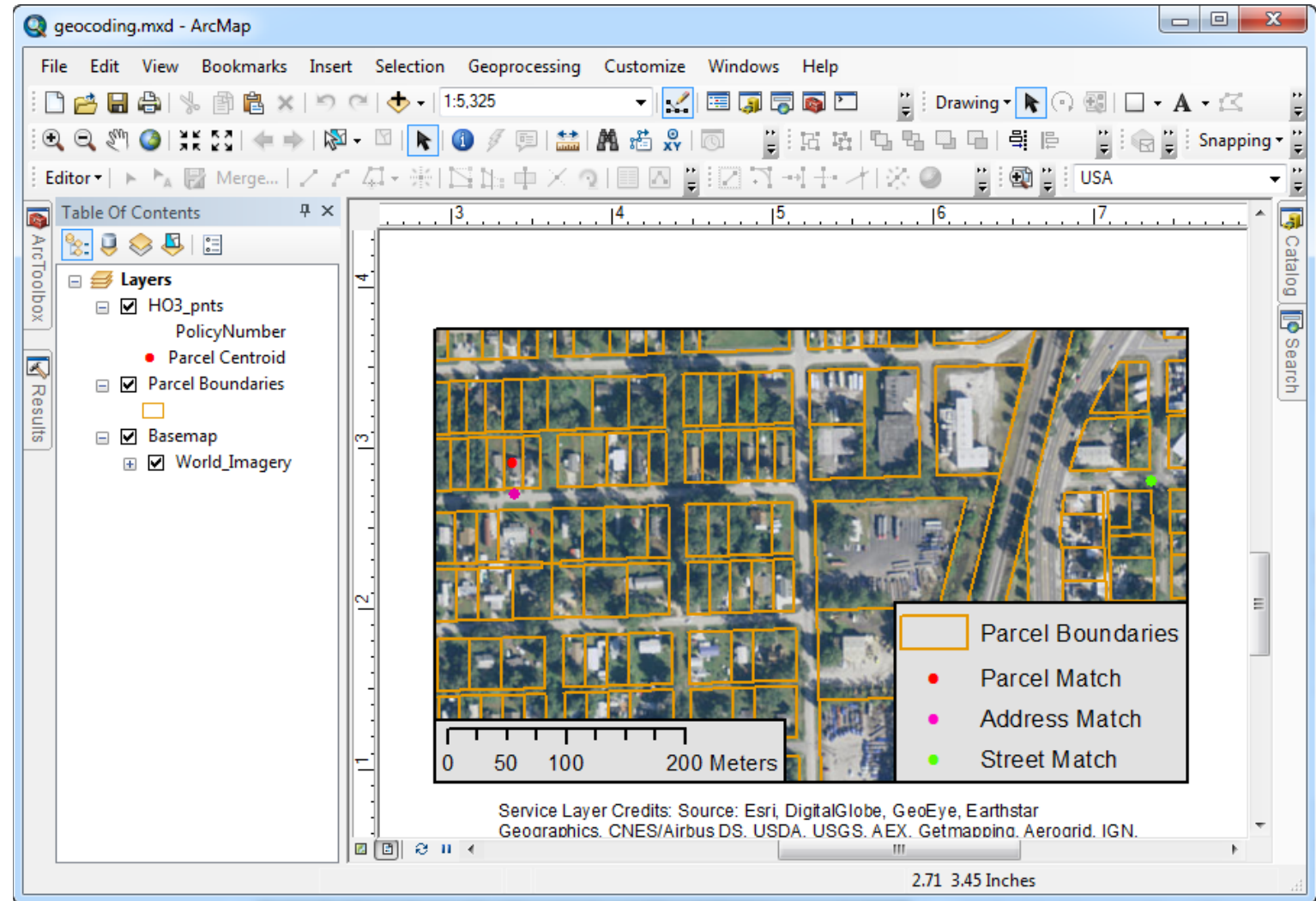
- Existing geographies:
 - territory, county, etc.
- Identifying new characteristics
 - Geocoding, joining on third-party data
- Spatial analysis:
 - Grouping and spatial statistics
 - Distance calculations



Comparison of example company's HO-3 in-force policy distribution (left) with estimate of total single family homes by county (right).

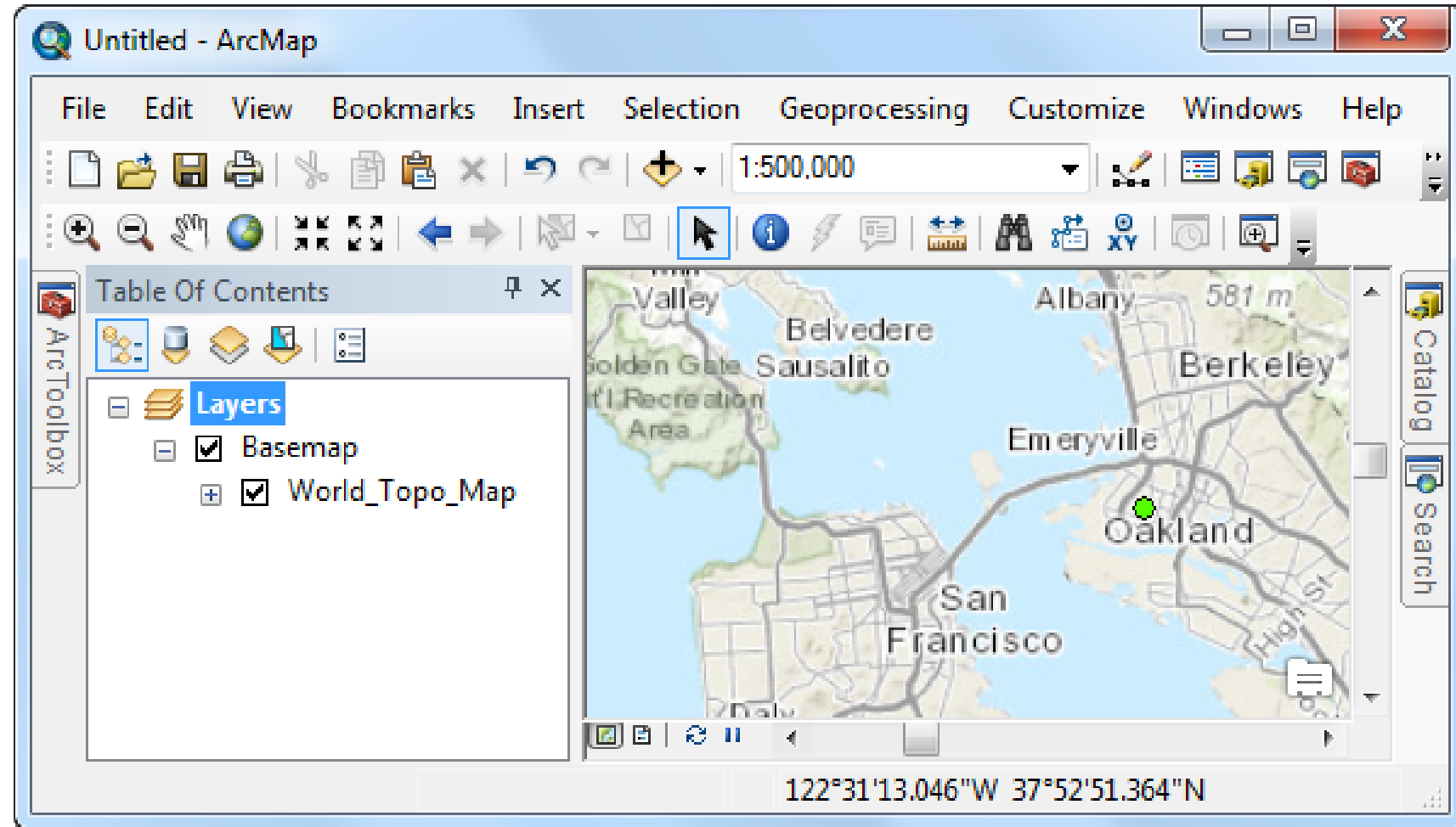
GIS Applications

- Desktop GIS applications:
 - **ESRI's ArcMap**
 - GRASS, QGIS, ERDAS...
 - R, SAS, SQL
- Web applications:
 - ArcGIS Online
 - CartoDB
 - Leaflet



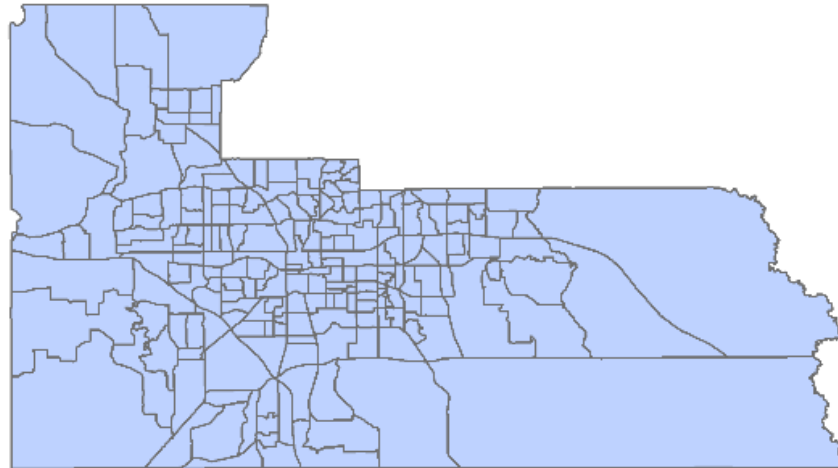
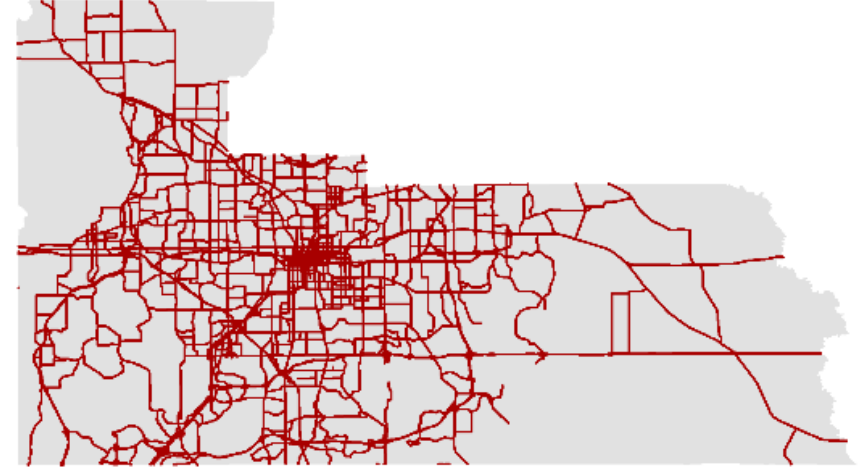
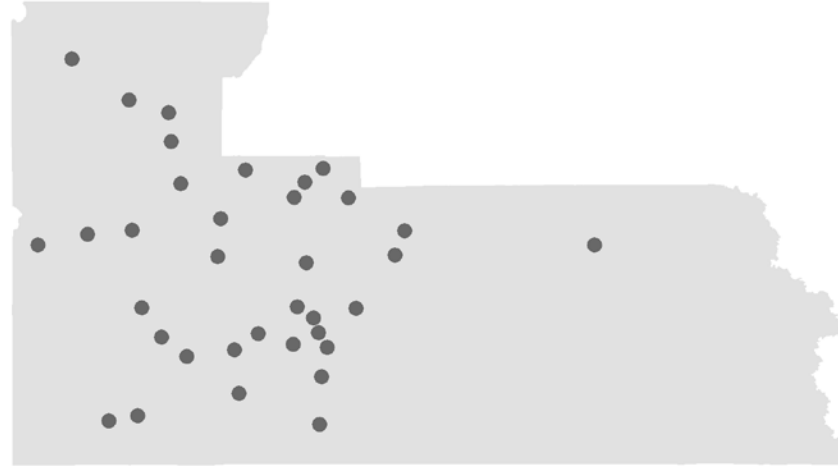
ArcGIS Desktop

- Table of Contents
 - All data in map document (.mxd)
 - Data frames, layers, etc.
- ArcToolbox
 - Geoprocessing tools
- Catalog
- Search
- Map tools
 - Zoom, pan...
- Customize
 - Add or remove tool bars



Data Types

- Point
- Line
- Polygon
- Raster



Data Types - Vector

Node	X	Y
1	-81.420841	28.482257

Node	X	Y
1	-81.420422	28.482211
2	-81.420890	28.482214

Node	X	Y
1	-81.420560	28.482554
2	-81.420559	28.482279
3	-81.420752	28.482278
4	-81.420753	28.482553



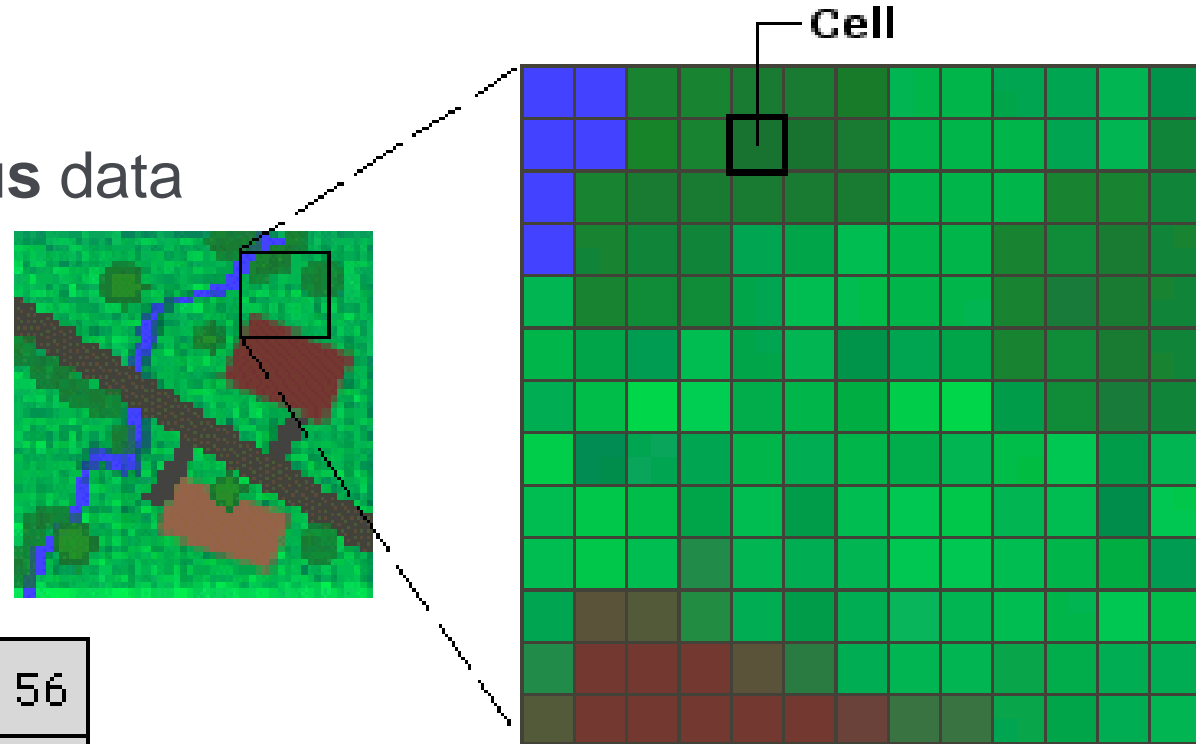
Data Types - Raster

- Matrix of values
- Used for both **thematic** and **continuous** data

```
ncols      5
nrows     5
xllcorner 52668.03
yllcorner 59382.65
cellsize   250
```

```
1 1 2 5 6
3 2 1 2 3
4 2 1 4 2
0 1 2 1 2
```

80	74	62	45	45	34	39	56
80	74	74	62	45	34	39	56
74	74	62	62	45	34	39	39
62	62	45	45	34	34	34	39
45	45	45	34	34	30	34	39

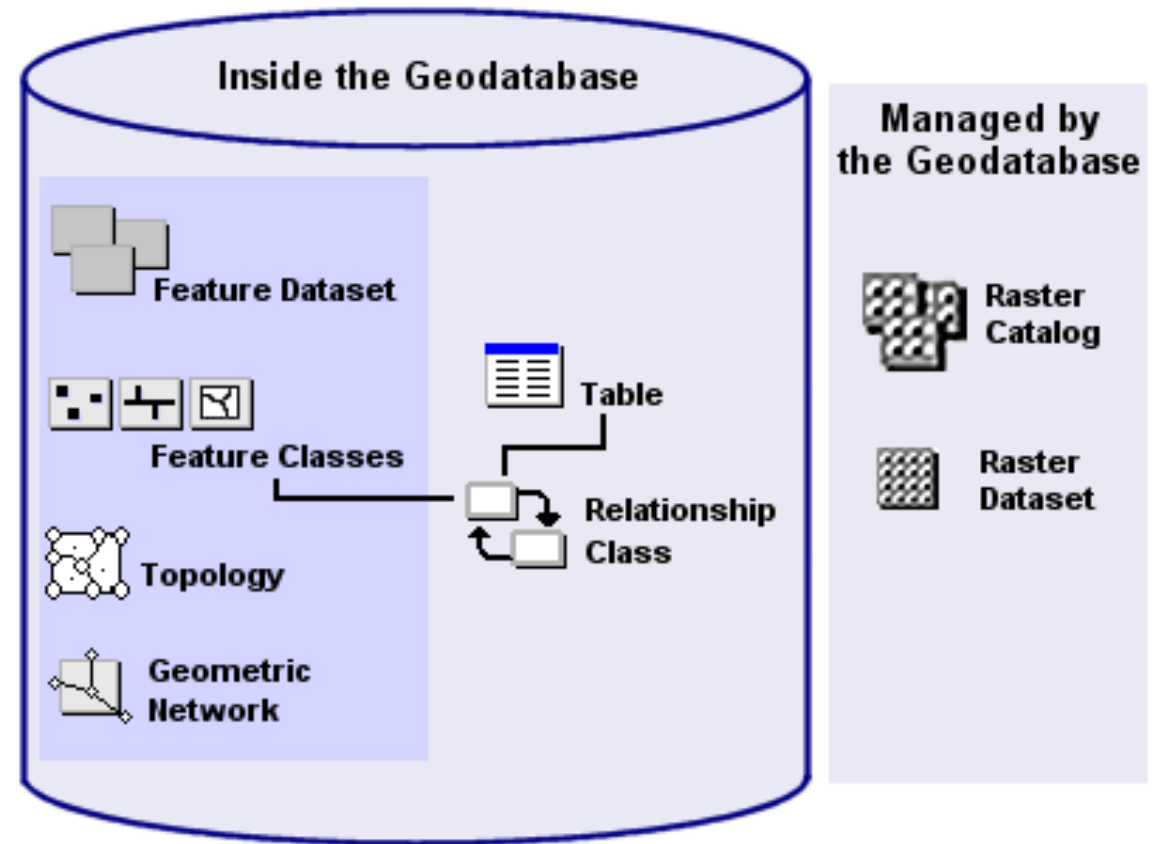
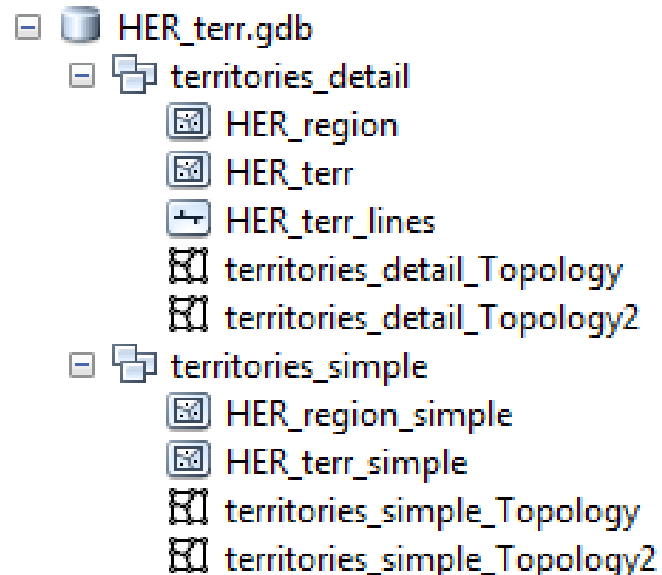


Images from ESRI ArcGIS Desktop Help

<http://resources.arcgis.com/en/help/>

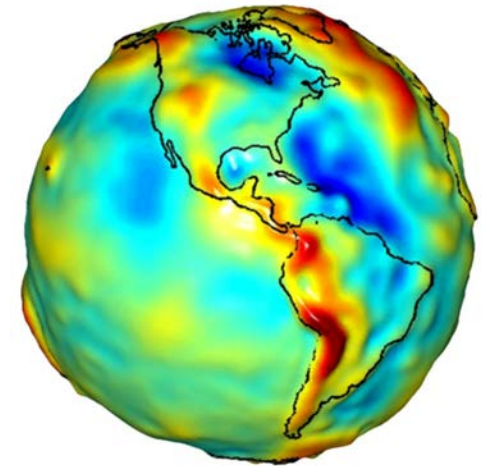
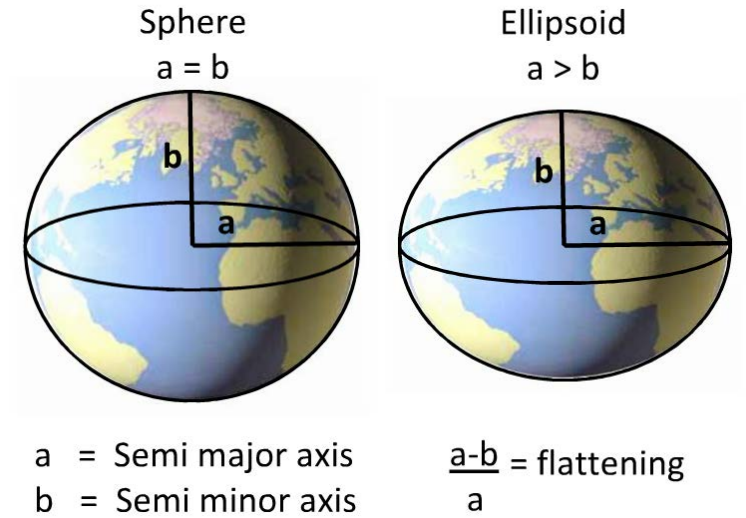
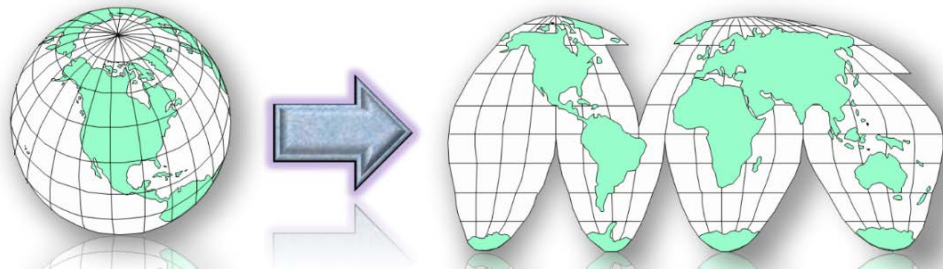
Data Formats

- Geodatabase
- Shapefiles (vector based)
- Rasters (pixel based)
- Others:
 - geoJSON
 - SQL geography/geometry



Coordinate Systems and Projections

- Geodesy: the measurement and representation of the Earth
- Earth is an ellipsoid, mostly
- The geoid: the 3D surface along which the pull of gravity is a specified constant
- Datums define point on the Earth's surface in terms of latitude and longitude
 - North American Datum of 1983 (NAD83)
 - World Geodetic System of 1984 (WGS84)
- Map projections: representing the Earth on a 2D map



Images NOAA eLearning module

https://coast.noaa.gov/digitalcoast/_/elearning/datums

Coordinate Systems in ArcGIS

Data Frame

Projected Coordinate System:
Albers Conical Equal Area
Projection: Albers
False_Easting: 400000.00000000
False_Northing: 0.00000000
Central_Meridian: -84.00000000
Standard_Parallel_1: 24.00000000
Standard_Parallel_2: 31.50000000
Central_Parallel: 24.00000000
Linear Unit: Meter

Geographic Coordinate System:
GCS_North_American_1983_HARN
Datum:
D_North_American_1983_HARN
Prime Meridian: Greenwich
Angular Unit: Degree

660561.829 3517.912 Meters

ArcToolbox

- Data Interoperability Tools
- Data Management Tools
 - Archiving
 - Attachments
 - Data Comparison
 - Distributed Geodatabase
 - Domains
 - Feature Class
 - Features
 - Fields
 - File Geodatabase
 - General
 - Generalization
 - Geodatabase Administration
 - Geometric Network
 - Graph
 - Indexes
 - Joins
 - LAS Dataset
 - Layers and Table Views
 - Package
 - Photos
 - Projections and Transformations**
 - Raster
 - Batch Project
 - Convert Coordinate Notation
 - Create Custom Geographic Transform
 - Create Spatial Reference
 - Define Projection
 - Project

Geocoding, Uncertainty, and GIS Data Sources

- Geocoding and location level data
- Data sources, scale, and topology
- Assignment 2

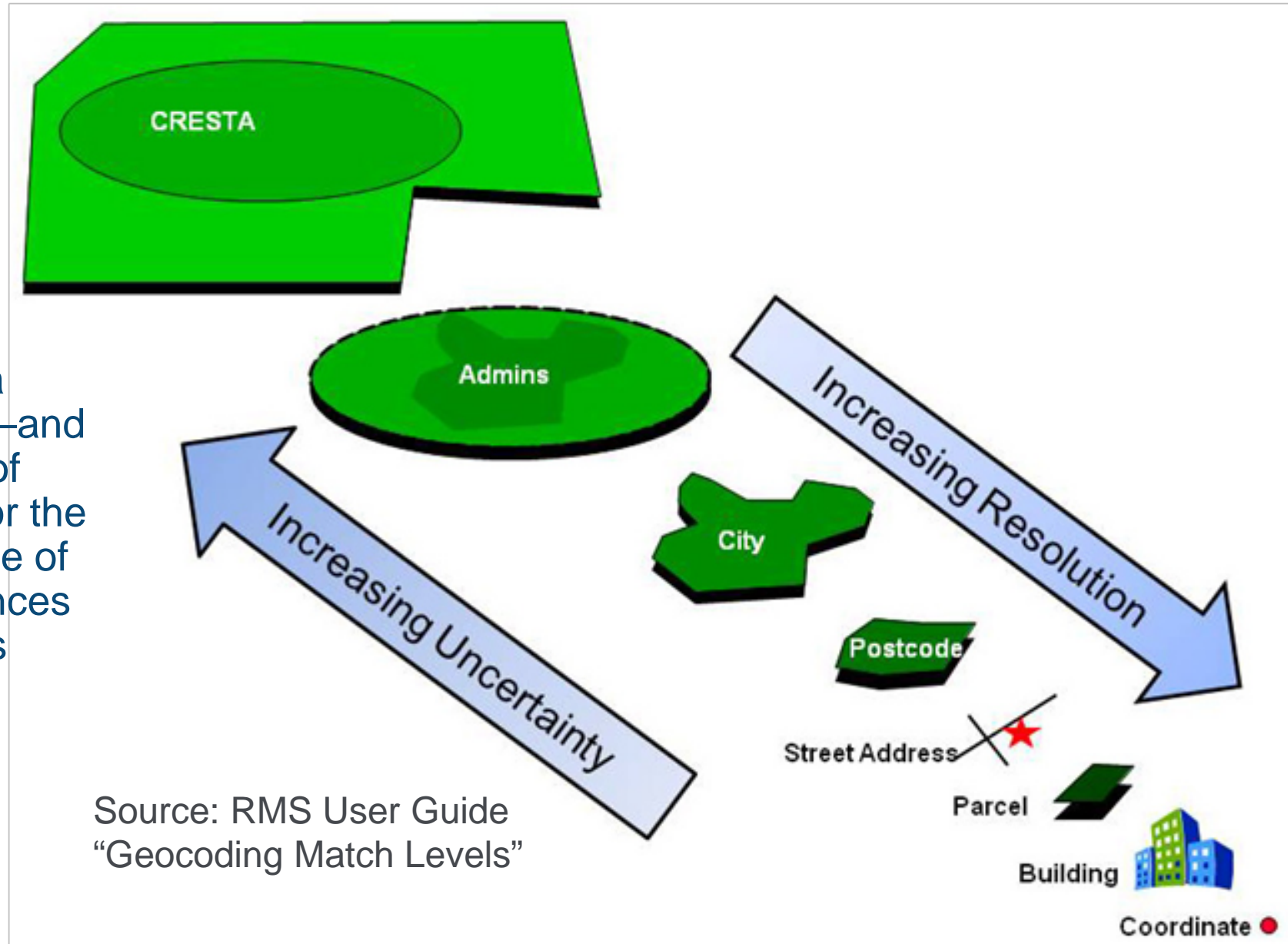
Geocoding and Location Level Data

- Geocoding: attaching a location or lat/lon to a record
- Often occurs in the catastrophe modeling process
- Every geocoder should also provide a match score and/or match type
 - Examples:
 - Parcel Point
 - Address Point
 - Address Range
 - Street Name
 - Postal Code

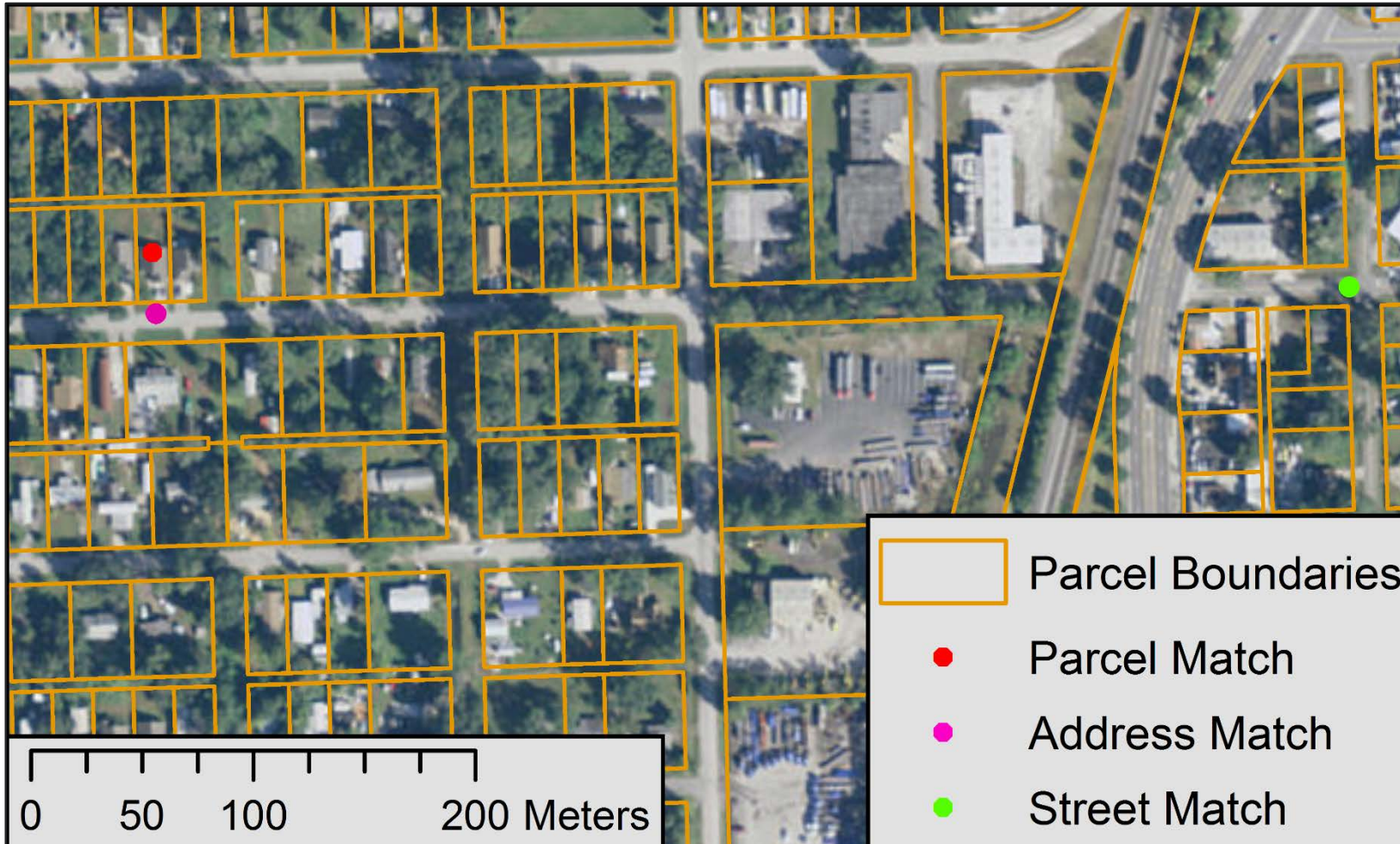
PHYADDR1	221 CORNER TREE CT	5319 HANSEL AVE APT E5	752 RIDENHOUR CIR	Input Fields
PHYCITY	ORLANDO	ORLANDO	ORLANDO	
PHYST	FL	FL	FL	
PHYZIP	32820	32809	32809	
LOC_NAME	StreetName	StreetAddress	PointAddress	Output Fields
MATCH_ADDR	Corner Tree Ct, Orlando, Florida, 32820	5319 Hansel Ave, Orlando, Florida, 32809	752 Ridenhour Cir, Orlando, Florida, 32809	
LAT	28.571006	28.482046	28.453134	
LON	-81.131031	-81.37137	-81.38701	

Geocoding and Location Level Data

“...the precision of a geocoded address—and hence the retrieval of hazard conditions for the location—can be one of the strongest influences on damage and loss results.”



Geocoding and Location Level Data



Distance from Parcel Centroid:

- Address Point:
25 m
- Street Point:
550 m
- Postal Point (not shown):
4 km

Geocoding and Location Level Data

Location	County	City	Match Type	Hurricane AAL
1	ORANGE	ORLANDO	Parcel	\$ 392.04
1	ORANGE	ORLANDO	Street	399.73
1	ORANGE	ORLANDO	City	384.88
2	BREVARD	MELBOURNE	Parcel	553.21
2	BREVARD	MELBOURNE	Street	603.85
2	BREVARD	MELBOURNE	City	650.16

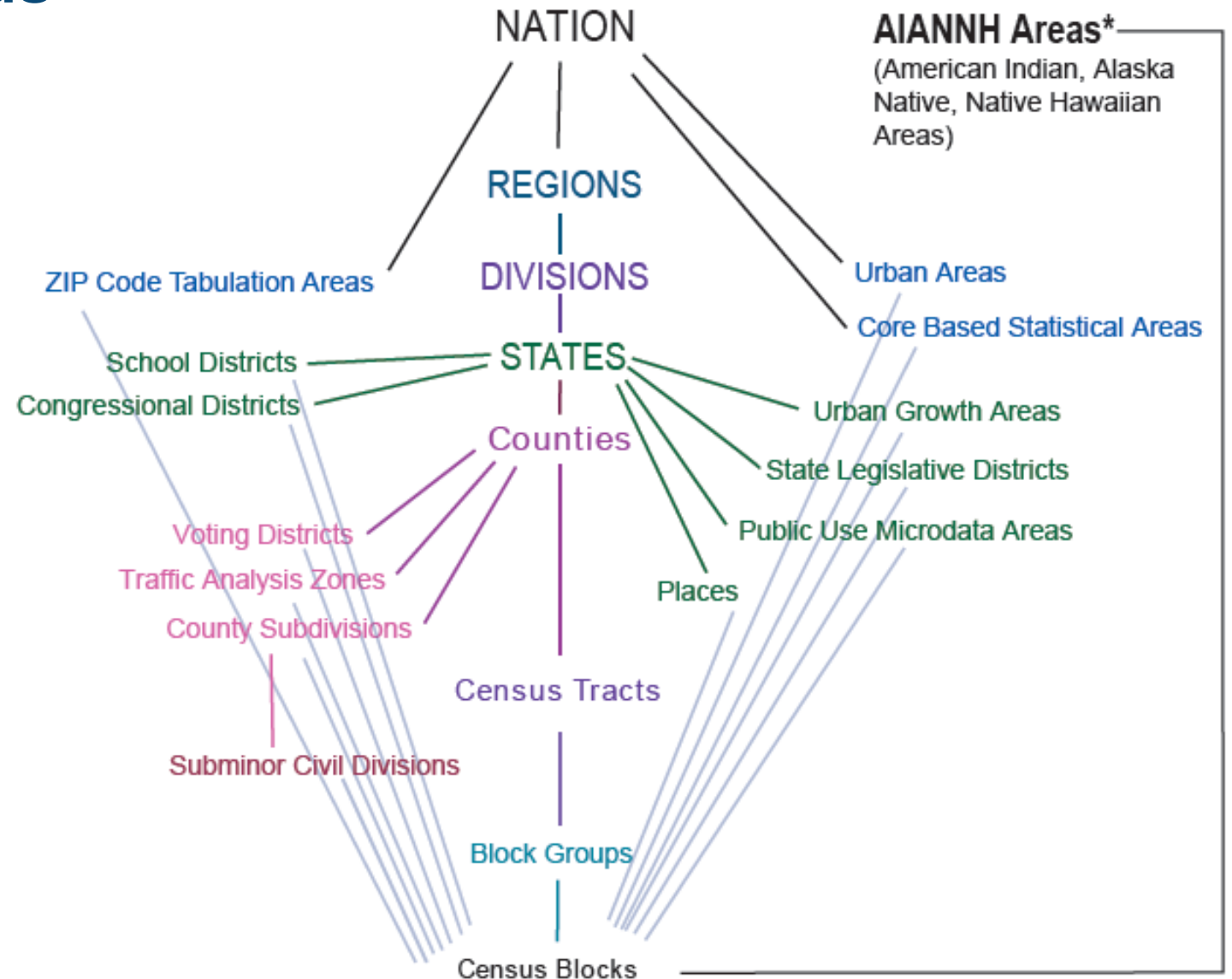
Data Sources – U.S. Census

- Census geographies
 - Source for political boundaries and base map information including hydrology and road networks

<https://www.census.gov/geo/maps-data/data/tiger-line.html>

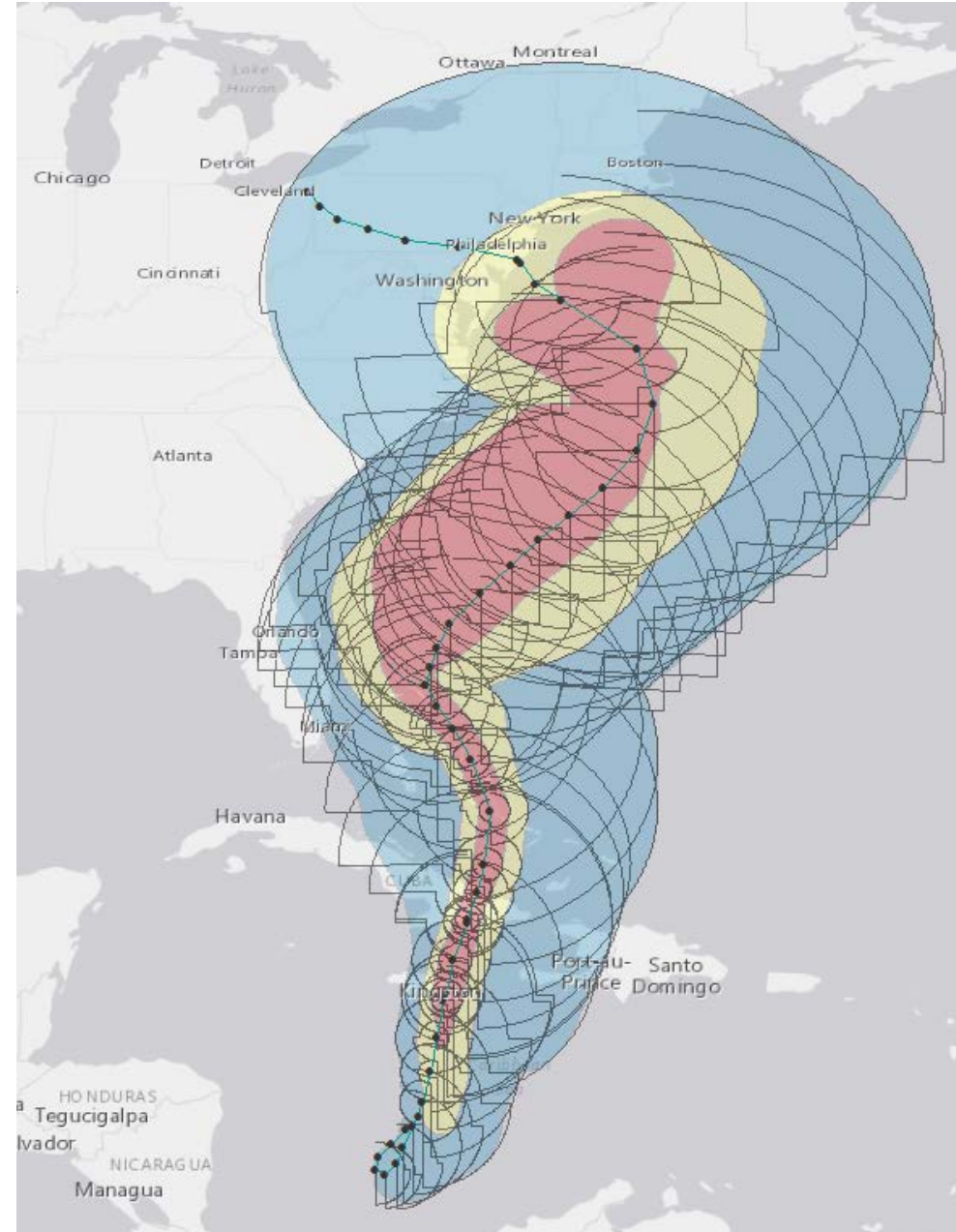
- Census data
 - Source for estimates of population, housing stock, available automobiles

<http://factfinder.census.gov/>



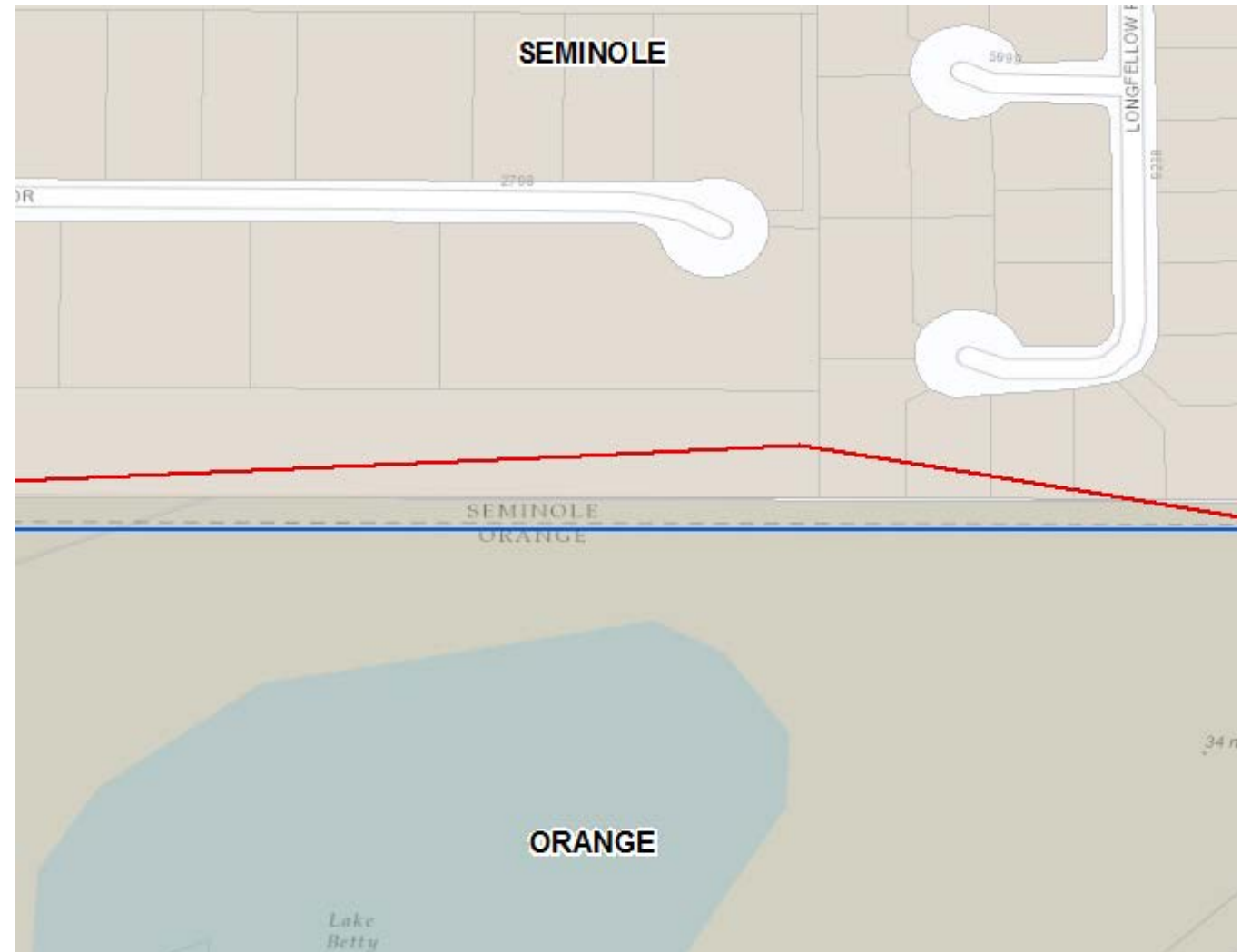
Data Sources

- U.S. Geological Survey
 - National Hydrology Dataset (NHD)
<http://nhd.usgs.gov/>
 - National Elevation Dataset (NED)
<http://nationalmap.gov/elevation.html>
 - National Land Cover Database (NLCD)
<http://www.mrlc.gov/>
- NOAA
 - Coastlines
<https://www.ngdc.noaa.gov/mgg/shorelines/>
 - National Weather Service
<http://www.nws.noaa.gov/gis>
 - National Hurricane Center
<http://www.nhc.noaa.gov/gis/>
- State and local agencies
 - Ex. Parcels and land records from county assessors



Data Sources

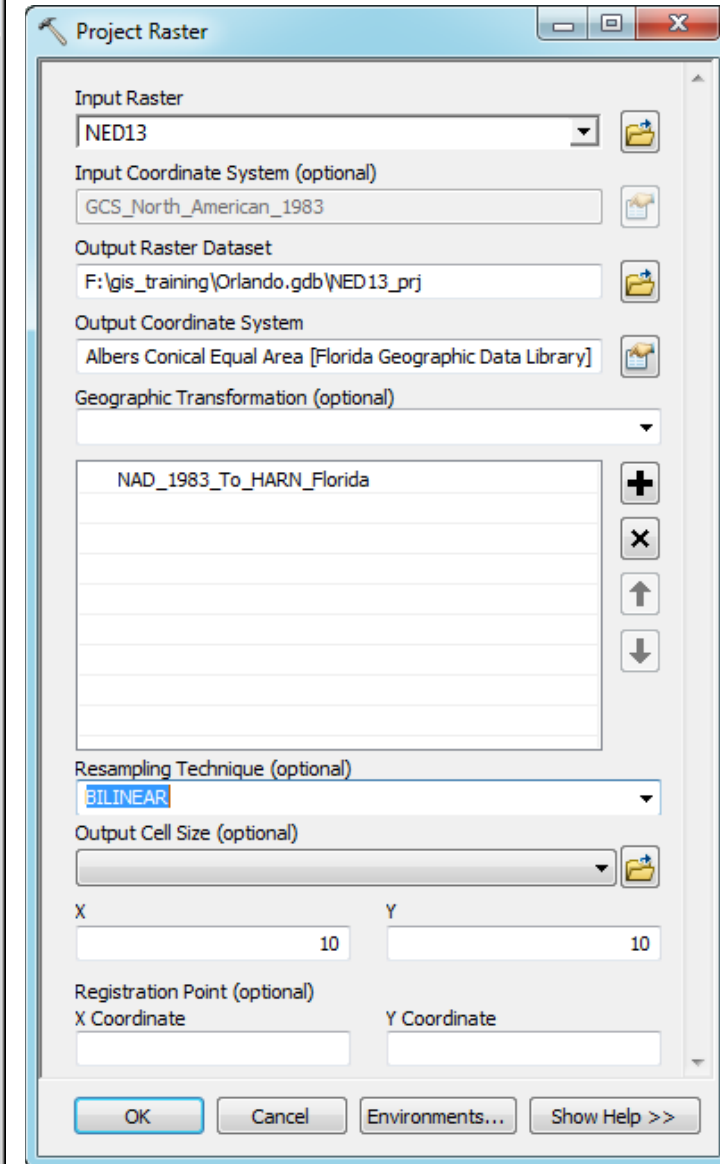
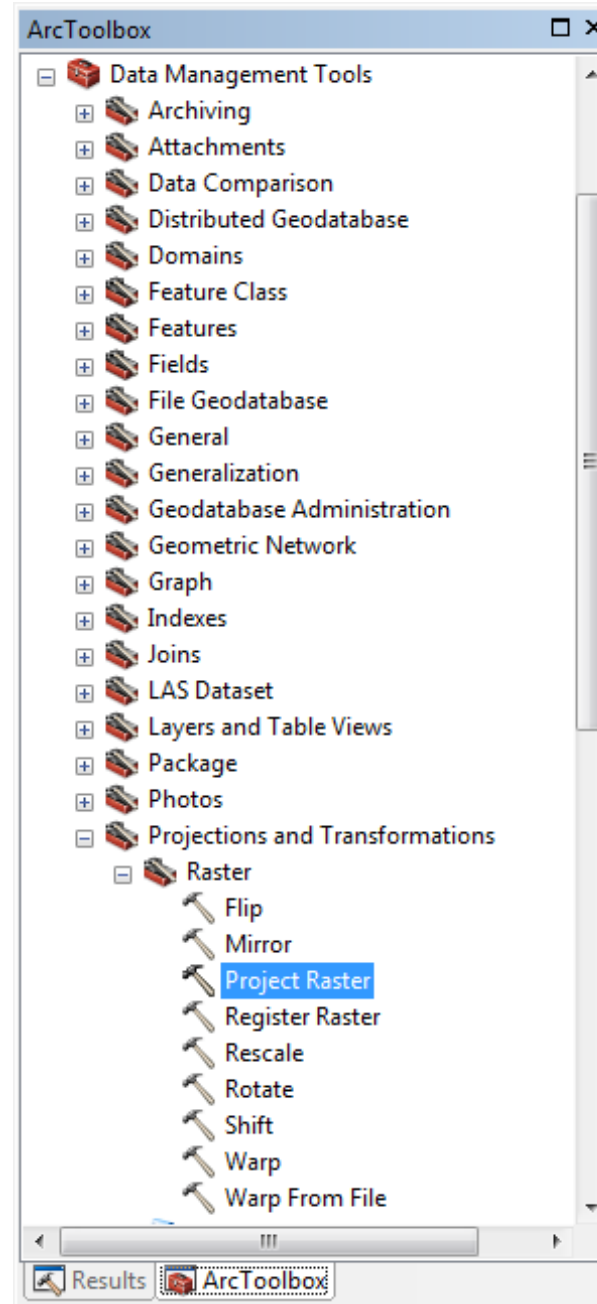
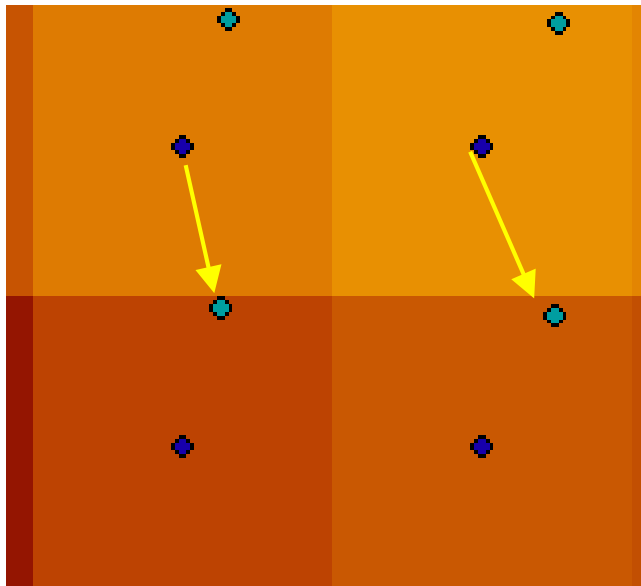
- Check scale and accuracy of source data
 - Metadata
- Map topology
 - Combine data from multiple sources
 - Create seamless coverage (no gaps, no overlaps, etc.)



Three different sources for county boundaries... and three different answers.

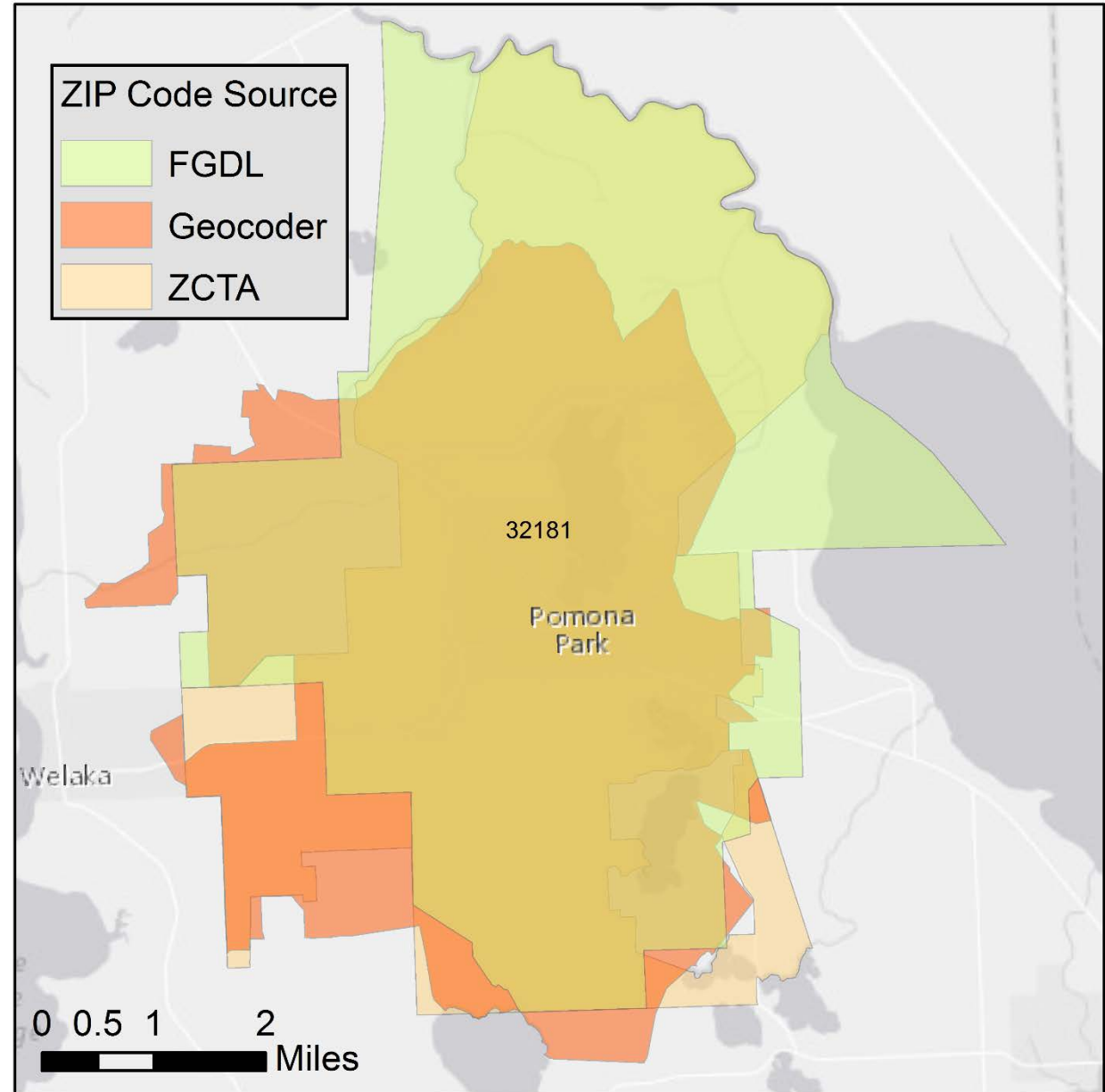
Data Sources

- Avoid re-projecting raster data
- If this is unavoidable, the use the appropriate technique
 - Nearest-neighbor for discrete or categorical data
 - Bilinear or cubic convolution for continuous data



Data Sources – ZIP Codes

- Defined by USPS as address ranges
- Continually updated
- ZIP Codes are discrete data (points)
 - Defined at the delivery address
- Often do not coincide with county or city boundaries
- Census ZIP Code tabulation areas (ZCTA)
 - Statistical areas that approximate ZIP codes

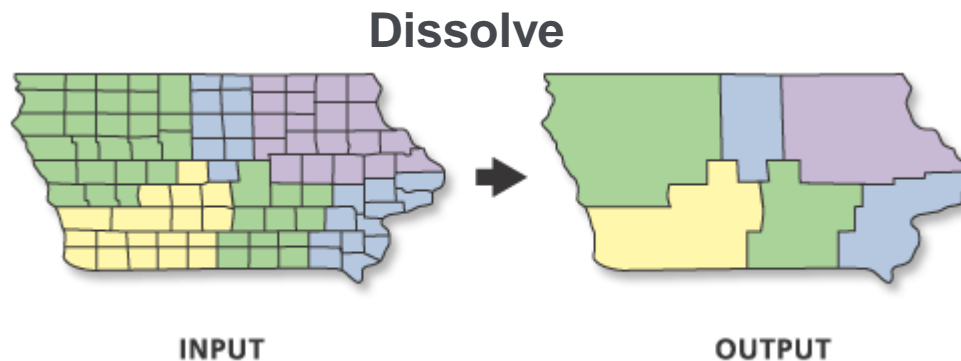


Spatial Analysis

- Vector data analysis
- Raster data analysis
- Grouping and spatial statistics
- Assignment 3

Data Management Toolbox

- Develop, manage, and maintain feature classes, datasets, layers, and raster data structures
 - Add XY Coordinates
 - Add/alter/calculate field
 - Dissolve features
 - Joins
 - Projections and Transformations

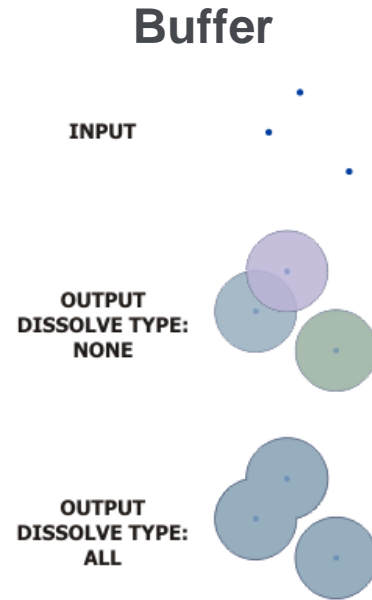
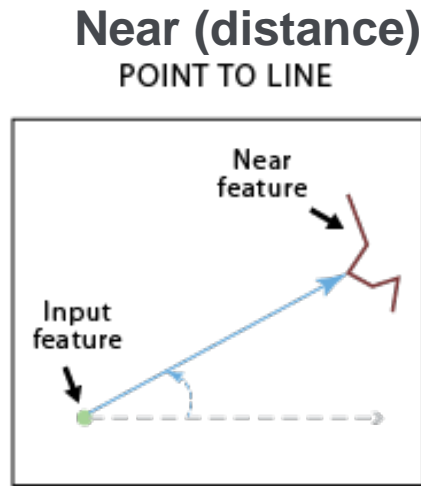
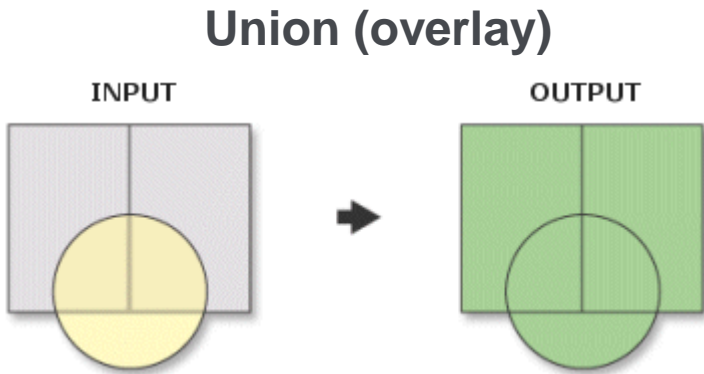


- [-] Data Management Tools
 - + Archiving
 - + Attachments
 - + Data Comparison
 - + Distributed Geodatabase
 - + Domains
 - + Feature Class
 - + Features
 - + Fields
 - + File Geodatabase
 - + General
 - + Generalization
 - + Geodatabase Administration
 - + Geometric Network
 - + Graph
 - + Indexes
 - + Joins
 - + LAS Dataset
 - + Layers and Table Views
 - + Package
 - + Photos
 - + Projections and Transformations
 - + Raster
 - + Relationship Classes
 - + Subtypes
 - + Table
 - + Tile Cache
 - + Topology
 - + Versions
 - + Workspace

<http://desktop.arcgis.com/en/arcmap/10.3/tools/data-management-toolbox/an-overview-of-the-data-management-toolbox.htm>

Analysis Toolbox

- The fundamental GIS operations for vector data
 - Subset
 - Overlay
 - Distance Calculation
 - Basic statistics

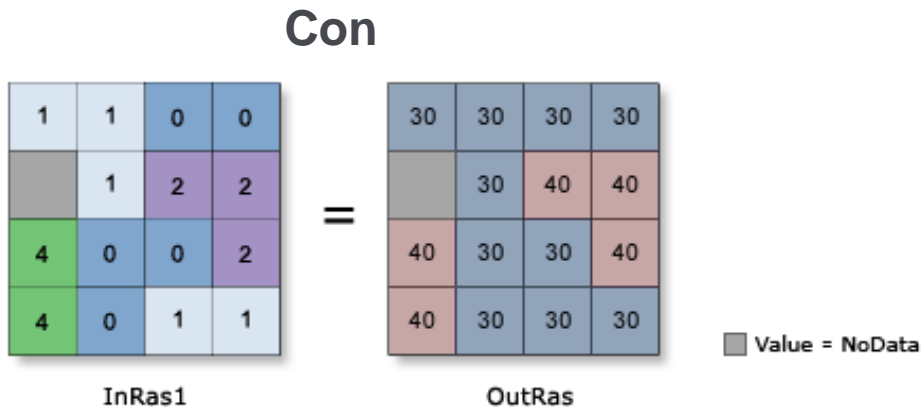


- Analysis Tools
 - Extract
 - Clip
 - Select
 - Split
 - Table Select
 - Overlay
 - Erase
 - Identity
 - Intersect
 - Spatial Join
 - Symmetrical Difference
 - Union
 - Update
 - Proximity
 - Buffer
 - Create Thiessen Polygons
 - Generate Near Table
 - Multiple Ring Buffer
 - Near
 - Point Distance
 - Polygon Neighbors
 - Statistics
 - Frequency
 - Summary Statistics
 - Tabulate Intersection

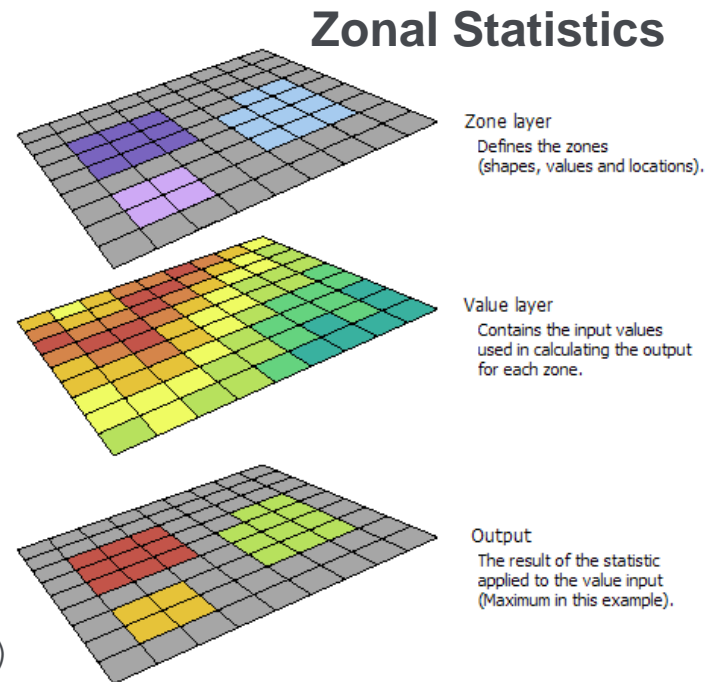
<http://desktop.arcgis.com/en/arcmap/10.3/tools/analysis-toolbox/an-overview-of-the-analysis-toolbox.htm>

Spatial Analyst Toolbox

- Requires additional software license
- Provides spatial analysis and modeling tool for raster data
- Some tools work with vector as well (mostly as inputs)
- Map Algebra

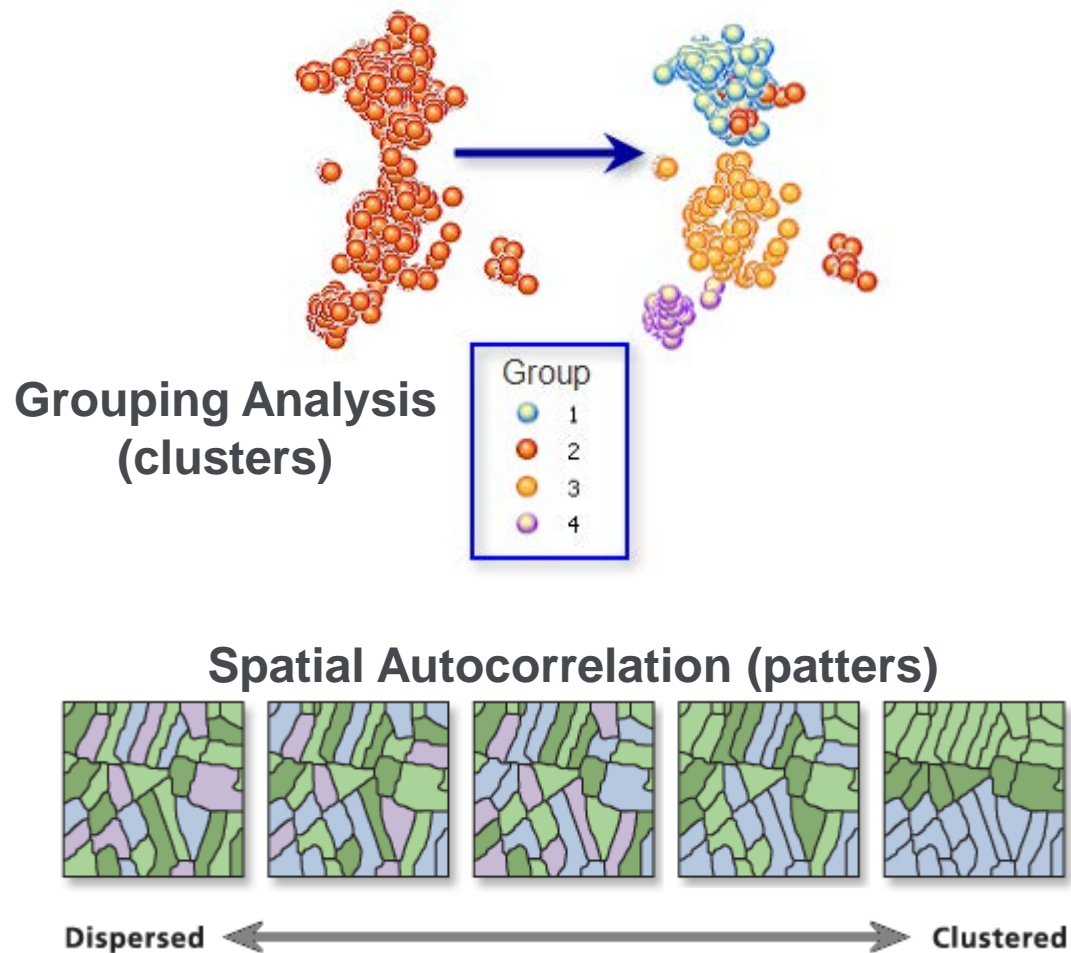



















OutRas = Con(InRas1, 40, 30, "Value >= 2")



- Spatial Analyst Tools
 - + Conditional
 - + Density
 - + Distance
 - + Extraction
 - + Generalization
 - + Groundwater
 - + Hydrology
 - + Interpolation
 - + Local
 - + Map Algebra
 - + Math
 - + Multivariate
 - + Neighborhood
 - + Overlay
 - + Raster Creation
 - + Reclass
 - + Segmentation and Classification
 - + Solar Radiation
 - + Surface
 - + Zonal

Spatial Statistics Toolbox

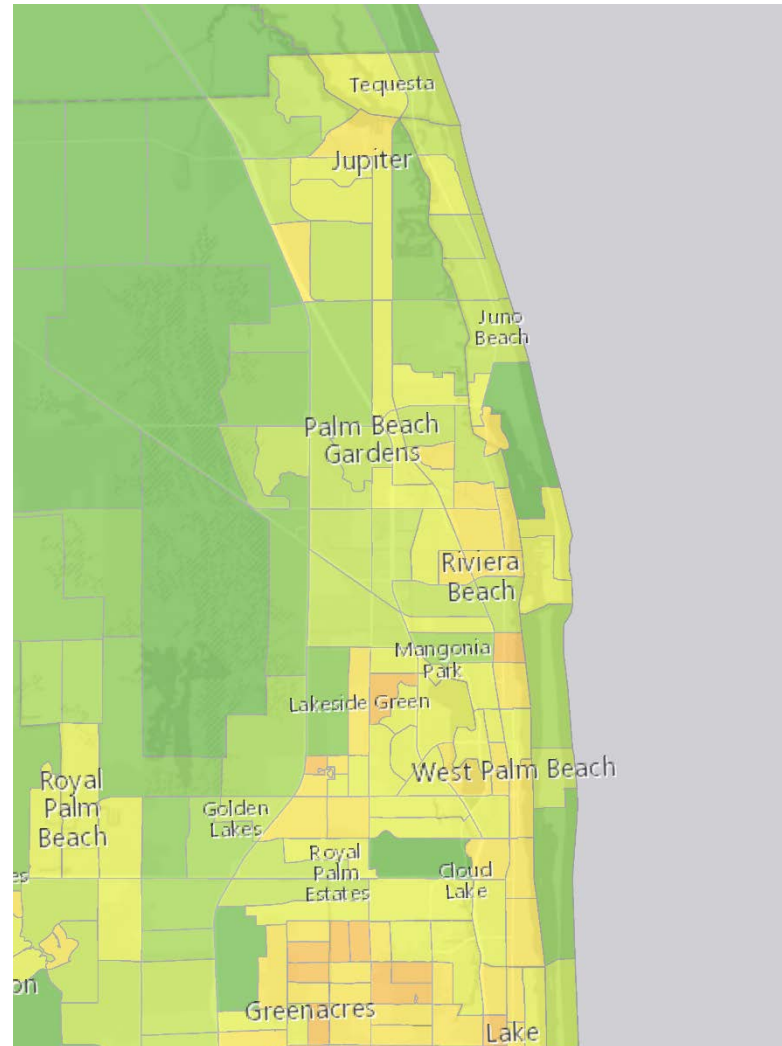


-  Spatial Statistics Tools
 -  Analyzing Patterns
 -  Average Nearest Neighbor
 -  High/Low Clustering (Getis-Ord General G)
 -  Incremental Spatial Autocorrelation
 -  Multi-Distance Spatial Cluster Analysis (Ripleys K Function)
 -  Spatial Autocorrelation (Morans I)
 -  Mapping Clusters
 -  Cluster and Outlier Analysis (Anselin Local Morans I)
 -  Grouping Analysis
 -  Hot Spot Analysis (Getis-Ord Gi*)
 -  Optimized Hot Spot Analysis
 -  Similarity Search
 - +  Measuring Geographic Distributions
 - +  Modeling Spatial Relationships
 - +  Rendering
 - +  Utilities

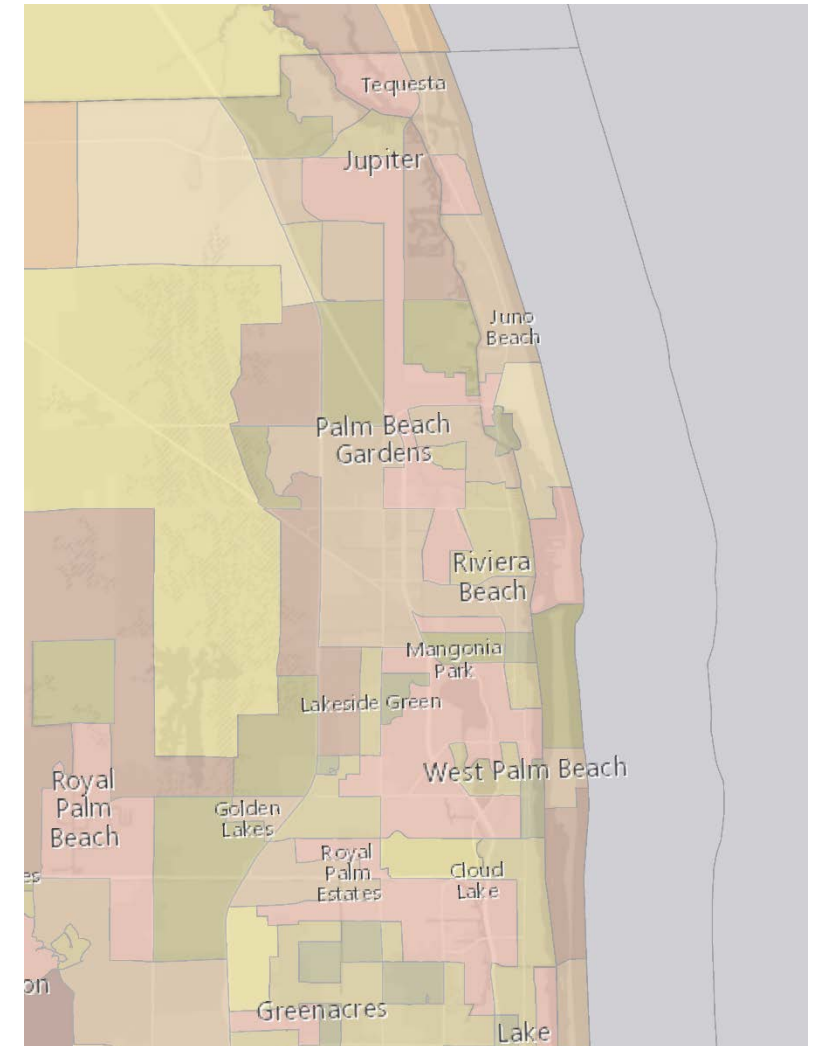
<http://desktop.arcgis.com/en/arcmap/10.3/tools/spatial-statistics-toolbox/an-overview-of-the-spatial-statistics-toolbox.htm>

Aggregate Census Blocks

- Goal: create representative areas for some binned demographic variable
- Data:
 - Estimated population
 - Census Tract polygons
- Tools:
 - Join Field
 - Add/Calculate Field
 - Dissolve



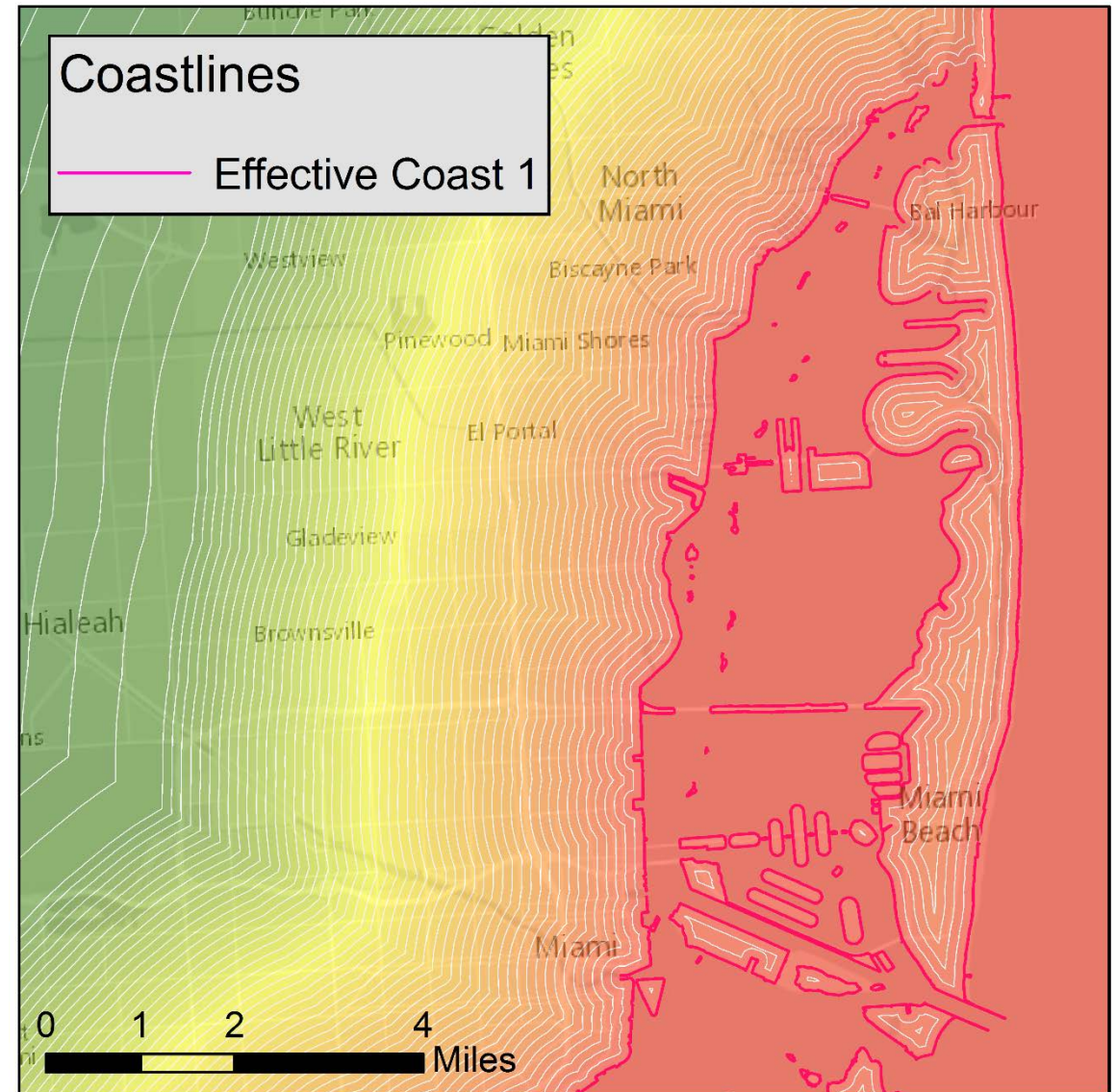
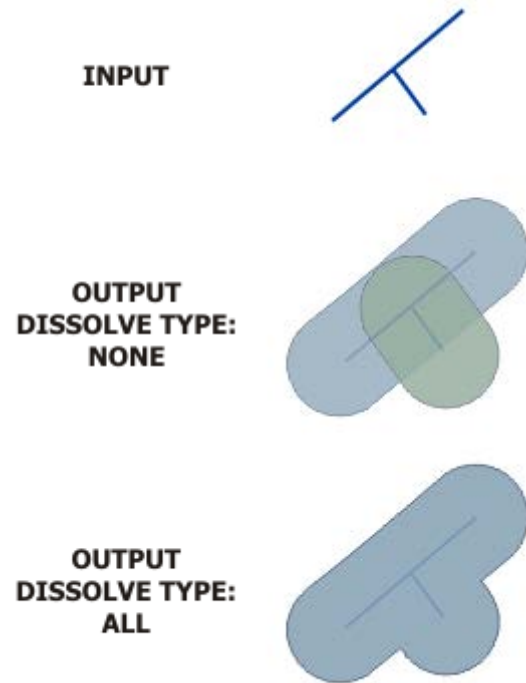
Population per square kilometer by
Census Tract



Aggregated Census Tracts

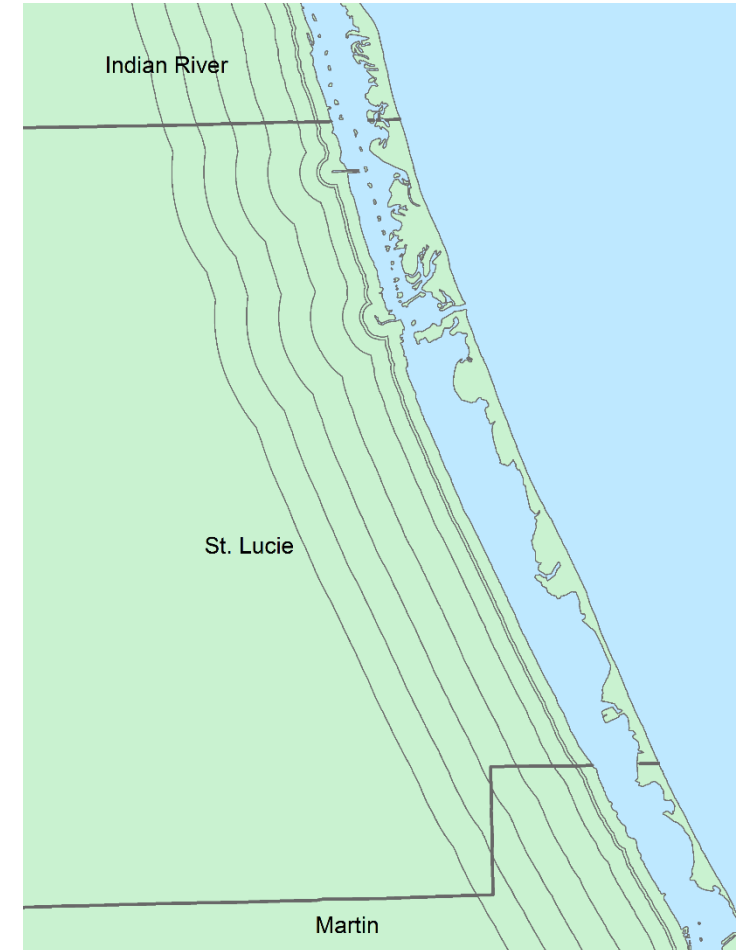
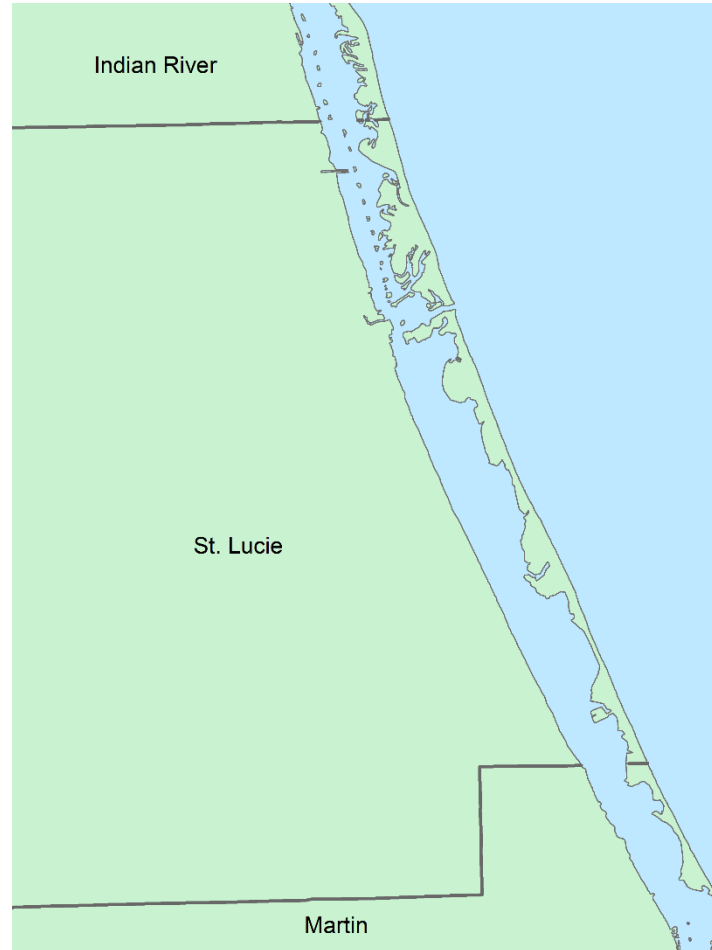
Buffer – Creating Distance Bins

- Goal: create polygon features for a distance to coast band
- Data:
 - Coastline line features
- Tool:
 - Multiple Ring Buffer



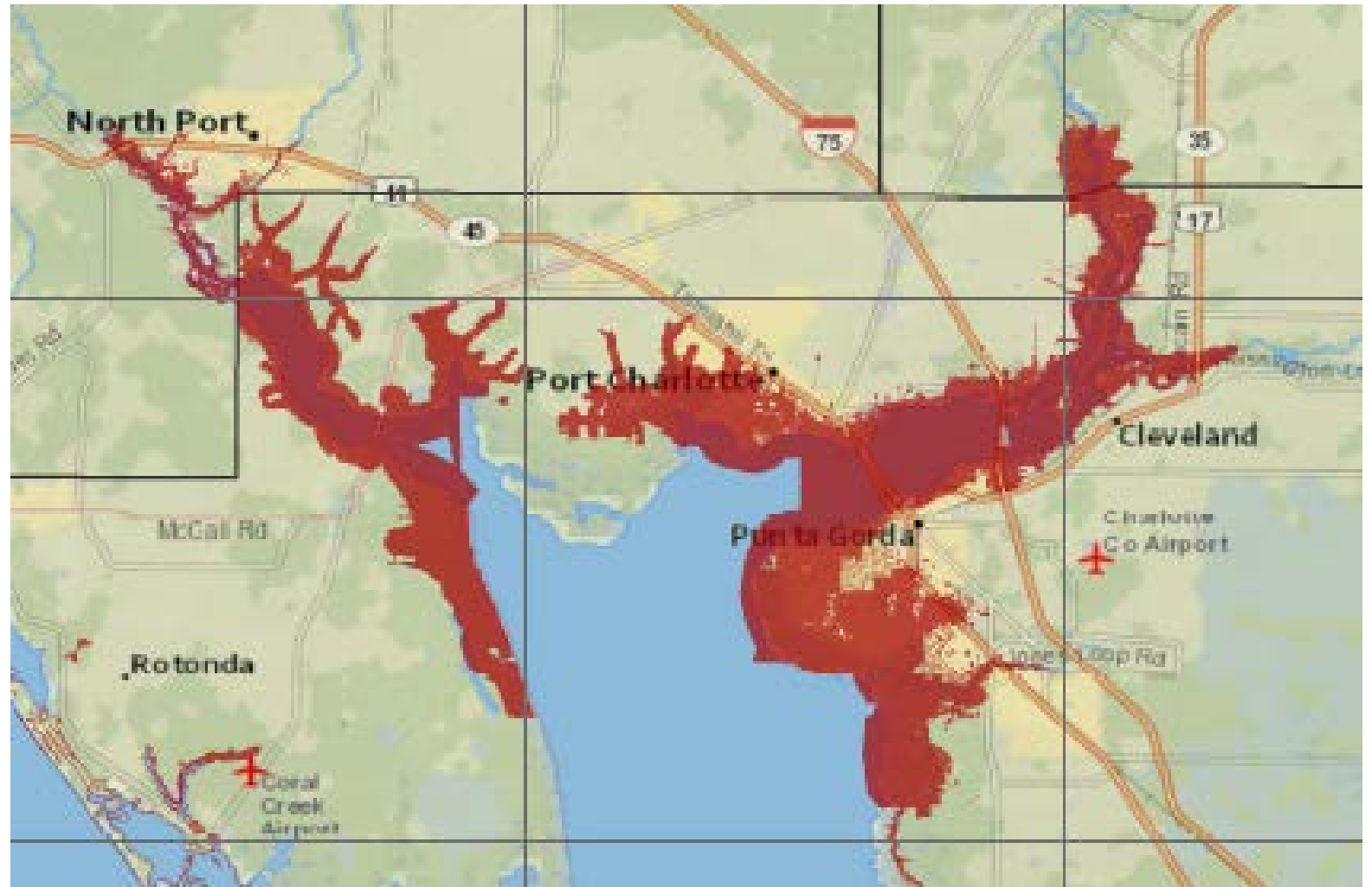
Overlay – DTC and Counties

- Goal: create polygon features that contain both DTC bin and county boundaries
- Data:
 - County polygons
 - DTC bin polygons
- Tool:
 - Union or Intersect



Minimum Permissible Elevation Model

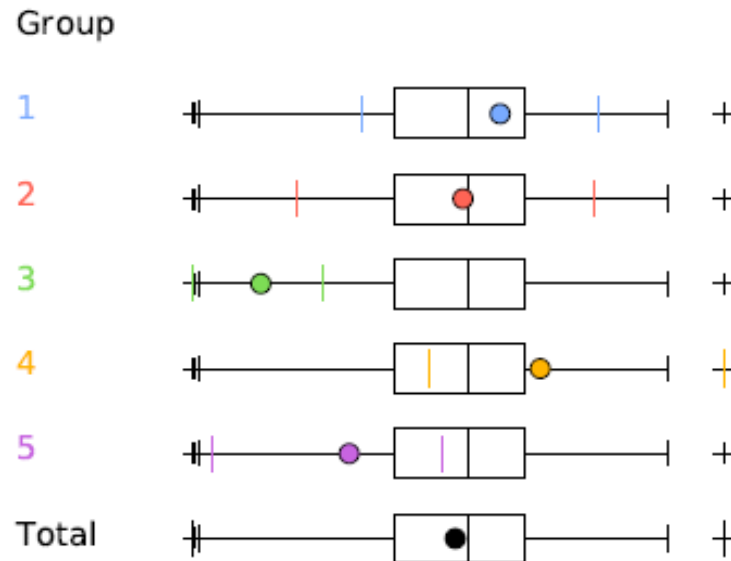
- For a given area, assign a minimum elevation and use the elevation dataset to create a layer to be used in underwriting
- Tools used:
 - Feature to Raster (conversion)
 - Reclassify (spatial analyst)
 - Map Algebra (spatial analyst)



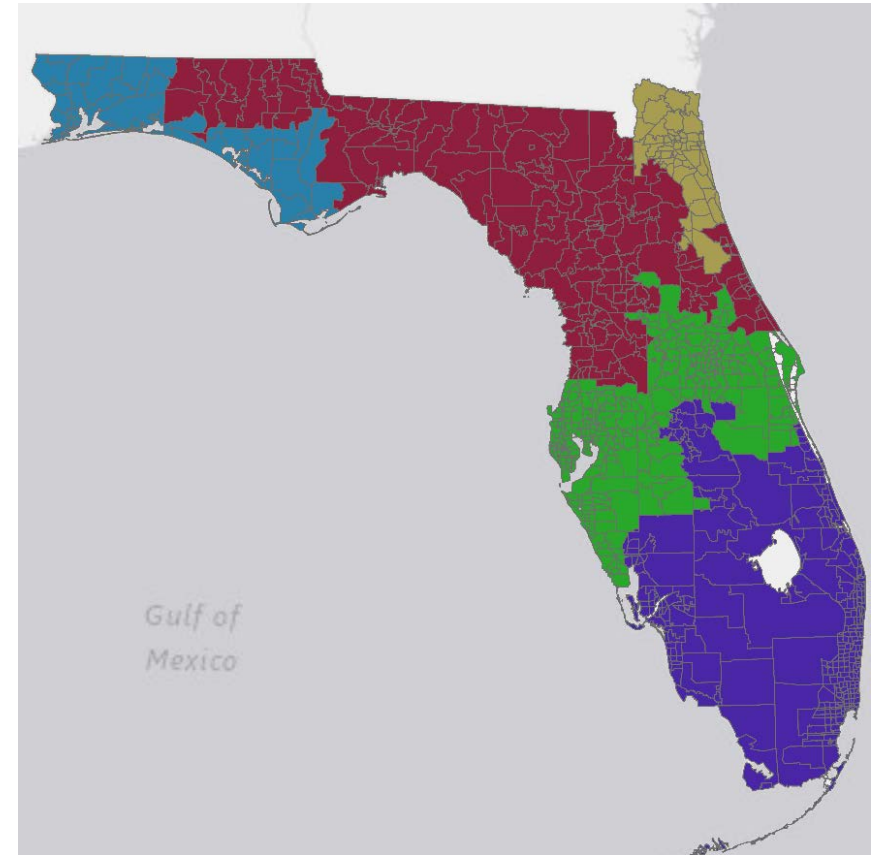
Example case showing ineligible areas near Punta Gorda, Florida

Grouping Analysis Example

- Grouping Analysis tool in ArcGIS
- Attempts to identify natural clusters
- Can use spatial relationships to define neighbors
 - Nearest neighbor
 - Contiguity
 - Triangulation
 - Custom Weights

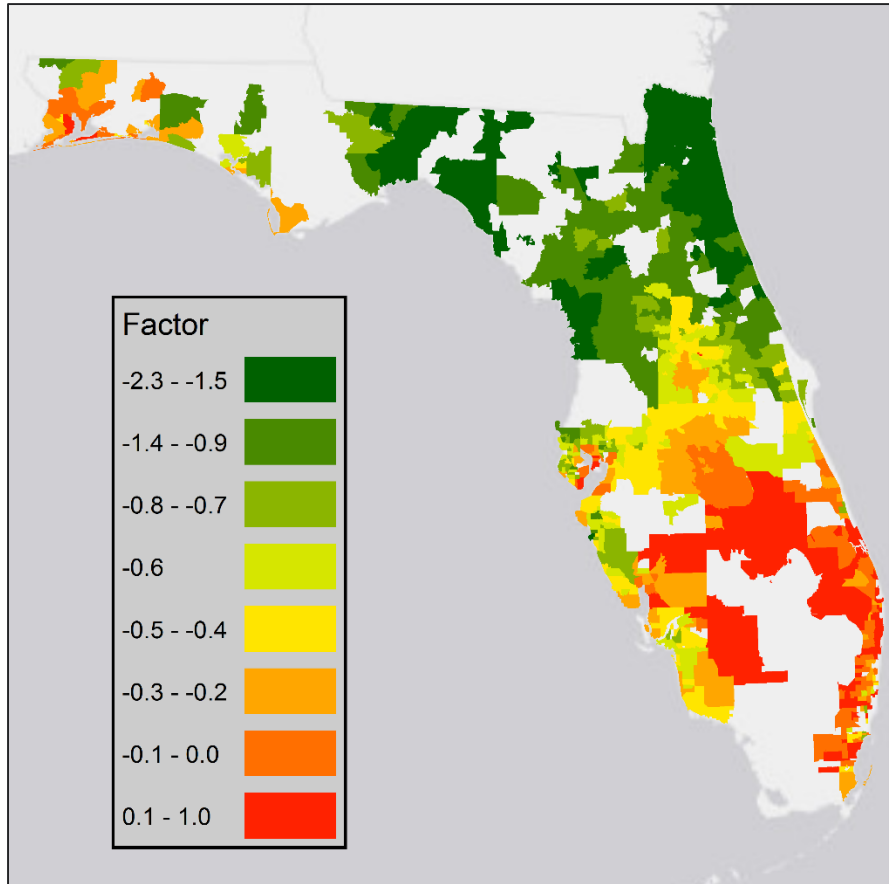


Box-and-whisker plots of each output group relative to the total.

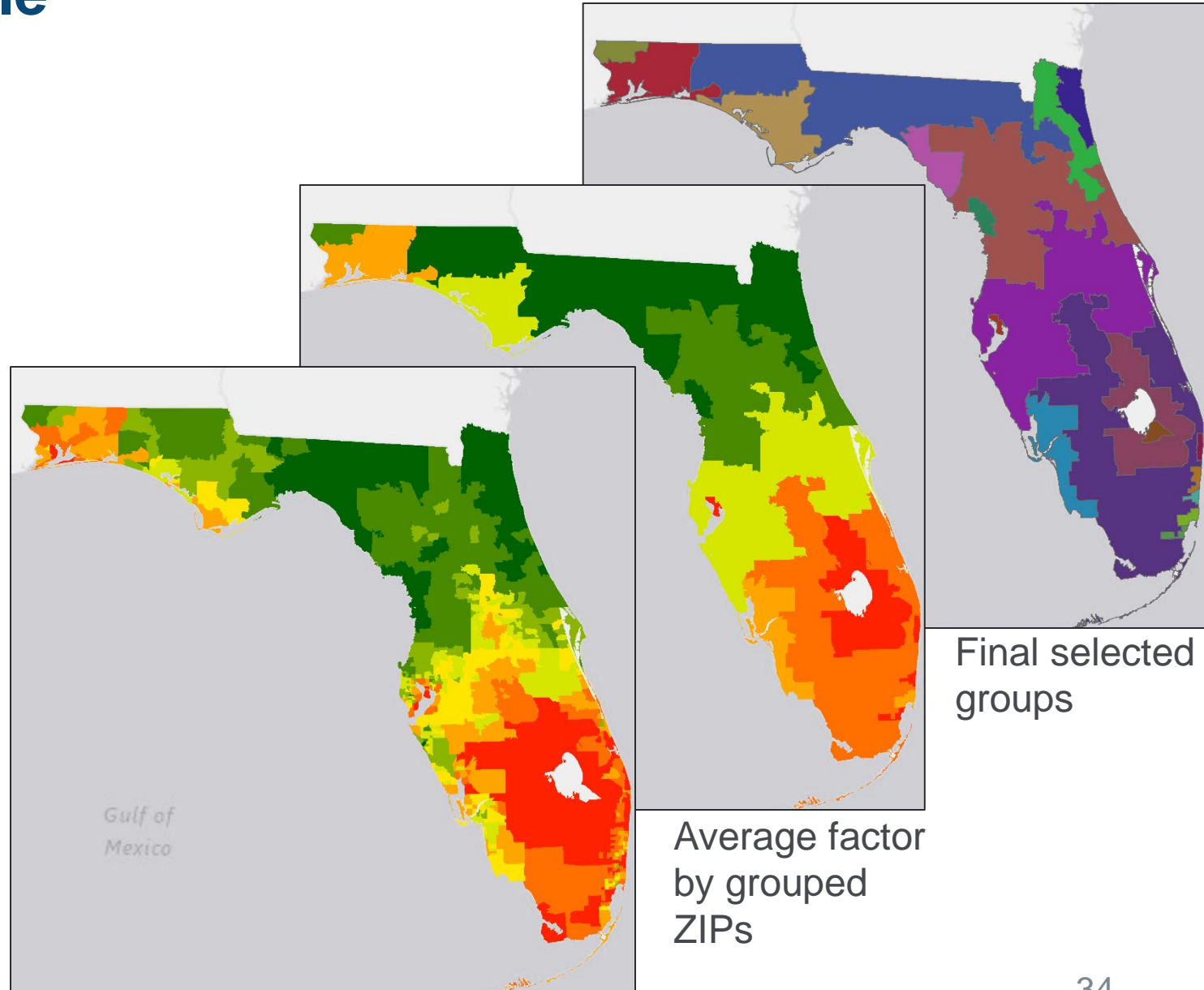


Example Grouping Analysis Output using Florida ZIP Codes with 5 output groups.

Grouping Analysis Example



Modeled factors by ZIP Code



Interpolated factors

Average factor by grouped ZIPs

Final selected groups



Thank you

Garrett Bradford
Cartographer / GIS Analyst
Milliman, Inc.
650 California Street, 17th Floor
San Francisco, CA 94108
garrett.bradford@milliman.com
(415) 394-3792



GIS for Actuaries Part 2 CAS RPM 2016

Garrett Bradford
March 15, 2016

Assignment 1

- Adding data from the Catalog
- Symbolizing data
- Import and join tabular data
- Displaying XY location data
- Creating basic maps

Assignment 2

- Geocoding locations
- Mapping census data
- Joining policy level data to census geography

Assignment 3

- Distance calculations
- Territory construction with unions
- Working with Spatial Analyst
- Grouping Analysis



Thank you

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San Francisco, CA 94108
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(415) 394-3792