



# THE SCIENCE OF MAPPING

Geographic Information Systems (GIS)

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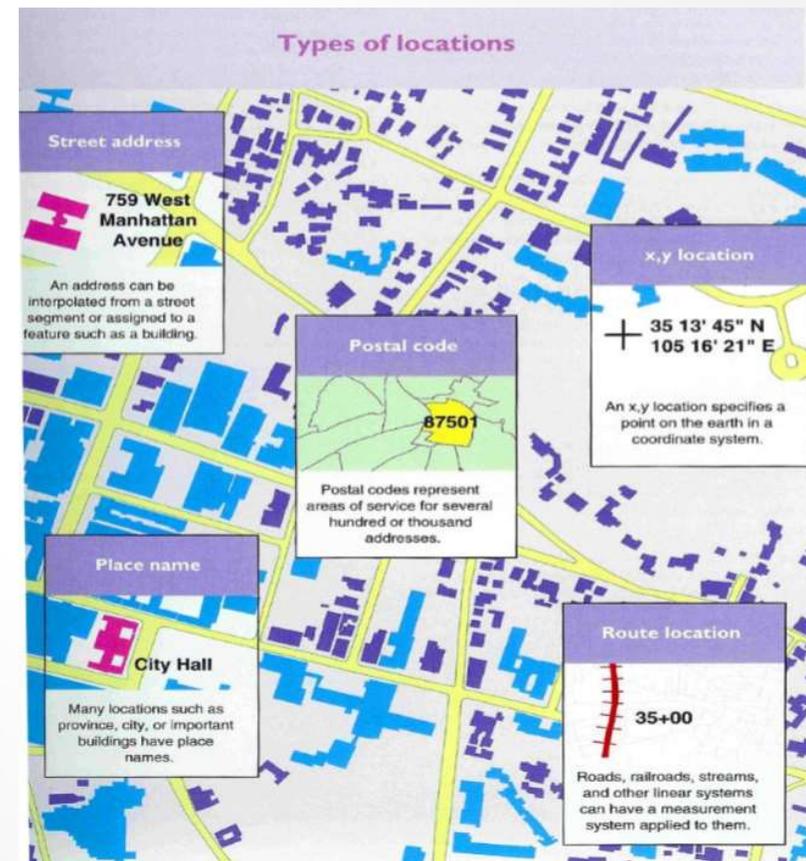
# GEOGRAPHIC INFORMATION SYSTEMS

- Geographic Information Systems (GIS) is a collection of:
  - hardware, software, data and trained personnel
- Used to:
  - Store, manipulate, analyze and present information

**GIS is the “Science of Where”**

The key is linking data to location →

Estimated that 80% of all data has a spatial component



# THE SCIENCE OF MAPPING REQUIRES CRITICAL SPATIAL THINKING

## **Critical Spatial Thinking:**

“...using spatial data to understand problems, derive solutions and communicate effectively...”

“Many of the issues and situations addressed with a GIS do not have one single correct solution but may have explanations and better choices that can be informed by critical spatial thinking and abductive reasoning.”

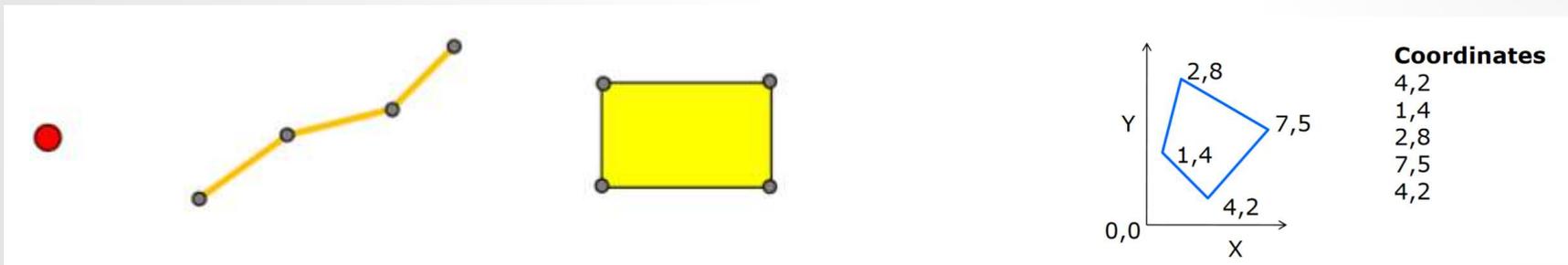
- Merely displaying spatially coincident datasets may yield incorrect assumptions regarding relationships. Most maps require some explanation.



(Source: Stinton et al. 2013)

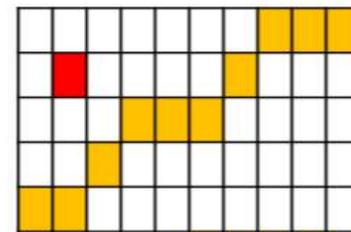
# ESSENTIALLY ALL MAPS ARE JUST:

**Points**, **Lines** and **Polygons** stored and represented by coordinates



- **Points** are single coordinate pairs,
- **Lines** are ordered sets of coordinate Pairs
- **Polygons** are closed sets of lines (areas) that have interiors and share edges (adjacency) with other polygons.

Maps also employ backgrounds “cells” (such as pixels in an aerial photo) stored and represented by a grid.



# GIS FEATURES HAVE ATTRIBUTES

- Attributes are stored as rows and columns in a table
- They define/describe a spatial feature (qualitative or quantitative)
- Every row corresponds to a point, line or polygon feature
- Currency and Authoritativeness is important

Point example: Census individuals

Polygon example: Census block groups

The screenshot shows the ArcMap interface with a map of census points and a table of attributes for '1930\_Census\_Latest'. The table has the following columns: Address, Street, LastName, FirstName, Relation, Property, HomeValue, RadioSet, Farm, Gender, Race, Age, BirthYear, Marital, AgeMarriage, AttendedSchool, Literacy, Birthplace, BirthFather, BirthMother, Language, Immigration, Naturalization, English, and OC.

Address	Street	LastName	FirstName	Relation	Property	HomeValue	RadioSet	Farm	Gender	Race	Age	BirthYear	Marital	AgeMarriage	AttendedSchool	Literacy	Birthplace	BirthFather	BirthMother	Language	Immigration	Naturalization	English	OC	
1100	Scamerson Street	Suhanda	Isabel	Head	Owned	1920	No	Male	White	30	1891	Married	24	No	Yes	Yes	Yugoslavia	Yugoslavia	Yugoslavia	Croatian	1912	Allen	Yes	Crime Ct	
1100	Scamerson Street	Suhanda	Isabel	Wife	-	-	-	-	Female	White	36	1894	Married	19	No	Yes	Yugoslavia	Yugoslavia	Yugoslavia	Slovenian	1912	Allen	Yes	-	
1100	Scamerson Street	Kenic	Ilica	Boarder	-	-	-	-	Male	White	41	1899	Single	-	No	Yes	Yugoslavia	Yugoslavia	Yugoslavia	Croatian	1905	Allen	Yes	Crime Ct	
1100	Scamerson Street	Henkovich	Heck	Roomer	-	-	-	-	Male	White	19	1911	Married	17	No	Yes	Pennsylvania	Yugoslavia	Yugoslavia	Croatian	-	-	Male	Yes	Red Gang
1100	Scamerson Street	Henkovich	Anna	Roomer	-	-	-	-	Female	White	21	1909	Married	19	No	Yes	Yugoslavia	Yugoslavia	Yugoslavia	Croatian	1930	Allen	Yes	Examiner	
1100	Scamerson Street	Ogromenich	Stojan	Boarder	-	-	-	-	Male	White	40	1890	Single	-	Yes	Yes	Yugoslavia	Yugoslavia	Yugoslavia	Croatian	1880	Free Papers	Yes	Machinal	
1102	Scamerson Street	Cresden	Louis A	Head	Owned	5500	No	No	Male	White	33	1897	Married	22	No	Yes	Pennsylvania	Pennsylvania	Pennsylvania	-	-	-	-	Yes	Photoeng
1102	Scamerson Street	Cresden	Margaret A	Wife	-	-	-	-	Female	White	32	1898	Married	20	No	Yes	Pennsylvania	Ireland	Ireland	-	-	-	-	Yes	-
1102	Scamerson Street	Cresden	Josephine H	Daughter	-	-	-	-	Female	White	11	1919	Single	-	Yes	Yes	Pennsylvania	Pennsylvania	Pennsylvania	-	-	-	-	Yes	-
1102	Scamerson Street	Cresden	Louis A	Son	-	-	-	-	Male	White	9	1921	Single	-	-	-	Pennsylvania	Pennsylvania	Pennsylvania	-	-	-	-	-	-
1102	Scamerson Street	Cresden	Rita Ann	Daughter	-	-	-	-	Female	White	5	1925	Single	-	-	-	Pennsylvania	Pennsylvania	Pennsylvania	-	-	-	-	-	-
1102	Scamerson Street	Cresden	Paul J	Son	-	-	-	-	Male	White	0	1930	Single	-	-	-	Pennsylvania	Pennsylvania	Pennsylvania	-	-	-	-	-	-
1104	Scamerson Street	Eggenheltz	John	Head	Owned	5500	No	No	Male	White	36	1892	Married	23	No	Yes	Austria	Austria	Austria	Slovak	1912	Allen	Yes	Laborer	
1104	Scamerson Street	Eggenheltz	Theresa	Wife	-	-	-	-	Female	White	36	1894	Married	21	No	Yes	Austria	Austria	Austria	Slovak	1912	Allen	Yes	-	
1104	Scamerson Street	Eggenheltz	Joseph	Son	-	-	-	-	Male	White	12	1918	Single	-	-	-	Pennsylvania	Austria	Austria	-	-	-	-	Yes	-
1104	Scamerson Street	Eggenheltz	Frank	Son	-	-	-	-	Male	White	11	1919	Single	-	Yes	Yes	Pennsylvania	Austria	Austria	-	-	-	-	Yes	-

The screenshot shows the Districts application interface. It features a table of district statistics and a map of Pittsburgh with census block groups. The table has the following columns: Districts, Number, Population, Deviation, Race, and Comp.

Districts	Number	Population	Deviation	Race	Comp.
	10,721,496	+10,721,496			
1	526,256	-179,432	24%		
2	707,618	+1,930	39%		
3	747,009	+41,321	26%		
4	0	-705,688			
5	0	-705,688			
6	0	-705,688			
7	0	-705,688			
8	0	-705,688			
9	0	-705,688			
10	0	-705,688			
11	0	-705,688			
12	0	-705,688			
13	0	-705,688			
14	0	-705,688			
15	0	-705,688			

The map shows Pittsburgh with census block groups. A legend for Blockgroup #6580 indicates the following racial composition: White (87%), Black (9%), Asian (4%), Hispanic (4%), and Other (2%).

Source: <https://app.districtbuilder.org>

# VALUE OF METADATA

Critical to evaluate “fit-for-purpose” spatial data

Identification Information

Data Quality

Spatial Data Organization

Spatial Reference

Entity and Attribute Information

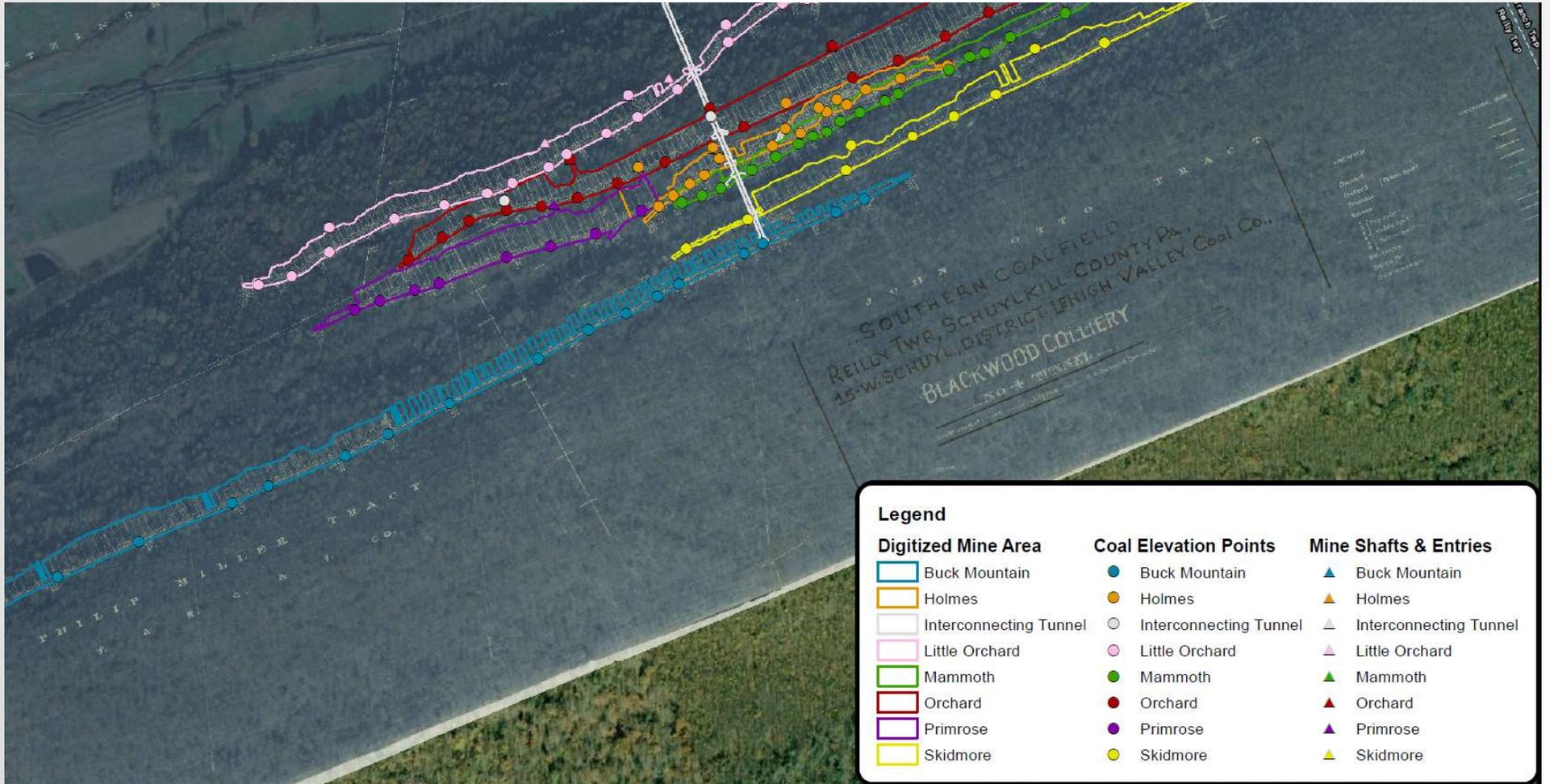
Distribution Information

Citation

Time Period

Contact Details

# GIS MAP EXAMPLE – ABANDONED MINE MAPPING



# TYPES OF GIS SPATIAL ANALYSIS – SCIENTIFIC INQUIRY

- **Understanding where** ...boundaries between and/or around demographic groups
- **Measuring size, shape and distribution** ...of population contained within polygons
- **Determining how places are related** ...boundaries aligned with census demographic data
- **Finding the best locations and paths** ...route to voting location
- **Detecting and quantifying patterns** ...of voter turnout or population changes
- **Making Predictions** ...based on past location data

A GIS works with thematic layers of spatial data



Answer questions by comparing different layers of data

## *Types of spatial questions:*

Which peaks are **near** trails?



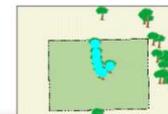
Which highways **intersect** Highlands County?



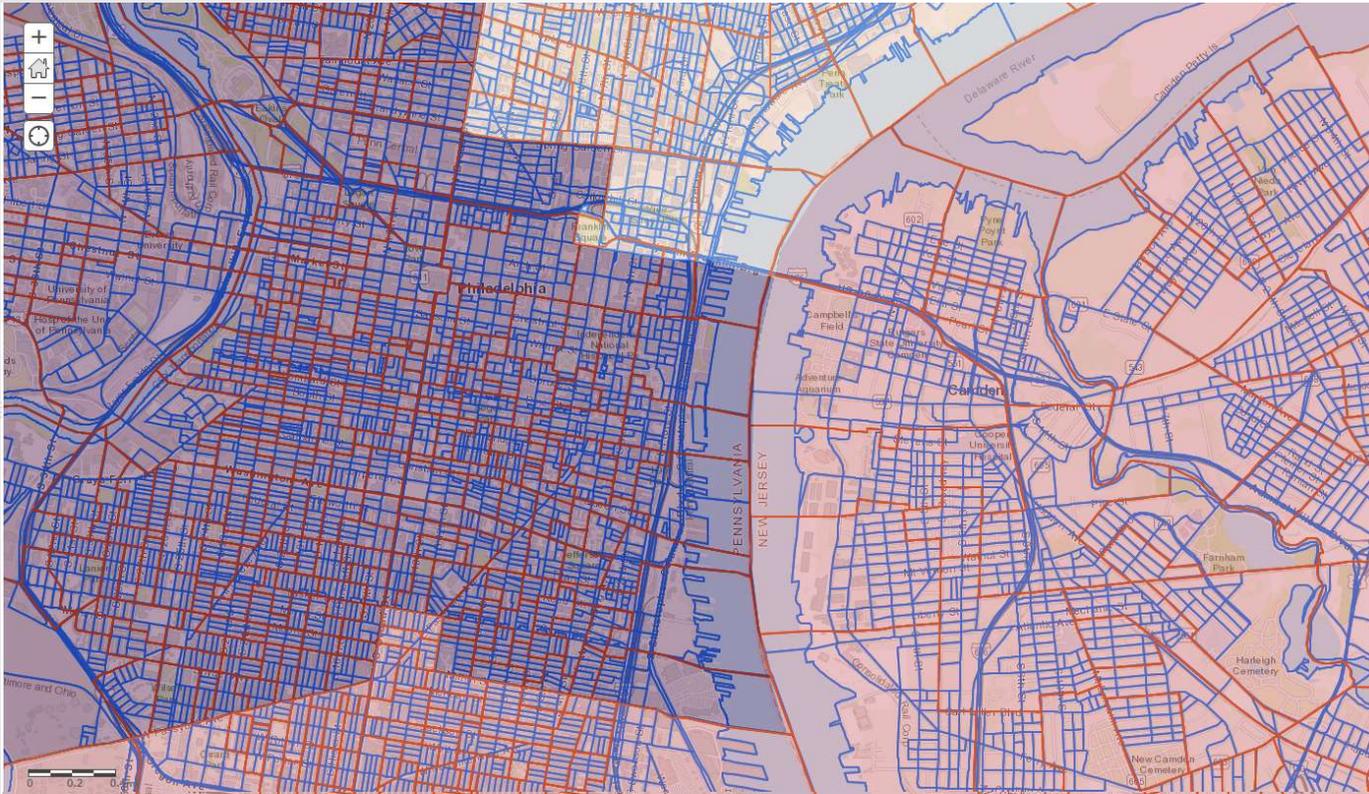
Which counties are **adjacent to** Highlands County?



Which trees are **inside** the park?



# BOUNDARY AND POLYGON OVERLAP



How many census block groups (blue), and their combined population details are contained within a voting district (red)?

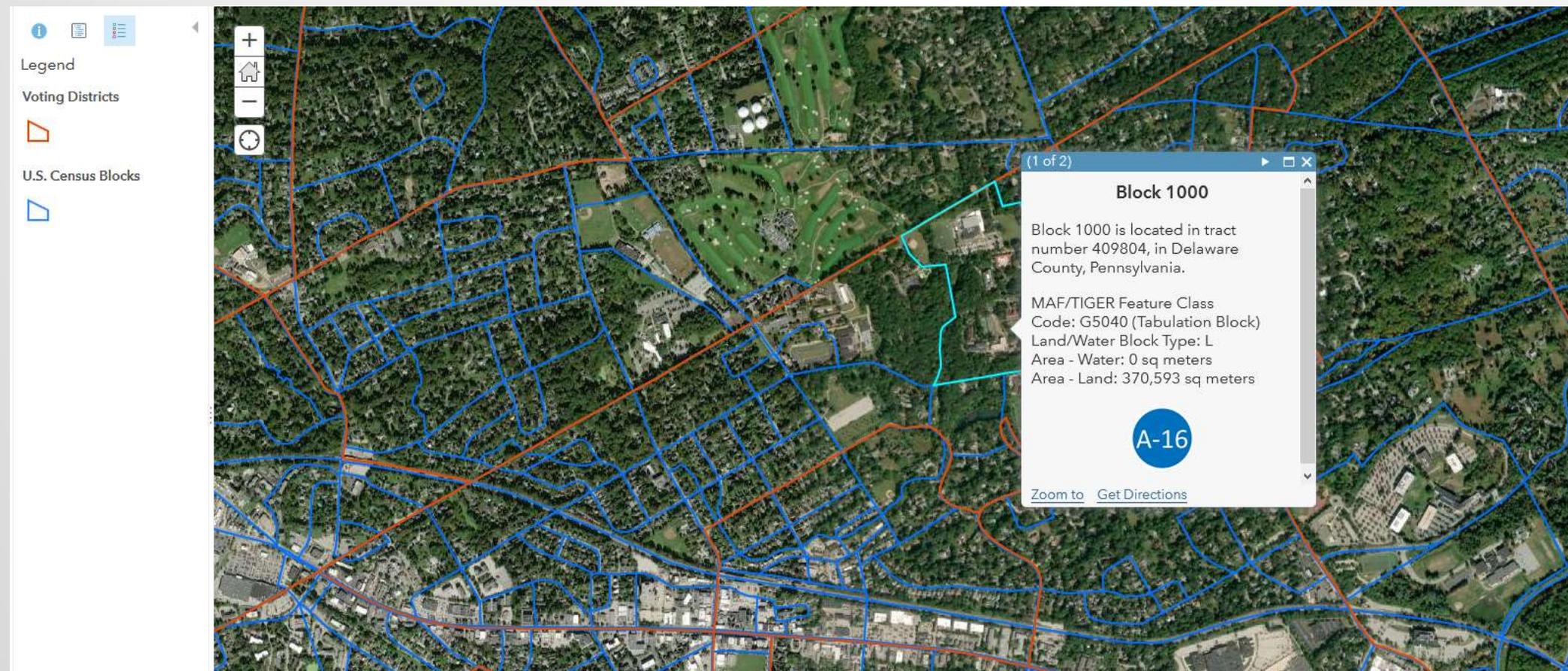
Every adjustment to a voting district boundary alters the demographic composition of the new and adjacent voting district polygons.

Adjustments are, by necessity, highly iterative.

Polygon shape and attribute accuracy is crucial! Job for GIS!

# OVERLYING POLYGONS – AGGREGATED POPULATION

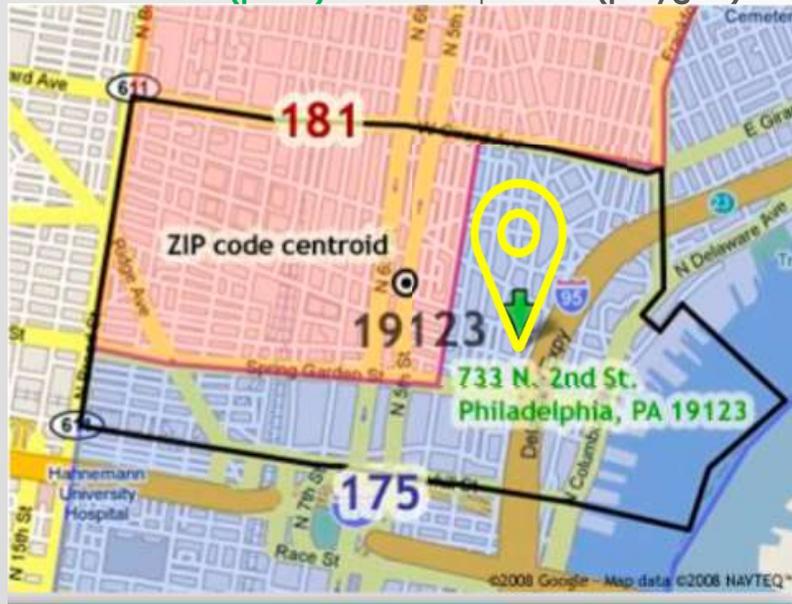
CHANGING AN OVERLYING POLYGON ALTERS THE NUMBER UNDERLYING POLYGONS



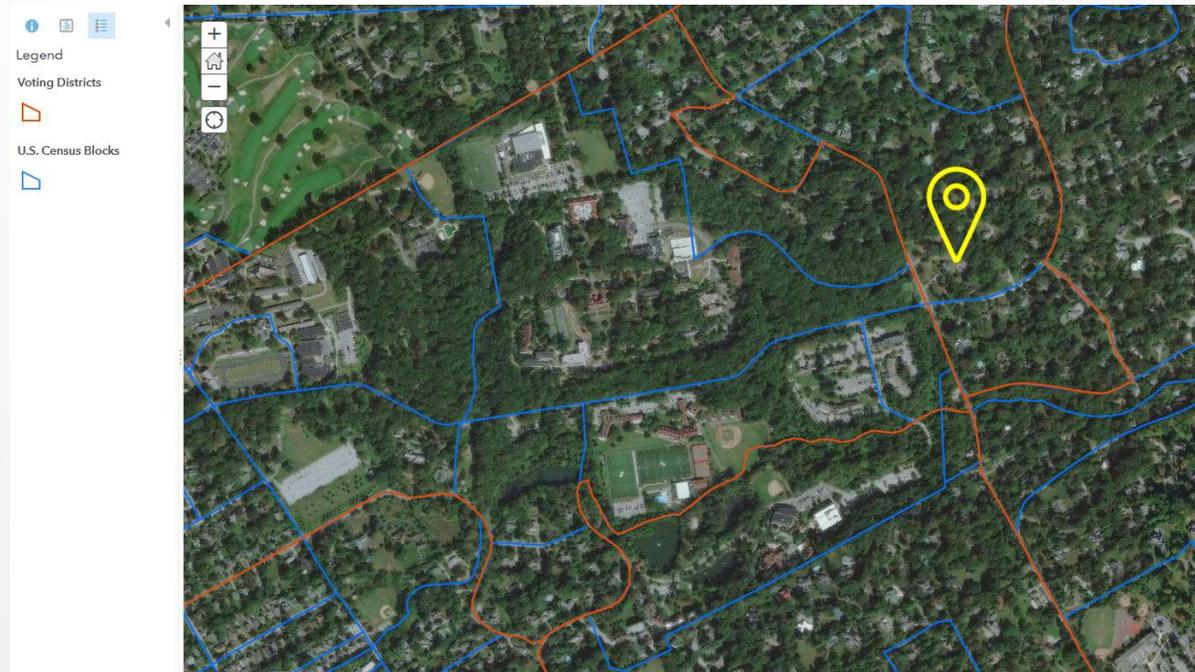
# VOTER LOCATION ACCURACY (GEOCODING)

Geocoding in GIS is the process of associating an x,y coordinate to a geographic feature such as an address.

Street address (**point**) within a zip code (**polygon**)



Ensures accurate placement of voters within districts

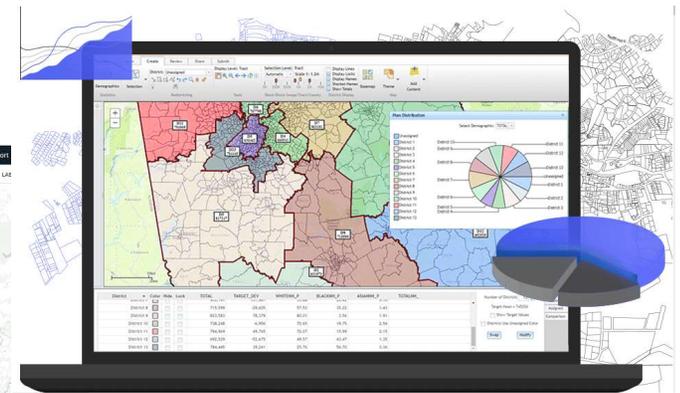
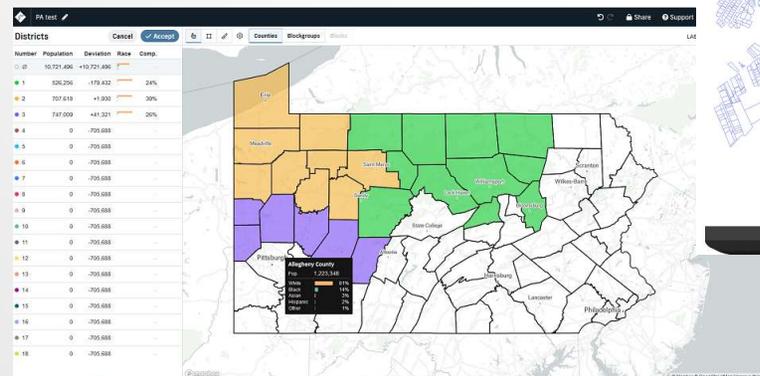


# RESOURCES FOR GIS AND ELECTIONS

- [National States Geographic Information Council](#)
  - Best practices for **Geo-enabling elections**
- [Federal Geographic Data Committee](#)
  - Geospatial Data Act of 2018 – supports development of **consistent and authoritative** spatial data
  - National Spatial Data Infrastructure (NSDI)
    - **Define standards** for spatial data themes



- Software Tools
  - ArcGIS, ESRI Redistricting, District Builder, etc



# GEO-ENABLED ELECTIONS

## NATIONAL STATES GEOGRAPHIC INFORMATION COUNCIL (NSGIC)

### GIS HELPS TO:

#### AVOID LOCATION ERRORS

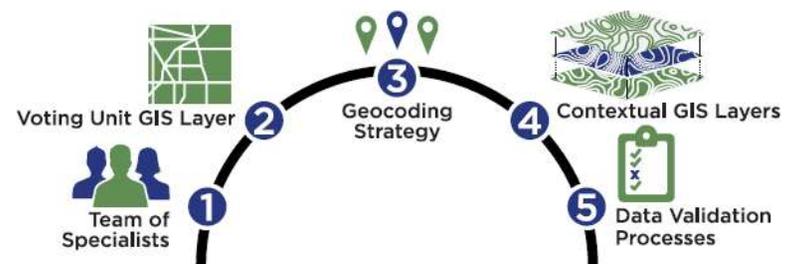
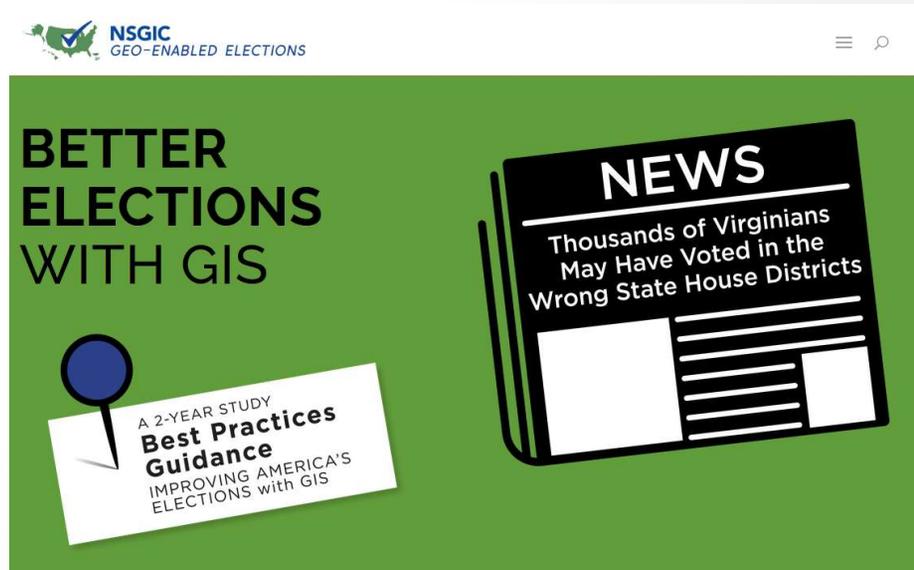
ELECTION ERRORS CAN LEAD TO LENGTHY LEGAL PROCESSES AND COSTLY DO-OVERS. MODERN GIS TECHNOLOGY TRANSFORMS VOTER LISTS INTO GEOSPATIAL PINPOINTS AND ENSURES THAT VOTERS AND CANDIDATES ARE PLACED IN THE RIGHT PRECINCT.

#### SAVE TIME AND WORK EFFORT

GEOSPATIAL DATA MADE VISUAL ON A MAP ARE MUCH EASIER TO CHECK FOR ACCURACY THAN LENGTHY VOTER ADDRESS LISTS. SIMILARLY, ASSIGNING VOTERS TO A NEW VOTING DISTRICT AND CREATING PRECINCT DEFINITIONS CAN BE DONE IN MINUTES WITH GIS.

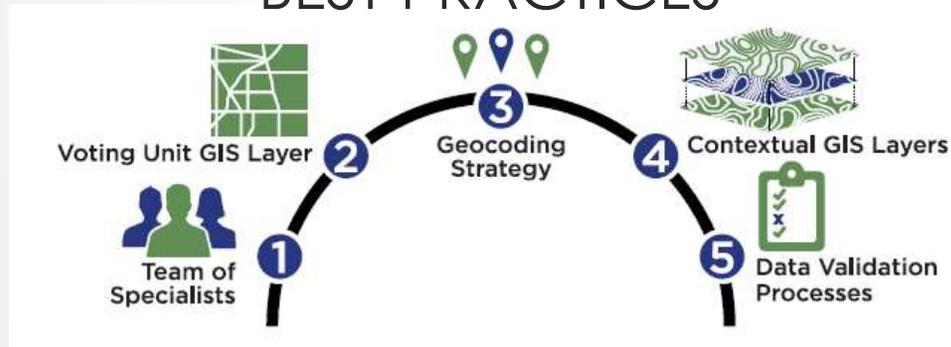
#### BOOST VOTER CONFIDENCE

WHEN FEWER ERRORS ARE REPORTED AFTER AN ELECTION, VOTERS' CONFIDENCE THAT THEIR VOICES ARE BEING HEARD INCREASES, AND THEIR FAITH IN THE DEMOCRATIC SYSTEM IS STRENGTHENED.



Source: <https://elections.nsgic.org/>

# NSGIC – GEO-ENABLED ELECTIONS BEST PRACTICES



## 1. Convene a team of specialists

- Collaboration between leaders, information technology, database administrators and GIS professionals

## 2. Collect and sustain a statewide voting unit GIS Layer

- Comprehensive, authoritative, current, and accurate boundaries

## 3. Implement a statewide geocoding strategy

- Assign accurate coordinates to each residential address

## 4. Assemble best available contextual GIS layers

- Relevant, accurate, verified and accessible for boundary alignment

## 5. Define and implement data validation processes

- Create spatial auditing processes for precinct creation and assignment

# SUMMARY

- GIS is a powerful tool to help make **accurate maps** so that the best, spatially-enabled, decisions can be made.
- For GIS to be useful it requires **documented and well-maintained data**.
- GIS requires **trained users** who use **critical spatial thinking** to evaluate implications of **mapping decisions**.
- Many **resources exist** to support the spatial element of elections.

