

# GIS Data, Resources, and Applications



Location matters

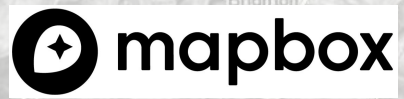
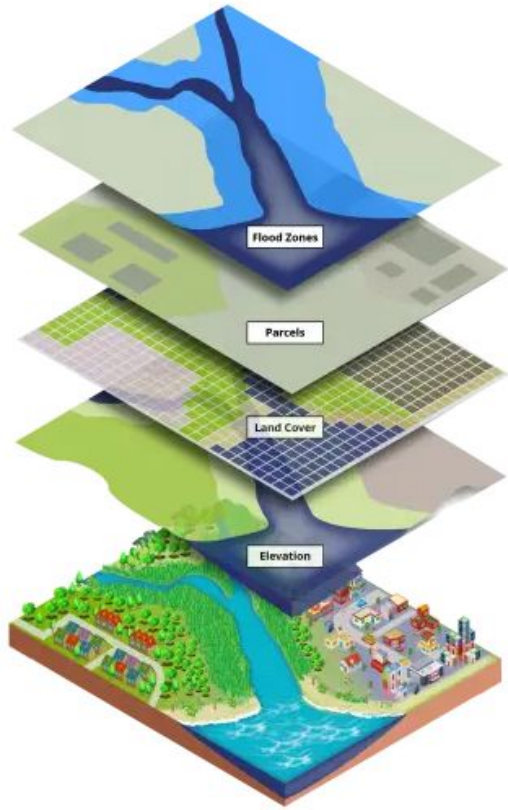
**Erik Neemann**  
**14 May 2022**

# Overview

- Quick GIS overview
- UGRC and Utah GIS resources
- Common GIS tasks and applications
- Python automation examples

# GIS Overview

- Geographic Information Systems (or Science)
  - Systems that store, process, analyze, and visualize geographic data
  - Data (database), Hardware, Software (ESRI, QGIS, Google Earth/Maps)
  - **Data** that pairs location with information
  - Adds the "where" component to a huge variety of datasets
  - Requires defined coordinate system and/or data projection



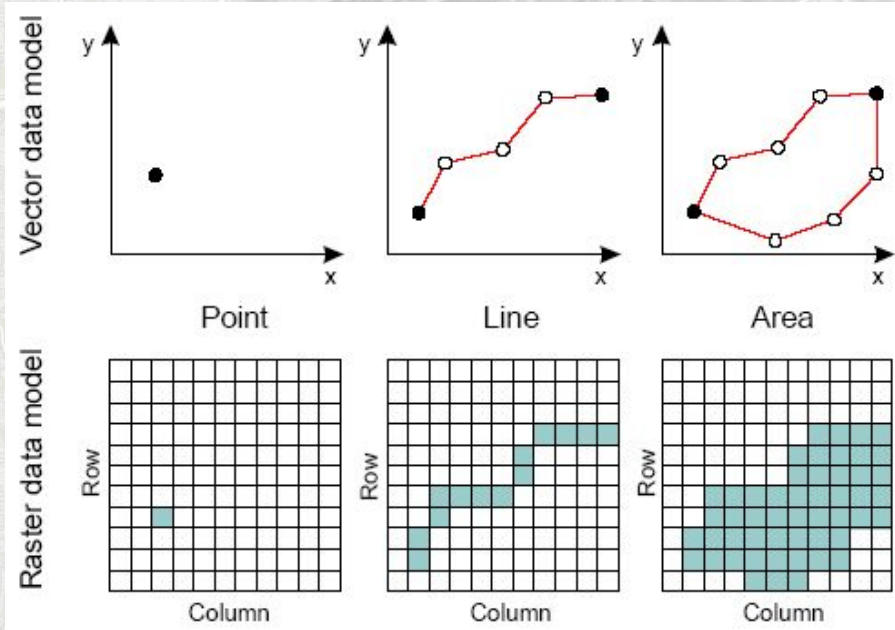
*"...collection of computer software and data used to view and manage information about geographic places, analyze spatial relationships, and model spatial processes. A GIS provides a framework for gathering and organizing spatial data and related information so that it can be displayed and analyzed."*

*A to Z GIS (ESRI Press)*

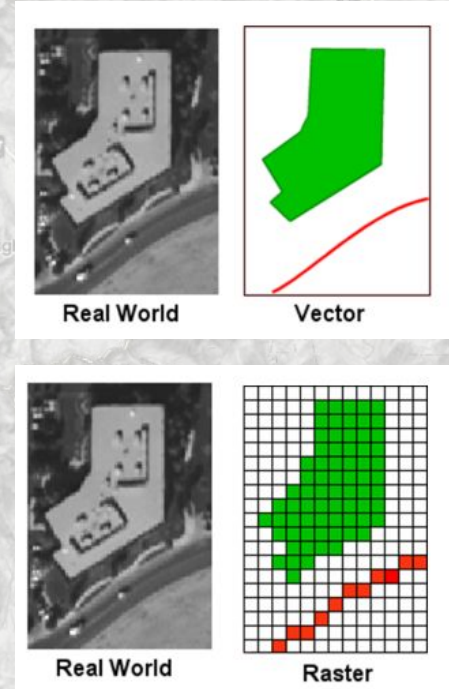
# GIS Overview

- Two primary data types used to represent the world:

## Vector

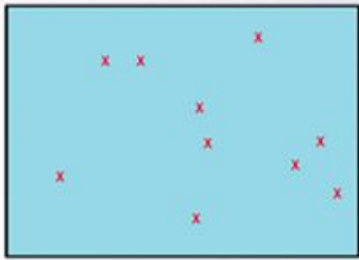


## Raster

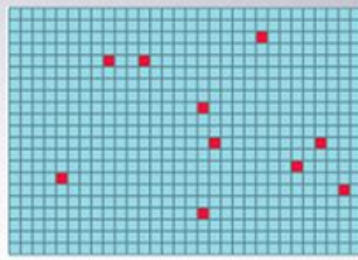


# GIS C

- Two



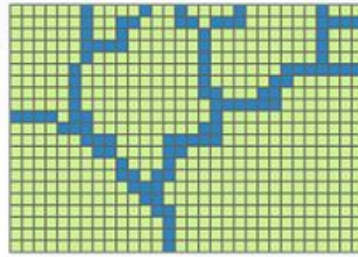
Point features



Raster point features



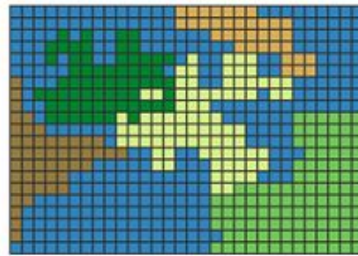
Line features



Raster line features

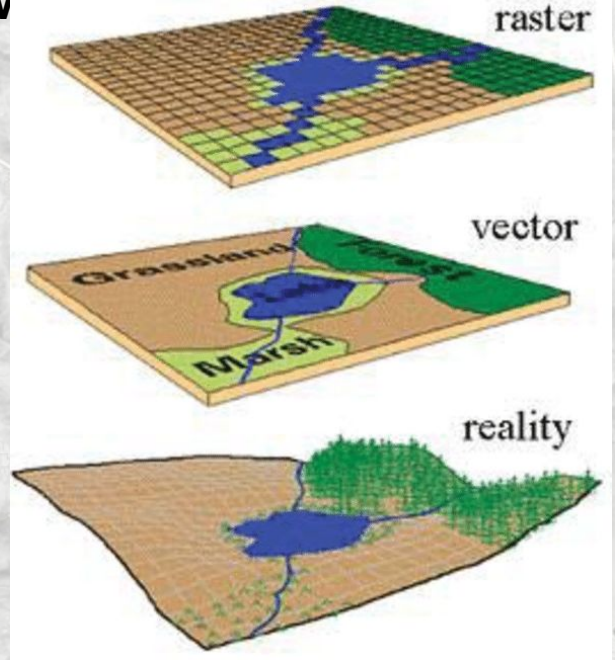


Polygon features



Raster polygon features

he words



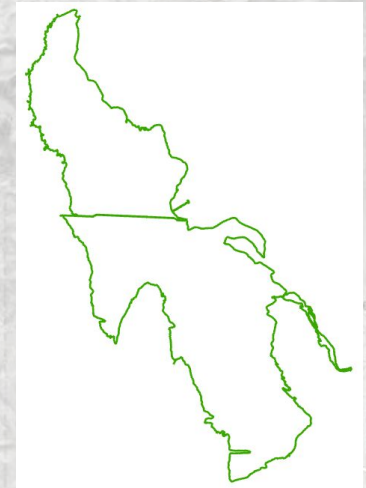
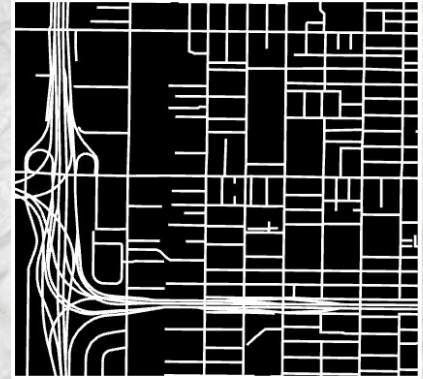
[Marc Spiller paper](http://gsp.humboldt.edu/olm/Lessons/GIS/08%20Rasters/RasterToVector.html)

<http://gsp.humboldt.edu/olm/Lessons/GIS/08%20Rasters/RasterToVector.html>

# GIS Overview - Vector

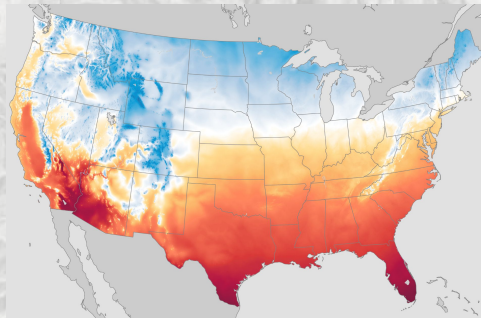
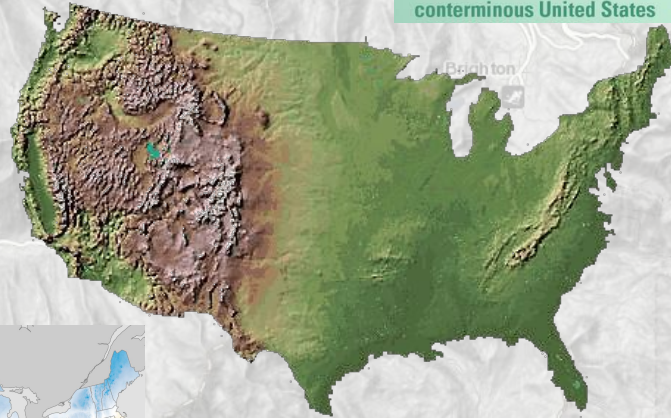
- Data representing points, lines, and polygons
- Precise coordinates are explicitly stored (geometry)
- Additional information is stored in an attribute table
- Think of a spreadsheet (attribute table), with a special column that stores the "geometry"
- Examples: Address points, road centerlines, parcels
- Data formats

- shapefile (.shp plus .shx, .dbf, .prj)
- geodatabase (.gdb)
- geopackage (.gpkg)
- GeoJSON (.geojson)
- KML (.kml/.kmz)
- and more



# GIS Overview - Raster

- Data that is stored on a regular grid
- Could be discrete or continuous data
- Examples: aerial imagery, elevation data, average temperature, land cover
- Data formats
  - GeoTIFF (.tif plus .tfw)
  - Image files (.img)
  - JPEG (.jpg)
  - geodatabase (.gdb)
  - geopackage (.gpkg)
  - netCDF (.nc)
  - many more

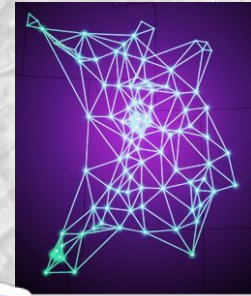


# UGRC



## Utah Geospatial Resource Center

- State of Utah's GIS office
- Established in 1989 via Utah Code 63F-1-506
- Department of Government Operations (DGO)
  - Division of Technology Services (DTS)
- State Geographic Information Datasource (SGID)
- Discover - Imagery & Basemap services
- TURN GPS Reference Network
- GIS & Web development
- Funded through combination of state funds and project work



**SGID**  
STATE GEOGRAPHIC  
INFORMATION DATASOURCE

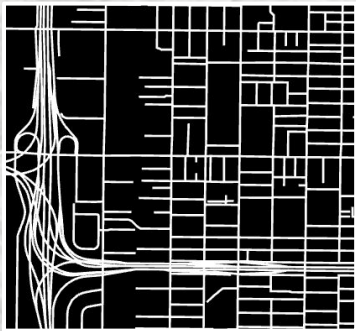


*"Encourage and facilitate the effective use of geospatial information and technology for Utah"*

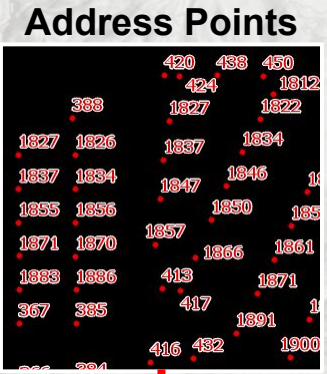


# Data Consolidation Efforts

- Aggregate data from counties into statewide datasource (SGID)
  - Frequency based on population
  - Roads, Address Points, Parcels
- Road centerline editing database pushed to production database monthly
- Data provided or maintained by other state agencies
- Other statewide data compiled and updated as needed



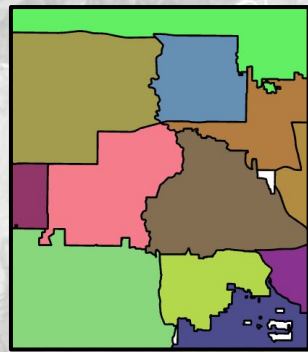
Roads



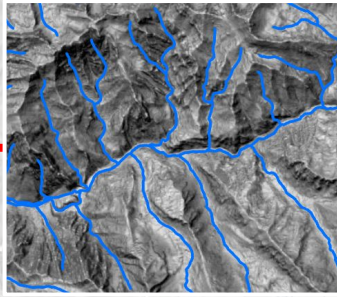
Address Points



Parcels



Boundaries



More...

# State Geographic Information Datasource (SGID)

[opendata.gis.utah.gov](https://opendata.gis.utah.gov)

[gis.utah.gov/data](https://gis.utah.gov/data)

ALL the data...(300+)

- Zip Codes
- Land Ownership
- Lakes
- Census
- Tax Areas
- Oil and Gas
- Geologic Faults
- Health Districts
- Building Footprints
- Address Quadrants
- Political Districts
- Golf Courses
- Trails
- Libraries



# SGID

STATE GEOGRAPHIC  
INFORMATION DATASOURCE

- Schools
- Transit
- Broadband
- Watersheds
- Great Salt Lake
- Flood Plains
- Court Districts
- and more!!!

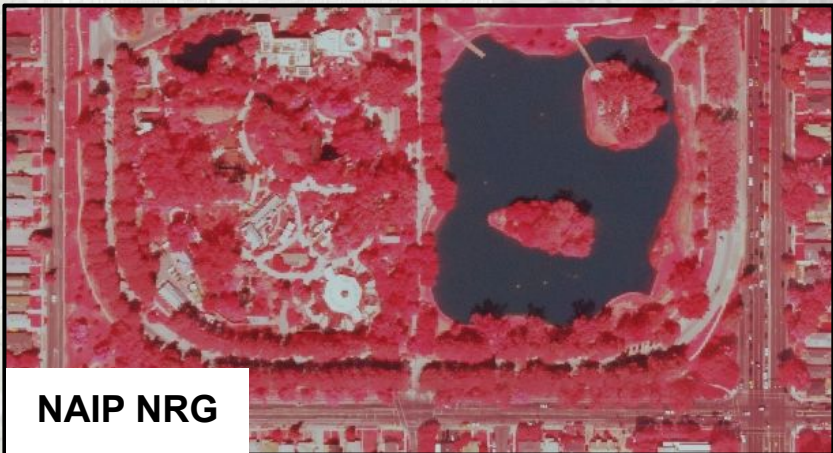
911 <b>911</b> 911	Addresses <b>Ad</b> Address	Aerial Photos <b>Ae</b> Aerial Photos	Bioscience <b>Bi</b> Bioscience
Boundaries <b>Bo</b> Boundaries	Cadastre <b>Ca</b> Cadastre	Climate/Weather <b>Ci</b> Climate	Contours <b>Co</b> Contours
Demographic <b>De</b> Demographics	Economy <b>Ec</b> Economy	Elevation/Terrain <b>El</b> Elevation	Energy <b>En</b> Energy
Environment <b>Ev</b> Environment	Farming <b>Fa</b> Farming	Geoscience <b>Ge</b> Geoscience	Health <b>He</b> Health
History <b>Hi</b> History	Indices <b>In</b> Indices	Location <b>Lo</b> Location	Planning <b>Pl</b> Planning
Political <b>Po</b> Political	Recreation <b>Re</b> Recreation	Society <b>So</b> Society	Transportation <b>Tr</b> Transportation
USGS Topo Maps <b>To</b> Topo Maps	Utilities <b>Ut</b> Utilities	Water <b>Wa</b> Water	

# UGRC - Discover Server

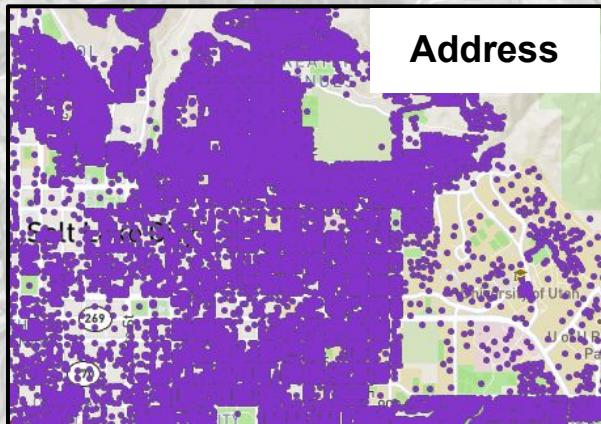
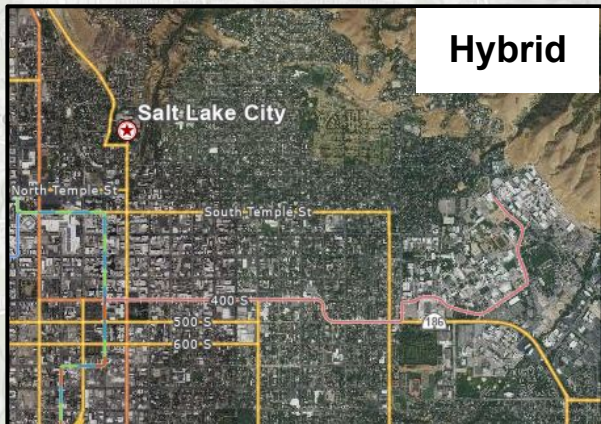
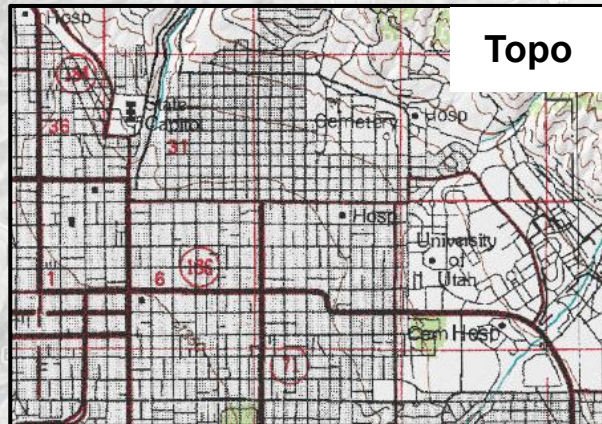
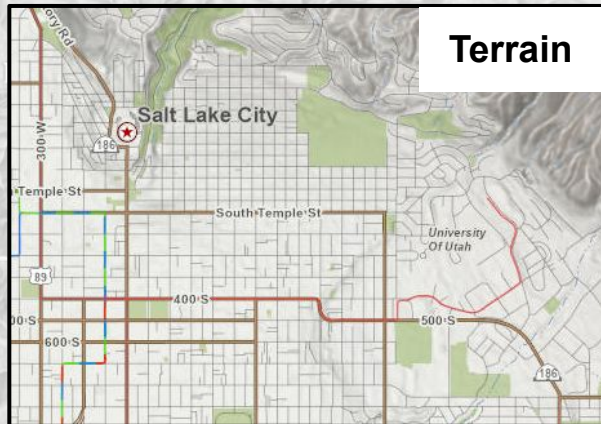
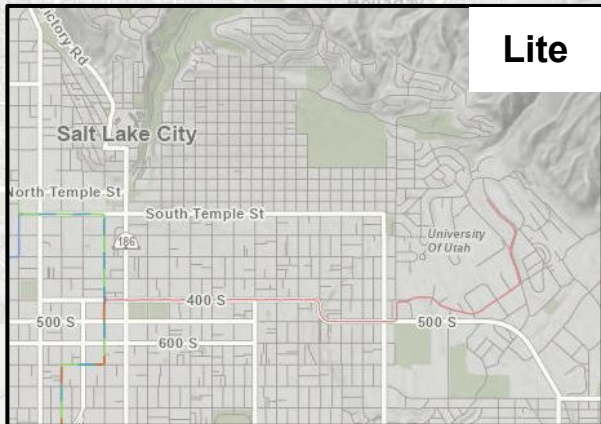
- [gis.utah.gov/discover](https://gis.utah.gov/discover)
- Free imagery and basemap services (WMTS and WMS) for anyone
  - 1) Sign up using the [web form](#)
  - 2) Get unique connection URL (quad-word, not a username/password)
  - 3) Add services in your software (GIS, CAD, web applications)
- Imagery
  - Licensed [L] - government (city, county, state, school, tribal), government contractor, student
    - Additional imagery/higher resolution imagery is available
  - Unlicensed - general access for anyone
  - Layers
    - 1990s B/W, NAIP (2006, 2009, 2011, 2014, 2016, 2018, 2021), Google [L], Hexagon (15cm [L])
- Basemaps
  - Available for everyone
  - Layers
    - Lite, Terrain, Topo, Hybrid/Overlay, Address Points, Hillshade



# UGRC - Discover Imagery



# UGRC - Discover Basemaps



# UGRC - Raster Data Downloads

- [raster.utah.gov](https://raster.utah.gov)
- Many datasets available
  - Aerial imagery
  - Digital Elevation Models (DEMs) and Surface Models (DSMs)
  - Contours
  - USGS Topo Maps

## UGRC Raster Data Discovery 2.2.7

Step 1 - Select Products

Step 2 - Define Area of Interest

Step 3 - Results

▼ LIDAR DEMs

▼ .5 Meter

▶ Bare Earth DEM / DTM

Extent

▼ First Return DEM / DSM

Extent

.5 Meter First Return LIDAR DEM / DSM

[more info](#)

[web page](#)

[Download](#)

▶ 10 Foot

▶ 1 Meter

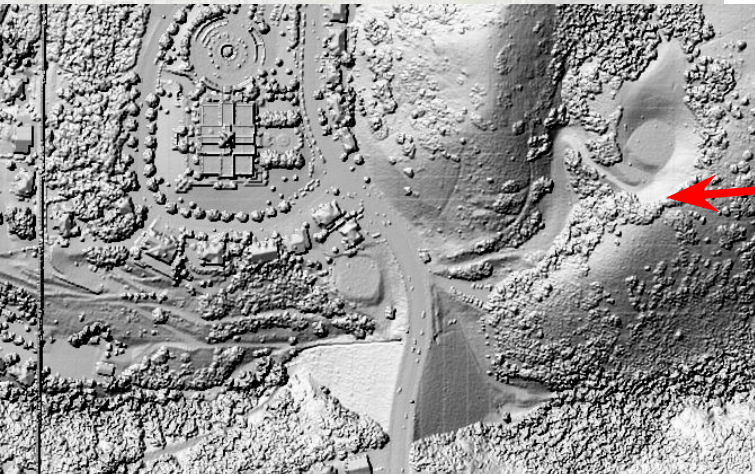
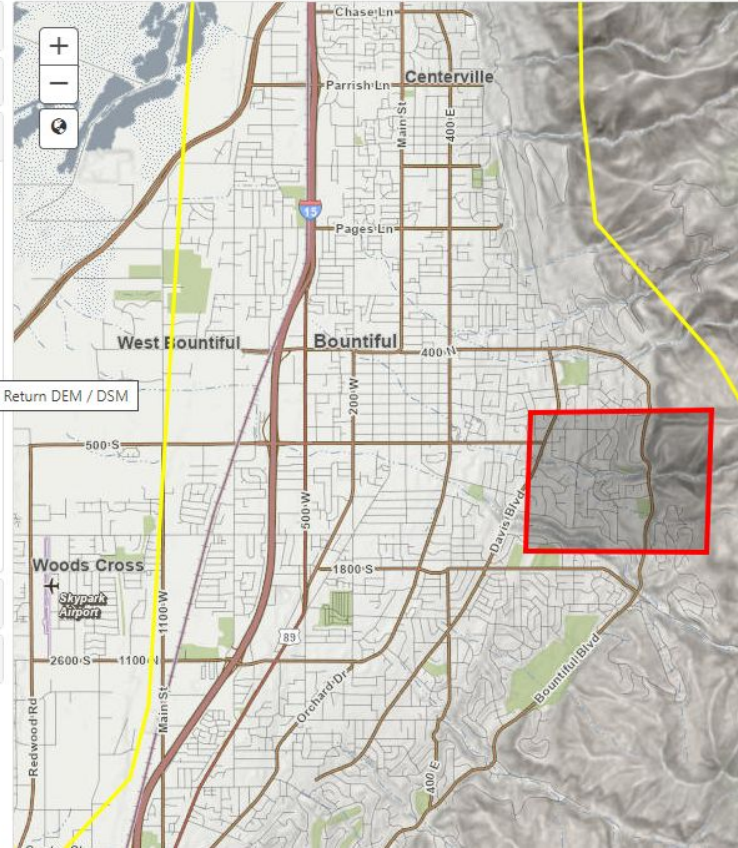
▶ 1.25 Meter

▶ 2 Meter

First Return DEM / DSM

Step 4 - Download Data

[Help | UGRC Imagery Services Info](#)



# UGRC - Web API and Geocoding

- [api.mapserv.utah.gov](https://api.mapserv.utah.gov)
- Search statewide data layers via the API
  - Perform queries and only gather the data you need
- Geocoding
  - Turn addresses into coordinates that can be used for mapping
  - Single or batch geocoding on large datasets
- API client - <https://github.com/agrc/api-client/releases>
  - Lightweight software that allows ANYONE to geocode
  - No GIS software required, no licensing
  - No programming skills required
  - Cross-platform, automatic updates
  - Drag and drop

API = Application Programming Interface

[API Client  
Blog Post](#)



```
{
  "result": {
    "location": {
      "x": 428015.1619961144,
      "y": 4512994.085205136
    },
    "score": 100,
    "locator": "AddressPoints.AddressGrid",
    "matchAddress": "1320 E 200 S, SALT LAKE CITY"
  },
  "inputAddress": "1320 E 200 S, Salt Lake City"
  "standardizedAddress": "1320 east 200 south",
  "addressGrid": "SALT LAKE CITY"
},
"status": 200
}
```

API  
Response  
Example





← BACK

### Add your data

The UGRC API requires 2 inputs to geocode. The first is a street address in the form of

<b>301</b> house number	<b>South</b> prefix direction	<b>Main</b> street name	<b>Street</b> street type or suffix direction
----------------------------	----------------------------------	----------------------------	---

The second required input is a zone. A zone can be a zip code or a city name. If your data has both available, prefer the zip code. This data needs to be structured data in a CSV format with a header row.

street	zone
154 CENTENNIAL RD	84536
105 MONUMENT RD	84536
67 TEAR DROP LOOP	84536
71 CENTENNIAL RD	84536
142 CENTENNIAL RD	84536
146 BLACK BRUSH HILL RD	84536
76 CENTENNIAL RD	84536
61 TEAR DROP LOOP	84536

**DROP THE CSV FILE HERE**

CHOOSE FILE

street	zone	x	y	score	match_address
154 CENTENNIAL RD	84536	-110.1277805	36.99849144	100	154 CENTENNIAL RD, BLANDING
105 MONUMENT RD	84536	-110.1339016	36.99876812	100	105 MONUMENT RD, BLANDING
67 TEAR DROP LOOP	84536	-110.1845248	36.99950781	100	67 TEAR DROP LOOP, BLANDING
71 CENTENNIAL RD	84536	-110.1265563	36.99917329	100	71 CENTENNIAL RD, BLANDING
142 CENTENNIAL RD	84536	-110.1302544	36.99945742	100	142 CENTENNIAL RD, BLANDING
146 BLACK BRUSH HILL RD	84536	-110.8116292	37.00262061	100	146 BLACK BRUSH HILL RD, BLANDING



# UGRC - PLSS Fabric and Data

- [plss.utah.gov](http://plss.utah.gov)
- Public Lands Survey System (PLSS) and Fabric
  - Corner monuments, Townships, Sections, quarters, etc.
- It's all tied together...
  - Plats, parcels, boundaries, land ownership data
- UGRC works with BLM and SITLA
- Monument Replacement and Restoration Committee



ATTACHMENT 2  
PLSS Monument Preservation Sheet

Township Range Section Meridian											
BLM Point ID											
UT	T	R	S	1	2	3	4	5	6	7	8
4	4	2	6	9	0	1	0	6	4	4	2
4	4	2	6	9	0	1	0	6	4	4	2
Meridian		Township			Range		Section			Corner	
UTAH		4			2		9			06	
Corner's Name		Corner's Phone			State		County			Date	
ROBERT J. JOHNSON		435.712.1317			UTAH		WASHINGTON			01.05.2010	
Corner's Address		Source Number			State		County			Date	
2101 W. STATE ST.		2101 W. STATE ST.			UTAH		WASHINGTON			01.05.2010	

PLSS Monument Coordinates

Date: 01/05/2010

NAD83:  NAD83 WGS84:  NAD83 UTM:  NAD83 UTM:  NAD83 UTM:  NAD83 UTM:  NAD83 UTM:  NAD83 UTM:

Latitude (DMS):  Longitude (DMS):

Northing:  Easting:

Uplift:  Horizontal Dist. (Feet):  Vertical Datum:  State Plane:  UTM Zone:  UTM Easting:  UTM Northing:  UTM Zone:  UTM Easting:  UTM Northing:

Uplift Height:  Vertical Datum:  State Plane:  UTM Zone:  UTM Easting:  UTM Northing:

Measurement and Markings

Stone	Type/Size	Post	Other
Size: 3"	Pipe/Cap: 3"	Size: 3"	Size: 3"
Material: BEAS	Material: BEAS	Material: BEAS	Material: BEAS

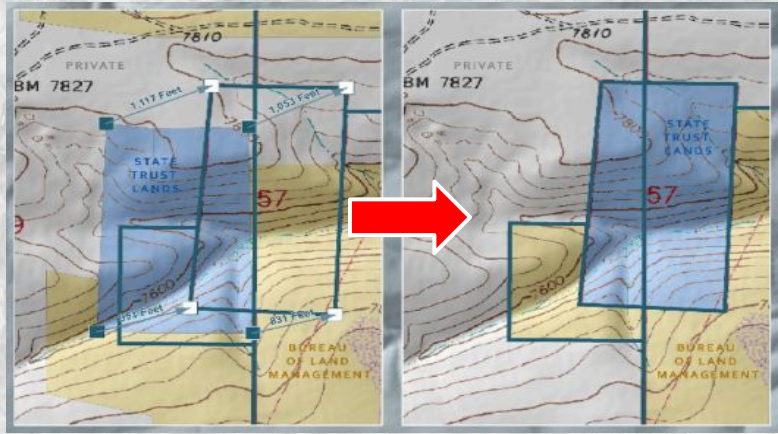
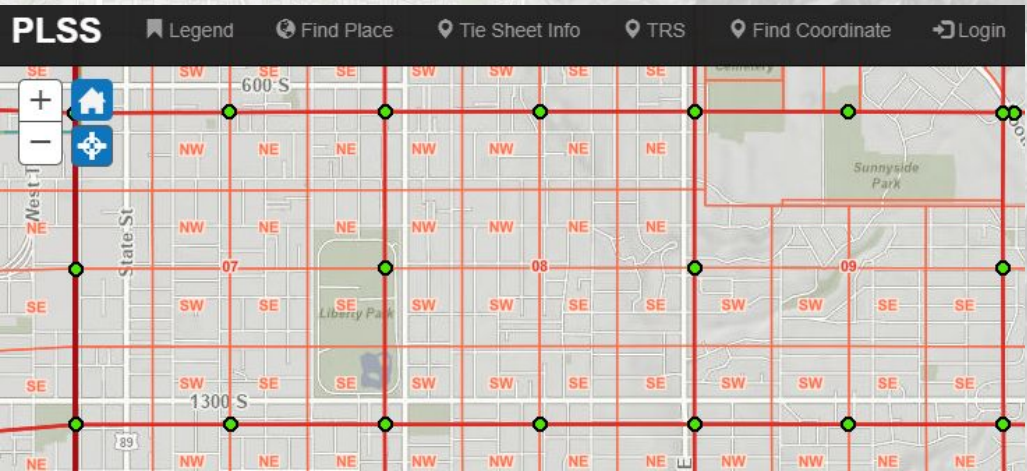
Navigation:  Legend:  Tie Sheet Info:  TRS:  Find Coordinate:  Login:

Description and Observation of Monument

SOUTH 1/4 OF SECTION 1 WAS FOUND IN GOOD CONDITION BY BARR WIRE FENCE

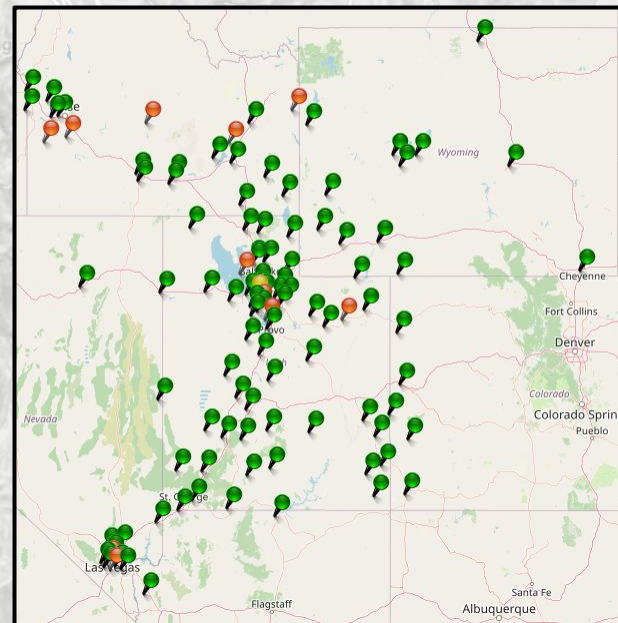
Sketch (drawing or actual photo of GPS Station Occupied)

Show number of observations relative to North and describe truth.



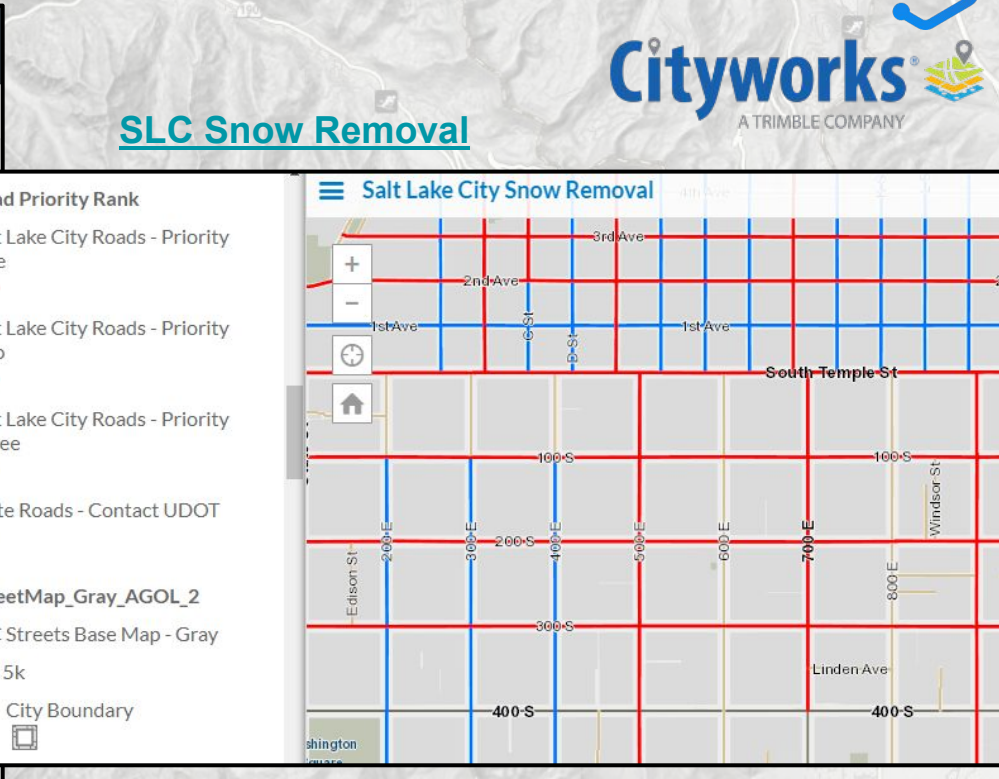
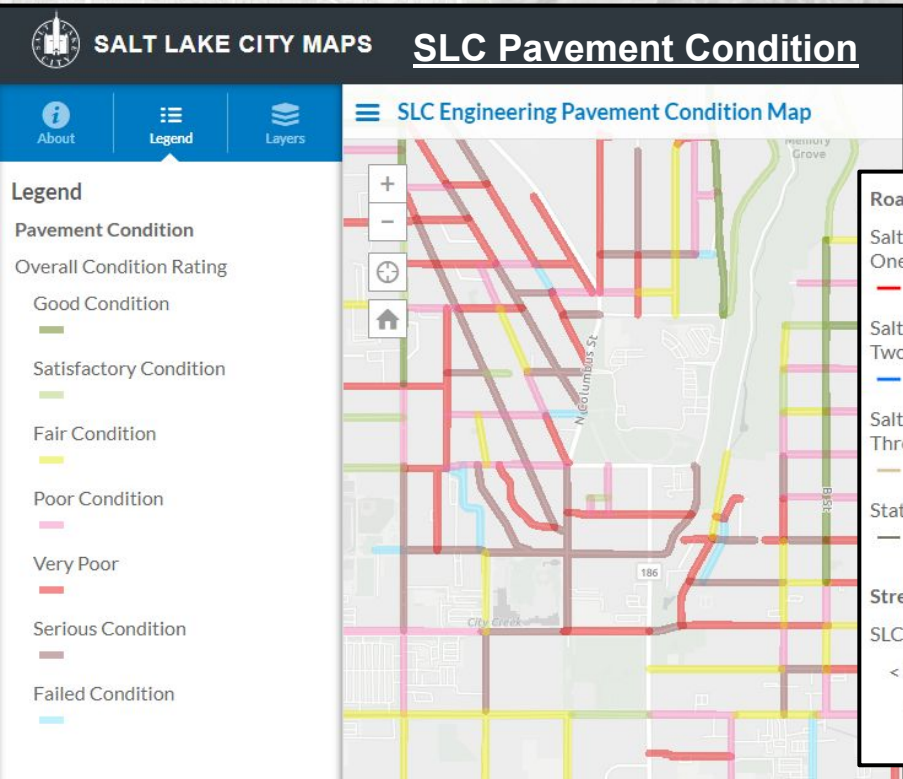
# The Utah Reference Network (TURN GPS)

- [gis.utah.gov/gps](https://gis.utah.gov/gps)      [turngps.utah.gov](https://turngps.utah.gov)      [Sensor and Status Map](#)
- High-precision GPS network of permanently located GPS receivers
  - real-time corrections
  - data for post-processing
- Sensors send data to the system, it analyzes, adjusts, and corrects data to provide the most accurate location possible
- Centimeter to sub-centimeter precision
- Ideal for:
  - Surveying
  - Construction & Engineering
  - Field data collection
  - GPS-controlled machinery (agriculture, ski groomers, etc.)
  - Self-driving cars, drone delivery, etc.
- \$600/year subscription per user
- Cloud migration - IPs will change in the near future



# Common GIS Tasks and Applications

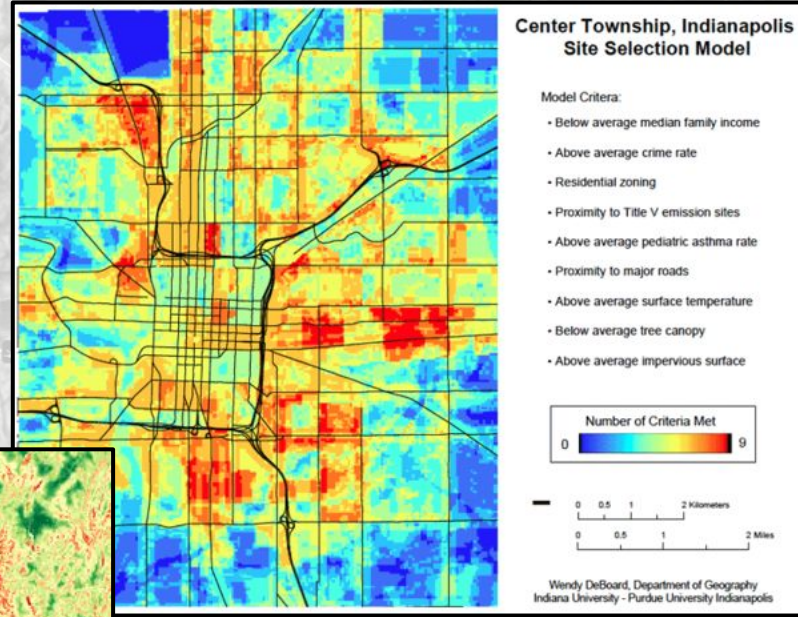
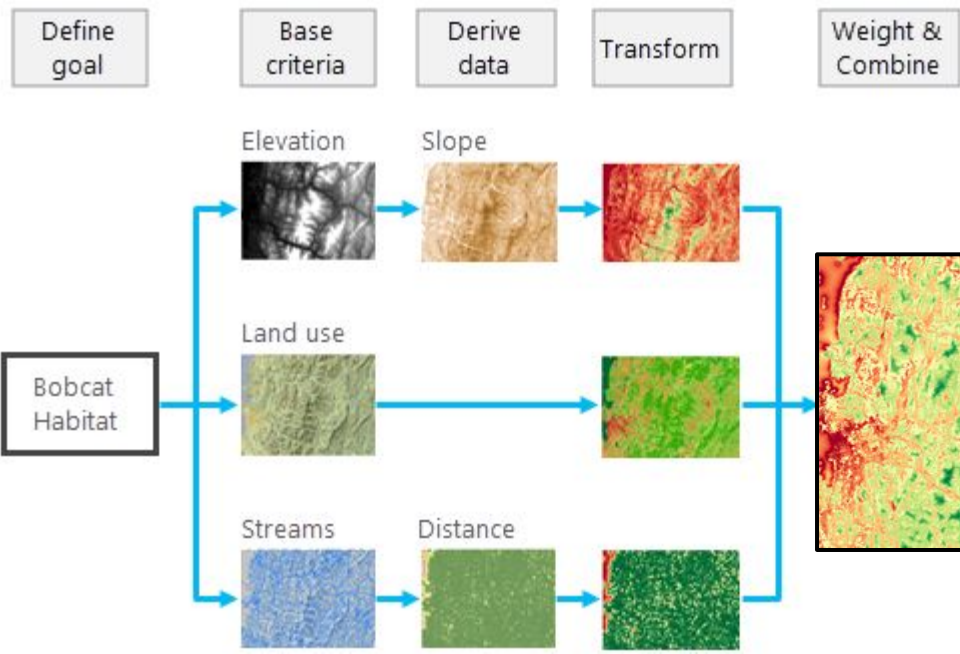
- **City operations: asset management, inspections, permitting, work orders**
  - Software packages integrate with GIS and manage spatial data



# Common GIS Tasks and Applications

- Site selection/suitability analysis, environmental impacts, habitats

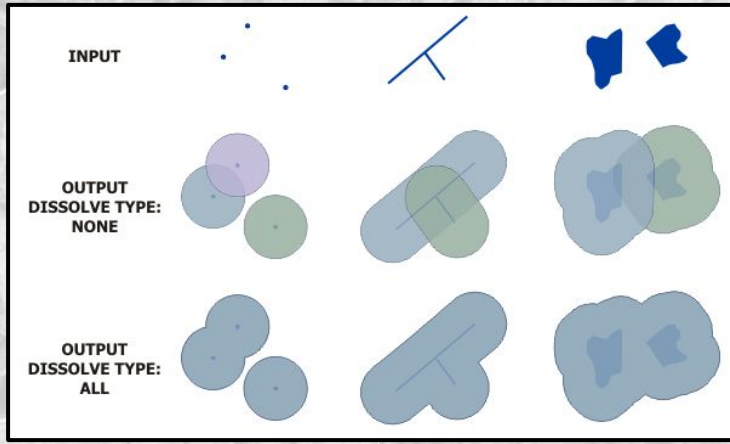
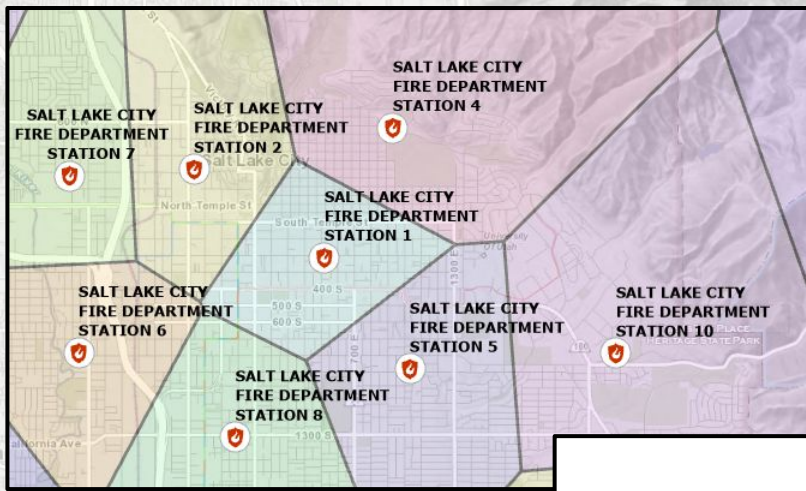
## ESRI Habitat Example



## Indianapolis Site Selection

# Common GIS Tasks and Applications

- Proximity tools: point-in-polygon analysis, thiesen polygons, buffers



[Buffer Examples](#)

Street Address  Zip Code   [Help?](#)

Find District...

## Thiessen Polygons

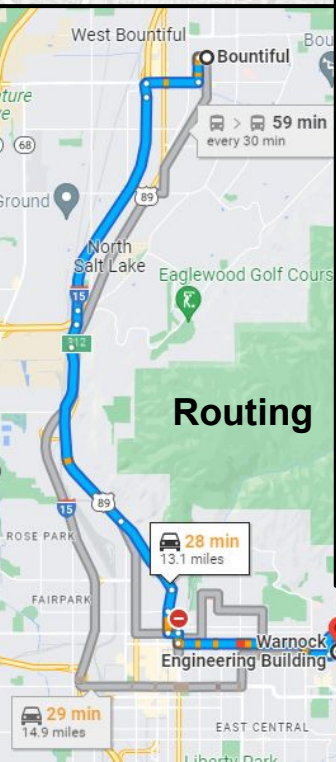
Utah Geospatial Resource Center

[Utah Legislative Districts](#)

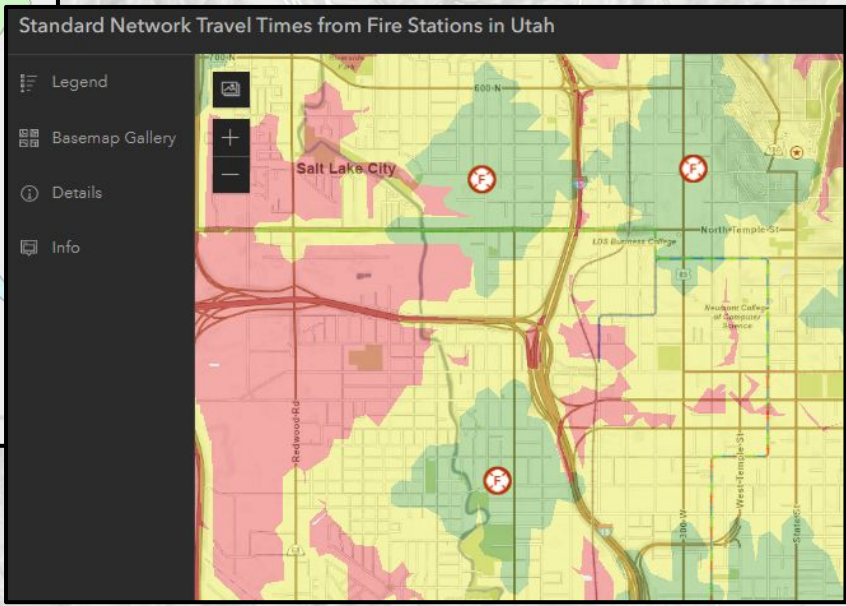
An aerial map view with a yellow location pin. A pop-up window displays information for two representatives:   
**Representative:** Joel K. Briscoe (D), House District 25.   
**Senator:** Derek L. Kitchen (D), Senate District 2.

# Common GIS Tasks and Applications

- Road network analysis: routing, drive-time analysis, service areas



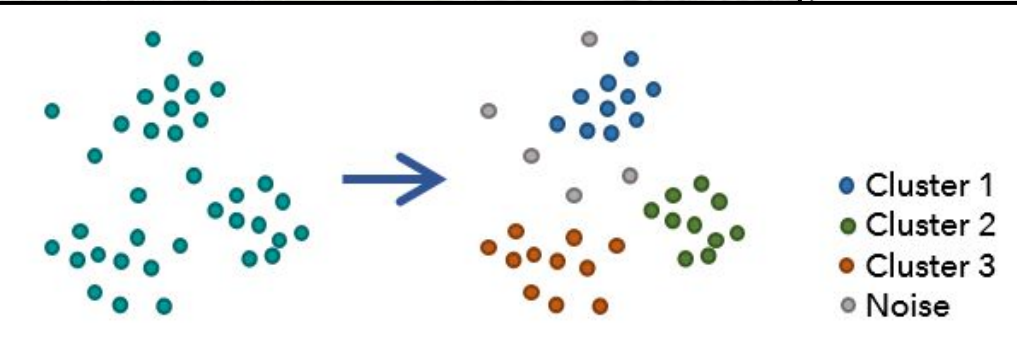
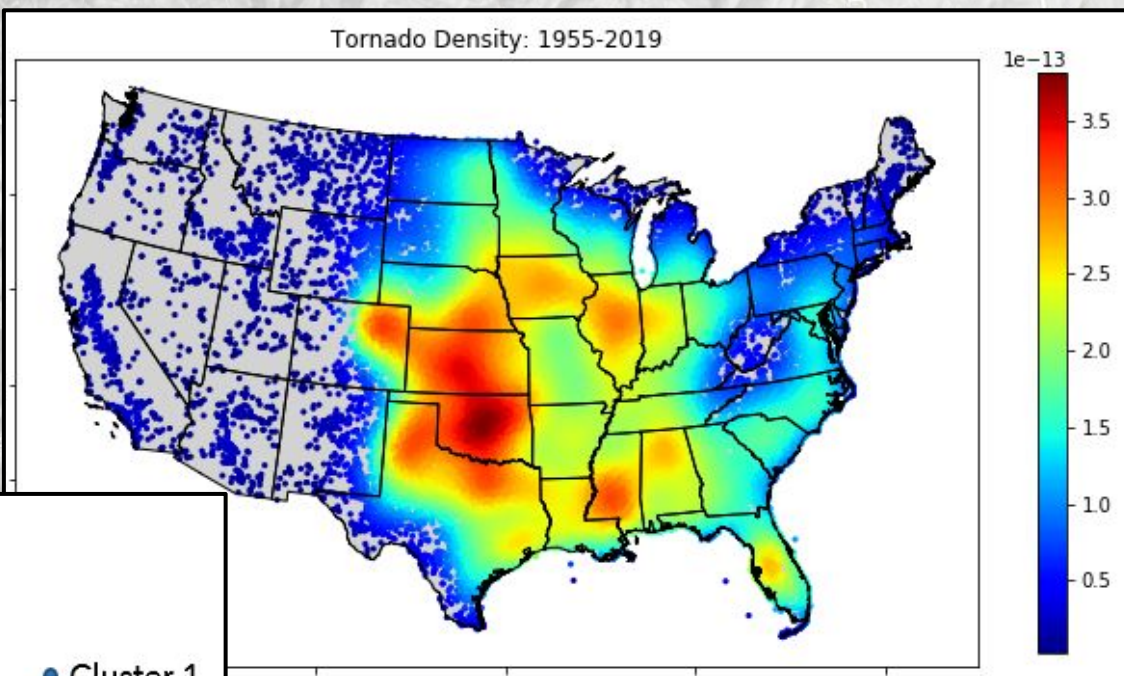
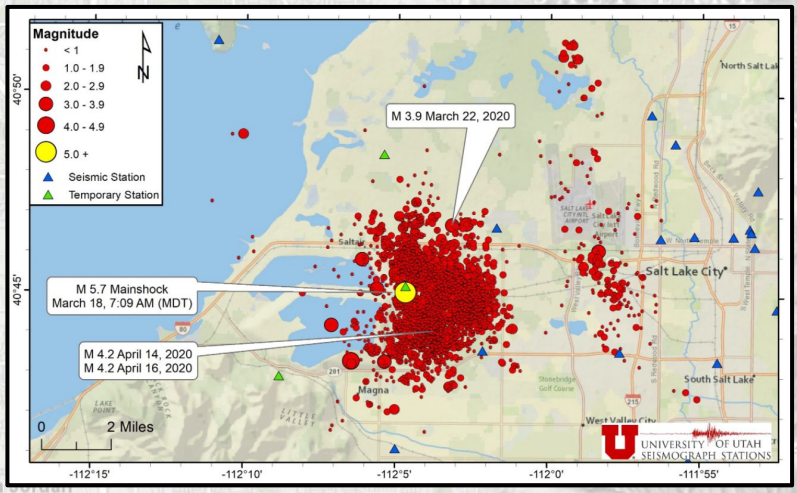
[Travel Times from Utah Fire Stations](#)



# Common GIS Tasks and Applications

## Magna Earthquake

- Point data analysis: density and hotspots, clustering



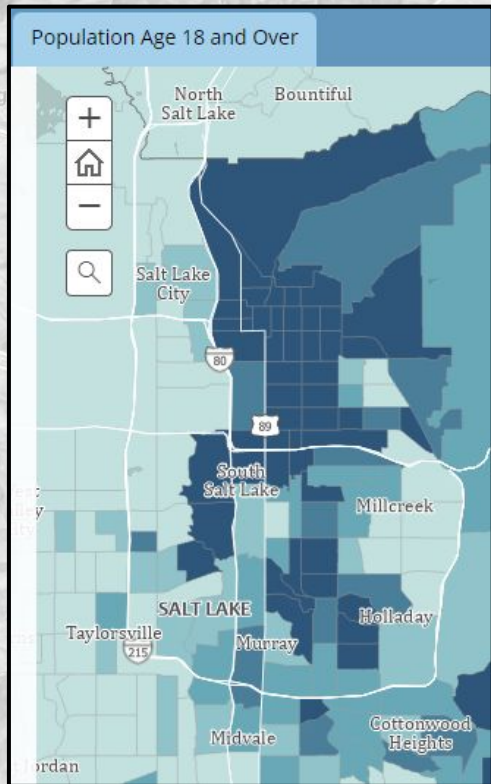
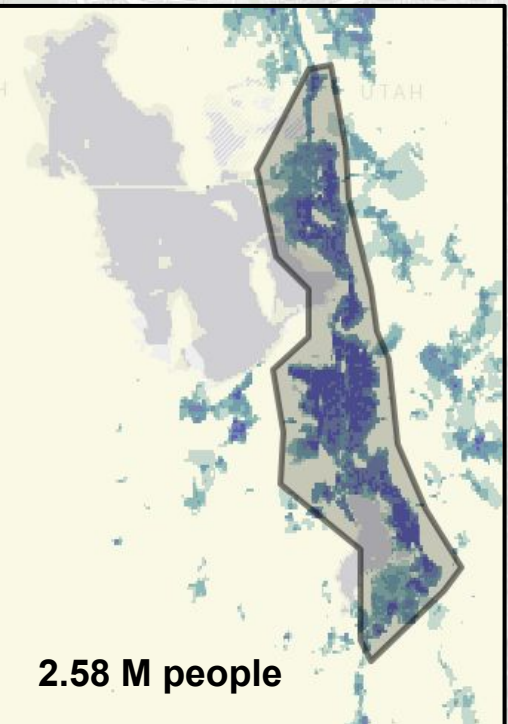
## ESRI Clusters

# Common GIS Tasks and Applications

- Geographic statistics and demographics

## Census Data

### NASA Population Estimate



## Tornado Warning

Valid Until  
6:15 PM CDT Monday  
May 2, 2022

**Threat Information**

- TORNADO**  
Radar Indicated
- HAIL**  
Golf Ball  
Sized Possible

**Potential Exposure**

- Population: 27,730
- Schools: 17
- Hospitals: 1

@NWSNorman

@NWSNorman Twitter



# Common GIS Tasks and Applications

- Planning: data and analysis (transportation, economy, city planning)
- [UDOT West Davis Corridor project](#)

[Centerville Zoning](#)

WASATCH FRONT REGIONAL COUNCIL

Access to Opportunities

ATO Page    WFRC Map Gallery

Find address or place

Show me  access to  within a typical commute time compared to the average for .

Map is currently displaying:

Auto Zoom

Transit Access to Jobs Compared to Average for Wasatch Front - Future Projections

below average    near average    above average

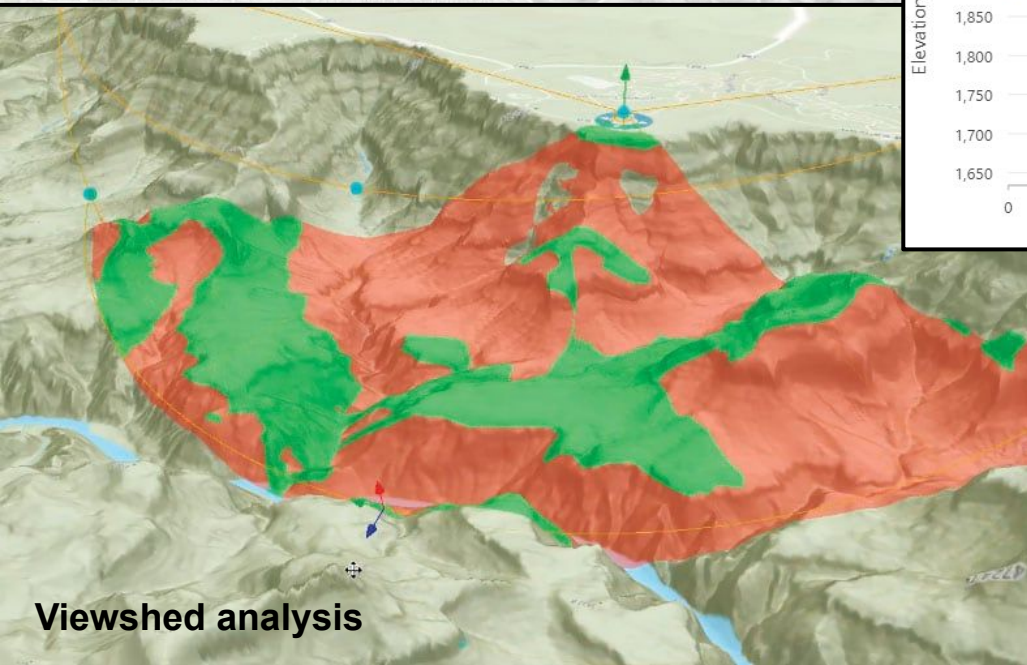
Travelshed Display when TAZ Selected:

[WFRC](#)

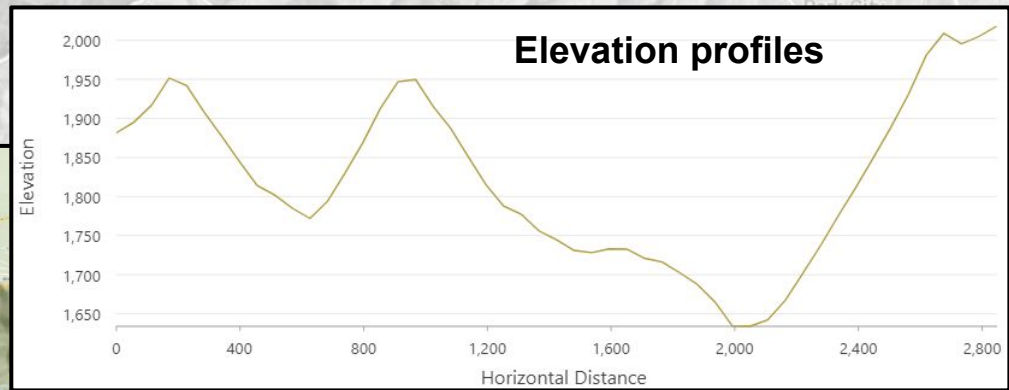


# Common GIS Tasks and Applications

- **3D: viewshed analysis, elevation profiles, volume calculations**
  - **Cut** - volume above surface feature
  - **Fill** - volume below surface feature
- **Shadow and solar analysis**



Viewshed analysis

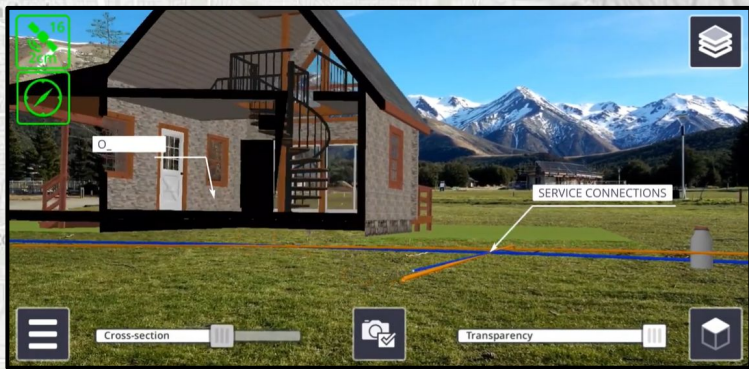
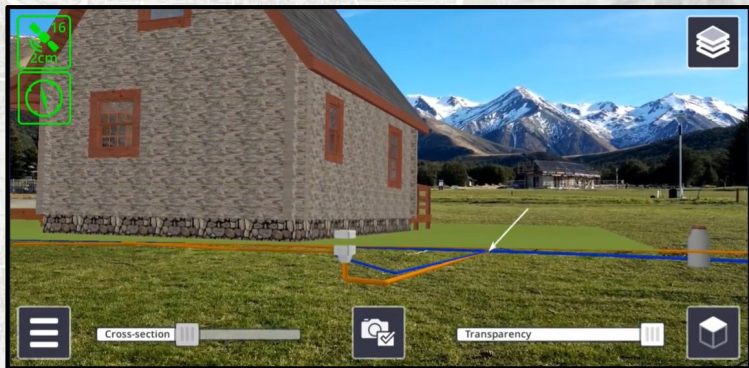


[ESRI viewshed](#)  
[ESRI volume calculation](#)

# Common GIS Tasks and Applications

- GIS and Building Information Modeling (BIM) integration
  - Detailed views and attribute information

[Trimble SiteVision](#), [construction](#)

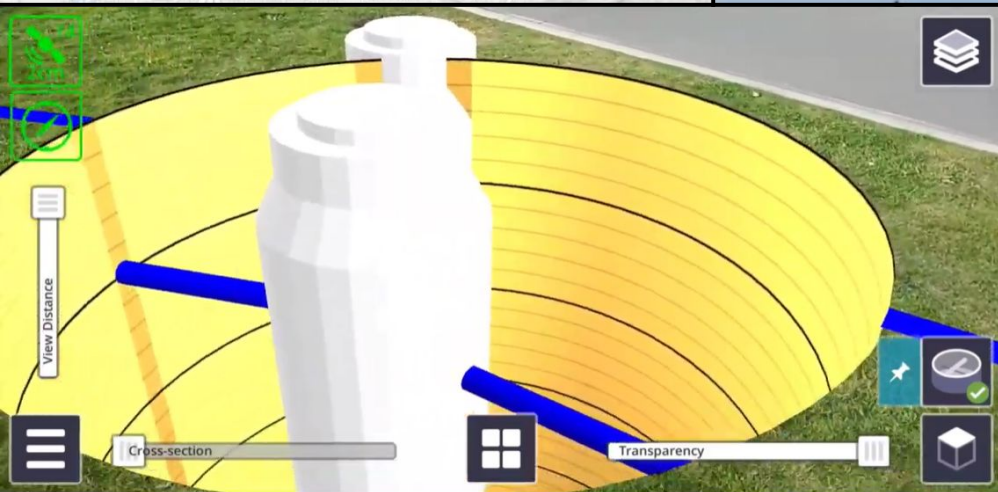
A screenshot of the Trimble SiteVision software interface showing a detailed view of a mechanical component. A pop-up window titled 'Attributes' is open, displaying the following information:

- 60HZ
- [Materials and Finishes]
- Air Inlet Unit Material: Grille
- Air Outlet Unit Material: Metal Grill
- Connectors: Metal Gold
- External Material: Galvanized Steel Plate
- [Mechanical - Loads]
- Coil Type: Cross fin
- Cooling Capacity (BTU): 27000
- Heating Capacity (BTU): 30000
- Unit Weight (LBS): 111
- [Plumbing]
- Drain Pipe Dimensions: 1 1/4

The interface includes a 'Cross-section' slider and a 'Transparency' slider. In the top left corner, there are icons for a 3D view, a 2D view, and a 16:9 aspect ratio. A stack of layers icon is in the top right. At the bottom, there is a 'Pause (k)' button and a 'CHECK COMPONENT DETAILS' button.

# Common GIS Tasks and Applications

- **Augmented Reality (AR) applications**
  - **View underground utility infrastructure**
  - **View proposed infrastructure**



VIEW EXISTING UNDERGROUND ASSETS

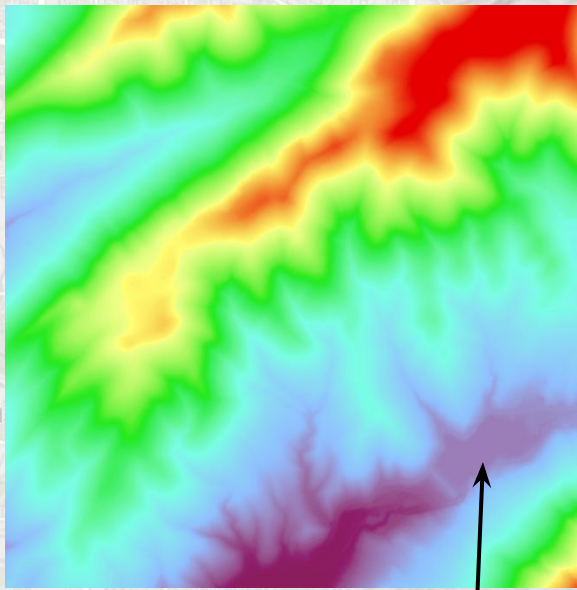


OR PROPOSED ABOVE GROUND SERVICES

[Trimble SiteVision](#)

# Common GIS Tasks and Applications

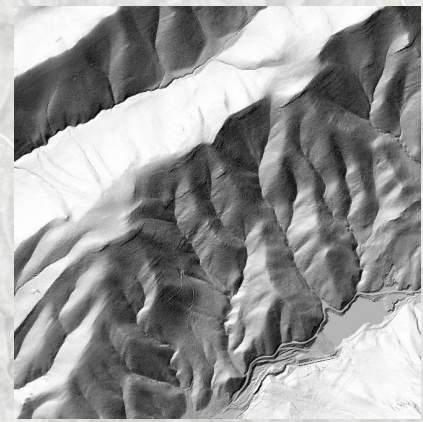
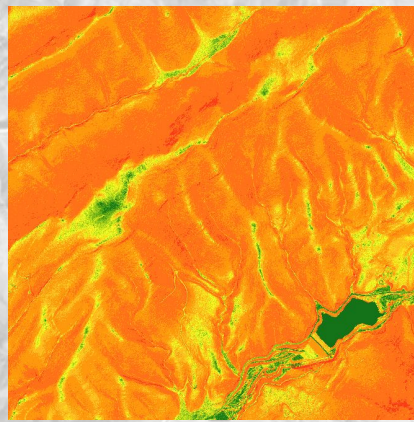
- Elevation: data models and analysis



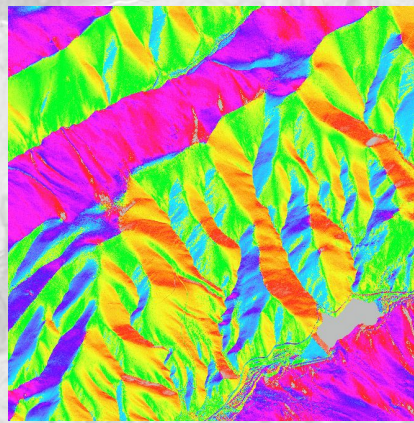
Elevation

Red Butte Reservoir

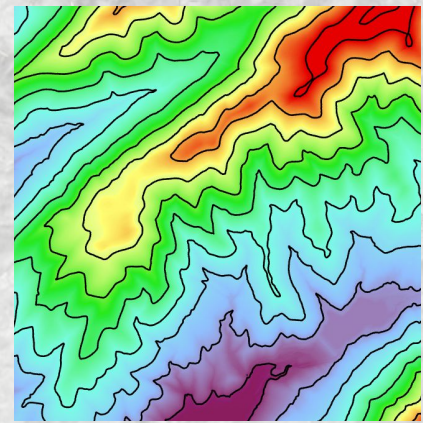
Slope



Hillshade



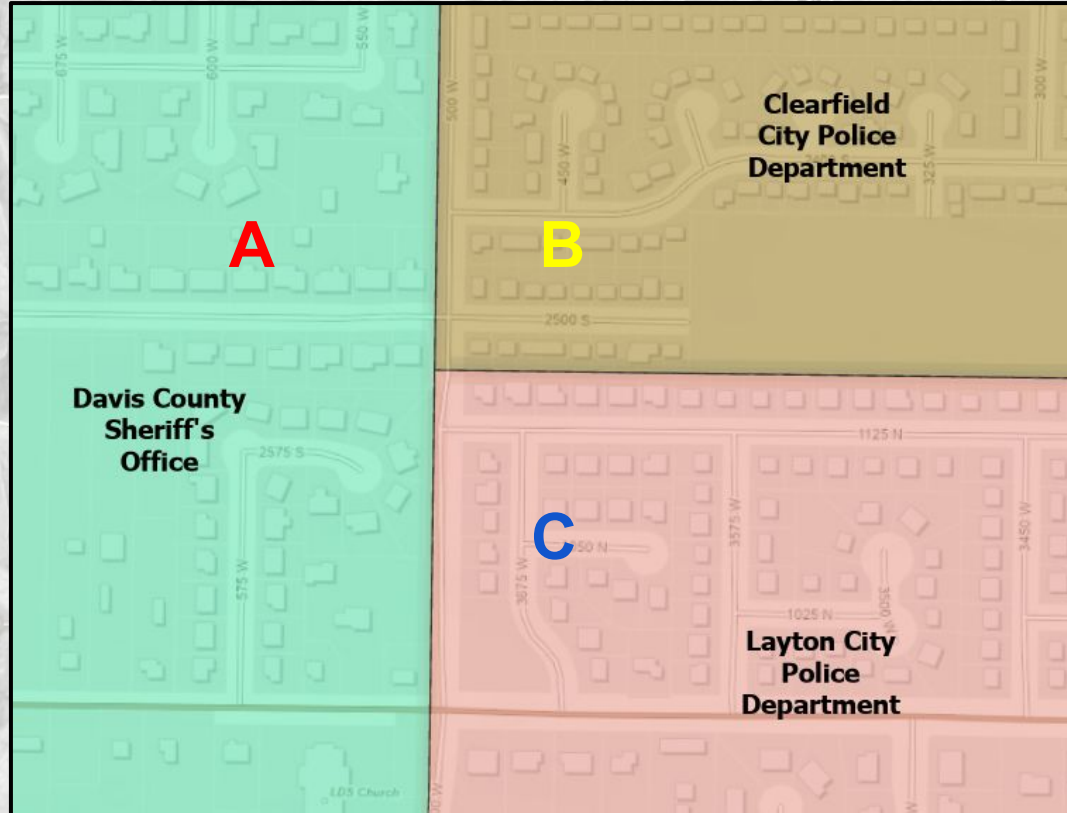
Aspect



Contours

# Common GIS Tasks and Applications

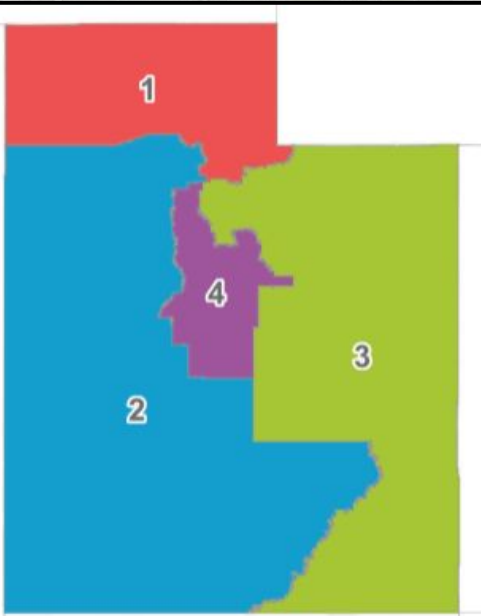
- **911 & Next-Generation call-routing**
  - Caller A → Davis County Sheriff's Office
  - Caller B → Clearfield City Police Department
  - Caller C → Layton City Police Department
- **Dispatch software can also recommend which fire and medical units should respond to the location**



# Applications of GIS never end ...

- Election Management: Redistricting, drawing precincts, voters and ballots
- Solar potential analysis
- Flood and inundation modeling
- Drone data capture, imagery, and 3D models

[Google Project Sunroof](#)



2082 E 270 S St, St. George, UT 84790, USA GO

✓ Analysis complete. Your roof has:

- ☀️ 2,158 hours of usable sunlight per year  
Based on day-to-day analysis of weather patterns
- 🏠 1,903 sq feet available for solar panels  
Based on 3D modeling of your roof and nearby trees

**\$5,000 savings**  
Estimated net savings for your roof over 20 years

Wrong building? [Click another roof to view details.](#)

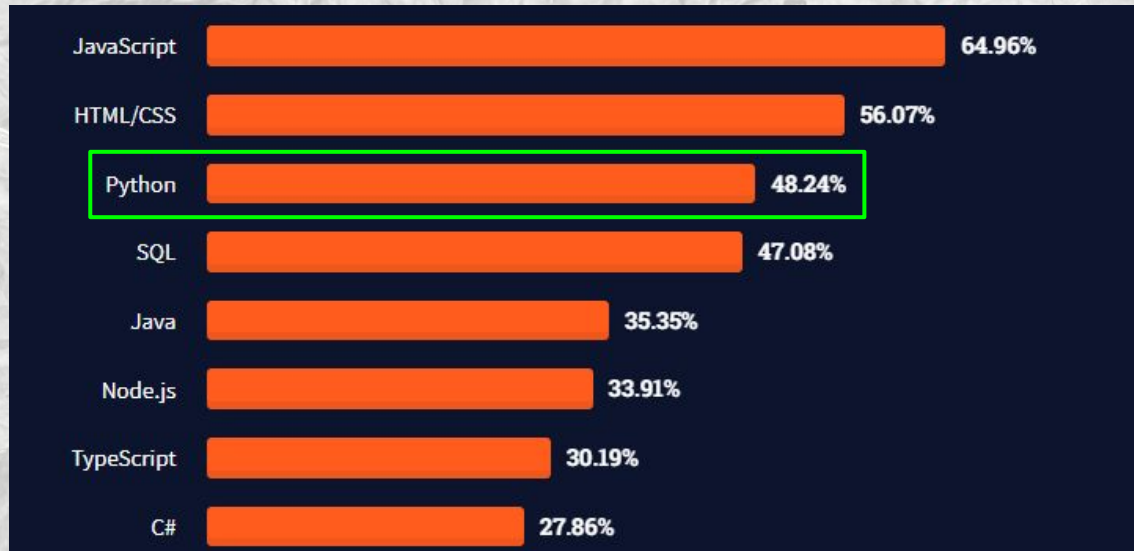


# Python and Automation

- Popular, readable, versatile, easy-to-use programming language
- Open source and has a very large community of users and developers
- Tons of packages for a wide variety of uses
- Ubiquitous in GIS, data science, and scientific/academic communities
  - Able to chain tasks together to automate and repeat complex processes
  - Analysis and visualization

StackOverflow  
[developer survey](#):

Most Popular  
Technologies





# Python and Automation in GIS

- **Geospatial packages**

- **ESRI: ArcPy, ArcGIS API for Python**
- **Open Source: GDAL, PyQGIS, Geopandas, Rasterio, Shapely, Fiona, geemap,**
  - **too many to list ...**

- **Automate several processes in GIS**

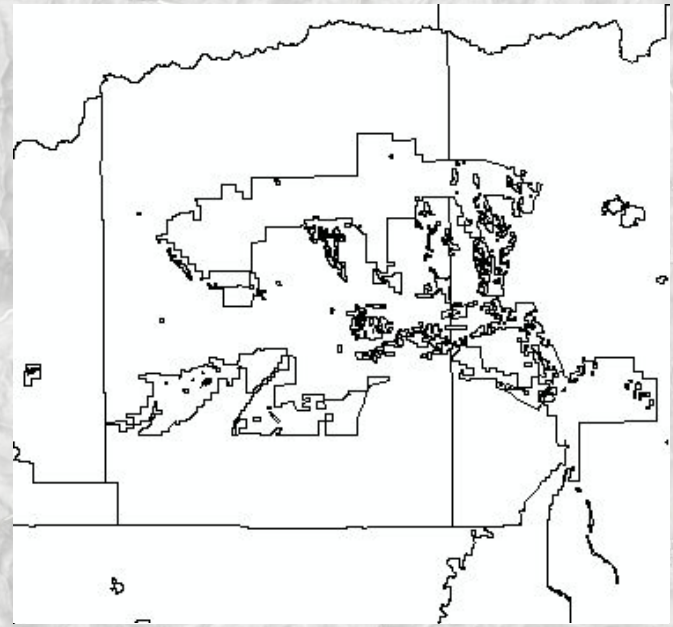
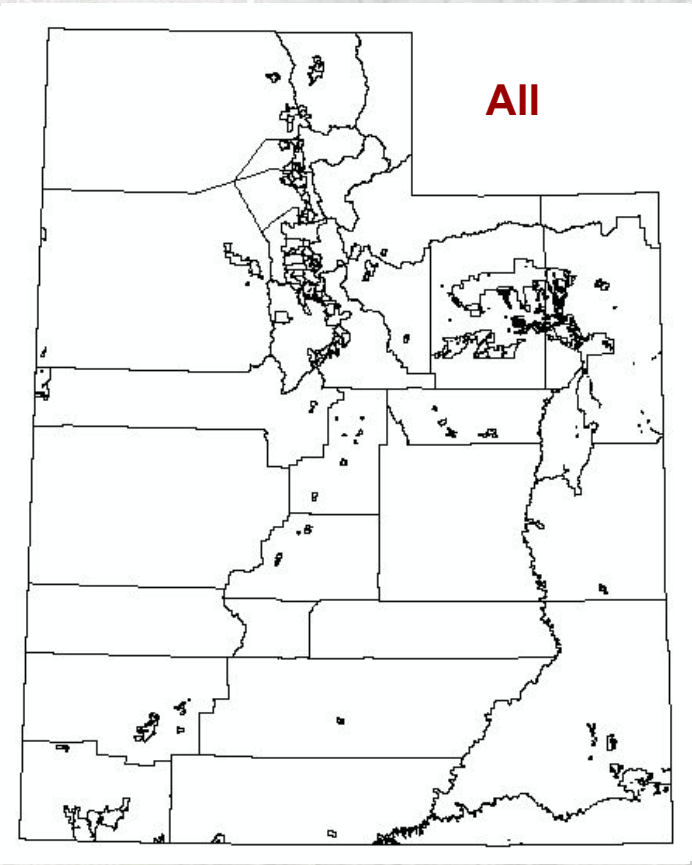
- **Perform analysis**
- **Create data**
- **Edit and update existing data**
- **Generate a series of maps**

- **Specific examples**

- **Get all addresses within a 500 ft buffer of a location**
- **Real-world example for UGRC: Build 911 law boundaries**
  - **Combine county, municipal, and special jurisdiction boundaries into a statewide layer**
  - **Recreate data at the "push of a button" to capture recent municipal annexations**
  - **Script builds data in less than 2 minutes**
  - **Don't need to manually edit data or track recent annexations**



# Utah 911 Law Boundaries



# Final words

- **GIS and GIS data can be very useful**
  - **Storing and managing data with "where" component**
  - **Answering questions**
  - **Solving problems**
  - **Visualizing data**
- **UGRC has a ton of GIS resources available for *ANYONE* to use**
- **Python can help automate tasks and improve workflows**

# Questions?



Location matters

**Erik Neemann**



email: [eneemann@utah.gov](mailto:eneemann@utah.gov)



twitter: [@Erik\\_UGRC](https://twitter.com/Erik_UGRC)