

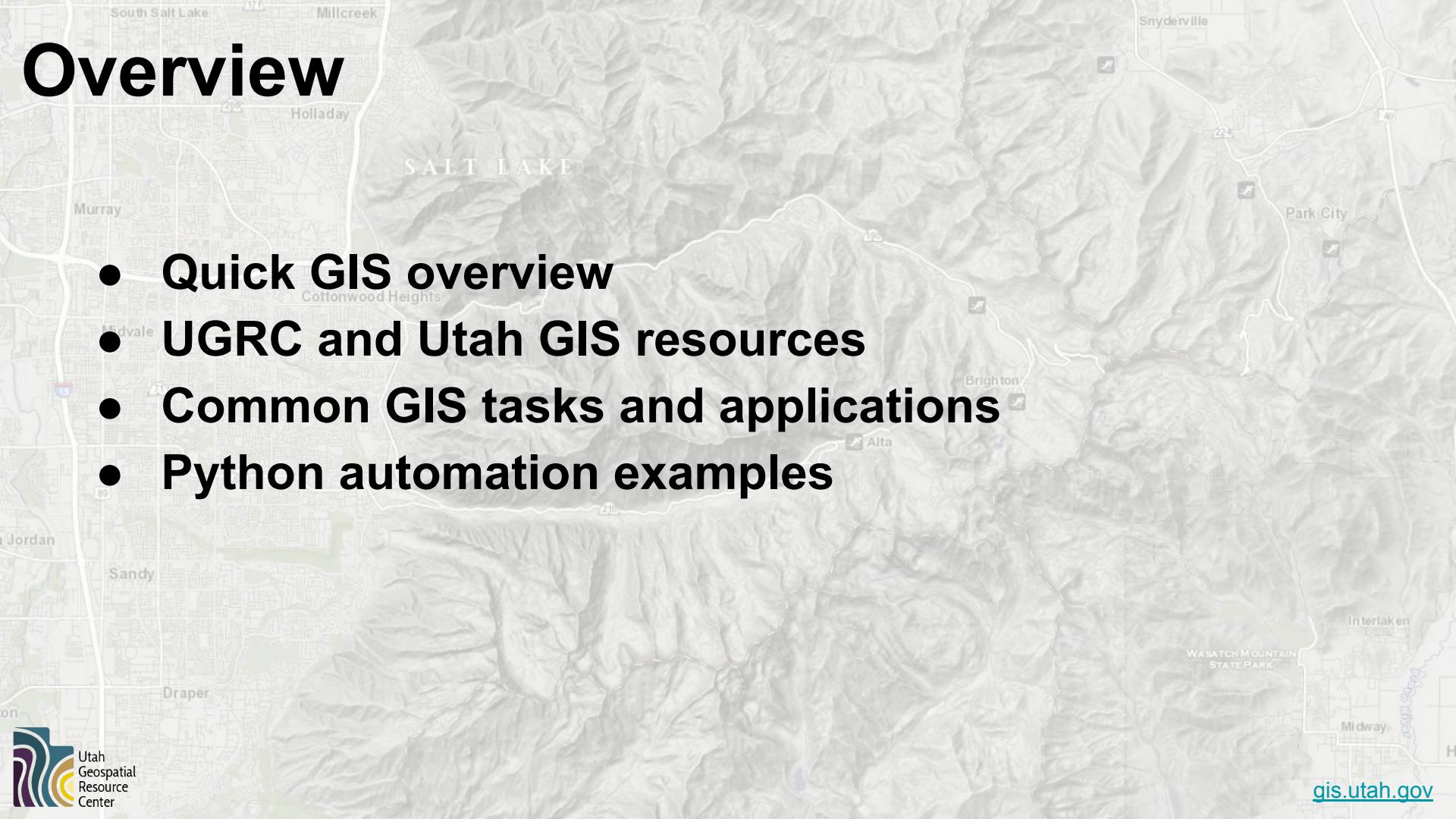
# GIS Data, Resources, and Applications



Erik Neemann  
14 May 2022

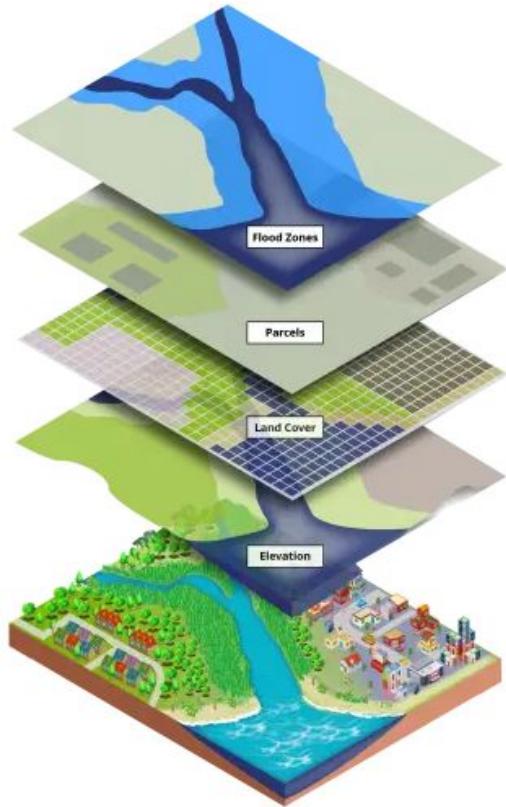
# Overview

- 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



QGIS

PostGIS



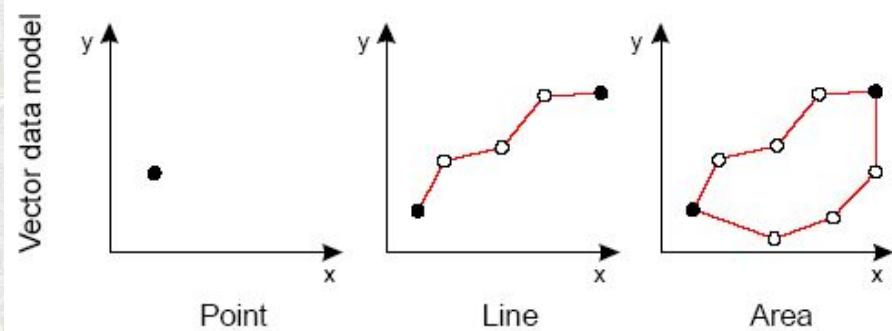
*"...collection of computer software and data used to view and manage information about geographic places, analyze spatial relationships, and model spatial processes. A GIS provides a framework for gathering and organizing spatial data and related information so that it can be displayed and analyzed."*

A to Z GIS (ESRI Press)

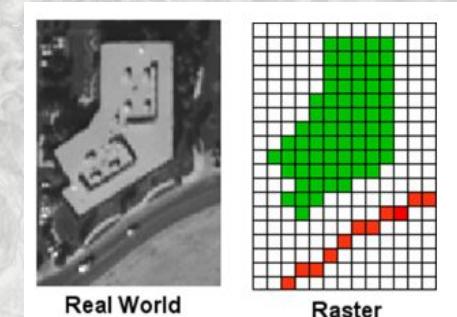
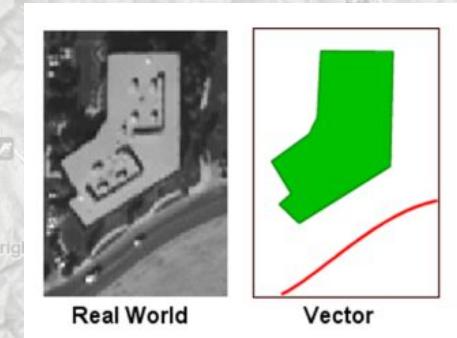
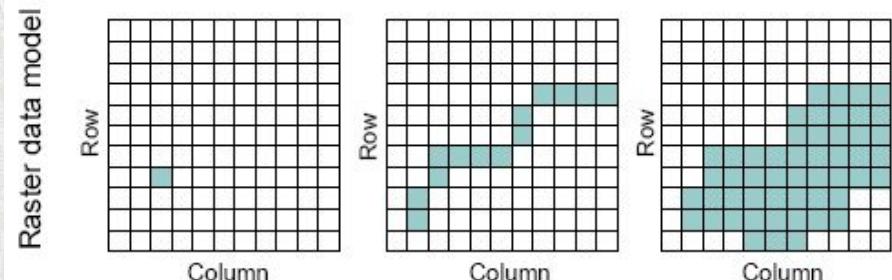
# GIS Overview

- Two primary data types used to represent the world:

**Vector**

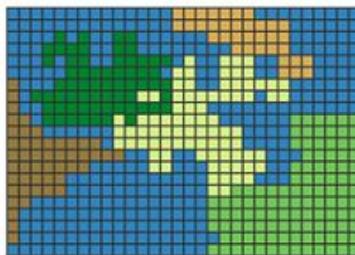
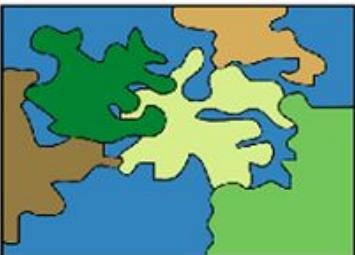
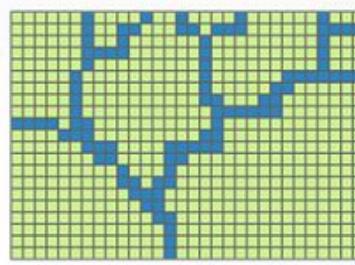
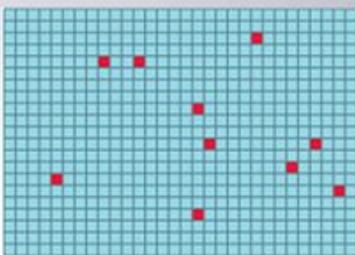
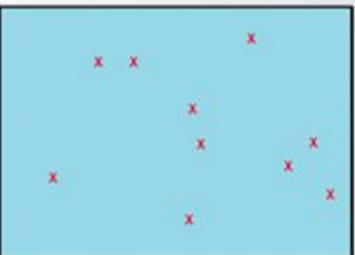


**Raster**

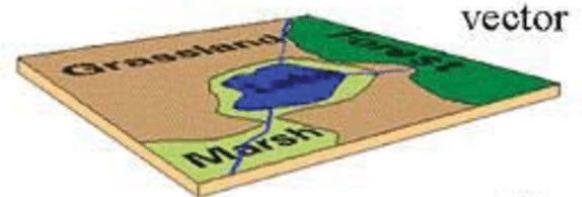
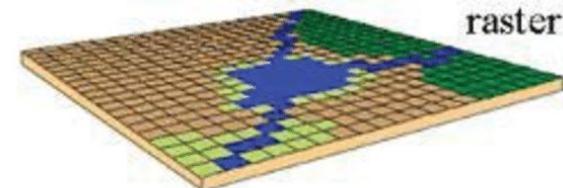


# GIS

- Two



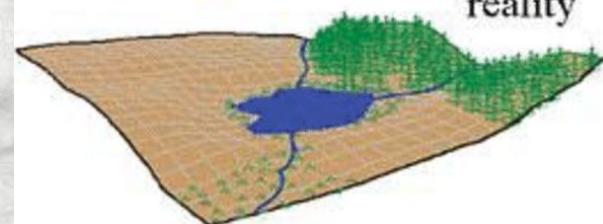
the world



raster

vector

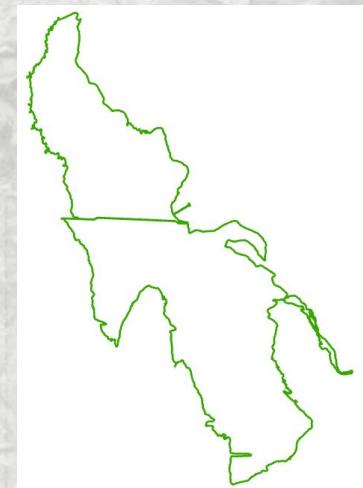
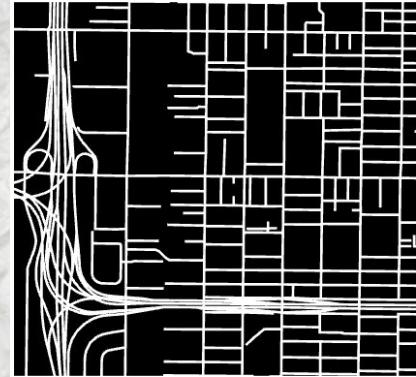
reality



[Marc Spiller paper](#)

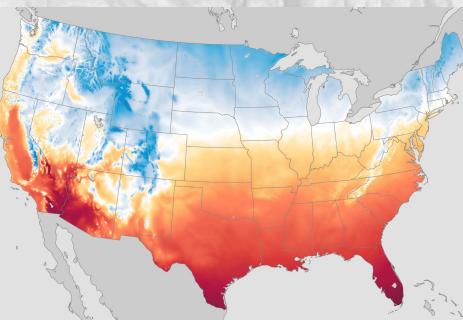
# GIS Overview - Vector

- 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



[USGS Elevation](#), [USGS Land Cover](#), [NOAA Climate](#), [ESA Sentinel-2](#)

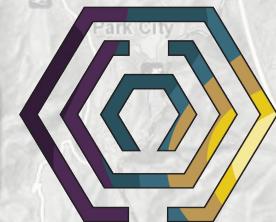
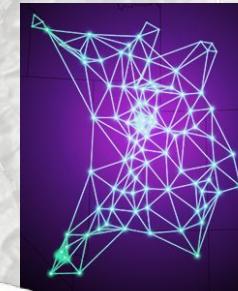
[gis.utah.gov](http://gis.utah.gov)

# 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

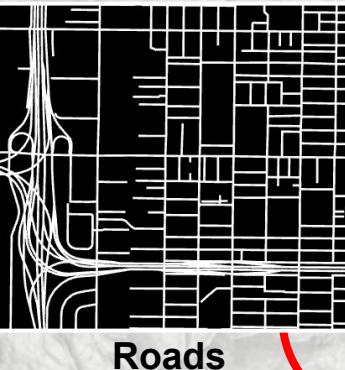
STATE GEOGRAPHIC  
INFORMATION DATASOURCE



*"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



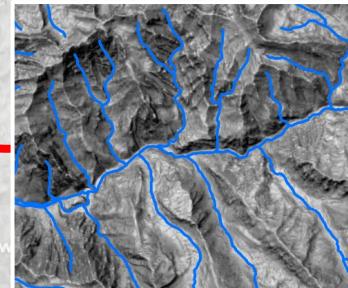
Parcels



## **Boundaries**



STATE GEOGRAPHIC —  
INFORMATION DATASOURCE



More

# State Geographic Information Datasource (SGID)

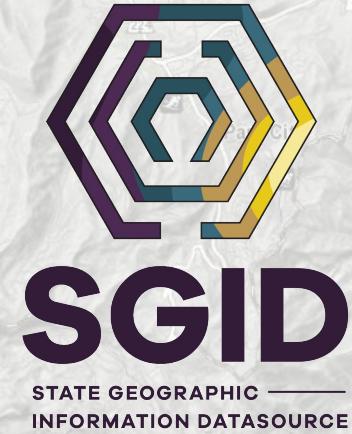
[opendata.gis.utah.gov](http://opendata.gis.utah.gov)

[gis.utah.gov/data](http://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
- Schools
- Transit
- Broadband
- Watersheds
- Great Salt Lake
- Flood Plains
- Court Districts
- and more!!!

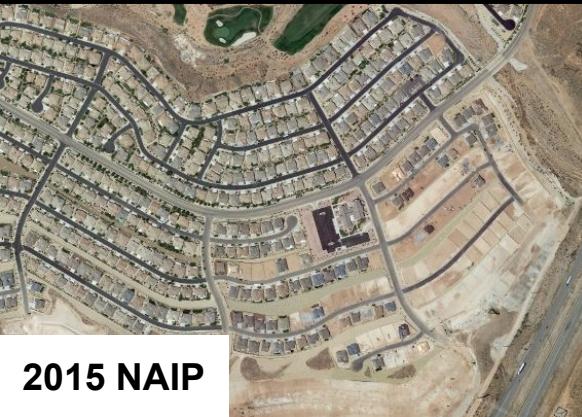
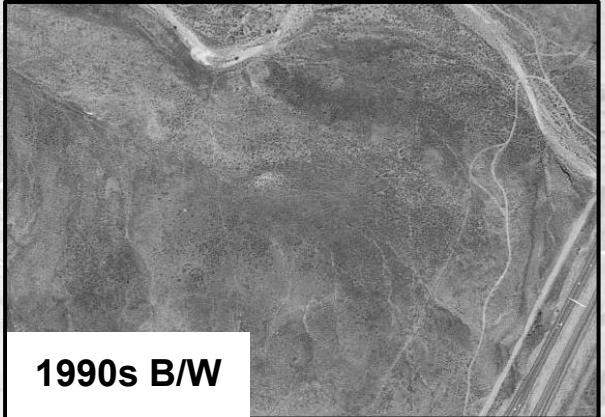


# UGRC - Discover Server

- [gis.utah.gov/discover](http://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



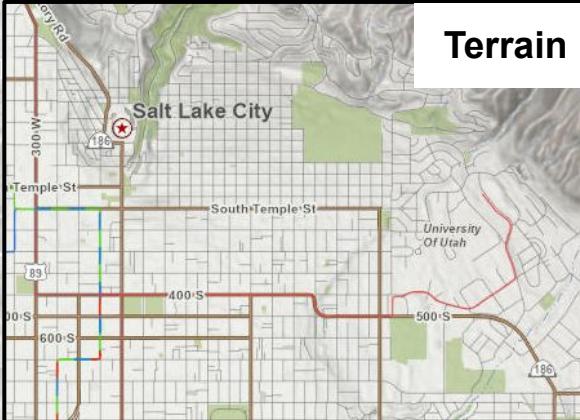
# UGRC - Discover Imagery



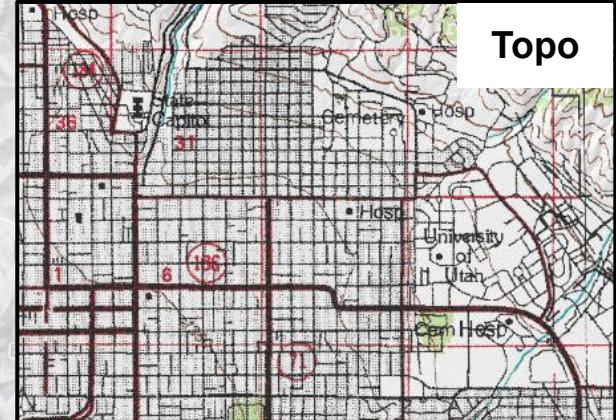
# UGRC - Discover Basemaps



**Lite**



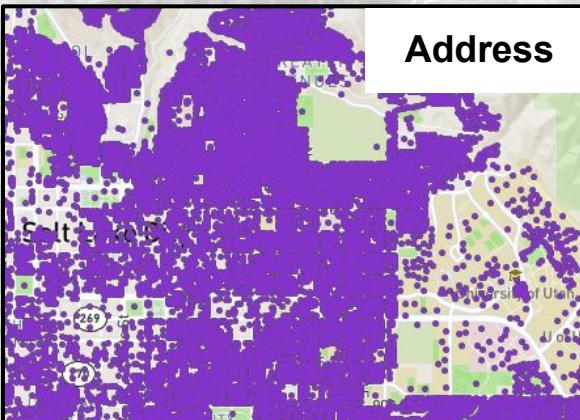
**Terrain**



**Topo**



**Hybrid**



**Address**



**Hillshade**

# UGRC - Raster Data Downloads

- [raster.utah.gov](http://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

[Clear Preview](#)

▼ .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

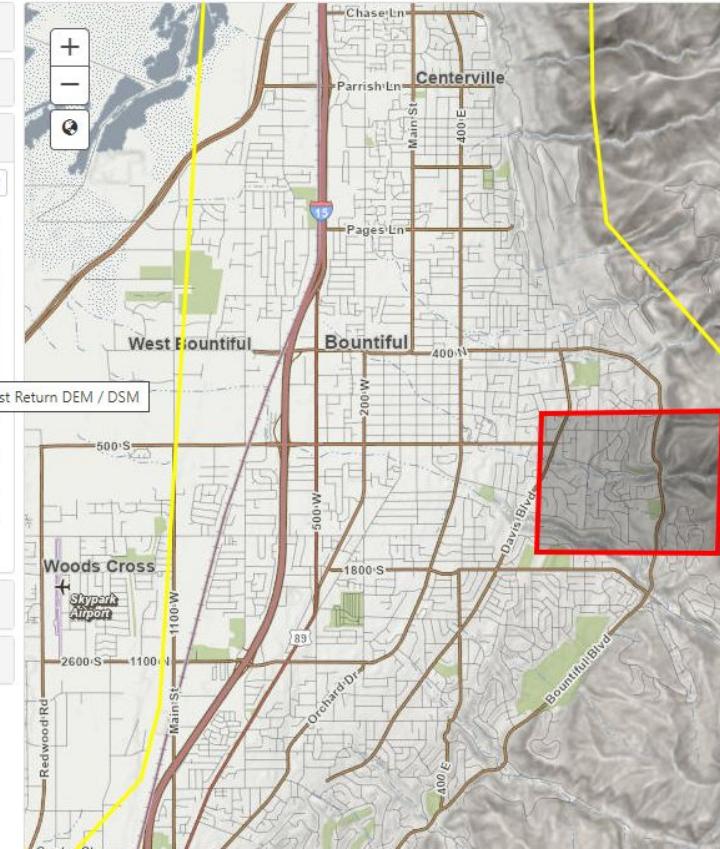
► 1.25 Meter

► 2 Meter

[First Return DEM / DSM](#)

Step 4 - Download Data

[Help](#) | [UGRC Imagery Services Info](#)



# UGRC - Web API and Geocoding

- [api.mapserv.utah.gov](http://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](#)

API Response Example

```
{  
  "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 Client

# UGRC



# API Client

← 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
----------------------------	----------------------------------	----------------------------	---

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

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.

**DROP THE CSV FILE HERE**

**CHOOSE FILE**

UGRC API Client v1.5.3



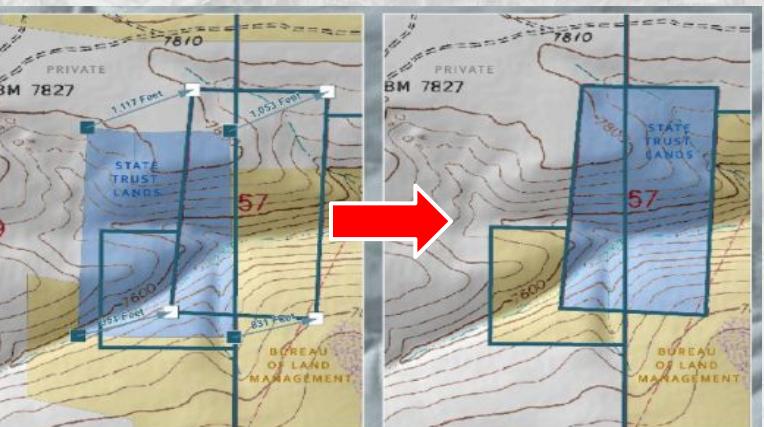
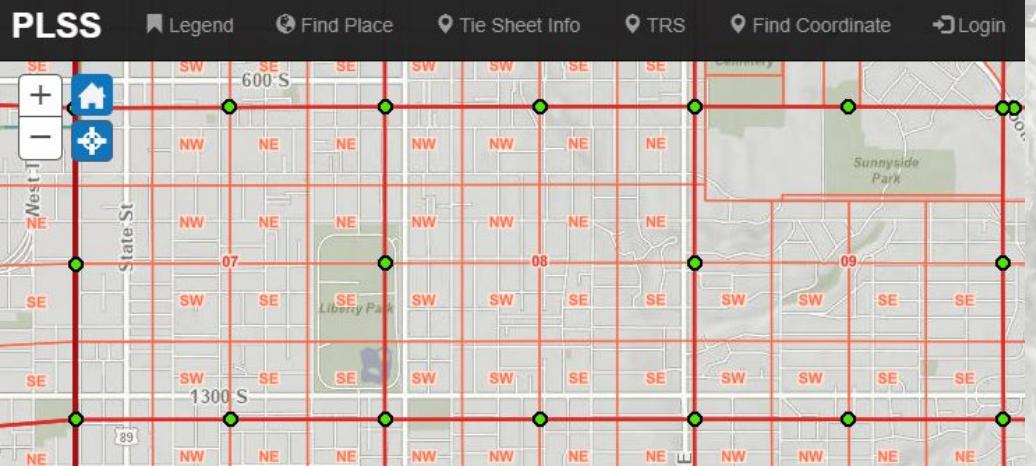
street	zone	x	y	score	match_address
154 CENTENNIAL RD	84536	-110.1277805	36.99849144	100	154 CENTENNIAL RD, BLANDING
105 MONUMENT RD	84536	-110.1339016	36.99876812	100	105 MONUMENT RD, BLANDING
67 TEAR DROP LOOP	84536	-110.1845248	36.99950781	100	67 TEAR DROP LOOP, BLANDING
71 CENTENNIAL RD	84536	-110.1265563	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

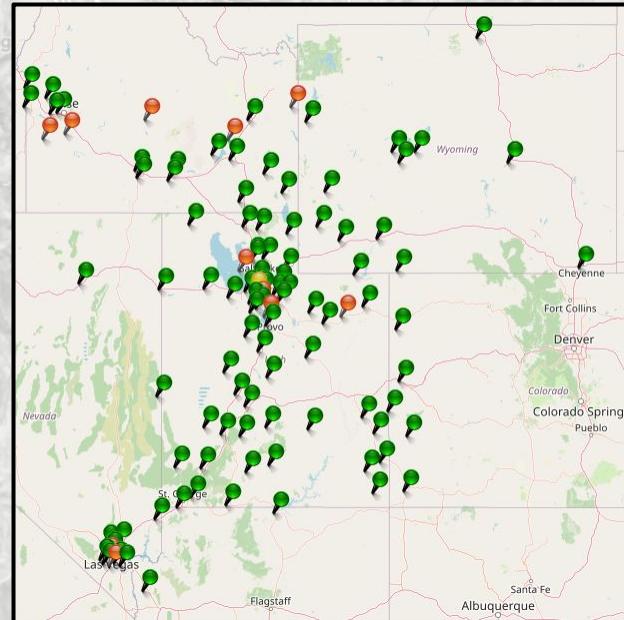


Attachment B PLSS Monument Preservation Sheet														
Township Range Section Meridian														
BLM Point ID	U	T	W	1	2	3	4	5	6	7	Date			
Meridian	U	T	W	1	2	3	4	5	6	7	01-01-2010			
Section	SW	SE	NE	SW	SE	NE	SW	SE	NE	SW	SW			
Corner's Name	ROBERT HERMANSON													
Corner's Phone	435-671-2337													
Land Office	Utah													
Surveyor Agency	BUREAU OF LAND MANAGEMENT													
County	WASHINGTON													
State	UTAH													
PLSS Monument Coordinates														
Datum: NGS National Spatial Reference System Adjustment														
NAD83	NAD83	NAD83	WGS84	NAD83	NAD83	NAD83	NAD83	NAD83	NAD83	NAD83	WGS84			
Latitude (DMS)	43° 3' 7"	70° 1' 20"	111° 4' 55"	43° 3' 7"	70° 1' 20"	111° 4' 55"	43° 3' 7"	70° 1' 20"	111° 4' 55"	43° 3' 7"	70° 1' 20"			
Longitude (DMS)	111° 4' 55"	111° 4' 55"	111° 4' 55"	111° 4' 55"	111° 4' 55"	111° 4' 55"	111° 4' 55"	111° 4' 55"	111° 4' 55"	111° 4' 55"	111° 4' 55"			
N	3	7	0	2	6	5	9	8	2	7	6			
W	1	0	2	6	5	9	8	7	1	0	1			
Northing	1	0	2	6	5	9	8	7	1	0	1			
Easting	3	7	0	2	6	5	9	8	2	7	6			
Surveyor Information														
Zone	10	Universal Transverse Mercator Zone	Topographic Sheet	Vertical Datum	Ellipsoid Height	State Plane	Vertical Datum	Ellipsoid Height	State Plane	Vertical Datum	Ellipsoid Height			
UTM	10	10	10	NGVD29	2087.55	UTM	NGVD29	2087.55	UTM	NGVD29	2087.55			
Elevation	M	FT	M	FT	M	FT	FT	M	FT	FT	M			
Monument and Markings														
Type / Size														
Size	State	Pipe/Cone	Post	Other										
Material	Size	Material	Size	Material										
Surveyor's Seal														
Section Location Diagram														
Monument Inscription														
Description and Observation of Monument														
SOUTH 1/4 OF SECTION 3 WAS FOUND IN GOOD CONDITION BY BARRY WIRE FENCE														
Surveyor Building or Anchoring Points of GPS Transits Occupied Show relation of monument to transits and describe results														
Surveyor Building or Anchoring Points of GPS Transits Occupied Show relation of monument to transits and describe results														



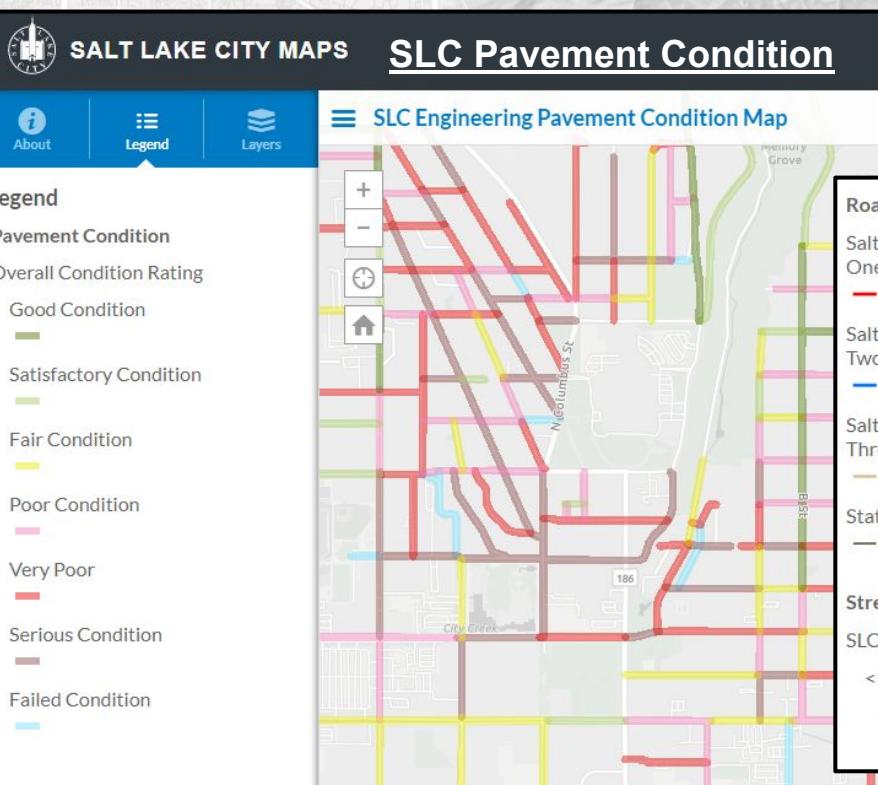
# The Utah Reference Network (TURN GPS)

- [gis.utah.gov/gps](http://gis.utah.gov/gps)    [turngps.utah.gov](http://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

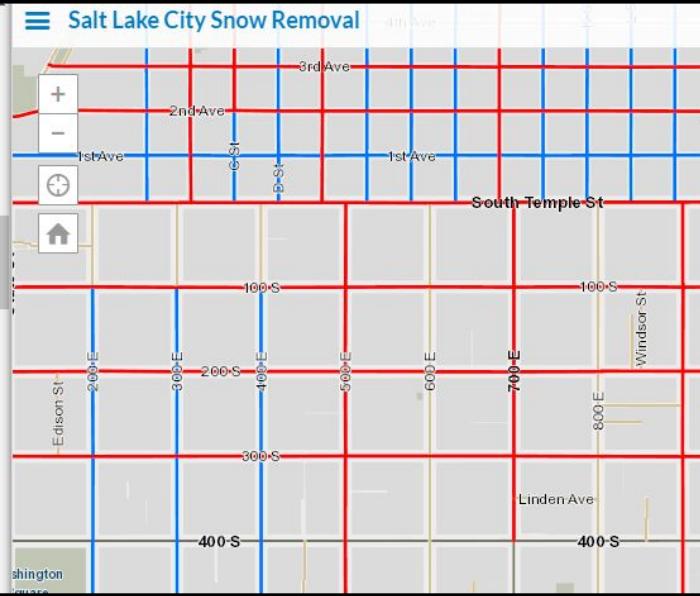


# Common GIS Tasks and Applications

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

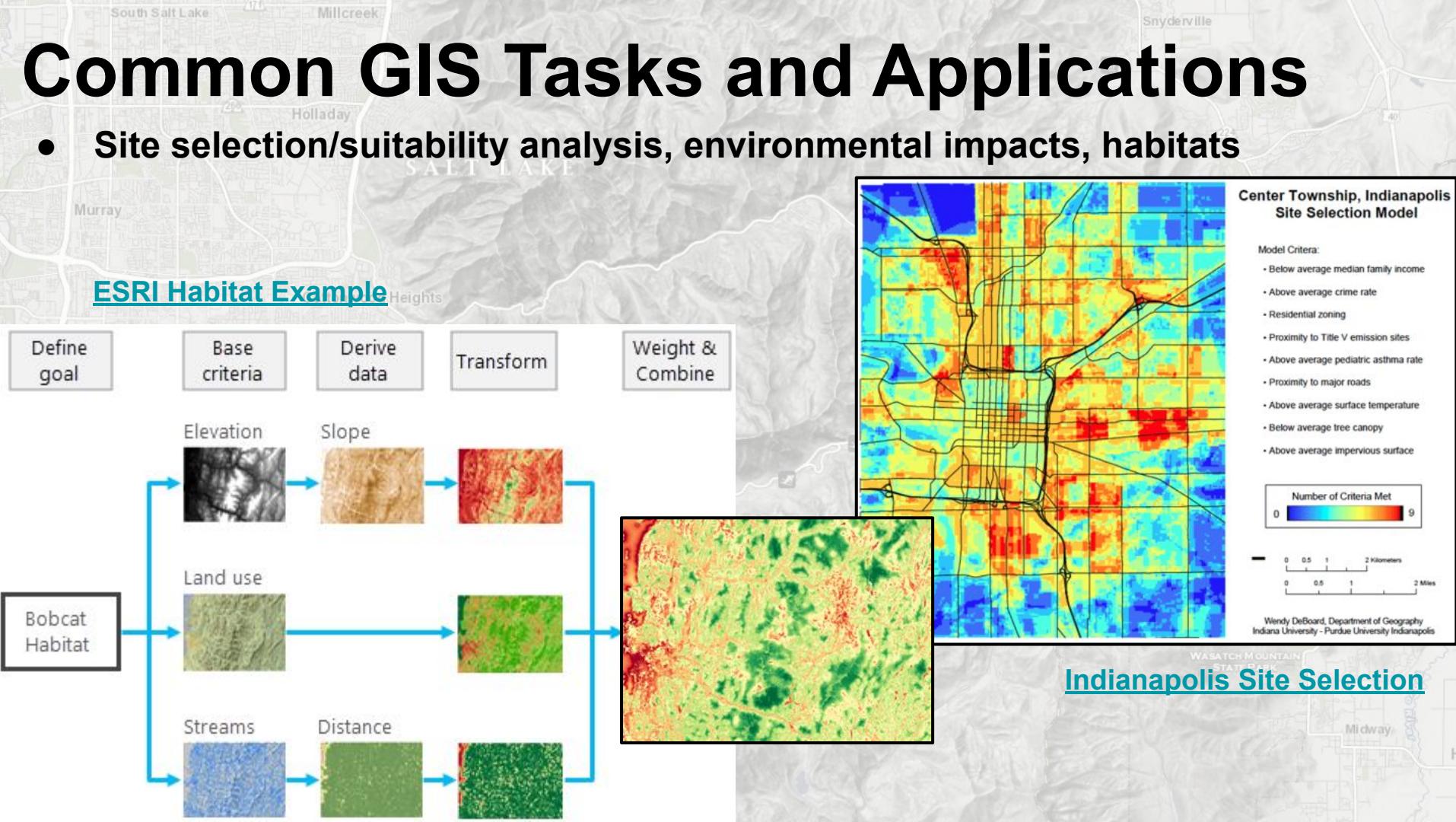


## SLC Snow Removal



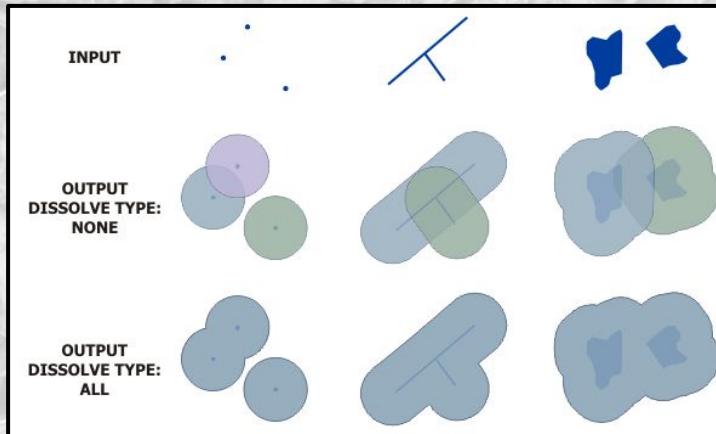
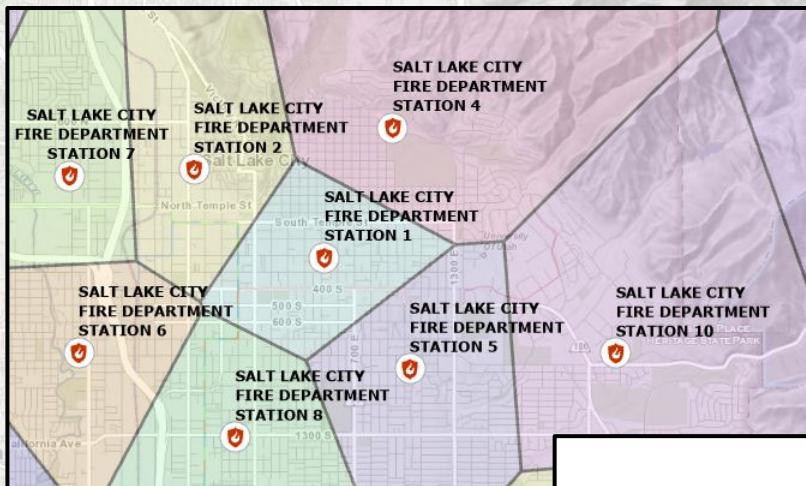
# Common GIS Tasks and Applications

- Site selection/suitability analysis, environmental impacts, habitats



# Common GIS Tasks and Applications

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



[Buffer Examples](#)

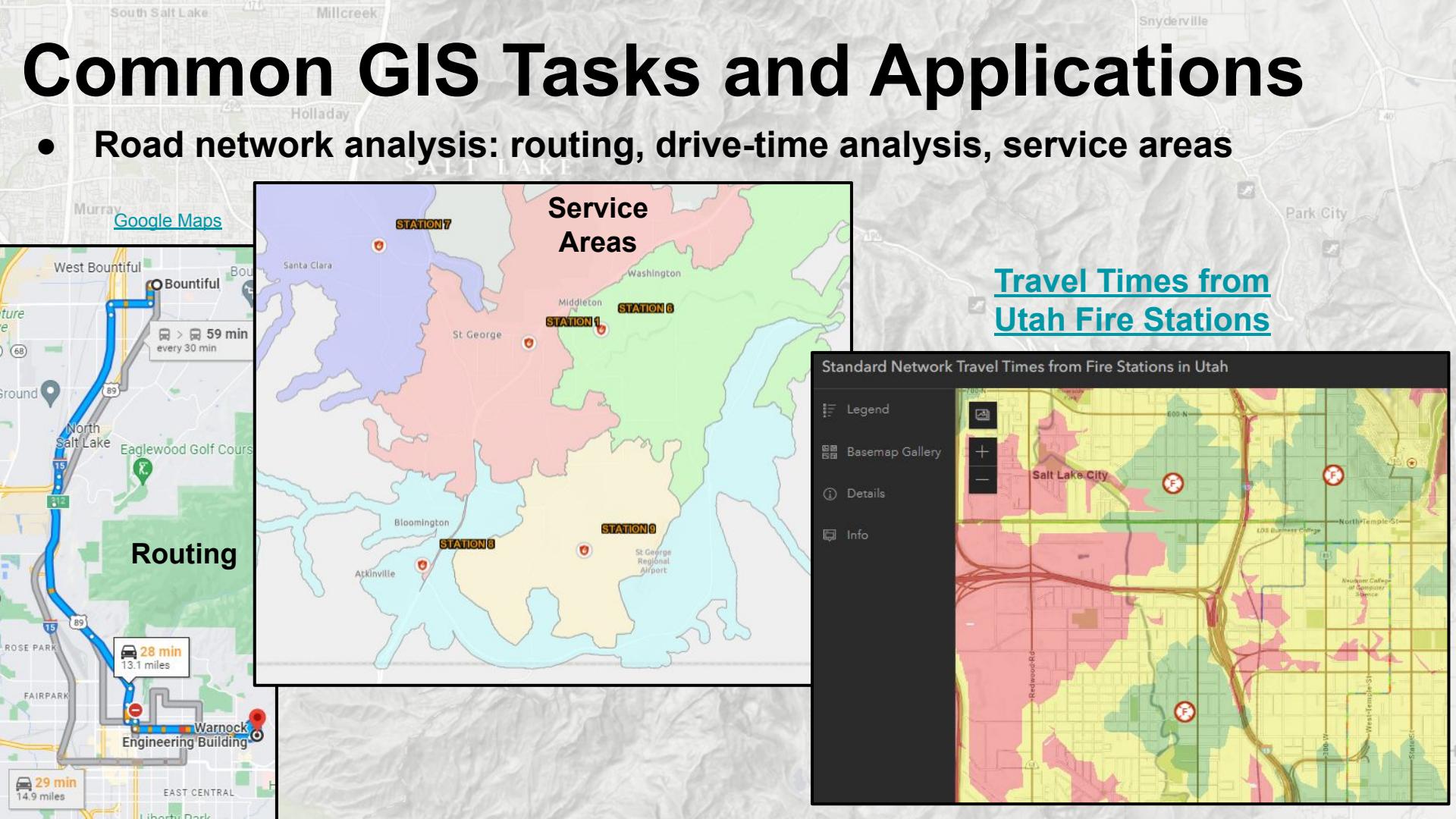
## Thiessen Polygons

A screenshot of a GIS application interface. At the top, there is a search bar with fields for 'Street Address' (1320 E 200 S), 'Zip Code' (84102), and buttons for 'Find' and 'Help?'. Below the search bar are buttons for 'Find District...' and 'Find'. To the right are buttons for 'Use map location' and 'Use physical location'. The main area shows an aerial map of a residential neighborhood with a grid pattern. A specific location is marked with a blue pin. Overlaid on the map are several light blue polygons representing legislative districts. In the bottom right corner, there is a callout box with a portrait of a man and the text: 'Representative Joel K. Briscoe (D) House District 25'. Another callout box to the right shows a portrait of a man and the text: 'Senator Derek L. Kitchen (D) Senate District 2'.

[Utah Legislative Districts](#)

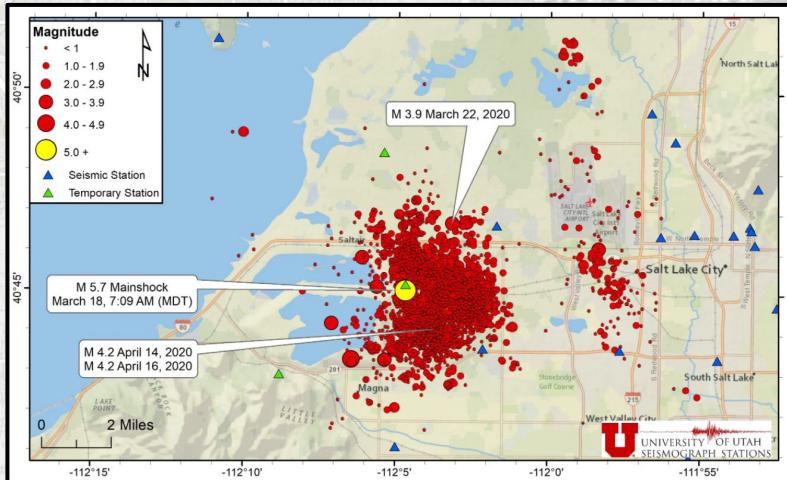
# Common GIS Tasks and Applications

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

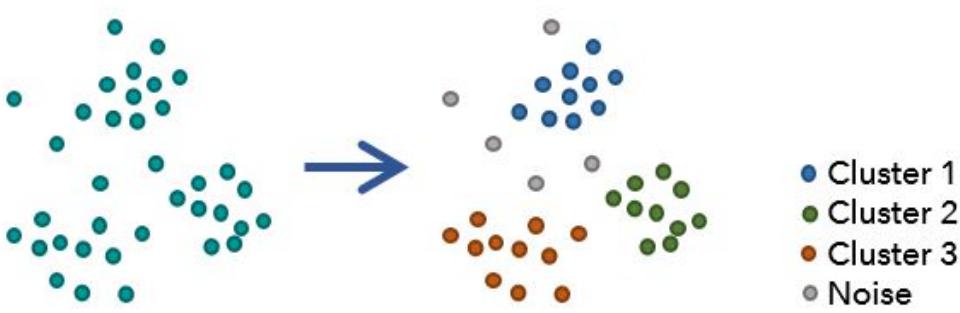
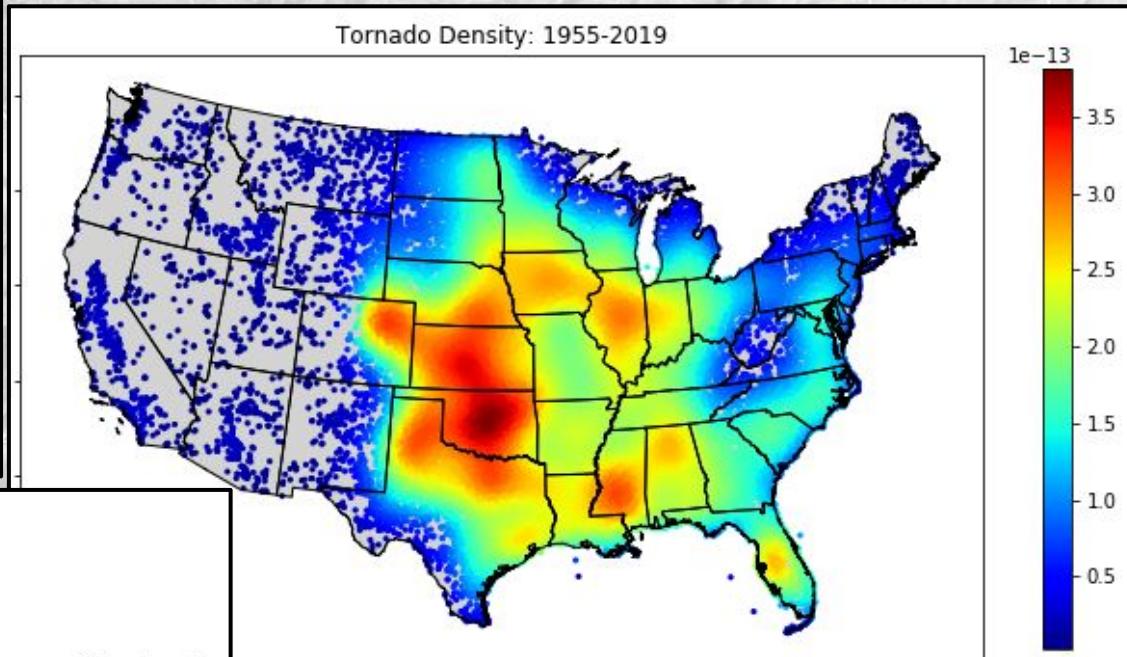


# Common GIS Tasks and Applications

## Magna Earthquake



- Point data analysis: density and hotspots, clustering

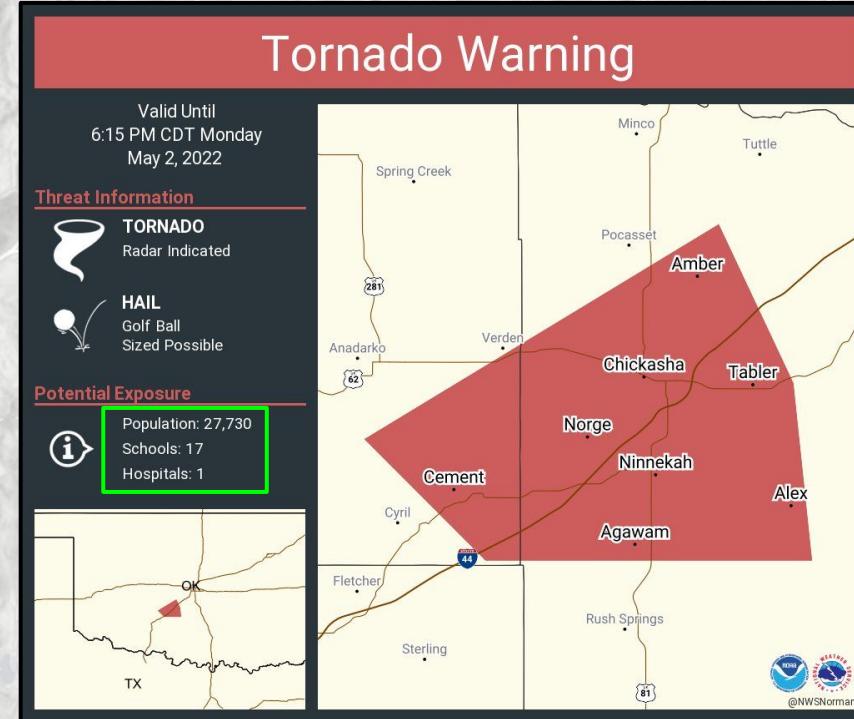
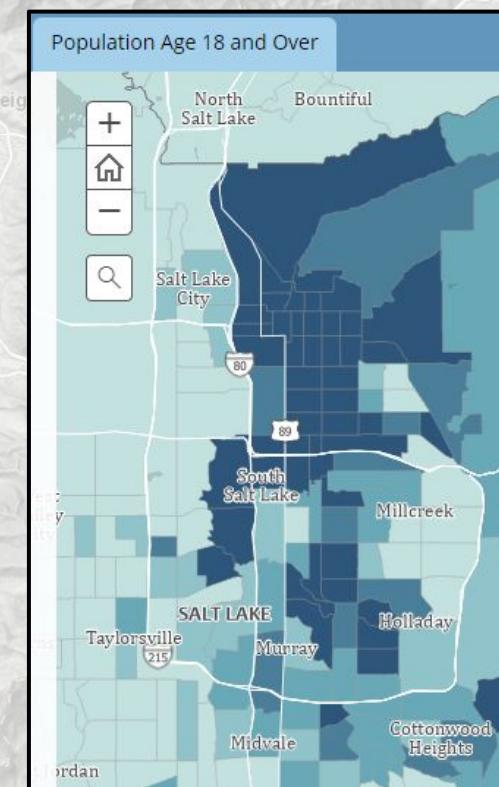
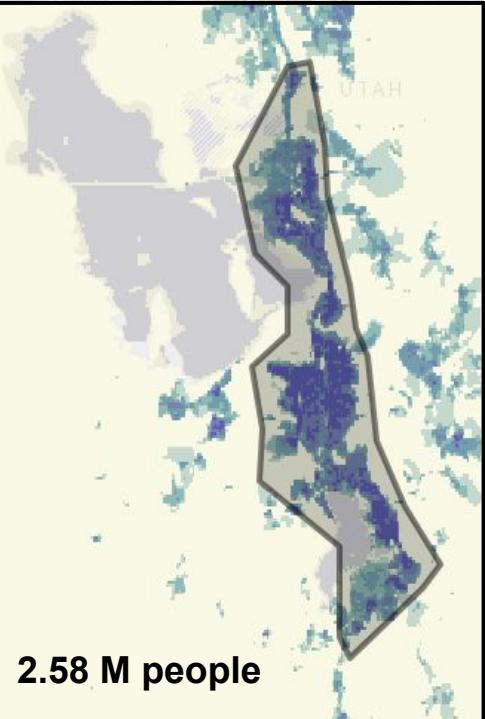


## ESRI Clusters

# Common GIS Tasks and Applications

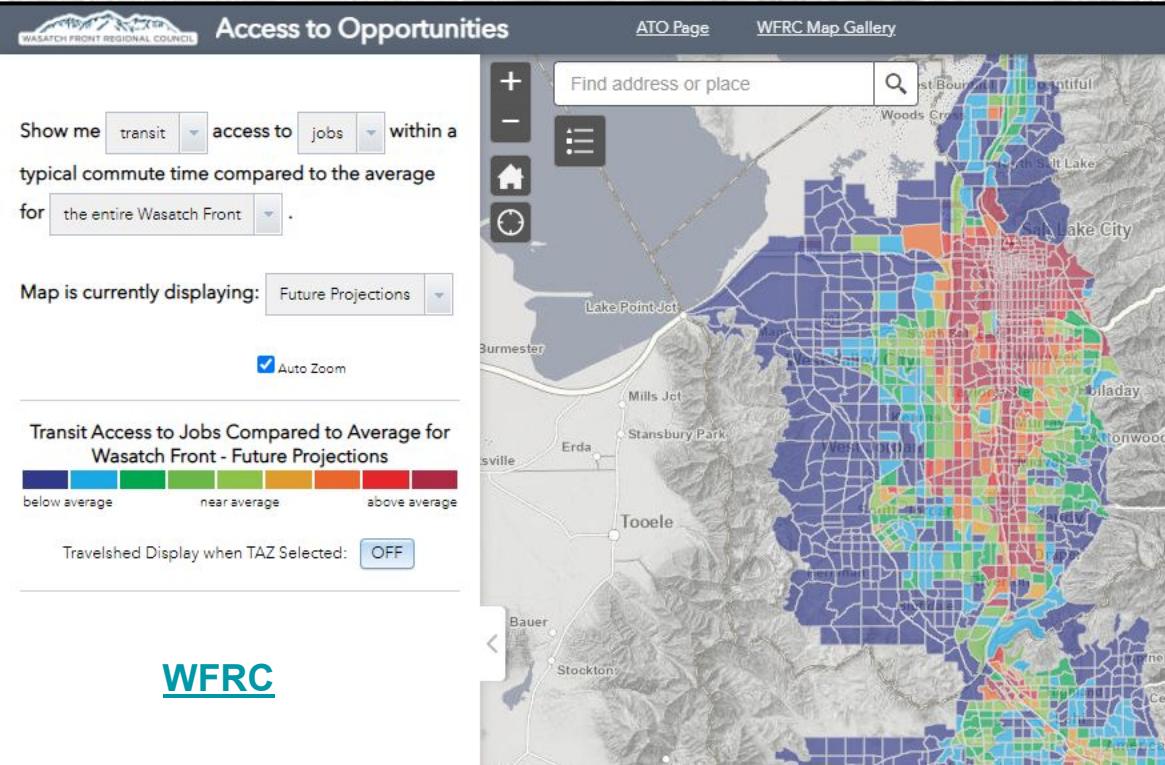
- Geographic statistics and demographics

## NASA Population Estimate



# Common GIS Tasks and Applications

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

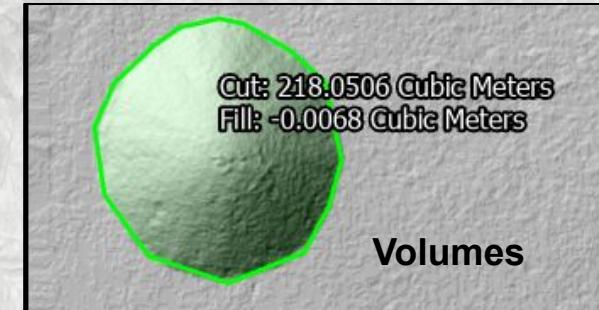
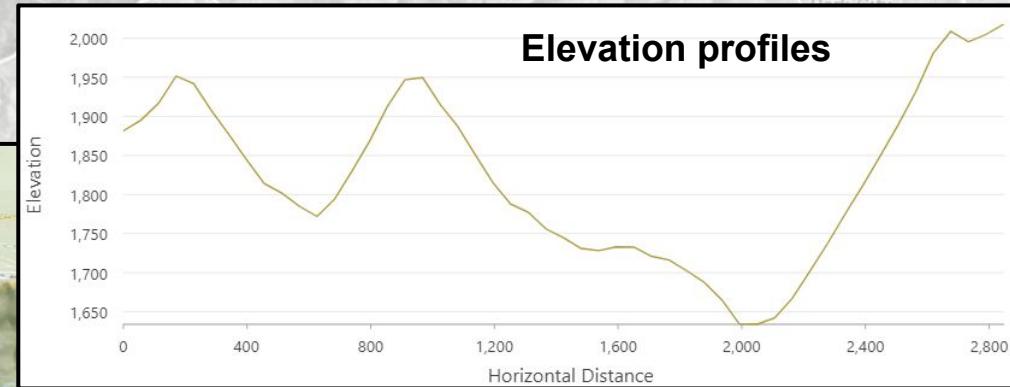
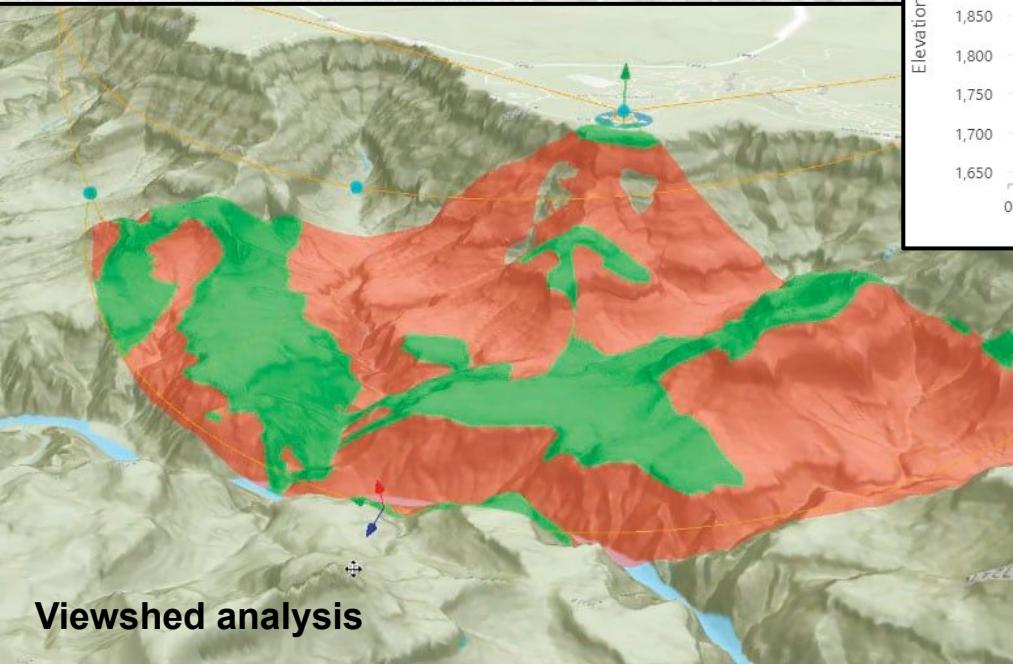


Centerville Zoning



# Common GIS Tasks and Applications

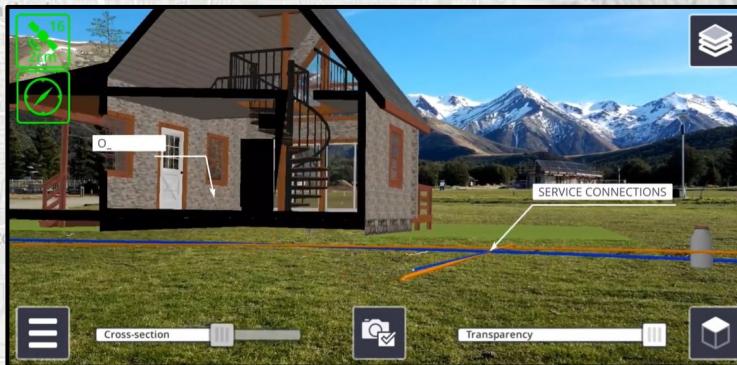
- 3D: viewshed analysis, elevation profiles, volume calculations
  - Cut - volume above surface feature
  - Fill - volume below surface feature
- Shadow and solar analysis



[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](#)

The image shows a 3D model of a building's underside with various pipes and structural elements. A callout highlights a specific component with a green border. An 'Attributes' overlay provides detailed information about the highlighted component:

**Attributes**

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

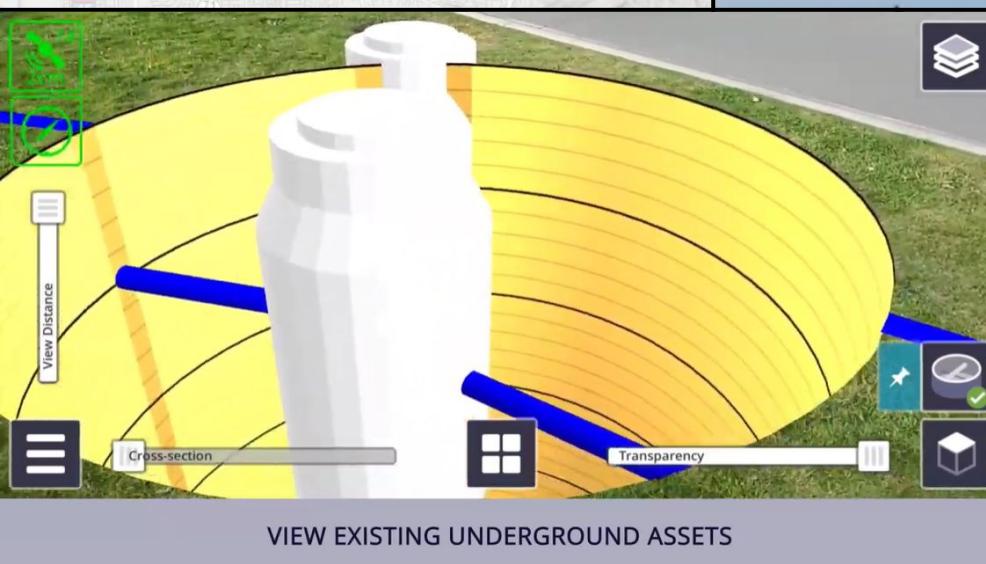
Below the overlay, there are controls for "Cross-section", "Transparency", and "Pause (k)". A legend icon in the top right corner shows a stack of three squares.

CHECK COMPONENT DETAILS

# Common GIS Tasks and Applications

- Augmented Reality (AR) applications

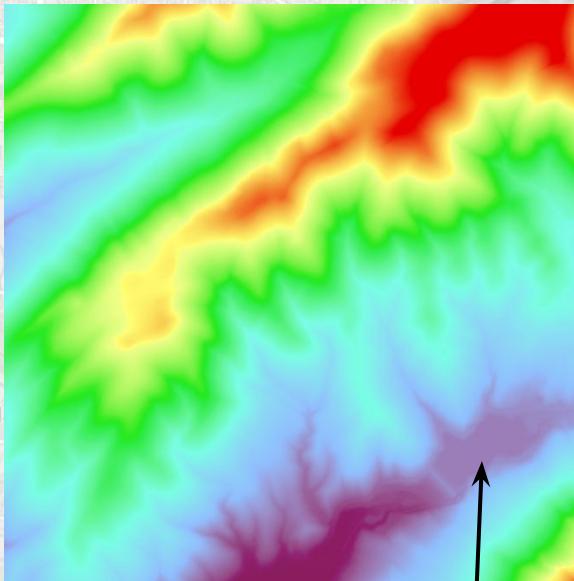
- View underground utility infrastructure
- View proposed infrastructure



[Trimble SiteVision](#)

# Common GIS Tasks and Applications

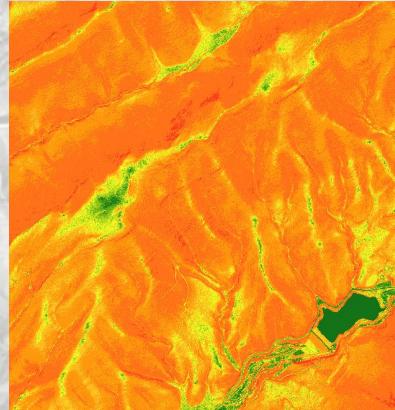
- Elevation: data models and analysis



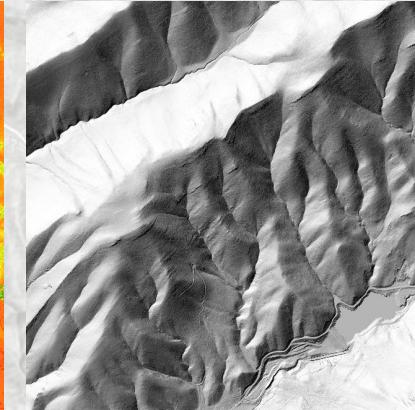
Elevation

Red Butte  
Reservoir

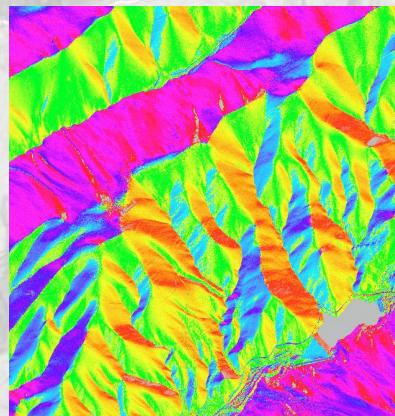
Slope



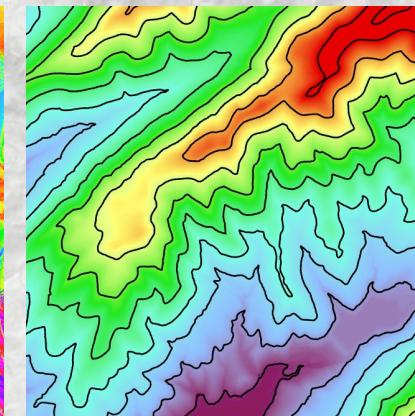
Hillshade



Aspect



Contours

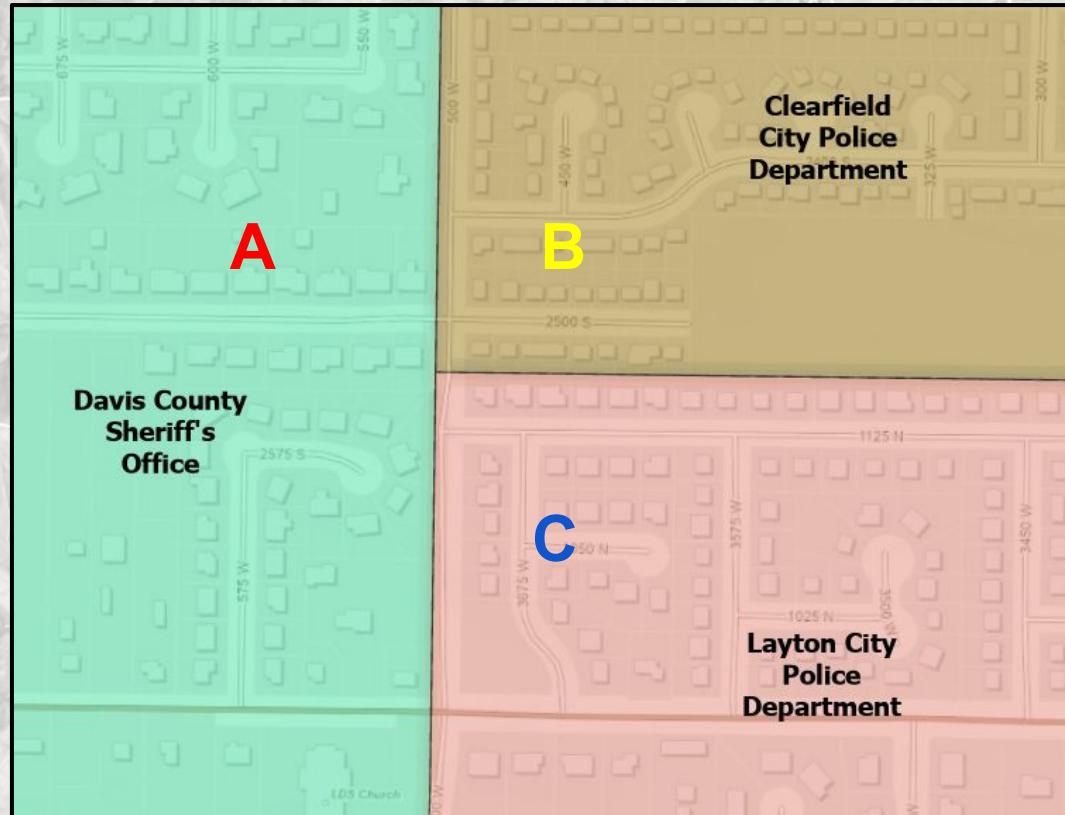


# Common GIS Tasks and Applications

- 911 & Next-Generation call-routing

- Caller A → Davis County Sheriff's Office
- Caller B → Clearfield City Police Department
- Caller C → Layton City Police Department

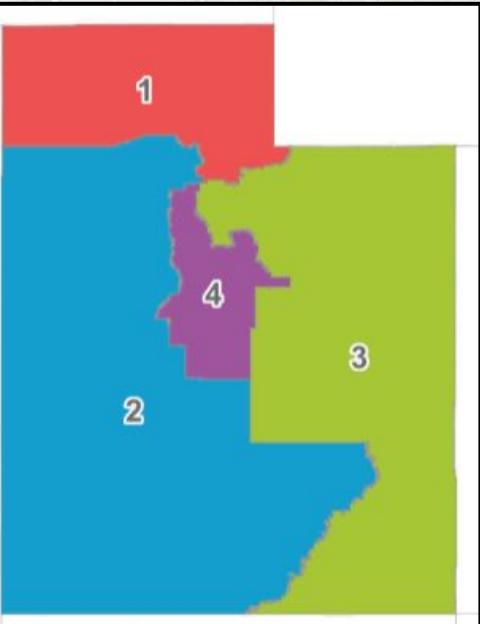
- Dispatch software can also recommend which fire and medical units should respond to the location



# 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.

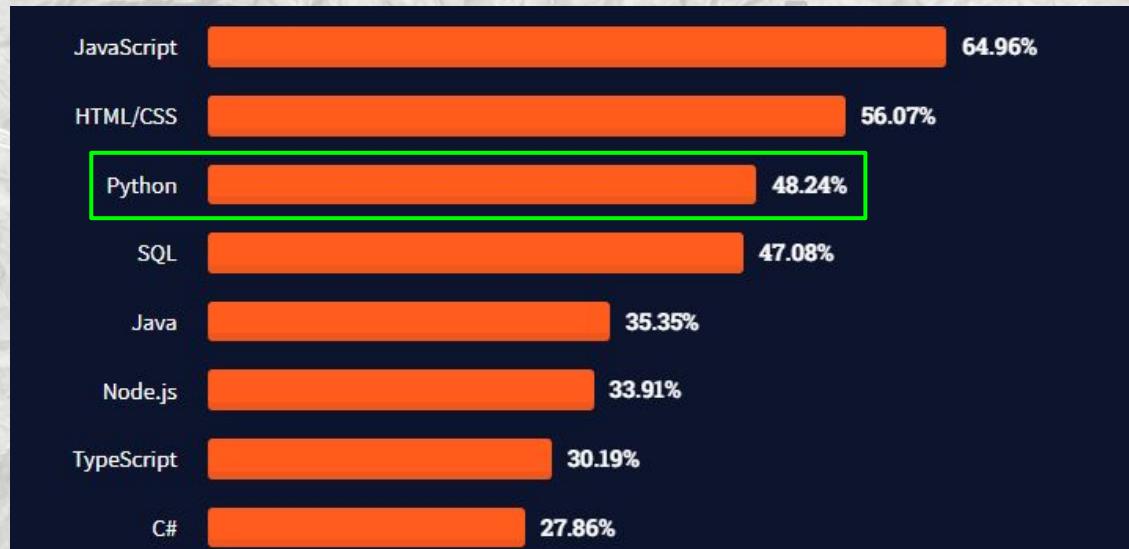
The screenshot shows the Google Project Sunroof web application. It displays a house at 2082 E 270 S St, St. George, UT 84790, USA. The analysis is complete, showing 2,158 hours of usable sunlight per year and 1,903 square feet available for solar panels. The estimated net savings over 20 years is \$5,000. A map overlay shows the solar panel potential for several buildings in the area, with yellow shading indicating available roof space.

# 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

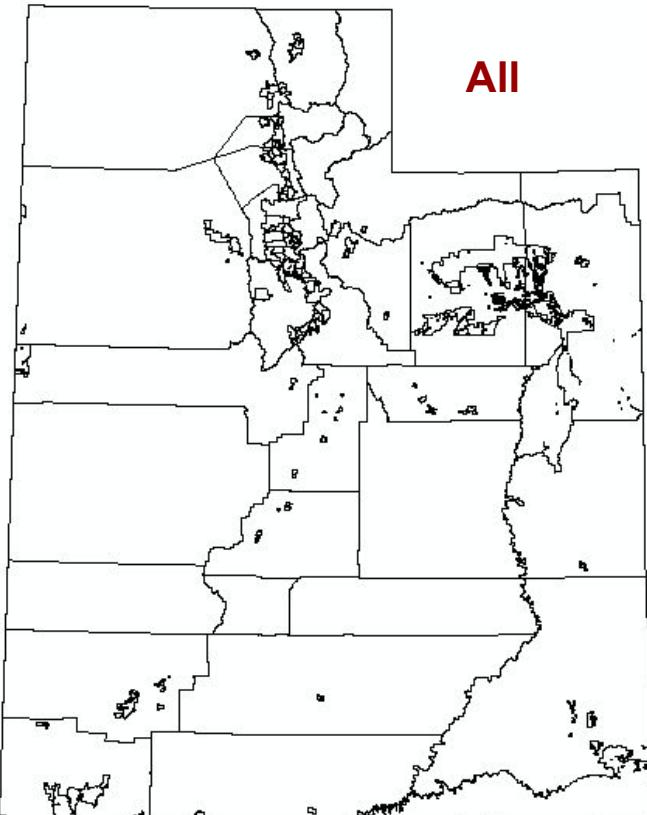


South Salt Lake

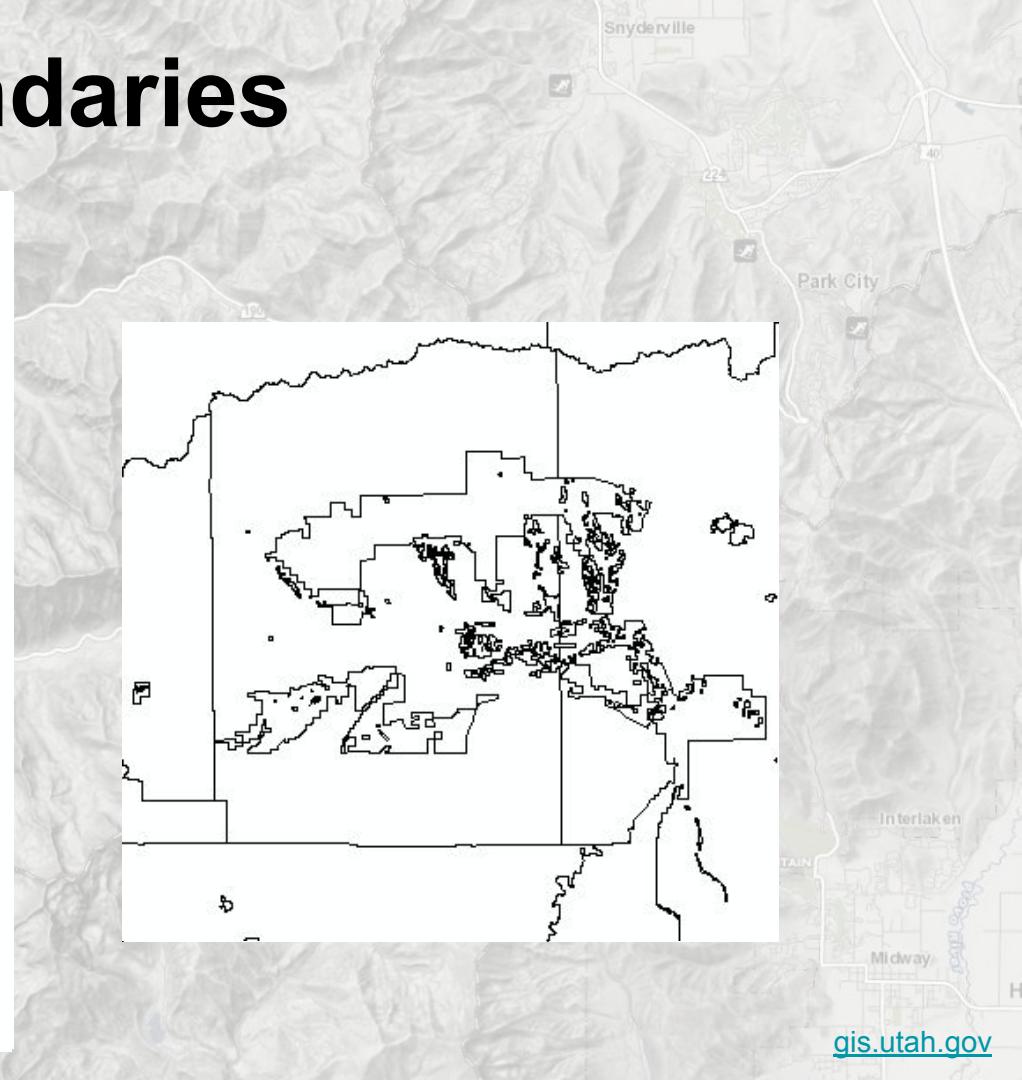
171

Millcreek

# Utah 911 Law Boundaries



All



# 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?



Utah  
Geospatial  
Resource  
Center

Location matters

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