Joe Tayabji
MSGIS Portfolio Defense

University of Utah
School of Environment, Society, and Sustainability

THE UNIVERSITY OF UTAH

Agenda

GEOG 6150: Geospatial Big Data
- Utah Mountain Biking GIS Database

GEOG 5170: Geospatial Field Methods
- Data Collection from Bonderman Field Station

GEOG 6000: Advanced Geographical Data Analysis
- Spatial Dynamics of the Red-Backed Shrike Annual Migration Cycle

GEOG 6180: Geoprocessing with Python
- Directional Slope: A Python Tool for Path Design

GEOG 6160: Spatial Modeling and Geocomputation
- Using Machine Learning for Alpine Land Classification in Mountainous Terrain

GEOG 6161: Capstone in GIS
- Cottonwood Heights: Emergency Management Assistance and Evolution of Property Valuations

Utah Mountain Biking GIS Database

GEOG 6150

Geospatial Big Data

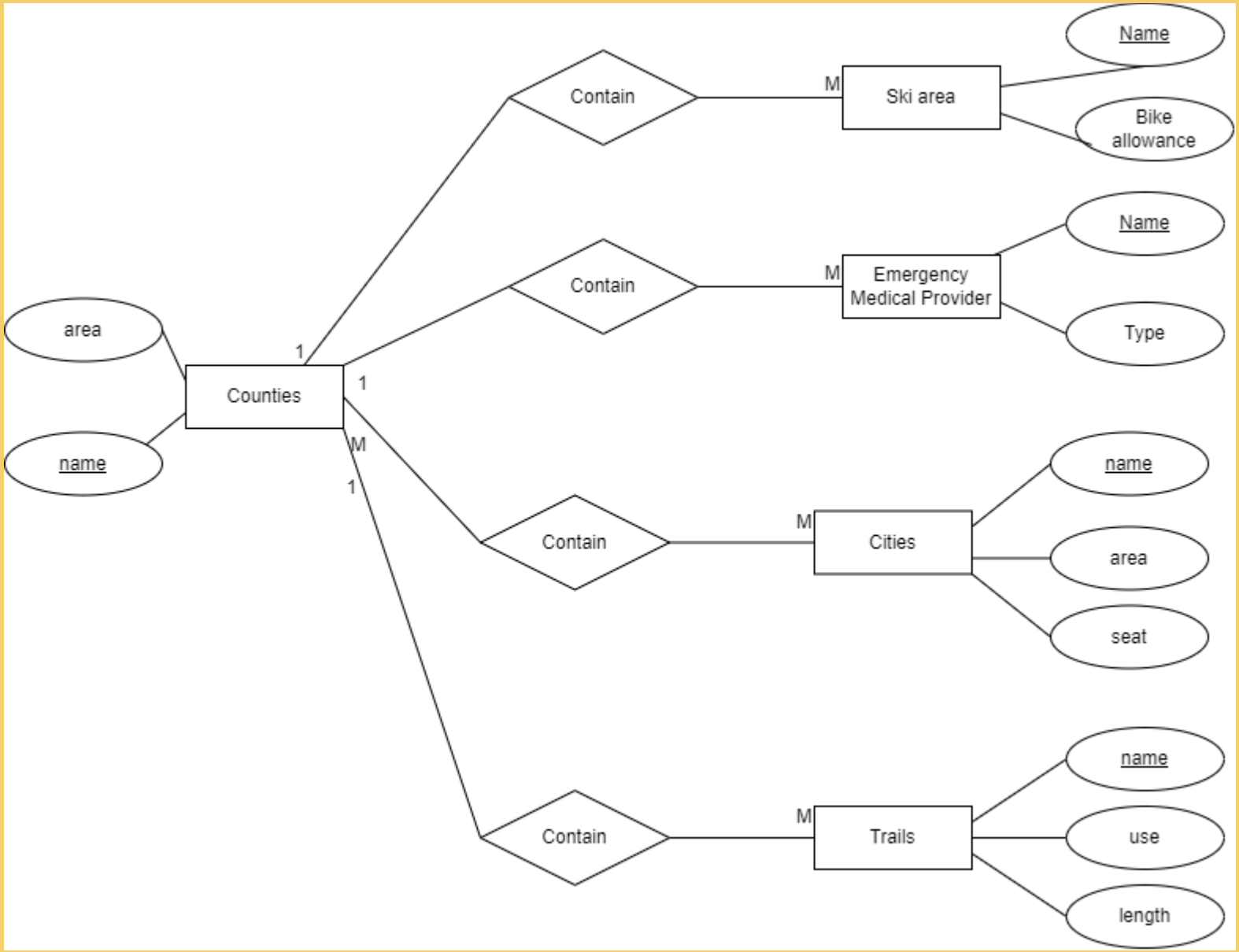
Dr. Alexander Hohl

Fall 2023

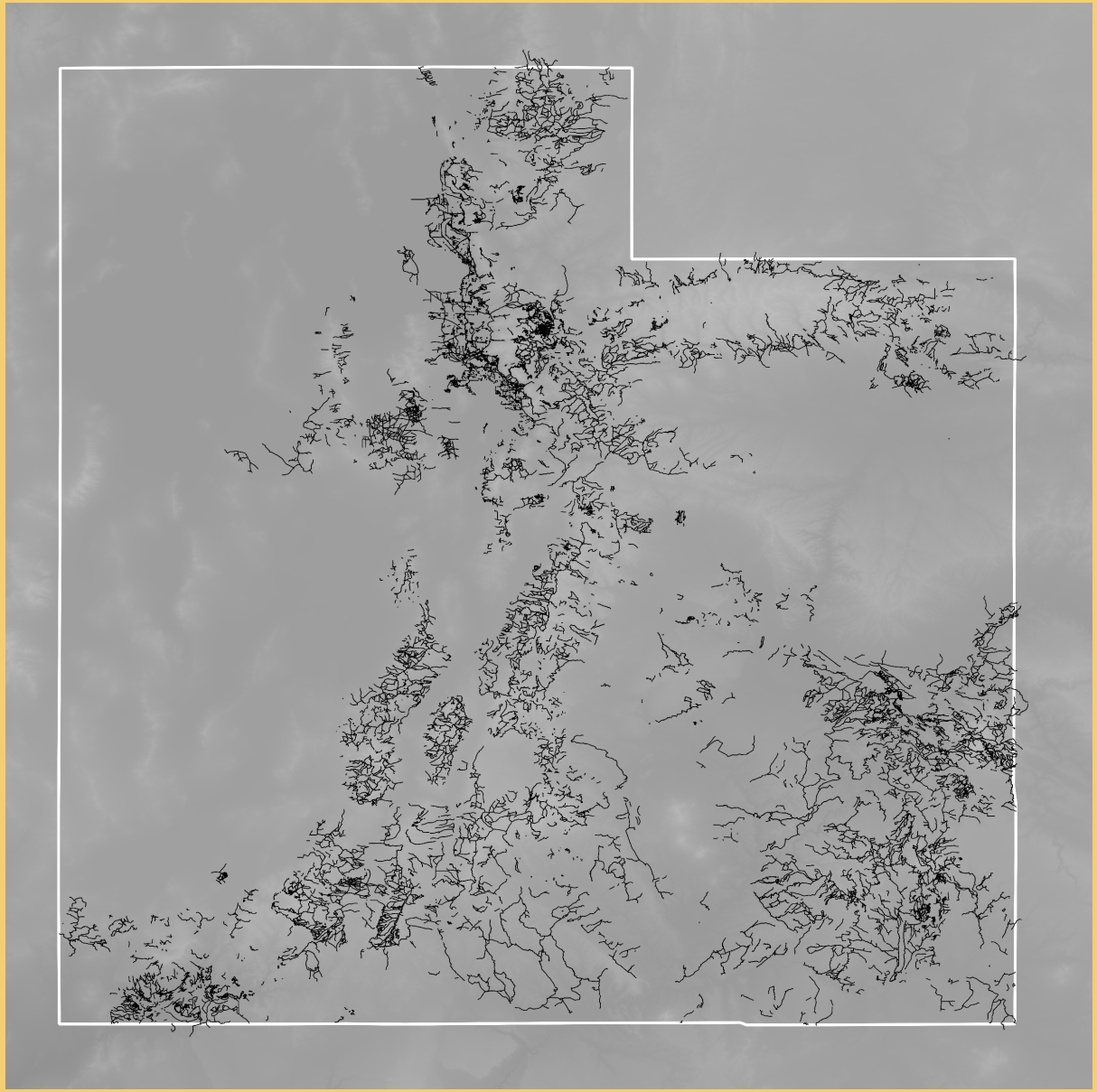
Utah Mountain Biking GIS Database

- Create an easy-to-update mountain bike database with trails, towns, and medical facilities
- Entity Relationship (ER) Diagram -> Data Collection -> QGIS <-> PostgreSQL
- Used the database to identify areas farther from medical services
- Can be used for trip planning and resource management

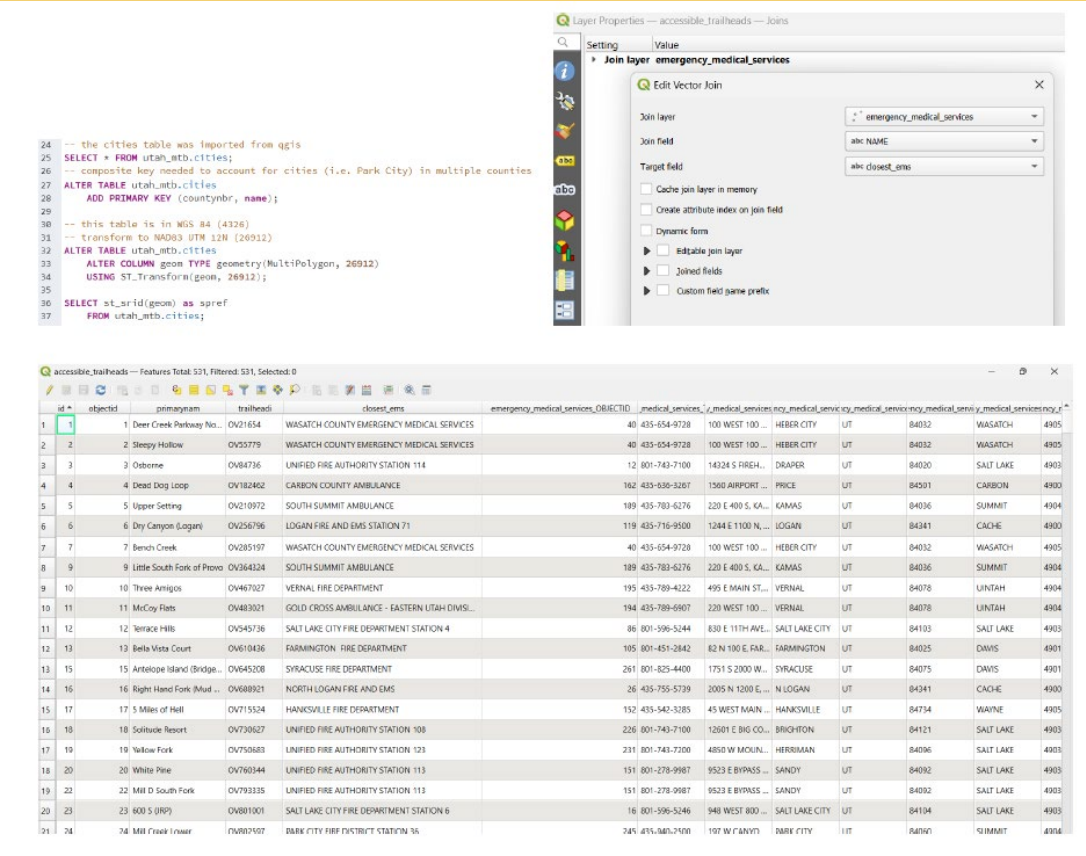
ER Diagram

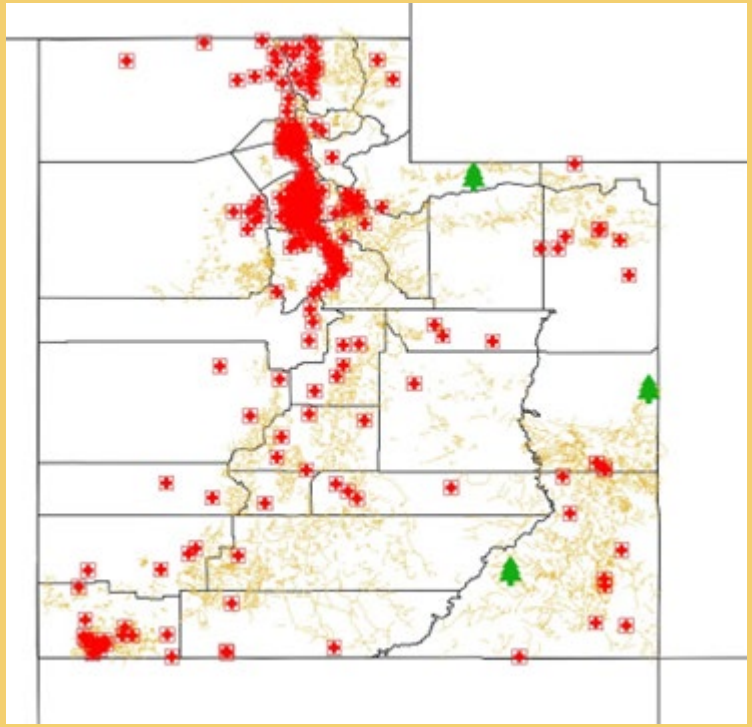

Name
Contain
M
Ski area
Bike allowance
Name
Contain
M
Emergency Medical Provider
Type
area
1
Counties
1
M
1
name
Contain
M
Cities
name
area
seat
Contain
M
Trails
name
use
length

Data collection



Data collection





Trailhead analysis

Data Collection from Bonderman Field Station

GEOG 5170

Geospatial Field Methods

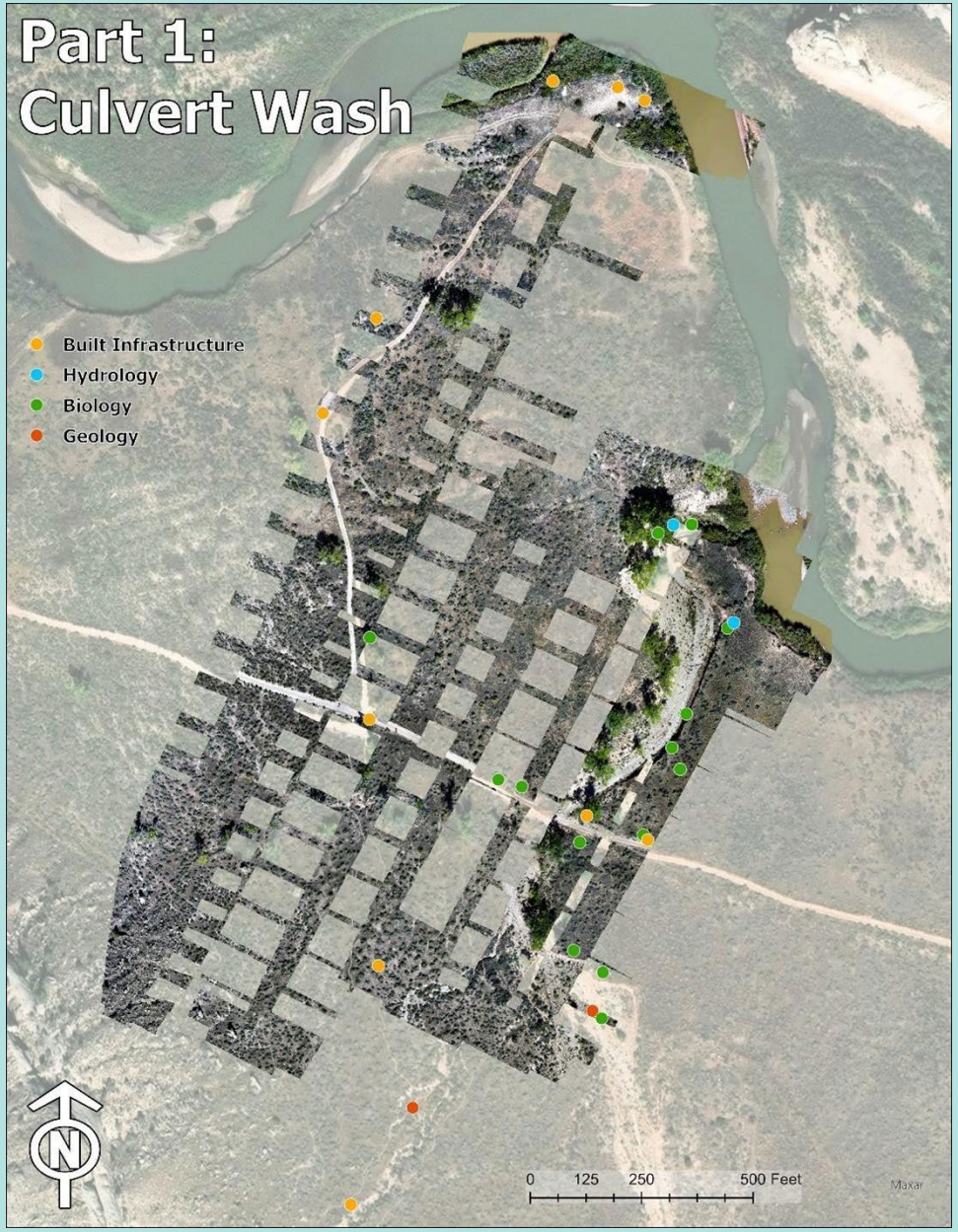
Dr. S. McKenzie Skiles

Fall 2024

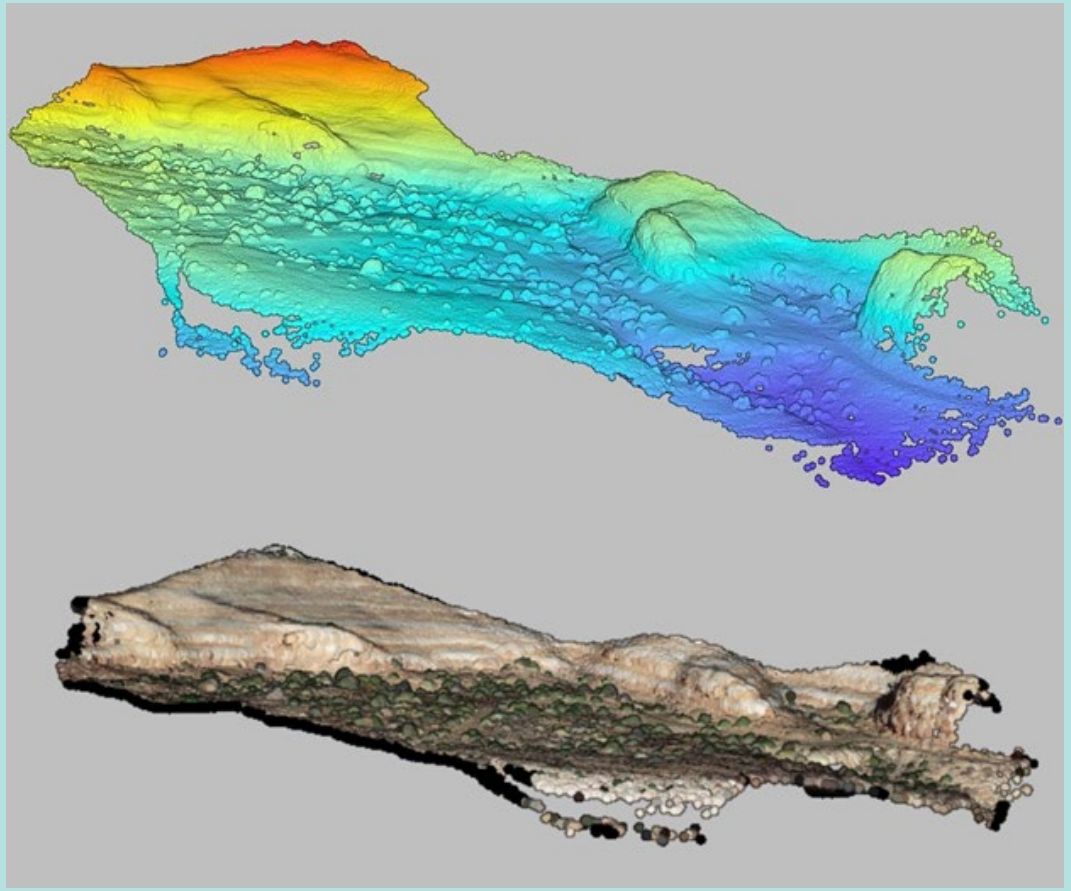
Data Collection from Bonderman Field Station

- Compare traditional and digital mapping techniques
- Drones, LiDAR, and GNSS
- Structure from motion, digital surface models, elevation difference
- Modern technology does not replace quality field work

ArcGIS Field Maps

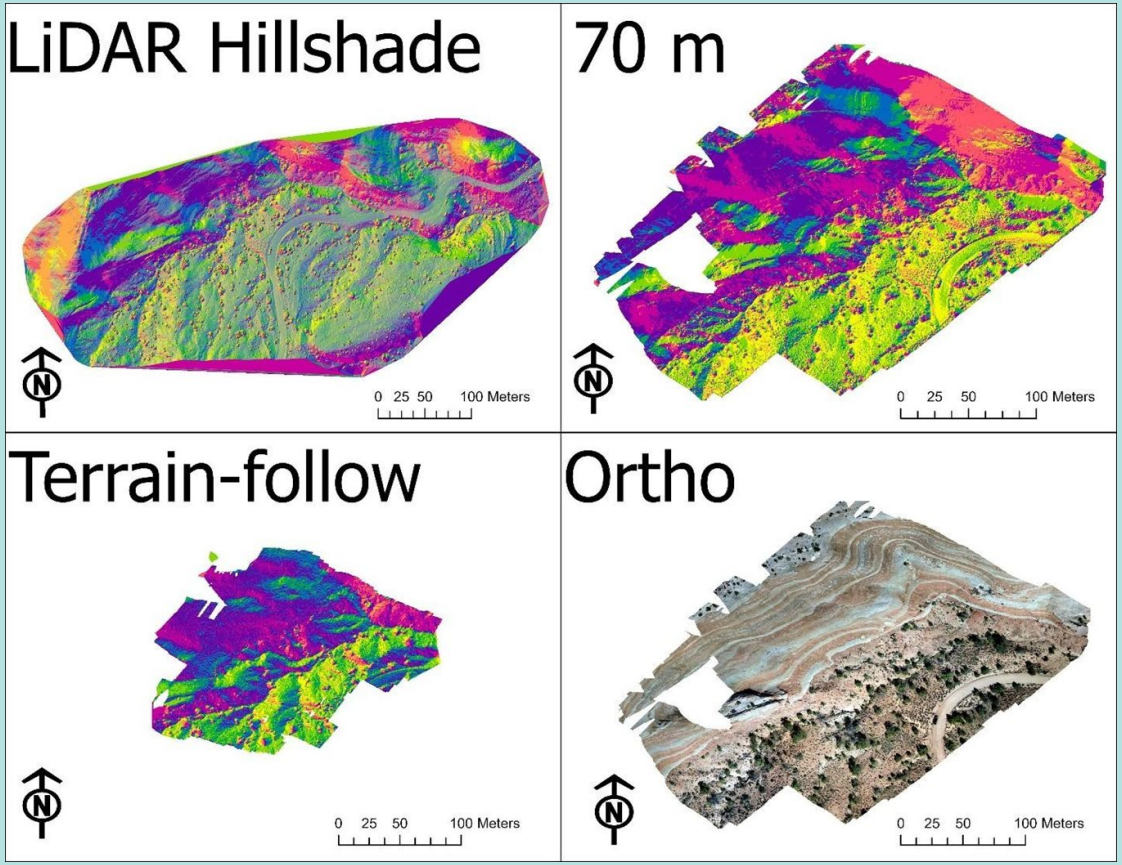


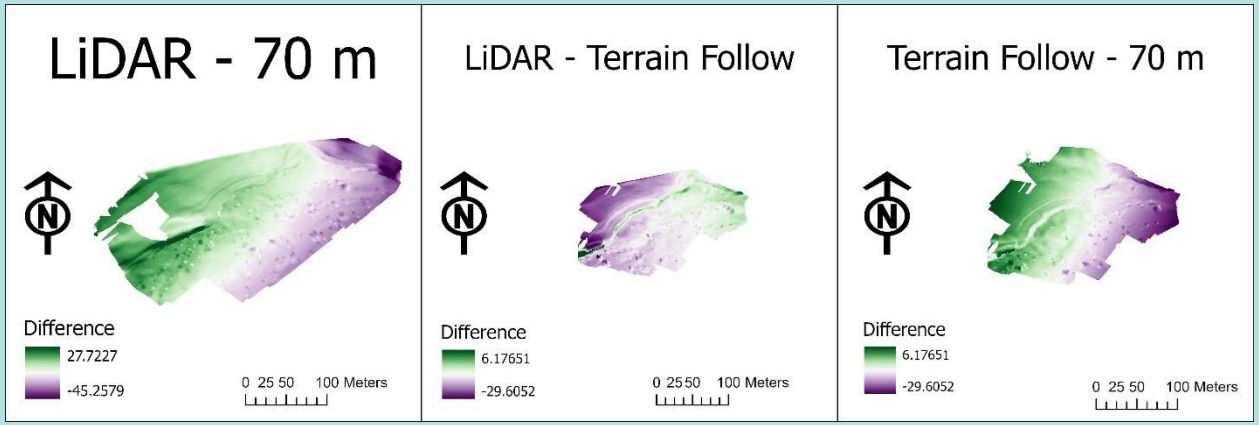
Ground control point planning



LiDAR elevation, RGB

Drone accuracies





Spatial Dynamics of the Red-Backed Shrike Annual Migration Cycle

GEOG 6000

Advanced Geographical Data Analysis

Dr. Simon Brewer

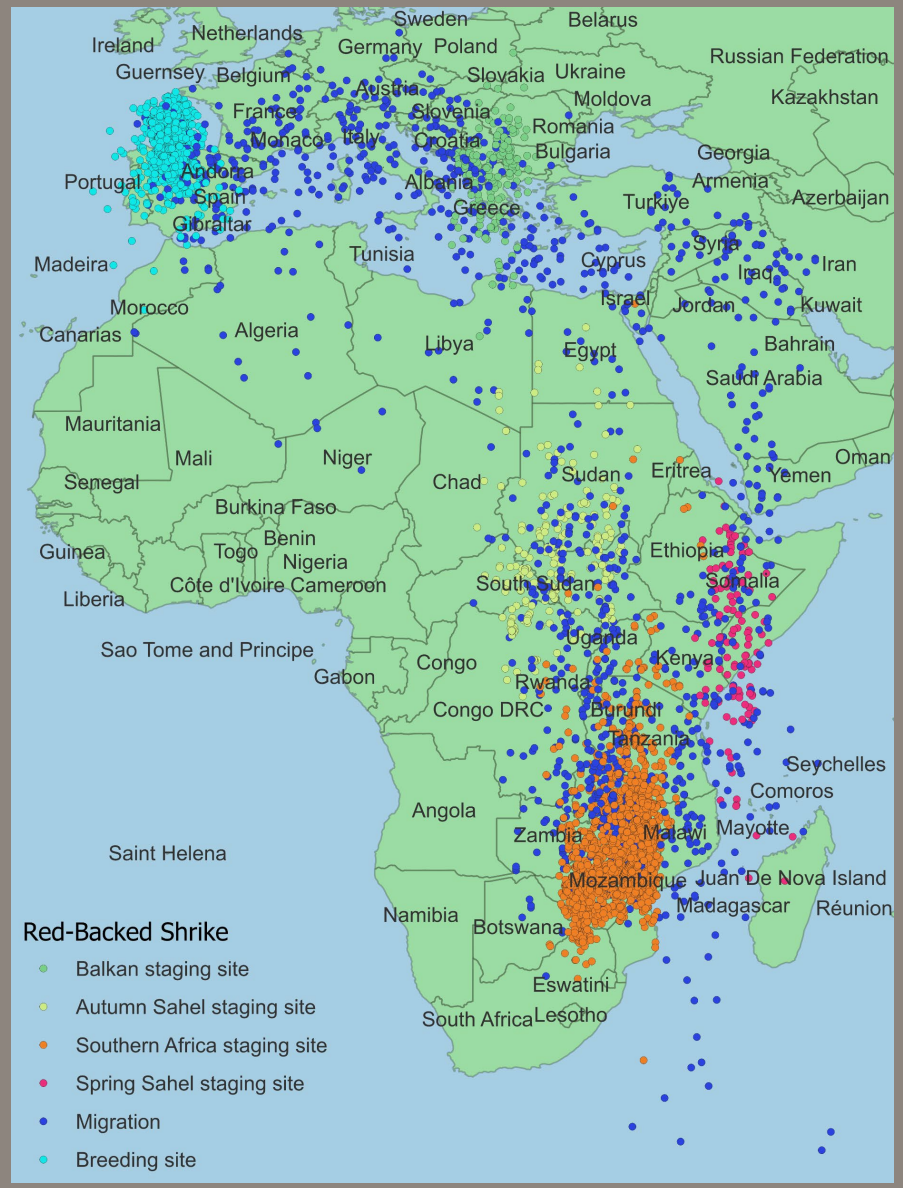
Fall 2023

Spatial Dynamics of the Red-Backed Shrike Annual Migration Cycle

- Bird migration as a baseline for monitoring environmental changes
- Indicator kriging in R, grid-based and polygon-based
- Migration stage prediction maps
- Adds understanding of migration patterns

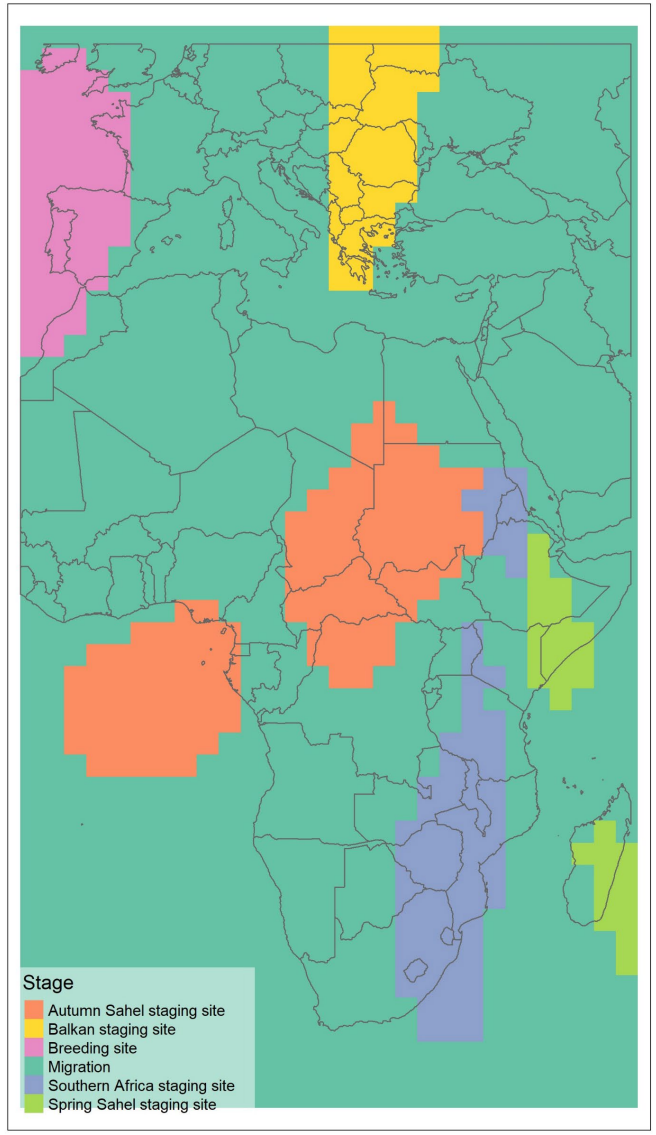
Red-backed shrike

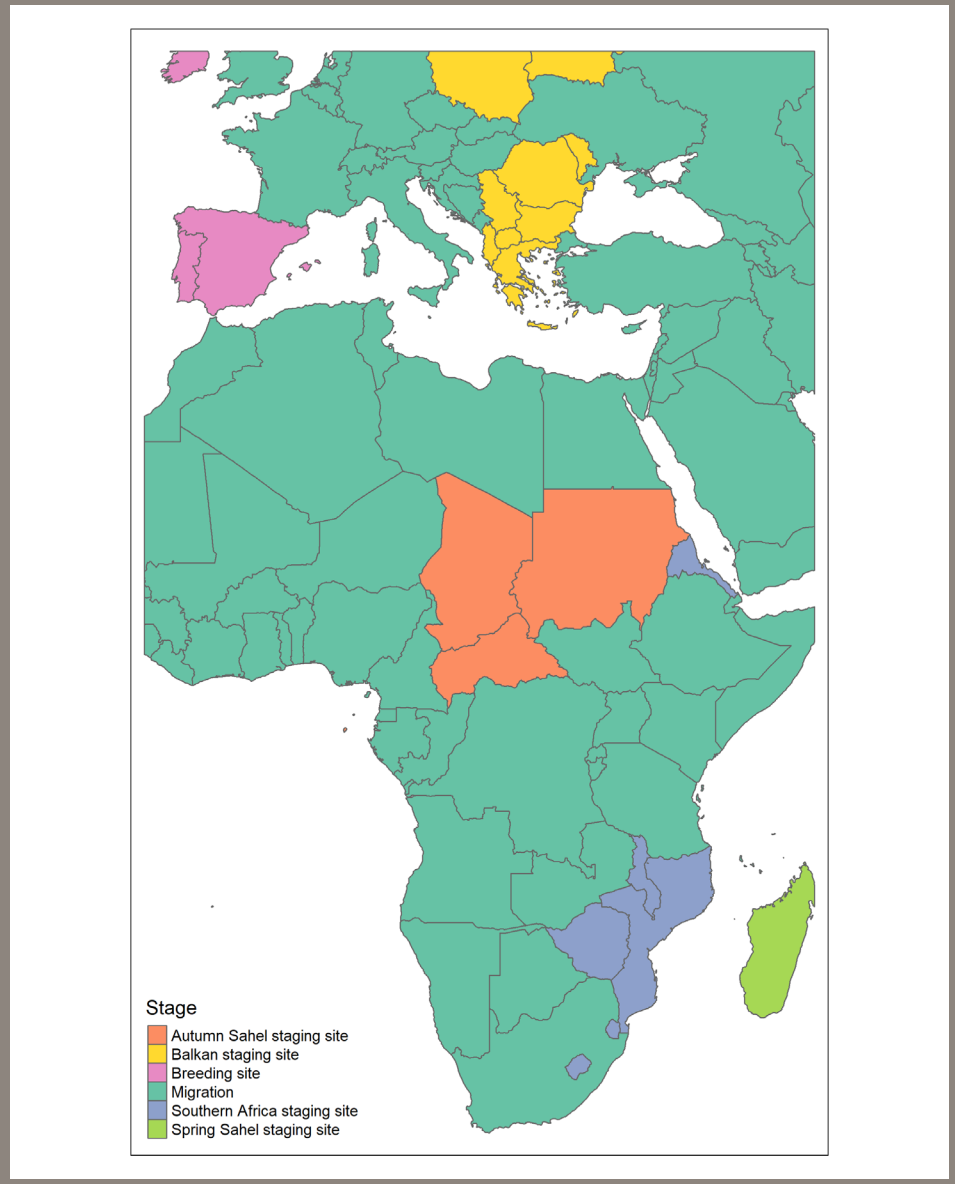
Source: Antonios Tsaknakis



Movebank observations

Prediction grid





Prediction by country

Directional Slope: A Python Tool for Path Design

GEOG 6180

Geoprocessing with Python

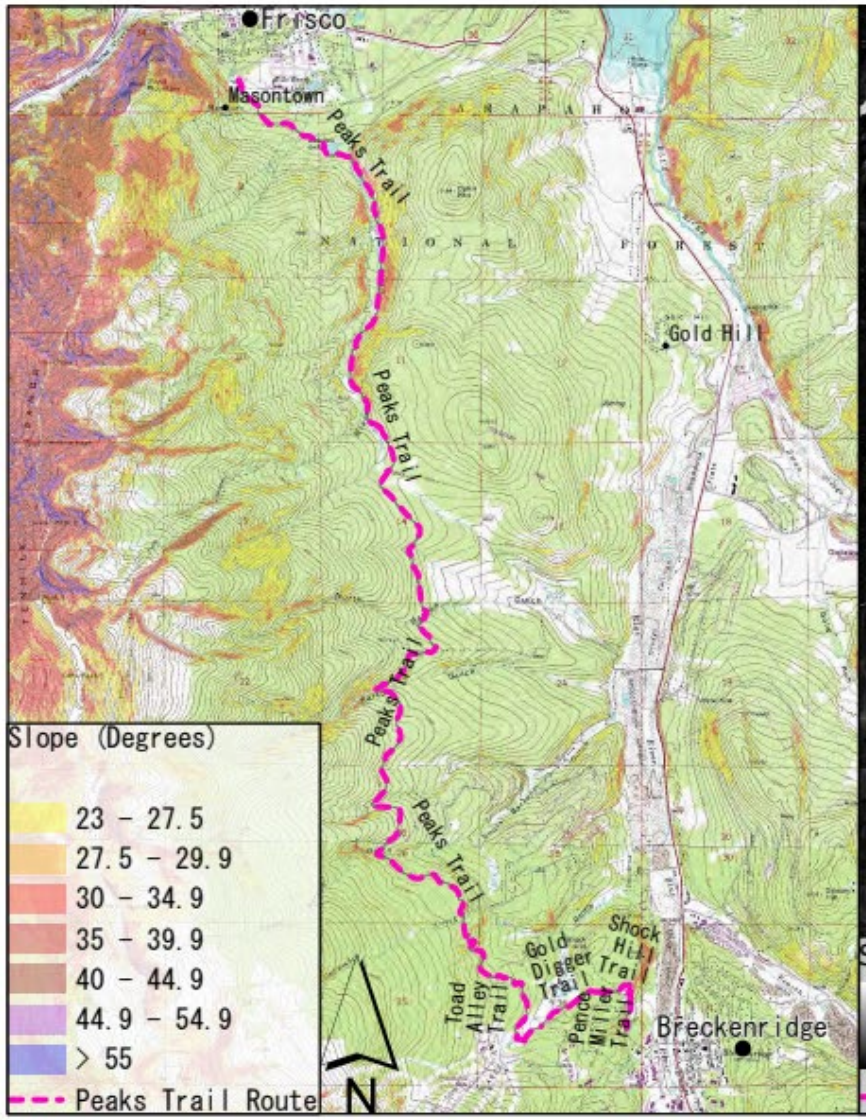
Dr. Thomas Cova

Fall 2023

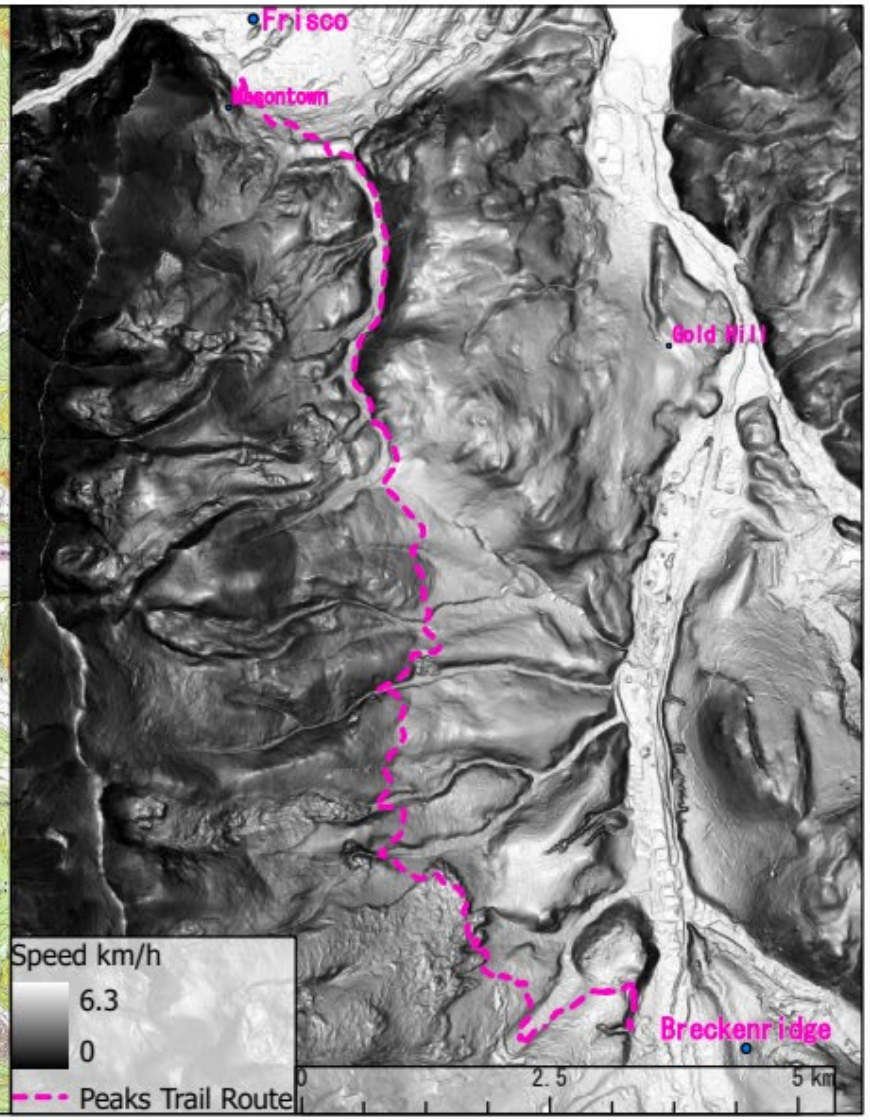
Tobler's Hiking Function

Peaks Trail Route, Frisco to Breckenridge

Slope Shading

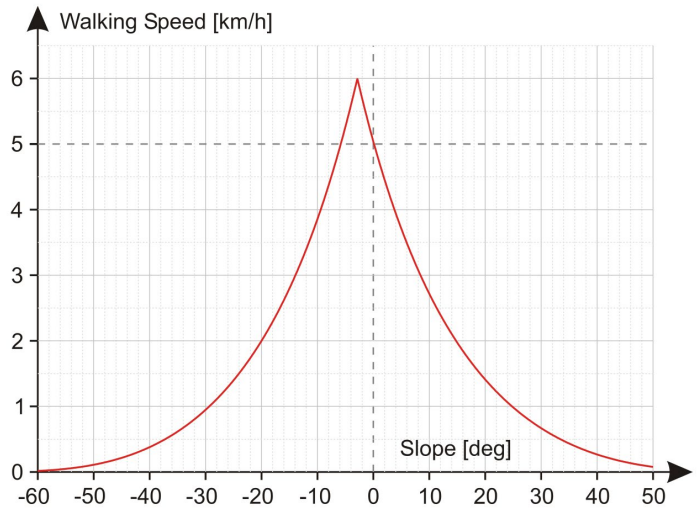


Travel Speed Cell Shading



Inspiration:

A personal project years ago, where travel times were estimated using Tobler's Hiking Function.



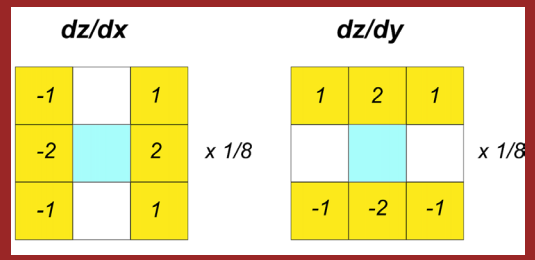
Directional Slope: A Python Tool for Path Design

- Calculate slope along the direction of travel
- Uses a digital elevation model and a line
- Outputs a line feature class with slope and bearing calculations
- Trail design, route planning, accessibility analysis

Neteler and Mitášová (2008)

$$dir\ slope(\alpha) = \tan^{-1}(\frac{dz}{dx} * \sin\alpha + \frac{dz}{dy} * \cos\alpha)$$

where α is the bearing, or direction of travel



Source: ESRI

a	b	c
d	e	f
g	h	i

```python
local_dem = dem_raster.ReadAsArray(px-1, py-1, 3, 3)
# top left = a
a = local_dem[0, 0]
# top center = b
b = local_dem[0, 1]
# top right = c
c = local_dem[0, 2]
# left = d
d = local_dem[1, 0]
# the pixel = e
e = local_dem[1, 1]
# right = f
f = local_dem[1, 2]
# bottom left = g
g = local_dem[2, 0]
# bottom center = h
h = local_dem[2, 1]
# bottom right = i
i = local_dem[2, 2]

# right column - left column
dz_dx = ((c+(2*f)+i)-(a+(2*d)+g))/(8*cell_size)
# top row - bottom row
dz_dy = ((c+(2*b)+a)-(i+(2*h)+g))/(8*cell_size)

return dz_dx, dz_dy
```

Python, using Horn's (1981) method

Neteler, M., & Mitasova, H. (2008). Open source software and GIS. In *Open Source GIS: A GRASS GIS Approach* (pp. 1-6). Boston, MA: Springer US.

Efficiency

At first

- Create a new raster holding slope values
- 4236 x 5854 DEM with 0.5 m resolution means 24,797,544 calculations!
- Living Room trail section broken into 2,541 segments
- 528.84 second script run time

Efficiency

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- Create a new raster holding slope values
- 4236 x 5854 DEM with 0.5 m resolution means 24,797,544 calculations!
- Living Room trail section broken into 2,541 segments
- 528.84 second script run time

GDAL.ReadAsArray() and Pixel Coordinates

- Only get relevant cells from the raster
- Create one calculation per segment
- 13.32 seconds

Using Machine Learning for Alpine Land Classification in Mountainous Terrain

GEOG 6160

Spatial Modeling and Geocomputation

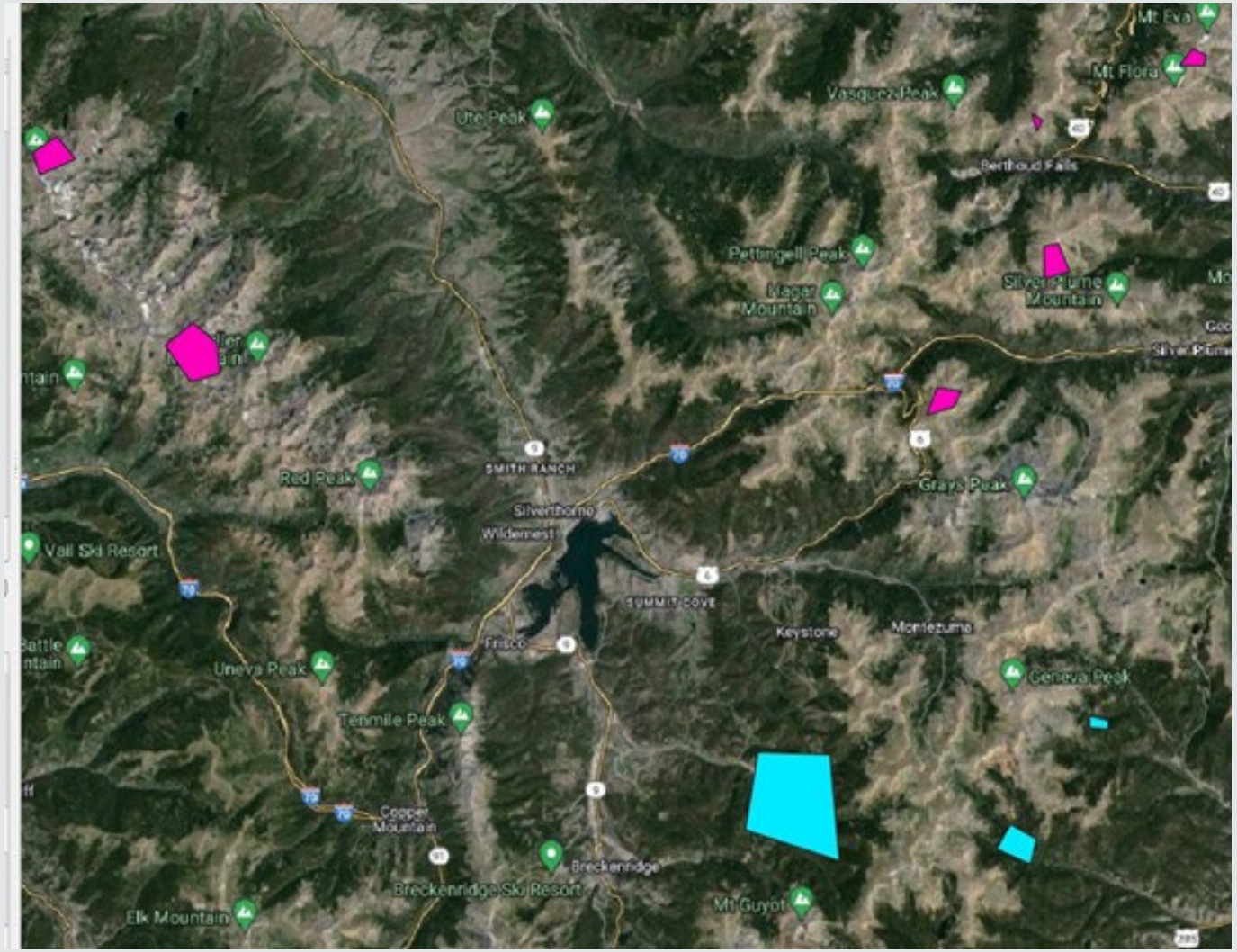
Dr. Moongi Choi, Dr. Simon Brewer

Spring 2024

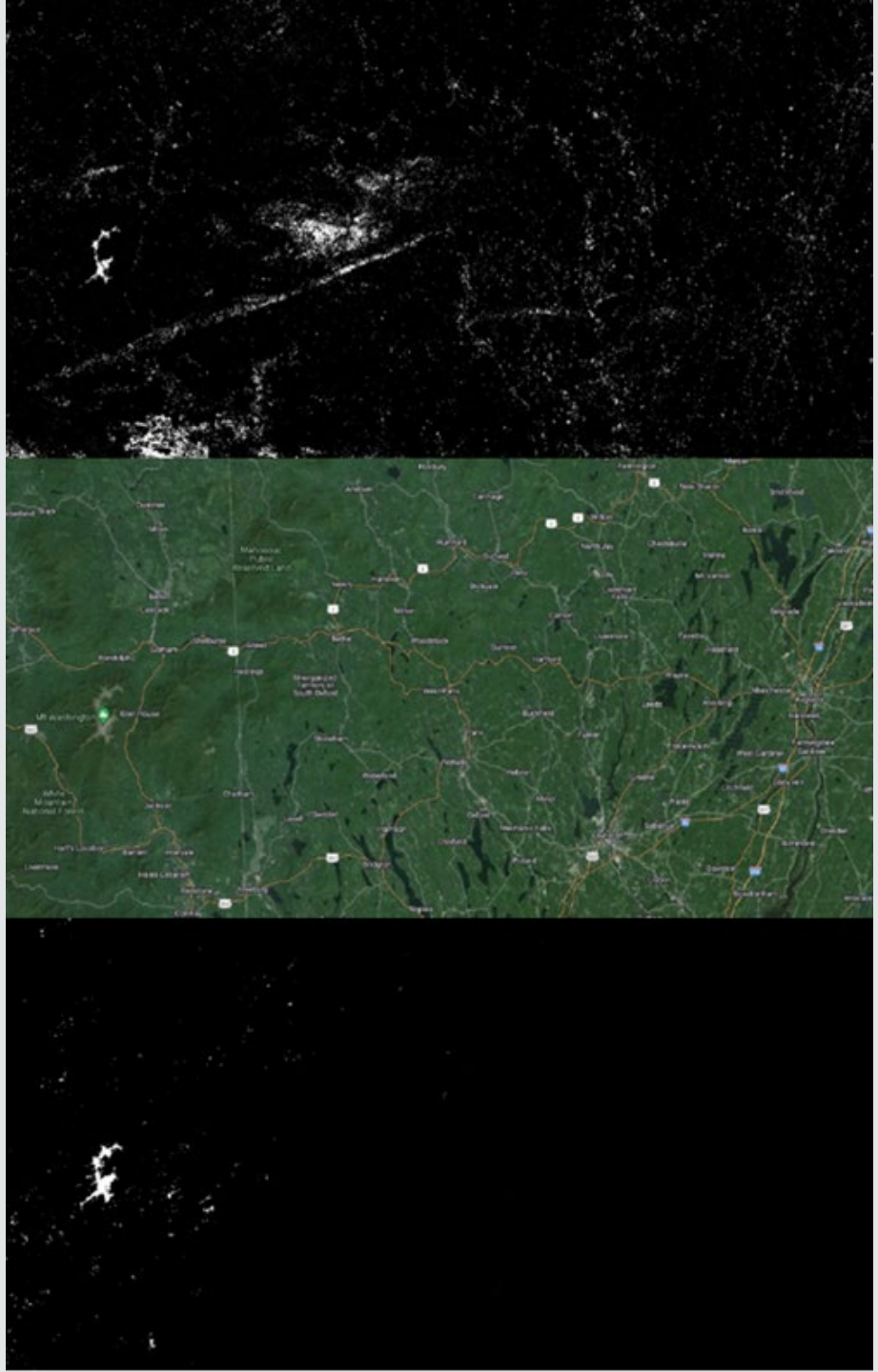
Using Machine Learning for Alpine Land Classification in Mountainous Terrain

- Betty Ford Alpine Gardens, Emily Griffoul, and Dr. Dara Seidl
- Use remote sensing (Landsat 9 OLI-2) as well as DEMs
- Use QGIS to classify
- Use R to sample
- Neural network, add elevation, and latitude
- Work has continued using Google Earth Engine

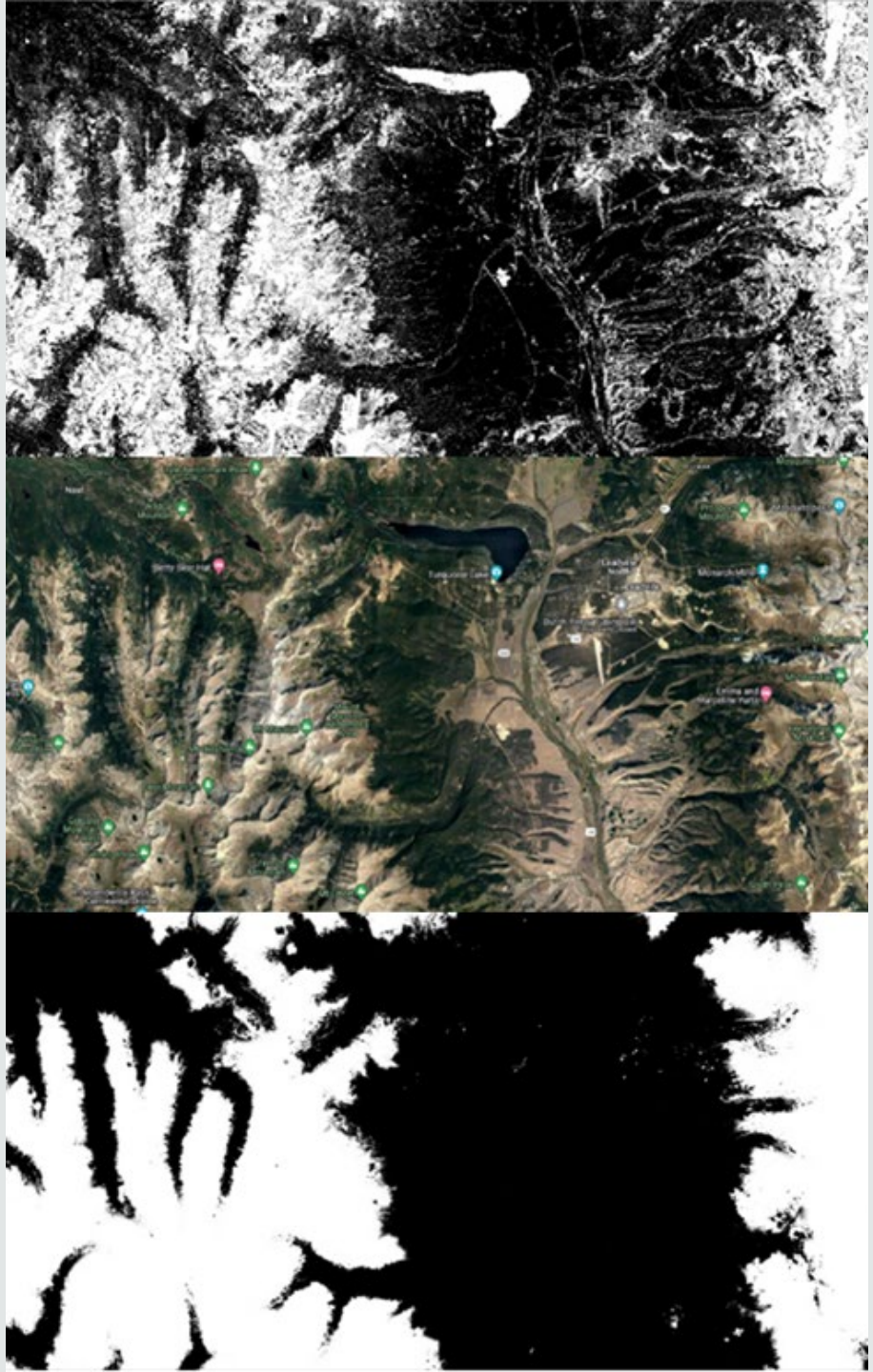
QGIS Classification



New England



Leadville, CO



Cottonwood Heights: Emergency Management Assistance and Evolution of Property Valuations

GEOG 6161

Capstone in GIS

Dr. Phoebe McNeally

Spring 2025

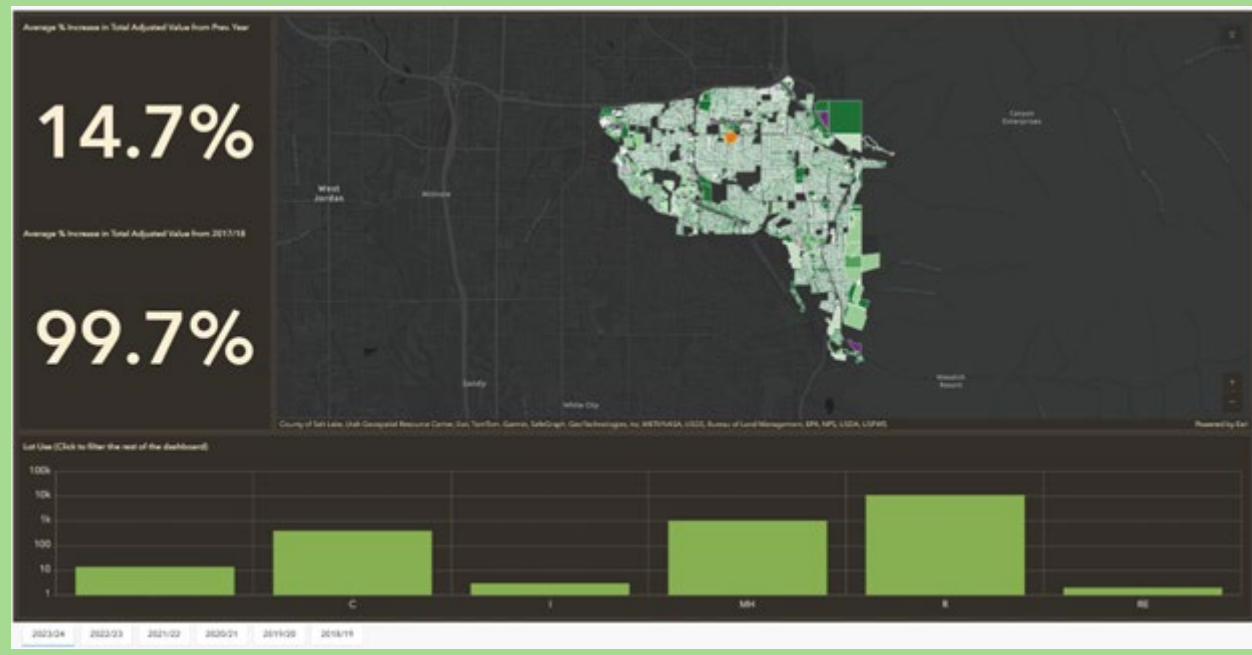
Capstone: Cottonwood Heights

Evolution of Property Valuations

- New town center, The Heights
- County parcel data
- ArcGIS Online (AGOL) Dashboard

The Heights

Source: Cottonwood Heights



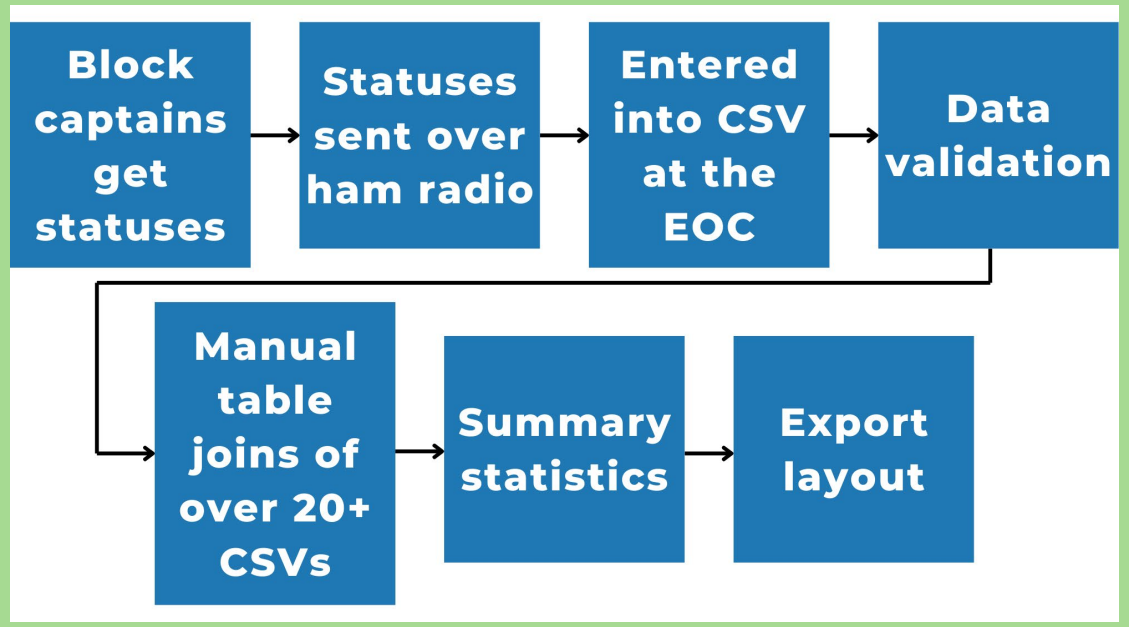
AGOL Dashboard

Capstone: Cottonwood Heights

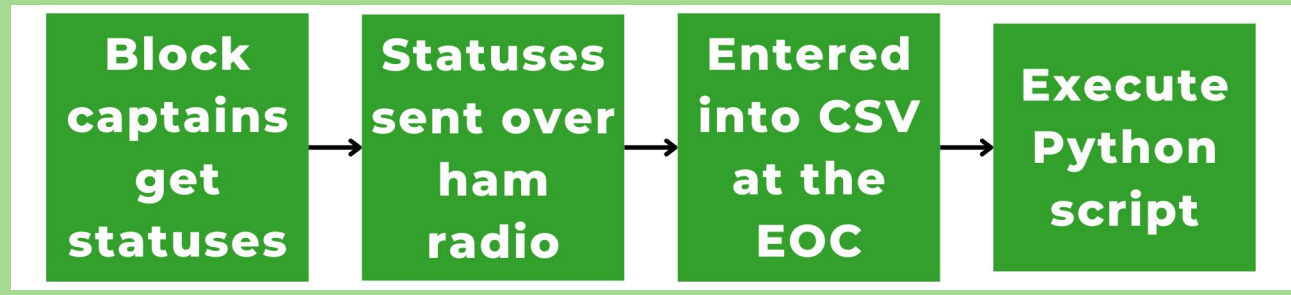
Emergency Management Assistance

- Reporting system using flags and ham radios
- Previously had to manually perform table joins and statistics
- Python script to automate
- Saves valuable time in an emergency

Before



After

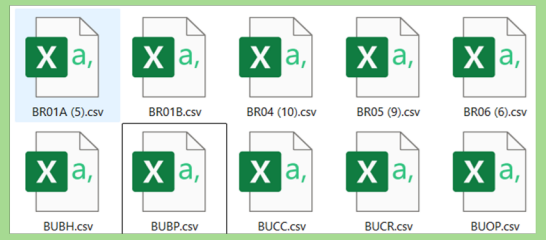


Pseudocode

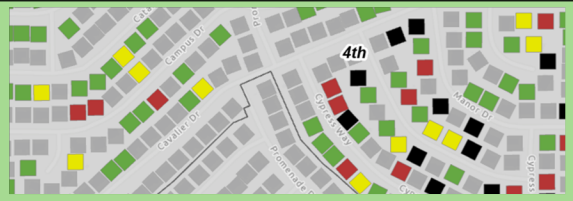
Data validation and normalization

AddressID	Status	Address		AddressID	Status	Address
18866	g	3464 E 7635 S	⇒	18866	g	3464 E 7635 S
18865	G	3442 E 7635 S	⇒	18865	g	3442 E 7635 S
18864	R	3430 E 7635 S	⇒	18864	r	3430 E 7635 S
18863	r	3420 E 7635 S	⇒	18863	r	3420 E 7635 S
18862	none	3408 E 7635 S	⇒	18862	n	3408 E 7635 S

Combine CSVs into one DataFrame



Update shapefile using ArcPy

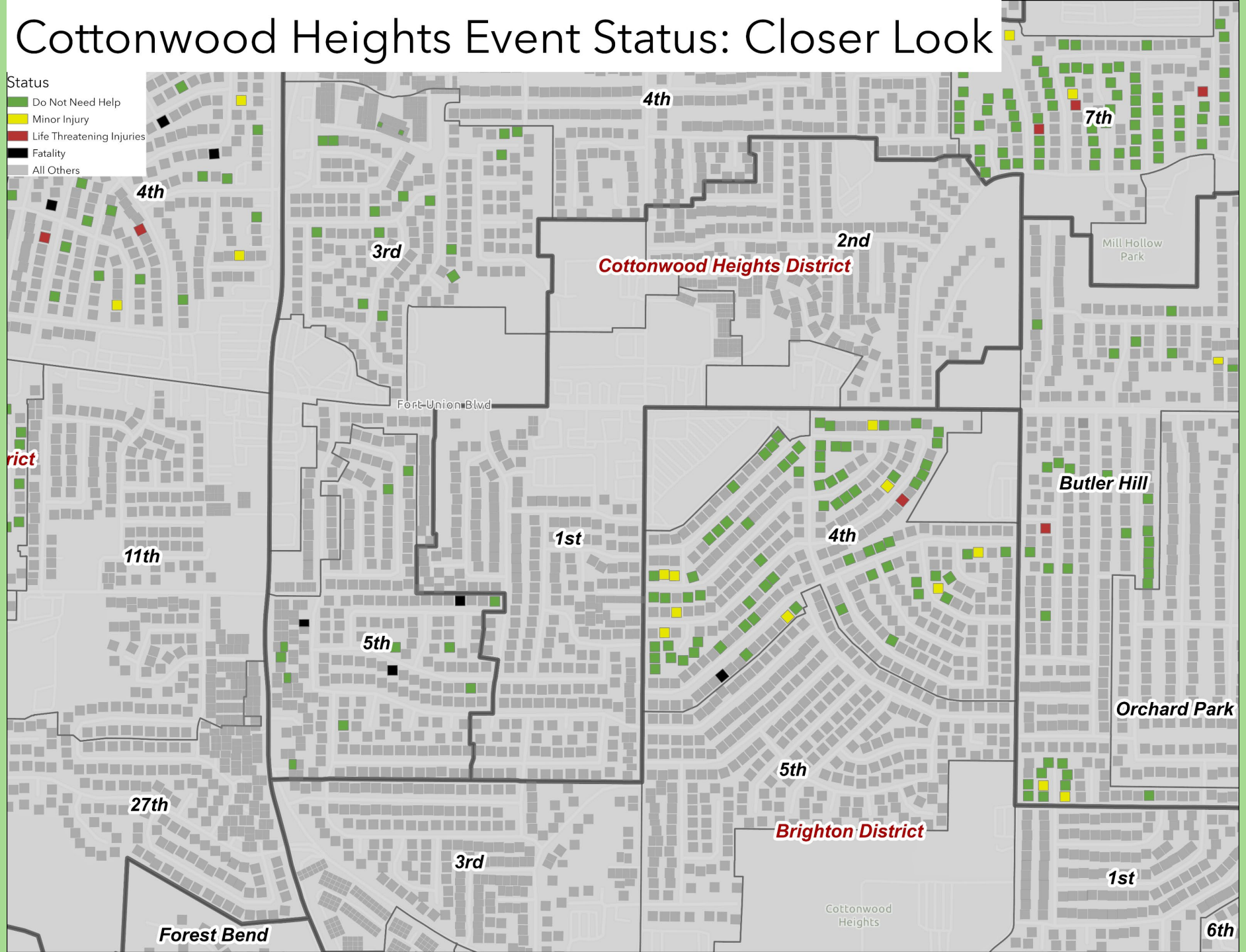


Summarize statistics

District	Fatality	Life Threatening Injuries	Minor Injury	Do
Brighton	23	29	33	236
Butler	8	23	38	290
Butler West	6	16	25	262
Cottonwood	0	0	0	0
Cottonwood Creek	0	2	3	7
Cottonwood Heights	1	15	14	160

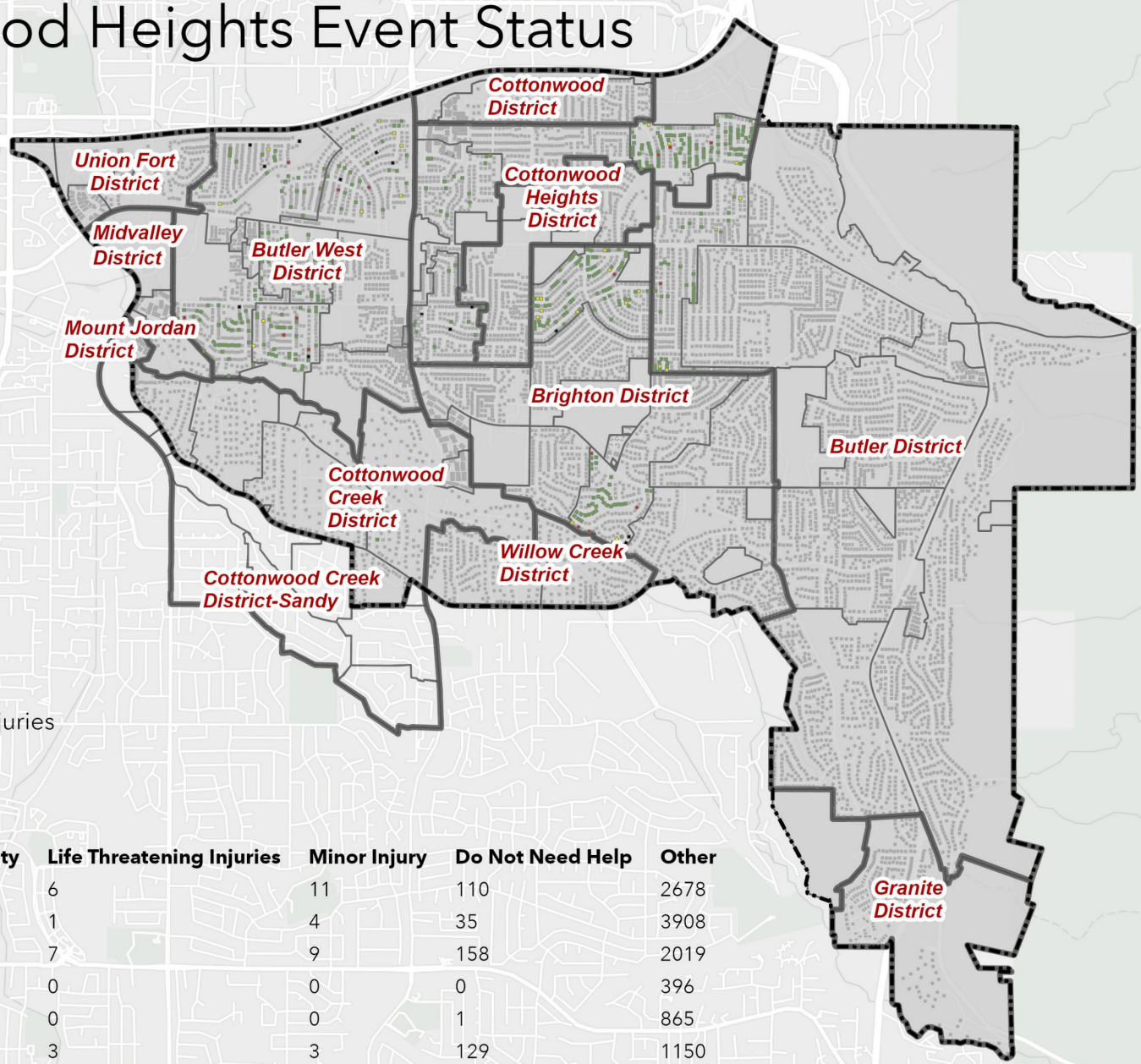
Export layout as JPEG

Cottonwood Heights Event Status: Closer Look



Cottonwood Heights Event Status

4/18/2025 12:40 PM



Status

- Do Not Need Help
- Minor Injury
- Life Threatening Injuries
- Fatality
- All Others

District	Fatality	Life Threatening Injuries	Minor Injury	Do Not Need Help	Other
Brighton	3	6	11	110	2678
Butler	0	1	4	35	3908
Butler West	8	7	9	158	2019
Cottonwood	0	0	0	0	396
Cottonwood Creek	0	0	0	1	865
Cottonwood Heights	3	3	3	129	1150
Granite	0	0	0	0	272
Mount Jordan	0	0	0	0	350
Union Fort	0	0	0	0	728
Willow Creek	0	0	0	0	332

Acknowledgements

Dr. Simon Brewer
Dr. Andrea Brunelle
Dr. Moongi Choi
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Dr. Alexander Hohl
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Brian Busch
Kellie Koester

Questions?

joe.tayabji.github.io

Thank you!