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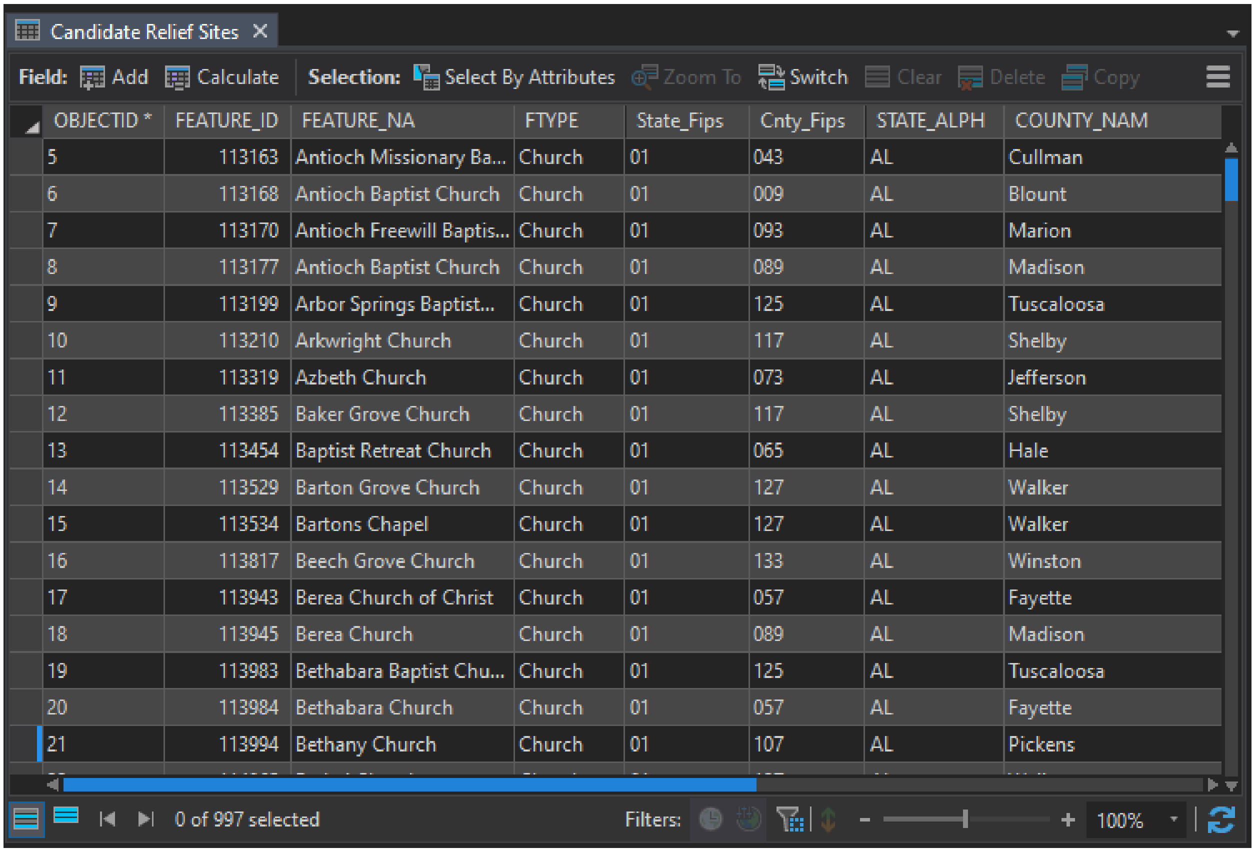
Lesson 3 Report
3/16/2021

Like Lesson 1, the general goal of Lesson 3 was to demonstrate the use of GIS in geographic decision-making. The case study used involved analyzing the paths of the several tornados that hit Alabama in 2011 and state population figures to (1) identify possible public facilities to be used as emergency relief sites for tornado victims and (2) classify the affected areas by their need for relief. To accomplish this, I would need to learn buffering and spatial overlay operations, and combine these with concepts learned in previous lessons to undertake this spatial analysis exercise.

To complete the exercise, I needed to be familiar with the following concepts: attribute and spatial queries, table manipulations, creating thematic maps, inserting buffers, and performing spatial overlays. In Lesson 1 I learned to use spatial and attribute queries to isolate relevant data records. In Lesson 2 I leaned to manipulate data tables, in particular creating and calculating fields and performing joins with other tables. I also learned in Lesson 2 to create thematic maps with gradated color schemes based on a particular attribute value. In addition, both previous lessons and GEOG 482 familiarized me with projecting spatial data. Since Lesson 2 involved much of the same data, I was already familiar with the projection and coordinate system in use (UTM Zone 16N, NAD 83) and made sure to adhere to this when adding new data to the project. New to Lesson 3 were buffers and spatial overlays. A buffer is a polygon surrounding a vector feature at a fixed or variable distance used for determining proximity. As explained by Paul Bolstad, "*overlays* involve combining spatial and attribute data from two or more data layers", be it vector or raster data. For this project I used an intersection overlay, in which overlapping features from different layers are split and combined into new features, carrying the attribute data from both.

As usual, I started the analysis by importing the relevant data: Alabama counties and tornado paths (both seen in Lesson 2) as well as places in the state and tables containing additional population and tornado attribute data. After checking the map projection and measurement units, I joined the county and tornado layers to the population and tornado attribute tables respectively, to enhance the available data. To prepare for further analysis I calculated additional fields. For the county layer I calculated population density for each county, and for the tornados I calculated the buffer width to be used, representing the measured width of each tornado path. With this data I then created a buffer for each tornado path. To identify candidate relief sites I created an additional buffer, 1 mile on each side of the tornado path, to represent the appropriate range for relief sites. These 1-mile buffer zones are referred to as the "Emergency Relief Zones". I then used an attribute query to select only the churches, hospitals and schools out of the place layer, and added a spatial query selecting only places located within the Emergency Relief Zones, thus establishing my candidate list.



Candidate Relief Sites

Field: Add Calculate Selection: Select By Attributes Zoom To Switch Clear Delete Copy

OBJECTID *	FEATURE_ID	FEATURE_NA	FTYPE	State_Fips	Cnty_Fips	STATE_ALPH	COUNTY_NAM
5	113163	Antioch Missionary Ba...	Church	01	043	AL	Cullman
6	113168	Antioch Baptist Church	Church	01	009	AL	Blount
7	113170	Antioch Freewill Baptis...	Church	01	093	AL	Marion
8	113177	Antioch Baptist Church	Church	01	089	AL	Madison
9	113199	Arbor Springs Baptist...	Church	01	125	AL	Tuscaloosa
10	113210	Arkwright Church	Church	01	117	AL	Shelby
11	113319	Azbeth Church	Church	01	073	AL	Jefferson
12	113385	Baker Grove Church	Church	01	117	AL	Shelby
13	113454	Baptist Retreat Church	Church	01	065	AL	Hale
14	113529	Barton Grove Church	Church	01	127	AL	Walker
15	113534	Bartons Chapel	Church	01	127	AL	Walker
16	113817	Beech Grove Church	Church	01	133	AL	Winston
17	113943	Berea Church of Christ	Church	01	057	AL	Fayette
18	113945	Berea Church	Church	01	089	AL	Madison
19	113983	Bethabara Baptist Chu...	Church	01	125	AL	Tuscaloosa
20	113984	Bethabara Church	Church	01	057	AL	Fayette
21	113994	Bethany Church	Church	01	107	AL	Pickens

0 of 997 selected Filters: 100%

Figure 1: Table of Candidate Relief Sites. Note there are 997 records.

The last task was to assign "priority" scores to the Emergency Relief Zones, reflecting their level of need. This score was calculated by multiplying the EF scale (intensity) of the associated tornado with the population density of the county the relief zone is located in. To do this calculation I had to divide up each Emergency Relief Zone by each county it passed through, thereby associating each new zone with the respective county's population density. This required an intersection overlay between the county layer and the Emergency Relief Zone layer. Once I had the new subdivided zones, I used a gradated color scheme to shade the zones, with a darker color representing a higher priority score, which I displayed with the candidate sites. This map could then help disaster responders assess the best locations to set up relief sites based on surrounding need.

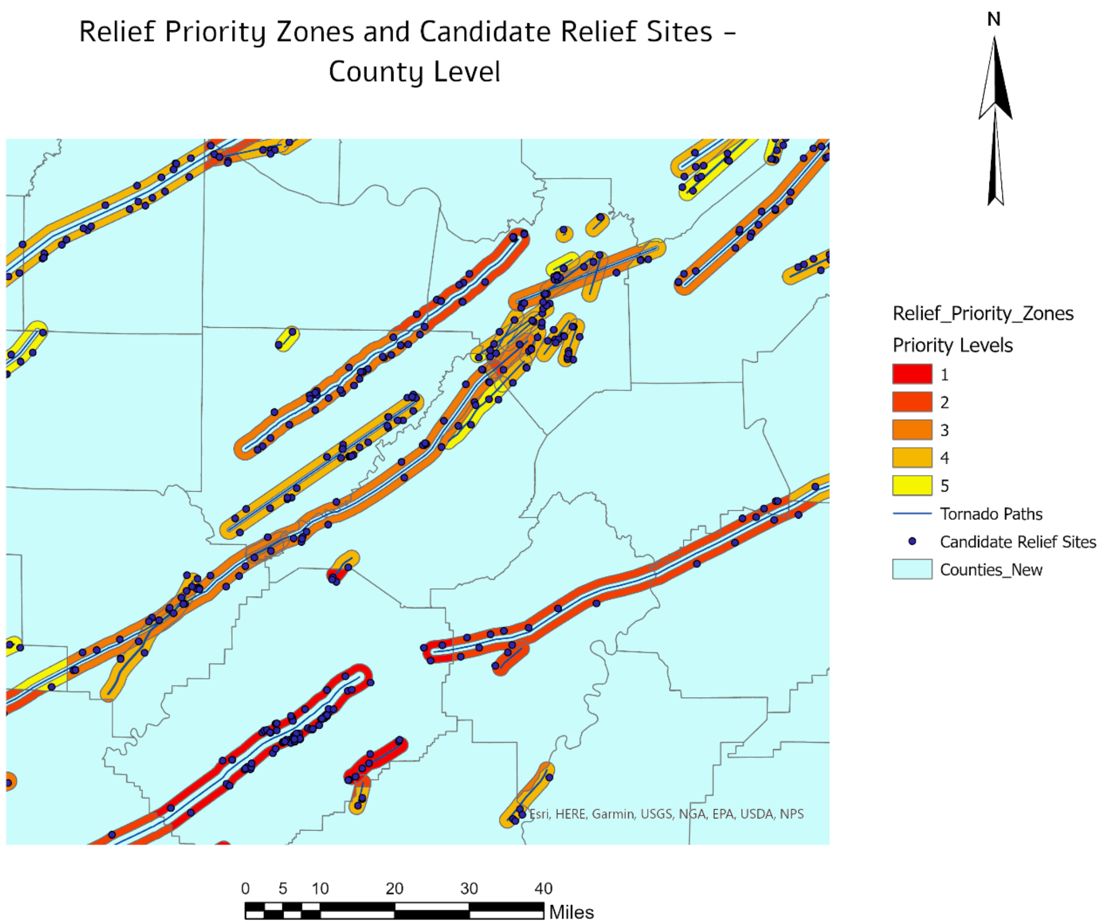


Figure 2: Candidate Relief Sites and Relief Priority Zones. (Blount County at center).

I then repeated these steps, but using census tract divisions rather than counties, for a more precise analysis.

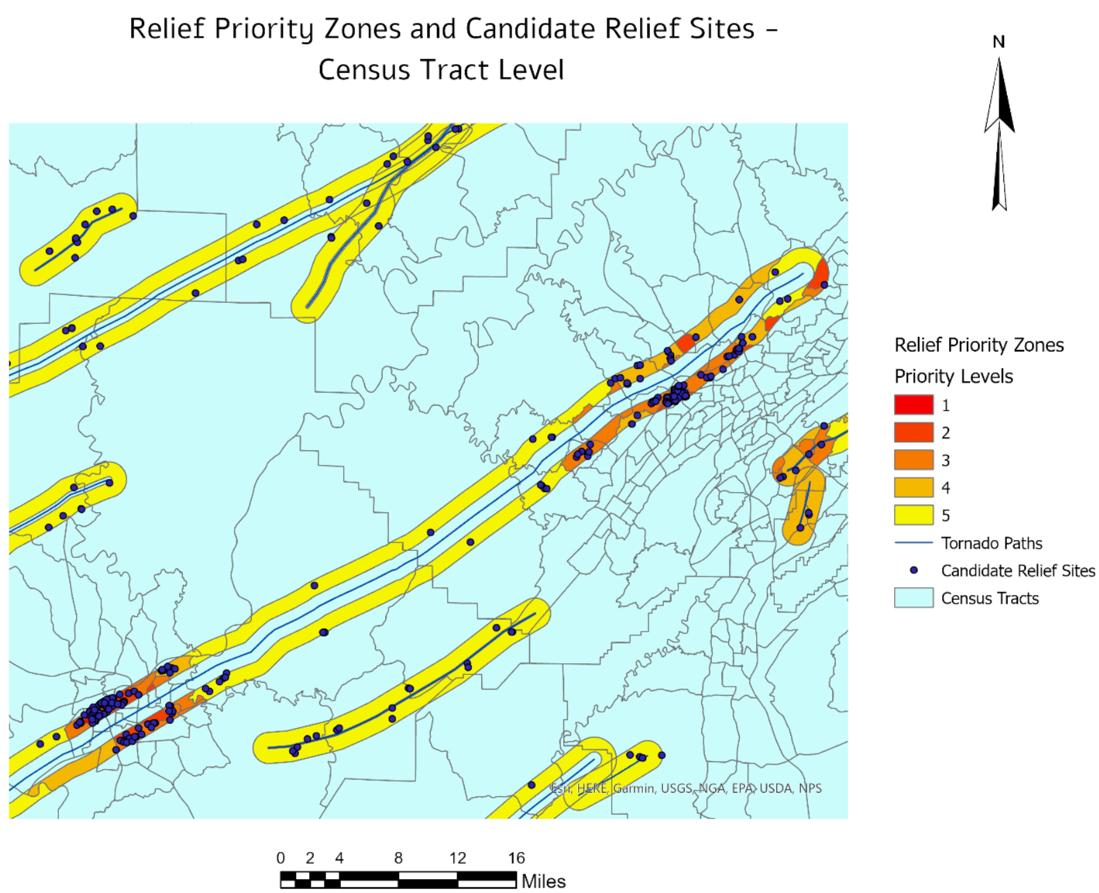


Figure 3: Candidate Relief Sites and Relief Priority Zones, re-calculated at the census tract level (zoomed to Jefferson and Tuscaloosa Counties).

There is clearly a significant number of potential emergency relief sites. As a northerner I have an impression of Alabama being a fairly religious state, and the density of churches seems to support that. There are some sparser sections, though there do not appear to be gaps greater than a few miles between candidate sites. The calculation to determine relief priority was simple: EF scale of the tornado*population of the subdivision (county or census tract). Since the EF scale is constant along the length of each tornado path, relief zones within denser areas would naturally have a higher priority, as is clear from the resulting map. This is particularly clear when using census tracts, as higher priority zones are generally clustered around the smaller, and thus more densely populated, census tracts.

While this analysis was a good start towards planning relief efforts, it was done with limited information. While at first thought it makes sense to put candidate sites in areas with higher population densities, there are other factors to consider. For instance, our use of population density does not account for actual settlement patterns. While a particular tract or county may be sparsely populated overall, its residents may be concentrated in a small handful of areas, and the damage could be more significant in those clusters than our priority scores imply. In addition, we would have to be careful when choosing where to locate a relief center in more remote areas, especially if there has been damage to roadways and/or many victims do not have access to cars (more information that we did not have for this analysis). Reviewing the full “Places” layer used in this lesson as well as aerial imagery could at least give relief planners a better idea of settlement patterns and help pinpoint better relief site locations. This analysis also assumes that denser population corresponds directly to a greater need for relief. While this is partially true, in a real-life situation we would need to have information about the actual damage caused by the tornados. I am not an expert in disaster response, but I imagine this would involve reconnaissance efforts and the use of up-to-date aerial/satellite imagery, as well as setting up emergency hotlines and other channels of communication to those affected. This would probably involve a lot of manual input and analysis in GIS, but estimates on casualty numbers and dollar damages could then be made and factored into calculations of relief priority.

On that note, I attempted to factor monetary damage into my analysis. In Lesson 2 we calculated the total dollar damage to each affected county, so I imported the layer containing this data into my new map. I first normalized the damage amount for each county by dividing by population. I then joined the layer with damage amounts per county with the Relief Priority Zone layer. After exporting to a new layer, I recalculated the relief priority score as Old Relief Priority*Dollar Damage per Person and created a new thematic map.

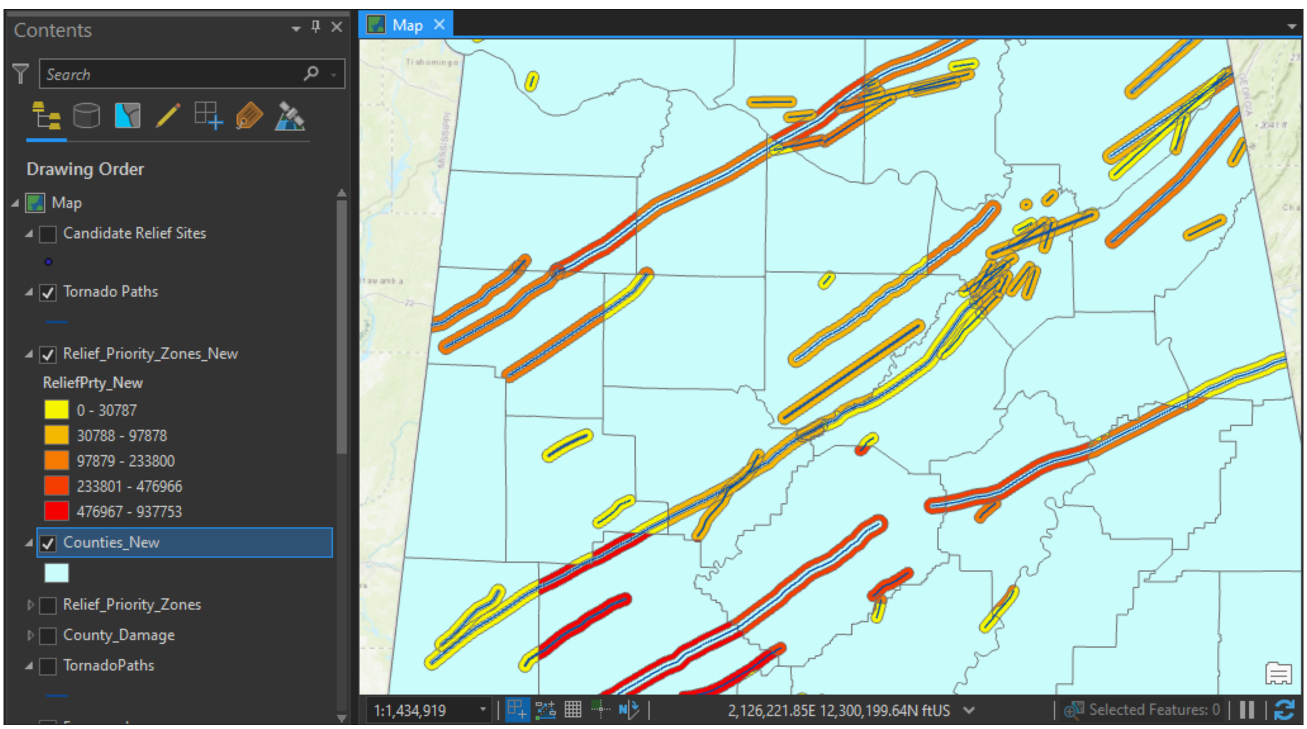


Figure 4: New Relief Priority Zones factoring dollar damage per person for each affected county. Candidate sites hidden for clarity.

OBJECTID_12_1	COUNTYNAME	EFSCALE	ReliefPrty	POP2010	tot_dollar	dol_per	ReliefPrty_New
1	Marion	EF3	166	30776	27940000	907.850273	150703
2	Marion	EF3	166	30776	27940000	907.850273	150703
3	Marion	EF5	248	30776	27940000	907.850273	225147
4	Marion	EF2	124	30776	27940000	907.850273	112573
5	Marion	EF5	248	30776	27940000	907.850273	225147
6	Pickens	EF3	89	19746	528000	26.739593	2380
7	Pickens	EF2	67	19746	528000	26.739593	1792
8	Pickens	EF2	67	19746	528000	26.739593	1792
9	Pickens	EF3	89	19746	528000	26.739593	2380
10	Pickens	EF4	111	19746	528000	26.739593	2968
11	Bibb	EF1	73	22915	1342800	58.599171	4278
12	Bibb	EF1	73	22915	1342800	58.599171	4278
13	Bibb	EF3	146	22915	1342800	58.599171	8555
14	Bibb	EF3	146	22915	1342800	58.599171	8555
15	Choctaw	EF2	45	13859	1270500	91.673281	4125
16	Choctaw	EF3	60	13859	1270500	91.673281	5500
17	Fayette	EF3	110	17241	2371700	137.561626	15132
18	Fayette	EF1	55	17241	2371700	137.561626	7566

Figure 5: Attribute table showing new Relief Priority scores.

References:

Bolstad, P. (2019). GIS Fundamentals (6th ed.). Ann Arbor, MI: XanEdu.

King, E., Walrath, D., & Zeiders, M. (1999-2021). Problem-Solving with GIS, Lesson 3. The Pennsylvania State University World Campus Certificate/MGIS Programs in GIS. Retrieved February 29, 2021.