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Geo 327G
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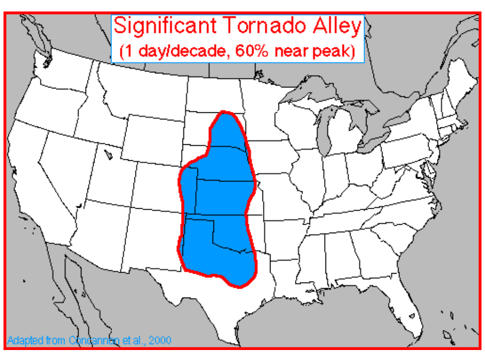
Texas Tornado Track Density: Which Areas Are At Risk?

Problem:

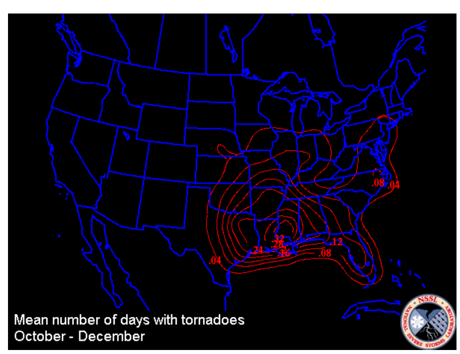
Tornados are dangerous hazards that occur annually within the United States that cause immense amounts of damage and loss. The purpose of this project is to identify areas in the state of Texas that have been at risk for tornado threat. By using historic tornado tracks, the density of tornado tracks were analyzed from the years 1950-2013 and every subsequent 10 years starting from 1954 to assess areas that have been prone to tornado threats. Because Texas is part of what is known as Tornado Alley, a term used for states that exhibit high amount of tornado activity, and the Dixie Alley, an area of high tornado activity in the Gulf Coast, it's vital to observe any kind of historic trends within Texas to determine which areas are at the most risk for tornado activity. Data that is gathered from national weather services is used in this project, mainly tornado track data, to attempt to quantify density measures of these tornado tracks. The track data will be implemented within ArcGIS and used in a kernel density function to create maps that dictate areas that have been affected by tornados historically, creating a reference for areas that are potential hotspots for tornados.

Background:

The state of Texas is prone to tornados around late spring and early fall. Two regions in the United States that have experienced a higher than usual tornado activity during the year have been termed "Tornado Alley" and "Dixie Alley". Tornado Alley is reserved for the southern plains of the United States, while Dixie Alley is reserved for areas along the Gulf of Mexico. Northern Texas falls within Tornado Alley, while eastern Texas falls within Dixie Alley. Since their boundaries can be inconsistent, a proper analysis of tornado tracks in necessary.



Tornado Alley



Dixie Alley

Source: http://www.ncdc.noaa.gov/climate-information/extreme-events/us-tornado-climatology/tornado-alley

Data Collection:

The majority of the data that was gathered for this project was obtained through the NOAA National Weather Service Website:

- http://www.spc.noaa.gov/gis/svrgis/
  From here, the Counties and States layers were obtained as well as the Cities and Tornado Tracks shapefiles.
- http://www.baruch.cuny.edu/geoportal/data/esri/esri_usa.htm
  From here, the Major Highways shapefile of the United States was obtained.
- http://txsdc.utsa.edu/Data/TPEPP/Estimates/Index.aspx
  Census data for the state of Texas was obtained here.

Data Preprocessing:

The majority of the data that was obtained was not solely limited to that of Texas, so many of the shapefiles and layers had to be edited. This includes the states and counties layers, as well as the tornado tracks, cities, and major highways shapefiles. As for the projections that were used, since the majority of the shapefiles and layers from the NOAA website came in the USA Contiguous Lambert Conformal Conic projection, the rest of the shapefiles and layers were projected to this coordinate system. The following are the steps necessary to prepare the data sets:

1. Since I obtained a shapefile only for the continental United States, I isolated the state of Texas by using the Editor Toolbar and selecting the “states” shapefile for editing. All 49 states were removed, which allowed for the “states” shapefile to only have the Texas shape. The edits were saved to allow for the “states” shapefile to permanently have an isolated Texas shape (figure 1).

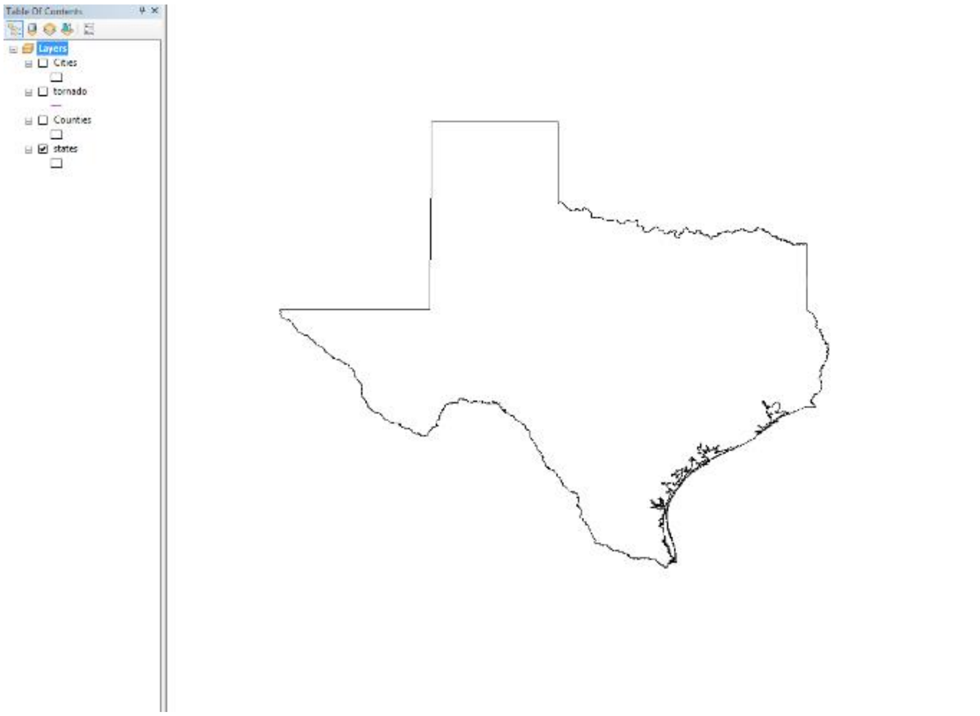


Figure 1: Clipped "States" shapefile of Texas

2. The shapefile for tornado tracks was also created on a national level, so the shapefile "tornado" had to be clipped to only show the tornado tracks for the state of Texas (figure 2). This was done by selecting "Clip (Analysis)" under ArcToolbox and selecting the "tornado" shapefile as the *Input Feature* and selecting the "states" shapefile as the *Clip Feature*. Tornado track data was now isolated to only the state of Texas (figure 3). The new shapefile was called "clipped_torn".

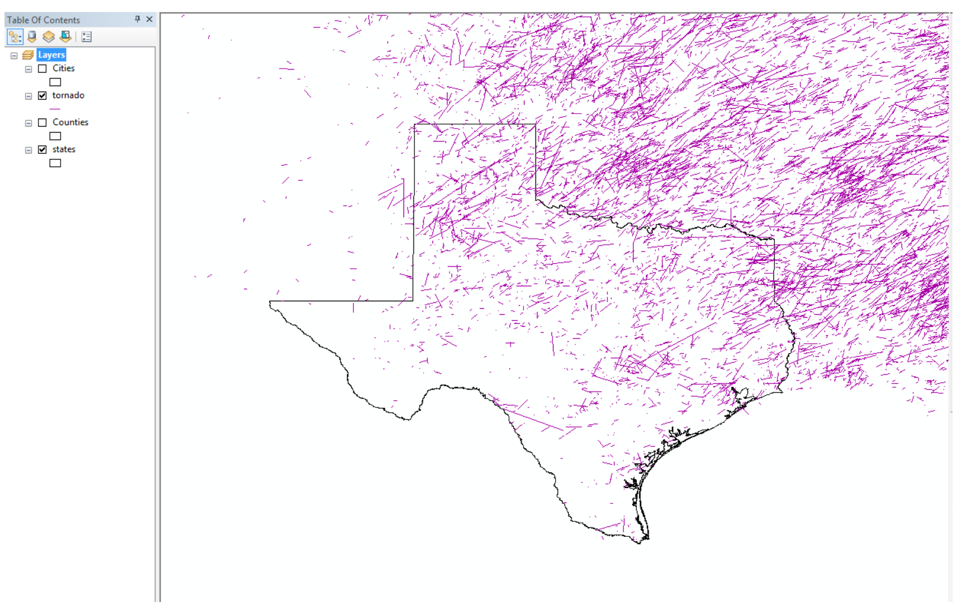


Figure 2: Original tornado track shapefile

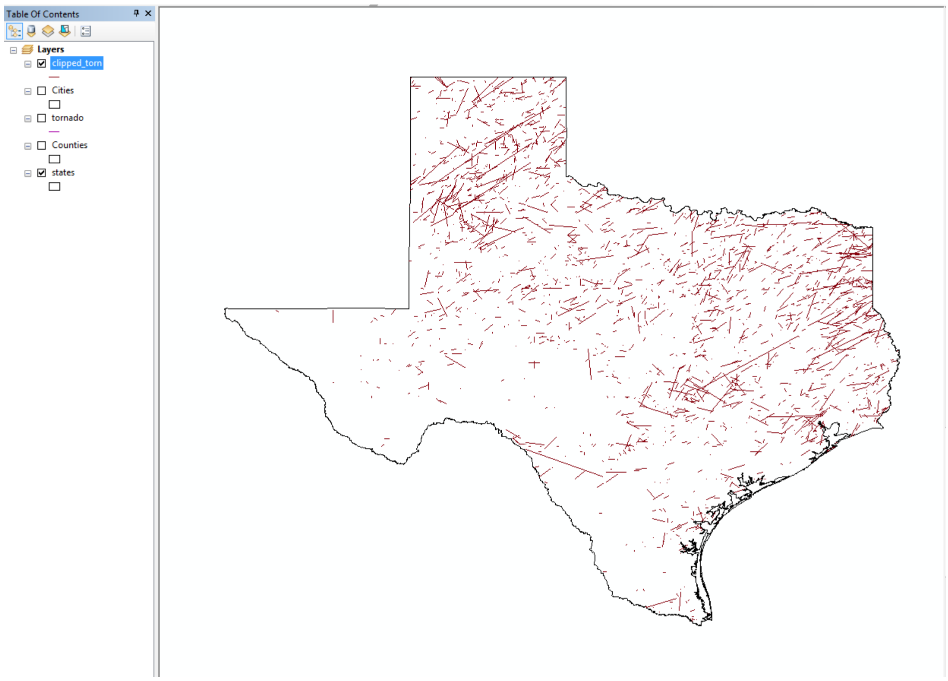


Figure 3: Clipped tornado track shapefile.

3. The layers and shapefiles for counties, cities, and major highways were also on a national level. As in step 2, they were clipped using the “Clip (Analysis)” feature in ArcToolbox. Counties, cities, and major highways were now isolated to the state of Texas (figure 4).

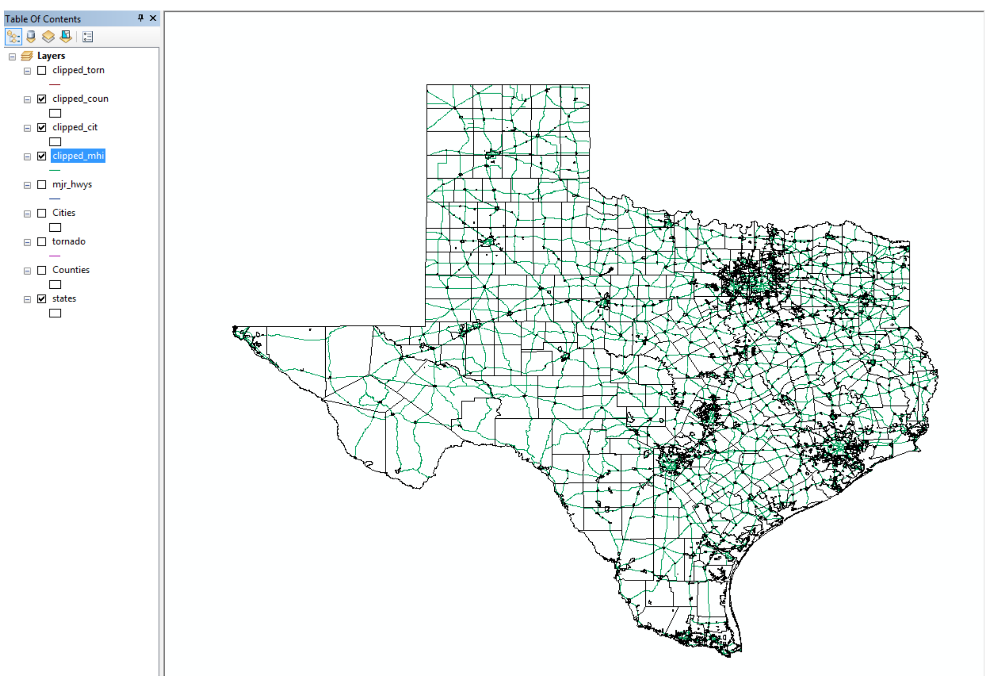


Figure 4: Clipped cities, major highways, and counties shapefiles and layers

ArcGIS Processing:

1. My main focus for this project is to demonstrate the density of tornado tracks within the state of Texas. The first step I took was utilize the "Kernel Density" tool in ArcToolbox. I chose this over the "Line Density" tool because although the "Line Density" tool creates a raster whose intensifications are based on the magnitude per unit area from a polyline feature using a radius around each cell, the "Kernel Density" fits a smooth surface to each polyline. This method was preferred because it gives a more conservative magnitude rather than an exact one that the "Line Density" tool would give, thus better demonstrating potential areas for tornado risks (figure 5).

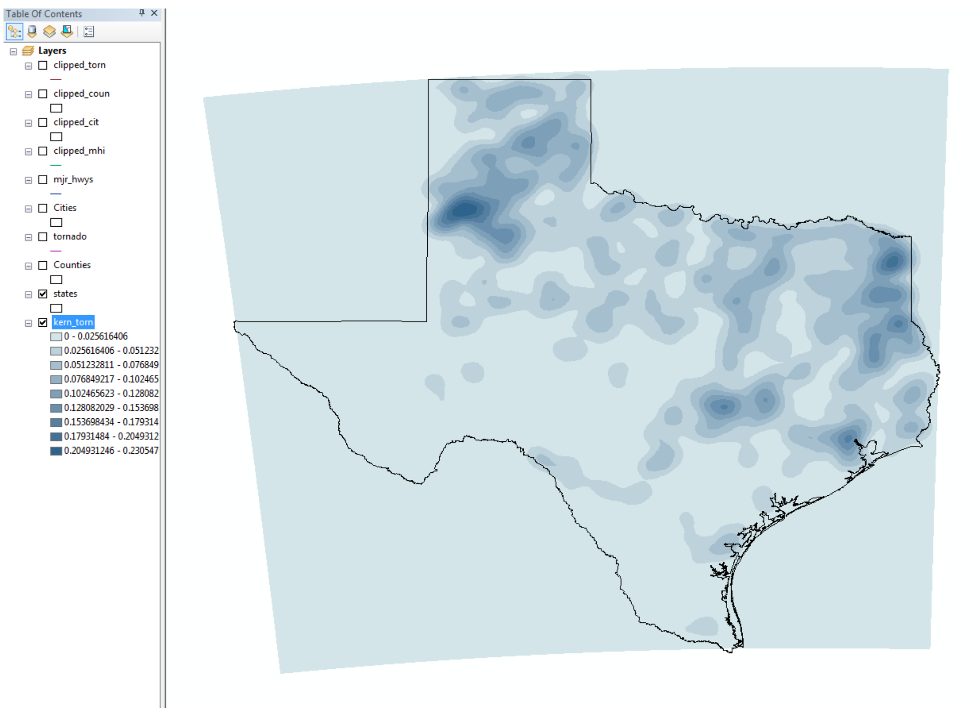


Figure 5: Original kernel density raster (1950-2013)

2. Since the resulting raster has to only show the density of tornado tracks within Texas, the new raster "kern_torn" has to be masked using the "states" shapefile as the mask. This was done by using the "Extract by Mask" tool in ArcToolbox. The resulting masked raster was now only showing density results within the boundaries of the state, whose symbology was then changed (figure 6). The raster was also stretched using Standard Deviations (with n=2) as the stretch type. This final raster demonstrates tornado track densities from the years 1950-2013.

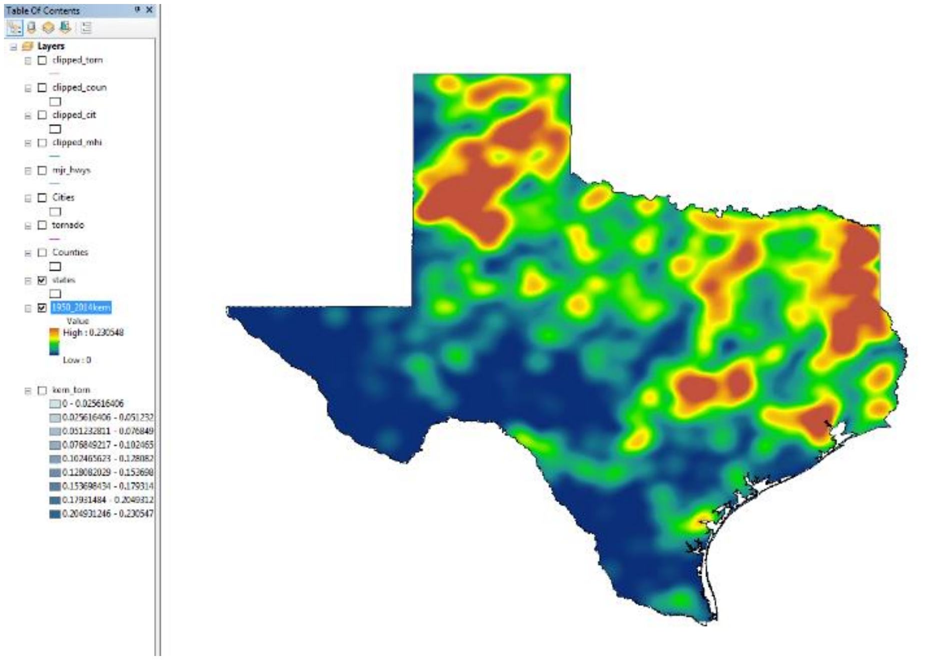


Figure 6: Clipped kernel density raster (1950-2013)

3. Because I wanted to demonstrate if there were any patterns in tornado track densities, I decided to use the following intervals (in years): 1950-1964, 1964-1974, 1974-1984, 1984-1994, 1994-2004, and 2004-2013. Therefore I began by creating density rasters for all these intervals. But because there was no data set for each of the individual intervals, the data had to be gathered from the "clipped_torn" shapefile (the clipped file was chosen over the original shapefile since the clipped file only has the data that we want, for the state of Texas). This was done by selecting the "Attribute Table" for the "clipped_torn_shapefile, sorted the "Date" field, and then selecting from the earliest data set of the year 1950 to the earliest of the year 1964 (figure 7). The selected data was exported and saved as a shapefile, which now only included data for the years 1950-1964 (figure 8).

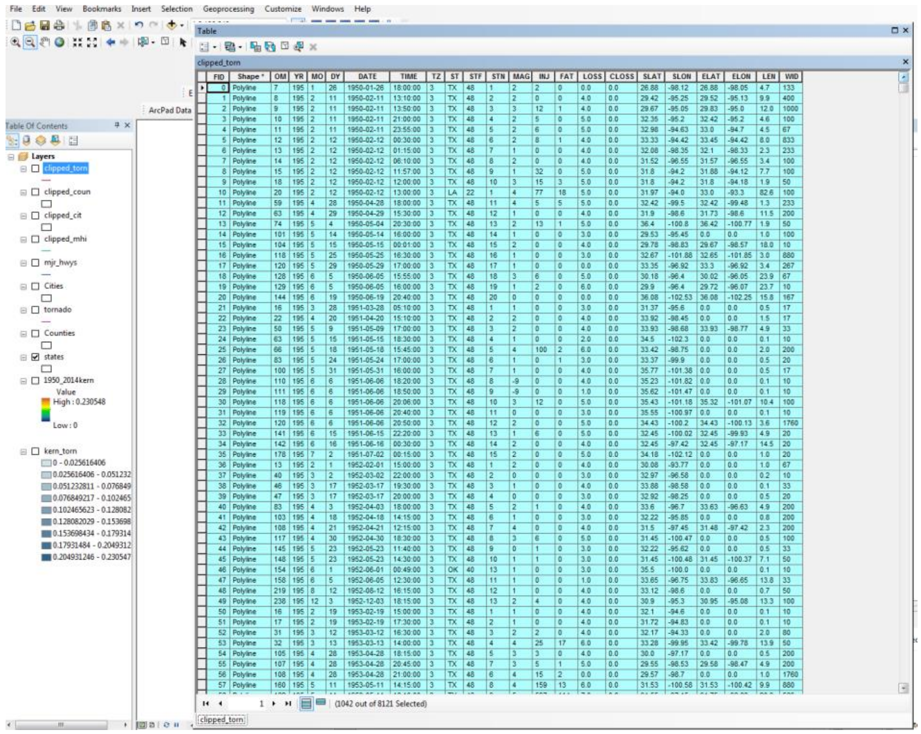


Figure 7: Selected years (1950-1964) from clipped_torn shapefile attribute table

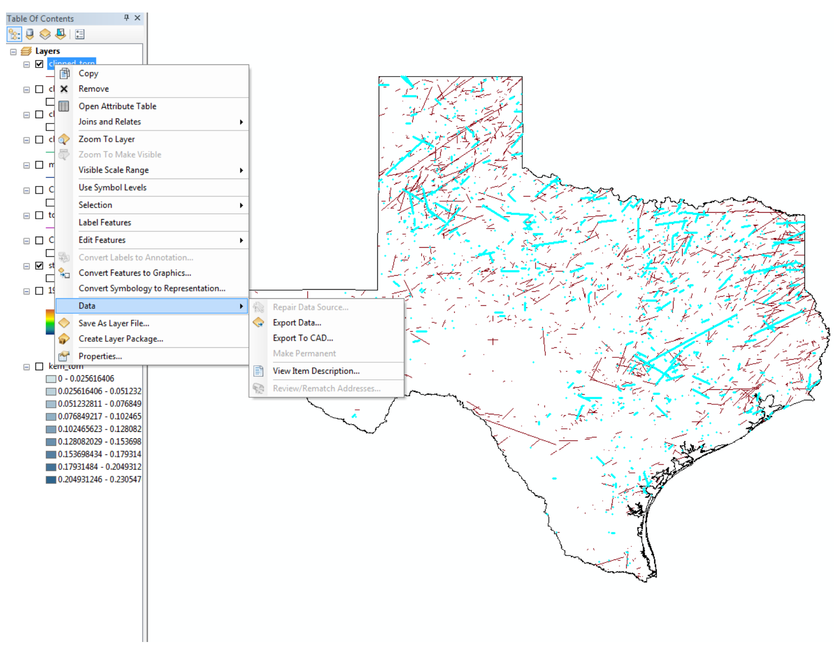


Figure 8: Exported data

4. As with the 1950-2013 kernel density raster, the "Kernel Density" tool in ArcToolbox was used to create a raster for the 1950-1964 data set (figure 9).

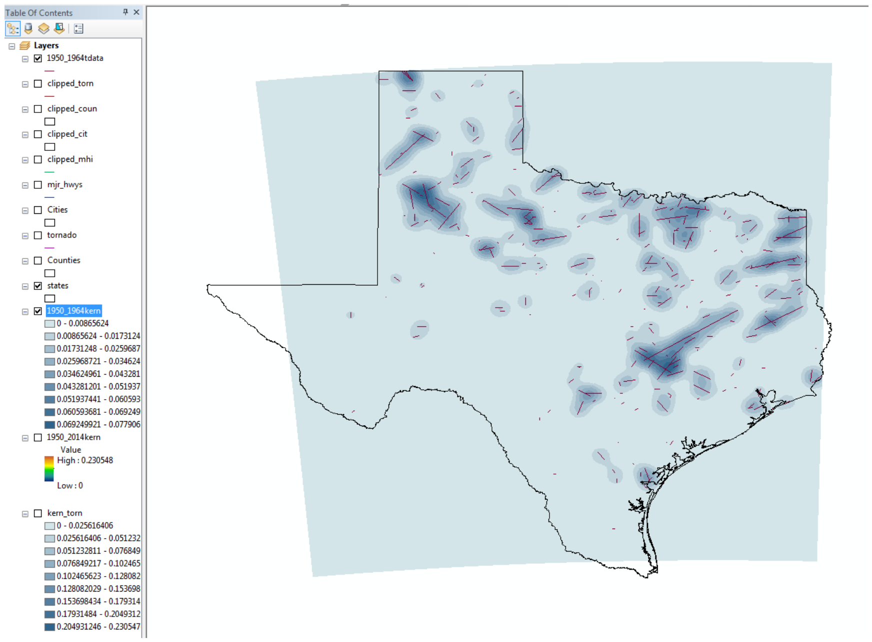


Figure 9: Original kernel density raster (1950-1964)

5. The resulting raster had to be masked again to only show data within the boundaries of Texas, so the "Extract by mask" tool in ArcToolbox was used, where the "states" shapefile was used as the mask. The resulting raster demonstrated density only within the boundaries of the state (figure 10). For the sake of brevity, the kernel density rasters for the remaining intervals were created using this same process (selection of attributes -> export data -> shapefile creation -> kernel density raster created -> masking of kernel density raster). The remaining rasters are demonstrated in the "Maps" section of this report.

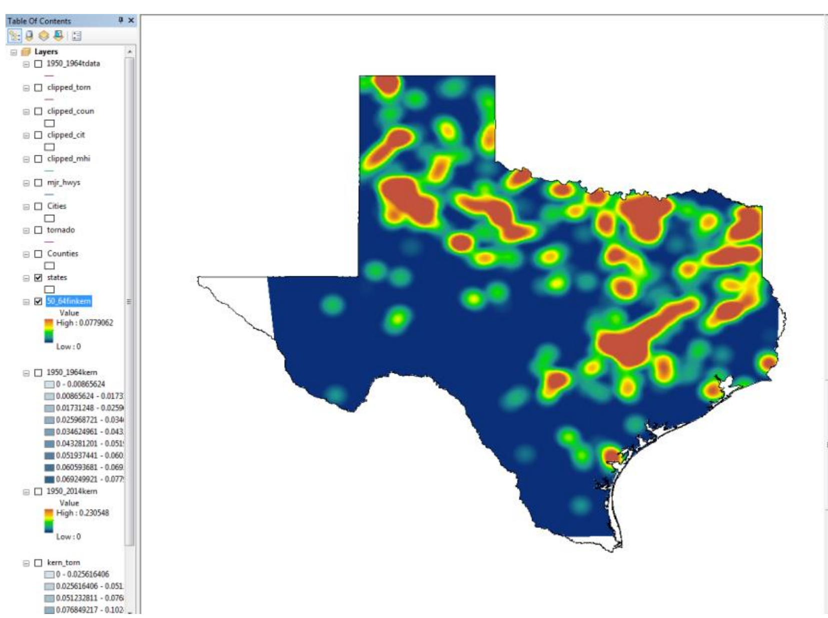


Figure 10: Clipped kernel density raster (1950-1964)

6. Since the purpose of the project is to show who would be at the most risk for tornados in Texas, a population raster had to be created. I chose to use the county layer for this. Because the county layer did not have any population information within its attribute table, a population file had to be joined with the “clipped_coun” layer (clipped county layer). This was done by selecting the “Join” feature in ArcMap, and selecting the “2012_txpopest_county” as the table to be joined to the “clilpped_coun” layer (figure 11).

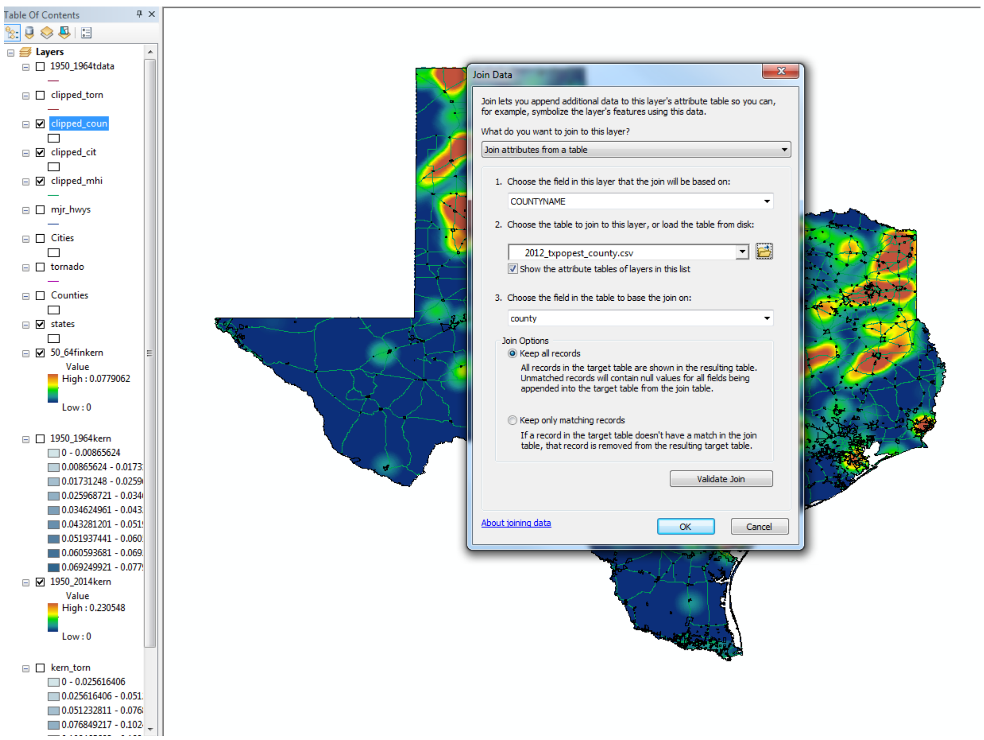


Figure 11: Joining census data to clipped county layer

7. Now that the population data is incorporated into the county layer, I wanted a raster that would demonstrate the spread of population within Texas. This was done by selecting the “Polygon to Raster” tool in ArcToolbox (figure 12). This allowed for the creation of a county raster that demonstrate population. The final raster is located in the “Maps” section of this report.

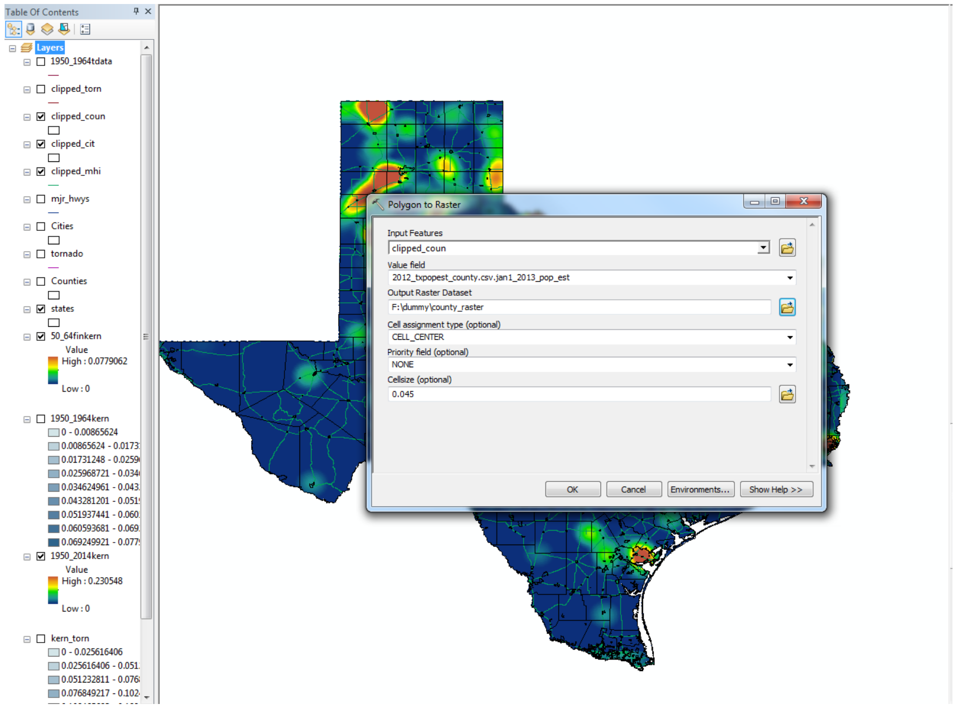


Figure 12: Polygon to raster feature

8. With the population data joined together with the counties layer, the population that live in moderate to high tornado activity were selected through the attribute table and the sum was gathered.

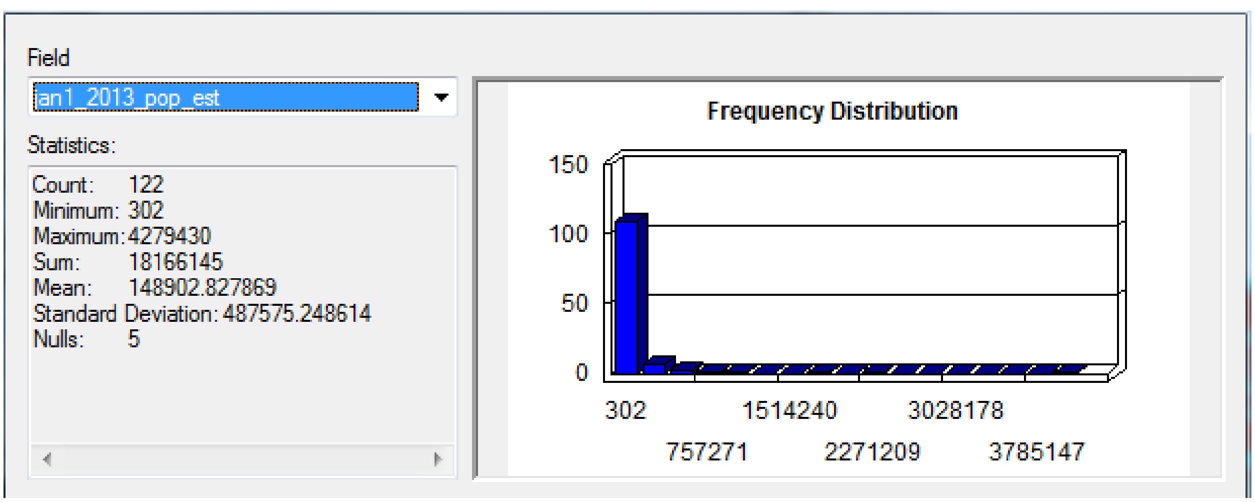


Figure 13: Frequency Distribution

Conclusion:

Results: From the raster that were created, these were the results for each time interval:

- 1950-1964: The concentrations of tornado tracks were centered around the Lubbock area, northern Texas, eastern Texas by Tyler, and east of the Austin area. As for the southwestern portion of the state, there was minimal to no tornado activity, mainly around the El Paso area (figure 14).
- 1964-1974: Compared to the previous interval, the concentration remained around the Lubbock area but extended closer to the Amarillo area. East of Tyler also shows to have had tornado activity, but was reduced compared to the previous interval. The Dallas area and Waco experienced moderate activity, while an increase in the Houston area occurred (figure 15).
- 1974-1984: Once again activity is centered around north Texas. The Lubbock area experienced heavy tornado activity, as well as the Austin and Houston area. Portions of central and eastern Texas also experienced an increase in tornado activity. Southwestern/ western Texas again showed no increase in activity, for the exception of an area west of San Antonio (figure 16).
- 1984-1994: North and east Texas once again dominate tornado track density. From Odessa to the uppermost part of the Texas panhandle, tornado activity ranges from moderate to high tornado activity. Eastern Texas, including Tyler, have high tornado activity as well as the Houston area. Surrounding areas had a moderate amount of tornado activity. Southwestern/south/west Texas had low tornado activity compared to the rest of the state (figure 17).
- 1994-2004: There is a drastic reduction in tornado activity throughout the state, for the exception of eastern Texas near the Tyler area. Northern Texas still had a spot of medium high tornados near the Amarillo area, but other than that, was quieter than the previous intervals (figure 18).
- 2004-2013: Tornado activity is centered around northern Texas, as well as the Dallas and Tyler area. Corpus Christi demonstrated an increase in activity, but the main density was centered around the panhandle and eastern Texas. Houston had a low density compared to previous intervals (figure 19).

Analysis: The concentration of tornado tracks, when analyzed in about ten year increments, demonstrate how sporadic tornado patters can be within the state of Texas. The majority of the concentration throughout all the incremented maps though shows that the west-southwest portion of Texas does not have a heavy concentration of tornado tracks. The main concentration of tornado tracks is present in north, east, and southeast Texas though. For the city of Houston, there are decades where there is hardly any tornado activity while the concentration rises in others. This is an indication that while the Houston area is not an area that is primarily heavy in tornado risks, there still exist a risk. As for eastern Texas, the main concentrations exist near the Texas-Louisiana and Texas-Arkansas boundaries. Areas such as Tyler, Texas are frequently experiencing tornados. The panhandle is the area with the highest density of tornado tracks in the state, as the Lubbock and Amarillo area have some of the highest track densities in the states. Major cities, such as Dallas and Austin, have moderately high track densities as well. The combined tornado densities can be seen in figure 20.

When compared to the population raster by county (figure 21), we see that most of the areas that some of the highest tornado track densities also have some of the highest populations in the state. Areas such as Amarillo, Dallas, Austin, Tyler, San Antonio, and Houston have historically a high concentration of tornado activities in the span of about fifty years. These are areas that should take the most precaution. Although there are areas, such as Houston, that didn't experience as frequent tornado activity as the panhandle, the possibility still exist. Even though northern Texas is included within "tornado alley", other areas within the state have also been shown to have moderate to high tornado threats.

When the historical raster is compared to that of the population of Texas for the year 2013, an approximate estimate of how many people could be affected by moderate to high tornado activity is 18,166,145 (figure 13). Since the census data indicates that there is about 26,498,895, a percentage of about 69% are potentially at risk for tornado activity.

Maps:

These are the final rasters created:

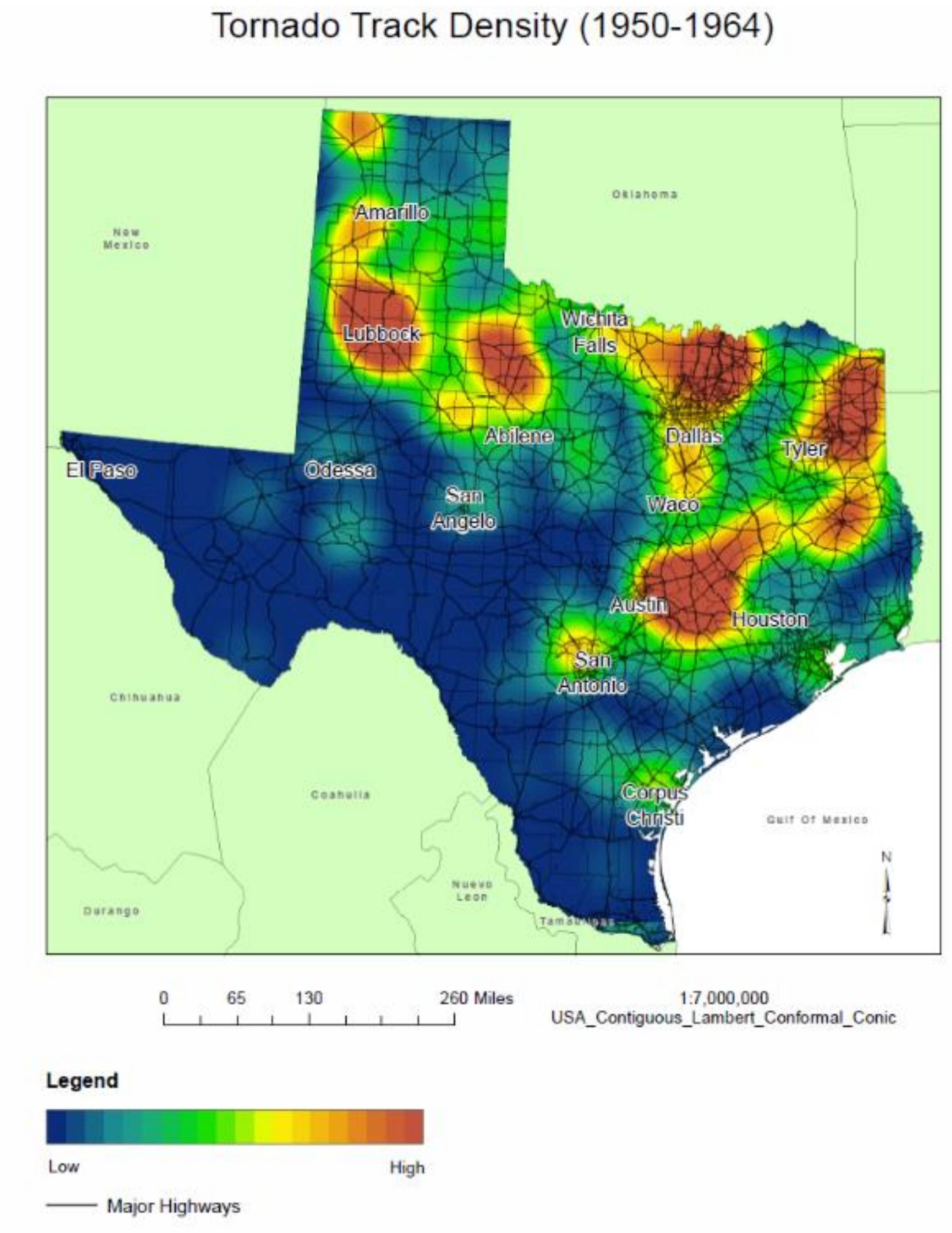


Figure 14: Tornado track density (1950-1964)

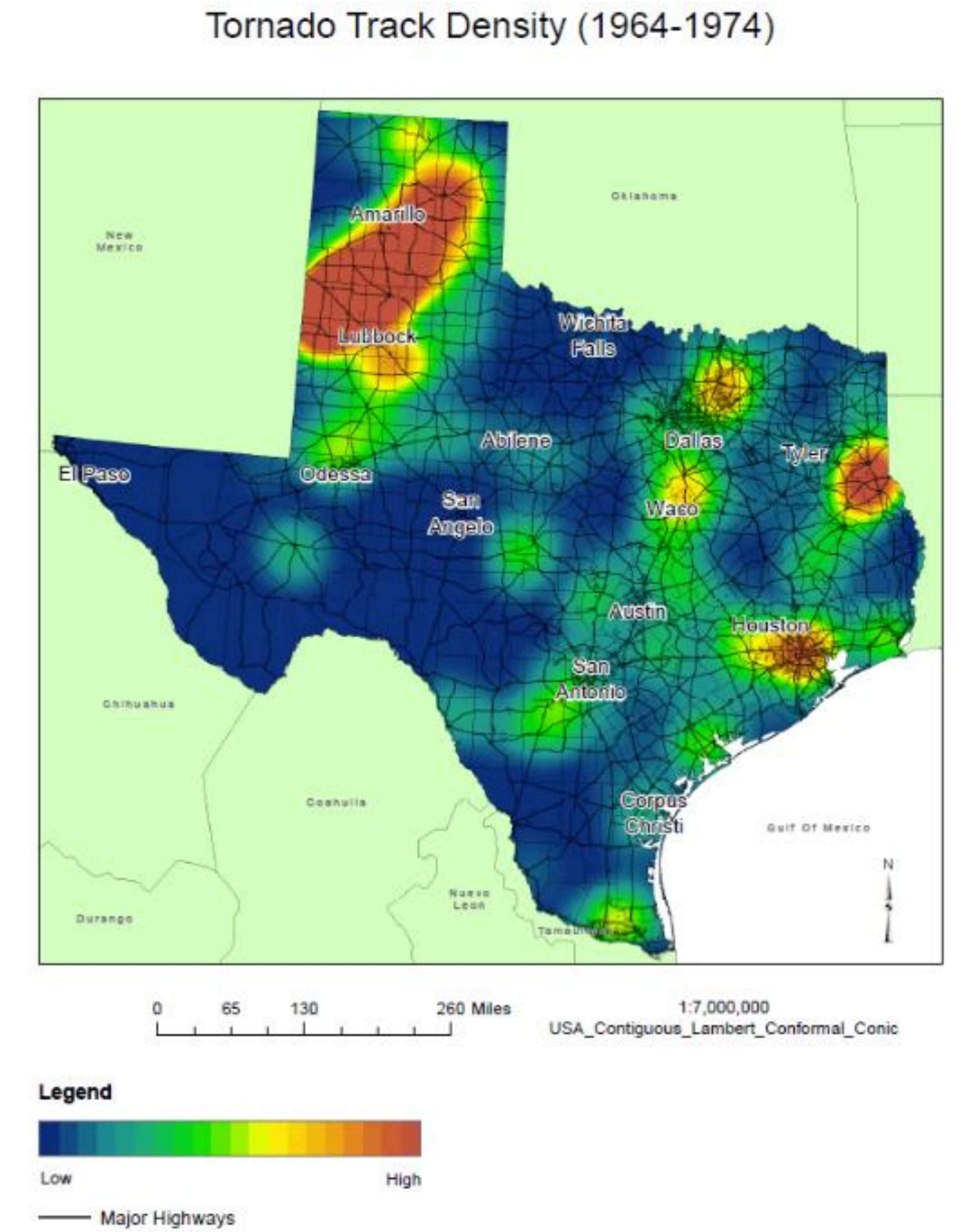


Figure 15: Tornado track density (1964-1974)

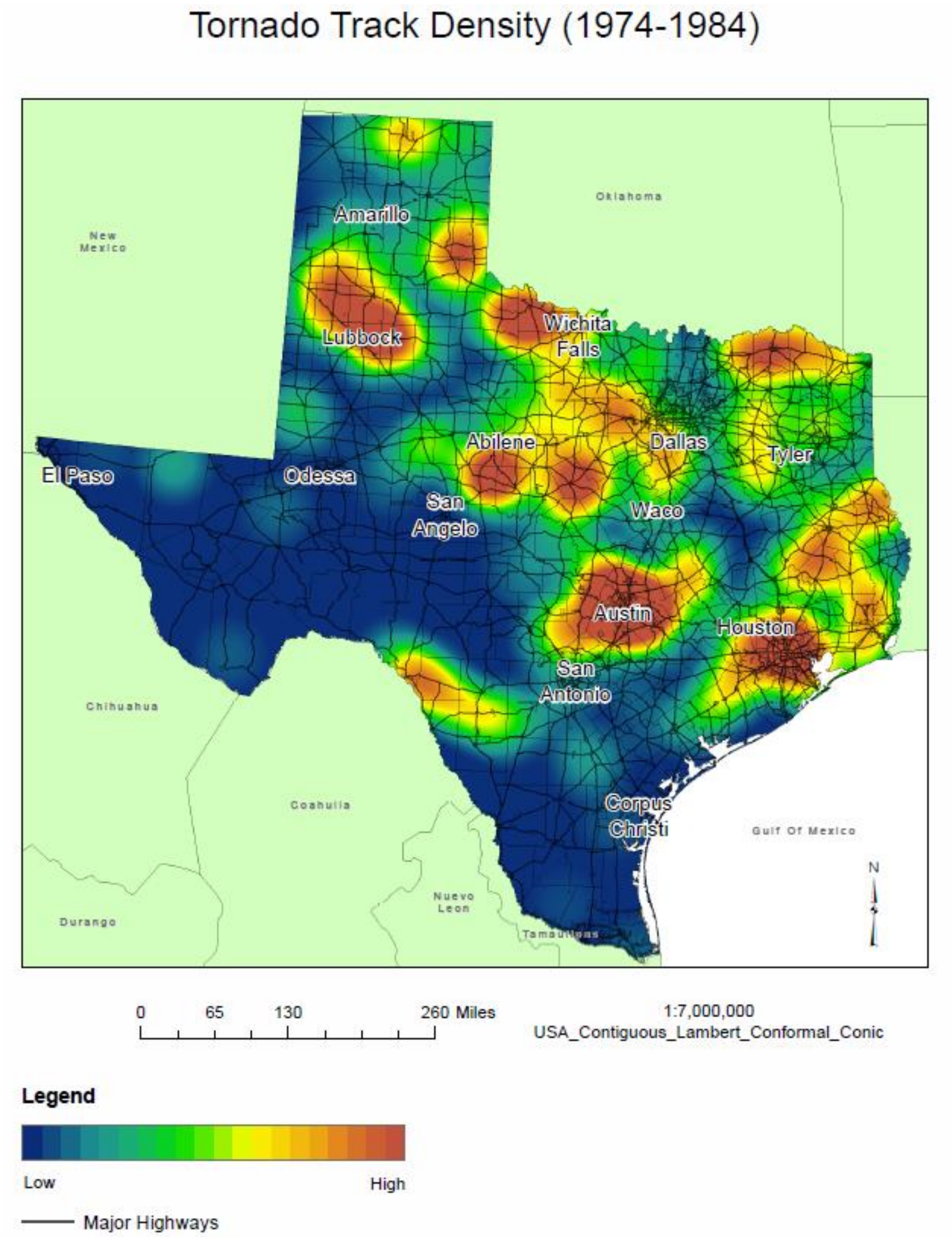


Figure 16: Tornado track density (1974-1984)

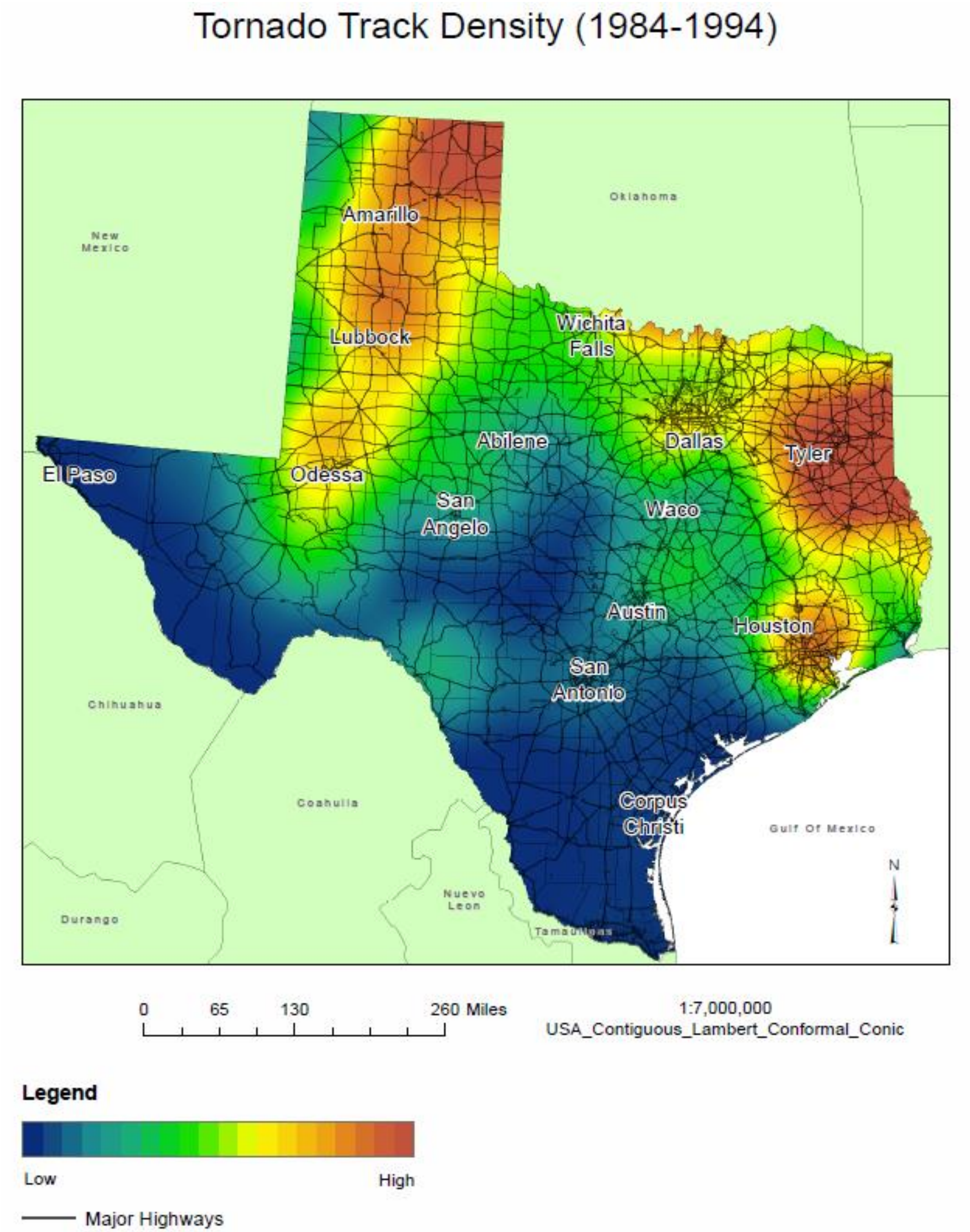


Figure 17: Tornado track density (1984-1994)

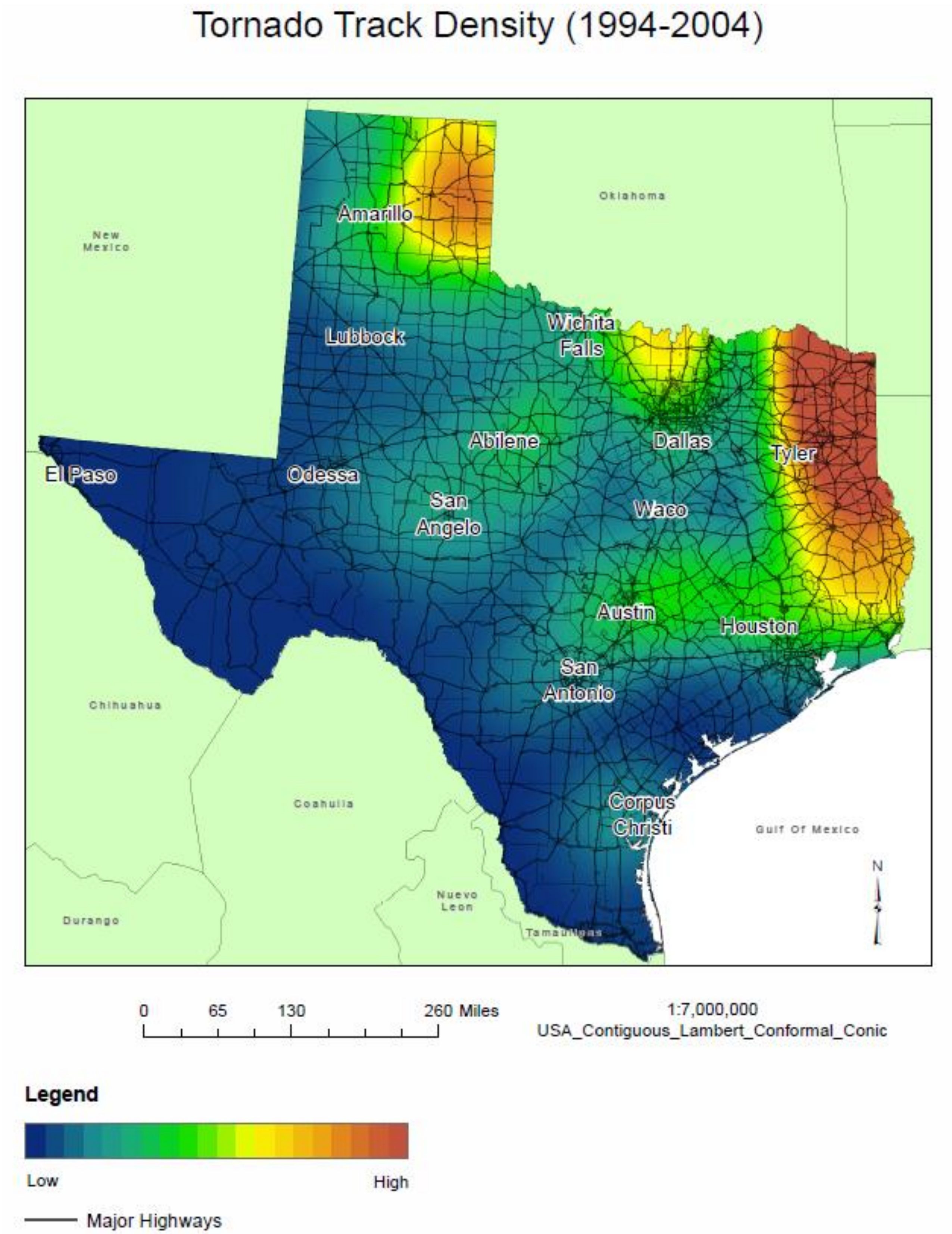


Figure 18: Tornado track density (1994-2004)

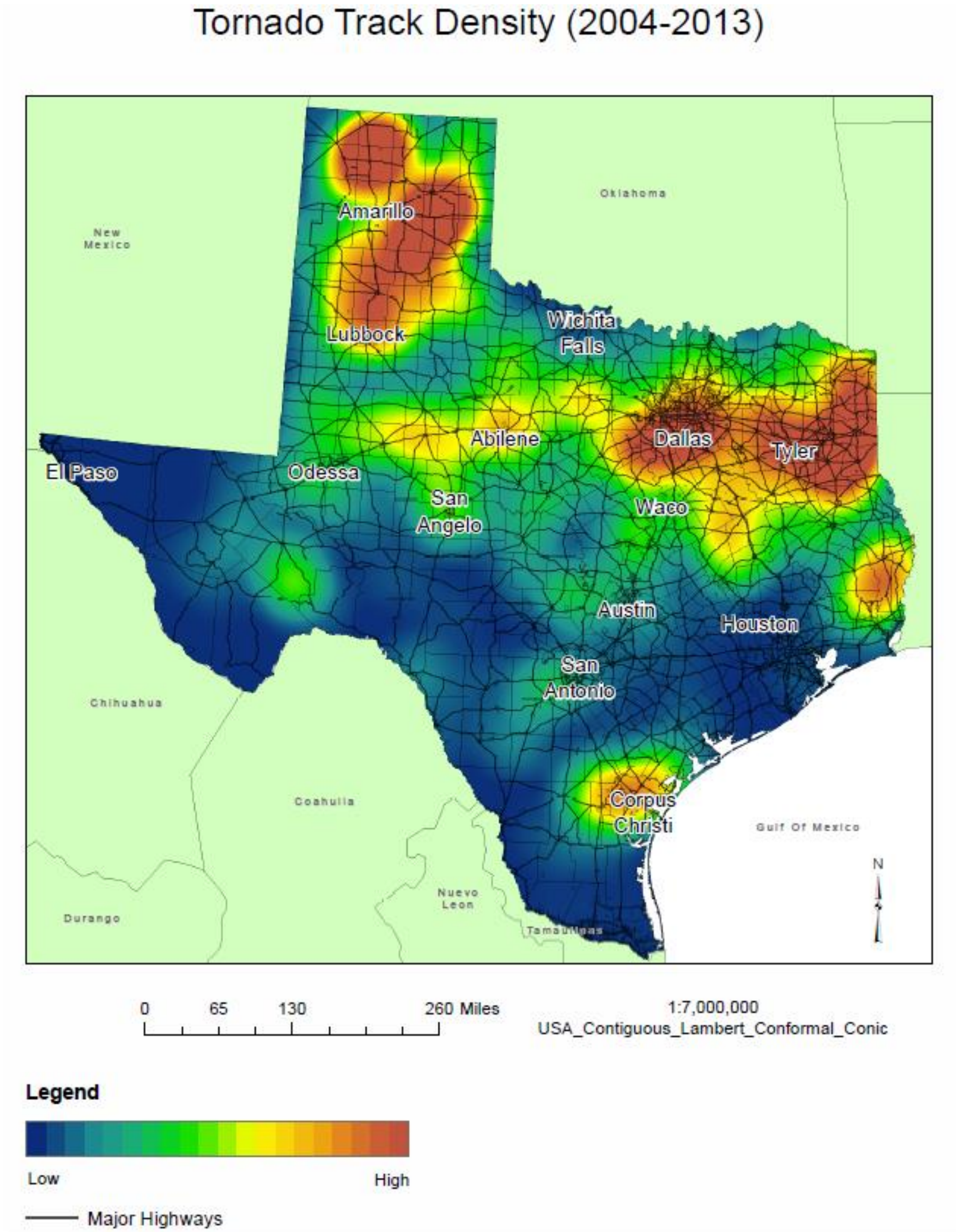


Figure 19: Tornado track density (2004-2013)

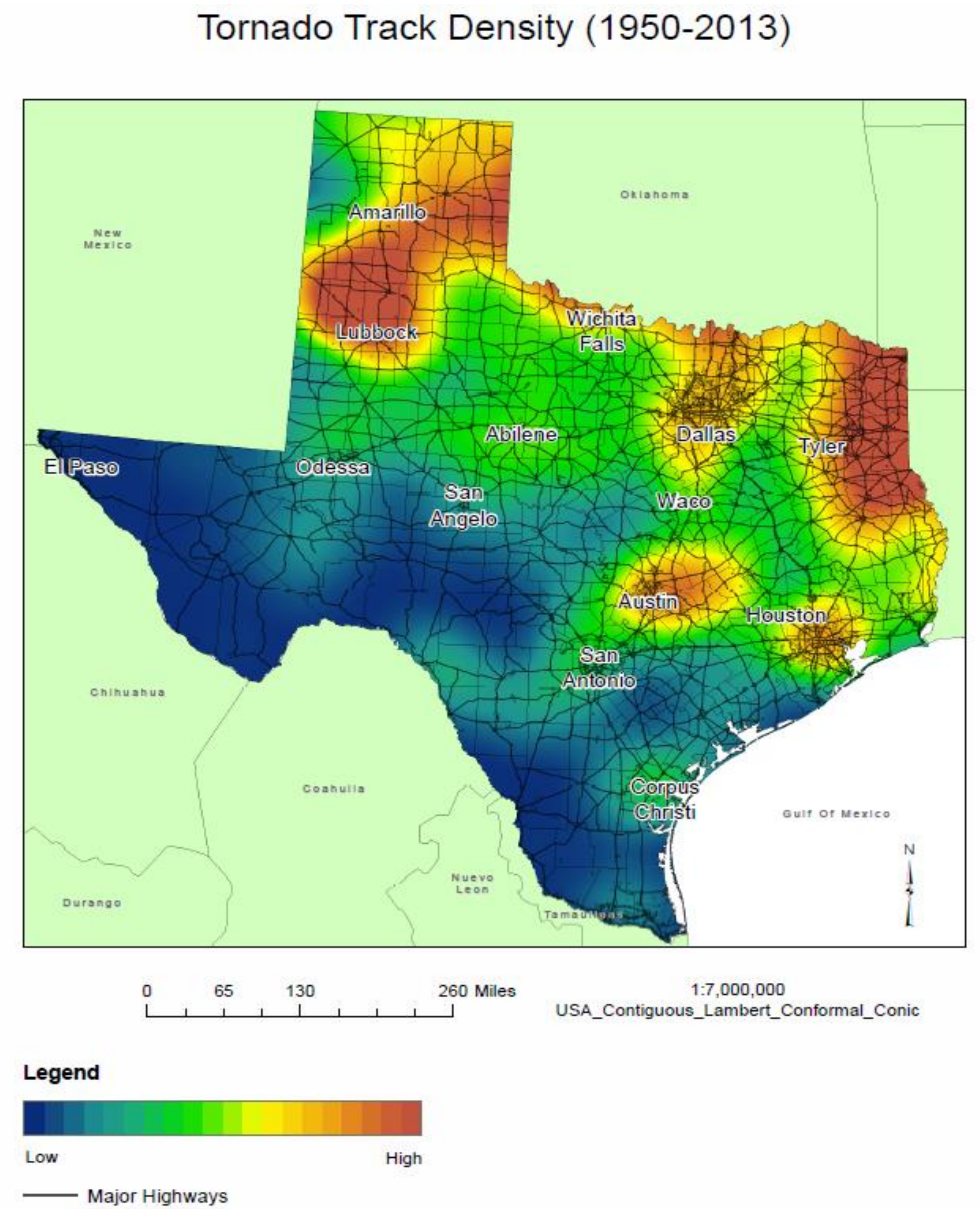


Figure 20: Tornado track density (1950-2013)

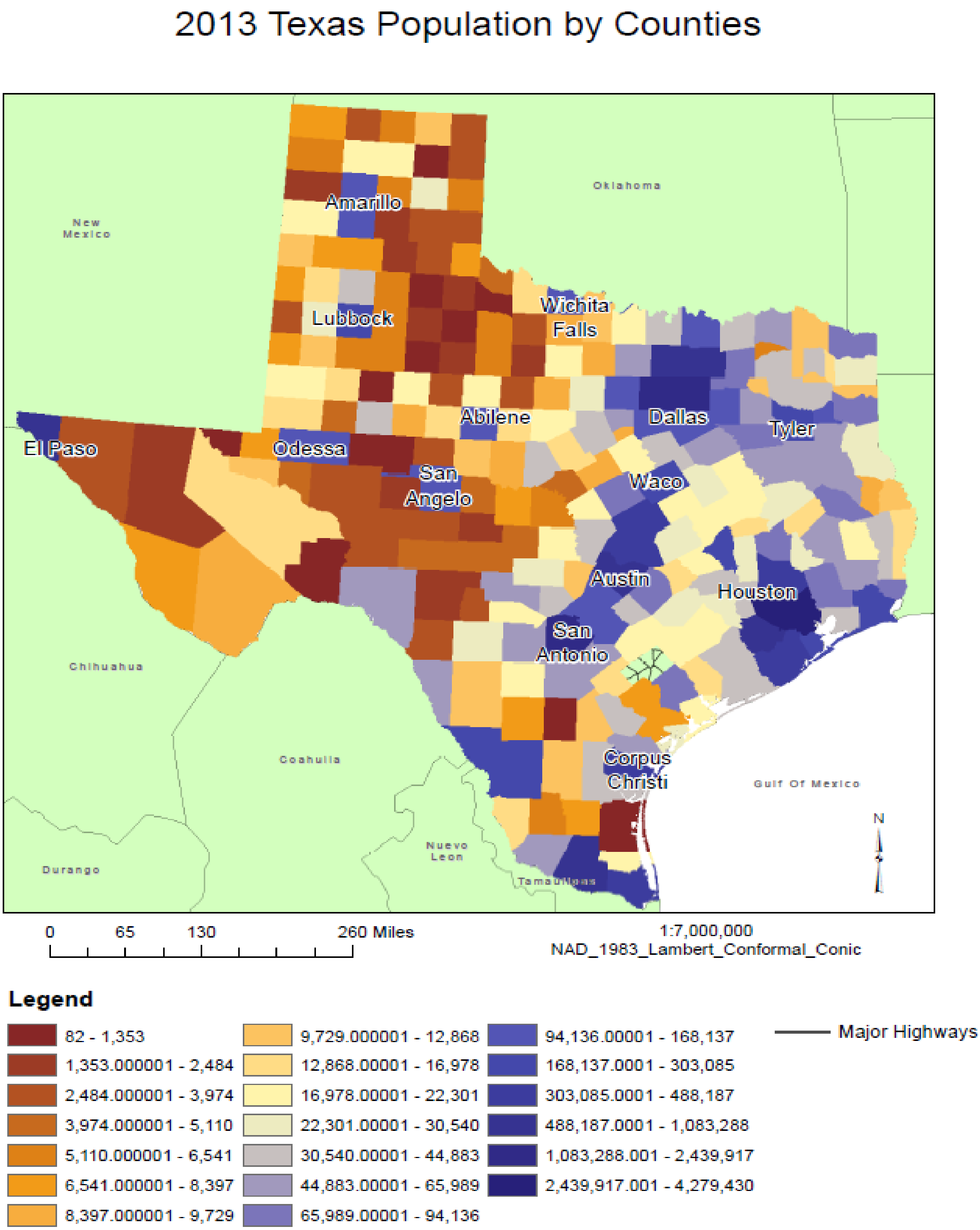


Figure 21: Population density by county for the state of Texas (2013)