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Expansion of the Sonoran Desert in Arizona and its Effect on Arizona's Populated Regions

I. Goal

Assess the increase of growth in the area of the Sonoran desert within Arizona and determine the effect this growth has on the urban sprawl of densely populated regions in Arizona. To do this I will use data from several sources, including the NASA Zulu database, the ESRI TIGER census database, as well as Google Earth and map data from previous GIS labs.

II. Problem

Desertification is a global issue that affects millions. Despite the clear expansion of many of the desert regions in the United States, metropolitan areas within these deserts such as Las Vegas and Phoenix have still managed to experience tremendous growth; causing one to question the effect that desertification in the American Southwest, in this case, specifically Arizona, has on urban development.

III. Data

In order to complete my project analysis I used data from:

1. The NASA Zulu database: https://zulu.ssc.nasa.gov/mrsid/
2. The ESRI TIGER census database: http://arcdata.esri.com/data/tiger2000/tiger_download.cfm
3. Lab 2: Map Projections and Coordinate Systems, specifically the "states" and "counties" shapefiles.

IV. Procedure

The general procedure of this project involved:

1. Creating a map area of Arizona.
2. Create polygons of Sonoran desert within Google Earth using converted MrSid files overlaying Google Earth's image of the Sonoran Desert's extent in Arizona.
3. Digitizing the desert area polygons created in Google Earth in ArcMap.
4. Add populated area data to ArcMap.

5. Using information from the attribute tables of both desert area and populated areas to assess the change in each from 1990 to 2000.

1. Create Map of Arizona

A.) Create new, empty map in ArcMap

B.) Connect to folder containing required data (in this case Lab_2_Data)

C.) Load "counties" shapefile to ArcMap. Select add data tab>Folder Connections>Lab_2_Data>Mapproj.mdb>USA>counties.

D.) Use selection by attributes to select Arizona counties. Click "Selection" tab>Select By Attributes. Select "counties" as layer, create formula: "[STATE_NAME]= 'Arizona'" as shown below.

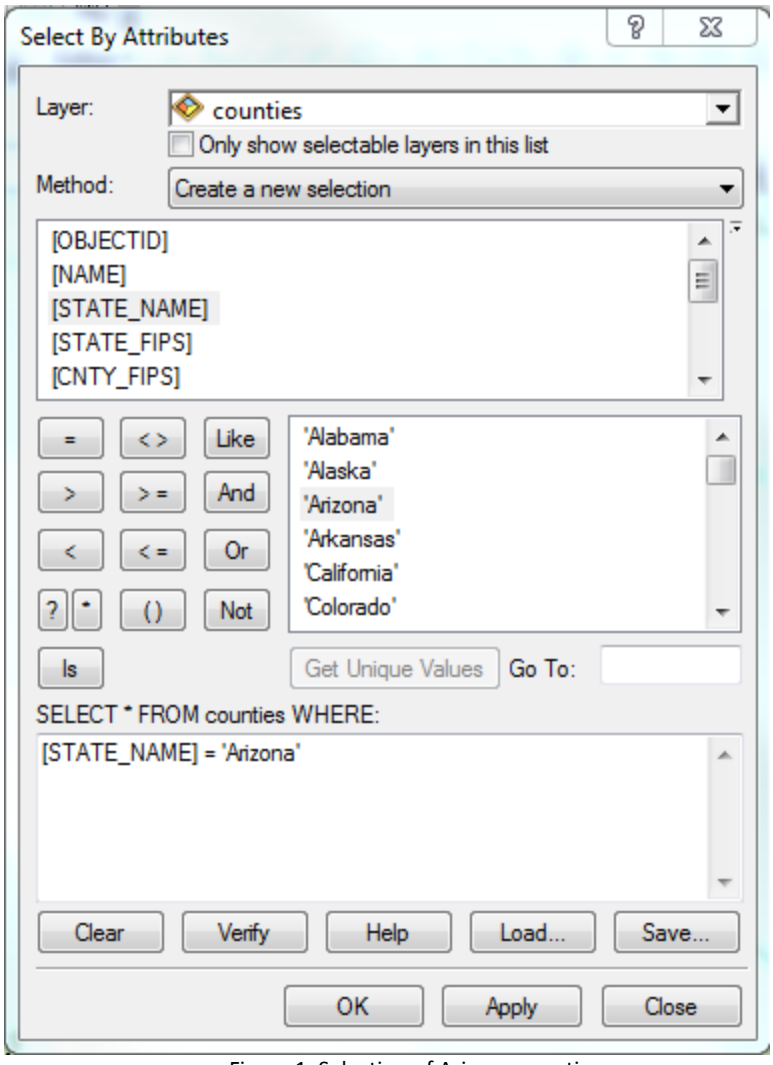


Figure 1. Selection of Arizona counties.

E.) Export data to create layer consisting solely of Arizona counties. Right click on "counties" layers>Data>Export Data.

2. Create Sonoran Desert polygons within Google Earth

A.) Obtain pertinent, MrSid files from NASA Zulu database (1990 and 2000 images covering full extent of Sonoran Desert. Use WinZip software to unzip MrSid files for future use.

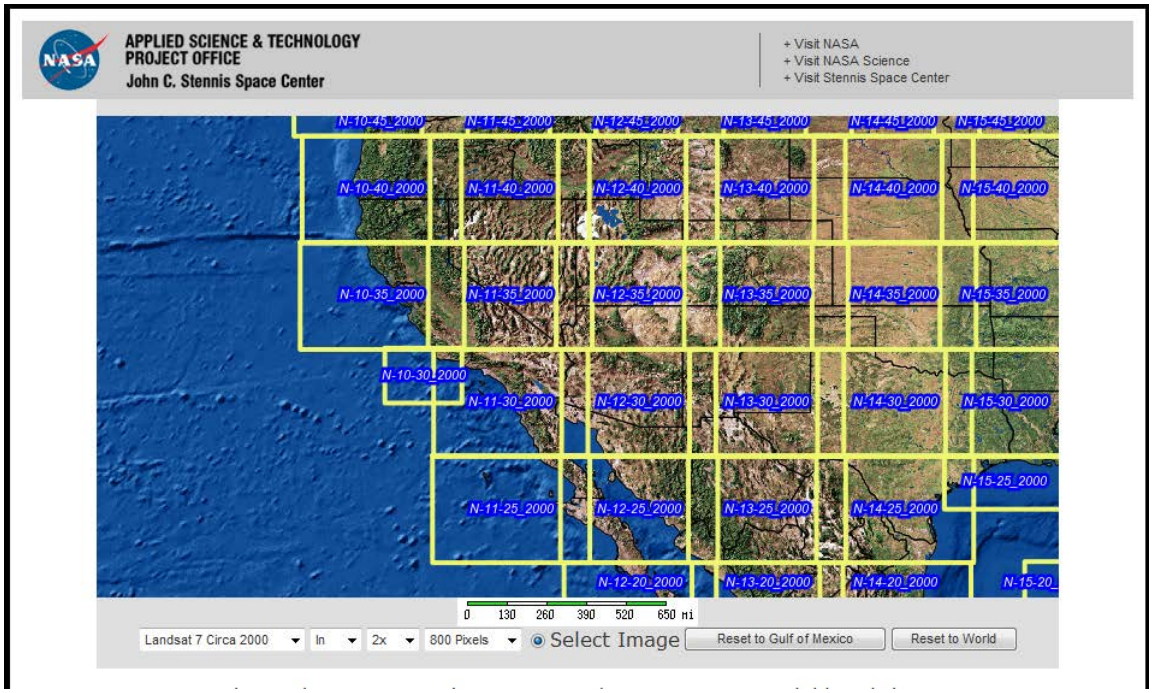
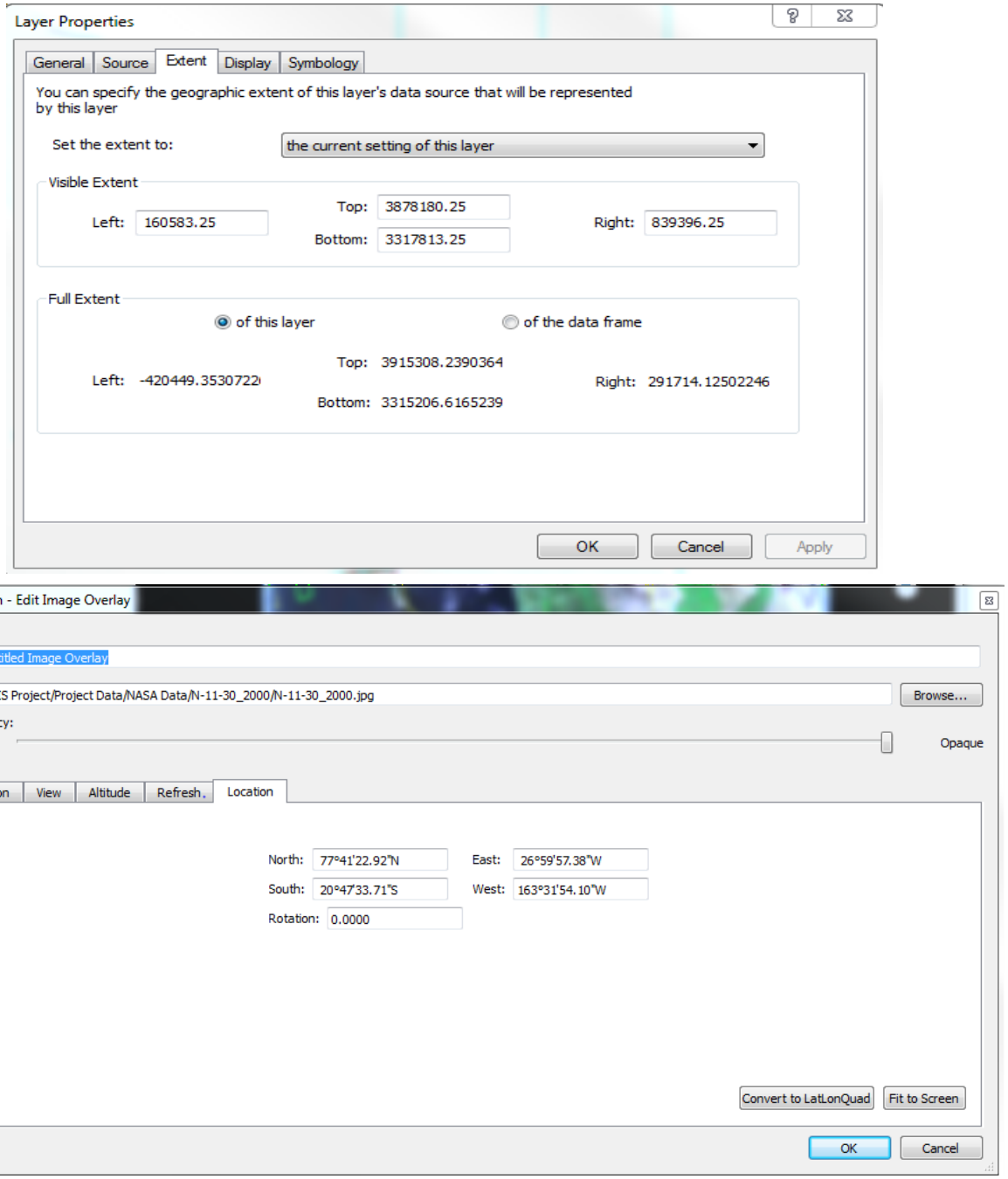


Figure 2. NASA Zulu MrSid database zoomed into American Southwest.

B.) Open Google Earth, zooming to area containing American Southwest.

C.) Add MrSid photos into Google Earth. Select "Add Image Overlay" tab at top toolbar. Browse to saved, unzipped MrSid files. Add all pertinent files to cover the specified area (full Sonoran Desert extent).

D.) Change coordinates of MrSid photos to match projection of Google Earth data by copying data from the MrSid files' Visible Extent information under Properties>Extent. Copy and paste the "Top, Bottom, Left, Right" information to appropriate North, South, East and West points within Google Earth added image through Properties>Location.



Figures 3 and 4. ArcMac MrSid file Extent properties (top) and Google Earth Image Location (bottom).

E.) Create new polygon within Google Earth using "add new polygon" feature  . Outline extent of Sonoran Desert using both MrSid image and Google Earth map to create most accurate polygon of desert area. (Create one polygon for 1990 using 1990 MrSid data, and one for 2000 using 2000 MrSid data.)

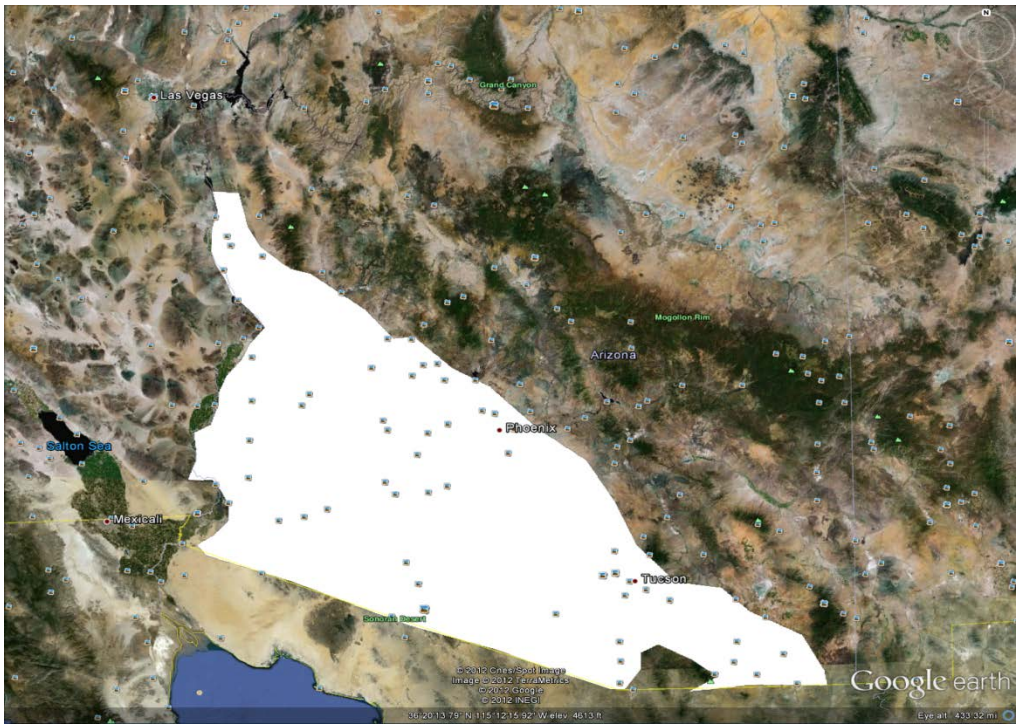


Figure 5. 1990 Sonoran Desert Polygon created in Google Earth.

3. Digitize polygons in ArcMap

A.) Save newly made polygon in Google Earth as .kml files. Right click on image overlay under Places>Save Place As> save to appropriate folder to be added to ArcMap.

B.) In ArcMap tools, select “KML to layer” tool: Conversion Tools>From KML>KML To Layer. Convert Google Earth KML polygons to shapefile layer. Add layers to ArcMap.

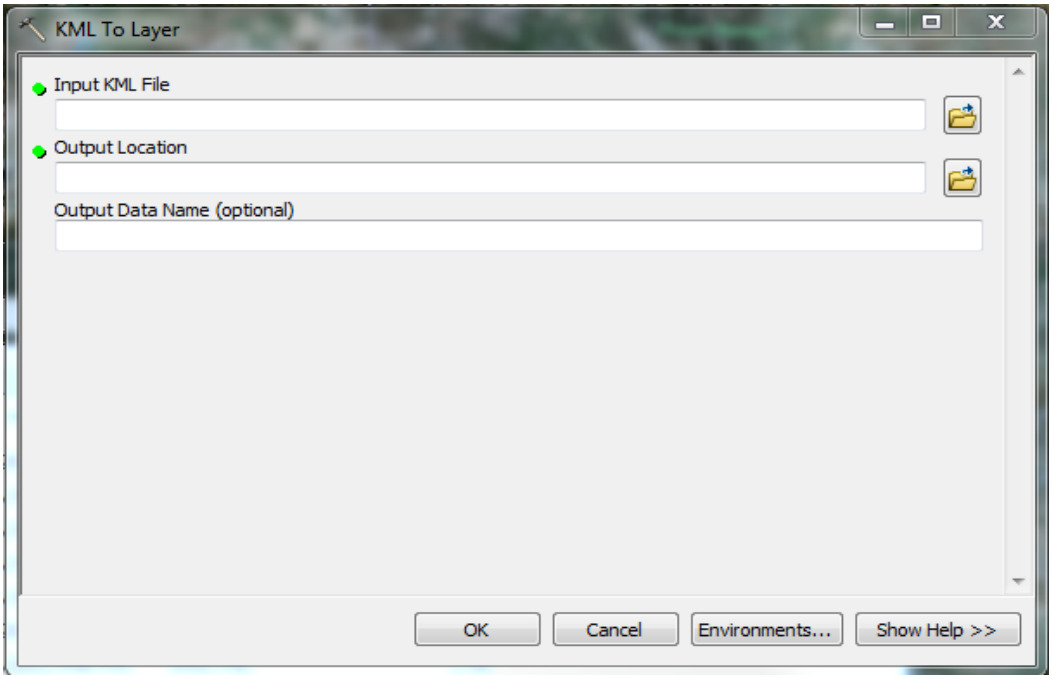


Figure 6. Converting KML to Layer

C.) Check that the correct extensions are on: Click Customize>Extensions>Spatial Analyst. Digitize desert polygons by right clicking on polygon layer within the Table of Contents>Edit Features>Start Editing. Select the “edit vertices” tool in the edit toolbar  . Pull the existing vertices along the state border outside of the border. Save edits.

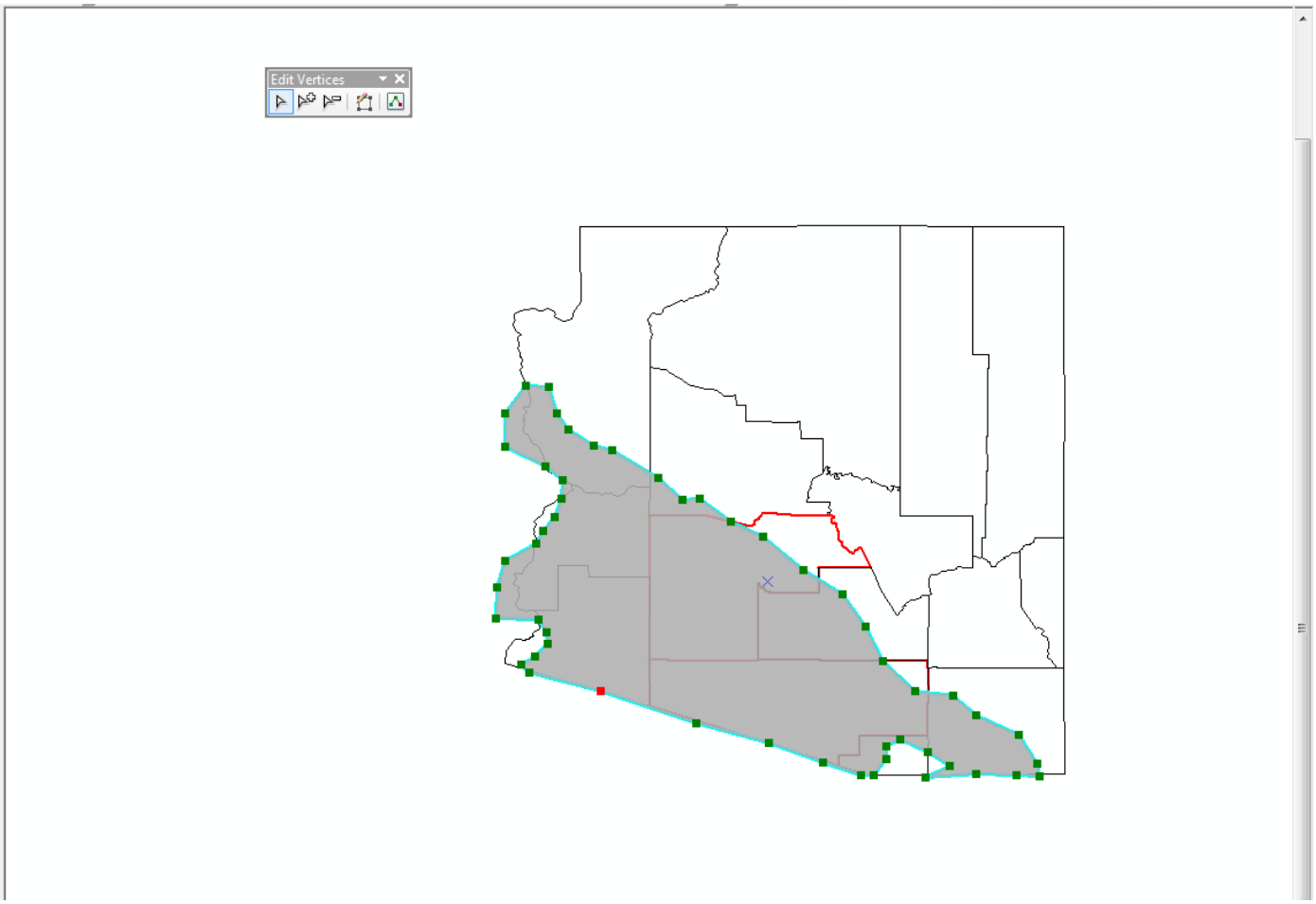


Figure 7. Editing vertices of desert polygon.

D.) Use clip analysis tool using the digitized polygon as input, counties layer as the clip feature, and save new shapefile as final polygon to be used for final map. In ArcToolbox: Analysis Tools>Extract>Clip.

E.) Complete above steps for both 1990 and 2000 polygons created in Google Earth.

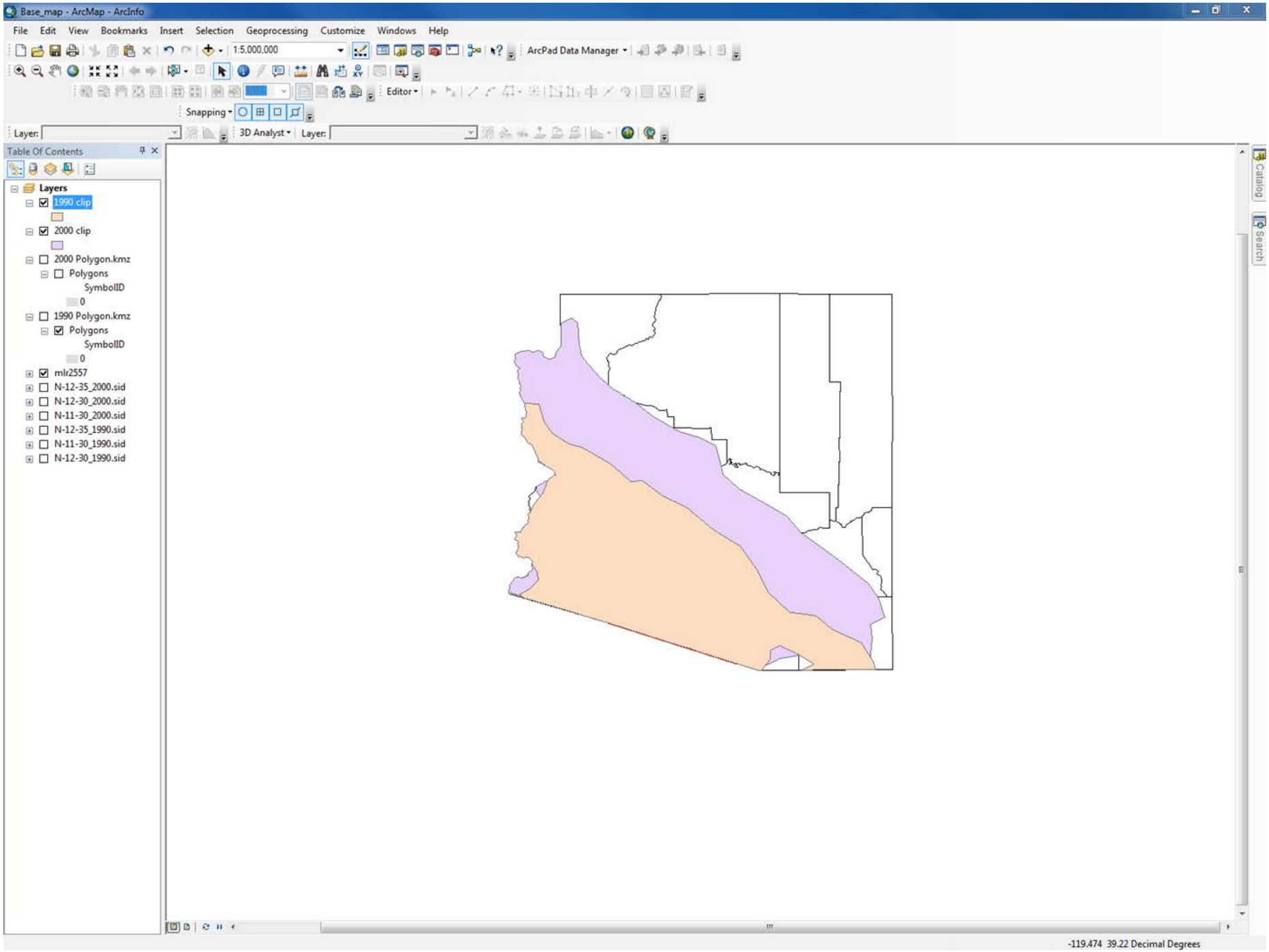


Figure 8. Edited and clipped 1990 (orange) and 2000 (purple) desert polygons.

4. Adding population data to ArcMap

A.) Download desired population data from ESRI TIGER website: http://arcdata.esri.com/data/tiger2000/tiger_download.cfm. Select Arizona state in dropdown menu. Under "Select by Layer" dropdown menu select "Census Block 1990" (you will do this and the following steps for 2000 as well), select all counties. Download files to appropriate folder. In this folder, right click on downloaded tiger folder, select "Extract All", this will unzip the folder. Under the newly unzipped folder do the same "extract all" step for all zipped data within the folder.

B.) Add population data to ArcMap. The data collected from the TIGER website will be compiled in several shapefiles according to the respective urban area they are representing. In order to create one layer for the 1990 populated areas and one layer for the 2000 we can use the append tool: Data Management Tools>General>Append. In ArcCatalog: create new layer which will be the designated shapefile for all of the appended population data for each year. In the "Input Datasets" field of the "Append" tool add all of the individual 1990 shapefiles, select the target dataset to be newly created layer. Select NO_TEST (this allows the .shp data to be appended in .lyr). Hit OK.

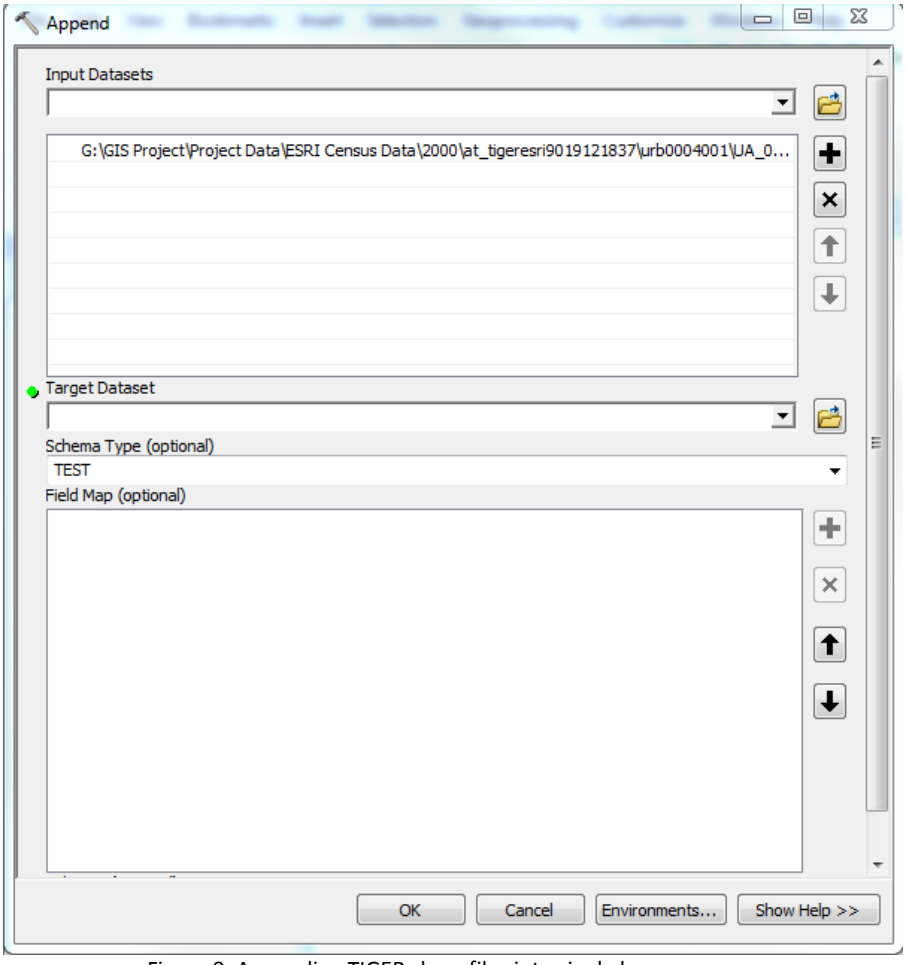


Figure 9. Appending TIGER shapefiles into single layer.

C.) Once 2 layers are made, one for 1990 population data and one for 2000 population data, add layers to map.

5. Use attribute table data to make determinations about desert vs. population growth.

A.) Desert Growth from 1990 to 2000: Calculating Area

Under the TOC, right click on 2000 Desert Polygon>Open Attribute Table. Under Table Options dropdown menu select “Add Field…”, Type “Area” in for the name and select “Long Integer” for type. Right click on newly made field and select “Calculate Geometry…”, hit Yes when warning comes up. Under “Property:” dropdown select “Area”, for “Coordinate System” select “Use coordinate system of the data frame:”, this ensures that calculating a geometry is possible as our dataframe is in projected as opposed to geographic coordinates. Under “Units:” select Square Kilometers. Hit OK. We now have the calculated area of the extent of the Sonoran Desert in the year 2000. Complete all the above steps in the 1990 Desert Polygon’s attribute table. With the two areas now calculated we are able to subtract the two to find the growth of the Sonoran Desert within Arizona between 1990 and 2000.

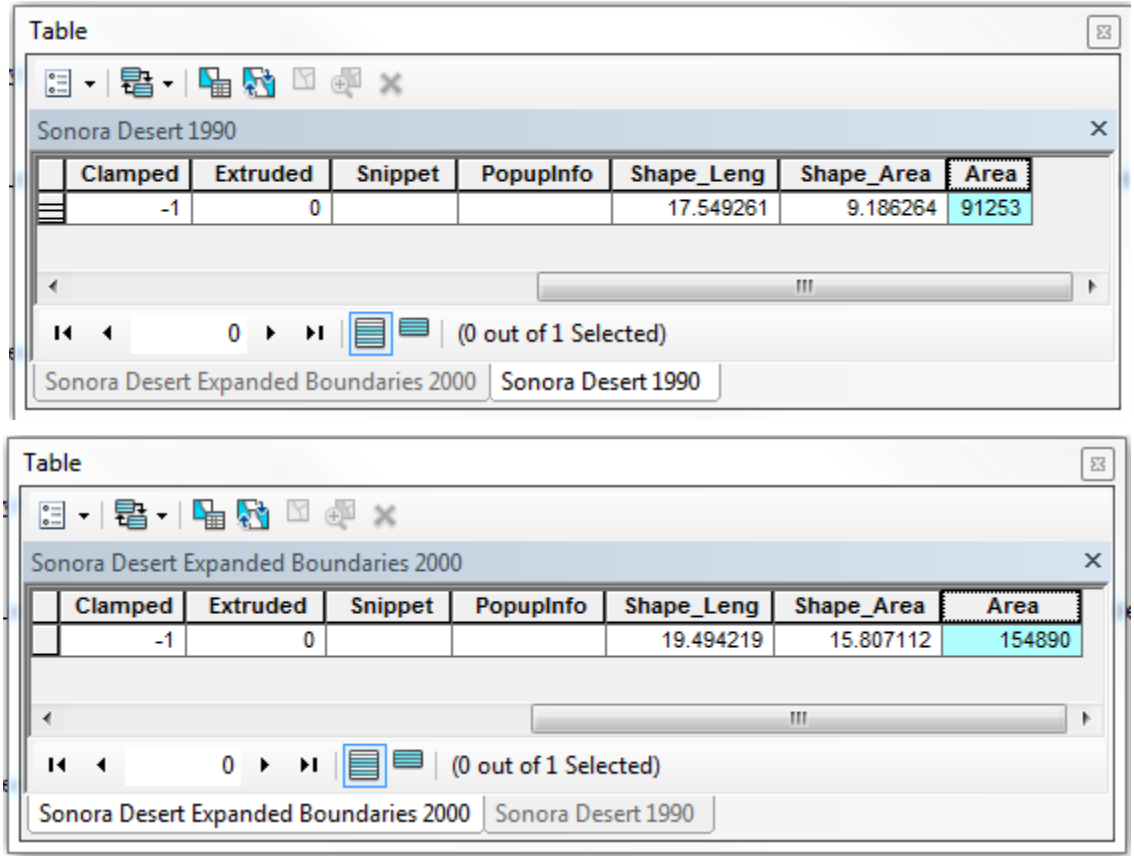


Figure 10. Calculated areas of 1990 Sonoran Desert (top) and 2000 Sonoran Desert (bottom).

B.) Change in populated regions from 1990 to 2000.

As we did for the areas of the desert polygons we are going to calculate the areas of the 1990 populated regions and 2000 populated regions. By completing the same steps as above (creating new field, calculating geometry) we can assess whether or not there was a change in the areas of densely populated regions within Arizona. (While this method will not produce specific population data it is an adequate way of comparing the change in area of populated regions with the change in desert area.) To find the total area of populated regions in Arizona in 1990 we must take one more step within the attribute table: right click on newly created "Area" field, select "Statistics". In the statistics table we can see the minimum, maximum, sum, mean, and standard deviation of all of the populated regions in 1990. We are most concerned with the sum. As with the desert areas we can subtract the 1990 and 2000 populated region areas to examine the change between the two years.

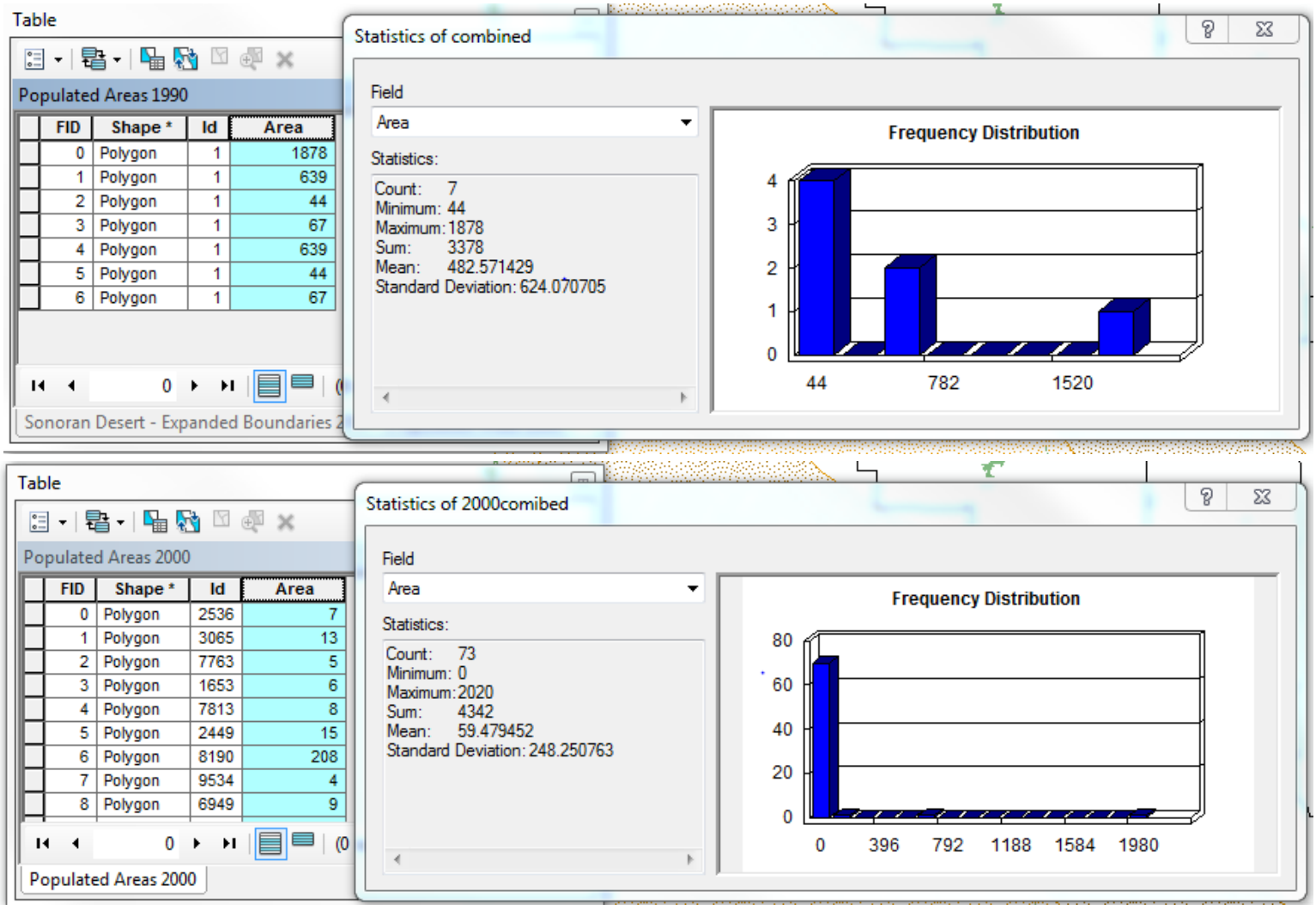


Figure 11. Attribute Table and Statistics of both 1990 (top) and 2000 (bottom) populated regions areas.

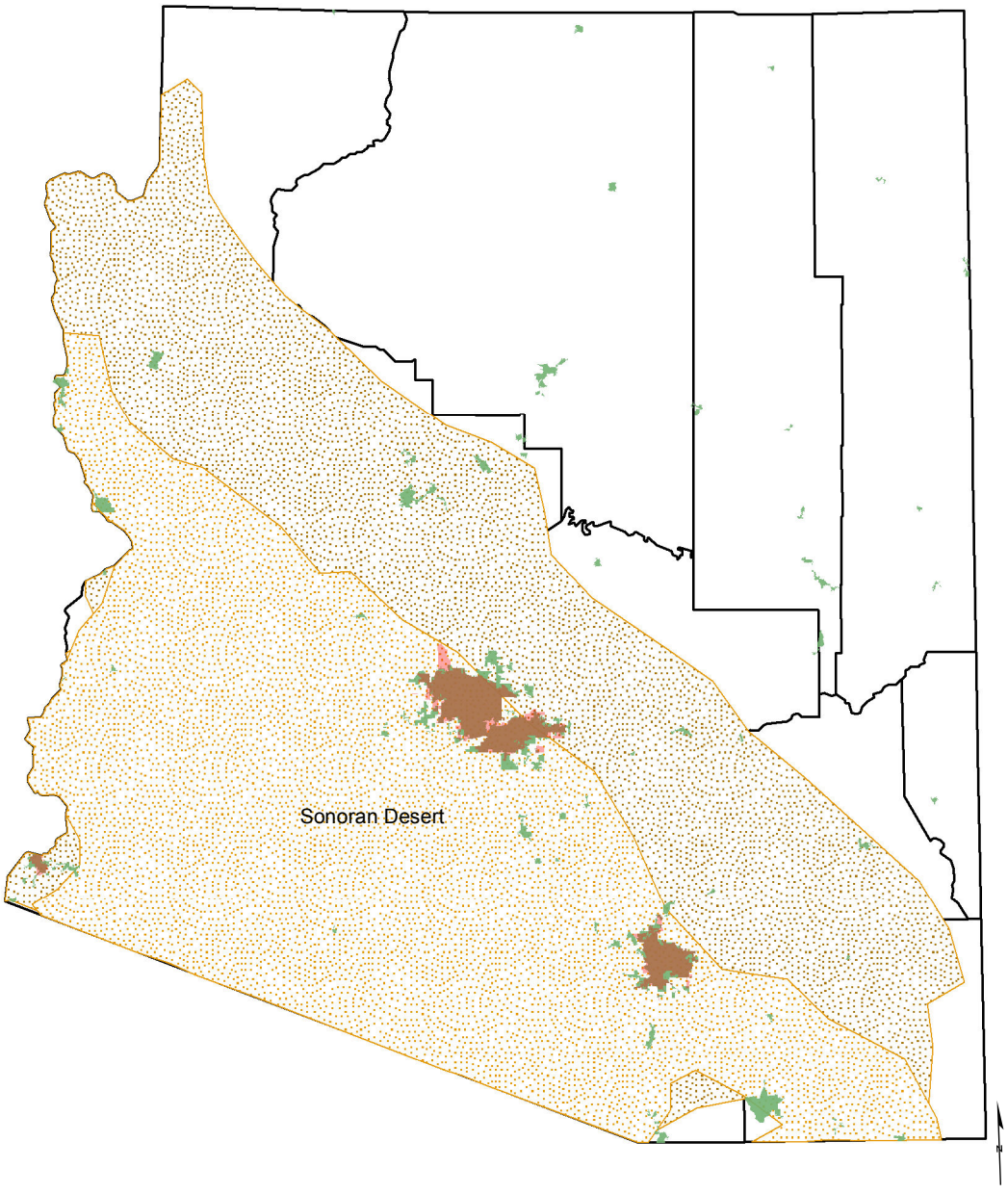
V. Conclusion

Several conclusions can be made from the completion of this project. First, by analyzing satellite data of the Sonoran Desert from 1990 and 2000 it is seen that the desert has expanded by 63,637 sq. km. in a 10 year span. This estimate seems surprisingly high and one would assume is tends towards the high range of acceptable growth models. Upon reanalyzing the process and method of my approach to calculating the growth of the Sonoran Desert I realized that by using both the NASA Zulu MrSid files and Google Earth to create polygons representing the desert's size I failed to take into account the time of year that the images were taken. In Google Earth for example the size of the Sonoran Desert varies depending on the month the image was taken. In late summer, September for example (when the 2000 image was taken), the extent of the desert is greater than in the wetter, spring months. Despite this possible source of error, it can be verified with certainty that the Sonoran Desert did indeed experience growth in the decade from 1990 to 2000. We can also conclude that the size and extent of populated regions grew as well. Using the attribute table data, we can calculate that the area of populated regions in Arizona grew by 964 sq. km. By looking on the map where this growth occurred, a fair amount of the growth has occurred in areas that were also densely populated in 1990 (these cities are Phoenix and Tucson) and these areas have remained within the extent of the Sonoran Desert throughout the decade in question. In the end we can say that despite the significant growth of the Sonoran Desert between 1990 and 2000, existing populated regions in Arizona have also experienced growth, and new regions of dense population have emerged, several of which lie within the extent of the Sonoran Desert.

VI. Problems

1. The MrSid files were very large causing ArcMap (a sensitive program already) to be very slow and occasionally crash. I circumnavigated this issue by loading the MrSid files into Google Earth instead and creating polygons which I then added to ArcMap. This allowed me to just use the much smaller polygon files in ArcMap.

Sonoran Desert Expansion from 1990 to 2000



0 25 50 100 150

Kilometers

Sonoran Desert 1990

Sonoran Desert - Expanded Boundaries 2000

Populated Areas 1990

Populated Areas 2000

Coordinate System: WGS 1984 UTM Zone 12N
Projection: Transverse Mercator
Datum: WGS 1984