Fall 2009 GIS Project: Correcting a Partial Geologic Map of Guadalupe Mountain National Park, New Mexico and west Texas and Developing a Geodatabase for McKittrick Canyon, New Mexico and west Texas

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GIS and GPS Applications in Earth Sciences

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PROBLEM

This project aims to serve two purposes. The first purpose is to correct a geological map of my field area located in McKittrick Canyon, Guadalupe Mountains, New Mexico and west Texas as well as to create a geodatabase for my field area. The map is from a website by Peter Scholle entitled, “An Introduction and Virtual Geologic Field Trip to the Permian Reef Complex, Guadalupe and Delaware Mountains, New Mexico-West Texas” (http://geoinfo.nmt.edu/staff/scholle/guadalupe.html). The problem with the map (Figure 1) is that it has the predominant formation in McKittrick Canyon labeled incorrectly as Grayburg Fm. when it should actually be Yates Fm. The map incorrectly shows the Yates Fm. truncating too far northeastward.

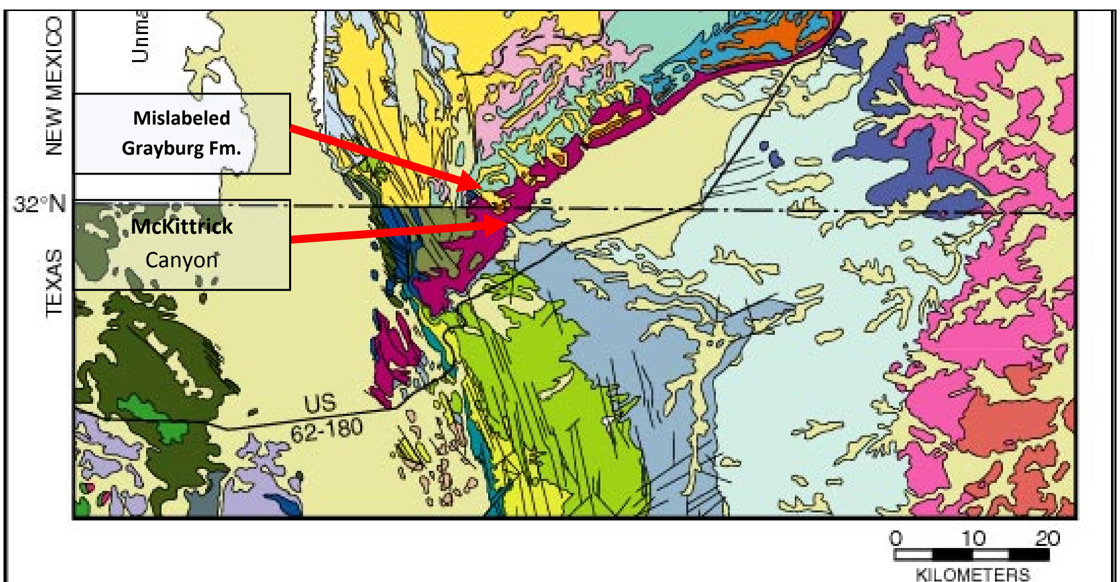
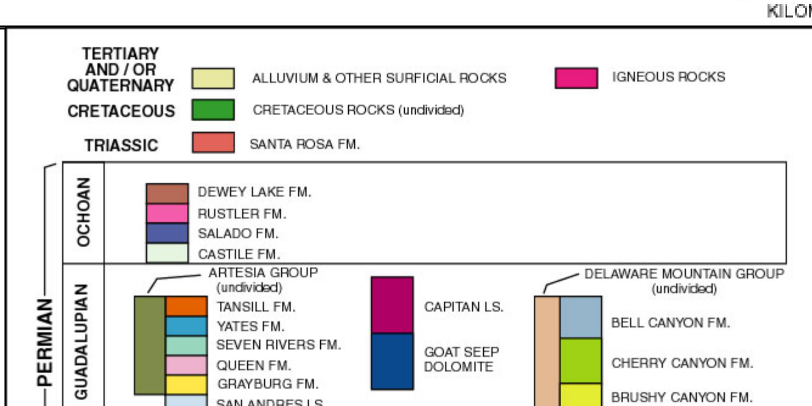


Figure 1: Geologic map showing the Capitan Reef margin in pink and Permian shelfal and basinal equivalents. McKittrick Canyon is indicated on the figure, as is the mislabeled formation.



The other purpose of this project is to utilize the personal geodatabase created for my field area in part one of the project and to bring in measured section data that I have collected via a handheld GPS unit. There has not been any prior ArcGIS work done specific to my field area. I utilized the U.S. National Park Service website (http://www.nps.gov/index.htm) to obtain data for the Guadalupe Mountains National Park (Figure 2). I downloaded a DEM (which required coversion from E00 format) as well as contour, park boundary, fire history, hyrography, private land, roads, trails, and vegetation shapefiles. In doing this part of the project, I hope to answer the question of whether or not there is a correspondence between vegetation and the occurrence of natural fires within the park, and to quantify the total acreage burned by fires from 1960-2002.

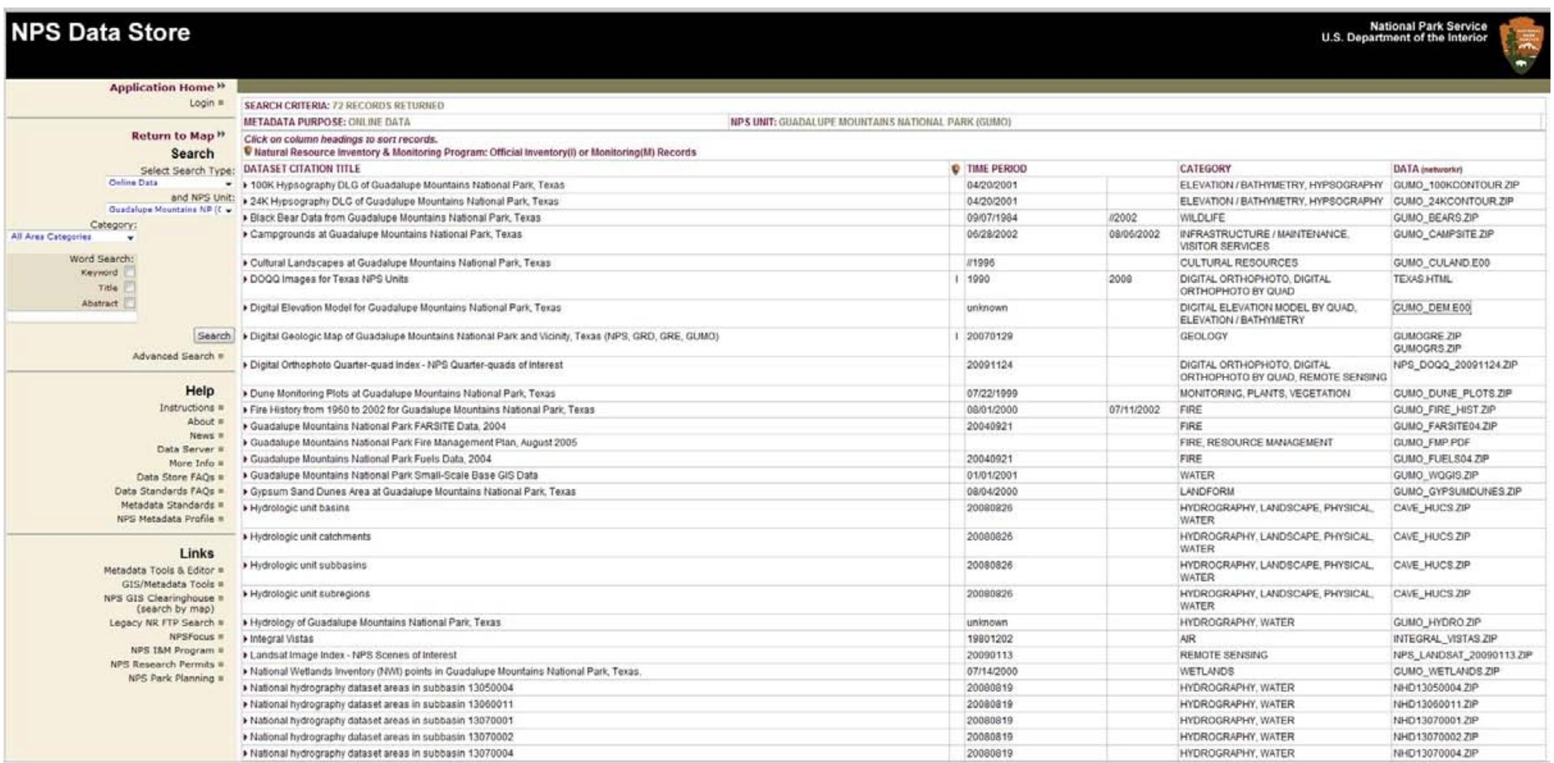


Figure 2: Screenshot of the NPS Data Store for Guadalupe Mountains National Park.

DATA PREPROCESSING

For the DEM covering the Guadalupe Mountains downloaded from the NPS website, I had to convert the GIS data into an ArcGIS-readable format from E00 interchange format to uncompressed coverage (Figure 3). To do so, I used ArcCatalog and went to Tools > Customize > ArcView 8x tools > Conversion Tools > Import from interchange file. I then filled out the box highlighted in red appropriately.

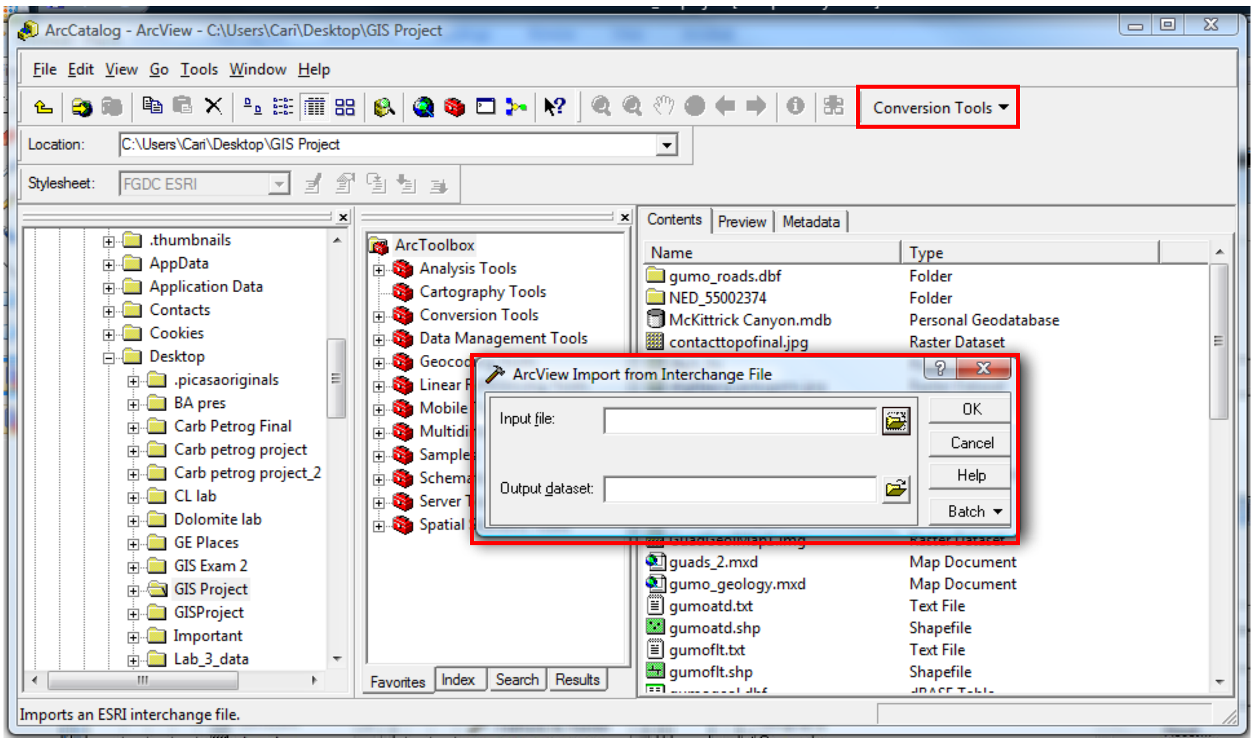


Figure 3: Steps taken to convert E00 file into an Arc-readable format.

Another preprocessing step I took was to bring the GPS points representing my measured sections into ArcGIS. They were saved as .kmz files in Google Earth, so I created a folder, indicated in Figure 4 under My Places in Google Earth, to save my measured sections. I then saved that folder to my desktop as a .kml file.

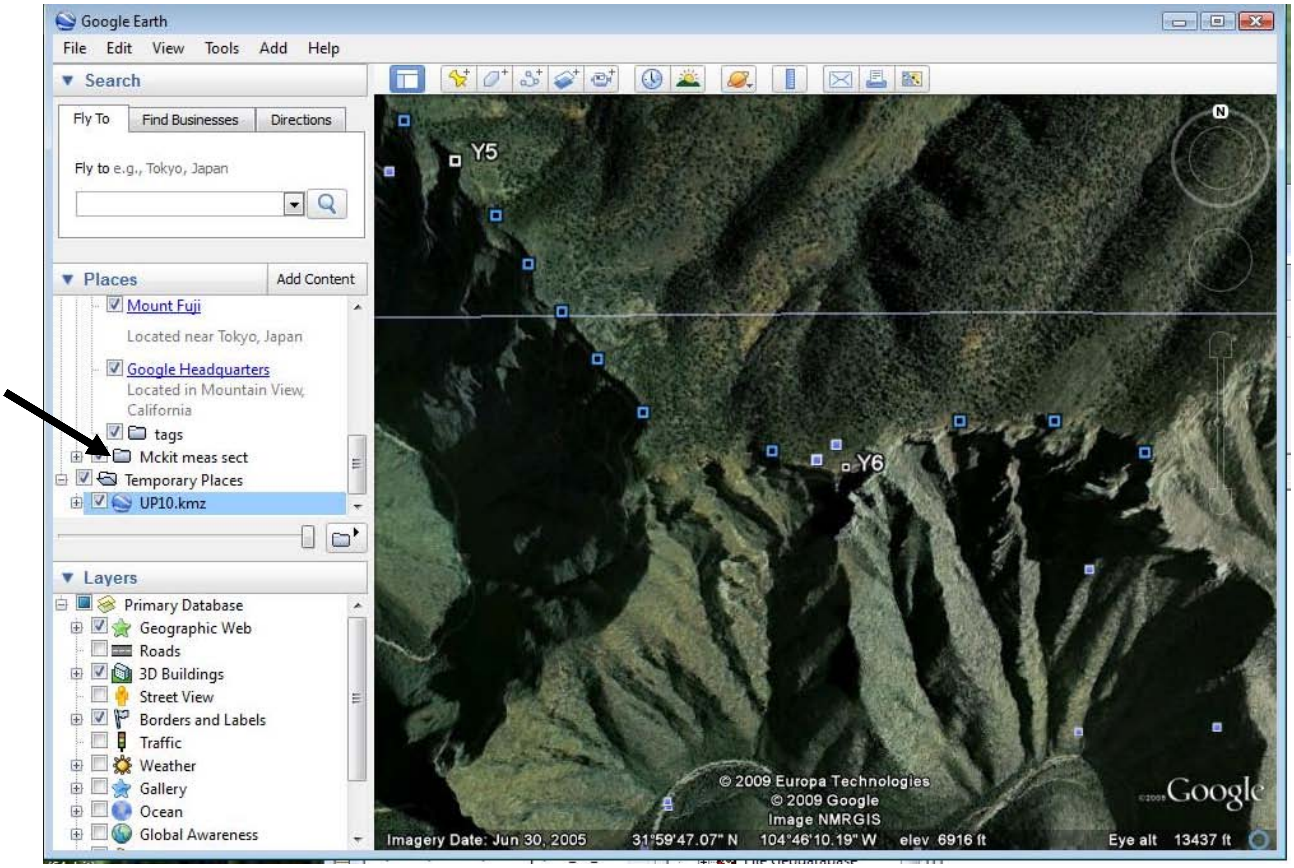


Figure 4: Creating a folder in GE to save my measured section locations in so that I could convert the folder to a .kml file. The folder is called Mckit meas sect, as indicated in the figure.

In order to convert the .kml file into a shapefile, I went to the ESRI support center and found a script that is capable of this process (Figure 5).

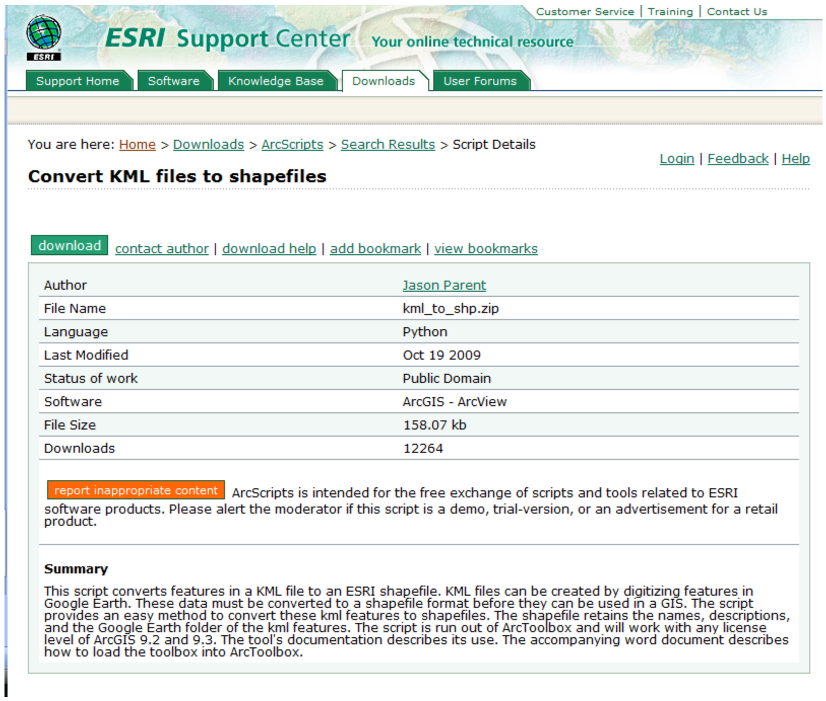


Figure 5: Screenshot of ESRI Support Center website where script was found.

After downloading the script, I added it to ArcToolbox in ArcCatalog by right-clicking on ArcToolbox and clicking on Add Toolbox (Figure 6). From here I was able to add the toolbox.

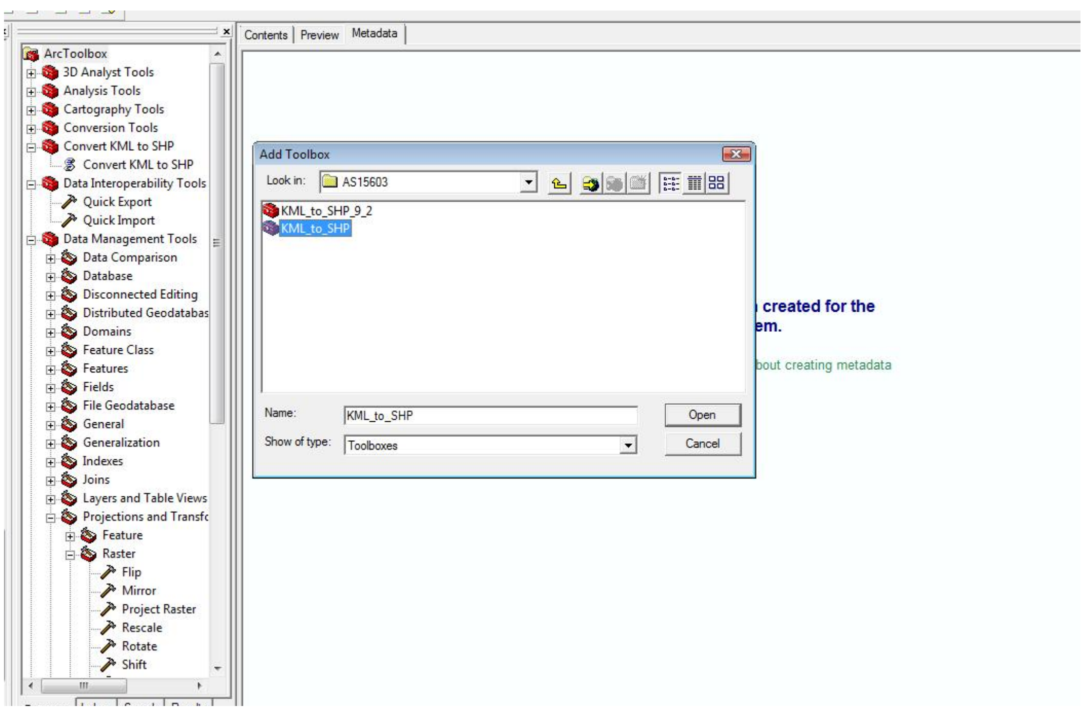


Figure 6: Using ArcCatalog to add the downloaded script through Add a Toolbox.

After adding the toolbox, I converted my .kml file to a shapefile (Figure 7). The toolbox is indicated with an arrow in the figure.

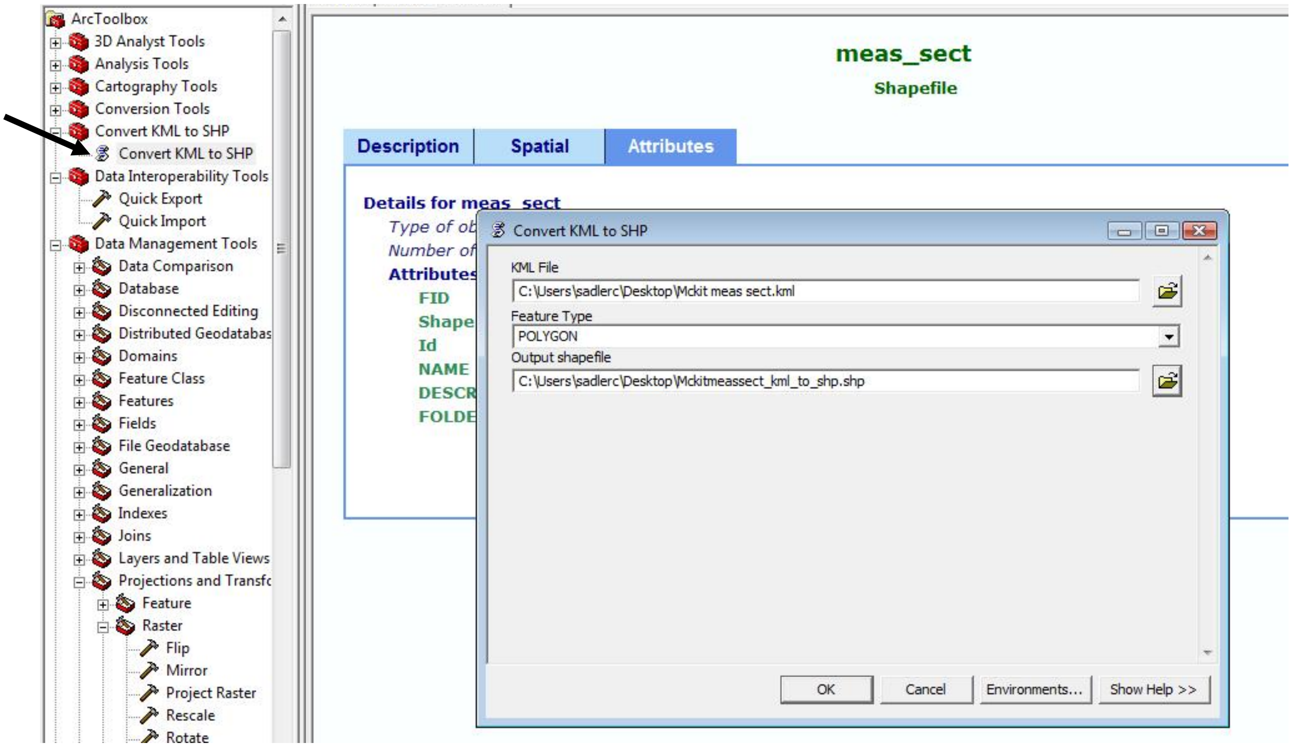


Figure 7: Converting the .kml file for my measured sections to a shapefile.

ArcGIS PROCESSING

<u>Part 1: Correcting a Partial Geologic Map</u>

To start off, I opened ArcMap to an empty document. I first added the referencing data, which in this case is the roads shapefile downloaded from the NPS website. It is referenced with a geographic coordinate system of NAD 1983. I then made sure the data frame had the same coordinate system. Next, I added the .jpg image of the geologic map (Figure 1). After turning on the Georeferencing Toolbar, I made sure my geologic map was displayed in the Layer box, then selected “Fit to display” from the georeferencing toolbar drop-down menu. I opened the Links Table and selected the Add Control Point tool and clicked on a road on the geologic map, then clicked on the same location in the roads layer. I clicked several more control points until the location of the geologic map was set properly (Figure 8). I then selected “Rectify…” from the Georeferencing toolbar drop-down menu to create a new file that is spatially referenced using nearest neighbor resampling (Figure 9). As a final step, I checked the coordinate system of the rectified image to make sure it was correct.

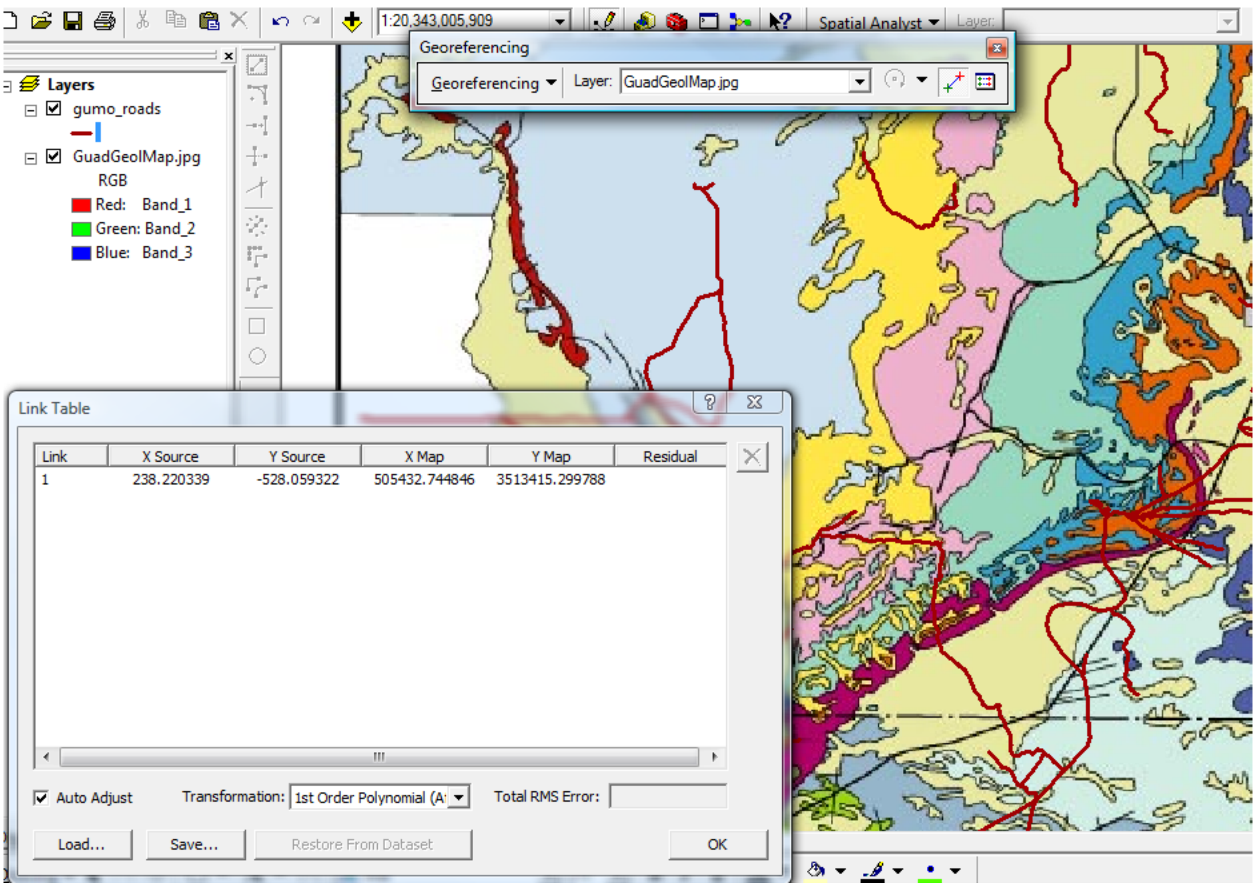


Figure 8: Steps taken to georeference the geologic map.

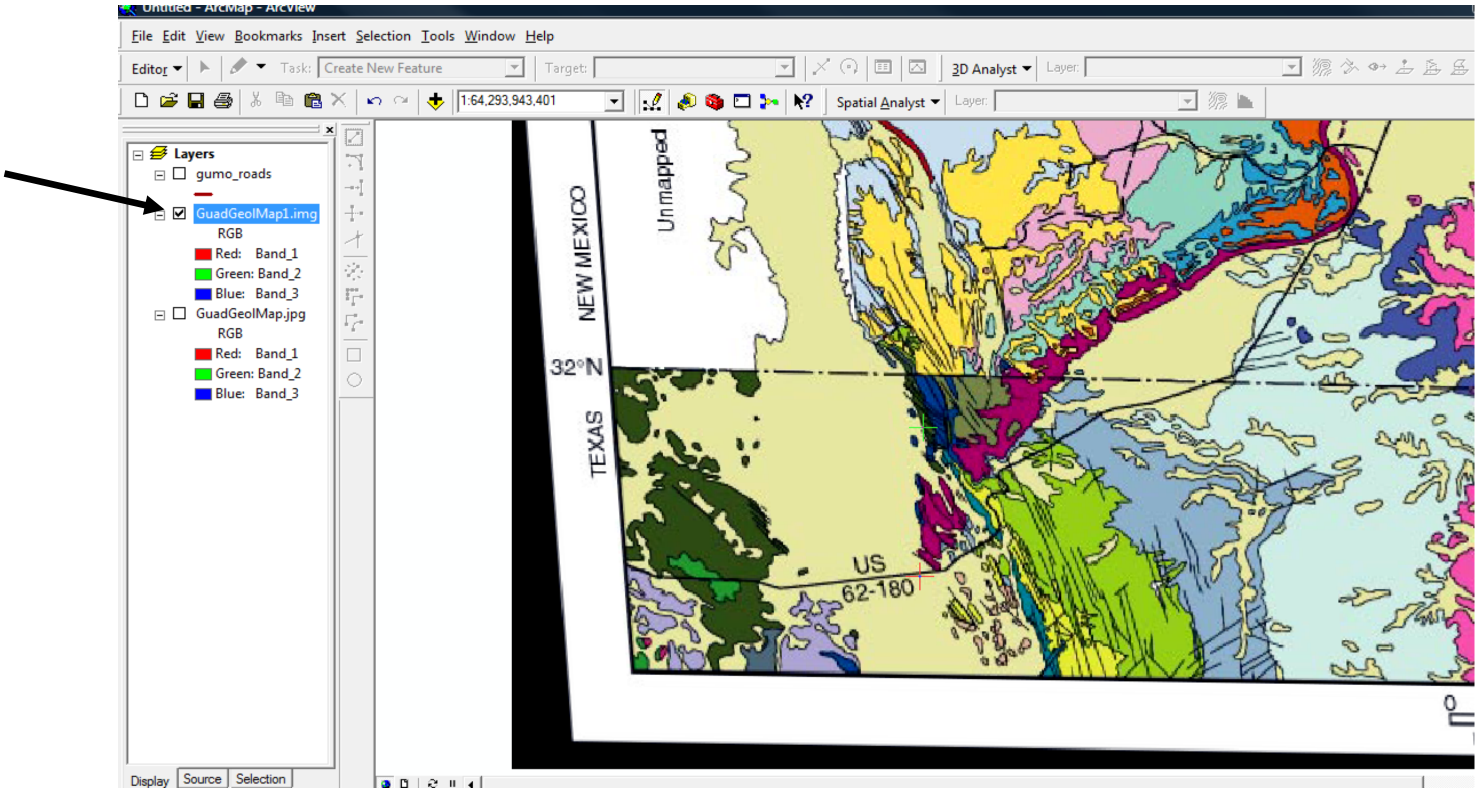


Figure 9: Rectified geologic map, as indicated in figure.

The next step was to create a personal geodatabase in ArcCatalog. I created a geodatabase named McKittrick Canyon. I then right-clicked on the McKittrick Canyon geodatabase icon, selected “Import”, then “Feature class (multiple)…” Before importing any data, I set some “Environment” variables by clicking “Environments…” at the bottom of the window, selecting “General Settings”, clicking the folder button next to “Current Workspace”, and browsing to my GIS Project folder and clicking “Add”. I then imported shapefiles, including contour, park boundary, fire history, hyrography, private land, roads, trails, and vegetation shapefiles.

After this, I created a feature dataset within my McKittrick Canyon geodatabase to hold files created by digitizing. To do so, I right-clicked on the icon for my McKittrick Canyon geodatabase, selected “New”, then “Feature Dataset”, and named it Geology. I set a geographic coordinate system for the feature dataset of NAD 1983. Next, I created feature classes within the Geology feature dataset (Figure 10). To do so, I right-clicked on the Geology feature dataset, selected “New”, then “Feature class…”. I created two line feature classes for Faults and Contacts and added fields to both. For the Faults feature class, I added a text field called Type with an alias of Fault type, and for the Contacts feature class, I added a text field called Exposure.

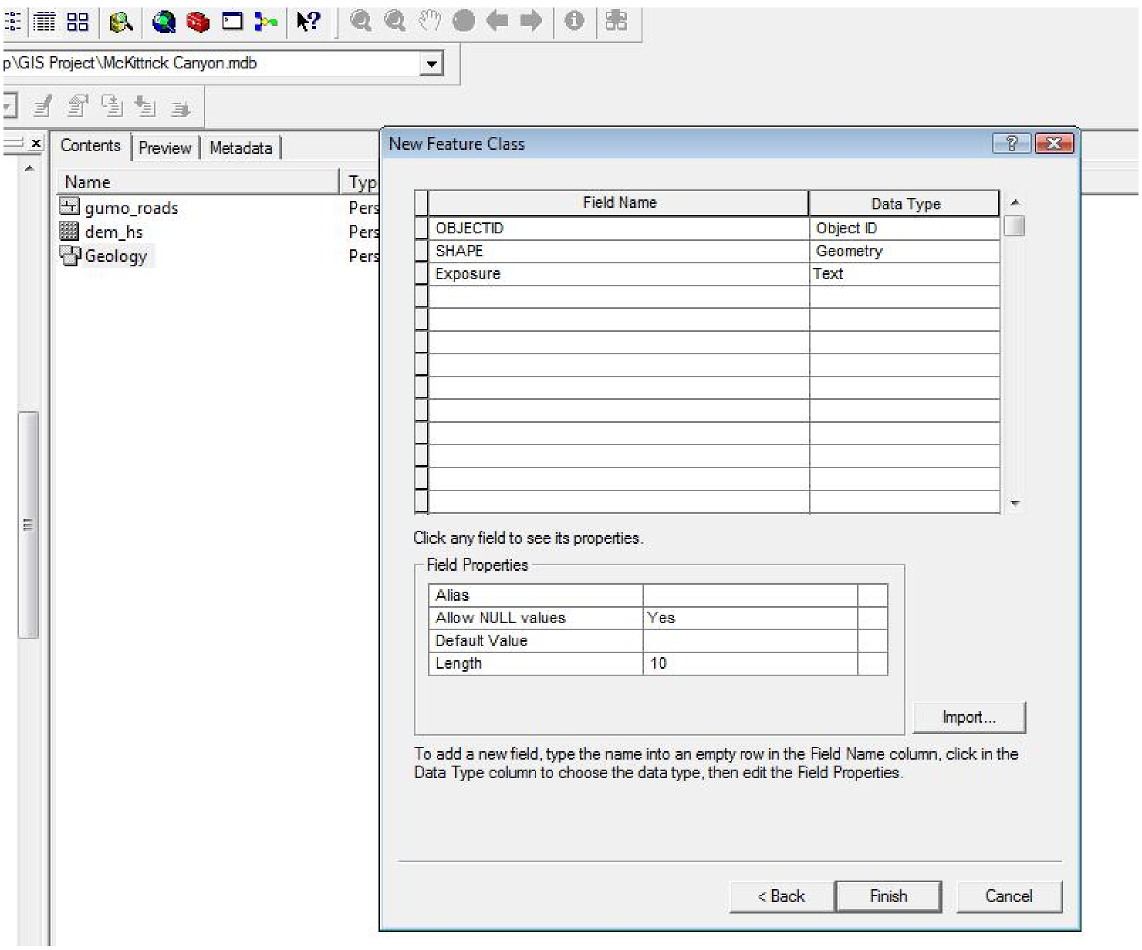


Figure 10: Contact feature class created for the Geology feature dataset.

The next thing I did was add domains to the McKittrick Canyon geodatabase (Figure 11). To do so, I right-clicked on the McKittrick Canyon geodatabase icon, selected "Properties", and clicked the "Domains" tab. The table below (Table 1) shows the domains added and their properties.

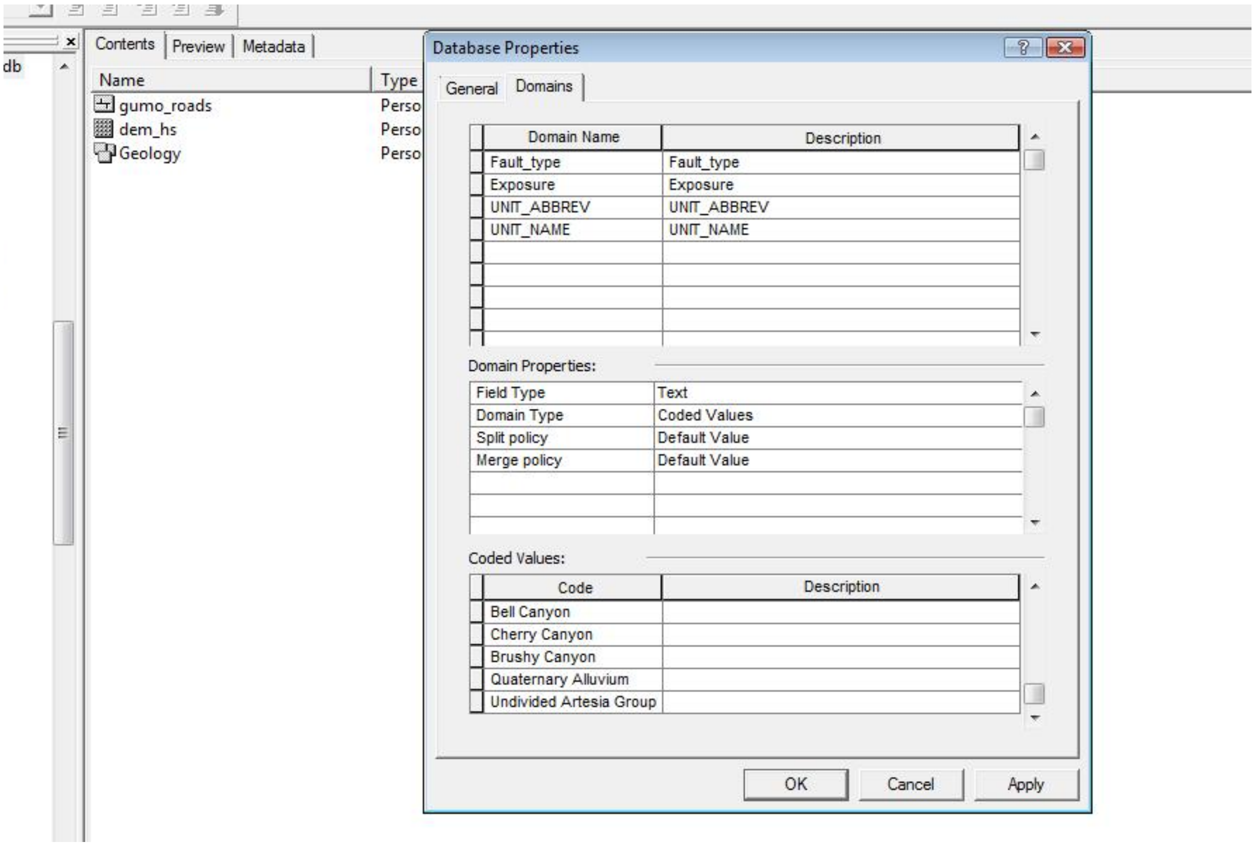


Figure 11: Adding domains to the McKittrick Canyon geodatabase.

Name/Description	Field Type	Domain Type	Codes/Descriptions
Fault_type	Text	Coded Values	Normal, Reverse
Exposure	Text	Coded Values	Exposed, Inferred, Covered
UNIT_ABBREV	Text	Coded Values	pTs, pYa, pSR, pQn, pGr, pSA, pCap, qAl, AG, pBC, pCC, pBrC
UNIT_NAME	Text	Coded Values	Tansill, Yates, Seven Rivers, Queen, Grayburg, San Andres LS, Capitan LS, Quaternary Alluvium, Undivided Artesia Group, Brushy Canyon Sand, Cherry Canyon Sand, Bell Canyon Sand

Table 1: Domains and their associated properties.

After creating domains, I attached them to feature classes (Figure 12). To do so, I right-clicked on the Contact feature class in the geodatabase, selected"Properties…" and clicked the "Fields" tab. I clicked on the Field Name "Exposure", and in the Field Properties area, clicked the blank cell to the right of "Domain" to reveal a drop-down menu, and selected the "Exposure" domain. In the blank area to the right of "Default Value", I typed Exposed. For the Faults feature class, I did the same thing but chose Fault_type from the drop-down menu beside Domain.

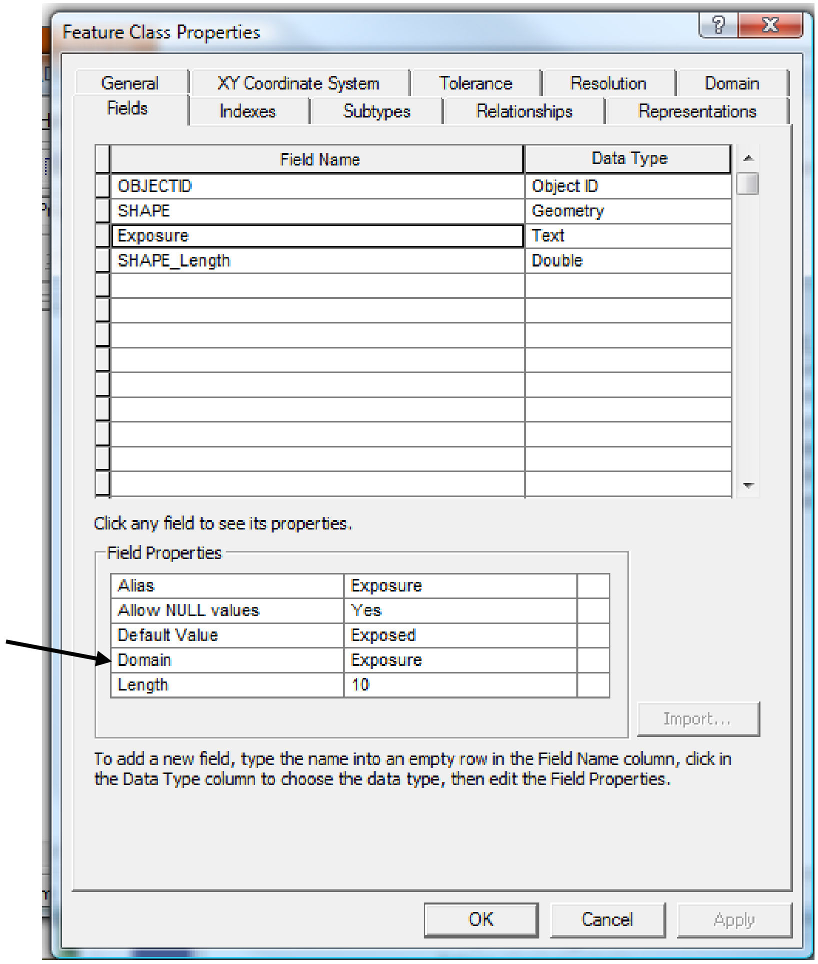


Figure 12: Attaching domains to feature classes. The Contact feature class is represented in the figure.

The next step was to digitize features, in this case contacts and faults (Figure 13). There is no map area to digitize because this is a correction of only part of a geologic map, specifically the part that pertains to my field area. After opening a new ArcMap document, I loaded the rectified geologic map and the Contact and Fault feature classes. I opened the Editing Toolbar and selected "Start Editing", setting the Target to either Fault or Contact depending on what I was digitizing. I set the snapping under the Edit menu on the Editing Toolbar. Next, I set the "task" to "Create new feature" and clicked on the pencil icon to start outlining features. I outlined all of the contacts and faults, making sure to "Save edits" frequently and assign attributes accordingly.

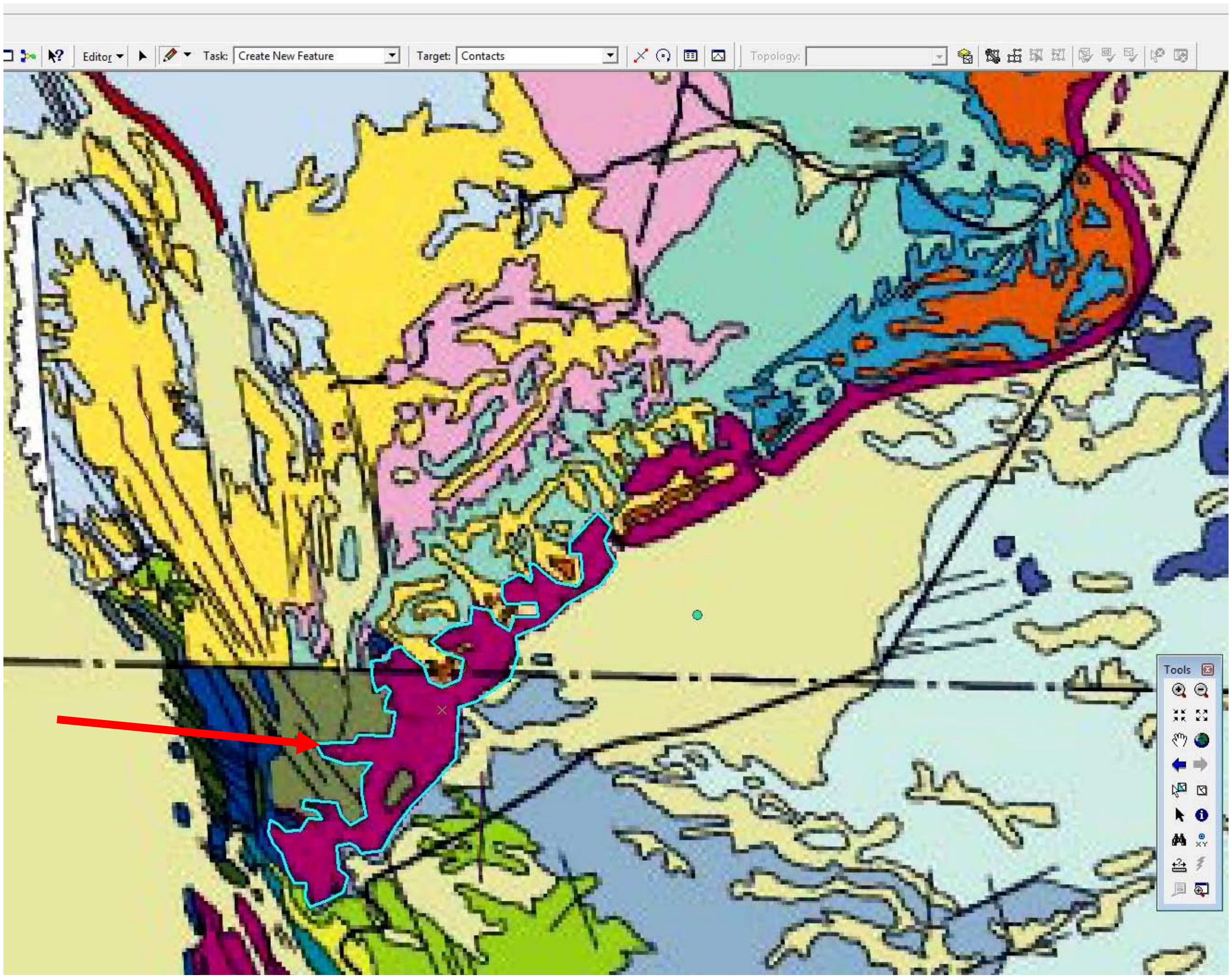


Figure 13: Digitizing faults and contacts. Example indicated by arrow is the Capitan LS contact.

The next step was to create a topology for the map lines. To do so, I closed ArcMap and opened ArcCatalog and right-clicked on the Geology feature dataset, selected "New", then "Topology". Once the Topology wizard opened, I named the new topology "Contact_topology" and clicked "Next" and placed a check in the boxes adjacent to the "Contacts" and "Faults" feature classes since they were the ones I wanted to check for dangling and/or crossing lines. I clicked “Next” and changed the number of ranks to 2 and changed the rank for Contacts to 2. Then, I clicked “Next” to bring up the topology rules dialog. I clicked the "Add Rule..." button and, for the Contacts feature class, selected the rule (from the drop-down menu) "Must Not Overlap". For the next rules, I followed this procedure from Lab 4:

b) Repeat step a), this time choosing "Must Not Have Dangles".

c) Repeat step a), this time choosing "Must Not Self-Intersect".

d) Repeat steps a) and c) for the Faults feature class. Do not repeat step b) for Faults; faults are allowed to dangle.

After clicking “Next”, I was able to review a summary of the topology properties. I clicked “Finish” to create the Topology feature class and clicked “Yes” to validate the topology.

After creating a topology, the next step was to fix topology errors. I opened a new document in ArcMap and loaded the “Contact_Topology” feature class (Figure 14). I turned on the Editing toolbar and the Topology toolbar and selected “Start editing” from the Editing toolbar and on the Topology toolbar set the layer to “Contact_topology”. On the topology toolbar, I clicked the Map topology tool and opened the “Error Inspector” window by clicking on the Error Inspector tool. From here, I started fixing line and point errors. To do so, I used the “Modify Feature” task from the Editing toolbar and zoomed into the errors to correct them. After I fixed the errors, I previewed the Contact_Topology feature class in ArcCatalog to verify that there were no remaining errors.

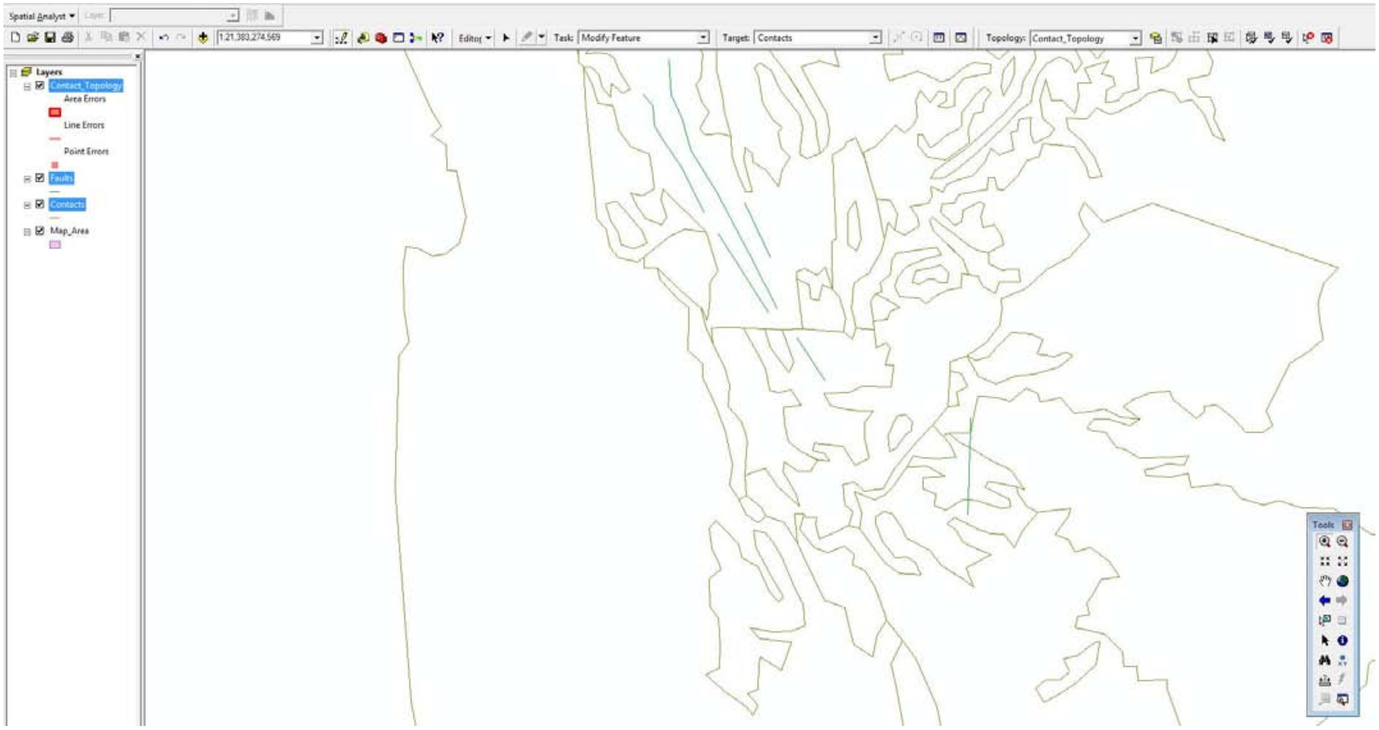


Figure 14: Contact_Topology loaded into ArcMap and all errors fixed.

After all of the topology errors were fixed, I moved on to making rock unit polygons. I closed ArcMap and opened ArcCatalog, then right-clicked on the Geology feature dataset within the McKittrick Canyon geodatabase. I selected "New", then "Polygon Feature Class From Lines…" (Figure 15) and named the new feature class "Rock_Units" and checked the box next to Contacts. After clicking ok, the polygon for Rock_Units was generated (Figure 16).

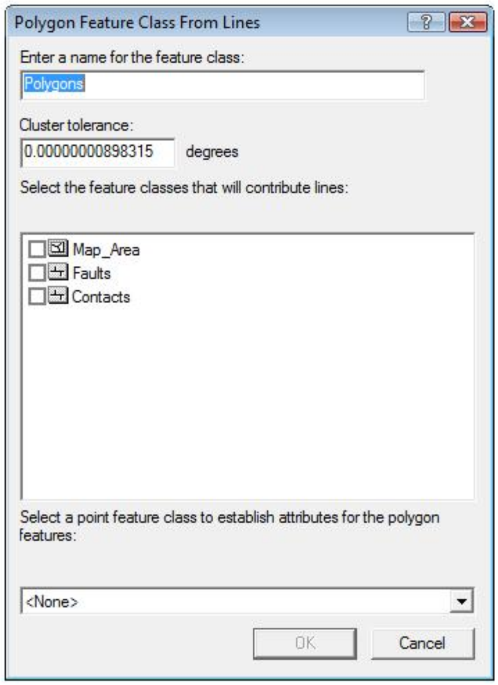


Figure 15: Creating a Polygon Feature Class From Lines.

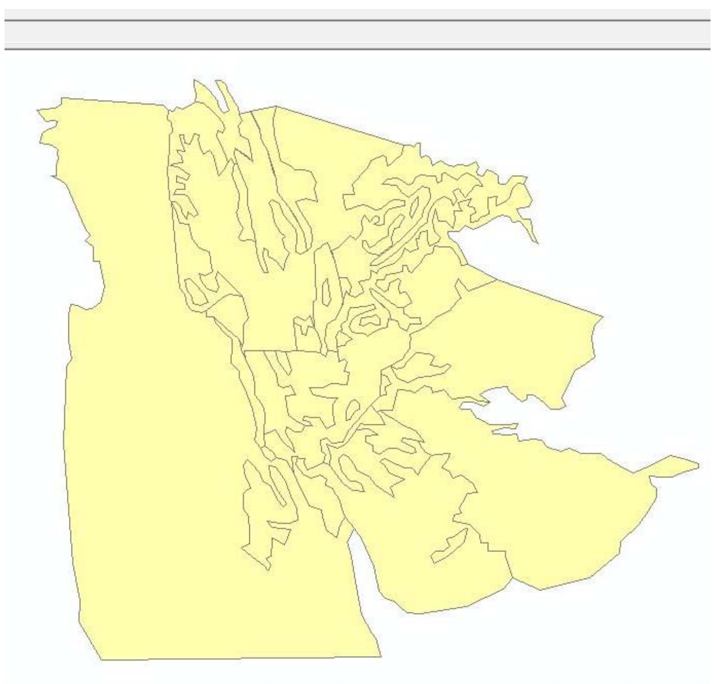


Figure 16: Rock_unit polygon feature class.

After creating a Rock_unit polygon feature class, the next step was to create attribute fields and assign domains to the feature class (Figure 17). To do this, I repeated the steps I outline earlier for adding text fields. I added “Name” and “Abbreviation” text fields to the Rok_unit feature class. For the “Name” and “Abbreviation” fields, I assigned the domains I created earlier, “UNIT_NAME” and “UNIT_ABBREV”, respectively.

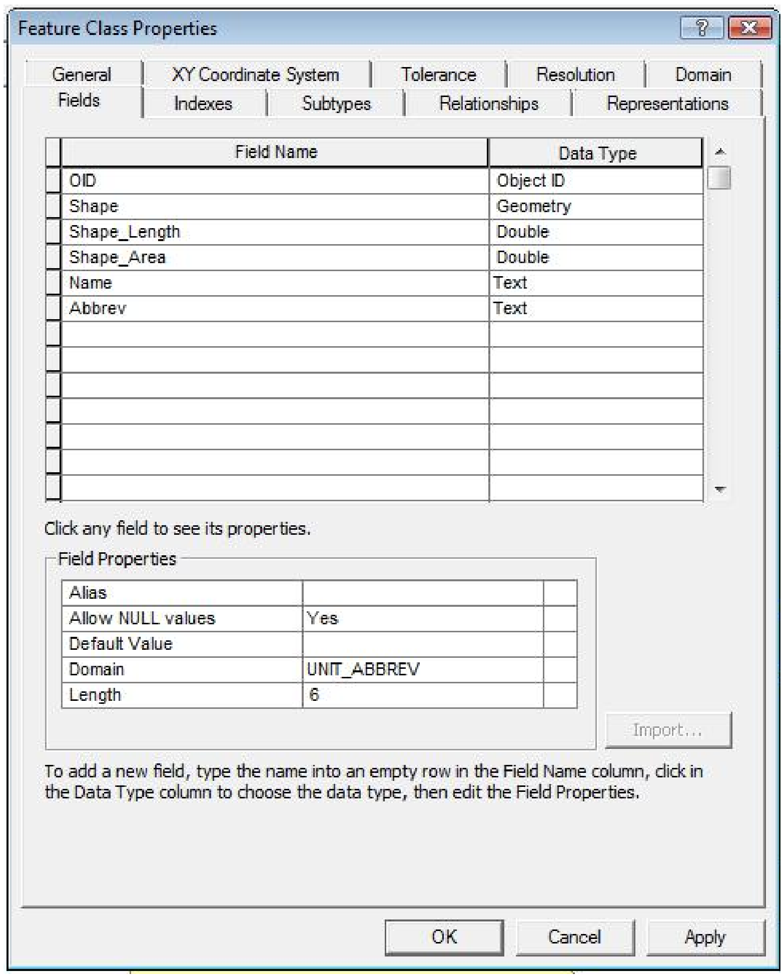


Figure 17: Assigning fields and domains to the Rock_unit feature class.

Now that I had fields and domains assigned to my Rock_unit feature class, I was able to open up ArcMap and load all of the feature classes from the Geology feature dataset and the rectified geologic map to start assigning names and abbreviations to the rock units. I overlaid the

Rock_unit layer on the geologic map so that I could see how the rock units needed to be labeled. To label the rock units, I turned on the Editing toolbar and set the target to “Rock_unit”, clicked the arrow tool, and began selecting polygons and naming them accordingly in the attribute table (Figure 18).

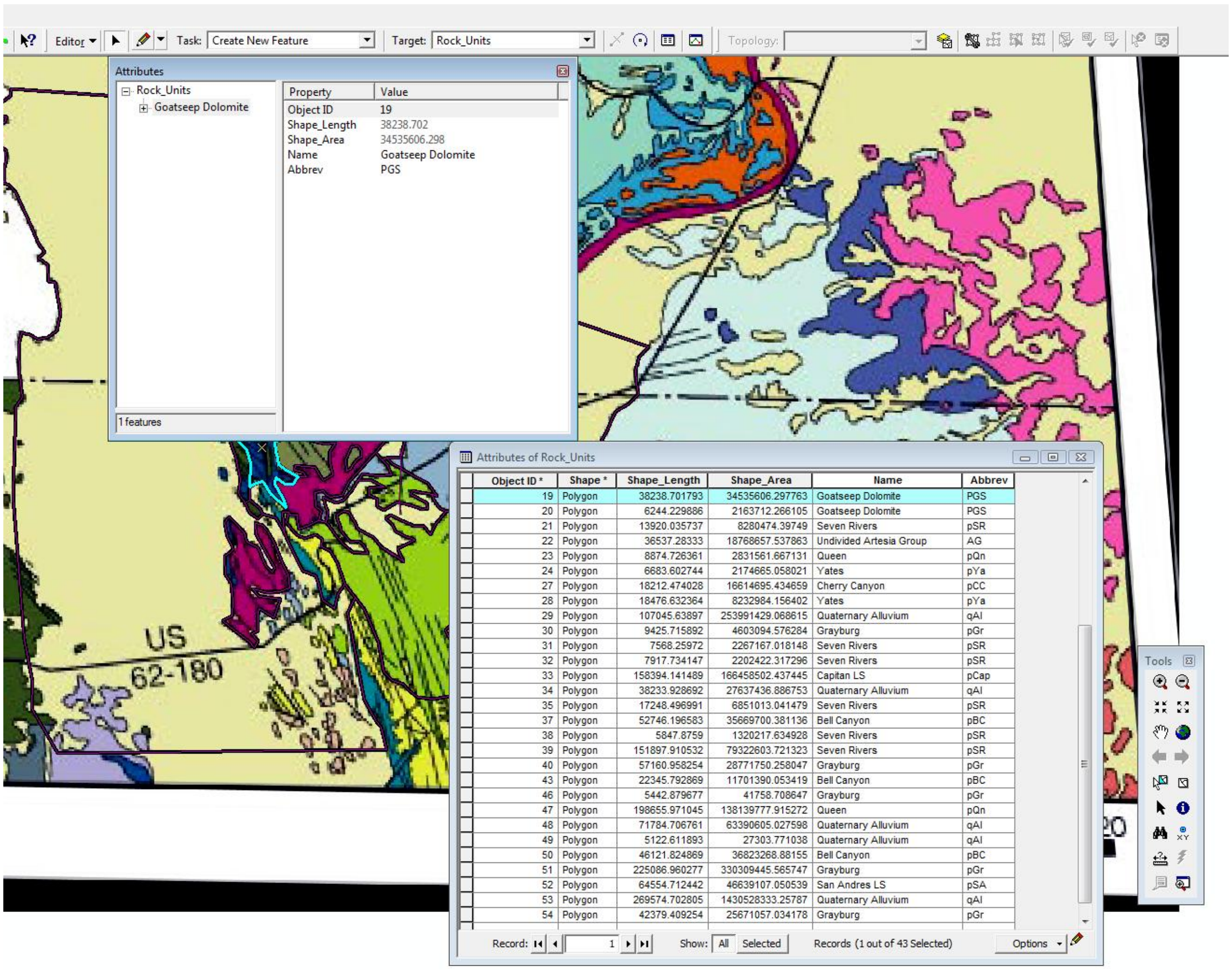


Figure 18: Naming the rock unit polygons.

After I named all of the polygons and fixed the mislabeled formation in McKittrick Canyon, I edited the symbology such that the rock units corresponded in color to the rectified geologic map. Next, I switched to layout view to display the final product (Figure 19).

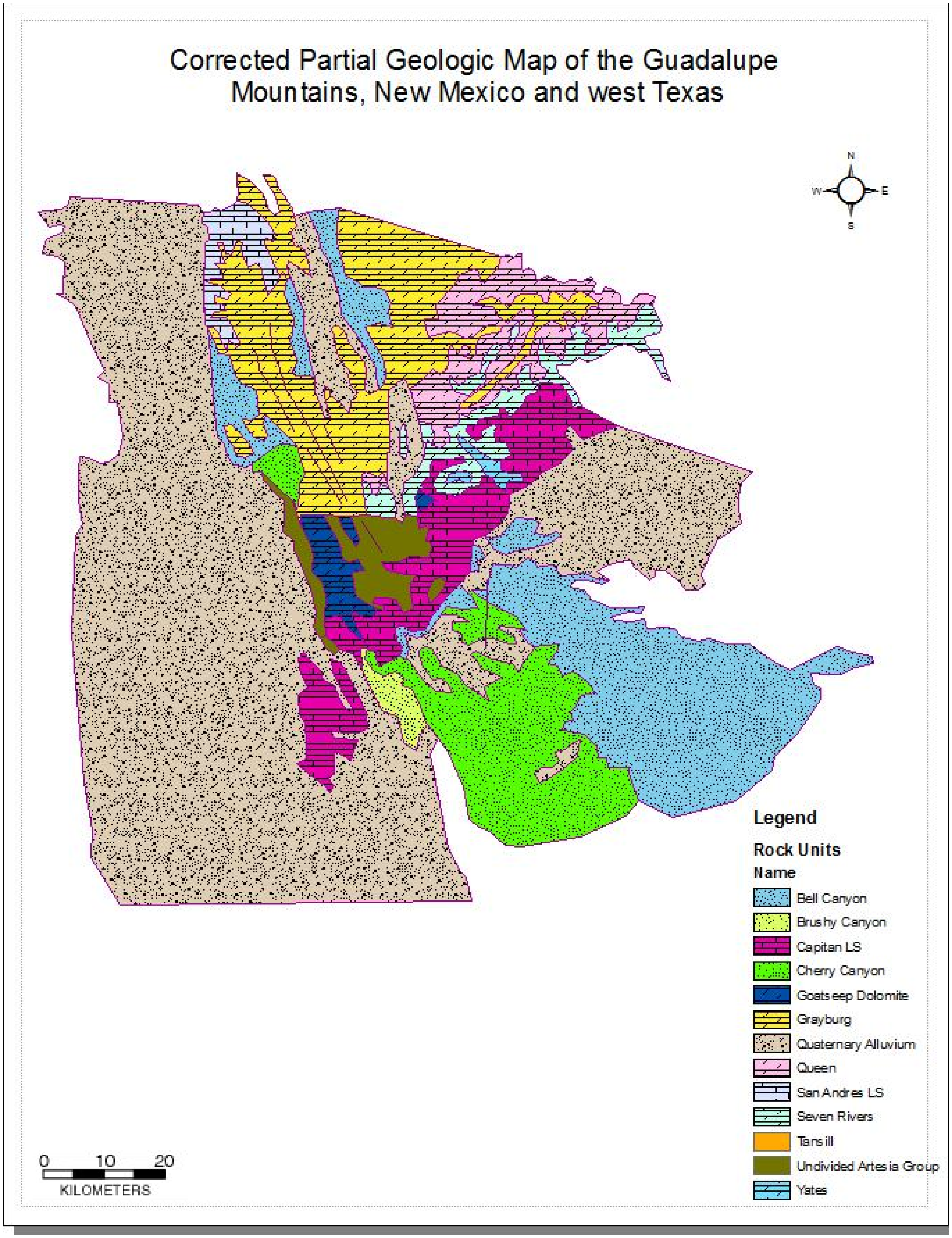
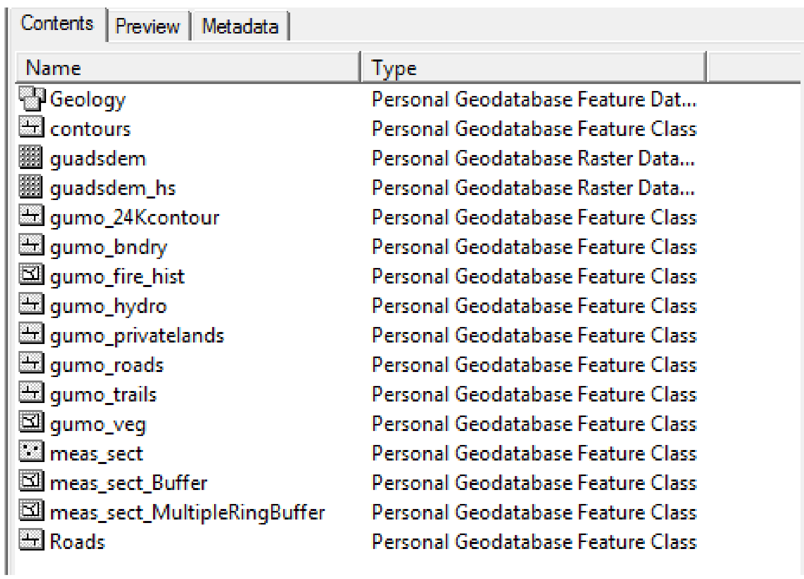


Figure 19: Final product. Bell Canyon=basinal sand, Brushy Canyon=basinal sand, Cherry Canyon=basinal sand, Capitan LS=limestone, Grayburg=dolomite, Queen=dolomite, San Andres=limestone, Seven Rivers=dolomite, Yates=dolomite

Part 2: Further Work and Analysis with the McKittrick Canyon Geodatabase

Since the geodatabase for my field area was created in the first part of my project, I used it as a launching pad for the second part. A summary of what is contained within the McKittrick Canyon geodatabase is in Figure 20. The goal of this part of the project is to use a DEM to produce a hillshade and show different aspects of Guadalupe Mountain Ntl. Park, get elevation data, import measured section points, and gather information regarding natural fires and vegetation in the park to see if there is any correlation between the two.



Contents | Preview | Metadata

Name	Type
Geology	Personal Geodatabase Feature Dat...
contours	Personal Geodatabase Feature Class
guadsdem	Personal Geodatabase Raster Data...
guadsdem_hs	Personal Geodatabase Raster Data...
gumo_24Kcontour	Personal Geodatabase Feature Class
gumo_bndry	Personal Geodatabase Feature Class
gumo_fire_hist	Personal Geodatabase Feature Class
gumo_hydro	Personal Geodatabase Feature Class
gumo_privatelands	Personal Geodatabase Feature Class
gumo_roads	Personal Geodatabase Feature Class
gumo_trails	Personal Geodatabase Feature Class
gumo_veg	Personal Geodatabase Feature Class
meas_sect	Personal Geodatabase Feature Class
meas_sect_Buffer	Personal Geodatabase Feature Class
meas_sect_MultipleRingBuffer	Personal Geodatabase Feature Class
Roads	Personal Geodatabase Feature Class

Figure 20: Summary of what is contained in the McKittrick Canyon geodatabase.

I have already described the processing I did to bring the DEM and measured section data into ArcGIS. Figure 21 below shows the result of combining the DEM and hillshade. In order to produce a hillshade, I opened the Spatial Analyst toolbar, set the layer to my DEM, selected "Surface Analysis" from the dropdown menu, then "Hillshade…".

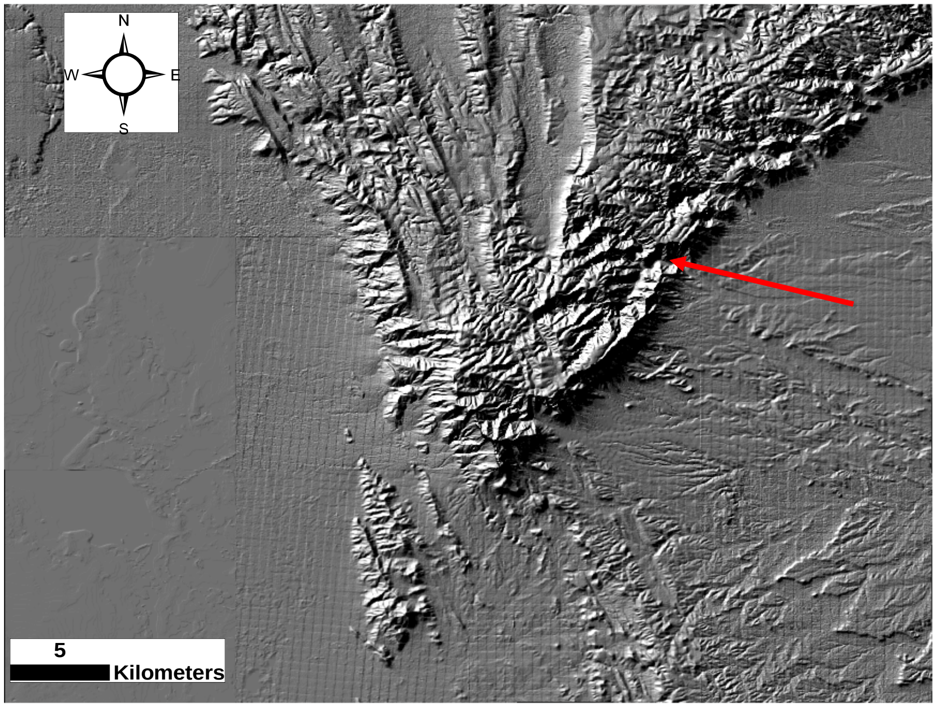


Figure 21: DEM of the Guadalupe Mountains with a hillshade over it. Arrow indicates McKittrick Canyon.

The next thing I did was to create an elevation model. I right-clicked on the DEM, selected "Properties", clicked on the "Symbology" tab, selected "Classified" and set the "Classification Method" to "Measured Interval" with the measured interval being 200 meters. I changed the color ramp to "Elevation #2" to symbolize the elevation better. I created a hillshade using the Spatial Analyst toolbar. The product of this is shown in Figure 22. It can be seen that from the valley floor to the rim of McKittrick Canyon, there is approximately 350 meters of relief.

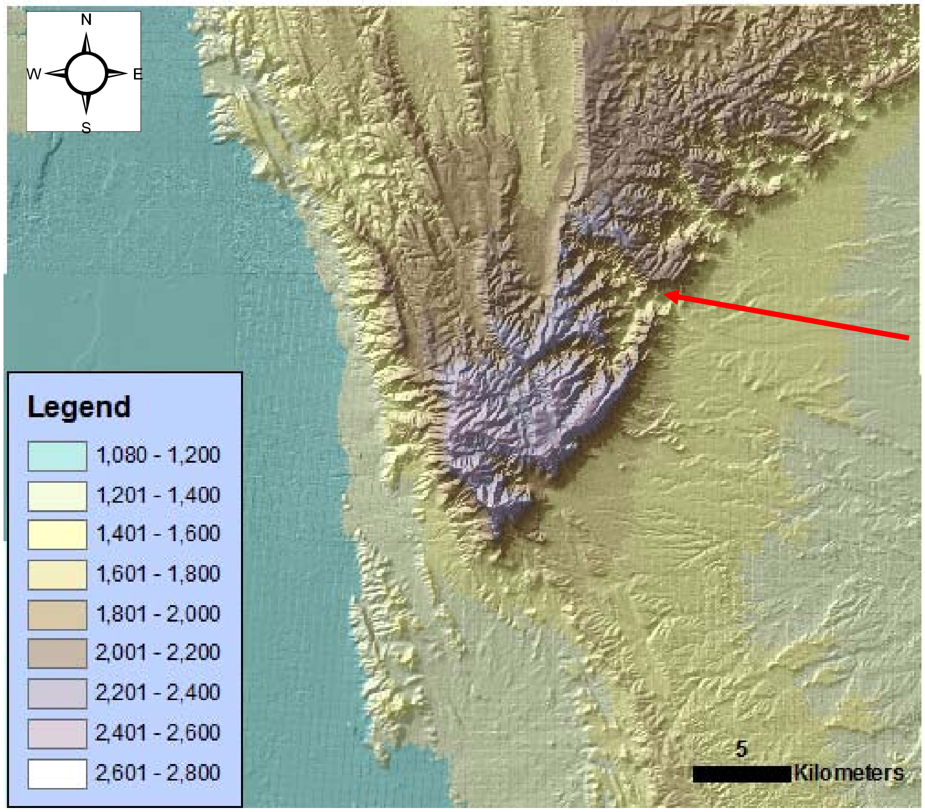


Figure 22: DEM of Guadalupe Mountains classified according to elevation (meters) and overlain by a hillshade. Arrow indicates McKittrick Canyon.

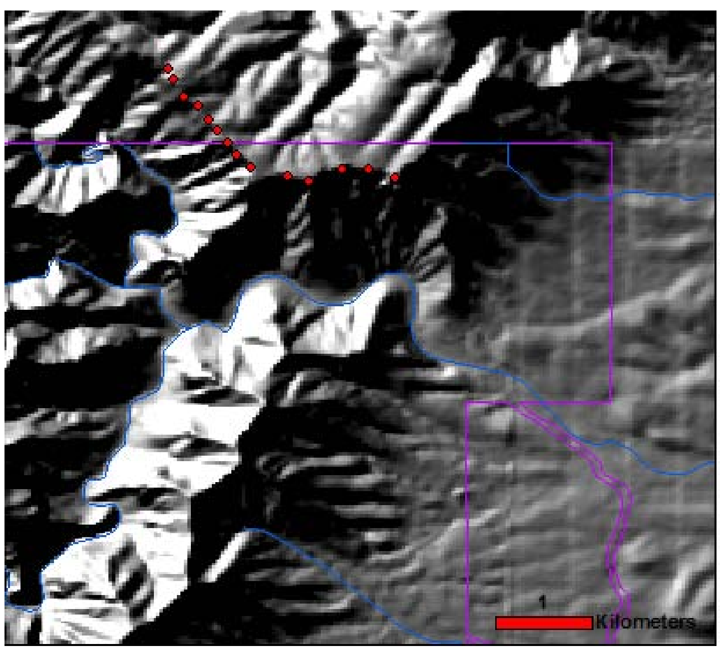


Figure 22: Zoomed in view of McKittrick Canyon. Purple boundary is the park boundary, blue lines are streams, and red dots are the sections I've measured so far. Scale bar = 1 km.

The next DEM and hillshade (Figure 23) show different characteristics of the Guadalupe Mountain National Park, which is defined by the purple boundary. Hiking trails in the park are shown in brown, streams are in blue, private lands are in red, and my measured sections in McKittrick Canyon are the red dots.

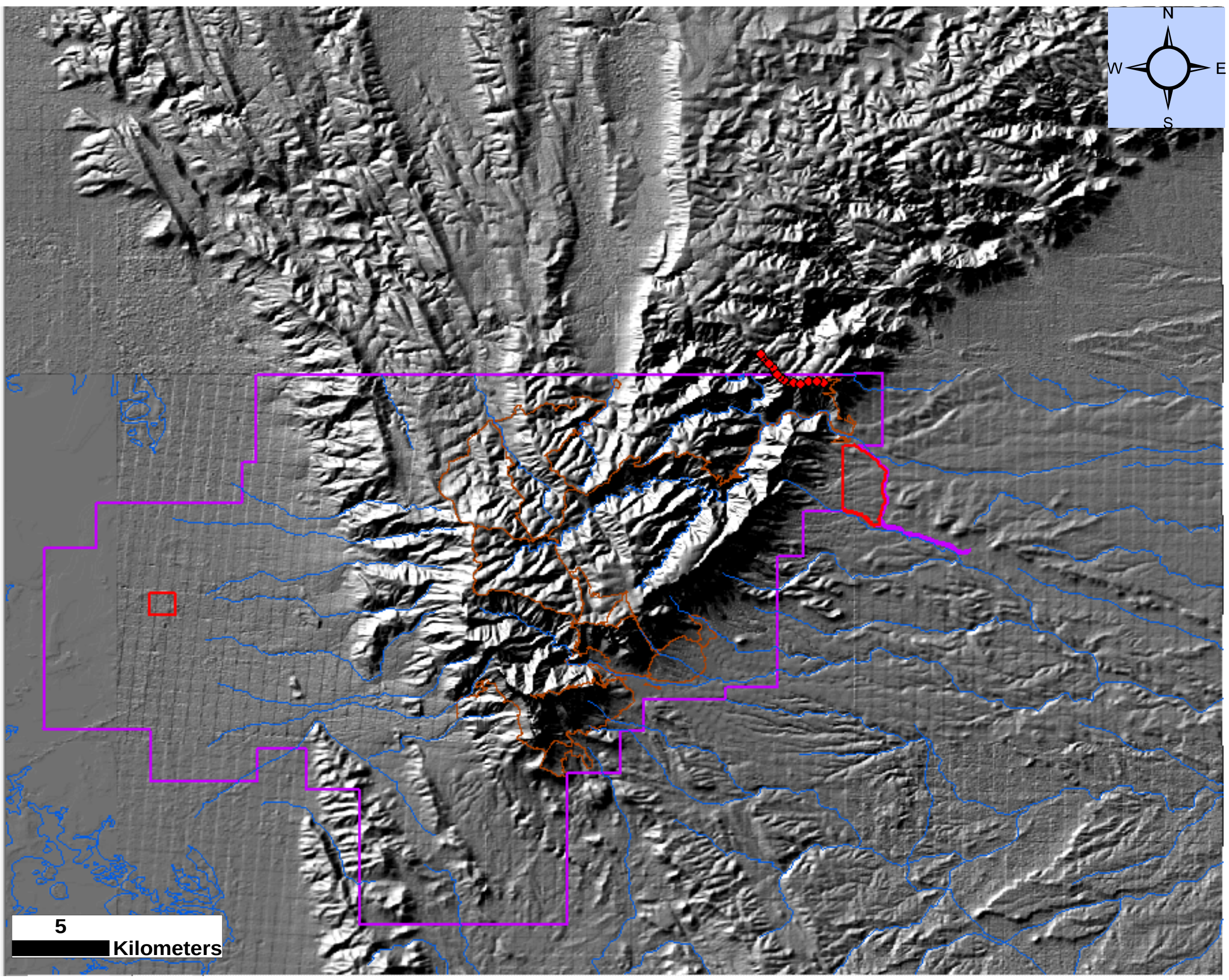


Figure 23: Overview of Guadalupe Mountain National Park, showing trails, streams, and private land.

The next DEM and hillshade (Figure 24) show the fire history from 1960-2002 and the legend explains their causes. Looking at the fire distribution and associated cause, it can be seen that fires caused by lightning, matches, and prescribed burn are the most common. Fires caused by matches burned 12,180 total acres, by lightning burned 15516.35 total acres, by prescribed burn 2619 total acres, and caused by person burned 3229.35 total acres. Total acres burned by other fires are negligible in comparison. These numbers were calculated from the attribute table of the fire history layer by selecting each "cause" of the fire one at a time and selecting the "total acres" row, right-clicking on it, and selecting "Statistics" to get the sum. The results are laid out in Table 2.

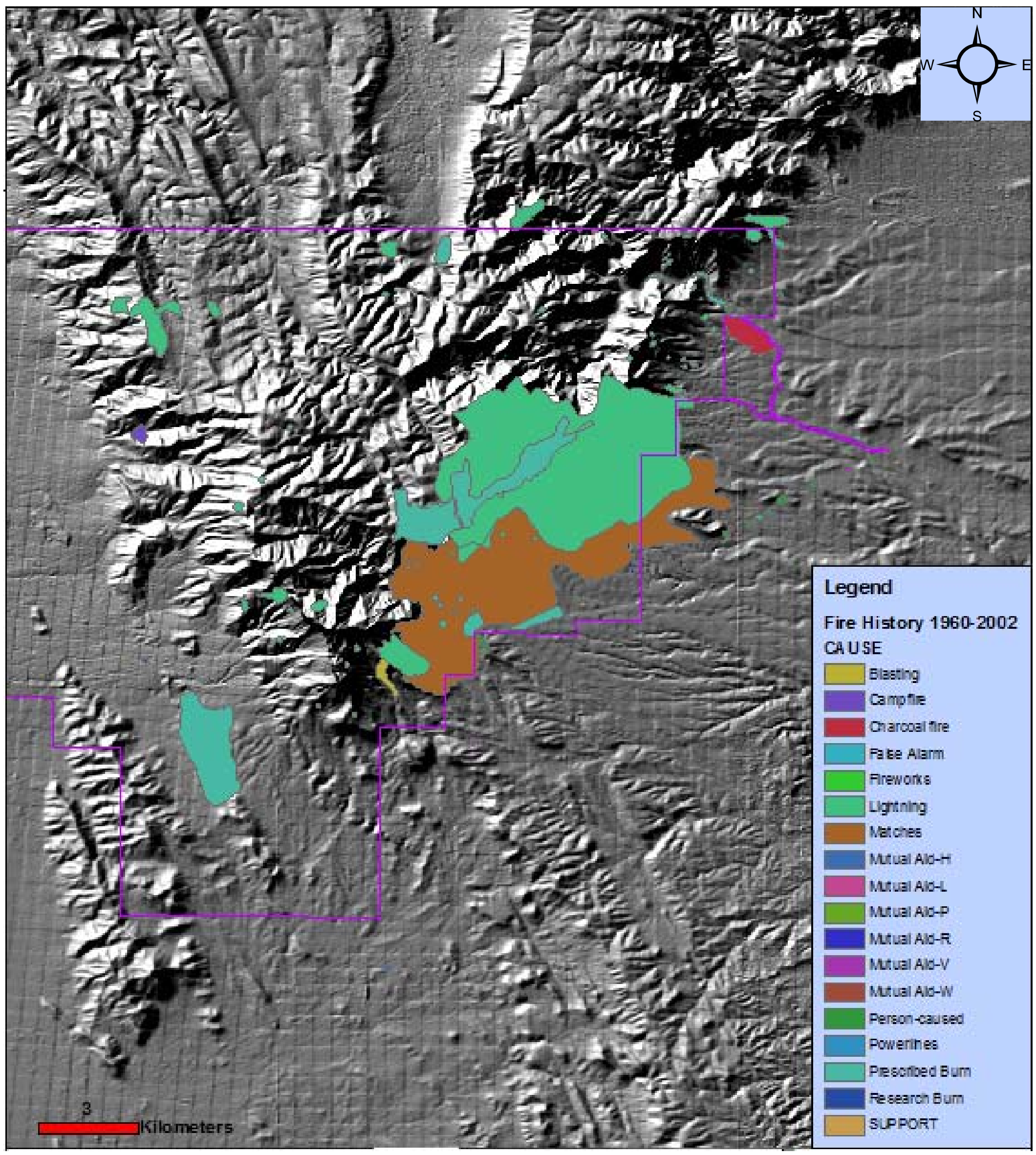


Figure 24: Fire history of the park from 1960-2002 showing different causes of fires.

Cause of Fire	Total Acres Burned
Blasting	165
Campfire	41.5
Charcoal fire	115
False alarm	0
Fireworks	0.1
Lightning	15516.35
Matches	12,180
Mutual Aid	130.3
Person-caused	3229.35
Powerlines	1
Prescribed burn	2619
Research burn	0.13
Total acreage burned by all fires	**33997.73**

Table 2: Different fire types and total acreage burned by them from 1960-2002.

The DEM and hillshade shade shown in Figure 25 show different types of vegetation present in the park. The vegetation layer is set to 30% transparency to show the correspondence between different types of vegetation and elevation. Conifers and mountain shrub dominate higher elevations, while creosote and desert shrub dominate lower elevations. Comparing the vegetation and fire layers, there is a correspondence between conifers and fires caused by lightning. This might be due to two reasons: first, conifers are located at higher elevations, where lightning is more prone to strike, and second, the conifers are taller because they are at higher elevations and thus act as conduits for lightning.

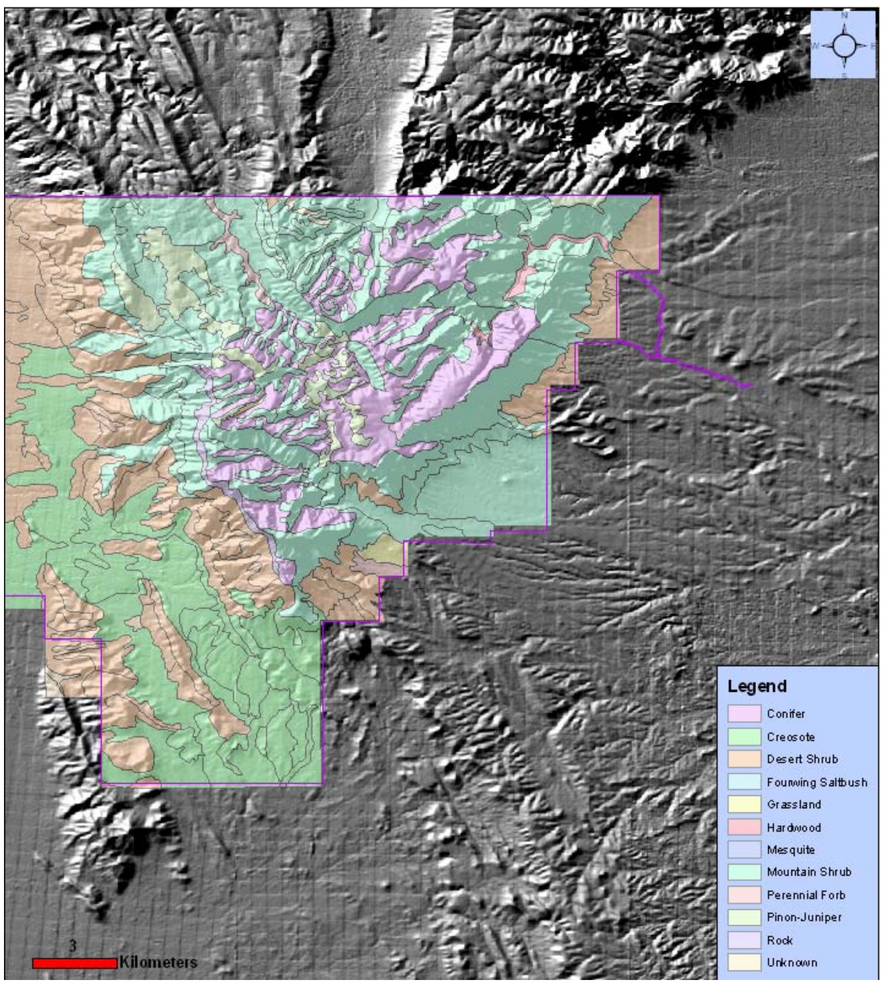


Figure 25: DEM and hillshade showing different types of vegetation found in the park. Scale bar = 3 meters

CONCLUSIONS

For the first part of the project, there is more work that could be done correcting the geologic map. I just focused on the part pertaining to my field area for the scope of this project. There are other formations that are mislabeled, and future work would include repeating the process of digitzing contacts and faults described above. The benefit of this is having an updated and correct geologic map.

For the second part of the project, there does not seem to be any direct correlation between vegetation and occurrences of natural fire. Any correlation might be attributed to two reasons: first, conifers are located at higher elevations, where lightning is more prone to strike, and second, the conifers are taller because they are at higher elevations and thus act as conduits for lightning. The causes of fire in the park are predominantly lightning, people, matches, and prescribed burns. The total acreage burned by all fires is 33997.73. Future work might include doing something similar to what was done with the Yellowstone lab analyzing erosion susceptibility caused by precipitation and fire. The data to do this, however, was not available at the time this project was done.