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Economic Suitability Map of the Lower Eagle Ford Shale Formation in Four Counties in South Texas

Problem:

As a starting point, where in the hydrocarbon rich Eagle Ford Shale Formation are the basic characteristics, depth and thickness, most conducive to economically successful exploration?

Goal:

To create a first order oil & gas exploration suitability map of the Eagle Ford Shale Formation in four core counties in South Texas by taking into account spatial thickness and depth. Thickness will be a positive attribute (larger pay zone) while depth will be a negative attribute (more costly and more risky).

Data Collection:

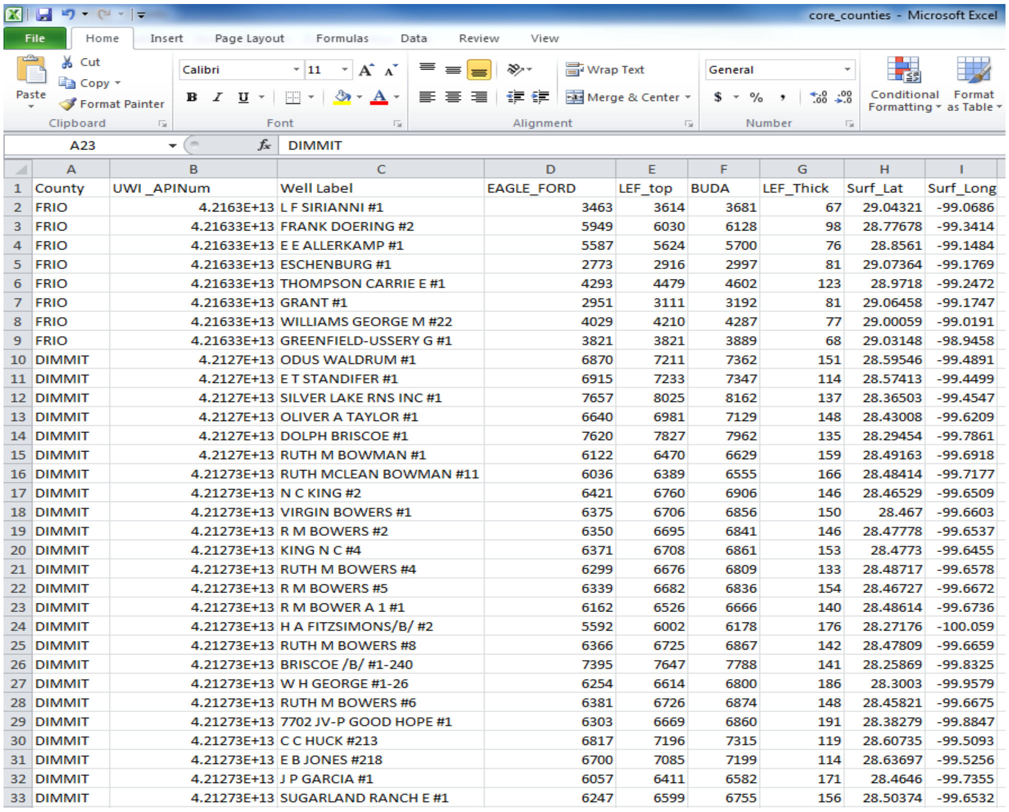
Gather data from Bureau of Economic Geology (have to go to BEG campus to get data, not available online). Tucker Hentz, a staff geologist at the BEG, interpreted public well logs to create databases of formation depths in South Texas and along the coast. To do this he lined up the well logs next to each other and correlated intervals by resistivity signatures. He did this using the PETRA Program. Once familiar with the resistivity signatures, he could determine depth of a formation at each well where well logs are available. Texas Railroad Commission makes well logs available to the public online, and there are several Geology libraries across the state that makes well logs available to members.

We decided to focus on the Lower Eagle Ford (LEF) formation because this formation, with its much greater total organic content, is more economically viable than its local counterpart, the Upper Eagle Ford. We also confined the area of interest to four counties (Dimmit, Frio, La Salle, Zavala), which are considered to be in the core of the play and have a significant amount of well data.

Download the texas counties shapefile from the Texas Natural Resources Information System website (http://www.tnris.state.tx.us/DigitalData/data_cat.htm)

Data Preprocessing:

The data is organized by county in four separate excel spreadsheets. Copy and past the data to consolidate everything into one spreadsheet. The data includes well API numbers, lat and long of well location, the depth of the top of the Lower Eagle Ford (LEF) formation, and the depth of the top of the underlying Buda formation. The lat and long have the defined projection of GCS NAD 1927. We are interested in the thickness of the LEF, so in order obtain this information we need to insert another column labeled LEF thickness. Then, use a function subtracting the depth of the top of the LEF formation from the depth of the top of the Buda formation. Next, convert the LEF thickness and depth from text data to number data in Excel. Also, delete all rows that do not have a top of the LEF value and eliminate any spaces, parenthesis, and periods (Fig. 1).



	A	B	C	D	E	F	G	H	I
1	County	UWI _APINum	Well Label	EAGLE_FORD	LEF_top	BUDA	LEF_Thick	Surf_Lat	Surf_Long
2	FRIO	4.2163E+13	L F SIRIANNI #1	3463	3614	3681	67	29.04321	-99.0686
3	FRIO	4.21633E+13	FRANK DOERING #2	5949	6030	6128	98	28.77678	-99.3414
4	FRIO	4.21633E+13	E E ALLERKAMP #1	5587	5624	5700	76	28.8561	-99.1484
5	FRIO	4.21633E+13	ESCHENBURG #1	2773	2916	2997	81	29.07364	-99.1769
6	FRIO	4.21633E+13	THOMPSON CARRIE E #1	4293	4479	4602	123	28.9718	-99.2472
7	FRIO	4.21633E+13	GRANT #1	2951	3111	3192	81	29.06458	-99.1747
8	FRIO	4.21633E+13	WILLIAMS GEORGE M #22	4029	4210	4287	77	29.00059	-99.0191
9	FRIO	4.21633E+13	GREENFIELD-USSERY G #1	3821	3821	3889	68	29.03148	-98.9458
10	DIMMIT	4.2127E+13	ODUS WALDRUM #1	6870	7211	7362	151	28.59546	-99.4891
11	DIMMIT	4.2127E+13	E T STANDIFER #1	6915	7233	7347	114	28.57413	-99.4499
12	DIMMIT	4.2127E+13	SILVER LAKE RNS INC #1	7657	8025	8162	137	28.36503	-99.4547
13	DIMMIT	4.2127E+13	OLIVER A TAYLOR #1	6640	6981	7129	148	28.43008	-99.6209
14	DIMMIT	4.2127E+13	DOLPH BRISCOE #1	7620	7827	7962	135	28.29454	-99.7861
15	DIMMIT	4.2127E+13	RUTH M BOWMAN #1	6122	6470	6629	159	28.49163	-99.6918
16	DIMMIT	4.21273E+13	RUTH MCLEAN BOWMAN #11	6036	6389	6555	166	28.48414	-99.7177
17	DIMMIT	4.21273E+13	N C KING #2	6421	6760	6906	146	28.46529	-99.6509
18	DIMMIT	4.21273E+13	VIRGIN BOWERS #1	6375	6706	6856	150	28.467	-99.6603
19	DIMMIT	4.21273E+13	R M BOWERS #2	6350	6695	6841	146	28.47778	-99.6537
20	DIMMIT	4.21273E+13	KING N C #4	6371	6708	6861	153	28.4773	-99.6455
21	DIMMIT	4.21273E+13	RUTH M BOWERS #4	6299	6676	6809	133	28.48717	-99.6578
22	DIMMIT	4.21273E+13	R M BOWERS #5	6339	6682	6836	154	28.46727	-99.6672
23	DIMMIT	4.21273E+13	R M BOWER A 1 #1	6162	6526	6666	140	28.48614	-99.6736
24	DIMMIT	4.21273E+13	H A FITZSIMONS/B/ #2	5592	6002	6178	176	28.27176	-100.059
25	DIMMIT	4.21273E+13	RUTH M BOWERS #8	6366	6725	6867	142	28.47809	-99.6659
26	DIMMIT	4.21273E+13	BRISCOE /B/ #1-240	7395	7647	7788	141	28.25869	-99.8325
27	DIMMIT	4.21273E+13	W H GEORGE #1-26	6254	6614	6800	186	28.3003	-99.9579
28	DIMMIT	4.21273E+13	RUTH M BOWERS #6	6381	6726	6874	148	28.45821	-99.6675
29	DIMMIT	4.21273E+13	7702 JV-P GOOD HOPE #1	6303	6669	6860	191	28.38279	-99.8847
30	DIMMIT	4.21273E+13	C C HUCK #213	6817	7196	7315	119	28.60735	-99.5093
31	DIMMIT	4.21273E+13	E B JONES #218	6700	7085	7199	114	28.63697	-99.5256
32	DIMMIT	4.21273E+13	J P GARCIA #1	6057	6411	6582	171	28.4646	-99.7355
33	DIMMIT	4.21273E+13	SUGARLAND RANCH E #1	6247	6599	6755	156	28.50374	-99.6532

Fig. 1: Comma-delimited (csv) Excel spreadsheet

Now we need to import the consolidated comma-delimited (CSV) Excel spreadsheet into ArcMap. Open the "Tools" menu and select "Add XY Data". Browse for the CSV file, select the longitude for the X Field and latitude for the Y Field, click OK (Fig. 2). A warning pops up stating that the table does not have a relational database and therefore is not a feature class yet. In order to make them feature classes, export them as shapefiles. To do this, right-click Table of Contents and choose Data> Export Data. Add the exported data to the map as a new layer.

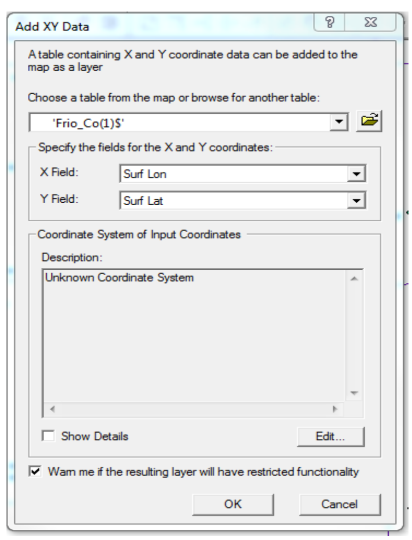


Fig. 2: "Add XY Data"

Add the Texas Counties shapefile as a new layer in ArcMap. Make sure the wells layer is above the Texas Counties layer. Select the counties in the area of interest and export the polygons as a new shapefile. Add the new county shapefile to ArcMap while deleting the old one, and turn on the labels (Fig. 3).

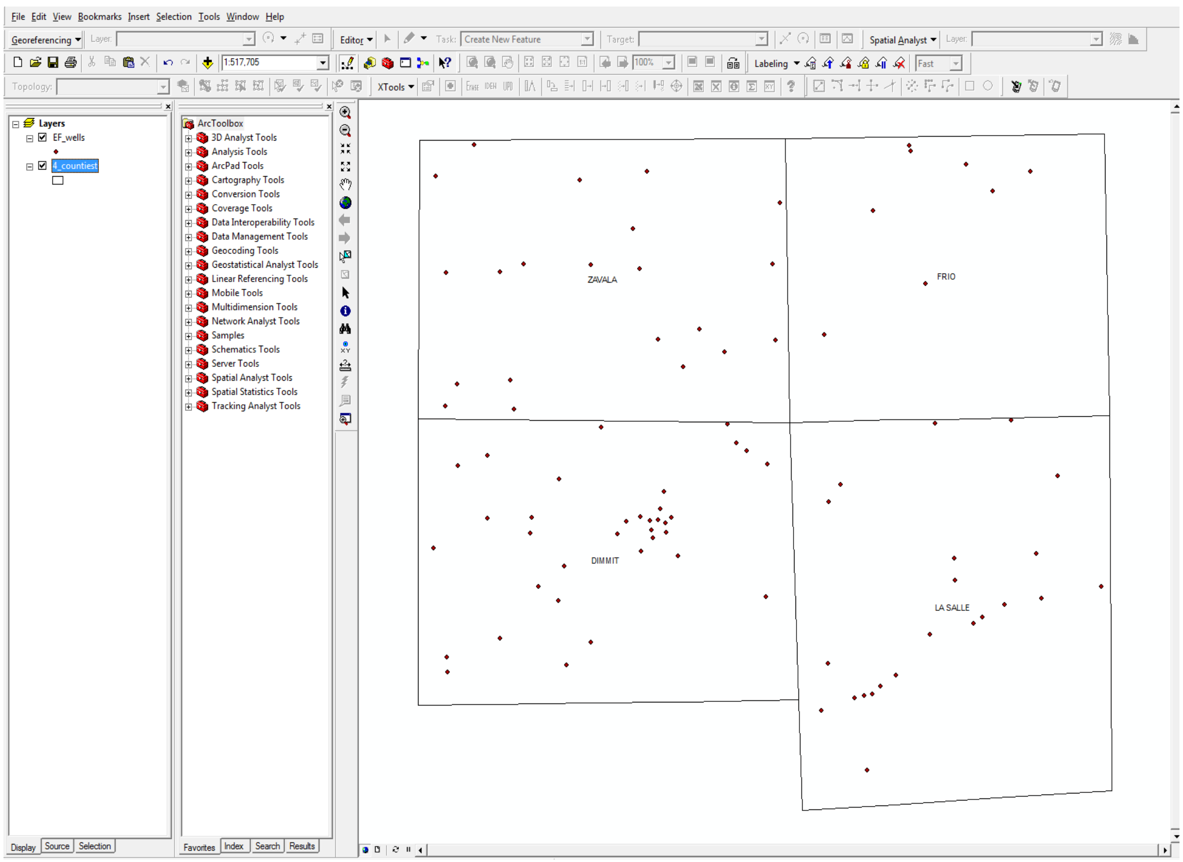


Fig. 3: Texas Counties shapefile and Well locations

ArcGIS Processing:

Create a raster using spline interpolation. Do this by going to the “tools” menu and selecting Spatial Analyses>Interpolation>Spline. Select wells layer as input and LEF thickness for the Z field. Make the cell size .004521 degrees (which equals 500 meters, a whole number in which we can do easy calculations if needed) (Fig. 4) . Click OK . Create another raster using spline interpolation using the same values, but this time use LEF top as Z file.

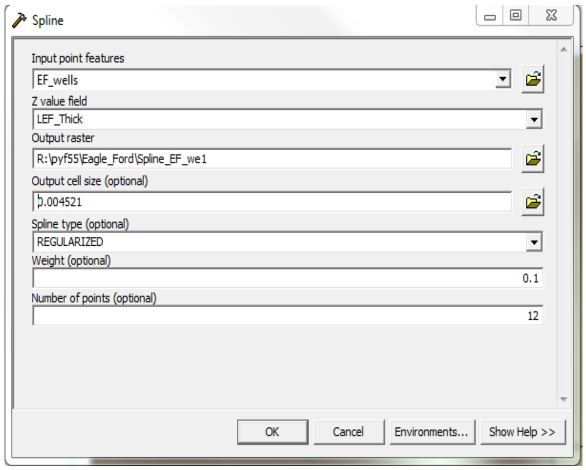


Fig. 4: Spline interpolation tool

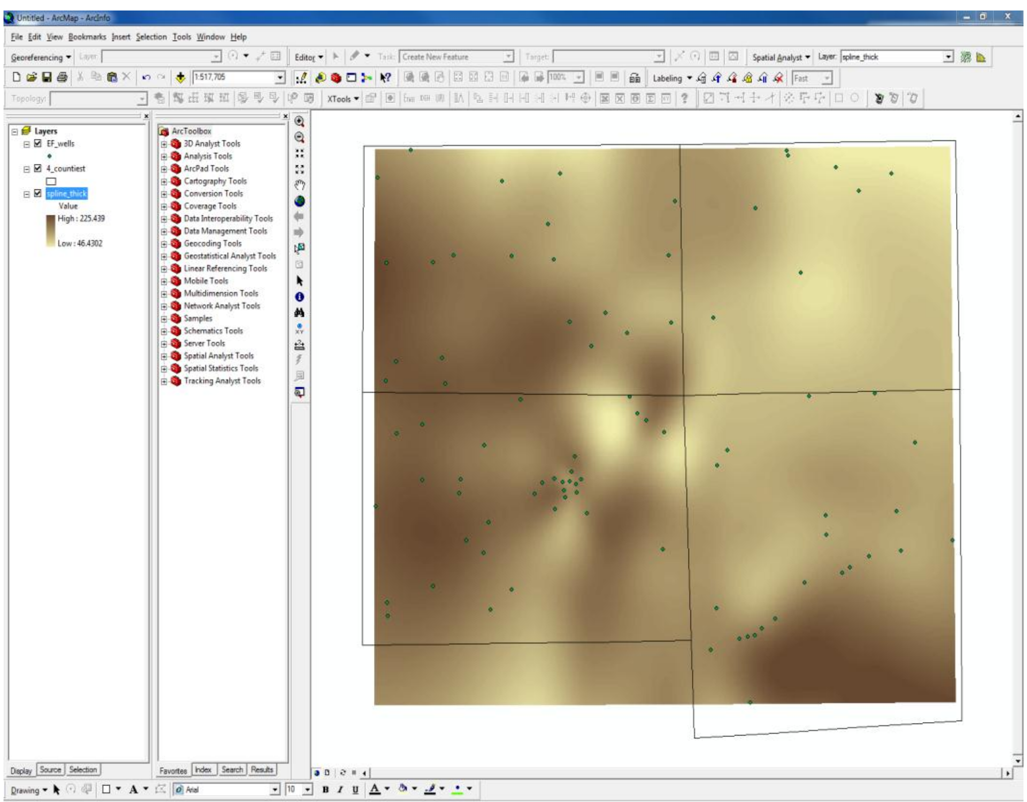


Fig. 5: Thickness raster created by spline interpolation

Reclassify newly created LEF thickness and depth rasters with qualitative interval values. Use the Spatial Analyst>Reclass>Reclassify tool. Select the depth raster for the input raster, then click the classify button. In this window, select defined interval as method and interval Size 1000 (Fig. 6). For depth, I chose 1000ft to be the base unit and attributed a value of 1. So, for the new values, I went with the upper limit of the depth intervals (Fig. 7). When reclassifying the thickness raster, I chose 20ft intervals and gave thickness values where 20ft of thickness has a positive affect 4x greater than the negative affect of 1000ft of Depth (except for the lowest interval for thickness, I used 13 to avoid any zeros). Thickness is a primary factor in the economic potential of hydrocarbon rich shale formations.

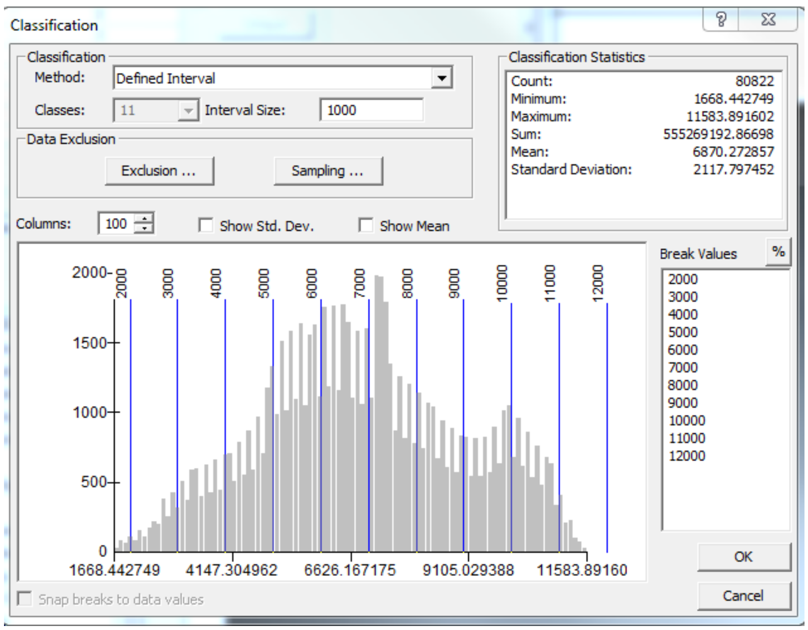


Fig. 6: Interval Clasissification

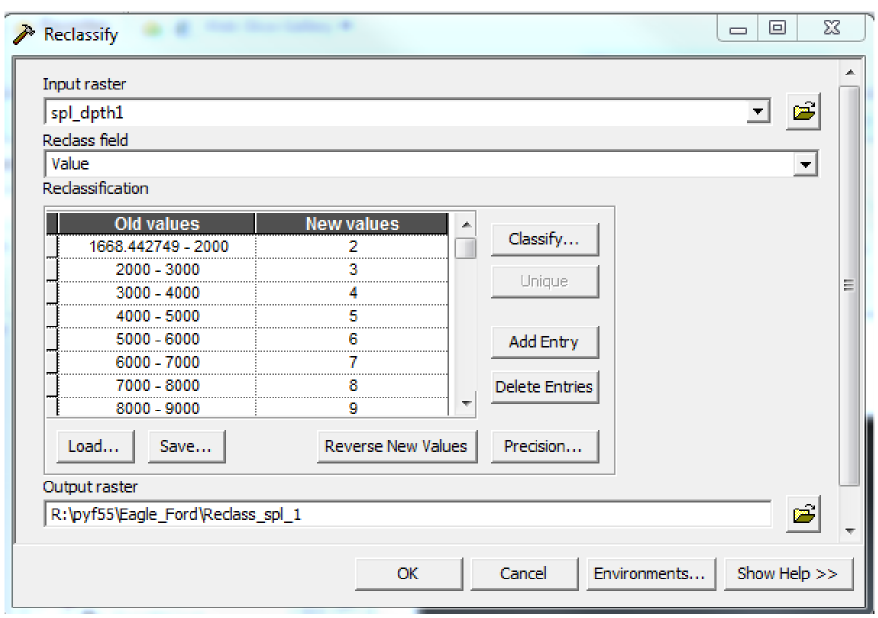


Fig. 7: Reclassify window

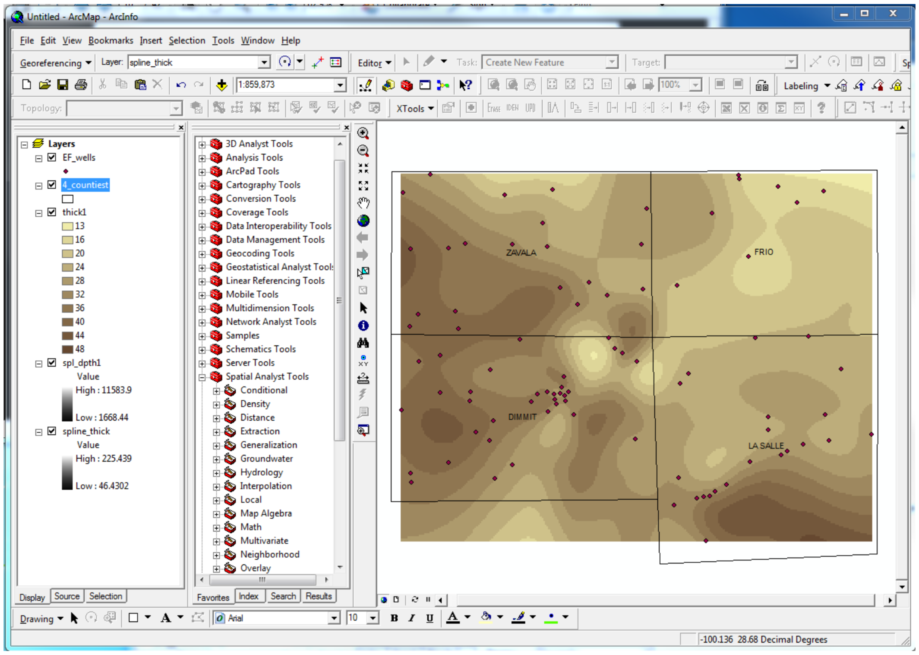


Fig. 8: Thickness reclassified

Clip the reclassified thickness and depth rasters to the 4 counties polygon to remove the overlap section. Go to Data Management>Raster>Raster Processing>Clip tool. Select reclassified thickness raster layer for input raster, 4 counties layer for output extent, and check the box next to “Use Input Features for Clipping Geometry” (Fig. 9). Do the same process for the reclassified depth raster.

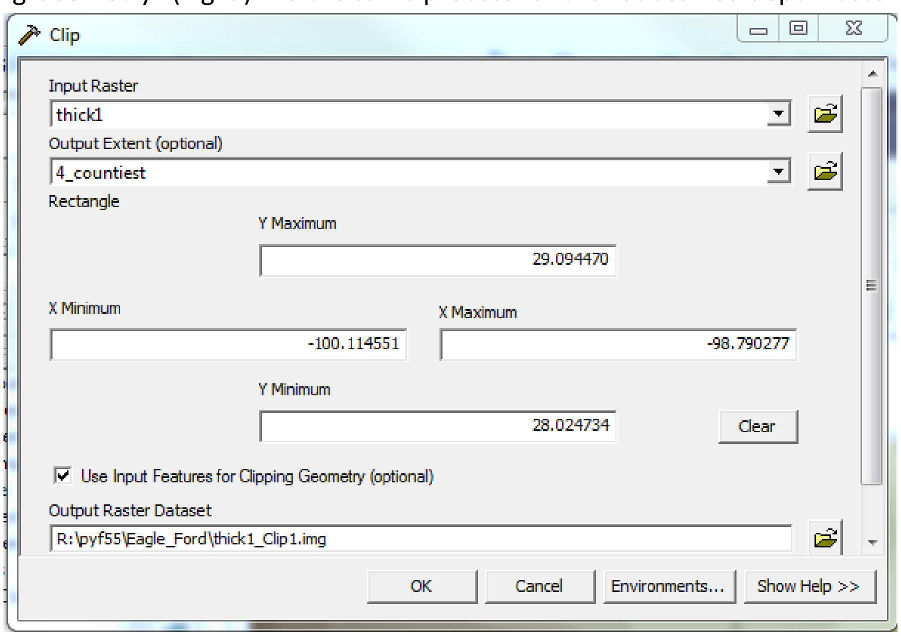


Fig. 9: Clip window

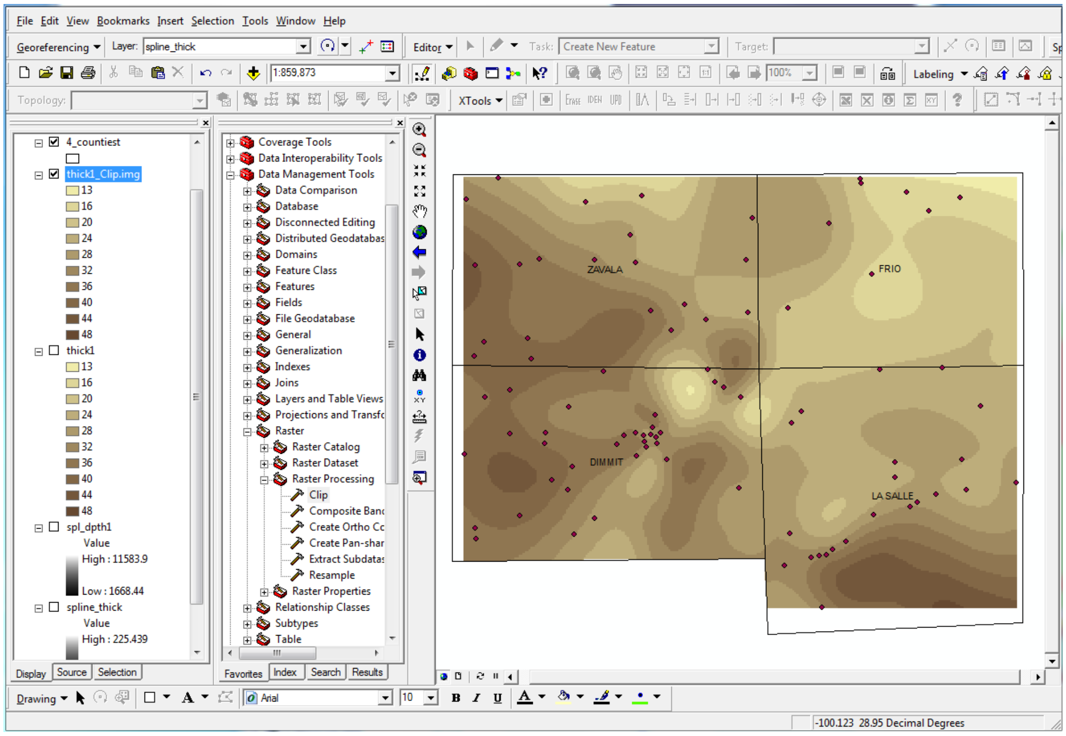


Fig. 10: Clipped Reclassified Thickness

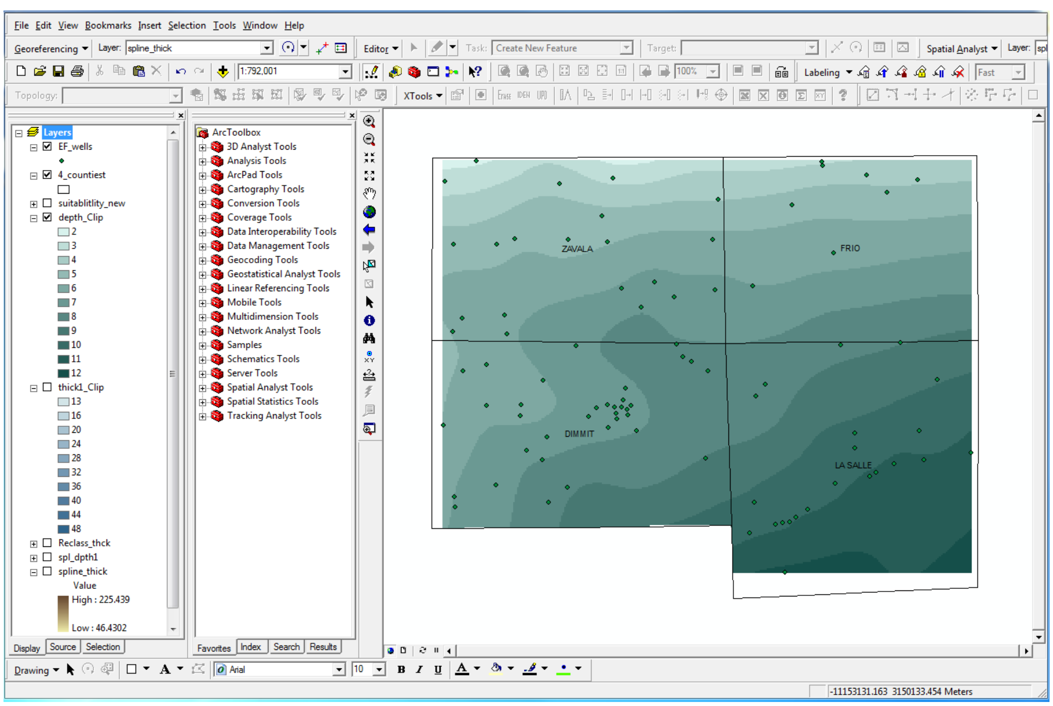


Fig. 11: Clipped Reclassified Thickness

Before performing the raster overlay, set up the extent of spatial analyses. Go to the Spatial Analyst drop down menu and select options. Under the General tab, select one of the clipped rasters for Analysis mask, and under the Extent tab, select one of the clipped rasters for Analysis extent (Fig. 12).

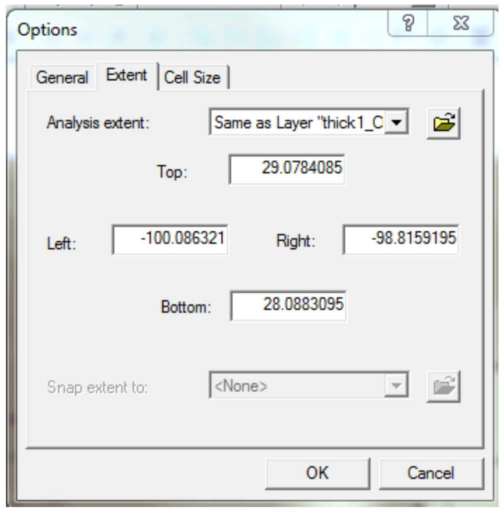


Fig. 12: Analysis extent

Create a raster that takes into account depth and thickness. Use the Raster Calculator that is in the Spatial Analyst drop down menu. Formulate an expression where the clipped reclassified thickness raster is being subtracted by the clipped reclassified depth raster (Fig. 13). Evaluate.

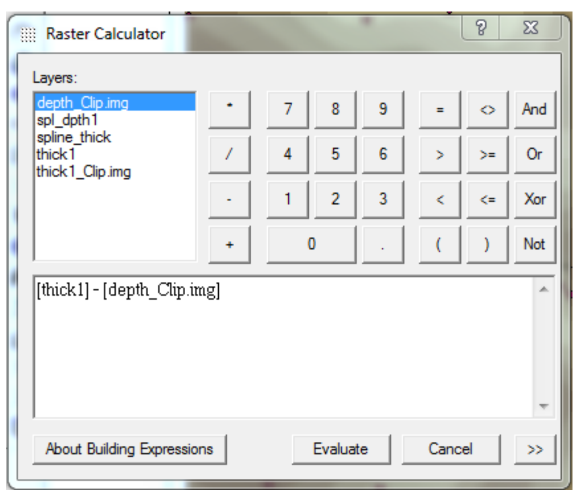


Fig.13: Raster Calculator

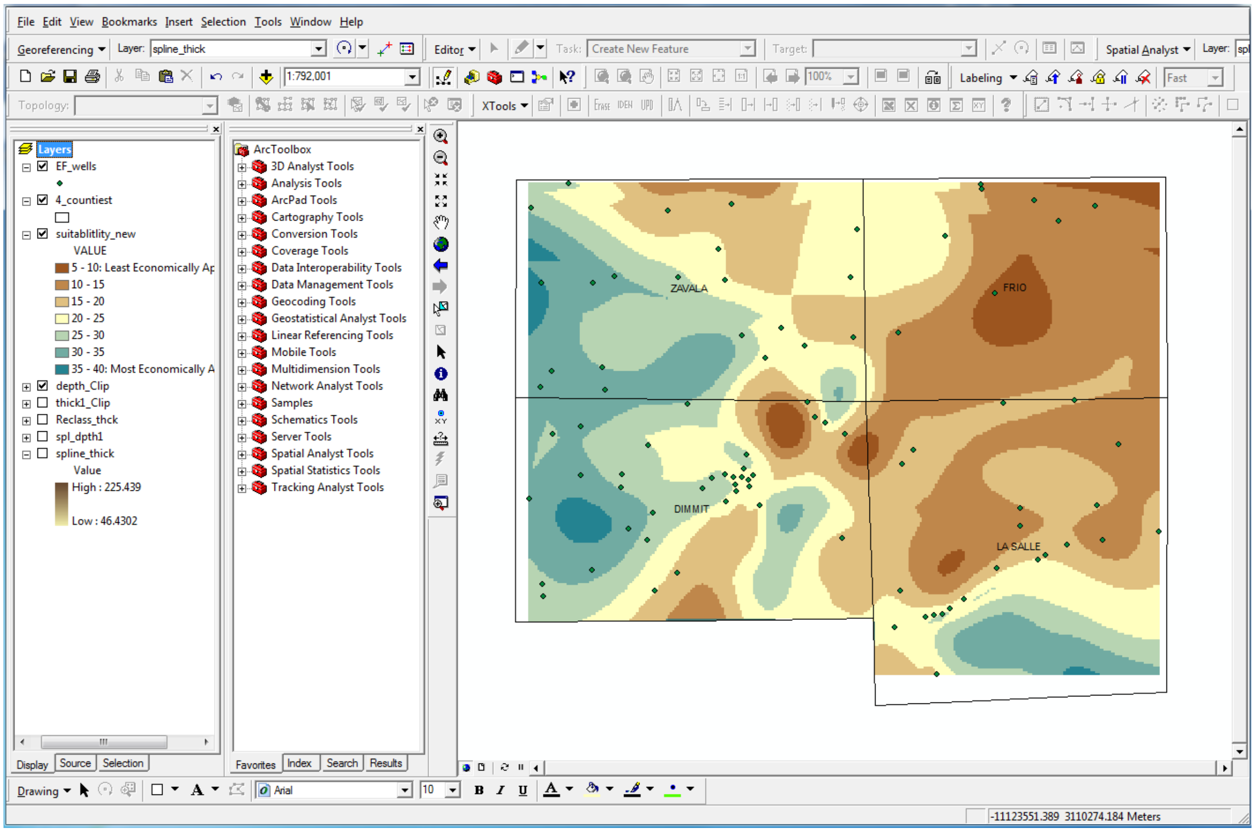


Fig. 14: Resulting Suitability Model Raster

Conclusion:

The trend of the Lower Eagle Ford formation is deepening to the southeast with thicker sections being in the west and southeast. The weight given to thickness caused the economic appeal raster to closely mimic the thickness raster, but there are some areas where depth changed the economic appeal contours. The most economically appealing areas are in western Zavala and Dimmit and in southern La Salle. There are islands of high economic appeal in southeast Zavala and southeastern Dimmit. Frio county is the least economically appealing county.

A Suitability Map of the Lower Eagle Ford Shale Formation in Zavala, Frio, Dimmit, and La Salle Counties in South Texas, Presenting Ranks of Economic Appeal.