Lab 05: Earthquake Analysis in ArcGIS
Due: *05 November 2010*

Objectives:

- Download online XY data and input into ArcMap
- Create a density map from a shape file.
- Create a grid having a shape, which conforms to a specific shape.
- Use join function to join attribute tables of separate layers based on a common field
- Use Extract and Proximity functions within ArcToolbox's Analysis Tools
- Explore ArcMaps's graphing capabilities

Purpose:
This exercise will introduce you different analysis tools available in ArcToolbox. You will become familiar with ArcGIS's plotting functions and learn how to analyze and display your data in both map and graphical formats.

Step 1: Log on to the computers and set up your folder
Log-on:

a) At the login window enter your student user name and password.
b) Create your own working directory:
   1) Open (dbl-click) **My Computer**
   2) Open (dbl-click) your USB flash drive under **Devices with Removable Storage**
   3) Navigate to the folder "***YourLastName_GEO157***", e.g. *Cochran_GEO157*
   4) Create new folder called "***Lab05***"

Step 2: Download earthquake data
In this lab we will be using freely available earthquake data from the Southern California Seismic Network (SCSN) made available by the Southern California Earthquake Center (SCEC). The data are provided in several formats and you can limit the earthquake list by time, magnitude, and location. We will examine earthquakes between 1995 to 2005.

a) Go to www.data.scec.org
b) Click on "Searchable Earthquake Archive (Catalog)"
c) Set the "Output Format" to **SCEDC**
d) Enter the following search parameters:
   1) **Start Date**: 1995 01 01 00 00 00
   2) **End Date**: 2005 01 01 00 00 00
   3) **Minimum Magnitude**: 3.0 **Maximum Magnitude**: 9.0
   4) **Minimum Depth**: 0.0 **Maximum Depth**: 20.0
   5) **Southern Latitude**: 32.0 **Northern Latitude**: 42.0
   6) **West Longitude**: -125.0 **East Longitude**: -114.0
   7) **Event Type**: Local, Regional (shift-click to select both)

8) **Send output to a file**: Yes

e) Click “Submit Request”
f) Save file onto your ***Lab05*** folder, with the name as *earthquakes.txt*.

Step 3: Format the earthquake data for use in ArcGIS

a) Start **Excel**, open a new file
b) Import *earthquakes.txt* file as "Fixed Width" and ensure that a line or column divider separates all of the columns. When you are finished with the Import Wizard, your catalog will open in Excel.
c) Delete all of the columns except Lat, Lon, Depth, Magnitude, and EVID. Delete any extra rows at the top of the file, but leave the column header.
d) Select the MAG, LAT, LON, DEPTH columns; select **Format** > **Cells.** The **Format Cells** window appears; select **Number** under “Category:” and **4** in “Decimal places”
e) To get rid of any hidden, unwanted Excel formatting, highlight all cells containing data and select **File – Save As.** Call the file *earthquakes* in **dBase IV** or **Comma Delimited** format and save to your *Lab05* folder.

Step 4: Copy GIS data from your Lab04 folder

This exercise will begin with a theme (aka shapefile) of California. To prevent corruption or disruption of these data files, you **MUST** first copy these files to your new ***Lab05*** folder.

NOTE: *you **MUST** copy **ALL** components of GIS themes, not just the *.shp component. ALL components of a theme are required for the theme to be visible and editable.*

a) Go to your ***Lab04*** directory. Copy all of the California.* files into your ***Lab05*** directory. There should be 7 files total.
b) If you do not have your ***Lab04*** directory, follow the steps from ***Lab04*** to download the states shapefile, isolate California and save California as a new layer.

Step 5: Start ArcMap, set Layer properties

a) Open Arcmap **(Start > ArcGIS > ArcMap)** and select “a new empty map”. An empty map window appears.
b) Set the Data Frame coordinate system to be NAD 1983 (**Layers** > **Properties > Coordinate System** > **Predefined** > **Geographic Coordinate Systems** > **North America > North American Datum 1983.**
c) Save your empty map as ***YourLastName_Earthquakes_Lab05*** in your new ***Lab05*** directory.
d) Press the **Add Data** button in ArcMap. Navigate to the California state boundary layer data in your new ***Lab05*** folder by clicking the **Connect to Folder** icon. Scroll to your ***Lab05*** folder and when you reach your folder,

press the **OK** button to actually open the folder.

e) Select *California.lyr* by single clicking on it and pressing **Add**.

Note: *California should appear in the ArcMap window. We need to check that ArcMap has the correct projection: North America 1983.*

f) Right click on the California Layer and click on the **Properties > Source** tab and check that the projection is North America 1983 then select **OK.**

Step 6: Add X-Y (lon-lat) data and create a new point theme

a) Add your earthquake data to the map (**Tools > Add XY data**). Set the coordinate system to be NAD 1983.
b) The *earthquakes Events* intermediate theme will be added to your ToC. To make this a fully editable theme, export the earthquakes data as a shapefile (***earthquakes Events*** **> Data > Export Data ...**). Save the new shapefile as *earthquakes_all* in your **Lab05** folder.

Note: *Points should be all over the map, not in a simple grid. If there are* ***NOT*** *a large number of (somewhat) randomly distributed points, you formatted the lat-long columns of the original Excel spreadsheet incorrectly; you must return to that step and perform it correctly.*

c) Remove ***earthquakes Events*** from your ToC and add the shapefile *earthquakes_all*. Change the symbology to fit your preferences.

Note: Don't panic *if the X and Y values do not all show 4 decimal places; AV has chopped off unnecessary zeroes. If you formatted the original Excel sheet correctly to 4 decimal places, each one of the points will plot as in the map above.*

Step 7: Extract subset of earthquake catalog and reclassify by magnitude
Next we want to select only earthquakes that are within California. To do this we can use the Clip function which extracts input features that overlay the clip, or "cookie-cutter", features.

a) Open ArcToolbox and open the **Clip** function (**Analysis Tools > Extract > Clip**)
    1) For **Input Features:** select the layer to be clipped, *earthquakes_all.*
    2) For **Clip Features:** select the layer that acts as the smaller feature, or "cookie-cutter", in this case *California*.
    3) The **Output Feature Class:** will be a new earthquake layer that only contains earthquakes that occurred in California. Navigate to you **Lab05** folder and call the new shapefile *earthquakes_state*. Click **OK**. The Clip function executes.

b) Add the new *earthquakes_state* shapefile to your ToC and change the symbology to fit your preferences.
c) Once you are satisfied that the new *earthquakes_state* file only contains earthquakes in California, remove *earthquakes_all.*
d) For display purposes, we want to show earthquakes of different magnitude as different colors. To do this, we will want to reclassify the magnitudes from unique values into a set of grouped values. To edit the attribute table, we need to start editing by going to the **Editor Toolbar** and select "**Start Editing**". *(**Hint:** If your Editor toolbar is not visible, click View > Toolbars > Editor)*
e) Now we want to query the table by earthquake magnitude and reclassify the records. To query the attribute table, go to **Options > Select by Attributes**.
f) Create an equation that will select earthquakes of magnitude 3-4, enter the equation "MAG" < 4. After clicking "**Apply**", you will find that records meeting your query criteria are now highlighted teal in the attribute table. *(**Hint:** remember that when Selecting by Attributes, you should use the button functions to display the equation instead of typing the equation into the box)*.
g) Now we want to reclassify these using qualitative productivity terms. Click **Options > Add Field**. Call the new field "**MAG_CLASS**" of **Type "Text"** with **length 10**.
h) Right-click on the column heading of the "**MAG_CLASS**" field and select **Field Calculator**. This will allow you to change the selected values in the "**Product MAG_CLASS**" field (column).
i) At the bottom of the Field Calculator window, input that **MAG_CLASS = "3.0-3.9"**. *(**Hint:** "3.0-3.9" must be in parenthesis).* Click **OK** and note that highlighted fields now have a value of "3.0-3.9" in the **MAG_CLASS** field.
j) Clear, or un-highlight, the selection (**Options > Clear Selection**) and perform the method for magnitudes between 4-4.9. Click **Options > Select by Attributes** and create an equation that reads **"MAG" >= 4 AND "MAG" < 5**.
k) Right-click on the column heading of the "**MAG_CLASS**" field and Select **Field Calculator**. Input **MAG_CLASS = "4.0-4.9"**. Click **OK** and note that highlighted fields now have a value of "4.0-4.9" in the **MAG_CLASS** field.
l) Clear, or un-highlight, the selection (**Options > Clear Selection**) and perform the method for magnitudes between 5-5.9. Click **Options > Select by Attributes** and create an equation that reads **"MAG" >= 5 AND "MAG" < 6**.
m) Right-click on the column heading of the "**MAG_CLASS**" field and Select **Field Calculator**. Input **MAG_CLASS = "5.0-5.9"**. Click **OK** and note that highlighted fields now have a value of "5.0-5.9" in the **MAG_CLASS** field.
n) Clear the selection and perform the method for magnitudes between 6-6.9. Click **Options > Select by Attributes** and create an equation that reads **"MAG" >= 6 AND "MAG" < 7**.
o) Right-click on the column heading of the "**MAG_CLASS**" field and Select **Field Calculator**. Input **MAG_CLASS = "6.0-6.9"**. Click **OK** and note that highlighted fields now have a value of "6.0-6.9" in the MAG_CLASS field.
p) Clear the selection and perform the method for magnitudes equal to or greater than 7. Click **Options > Select by Attributes** and create an equation

that reads **"MAG" >= 7**.

q) Right-click on the column heading of the "**MAG_CLASS**" field and Select **Field Calculator**. Input **MAG_CLASS = "> 7"**. Click **OK** and note that highlighted fields now have a value of "> 7" in the **MAG_CLASS** field.
r) When all earthquake records have been reclassified by magnitude, clear any selected attributes, and stop editing by clicking **Editor > Stop Editing. Save** your edits.
s) Change the symbology of the earthquakes to reflect the new reclassification scheme. Go to the **Symbology** tab in the **Properties** of the layer. In the **Show:** window, click "**Categories**" then "**Unique Values**".
t) From the **Value Field** select "**MAG_CLASS**" and then click "**Add All Values**"
u) Choose a color ramp of your preference.
v) Now we want to want to change the size of the symbols so that smaller magnitude earthquakes are represented by smaller symbols and the larger magnitude earthquakes are represented by larger symbols. Double-click the symbol next to the **'>7'** value and change the symbol to **size 20**. Change **'6.0-6.9'** to **size 17**, **'5.0-5.9'** to size **13**, **'4.0-4.9'** to **size 8**, and **'3.0-3.9'** to **size 4**.
w) Next we want to change the symbol levels so that the largest magnitude earthquake appears "on top" of the smaller magnitude earthquakes. Click on **Advanced > Symbol Levels** and check "**Draw this layer using the symbol levels specified below**".
x) Click on the **'>7'** value and using the arrow on the right-hand side of the window, move this value to the top. Position the '6.0-6.9' directly below it and so on to the magnitude '3.0-3.9'. Keep <all other values> at the bottom. Click **OK**, then **Apply, OK** to exit the **Properties** window.

Step 8: Create a Layout and Export your Map

Create a map displaying the earthquake density map and reclassified fault segments for the state of California.

a) Layers that should be turned on are: *California* and *earthquakes_state*.
b) Select **Insert** > **Title** and create a title that briefly describes mapped data and includes location.
c) Select **Insert** > **Legend**. Legend should only have *earthquakes_state*. Change the text of the legend as it should not have '_''s, so you may need to convert the legend to graphics to make edits.
d) Select **Insert** > **North Arrow**. Choose from the long list whichever arrow you prefer and reposition it on your map as you see fit.
e) Select **Insert** > **Scale Bar**. Select a scale bar and use units of kilometers.
f) Select **Insert** > **Text**. Drag the box that appears to the bottom right corner of your layout. Double click the word "Text" and type your name, the lab number, and the date that you created the map.
g) Select **Insert** > **Text.** Enter metadata information for the electronic data used in the lab. Remember to label the information with "Metadata:" and identify each dataset before listing the associated metadata.
h) Export your map as "*YourLastName_EQ_California_Lab05*" in both jpeg and

pdf formats.

i) Select **File** > **Save** to save your ArcMap project before you close.

Step 9: Create an Earthquake Density Map

To create a surface, we will need to use the 3D Analyst and Spatial Analyst functions. Make sure that these extensions are available for use by going to **Tools > Extensions** and then select **3D Analyst** and **Spatial Analyst**.

a) In your **Data View** (NOT Layout View), open the **Geostatistical Analyst, 3D Analyst,** and **Spatial Analyst** toolbars by going to **View > Toolbars > Geostatistical Analyst, 3D Analyst, and Spatial Analyst**. Dock the new toolbars by dragging and dropping them near the ArcGIS main menu.

a) From the **Spatial Analysis** pull-down menu, select **Density**. Input the following parameters:
   1) For the **Input** data use *earthquakes_state*.
   2) Leave **<None>** as the **Population Field**.
   3) Use **Density Type** "**Kernal**"
   4) **Search radius = 0.3**
   5) **Area Units = Square Map Units**
   6) **Output Cell Size = 0.01**
   7) **Output Raster** = *eq_density* (Make sure that you are saving to your ***Lab05*** folder!)
   8) Click **OK**.

b) A theme titled *eq_density* appears in the ToC. Move *eq_density* to the top of the ToC.

c) Change the symbology of your map (***eq_density*** **> Properties > Symbology**), and select the Orange monochromatic color ramp (light to dark orange).

Note: *Notice that the grid is rectangular and has the same north-south and east-west extents as the earthquakes_state theme. Also notice how the grid assumes a shaded appearance, with the darker shades of orange being those areas where earthquake density was greatest.*

Step 10: Masking the Earthquake Data to only show California

The density map we have, while good, doesn't yet have the appearance we want. What we're after is a density map having a shape similar to that of the State of California. In the next several steps we'll create a grid from a shapefile (California) and using map algebra (map calculator), we will subtract one map from the other, again sort of like using a cookie cutter, to obtain a new density map having the same shape as the State of California.

a) In **ArcToolbox** find **Extract by Mask** by going to **Spatial Analyst Tools > Extraction** > **Extract by Mask**

b) In the **Extract by Mask** window that opens:
   1) Use the *eq_density* as the **Input raster**, *California* as the **Input raster**

or feature mask data, and use *eq_den_state* for the name of the **Output Raster**. Remember to save to your ***Lab05*** folder! Then click **OK**.

2) Change the symbology of the *eq_den_state* grid theme (*eq_den_state* > **Symbology**) to a color ramp that shows blue representing low earthquake density and red representing high earthquake density.

Note: *If you've followed the directions, you will have a density map in the shape of California.*

Step 11: Download and Map Faults in California

Scientists agree that movement on faults creates earthquakes. In this section we will download fault data and determine if fault location corresponds to the highest density of earthquakes.

a) Go to http://nationalatlas.gov/.

Note: *The National Atlas is a great resource for digital data, spend a minute clicking through the links at the top of the page (Agriculture - Water) and see if they have data that you may need for your final project in this class.*

b) Near the top of the page, click "**Geology**". On the resulting page, click "**More ...**" under the **Map Layers** section. You are presented with a list of all digital geologic data available for download.
c) Scroll down the page to "**Quaternary Faults**" and click "**View Map Layer Description**."

Note: *The info for this layer states that it is a database containing faults and fault zones in and surrounding the United States. The database only contains major faults which are thought to have produced earthquakes of magnitude 6 or greater in the past 1,600,000 years. Thus this layer maps sources of both historical (less than 150 years) and ancient earthquake sources that can be used in seismic hazard analysis.*

d) Under "**Raw Data Download**", click "**Quaternary Faults**". We want to use the ArcGIS compatible shapefile format, so click on **"qfaultm_25.tar.gz". Download** and **save** the file into your ***Lab05*** folder.
e) Open your ***Lab05*** folder and unzip and then untar the file. If the machines in the computer lab do not have the software to untar, the untarred folder can be found with the **Lab05** assignment on the iLearn website.

Note: *Notice that the qfaultm_25 directory contains a shapefile and several other ArcGIS format files.*

f) Move all of the files into the top tier of your ***Lab05*** folder and clean up your directory by removing the original download file and the *qfaultm_25* folder.

g) Add the *qfaultl_25* layer to your map.

Note: *If you don't see anything in your map display, check that you added* ***QFAULTL_25****, NOT* ***QFAULTM_25****!!!*

h) This is a layer of faults covering the entire United States, but we want to focus our analysis on California. Use the **Clip** function to plot only those faults within the state (**ArcToolbox > Analysis Tools > Extract > Clip**). Based on our previous use of **Clip**, decide which layer should be the "**Input Feature**" and which should be the "**Clip Feature**". Call the new shapefile, "*faults_state*".

Note: *If you have uncertain which feature should be the Input and which should be the Clip, look at the previous step (Step 7) in which we clipped the earthquake catalog to contain only earthquakes that occurred in California.*

i) Add the new *faults_state* shapefile to your ToC and change the symbology to fit your preferences.
j) Once you are satisfied that the new *faults_state* file only contains earthquakes in California, remove *qfaultl_25.*
k) If you will remember, when you first added *qfaultl_25* to your map you received a warning that the layer had no spatial reference. We need to correct this error by assigning a projection to the layer. Open the text file that you downloaded with the National Atlas data, *qfaultm_25.txt*, and determine the projection of the dataset. Define the projection of the layer *faults_state* using ArcToolbox (**Data Management Tools > Projections and Transformations > Define Projection**).

Step 12: Reclassification of Faults based on Slip Rate

Faults with the highest slip rate (amount of movement in a given amount of time) are considered active and the most prone to producing earthquakes. In this section we will examine the relationship between slip rate and earthquake density.

a) Open the **Attribute Table** for *faults_state*. Note that there is a field called "**Rate**"; this is the rate of motion on the fault in mm/year.

Note: *More information on the fields contained in the attribute table can be found in the qfaultm_25.txt file.*

b) We want to reclassify the table to simplify the quantitative slip rate into qualitative potential earthquake productivity with faults having high slip rates corresponding to high productivity (more earthquakes) and faults with low slip rates having low productivity (few earthquakes). To do this we will need to edit the attribute table of *faults_state.* Click the drop down menu of the **Editor Toolbar** and select "**Start Editing**". *(****Hint****: If your Editor toolbar is not visible, click View > Toolbars > Editor)*

c) Now we want to query the table to find the numerical fault slip rate and reclassify to a descriptive slip rate. To query the **Attribute Table**, go to **Options > Select by Attributes**.
d) Create an equation that will select faults with slip rates (**Field: RATE**) equal to **<0.2 or 0.2-1 mm/year**. You may want to use a Boolean operator to define your query. After clicking "**Apply**", you will find that records meeting your query criteria are now highlighted teal in the **Attribute Table.** ***(Hint:** remember that when Selecting by Attributes, you should use the button functions to display the equation instead of typing the equation into the box)*.
e) Now we want to reclassify these using qualitative productivity terms. Click **Options > Add Field**. Call the new field "***Qual_Rate***" (for Qualitative Rate) of Type "**Text**" with **length 10**.
f) Right-click on the column heading of the "***Qual_Rate***" field and select **Field Calculator**. This will allow you to change the selected values in the "***Qual_Rate***" field (column).
g) At the bottom of the **Field Calculator** window, input that **Qual_Rate = "low"**. ***(Hint:** "low" must be in parenthesis).* Click **OK** and note that highlighted fields now have a value of "***low***" in the ***Qual_Rate*** field.
h) Clear, or un-highlight, the selection (**Options > Clear Selection**) and perform the method for medium and high earthquake productivity (**Options > Select by Attributes**), where "**medium**" potential earthquake productivity has a slip rate equal to **1-5 mm/yr** and "**high**" potential earthquake productivity has a slip rate equal to **>5 mm/yr**.
i) When all fault records have been reclassified by potential earthquake productivity, clear any selected attributes, and stop editing by clicking **Editor > Stop Editing.** Save your edits.
j) Change the symbology of the faults to reflect the new reclassification scheme. Go to the **Symbology** tab in the **Properties** of the layer. In the **Show:** window, click "**Categories**" then "**Unique Values**".
k) We want to color the faults based on their potential productivity (potential for producing earthquakes), so in the **Value Field** select "***Qual_Rate***" from the drop-down menu and then click "**Add All Values**".
l) Make sure that the "**Qual_Rate**" values are in the order of "high", "medium", "low". If they are <u>not</u> in this order, click the value that needs to be moved and use the arrows on the right-hand side of the window to change the value's position.
m) Change the color ramp to meet your preferences, making sure that the colors you choose are clearly visible over the earthquake density map.
n) **Save** your project.

Step 13: Create a Layout and Export your Map

Create a map displaying the earthquake density map and reclassified slip rate for fault segments in the state of California.

a) Layers that should be turned on are: *California, eq_den_state*, and *faults_state*.
b) Select **Insert** > **Title** and create a title that briefly describes mapped data and

includes location.

c) Select **Insert** > **Legend**. Legend should include layers *eq_den_state* and *faults_state*. Change the text of the legend as it should not have '_''s, to do this you may need to convert the legend to graphics to make edits. Also, "high", "medium" and "low" should include the range of numeric slip rates represented by each class *(**Hint:** for example "high (>5 mm/yr)")*.
d) Select **Insert** > **North Arrow**. Choose from the long list whichever arrow you prefer and reposition it on your map as you see fit.
e) Select **Insert** > **Scale Bar**. Select a scale bar and use units of kilometers.
f) Select **Insert** > **Text**. Drag the box to the bottom right corner of your layout. Double click the word "**Text**" and type your name, the lab number, and the date that you created the map.
g) Select **Insert** > **Text.** Enter metadata information for the electronic data used in the lab. Remember to label the information with "Metadata:" and identify each dataset before listing the associated metadata.
h) Export your map as "*YourLastName_EQ_Density_Lab05*" in both jpeg and pdf formats.
i) Select **File** > **Save** to save your ArcMap project before you close.

Step 14: Using Proximity Buffer function to correlate faults and earthquakes

In this section, we will explore the relationship between faults and earthquake location. To answer this question, we will use the Proximity tool **Buffer** to create a buffer and determine how many earthquakes in our California earthquake layer are located within a set distance of a mapped fault. We will show our results in both map and plot formats. In general, Excel will do a much better job with plotting tabular data, but we will use the Graph Function in ArcGIS for the purpose of this exercise.

a) In your **Data View** (NOT Layout View), open the **Buffer** function by going to **ArcToolbox > Analysis Tools > Proximity > Buffer**.
    1) The **Input Feature** should be the layer you want to use to create the buffer, in our case, *faults_state*.
    2) The **Output Feature** will be the name of the new buffer. Navigate to your ***Lab05*** folder and name the new feature *faults_state_10km*.
    3) For **Distance**, the **Linear Unit** that we want to buffer will be **10 km**.
    4) Change the **Dissolve Type** to '**All**'. This will 'dissolve' the borders of fault buffers that overlap to create one continuous polygon layer.
    5) Click '**OK**', wait for the buffering calculation to complete, and then add the new buffer layer to your map. You should see that the faults are now surrounded by a 10 km buffer.
b) Open the **Attribute Table** for *faults_state_10km* and note what attributes were saved in the calculation. Close the **Attribute Table** when you are satisfied that you understand any changes that were made during the

buffering process.

c) Now we want to determine how many earthquakes occur within 10 km of the faults. To do this we will want to intersect the buffered fault layer with the earthquake layer. Find the **Intersect** function by opening **ArcToolbox > Analysis Tools > Intersect**.
    1) The **Input Features** will be the two layers that we want to intersect, *faults_state_10km* and *earthquakes_state*.
    2) The **Output Feature** will be the name of the new layer that is created, we will call the new layer *faults_eq_10km*.
    3) Click '**OK**'. Once the intersection calculation is complete, add the new layer *faults_eq_10km* to your ToC.

d) Open the **Attribute Table** for *faults_eq_10km* and note what attributes were saved in the calculation.
e) Next we want to graphically represent the data. In the **Attribute Table** of *faults_eq_10km,* click **Options > Create Graph**. The **Create Graph Wizard** opens to guide you in making a graph.
f) For "**Graph Type**" there are many options, but we want to display the data in **histogram** format.
g) The **Layer/Table** that we want to graph is *faults_eq_10km.*
h) We want to determine what magnitude earthquake is most represented in our 10 km fault buffer. For **Value Field**, select '**MAG**'.

NOTE: *ArcGIS Graph Wizard only plots numerical fields, and because our MAG_CLASS field was assigned 'text' when we created it, we cannot use this field for plotting purposes.*

i) To mimic our **MAG_CLASS** field, we will change the number of bins, or range of data values represented by a single bar. Change "**Number of bins:**" to **5**.
j) Check the box next to "**Show labels (marks)**" to determine the exact number of earthquakes represented by each bar in the histogram.
k) Change the color of the graph to fit your preferences and then click "**Next >**"
l) Change the text of the title to describe what you are showing in the graph.
m) Under **Axis Properties**, we can change the name of axis labels. Change "**MAG**" to "***Magnitude***". Then click "**Finish**".
n) The graph should pop-up in a new window. To save your graph, right-click in the window and choose "**Export**".
o) Under the "**Picture**" tab, choose "**JPEG**", then "**Save**".
p) Navigate to your ***Lab05*** folder and save as *faults_eq_10km_graph*.
q) Repeat steps v-x to also save your graph as a **PDF**.

Step 15: Create a Layout and Export your Map

Create a map displaying the all earthquakes in our catalog in California and earthquakes that occur within 10 km of a fault segment.

a) Layers that should be turned on are: *California, earthquakes_state, faults_eq_10km*.

b) Select **Insert** > **Title** and create a title that briefly describes mapped data and includes location.
c) Select **Insert** > **Legend**. Legend should include layers *earthquakes_state* and *faults_eq_10km*. Change the text of the legend as it should not have '_''s, so you may need to convert the legend to graphics to make edits.
d) Select **Insert** > **North Arrow**. Choose from the long list whichever arrow you prefer and reposition it on your map as you see fit.
e) Select **Insert** > **Scale Bar**. Select a scale bar and use units of kilometers.
f) Select **Insert** > **Text**. Drag the box that appears to the bottom right corner of your layout. Double click the word "**Text**" and type your name, the lab number, and the date that you created the map.
g) Select **Insert** > **Text.** Enter metadata information for the electronic data used in the lab. Remember to label the information with "Metadata:" and identify each dataset before listing the associated metadata.
h) Export your map as "*YourLastName_EQ_Buffer_Lab05*" in both jpeg and pdf formats.
i) Select **File** > **Save** to save your ArcMap project before you close.

Step 16: Using the Proximity function Point Distance to determine if there is a correlation between the size of an earthquake and the number of aftershocks.
In this section, we will explore the relationship between number of earthquake aftershocks and mainshock magnitude. Aftershocks are smaller magnitude earthquakes that occur after a larger magnitude earthquake. Aftershocks usually occur near the epicenter of the mainshock as the Earth's crust responds to the energy of the larger earthquake. Here we will use the Proximity function **Point Distance** to determine which earthquakes in our earthquake catalog may be aftershocks of large magnitude mainshock events. **Point Distance** computes the distances between point features in one layer to all points in a second layer that are within the specified search radius.

a) Open the **Data View** of your ArcMap project. First we need to create a layer containing just earthquakes of magnitude > 6.0. Open the **Attribute Table** for *earthquakes_state* and click **Options > Select by Attributes**.
b) Create a query equation using the **MAG_CLASS** field to select earthquakes of magnitude 6.0 or greater. *(**Hint:** Alternatively you could also use the MAG field).*
c) When you have completed your query and ArcGIS has returned selected records, export the table of selected results (**Options > Export**). Save the table as *large_mag_eq* in your ***Lab05*** folder.
d) Add the *large_mag_eq* table to your map by the method of adding X,Y Data (**Tools > Add XY Data**). Assign the X,Y Data the same projection as the Data Frame *(**Hint**: To find the coordinate system of the Data Frame right-click Layers > Properties > Coordinate System).*
e) Make the *large_mag_eq Events* layer an editable feature by exporting it as a shapefile (***large_mag_eq Events*** **> Data > Export Data ...**). Call the new shapefile *large_mag_eq_lyr* and save it in your ***Lab05*** folder.

f) Remove the *Events* layer and add the new shapefile *large_mag_eq_lyr* to your ToC and change the symbology to your personal preferences.
g) Open the **Point Distance** function by clicking **ArcToolbox > Analysis Tools > Proximity > Point Distance**.
    1) The **Input Feature** will be *large_mag_eq_lyr.*
    2) We are looking for smaller magnitude earthquakes near the large magnitude earthquakes, so the **Near Features** will be *earthquakes_state*.
    3) The **Output** table should be called *large_mag_eq_aftshk* and should be saved in your ***Lab05*** folder.
    4) The **Search Radius** will be 15 kilometers.
    5) When you click **OK**, ArcGIS computers the proximity of earthquakes within 15 km to the large magnitude mainshock and creates a table in your ***Lab05*** folder called *large_mag_eq_aftshk*.
h) Change your ToC from **Display** (so called because your ToC contains layers that are displayed on the map) to **Source**. You can do this by simply clicking the tab "**Source**" at the bottom of the ToC.
i) Find your *large_mag_eq_aftshk* file and open the **Attribute Table**. Note that INPUT_FID is the FID of a large magnitude event (> 6.0), NEAR_FID is the FID of an earthquake in the *earthquakes_state* layer, and DISTANCE is the distance between the smaller magnitude aftershock and the mainshock. Note that there are no positional coordinates (LAT, LON) so we cannot simply add the table to our map using the X,Y Data method.
j) To add the *large_mag_eq_aftshk* file to our map, we will need to assign it coordinates. We can do this by joining *large_mag_eq_aftshk* with a mapped layer that has coordinates, but we will need a common field to join the two tables. We can join *large_mag_eq_aftshk* with *earthquakes_state* using the ID field. From the **Source** tab, right-click *large_mag_eq_aftshk* and select **Joins and Relates > Joins ...**
k) We want to "**join attributes from a table**", with field INPUT_FID in *large_mag_eq_aftshk* matching the FID in *earthquakes_state.*
l) Once the join is complete, open the **Attribute Table** of *large_mag_eq_aftshk*, note that it now has LAT and LON fields for the aftershocks.
m) To map the aftershocks, right-click *large_mag_eq_aftshk* **> Display X,Y Data.** Choose the X,Y fields to be LON, LAT respectively and set the **Coordinate System** to be that of the Data Frame.
n) View the ToC **Display** (click Display tab), and note that now you have a *large_mag_eq_aftshk Events* layer. Convert it to a shapefile called *eq_aftershocks* and save it in your ***Lab05*** folder.
o) Remove *large_mag_eq_aftshk Events* and add *eq_aftershocks* to your ToC. Change the symbology to meet your preferences.
p) Now we want to plot our results. Open the **Attribute Table** for *eq_aftershocks* and click **Options > Create Graph**.
q) For "**Graph type**", choose **Histogram** and for "**layer to graph**" choose *eq_aftershocks*.

r) We want to determine how many aftershocks are associated with each mainshock, so choose "***large_magnitude***" as the **Value Field** or whichever field in your table corresponds to the three large magnitude mainshocks.
s) Because the mainshocks were assigned FID values of 0,1, and 2 in the *large_mag_eq_lyr*, you will want to set the **number of bins** to **3** (there are only 3 earthquakes). Ignore the strange division of values along the X-axis, the ticks actually represent values of 0, 1, and 2.
t) Check the box next to "**Show labels (marks)**" to determine the exact number of aftershocks represented by each bar in the histogram.
u) Click '**Next >**' and change the X-axis label to "***Mainshocks***" (**Axis Properties > Bottom**).
v) Change the title to be more descriptive considering the data displayed.
w) When satisfied, click "**Finished**" and the graph should pop-up in a new window.
x) To save your graph, right-click in the window and choose "**Export**". Under the "**Picture**" tab, choose "**JPEG**", then "**Save**". Navigate to your ***Lab05*** folder and save as *eq_aftershocks_graph*.
y) Repeat step cc) to also save your graph as a **PDF**

Step 17: Using Proximity function Near to determine which earthquakes occur due to movement on certain faults

In this section, we will determine which mapped segment of the San Andreas Fault (SAF) is the most active, or the segment that has the largest number of earthquakes occurring in close proximity. We will use the Proximity function **Near**, which computes the distance from each point in a feature class to the nearest line or point in another feature class.

a) Open the **Near** function by going to **ArcToolbox > Analysis Tools > Proximity > Near.**
b) We want to determine the proximity of earthquakes to certain faults, thus our **Input Feature** will be *faults_eq_10km* and the **Near Feature** will be *faults_state*. Click **OK**.
c) When the Near calculation is finished, open the **Attribute Table** for *faults_eq_10km.* Note there are two new fields, NEAR_FID and NEAR_DIST. NEAR_FID corresponds to the ID of the fault that the earthquake is closest to in distance (NEAR_DIST).
d) We can then correlate the numerical fault ID with the name of the fault by joining the tables. Right-click on *faults_eq_10km* and select **Joins and Relates > Join ...**
e) We want to "**join attributes from a table**" with the field in the *faults_eq_10km* layer being NEAR_ID.
f) We want to join *faults_eq_10km* to the layer *faults_state,* which contains both the name of the fault and the numeric fault ID. The matching field of NEAR_ID in *faults_state* is FID. Click **OK.**
g) Open the **Attribute Table** for *faults_eq_10km* and note that it now contains all the fields from *faults_state* (NAME, RATE, Qual_Rate, ...).

h) Next we want to determine which earthquakes are a result of movement on segments of the San Andreas Fault (SAF) based on the earthquake's proximity to the fault. We will do this with a query equation. Open the **Attribute Table** for *faults_eq_10km* and click **Options > Select by Attributes**.
i) Create an equation that selects earthquakes that have occurred closest to segments of the San Andreas Fault - be sure to include ALL segments that are part of the San Andreas fault system (labeled "San Andreas..."). *(**Hint:** You may need to use Boolean Operators! And be mindful of the ArcGIS query format, for example, you may need to create your query such that Name = A OR Name = B ...)*.
j) When you have completed your query and ArcGIS has returned the selected records, export the table of selected results (**Options > Export**). Save the table as *faults_eq_SAF* in your ***Lab05*** folder.
k) Add the *faults_eq_SAF* table to your map by the method of adding X,Y Data (**Tools > Add XY Data**). Assign the X,Y Data the same projection as the Data Frame (**Layers > Properties > Coordinate System**).
l) Make the *faults_eq_SAF Events* layer an editable feature by exporting it as a shapefile (***faults_eq_SAF Events*** **> Data > Export Data ...**). Call the shapefile *faults_eq_SAF_layer* and save it in your ***Lab05*** folder.
m) Remove the *Events* layer and add the new shapefile *faults_eq_SAF_layer* to your ToC. Change the symbology to meet your personal preferences.
n) Our next step in the analysis is to create a plot showing our results. We will export the pertinent data from the **Attribute Table** in a tabular format that we can then graph in Excel. Open the **Attribute Table** for *faults_eq_SAF_layer.*
o) Right-click the "NAME" field and choose "**Summarize**".
p) In the **Summarize** window, make sure the selected field is "NAME".
    1) Also include in the output table the **MAG** field
        i) check **Minimum**, **Maximum**, and **Average**
    2) Also include in the output table the **Qual_Rate** field
        i) check **First** and **Last** (same as minimum and maximum for text-based fields)
    3) Navigate to your ***Lab05*** folder and save the **Output table** as *faults_eq_SAF_tbl* in **Text File** format.
j) Open **Excel** and import the text file *faults_eq_SAF_tbl* as a '**Delimited**' file type that uses a **comma** delimiter.
k) To determine which segment of the San Andreas fault is the most active, we will count how many earthquakes were calculated to be in close proximity to each segment of the SAF. Create a bar graph plotting the columns NAME on the X-axis and Count (Cnt_NAME) on the Y-axis. If you need assistance plotting in Excel use online help resources.
    1) Give the plot a title and label the X- and Y-axes.
    2) Make sure that each tick label *(i.e. "San Andreas fault ... ")* is visible.
    3) Do <u>not</u> include a legend.

4) Save the Excel file in Excel format as *faults_eq_SAF_xcel* in your ***Lab05*** folder.

l) Export the plot as *faults_eq_SAF_plot*.

Step 18: Prepare a Report (~250 word, or ~1 page)

Use the outlined format below in your report. Be sure to include lab number and title, date report is due, and your name. Please number the pages of your report.

a) Briefly summarize the procedure you used to perform this exercise.
    1) Explain the functions of any Analysis tools that were used.
b) Print a copy of your *YourLastName_EQ_Density_Lab05* final map.
    1) What is the difference between the Analysis functions Clip and Extract by Mask? Consider the circumstances in which we used them in this lab and refer to the online ESRI ArcGIS Desktop Help for more information.
    2) Explain how the earthquake density surface would differ if we had included all earthquakes in our catalog, rather than just earthquakes occurring in California? *(**Hint:** To better answer this question, you may want to visually compare the layers earthquakes_all and earthquakes_state.)*
    3) Is there a strong correlation between mapped faults and areas of high earthquake density? Explain why some earthquake clusters may appear offset from mapped faults.
c) Print copies of your *YourLastName_EQ_Buffer_Lab05* and *YourLastName_EQ_California_Lab05* final maps.
    1) After exploring the relationship between earthquakes and faults, would you be able to look at your earthquake location maps (*YourLastName_EQ_California_Lab05* and *YourLastName_EQ_Buffer_Lab05*) and determine the locations of major faults? Explain your reasoning.
    2) In pencil (and without looking at your mapped fault layer!) draw on your *YourLastName_EQ_California_Lab05* map where you think major faults are located in California. (This is for fun, don't worry about being right or wrong!)
d) Print a copy of your *faults_eq_10km_graph* plot.
    1) What percentage of California earthquakes from our 1995-2005 catalog occurred within 10 km of mapped fault?
    2) Of the earthquakes that occurred within 10 km of a mapped fault, what percentage were less than a magnitude 3.55?
e) Print a copy of your *eq_aftershocks_graph* plot.
    1) Considering the magnitude of the three largest earthquakes in our California earthquake catalog, is there a correlation between number of aftershocks and the magnitude of the mainshock? Explain your answer.
    2) What other datasets should we consider to determine that the smaller magnitude earthquakes are actually aftershocks of the

mainshock? Explain your answer.

f) Print a copy of your *faults_eq_SAF_plot* plot.
    1) From your plot, what percentage of earthquakes in the state occur in close proximity to the San Andreas Fault?
    2) From your plot, which segment of the SAF is the most active based on the number of earthquakes occurring in close proximity? Include percentage of earthquakes occurring on each segment relative to total number of earthquakes occurring near the San Andreas Fault.
    3) What are the maximum, minimum, and average magnitudes of the earthquakes occurring on the most active SAF segment?
    4) What is the qualitative slip rate on the most active SAF segment? From this dataset, does a relationship exist between slip rate and the potential earthquake productivity (number of earthquakes) of a fault? Explain your reasoning.

g) What is the difference between the Analysis functions Near and Point Distance? Consider the circumstances in which we used them in this lab and refer to the online ESRI ArcGIS Desktop Help for more information.

Feel free to also indicate what you liked and didn't like about the exercise, as well as areas for improvement or expansion. Your feedback always improves GIS exercises for future classes.

Turn in a print-out of your report to your TA by the due date. Reports are to be handed in at the beginning of the lab on the due date. An electronic copy of your lab folder from your external storage will also be turned in to TA at this time.

Electronic reports will **not** be accepted for grading. Lab reports turned in after the beginning of lab will be considered late. Late lab reports will incur a point deduction. See course syllabus for more information.