Exercise 2: Map Projections and Coordinate Systems

Before beginning this exercise, read about coordinate systems and map projections at:
https://courses.washington.edu/gis250/lessons/projection/

It is important to understand the difference between a geographic coordinate system and a projected coordinate system and the spatial reference system for each.

Introduction:
Within ArcGIS, every dataset has a coordinate system which is used to integrate it geographically with other layers. It is important that the user ensures that all datasets which they wish to use for a particular map or series of analysis are projected/reprojected according to the same coordinate system. Within ArcGIS, coordinate systems are classified either as geographic coordinate systems (latitude and longitude) or projected coordinate systems (such as the UTM or State Plane).
There are 3 situations in ArcGIS:

1. The original data has no coordinate system **definition (**the data was collected using a particular coordinate system, but the software has not been told what that coordinate system is), you must assign one (**Define**)
2. The original data has a coordinate system definition, and you wish to convert it to another (**Project**).
3. The data has a defined coordinate system, that is different from other data in the data frame. Arc Map will project the data "on the fly", so that all of the data appears together.

The first two situations are dealt with in ArcToolbox and result in the creation of a projection file (*.prj), a simple text document containing coordinate information. ArcGIS provides projection files (.prj) for many predefined coordinate systems, but you can also create and save a projection file for a new coordinate system. That new file can be used to define or project other data sets.

Note that it is possible to map data without having defined a coordinate system. ArcGIS will inform you that your data do not have a spatial referencing system defined but it will enable you to proceed, and map the data without defining one. If you wish to undertake any spatial analysis involving the calculation of distances, areas etc. you must define a coordinate system. In general, it is good practice to define a coordinate system, even if you are not going to specifically undertake spatial analysis.

Procedures:
Setup

1. Download and extract the Exercise 2 data from the class website.
2. Open ArcMap to a blank map.
3. From the Geoprocessing menu > Environments, set your work space and scratch space to your Ex_02 folder.

4. Give your project a name and save it.

Part A: Addressing A Common Problem

1. a. Add the *Maine.shp*.
   b. Right-click on the shapefile name in the Table of Contents (TOC), and select the Source tab.

Q1. What does it say about the coordinate system?

   c. Click OK to close the dialog box.

2. Look at the bottom right side of the screen. The units for the coordinate system are Decimal Degrees, suggesting that this is a **geographic coordinate system**. You should see two numbers. The first (the **longitude**) is negative because Maine is west of the Prime Meridian. The second number (**latitude**) is positive, because it is north of the Equator. Note that ArcMap had no difficulty using the coordinates to draw the map, even though the software did not know that is was a geographic coordinate system.

3. Place your cursor somewhere in the middle of the State and move your cursor right and left (east then west) and note which number changes and how it changes. Then do the same north and south.
4. The add the *Schools.shp.*

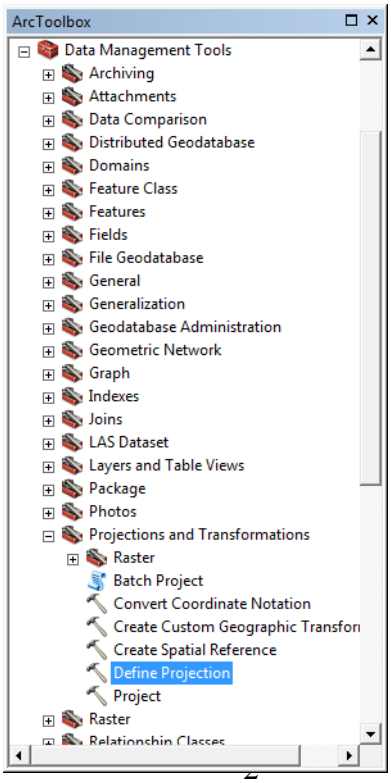
Note: If you get a warning message, click OK to dismiss it.

Q2. Do you see the schools ?

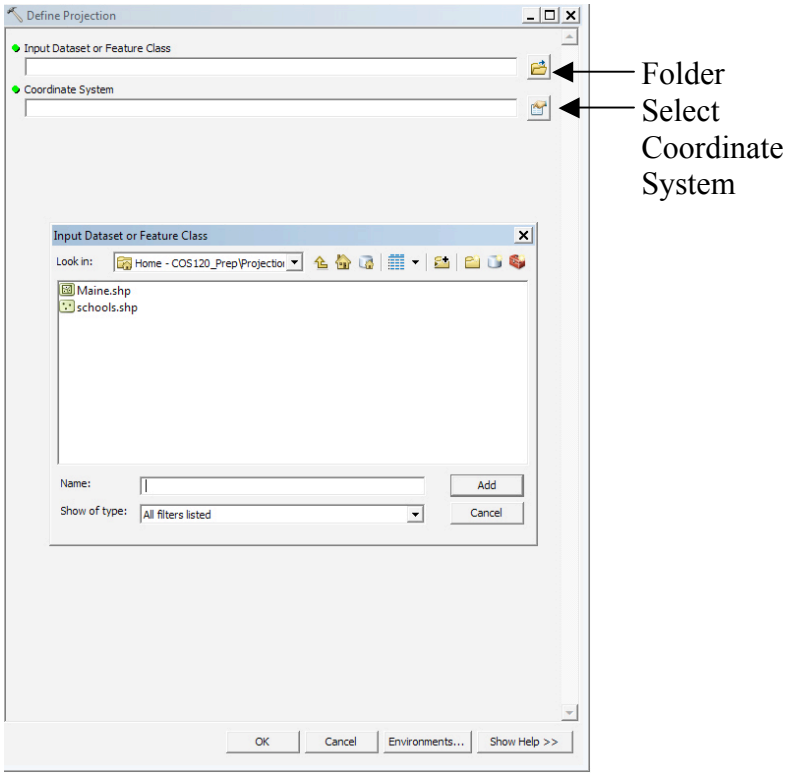
5. Right-click again and choose Properties and click on the Source tab.

Q3. What is the coordinate system for this layer?

6. Close the dialog box.
7. Again right-click on schools in the TOC and select Zoom to Layer. Look at the units. These numbers are so much larger than the latitude and longitude of the state. that they cannot be draw in the same space. This is the problem we want to fix.
8. Sect Insert from the menu bar and insert a new Data Frame.
9. Right-click on New Data Frame in your TOC and select Properties.
   a. Click on the General tab.
   b. Change the name to Geographic
9. Open ArcToolbox. 



10. Go to Data Management Tools > Projections and Transformations > Define Projection, to open the Define Projection dialog box.
11. Click on the folder to open another dialog box. If necessary navigate to your Ex_02 folder and select the *Maine.shp* and click Add.
12. Click on the Select Coordinate System icon.
    a. Expand Geographic Coordinate Systems.
    b. Expand North America
    c. Scroll down to NAD83.



13. Click OK until all dialog boxes have closed.
14. Watch the lower right-hand corner of the screen. You should see that the computer is processing that command, and if it is completed successfully, a grey box with a green check mark will appear (if not successful an error message will appear), and Maine is added to your Geographic Data Frame.
15. Add *Schools.shp* to the Geographic data frame. Even though we now have files in two different projections, the software knows what these projections are and has reprojected the schools file **"on the fly"** to match *Maine.shp*.
16. Right-click on schools.shp in the TOC and select Properties > Source.

Q4. Did the reprojection change the defined projection?

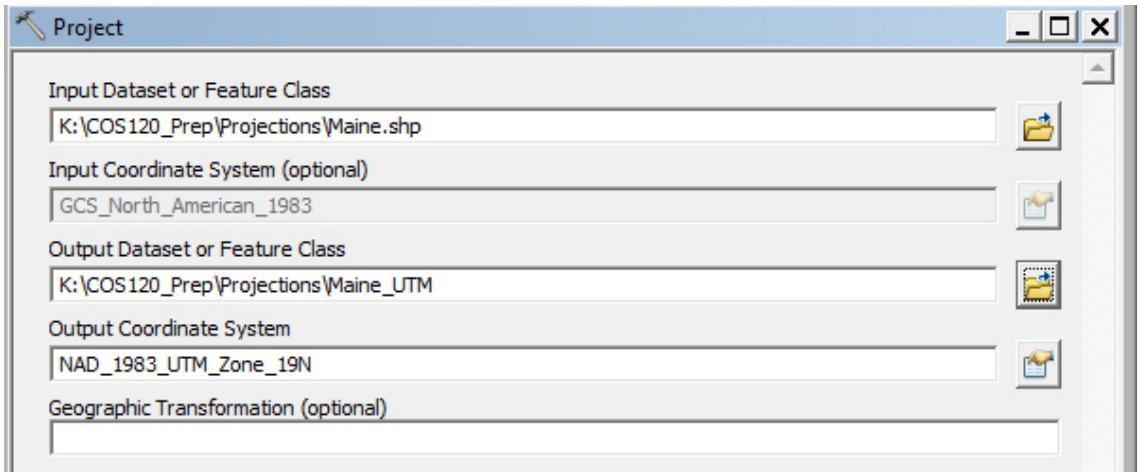
17. Close the Properties dialog box.

A map of Maine doesn't look "right" in a geographic coordinate system. That is because when it is shown alone, it is usually shown in a UTM (Universal Transverse Mercator) coordinate system. Once we have a file defined, we can project it to a different system. In Part B we will

change Maine grom a Geographic Coordinate System to a Projected Coordinate System. Before proceding to Part B, read about the UTM system at http://geokov.com/education/utm.aspx.

B. Projecting/Reprojecting a Data FIle

1. Insert a new Data Frame and name it UTM.
2. Open ArcToolbox and Select Data Management Tools > Projections and Transformations > Project to open the Project dialog box.
   a. Your Input Dataset is Maine.
   b. Your Output Dataset is Maine_UTM.
   c. For your Output Coordinate System:
      i. Expand Projected Coordinate Systems,
      ii. Expand UTM,
      iii. Expand NAD83.
      iv. Scroll down to and select NAD83 UTM Zone 19N.
   d. Click OK.



3. Add Maine_UTM.shp and schools.shp to your UTM data frame.

Q5. Describe the change in the map. (To go back and forth between Data Frames, right-click on the Data Frame Name and select Activate).

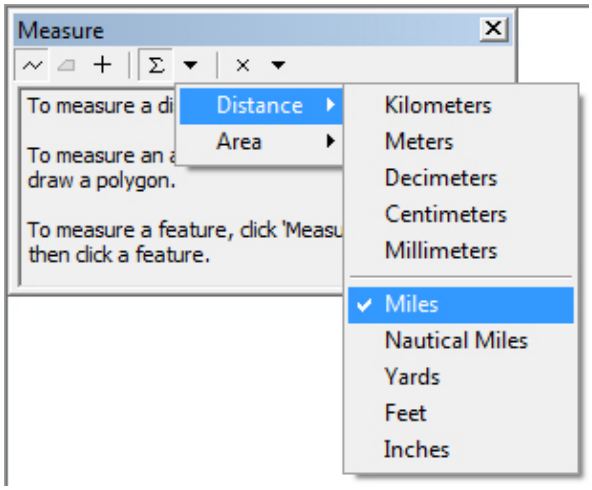
All projections create some distortion in the map, so when we choose a projection, we should be aware of those distortions. We have already seen a change in shape when we went from a Geographic Coordinate System to a UTM System. What about area and distance, Getting the area is beyond the scope of this exercise, but you should be aware that maintaining shape and area are mutually exclusive. If you choose a projection that maintains the shape, area will change and vice versa.

Part C. Projections and Distance

1. Activate the Geographic Data Frame.
   a. Uncheck schools in the TOC.

b. Add North_South_Points_GCS.
c. Change the point color to something easily seen on the map.

2. Use the measuring tool to find the distance, in miles, between the two points.



3. Double click to stop measuring.

Q6. What is the distance (rounded to the nearest whole mile) between the two points?

3. Activate the UTM Data Frame
   a. Uncheck schools in the TOC
   b. Add North_South_Points_UTM
   c. Repeat the distance measurement.

Q7. What is the distance (rounded to the nearest whole mile) between the two points?

Part D: Choosing a Projection

In this class, most of the time we will be working with Maine data, and so the projected coordinate system: **NAD83 UTM Zone 19N** is the one we will use. When mapping the contiguous 48 states, we will use **Albers EqualArea Conic** projection. If you were mapping another state, another country or the world you would need a different projection. A guide to these projections can be found at:
http://webhelp.esri.com/arcgisdesktop/9.2/index.cfm?id=1408&pid=1406&topicname=Choosing_a_map_projection