### Lab 4: Coordinate Systems and Projections

**Introduction**

This lab will introduce you to GIS techniques for dealing with coordinate systems and projections.

**Instructions**

Based on the assigned readings for this week, answer questions in Part I of this lab. Then proceed to the next Parts and complete the hands-on exercises. Before working with the lab data, copy it from the course website onto your flash drive.

**Deliverables**

Answer the following questions and produce the required outputs. Your lab document should be typed, well organized, and submitted based on the “How To” guidelines provided in the course syllabus.

**PART I – Assigned Readings**

***Textbook – Bolstad (Chap. 3)***

1. Briefly describe how Eratosthenes estimated the circumference of the Earth.
2. Why is an ellipsoid, rather than a sphere, a better geometric model of the Earth’s surface?
3. What is the geoid? How does it differ from an ellipsoid in representing the Earth’s surface?
4. What separates east from west longitudes?
5. What is a datum? What are two major components of a datum?
6. Do monumented points move during a datum shift? Why or why not?
7. Why are distortions unavoidable when making flat maps?
8. Is the type of distortion consistent across all portions of a map? Provide an example.
9. What are the three types of developable surfaces used to create most map projections?
10. Which type of map projection - transverse Mercator or Lambert conformal conic – is most appropriate for each country, in order to minimize overall distortion?
    1. Benin
    2. Bhutan
    3. Slovenia
    4. Israel
11. In the State Plane coordinate system, is each US state covered by a single zone?
12. In the UTM coordinate system, how are distances specified?
13. How can distortion be reduced for maps showing the entire world?

***ESRI ArcGIS 10 Online Help Files***

1. What is the difference between geographic and projected coordinate systems?
2. What are the three most commonly used datums in North America?
3. What is the only use for the “Define Projection” tool?
4. What does the “Project” tool do?
5. How does the coordinate system of a data frame get chosen?

**PART II – Using the “Define Projection” & “Project” tools**

***Goal***. Familiarize yourself with the tools available in ArcGIS that deal with defining and changing projections in your data. The data for this exercise is located in the Lab 4, Part 2 folder.

* Open a blank .mxd in ArcMap and add the ***OregonState shapefile first***, and the ***OregonRailroads shapefile second***. If you get a warning message that says “unknown spatial reference” click OK. You will notice that the Oregon Railroads layer does not show up.
* Right-click on the railroads layer and click “Zoom to Layer.” It has actually been added to the map, but does not overlay with the OregonState layer. Open the Layer Properties window for OregonRailroads - right-click on the layer name in the Table of Contents, and select the Properties option. Click on the Source tab.

1. **Does the data have a defined coordinate system or projection?**

* Close the Layer Properties window. Open the ArcToolbox window, then look in the toolbox called “Data Management.” Expand the “Projections and Transformations” toolset and open the “Define Projection” tool. Define the coordinate system for OregonRailroads as: “WGS 1984 UTM Zone 10N”. This is a *projected coordinate system*, so browse to thefolder: Projected Coordinate Systems > UTM > WGS 1984> Northern Hemisphere.

1. **After defining the projected coordinate system, did the layers line up?** **Explain why this happens.**

* Look again at the Layer Properties > Source tab for OregonRailroads.

1. **Did you correctly add a projection definition file? How can you tell?**

* Let’s assume that you need to calculate area for the OregonState shapefile. You’ll need to use the “Project” tool to create a new dataset that has an Equal Area projection. Look for the Project tool in the ArcToolbox > Data Management > Projections and Transformations > Feature toolset.
* Open the Project tool and set OregonState as your input dataset. Name the output file “OregonAlbers”. Select an appropriate Equal Area projection – a good choice for the US is “USA Contiguous Albers Equal Area Conic.” Browse through the coordinate system folders to find this projection (Hint: it’s a *projected* coordinate system that also works well to show the entire *continent* of North America). Add the new dataset to your map.

1. **Does it look any different from the original file? Explain why or why not.**
2. **In Layout view, display the OregonRailroad and OregonAlbers datasets. (I should be able to see that both layers) Add your name to the layout, export the map as a .jpg and insert into your lab document.**

**PART III: Troubleshooting Projections**

Goal: Using a new lab dataset, practice how to troubleshoot through all the possible reasons your data is misaligned due to possible projection issues. ***Note: This assignment is meant to “not work” through the first few steps. Be patient, and understand that it is a troubleshooting exercise.***  You will need to access three shapefiles (Willamette Valley boundary, streams for the Willamette Valley and highways for the Willamette Valley) that are in the Lab 4, Part 3 folder.

Coordinate system information for your reference. Do not make changes in your dataset until you are instructed to do so!

The **boundary** file is in a projected coordinate system of NAD 1983 (US feet) State Plane Oregon North (FIPS 3601). The **highways** file is in a projected coordinate system of NAD 1983 UTM Zone 10N.

* Open a new empty map in ArcMap and add the Willamette Valley layers in the following order: ***Boundaries* first, *highways* second and *streams* third**. You will see that the different layers do not overlay each other and display together.
* Click on the View Full Extent button (the globe). Only two layers are shown.

1. **Why do think you cannot see the third layer?** If you select Zoom to Layer, you will see that it is on the map. (Hint: Zoom out repeatedly on the third layer. Also use the Layer Properties > Source tab to examine the ***units*** of the three layers.)

* Next, define the projection coordinate system for the highways layer using the coordinate system information listed above.

1. **Did the position of the layers change? Why or why not?**

* Now open a new empty map in ArcMap, and this time add the datasets in the following order: ***Highways* first, *streams* second and *Boundary* third**.

1. **Explain why two of the datasets now align and the other does not?**

* Now change the coordinate system for the map’s *Data Frame*. To do this, right-click on “Layers” (the yellow icon at the top of the Table of Contents), select the Properties option, then the Coordinate System tab.

1. **You will see that it is currently set to the projected coordinate system of the highways layer. Why is this?**

* Close the Data Frame Properties window. Next, define the projected coordinate system for the Boundary layer using the coordinate system information listed above.

1. **Describe what happened on your map after you made this change.**

* Re-open the Data Frame Properties window, and change the Data Frame coordinate system to match that of Boundaries. Note whether any of the layers are removed from your map.

1. **Do you need to have all of the datasets in the same spatial reference system to display them together? Why or why not?**
2. **Add your name to the layout, export the map as a .jpg and insert into your lab document.**

**PART IV: Distance Measurement and Type Basics**

Goal: To better understand how distance on a map changes when the map projection changes.

* Start ArcMap, and add two data frames. Name one “Albers”, and the other “Mercator”.

*Working with the Albers Data Frame*

* **Activate** the Albers data frame, and add the layers "twocity\_Albers.shp” and “USA\_48\_Albers.shp” from the Lab4data, Part4 folder.
* Click on the **Measure Tool** Description: measure tool to enable it, and set the **Distance Units** to Miles.
* Left-click once on Los Angeles, then move the mouse to New York and double left-click on New York.

The distance between the two cites is displayed, either in a drop-down window, or at the bottom left of the ArcMap window (it depends on the version and setup). Your measured distance should be approximately 2,440 miles.

*Working with the Mercator Data Frame*

* **Activate** the Mercator data frame, and add the layers” twocity\_Mercator.shp” and “USA\_48\_Mercator.shp”.
* Re-measure the distance from LA to NY. The new measurement should be approximately 3,127 miles.

The on the “ground distance” between LA and NY is actually 2,444 miles.

1. **Why is there a difference in measurements between the “Albers” and “Mercator” data frames?**
2. **Create a map layout containing both data frames. Add a map title and your name to the layout, export the map as a .jpg and insert into your lab document.**