MANAGING COMMON OREGON MAP PROJECTIONS IN ARC MAP

I. Common Map Projections Used in the State of Oregon

The following text blocks provide a listing of the critical parameters for UTM Zone10 N, StatePlane North, and Oregon Custom Lambert. These will be the primary projections we will be using for work on Oregon GIS in our neighborhood.

UTM Zone 10 N NAD1927
Units: meters
False Easting: 500000
False Northing 0
Prime Meridian: Greenwich
Transverse Mercator
Central Meridian: -123
Central Parallel: 0
Scale Factor: 0.9996
Ellipsoid (spheroid): Clarke 1866

UTM Zone 11 N NAD1927
Units: meters
False Easting: 500000
False Northing 0
Prime Meridian: Greenwich
Transverse Mercator
Central Meridian: -117
Central Parallel: 0
Scale Factor: 0.9996
Ellipsoid (spheroid): Clarke 1866

Oregon State Plane North - NAD 1983 – Feet International
Units: feet
False Easting: 2500000
False Northing 0
Prime Meridian: Greenwich
Lambert Conformal Conic
Central Meridian: -120.5
Central Parallel: 43.6666
Standard Parallel 1: 44.333333
Standard Parallel 2: 46
Ellipsoid (spheroid): GRS 1980

Oregon State Plane South - NAD 1983 – Feet International
Units: feet
False Easting: 1500000
False Northing 0
Prime Meridian: Greenwich
Lambert Conformal Conic
Central Meridian: -120.5
Central Parallel: 41.6666
Standard Parallel 1: 42.333333
Standard Parallel 2: 44
Ellipsoid (spheroid): GRS 1980

Oregon Custom Lambert Projection (Statewide Lambert – Feet International)
Geographic Datum: 1983_NAD
Units: Foot (international 1 ft - 0.3048 m)
Geographic Coordinate System: GCS_North_American_1983
False Easting: 1312335.958
False Northing: 0.0
Prime Meridian: Greenwich
Base Projection: Lambert_Conformal_Conic
Central Meridian: -120.5
Central Parallel (Latitude of Origin): 41.75
Standard Parallel 1: 43
Standard Parallel 2: 45.5

II. DEFINING PROJECTIONS FOR UNKNOWN DATA SOURCES

Arc Toobox provides tools for converting and defining projections for vector and raster data files. "Defining projections" creates a *.prj file that helps ArcMap complete "on-the_fly" projection transformations. The "project" tool, takes map data of a known projection, and reprojects into a completely new file format with a new projection system.

"Define" projection tool simply designates a projection

"Project" tool – transforms the data into a new coordinate system.

NOTE: IT IS IMPERATIVE THAT YOU USE THE "DEFINE" AND "PROJECT" TOOLS IN ARCTOOL BOX FROM THE ARC-CATALOG PLATFORM (NOT IN ARCMAP)

A. **Defining projections** for feature data sets with unknown source (creating *.prj files)
    a. **Open the ArcCatalog Software Environment (do not use projection tools in ArcMap; the "on-the-fly" projection routines in ArcMap can cause confusion and run-time errors)**
    b. Open Arctoolbox – pull down "Data Management" tools Menu
        i. Pull down Projections and Transformations menu
            1. Pull down Features menu (for vector projections)
            2. Pull down Raster menu (for images and grids)
            3. Locate the "Define" projection tool on the list below features and rasters

Examine the tools available for managing vector and raster-based data files and related projections. Explore the collective functions using the help menu to familiarize yourself with the objectives of the tools.

B. In-Class Exercise – Defining Projections for Data Source Files in Oregon / Monmouth Area

Step 1. Download Class Exercise Data From Website and Save to Your Local Drive (H:/student folder)

A) go to web site, look under the Lab Data Section - Map Projection Exercise

i) sequentially click on the monmouth quad geology, roads, vegetation, and DRG *.zip files

ii) save them to your network H:/ student folder

iii) Use WinZip to Extract the Compressed Files

a) use my computer - H:/ folder - click on *.zip file to extract

NOTE: All of these map themes are from the Monmouth 7.5' Quadrangle.

Step 2. Activate ArcMap Software

A) In the "Table of Contents" , add the following "feature data source" shape files to the data frame: mongeo.shp, roads.shp, stateveg.shp

B) 1 by 1, examine each theme, checking them on / off, rt-click and zoom to the active layer

C) Check all themes on the table of contents, zoom to full extents.

QUESTION: Why don't the themes overlay one another? Why is the full extent map view so screwy?

D) Remove / delete all of the above themes from the table of contents / data frame.

Step 3. add the following "image data source" file: monmouth.tif; add the following "feature data source" mongeo.shp (monmouth geology)

A) Check both themes in the table of contents. Explore the data in both themes by zooming, overlaying, inquiring.

QUESTIONS: **What type of data is associated with the mongeo.shp map theme?**

Do both of these themes overlay one another properly in geospace?

B) Now try adding the other vegetation and roads themes, do they properly line up in geospace?

What is the problem with this set of data?

Step 4. Your first goal is to define the projections for the Monmouth.tif, mongeo.shp, roads.shp and stateveg.shp files, and create related *.prj files

A) Use "my computer" and click on the following text files to examine the metadata for these map themes: road_meta.txt, mongeo_meta.txt, and stateveg_meta.txt (these are metadata text files that provide information on the projections for each of the files)

Task: **list and the discuss the map projections used for each of the map layers, fill in the table below:**

File Name	Projection	Datum
monmouth.tif	____________	_____________
mongeo.shp	____________	_____________
roads.shp	____________	_____________
stateveg.shp	____________	_____________

B) Now in your main project folder on the "H:\" drive, create the following 3 subfolders to organize your data according to projection type:

a. UTM
b. State_Plane
c. Oregon_Lambert

Sort, Organize / cut and paste the 4 data files into their respective folders according to projection, as you determined in 4A above.

Step 5 – Download and save feature data sources of the state of Oregon, with known projections. You will use these now and in the future as calibrated, known "projection checks" for Oregon data in which you are unsure of the projection.

A) go to web site, look under the Lab Data Section - Map Projection Exercise; locate the following links:

- Shape File of Oregon Counties in UTM (use as projection check)
- Shape File of Oregon Counties in Custom Oregon Lambert (use as projection check)
- Shape File of Oregon Counties in State Plane (North) (use as projection check)

i) sequentially save the above *.zip files, and extract them into the appropriate project subfolders on your H:\ drive (i.e. UTM, State Plane, OR_Lambert)

iii) Extract the Compressed Files

a) use my computer - H:/ folder - click on *.zip file to extract

NOTE*:* All of these map themes show outlines of the state of Oregon with county boundaries. You will be able to use these shape files as projections checks if you have feature data sources of unknown projection. THESE WILL BE IMPORTANT TO USE WITH WORK ON YOUR FINAL CLASS PROJECT.

iv) you should now have the following files in your respective folders:

UTM folder\ utm_state.shp
StatePlane folder\ spcounty.shp
OR_Lambert folder\ orcounty.shp

v) use ArcMap or ArcCatalog to view the above shapes files to familiarize yourself with their characteristics

Step 6 – CLOSE ARCMAP AND OPEN ARC-CATALOG: Use the "Define Projection" Tool in ArcToolbox to properly delineate the projections for all of the data files that you have downloaded and saved as part of this exercise:

UTM (NAD1927 meters):	utm_state.shp, mongeo.shp, Monmouth.tif
State Plane North (NAD1983 feet International):	roads.shp, spcounty.shp
OR_Lambert (NAD1983 feet International):	vegetation.shp, orcounty.shp

Currently all of your data that you've downloaded does not have defined projection files associated with them (i.e. there are not *.prj files that accompany your data).

Your goal will be to use Arc Toolbox via ArcCatalog to create *.prj files for the above data layers. NOTE: the UTM, State Plane, and Statewide Oregon Lambert projection protocols in ArcToolbox are known standards and are shipped as part of the default software package.

*****NOTE: In the ArcToolbox projection lists, be sure to select the following:**

> **State Systems – Oregon Statewide Lambert NAD1983 – Feet Intn'l**
> **State Plane – State Plane Oregon North NAD1983 – Feet Intn'l**

There are other state system and state plane options that will cause projection errors.

Let's start with the UTM and State Plane files first, then we'll worry about the Oregon Custom Lambert.

a. Open the ArcToolbox Menu (the following first example is for defining the projection of the mongeo.shp file)

- -pull down "Data Management" tools Menu
  - ii. Pull down Projections and Transformations menu

c. Click on the "Define Projection" tool (to define a projection for files of unknown sources; the product of this exercise will be a *.prj file that defines the projection criteria, that ArcMap can then use for "on-the-fly projections" in the data frame.

- i. Browse – select the **<u>mongeo.shp</u>** file in the input window
  1. note the status window indicating "coordinate system unknown"
- ii. click on coordinate system icon (to right of window)
  1. select the X-Y Coordinate System Tab (don't worry about Z values)
  2. Select "pre-defined coordinate system"
  3. Open "projected" coordinate system folder
  4. browse to appropriate projection type (e.g. "UTM" or "State Plane") (note: the following procedures are for use in setting a "UTM" zone10 n projection)
     a. Select UTM folder
  5. select NAD1927 folder
  6. select "NAD 1927 UTM Zone10 N" projection option
  7. click "ADD" – examine the default parameters associated with this projection in the display window to familiarize yourself with the settings
  8. click "Apply" and "OK"–
     a. a log window will now open and show the results of the action – "completed" message will appear; close the log window
     b. A **<u>mongeo.prj</u>** projection file is now created, and included in the source folder/directory. Use a text editor like Notepad or Word to open the **<u>mongeo.prj</u>** file and examine it's contents to familiarize yourself with the file structure. Compare the information presented in the *.prj file with that provided on page 1 of this handout.

Note: the **<u>mongeo.shp</u>** vector file now has a defined projection, and ArcMap will be able to know how to manage it, and apply "on-they-fly" reprojection algorithms in the data frame environment.

Step 7. Repeat the above steps. Systematically define projections and create *.prj for all of the UTM and State Plane shape files in your exercise folder. When you finish with Step 6 and 7, you should have created the following projection definition files:

UTM: utm_state.prj, mongeo.prj, monmouth.prj (all zone 10 N)
State Plane: roads.prj, spcounty.prj(both in Oregon State Plane North Feet International)

Step 8. Now let's define projection files for the Oregon_Lambert data.

a. Open the ArcToolbox Menu (the following first example is for defining the projection of the **stateveg.shp** file which is in the Oregon Custom Lambert Projection)

pull down "Data Management" tools Menu

iii. Pull down Projections and Transformations menu

d. Click on the "Define Projection" tool (to define a projection for files on unknown sources; product will be a *.prj file that defines the projection criteria, that ArcMap will then use for "on-the-fly projections"

- i. Browse – select the **stateveg.shp** file in the input window
  1. note the status window indicating "coordinate system unknown"
- ii. click on coordinate system icon (to right of window)
  1. select the X-Y Coordinate System Tab (don't worry about Z values)
  2. Select "pre-defined coordinate system"
  3. Open "projected" coordinate system folder
  4. browse to the "State Systems" folder
  5. select "**NAD 1983 Oregon Statewide Lambert Feet Intnl.prj**" option
  6. click "ADD" – examine the default parameters associated with this projection in the display window to familiarize yourself with the settings
  7. click "Apply" and "OK"–
     a. a log window will now open and show the results of the action – "completed" message will appear; close the log window
     b. A **stateveg.prj** projection file is now created, and included in the source folder/directory. Use a text editor like Notepad or Word to open the **stateveg.prj** file and examine it's contents to familiarize yourself with the file structure. Compare the information presented in the *.prj file with that provided on page 1 of this handout.

Note: the **stateveg.shp** vector file now has a defined projection of Oregon Custom Lambert, and ArcMap will be able to know how to manage it, and apply "on-they-fly" reprojection algorithms in the data frame environment.

Step 9 - Repeat the above steps for the Oregon County shapefile that is in your Oregon Custom Lambert Folder. When you finish with Step 9, you should have created the following projection definition files:

Oregon Lambert: stateveg.prj, orcounty.prj

REPROJECTING DATA INTO NEW PROJECTIONS AND NEW DATA FILES

The "Project" tool can now be effectively used to reproject the map layers between different coordinate systems. This tool actively changes the X,Y coordinates and creates a new output data file in an entirely different projection.

Step 9. Open the ArcCatalog software environment (do NOT use the project tool in ArcMap)

a. Open the ArcToolbox Menu (the following first example is for defining the projection of the mongeo.shp file)

-pull down "Data Management" tools Menu

iii. Pull down Projections and Transformations menu

1. pull down the "feature" and "raster" tool tabs, examine the options

Note: we will be transforming projections between UTM Zone10 N 1927_NAD, State Plane North 1983_NAD, and Oregon Custom Lambert 1983_NAD – Feet International. See step 2 below to make sure the software environment provides the necessary transformation tools to migrate between 1927_NAD and 1983_NAD

Step 10. Under the "Feature" option, open the "Project" tool dialogue window

a. Before we begin, we will need to set the software environment variable, to make sure it includes a 1927 to 1983 datum conversion option.
    i. Click on the "environments" icon
        1. pull down menu: "General Settings"
        2. scroll down the list to "Geographic Transformations"
        3. pull down the transformation list, scroll down and select the "NAD_1927_To_NAD_1983_NADCON" option
            a. This option should now be listed on the "Geographic Transformation Names" list below.
                i. If you accidentally add the wrong item, the "X" will delete it from the list, and you can pick over.
        4. Click OK – and return to the main "project tool" dialogue window

Now we have the environment variables set, let's re-project a file into UTM. The tutorial below will guide you through re-projection of the State_Plane_NAD_1983 "roads.shp" layer into a UTM_NAD_1927 projection.

b. On the "input file" pull down, browse to your State Plane\roads.shp file, and ADD
   Note: since we already defined the *.prj file, note that ArcToolbox automatically knows that the roads.shp file is in the state plane north projection (hence the "input coordinate system" window is grayed out / not active).
c. On the "output dataset" pull down, browse to the UTM\ folder, and name the new shape file that you will create: "roads_utm.shp"
d. On the "output coordinate system" menu, pull down and click the following sequence…
    a. X-Y Coordinate System - Select – Projected Coordinate Systems – UTM – NAD 1927 – NAD_1927_Zone10_N.prj"
    b. ADD – APPLY – OK
e. On the "Geographic Transformation (optional) pull down, select the "NAD_1927_To_NAD_1983_NADCON" option that you installed on the environment variables under Step 2-a-i-3 above.
f. Click OK
    a. A log window will now open and provide you with feedback, if it ends with a "successfully completed" message, then you have completed the task.

Step 11 – Now check the results of your projection work in ArcMap – open ArcMap, browse to your “UTM” folder, and add the “roads_utm.shp”, “mongeo.shp” and “Monmouth.tif” layers and make sure that they all align and that there are no projection errors.

Step 12 - Repeat steps 2b-2f and 3 above, for the “stateveg.shp” layer that is in the Oregon Custom Lambert folder.

- reproject the statveg.shp into UTM Zone 10N
- check the results of your work

Step 13 – print out your results. Once you have all of your files reprojected into UTM, add them into the dataframe in ArcMap and create the following layouts:

A. State Vegetation overlaying the Monmouth DRG	(include name, neatline, north arrow, scale)
B. Monmouth Geology overlaying the Monmouth DRG	(include name, neatline, north arrow, scale)
C. Roads overlaying the Monmouth DRG	(include name, neatline, north arrow, scale)
D. Road overlaying the Monmouth Geology	(include name, neatline, north arrow, scale)

Step 14 – Go back to the beginning of this exercise and start it over from scratch. Download fresh *.zip data files from the web site, and re-do the entire tutorial a total of 3 times. Once you have completed this by the third time, without looking at the notes…. YOU ARE THERE!! YOU WILL THEN BE A CERTIFIED GIS PROJECTION GEEK!!!

Overview of Datums from ArcGIS Help Menu
Geocentric datums - Local datums

While a spheroid approximates the shape of the earth, a datum defines the position of the spheroid relative to the center of the earth. A datum provides a frame of reference for measuring locations on the surface of the earth. It defines the origin and orientation of latitude and longitude lines.

Whenever you change the datum, or more correctly, the geographic coordinate system, the coordinate values of your data will change. Here are the coordinates in DMS of a control point in Redlands, California, on the North American Datum of 1983 (NAD 1983 or NAD83).

-117 12 57.75961
34 01 43.77884

Here's the same point on the North American Datum of 1927 (NAD 1927 or NAD27).

-117 12 54.61539
34 01 43.72995

The longitude value differs by approximately three seconds, while the latitude value differs by about 0.05 seconds.

NAD 1983 and the World Geodetic System of 1984 (WGS 1984) are identical for most applications. Here are the coordinates for the same control point based upon WGS 1984.

-117 12 57.75961
34 01 43.778837

Geocentric datums
In the last 15 years, satellite data has provided geodesists with new measurements to define the best earth-fitting spheroid, which relates coordinates to the earth's center of mass. An earth-centered, or geocentric, datum uses the earth's center of mass as the origin. The most recently developed and widely used datum is WGS 1984. It serves as the framework for locational measurement worldwide.

Local datums
A local datum aligns its spheroid to closely fit the earth's surface in a particular area. A point on the surface of the spheroid is matched to a particular position on the surface of the earth. This point is known as the origin point of the datum. The coordinates of the origin point are fixed, and all other points are calculated from it.

The coordinate system origin of a local datum is not at the center of the earth. The center of the spheroid of a local datum is offset from the earth's center. NAD 1927 and the European Datum of 1950 (ED 1950) are local datums. NAD 1927 is designed to fit North America reasonably well, while ED 1950 was created for use in Europe. Because a local datum aligns its spheroid so closely to a particular area on the earth's surface, it's not suitable for use outside the area for which it was designed.The two horizontal datums used almost exclusively in North America are NAD 1927 and NAD 1983.

NAD 1927

NAD 1927 uses the Clarke 1866 spheroid to represent the shape of the earth. The origin of this datum is a point on the earth referred to as Meades Ranch in Kansas. Many NAD 1927 control points were calculated from observations taken in the 1800s. These calculations were done manually and in sections over many years. Therefore, errors varied from station to station.

NAD 1983

Many technological advances in surveying and geodesy—electronic theodolites, global positioning system (GPS) satellites, Very Long Baseline Interferometry, and Doppler systems—revealed weaknesses in the existing network of control points. Differences became particularly noticeable when linking existing control with newly established surveys. The establishment of a new datum allowed a single datum to cover consistently North America and surrounding areas.

The North American Datum of 1983 is based on both earth and satellite observations, using the GRS 1980 spheroid. The origin for this datum is the earth's center of mass. This affects the surface location of all longitude–latitude values enough to cause locations of previous control points in North America to shift, sometimes as much as 500 feet. A 10-year multinational effort tied together a network of control points for the United States, Canada, Mexico, Greenland, Central America, and the Caribbean.

The GRS 1980 spheroid is almost identical to the WGS 1984 spheroid. The WGS 1984 and NAD 1983 coordinate systems are both earth centered. Because both are so close, NAD 1983 is compatible with GPS data. The raw GPS data is actually reported in the WGS 1984 coordinate system.

HARN or HPGN

There is an ongoing effort at the state level to readjust the NAD 1983 datum to a higher level of accuracy using state-of-the-art surveying techniques that were not widely available when the NAD 1983 datum was being developed. This effort, known as the High Accuracy Reference Network (HARN), or High Precision Geodetic Network (HPGN), is a cooperative project between the National Geodetic Survey and the individual states.

Currently, all states have been resurveyed, but not all of the data has been released to the public. As of January 2004, the grids for 46 states and four territories have been published.

Other United States datums

Alaska, Hawaii, Puerto Rico and the Virgin Islands, and some Alaskan islands have used other datums besides NAD 1927. New data is referenced to NAD 1983.