Projections and Coordinate Systems

One of the basic concepts to understand in GIS or map-making concerns projections and coordinate systems. This document is meant to help demystify the concept of projections and provide step-by-step instructions for managing shapefiles and feature class projections in ArcGIS.

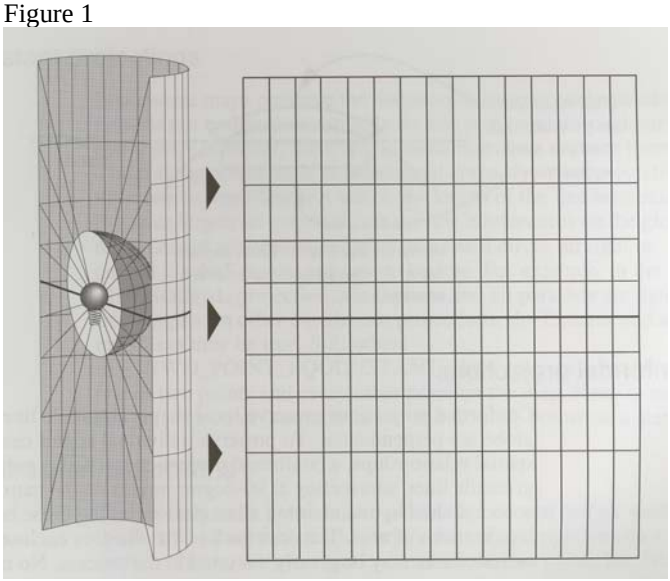
What is a Projection?

In short, a map projection is a method of representing a curved surface (e.g., the earth) on a flat surface (e.g., a computer screen or a paper map). This document is meant to help demystify the concept of projections, and provide step-by-step instructions for managing shapefiles and feature class projections in ArcGIS. If you want more detail than is provided in this document, you can check out this website at the University of Colorado.

Map Projections

All maps need to be "projected" in order to transfer what is essentially a spherical surface (i.e., the surface of the earth) onto a flat surface (a map). This term derives from the fact that this method is akin to shining a light through a globe and "projecting" it onto a flat surface (Fig. 1).

Figure 1



Before the age of computers, this required complicated calculus and tedious plotting in order to transfer coordinates taken in the real world onto a map by hand. Computers (through the use of GIS products like ArcView or ArcGIS) can now perform all these calculations quickly using algorithms, and even change how the map is projected if need be. Each different kind of projection has a set of parameters (including the datum it is based on) associated with it that define how a point on the globe (latitude and longitude coordinates) are placed on a flat map (for a more detailed look at these parameters see Projection and Coordinate System Details below). Because of the projection process, some areas of the globe will be more distorted than others (in the example in Fig. 1, areas near the poles will be more distorted than those near the equator). Some examples of projection names are Albers Conic Equal-Area, Lambert Conformal Conic, and Geographic Reference System.

Datums

The shape of the Earth is not perfectly spherical. In order for the projection process to be accurate, the shape of the Earth must be known with precision. The "definition" of the shape of the Earth (including all

the bumps, lumps, and deformities) is called a datum. Typically, these are named using an acronym and the year it was surveyed. Hence, NAD27 refers to North American Datum 1927. Some other examples of common Datum names are NAD83 and WGS84.

Coordinate System

Since every type of projection distorts some areas worse than others, the goal is to place the area of interest over the area of least distortion. To accomplish this, we use a coordinate system unique to a certain area of the globe. It includes information about the projection used (including the datum), as well as some defining characteristics about where exactly the area of interest is located. For example, the state government uses the coordinate system NC State Plane Meters (for a more detailed list of these parameters see Projection and Coordinate System Details below). When distortion of images is not a concern, some areas will not have this information and be simply in a projection (with no information defining how to orient the projection).

ArcGIS 9

Products like ArcGIS make the managing of these datums, projections, and coordinate systems relatively easy. ArcGIS provides a number of the most commonly used coordinate systems/projections predefined. That is, they have already compiled the necessary parameters needed to define a particular coordinate system/projection. Let's use a simple example of a shapefile containing point locations. Whoever created the shapefile used a specific coordinate system to plot the points on a map (let's say it is in "NAD83 North Carolina State Plane (feet)"). Therefore, the points in the shapefile are defined in this coordinate system. They give you the file and you want to include it in another map of the NC coast. In order for ArcGIS to place these locations correctly in relation to the other layers you plan to add, it must know what coordinate system or projection the data were defined in (ArcGIS may or may NOT know this). If ArcGIS does not know this information, it will make a guess, and it will be wrong (i.e., the points that are actually on the NC coast will appear where New Jersey should be – not good). Therefore, you need to tell ArcGIS what coordinate system or projection it is defined in (see below – Defining the Coordinate System/Projection). Now, if you would like to change the projection of a shapefile, you must run a tool within ArcGIS to redefine the points in the coordinate system/projection of your choice (see below – Reprojecting a Shapefile to a Different Coordinate System/Projection). **Important: If ArcGIS does not know what projection the shapefile was defined in, it cannot reproject the shapefile correctly! In this case, you must define the coordinate system/projection of the shapefile before reprojecting.**

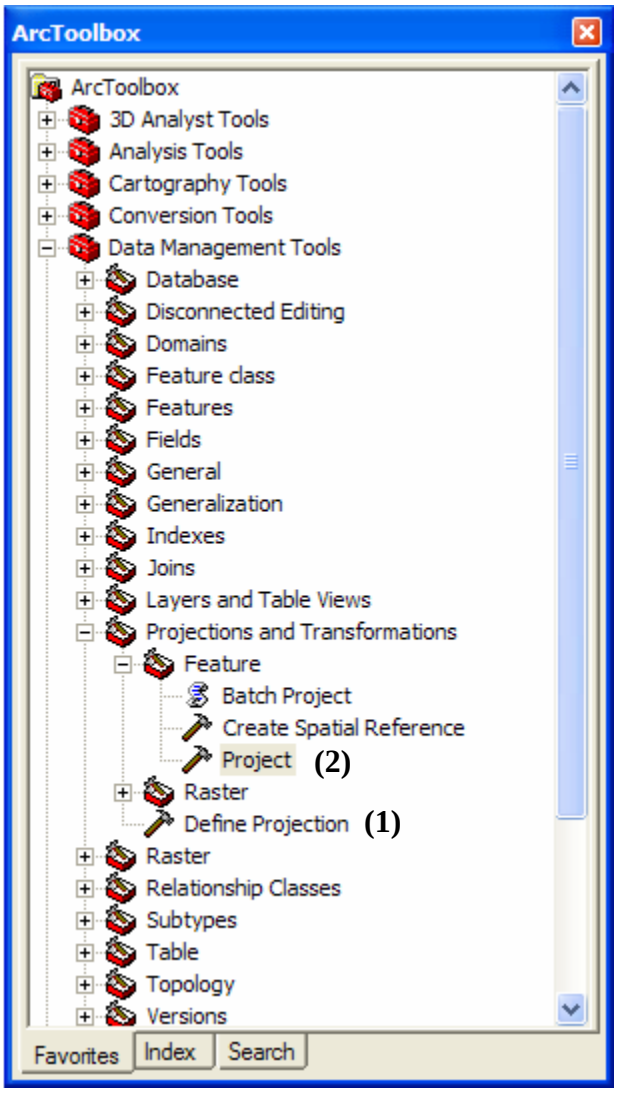
Step-by-step

Defining the Coordinate System/Projection of a Shapefile

This procedure must be followed to define the projection of a shapefile. If ArcGIS does not know what projection a shapefile is defined in, this procedure must be followed **BEFORE** reprojecting the data.

1. Open ArcCatalog.
2. Open the ArcToolbox by clicking on the button  . This will open the ArcToolbox window (fig. 2).

Figure 2.

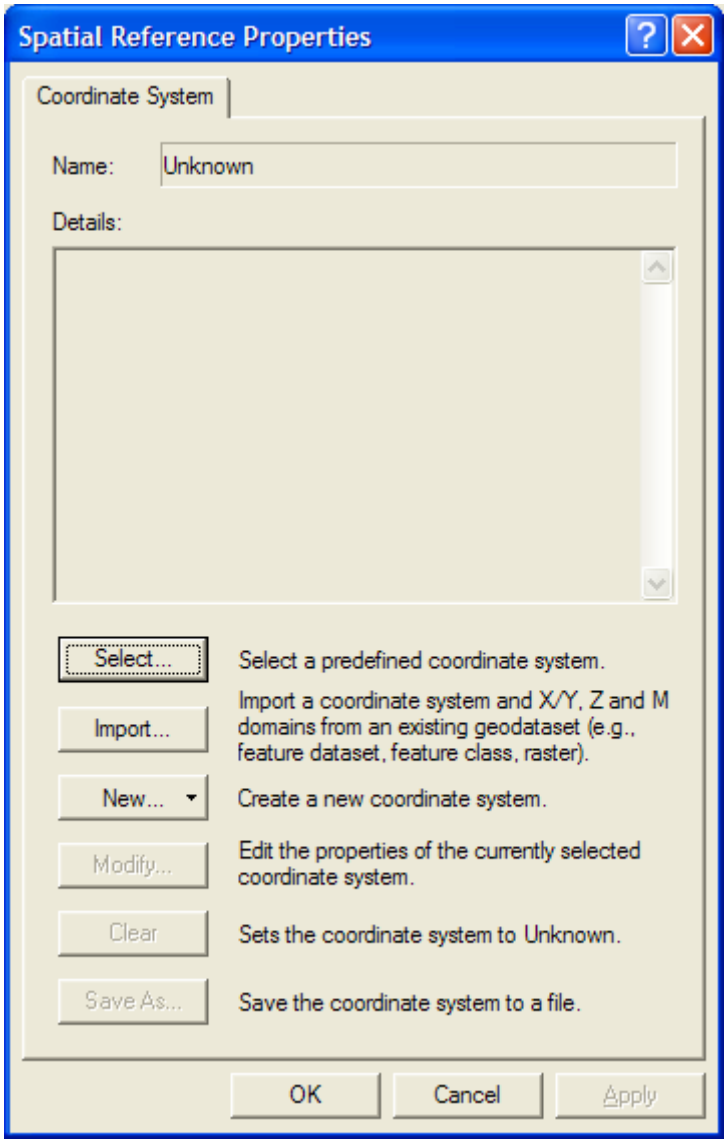


3. Navigate to the “Define Projection” heading (1), and double-click it. This will open the “Define Projection” window.

4. Click on the  button, and navigate to the shapefile for which you want to define the coordinate system/projection. Once you have selected the file, click on the "Add" button to return to the "Define Projection" window.

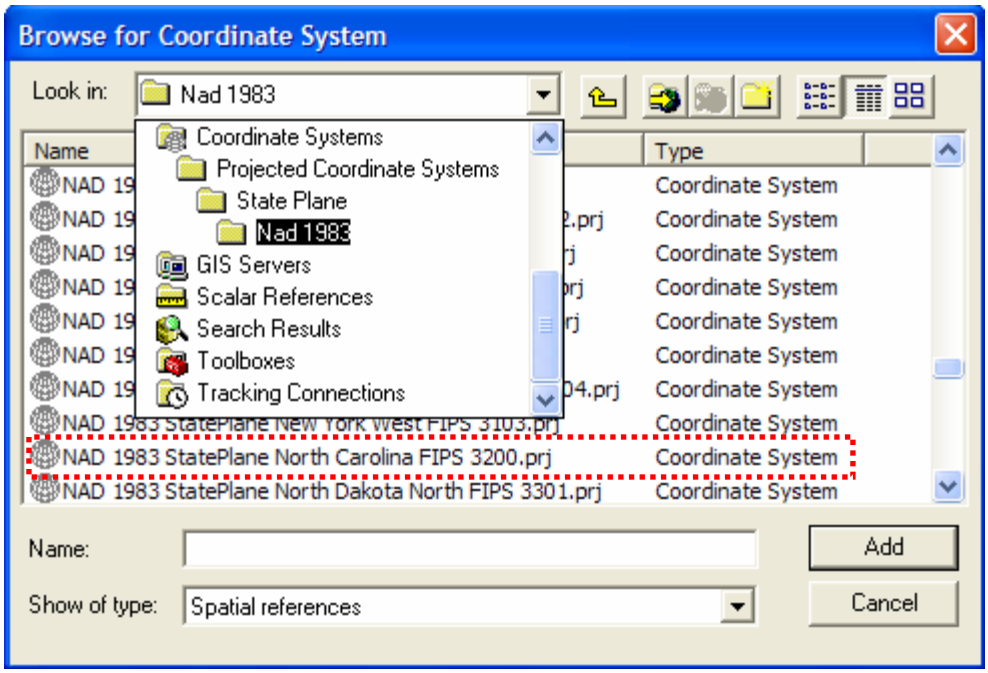
5. Click on the  button, and the "Spatial Reference Properties" window will appear. This is where you will choose the predefined coordinate system the shapefile was originally defined in (fig. 3).

Figure 3.



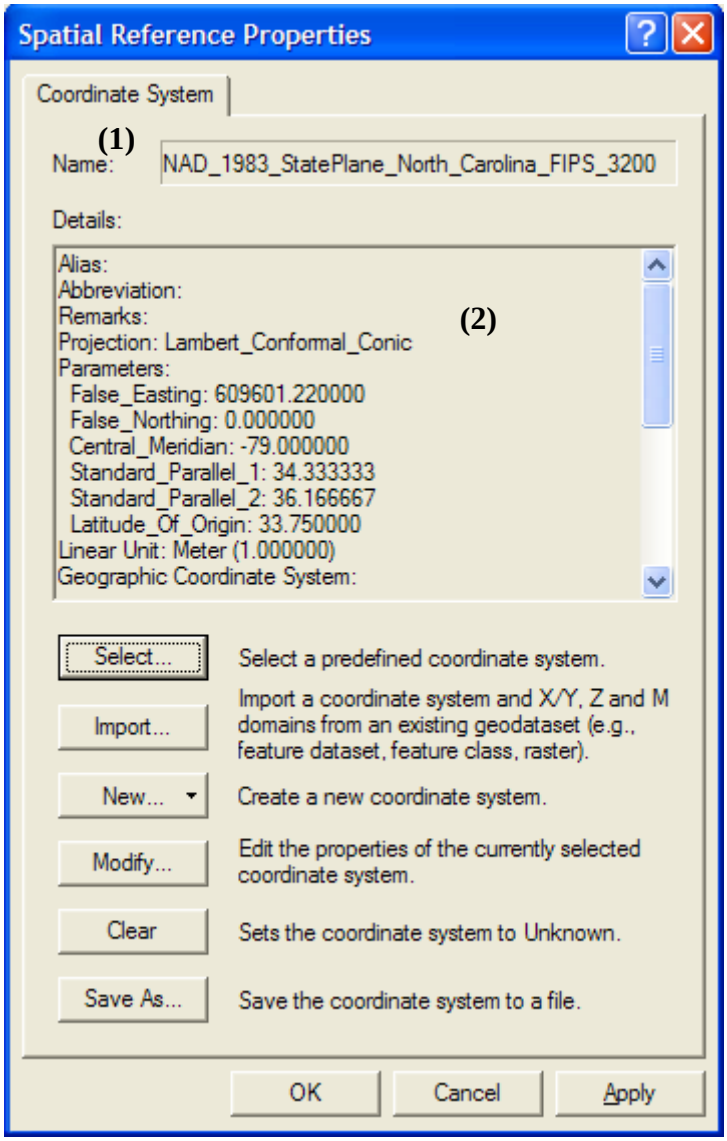
6. Click on the "Select…" button to choose the predefined coordinate system. This will open the "Browse for a Coordinate System Window". Alternatively, you can also import a coordinate system from a previously defined shapefile by clicking the "Import…" button (fig. 4).

Figure 4.



7. Navigate through the folders to locate the correct coordinate system file (in this example, we are looking for “NAD 1983 StatePlane North Carolina FIPS 3200.prj”). It is located in the Coordinate Systems/Projected Coordinate Systems/State Plane/Nad 1983 folder.
8. Highlight the appropriate file and click on the “Add” button. This will return you to the “Spatial Reference Properties” window. Note that now the “Name:” field no longer says “Unknown” (1), and there is text in the “Details:” (2) window (fig. 5).

Figure 5.



9. If these settings are acceptable, click on the "Ok" button to set the coordinate system, and you will be returned to the "Define Projection" window.
10. Click on the "OK" button in this window to define the shapefile with the coordinate system you just selected.

Done! Note that in some cases, the shapefile you receive from someone else may not be defined as one of the predefined coordinate systems available through ArcGIS. Once you have selected a coordinate system, you can modify the parameters (as discussed in the "Coordinate Systems" section above, and detailed in the "Projection and Coordinate System Details" section below) by clicking on the "Modify…" button. You will have to be provided the correct parameters from the creator of the shapefile.

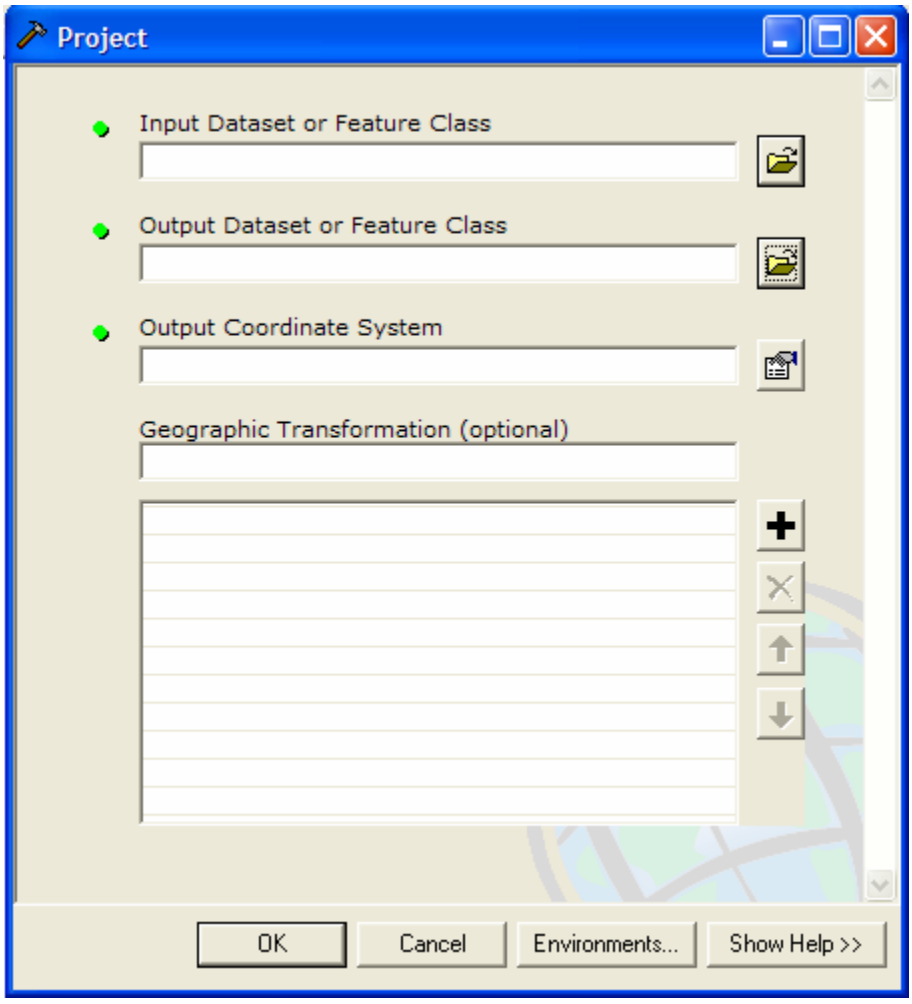
Reprojecting a Shapefile to a Different Coordinate System/Projection

This procedure explains how to reproject a shapefile from one coordinate system/projection to another. In order for this procedure to work properly, ArcGIS must know what projection the shapefile is currently

defined in (see the procedure above). This procedure will create a **new** shapefile with the same features, but in a different coordinate system/projection.

1. Open ArcCatalog.
2. Open the ArcToolbox by clicking on the button  . This will open the ArcToolbox window (fig. 2).
3. Navigate to the "Project" heading (fig. 2 - 2), and double-click it. This will open the "Project" window (fig. 6).

Figure 6.



4. Click on the  button next to "Input Dataset or Feature Class", and navigate to the shapefile for which you want to define the coordinate system/projection. Once you have selected the file, click on the "Add" button to return to the "Define Projection" window.
5. Click on the  button next to "Output Dataset or Feature Class", and navigate to the folder where you would like to place the new, *reprojected* shapefile.
6. Click on the  button, and the "Spatial Reference Properties" window will appear. The procedure for selecting a coordinate system is identical to the procedure outlined in "Defining the

Coordinate System/Projection of a Shapefile" above. Follow the steps 6-9 above. This is where you will choose the predefined coordinate system that you wish to project the shapefile into. After following these steps, you should be back at the "Project" window (fig. 6).

7. In some cases, you may need to pick a geographic transformation. This is required if you are choosing a coordinate system/projection that uses a different datum than the original shapefile. If this is the case, choose the first item in the list.
8. Once the information is filled out, click the "OK" button to perform the reporject procedure. This will create a new shapefile in the new coordinate system/projection.

Projection and Coordinate System Details

Below is an example of the parameters associated with the NAD 1983 North Carolina State Plane (meters) coordinate system.

Name: "NAD_1983_StatePlane_North_Carolina_FIPS_3200",

Projection Information:

Name:	Lambert Conformal Conic
False_Easting:	609601.22
False_Northing:	0.0
Central_Meridian:	-79.0
Standard_Parallel_1:	34.33333333333334
Standard_Parallel_2:	36.16666666666666
Latitude_Of_Origin:	33.75

Linear_Unit:

Name:	Meter
Meters per unit:	1

Geographic Coordinate System:

Name:	GCS_North_American_1983
Angular Unit:	Degree (0.0174532925199433295)
Prime Meridian:	Greenwich (0.0)
Datum:	D_North_American_1983
Spheroid:	GRS_1980
Semimajor Axis:	6378137
Seminor Axis:	6356752.3141403561
Inverse Flattening:	298.25722210100002

Questions?

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