

Tufts GIS Tip Sheet
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Trouble Shooting Map Projections in ArcMap

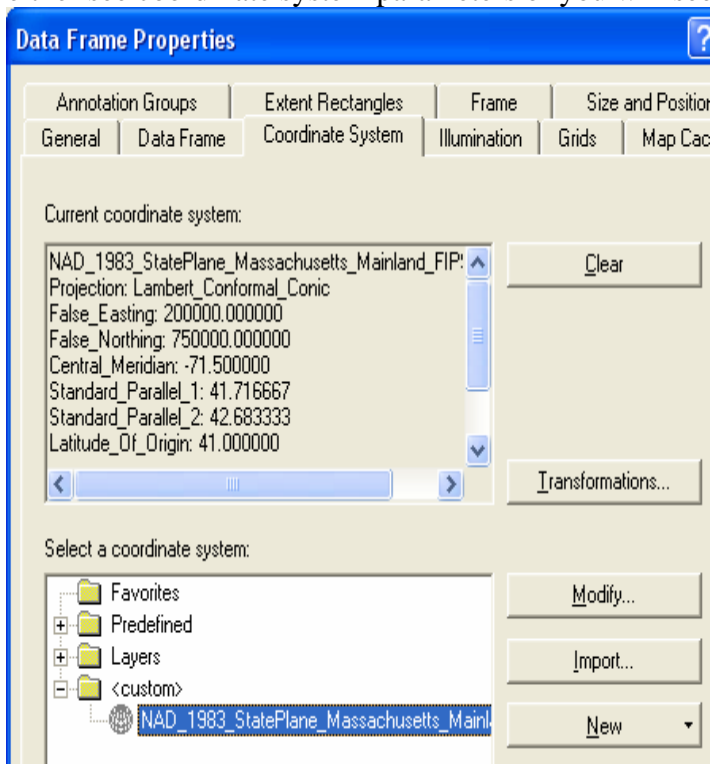
Overview of a vexing problem

A common problem in using GIS data arises when different data sets are in different map projections/coordinate systems. If you add two or more data layers that should overlap to your GIS session, and they show up in two different places (or your screen appears to show a blank map), the most likely cause is a problem with the map projection. ArcGIS can handle data in different coordinate systems as long as the projection/coordinate system of each data set is *defined* in a way that the software can understand. Typically this means a shape file has a .prj file in addition to all the other files that make up the data set (e.g., parks.prj). When you pull up data in different coordinate systems, ArcGIS tries to use the information in the various .prj files to project all the layers into one projection so that they all correctly overlay each other.

Unfortunately, many data sets do not have their projection/coordinate already defined, even though they are projected into some coordinate system. That means that the software can't figure it out, and data layers that should overlay one another end up in two different places. This is a confusing concept for students new to GIS, so read carefully:

Every data set is in some coordinate system, either a geographic coordinate system (using latitude and longitude expressed in decimal degrees - e.g., 30.52 degrees north and -99.25 degrees west) or a projected coordinate system (e.g., State Plane). But in ArcGIS and its predecessors, it was and is possible to create data without explicitly documenting the map projection or coordinate system. So there was and is lots of GIS data out there with no defined coordinate system.

When you first add data to an ArcMap data frame, the data frame sets itself to the coordinate system of the first data set to load. If the first data set has a .prj file, the data frame takes on the coordinate system specified in that .prj file. If the first data set has no defined coordinate system, the data frame coordinate system remains unknown. You can always tell what coordinate system your data frame is in by right-clicking on the *data frame name* in the ArcMap *table of contents* and choosing *Properties*. Then go to the *Coordinate System* tab. You will either see coordinate system parameters or you will see that it says *unknown*:



Now listen up!

If the first data set to load has no .prj file, you will get a message that "One or more layers are missing spatial reference information. Data from these layers cannot be projected."

That is not a problem if all your data layers are in the same coordinate system and if you are not using analysis functions (e.g., if you are only creating maps to look at). But once you start using data layers in two or more undefined coordinate systems you will have problems because the software does not have the information it needs to project them into one system.

Best Practice for GIS

To ensure that your GIS analysis works correctly, it is best practice to have all your data layers in the same projection. However, you can use GIS data sets in different map projections for mapping purposes if that is all you are doing. The following tips apply to these situations when you are using the GIS data for only for mapping. If you are performing analysis on the GIS data, you should not only define each data layer's projection as needed, but also PROJECT the different data layers into a common map projection. DEFINE and PROJECT are two different tools! Use DEFINE to define the projection of a data layer for which the projection is undefined. Use PROJECT when you want to project the data into a new or desired projection. DO NOT EVER USE DEFINE to put a data set into the desired projection – that will really mess things up.

In ArcToolbox, the DEFINE and PROJECT tools are found under Data Management Tools – Projections and Transformations. The DEFINE PROJECTION tool is there, The PROJECT tool for vector data is found under FEATURES, and the PROJECT tool for Raster data is found under RASTER.

What to do when you see problems in ArcMap with your data

The first thing to do is figure out why you are having problems. Typically there is one of several scenarios occurring (see below), but it may not be obvious which one. In any case, at least one of your data sets is probably undefined in terms of its coordinate system. To know which one (or ones) it is, you can right-click on each layer to get its properties, and click on the *Source* tab. In the Data Source portion of the box you will see information about the coordinate system. It will say "undefined" or "unknown" if no coordinate system has been defined. This layer is probably at least one of your culprits - there may be several of them. Next, look at the following scenarios and figure out which one applies to you.

Continue to next page for the trouble-shooting options table...

<i>Scenario</i>	<i>What Happens on Screen in ArcMap</i>	<i>What to Do</i>	<i>Special Notes</i>
<p>Scenario A - Data sets are in different coordinate systems, and they all have defined projections (.prj files or other coordinate system information is present).</p>	<p>ArcMap should be able to project all the data into one view.</p>	<p>You shouldn't have to do anything - it works!</p>	<p>Not all data layers may be projected accurately if they are based on different datums. Data layers may appear offset by a significant distance. This is a bigger problem than we are covering in this tip sheet. Also, data layers may be incorrectly defined. This requires you to go back to the metadata or to the data producer to find out the correct coordinate system and to re-define it.</p>
<p>Scenario B - All your data sets are in the same coordinate system, but are not explicitly defined</p>	<p>The data will overlay each other accurately because they are all in the same coordinate system, even though ArcGIS doesn't know what that is. However, you won't be able to measure or set up a good map scale on a layout because ArcMap doesn't know what units the coordinates are using.</p>	<p>If you know what the coordinate system is, you should use the <i>Data Frame Properties-Coordinate System tab</i> to define the coordinate system for ArcMap. This will allow you to measure and set up a map scale on your layouts.</p>	<p>To establish units for measuring and for the scale, you can also set the map and display units in the <i>Data Frame Properties-General tab</i>. The <i>map</i> units must be the units of the coordinate system the data is actually in. The <i>distance</i> units can be the units you want to use for measuring or scales.</p>

<i>Scenario</i>	<i>What Happens on Screen in ArcMap</i>	<i>What to Do</i>	<i>Special Notes</i>
<p>Scenario C - You have data sets in two different coordinate systems. All data sets in one coordinate system have .prj files, but the data in the other coordinate system does not. However, you know the coordinate system for the undefined data sets.</p>	<p>Data that should overlay each other may show up in two different places. If you go to a full map extent, the screen may appear blank (because ArcMap is trying to interpret the coordinate system as one large x-y axis).</p>	<p>Use the Define Projection tool to define the projection for the data that is undefined. To do this, you can use ArcToolbox. (see the Tip Sheet for <i>Projections – Defining a Projection</i>) Also, check the Data Frame’s coordinate system – if it is undefined, use the <i>Data Frame Properties-Coordinate System tab</i> to define the coordinate system for the data frame – you can import the coordinate system from one of the layers in the Data Frame.</p>	
<p>Scenario D - There are data sets in at least two coordinate systems without defined coordinate systems (lacking .prj files). You know the coordinate systems for all your data sets.</p> <p>Scenario E – You have multiple data layers with no coordinate system defined and you don’t know that the coordinate system is</p>	<p>Data that should overlay each other will show up in two different places.</p> <p>Data that should overlay each other will show up in two different places.</p>	<p>You have to define the coordinate systems for each data set. To do this, you can use ArcToolbox. (see the Tip Sheet for <i>Projections – Defining a Projection</i>)</p> <p>You need to search for metadata or contact the data provider to find out what coordinate systems the data layers are in, then use the <i>Define Projection</i> tool to define them.</p>	

Basic advice on coordinate systems

The easiest way to get everything to work properly in ArcMap is to make sure that *every layer you will be using has a defined coordinate system*. The easiest way to do this is using **ArcToolbox**. But prior to doing this you must know the coordinate system of the data set, either through its metadata or from information given to you by some other source. If you do not know the coordinate system, you cannot define it.

Remember, your data set is *always* in some coordinate system! It is up to you to figure out what coordinate system it is, and if it is undefined, define it accordingly. You cannot define a coordinate system simply by what you would like it to be - you need to define the coordinate system it is actually in! For more help with *Define* and *Project* tools in ArcGIS, go to the ArcGIS Desktop Help and search the index for *Define* - choose *Define Projection (Data Management)* or *Project* - choose *Project (Data Management)*

Other tip sheets for working with projections and coordinate systems in ArcGIS

<http://gis.sfsu.edu/helpdesk/arcmap/projections.htm> - from San Francisco State University - this site has a help topics/FAQs about projections and coordinate systems

<http://www.gsd.harvard.edu/gis/manual/projections/index.htm> - from Harvard's Graduate School of Design - this page discusses what to do if your layers don't line up.

http://gis.washington.edu/esrm250/lessons/projection/#projecting_data - from The University of Washington - troubleshooting coordinate system, include ArcGIS screenshots. Further up the web page there is also an overview of the different kinds of projections.