CHAPTER 3

IDENTIFYING THE PROJECTED COORDINATE SYSTEM

"When I add my new data to ArcMap, I get a Warning box that says 'Inconsistent extent' and the data doesn't line up. What is the problem?"

You determined in chapter 1 that the data with the unknown coordinate system is in a projected coordinate system (PCS), because when you examine the data in ArcMap there were 6, 7, or 8 digits to the left of the decimal—Top, Bottom, Left, and Right—in the Extent box on the Layer Properties > Source tab. Now you need to find out *which* PCS. It may help to know that in the United States, data in a PCS is most often projected to either the state plane or UTM (universal transverse Mercator) coordinate system. So let's discuss these coordinate system options first.

STATE PLANE COORDINATE SYSTEM

The state plane coordinate system (SPCS) was designed by the US Coast and Geodetic Survey of the United States in the 1930s, in order to provide a standard for map projections within the United States. The SPCS provides mapping accuracy of 1:10,000 within the area of each zone.

ORIGINAL ZONES IN THE STATE PLANE COORDINATE SYSTEM

In creating the SPCS, larger states were divided into zones whereas small states were assigned to a single zone. In some cases, such as New England, several small states were grouped into a single zone. The zone boundaries were defined along state lines and almost always along county boundaries within the state. When originally defined, the SPCS was based on the North American Datum (NAD) 1927 datum and Clarke 1866 spheroid.

Three different base projections were selected for these zones, depending on the shape of the zone. These projections were selected in order to minimize distortion of data within the zone. For zones that have an extent greater in the east-to-west direction, the Lambert conformal conic projection is used as the base projection. For zones that have an extent that is greater in the north-south direction, the transverse Mercator projection is used. Hotine oblique Mercator is a special case, used only for the Alaska Panhandle, because this zone lies at an angle, instead of being oriented either north-south or east-west.

Figure 3-1 shows the state plane coordinate system zones as they were originally defined on the NAD 1927 datum by the US Coast and Geodetic Survey.

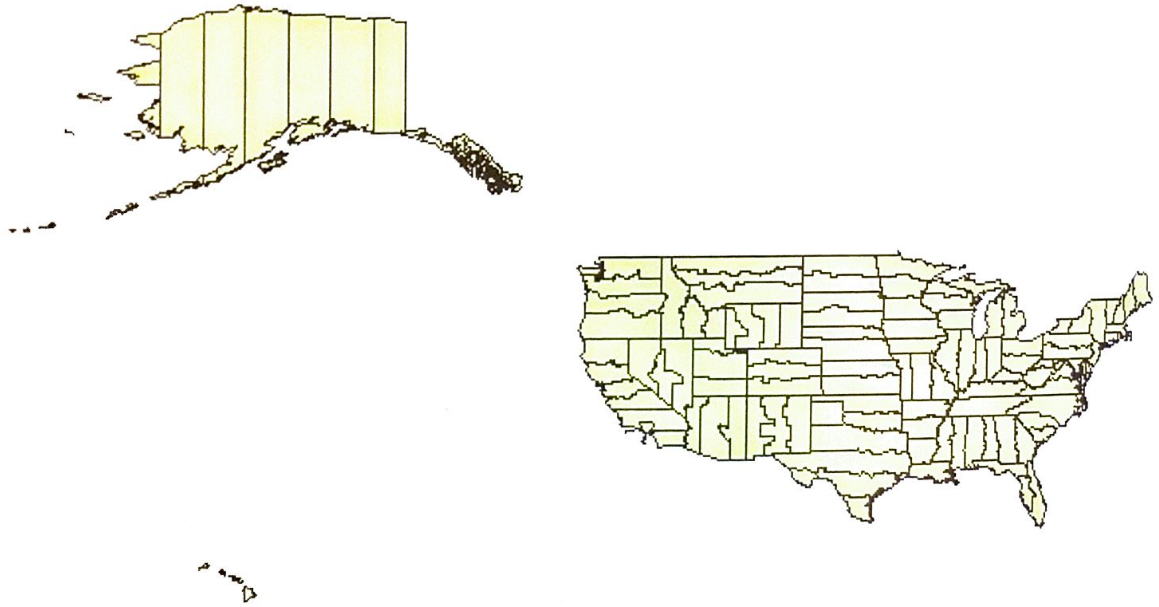

Figure 3-1 Original state plane coordinate system zones, defined on the NAD 1927 datum.

Viewing the zone shapes in the diagram, it is easy to see which base projection is used for each state plane coordinate system zone. The zones that are wider east to west are projected in Lambert conformal conic. Zones with a greater extent north to south are projected in transverse Mercator. The

Alaska Panhandle, which lies at an angle, is projected in Hotine oblique Mercator. These projections minimize distortion in the areas thusly shaped.

Each zone has projection parameters calculated specifically for that geographic area. The SPCS projection for one zone should not be used for data in another zone in the same state or for data in another state.

FIPS ZONES IN THE STATE PLANE COORDINATE SYSTEM

The Geodetic Reference System (GRS) 1980 spheroid was calculated from satellite measurements of the earth's surface, and NAD 1983 is based on GRS 1980. Figure 3–2 illustrates the distribution of the state plane coordinate system FIPS zones, as defined on NAD 1983.

When the NAD 1983 datum was incorporated into the SPCS, the new keyword "FIPS" was used to designate each area. The acronym FIPS stands for Federal Information Processing Standard. Although the standard was never officially adopted, the zone numbers with the FIPS keyword are used regularly. What's important to remember is that the FIPS keyword, along with the associated FIPS zone number, is used in ArcGIS for Desktop.

In ArcInfo Workstation, either ZONE or FIPS keywords can be used with the associated number, when defining the coordinate system for data projected to the state plane coordinate system. When ArcInfo coverage or grid data projected to the SPCS is added to ArcMap, and the coverage/grid has the coordinate system defined using the ZONE keyword, ArcMap automatically translates that zone number into the corresponding ArcGIS coordinate system and FIPS zone number.

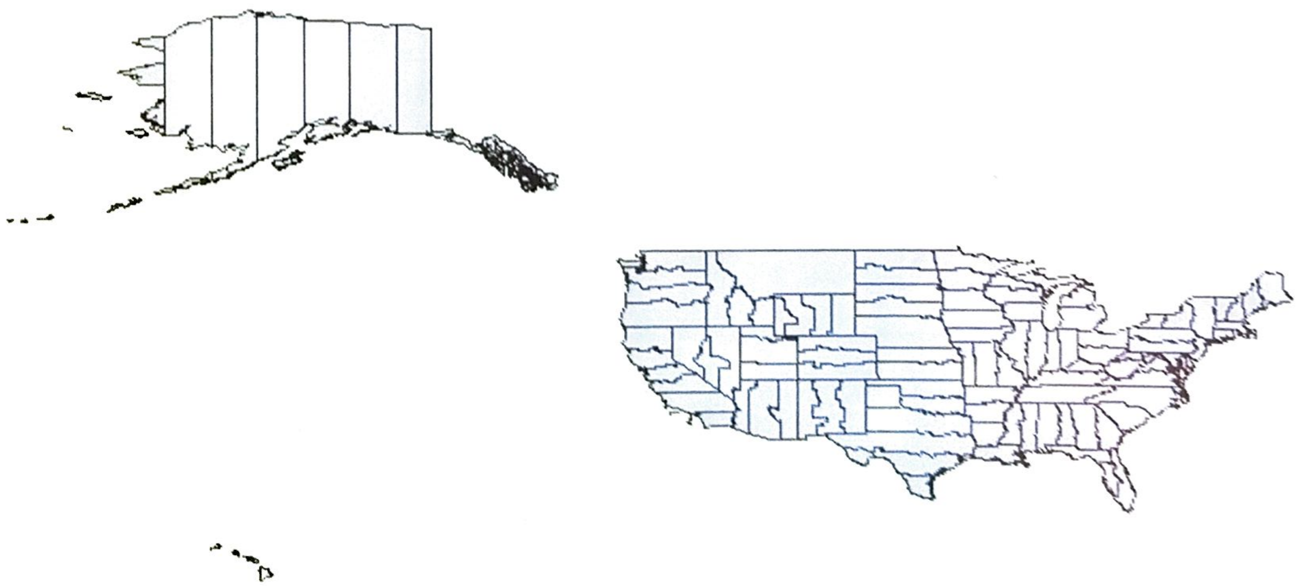

Figure 3–2 Updated state plane coordinate system zones, as defined on the NAD 1983 datum. Comparing these zones with those in figure 3–1, you can see evidence of the realignment of certain zone boundaries here: Montana has become one zone, for example, and Los Angeles County is now merged into California zone 5.

If the coordinate system of the unknown data is state plane, and the data lies in a zone that uses the Lambert conformal conic projection, Left and Right coordinate values will be larger numbers than the Top and Bottom, *unless the data is in eastern Texas*. Because the east-west extent of Texas is so large, in eastern Texas the Top and Bottom coordinate values will be larger than the Left and Right with the Lambert conformal conic projection. All other zones using the Lambert conformal conic projection will have larger Left and Right extent values.

If the data is projected to the SPCS, and lies in an area in which the base projection is transverse Mercator, the Top and Bottom coordinate values will almost always be larger numbers than the Left and Right.

The state of Florida (in figure 3-3) provides an excellent means of comparison between the SPCS base projections, because Florida is divided into zones that use Lambert conformal conic as well as transverse Mercator projections for different areas of the state.

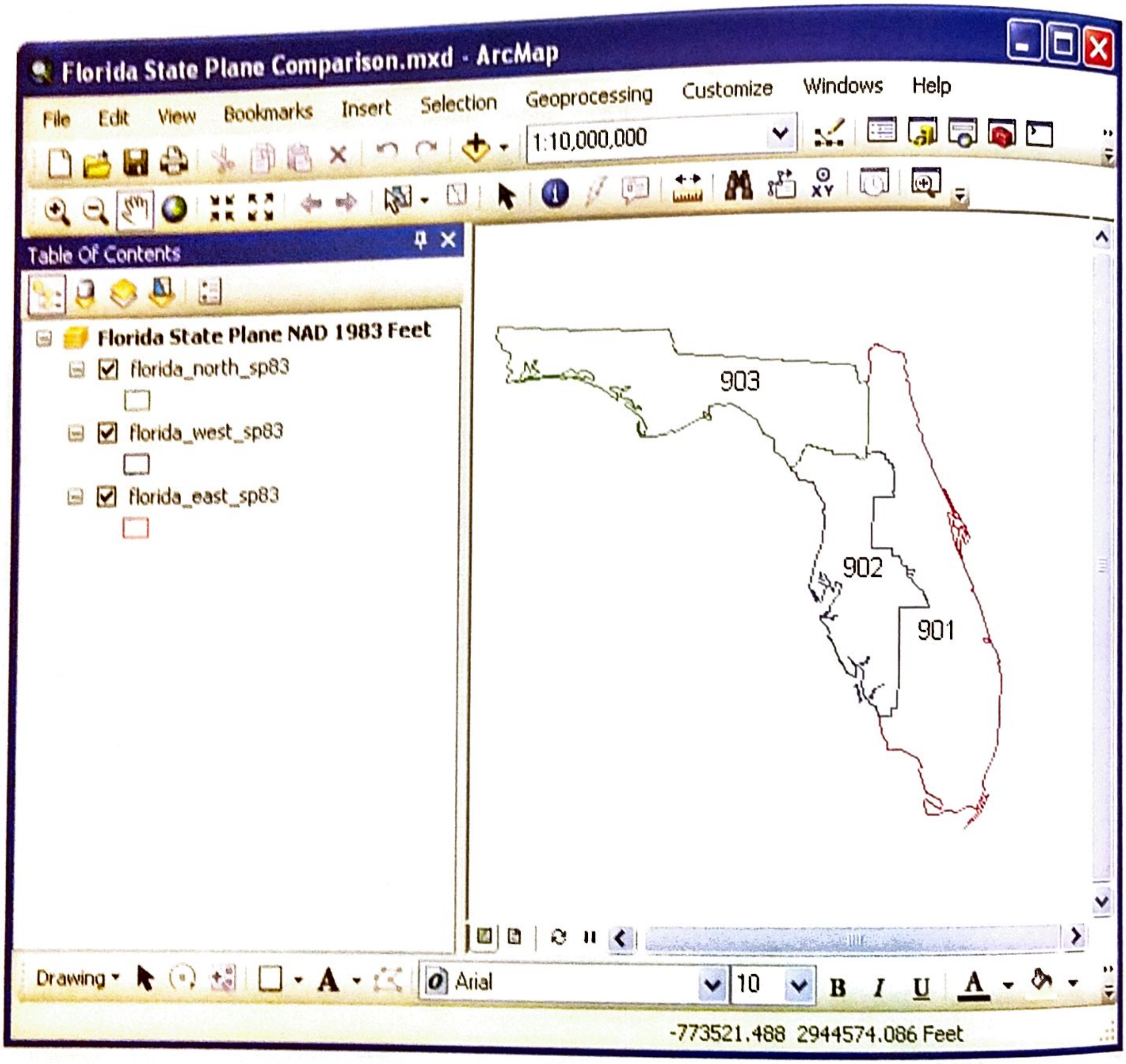

Figure 3-3 State plane zone boundaries for the state of Florida. Because of the shape and orientation of these areas, FIPS zones 901 and 902 are projected using transverse Mercator. FIPS zone 903 is projected using Lambert conformal conic.

Examining the shape of each zone, you can see that Florida North, FIPS 903, uses Lambert conformal conic as the base projection because the extent of the zone is greater east to west. Florida East and Florida West, 901 and 902, on the other hand, uses transverse Mercator as the base projection because these zones have a greater extent north to south.

Examine the coordinate extents for these three zones in figures 3-4, 3-5, and 3-6 and compare them.

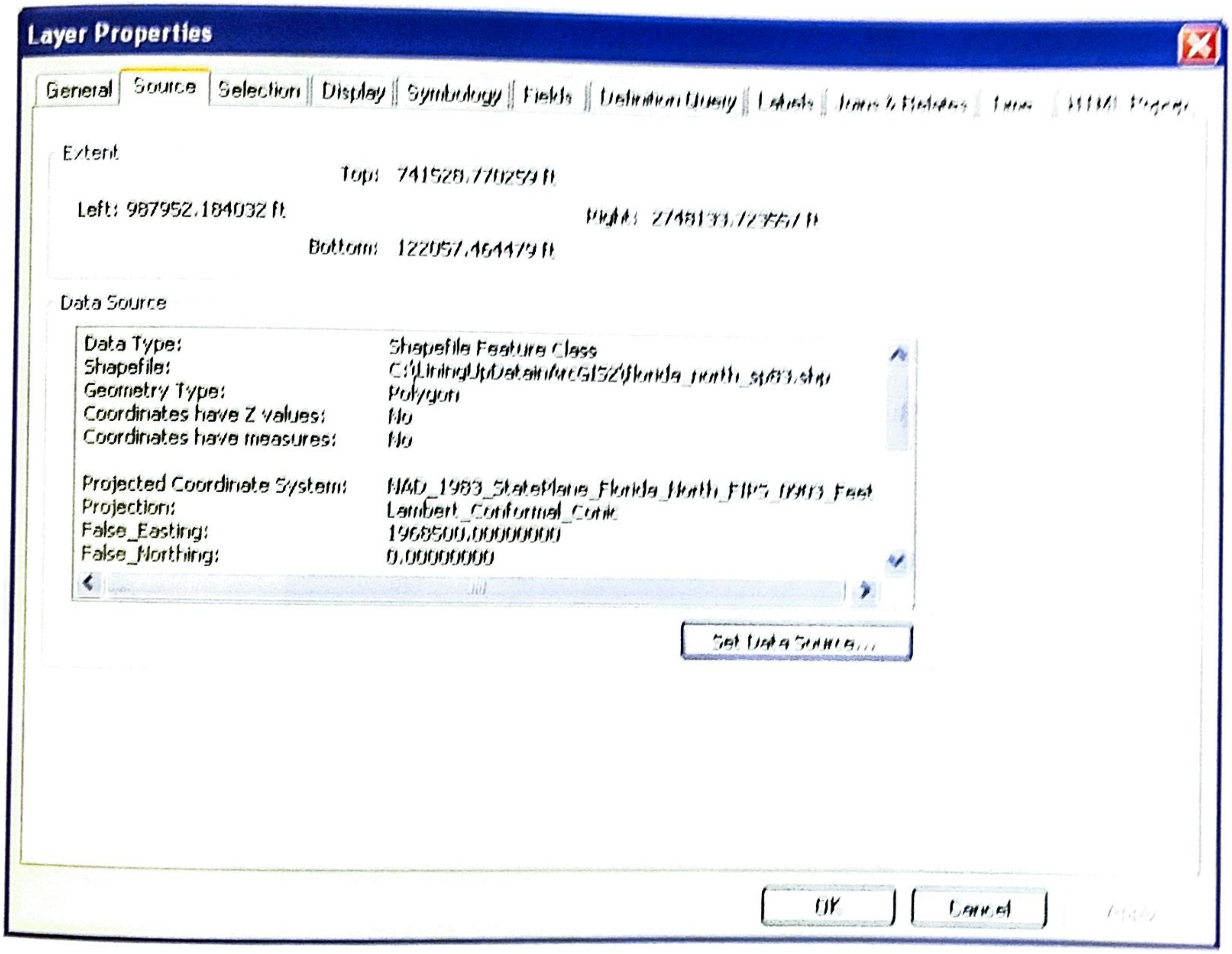

Figure 3-4 Coordinate extent for 903, Florida North.

For Florida North, the Left and Right (longitude) coordinates are the larger numbers. Note that the projection is Lambert conformal conic.

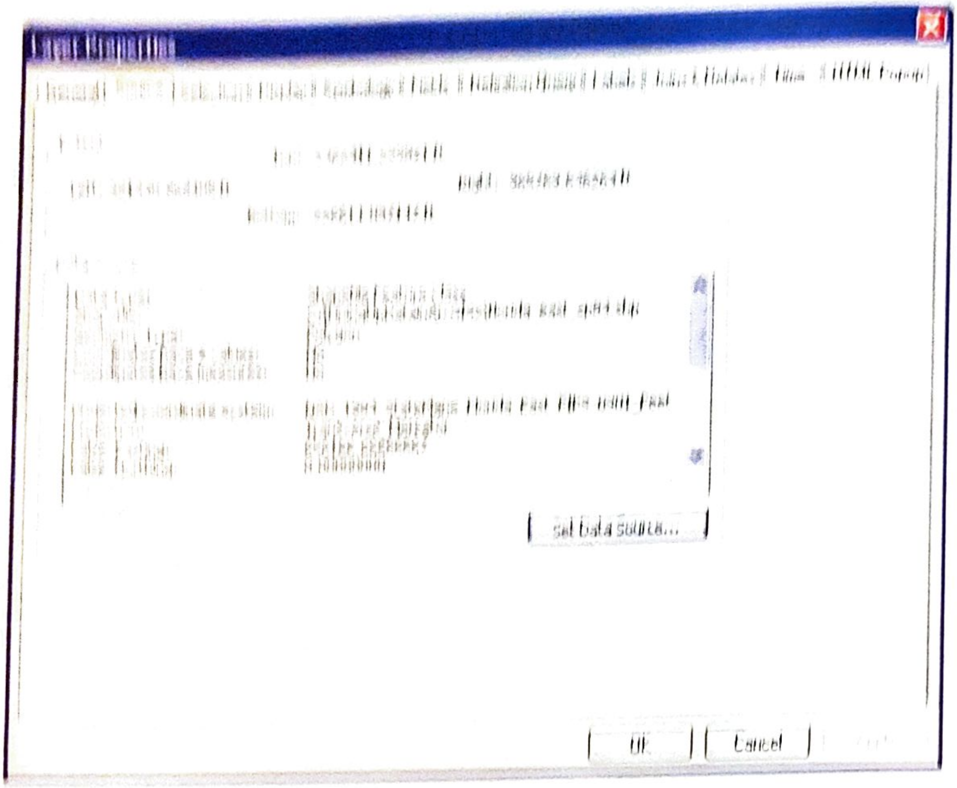

Figure 3-5 Coordinate extent for 901, Florida East

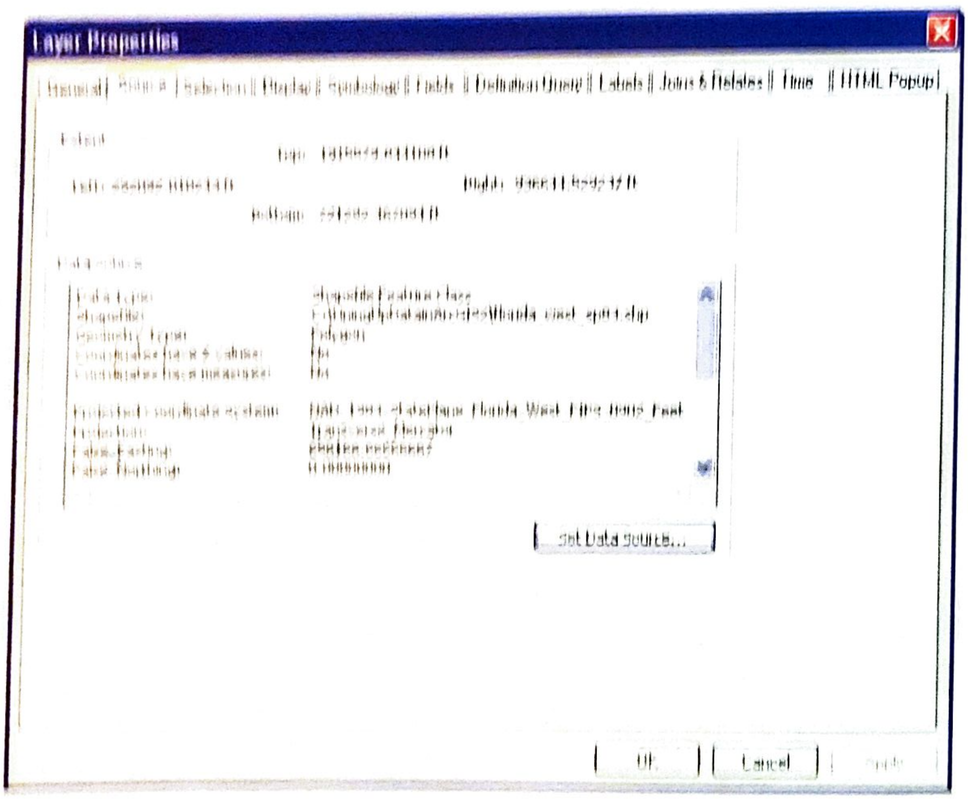

Figure 3-6 Coordinate extent for 902, Florida West

For Florida East and Florida West, which are projected to the transverse Mercator projection, the Top coordinates are larger numbers than the Left and Right.

DATUMS USED WITH THE STATE PLANE COORDINATE SYSTEM

Five standard datums are available for use with the state plane coordinate system: NAD 1927, NAD 1983, NAD 1983 (CORS96), NAD 1983 (HARN [High Accuracy Reference Network]), and NAD 1983 (NSRS2007). Additional datums are also supported for the state of Hawaii, Guam, and other US territories.

Publication information for variations of the NAD 1983 datum

The definition of the NAD 1983 is continually revised by order of Congress, by the National Geodetic Survey (NGS), and by the National Oceanographic and Atmospheric Administration (NOAA). Here is publication information for these revisions:

- Corner coordinates for US Geological Survey map sheets were originally published by the National Geodetic Survey in NOAA Technical Memorandum NOS NGS-6, 1976. Second prediction of these coordinates was published in NOAA Technical Memorandum NOS NGS-16, 1979. Both papers were authored by T. Vincenty. The realization of NAD 1983 used in ArcGIS 10.1 for Desktop is NAD 1983(1986).
- NAD 1983 (CORS96) is the equivalent of the HARN datum on a national scale at Epoch 2002.0.
- HARN was published at various times, primarily on a state-by-state basis, by the NGS and NOAA. Additional details are provided in chapters 7 and 8.
- NAD 1983 (NSRS2007) is a readjustment of GPS (Global Positioning System) survey control published February 10, 2007 by the NGS to reconcile inconsistencies between HARN and CORS96 (`http://www.ngs.noaa.gov/NationalReadjustment/`).

UNITS OF MEASURE USED WITH THE STATE PLANE COORDINATE SYSTEM

Three units of measure can be used with the state plane coordinate system: the US survey foot, the international foot, and the meter. Coordinate system definitions that use these units, in conjunction with the above datums, are provided with ArcGIS 10.1 for Desktop. State plane projection definitions that incorporate units of the international foot are provided for those states where the state legislature has mandated use of that unit with the state plane coordinate system.

Conversion factors

Units of US survey feet (Foot_US) or international feet (Foot) can be used with the state plane coordinate system (SPCS). Certain states have legislated that the international foot can be used with the SPCS because the international foot converts exactly to a meter. The US survey foot does not. Here are the conversion factors.

International foot (Foot) = 0.3048 of a meter exactly.

US survey foot (Foot_US) = 1200/3937 of a meter or

0.30480060960121920243840487680975. . . which is an infinite, nonrepeating decimal.

UNIVERSAL TRANSVERSE MERCATOR (UTM) COORDINATE SYSTEM

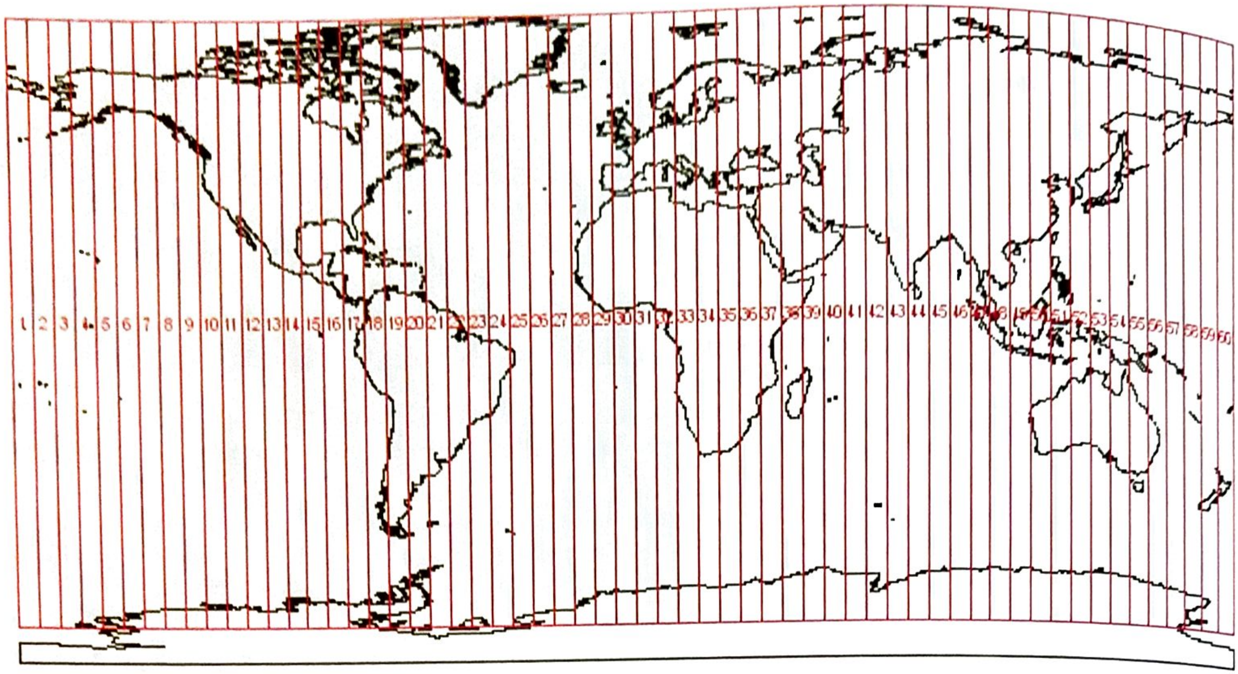

Figure 3-7 UTM zones of the world.

The UTM coordinate system, as shown in figure 3-7, divides most of the earth into sixty zones, each 6 degrees wide. The UTM zones extend from 84° north latitude (+84) to 80° south latitude (−80°). This coordinate system was devised by the US military, and the military specification for UTM includes meters as the standard unit of measure.

In the UTM projection definitions installed with ArcGIS for Desktop, the UTM zones are designated by a number, followed by the letters N or S. N refers to the area within the zone that is north of the equator. S refers to the area within the zone that is south of the equator.

The UTM coordinate system also includes band designations. The bands run east-west, and can measure 6 or 8 degrees in the north-south direction. Each band is assigned a letter designation. The band designations are used in the Military Grid Reference System (MGRS) graticule, and are *not* included in the projection names in ArcGIS for Desktop. The band designations are sometimes specified when collecting data with a GPS unit in the UTM coordinate system, but are not included in the projection name. For example, when collecting GPS data in Arkansas, Tennessee, or other states in UTM, the GPS unit must be set to collect data in UTM zone 15N for data north of the equator, not UTM zone 15 "S" for the band designation. Setting the GPS unit to collect data in UTM zone 15S would result in data displayed south of the equator in the Pacific Ocean when added to ArcMap. Additional information and diagrams of the UTM coordinate system are available at **`http://earth-info.nga.mil/GandG/coordsys/grids/universal_grid_system.html`**.

If data is in the UTM coordinate system with units of meters, Top and Bottom coordinates will be 7 digits to the left of the decimal (unless near the equator in the northern hemisphere). Left and Right coordinates will always be 6 digits to the left of the decimal.

EXTENT LIMITS OF UTM

The UTM coordinate system is based on the transverse Mercator projection. Because the transverse Mercator projection is calculated to minimize distortion in north-south trending areas, the east-west extent of data that can be projected using UTM is very limited.

The UTM coordinate system should not be used for any data that extends beyond the neighboring zones to the west or east, so the maximum east-west extent for data that can be projected in UTM must not be greater than 18 degrees. However, the distortion due to the projection increases a lot outside the base UTM zone. A UTM zone is designed to have no worse distortion than 1 part in 2,500 for data within the bounds of the zone. Compare this to the state plane's 1 part in 10,000. View this limitation in figure 3-8, which shows the extent of Texas east to west, in relation to the three UTM zones this large state crosses.

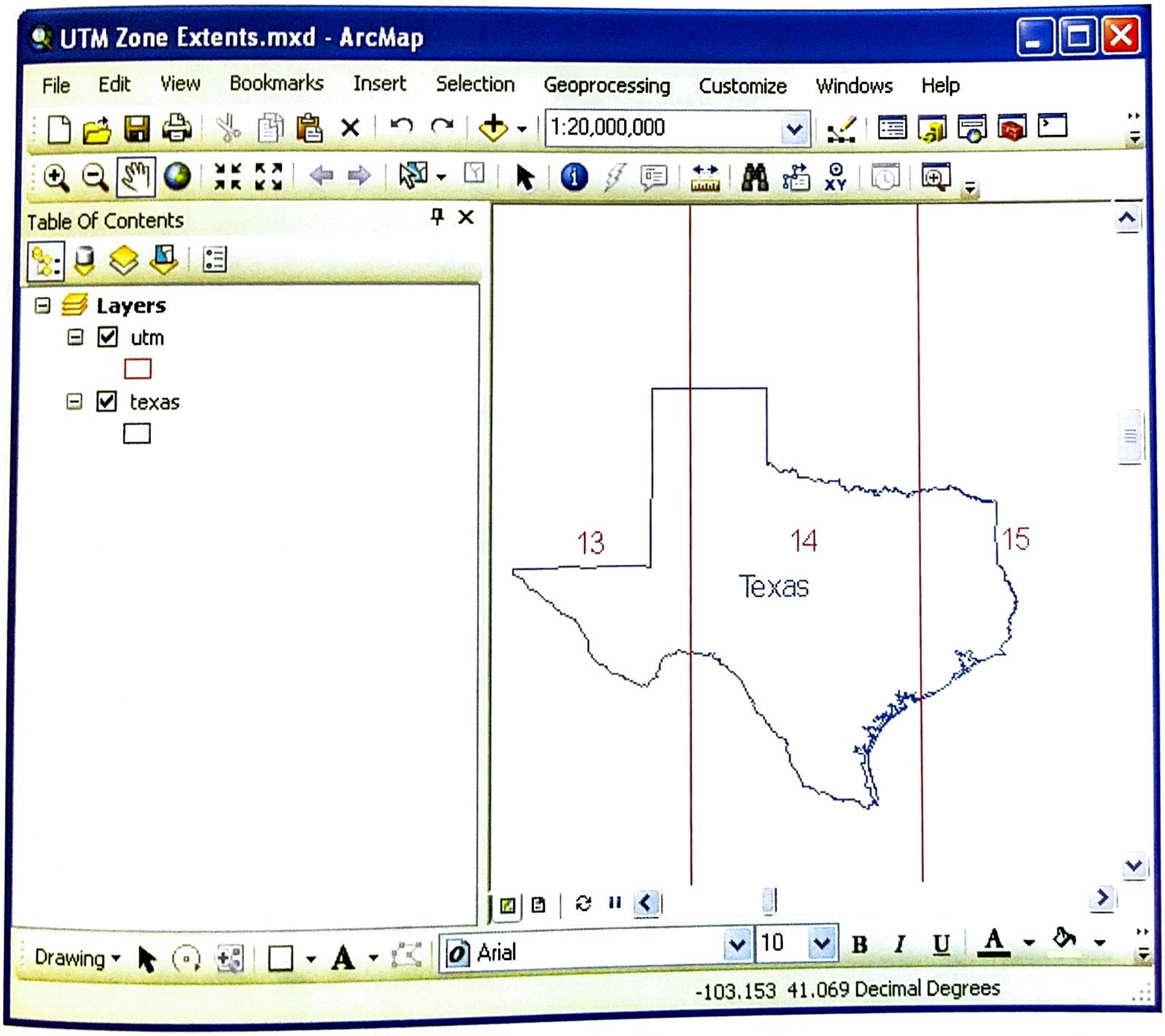

Figure 3-8 The UTM coordinate system should not be used for data covering the entire state of Texas. Although the state fits within three UTM zones, the distortion due to the projection would be unacceptably high if statewide data were all projected to UTM zone 14N.

DATUMS USED WITH THE UTM COORDINATE SYSTEM

Because the UTM coordinate system can be used for data in all inhabited regions of the earth, this projected coordinate system can be used in conjunction with nearly any geographic coordinate system (GCS). In the United States, UTM is most commonly used with the World Geodetic System (WGS) 1984, NAD 1983, or NAD 1927 datums, but in other countries or areas of the world many other datums are also used.

A wide variety of coordinate system definitions for UTM zones, which include GCS for specific countries or regions of the world, are installed with ArcGIS for Desktop. You will need to refer to the file UTM.shp installed with ArcGIS for Desktop to determine the UTM zone in which your data falls. You will find UTM.shp in the install folder for ArcGIS\Desktop10.1\Reference Systems. Projection definitions for the UTM coordinate system can be accessed in ArcMap through Data Frame Properties > Coordinate System tab > Projected Coordinate Systems > UTM.

Refer to appendix B for the default installation location of ArcGIS for Desktop for your version of the software and your computer operating system. In addition, refer to the list of geographic coordinate systems and their areas of use linked to Knowledge Base article 29280, as noted in appendix A, in order to determine the proper GCS for your data.

NEW OPTIONS FOR THE UTM COORDINATE SYSTEM ADDED TO ARCGIS FOR DESKTOP VERSION 10.1

As requested by the Bureau of Land Management (BLM), a division of the US Department of the Interior, new projection definitions for UTM Zones 59, 60, and 1 through 19 have been added to ArcGIS for Desktop for version 10.1. These zones cover all 50 states from the westernmost tip of Alaska to the easternmost tip of Maine.

These projection definitions are not strictly UTM, however, because the linear unit used in these projection definitions is ***Foot_US*** instead of the military specification of meters. The projection names, therefore, refer to the datum, followed by BLM, and the Zone number, and "N" for north of the equator. For example, NAD 1927 UTM Zone 12N with units of feet is named NAD 1927 BLM Zone 12N (US Feet).

These new definitions can be found in Projected Coordinate Systems > UTM, in the folder labeled "BLM (US Feet)" and are available on both the NAD 1927 and NAD 1983 datums.

Addition of these new projection definitions for UTM zones across the United States eliminates the need to customize projections to incorporate units of the US survey foot that was required in previous versions of ArcGIS for Desktop.

TESTING TO IDENTIFY THE PROJECTED COORDINATE SYSTEM FOR DATA

You can work through the available coordinate systems to find which one fits your data. If the data with the unknown coordinate system lies within the United States, click Add Data, and then navigate to the Reference Systems folder. Add the shapefile usstpln83.shp to ArcMap.

Right-click the name usstpln83.shp in the ArcMap Table of Contents and go to Properties > Source tab. Note that usstpln83.shp is in geographic coordinates, with units of decimal degrees. The projection is defined as GCS_North_American_1983. The data with the unknown projected coordinate system and the newly added shapefile will not line up in ArcMap, and there will be a very large distance between the two data layers when zoomed to the full extent. Refer to figure 2-8 for an illustration of this issue.

Before you begin testing for the projections of data, change the drawing order or the draw properties, so that the reference data you add to ArcMap doesn't cover the data you are trying to identify. Make the polygon shapefile hollow or drag the file below your data, so that usstpln83.shp does not cover your data.

Now think about the extent numbers for your data. The unknown data has coordinates in the Extent box on the Layer Properties > Source tab, which are all positive numbers, and the coordinates are most likely 6, 7, or 8 digits to the left of the decimal.

APPLYING STATE PLANE COORDINATE SYSTEM OPTIONS TO THE ARCMAP DATA FRAME

The state plane coordinate system is the most commonly used projected coordinate system in the United States. Therefore, it makes sense to test the SPCS options first, when working to identify the coordinate system for your data.

In ArcMap, click the View > Data Frame Properties > Coordinate System tab.

In the upper window open the folders Projected > State Plane. Each of the folders in the State Plane directory (except international feet) will contain a projection file for each of the 121 SPCS zones. Select and apply the coordinate system for the state plane zone in which the data should be located from each of the folders as listed below:

- NAD 1927 (US Feet)
- NAD 1983 (CORS96) (Intl. Feet)
- NAD 1983 (CORS96) (Meters)
- NAD 1983 (CORS96) (US Feet)
- NAD 1983 (Intl Feet)
- NAD 1983 (Meters)
- NAD 1983 (US Feet)
- NAD 1983 HARN (Intl Feet)
- NAD 1983 HARN (Meters)
- NAD 1983 HARN (US Feet)
- NAD 1983 NSRS2007 (Intl Feet)
- NAD 1983 NSRS2007 (Meters)
- NAD 1983 NSRS2007 (US Feet)
- Other GCS

For example, the data used in figure 3-9 is supposed to be located in Riverside County, California. That county is located in California FIPS zone 0406. That specific FIPS zone will have a projection definition included in *each* of the folders listed previously. The projection definition from each folder will have the specified datum and units shown in the bulleted list above. If the projection definition with a specific combination of datum and units of measure does not make the data draw in the correct location in relation to usstpln83.shp, open the next folder and try that datum/units combination.

Note the differences in position of data defined as (US Feet) and (Intl Feet) are small in most cases, as are the differences between the variations of the NAD 1983 datum. To facilitate the process of testing these units and datum combinations, begin by testing the following options:

- NAD 1927 (US Feet)
- NAD 1983 (Meters)
- NAD 1983 (US Feet)

After the data is positioned in the correct area within the state, it will be necessary to compare the position of the data with more accurate data to determine the exact units and datum definition.

After selecting a projection definition, click Apply. If the geographic transformation warning shown in figure 2–5 appears, be sure to set the geographic transformation for the ArcMap data frame, click OK, and then zoom to the full extent.

If you are unable to see the data with no projection definition because it is too small in relation to the extent of the entire United States, right-click the name of the dataset with the undefined projection, and select "Zoom to Layer."

From the ArcMap Drawing toolbar, click the drop-down list next to the New Rectangle tool (the white square) and select the New Marker symbol from the bottom row.

Left-click with your mouse to drop a marker symbol in the middle of the data with the unknown coordinate system.

Zoom to the full extent again. You will not be able to see the data, but you will see the marker symbol showing the location of the data in relation to the map of the United States.

Units tip: It's easy to tell if the units from the selected projection file are right or wrong for the unknown data.

If the data draws to the northeast of where the data should be, the linear units of the selected projection definition are too big. If the data draws to the southwest of where the data should be, the units of the selected projection definition are too small.

If the data was created with units of feet, but the selected projection has units of meters, the data will draw a long distance to the northeast of where the data should be. The data will also be about three times too large, but at that scale you will not be able to see the size difference.

If the data was created with units of meters, but the selected projection has units of feet, the data will draw a long way southwest of where the data should be. The data will also be only one-third the proper size, but you also won't be able to see the size difference at the current map scale.

The solution: Select a different projection definition, for the same zone with the same datum, but with different units. Refer to figure 3–9 for an illustration.

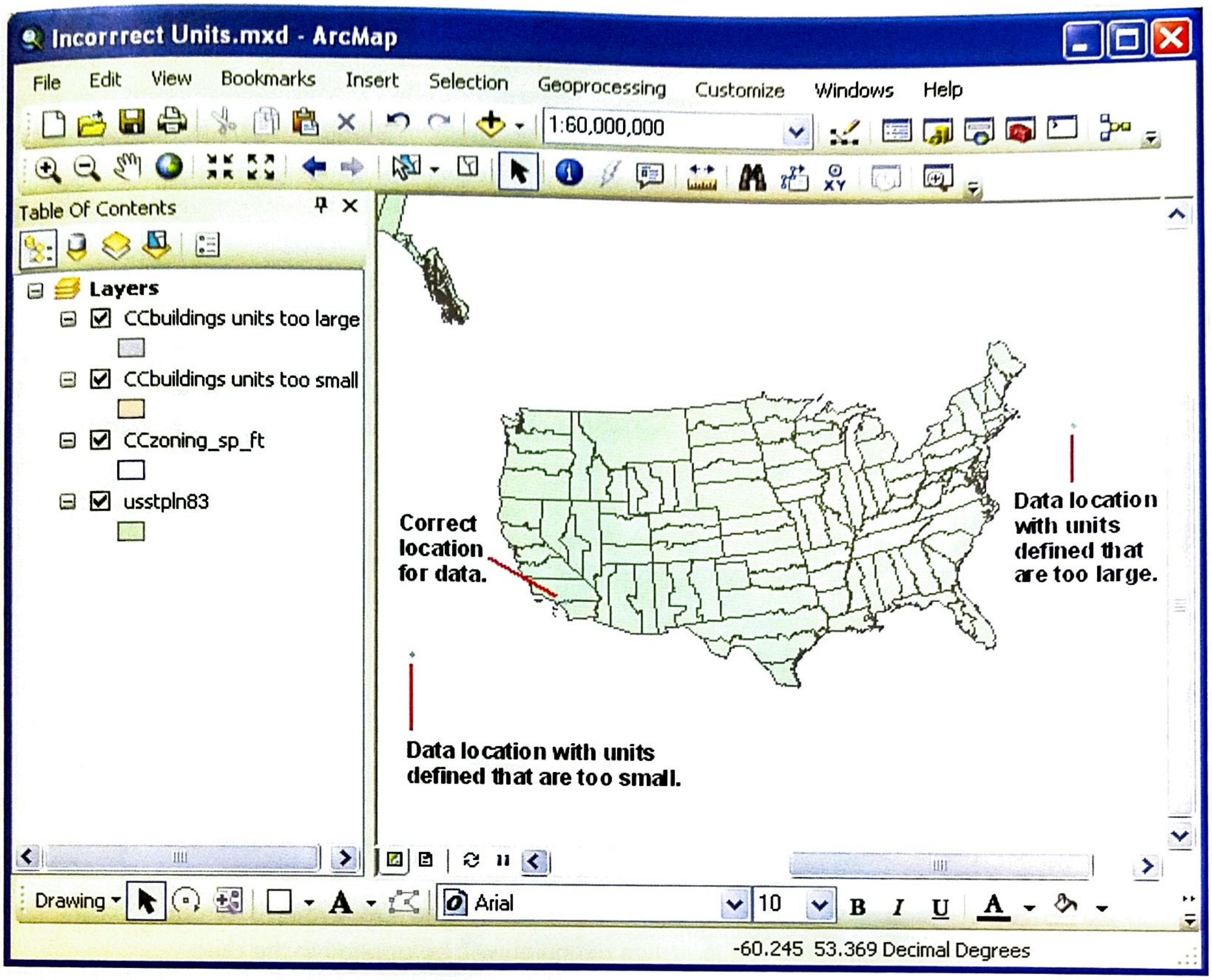

Figure 3–9 Illustration of the units tip. The data that draws northeast of the correct location is projected to the state plane coordinate system with units of feet, but has been *defined* with units of meters. The data southwest of the correct location is projected to the state plane coordinate system with units of meters, but has been *defined* with units of feet. Redefining the projections using the projection files that have the correct units will align the data. Turn to figure 4–1 for an illustration of the units offset in the UTM coordinate system.

Datum tip: For nearly all state plane zones, the difference between the false easting projection parameter defined on the NAD 1927 and NAD 1983 datums is *very* large.

For example, if the projection for the ArcMap data frame for FIPS 0401 (in the northern part of California) is set as NAD 1927 StatePlane Feet but the data is really projected to NAD 1983 StatePlane Feet, the data will draw in Wyoming instead of California. If the data is really projected to NAD 1927 StatePlane Feet but the projection of the data frame is set to NAD 1983 StatePlane Feet, the data will draw in the Pacific Ocean. You can immediately tell, therefore, if the datum selected for use with the SPCS and applied in the ArcMap data frame matches the data.

Watch out for North Carolina and South Carolina, though. The false easting values for the SPCS on the NAD 1927 and NAD 1983 datums for data in these two states are nearly identical. Therefore, offsets for data in these states between NAD 1927 and NAD 1983 will only be about 90 to 140 feet, the difference of the datum shift for that part of the country.

Repeat assigning a state plane projection definition from the available folders until usstpln83.shp snaps into place and the data with the unknown coordinate system appears in the correct area in the proper state. If the Geographic Coordinate System Warning dialog box appears, review the process for setting the geographic transformation in ArcMap outlined in chapter 2 and set the appropriate geographic transformation.

Verify the location by zooming in on the layer and using the Identify tool on the state where the data is drawn. Verify further by adding detailed reference data, such as parcels, streets, or other data that have projections correctly defined to the ArcMap document.

DEFINING THE COORDINATE SYSTEM FOR THE DATA AS STATE PLANE

If you have identified the projected coordinate system for the data as one of the state plane coordinate system options, note the name of the correct state plane coordinate system projection and the location of that definition in the directory structure.

- Open ArcToolbox > Data Management Tools > Projections and Transformations > Define Projection Tool. (In ArcGIS 10.1 for Desktop from within ArcMap, you can also access this tool by opening the Catalog window > Toolboxes > System Toolboxes.)

- From the Input Dataset or Feature Class drop-down list, select the name of the dataset with the undefined coordinate system.

- To apply the coordinate system to the data, click the Browse button > Projected Coordinate Systems > State Plane, and open the folder containing the correct coordinate system definition for the data.

- Select the correct projection definition, click Add > Apply and OK > then OK again on the Define Projection tool. The selected coordinate system definition will be applied to the data.

IF STATE PLANE OPTIONS DO NOT ALIGN THE DATA, TEST FOR UTM

If applying the various state plane coordinate system options does not align the data in ArcMap, examine the coordinate extent again. Are the extent numbers all positive? Are the extent numbers 7 digits to the left of the decimal on the Top and Bottom, and 6 digits to the left of the decimal on the Left and Right? If these conditions are met, the data may be projected to universal transverse Mercator (UTM) with units of meters.

Go back to View > Data Frame Properties > Coordinate System tab > Predefined > Projected coordinate systems > UTM folder. Select the correct UTM zone for the unknown data from the following datums:

- NAD 1927
- NAD 1983
- WGS 1984

Coordinates in UTM meters on the NAD 1983 datum and coordinates for the same point on the WGS 1984 datum in the continental United States will be within approximately 1.2 meters (4 feet) of each other. On the other hand, data in the UTM projection on the NAD 1983 datum will appear approximately 200 meters north of the same data on the NAD 1927 datum. There may be a slight shift either east or west between data on these two datums but an approximate 200-meter difference in the north-south direction is diagnostic. Actual offset distances between NAD 1927 and NAD 1983 coordinates may range from about 190 meters to 220 meters The 200-meter difference is comparatively slight; therefore, it is essential that accurate comparison data be used to determine whether the correct datum has been selected. (For steps to set the geographic transformation in ArcMap, refer to chapter 2.)

After setting the projection of the ArcMap data frame to the proper UTM zone with units of meters, you may see the data with the unknown coordinate system draws a great distance north and slightly east of the proper location. The data may be projected to the UTM coordinate system, but with units of feet. To investigate this possibility, assign the projection for the proper zone from the folder labeled BLM (US Feet). Refer to figure 3–10 for an illustration of this offset.

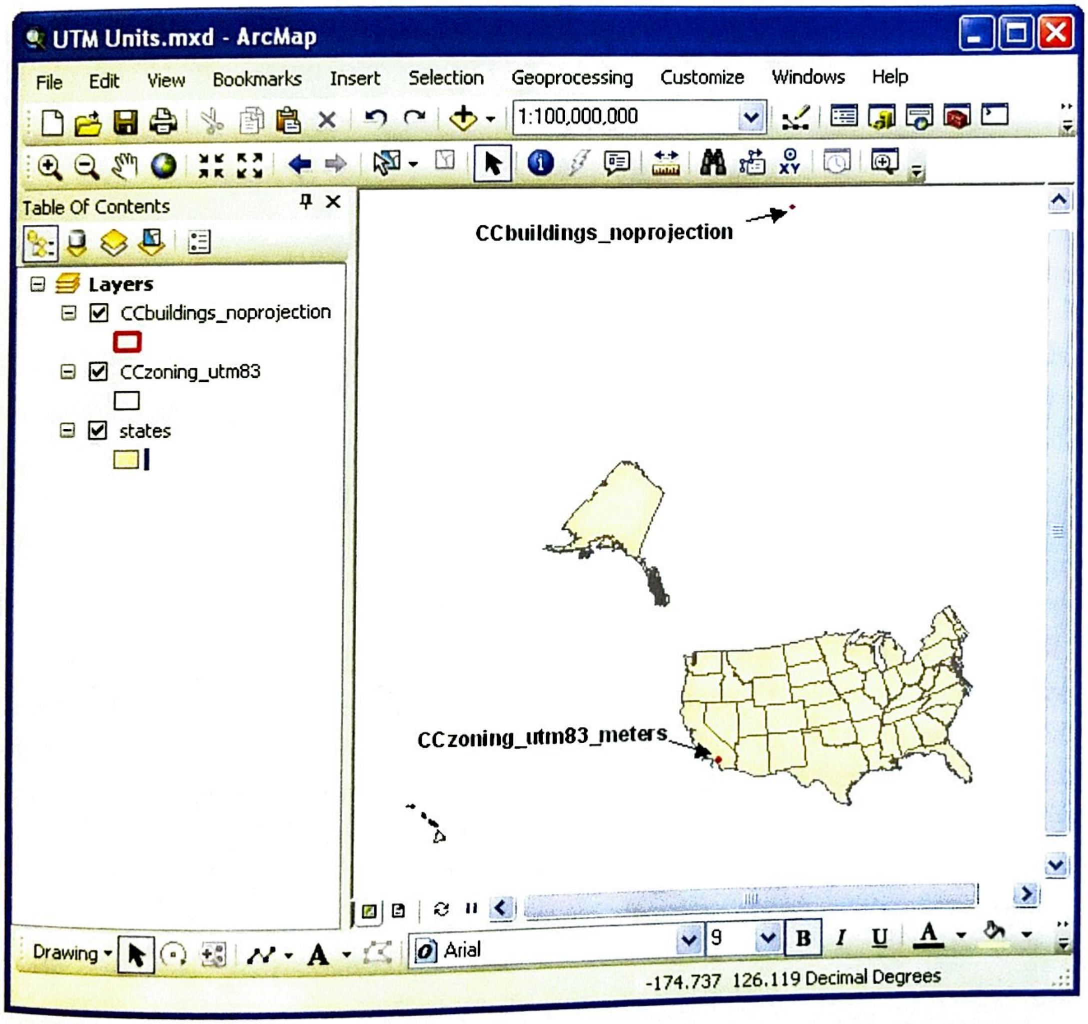

Figure 3–10 The layer CCzoning_utm83 is projected to NAD 1983 UTM Zone 11N, with units of meters, and the ArcMap data frame is set to that coordinate system. In relation to the position of that layer, CCbuildings_noprojection literally draws in the Arctic Ocean. The relative position of the layer clearly indicates that CCbuildings_noprojection was not created with units of meters.

What UTM zone should be selected?

- To determine which UTM zone projection should be selected in ArcMap, click Insert > New Data Frame.
- Click Add Data, and add some of your own data, with the coordinate system correctly defined, to the new data frame.
- Click Add Data again, navigate to the Reference Systems folder, and add utm.shp to the map.
- Use the Identify tool to identify the zone number from utm.shp. UTM zone numbers for the fifty United States range from 59 for western Alaska to 19 for eastern Maine. *The correct zone number is in the field named ZONE.* Ignore the values in the fields named ZONE_ and ZONE_ID. These fields were carried over from the original ArcInfo coverage, and these fields do not contain the correct UTM zone numbers.
- The new data frame can be deleted from the map document when the correct UTM zone number has been identified.

If you have identified the projected coordinate system for the unknown data as one of the UTM options, note the name and location of the correct UTM coordinate system projection definition.

- Open ArcToolbox > Data Management Tools > Projections and Transformations > Define Projection Tool. In ArcGIS 10.1 for Desktop from within ArcMap, you can also open the Catalog window > Toolboxes > System Toolboxes.
- From the Input Dataset or Feature Class drop-down list, select the name of the dataset with the undefined coordinate system.
- For the Coordinate System, click the Browse button and open Projected Coordinate Systems > UTM, and open the folder with the correct datum name. If you have identified the units as US Feet, the required projection definition will be located in the BLM folder.
- Select the projection definition for the correct UTM zone, click Add > Apply and OK > then OK again on the Define Projection tool. The selected coordinate system definition will be applied to the data.

DATUM OFFSET BETWEEN NAD 1927 AND NAD 1983 IN UTM

If you see a north-south shift of about 200 meters or 650 feet between the datasets, the unknown data may be on NAD 1927 instead of NAD 1983. If the datum for the projection file you just modified is NAD 1983, and the data draws south of where it should be (as shown in figure 3-11), change the projection of the ArcMap data frame to NAD 1927 for the proper UTM zone.

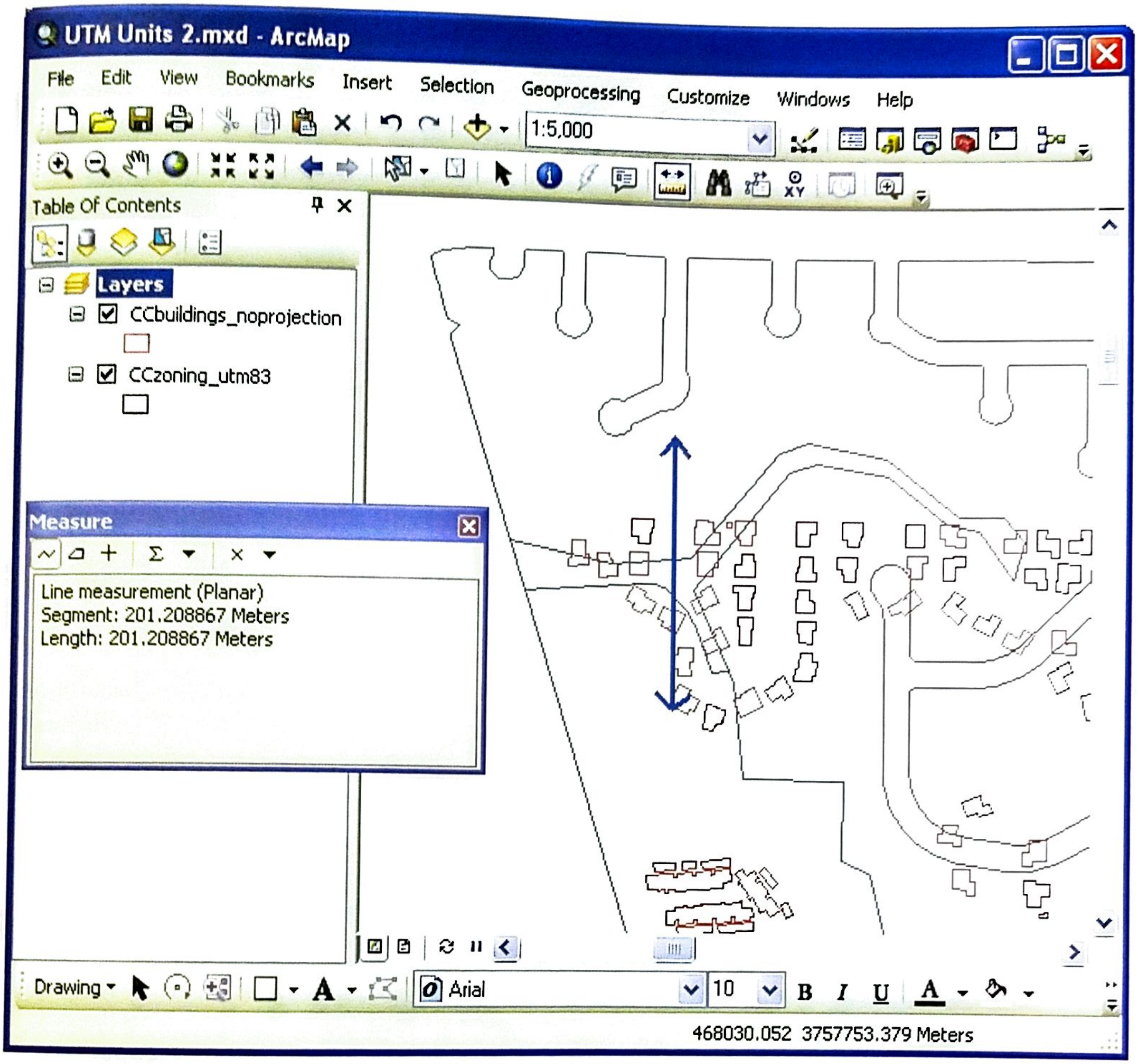

Figure 3-11 Offset, measured in meters, between NAD 1983 UTM and NAD 1927 UTM coordinates in Southern California.

When you click Apply in the Data Frame Properties dialog box, the geographic coordinate system Warning box shown in figure 3-12 will appear. Click Yes, then go to View > Data Frame Properties > Coordinate System tab.

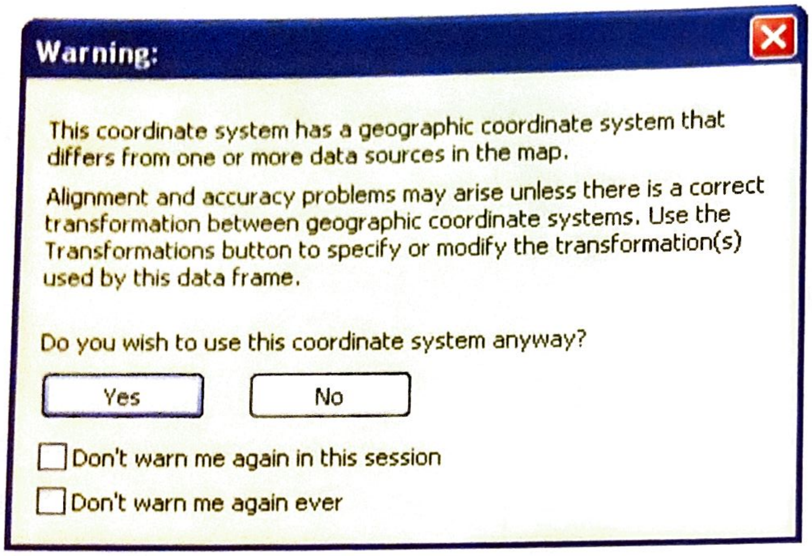

Figure 3-12 Sample of the geographic coordinate system Warning dialog box.

On the lower left of the Coordinate System tab, click Transformations. A screen capture of the dialog box that opens is shown in figure 2-6. In the Geographic Coordinate System Transformations dialog box, the "Convert from" box lists the geographic coordinate systems of the layers in the map document. The Into box displays the GCS of the ArcMap data frame. The Using drop-down list contains any available geographic (datum) transformations between the two GCS.

The content of the Into box in this dialog box must *not* be changed. The Into box displays the GCS set for the data frame of ArcMap as demonstrated in figure 3-13. Changing the GCS in the Into box will defeat the purpose of this process. In the "Convert from" box, select the GCS that is different from the one shown in the Into box.

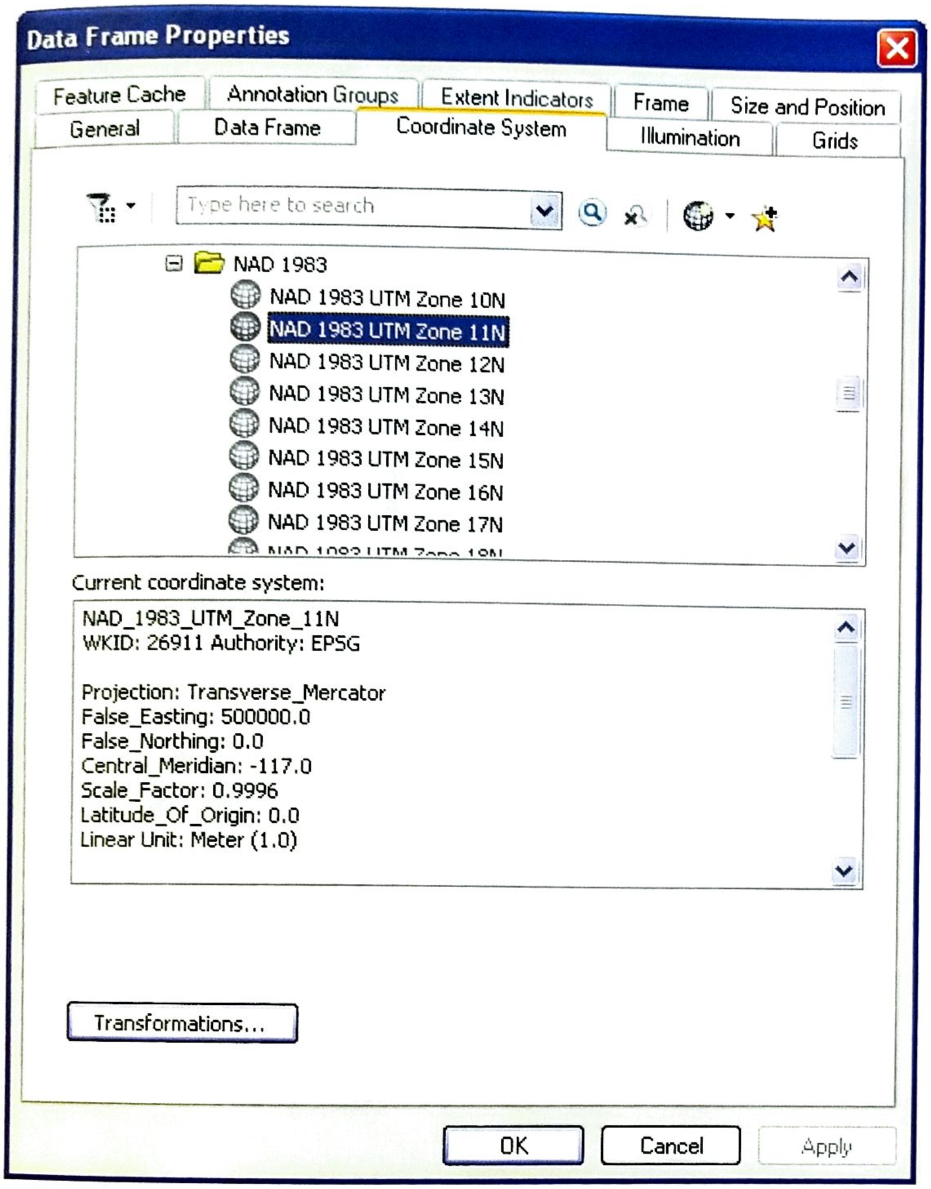

Figure 3-13 Display of the coordinate system assigned to the ArcMap data frame.

Click the Using drop-down list, and then select the correct geographic (datum) transformation for the area in which your data is located.

For data within the 48 contiguous states, select the transformation name NAD_1927_To_NAD_1983_NADCON. For data in Alaska, select the transformation name NAD_1927_To_NAD_1983_Alaska.

Old Hawaiian datum

Hawaii was never defined on the NAD 1927 datum. Originally, each major island of Hawaii was defined on a different datum, and these datums were collectively grouped as the "Old Hawaiian Datum." The transformation Old_Hawaiian_To_NAD_1983 is provided in ArcGIS for Desktop to transform data for the state of Hawaii.

Remember that ArcMap applies geographic transformations in either direction. The same transformation name will be selected whether you are going *from* NAD 1927 *to* NAD 1983 or in the reverse direction, *from* NAD 1983 *to* NAD 1927.

Click OK in the Geographic Coordinate System Transformations dialog box, and then click Apply and OK in the Data Frame Properties dialog box.

OTHER PROJECTED COORDINATE SYSTEM OPTIONS

If neither the state plane nor UTM options align the data correctly, and your unknown data has coordinate extents with values larger than 6, 7, or 8 digits to the left of the decimal, or if the extent coordinates include negative values, read on.

COUNTY COORDINATE SYSTEMS

In addition to SPCS and UTM, the states of Minnesota and Wisconsin have also developed specific county coordinate systems for each county in the state. GIS professionals in both these states are sensitive to these options, so will nearly always provide coordinate system information if data is in these county systems. These county coordinate system options must be kept in mind when working with data from either of these states.

STATEWIDE PROJECTED COORDINATE SYSTEMS

As mentioned earlier, some states have developed specific projected coordinate systems to project data for the entire state. This has been done for states such as Alaska, Texas, and California, where the state is very large, and both state plane and UTM coordinate systems split the state into multiple zones. (Remember that the state plane coordinate system should not be used for data outside the defined zone boundaries, whereas UTM should not be used for data more than 18 degrees wide that extends past the neighboring zones to the west or east.) Other states that also use statewide projections are Florida, Georgia, Idaho, Michigan, Mississippi, Virginia, Wisconsin, and Wyoming. Data in these statewide projections may display negative coordinate values in the Extent box.

If your new data lies within these states, and did not align when either state plane or UTM options were investigated, to test the statewide projections installed in ArcMap do the following:

- Go to View > Data Frame Properties > Coordinate System tab.

- Open Projected Coordinate Systems > State Systems. These projection files may be on the NAD 1927, NAD 1983, NAD 1983 (CORS96), NAD 1983 (NSRS2007) or HARN datums. Some of the statewide projection files are provided with units of meters as well as feet.

- Remember to set the geographic transformation in ArcMap if the geographic coordinate system Warning dialog box (shown in figure 3–12) appears.

CONTINENTAL COORDINATE SYSTEM OPTIONS

Other projection definitions available with ArcGIS for Desktop have parameters for continent-wide datasets. Data projected to these coordinate systems may have negative values in the coordinate extents. If the data does not align using state plane, UTM, or specific state projections, these continental coordinate systems should also be tested.

To test these coordinate system options go to View > Data Frame Properties > Coordinate System tab > Projected Coordinate Systems > North America.

If the unknown data is found to be in one of these predefined projections, use the Define Projection tool in ArcToolbox to define the coordinate system appropriately.

WEB MERCATOR

Increasing amounts of data are being distributed on the Internet in the web Mercator projection. This projection, originally calculated by Gerardus Mercator in 1569, was intended for use in navigation. Coordinates for data in this projection may be either positive or negative, in both X and Y. The projection may be defined on either the WGS 1984 sphere, or on the WGS 1984 datum. Data projected to WGS 1984 web Mercator on a sphere (WKID 3785) will not align with data on a datum and spheroid, because there are no geographic transformations between a sphere and any datum. Refer to Knowledge Base article 32001 available from the Esri Support Center for additional information.

WGS 1984 web Mercator (auxiliary sphere) (WKID 3857) in ArcGIS for Desktop is based on the WGS 1984 datum and spheroid, so transformations are available between this datum and other GCS in ArcGIS for Desktop.

When performing analysis of data, or if measurements of distance or area are important considerations for a project, use of this projection should be avoided. While this projection preserves direction, and the shape of data, both distance and area measurements are severely distorted. For comparison, refer to Knowledge Base article 39404 available from the Esri Support Center. This article includes screenshots of a variety of world projections, and their properties, for comparison with web Mercator.

If none of the available projection definitions installed with ArcGIS for Desktop aligns the data, refer to chapters 4, 5, and 6 for the guidance you need, whether instructions on modifying existing projections to align data or instructions on creating custom projection files to meet this objective.

SUMMARY

Chapter 3 is predicated on the assumption that your data is in a projected coordinate system (PCS), but you do not yet know which PCS. This chapter outlines the process for identifying data in an unknown projected coordinate system and the techniques for identifying the units of the projection, using the project-on-the-fly utility in ArcMap. The chapter also provides suggestions for additional projected coordinate systems to check if the standard options do not align the data.

All the options so far have been in feet or meters. The next chapter outlines techniques that you can apply in identifying units of measure used to create data that is not in feet or meters. Chapter 4 also includes instructions for modifying projection definitions provided with ArcGIS for Desktop to accommodate other units of measure.