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Chapter 2 Review Questions

1. Describe the three levels of approximation of the shape and size of the Earth for GIS applications.

The simplest model for approximating the Earth is a *sphere*, which is typically used in discussing map projections. But the Earth is wider along the equator than between the poles. Therefore a better approximation to the shape of the Earth is a *spheroid*, also called *ellipsoid***,** an ellipse rotated about its minor axis. The *geoid* is an even closer approximation of the Earth than a spheroid. The geoid has an irregular surface, which is affected by irregularities in the density of the Earth's crust and mantle.

2. Why is the datum important in GIS?

A datum is important in GIS because it serves as the reference or base for calculating the geographic coordinates of a location.

3. Describe two common datums used in the United States.

The first common datum used in the United States is NAD27 (North American Datum of 1927), which is a local datum based on the Clarke 1866 ellipsoid, a ground-measured spheroid. The second common datum is NAD83 (North American Datum of 1983), an Earth-centered or geocentered datum, based on the GRS80 (Geodetic Reference System 1980) ellipsoid.

4. Pick up a USGS quadrangle map of your area. Examine the information on the map margin. If the datum is changed from NAD27 to NAD83, what is the expected horizontal shift?

[The expected horizontal shift is listed on the lower margin of a USGS quadrangle map.]

5. Go to the NGS-CORS website (http://www.ngs.noaa.gov/CORS/). How many continuously operating reference stations do you have in your state? Use the links at the website to learn more about CORS.

[Go to the above website, click a state on the map, and see how many continuously operating reference stations are within the state.] Surveyors, GIS professionals, engineers, scientists, and others can apply CORS data to position points at which GPS data have been collected. The CORS system enables positioning accuracies that approach a few centimeters relative to the National Spatial Reference System, both horizontally and vertically.

6. Explain the importance of map projection.

A map projection offers a couple of advantages. First, a map projection allows us to use two-dimensional maps, either paper or digital, instead of a globe. Second, a map projection allows us to work with plane or projected coordinates rather than longitude and latitude values. Computations with geographic coordinates are more complex.

7. Describe the four types of map projections by the preserved property.

A conformal projection preserves local angles and shapes. An equivalent projection represents areas in correct relative size. An equidistant projection maintains consistency of scale along certain lines. And an azimuthal projection retains certain accurate directions.

8. Describe the three types of map projections by the projection or developable surface.

A cylindrical projection uses a cylinder as the projection or developable surface, a conic projection uses a cone, and an azimuthal projection uses a plane.

9. Explain the difference between the standard line and the central line.

A standard line refers to the line of tangency between the projection surface and the reference globe. In other words, there is no projection distortion along a standard line. The central lines (i.e., the central parallel and meridian) define the center of a map projection.

10. How is the scale factor related to the principal scale?

The scale factor is defined as the ratio of the local scale to the principal scale. In other words, the scale factor is the normalized local scale.

11. Name two commonly used projected coordinate systems that are based on the transverse Mercator projection.

They are the Universal Transverse Mercator (UTM) grid system and the State Plane Coordinate (SPC) system.

12. Google the GIS data clearinghouse for your state. Go to the clearinghouse website. Does the website use a common coordinate system for the statewide data sets? If so, what is the coordinate system? What are the parameters values for the coordinate system? And, is the coordinate system based on NAD27 or NAD83?

[The coordinate system information is typically included on the clearinghouse page for data download.]

13. Explain how a UTM zone is defined in terms of its central meridian, standard meridian, and scale factor.

A UTM zone is mapped onto a secant case transverse Mercator projection, with a scale factor of 0.9996 at the central meridian. The standard meridians are 180 kilometers to the east and west of the central meridian.

14. Which UTM zone are you in? Where is the central meridian of the UTM zone?

[The answer can be found on the margin of a 1:24,000-scale USGS topographic map. It may also be available in the download information of the clearinghouse for your area. Figure 2.12 in the text can also provide the answer, but it is not as clear as on a USGS topographic map.]

15. How many SPC zones does your state have? What map projections are the SPC zones based on?

[Information on the SPC zones is available on the USGS topographic maps. It may also be available in the download information of the clearinghouse for your area.]

16. Describe how on-the-fly projection works.

A GIS package, if it offers on-the-fly projection, can use the projection files available with the data sets and automatically convert the data sets to a common coordinate system. This common coordinate system is by default the coordinate system of the first data set in display.

Chapter 2

Q1. Summarize in your own words the steps you have followed to complete Task 1.

Task 1 involves two steps. First, because *idll.shp* has an assumed coordinate system, the Define Projection tool is used to define its geographic coordinate system. Second, the Project tool is used to project *idll.shp* from a geographic coordinate system to a projected coordinate system (IDTM).

Q2. Describe in your own words what you have done in Step 1.

Step 1 imported the coordinate system of *idll.shp* to be *stationsll.shp*'s coordinate system.

Q3. You did not have to ask for a geographic transformation in Step 2. Why?

A geographic transformation was not necessary because in Step 1 *snow.txt* had already been projected onto NAD83.

Q4. Can you use Import instead of Select in step 3? If yes, how?

Yes, Import can be used instead of Select. Import the coordinate system of *snowutm83.shp* to be the coordinate system of *idutm83.shp*.

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Coordinate System

Two map layers are not going to register spatially unless they are based on the same coordinate system.

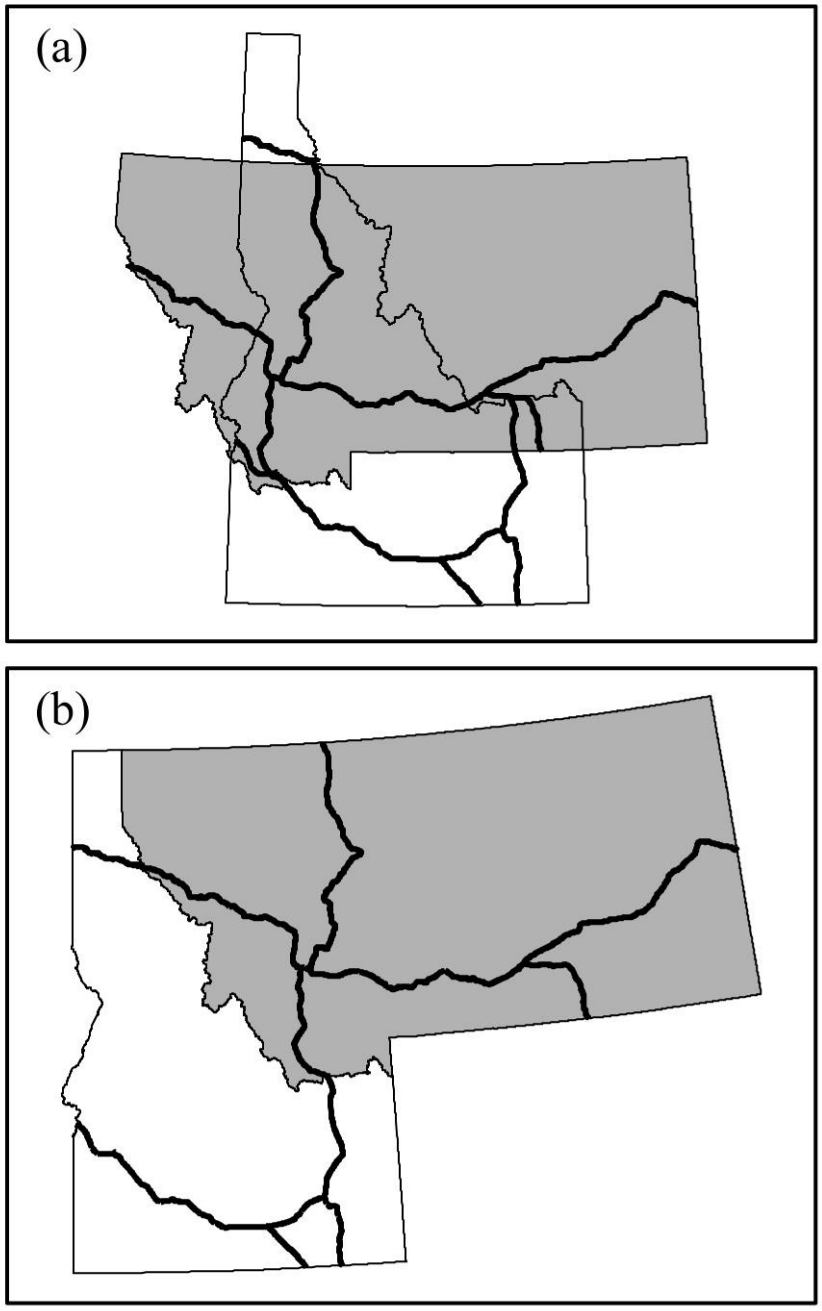

Figure 2.1
The top map shows the interstate highways in Idaho and Montana based on different coordinate systems. The bottom map shows the connected interstate networks based on the same coordinate system.

Geographic Coordinate System

- The geographic coordinate system is the location reference system for locating spatial features on the Earth's surface.
- The geographic coordinate system is defined by longitude and latitude.

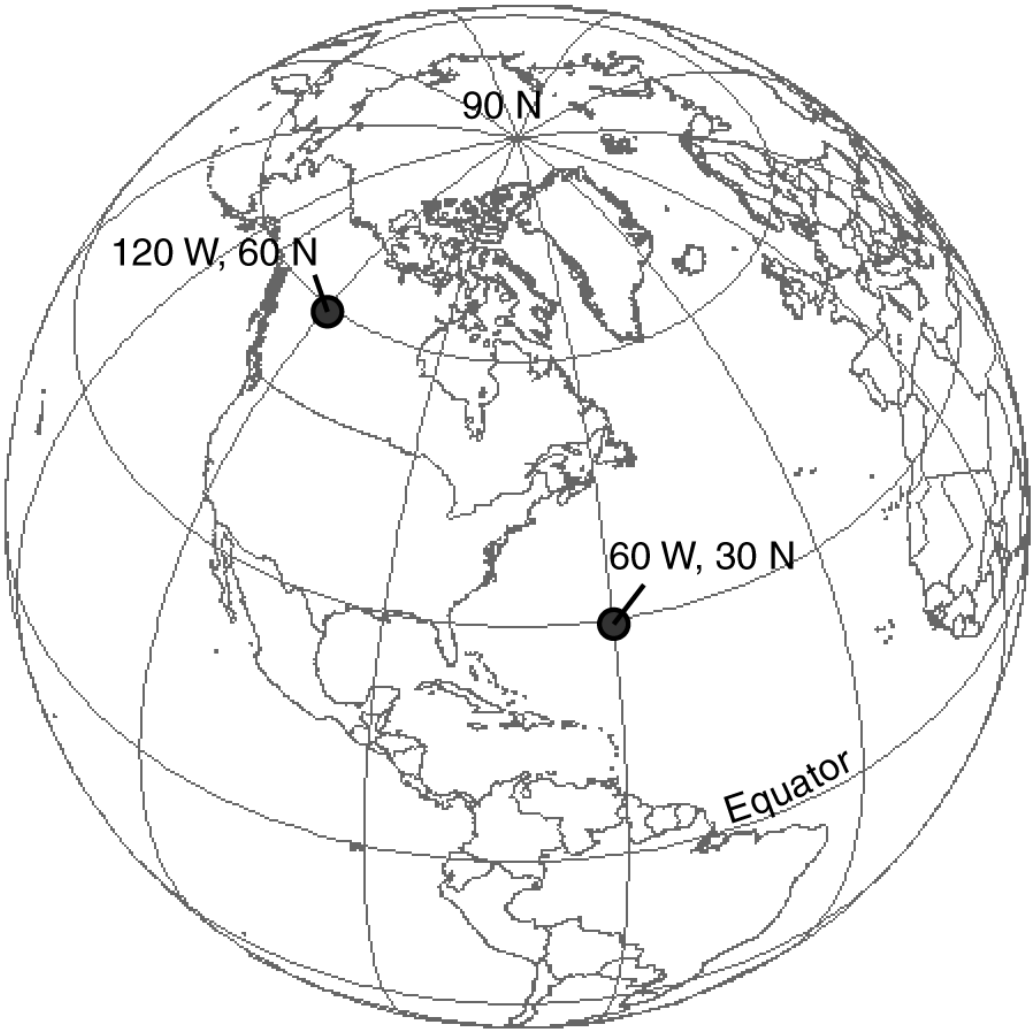

Figure 2.2
The geographic coordinate system.

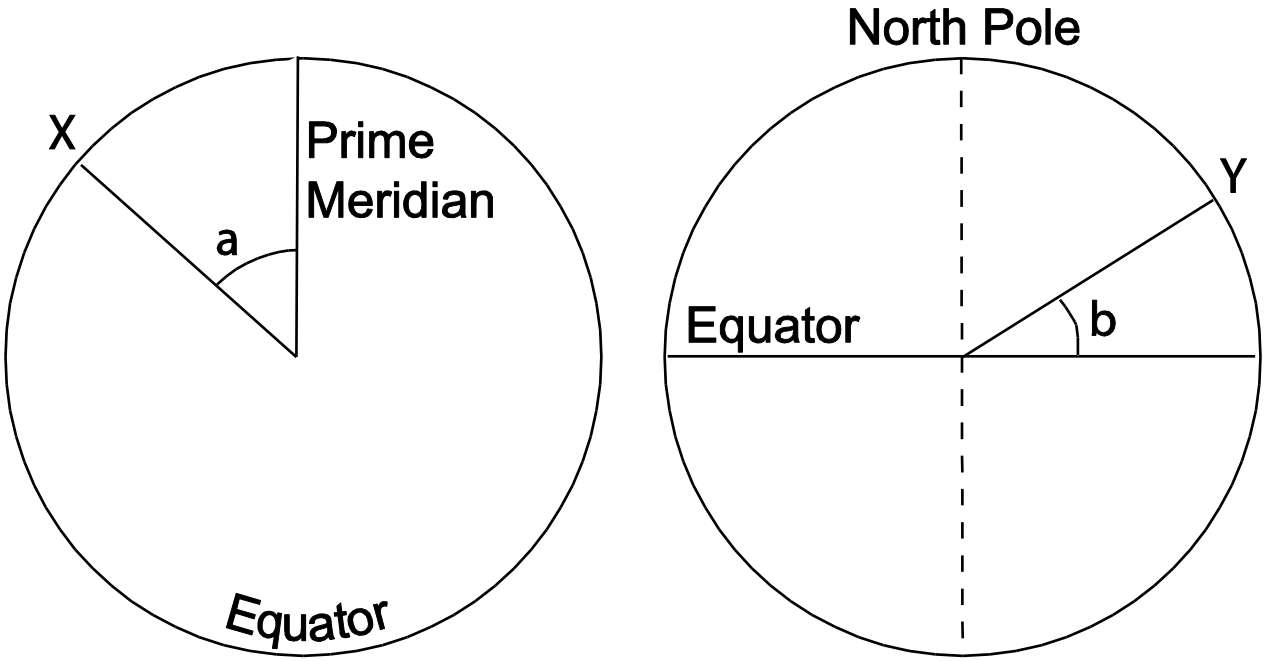

Figure 2.3
A longitude reading at X is represented by *a* on the left, and a latitude reading at Y is represented by *b* on the right. Both longitude and latitude readings are angular measures.

Approximation of the Earth

- The simplest model is a sphere, which is typically used in discussing map projections.
- But the Earth is not a perfect sphere: the Earth is wider along the equator than between the poles. Therefore a better approximation to the shape of the Earth is a *spheroid*, also called *ellipsoid***,** an ellipse rotated about its minor axis.

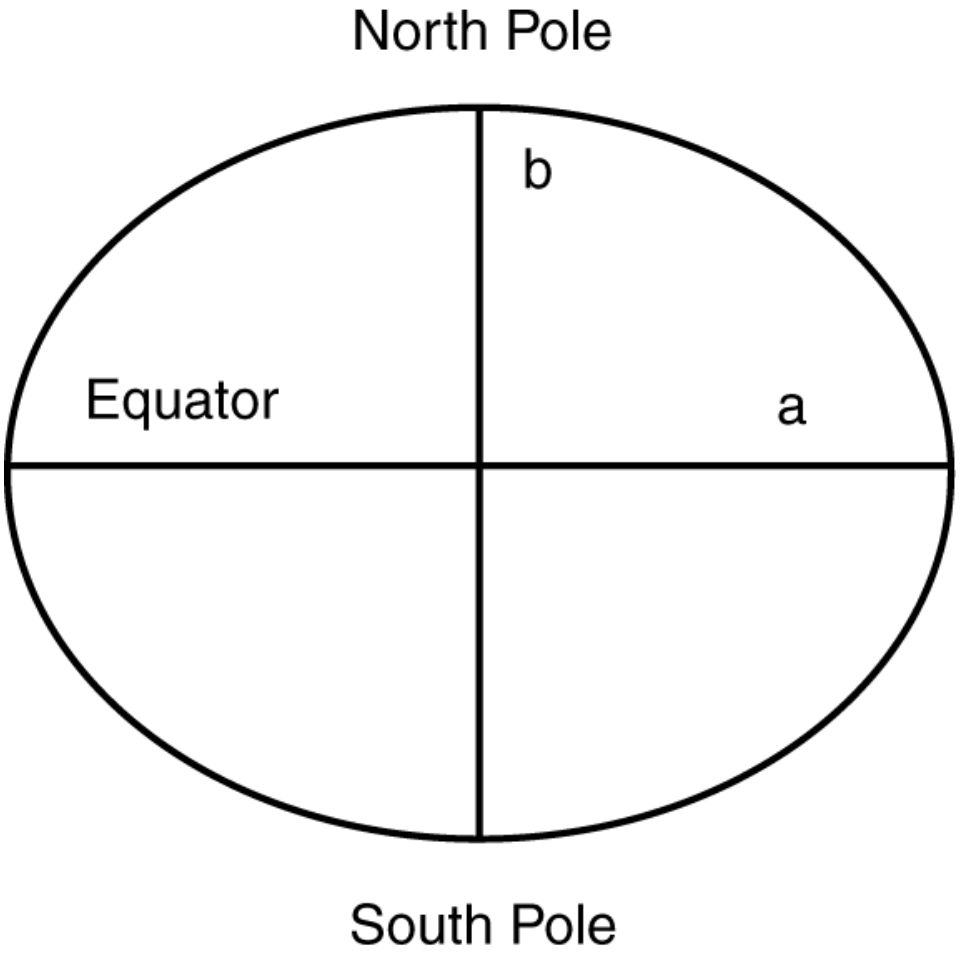

Figure 2.4
The flattening is based on the difference between the semimajor axis *a* and the semiminor axis *b*.

Datum

- A datum is a mathematical model of the Earth, which serves as the reference or base for calculating the geographic coordinates in the case of a horizontal datum and for calculating elevations in the case of a vertical datum.
- A shift of the datum will result in the shift of positions of points.

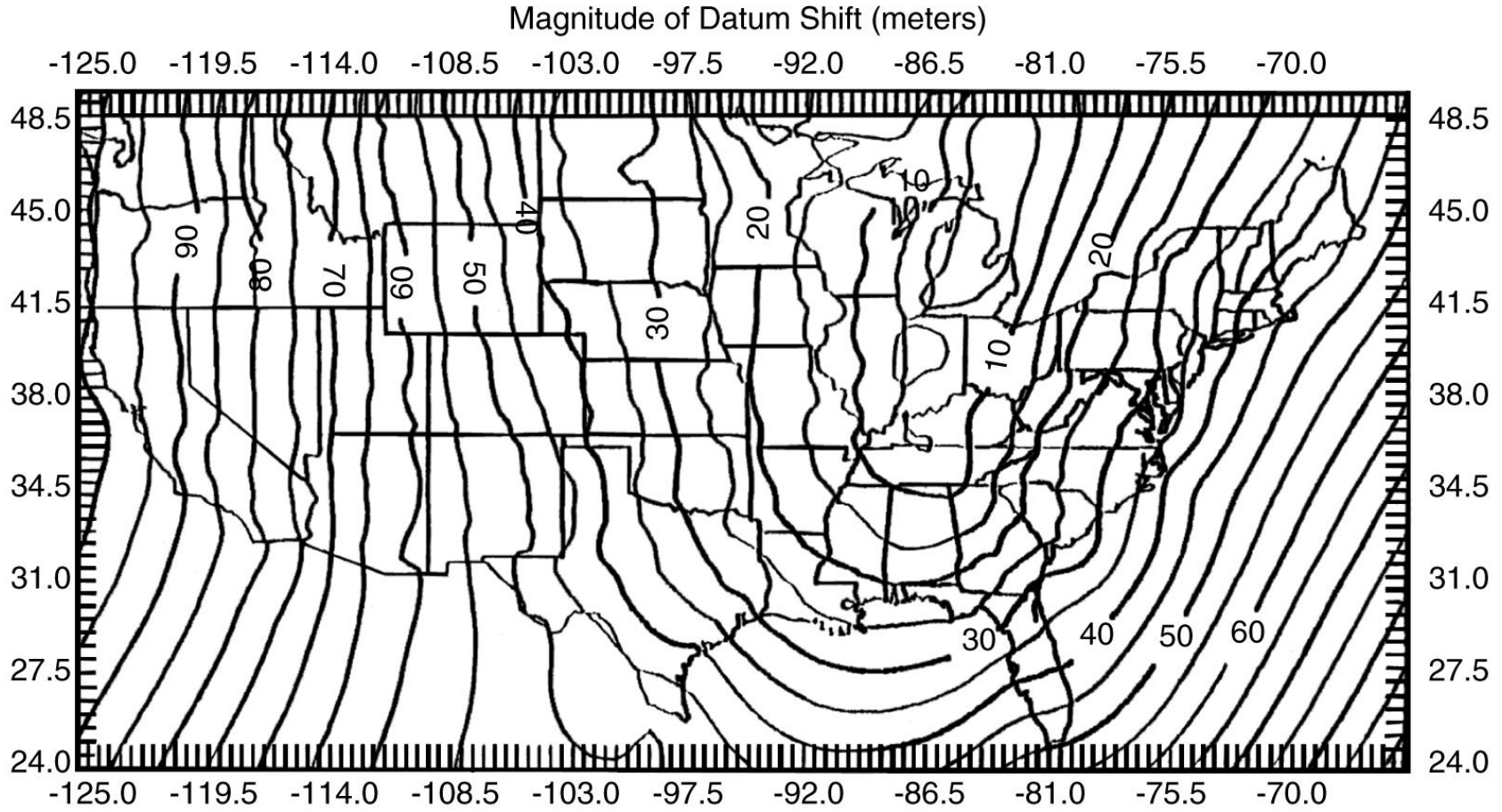

Figure 2.5
The isolines show the magnitudes of the horizontal shift from NAD27 to NAD83 in meters. See text for the definition of the horizontal shift. (By permission of the National Geodetic Survey.)

Map Projection

- A map projection transforms the geographic coordinates on an ellipsoid into locations on a plane. The outcome of this transformation process is a systematic arrangement of parallels and meridians on a flat surface.
- Cartographers group map projections by the preserved property into conformal, equal area or equivalent, equidistant, and azimuthal or true direction.
- Cartographers also use a geometric object (a cylinder, cone, or plane) and a globe (i.e., a sphere) to illustrate how to construct a map projection.

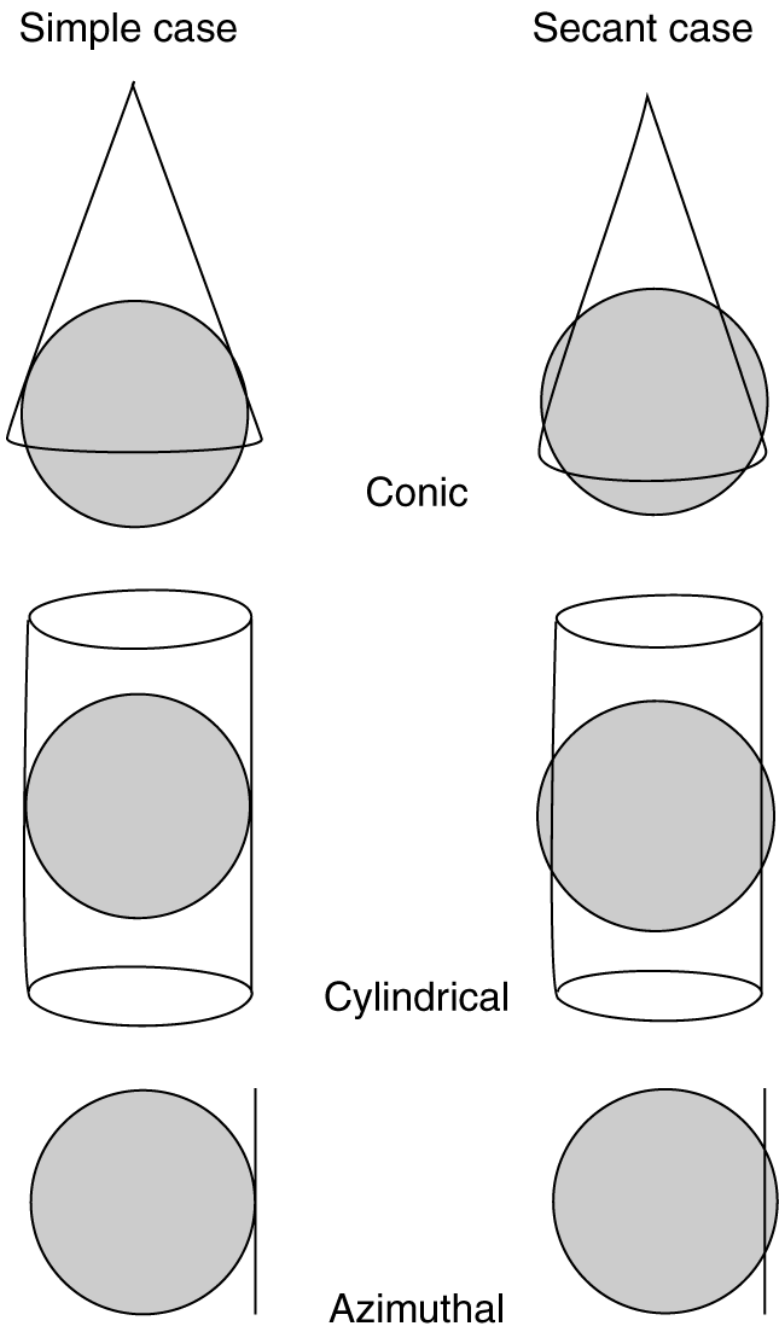

Figure 2.6
Case and projection.

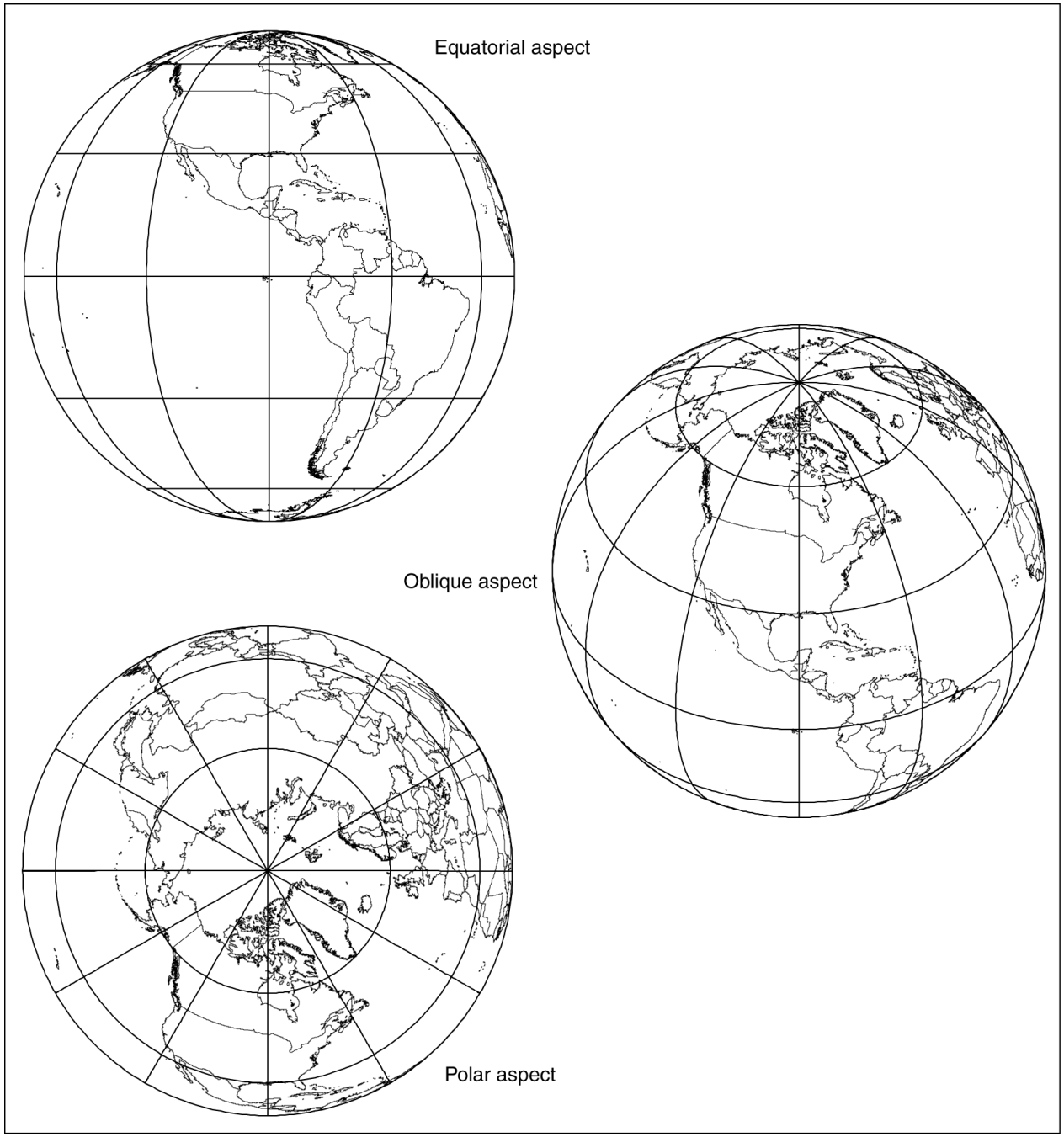

Figure 2.7
Aspect and projection.

Map Projection Parameters

A map projection is defined by its parameters. Typically, a map projection has five or more parameters, including standard lines (standard parallels and standard meridians), principal scale, scale factor, central lines, false easting, and false northing.

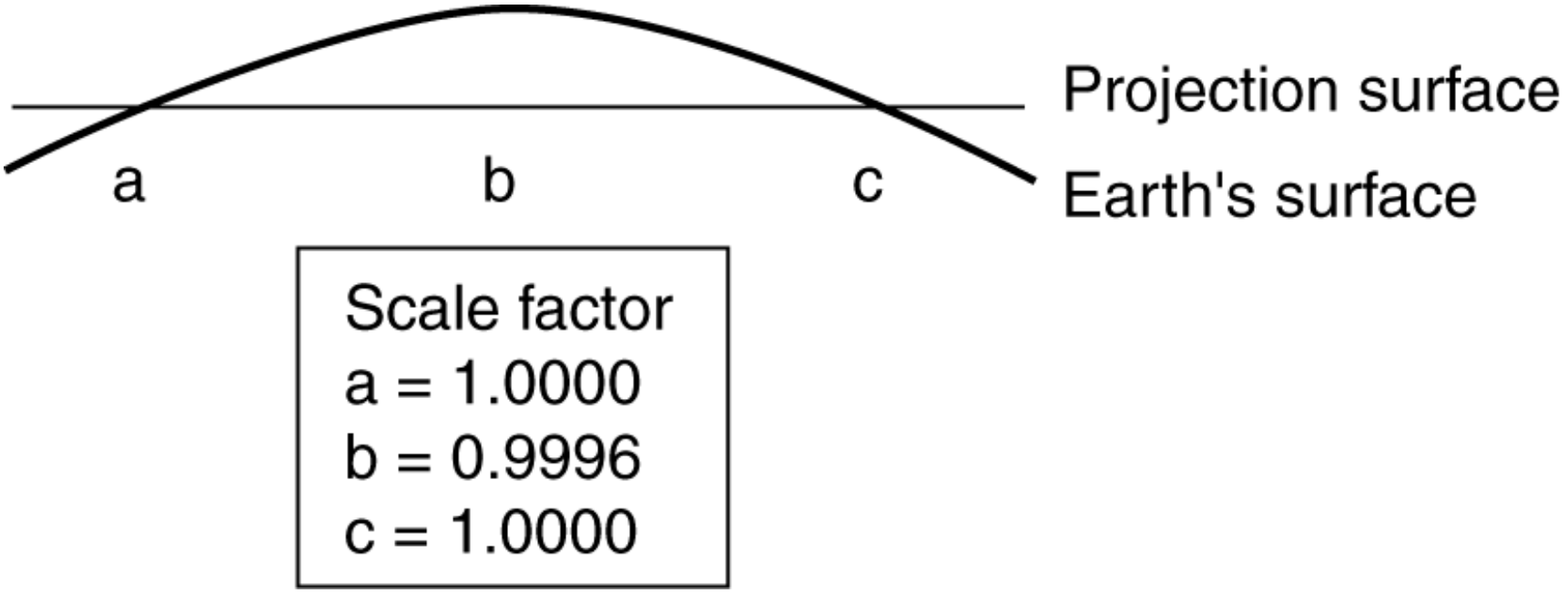

Figure 2.8
The central meridian in this secant case transverse Mercator projection has a scale factor of 0.9996. The two standard lines on either side of the central meridian have a scale factor of 1.0.

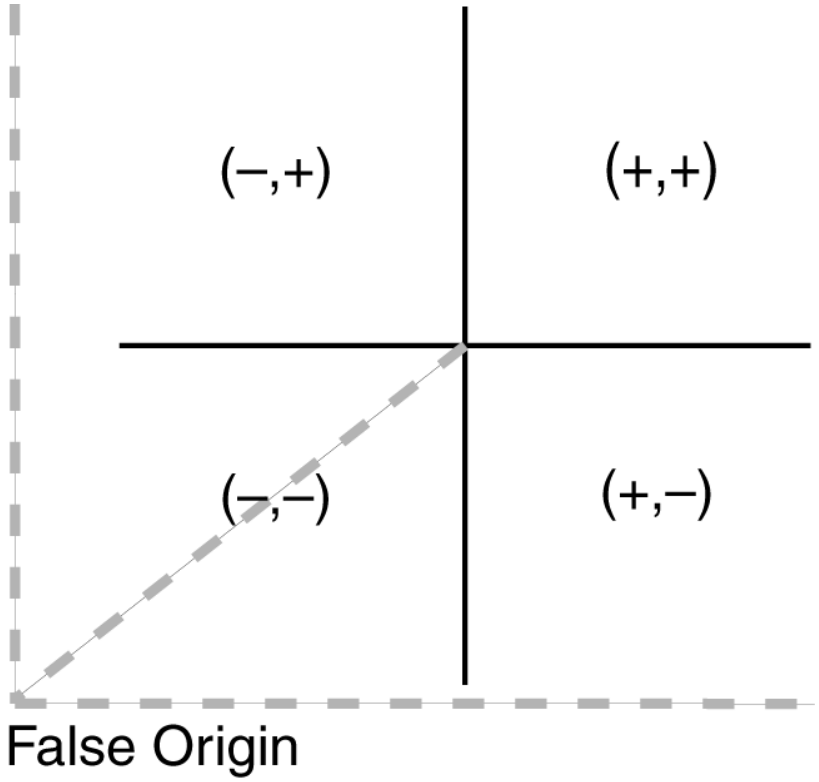

Figure 2.9
The central parallel and the central meridian divide a map projection into four quadrants. Points within the NE quadrant have positive *x*- and *y*-coordinates, points within the NW quadrant have negative *x*-coordinates and positive *y*-coordinates, points within the SE quadrant have positive *x*-coordinates and negative *y*-coordinates, and points within the SW quadrant have negative *x*- and *y*-coordinates. The purpose of having a false origin is to place all points within the NE quadrant.

Commonly Used Map Projections

1. Transverse Mercator
2. Lambert conformal conic
3. Albers equal-area conic
4. Equidistant conic
5. Web Mercator

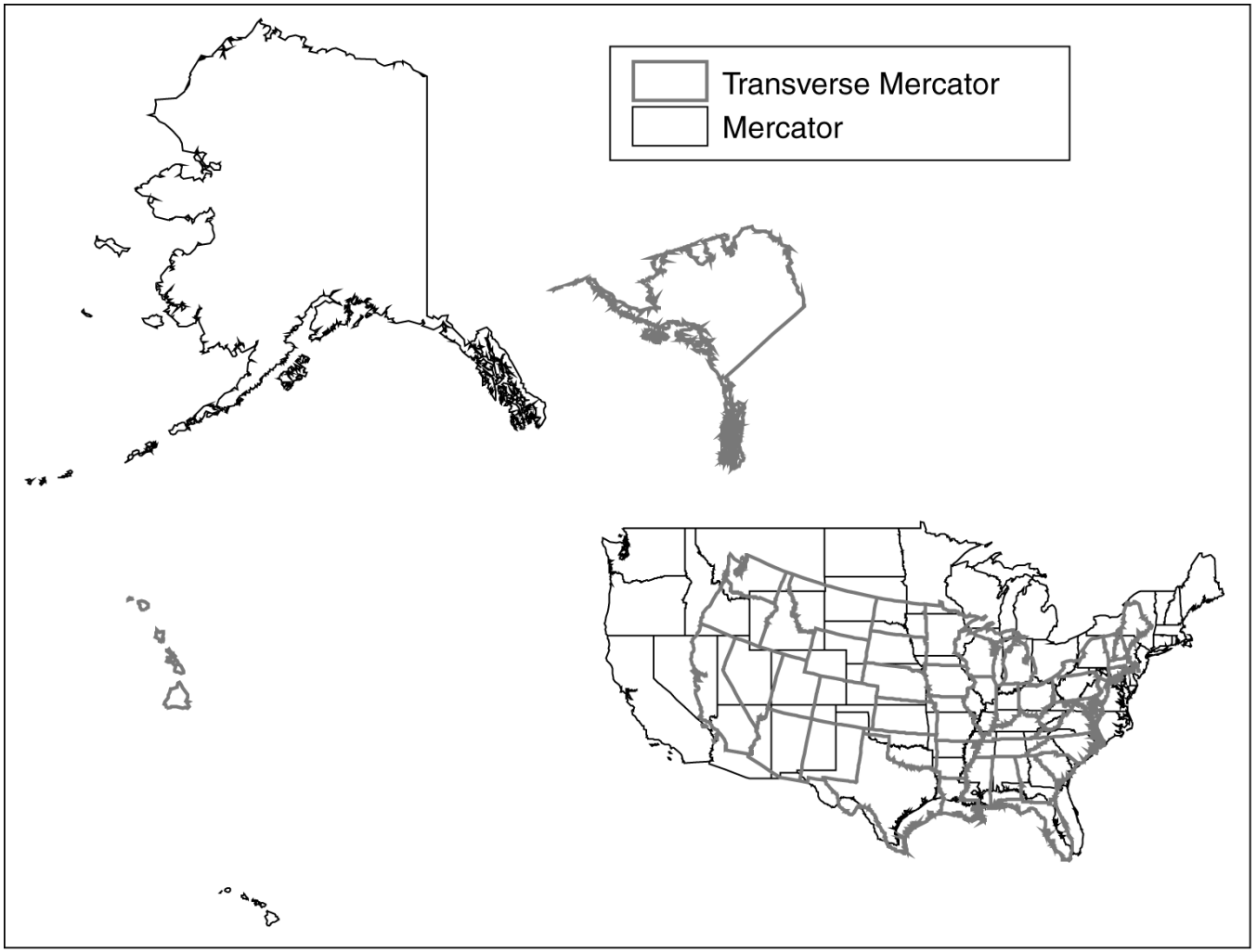

Figure 2.10
The Mercator and the transverse Mercator projection of the United States. For both projections, the central meridian is 90°W and the latitude of true scale is the equator.

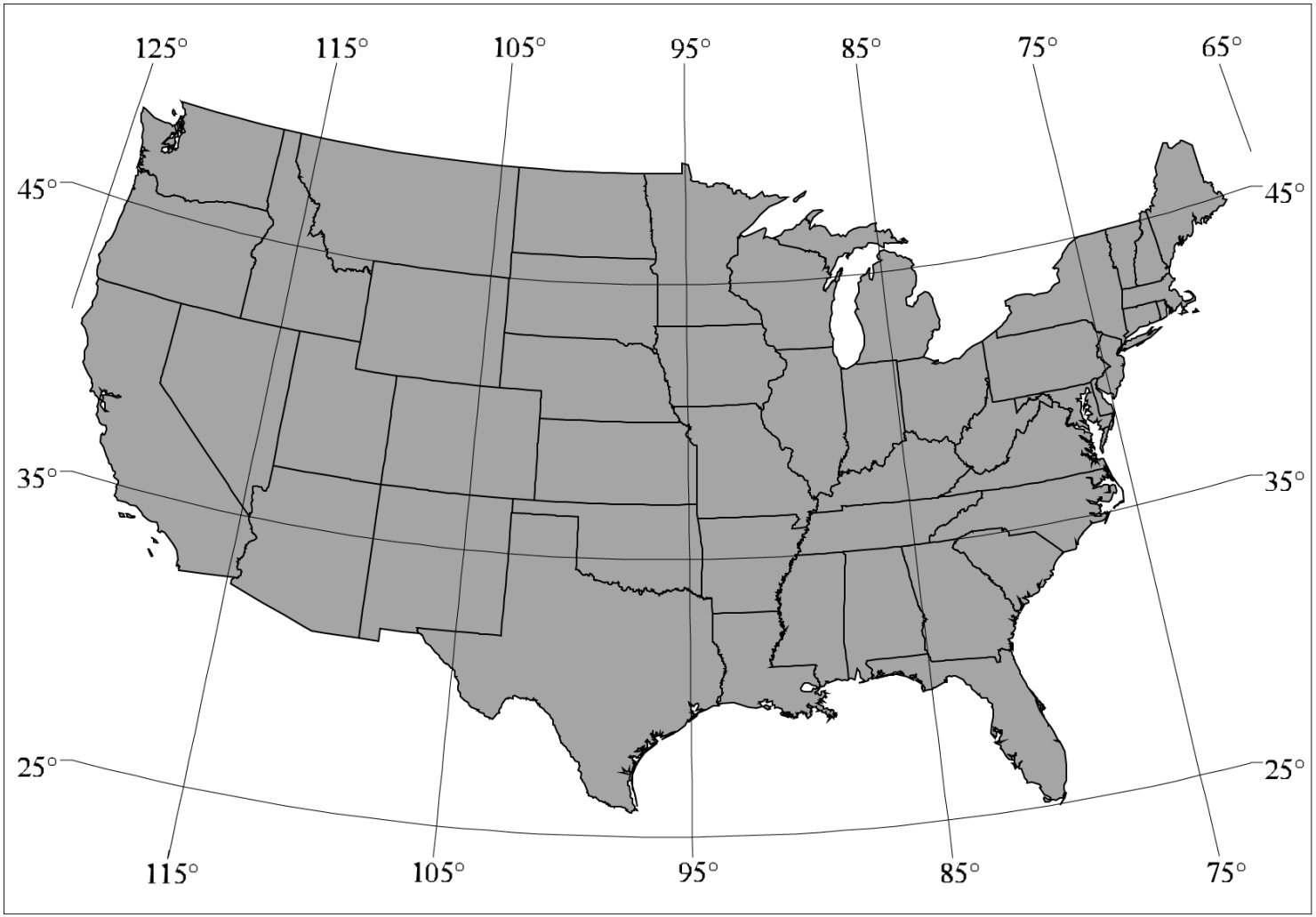

Figure 2.11
The Lambert conformal conic projection of the conterminous United States. The central meridian is 96°W, the two standard parallels are 33°N and 45°N, and the latitude of projection's origin is 39°N.

Projected Coordinate Systems

- The Universal Transverse Mercator (UTM) grid system
- The Universal Polar Stereographic (UPS) grid system
- The State Plane Coordinate (SPC) System
- The Public Land Survey System (PLSS)

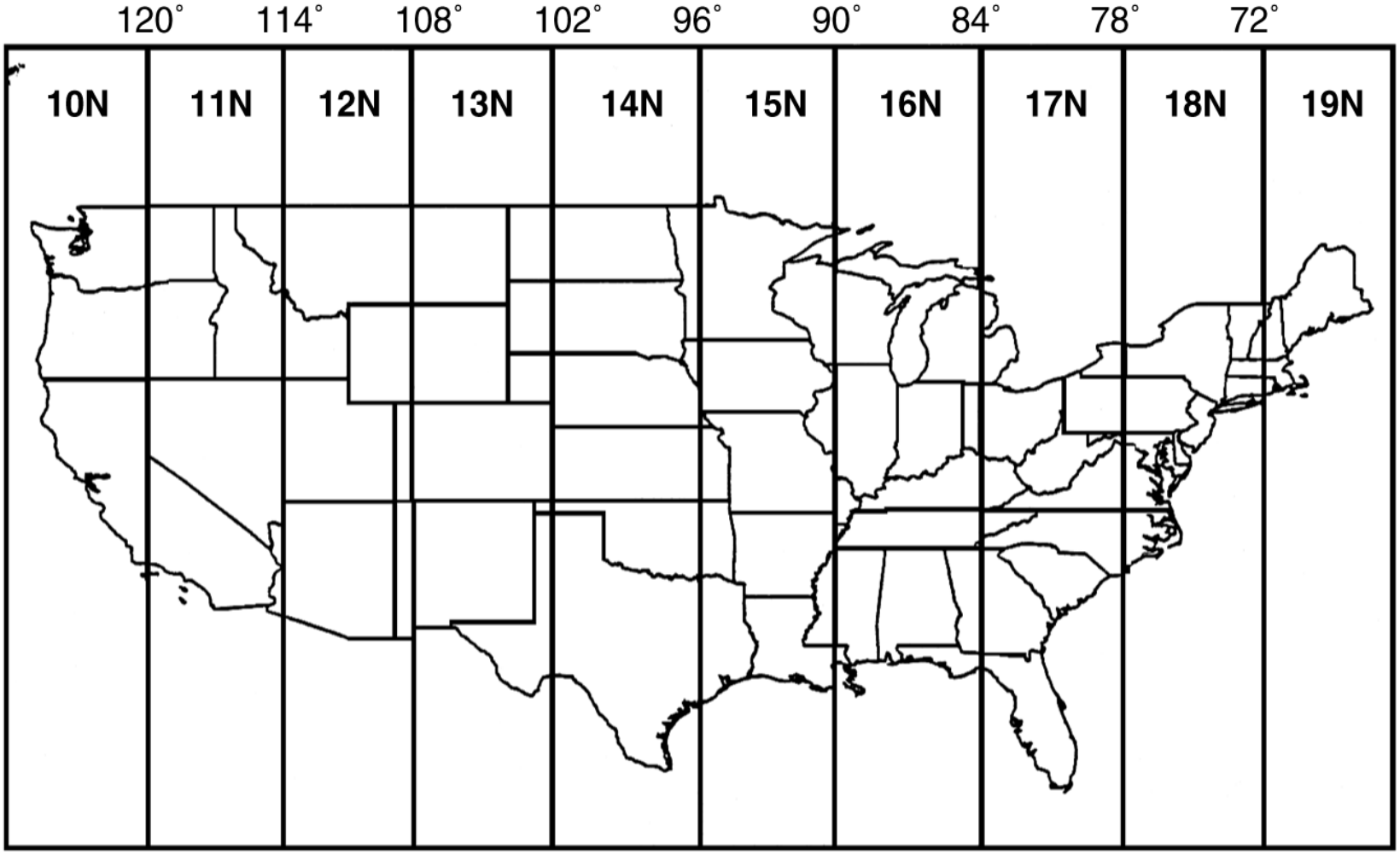

Figure 2.12
UTM zones range from zone 10N to 19N in the conterminous United States.

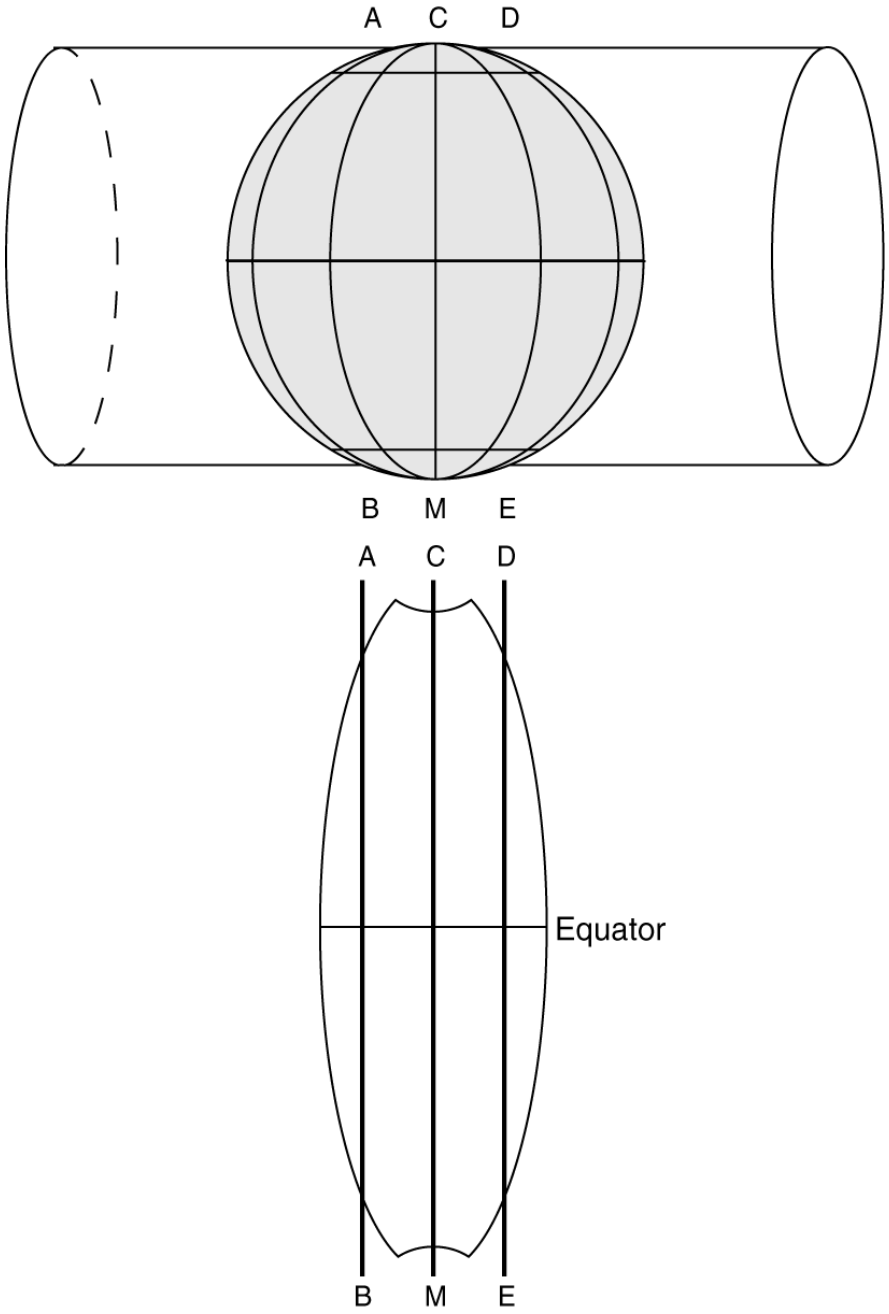

Figure 2.13
A UTM zone represents a secant case transverse Mercator projection. CM is the central meridian, and AB and DE are the standard meridians. The standard meridians are placed 180 kilometers west and east of the central meridian. Each UTM zone covers 6° of longitude and extends from 84°N to 80°S. The size and shape of the UTM zone are exaggerated for illustration purposes.

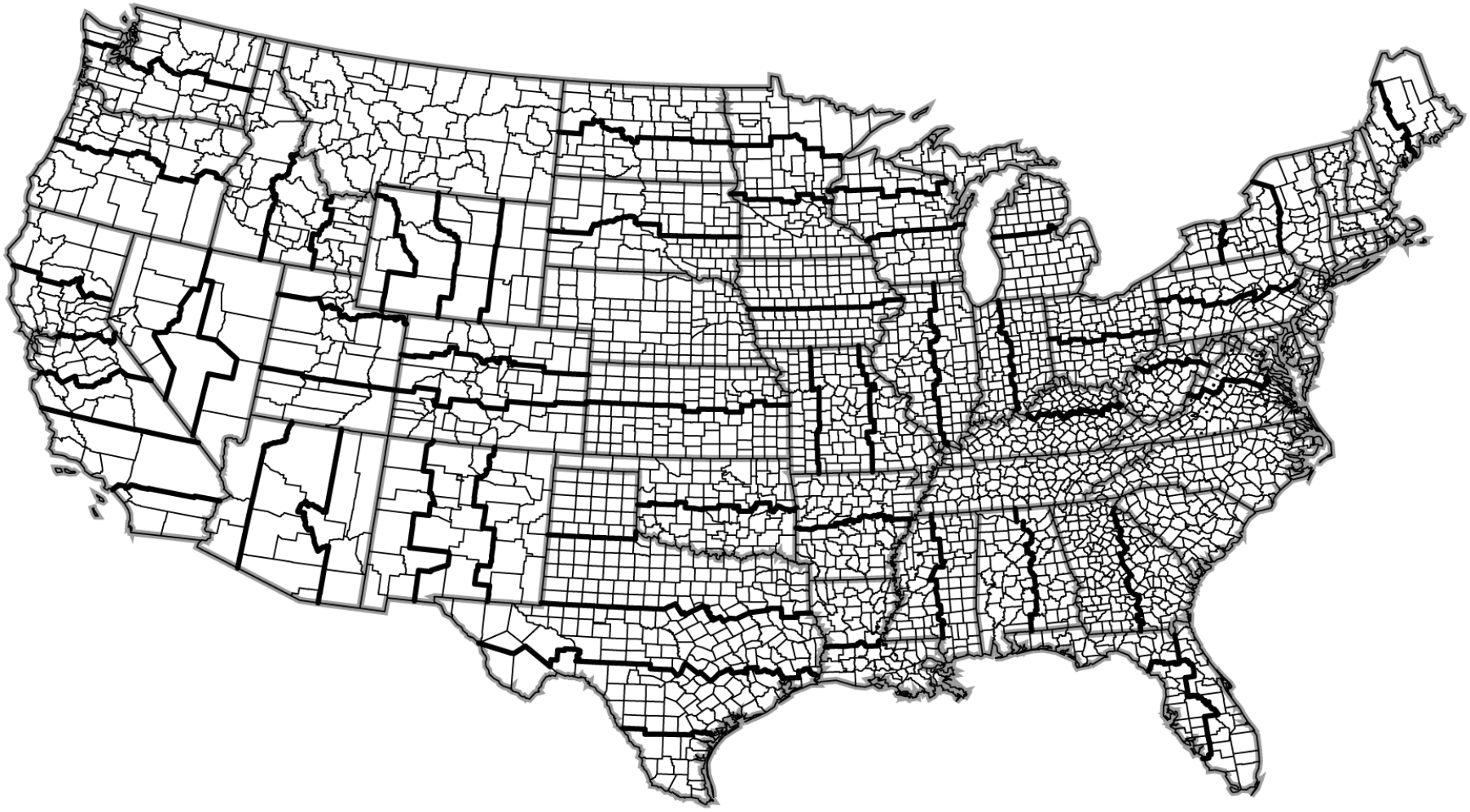

Figure 2.14
SPC83 zones in the conterminous United States. The thin lines are county boundaries, and the bold lines are SPC zone boundaries. This map corresponds to the SPC83 table on the inside of this book's back cover.

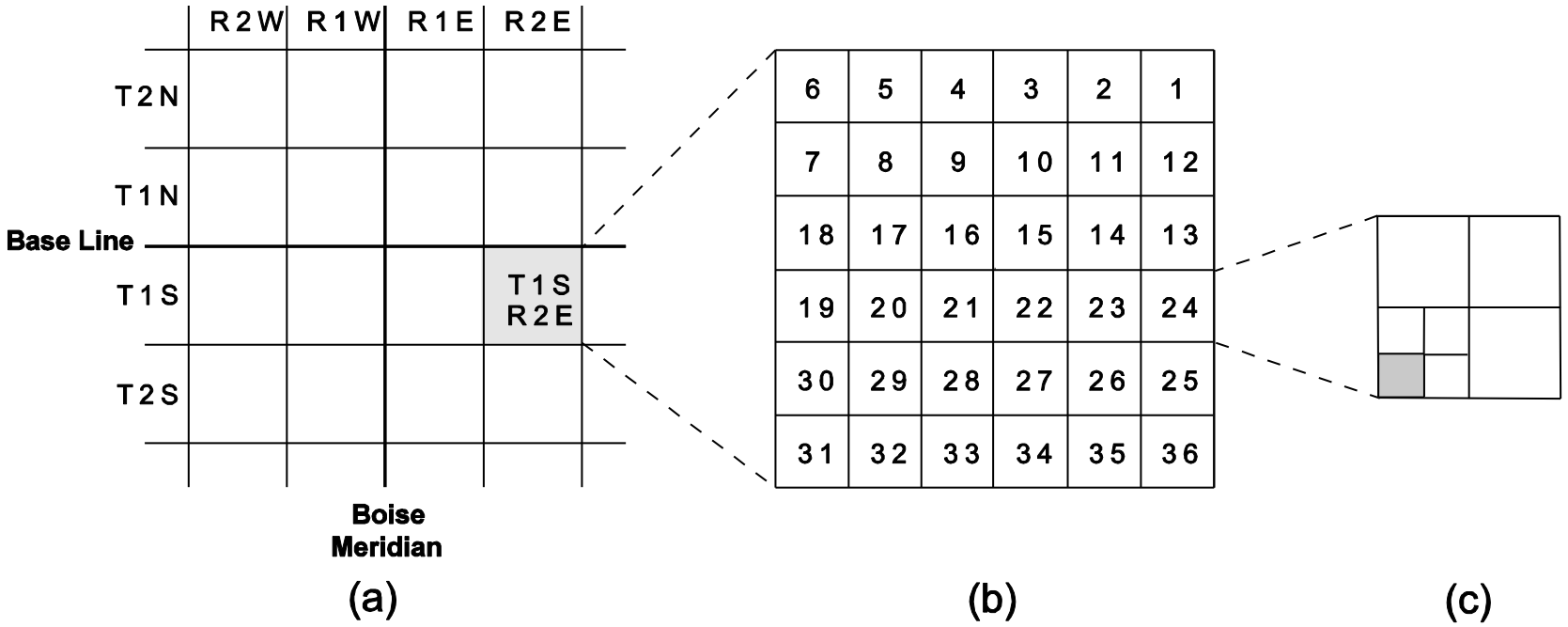

Figure 2.15
The shaded survey township in (a) has the designation of T1S, R2E. T1S means that the survey township is south of the base line by one unit. R2E means that the survey township is east of the Boise (principal) meridian by 2 units. Each survey township is divided into 36 sections in (b). Each section measures 1 mile by 1 mile or 640 acres and has a numeric designation. The shaded square in (c) measures 40 acres has a legal description of the SW 1/4 of the SW 1/4 of Section 5, T1S, R2E.

	Predefined	**Custom**
Geographic	NAD27, NAD83 (1986)	Datum transformation
Projected	UTM, State Plane	IDTM

Table 2.1 A classification of coordinate systems in GIS packages

National Geodetic Survey: Nadcon
http://www.ngs.noaa.gov/TOOLS/Nadcon/Nadcon.html

Bureau of Land Management: Geographic Coordinate Data Base
http://www.blm.gov/wo/st/en/prog/more/gcdb.html

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