Chapter 3
Geographic Location Systems

In this chapter you will learn about:
- *Latitude and longitude*
- *Universal Transverse Mercator (UTM)*
- *U.S. Public Land Survey*
- *Other geographic location systems*

Geographic location systems or coordinate systems were developed as a tool to describe specific geographic locations and are used for navigation and mapping. Generally, they consist of a grid of imaginary intersecting lines which are used to describe a position on a map. Most of these systems use coordinate values, which are expressed as numeric or alphanumeric characters, to define geographic locations. Coordinate systems are based on reference points from which position measurements are made. For example, the reference points for latitude and longitude are the prime meridian and equator.

This chapter discusses two types of global geographic location systems commonly used in the United States – latitude/longitude and UTM. Then, it describes the U.S. Public Land Survey (section, township, and range) and other types of geographic location systems.

Refer to Chapter 6, Navigation and Field Mapping, for information on how to plot and map points using geographic location systems.

Latitude/Longitude

Latitude/longitude is a global system which precisely identifies locations using the equator as a reference point for latitude and the prime meridian as a reference point for longitude (Figure 3-1).

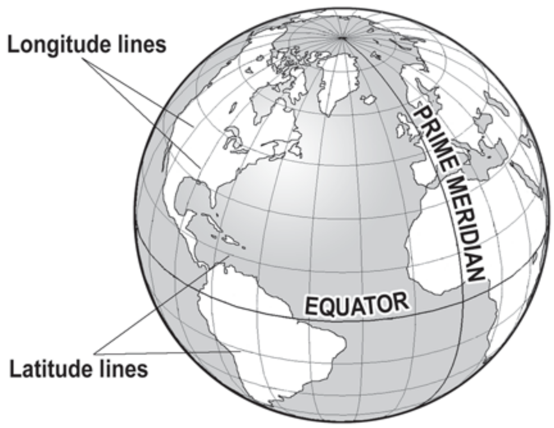


Figure 3-1. Latitude and longitude lines.

Latitude

Latitude lines circle the world parallel with the equator, running in an easterly and westerly direction. These lines are identified by their position either north or south of the equator. The equator is 0° latitude and the North Pole (90° N) and South Pole (90° S) are both 90° latitude. All other points on earth have latitudes ranging between 0° to 90° north or 0° to 90° south. When stating the position coordinates, latitude is always said first (Figure 3-2).

Longitude

Longitude lines run true north to true south – North Pole to South Pole. Longitude is the distance east or west of the prime meridian (Greenwich, England). The prime meridian is 0° longitude.

All other points on earth have longitudes ranging between 0° to 180° east and 0° to 180° west. Lines of longitude are not parallel; the closer they are to the poles, the shorter the distance between them. Principal meridian lines run in the same direction as the lines of longitude.

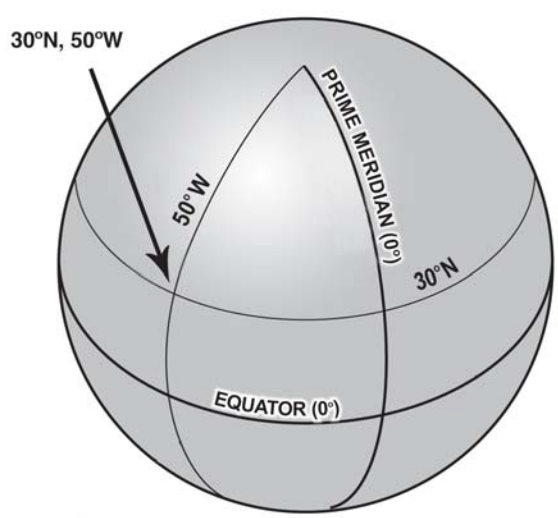


Figure 3-2. The coordinates for the point where latitude and longitude meet are described as 30°N, 50°W.

Latitude and Longitude Coordinates

There are three primary ways of describing locations using latitude and longitude coordinates:

1. Degrees Minutes Seconds (ddd° mm' ss.s")

   This is the most common format that is used on maps:

43° 23' 45" (Latitude)	71° 8' 36" (Longitude)

2. Degrees Decimal Minutes (ddd° mm.mmm')

   This format is used by aircraft guidance systems:

43° 23.75' Latitude	71° 8.6' Longitude

   On incidents, this system should be used by personnel to establish common terminology between incident personnel and air operations.

3. Decimal Degrees (ddd.dddd°)

   This is used by National Weather Service and other agencies, as well as some computer based mapping systems:

43.395833° Latitude	71.143333° Longitude

Counting and Converting Minutes and Seconds

When working with latitude and longitude, it is essential to know how to count minutes and seconds and be familiar with conversions. Counting minutes and seconds for latitude/longitude is the same as counting time on a clock. When the seconds count reaches 60, carry over and add 1 minute to the minute number in the coordinate, and start counting seconds again from 0. When the minute count reaches 60, carry 1 degree over and add it to the degrees number and start counting minutes again from 0.

If the point lies in the western hemisphere, count degrees, minutes and seconds from right to left (east to west).

Common conversions include:

60 seconds (60") = one minute (1')
60 minutes (60') = one degree (1°)
7.5 minutes = 1/8 of 60 minutes = 1/8 of a degree
15 minutes = ¼ of 60 minutes = ¼ of a degree
15 seconds = 0.25 minutes
30 seconds = 0.5 minutes
45 seconds = .75 minutes

To convert from **degrees minutes seconds** to **degrees decimal minutes** divide the seconds by 60 to get the decimal minutes, for example:

48° 20' <u>30"</u> ➔ <u>30"</u> ÷ 60 = .5' ➔ 48° 20.5'

To convert **degrees decimal minutes** to **degrees minutes seconds** multiply the decimal (e.g., .5) by 60, for example:

48° <u>20.5'</u> ➔ .5 x 60 = 30" ➔ 48° 20' 30"

Universal Transverse Mercator (UTM)

Universal Transverse Mercator is a global coordinate system that is defined in meters rather than degrees-minutes-seconds. UTM is a very precise method of defining geographic locations; therefore, it is commonly used in GPS and GIS mapping. When using the UTM coordinate system, a location can be identified within a meter.

UTM Grid Zones

The UTM grid divides the world into 60 north-south zones; the zones are numbered 1-60 (Figure 3-3). Each zone is 6 degrees wide in longitude. The contiguous 48 states has 10 zones. Within each zone is superimposed a square grid, and although the zone lines converge toward the poles, the grid lines do not. Therefore, as one travels north from the equator, the grid becomes smaller, although the grid squares remain the same.

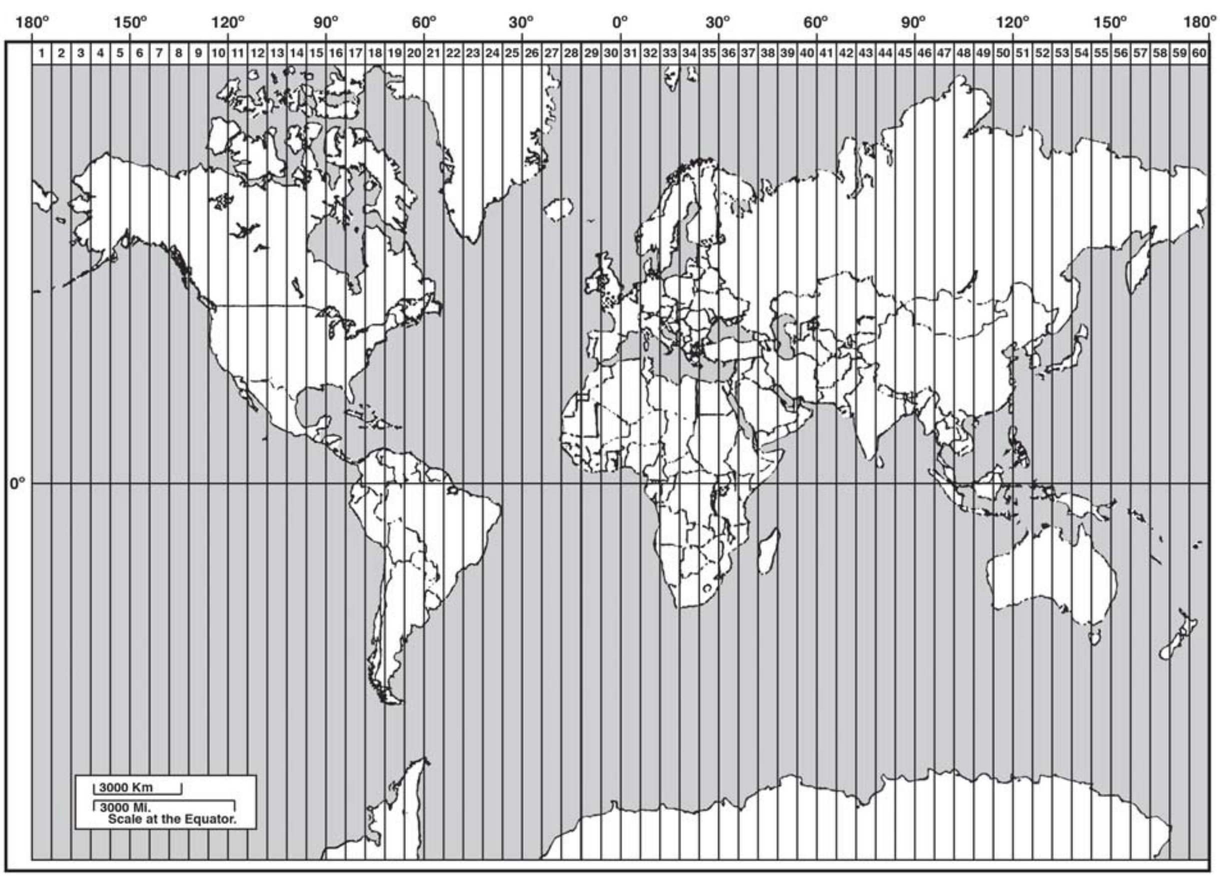


Figure 3-3. Universal Transverse Mercator zones.

UTM Coordinates

UTM uses two coordinates – easting and northing – to determine a location. Locations within a zone are measured in meters east and west from the central meridian, and north and south from the equator (Figure 3-4).

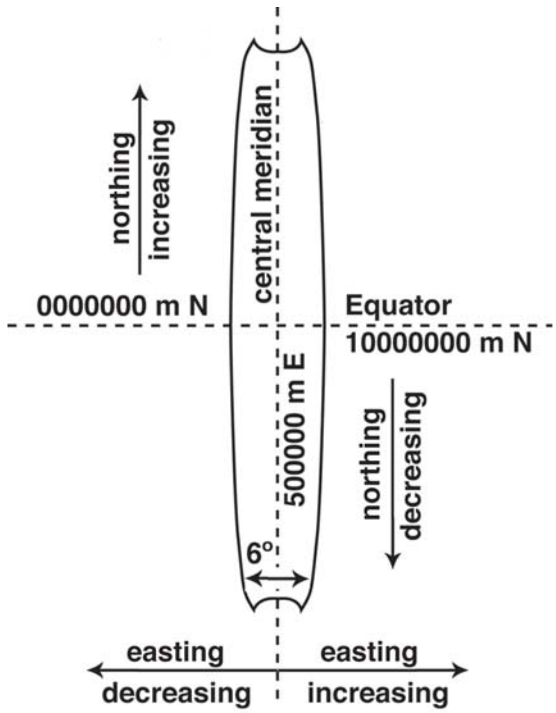


Figure 3-4. Numbering system for UTM coordinates within a zone.

- Easting coordinate

  The central meridian is an arbitrary line drawn down the center of each zone, and given a false easting value of 500,000 meters so that only positive eastings are measured anywhere in the zone. Eastings increase eastward and decrease westward from the central meridian. Each zone at its widest point cannot exceed 999,999 meters. As you move north and south from the equator, the zones become narrower, just like meridians of longitude, so, depending on where you are in relation to the equator, the east edge of each zone will end at different distances from the central meridian.

- Northing coordinate

  Northing is the distance in meters north and south of the equator (measured along a zone line). If the point lies north of the equator, coordinates always increase from south to north (bottom of map to the top) of the equator, with the equator given a value of 0 meters. For locations south of the equator, the equator is given a false value of 10,000,000 meters and values decrease from north to south.

A UTM coordinate includes the zone, easting coordinate, and northing coordinate; this coordinate describes a specific location using meters (Figure 3-5).

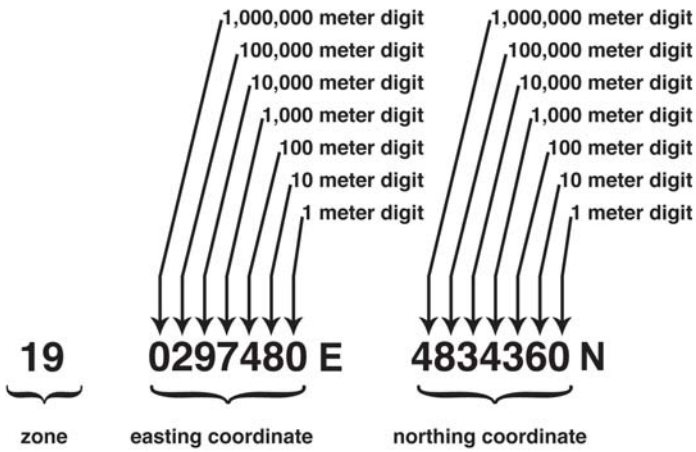


Figure 3-5. UTM coordinate.

There are different ways that UTM coordinates are written, for example:

- 19 0297480E 4834360N
- 0297480mE 4834360mN
- $^{2}\mathbf{97}^{480m}$E $^{48}\mathbf{34}^{360m}$N

UTM coordinates are also abbreviated to the extent of accuracy desired; for example, possible abbreviations for UTM 19 0297480E 4834360N include:

UTM Coordinate	**Area Covered**
297 4834	1000 m by 1000 m square
2974 48343	100 m by 100 m square
29748 483436	10 m by 10 m square
297480 4834360	1 m by 1 m square

Example: This coordinate – 19 0297480E 4834360N – describes a location in New Hampshire.

- The coordinate 0297480E represents an east-west measurement and is the easting. This coordinate is located 202520 meters west of the 19th zone's central meridian line. This number – 202520 meters – was calculated by subtracting the value of 297480 from the false value for the central meridian, which is designated as 500000. The location of this coordinate is 202 thousand, 520 meters west of the 19th zones central meridian line and 4 million, 834 thousand, 360 meters north of the equator.

- The coordinate 4834360N represents a north-south measurement and is the northing. The location of this coordinate is 4,834,360 meters north of the equator in zone 19.

U.S. Public Land Survey

The U.S. Public Land Survey System is another system that is used to describe locations; however, it is not as precise as latitude/longitude or UTM and it is not a global system. It has been used in several states for over 200 years, with only minor modifications. Similar systems are used in parts of Canada, Australia, and a few other areas of the world.

The Public Land Survey System consists of several separate surveys that were used to develop grids for each state. The grid is based on two reference points: a principal meridian running north-south, and a base line running east-west (Figure 3-6). Each grid square represents approximately 36 square miles and is identified as being north or south of a particular base line (township) and east or west of a particular principal meridian (range).

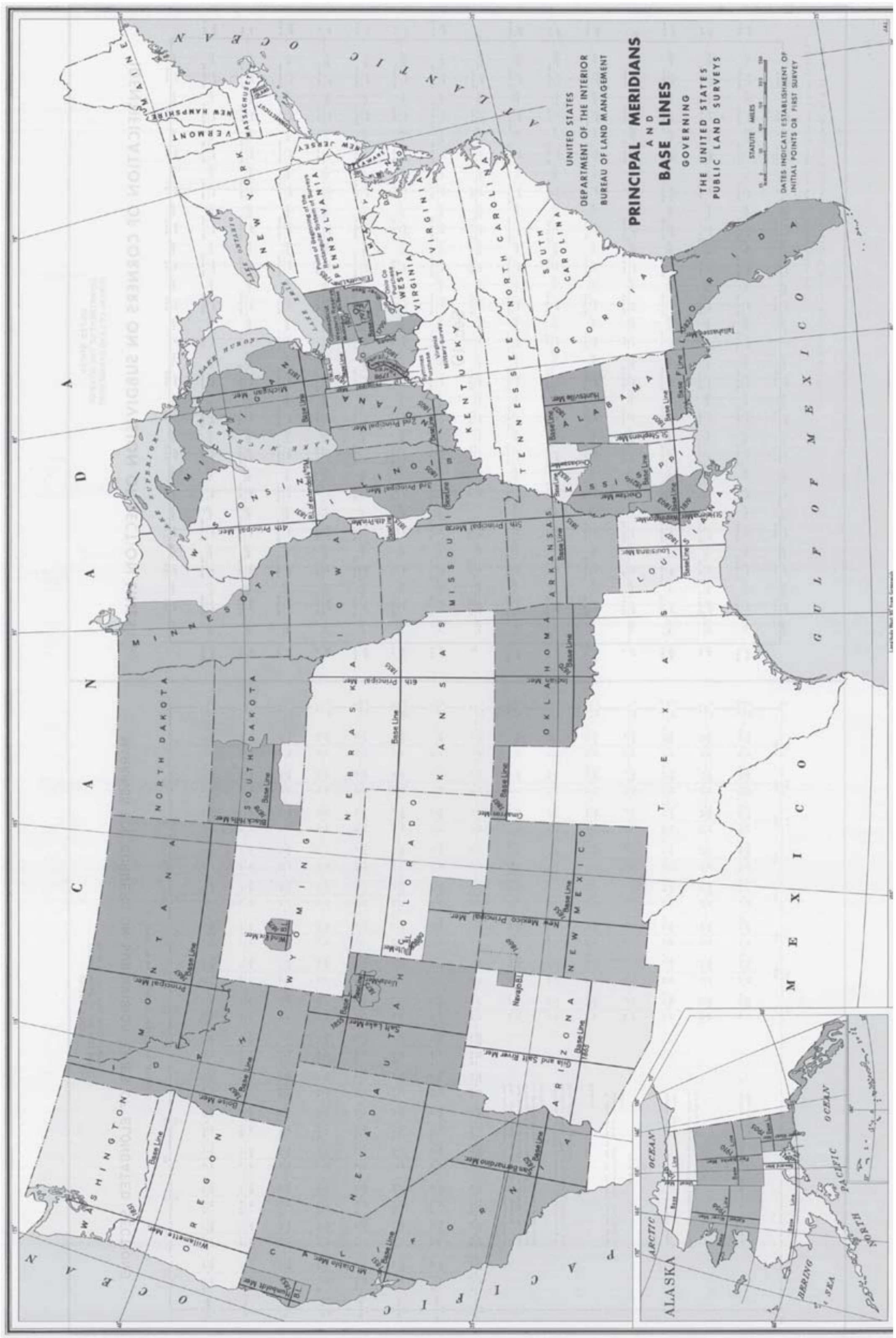


Figure 3-6. Principal meridians and base lines. There are 34 principal meridians and each one has its' own name. Most states on the east coast and Texas (white areas) did not participate in the U.S. Public Land Survey.

Townships

Township lines, which run east/west and are parallel to the base line, are 6 miles apart (Figure 3-7). Each township is 6 miles square and are numbered based on their location from the principal meridian and base line. For example, the first township line north of the base line is identified as Township 1 North; the second township line north of the base line is identified as Township 2 North, and so on. The township lines south of the base line are numbered the same (Township 1 South, etc.).

Ranges

Range lines, which run north/south and are parallel to the principal meridian, are 6 miles apart and are numbered much the same as the Township areas (Figure 3-7). For example, the first range line east of the principal meridian is identified as Range 1 East; the second range line east of the principal meridian is identified as Range 2 East, and so on. The range lines west of the principal meridian are numbered the same (Range 1 West, etc.).

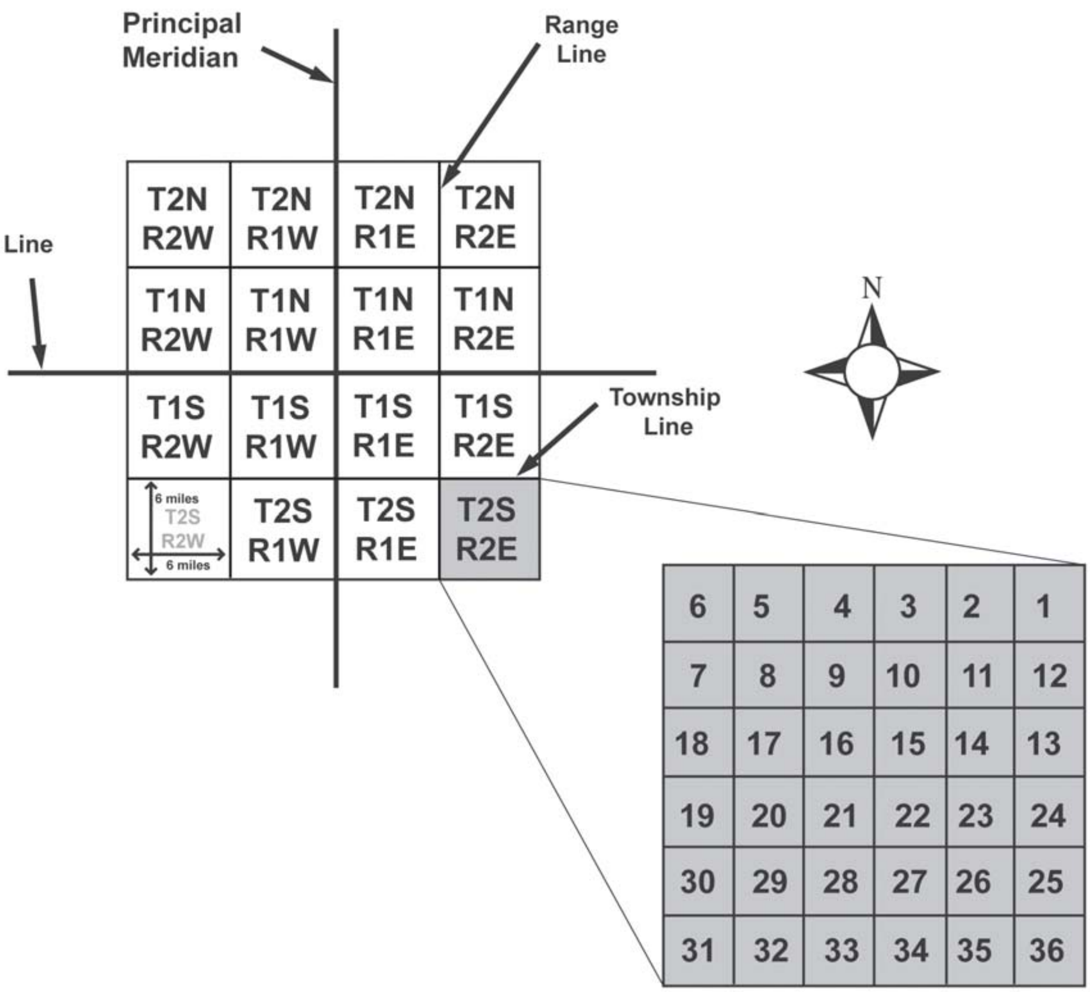


Figure 3-7. Example of township and range numbering system.

Sections

Within each township are 36 sections, each one mile square. Each section contains 640 acres. The sections are numbered starting in the northeast corner of the township with section 1 and ending in the southeast corner with section 36 (Figure 3-7). If you remember that the northeast corner is always number 1, and that the numbers go sequentially back and forth to the bottom, you will be able to locate section numbers as necessary.

A typical section of 640 acres may be broken down into smaller areas; for example, a half section contains 320 acres, a quarter-section contains 160 acres, half of a quarter contains 80 acres, a quarter of a quarter contains 40 acres, and so on (Figure 3-8). Typically, 2½ acre parcels is the smallest area of a section.

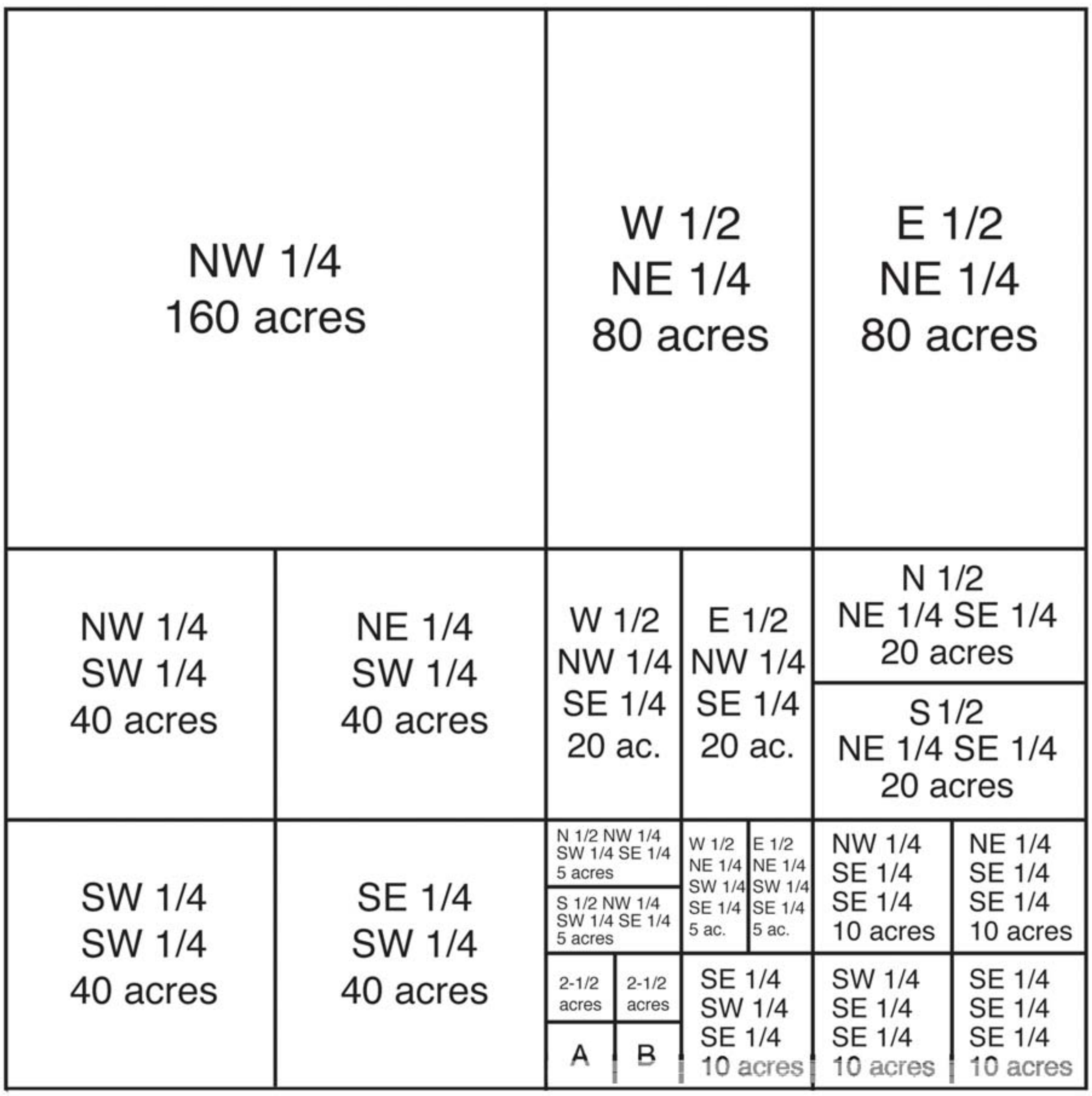
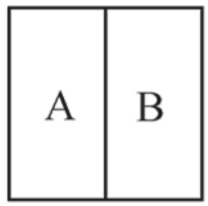


Figure 3-8. This 640 acre section is divided into smaller areas. Areas "A" and "B" in the bottom row represent 2½ acre parcels.

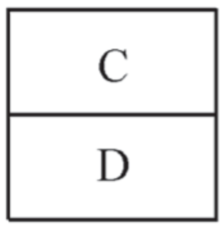
Each area of a section has a unique location description of its own. Below are examples of location descriptions for ½ and ¼ sections within Section 22, Township 5 North, Range 7 West:



Section 22

Area "A"
W½, Sec. 22, T. 5 N., R. 7 W.

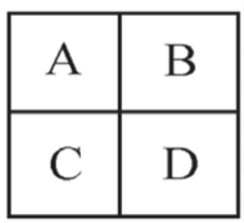
Area "B"
E½, Sec. 22, T. 5 N., R. 7 W.



Section 22

Area "C"
N½, Sec. 22, T. 5 N., R. 7 W.

Area "D"
S½, Sec. 22, T. 5 N., R. 7 W.



Section 22

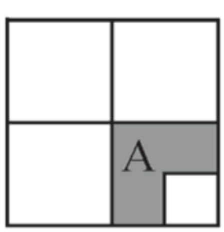
Area "A"
NW¼, Sec. 22, T. 5 N., R. 7 W.

Area "B"
NE¼, Sec. 22, T. 5 N., R. 7 W.

Area "C"
SW¼, Sec. 22, T. 5 N., R. 7 W.

Area "D"
SE¼, Sec. 22, T. 5 N., R. 7 W.

Location description for two separate portions of a section (use "and" in the description):



Section 22

Area "A"
N½ and SW¼ SE¼, Sec. 22, T. 5 N., R. 7 W.

Proper descriptions of locations have the section written first followed by the township and range. Descriptions start with the smallest area and end with the largest area. Sometimes, the easiest way to interpret location descriptions is to read them backwards. For example, this is a location description in Leon County, Florida:

> SE ¼, Sec.8, T.2N, R.3E, Florida, Tallahassee Meridian
> or
> Southeast ¼ of section 8, township 2 north and range 3 east, Florida, Tallahassee Meridian

Other Geographic Location Systems

Military Grid Reference System (MGRS)

The Military Grid Reference System is an extension of the UTM system. It is a global reference system used by the U.S. Armed Forces and North Atlantic Treaty Organization (NATO) to locate points on earth. The coordinates are 2 to 10 digits which represent a precision range of 10 kilometers to 1 meter.

Spanish Land Grants

In the southwestern United States, a township frequently will be occupied partially by a Spanish Grant. United States Government Surveys do not cover areas under these grants – the survey stops at the grant boundary. For field references you can just continue known township and range lines into the grant and use the Township/Range description.

Metes and Bounds

Metes and Bounds is a regional system that is a common method of land division in the eastern United States. Metes and bounds is a system of establishing boundaries of tracts of land by reference to natural or artificial monuments along it, as distinguished from those established by beginning at a fixed starting point.

State Land Coordinate Systems

Established in several western states, these systems were developed to measure and record boundary lines, monuments, and other features.

Checking Your Understanding

Answers to "Checking Your Understanding" can be found in Appendix B.

1. What are two common global coordinate systems used in the United States?

2. Latitude is a measure of how far ________ or ________ a point is from the ____________.

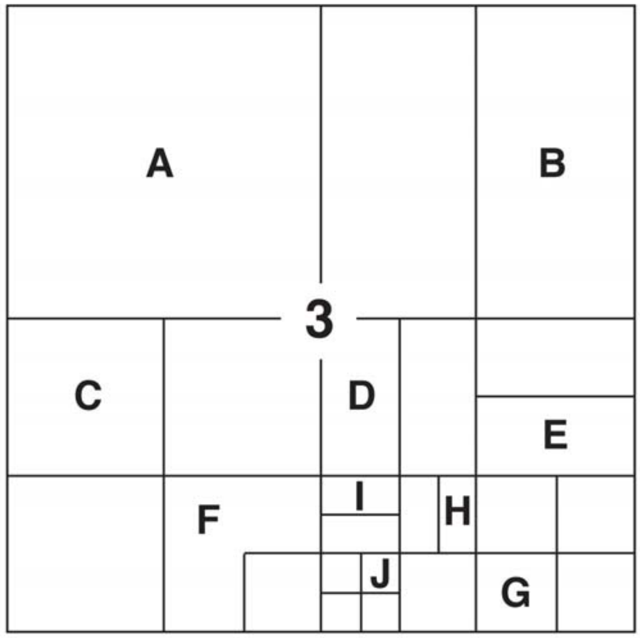
   Longitude is a measure of how far ______________ or ______________ a point is from the ___________________________.

3. On USGS topographic maps, UTM grid lines are marked every _______________ meters.

4. This is an abbreviated UTM coordinate: ^{5}66E and ^{51}96N. How else could it be written?

5. Given this UTM position in Montana – 12 683456E 5346782N – the easting is located ___________________ meters east of the 12th zone central meridian and the northing is located ___________________ meters north of the 12th zone equator.

6. Write the acreage and location description (section, township and range) for each of the lettered areas.



Section 3, Township 2 South, Range 4 E

A. Acres: ________ Location Description: ________________________________

B. Acres: ________ Location Description: ________________________________

C. Acres: ________ Location Description: ________________________________

D. Acres: ________ Location Description: ________________________________

E. Acres: ________ Location Description: ________________________________

F. Acres: ________ Location Description: ________________________________

G. Acres: ________ Location Description: ________________________________

H. Acres: ________ Location Description: ________________________________

I. Acres: ________ Location Description: ________________________________

J. Acres: ________ Location Description: ________________________________

7. Name two other Geographic Location Systems besides latitude/longitude, UTM, and U.S. Public Land Survey.