Navigation

"No, I can't say as I was ever lost, but I was bewildered once for three days."

—Daniel Boone (1734–1820), frontiersman

Nature has provided many of its creatures with keen senses of direction. Species of birds migrate thousands of miles between warm southern climes and northern breeding grounds. Some butterflies also are migratory, and animals as diverse as honeybees, bats, whales, and reindeer seem to move with great certainty about where they are and where they wish to go.

Humans do not have the gift of strong directional instinct. What we do possess, however, is the ability to think clearly. By supplementing our reasoning with a few navigational instruments, we can make our way through even the most complicated wilderness terrain.

Navigation is problem solving of the highest order. It demands that you pay attention to details and make sense out of many bits of information. As with most outdoor skills, navigational competence can be developed only with practice. Increase your awareness of topography by observing your surroundings on outdoor trips and noting the lay of the land. Imagine the most likely locations for trails, campsites, portages, and summit routes, and then see if your guesses are right. Hone your ability to use maps and compasses by referring to them from the time you leave the trailhead. Before long you will seldom find yourself confused.
Maps
Maps are written records of places. Featuring both natural and constructed features, planometric maps offer an artistic representation of an area. Topographic maps go a step further by including three-dimensional representations of the shape of the terrain. The most useful maps for trek adventures are those based upon data prepared by the U.S. Geological Survey (USGS) of the Department of the Interior. Sporting goods stores often carry maps of nearby recreational areas. Maps for many parts of the country can be downloaded from Internet sites or ordered directly from the USGS.

For more on the U.S. Geological Survey and on downloading maps, see the Fieldbook Web site.

Latitude and Longitude
As a means of pinpointing geographic locations, cartographers (those who make maps) have overlaid the globe of Earth with a grid of numbered, intersecting lines. The north-south lines—meridians of longitude—are drawn from the North Pole to the South Pole. Just as there are 360 degrees in a circle, there are 360 lines of longitude. The prime meridian—the line passing through the Royal Observatory at Greenwich, England—is zero degrees longitude. The numbering of meridians proceeds both westward and eastward from the prime meridian, meeting in the Pacific Ocean at 180 degrees longitude. (This 180th meridian also serves as the international date line.)

The east-west lines of the grid are parallels of latitude. The equator serves as zero degrees latitude. Lines running parallel with it are numbered sequentially to the poles. The North Pole is 90 degrees of latitude north of the equator; the South Pole is 90 degrees south. In a manner similar to that by which an hour of time is divided into smaller units, each degree of longitude and latitude is divided into 60 minutes; and each minute of longitude and latitude is divided into 60 seconds.
A position on the globe is stated latitude first, followed by longitude. For example, the coordinates of latitude and longitude for the summit of Baldy Mountain, the highest point on Philmont Scout Ranch in New Mexico, are 36°37'45" N and 105°12'48" W. That means that hikers standing atop Baldy are 36 degrees, 37 minutes, 45 seconds north of the equator, and 105 degrees, 12 minutes, 48 seconds west of the prime meridian.

Often used by search-and-rescue teams, the *universal transverse meridional* (UTM) grid is a metric coordinate system designed to pinpoint any location on Earth, with the exceptions of north and south polar regions. UTM grid lines are always 1 kilometer apart (about six-tenths of a mile) and are aligned with true north (discussed later in this chapter). Numerical notations for the UTM grid appear in the margins of many topographic maps.

Map Margins

The margins of a USGS map contain a wealth of useful information:

**Date**

Time is the enemy of map accuracy. The newer a map, the more precisely it can portray the current appearance of an area and the more exactly it will note the declination of magnetic north (discussed later in this chapter). The date printed in a map's margin indicates the year the map was created or most recently revised.

**Location and Size**

The geographical area covered by a topographic map is indicated by the coordinates of latitude and longitude printed in the map's corners. (Each map also will bear the name of a prominent geographic feature appearing somewhere within its boundaries—Knick Bluffs, for instance, or Wabonsie Peak.) The size of that area can be cited in the margin in terms of minutes. The maps most useful for backcountry travelers are 7.5-minute maps and 15-minute maps:

- **7.5-minute maps** encompass an area that is 7.5 minutes of latitude south to north, and 7.5 minutes of longitude east to west. (Since 1 minute of latitude on the ground is 6,200 feet, a 7.5-minute map will cover about 9 miles, north to south. The area covered by a 7.5-minute map ranges from 49 to 71 square miles, depending upon its latitude. The width of a minute of longitude, and thus the width of the map, will vary depending on the map's distance from the equator.)

- **15-minute maps** enclose an area that is 15 minutes of latitude south to north, and 15 minutes of longitude east to west.
**Contour Lines**

A topographic map is a two-dimensional model of the three-dimensional world. The sense of three dimensions is portrayed through the use of contour lines, which are drawn with brown ink. Each contour line represents a specific elevation above sea level. The vertical difference between adjacent lines is indicated in the margin of a map as that map’s contour interval—anywhere from 10 feet to 200 feet, depending on the scale of the map and the ruggedness of the terrain.

Each contour line forms a loop. If you could follow a line and, because you will stay at exactly the same elevation, you eventually will return to your starting point. Lines close together indicate steeper areas than regions with contour lines far apart. Maps with few contour lines signify relatively flat territory such as that forming a prairie or wetland.
### Map Symbols

For more information on map symbols, see the Fieldbook Web site.

### TOPOGRAPHIC MAP SYMBOLS

#### Roads, Railroads, and Other Features

- **Primary highway**
- **Secondary highway**
- **Light-duty road**
- **Unimproved road**
- **Trail**

- **Railroad: single track**
- **Railroad: multiple track**
- **Overpass; underpass**
- **Power transmission line**
- **Landmark line**

#### Land Surface Features

- **U.S. mineral prospect**
- **Quarry; gravel pit**
- **Mine shaft**
- **Mine dump**
- **Tailings**
- **Tailings pond**
- **Dune area**
- **Sand area**
- **Levee**

- **Disturbed surface**
- **Gravel beach**
- **Glacier**
- **Woodland**
- **Orchard**
- **Vineyard**
- **Mangrove**
- **Scrub**

#### Buildings and Related Features

- **Buildings**
- **School**
- **House of worship**
- **Cemetery**
- **Tanks**
- **Wells**
- **Picnic area**
- **Landmark**

- **Airport, paved landing strip, runway, taxiway, or apron**
- **Campground; campsite**
- **Winter recreation area**
- **Ranger district office**
- **Guard station or work center**

#### Water Features

- **Dam with lock**
- **Canal with lock**
- **Exposed wreck**
- **Rock or coral reef**
- **Rock; bare or awash**
- **Wide wash**
- **Narrow wash**
- **Perennial streams**
- **Intermittent streams**
- **Water well; spring**

- **Rapids**
- **Falls**
- **Intermittent lake**
- **Dry lake bed**
- **Marsh (swamp)**
- **Submerged marsh**
- **Wetland**
- **Aqueduct tunnel**
- **Channel**
- **Sounding; depth curve**

#### Elevation

- **Horizontal control station**
- **Vertical control station**
- **Checked spot elevation**
- **Unchecked spot elevation**

- **Index contour**
- **Supplementary contour**
- **Intermediate contour**
- **Depression contours**

#### Boundary

- **Federally administered park, reservation, or monument (internal)**

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### Meaning of Map Colors

- **Green**: Major vegetation (forest, brush, orchard)
- **Blue**: Water (lake, stream, spring, marsh, water tank)
- **Red**: Highways or boundaries
- **Black**: Human-made structures and place names (buildings, roads, trails, bridges, railroads)
- **White**: Absence of major vegetation, (prairie, meadow, tundra—above timberline)
- **Brown**: Contour lines and standard elevations
Determining Distance
A compass bearing can point you in the direction you wish to travel, but it can’t tell you how far along that route you will need to go in order to reach your destination. For that, you can refer to the distance rulers in the map’s margin.

1. Place one end of a piece of string on the map at your starting point.
2. Lay out the string on top of the route you plan to use, bending the string to conform with any twists and turns of the route.
3. Pinch the string where it touches the map symbol for your destination.
4. Stretch the string on the bar scale in the bottom margin of the map and measure it to the point where you are pinching it. That’s the approximate length of your route.

Compasses
For directional guidance, early explorers relied on the North Star, the prevailing winds, the movements of ocean currents, the migrations of birds, and other observations of the natural world. When they could, they followed sketchy maps and the reports of fellow wanderers. Then came the compass, appearing a thousand years ago in Asia and a century later in Europe. At first it was nothing more than a magnetized bit of metal floating on a piece of wood in a bowl of water. By Columbus’s time it had evolved into an instrument sufficiently reliable to guide the explorer’s three ships across the Atlantic. Today, the liquid-filled compass is an indispensable navigational tool.

The compass most useful for adventure-trek navigation consists of a magnetized needle balanced inside a circular, rotating housing mounted atop a baseplate. The plate is etched with a direction-of-travel arrow. The floor of the compass housing is engraved with an orienting arrow and, parallel with it, several north-south orienting lines.

The circumference of the housing is divided into directions—north, south, east, and west—and further divided into 360 degrees, just as in any circle: 0° coincides with north, 90° with east, 180° with south, 270° with west, and 360° is again north (0° and 360° overlap as they close the circle). Any direction can be expressed in degrees. For example, 95° is a little south of straight east, while 315° is midway between west and north.
Marking a Compass for Declination
A basic baseplate compass can be marked to help travelers adjust for declination. On the compass housing, place a tiny declination dot of indelible ink, brightly colored enamel paint, or fingernail polish at the degree reading that matches the declination of the area where you intend to travel. For example, if the declination is 15 degrees to the east of true north, place the dot at 15 degrees on the circumference of the compass housing. If the declination is 15 degrees to the west of true north, place the dot at 345 degrees—that is, 360 degrees (true north) minus 15 degrees. A careful look at the declination information in the map margin should make it clear whether magnetic north is to the left or to the right of true north.

When your adventures take you to a region with a different declination, remove the original declination dot of ink, paint, or polish with a cotton swab dipped in denatured alcohol. Replace the dot with a fresh one correctly positioned on the compass housing.

Turn the compass housing so that N (true north) touches the direction-of-travel arrow. Then, holding the compass in the palm of your hand, turn your body until the red tip of the magnetic needle points at the declination dot. The needle is pointing to magnetic north, but the rest of the compass is speaking the language of true north.

Adjusting a Compass for Declination
For a few dollars more than the price of a basic compass, you can purchase a compass that can be corrected for declination. Follow the manufacturer's instructions to make the adjustment, usually by turning a small screw or gently twisting an inner portion of the compass housing to change the position of the orienting arrow etched on the housing floor.

After you have adjusted it, turn the entire housing of the compass so that north on the circumference of the housing (indicated by $0^\circ$ or the letter N) is aligned with the direction-of-travel arrow on the baseplate. For the moment, think of that as the line drawn to true north. The angle the true-north line forms with the newly adjusted orienting arrow should be the same as the angle formed in the map margin by the true-north and magnetic-north lines.

Changing the Map for Declination
Another way to deal with declination is by teaching a map to understand the language of magnetic north. Use a protractor (and the skills you learned in geometry class) to transfer the angle of declination to the map, then use a straightedge ruler to extend a magnetic-north line across the map. Draw additional lines parallel with the first line, a ruler's width apart. Use these lines as your references when using an unadjusted compass (that is, one that is also speaking the language of magnetic north) to orient the map and find your way.

(Note: The margin arrows indicating the angle of declination of older maps might not be drawn to scale. Though good for suggesting the general aspect of declination, they are not a reliable guide for extending magnetic-north lines across a map.)
food and clothing to survive hours or even days of temporary confusion.”


**Using Maps and Compasses Together**

Maps and compasses used together serve as a much more powerful navigational aid than either a map or a compass alone.

**Orienting a Map**

A map that is oriented is aligned with the topography it represents. North on the map points toward the North Pole. Landscape features in the real world have the same directional relationships to one another as are indicated on the map.

To orient a map, first rotate the compass housing until N lines up with the direction-of-travel arrow on the baseplate. The compass bearing is north.

Next, place the long edge of the compass baseplate alongside any true-north line on the map—the left or right border, any line of longitude, township boundaries, etc. Turn the compass and the map as a unit until the red tip of the compass needle points toward the declination dot (for declination-marked compasses) or the compass needle settles inside the orienting arrow on the floor of the compass housing (for declination-adjusted compasses). When that happens, the map is oriented. (If you have adjusted the map for declination but not the compass, line up the baseplate with any magnetic-north lines you have extended across the map and allow the compass needle to settle inside the orienting arrow.)

**True-north lines on a map are any lines that parallel meridians of longitude—most notably the map’s vertical borders. Based on longitude meridians, north-south township lines and UTM grid lines also can be used as true-north lines. In the field, a map without many true-north lines can prove difficult to use with a compass. Prepare the map ahead of time by using a straightedge and a pencil to scribe lines on the map running parallel with the map’s north-south borders.**

**Identifying Landmarks**

Have you ever seen a mountain range and wondered what each summit was called? With a compass and a sharp eye, you can identify any landmark prominent enough to appear on your map.

Here’s how:

Hold the compass in the palm of your hand, and point the direction-of-travel arrow on the baseplate at the landmark in question. Turn the compass housing until the red end of the needle points at the declination dot (for declination-marked compasses) or until the needle is aligned with the orienting arrow (for declination-adjusted compasses). That will give you the bearing from your position to the landmark.

Next, place the compass on your map with the long edge of the baseplate touching the spot that represents your present location. (The map does not need to be oriented.) Ignoring the needle, rotate the compass baseplate around that point on the map until the orienting arrow and orienting lines are parallel with any true-north lines on the map. Beginning from the map symbol for your location, draw an actual or imaginary line away from yourself along the edge of the baseplate. The line should intersect the point on the map representing the landmark.

To identify landmarks with a compass that has not been adjusted for declination, use the magnetic-north lines you have drawn across the map instead of the true-north lines. The same is true of other map-and-compass procedures, including pinpointing your location and finding your way.

![Image: Using Maps and Compasses Together](image-url)
Avoiding Obstacles
To avoid an obstacle such as a lake or rock outcropping, take a 90-degree reading to both sides of your course of travel and count your paces as you go. When you have cleared the obstacle, continue on your original bearing until you completely bypass the obstacle. Then take a reverse 90-degree reading and take the same number of paces as you did previously. At that point, continue on your original course of travel.

Pinpointing Your Location
If you're not sure where you are but you can see a couple of features on the land that are also indicated on your map, it's easy to determine your location. First, point the baseplate direction-of-travel arrow on your compass at one of the landmarks—a mountaintop, the outlet of a lake, a building, etc. Then, holding the baseplate still, turn the compass housing until the red tip of the needle points at the declination dot (for declination-marked compasses) or until the needle lines up in the outline of the orienting arrow (for declination-adjusted compasses). You've just taken a bearing on the landmark.

Now place the compass on your map with the edge of the baseplate touching the symbol representing the landmark. (The map does not need to be oriented.) Ignoring the needle, rotate the entire compass around that point on the map until the orienting lines on the floor of the compass housing are parallel with any true-north lines on the map. Lightly pencil a line toward yourself along the baseplate edge from the landmark symbol.

Find a second landmark and repeat the process of taking a bearing, placing the compass on the map, and drawing a line toward yourself. The spot on the map at which the two lines intersect indicates where you are.

To confirm your readings, repeat the procedure with another landmark.

Finding Your Way
Assume you know where you are. On the map you see a lake you would like to reach by the most direct route. Place the long edge of your compass baseplate on a real or imaginary line connecting the map points representing your present location and that of the lake. Turn the compass housing until the orienting lines in the compass housing parallel any true-north lines on the map.

Hold the compass at waist level with the direction-of-travel arrow on the baseplate pointing away from you. Without changing the compass setting, turn your body until the compass needle aligns itself with the orienting arrow (for declination-adjusted compasses) or the red tip of the needle points to the declination dot (for declination-marked compasses). When that happens, the direction-of-travel arrow will be aimed at the lake. You have just taken a bearing for the route to your destination.

Look up along the direction of travel. If you can see the lake, you need make no further use of the compass. If the lake is out of sight, though, locate an intermediate landmark toward which the direction-of-travel arrow is pointing—a tree, boulder, or other feature—and walk to it. Take another bearing, identify the next landmark in line with the direction-of-travel arrow, and go to it. Continue until you reach your destination.
Offset Technique

Hiking uphill, crossing streams, ducking under brush, and scratching bug bites as you navigate your way through the backcountry can cause lateral drift, an accumulation of small errors in taking and following compass bearings that can throw you off your intended course. Compensate for lateral drift by using offset technique—deliberately aiming a little to the left or right of your destination.

For instance, assume the lake you want to reach is very small. You notice on the map that a creek flows from it to the left, perpendicular to your line of travel. Rather than take a bearing on the lake itself and risk missing it by passing too far to the right, set a course for a point on the creek a few hundred yards below the lake. When you reach the creek anywhere along its length, all you need to do is follow it upstream until you arrive at the lake. (Streams, power lines, fences, drainage ditches, trails, roads, and ridges all make good backstops or handrails for offset technique.)

Global Positioning Systems (GPS)

Modern technology has provided travelers with a powerful electronic means of navigation—the global positioning system. A GPS receiver accurately calculates the latitude and longitude of any spot on the globe by taking bearings on satellites orbiting 12,000 miles above Earth. Small enough to carry in the pocket of a pack, a GPS receiver can be used to

- Identify precise locations.
- Note elevations above sea level.
- Chart routes by inputting coordinates of latitude and longitude, or by downloading entire maps.
- Plot the record of a trek, creating a history that can guide a group retracing its steps.

Electronic navigational instruments surely will continue to improve in accuracy, versatility, and ease of use. But just as having a calculator does not eliminate the need to know how to add and subtract, a GPS receiver (especially one with dead batteries) is no substitute for being able to navigate with traditional tools. Develop confidence in your ability to use maps and compasses and then, if you wish, augment them with a GPS receiver.

For more on augmenting navigational skills with the global positioning system, see the Fieldbook Web site. x