OA Guide to Map & Compass - Part 1
part of
The Backpacker's Field Manual
by Rick Curtis
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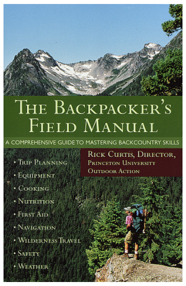

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This material is taken from Chapter 6 - Wilderness Travel from *The Backpackers Field Manual* by Rick Curtis. For more details on this exciting book check out [The Backpacker's Field Manual Page.](#)

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Traveling anywhere in the wilderness means determining where you want to go. Maps and guidebooks are the fundamental tools both for trip planning see (Chapter 1 - Trip Planning) and while you are out on the trail.

Maps & Map Reading

A map is a two-dimensional representation of the three-dimensional world you'll be hiking in. All maps will have some basic features in common and map reading is all about learning to understand their particular "language." You'll end up using a variety of maps to plan and run your trip but perhaps the most useful map is a topographic map. A topographic map uses markings such as contour lines (see page 00) to simulate the three-dimensional topography of the land on a two-dimensional map. In the U.S. these maps are usually U.S. Geological Survey (USGS) maps. Other maps that you'll find helpful are be local trail maps which often have more accurate and up-to-date information on specific trails than USGS maps do. Here's a brief overview of the basic language of maps.

Latitude and Longitude:

Maps are drawn based on latitude and longitude lines. Latitude lines run east and west and measure the distance in degrees north or south from the equator (0° latitude). Longitude lines run north and south intersecting at the geographic poles. Longitude lines measure the distance in degrees east and west from the prime meridian that runs through Greenwich, England. The grid created by latitude and longitude lines allows us to calculate an exact point using these lines as X axis and Y axis coordinates.

Both latitude and longitude are measured in degrees (°).

1° = 60 minutes

1 minute = 60 seconds

Therefore:

7 ½ minutes = $^{1}/_{8}$ of 60 minutes = $^{1}/_{8}$ of a degree

15 minutes = ¼ of 60 minutes = ¼ of a degree

Scale:

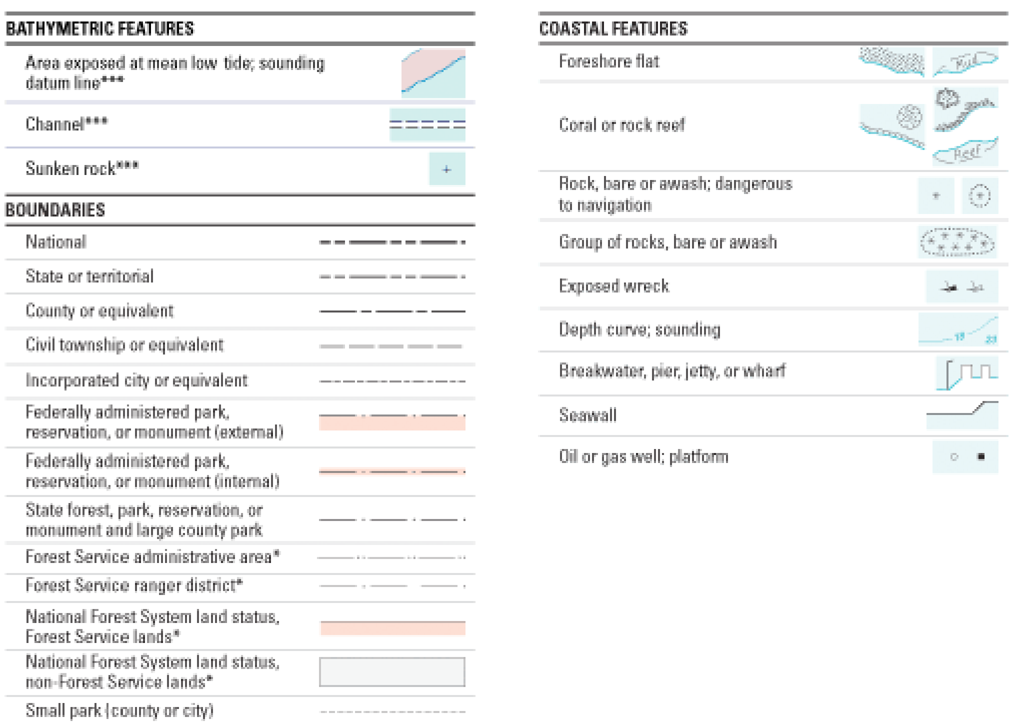
All maps will list their scales in the margin or legend. A scale of 1:250,000 (be it inches, feet, or meters) means that 1 unit on the map is the equivalent of 250,000 units in the real world. So 1 inch measured on the map would be the equivalent of 250,000 inches in the real world. Most USGS maps are either 1:24,000, also known as 7 ½ minute maps, or 1:62,500, known as 15 minute maps (the USGS is no longer issuing 15 minute maps although the maps will remain in print for some time). Standard topographic maps are usually published in 7.5-minute quadrangles. The map location is given by the latitude and longitude of the southeast (lower right) corner of the quadrangle. The date of the map is shown in the column following the map name; a second date indicates the latest revision. Photo-revised maps have not been field checked.

Map Size	Scale	Covers	Map to Landscape	Metric
7 ½ minute	1:24,000	$^{1}/_{8}$ of a degree	1 inch = 2,000 feet ($^{3}/_{8}$ mile) 2.64 inches = 1 mile	(1 centimeter = 240 meters)
15 minute	1:62,500	¼ of a degree	1 inch = ~1 mile	(1 centimeter = 625 meters)

Map Symbols and Colors:

1. USGS topographic maps use the following symbols and colors to designate different features (see Figure 6.2)

- Black - man-made features such as roads, buildings, etc.
- Blue - water, lakes, rivers, streams, etc.
- Brown - contour lines (see page 00)
- Green - areas with substantial vegetation (could be forest, scrub, etc.)
- White - areas with little or no vegetation; white is also used to depict permanent snowfields and glaciers
- Red - major highways; boundaries of public land areas
- Purple - features added to the map since the original survey. These features are based on aerial photographs but have not been checked on land.



BUILDINGS AND RELATED FEATURES	
Building	
School; house of worship	
Athletic field	
Built-up area	
Forest headquarters*	
Ranger district office*	
Guard station or work center*	
Racetrack or raceway	
Airport, paved landing strip, runway, taxiway, or apron	
Unpaved landing strip	
Well (other than water), windmill or wind generator	
Tanks	
Covered reservoir	
Gaging station	
Located or landmark object (feature as labeled)	
Boat ramp or boat access*	
Roadside park or rest area	
Picnic area	
Campground	
Winter recreation area*	
Cemetery	Cem

CONTOURS	
Topographic	
Index	6000
Approximate or indefinite	
Intermediate	
Approximate or indefinite	
Supplementary	
Depression	
Cut	
Fill	
Continental divide	
Bathymetric	
Index***	
Intermediate***	
Index primary***	
Primary***	
Supplementary***	

CONTROL DATA AND MONUMENTS	
Principal point**	3-20
U.S. mineral or location monument	USMM 438
River mileage marker	Mile 69
Boundary monument	
Third-order or better elevation, with tablet	BM 9134 BM 277
Third-order or better elevation, recoverable mark, no tablet	5628
With number and elevation	67 4567
Horizontal control	
Third-order or better, permanent mark	Neace Neace
With third-order or better elevation	BM 52 Pike BM393
With checked spot elevation	1012
Coincident with found section corner	Cactus Cactus
Unmonumented**	

CONTROL DATA AND MONUMENTS – *continued*	
Vertical control	
Third-order or better elevation, with tablet	BM 5280
Third-order or better elevation, recoverable mark, no tablet	528
Bench mark coincident with found section corner	BM 5280
Spot elevation	7523
GLACIERS AND PERMANENT SNOWFIELDS	
Contours and limits	
Formlines	
Glacial advance	
Glacial retreat	

PROJECTION AND GRIDS	
Neatline	39°15′ 90°37′30″
Graticule tick	55′
Graticule intersection	
Datum shift tick	
State plane coordinate systems	
Primary zone tick	640 000 FEET
Secondary zone tick	247 500 METERS
Tertiary zone tick	260 000 FEET
Quaternary zone tick	98 500 METERS
Quintary zone tick	320 000 FEET
Universal transverse metcator grid	
UTM grid (full grid)	273
UTM grid ticks*	269

LAND SURVEYS

Public land survey system	
Range or Township line	
Location approximate	
Location doubtful	
Protracted	
Protracted (AK 1:63,360-scale)	
Range or Township labels	R1E T2N R3W T4S
Section line	
Location approximate	
Location doubtful	
Protracted	
Protracted (AK 1:63,360-scale)	
Section numbers	1 - 36 1 - 36
Found section corner	
Found closing corner	
Witness corner	WC
Meander corner	MC
Weak corner*	
Other land surveys	
Range or Township line	
Section line	
Land grant, mining claim, donation land claim, or tract	
Land grant, homestead, mineral, or other special survey monument	
Fence or field lines	

MARINE SHORELINES

Shoreline	
Apparent (edge of vegetation)***	
Indefinite or unsurveyed	

MINES AND CAVES

Quarry or open pit mine	
Gravel, sand, clay, or borrow pit	
Mine tunnel or cave entrance	
Mine shaft	
Prospect	
Tailings	Tailings
Mine dump	
Former disposal site or mine	

RAILROADS AND RELATED FEATURES

Standard guage railroad, single track	
Standard guage railroad, multiple track	
Narrow guage railroad, single track	
Narrow guage railroad, multiple track	
Railroad siding	
Railroad in highway	
Railroad in road	
Railroad in light duty road*	
Railroad underpass; overpass	
Railroad bridge; drawbridge	
Railroad tunnel	
Railroad yard	
Railroad turntable; roundhouse	

RIVERS, LAKES, AND CANALS

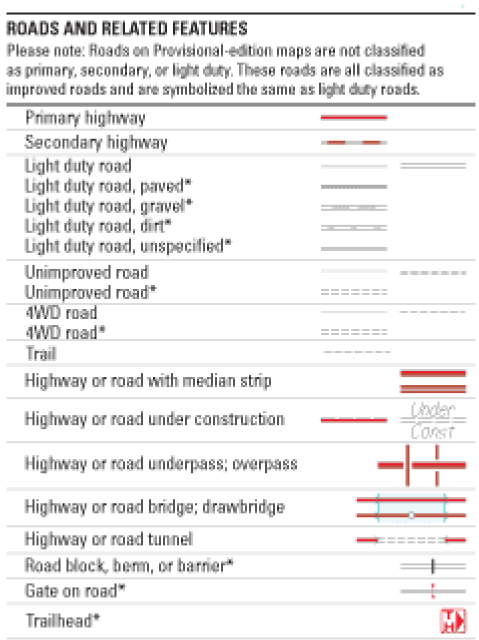
Perennial stream	
Perennial river	
Intermittent stream	
Intermittent river	
Disappearing stream	
Falls, small	
Falls, large	
Rapids, small	
Rapids, large	
Masonry dam	
Dam with lock	
Dam carrying road	

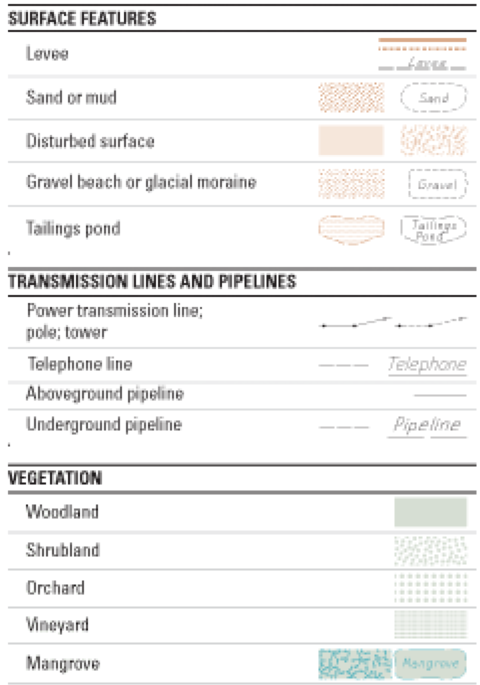
RIVERS, LAKES, AND CANALS – *continued*

Perennial lake/pond	
Intermittent lake/pond	
Dry lake/pond	
Narrow wash	
Wide wash	Wash
Canal, flume, or aqueduct with lock	
Elevated aqueduct, flume, or conduit	
Aqueduct tunnel	
Water well, geyser, fumarole, or mud pot	
Spring or seep	

SUBMERGED AREAS AND BOGS

Marsh or swamp	
Submerged marsh or swamp	
Wooded marsh or swamp	
Submerged wooded marsh or swamp	
Land subject to inundation	Max Pool 431

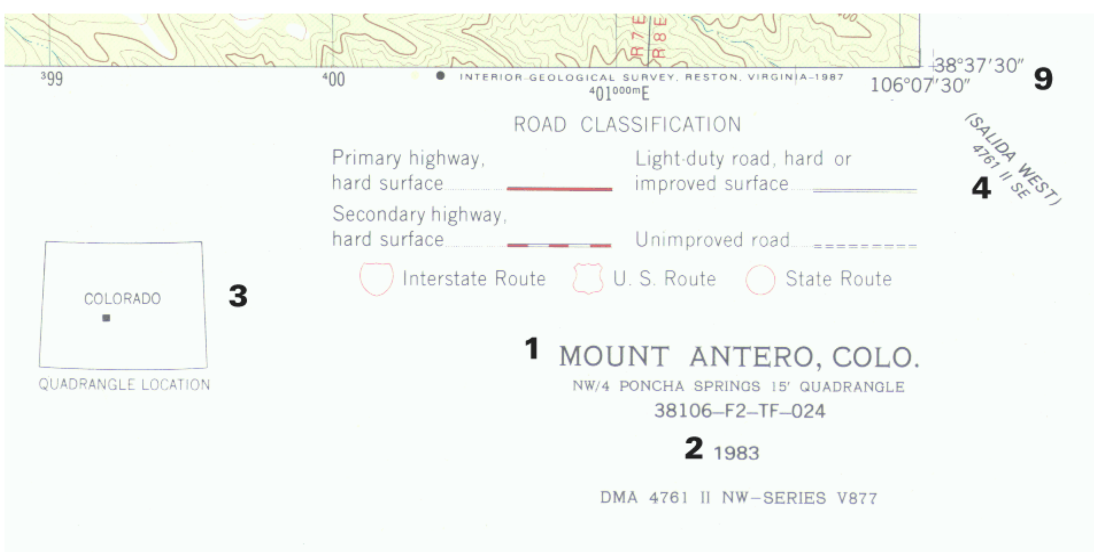


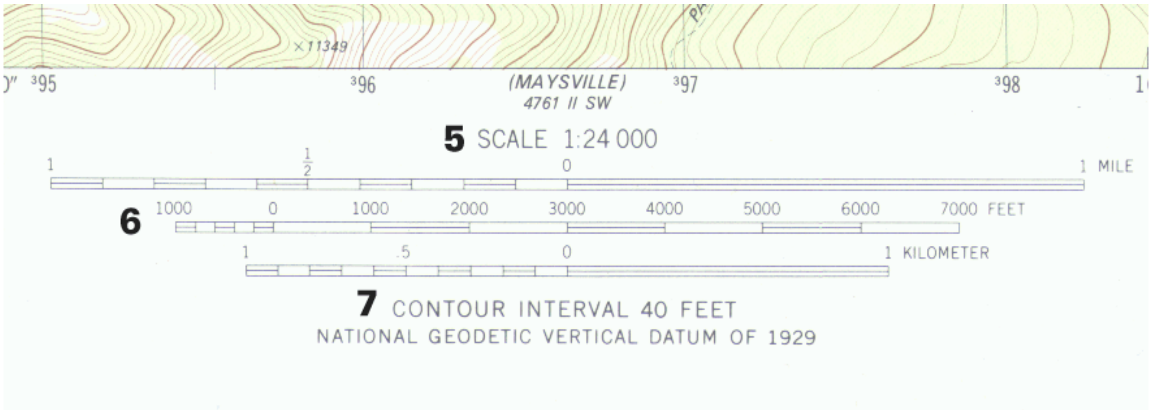


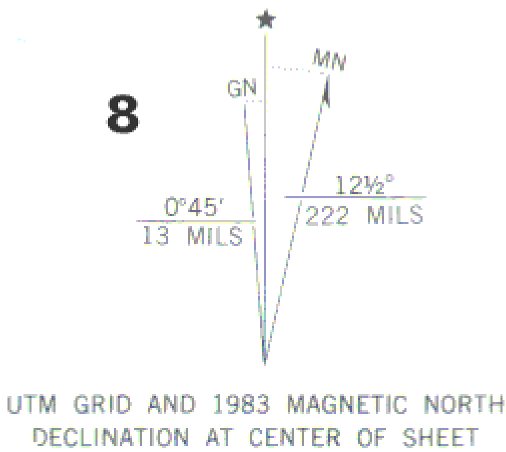
Map Legend

The map legend contains a number of important details. The figures below display a standard USGS map legend. In addition, a USGS map includes latitude and longitude as well as the names of the adjacent maps (depicted on the top, bottom, left side, right side and the four corners of the map). The major features on the map legend are show in Figure 6.3 and labeled below.

1. Map Name
2. Year of Production and Revision
3. General Location in State
4. Next Adjacent Quadrangle Map
5. Map Scale
6. Distance Scale
7. Contour Interval
8. Magnetic Declination
9. Latitude and Longitude







Contour Lines

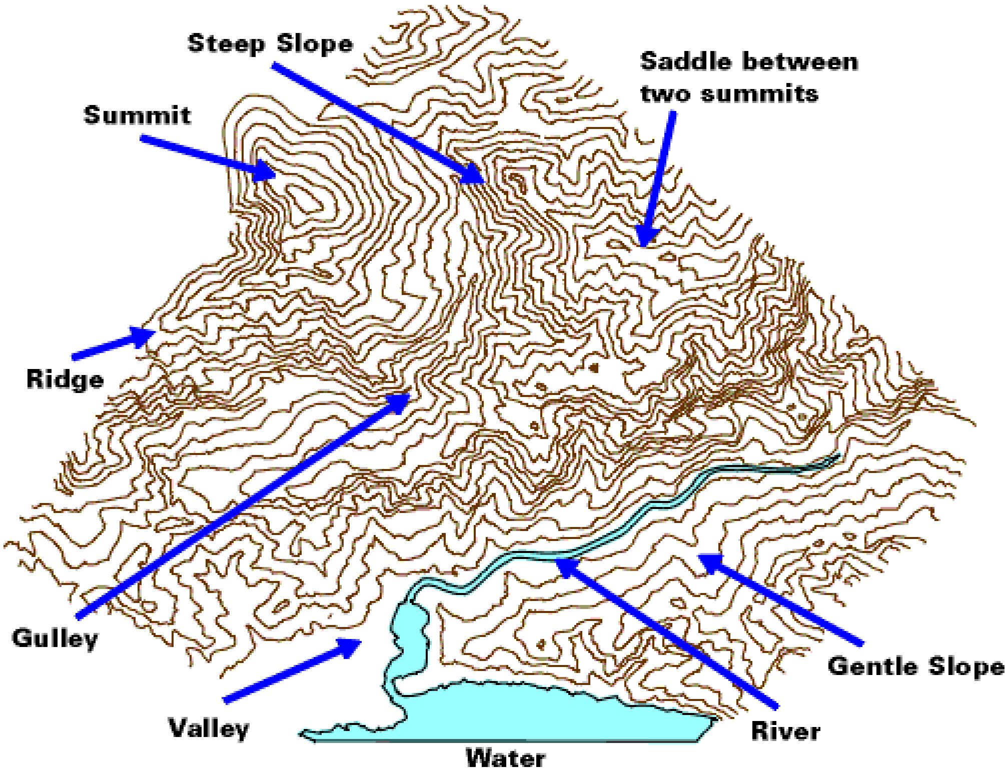
Contour lines are a method of depicting the 3-dimensional character of the terrain on a 2-dimensional map. Just like isobars in the atmosphere depict lines of equal atmospheric pressure, contour lines drawn on the map represent equal points of height above sea level.

Look at the three-dimensional drawing of the mountain below. Imagine that it is an island at low tide. Draw a line all around the island at the low tide level. Three hours later, as the tide has risen, draw another line at the water level and again three hours later. You will have created three contour lines each with a different height above sea level. As you see in Figure 6.4, the three dimensional shape of the mountain is mapped by calculating lines of equal elevation all around the mountain, and then transferring these lines onto the map.

On multi-colored maps, contour lines are generally represented in brown. The map legend will indicate the contour interval—the distance in feet (meters, etc.) between each contour line. There will be heavier contour lines every 4th> or 5th contour line that are labeled with the height above sea level. Figure 6.5 illustrates how a variety of surface features can be identified from contour lines.

3D View of Mountain showing how contours relate to height

Top View of Mountain showing contours



Drawn Contour Lines

- **Steep slopes** - contours are closely spaced
- **Gentle slopes** - contours are less closely spaced
- **Valleys** - contours form a V-shape pointing up the hill - these V's are always an indication of a drainage path which could also be a stream or river.
- **Ridges** - contours form a V-shape pointing down the hill
- **Summits** - contours forming circles
- **Depressions** - are indicated by circular contour with lines radiating to the center

Measuring Distances

There are a number of ways to measure distance accurately on a map. One is to use a piece of string or flexible wire to trace the intended route. After tracing out your route, pull the string straight and measure it against the scale line in the map legend. Another method is to use a compass (the mathematical kind) set to a narrow distance on the map scale like ½ mile and then "walk off" your route. It is a good idea to be conservative and add 5-10% of the total distance to take into account things like switchbacks that don't appear on the map. It's better to anticipate a longer route than a shorter one.

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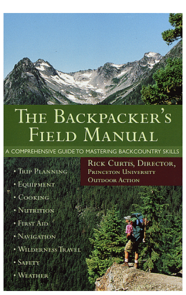

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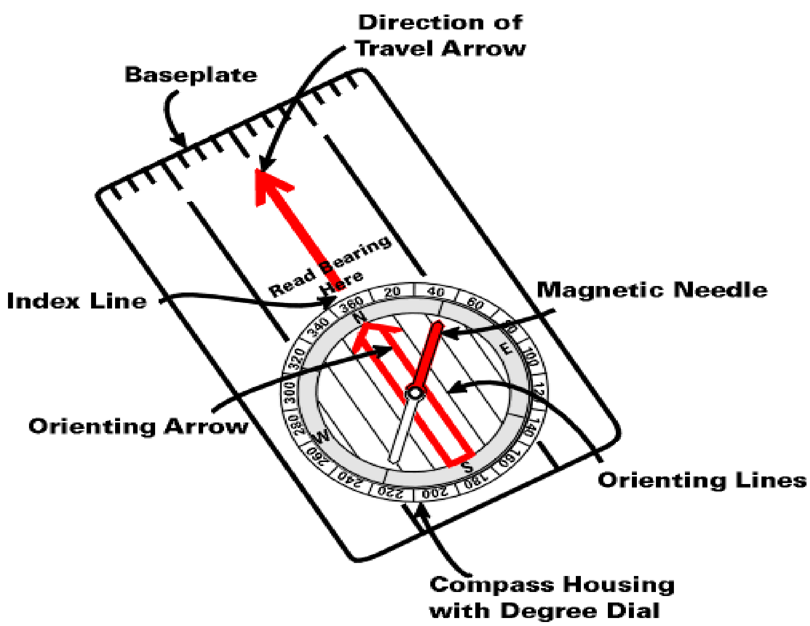
Using the Compass

The compass consists of a magnetized metal needle that floats on a pivot point. The needle orients to the magnetic field lines of the earth. The basic orienteering compass is composed of the following parts: (See Figure 6.6)

- Base plate
- Straight edge and ruler
- Direction of travel arrow
- Compass housing with 360 degree markings
- North label
- Index line
- Orienting arrow
- Magnetic needle (north end is red)

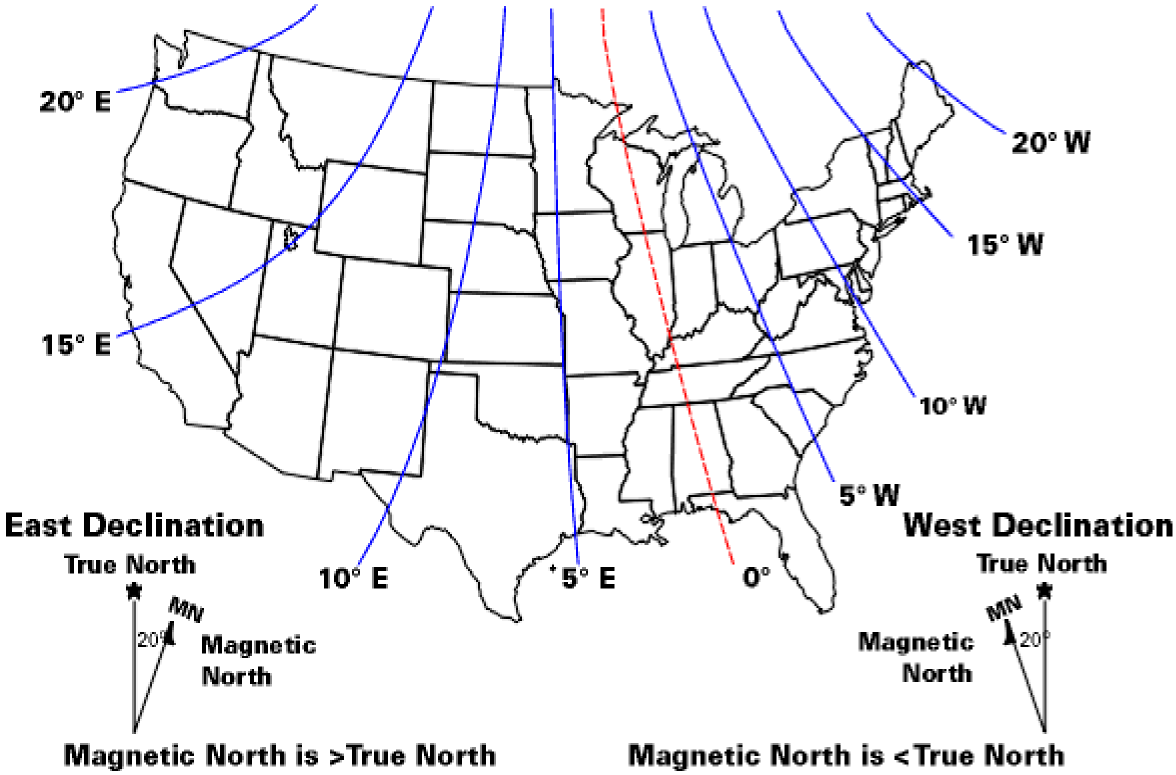


What is North?

No, this is not a silly question, there are two types of north.

- **True North:** (also known as Geographic North or Map North - marked as H on a topographic map - see Figure 6.8) is the geographic north pole where all longitude lines meet. All maps are laid out with true north directly at the top. Unfortunately for the wilderness traveler, true north is not at the same point on the earth as the magnetic north Pole which is where your compass points.
- **Magnetic North:** Think of the earth as a giant magnet (it is actually). The shape of the earth's magnetic field is roughly the same shape as the field of a bar magnet. However, the earth's magnetic field is inclined at about 11° from the axis of rotation of the earth, so this means that the earth's magnetic pole doesn't correspond to the Geographic North Pole and because the earth's core is molten, the magnetic field is always shifting slightly. The red end of your compass needle is magnetized and wherever you are, the earth's magnetic field causes the needle to rotate until it lies in the same direction as the earth's magnetic field. This is magnetic north (marked as MN on a topographic map). Figure 6.7 shows the magnetic

lines for the United States (as of 1985). If you locate yourself at any point in the U.S., your compass will orient itself parallel to the lines of magnetic force in that area.



Declination

You can see that location makes a great deal of difference in where the compass points. The angular difference between true north and magnetic north is known as the **declination** and is marked in degrees on your map as shown in Figure 6.7. Depending on where you are, the angle between true north and magnetic north is different. In the U.S., the angle of declination varies from about 20 degrees west in Maine to about 21 degrees east in Washington. (See Figure 6.7). The magnetic field lines of the earth are constantly changing, moving slowly westward (½to 1 degree every five years). This is why it is important to have a recent map. An old map will show a declination that is no longer accurate, and all your calculations using that declination angle will be incorrect. As you will see, understanding this distinction becomes important when navigating with a map and a compass.

Tricks of the Trail

Buy Your Compass for the Right Area: As well as the magnetic deviation east or west, compasses also show a vertical "dip" up and down. This dip varies in different parts of the world and compasses are specially calibrated for that dip. So you can't take a compass made for North America and use it in South America and get accurate readings.

Which North to Use

So we have two types of north to contend with. When you look at your map, it is drawn in relation to true north;, when you look at your compass, it points to magnetic north. T to make the map and compass work together you must decide on one North as your point of reference and base all your calculations on that. As you can see the following chart, failure to take declination into account can put you way off target.

Declination or Degrees Off Course	Error Off Target after Walking 10 Miles
1°	920 feet (280meters)
5°	4,600 feet (1,402 meters)
10°	9,170 feet (2,795 meters)

Using Map and Compass

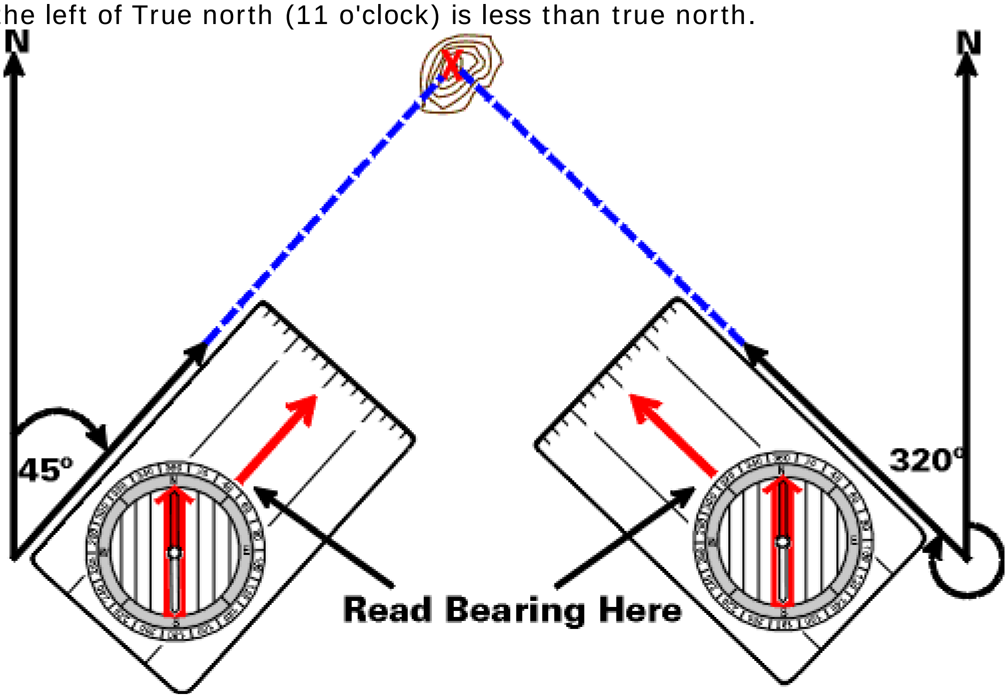
Even after years of using a map and compass I could never remember how to correct for declination. Do I add declination or subtract it? What if I'm out west versus in the east? While navigating through dense fog on a sea kayaking trip, I finally came up with an easy way to remember. As long as you remember the basic principles, you can easily work it out in your head.

What's your Map Declination?

The first thing you need to know is where you are in relation to magnetic north. You can find this information by looking on your map legend. If you look at the map of North America in Figure 6.8 you will see the line roughly marking 0° declination. If you are on the line where the declination is 0 degrees, then you don't have to worry about any of this, since magnetic north and map north are equivalent. (Wouldn't it be nice if all your trips were on the 0 degree of declination line?) If you are to the right of that line, your compass will point toward the line (to the left) and hence the declination is to the west. If you are to the left of the line, your compass will point toward the line (to the right) and hence the declination is to the east.

Bearings:

The compass is used primarily to take bearings. A bearing is a horizontal angle measured clockwise from north (either magnetic north or true north) to some point (either a point on a map or a point in the real world) (see Figure 6.8). Bearings are used to accurately travel to a destination or to locate your position. If you are working from your map, it is called a map bearing and the angle you are measuring is the angle measured clockwise from true north on your map to this other point on the map. If you are taking a bearing off a real point on the landscape with a compass, you are using your compass to measure the angle clockwise from magnetic north to this point on the landscape. This is called a magnetic bearing. Remember that the bearing is measured clockwise. If you think of true north as 12 o'clock then a bearing to the right of that (1 o'clock) is greater than true north and a bearing to the left of True north (11 o'clock) is less than true north.



Map Bearings & Magnetic Bearings:

If, you think about your map as an artist's rendition of the world. It displays true north, but it doesn't include magnetic fields as the real world does, so you need to make accommodations when going from your map to the real world. The real world doesn't have a true north—it's merely a construct of the map—so you have to make accommodations when going from the real world to your map.. The basic principle is this: *to correct for declination, you want the map bearing and the magnetic bearing to be equivalent.* If you are lucky enough to be on the line where the declination is 0°, both are already equivalent, or if you orient your map with your compass (see page 00) then you have made the two equivalent. Otherwise, you will need to make your own bearing corrections by adding or subtracting the declination amount. That gives us 4 possible permutations to work with:

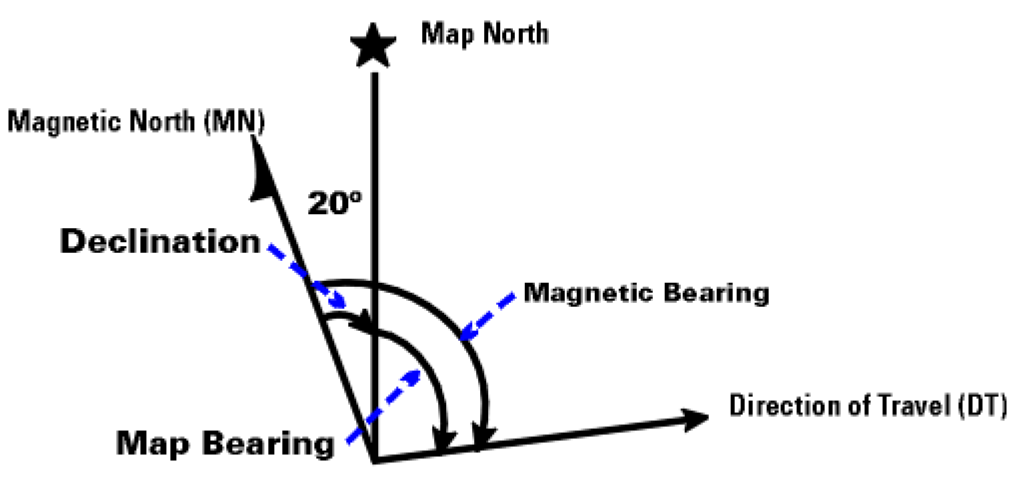
1. **West Declination** - Going from a Map Bearing to a Magnetic Bearing
2. **West Declination** - Going from a Magnetic Bearing to a Map Bearing
3. **East Declination** - Going from a Map Bearing to a Magnetic Bearing
4. **East Declination** - Going from a Magnetic Bearing to a Map Bearing

West Declination:

If your declination is west, then magnetic north is less than true north and the map bearing is less than (<) the magnetic bearing . You need to make the two bearings equivalent by adding or subtracting the declination. This is illustrated in Table 6.2 and Figure 6.8b.

- **Map Bearing to Magnetic Bearing:** If you are taking a bearing from one point on your map to another point on the map with respect to true north, then you are working with the map bearing. Now you want to figure out where your position is in the magnetic bearing. In order to transfer this information back to your magnetic bearing you need to add the declination to your map bearing bearing to create the proper magnetic bearing. **Map bearing + Declination = Magnetic Bearing.**
- **Magnetic Bearing to Map Bearing:** If you use your compass to take a bearing from your current position to a point on the landscape, then you are working with the magnetic bearing. Now you want to figure out where your position is on the map. In order to transfer this information back to your map you need to subtract the declination from your magnetic bearing compass bearing to create the proper map bearing. **Magnetic Bearing - Declination = Map Bearing.**

West Declination



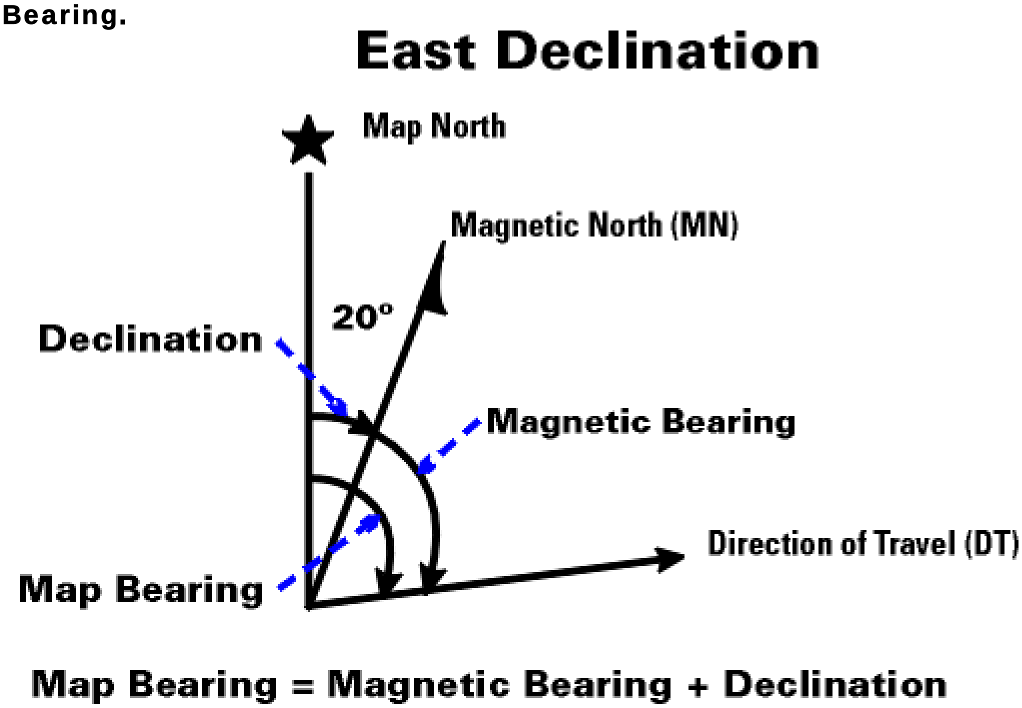
Map Bearing = Magnetic Bearing - Declination

East Declination:

If your declination is East then magnetic north is greater than true north the map bearing is greater than the magnetic bearing. You need to make the two worlds equivalent by adding or subtracting the declination. This is illustrated in Table 6.2 and Figure 6.8a.

- **Map Bearing to Magnetic Bearing:** If you are taking a bearing from one point on your map to another point on the map with respect to true north, then you are working with the map bearing. Now you want to figure out where your position is in the magnetic bearing. In order to transfer this information back to your magnetic bearing you need to subtract the declination from your map bearing compass bearing to create the proper magnetic bearing bearing. **Map bearing - Declination = Magnetic Bearing.**

- **Magnetic Bearing to Map Bearing:** If you use your compass to take a bearing from your current position to a point on the landscape, then you are working with the magnetic bearing. Now you want to figure out where your position is on the map. In order to transfer this information back to your map you need to add the declination from your magnetic bearing compass bearing to create the proper map bearing. **Magnetic bearing + Declination = Map Bearing.**



If the declination is...	Then...	Map Bearing to Magnetic Bearing	Magnetic Bearing to Map Bearing
West	Magnetic North < True North Map Bearing is < the Magnetic Bearing	Map Bearing + Declination = Magnetic Bearing.	Magnetic Bearing - Declination = Map Bearing.
East	Magnetic North > True North Map Bearing is > the Magnetic Bearing	Map Bearing - Declination = Magnetic Bearing.	Magnetic Bearing + Declination = Map Bearing.

Outdoor Action trips and activities are only open to Princeton University students, faculty, and staff. Specially listed activities are open to Princeton University alumni and their families.

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Using Map & Compass Together

Adjusting Your Compass for the Local Declination:

Another way to deal with declination is to adjust your compass. Some compasses have an outer degree ring that can be unlocked either with a set screw or a latch. This allows you to reset the compass to account for declination. For example, if the declination were 14 degrees East, you could rotate the degree dial to the right so that the magnetic needle was pointing to 14 degrees instead of 360 degrees. Once you do this, you will no longer have to add or subtract for declination because your compass is aligned to true north. Now when the compass needle is inside the orienting needle, the compass bearing that you read off your compass will be in relation to true north instead of magnetic north. If you have a fixed-ring compass, you can mark the declination angle on the compass ring with a piece of tape.

Wilderness Navigation

Navigation in the wilderness means knowing your starting point, your destination, and your route to get there.

Check Your Position Regularly:

Make it a habit of keeping your map and compass handy and refer to them every hour or so to locate your position (more often in low visibility). Keep track of your starting time, rest breaks and lunch stops, and general hiking pace. This will also give you an idea of how far you have traveled and whether your Time Control Plan is accurate (see Planning Your Day, page 00).

Orienting the Map:

It is easiest to read a map if the map is oriented to the surrounding landscape. If you see a valley on your left, then the valley shows on the left on the map. You can do this by eye or with your compass.

- **Using Land Features:** Lay the map on the ground or hold it horizontally. Rotate the map until recognized features on the ground roughly align with those on the map.
- **Using a Compass:**
    1. Identify your declination from your map. If your declination is West of true north, subtract the declination from 360 degrees. If your declination is East of true north
    2. Set the compass at the correct declination bearing so that you compensate for declination.
    3. Place your compass on the map so that the edge of the baseplate lies is parallel to the east or west edge of the map with the direction of travel arrow toward the north edge of the map.
    4. Holding the compass on the map, rotate the map <u>with</u> the compass until the north end of the magnetic needle points to the **N** on the compass housing (i.e. the red north end of the magnetic needle and the orienting arrow align). This is often referred to as "boxing the needle" since the magnetic needle is inside the "box" formed by the orienting arrow. The map is now oriented with respect to magnetic north. This means that the compass needle direction north is the same as true north

on the map. You can also place the compass on the map so that the edge of the baseplate lies along the magnetic north indicator line on the map legend at the bottom and rotate the map as described above. This may give you a more accurate orientation for your map.

Identify Terrain Features:

With the map oriented, look around for prominent features landscape features such as mountains, valleys, lakes, rivers, etc. Make a mental note of the geographical features you will be traveling along and seeing during the day. If you keep the terrain in your mind, you will usually have a general idea of where you are just by looking around.

Tricks of the Trail
Orient Your Map: You can eliminate the need to correct for declination if you use your compass to orient the map each time. As long as the map is oriented with respect to magnetic north, any bearings you take from map to compass or compass to map will be the same. For this reason, it's a good idea to always take the time to orient your map. It will make your life much easier. It also means that each time you use your map, your will need to re-orient it with your compass.

Real Life Scenarios

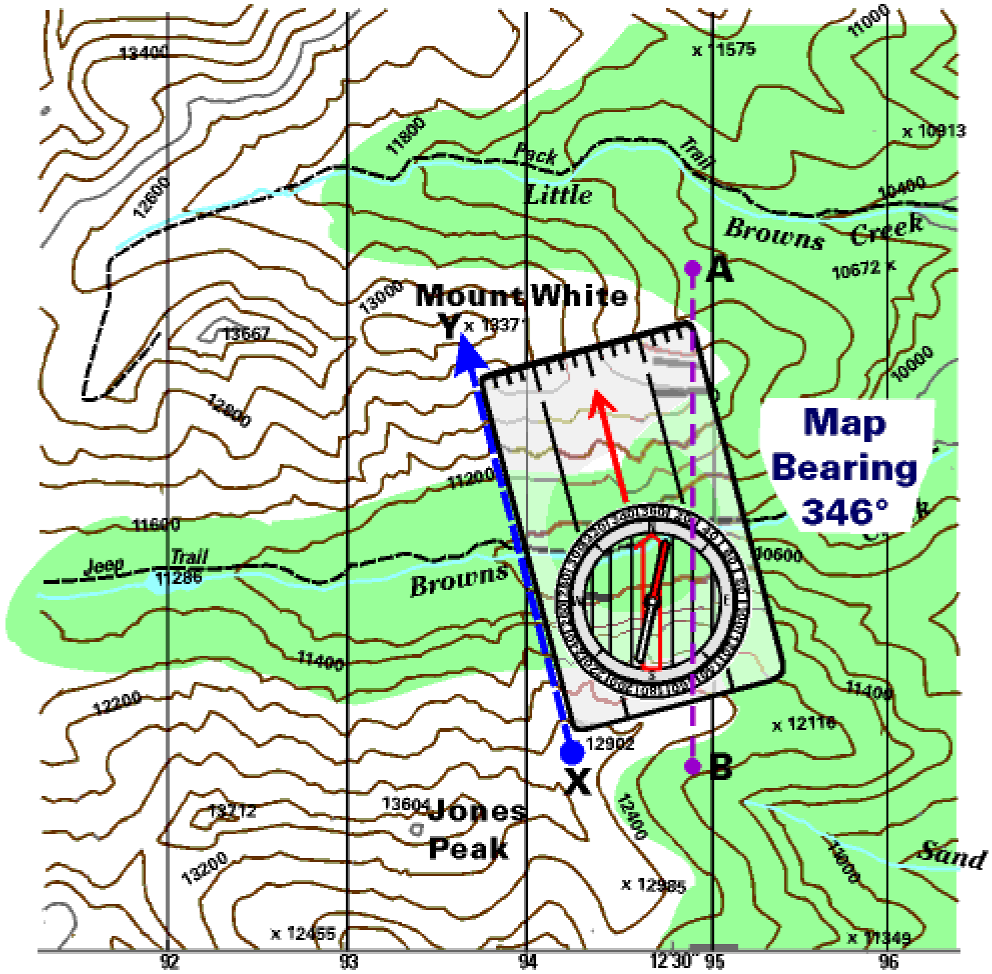
Let's look at some common backcountry scenarios and see how you can use your map and compass to navigate.

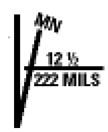
Scenario #1 - Lost in the Fog:

Okay, you hike in along the trail and then bushwack off trail to a nearby alpine lake to camp. When you wake up the next morning, you are fogged in. You know where you are on the map, but you can't see to find your way out. What you need to do is take a bearing on your map from your known campsite back to a known point on the trail that you can identify on the map. Then follow your bearing through the fog (or you might decide to wait out the fog if there is difficult terrain to traverse - see Chapter 7: Safety and Emergency Procedures: Dynamics of Accidents page 00). Here's your procedure:

Taking a Bearing from the Map (Map Not Oriented):

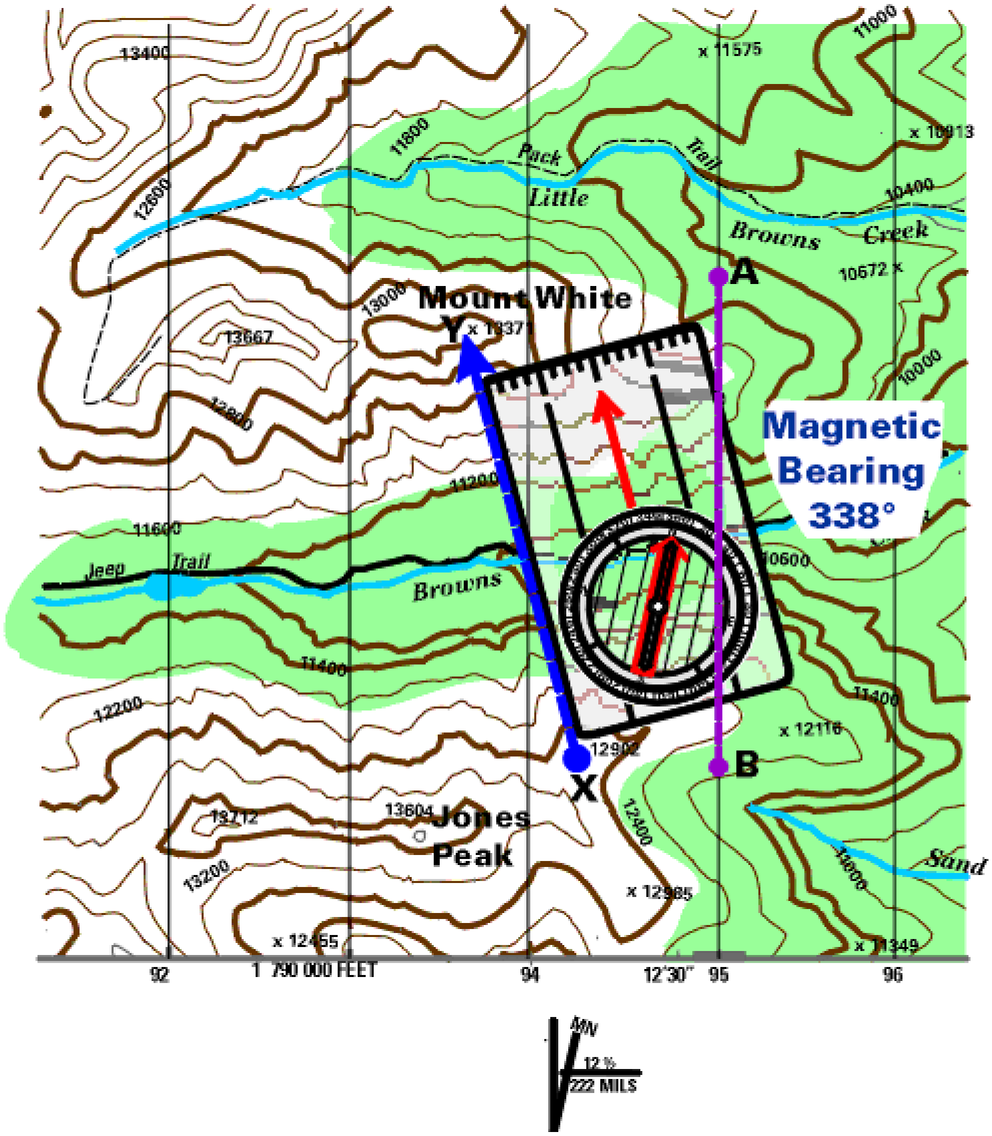
1. Lay the long edge of the compass base plate on the map, making a line from the starting point to the destination (from point X to point Y). Since the base plate is parallel to the direction of travel arrow, the base plate can be used to set the direction to the destination.
2. Holding the base plate steady, rotate the compass housing until the compass orienting lines and orienting arrow are pointing to true north. Here you see the orienting lines and arrow are parallel to the line from A to B as well as to the map gridlines.
3. Read the bearing (in degrees) from the degree dial at the point on the compass base plate marked "Read bearing here." In this case the bearing is 346 degrees.





Taking a Bearing from the Map (Map Oriented to Magnetic North):

1. Orient the map with the compass (see page 00).
2. Lay the long edge of the compass base plate on the map, making a line from the starting point to the destination (from X to Y). Since the base plate is parallel to the direction of travel arrow, the base plate can be used to set the direction to the destination.
3. Holding the baseplate steady, rotate the compass housing until the orienting arrow coincides with the North end of the magnetic needle (known as "boxing the arrow").
4. Read the bearing (in degrees) from the degree dial at the point on the compass base plate marked "Read bearing here." In this case the bearing is 338 degrees.



Scenario #2 - Heading to the Summit:

You have been hiking along the trail and found a good campsite that is marked on the map. You see a summit ridge above treeline that looks like a great place for photographs, but there's a valley thick with Douglas fir between you and the summit. What you need to do is take a bearing from your current position to the summit and use that to travel through the forest. Here's your procedure:

Taking a Bearing from the Land:

1. Point the compass direction of travel arrow to the destination on the land.
2. Rotate the compass housing until the north orienting arrow of the compass housing lines up with the red magnetic needle. This is referred to as "boxing the needle," since you want the needle to be inside the box defined by the orienting arrow. The north orienting arrow must be pointing in the same direction as the red (north) magnetic needle. Your compass will look like the figure above with the needle boxed.
3. Read the bearing (in degrees) from the degree dial at the point on the compass base plate "Read bearing here."

Walking a Bearing Taken from the Land:

1. After taking the bearing, as described above, hold the compass level and in front of you, so that the direction of travel arrow points to the destination.
2. Rotate your whole body until the magnetic needle lies directly over the orienting arrow. Make sure the north end of the magnetic needle points to N on the compass housing. The direction of travel arrow points to the destination.

3. Site a prominent feature to which your direction of travel arrow points. Walk to that feature. Continue to sight on other features along the bearing and walk to them, until you reach your destination.

Walking a Bearing Taken from the Map:

To walk a bearing taken from the map, you may need to correct for declination if you did not orient the map to magnetic north before you took your bearing. Once you have corrected for declination, follow the same procedure as indicated above for walking a bearing taken from the land.

Techniques for Walking a Bearing:

Sometimes the terrain isn't always so cooperative to let you just follow your bearing in a straight line so there are a number of techniques to use when traveling on a bearing.

- **Line of Sight** Walk to an obvious landmark—a tree or boulder that is directly on the bearing. Then take another bearing on the next obvious landmark and walk to that. Keep it up until you reach your destination. By going to intermediate landmarks, you minimize the chances of veering off your bearing.

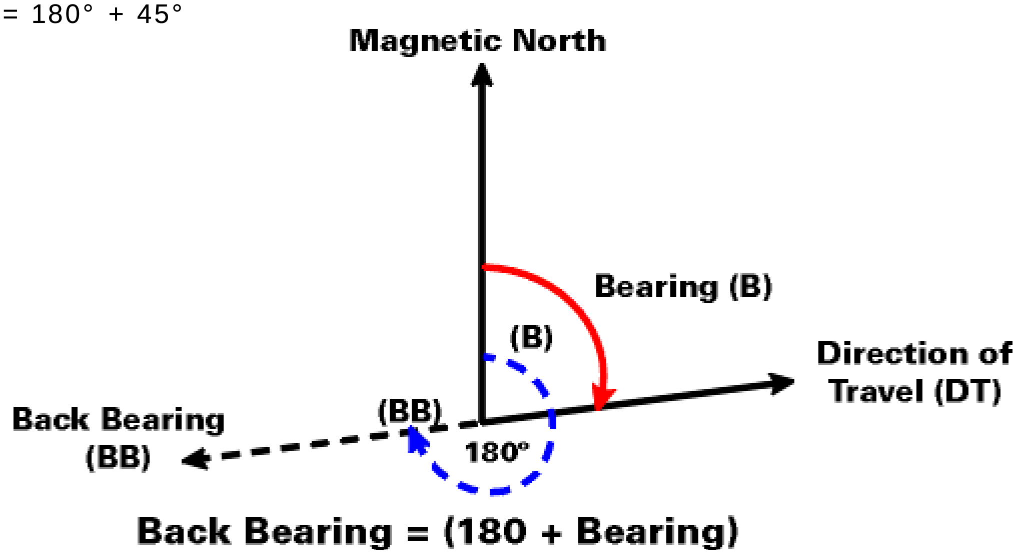
Scenario #3 - Retracing Your Steps to Camp:

You got to the summit and got some great photos, even one of a baby mountain goat. Now it's time to get back to your campsite. You could just follow your back bearing (see below) back to your location, but there is bound to be some error, when you hit the trail where will you be in relation to your campsite? The best bet is to intentionally aim off. Here's your procedure:

- **Back Bearings** To check your position while walking a bearing, you can take a back bearing. Before you start to walk on your bearing, turn around take a bearing 180 degrees off of the bearing you are going to walk. For example, if you are going to walk a bearing of 45 degrees, shoot a bearing directly opposite your course of 225 degrees. Locate some landmark along this bearing. Once you have moved a short distance along your bearing, turn around and shoot a bearing back to that landmark. If you are on course, that bearing will still read 180 degrees off your bearing of travel (in this case 225 degrees). If it doesn't, it means that you are off course. Sailors and sea kayakers use back bearings all the time to check for lateral drift from wind or currents. Back bearings are also useful if you are heading out to someplace and then returning along the same line of travel (see Figure 6.14). There are two basic formulas for calculating a back bearing.

When the Direction of Travel Bearing is Less than 180° (see Figure 6.14):

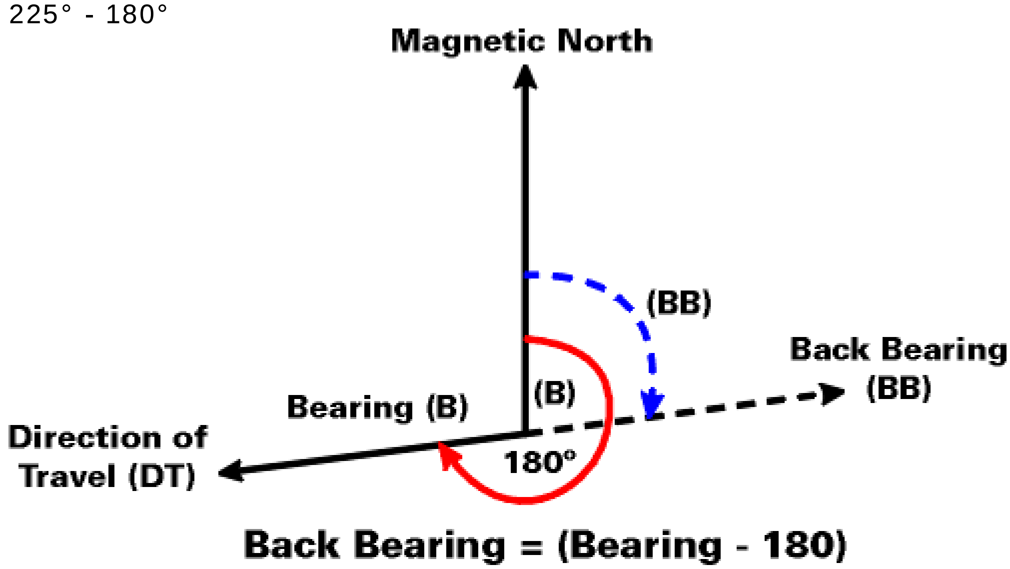
- Back Bearing = (180° + Direction of Travel Bearing)
- BB = 180° + B
- 225° = 180° + 45°



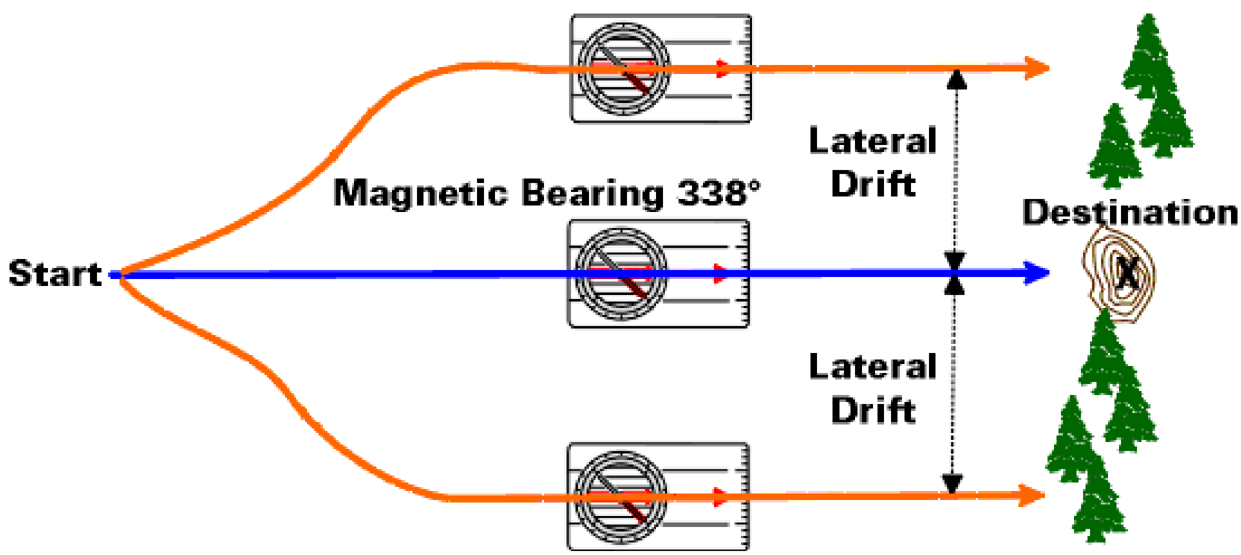
When the Direction of Travel Bearing is Greater than 180 degrees (see Figure 6.14):

- If the Direction of Travel Bearing is **more than 180 degrees** you use a different formula (otherwise you will have a Back Bearing greater than 360 degrees). If we reverse our example from above, let's say your Bearing is 225 degrees (which is greater than 180 degrees) then your Back Bearing works out to 45 degrees.
- Back Bearing = (Direction of Travel Bearing - 180°)

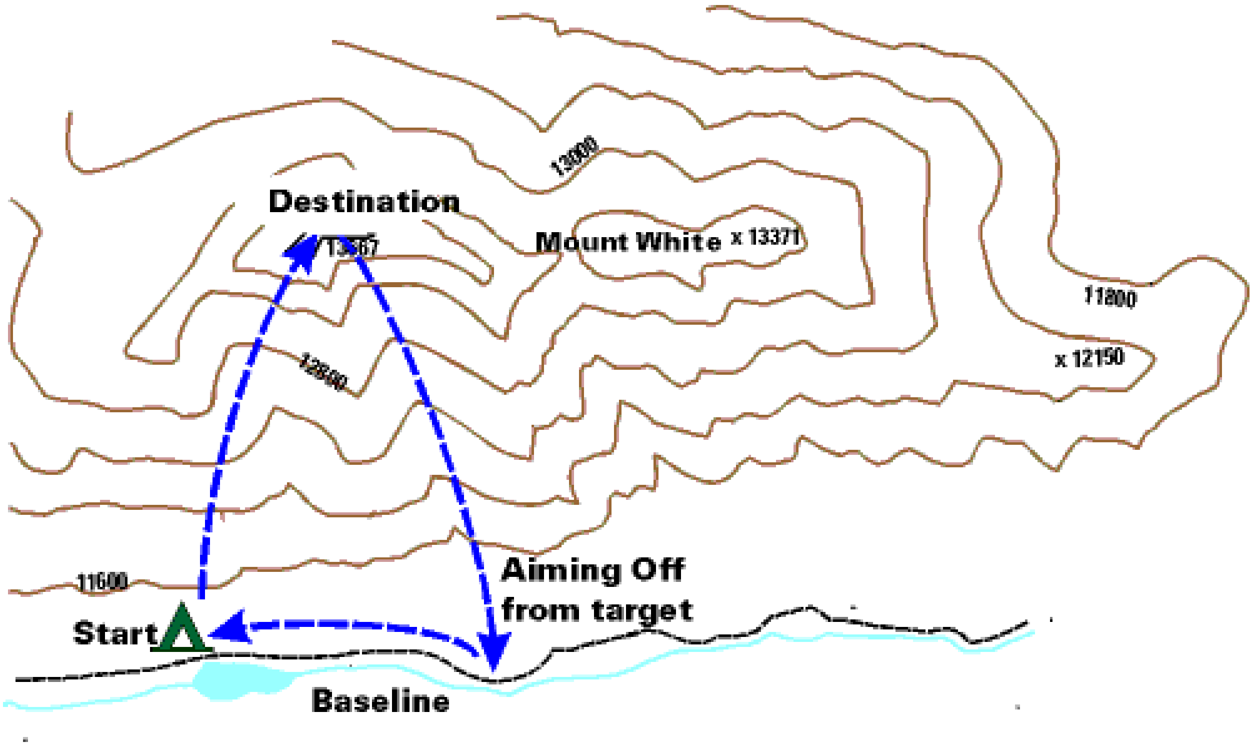
- BB = B - 180°
- 45° = 225° - 180°



- **Aiming Off:** It is almost impossible to walk a perfect bearing. In most cases your error can be anywhere from 3-5°. This is known as lateral drift (see Figure 6.12) Being off just a few degrees can make a major difference after several miles (see Table 6.1). Therefore, rather than head straight for your target, it is best to deliberately aim to one side of your target (left or right). Then you will know whether to turn right or left and walk to the target.



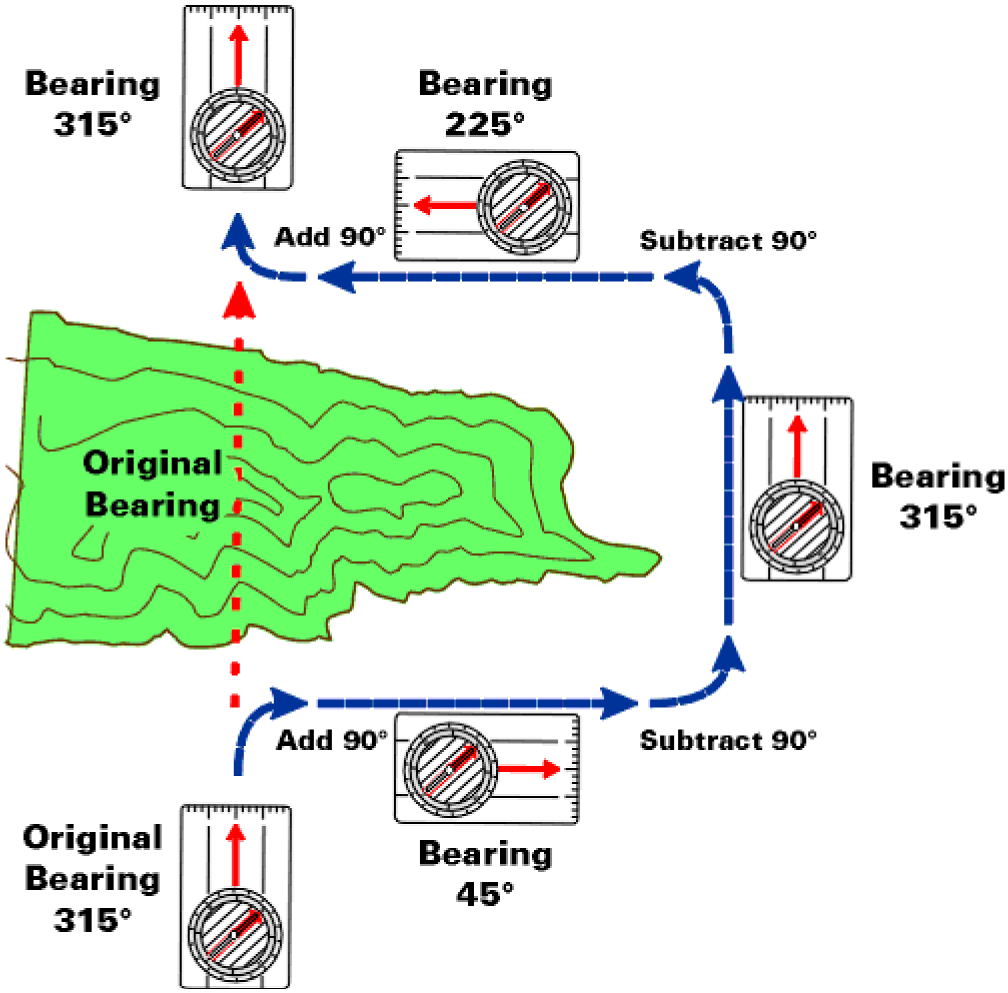
- **Baselines:** Baselines are helpful because they provide a large target to aim for. A baseline is a reference line that lies across your course. It can be a trail, cliff face, road, stream, or other feature. You can combine a baseline with aiming off to help navigate (in Scenario #3 the trail served as a baseline). Find a baseline near your destination, then aim off of it. When you hit the baseline, you now know which direction to turn to walk along the baseline to reach your destination (see Figure 6.13).



Scenario #4 - There's Something in Your Way:

You're doing this incredible bushwack and you've been diligently following a compass course, sighting from tree to tree. Up ahead there is a clearing, when you enter it you discover a bog. There's no way you can go straight through on your compass course. Now what? Here's your procedure:

- **Walking Around Obstacles** - When you reach an obstacle, the best method for maintaining your course is to hike a rectangle around the object (see Figure 6.14).
  - Set a new bearing 90 degrees from your original heading and walk that until you have cleared the obstacle along that axis. For example, if you original bearing was 30 degrees, hike a new bearing of 120 degrees. While walking, maintain a count of paces or otherwise track the distance traveled.
  - Go back onto your original bearing, parallel to you original course until you clear the obstacle along that axis.
  - Set a bearing 90 degrees back to your original bearing (in this case 300 degrees) and walk the same number of paces.
  - Now turn back to your original bearing. You will be along your original line of travel.



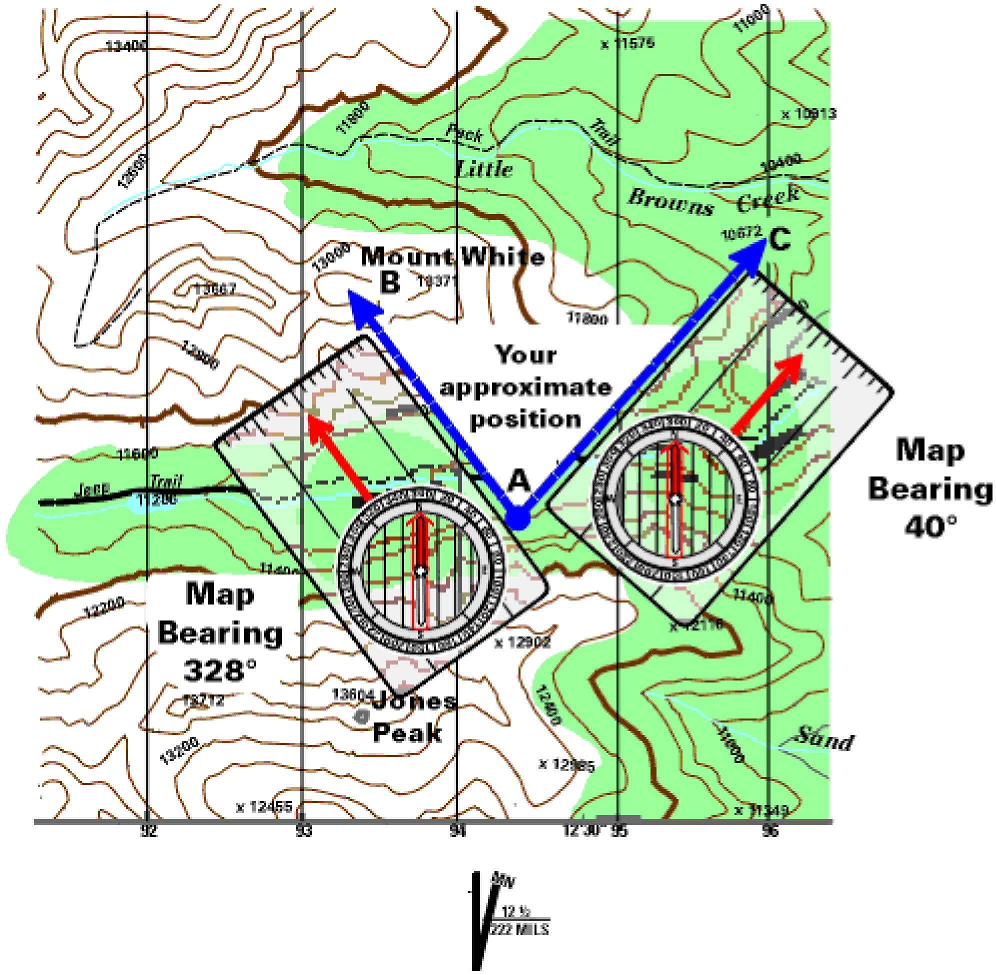
Scenario #5 - Now You are Really Lost:

You're hiking off trail through the broad alpine valleys and your having this deep philosophical conversation about the connection of man with nature, so deep that you have lost some of your connection with nature. You look around and you don't know where you are. One alpine valley looks a lot like the last one you came through. Okay, so you're lost. Now what? Here's your procedure:

Triangulation

Triangulation is used to locate your position when two or more prominent landmarks are visible. Even if you are not sure where you are, you can find your approximate position as long as you can identify at least 2 prominent landmarks (mountain, end of a lake, bridge, etc.) both on the land and on your map. (See Figure 6.15).

1. Orient the map.
2. Look around and locate prominent landmarks.
3. Find the landmarks on the map (preferably at least 90 degrees apart).
4. Determine the bearing of one of the landmarks (see Bearings page 00).
5. Place the compass on the map so that one side of the base plate points toward the landmark.
6. Keeping the edge of the base plate on the symbol, turn the entire compass on the map until the orienting arrow and the compass needle point to north on the map.
7. Draw a line on the map along the edge of the base plate, intersecting the prominent landmark symbol. Your position is somewhere along this line.
8. Repeat this procedure for the other prominent landmark. The second landmark should be as close to 90 degrees from the first as possible. Your approximate position is where the two lines intersect.
9. You can repeat this process a third time to show an area bounded by three lines. You are located within this triangle.
10. If you are located on a prominent feature marked on the map such as a ridge, stream, or road, only one calculation from a prominent landmark should be necessary. Your position will be approximately where the drawn line intersects this linear feature.



Other Tools

Altimeters

An altimeter can also be a useful navigation tool. An altimeter measures the local atmospheric pressure of the air just like a barometer. This is usually expressed in inches or millibars of Mercury. The altimeter displays the current altitude on a dial with a needle or with a digital display. Since atmospheric pressure is constantly changing due to weather (see Chapter 7 - Natural History: Weather page 00), you must calibrate the altimeter by first setting it when you are at a known elevation. Say you arrive at the trail head parking lot which the map indicates is at 2,400 feet (730 meters). Set your altimeter for 2,400 feet (730 meters). As you hike the altimeter shows the current altitude as your elevation increase or decreases. In order to maintain accurate readings you should recalibrate your altimeter several times each day. One good trick is to recalibrate or at least look at your altimeter reading before you go to bed. If the altimeter reads a lower altitude the next day, then the atmospheric pressure has gone up during the night (typically indicating stable or improving weather). If the altimeter reads a higher altitude, then the atmospheric pressure is falling (indicating potential stormy weather).

You can use your altimeter in navigation as another information source to help locate your position. If the altimeter is properly calibrated, you know that you are at a specific altitude. Think of this altitude as corresponding to a particular contour line on your map. This may be enough to give you a very accurate fix on your location. If you are hiking up a trail and it crosses a particular altitude (contour line) at only one point, then you know exactly where you are. In other situations, you know that you are somewhere along a contour line that lies at that altitude (elevation). Other clues may help pin down exactly where along that contour line you are.

Inexpensive altimeters are available for under $50 and are also prone to inaccuracies due to temperature. To minimize temperature problems it is best to let your altimeter adjust to the ambient air temperature before taking a reading. More expensive altimeters that automatically correct for temperature changes can run over $200. A digital watch with an altimeter/barometer is an item that combines two useful tools.

Watches

Wearing a watch in the backcountry is a point of personal wilderness ethics. Many people like to let nature set the pace of the day rather than a watch. I may not **wear** my watch, but I **always** bring one along. There are too many times when I have needed a watch. For example, to get an accurate check on how fast I am hiking to see if my Time Control Plan is correct (see Chapter 1 - trip Planning: Planning Your Day page 00), and especially in first aid and emergency situations where timing vital signs and knowing the exact time that things are occurring may be essential in proper diagnosis and treatment (see Chapter 9 - First Aid & Emergency Care: Patient Assessment page 00). Watches can also be used to determine basic direction (see page 00).

Global Positioning Systems (GPS)

The Global Positioning System is a network of satellites in orbit above the earth. A GPS unit is basically a radio receiver. The satellites transmit to the GPS unit which interpolates the signals into latitude and longitude which are displayed on the unit. Typically signals from three satellites are needed to identify a specific position and a fourth to interpolate altitude. GPS units are accurate to within a few hundred feet of your actual location. Although they can be used to very accurately determine your location and establish compass courses, **don't rely on a GPS unit in place of solid knowledge of map and compass.** Battery failure, damage to the GPS unit, or even leaving it behind at a rest stop could leave you lost if you don't have good map and compass skills. GPS units are particularly useful in locations where there a few landmarks to identify your location (for example long canoeing trips in northern Canada). GPS units are available as hand held units easily transportable in the backcountry.