MountainSphere
ADVENTURES AND EDUCATION

Navigation Weekend

A 2 day hike in the Wollangambe Wilderness to learn map and compass skills

Led by Ashley Burke

Course Notes

These course notes cover the navigation principles and concepts that are taught and put into practise on the MountainSphere Navigation Training Weekend.

These course notes are the same as what is provided online in the online navigation tutorial.

It is not necessary or required for participants to study or read this material prior to attending the navigation training. Nor is it required that participants print out and bring this material with them on the course.

This material is intended as a resource for participants on the navigation weekend to use to refresh their skills after attending a navigation weekend, as a resource for people to use to learn the skills themselves, or if anyone ever wants to print the material that is provided online.

It is strongly advised that you attend a MountainSphere Navigation Training Weekend as this is the best way to put into practise and learn the skills outlined in this document.

WARNING: This document is over 55 pages long. Please think twice before you print it.

Contents

Lesson 1 of 3

Map Reading

1. Essentials of a Topographic Map

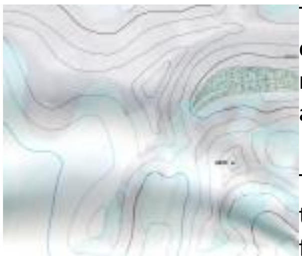
1.1 Representing the Elevations of Landforms

A **topographic map** is any map which shows the elevations of landforms. To do this, a method must be used to represent the uneven three-dimensional surface of the Earth on a flat two-dimensional sheet of paper. One of the most visually intuitive methods of doing so is to colour regions of different elevations as in Fig 1.1.

This map of Australia uses colours to depict different elevations. For example, dark green might represent land between 0 and 200m above sea level. Lighter green is used to represent land between 200 and 400m above sea level. Brown is used for land between 400 and 600m, and this gets successively lighter in colour in 200m increments until it is pure white for land above 1200m.

Fig 1.1

An alternative to this colour coding method is to use **contour lines**. It is this latter method that is used on all maps that are used for navigation. A contour line is a line on a map that joins all the points of an equal elevation. To understand this, imagine the above map with lines drawn on the map following the boundary between one colour and the next. Then remove all the colours, leaving just the lines, and you have a contour map, such as the one shown in Fig 1.2.



This map uses contour lines instead of colours to delineate elevations. The various curved lines on this map are the boundaries between one altitude range and the next. Imagine the colour coded map of Australia above with the colours removed and only the boundaries between one colour and the next delineated by a line.

This method of representing elevations is much more useful because colours can then be used for other purposes, such as marking vegetation zones, cleared land, forests, grasslands, etc.

Fig 1.2

The rest of this course regards contour lines as the standard method of representing topography on a map.

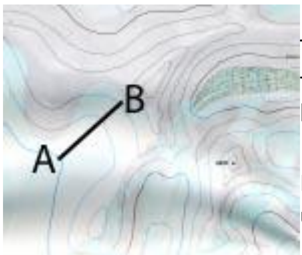
1.2 Properties of Contour Lines

Contour lines display recognisable properties depending on the type of ground that they represent, and these will be discussed in detail later in this course. The following general observations can be made about all contour lines on all topographic maps:

- The closer that contour lines are to each other on the map, the steeper the slope that they represent.
- The further apart that contour lines are from each other on the map, the gentler the slope.
- On ground that is perfectly flat, contour lines are absent, because there is no change in elevation.
- On vertical ground (cliffs), contour lines converge so that they are literally one on top of another.

1.3 Contour Interval

All topographic maps indicate what the vertical displacement is between one contour line and the next. This value is called the **contour interval** and is consistent across the entire map. Most metric maps used for navigation have a contour interval of 10 or 20 metres. On imperial scale maps the contour interval is normally 50 or 100 feet. Knowing the contour interval allows you to read the change in elevation during a journey on the map, as Fig 1.3 shows.



The contour interval on the map in Figure 1.3 is 200 metres. Therefore on a journey from A to B on this map as shown, there is a change in altitude of 400 metres, because the journey crosses two contour intervals.

Later in this course you will learn how to determine whether this altitude change is uphill or downhill!

Fig 1.3

1.4 Map Scale

The scale of a topographic map is normally given as a ratio, and most topographic maps used for walking, trekking and mountaineering are of one of the following scales:

Scale	**Metric / Imperial**	**Conversion**	**Example Maps**
1:24 000	Imperial	1 inch to every 2000 feet	USA uses this scale in their USGS 7.5 minute series maps
1:25 000	Metric	4cm to the km	New South Wales topographic maps Tasmania “TasMap” 1:25000 series (no longer printed) French "Top 25" series UK Ordinance Survey "OS Explorer" series
1:31 680	Imperial	2 inches to the mile	Pre-metric New South Wales first edition sheets, some USA maps
1:50 000	Metric	2cm to the km	New Zealand topographic maps Swiss topographic maps UK Ordinance Survey "OS Landranger" series
1:63 360	Imperial	1 inch to the mile	Older New Zealand maps, some USA maps
1:100 000	Metric	1cm to the km	Tasmanian "Tasmap" 1:100000 series, Australian "Natmap" 1:100000 series

Scales larger than 1:24 000 or smaller than 1:100 000 are not normally useful for walkers.

People often use the scale of the map when planning a trip to work out the length of the trip in kilometres or miles. Yet in most cases it is not the distance covered but the time needed to cover it which is the most important measure. Terrain can vary greatly, as can such factors as the density of the scrub, number of creek crossings, difficulty of any climbing, steepness of slopes and of course the fitness and size of the group. These factors more greatly affect the difficulty of the trip than does the overall distance travelled. So take such factors into consideration when planning your trip and think of your trip in terms of the time needed rather than the distance to be travelled.

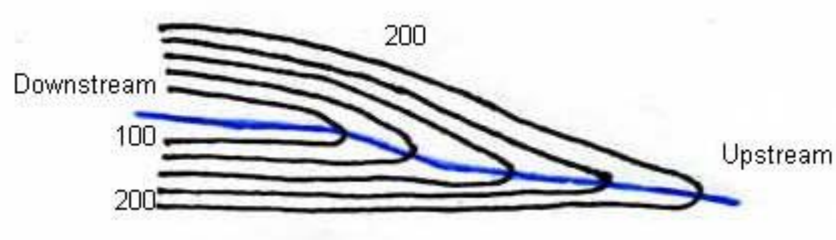
2. Interpreting Contour Features

As discussed in Section 1.2, contour lines on a topographic map represent steeper ground if they are closer together, and gentler ground if they are further apart. In fact, contours on topographic maps tend to form recognisable patterns depending on the form of the land surface that they represent. Land surface features such as hills, ridges, valleys, spurs and gullies are all depicted by recognisable patterns of contours on a map. Being able to form a mental picture of the surface of the ground by studying the arrangement of contours on a map is one of the key skills to navigation.

In this section we will examine what map contours look like for some common landforms. With this information you will be able to study a map, interpret the contours and form a mental image of the ground represented by the map. This is an essential skill, both in trip planning, and also while en route, as it allows you to make predictions about the terrain that you are heading into.

2.1 Gullies

A gully is a small sloping watercourse - a small valley with a sloping profile. On the map a gully is represented by a series of contours nested within eachother in a V or U shape where the outermost contours in the V or U represent higher elevations. See Figure 2.1.



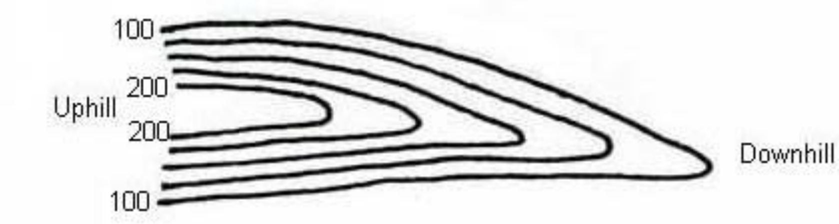
These contours depict a gully because they are nested within eachother in a V or U shape and the outermost contours are at a higher elevation than the innermost contours.

The map cartography will often aid in the interpretation by marking watercourses and creeks in blue as shown.

Fig 2.1

2.2 Spurs

A spur is a sloping ridge - a ridge that rises from a valley or other low ground or descends from a peak or range. Like gullies, a spur is represented by a series of contours nested within each other in a V or U shape. However, spurs differ from gullies in that the outermost contours in the V or U represent lower, not higher elevations. See Figure 2.2.



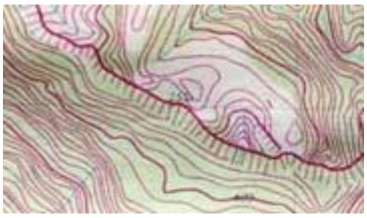
These contours depict a spur because they are nested within each other in a V or U shape and the outermost contours are at a lower elevation than the innermost contours.

Fig 2.2

2.3 Cliffs

A cliff is where the ground is so steep it is vertical or nearly vertical. Some topographic maps have special markings to represent cliffs, whereas on other maps there are no cliff markings and contours become so close to each other they simply fuse together. For example, NSW 1:25000 maps do have cliff markings, whereas Tasmania 1:25000 maps do not. Figure 2.3 shows different representations of cliffs on two different topographic maps.

Example of map where cliffs are marked.
NSW 1:25000 map



Example of map where cliffs are not marked and the contours just fuse together.
Tasmania 1:25000 map

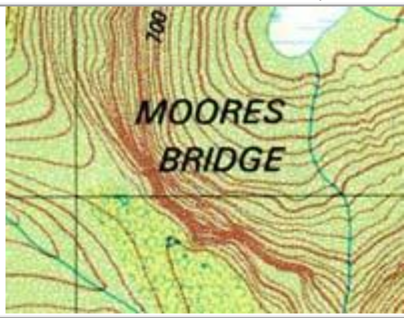


Fig 2.3

A word of caution: if a map marks cliffs, do not assume that there are therefore no cliffs in areas not so marked. Frequently you will encounter cliffs in places where none are marked on the map. Any region of a map where contours come close together, particularly on maps with a 20m contour interval, you can suspect that cliffs are there that may be hard to negotiate.

2.4 Hills

Hills, knolls or peaks can be recognised on maps as being where the contours are in closed loops, with one or more contours inside eachother, as shown in Fig 2.4.

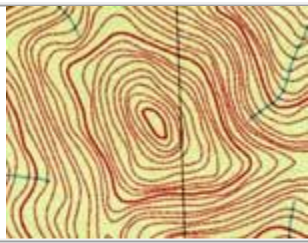


Fig 2.4

2.5 Depressions

A depression is an area of ground that is surrounded in all directions by higher ground. For example, volcanic craters, quarries and limestone sink holes. As with hills, depressions appear on maps in the form of closed loops of contour lines. To distinguish depressions from hills, maps will normally show short inward pointing bars on countour lines that represent depressions. See Figure 2.5.

In the Blue Mountains the sorts of landscapes that might exhibit depression contours are generally rare. A quarry or open cut sand mine would be the only landscape in the Blue mountains likely to classify as a depression. Depressions are more likely to be observed in New Zealand and Papua New Guinea, where wide areas of limestone country form extensive depressions. Depressions can also be noted on glaciers and ice fields on some maps of New Zealand.

Fig 2.5

2.6 Ridges

A ridge is a range of hills or mountains. It can also be thought of as the high ground or watershed that divides one valley from the next. On a topographic map it will be depicted by two contours of equal elevation (often these are the same contour) running side by side for a distance. These parallel contours usually diverge from eachother as the elevation of the ridge rises and and converge toward eachother as the elevation of the ridge falls.

If the elevation along a ridge falls by more than one contour interval, the two contours will join, creating a spur. If the elevation along a ridge rises by more than one contour interval, a new contour is formed (this is the same thing viewed in a different direction). Figure 2.6 shows a typical ridge formation, with rises and falls along the length of the ridge causing the contours to diverge and converge in the manner that I have just described. In Figure 2.6 I have shaded a region of ridge on this map. Note the parallel contours that diverge and converge, and the closed loops within these parallel contours. These closed loops represent bumps or knolls along the ridge.

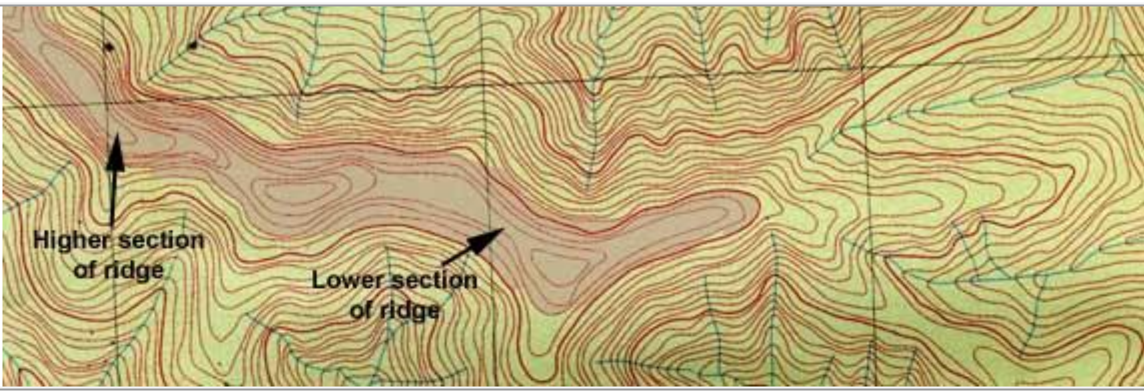
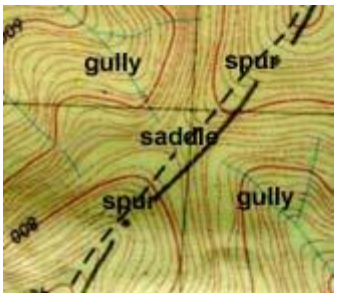
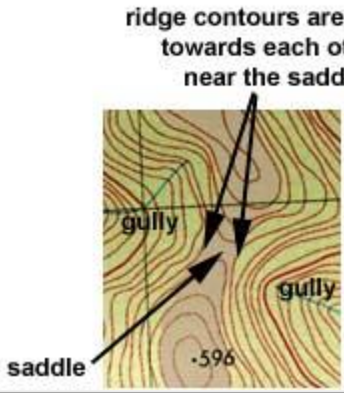


Fig 2.6

2.7 Saddles

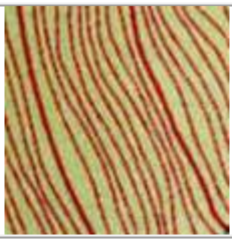
A saddle is a point on a ridge which is lower in elevation than points in either direction along a ridge. ie: it is a dip in the ridge, or the low ground between two hills that lie along the one ridge. Saddles exhibit the following contour features:

- Ridge contours are pulled in towards eachother at a saddle, and will join up whenever the saddle is deeper than one contour interval.
- Saddles may be a point on the ridge where two spurs face each other.
- Saddles often have gullies emanating from either side of the saddle.

<table>
<tr><td>In the example below, the dotted line follows the ridge in which this deep saddle is found. This saddle shows facing spurs and gullies either side.</td><td>In this example, the shaded region is the ridge. The saddle is where shown.</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td colspan="2">Fig 2.7</td></tr>
</table>

2.8 Sloping Ground

Sloping ground is depicted on the map by the presence of contours. Wherever the map shows contours, this is an indication of sloping ground in some shape or form. Some of these forms have already been discussed. The steepness of the sloping ground is indicated by how close together the contours are. The closer together the contours, the steeper the ground. Figure 2.8 shows the difference in the way steep and gentle slopes are depicted.

<table>
<tr><td>Steep slope - contours are close together.</td><td>Gentle slope - contours are far apart.</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">Fig 2.8</td></tr>
</table>

On very steep slopes the contour lines may be so close together there is no space between them. This can be depicted as contours merging together as already described for cliffs in Section 2.3 . On other maps, the contour interval may be doubled over the region of steepness, meaning that every second contour is omitted. On such maps, vertical bars mark the boundary where this omission of every second contour occurs. See the example in Fig 2.9.

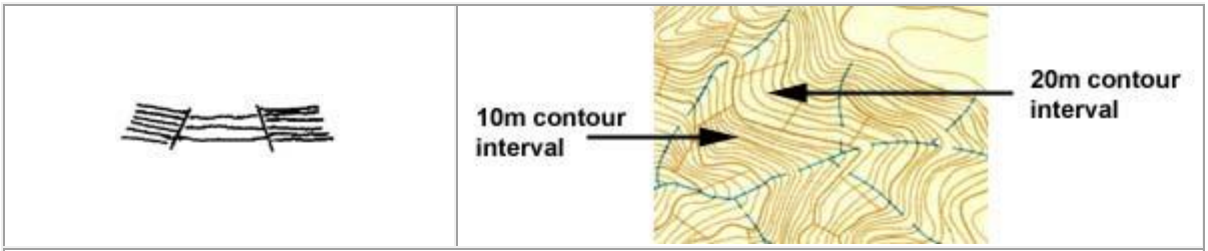


Fig 2.9. Steep slope depicted by a doubling of the contour interval.

For gentle slopes where contours are spaced far apart, some maps introduce auxiliary contours to effectively halve the contour interval and introduce more detail. Examples of such maps are the NSW first edition 1:25000 maps with a 20m contour interval. On some areas of these maps auxiliary contours are introduced as broken lines, taking the contour interval down to 10m. See Fig 2.10.

Fig 2.10. Gentle slope with auxiliary contours.

2.9 More Subtle Contour Features

So far we have discussed the macroscopic features of landscapes such as hills, gullies, ridges and so forth. Often when navigating we need to study the map and our surroundings in more detail in order to gain the information needed to navigate accurately and confidently. An important skill of navigation is attention to detail. Even the slightest bend, wiggle or bump on a contour line tells you something about the landform that it represents. A common mistake is to overlook such features when studying a map, thereby missing out on important information which may prove vital in enabling you to determine your position from the map and identify the features around you.

Here are shown just a few of the more common contour features that are more subtle and less obvious than those already discussed. Most of these features are landforms already discussed, such as saddles, knolls, gullies and spurs. The difference is a question of scale. These features are smaller versions of those already discussed, and therefore require more detailed inspection of the map to discern.

	This is a knoll or bump along a ridge that is too small to generate its own closed loop contour. Where the ridge contours diverge and then converge again is a sign that there is a small hill less than one contour interval in height above the surrounding ground. The top of the hill or bump can be assumed to be near where the contours are furthest apart.
	This is a saddle which is not deep enough to cause two parallel contours of the same elevation to cross the ridge and connect. Instead, parallel ridge contours come closer together, as if pinched, but without actually joining. The lowest point in the saddle may be assumed to be near where the contours are closest together.
	This is a dent in the side of a ridge or slope. It may be the beginnings of a gully that is too high in the headwaters to form a channel or watercourse.
	This is a bump on the side of a ridge or slope. It may be an outcrop of land on a slope causing localized flattening or the slope, or it may be the top of a small spur blending into the slope.

3. Other Natural Features on the Map

So far we have discussed contour lines and the features that these lines depict on the map. There are other natural and man made features on the map that are depicted in various ways. The map legend will indicate what these features are. In this section I'll discuss two common natural features on the map, these being water courses and vegetation types. I'll discuss these because there is often more information that you can glean from studying these features on the map than a cursory glance at the map and its legend would reveal. Much of this information is specific to the Blue Mountains, near Sydney, Australia, but the material can usefully be applied to other areas as well.

3.1 Watercourses

A watercourse can be considered perennial or non-perennial. A perennial one is one which flows, or at least contains water, all year. It is considered a permanent source of water. A non-perennial or intermittent watercourse is a stream which only flows at certain times of year or only after rain. On New South Wales maps, perennial watercourses are marked with heavy blue lines. Fainter blue lines are used to mark non-perennial watercourses.

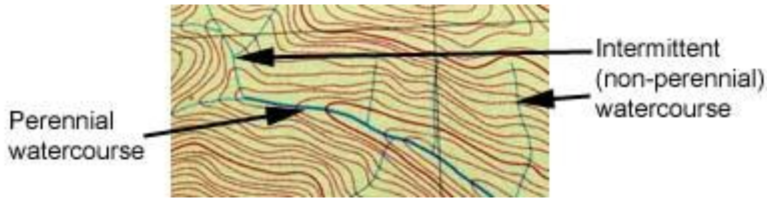


Fig 3.1

Don't always rely on the map as being authoritative on whether a creek will be flowing or not. Just because the map marks a creek with a solid blue line doesn't mean there is always water along its entire length during drought or dry summer seasons. In the Blue Mountains, the likelihood of finding water in a creek will depend on a variety of factors such as:

Direction of water flow	Streams that flow southwards and eastwards are more likely to have water than streams flowing northwards and westwards.
Altitude of headwaters	The higher the altitude of the headwaters relative to the surrounding country, the more likely the creek will contain water.
Geology of headwaters	Streams that originate in basalt caps and flow down into sandstone gorges are more likely to contain permanent water. See the Blue Mountains geology section for more information.
Depth of the gorge	Creeks that form deep and narrow gorges are more likely to hold water than wide shallow valleys
Presence of swamps	Swamps are like sponges that act as repositories and filters of water. Creeks that have swamps in their headwaters are more likely to have good water downstream of these swamps than creeks with no swamps in their headwaters.

3.2 Waterfalls

On New South Wales maps, waterfalls may be marked with blue bars along the watercourse as shown in Fig 3.2.

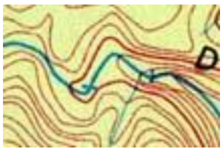


Fig 3.2

If the map doesn't mark waterfalls in this way, then that doesn't mean that there are no waterfalls on the creek. Often waterfalls exist that are not marked as such on the map. In these cases you may be able to infer their existence by examining where the contours cross the watercourse. If contours are close together in a region of creek, then that region of creek is more likely to contain waterfalls. A tell-tale sign on the map is a flat section of creek followed by a short steep section, followed by a flat section. In this case the short steep section is likely to contain a waterfall. Fig 3.3 shows an example.

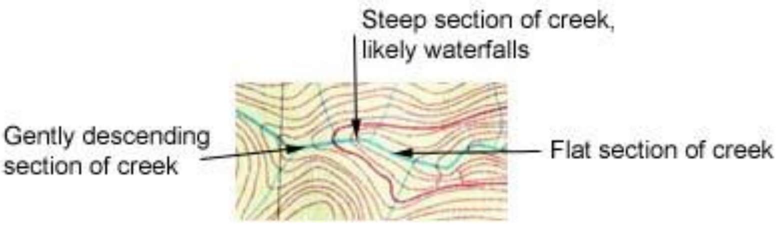


Fig 3.3

3.3 Vegetation

Topographic maps will usually include colouring that indicates the vegetation types likely to be encountered over an area of a map. The extent and accuracy of these colourings varies depending on the publisher of the map and you should consult the map key for information on the types of vegetation that are represented. Knowing the type of vegetation you will encounter on your trip is an important component of trip planning, especially when planning off-track walking. These plans need to take into account how dense the scrub is that you will have to walk through, the likelihood of finding camp sites in a given area, the amount of protection the vegetation will provide from the elements and so on. Knowing such factors in advance helps you plan a trip of an appropriate length and level of difficulty for your group. In the absence of first hand experience of actually having been there, your map can be used as a source of this necessary information.

Characteristics of the vegetation and how it is represented on the map varies from region to region, but the following general statements can be made about New South Wales topographic maps, particularly those of the Blue Mountains.

- White areas on the map are generally low heath or scrub that may be dense in places. It may also represent cleared areas such as farmland, or it might represent open rocky ground. If the area of white on the map is a high elevation plateau, then mountain heath or scrub may be assumed.
- Light green areas are normally open forest, where open forest means an open tree canopy. There may be areas of scrub beneath the open tree canopy. The nature of this undergrowth varies from open parkland to dense scrub and this is not easy to discern from the map except that as a general rule, often not obeyed, is that broader ridges are less scrubby than narrow ridges in the northern Blue Mountains.
- Dark green areas are rainforest, meaning closed tree canopy. Because of this, little direct sunlight reaches the forest floor. This lack of sunlight can result in the forest floor being less scrubby than open forest to walk through but since these areas are generally in moist gorges, other vegetation such as ferns, vines, weeds and other dense and slow undergrowth can proliferate.

4. Human Features on the Map

Almost all topographic maps used by bushwalkers will depict some human geography such as tracks, roads, farms, buildings, power lines and so on. You should consult the map key when studying your map and acquaint yourself with the human made features that you are likely to encounter on your walk. Some man-made features such as roads can assist with navigation but there are some catches that you should be aware of before relying too much on the accuracy of these features on your map. In this section we discuss some common man-made features encountered by bushwalkers and how they might assist - or confuse - your navigation effort.

4.1 Tracks and Roads

Beware of minor tracks and roads that are marked or not marked on the map. Tracks can become overgrown since the map was made and new ones can be forged. Existing trails may be rerouted in new directions. Consider tracks and minor roads on the map to be a guide only. A good idea is to check the date of publication of the map you are using. Older maps (say 20 years old) are likely to be less accurate than new maps (10 years or younger).

4.2 Power Lines

Minor power lines may be marked on the map and are notoriously unreliable and are likely to have changed since map publication.

Large power stanchions, where present, are more reliable and can be used as navigation aids.

4.3 Farm Gates

If a track or road has farm gates marked on it, then this may indicate that the road is privately owned and not accessible by walkers. Check the map for boundary markings indicating whether the area is national park, state forest, or private title. This might help you work out whether access through the gate is allowed or not.

4.4 Property Boundaries, Park Boundaries and Cadastral Boundaries

Inspect your map for boundaries to help determine whether you have right to access the area. Maps will often indicate whether an area is national park, state forest, private title, crown land, reserve or whatever.

The boundary of a private property may be fenced, but don't assume that the fence you see on your walk follows the property boundary as shown on the map. Fence lines tend to proliferate in farm hinterland and typically bear no correlation with boundaries indicated on the map.

Some maps show a bounded region with a number inside it. These are designated titles, that is, private land.

Where the map marks private property within or surrounded by national park or bush, these are often cleared areas or fenced areas and useful to take note of when reading the map.

Occasionally cadastral boundaries are marked routes.

5. Summary - Applying Your Map Reading Skills

In this lesson you have learnt about topographic maps and how to read them. You use these map reading skills when studying the map prior to the trip and also when following the map during the trip itself. Your aim in studying the map is to form a mental picture of the landscape that the map represents, and this enables you to make predictions about the terrain that you are likely to encounter and how difficult it might be to pass through. Here are some tips to remember when applying the map reading skills that you have learnt in this lesson.

5.1 Before the Trip

- Study the map in detail prior to the trip to form a mental picture of the terrain you will encounter.
- Use the map to plan a sensible route that follows natural features such as ridges, spurs and creeks. Bear in mind that usually creek walking is harder and slower than ridge walking.
- Take account of human features such as roads and private land.
- Make educated predictions about the vegetation that you might encounter and how long it will take to get through it if you are not on a trail.
- Pay great attention to the contour lines as these provide a wealth of information about the terrain you will be walking through.

5.2 On the Trip

Use your memory when walking and remember the topographic features that you have passed through and correlate these with the map as you go.

- Count the knolls and saddles when following a ridge or spur.
- Count the side creeks entering a creek as you follow it along its course.
- Count the number of bends and the direction of them as you follow a creek.
- Count the road junctions and recall human features such as power lines, park boundary signs etc.
- Annotate the map with features that aren’t marked so you know for next time.

You have now completed the map reading section of this course. But before heading out into the bush you do need to know how to use a compass. Click the Next button below to continue to the next lesson, how to use a compass.

Lesson 2 of 3

Compass Skills

MountainSphere
ADVENTURES AND EDUCATION

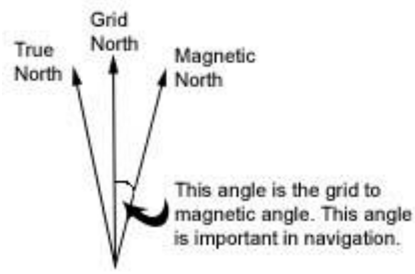
6. Orientation

6.1 The Three Different Norths

Before we get onto the compass and how to use it, I need to describe to you what we mean when we say "north". As I'm sure you are aware, the word "north" refers to the direction of the world's North Pole from where you are now. In actual fact, there are three different types of north, **magnetic north**, **true north**, and **grid north**. Here is the definition that I use for each of these:

Magnetic North	This is the direction of the Earth's magnetic north pole, which is the axis along which the Earth's magnetic field is aligned. It is not the same as the Earth's axis of rotation or the Earth's lines of longitude. The magnetic north pole is a region in the Canadian arctic. Magnetic North is important to navigation because it is where your compass needle points.
True North	This is the direction of the true north pole, which is the Earth's axis of rotation. It is the direction of the Earth's lines of longitude. True north is not normally relevant when navigating.
Grid North	This is the direction of the north-south running grid lines on your map. All topographic maps used by bushwalkers have a grid superimposed upon them, and this grid is aligned to grid north. Grid north is slightly different to true north because of the distortion caused by the curvature of the Earth being represented on a flat map sheet.

Your map will normally have a key showing all of the three norths and the angle between them. The angle that is important to navigation is the angle between **magnetic north** and **grid north**, shown below.



The **grid to magnetic angle** is the difference between grid north and magnetic north. In New South Wales, this angle is 12°. It may be different in different parts of the world so check your map.

6.2 Map Grid and Quoting a Grid Reference

One last thing about the map before we get to the compass and how to use it. Every topographic map used by bushwalkers has a grid on it, and this grid is aligned with **grid north**. These grid lines are very important for navigation.The grid lines that run north-south are called **eastings** and the grid lines that run east-west are called **northings**.

On most metric scale topographic maps used for bushwalking each square in the grid represents one square kilometre of area.

The grid lines are numbered and these numbers are shown at the margins of the map. These numbers can be used to give coordinates for any point on the map. A **grid reference** is a set of coordinates for a point on the map. These coordinates are read off from the numbers along the margins of the map with the eastings quoted first. If this is confusing, let's illustrate this with an example.

Figure 6.1 shows a section of a map with the grid lines and their numbering at the margins clearly shown. In this image, the vertical grid lines run north-south and are called eastings, and the horizontal grid lines run east-west and are called northings. Each square formed by the grid lines represents one square kilometre in area.

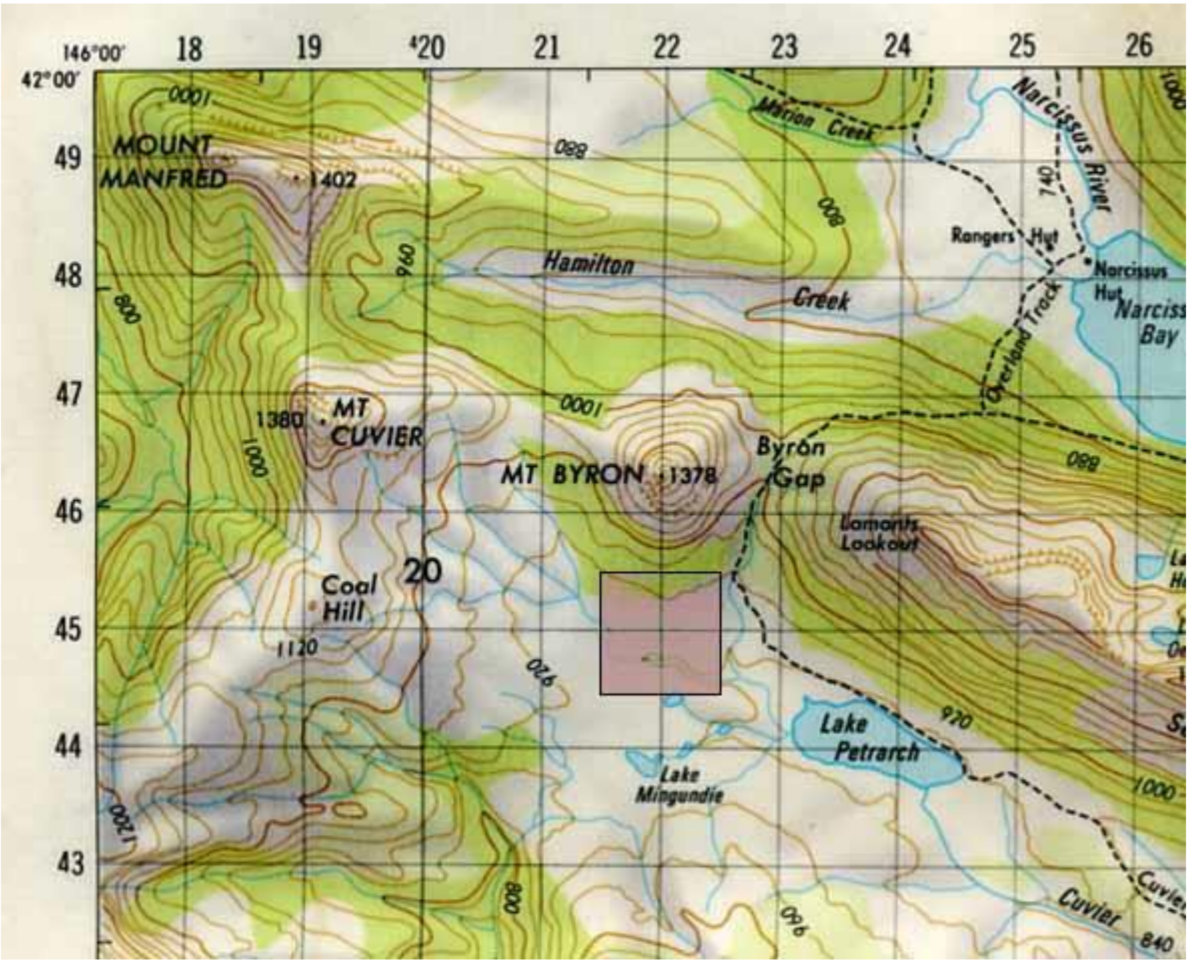


Fig 6.1: A section map showing the numbered grid lines.

Please look at Figure 6.1 above. Look at the vertical line with the number 22. Now look at the horizontal line with the number 45. These two lines meet to the south of Mt Byron. The grid reference for this point where vertical line 22 meets horizontal line 45 can be given as 2245. This is called a **four-figure grid reference**. 22 is the longitudinal part, 45 is the latitudinal part of the grid reference. It is only accurate to an area of one square kilometre. This four-figure grid reference could actually represent anywhere in the one square kilometre area that I have shaded on the map surrounding the intersection of these two grid lines. This is not normally accurate enough for the purposes of navigation so we normally quote a **six-figure grid reference** instead. This means we divide each 1km square on the map into a 10x10 grid and include an additional latitudinal and longitudinal digit into the grid reference that allow us to specify the point with greater accuracy. The additional digits are at positions 3 and 6 of the 6 figure grid reference. Thus the intersection of vertical line 22 with horizontal line 45 would have a six-figure grid reference of 220-450. This grid reference is accurate to one hectare (100m x 100m) and therefore much more accurate. For points on the map which don't lie at the intersection of two grid lines, the additional two digits have non-zero values.

So, let's work out the six-figure grid reference for some of the features on the map in Figure 6.1:

- The grid reference of Mt Byron is 220463.
- The grid reference of Narcissus Hut is 256481.
- The grid reference of Mt Cuvier is 191468.
- The grid reference of Mount Manfred is 182490.

Navigators will often use six-figure grid references when communicating locations so it is important that you know how to resolve a grid reference. If someone tells you to meet at 241493 then at least you'll know where on the map they are talking about!

6.3 Orienting the Map

Orienting the map is the process of positioning the map so that north on the map is aligned with north on the ground. When the map is positioned in this way, the orientation of objects on the map is the same as the orientation of those same objects on the ground.

Whilst orienting the map is sometimes useful, a common mistake by people learning to navigate is to do this too often, or to assume that orienting the map is a necessary part of navigation. Experienced navigators rarely orientate the map when navigating through the bush and reserve this activity for curiosity's sake alone when browsing the map and the surrounding countryside. In general I would make the following general remarks about when and when not to orient the map:

- Do it when you want to get general bearings, such as when you are at a lookout or after being dropped off in a new location.
- It is not generally useful when walking along or for route finding.
- It is not necessary when taking and following bearings or when using a compass.
- It should not be used for accurate identification of subtle or minor features.

Anyway, bearing in mind all of this, here is how to orient the map:

1. Spread the map out on level ground with plenty of space around it so that you can rotate the map.

2. Place the compass on the map and wait for the needle to settle.

3. Rotate the map slowly until the grid lines on the map are aligned with the compass needle that is pointing to magnetic north.

4. Adjust for the grid to magnetic angle by rotating the map anticlockwise by 12°.

The map is now roughly oriented. Figure 6.2 shows an example of a map that is correctly oriented.

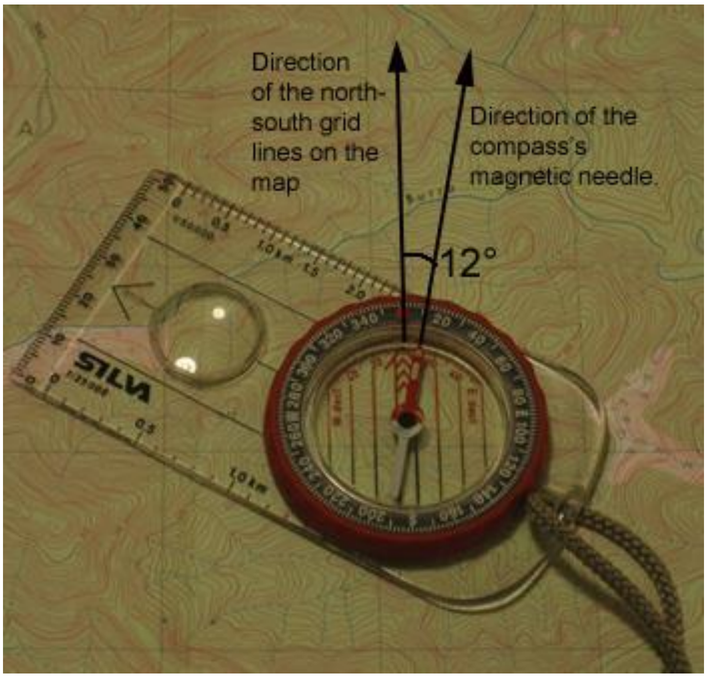


Figure 6.2. Example of a map that is correctly oriented.

7. The Compass

7.1 Parts of a Compass

Figure 7.1 shows a compass of the type that is normally used in bush navigation.

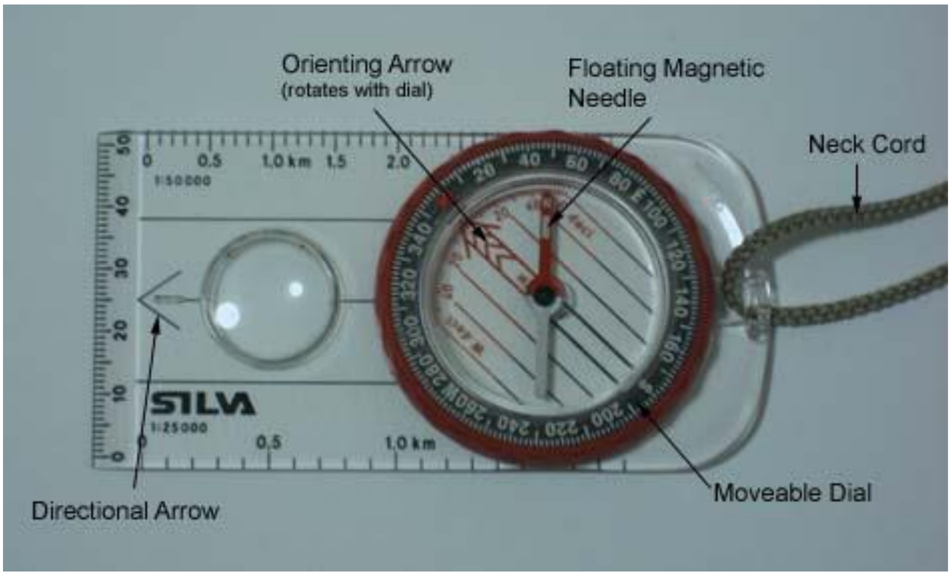


Fig 7.1: Parts of a compass.

Take a look at Figure 7.1 in which the parts of a compass are labelled. Here is a description for each of the parts of the compass:

Floating magnetic needle	When the compass is held level and away from metal objects or magnetic fields, then the red end of this needle points to magnetic north.
Movable dial	This dial can be rotated. You use this to set your bearing. You will learn how to use this later.
Orienting arrow	This is fixed to the dial so it rotates with the dial when you move it.
Directional arrow	Use this to follow your bearing. See later.
Neck cord	Hang your compass around your neck so you don't lose it.
Declination Scale (not shown)	Some compasses (eg: the Suunto M-3) have an adjustable declination scale on the inside of the movable dial. This allows you to set the grid to magnetic angle, eliminating the need for you to adjust for it manually. See Sections 8 and 9 and Appendix A.

7.2 Choosing a Compass

Compasses come in a wide variety of shapes and sizes and they can also vary quite widely in price. When choosing a compass to buy, here are some general guidelines:

- In Australia, expect to pay in the range of $40 to $100 for a decent compass.
- Quality brands of compass are Silva and Suunto.
- The compass should have a clear and transparent plastic base plate like the one in Fig 7.1.
- The floating needle should settle quickly when the compass is held horizontal and it should hold its position even if you rotate the compass steadily around a horizontal axis.
- The orienting arrow on the inside of the compass dial should be clearly visible.
- There should be several parallel lines on the inside of the compass dial aligning with the orienting arrow.
- A 1:25000 and a 1:50000 measuring scale on the compass's base plate is useful.
- A magnifying glass built into the base plate is useful.
- Some higher end compasses have a mirror for sighting. This helps take more accurate bearings and the mirror itself has other uses for camping and as a safety item. The downside is that the mirror makes the compass bulkier and heavier, a significant issue given that the compass is carried on your person, hanging around your neck or in your breast pocket.
- If your compass develops a bubble inside the dial then it may soon be time to replace your compass. Small bubbles are tolerable but if they grow too large they can interfere with the floating needle and render the compass inaccurate.
- Check with your retailer whether your compass is balanced only for your region or whether it works anywhere in the world. Some compasses only work in the northern hemisphere or southern hemisphere!

Compasses with a coloured or not perfectly transparent base plate, compasses with a very short base plate, or compasses in wildly different shapes and sizes to those reviewed below should be avoided unless you know otherwise.

Here is a review of a few widely available compasses.

7.2.1 Silva Ranger

Manufacturer:	Silva
Model:	Ranger
Retail Price:	$60
My Rating:	
Image:	
Review Comments:	The Silva Ranger and the Silva Ranger S are my two favourites. The Silva Ranger is the compass I use on most trips, though on my navigation courses I choose the version with a mirror (see "Silva Ranger S" below). You'll see the advantages of the mirror if you join a navigation training weekend. The Silva Ranger is a great compass, it is small, light, has all the features you need and the lines on the inside of the compass dial make it easy to set bearings from the map. Choose a model that is weighted for your hemisphere. There are southern hemisphere, northern hemisphere and equatorial models.

7.2.2 Silva Ranger S

Manufacturer:	Silva
Model:	Ranger S
Retail Price:	$85
My Rating:	★★★★★
Image:	
Review Comments:	This is the other compass in the Silva Ranger series and features a mirror for sighting. If you join one of my navigation training weekends, you will see that this is the compass I take on those navigation weekends. The mirror allows for more accurate sightings, as you will see if you join a navigation weekend. Although the mirror adds weight and bulk to the compass, this latest Silva Ranger S is nonetheless light and compact and the unit fits comfortably in your shirt pocket. The mirror flips up and down easily. Like the Silva Ranger, this compass is weighted for your hemisphere and may not work well in other parts of the world.

7.2.3 Suunto M-3 Global

<table>
<tr><td>Manufacturer:</td><td>Suunto</td></tr>
<tr><td>Model:</td><td>M-3 G</td></tr>
<tr><td>Retail Price:</td><td>$95</td></tr>
<tr><td>My Rating:</td><td>★★★★☆</td></tr>
<tr><td>Image:</td><td></td></tr>
<tr><td>Review Comments:</td><td>
A quality compass from Suunto. It has many advantages but also some disadvantages.

Pros

High build quality and good feel.
Needle settles quickly.
The compass has a declination adjustment which allows you to set the grid to magnetic angle permanently on the compass. This eliminates the need to add or subtract the grid to magnetic angle .... if the declination is set correctly in the first place!
The compass is global, meaning that it will work anywhere in the world without the needle sticking (though I have not personally verified this. It is the manufacturer claim only).
Has a clinometer (for measuring the steepness of a slope), though this is a bit of a gimmick.

Cons

Suunto puts its logo on the inside of the compass dial, a space which would be far better used for the orienting lines.

Although the compass does have 1:25000 and 1:50000 measuring scales, these are not located along the edge of the compass. Instead, the front edge of the compass provides a 1:24000 (1 inch = 2000 foot) measuring scale which is a non-metric map scale, only the USGS 7.5 minute series of maps use this scale that I am aware of. The more widely used 1:25000 and 1:50000 scales are not as prominent or as easily used on this compass as on the Silva Ranger.
</td></tr>
</table>

7.2.4 Suunto MC-2 Global

Manufacturer:	Suunto
Model:	MC-2 G
Retail Price:	$130
My Rating:	★★★★☆
Image:	
Review Comments:	All the features of the Suunto M-3 G plus a mirror for sighting. As mentioned, the mirror enables more accurate sightings. Like the M-3 it has a declination adjustment, a clinometer, and will work globally. I am pleased that the 1:24000 measuring scale is absent on this model, but the 1:25000 and 1:50000 measuring scales are not as easy to use as the ones on the Silva.

7.2.5 Kathmandu V2

Manufacturer:	Kathmandu
Model:	V2
Retail Price:	$20
My Rating:	★★★☆☆
Image:	
Review Comments:	A popular compass because it's cheaper. It lacks an orienting arrow and instead just has fluorescent marks where the orienting arrow should be. Not as high quality construction as the Silva and Suunto brands and the needle is less settled. This is your budget option.

7.2.6 Suunto A-30

Manufacturer:	Suunto
Model:	A-30
Retail Price:	$50
My Rating:	★★★★☆
Image:	
Review Comments:	This is a good compass for its price. The needle is more jittery (less stable when the compass is moved) than more expensive models. It comes in metric and non-metric variants. The one I reviewed was metric, meaning that the scales on the edges of the compass are suitable for measuring distances on a 1:25000 or a 1:50000 scale map. Choose a variant for your hemisphere. The compass I reviewed was weighted for the southern hemisphere and most likely does not work well in the northern hemisphere. The baseplate is uncluttered and whilst it lacks some features of high end compasses, it has all the necessary basics at an affordable price. Good choice for a basic all purpose compass. Like all Suunto models, I am disappointed that the Suunto logo has to be inside the compass dial. This space would be better left for the orienting lines only, as this is critical to accurate navigation.

7.2.7 Silva Expedition

Manufacturer:	Silva
Model:	Expedition
Retail Price:	$85
My Rating:	★★★★★
Image:	
Review Comments:	The "Silva Expedition" is one of the more advanced and full-featured compasses in the Silva range. It is notably larger than the Silva Ranger, the baseplate being both longer and wider, which gives more "real estate" for ruling lines on your map and for incorporating other features. It does make the compass bulkier in your shirt pocket though. The compass has several additional features, not all of which are especially useful in most Australian conditions. Like most good compasses, it has a magnifiying glass and 1:25000 and 1:50000 measuring scales on the baseplate. It also has a 1:40000 measuring scale though maps at this scale are uncommon. It has a declination adjustment which allows you to set the grid to magnetic angle permanently in the compass, much like the Suunto M-3 global compass does. It also has a clinometer for measuring the steepness of a slope, though this is not especially useful. It comes with cards that allow you to determine the angle of a slope from the contours on a map. This is only really useful for assessing avalanche risk, so not applicable in the Blue Mountains or most of Australia. It has friction feet to stop the compass slipping on the map - this is very useful. And finally, it has a stencil in the baseplate for drawing on the map - not very useful at all. It is non-global, meaning you should pick a variant for your magnetic hemisphere.

7.3 Carrying the Compass

Wear the compass around your neck using the neck cord. This will help ensure you don't lose it. Your compass is an essential tool and once out in a remote area you are sometimes completely dependent on it to prevent yourself from getting lost so don't lose it!

Ensure the neck cord is long enough so that the compass can be held out at arm’s length without taking it off.

When you are using the compass hold it horizontally so that the magnetic needle floats easily and does not rest on the surface of the dial that it is suspended in.

When reading the compass, ensure that it is held away from metal objects or possible sources of interfering magnetic fields such as other compasses, mobile phones, digital cameras, etc.

7.4 What is a Bearing?

A **bearing** is simply a direction of travel. ie: whenever you are walking in a straight line, you are following a bearing. We normally quote bearings as an angle relative to magnetic north or grid north:

A **magnetic bearing** is the direction of travel as an angle relative to magnetic north.
A **grid bearing** is the direction of travel as an angle relative to grid north.

The angle that bearings are quoted in is a number between 0 and 360 degrees that refers to the angle to the east (clockwise) of north. So a magnetic bearing of 0° means you are heading towards magnetic north. A bearing of 90° is due east, 180° is due south, 270° is due west, and so on. It will always be a number between 0 and 360. 45° is north east and so on.

Navigation is about using your map and compass to determine the magnetic bearing that corresponds to the direction that you want to walk in. You set the compass so that it points along this bearing and then you use it to guide you in walking in that direction.

You will now learn how to do this by a series of steps.

8. Navigating from point to point using map and compass

Let us imagine that right now you are at point A on the map shown in Figure 8.1 and that you know that this is your location. You want to get to point B. There is no trail or track between A and B and therefore you are going to have to use the map and compass to navigate there by yourself.

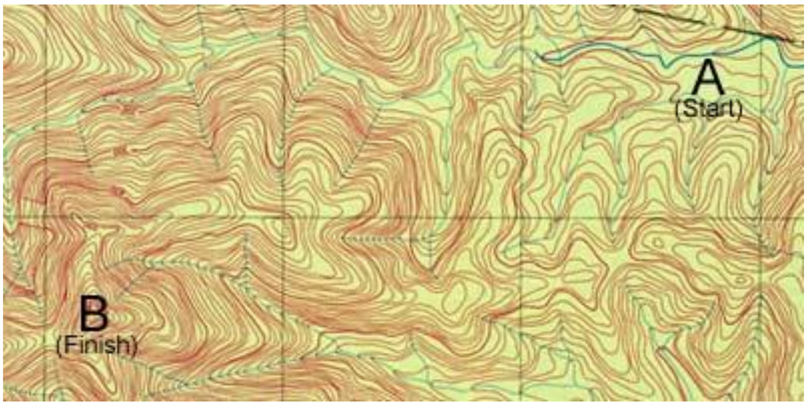


Fig 8.1

We are now going to work through the steps that you would use to accurately navigate your way from point A to B on the map in Figure 8.1 (above).

8.1 Step1 - Divide your route on the map into a series of bearings

The first step in the process of navigation is to study the map and decide upon a suitable route for you to follow to get from your starting point for your destination. Use the skills you learned in Sections 2, 3 and 4 to form a mental picture of the landscape by examining the map contours. Remember that your route should follow natural features such as ridges, spurs or water courses. Usually ridges and spurs are easier and safer to follow than creeks and gullies.

Once you've decided on what landforms you are going to follow to get to your destination, divide your route into a series of points joined by straight lines. By dividing your route into a series of straight lines, you are creating a series of bearings that you can then follow using your compass to reach your destination. After doing this for our journey from A to B we get something like Figure 8.2:

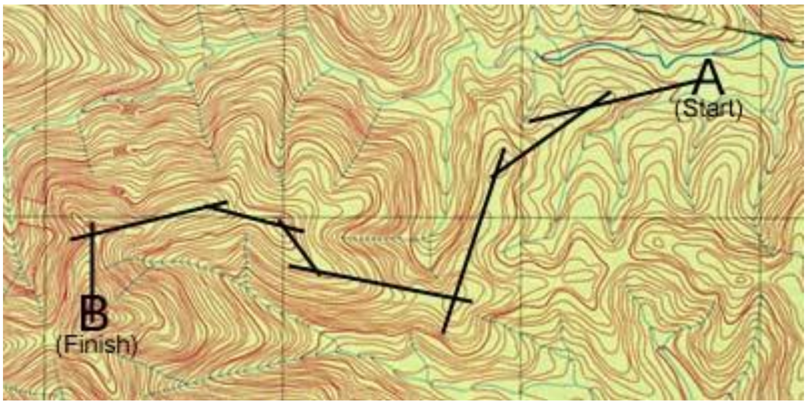


Fig 8.2

Notice that we have chosen a series of spurs and ridges as the landforms that we will follow to get from A to B. These landforms offer a series of natural features that connect A to B and thus by following these our task of navigation will be made much easier.

This step that we have just done is one of the keys to navigating! I cannot emphasise enough that good navigation depends on choosing a good set of bearings to get you from A to B! Whether or not you follow your bearings accurately is not important if the bearings are set poorly in the first place!

Let us pause for a moment and take a bit of a closer look at the art of choosing a good set of bearings for your route. There are common traps which lead to bad bearings being set. No matter how good you are at following your compass, if you have chosen a bearing wrongly, you will go the wrong way! Consider the example in Figure 8.3. Here we compare a good bearing with a bad one. In Figure 8.3 we want to go from A to B, and the easiest way to do this is to follow the ridge which joins them. But a single bearing going directly from A to B won't follow the ridge. Instead it will have you traversing obliquely across a slope, losing the ridge and not following the natural feature that links A to B. It is much better to use two bearings, one to the saddle and then another one from there to the next knoll.

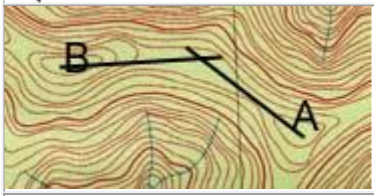
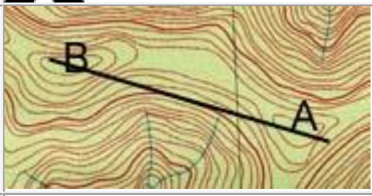
✔	✘
	
Good bearing	Bad bearing

Fig 8.3

Remember this: Your bearings should start and end at places where there is a noticeable change in the lie of the land. For example, the top of a hill, a bend in the ridge, a saddle, the edge of a flat area where the land begins to fall away or rise. Doing this will help you know when you have reached the end of your bearing and when it is time to change direction.

8.2 Step 2 - Set your compass

Ok, so we have now decided on the route we are going to take from A to B and have drawn a set of straight line bearings on the map as shown in Figure 8.2. Lets say that we are standing at point A right now. What we now need to do is set the compass so that we can use it to follow the first of these straight line bearings. We do that by following these next steps carefully.

First, place the compass on the map with the edge of the compass along the first bearing as shown in Figure 8.3.

Second, while keeping the edge of the compass in place we rotate the movable dial until the orienting arrow points to grid north on the map. You will see that when this is done the hairlines on the inside of the dial are aligned with the north-south grid lines of the map. See Figure 8.3.

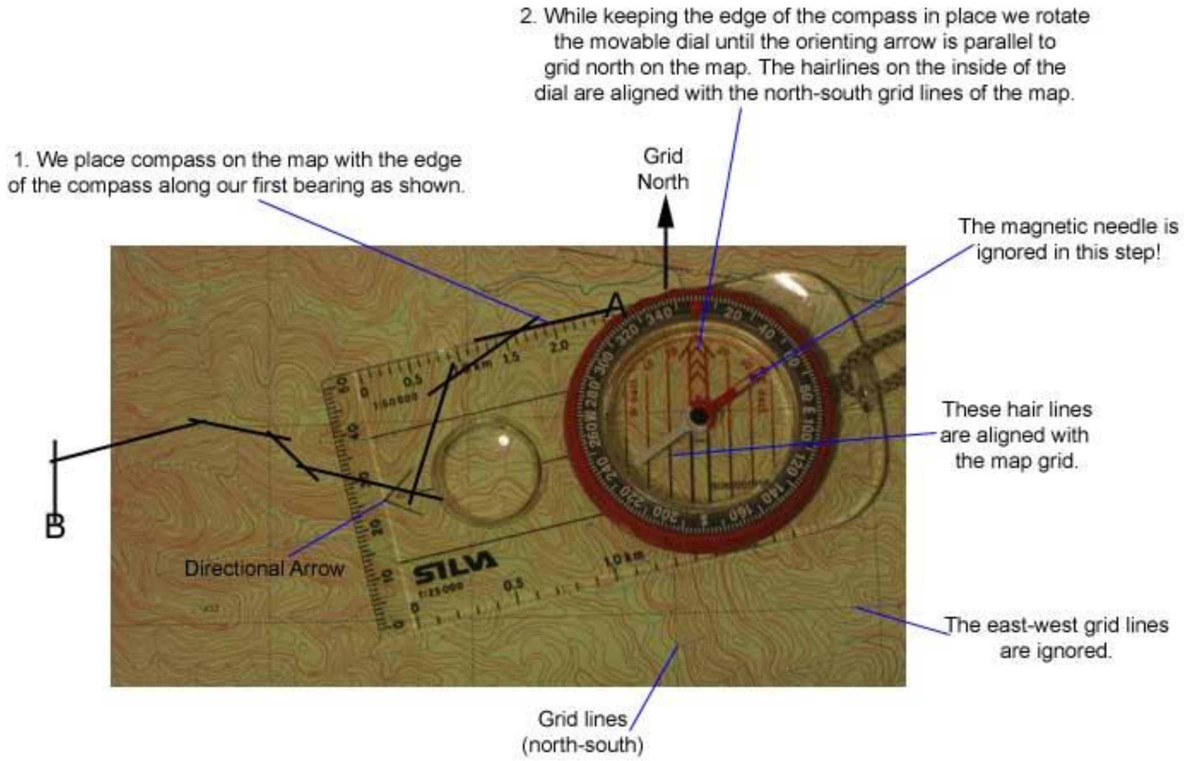


Fig 8.3

Here are some important things to look out for when doing this particular step.

- Make sure you align the lines on the inside of the compass dial with grid north, not grid south, east or west! This is an easy mistake to make!
- Make sure the directional arrow of the compass is pointing in the direction you will be going. In other words, don't put the compass on the map facing in reverse! This is also a common mistake!
- You can ignore the magnetic needle in this step. You won't be needing this until Step 4.
- The map doesn't need to be oriented during this step.
- Don't let the compass slip out of place when rotating the dial. The edge of the compass must be along the bearing you are going to take as shown in Figure 8.3.

Above all, remember that what you are doing in this step is determining your grid bearing from the map. That is, you are using your compass to measure the angle between grid north and the direction that you want to walk in. This angle will be a number between 0 and 360 degrees, clockwise from north. You can read this number from the compass dial. For the example we are using here this gives us a value of 257°. See Figure 8.4.

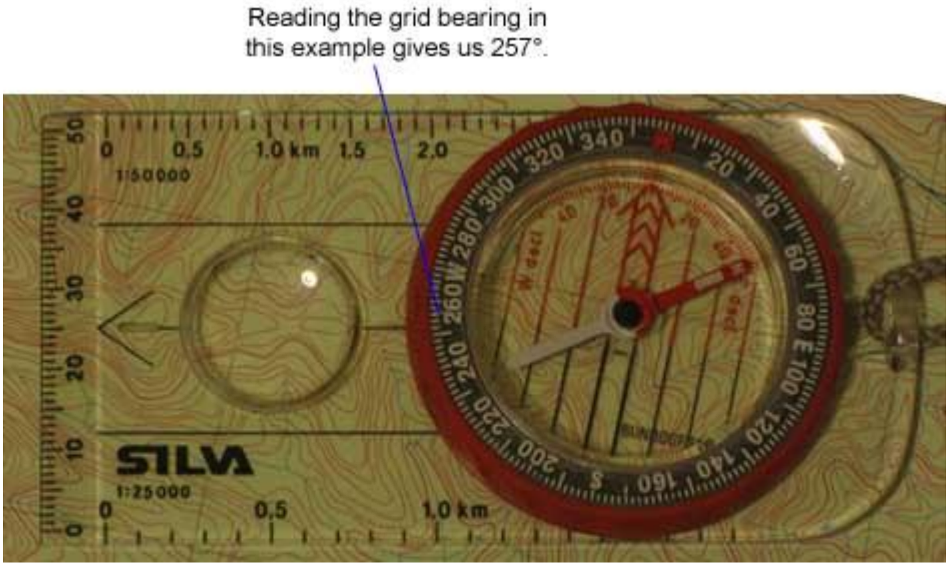


Fig 8.4

8.3 Step 3 - Subtract the grid to magnetic angle

Does your compass have an adjustable declination correction scale or an arrow that can be adjusted to set the declination? If so, you can skip this step. Instead, read the note about compasses with a declination scale in Appendix A.

Remember from Section 6.1 that magnetic north is 12 degrees to the east of grid north. Our bearing of 257° that our compass is now set on is relative to grid north. That is, 257° is the angle between grid north and the direction we want to go in our example. Before we can use the compass to follow our bearing, we need to adjust for the difference between grid north and magnetic north. That is, we have to subtract 12° from our grid bearing. We do this by rotating the compass dial clockwise by 12°. You can take the compass away from the map to do this. The value of 12° is the difference between grid north and magnetic north in south eastern Australia. This value may be different in other parts of the world.

So, here's what we do:

- Take the compass away from the map.
- Rotate the dial of the compass clockwise by 12° to subtract 12 from our bearing of 257°.
- This gives us a magnetic bearing of 245°.

See Figure 8.5 which shows this step.

BEFORE	AFTER
Our compass is set on our **grid bearing** of 257°. We then rotate the dial clockwise by 12°.	Once this has been done, our compass reads a new bearing of 245°. This is our **magnetic bearing**.
	

Fig 8.5

In this step we have again ignored the magnetic needle.

Our compass is now set.

8.4 Step 4 - Follow your bearing

Your compass is now set and you are ready to follow your bearing. Do not rotate the dial again until a new bearing needs to be set. We now use the magnetic needle for the first time. What we do is to hold the compass so that the magnetic needle floats over the orienting arrow, and when this is done the directional arrow points in the direction you need to walk in.

So, here's what we do:

- Hold the compass horizontally so that the magnetic needle floats easily and does not rest on the surface of the dial that it is suspended in.
- Ensure that the compass held away from metal objects or possible sources of interfering magnetic fields such as other compasses, mobile phones, digital cameras, etc.
- Hold the compass in such a position that the floating magnetic needle is in line with the orienting arrow. That is, the red part of the magnetic needle floats over the orienting arrow. Remember the orienting arrow is the red arrow that is on the inside of the compass dial.
- When the compass is held in this way, the directional arrow points in the direction you need to walk in.

Figure 8.6 shows a compass that is held on our bearing of 245°.

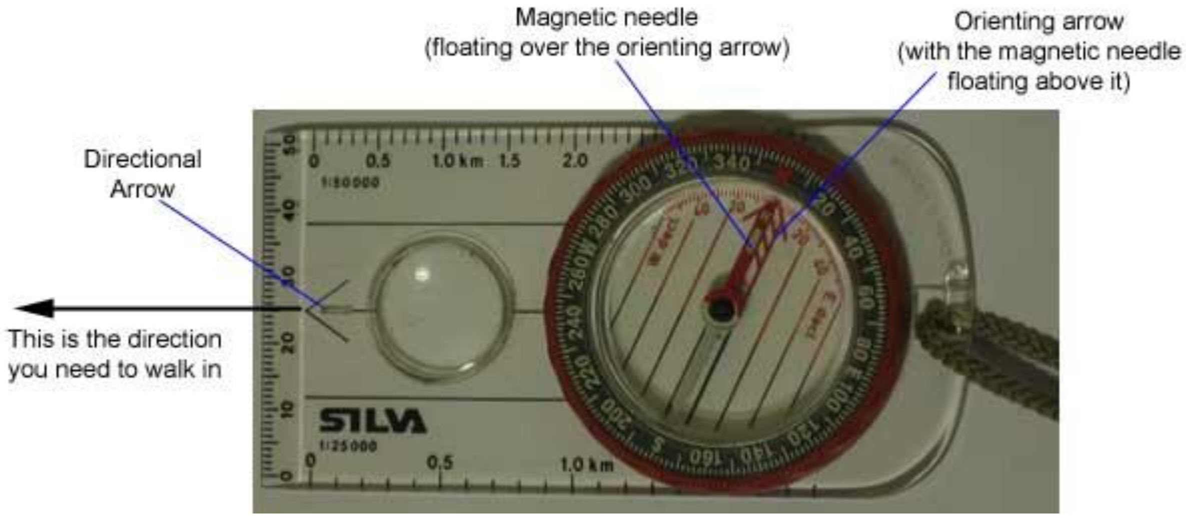


Fig. 8.6

8.5 Tips for following your bearing

Now that the compass is set and held right and you are following your bearing by going in the direction of the directional arrow, how do you go about doing this when off track in rough country when there may be all sorts of obstacles to overcome as you follow your bearing such as thickets of scrub, rocky ground, slippery rocks to avoid, mud to avoid, fallen logs to get around, or whatever? Here are some general tips.

Enjoy your walk

You go bushwalking for the joy of it, not to march along a set bearing regardless of what stands in the way. Your compass is a guide to the general direction that you should prevail in. Keep in that direction but be flexible enough to deviate around obstacles that lie in the path. You don't have to thrash through a thicket of dense scrub if you can go around it, even though the compass might be pointing straight into it. Make sure that if you do deviate around such obstacles, that you return to your original bearing once ahead of the obstacle. Don't make long detours and don't walk for long in a direction other than your bearing. Prevail in the direction of your bearing using your compass to guide you in that direction. Above all, enjoy the walk. That's what you're there for.

Let the land do the navigating

Remember Step 8.1. The bearing you chose should follow a natural landscape feature such as a ridge, a spur or a gully. Follow it. If your bearing was along a ridge then make sure you keep to the crest of the ridge and ensure that while so doing, that you remain on your bearing. If you find that by keeping along the ridge you are no longer following the bearing then that means it is time to check the map and compass again and possibly set a new bearing, starting at Step 8.2. The whole idea of choosing bearings that follow landscape features is so that you can use both the land and the compass to keep on track.

When to stop and change bearing?

If you chose good bearings in Step 8.1, then you will know when you are at the end of one bearing and the start of the next by the fact that you arrive at a noticeable change in the landscape. For example, you might arrive at the top of a knoll, or the ridge might change direction, or the slope you are climbing may flatten out, or you might reach the bottom of the hill. In such cases, were you to continue along your original bearing you might no longer be following the landscape feature that you have been following until now. This tells you that it is now time to change your bearing.

Let's take another look at the example we have been using in this chapter, in which we set out from our starting point A, following a magnetic bearing of 245°. How would we know when we are at point C (see Figure 8.7) which is where we need to change from our bearing of 245° to your next bearing? Take a look at Figure 8.7.

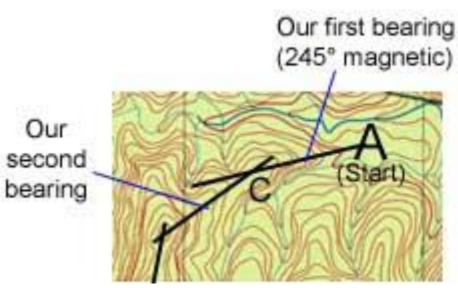


Fig 8.7

We can see from Figure 8.7 that as we follow our bearing from A heading towards C that we climb a spur. When we reach point C, the spur flattens out, we temporarily stop climbing and reach a level area. There may even be a very slight descent before it climbs again along our second bearing. In addition, when the spur resumes at the other end of the level area, it is more southerly than the spur between A and C. That is, we need to swing left a little when we reach the level area. Reaching the level area is our signal. When we are there we know we have reached the intersection of our first and our second bearing. Now we must stop, have a look at the map and reset the compass along our second bearing by following Steps 8.2, 8.3 and 8.4.

Some navigation schools teach you to count your paces as a means of determining when you have reached the end of your bearing. This is generally a waste of time when navigating in the manner described in this course.

Keep your eyes open

Look around you as you walk. Correlate the landscape features that you see around you with the map. In the next section you'll learn other ways of identifying features around you and working out your location using your compass.

8.6 Conclusion

The skills you have learnt in this section are the core skills of navigation. This is what navigation is all about. An experienced navigator may repeat the steps described in Sections 8.1 - 8.4 dozens of times a day when navigating through the bush. Essentially navigation is about point to point navigation from a starting point to a final destination in the manner described in this section.

What we will learn in the remainder of this course are additional skills that are useful to supplement the skills described in this section. These are skills to help you identify features around you and to work out your location.

9. Identifying the features around you

Imagine that you have been walking through the bush for a while, and then you reach a prominent place with expansive views of the surrounding area. From here you see peaks and ranges that you have not seen before. It would be a good idea at this point to identify what these peaks and ranges are on the map. Often you will do this just for interest. But doing this is also a very important navigation tool. Identify features around you when you know your location, so that later on, if you are unsure of your location, you can reverse the logic to work out your location from that feature.

In this section we assume that you know your current location. We assume that you can see a hill that is several kilometres away, and you are unsure what it is on the map. You will now use your map and compass to work out what that feature is.

9.1 Step 1 - Mark your current location on the map

With a pencil, mark a dot or a cross on the map that represents your current location. Remember: we are using this technique when we know where we are. We will use it to identify a distant object.

9.2 Step 2 - Get the magnetic bearing of the feature from your location

We need to get the magnetic bearing of the straight line between you and the feature that you want to identify. Do this:

- Point the **directional arrow** of your compass at the distant object (eg the hill) that you are trying to identify.
- While keeping the directional arrow pointing at the feature, rotate the dial until the magnetic needle is floating over the orienting arrow.

  Figure 9.1 shows a navigator in the process of carrying out this technique.

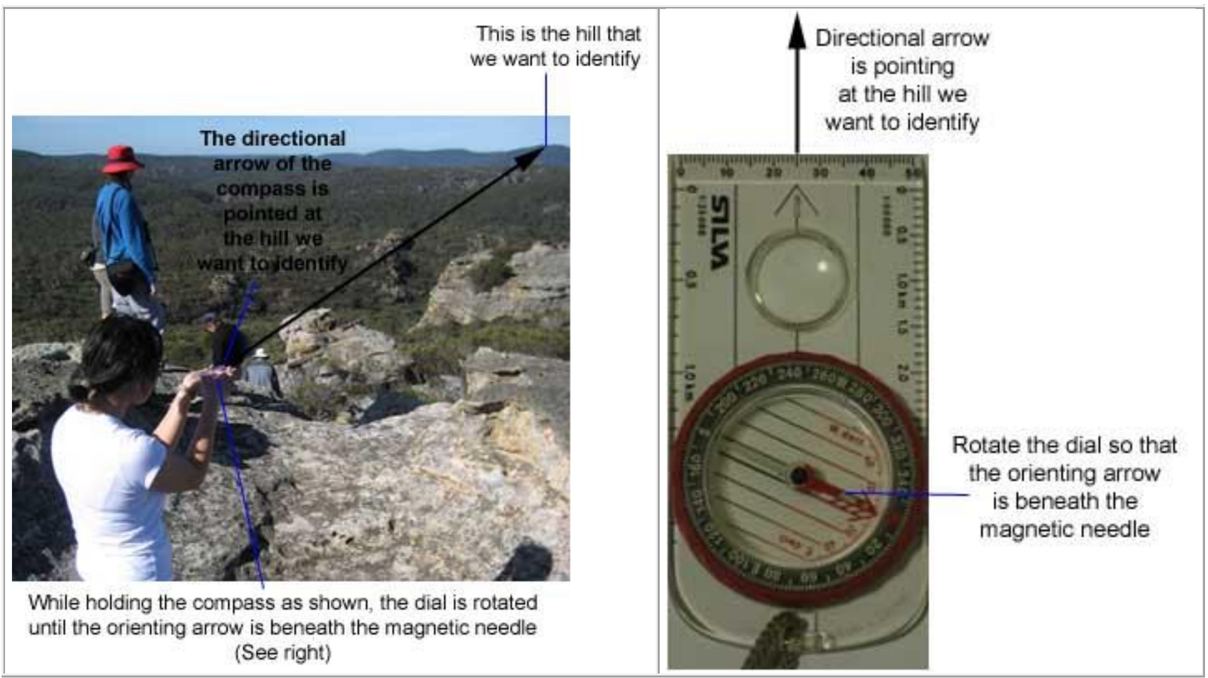


Fig 9.1

9.3 Step 3 - Add the grid to magnetic angle

Does your compass have an adjustable declination correction scale or an arrow that can be adjusted to set the declination? If so, you can skip this step. Instead, read the note about compasses with a declination scale in Appendix A.

When Step 2 is done we have a **magnetic bearing** from our current location to the feature we are trying to identify. Before we can use the map we need to convert this to a **grid bearing**. To do this, we add the grid to magnetic angle. That is, we rotate the compass dial anticlockwise by 12°.

9.4 Step 4 - Line up the compass on the map

Now we place the compass on the map in such a way that ALL of the following are simultaneously true:

- The long edge of the compass crosses the point representing your current position and which you marked in Step 1.
- The orienting arrow of the compass and the hairlines on the inside of the compass dial are parallel with the map's north-south grid lines.

See Figure 9.2 for an example showing the compass correctly positioned on the map.

9.5 Step 5 - Rule a line and deduce the identity of the feature

Without moving the compass after correctly positioning it in Step 4, rule a line along the edge of the compass that intersects your known location. Now you can take the compass away from the map if you wish.

The feature that you want to identify lies somewhere along this line. You should now be able to identify the feature by studying the map along the ruled line. Make an estimate of how far away from you the feature is, and look on the region of the map that is that distance along your ruled line. Study the map contours and correlate these with what you see as you look in the country between you and the feature that you want to identify. You should now be able to identify it on the map. See Figure 9.2 for an example.

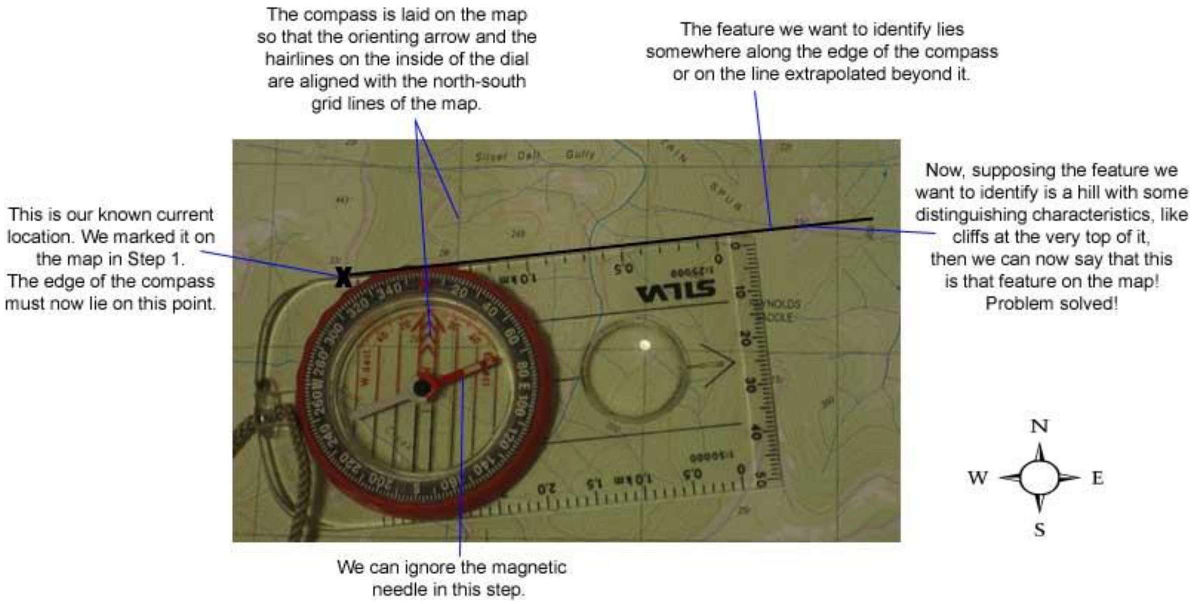


Fig 9.2

You have now learned how to identify features around you when you know your location. You can reverse the logic to work out where you are if you recognise a landscape feature and can identify it on the map. In the next section you'll learn how to do this.

Lesson 3 of 3

Additional Techniques

10. Working out your location

Working out where you are is a skill which ties together everything you have learned about navigation, and your experience. This is where your experience will help you, as will your memory of the terrain you have passed through, how frequently you have been cross-checking your location against the map, and so on. There are many techniques that you will use for working out your position, and one of these is to reverse the logic that I described in Section 9. I will go through this logic with you shortly, but first I'd like to describe one or two other tips and techniques for working out your position. There are many more, but most of these are a matter of applying the basic map reading and compass skills outlined in this course, along with practise, practise and more practise.

10.1 Use deductive reasoning

Study the map and use deductive logic to work out your position by a process of elimination. For example, look at the map and then think like this:

- If we're here then the ground ahead of us should drop away.
- If we're here then we should see higher ground to our right.
- If we're here then if we walk that way, we should come to a knoll.
- If we're here then we should see a ridge coming towards us from the opposite side of the valley.
- Etc

10.2 Use your memory

Think back to when you last knew with high certainty where you were. Then think about the country that you walked through since that point and what bearings you followed between then and now. This should narrow down your position to a relatively small area on the map. Then you can use deductive reasoning to narrow down the possibilities further.

10.3 Move to a recognisable point

If you're unsure of your location, then perhaps there is a prominent feature not far away that is easier to identify. Provided it is visible, not far away, and easy to get to, then it might be easier to go there and then work out where you are from there. Such a feature might be the top of a hill, crest of a ridge, sharp bend in a river, shore of a lake, or anything that has a view and is recognisable. Then the number of possible matching features on the map will be fewer than if you were in featureless open country, which could quite literally be anywhere.

10.4 Using your compass to work out your location

If you can recognise a distant object, such as a mountain, and can identify that object on the map, then you can use your compass to work out where you are from it, by reversing the logic that I described in Section 9. I'll run through that logic with you now, to illustrate how this is done. This technique is only useful if you can identify one or more distant objects. In poor weather, or at times when your view of the surrounding country is obscured, then you can't use this technique and you'll have to resort to other methods.

Let's assume that you're walking through the bush and are unsure of your location. To work out where you are, you decide to move to somewhere with a view of the surrounding area. When you get there, you recognise a peak and can identify that peak on the map. Now you can use the following technique to work out where you are.

Step 1 - Get the magnetic bearing of the feature from your location

We need to get the magnetic bearing of the straight line between you and the feature that you recognised. Do this:

- Point the **directional arrow** of your compass at the distant object (eg the peak) that you recognised.
- While keeping the directional arrow pointing at the feature, rotate the dial until the magnetic needle is floating over the orienting arrow.

Figure 10.1 shows a navigator in the process of carrying out this technique.

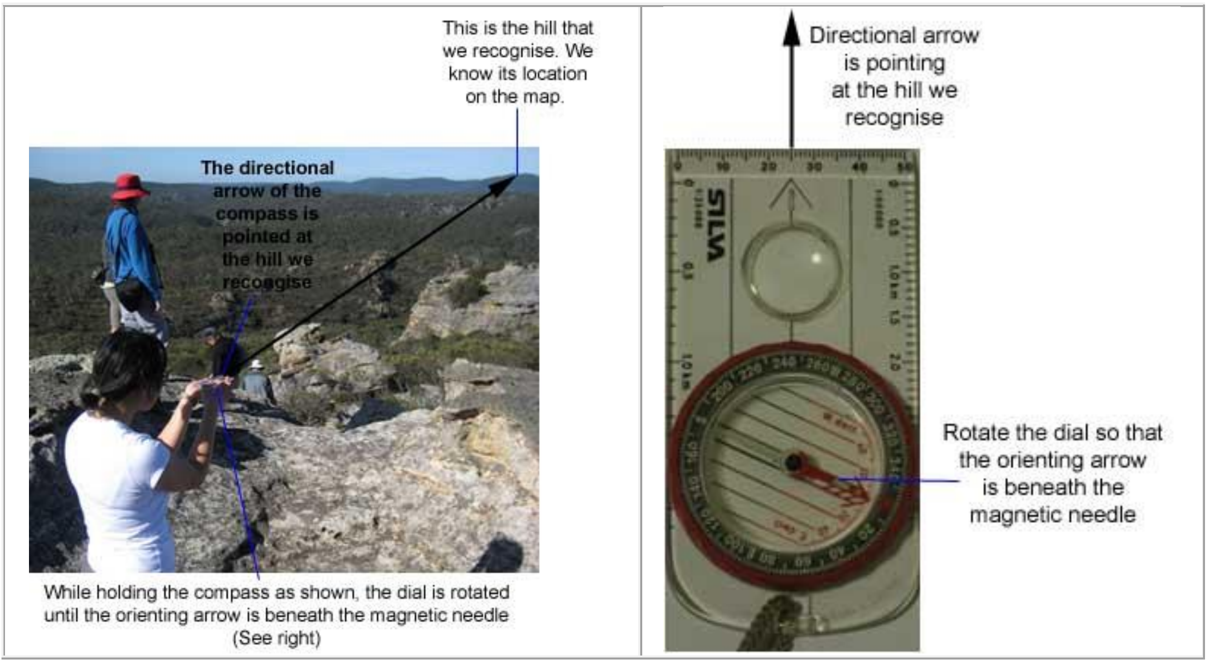


Fig 10.1

Step 2 - Add the grid to magnetic angle

When Step 1 is done we have a **magnetic bearing** from our current location to the feature we recognise. Before we can use this to work out our position we need to convert this to a **grid bearing**. To do this, we add the grid to magnetic angle. That is, we rotate the compass dial anticlockwise by 12°.

Note: If your compass has a separate declination scale inside the dial and if this has been set correctly to 12° east of North then you can omit this step.

Step 3 - Line up the compass on the map

Now we place the compass on the map in such a way that ALL of the following are simultaneously true:

- The long edge of the compass crosses the point representing the recognised object.
- The orienting arrow of the compass and the hairlines on the inside of the compass dial are parallel with the map's north-south grid lines.

See Figure 10.2 for an example showing the compass correctly positioned on the map.

Step 4 - Rule a line and deduce your location

Without moving the compass after correctly positioning it in Step 3 , rule a line along the edge of the compass that crosses the recognised feature. Now you can take the compass away from the map if you wish.

Your location is somewhere along this line. You should now be able to work out your position by studying the map along the ruled line. Make an estimate of how far away from you the recognised peak is, and look on the region of the map that is that distance along your ruled line. Study the map contours and correlate these with what you see as you look around you. You should now be able to identify it on the map. See Figure 10.2 for an example.

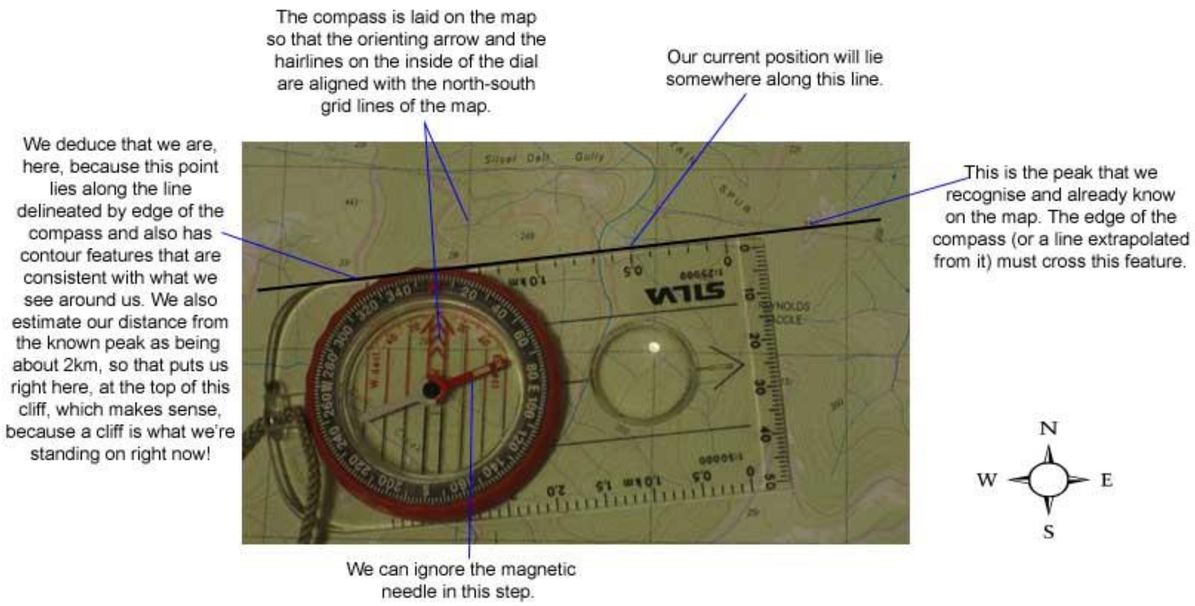


Fig 10.2

Sometimes you might recognise more than one peak around you. If so, you can repeat this procedure for the second peak to give you a second line on the map. Your location is in the vicinity of where the lines intersect. Figure 10.3 shows the map after having repeated Steps 1-4 for the second peak.

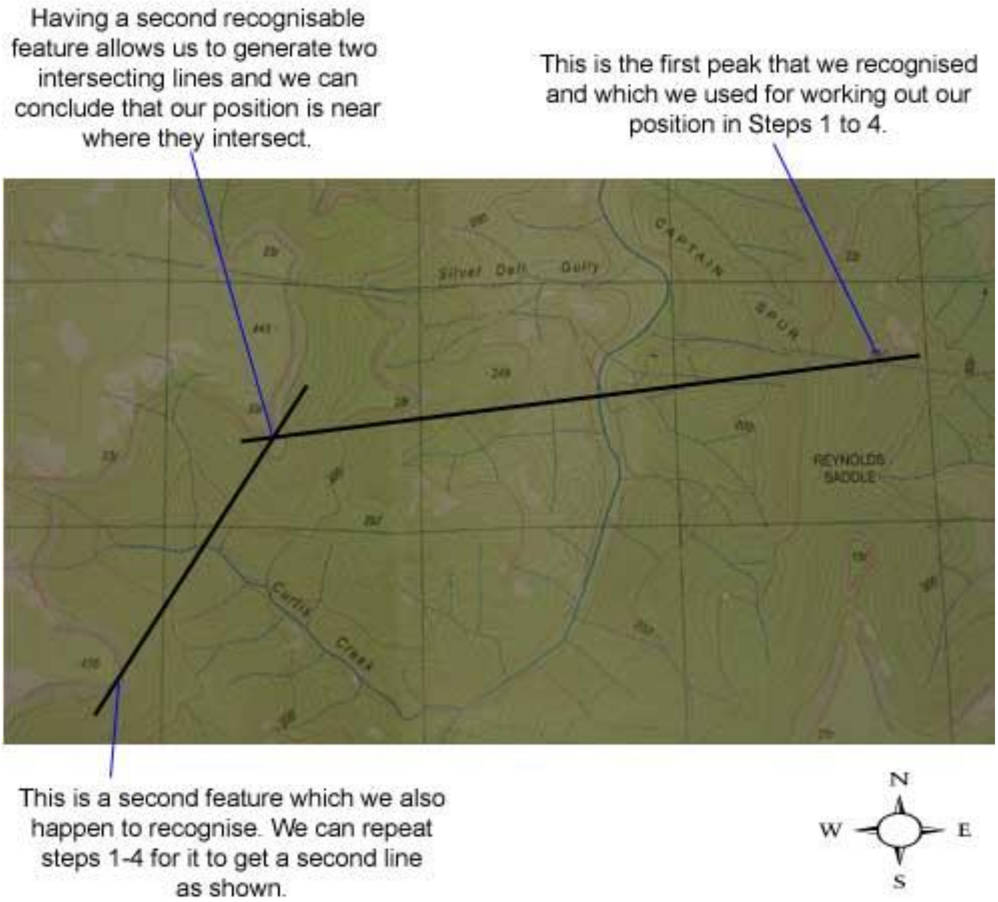


Fig 10.3

10.5 What is a resection?

What you have just learned and what is shown in Figure 10.3 is approaching what is known as a **resection**. That is, in Figure 10.3 you have used two known points to derive your location as being the intersection of the bearings of each of those points from your current position. If you have three or more points, then this is called a resection, or **triangulation**. Figure 10.4 shows a full 3-point resection.

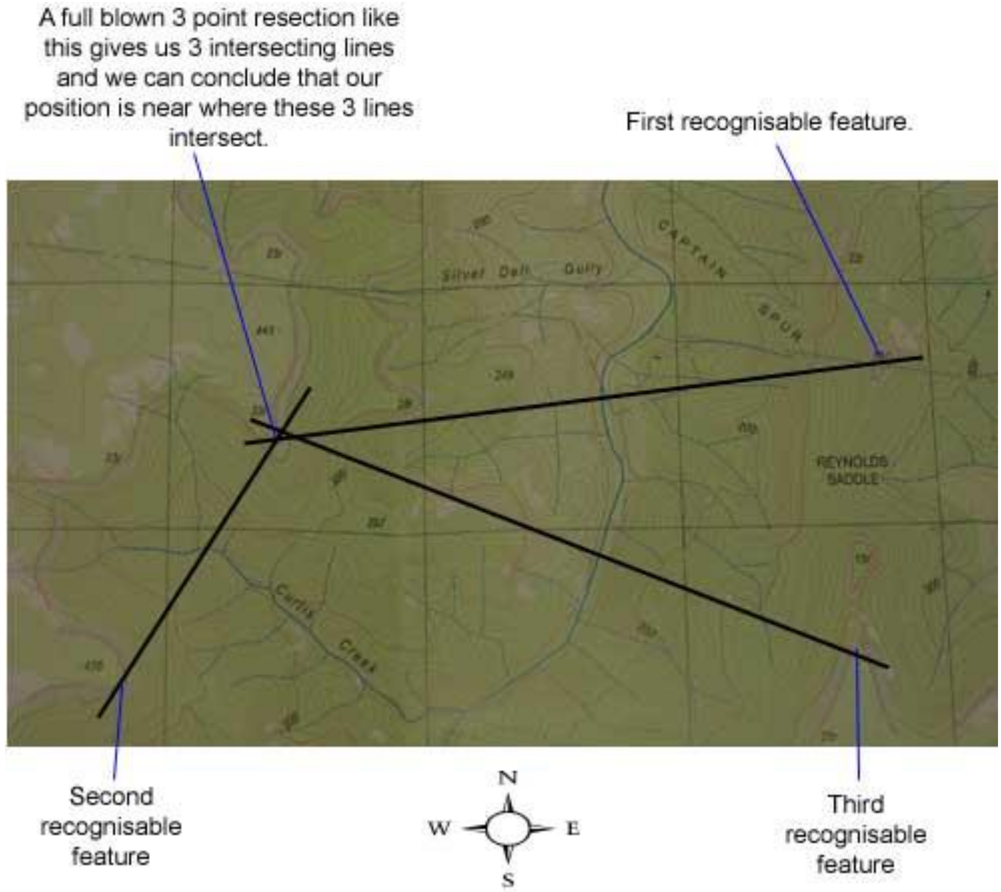


Figure 10.4

Although the resection is a commonly taught method in some schools of navigation, the technique of performing a full 3 point resection is rarely of any use in real situations that bushwalkers would normally find themselves in. In my personal experience I have only ever needed to perform a full 3-point resection once in my life. To see why a resection is rarely applicable in real life, consider the following:

- To do a full blown 3 point resection you need to be able to recognise three geographic features around you and be able to identify these on the map. What's more, you need to be able to see them all at the same time. How often can you do this and yet not know where you are? After all, you only need to do a resection if you don't know where you are. In my experience, you rarely find yourself in this situation.
- A resection is less accurate if any of the 3 objects you are triangulating are so close or so far apart that the lines you draw on the map are nearly parallel (see Figure 10.5 for what I mean). In such cases, small inaccuracies in your compass bearings will result in a large inaccuracies in the point where these lines intersect.
- Often all three points will not be on the same map, meaning that you have to align several maps to eachother, making it harder to do an accurate resection, especially if a wind is blowing or if it's raining.
- You often need a long straight edge to rule your lines. You can use the neck cord of your compass to extraopolate the lines but drawing a long straight line across a map is not as easy as it seems when you are in a wild place with wind blowing on uneven ground that may be wet.
- More often than not you need to determine your position at times of poor visibility, such as when mist or cloud obscure your view, or when scrub or close terrain reduces your field of view. At such times a resection is impossible, yet it is when you need it most of all.

Rather than attempting to perform a resection to determine your position it is usually far more practicable to use a single bearing on one known object and combine that with deductive reasoning and scrutiny of the map using the procedure described in Section 10.4. There are a few other techniques that you can use to work out your position when you have a more limited field of view, and I will briefly mention these in the next section.

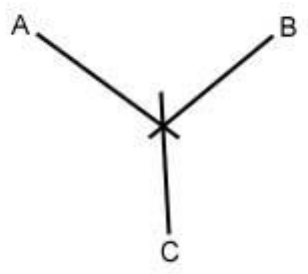
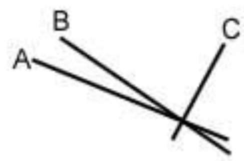
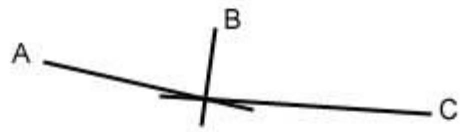
<table>
<tr><td colspan="3">In this example I show three resections, in which your position is triangulated from three known points A, B and C. These diagrams illustrate that the resection is more prone to be inaccurate if two or more of the points A, B or C are either too close together or too far apart, causing the lines to be nearer to parallel, which results in the resection being more prone to inaccuracy.</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>Here in our first example is an ideal resection, where the 3 points A, B and C are roughly equally spaced in a 360° field of vision. Obviously the likelihood of you being able to produce such a resection just when you need to is minimal.</td><td>In our second example, A and B are close together. Any small inaccuracy in your bearings taken of either A or B causes a disproportionately large difference in the point on the map where these two lines meet. In this case you rely on your bearing from C and look at where it intersects the lines from A and B. This is therefore little better than the 2 point method shown in Figure 10.3.</td><td>In our third example, A and C are almost in opposite directions from where you are standing. Any small inaccuracy in your bearings taken of either A or C causes a disproportionately large difference in the point on the map where these two lines meet. You therefore rely on your bearing from B to determine where along the line between A and C you are located.</td></tr>
</table>

Figure 10.5

10.6 Working out where you are when visibility is limited

One of the most difficult aspects of navigation is working out where you are when your view of the surrounding country is obscured causing you to be limited in the extent to which you can validate your position using the methods so far described. Examples of these difficult situations are when the weather closes in around you, when you are in dense forest or scrub, or when you are in close country where the terrain in your immediate vicinity obscures your view of the surrounding area. By far the most difficult environment of all to navigate in is when skiing or mountaineering in white-out. That is, when there is complete snow cover and you become enveloped in dense cloud. When this happens everything around you is completely white and it is impossible to even distinguish where the ground ends and the air begins. Your only sense of the lie of the land in these situations is where is downhill and where is uphill. Such circumstances are common when cross country ski touring or mountaineering and it is at times like this when navigation requires all your skills, experience and concentration, and even then it is easy to go astray and lose your way. In some cases it may be prudent judgement to stay put and setup camp rather than moving around with no certainty in your position, which can in turn lead you further astray and into further trouble.

Having said this, it is still possible to navigate in such conditions and there are a few techniques that you can use to help you find your way. Ultimately in these conditions safety is your first priority and you should use careful judgement when attempting to move in these conditions. Do not set out from a point of safety in such conditions. Rather, wait until conditions improve before venturing out. These tips are only intended for when you are caught out in such conditions and you have no other way of getting to safety. As previously stated, consider staying put until conditions improve if you have the necessary equipment and supplies for doing so.

Ok, let's assume the worst case, that you are caught in complete white-out in a snowscape and have no visibility and that you do not have the option of staying put. Let's also assume that modern electronic navigation aids such as a GPS are unavailable. Under such circumstances, the only resources available to you are your map, your compass, and your sense of where is uphill and where is downhill. It is this latter sense in conjunction with your map and compass that you will have to rely upon.

Tip 1: Go Straight and Remember Everything

Let's say that if you keep heading south you'll eventually come to a road which will take you to safety. Set your compass on a south bearing and head steadily in that direction, keeping as closely as possible to the bearing without deviating. Then pay careful attention to whether you are climbing and descending and how steeply. Remember every change in steepness in the terrain you are walking through whilst keeping to that bearing. Now study the map carefully. Look along an imaginary line on the map that represents the bearing that you are following. Study the contours along that line and see how well they fit with your mental picture of the ups and downs that you have been experiencing. You may be able to narrow down your position on the map based on what areas of the map have contours that match what you've been doing.

For example, as you head south, you might find that you climb steeply, then level out, then drop gently, then climb to the crest of a ridge. Study the map and see if you can find this sequence of terrain in a line going from north to south.

Tip 2: Take Uphill / Downhill Bearings

If you can't see a thing, then at least you'll still have a sense of where is uphill and where is downhill. With your compass take a bearing directly uphill or downhill from where you're standing. Add the magnetic angle and then line up your compass on the map. Look for slopes on the map which slope in the same direction as your correctly aligned compass. This will help narrow down to position to a relatively small number of possibilities.

Note that for this technique to work you must establish that your sense of where is uphill and where is downhill is accurate and the slope you are on is consistent over a large enough area to show up on the map. For example, don't use this technique when standing on the side of a small irregularity in the side of a hill. Move around a bit to get a profile of the overall direction of the slope before concluding what the uphill / downhill bearing should be.

Tip 3: Take Contour Bearings

If you have a sense of where is uphill and where is downhill then you should also have a sense of what direction you can move without going either up or down. That is, what direction would you walk or ski in so that you would be going neither uphill nor downhill but instead would be traversing sideways across a slope? If you move along a bit, neither climbing nor descending, you will be able to set your compass on a bearing that represents this direction. Add the magnetic angle and then line up your compass on the map. Look for contours lines on the map that are parallel to your correctly aligned compass. Your position should be somewhere on the map where the contours go in the same direction as your correctly aligned compass.

Obviously these techniques don't work very well if you are in featureless dead flat terrain with zero visibility. In such situations your only options are either to stay put, or set a bearing in the direction of safety and to go for it.

Congratulations!

Well that's the end of the main content of this navigation tutorial. I hope you have found it useful. By far the best way to learn how to navigate is to get away from the computer and out into the bush and apply the skills that I have tried to pass on via this web page. To do this, why not join one of my 2 day navigation training weekends:

Joining a Navigation Weekend

Before you go, check out The Back Page! If there is one page of this document that you should print and take with you, it is this one!

The Back Page

Quick Tips

11. The Back Page – Quick Tips

Before you go, here is a list of general tips that pull together some of the skills of navigation. Enjoy the world's wild places, and don't forget to take your map and compass with you!

Your memory serves you well	Remember the country you have passed through. How many bumps along a ridge have there been? How many side gullies have you seen entering the creek you have been walking down? How many bends in the road?
Uphill is easier than downhill	Navigating up a hill is easy because you are converging to the same point regardless of what direction you are coming from. Contrast that with walking downhill, where you start at one point and could end up at a different place if you go in a different direction.
Downstream is easier than upstream	Same as for uphill versus downhill. Walking downstream is easy because tributaries are converging into a common course. Walking upstream leaves you having to make choices each time a creek forks.
Scientific method rules!	Use deductive reasoning when trying to work out where you are. Ask logical questions. If we are here on the map then there would have to be high ground to our left etc. Eliminate possibilities by finding a contradiction: we can't be here because there is no spur in front of us!
Let the land do the navigating	Choose routes for your trip that take advantage of the lie of the land. Follow ridges, spurs and creeks. Avoid sidling. Traversing hillsides should be minimized. Don't take short cuts, these usually end up long cuts.
Divide and Conquer	Divide your route into smaller straight line sections for increased accuracy. Several short bearings (eg: 300-500m each) are better than a few long bearings.
How far is far enough?	Knowing how long to follow a bearing before changing to a new bearing is made much easier by using the features around you. Choose bearings that start and end at a recognisable feature such as the top of a hill, bottom of a saddle, bend in the ridge or change in the steepness of a slope.
Read between the lines	Mine the map for information. The contours tell a rich story. Even the slightest change in a contour tells you something. Scrutinize the map in fine detail. The longer you study the map, the more you learn.
Enjoy your walk	Don't walk off a cliff just because the compass says so! The compass is your guide not your gospel. Glance at your compass frequently to check your bearings but be flexible in route finding. Avoid scrub and other obstacles but don't digress from your bearing for long.
The map is innocent until proven guilty	"The map must be wrong" is the cry of the lost walker. The map is always right unless you can prove otherwise. Some topographic maps have inaccuracies, particularly of human geography such as forest roads which are subject to change since map publication. However if some natural feature is amiss on a large scale, then it is 99% likely that it is you that is wrong. Check, recheck and check again.
Keep at arms length	The neck cord of your compass should be long enough so that you can hold the compass in your hand with your arm straightened in front of you without taking our compass off from around your neck. Always wear your compass around your neck when walking and don't store it loose in your pocket or pack. If you lose your compass then you will likely lose yourself soon afterwards!
The unit of distance is time	When planning your trip or when trying to predict how far it is to a particular point, think not in distance but time. Distances can often be a less useful measure for gauging the length and difficulty of a trip than time. Terrain can vary greatly, as can impediments such as scrub, creek crossings, difficult climbs, steep slopes, fitness and size of the group etc. So for example, when planning the next stage of your trip, don't think in terms of

	how many kilometres it is to the next camp site, but how many hours it is. If someone asks you "how far?" answer in hours.
Add or subtract?	As described in these notes, you always need to take account of the difference between grid north and magnetic north when converting from a compass bearing to a map bearing and vice versa. The rule is "Grid to magnetic subtract, magnetic to grid add". A good way to remember it is that when taking your compass away from the map, subtract, when placing the compass on the map, add. Note: Some compasses eliminate the need to add or subtract the grid to magnetic variation by means of a declination scale on the inside of the dial. When set correctly, there is no need to add or subtract the grid to magnetic angle manually. But you must make sure that the declination scale is set correctly in the first place! Don't rely on it always being set right! Check it carefully before relying on it rather than adding or subtracting manually.

12. Compasses With a Declination Adjustment

Some compasses, such as the Suunto M-3, have a separate declination scale on the inside of the compass dial that can be set to compensate for the difference between grid north and magnetic north. Using a little screw on the back of the compass you can set this to the grid to magnetic angle. For example, in NSW Australia you would set this to 12 degrees east of North. Then, you don't need to worry about adding or subtracting the grid to magnetic angle each time you set your compass. This is already done for you. Everything else is unchanged, it's just that Step 3 in Section 8.3 and Step 3 in Section 9.3 can be omitted.

A WORD OF CAUTION

Relying on the declination scale on your compass rather than adding and subtracting manually means the declination scale must be set correctly first, otherwise you will be out by 12 degrees or even 24 degrees! Be very careful before relying on the compass declination scale. I always prefer to add and subtract the magnetic angle manually. That way I am sure that it gets done and I am not relying on "set and forget" mentality to do the work for you. When set correctly it works. But when set incorrectly or not at all, you could have problems if you ignore the grid to magnetic conversion.

Thank You

Ok, that's all you're going to learn sitting in front of a computer. If you want to learn more come on a MountainSphere navigation training weekend.

Joining a Navigation Weekend

The End

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ADVENTURES AND EDUCATION