Land Navigation III
Wayfinding, Telling North

Unit 11, Land Navigation III. Wayfinding, Telling North
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"The prudent mariner will not rely solely on any single aid to navigation"

Good advice found on nautical charts:

"The prudent mariner will not rely solely on any single aid to navigation."

Learn to use multiple tools for navigation at the same time.

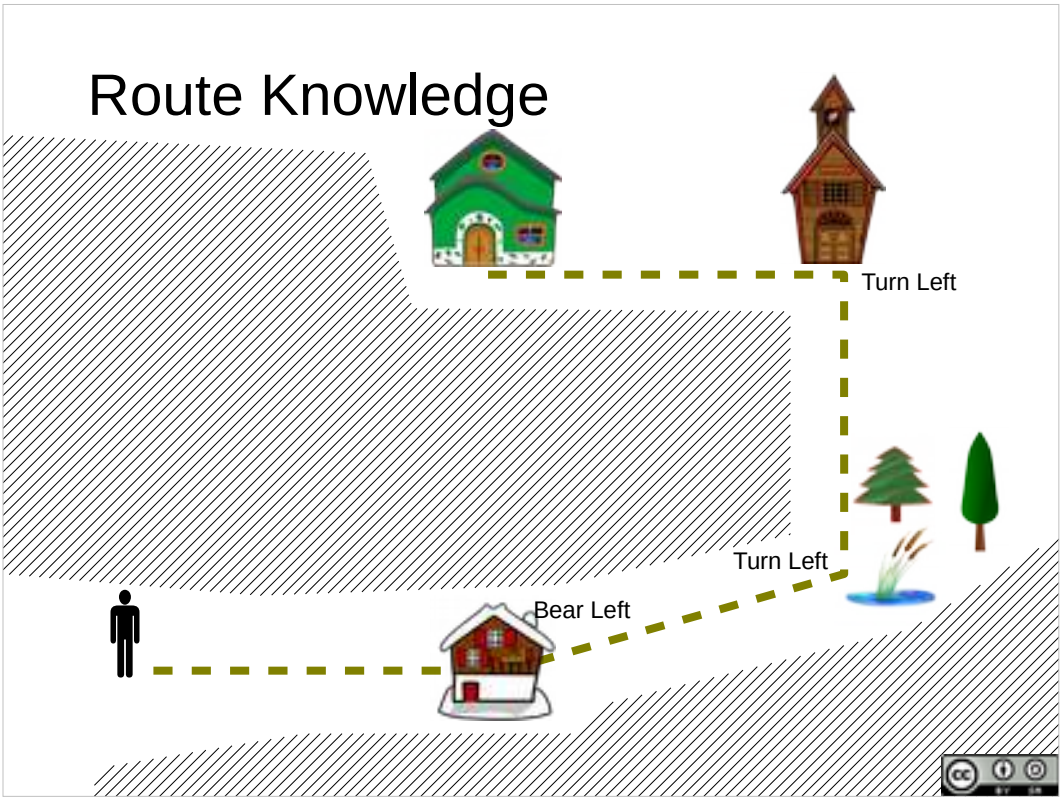
Sorts of navigational Knowledge

- Landmarks
- Route Knowledge
- Survey Knowledge

Classically, navigational knowledge has been seen as a sequence from identifying landmarks, to connecting landmarks together into knowledge of routes, to broader spatial knowledge of how to navigate cross-country on arbitrary routes.

More recent work suggests that this isn't a simple hierarchy of improving skill, but are interrelated skill sets that are used for different purposes.

Navigational knowledge uses a **mental map** – this mental map is fluid and continually being updated as you observe the environment you are moving through. These updates may make the mental map a more accurate, or less accurate representation of the world.

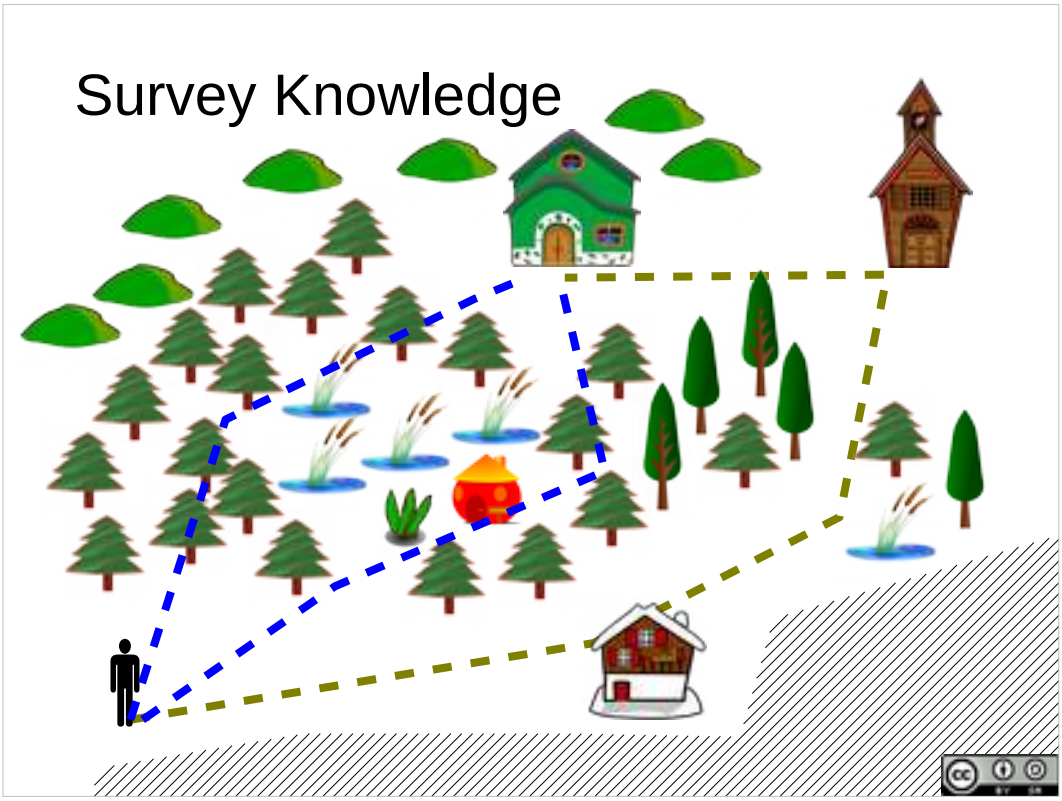


Route knowledge – mental map is of connections between landmarks - travel a route from one landmark to the next to the next.

With route knowledge, there is no clear mental map of the spaces between the routes. Weak perception of distances between landmarks. Weak perception of changes in direction.

Repeated traveling of the route improves the mental map.

What might the expected consequences be of taking a shortcut with just Route Knowledge?



Survey knowledge fills in the map between the landmarks. Survey knowledge lets you plan new routes in your mental map.

Knowledge of where features are with respect to one another allow you to use dead reckoning to navigate – travel in a direction for some distance and turn to another direction for another distance.

The mental map has landmarks, direction (either with respect to home or to north), and probably distances perceived as travel time.

Repeated traveling in the area improves the mental map. It still can be a poor representation of reality.

Wayfinding

- **Maintain orientation**
- **Plan a Route – pick a course towards your destination**
- **Route Monitoring – keep evaluating that you are on course**
- **Recognize your destination, or that you've gone past it.**

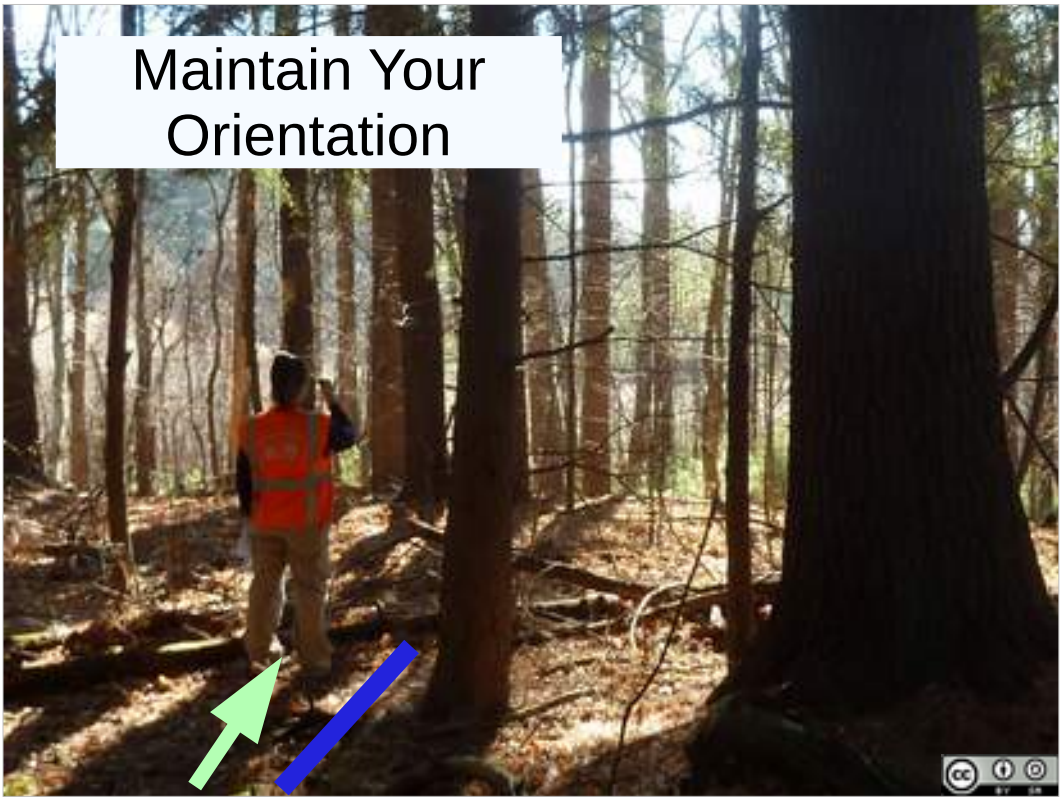
Wayfinding involves four skills:

Maintaining your orientation.

Planning your route.

Monitoring that you are on your planned route.

And recognizing when you are at (or past) your destination.



Traveling short distances (e.g. on grid lines), you can continually check that you aren't going off course by keeping the sun/shadows/the moon/a bright star in the same place.

Here the searcher is navigating on a grid line almost into the sun, and should be crossing shadows at about the same angle over that one grid line.

When coming back on the next leg on the back bearing, the searcher should have the sun over their left shoulder and should again be traveling almost parallel to the shadows.

Not accurate, but a good constant sanity check.

Sun/stars/moon move a handspan in the sky in an hour (360/24 = 15 degrees/hour).

Maintain Orientation?

Practical Evolution

Take the class outside.

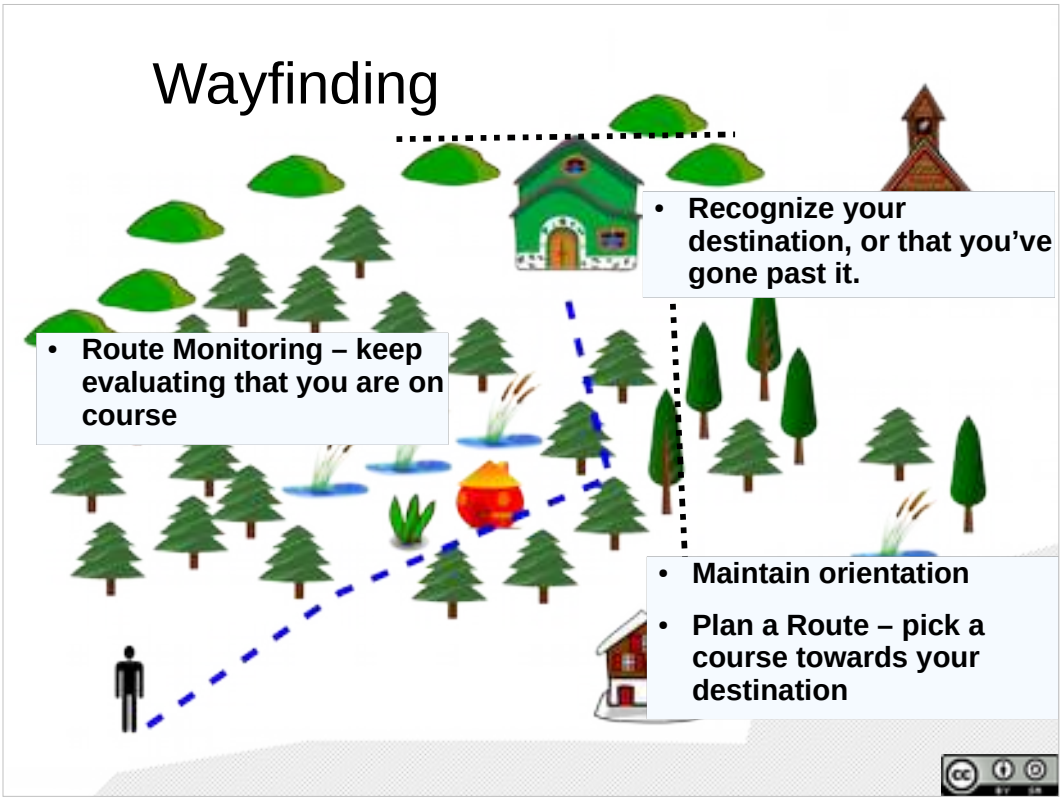
What means do you have to maintain your orientation?

Discuss.

Walk towards a landmark.

Keep environment (sun/shadow/moon/planets/clouds/ wind/waves) in same position as you move.

Use a compass



Survey Knowledge lets you plan your route (go northeast into the pine woods, turn north after the swamp to the green house), monitor it to know that you are on course (pass the orange house in the woods), and recongnize if you've gone past your destination (or a turn – turn north before getting into the deciduous woods, if you get into the hills, you've gone too far north).

Survey knowledge helps you maintain orientation, but also requires that you maintain orientation – start traveling north instead of north east, and the swamp will be on your right instead of your left.

Wayfinding Errors

- Mental maps are fluid.
- Confirmation Bias
  - You tend to only notice things that confirm what you already believe.
  - You tend to ignore things that don't fit in with your belief about where you are.
- Bending The Map
  - You tend to warp the map in your mind to make it fit with what you see around you.

Treat your location as a hypothesis, continually test it.

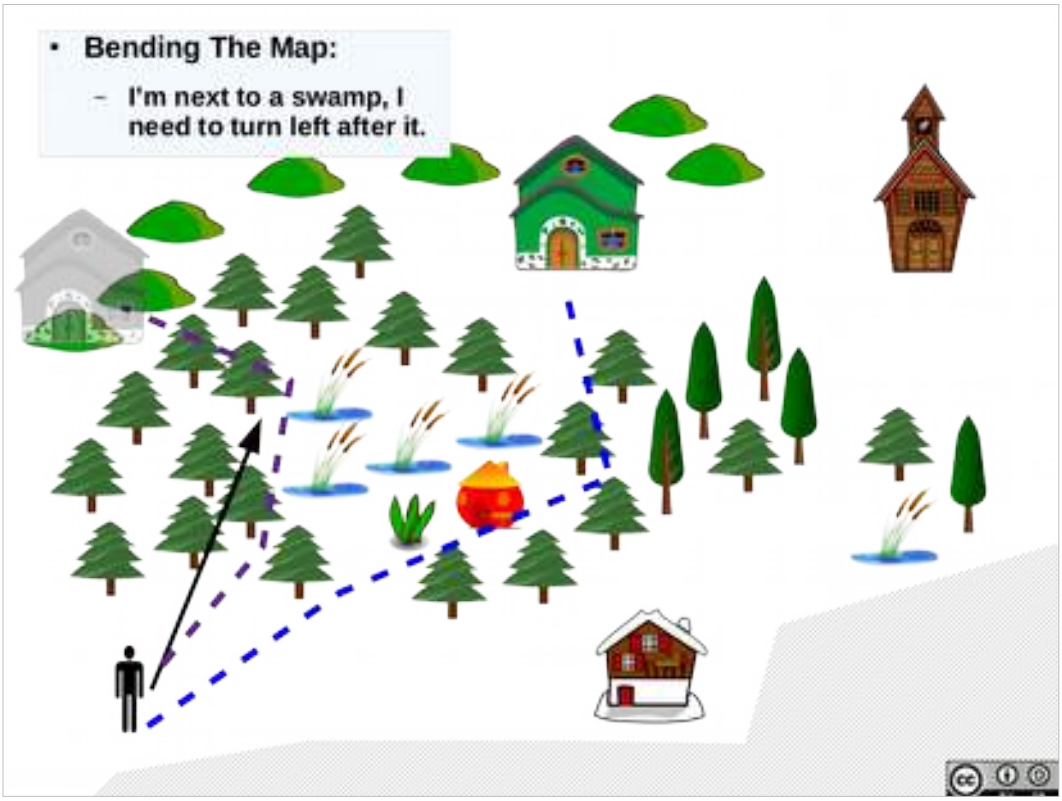
There are several kinds of mental illusions that our minds follow when we are trying to find our way.

Most importantly: Our mental maps are fluid, our observations of the environment continually change them. Weak mental maps are easily bent.

One illusion is confirmation bias – we tend only to notice things that fit with our pre-concieved idea of what reality should be, and tend to ignore things (like that mountain over there) that don't fit our beliefs.

Another illusion is bending the map – instead of shifting our belief of where we are on the map, we tend to warp the map to fit the things we see around us: a downhill slope gets misinterpreted as uphill, the distance to a faraway hill on the map gets warped into a short distance because there's a hill right next to us...

Avoid these traps by continually testing what you see around you against a physical map.

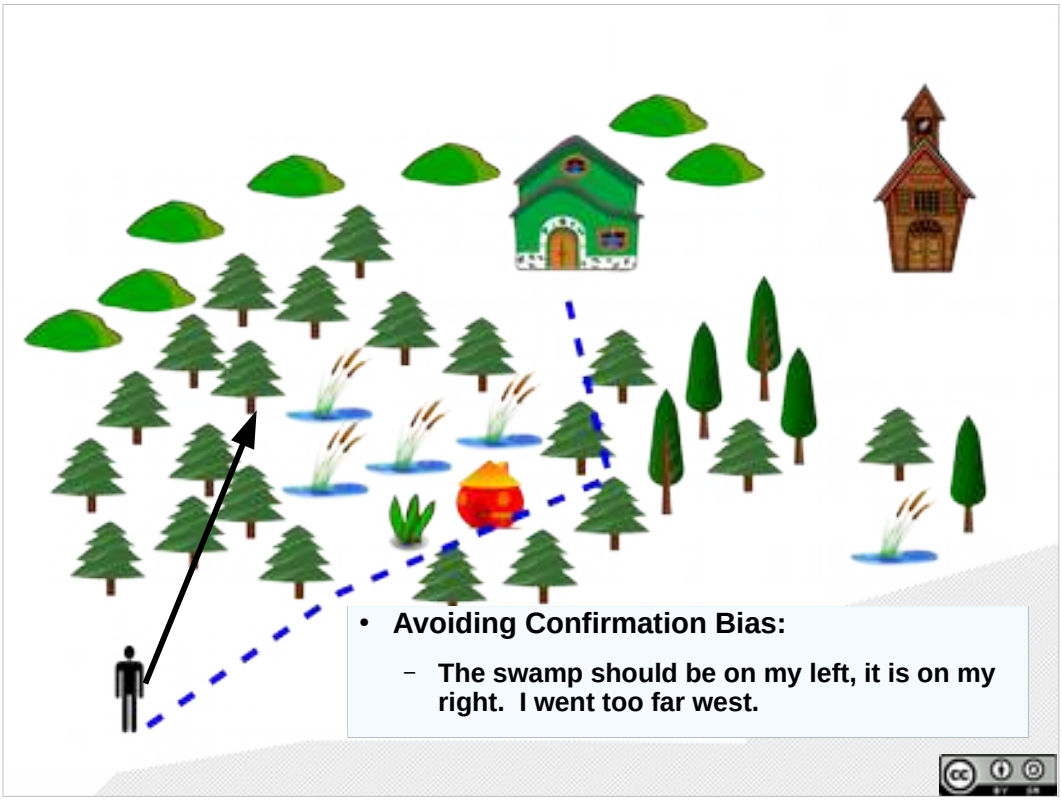


Avoid Bending the map – it is all too easy to shift your mental map around to fit where you think you are.

You pass the swamp on the right, and instead of thinking that you are on the wrong side of the swamp, you bend your mental map to put the swamp on the other side of your planned routed.

Thus, you come to the end of the swamp and turn left, having bent the map to put your destination off to the left, and you wander off....

There might be the nagging feeling that you should have passed the orange hut...



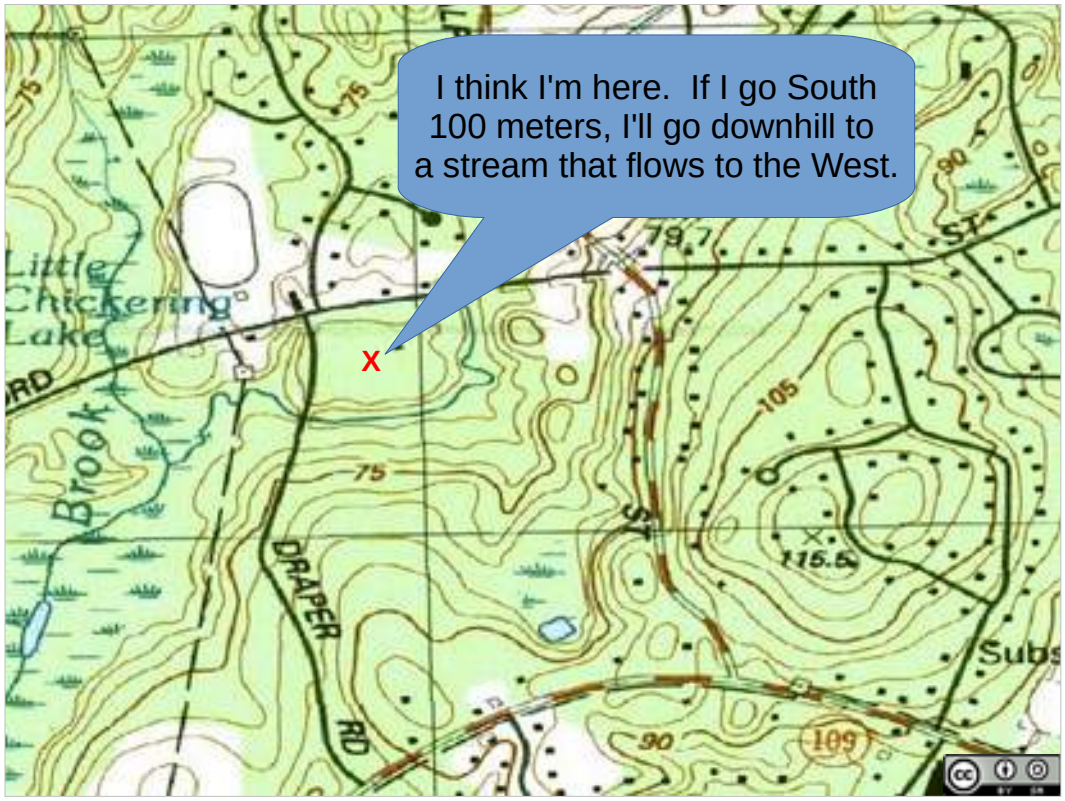
Avoid Confirmation Bias: Look for things that Don't fit, not things that do fit.

Not: There's a swamp, I'm supposed to pass a swamp, but:

The swamp isn't supposed to be on my right, I'm either on the wrong side of it, or it is some other swamp....

Where's the orange hut?

If I go right along the south edge of the swamp for a few minutes, I should come to the orange hut.



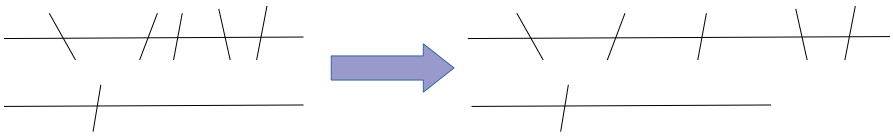
Treat your location as a hypothesis: ask what does the map say should happen if you move in some direction.

If you move in that direction and you don't find what the map says you should find when you should find it, then either – you weren't where you thought you were, or you aren't traveling in the direction you thought you were traveling in, or both.

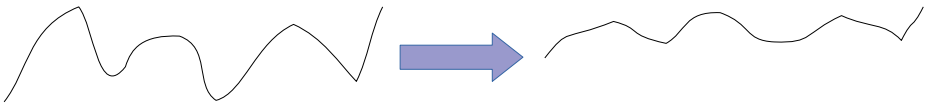
Use as many tools as you can to continually test your belief of what your location is.

Some Spatial Mental Illusions

- More intersections (falsely) remembered as a longer path.



- Winding routes (falsely) remembered as straighter.



There are several sorts of common missperceptions that result from how our brain treats spatial information.

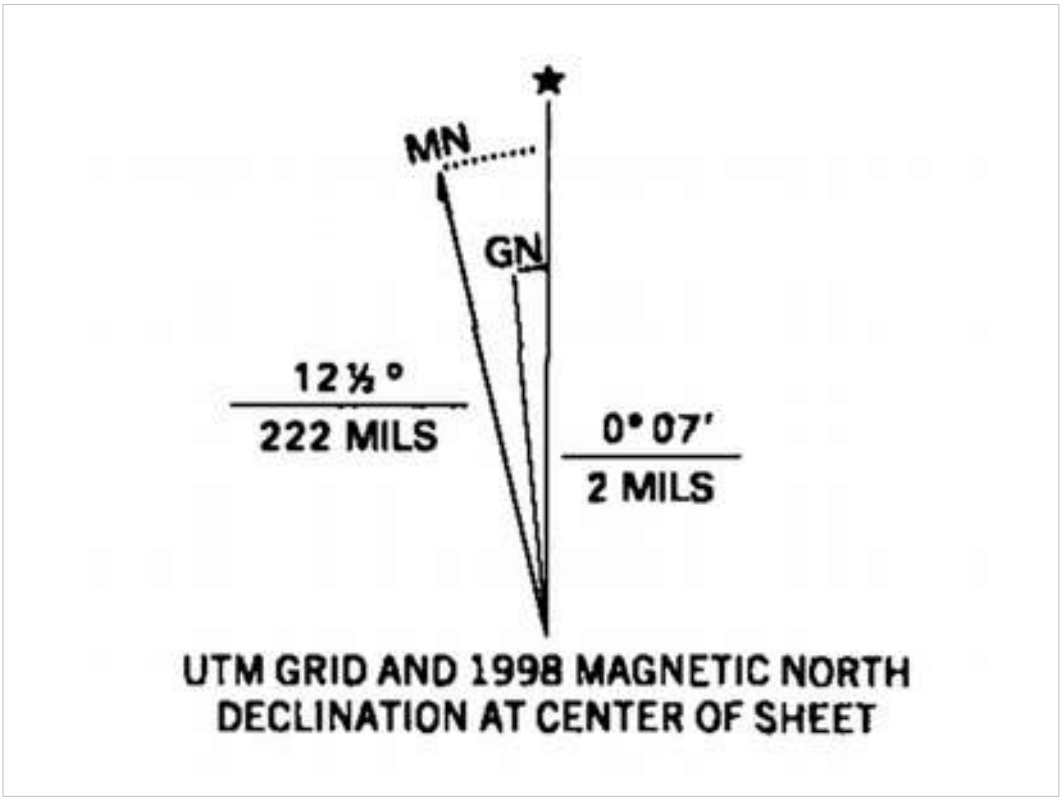
We tend to think of routes that have more points (landmarks, intersections, etc) on them as longer than routes of the same length with fewer points. (The simple seems shorter).

We tend to forget that twisting, turning, windy paths wind and tend to straighten them out in our mind. (What is a potential consequence of this? [e.g. you maintain orientation and don't understand why the path west is taking you north])

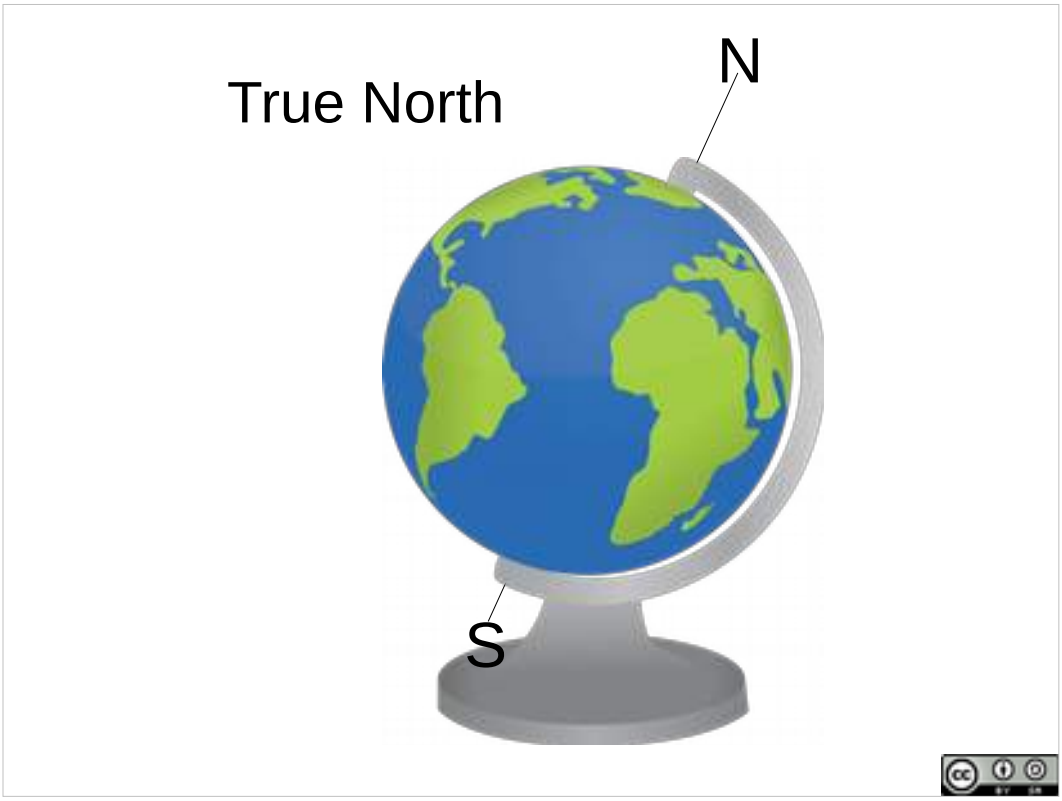
Where does the compass needle point?

North.

Which North?

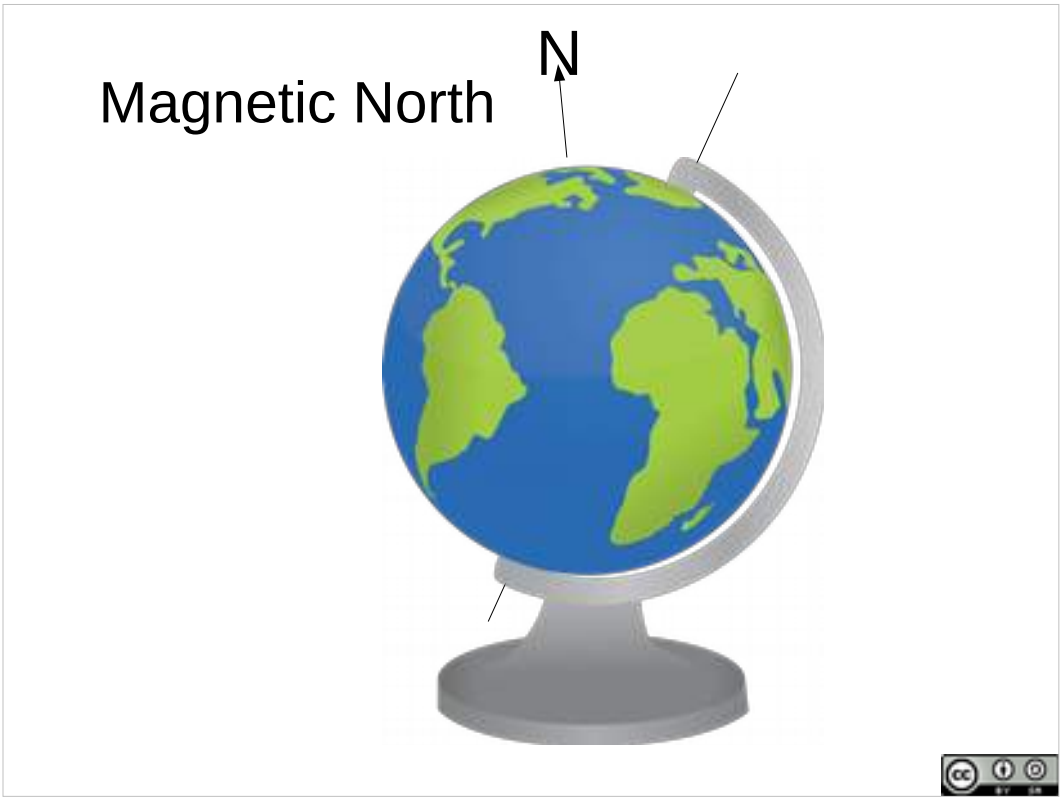


There's true north, magnetic north, and grid north.



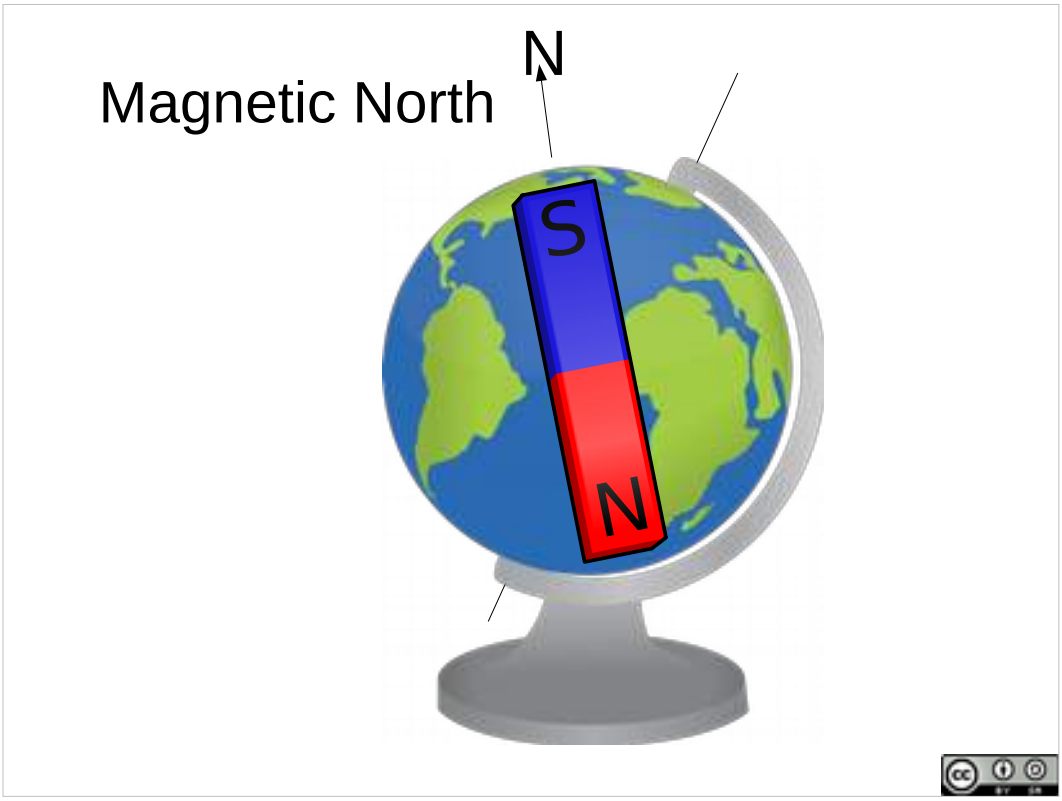
The Earth rotates around its axis.

That’s true north.



The north magnetic pole isn't in the same place as the north pole (right now) – it is somewhere off the north edge of Canada (and it is headed towards Russia).

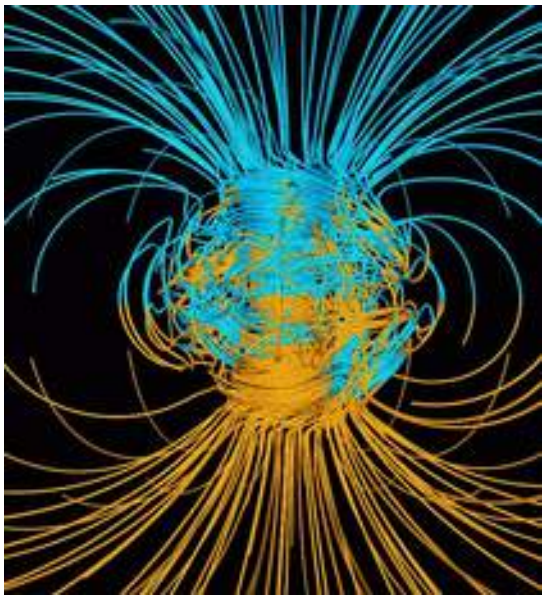
The South magnetic pole, likewise, isn't in the center of Antarctica, it is (currently) just off the coast of Antarctica, between Antarctica and Australia.



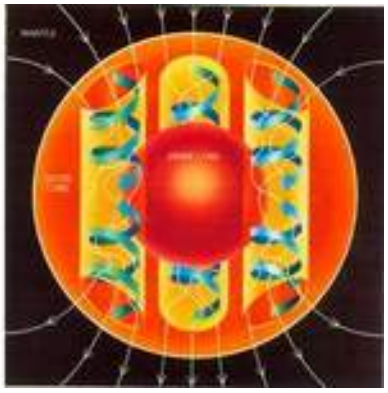
We can simplistically think of the Earth as a giant bar magnet, with the poles of the magnet not quite lining up with the axis of rotation of the earth.

(And yes, opposites attract, if it were a bar magnet, the south end would be at the north pole attracting the north ends of magnets in compasses – we call the north end of a magnet the end that points towards the Earth's north pole).

Not quite that simple...



Geodynamo magnetic field line model: NASA

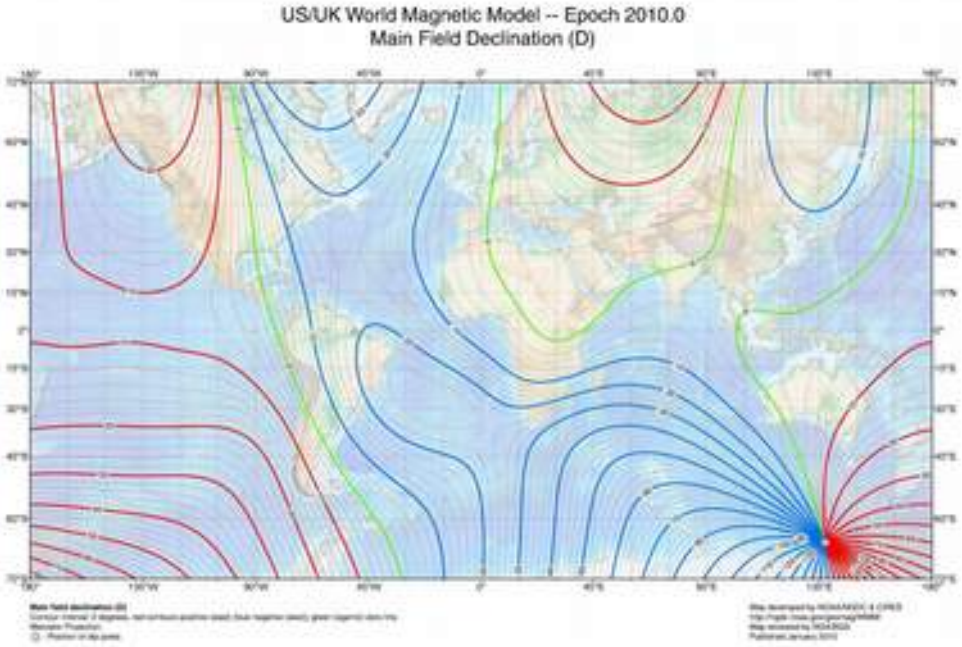


Flow rolls in the outer core: USGS

But, it isn't that simple: The Earth's outer core is iron rich fluid, it conducts electricity, it flows, moving electrical current produces a magnetic field. Heat from the inner core causes the fluid inner core to rise, the coriolis force causes the flow to be organized into N-S organized flow rolls: This forms a geodynamo, in essence a gigantic messy electromagnet. The resulting magnetic field is messy.

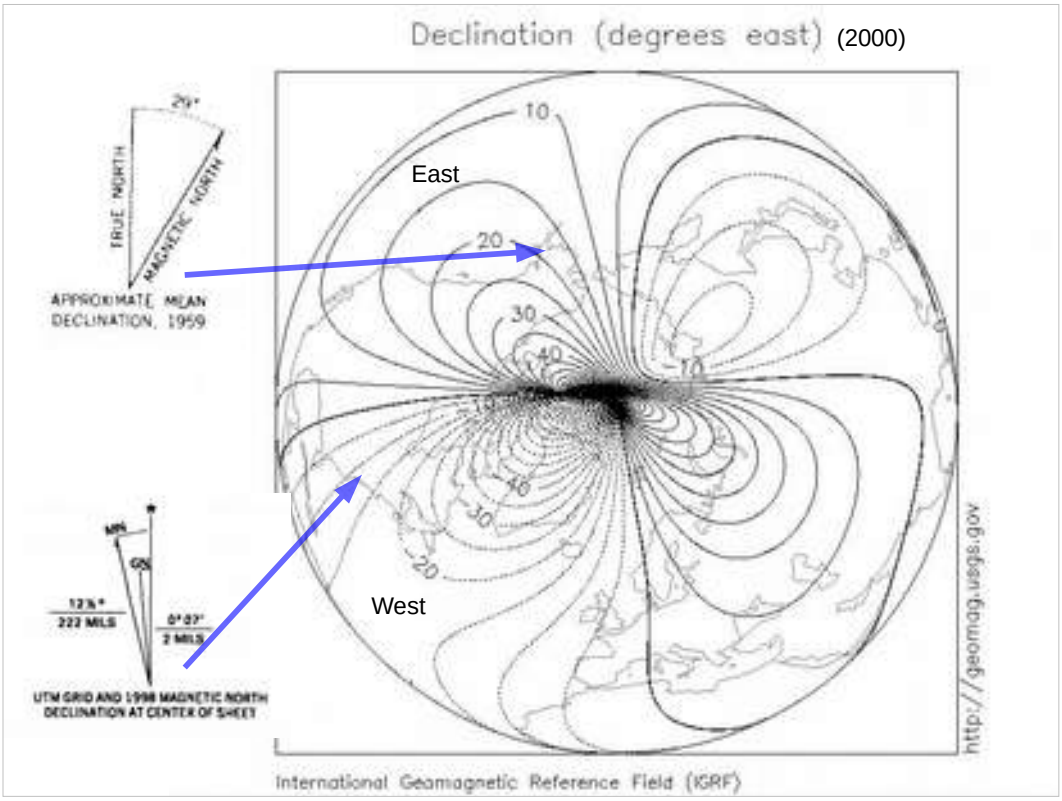
Also note – near the poles, the magnetic field lines point up and down, near the equator they are paralell to the Earth's surface – this is why you want a global compass, in the northern hemisphere the north end of the compass needle is pulled down, in the southern hemisphere it is pulled up, a compass not designed for it can get the needle stuck when held flat in the wrong hemisphere...

The Earth's magnetic field is messy



The key point: things are messier than just a bar magnet, the core of the Earth is like a giant fluid electromagnet, it produces a **messy** magnetic field.

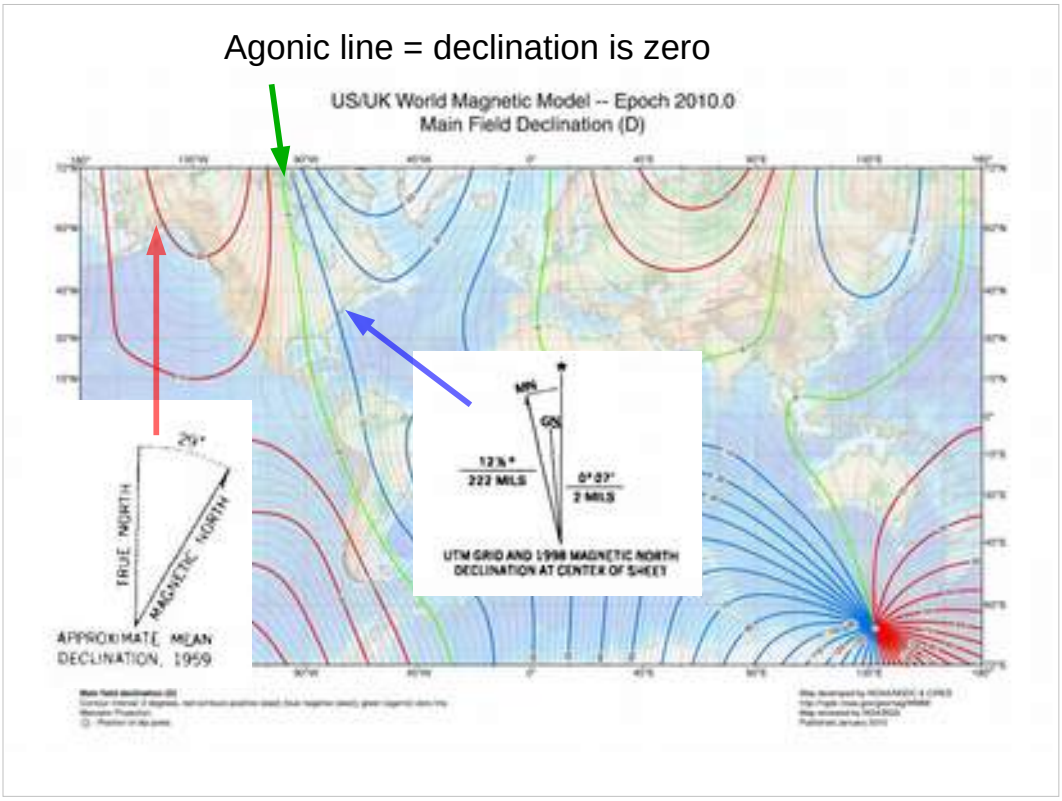
Your compass needle doesn't point straight at the North magnetic pole – it points towards North in your local bit of the Earth's (messy) magnetic field.



The difference between where the compass needle points north in the Earth's magnetic field (magnetic north), and the Earth's axis of rotation (true north) is known as declination.

When local magnetic North is East of true North, we say we have an East declination.

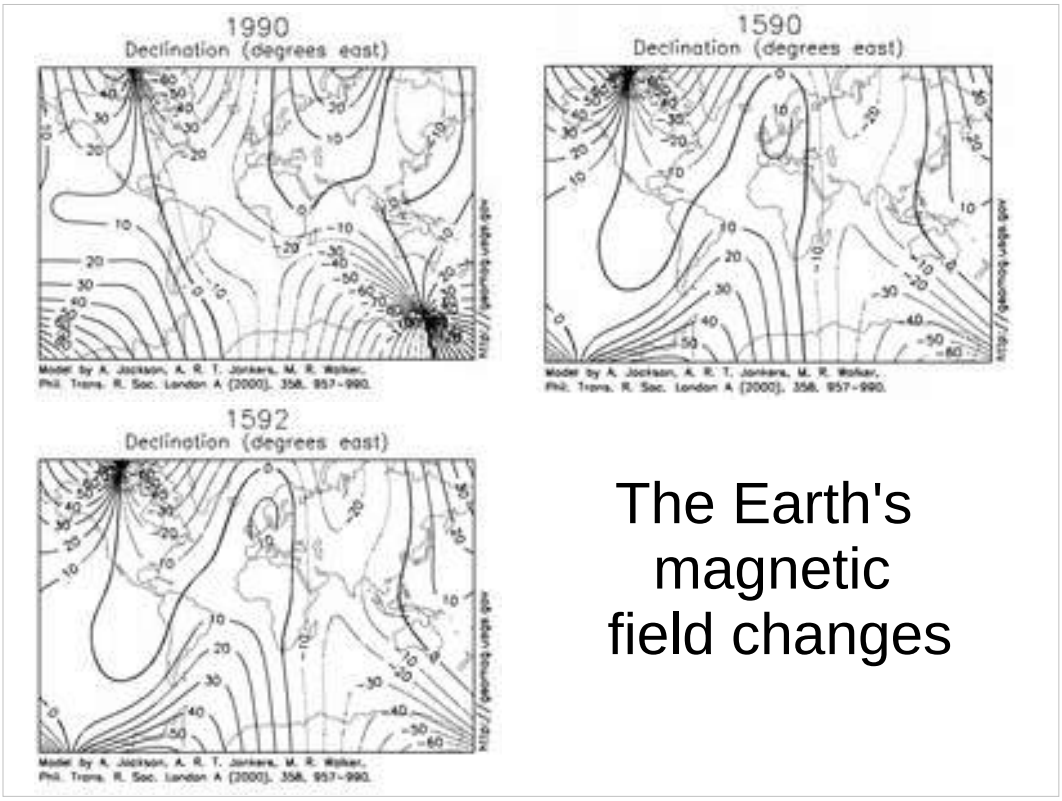
When magnetic North is West of true North, we say we have a West Declination.



Roughly, East of the Mississippi (in the US) magnetic North is West of True North.

Roughly, along the Mississippi, magnetic north and true north are the same. This line where the declination is zero is called the Agonic line (without angle, (goniometer, tool for measuring angles)).

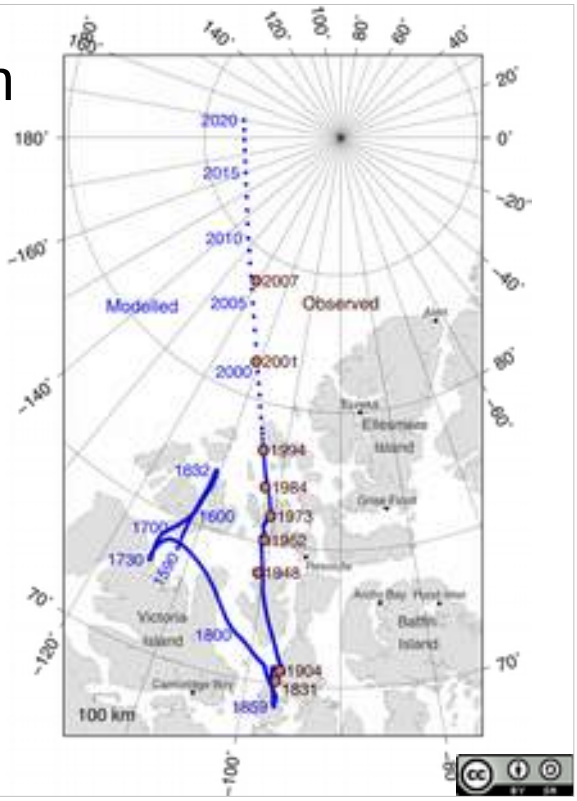
Other side of the Mississippi, magnetic North is East of True North.



And, the earth's magnetic field changes over time...

(Upper right is an animation of the shifting declination from 1592 to 1990. Left is declination map in 1592 and in 1990.)

Changing position of the North Magnetic Pole



And as part of those changes, the north and south magnetic poles move.

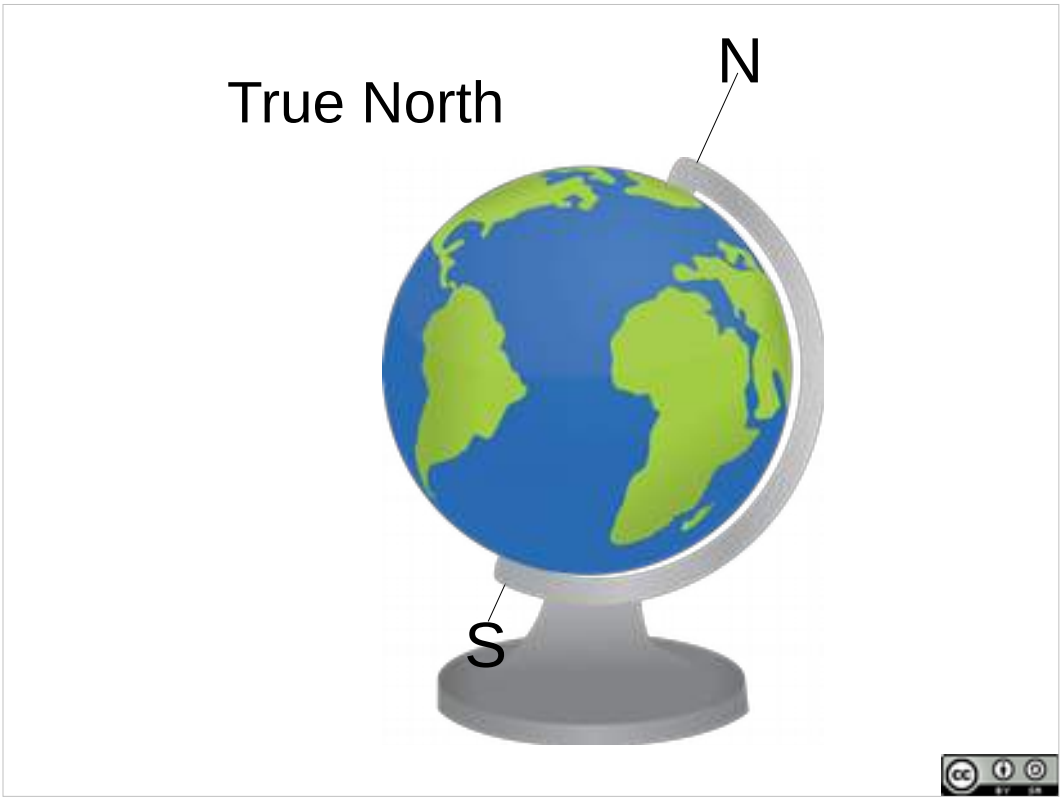
In the 1980s, the Earth's magnetic pole was in Northern Canada.

Now, it is in the Arctic ocean, about 4 degrees away from the North pole, headed towards Russia.

How can you tell North at night?

Northern hemisphere – Polaris, the north star.

Two stars on the end of the cup of the big dipper are the pointers, point to the end of the handle of the little dipper, that star is Polaris and almost at the North pole.



The Earth rotates around its axis.

Polaris, the North Star, happens to line up with the axis of rotation – look straight up at the North pole and you'll be looking at Polaris.

Over the course of the night, Polaris stays in the same place, all the rest of the stars rotate around it – stars/ sun/moon move a handspan in the sky in an hour (360/24 = 15 degrees/hour).

Polaris, sun, moon, others stars all tell you about true north – the rotation of the earth about its axis.

Telling North

- Sun
- Moon
- Stars

Everything else moves in the sky as the Earth rotates.

With some sense of time, we can tell direction from the things in the sky.

Simplest: The sun rises in the East and sets in the West.

More involved: analog watch: point the hour hand of your watch at the sun, half the distance between the hour hand and noon is a north south line.

Here 9:27 AM, sun to the east. Line half way between the hour hand and noon is N-S, knowing it is morning tells us which way is North.

Can you tell which way you are looking?

Where is the sun?

What time of day do you think this is?

Crescent Moon, just after sunset, southern hemisphere, thus looking west.

You would get this view just before dawn in Northern hemisphere, looking East.

Draw a line through the tips of the crescent moon – that's a north-south line (you then need to think about what hemisphere you are in to figure out which way is North)

Full moon is opposite the sun. Crescent moon is near the sun. Full moon rises near sunset. Full moon sets near dawn.

Moon and sun are at their highest elevation when in the South.

Avoiding Getting Lost

- Maintain a straight course, use environmental cues for direction
- Identify backstops (recognize when you've gone past your destination)
- Pay close attention to landmarks
  - Pay close attention to your surroundings (terrain, vegetation, smells, etc)
  - Remember the identity of locations you travel through (give places memorable identities).
  - Look behind you regularly (particularly at trail junctions).
- Track times and directions
- Structure your path

To avoid getting lost....

Direction.

Backstops.

Pay attention.

Direction, and travel time.

Structure your path.

Backstops

I'm traveling along the edge of the slope to Willis Road.

If I cross Willis Road (or it is overgrown or doesn't exist any more), if I hit the swamp, I'll know I've gone too far.

The swamp serves as a backstop.

What feature am I navigating along as a handrail?

The slope break serves as a handrail to keep me oriented in the right direction.

What other environmental clues did we just look at for maintaining orientation?

Avoiding Getting Lost

- Identify backstops (recognize when you've gone past your destination)
- Maintain a straight course, use environmental cues for direction
- Pay close attention to landmarks
  - Pay close attention to your surroundings (terrain, vegetation, smells, etc)
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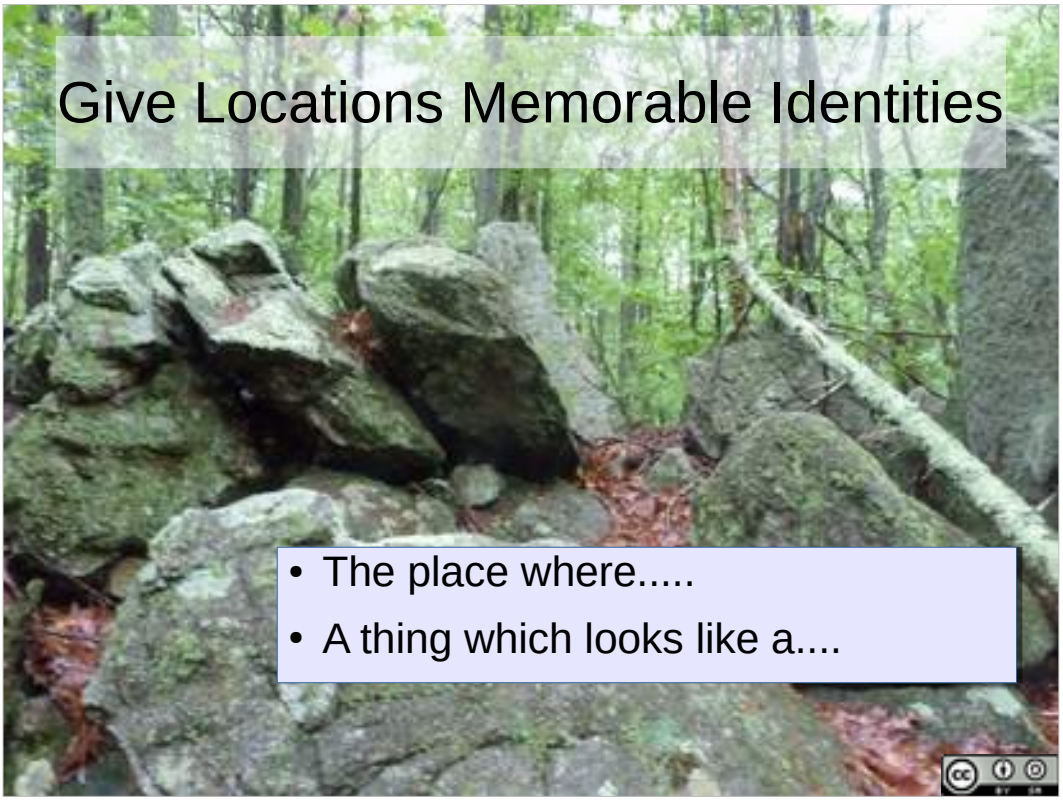
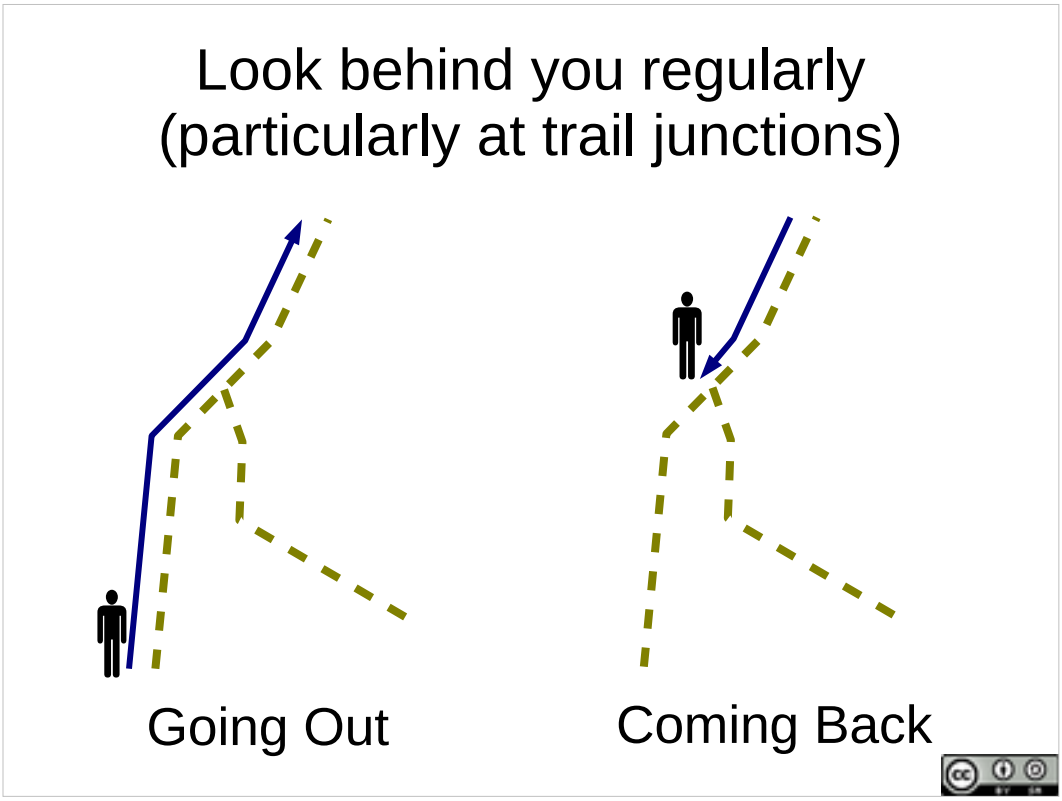
Pay attention.

Give places memorable identities.



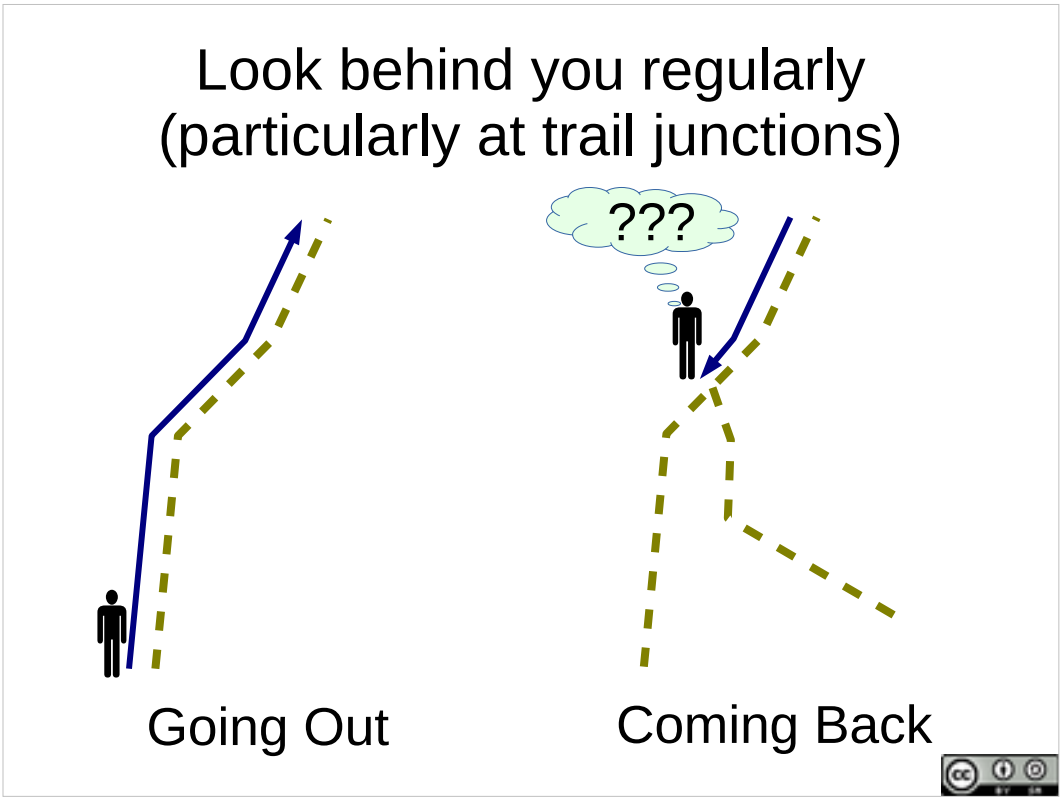
This is the place where....

You will remember landmarks better if you give them identities, particularly if you give them emotional meaning.



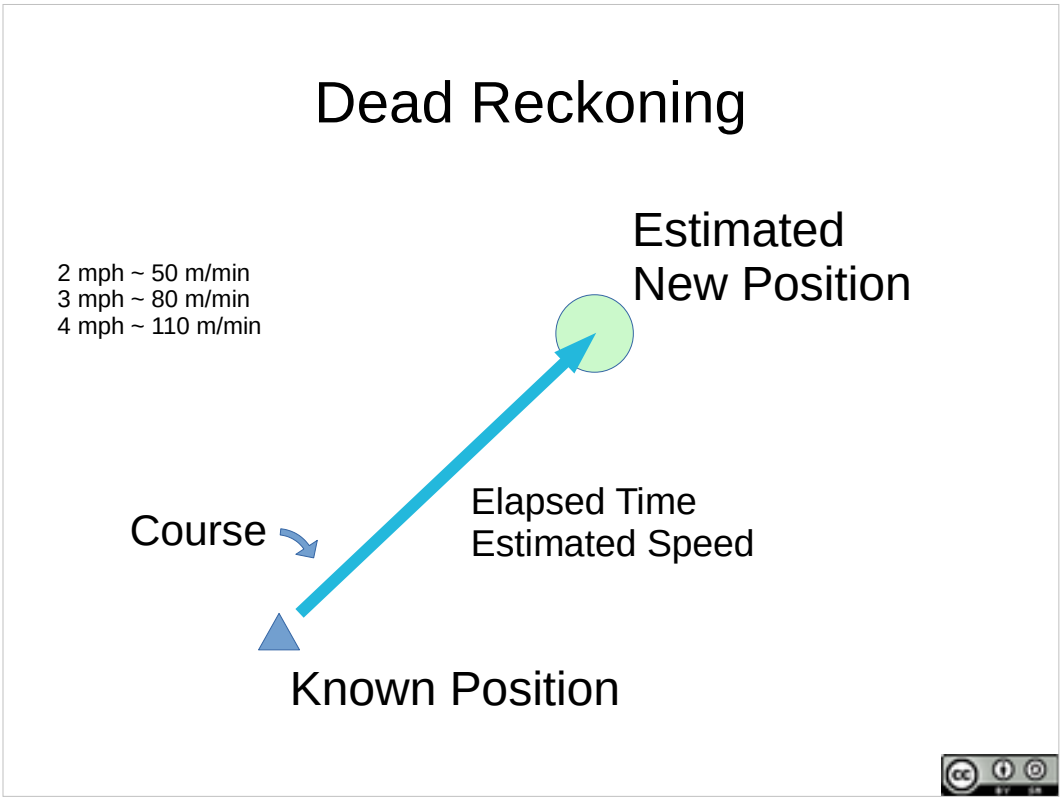
How often have you done this?

Gone one way on a trail, then returned, and come to a trail junction where you don't remember which way to turn...



or even that there was a trail junction there at all...

When you come to a trail junction, turn around an look at it as you will when returning, and make the trail you came from memorable.



Dead Reckoning: Traveling from a known position along some bearing at some speed for some time.

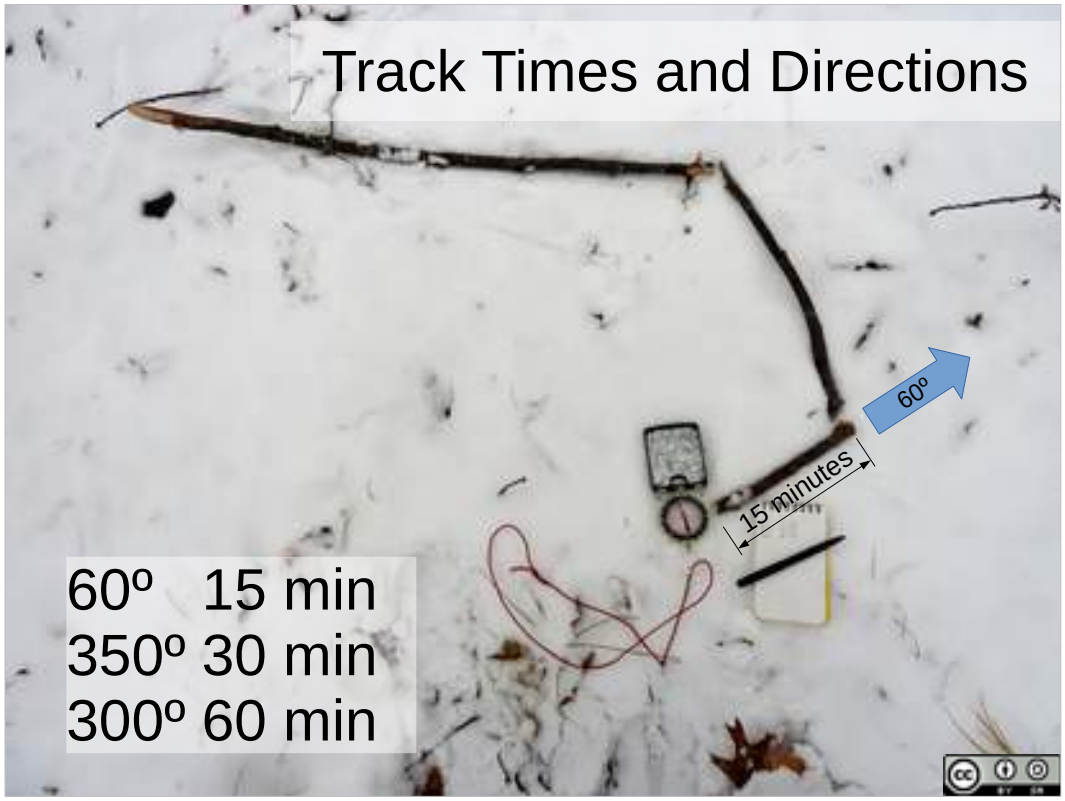
Estimating a new position as an offset (with some error) from the known position based on the travel time and speed on the course.

Good numbers for thinking about distance and time:

2 mph is about 50 meters per minute.

3 mph is about 80 meters per minute.

4 mph is about 110 meters per minute.

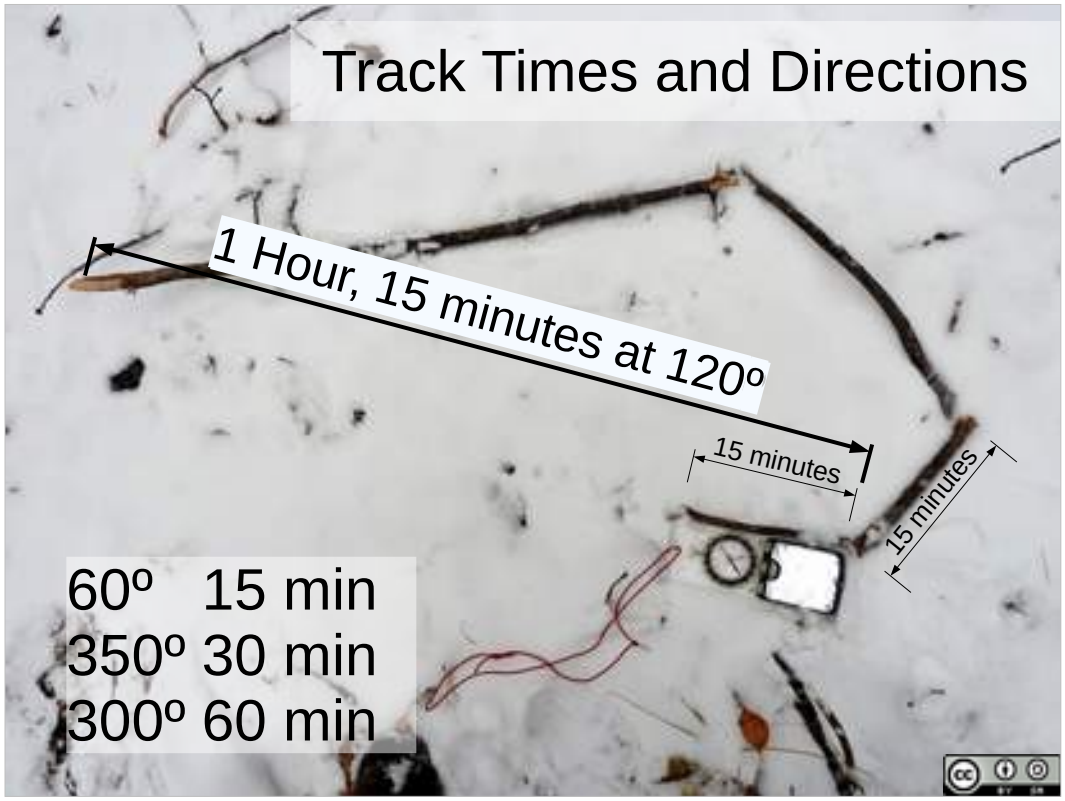


Using Dead Reckoning (or path integration).

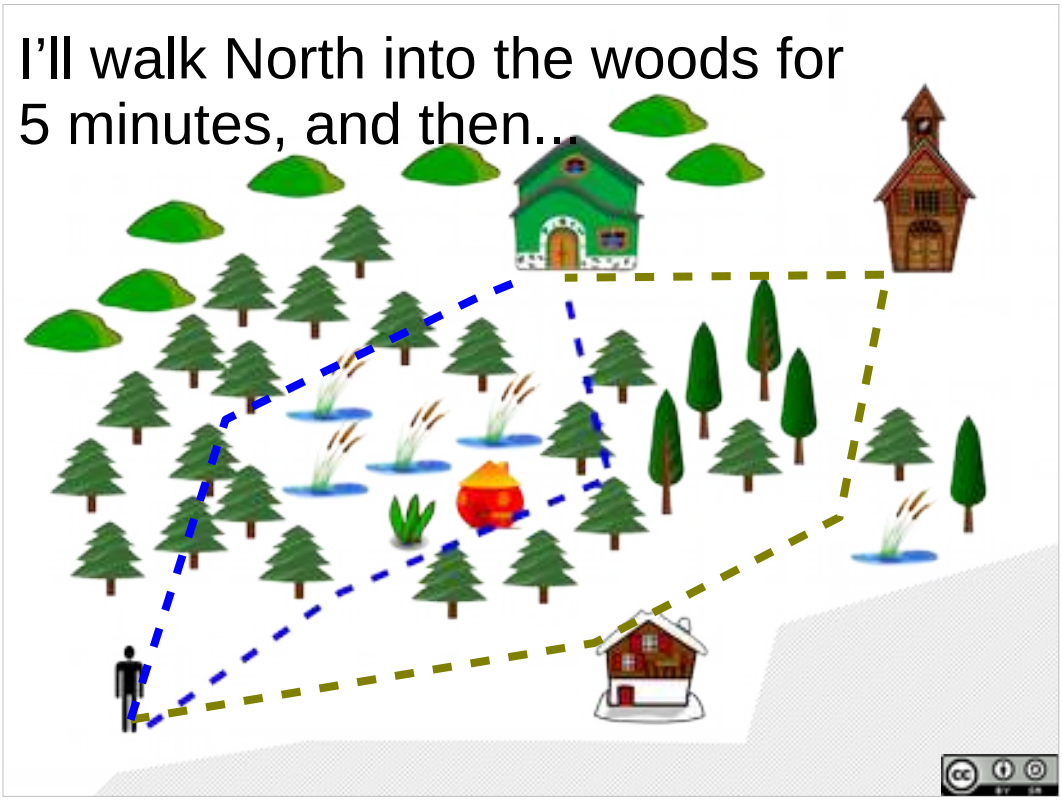
Break sticks into lengths representing travel time on bearings.

Place sticks from the starting point along the bearings that you traveled.

Record approximate direction of travel and travel time, then you can create a dead reckoning map of how you got from where you started to where you are.



Then you can estimate your bearing and travel time back to your starting point.



You can use time as a proxy for distance to plan your route.

How do I get from where I am to the green house?

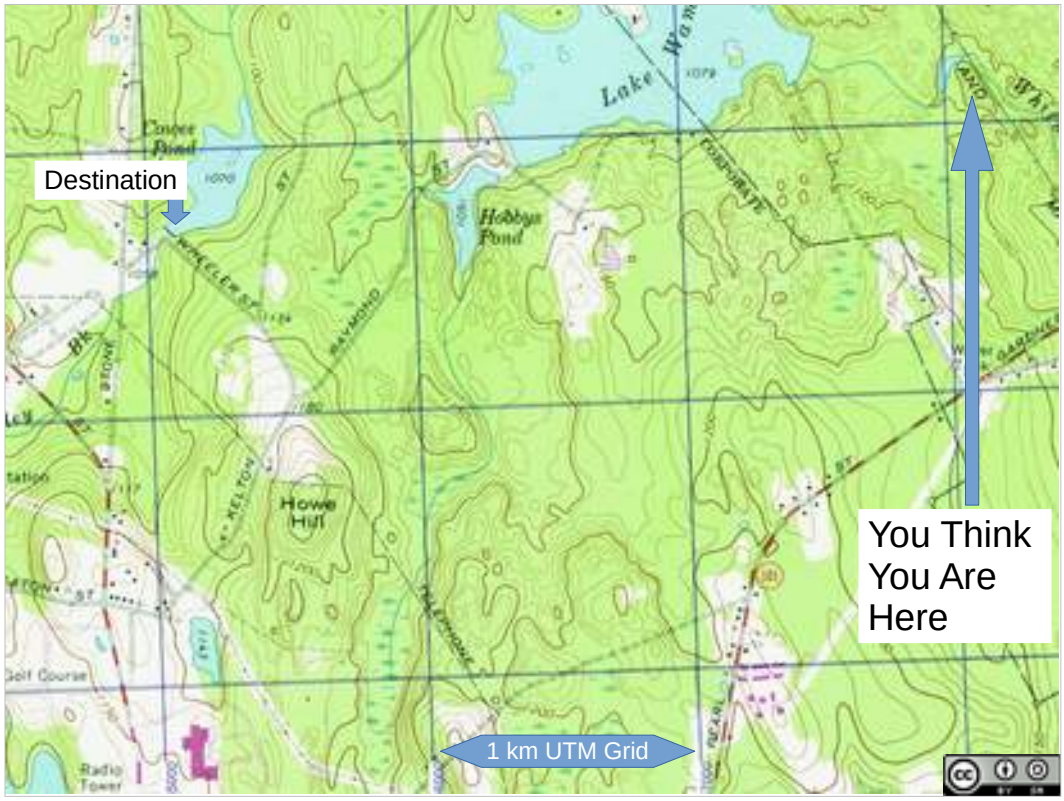
Plan out your route – structure it, identify things you can monitor along the way, estimate distances (travel times). Give the landmarks names (and emotional meanings).

Identify backstops – how do you know if you have gone too far along some leg of the route.

Structure your Path
Connect places with memorable identities

- **Plan a Route – plan your path – give yourself a structure to follow.**
- **Route Monitoring – keep evaluating that you are on your path.**
- **Recognize your destination, or that you've gone past it.**

Structure your path – connect places (landmarks) with memorable identities (and backstops) into a path with approximate distances/times of travel.



Construct a memorable path from where you think you are to your destination.

Discuss.

Have students identify landmarks and give them memorable identities.

Identify backstops.

Identify places where the route may be miss-remembered.

Identify decision points.

Have students estimate travel times along the path.