#### **Geographic Information for Vector Surveillance**

ographic Information Vector Surveillance

Week 1 Day 3

Generating spatial data

Learning objectives

- understand what is meant by GPS
- able to collect GPS points and paths using GPSEssentials
- able to produce a map of collected points and paths using QGIS
- able to create shapefiles using QGIS

Length : 1 day Updated : September 2018 Creative Commons Attribution license

## 3.1. What is GPS

During day 1, you were informed that GPS (global positioning system) is a satellite-based based navigation system that enables us to allocate coordinates to a location on the Earth's surface. The GPS system we currently use to establish our location is owned by the United States and consists of 30-35 active satellites orbiting the earth (see Figure 3.1), such that at any location on the globe you are able to have a direct line of sight to at least four satellites. Each of these satellites carry an atomic clock and are continuously transmitting their current time and position. These transmissions are received by a GPS receiver on the earth's surface. The receiver needs to receive a transmission from at least three to enable it to calculate its longitude and latitude. If four or more transmissions are received, it is also possible for the receiver to calculate its altitude. Note that as GPS is dependent on receiving signals from satellites, the receiver must be placed outside with an unobstructed view of the sky in order to operate properly.



Figure 3.1: (left) A diagram of the satellite-based GPS system, (right) examples of devices that can receive transmissions for the GPS satellites.

The GPS that we use today was initially launched by the United States in 1973 and has been fully operational since 1995. It was initially restricted to military use but became available to civilians in 1996, meaning that anyone with a GPS receiver can record locations with an accuracy of approximately 3-4 metres. The accuracy of the receiver can however be affected by a number of external features. Firstly, as mentioned the receiver needs to be placed outdoors with a clear view of the sky. Any surrounding obstructions including tall buildings and trees will affect the accuracy of the coordinates. Further, placing the receiver in a bag, pocket or case may affect its ability to receive a signal.

GPS receivers can be found in many devices. Until relatively recently, researchers were restricted to using dedicated GPS devices (see the yellow device in Figure 3.1) to collect coordinates. These devices can be very expensive, and further cannot be easily used to collect other information associated with the location. However, the vast majority of modern smartphones also now contain a GPS receiver and as such are being increasingly used to collect coordinate data (Figure 3.1). The benefit of using smartphones is that they can be much cheaper than a dedicated GPS device and they allow the user to record much more information associated with the location including questionnaire responses, survey data, photographs, bar codes and even sounds and videos. As a result, there are now many apps on the market that allow people with little technical experience to use their smartphones as GPS and data collection devices.

# 3.2. Introduction to the GPSEssentials app

During this course we will be using the GPS Essentials app to record location information. GPS Essentials is an app for Android phones that is freely available. Currently the app is only in English, but there is a Spanish user manual available. Whilst there are many more sophisticated apps available that enable you to record a lot more information in addition to GPS coordinates (e.g. Open Data Kit for Android phones), the GPS Essentials app allows the user to start collecting point and track data (plus additional labels and descriptions) straight away without requiring any account set up. Users are able to transfer the data they collect to their computer very easily via email. We will now use this app to collect coordinates in the surrounding area.

## 3.2.1. Installation of GPS Essentials on an Android phone or tablet

- → 1. Tap 'Play Store' icon
- → 2. Tap where it says 'Google Play' and type 'GPS Essentials'



- → 3. Tap the first result with an icon like this:
- → 4. Tap 'Install'

The above method from Google play is the most likely method you will use. If, however, you don't have access to Google Play you can download an 'apk' file to install from the Downloads tab at http://www.gpsessentials.com/. Download the file to your phone. To allow installation go to Menu > Settings > Security > and check Unknown Sources. To install find the APK file, tap it, then hit Install. We will assist you individually if this alternative installation method is required.

### 3.2.2. Starting GPS Essentials



- → Tap the GPS Essentials icon:
- → Go to 'All Apps' if you can't find it.

The 'home' screen of the App should look like this (you can ignore the advert at the bottom of the screen):



→ Scroll down to 'Units' and 'Position Format'.

 $\rightarrow$  Tap settings:

$\equiv$ Settings
Units Selects which unit system to use when showing values
Position Datum Selects the datum of locations
Position Format Selects the location format and coordinate system
Angular Unit Switches the angular unit
Bearing Switches bearing values between magnetic and true values

→ Set 'Units' to km:



→ set 'Position Format' to Decimal:

	Settings
Po	osition Format
- C	) Degrees, Minutes, Seconds
C	) Degrees, Minutes, Fractions
	Decimal
C	) UTM
C	) MGRS
C	) OSGB36
	CANCEL
Clamp Clamp compa	Heading heading to bearing when moving, improves ss readouts in vehicles

As we know GPS relies on satellites.



### → Tap the 'Satellites' icon

If you are doing this indoors (as I am), you will probably find that the App isn't able to 'see' any satellites.



When you go outside the App should be able to see more satellites and then it will give you an estimate of your position:



→ To return to the App home screen, tap 'back' on your phone.

This button looks slightly different on different phones. For example, you may have a small triangle pointing left at the bottom of your screen.



### 3.2.3. Storing maps offline

The GPSEssentials App allows you to download background maps while you have an internet connection to allow for use in areas where you don't have access to the internet. This can be accessed through the 'Portable Maps' icon from the home screen. It is called a portable map because you can then carry it anywhere, even away from an internet connection.

Before we go to the portable map icon, we want to increase the default amount of space the GPS Essentials app allocates to storing maps 'offline'. This will allow you to store larger geographical areas on your phone without needed an internet connection.

→ Go to the settings screen, and scroll down to 'Storage Setup' which is under the 'Miscellaneous' heading.

≡ Settings
Default Map Type Chooses a map to open by default, e.g. when you select 'Show on Map'
Miscellaneous
Storage Setup Controls how data is stored locally
Storage Location Controls where data is stored locally
Plugins Configures extensions for GPS Essentials
Edit Scripts Edits script files and reloads them
Keep Screen On Keeps the screen on while the app is active
Geocoder Selects the service to search locations

→ In the Storage screen, slide the orange slider to increase the *Cache Limit* to its maximum. Once this is done, return to the Settings screen, then go back to the home screen.



→ tap on the 'Portable Maps' icon to download maps to view offline.



This should bring up a map of your local area. The map you see is automatically downloaded so that you will continue to be able to access it if you lose your internet connection. To download more 'zoomed in' maps, you need pinch in and out with two fingers to zoom in and out. Pan around the screen to cover as much of the area outside of the building as possible as you can only be certain that the map has been downloaded to your phone once you have seen it on your screen. Do not worry about the message saying that the Dashboard is empty for now.



→ To prepare for the practical exercise, tap on 'Portable Maps' and zoom in to see the area that we will be walking in. We will demonstrate this to show you the region to zoom into.

## 3.2.4. GPSEssentials Practical Exercise: Collecting data

For the practical exercise we will go outside and record both: A. a 'track' where the app automatically records a series of points of a route B. 'waypoints' specific points that we identify

#### A. Tracks

You are able to record tracks either when walking on foot, or travelling in a vehicle. Today we will record your walking route.

11 11

→ To start recording a track first tap the Tracks icon.

This should bring up the following screen:

_				
MPTY	REMOTE	TRACK	IMPORT	STRAI
Start re	ecording your	current loc	ation.	
Press	Start to begin	tracking in	to a new stre	am.
				- 1
				- 1
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				- 1
				2
				- 1
				- 1
				- 1
				- 1
				- 1
				- 1
-				_
		Start		- 1

- → Tap Track at the top
- → Tap Start at the bottom

The app will automatically start recording your track until you press stop.



The small paw icon shows that a track is being recorded.

→ Tap and type in the 'Add a description' box

Once you go outside and start moving information about the track will appear. e.g. the length and altitude, check that these measurements are in metres (m). This will show that you successfully changed the units above. In the screenshot below the units are in yards and feet, this shows that the units haven't been changed and is not what we want for this exercise where we want to record in metres.



#### B. Waypoints

It is possible to record specific points (Waypoints) at the same time that the track is being recorded. Waypoints are simply locations of interest. You may want to record the location of a house included in a survey, or a location of a trap you have set up for example. In this exercise we will simply record interesting landmarks that you find on your walk.

 $\rightarrow$  Tap the orange circle with a '+' in at the lower right:



- → Swipe right until you get to the 'WAYPOINT' screen. Here you can choose an icon, add a name and description
- → tap 'Create' at the bottom



You can choose any landmarks for your waypoints, maybe a building entrance, tree or sign. After you have recorded three waypoints and walked a few hundred metres, we will stop the recording of the track.

→ To stop recording of the track you can press the square stop button if the app screen is visible.



If the app is in the background (it can continue to record without being visible) swipe down from the top of the screen and you should see the screen as below where you can press 'stop':



→ Tap 'Add a description' to bring up a screen where you can name and save the track:



# 3.2.5. GPSEssentials Practical Exercise: Download data from phone to PC and into QGIS

There are a number of ways of getting the data we have collected from the phone to a PC and into QGIS. We will use a GPX file. GPX stands for GPS Exchange format and is the most common format for transferring GPS track and waypoint data. We will use GPX 1.1 - the more recent version. You could also use a KML file which is a format designed for Google Earth and can also be imported into QGIS, but it tends not to work so well.

→ First go to Tracks, you will see a list of saved tracks, tap to select one:



→ Once you have selected a track, tap the 3 vertical dots at the top right to access options including Export :



- → Tap 'Export' to bring up a screen as shown below.
- → Tap to change the 'KML (Google Earth)' option to 'GPX 1.1'.



There are two main options to get the GPX file from the phone to your computer. Either you can use email to send the file over the internet or you can use a cable to plug the phone into your computer and download the file directly. Email works much better, using a cable can be tricky. If you have email on the phone and access to wifi then this method is the most straightforward. We will cover that first and cover the backup option of using a cable afterwards.

To use the email option to send yourself a copy of the GPX file :

→ select your email program from underneath SHARE. Because I use gmail I have a red M representing gmail. If you use different email software on your phone choose the icon that you usually use.

GPX 1.1 🔹 🖑 🗄	
Written 21.26KB to /storage/emulated/0/ Track-170124-153802.gpx in 0"	
/storage/emulated/0/Track-170124-15	>
Exporting one element	
From southandy@gmail.com	
To endy south ~	
Track-170124-153802.gpx	
Compose email	
Track-170124-153802 gpx	
q w e r t y u i o p	)
asd fghjkl	
🛧 z x c v b n m 🖾	
?123 @	

If you do not have access to the internet and email from your phone you can use a USB cable to transfer the GPX file from phone to computer.

Connect phone to computer with a USB cable. You may be asked if you want to charge your phone or connect it as a 'media device'. If so choose Media device. Exactly what happens will depend on

both your phone and computer so may look different to what we show here. What we want to do is to use the computer to browse the memory of the phone and find the GPX file.

When you initially connect your phone it may bring up Windows file explorer and say 'This folder is empty'. If it does this try refreshing the phone screen and that should bring up the phone file system as shown below. If it doesn't try using Windows file explorer to find the phone in your computer's file system.



Because we are not sure where the App has saved the file we will search for GPX files. Type .gpx into the search box and press return, the search may take a few minutes.



The GPX file(s) should be found as shown below. You can select and use Ctrl C to copy, ready to paste to the folder indicated in the next section, or you can drag and drop. If a GPX file is not found this may be because the phones file system has not refreshed on the computer. Try unplugging and replugging in the cable. If that does not work try re-saving the file again and repeating the search.

Search Too	ی .gpx - search-ms:dispt	×
File Home Share View Search		~ ?
$\leftarrow \rightarrow \checkmark \uparrow   \bullet >$ Search Results in FP2	✓ ひ .gpx	×
<ul> <li>Documents</li> <li>Downloads</li> </ul>	Track2.gpx Size: 21.2 KB	
🔊 FP2 🥪 Internal storage	Track1.gpx Size: 21.2 KB	
SD card	☑	
<ul> <li>Pictures</li> <li>Videos</li> </ul>	Track-170124-153802.gpx Size: 21.2 KB	
<ul> <li>Windows (C:)</li> <li>RECOVERY (D:)</li> </ul>		
🥩 Network		
4 items 1 item selected 21.2 KB		: :

Either way that you transferred the GPX file now we will save it to a folder on your computer where we can access from QGIS.

- → Save the GPX file to the folder '/my\_work/data/gps/' on your computer.
- → Create this folder if it does not exist already (e.g. within the data folder : right click, New, Folder).
- → Open QGIS and click 'Project, New'



- → Select Layer, Add Layer, Add Vector Layer as we have done before
- → Press Browse and navigate to where you saved the GPX file (/my\_work/data/gps/)

When you do this you may be surprised to see that it says 'No items match your search'. Can you think whey this is ? (hint: it is to do with an option we changed on an earlier day).

🕺 Open an OGR Supported Vector La	yer				Cr.					×
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🤳 zikagis					NO Items mat	ch your searc	11.			
la OneDrive										
Ithis PC										
and Desktop										
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🔈 Downloads										
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RECOVERY (D:)										
🕩 Network	~ <									>
File name:						~	ESRI Sha	pefiles (*.sh	p *.SHP)	~
							Ope	en	Cancel	

It is because we had a filter set just to show Shapefiles, if we change the filter on the lower right to either 'All files' or 'GPS eXchange Format' you should see your GPX file.

- → × ↑ 📜 « QGIS Tra	ining > QGIS_training > my_work > data >	y gps v ♥ ♥ Search g	gps 🔎
Organise 👻 New folder			:
🚴 useR2013	↑ Name	Date modified	Type Size
a vmsGrids	Track-170124-153802.gpx	25/01/2017 12:43	GPX File
🤳 zikagis			
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File <u>n</u> ame:		∽ GPS eX	change Format [GPX] (*. 🗸
			Cancel 6

- → Double click on the gpx file
- → click the Open button in the following window as we have done before.

This should bring up a window called 'Select vector layers to add ...' with options to add route\_points, routes, track\_points, tracks and waypoints. Routes are a little different than tracks and we have not looked at them here so we will select the others.

→ Select track\_points, tracks and waypoints (using Ctrl to select multiple options) then click OK.

Layer ID	Layer name	Number of features	Geometry type
	route_points	0	Point25D
-1	routes	0	LineString25D
	track_points		Point25D
	tracks		MultiLineString25D
	waynoints		Point25D

This should bring up 3 separate layers of your track (line), track\_points and waypoints (points) in QGIS! Try turning on and off the different layers and zooming in and out. Are the positions similar to how you remember them ?



#### Exercise 3.1

Produce a map of your data, adding labels to the waypoints you have collected, plus a basemap. Save the file as a png.

# 3.3. Editing and creating shapefiles

The previous exercise demonstrated how you can use GPS receivers in devices such as smartphones to collect point and track data that may be relevant to your work. There are however other ways in which you can create spatial data that does not involve physically visiting the location that you want to record. In this section we will be showing you how you can use the tools within QGIS to 'draw' your own shapefiles.

### 3.3.1. Using satellite imagery to georeference locations

We will be using some of the available basemaps within the OpenLayers plugin that we introduced in Section 1.7 to help us to locate areas and points of interest within QGIS. Within the OpenLayers plugin we can add basemaps obtained from resources such as Google Maps and OpenStreetMaps. Both of these resources are derived from satellite imagery, although they use these resources in different ways. There are hundreds of satellites orbiting the earth, many of which contain sensors that are used to measure radiation that is being emitted from objects on the Earth's surface. This process is called *remote sensing* (Figure 3.2). Aerial images that you see displayed in services Google maps are primarily collected by remote sensing satellites, using sensors that measure the visible part of the electromagnetic spectrum (red, green, blue). We will learn a little more about what else can be measured using the sensors on board satellites on Day 4.



Figure 3.2: Satellites orbiting the earth use sensors to measure the radiation being emitted from objects on the Earth's surface. This process is called *remote sensing*.

The images that Google Satellite Maps displays are often collated from many different satellites, which produce images at varying spatial resolutions (grid/pixel sizes). You may notice that some places on the Earth you are able to see in Google maps more clearly than others. This is because Google obtains some of its imagery from commercial satellites that have a very high spatial resolution (less than 5m) such as QuickBird, RapidEye, IKONOS, WorldView and GeoEye. This imagery is not available for all areas however, so some areas can only be viewed using coarser images (~30m resolution) obtained from freely available resources such as Landsat. We can see that Google has obtained high resolution satellite images for our current location in Figure 3.3 below. As well as the aerial imagery, Google also has created street maps for the area. These maps have been derived by

'drawing' around objects seen in the aerial images, plus using local information to add specific landmarks and locations of interest.



Figure 3.3: (left) Aerial map of local area obtained using Google maps satellite view, and (right) map obtained using Google street maps.

Google maps is not the only freely available mapping resource. We have also been using OpenStreetMaps within QGIS as a basemap for some of our examples. OpenStreetMaps images, or OSM, are a little different to those provided by Google. The maps provided by OSM are developed by a global team of volunteers who identify interesting features such as roads, buildings, waterbodies etc through tracing around high resolution satellite imagery, or local volunteers who use GPS receivers to record the coordinates of interesting features and upload them to OSM. All of the data collected by OSM volunteers is free to download, and can often be more detailed that the street maps produced by Google as seen in Figure 3.4 for example. We shall give you a few more details on OSM on Day 4.



Figure 3.4: Maps of the local area produced by Google street maps (left) and OpenStreetMaps (right)

The maps produced by Google and OpenStreetMaps can be very helpful when trying to identify the coordinates of locations of interest without needing to physically visit the location. In the next sections we will be showing you how you can use these resources to create additional polygon and point-level spatial data within QGIS.

## 3.3.2. Editing polygon data

Often the shapefiles for larger administrative areas (e.g. country, regions, districts) will be available to download for free from the internet. However, there are many reasons it will be necessary to create your own shapefiles, for example: available files may not be up to date with the latest administrative changes in the country, administrative areas may not match the health areas, available shapefiles may not be detailed enough for your purposes, or available files may not exist at the operational scale you need (for example survey zones). It can therefore be useful to be able to edit shapefiles or to create new ones.

The blocks.shp layer we have been using in days 1 and 2 is an example of a shapefile of polygons that have been created by 'drawing' around areas identified using a base layer. Our imagined entomological survey took place in a small defined part of Mexico City. This could have been an area identified in response to the provenance of reported disease cases, or a sentinel site for surveillance,

or perhaps an area chosen by random selection for a study. The indicators of interest were to be displayed at block level, blocks in this instance being a known unit of ten houses. When putting together your own maps, you will find that some shapefiles are available to download for free from the internet, this is something we will explore further in section 4. However, these are generally shapefiles for large scale administrative areas (Districts rather than Blocks). For smaller scale operations, or project-specific areas, it may be necessary to create your own shapefiles or modify existing ones to suit your needs. We are therefore going to run through some examples of how to do this.

To start, we will edit our existing blocks shapefile. It contains 50 example blocks which were created based on satellite imagery of the area. We will add 5 extra blocks to these, by drawing around areas outlined by a base layer.

- → Open QGIS and start a new project.
- → Save this project in your my\_work folder, name it Day3\_shape.qgs.
- → Using the OpenLayers plugin, add Google Satellite or OpenStreetMap as a base layer.
- → Add the blocks.shp polygons as a layer. Zoom to this layer.

Before we begin editing, we will save a copy of the blocks shapefile, so that the original can be retained untouched.

→ right-click on the blocks layer and choose the option 'Save as'.

This will pull up a 'Save vector layer as...' window, as below.

Format	ESRI Shapefile		•			
File name	S/QGIS_training/da	ata/spatial/Polygons/new_blocks.shp	Browse			
Layer name CRS	Selected CRS (EPSG: 4326, WGS 84)					
Encoding		System	<b>•</b>			
200000000000 <del>0</del> 00		bystem				
Save on	ly selected features	and their export options				
Save on Select	ly selected features fields to export a ed file to map	and their export options				
Save on Select Add save	ly selected features fields to export a ed file to map export	and their export options	[			
Save on Select Add save Symbology e	ly selected features fields to export a ed file to map export	No symbology 1:50000				
Save on Select Add save Symbology of Scale	ly selected features fields to export a ed file to map export etry	No symbology  1:50000	•			

- → Select ESRI Shapefile as your format.
- → Browse to your Polygons folder (within Data, Spatial)
- → type a new file name of "new\_blocks" in the box for file name.
- → Tick the 'Add saved file to map' box if it is not already selected.
- → Click OK.

You should see that your new shapefile has been added to your map in the layers panel. The new files should also be present in your documents library if you check.



To ensure that we edit the new\_blocks layer, we can remove the original blocks layer from our project.

- → right-click on the blocks layer, then select "Remove" from the menu that appears.
- → Click OK in the warning that follows.

The shapefile will remain available for future use and can be added to the project again later if required.



Now we are ready to start editing our polygons.

- → Click on the layer you wish to edit (new\_blocks) in Layers panel to ensure it is active
- → To edit we will use the 'digitizing toolbar' pictured below
- → Remember to make a panel or toolbar visible right-click in the menu/toolbar area at the top of the screen and select options from the dropdown list



 $\rightarrow$  To begin editing, select the "Toggle editing" (pencil) button

Clicking on this will make the other tools available for selection. Notice that when you are in this mode the items in your active layer will be marked with small red crosses at the vertices.



There are different "add feature" tools for the different types of feature to be added. This is the icon for adding a polygon.

- → Left click the add polygon button
- → left click on your map to add the first point in the polygon
- → release the mouse button and move the pointer to the next point you want to add
- → left click again to add the next point
- → repeat
- → **Right-click** to finish drawing your shape.
- → You will be presented with a "Features attributes" table. This is a list of the data associated with your shape. The new\_blocks file only has an identifier for now. If you edit a shapefile with more data associated with it, you will see these variables listed. These fields can be used to enter data directly, or can be left blank to be filled later.
- $\rightarrow$  Click on "OK" and your shape will appear on the map canvas.
- → use the "Save Layer Edits" button to save your changes as you go along.





BlockID	NULL	
septHI	NULL	
septCI	NULL	
septBI	NULL	



editing mode. Use the select feature tool, what you have selected will be highlighted in yellow. Then click the trash can icon to delete.

#### Open Attribute Table

To access the table and enter data manually, right-click on the layer in the layers panel and click on the "Open Attribute Table" icon. You will see the data associated with the blocks.

If you scroll to the bottom rows you will find blank fields for any new blocks you have created, or whatever data was entered via the feature attributes window.

If you are unsure of which block corresponds to which row, clicking on the row (at the far left-hand side, for example where row 51 is indicated) will highlight the corresponding polygon in the map as well as the row in the attribute table.

There is a "deselect all" button that you can use to unselect your highlighted

areas.

We will learn more about how to navigate and manipulate spatial data in QGIS later.



Data can be added manually to the table by simply clicking in the cells in question and typing in the desired values. If the value is unknown, the cells can be left blank.

Note that you will still need to be in toggle editing mode to be able to make changes. There are toggle edit and save edit buttons available at the top of the table attributes window if required, in addition to the main screen toolbar.

→ When you have finished, save your edits and click again on the edit button to exit the editing mode.

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/	<b>8</b> 8 8 1	🛱 💼 🖥	S 💊 🕇 🛙	•
123	ID_0	3 =	]	
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1	53	COL	Colombia	COL

Adding data manually in this way can be quite time consuming and is best limited to minor edits or where there are only a small number of additions. If a large number of edits are needed then the best approach is to make these changes in the Excel/csv file before joining your survey data to the block shapefile.

🤊 Add Delimited Text Layer...

## Exercise 3.2

To practice what we have learnt in this section, add five new blocks to your polygon layer, add your indices data (HI, CI, BI), enter indices data for your new blocks. Some steps to do this are outlined below if you need them.

- → Continue to work in your Day3\_shape project (re-open it if necessary).
- → Check you have a base layer (OpenStreetMap or Google Satellite), and your new\_blocks layer..
- → Join the HI, CI and BI indices from September if you calculated them, July if not. (Add and join the CSV file).
- → Save this as a shapefile (call it new\_blocks\_sept or new\_blocks\_july)
- → Draw three additional blocks. Give them BlockIDs 51-53 (or similar if you have already used these). Manually enter indices data for your new blocks as you go along. Some example data is provided in the table below.
- → Draw two more blocks. Give them BlockIDs 54-55 (or similar). Leave the rest of the data blank for now.
- → Enter the remaining indices data via the attributes table.
- → Save your edits and come out of editing mode.

BlockID	HI	CI	BI
51	40	12.20	50
52	30	14.28	50
53	80	24.44	110
54	70	40.00	200
55	20	10.81	40





# 3.3.3. Creating point data

In addition to editing existing shapefiles, as above, you may wish to create a whole new shapefile. Let's look at how to create a point shapefile as an example. Imagine we have some historical bioassay data, mosquitoes collected at ten sentinel sites were tested for susceptibility to a given insecticide. GPS coordinates were not collected at the time, but the site locations are known and can be identified on a map. You can create these sites as points on a map, in a similar way to the way you added the extra blocks in the previous exercise.

This time use "New Shapefile Layer" (Menu bar: Layer, Create Layer, New Shapefile Layer; shortcut: Ctrl+Shift+N).

y+	3 2												
N	Layer	Settings	Plugins	Vector	Raster	Datab	ase	Web	Processing	Help			
E	c	Create Layer	•			•	V	New S	Shapefile Laye	r		Ctrl+Shift+N	
-	A	dd Layer				•	Co	New S	SpatiaLite Laye	er	3		-

In the "New Shapefile Layer" window you are presented with various options.

Warman					_
Туре					
Poin	e.	() u	ne	Polygon	
le encodi	ng	Syste	m		14
selected (	CRS (EPS	G:4326, WGS 84	)		
New fie	ld				
Name	-				
Type	Text da	ta			
Length	3		Precision		
				Add to fields list	
Fields li	ist				
Fields li	ist	Туре	Length	Precision	
Fields li Name mortali	ist ty%	Type Integer	Length 3	Precision	
Fields li Name mortali res_sta	ist ty% atus	Type Integer String	Length 3 20	Precision	
Fields li Name mortali res_sta siteID	ist ty% abus	Type Integer String String	Length 3 20 3	Precision	
Fields li Name mortali res_stz siteID	ist ty% sbus	Type Integer String String	Length 3 20 3	Predision	
Fields II Name mortali res_sta siteID	ist ty% sbus	Type Integer String String	Length 3 20 3 m	Precision	, eid

- → select 'Point' for 'Type', note that you can also create lines or polygons from here
- → for 'File encoding' leave it on 'System'
- → next is a dropdown for the Coordinate Reference System, check that the option CRS (EPSG:4326, WGS 84) is selected. Coordinate Systems such as WGS 84 will be explained in more detail later.

Under 'New field' we have the option to add and define the fields to be associated with the shapes. What variables will be associated with our points (what will they be called), what format will that take (String for text, integer for whole number, decimal, date), and how many characters will be permitted (Length).

- → Type a variable name into the 'Name' box
- → choose a field 'Type' from the drop-down list
- → change 'Length' to the number of characters you want to allow. Make sure this is enough, it is better to be longer rather than shorter. e.g. for an integer if you set the length to 2 you will only be able to have numbers up to 99)
- → When you have defined each field, click on the "Add to fields list", and your variable will appear in the list of fields below.
- → Repeat the new field step until you have all the variables you want. Note that there is a "Remove field" button which can be used to edit your fields list. Note also that there will be an automatic id field as a minimum requirement to distinguish your points.

- → create three fields, two text fields (siteID and res\_status) and a whole number to represent percentage mortality (mortality%)
- → delete the automatic id field that we will not be using.
- → When you have set the desired formatting and added all the required fields, click OK.

This will prompt the "Save Layer as" window. Give your new shapefile a name ("points\_example") and save it somewhere appropriate in your filing system (QGIS\_training, data, spatial, points). You will see that your new shapefile has been added to your layers panel. So far there is no data in this layer.

To add new features for this layer, you will need to edit it.

→ Use the toggle edit button to activate the "add feature" button.

The button corresponding to the Type selected will be active. In this example, the button to add points to your map will be shown.

→ click on the map canvas to add a point

A window called "Feature Attributes" table with fields for data entry as specified in the list when you created the new layer. As before, you can choose to enter the data directly, revisit the attributes table later, or join a CSV file. When you click OK, you should see a point appear on your map.

mortality%	NULL	
res_status	NULL	
siteID	NULL	
•	III.	•

Note that you will need to familiarise yourself with the base layer map to find your desired locations. Notice in OpenStreetMap you can see street names, and if you zoom out, parks and hospitals also marked. Use whatever local landmarks necessary to orientate yourself. If you have Google Satellite you may be able to zoom in to a very detailed image of buildings, gardens and alike.

Note that there is a tool available to move your points, should you wish to adjust their position.

When you are satisfied with your points, save your edits, and stop editing.

Remember that you can modify the style of your points by opening up the Layer Properties window.

# Exercise 3.3

Create a new layer of ten points. The locations for these points is your choice, use a base layer to navigate around the study area and make your selection. These are your 10 Sites. Make a map of the below resistance data. Experiment with changing the symbols and colours used to represent your points. An example is given below.

Deltamethrin bioassay result summary					
SiteID	Corrected Mortality %	Resistance status			
S01	45	Confirmed Resistant (<80%)			
S02	81	Suspected resistance (80-97%)			
S03	91	Suspected resistance (80-97%)			
S04	99	Susceptible (>=98%)			
S05	98	Susceptible (>=98%)			
S06	75	Confirmed Resistant (<80%)			
S07	85	Suspected resistance (80-97%)			
S08	80	Suspected resistance (80-97%)			
S09	99	Susceptible (>=98%)			
S10	100	Susceptible (>=98%)			



## 3.4. Coordinate Systems

In the examples and exercises so far, we have been using longitude and latitude to indicate the position of survey locations on the map. Longitude and latitude are one of the most common measures of location, and form the coordinates of the geographic coordinate system referred to as WGS 84, where WGS stands for World Geodetic System, and 84 represents the year 1984 which is the year in which it was established. There are however many other ways of recording coordinates which means that there are many other types of coordinate systems. Whilst we will not be using these other coordinate systems, it is important to be aware of others as you may receive or download data that may use these other systems. It is also beneficial to understand why longitude and latitude may not the best coordinate system to use.

WGS 84 is the most commonly used geographic coordinate system which are systems that represent the world as a sphere. One of the biggest disadvantages to using longitude and latitude is that it is not a good measure of distance, as the distance measured by 1 degree is dependent on the location being measured. In the images below (Figure 3.3) you can see that whilst distances in latitude (measured north to south) remain roughly constant around the globe, the distances in longitude (east to west) get much shorter towards the poles.



Figure 3.3: (left) A diagram of the globe indicating lines of longitude and latitude, (right) a two dimensional image of the United States of America displaying lines of longitude and latitude.

To overcome this issue, *projected coordinate systems* have been developed. We use the term 'projected' to represent the process of translating a three dimensional surface, i.e. the globe, onto a two dimensional surface e.g. a piece of paper or your computer screen. This can be very difficult, and many different methods of projecting the globe to a two dimensional surface have been developed. One of the main goals of projected coordinate systems it to make sure that distance is constant across the entire projected surface. This means that the length of 1 unit in the coordinate systems represents the same measure of distance regardless of its location. One very common (and familiar) projected coordinate system is the Mercator projection (Figure 3.4). In this projected coordinate system 1 unit represents 1 metre. However, this projection is flawed as it represents land surface area very poorly. For example, in this projection Africa appears similar in size to Greenland of the United States where in reality it is much greater (Figure 3.4).



Figure 3.4: (left) a map of the world in the mercator projections, (right) a demonstration of how the mercator projection does not represent land surface area well.

There are other coordinate systems that better represent land surface area such as the Gall-Peters projection (Figure 3.5), however this is less commonly seen in the maps that we use.



Figure 3.5: (left) the Mercator projections, (right) the Gall-Peters projection

QGIS is able to present spatial data stored in many different geographic and projected coordinate systems. You need to take care when mapping your own data as if you assign your data the wrong projection system, your data may appear in the wrong location on your map. For example, projected coordinates are often referred to as Eastings and Northings where usually one unit represents one metre. These coordinate values are often very large numbers. If you try to map these values in QGIS as longitude and latitude you will receive an error as the coordinates will be out of bounds. To check the coordinates of a shapefile you have added to QGIS, right click on the layer name and look at the layer properties. The assumed coordinate system will be under the *General* tab.

End of Day 3