QGIS 3 TUTORIAL FOR BEGINNERS #1

GEOREFERENCING AND DIGITIZING

QGIS Tutorial and Video Course

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First Printing: April 2019

Geocode Mapping and Analysis pl

ISBN:

An insightful GIS analyst can be the glue that bonds a mapping team, and the catalyst for the production of maps that field scientists could only hope for in their wildest dreams.

The mindset of a GIS technician can lead to frustrated clients and missed opportunities.

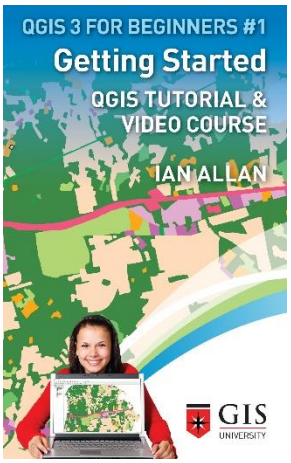
OTHER QGIS TUTORIALS BY IAN ALLAN

All my QGIS tutorials are aimed at researchers, college students and professionals who just want to learn the essentials of a mapping tool. Every text is paired with a companion video course hosted on Udemy.com. I teach you, step-by-step, the essential elements of a QGIS task.

GIS 3 for Beginners #1: Getting Started

Learn the beginner basics of QGIS 3. How to…

- Open GIS maps and photos in QGIS 3
- Zoom, pan, etc
- Shade a map
- Create time series maps
- Think like a GIS analyst



Available on Amazon.com (kindle and paperback)

https://www.amazon.com/GETTING-STARTED-TUTORIAL-COURSE-BEGINNERS-ebook/dp/B07P1FCKZF/

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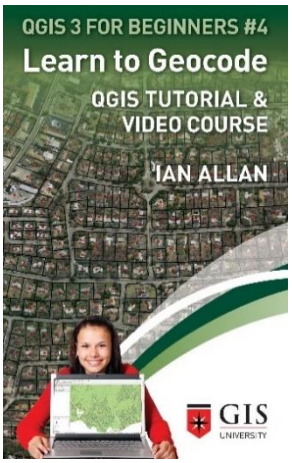


ABOUT IAN ALLAN

I have authored and co-authored fifteen peer reviewed publications. I have worked professionally as a GIS researcher, taught GIS to thousands of students, and worked as a GIS consultant on projects as diverse as the following…

- **United Nations:** Post tsunami strategic planning in Banda Ache
- **Australian Federal Government:** National Broadband strategic assessment.
- **Victoria Australia's Department of Premier and Cabinet:** Housing affordability modelling.
- **Local Government**: Environmental sustainability modelling for planners.
- **Water industry:** Buried water pipe condition modelling and ease-of-digging modelling.

Since the mid 1990's I've been a GIS researcher, teacher and consultant. Over 5000 students have enrolled in my Udemy GIS courses. Here's what some of my students say about my teaching style…

Anna says: *"Good course! The instruction is clear and engaging and the exercises reflect real-world application."*

Brian says: *"It was very thorough and comprehensive. It gave you much more than just the technical functioning of how to digitise a map in QGIS. Ian also covered aspects of GIS Analysis - which increases your learning and appreciation of the capabilities of how powerful the GIS tool can be."*

Hannel says: *"Very informative and decent [pace]"*

Lazar says: *"I like this course because it has live example of the georeferencing procedure."*

Stravos says: *"A very good beginners course which gives a good amount of detail regarding the GIS theory. I enjoyed the content that was supplied and found myself learning quickly and spending lots of time in between lectures playing around with what I had just been taught."*

Viabhav says: *"Anyone who has to geo-tag or use physical maps in computerized form on a daily basis must go through this course. It is really helpful. The way the course is structured i.e. the steps gives a person a fair understanding (even to an amateur) of how to digitize a map."*

INTRODUCTION

Generalist GIS maps such as roads, infrastructure and property are available in most places these days. Often these are very accurate maps that have their origins in the work of licensed surveyors.

In contrast, GIS maps that are both appropriate and detailed enough for highly focused GIS projects, are often not available. Most of the missing maps are old, social themes or environmental themes.

When a GIS map is not available, you will need to either abandon that part of your project, or create your own map. You create a GIS map using one of three methods…

1. by starting from scratch (fieldwork), or
2. using seemingly unrelated GIS maps as information surrogates, or
3. by reinterpreting an existing study.

I want to encourage you to think like a GIS analyst. Some of my thought are directed to those students who are part of a mapping team. An insightful GIS analyst can be the glue that bonds a mapping team, and the catalyst for the production of maps that field scientists could only hope for in their wildest dreams. In contrast, the mindset of a GIS technician can lead to missed opportunities.

I'm about to teach you how to bring a field-interpreted map into QGIS using methods 1 and 2. We will be digitizing the Land Use interpretation over Yarmouth in Massachusetts (USA) that's shown in Figure 2. This map is typical of a finished field-interpreted map – hand drawn wobbly lines and stained.

If you're doing this course to learn how to digitize your own GIS maps, you'll be pleased to hear that digitizing often presents an opportunity to improve the quality of field interpretations.

- Using QGIS zooming and panning functionality, you can identify many boundaries more easily and accurately on GIS airphotos.
- You can copy and paste GIS features from other GIS maps into your map. This not only saves you time, but can improve the quality of your map by making it compatible with other GIS maps.

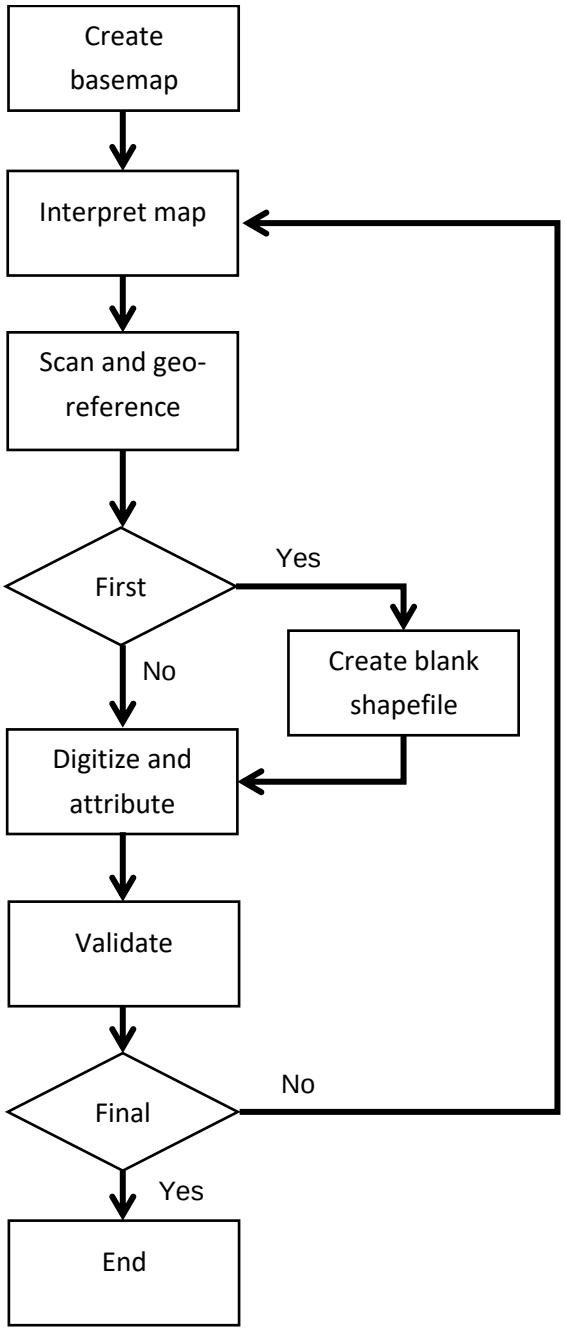


Figure 1: Digitizing flowchart

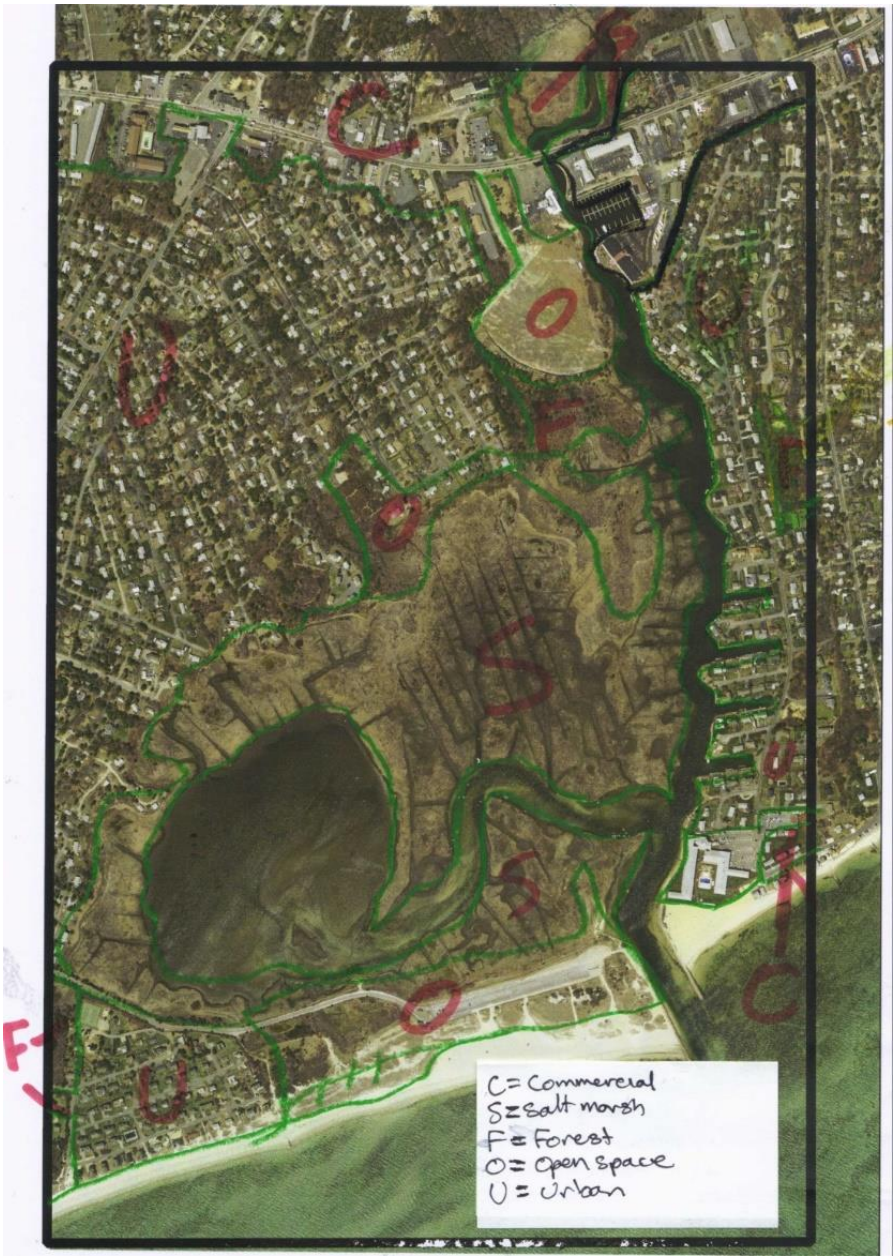


Figure 2: The Land Use Interpretation that we'll be digitizing in this lesson (YarmouthLandUseInterpretation.jpg). It is typical of field-interpreted maps that make their way into a digitizing in-box.

PART 1: SET UP THE TUTORIAL WORKING ENVIRONMENT

Setting up for the Tutorial

Pre-requisites

You should have…

- QGIS installed on your computer. Download this from QGIS.org. **Ideally, you should download the Long Term Release (LTR) version**. On some Windows computers, the 32 bit version is more stable.
- Completion of my Udemy "GIS for Beginners" course, or equivalent.
    - By equivalent, I mean that you should have a working knowledge of how to open a GIS map in QGIS, inspect a QGIS table, zoom, pan, etc.

I teach this QGIS tutorial using QGIS 3 for Microsoft Windows. QGIS also runs on Linux, MacOS X and Android. QGIS should look very similar on every platform. However, **I cannot support platforms other than MS Windows**.

Having said that, you should search the Q&A area for solutions to version specific problems that occur from time-to-time.

How to download the Sample Dataset

REVIEW THIS SECTION ONCE THE BASICS OF THE COURSE ARE SETUP

From the resources area at the bottom of the lecture titled "*Download the Course GIS Dataset Here"*, download gisforbeginnersdigitizing.zip. Use Winzip, 7-Zip or some other program to unzip it onto your desktop... *"..\Desktop\QGIS for Beginners\Learn Digitizing Using QGIS".*

You download the sample dataset from the resources area of the Udemy lecture titled…

"QGIS 3 - Download the practice activity dataset here".

The resources area appears when you hover your mouse cursor in the top-left corner of the screen. Click on the zip file link it will download.

Students who purchased this tutorial from *Amazon* will find a coupon code to access the videos and dataset under the *Coupon for the Companion Video Course* heading on page 71 of this book.

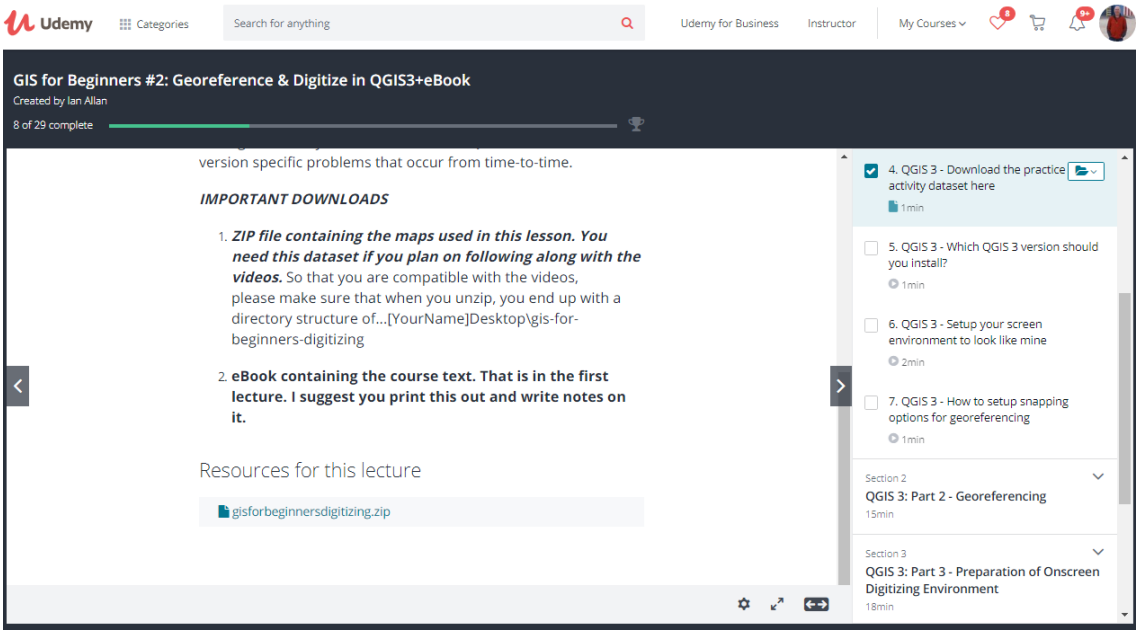


Figure 3: Download QGIS Orientation.zip from the bottom of the "QGIS 3 - Download the practice activity dataset here" lecture.

It will be much easier for you to follow along with this tutorial if you place the downloaded **QGIS Orientation.zip** file into a folder called **QGIS for Beginners** on your desktop. Then when you unzip the file, the contents should unzip into a folder called **QGIS Orientation** and you'll end up with a directory structure that's the same as in the Udemy videos…

"..\Desktop\QGIS for Beginners\Learn Digitizing Using QGIS"

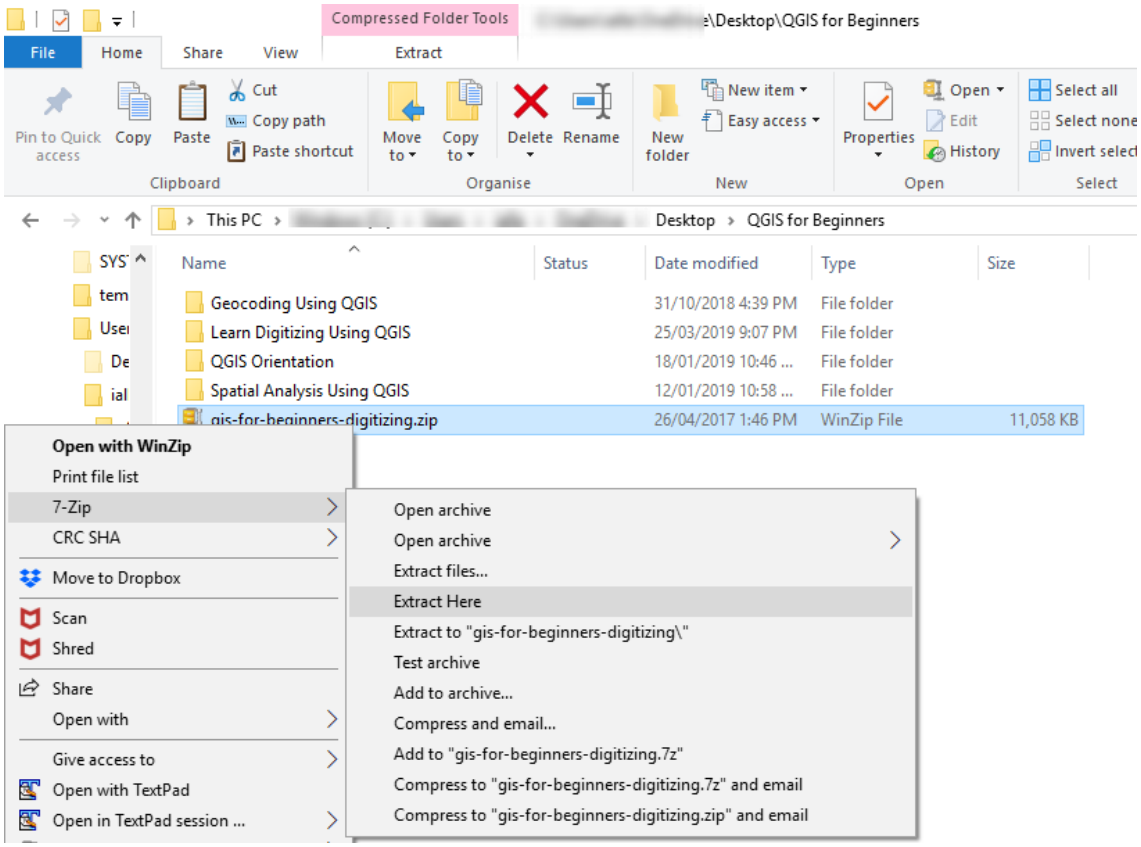


Figure 4: This is what your folder structure should look like. The other folders in the screen capture relate to my other Udemy QGIS tutorials.

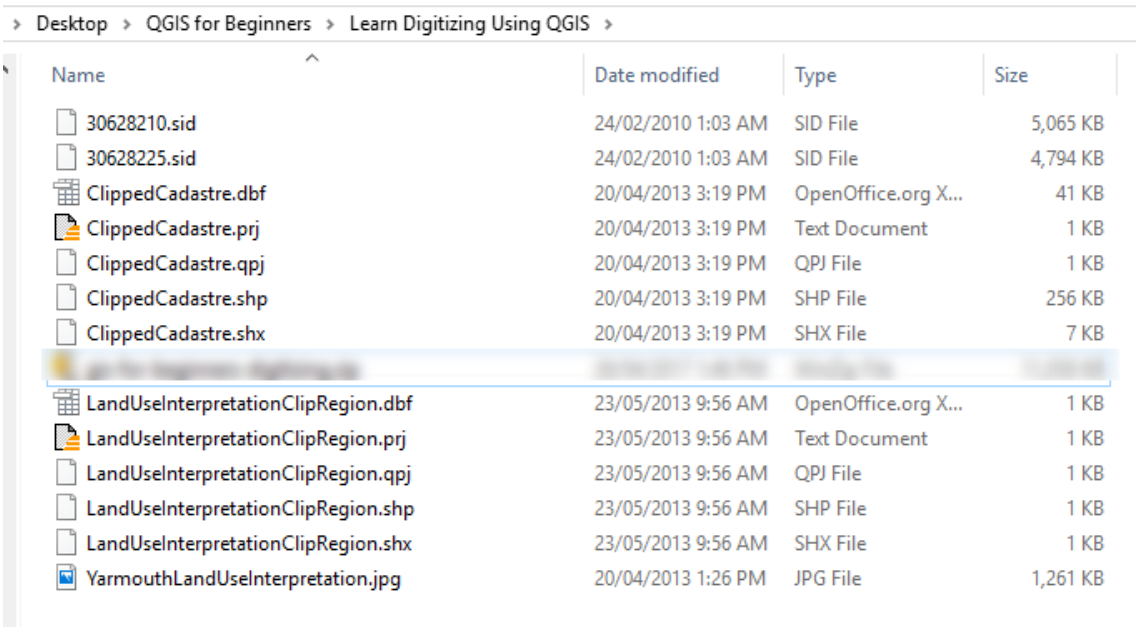


Figure 5: This is what your folder should look like when the datasets have been extracted. I used 7-Zip, but you could use WinZip if you wanted.

At this point I would like to very gratefully acknowledge the Office of Geographic Information (MassGIS), Commonwealth of Massachusetts, Information Technology Division. They have compiled and made available the GIS data used in this tutorial.

How to Make Your QGIS Interface Look Like Mine

You will find that the QGIS interface looks different from installation-to-installation. Sometimes this is because QGIS picks up the way previously QGIS installations were configured. Other times it looks different simply because the default installation changes.

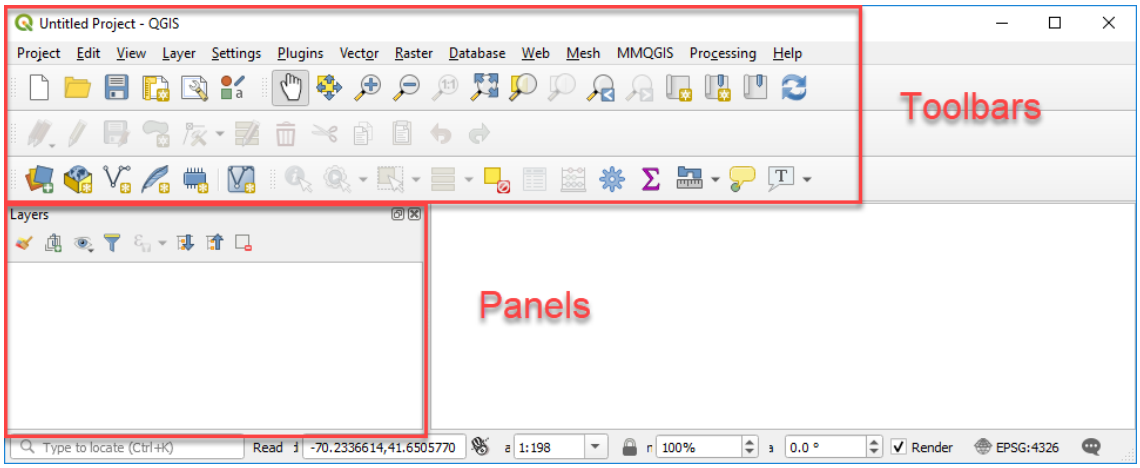


Figure 6: The format for the QGIS interface that I use throughout this tutorial.

My QGIS interface looks like this (Figure 6). Its best if you get your interface looking like mine so you can follow along with the videos more easily. To do that you need to know about QGIS Panels and Toolbars. Both are modified from within the 'View' drop-down menu…

Panel Options

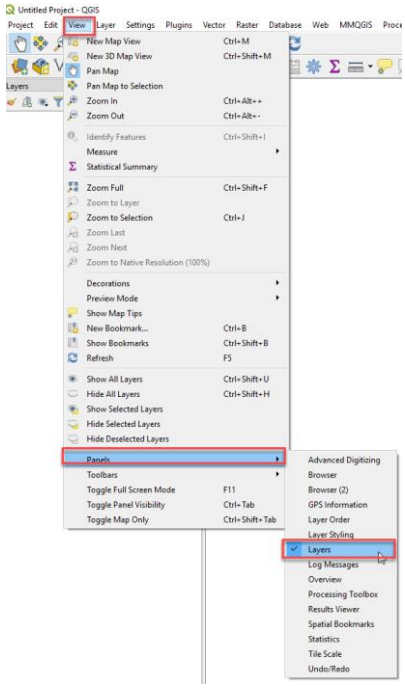


Figure 7: To make your desktop look like mine you should have only the Layers panel enabled

I only have only the Layers Panels active. For me, having other panels open takes up too much screen real estate (Figure 7)

Toolbars

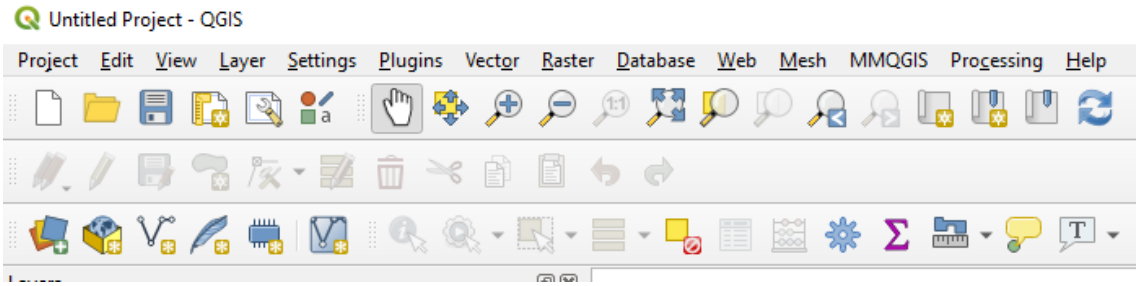


Figure 8: Here's what my toolbar looks like

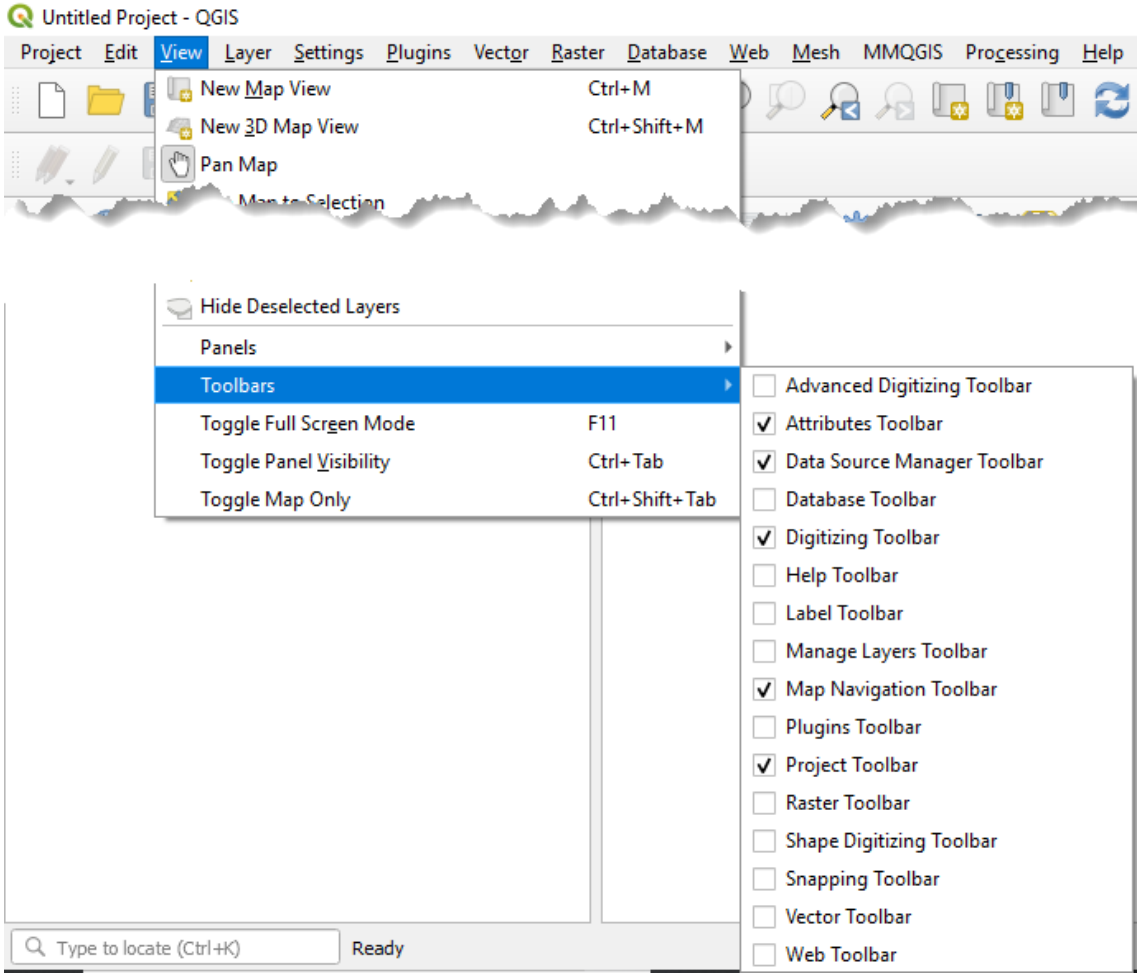


Figure 9: To make your toolbar to look like mine, enable these four toolbars.

All menu toolbars can be picked up and dragged around the screen. To make your desktop look like mine (Figure 6)…

- Enable the toolbars shown in Figure 9.
- Position the toolbars to be in the same place as mine. Holding down your left mouse button over the 7 vertical dots on the left side of the toolbar you want to move. Then drag and release it.

PART 2: HOW TO SCAN AND GEOREFERENCE A MAP

An easy introduction to scanning and georeferencing your map

In this section I will show you how to…

1. scan a map
2. georeference a scanned map

In Part 3, we'll use the georeferenced scan as a backdrop to on-screen digitize from.

How to Scan a Map

Do your best to lay your map flat and square in your scanner with north oriented at the top. The closest you can get your scan to how it should look as a digitizing backdrop, the better. Usually a scan resolution of 300 Dots Per Inch (DPI) is sufficient.

Ideally you should save the scan in jpg format. Tif format would be OK too. Sometimes you need to do a few experiments. The format that works best can sometimes depend on your equipment. The proprietary software that often comes bundled with scanners sometimes saves files in slightly different file formats than QGIS is expecting.

Once you've worked out a scanning process that works well with the equipment you have, document the process and then use that process all the time.

If you don't have a scanner, many office stores have scanning services. Some even have large format scanners for bigger maps.

If necessary, use photo editing software to ensure your scan is oriented north and alter its brightness and contrast. Two free photo editors are fotor.com (cloud) and gimp.org (download).

How To Georeference A Scanned Map

Once your map is scanned, it is ready to become a QGIS backdrop using a process known as georeferencing. We need to do this because our scan (YarmouthLandUseInterpretation.jpg) is in scanner coordinates, and our QGIS project is in the Massachusetts Mainland coordinate system.

Geo-referencing involves finding features that are common to the scanned map and the QGIS maps on your screen. These common features are called Ground Control Points (GCPs). Road intersections, and property boundaries are commonly used as GCPs. Urban areas tend to be GCP-rich. In contrast, I've been known to resort to fences, trees, buildings and even distinct shapes in water features in rural areas.

The Importance of a Base Map

A base map is a customized map that a field scientist can take into the field and draw an interpretation on. It has all (and preferably only) the themes that a field scientist requires to do their work. GIS-techies often technologize this part. They make the project about the tools rather than about the problem being mapped. Can I just say…*"its not all about you"!*

My experience is that for many types of field mapping, few field scientists will embrace the technical aspects of mapping. Many field scientists do not think like desk-bound people think. Most field-scientists will appreciate it if you bring the technology to them in the form of customized base mapping. Technology has its place. It can get in the way sometimes. But used thoughtfully, GIS can present useful information to field scientists in a way that empowers them to do their best work.

- A small screen does not give *context* like a mapsheet does.

- Some projects call for old-fashioned stereoscope interpretation from contact prints. Field scientists either…
    - eyeball what they're seeing onto your base-map, or
    - draw directly onto the contact prints
- Use a primary base map for the field scientist to draw their interpretation on. Complimentary map themes printed at the same scale can help too. They can be overlaid on a light table, or even held up to the light if necessary.

Whenever you're involved in a field mapping project from it's beginning, you should aim to create a basemap along the lines of the one I created for this project.

- It has its foundation in accurate GIS maps that the digitized map will be related to in real life.
- It has a bounding rectangle with known coordinates that are in the target reference system
- Due to careful scanning it is already oriented north.

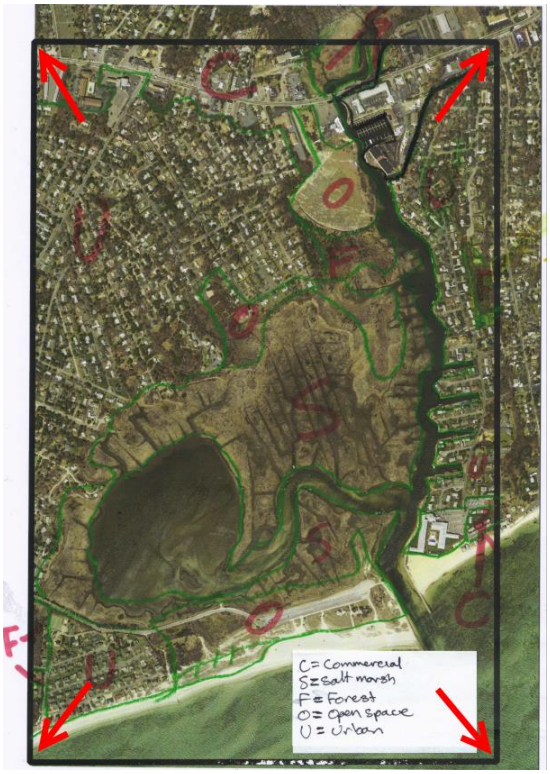
A good way to guarantee the accurate georeferencing of a scan is to incorporate ground control points (GCPs) in your base-map prior to printing it out. The aim is to end up with your scanned field-interpretation underneath any GIS maps you're using. When georeferenced, the roads in your GIS should overlay the roads on your scan, contours overlay contours, etc.

When I prepared the basemap for this exercise, I overlaid a rectangular clip-region before I printed it out. This is the black border in Figure 2. The rectangular clip region is now common to both the scanned Land Use interpretation AND any other GIS maps we have in QGIS (see Figure 10). The *Ground Control Points* for our georeferencing exercise will be defined with reference to the four corners of the clip-region map.

- Basemap for fieldwork
    - air photo
    - cadastre, contours, roads, etc, as required
    - clip region with known min/max X/Y coordinates
- Print for use in the field

- Draw interpretation
- Scan interpretation
- Georeferenced interpretation
- On-screen digitize using other GIS maps and air photo backdrop to improve the spatial accuracy
- Attribute the map
- Validate the map

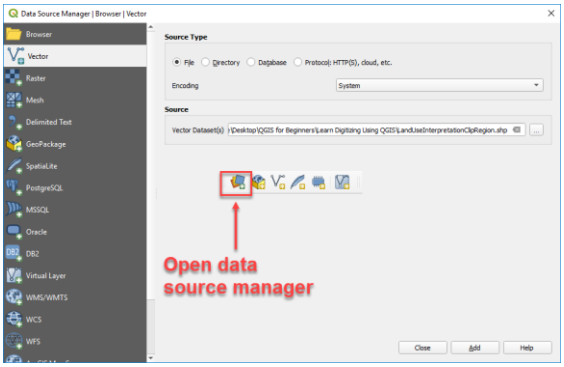
(A) The basemap in QGIS is in the Massachusetts Mainland coordinate system. I printed this out and the interpretation in (B) was drawn on it. The four corners of the clip region are common to both the interpretation and the QGIS maps.



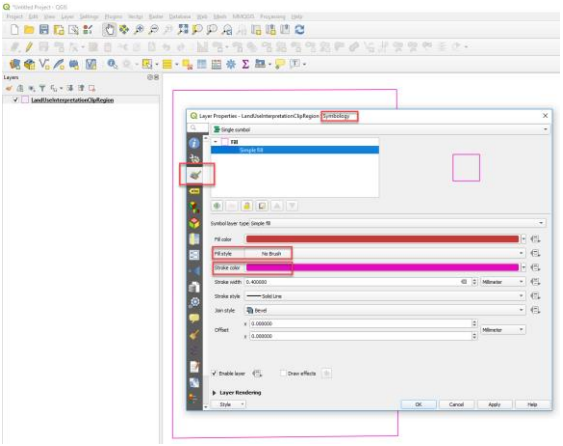
(B) The Land Use interpretation. We need to relate this to the Massachusetts Mainland coordinate system so we can digitize the Land Use interpretation off it.

Figure 10: We're going to georeferenced the four corners of the rectangular clip region. The clip region is common to both the scanned Land Use interpretation map and the GIS map. In the absence of a clip region we would need to find items in common with both the scanned map and the GIS map. That would be easy here because our GIS air photo is used in the base map for the interpretation. This process is far more difficult when matching two very different maps.

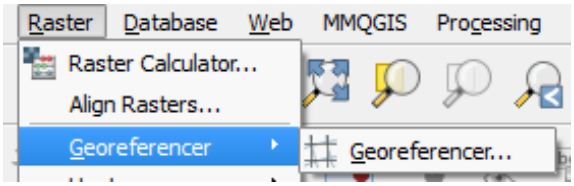
1 Click the Open Data Source manager button and from the dialog open LandUseInterpretationClipRegion.shp



2 In the Layers area, right-click LandUseInterpretationClipRegion. Launch the Layer properties dialog. In the Symbology tab, change the Fill Style to be *no brush* and the stroke color to be bright pink (pink is a good color for contrast).

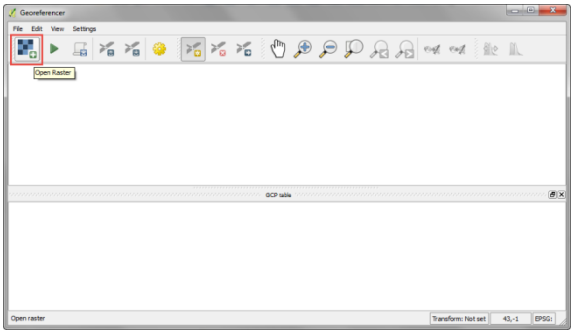


3 From the Raster drop-down menu, click on *Georeferencer and the Georeferencer* dialog box will appear.

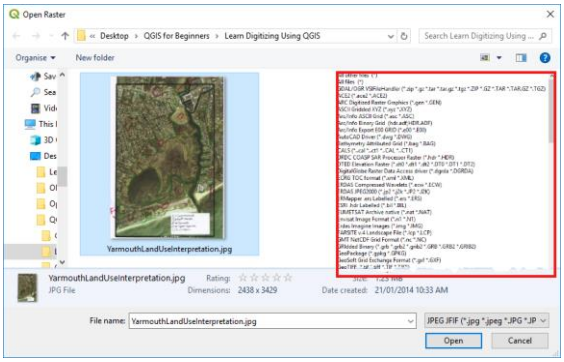


4 Click the *Open raster* button to open the scan.

Scans are also known as *rasters* and *bitmaps*.

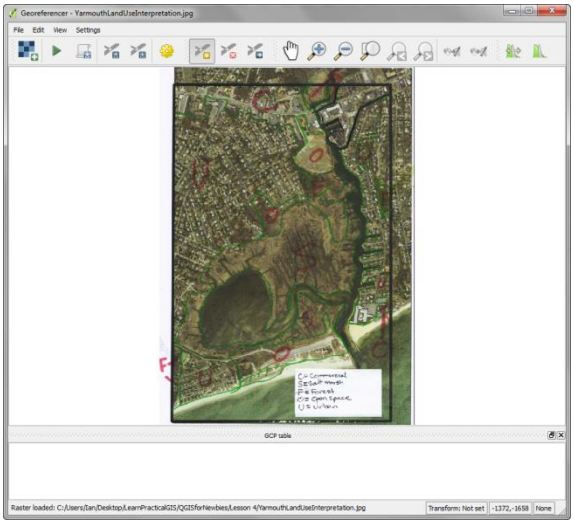


From the drop-down menu, choose the file type as *.jpg. Take the time to explore this menu. There's a bunch of raster file types that QGIS can use.

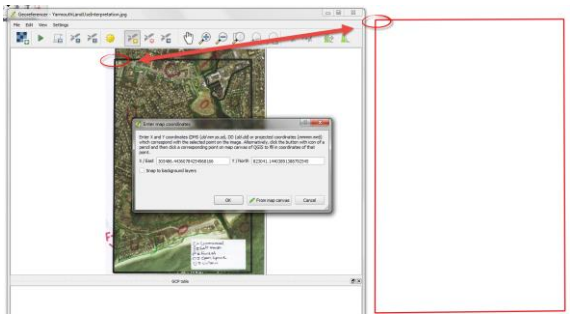


I've already scanned the map for you, so select the scan called YarmouthLandUseInterpretation in *…\Desktop\QGIS for Beginners\Learn Digitizing Using QGIS* and click the *Open* button.

5 The scanned Land Use interpretation opens and its ready to be geo-referenced.



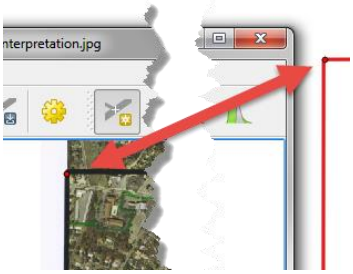
6 Now we need to find common points in both the scan and the GIS maps in QGIS. In this case, we're matching the surrounding rectangle on the scan, to its GIS version. So be sure that LandUseInterpretationClipRegion.shp is open.

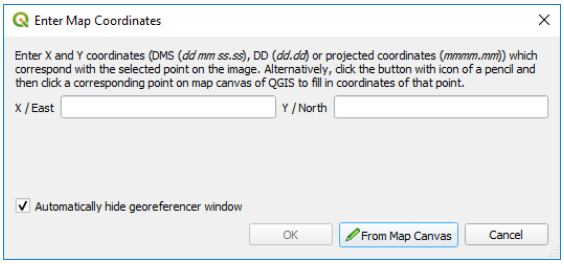


Begin by zooming into a corner of the clip region on the scan.

 Then click the Add point button…

- On the scan, click your left mouse button on the top-left corner of the clip region.
- The *Enter map coordinates* box will appear.





From the *Enter map coordinates* dialog…

- Click the From map canvas button and the map canvas will display.
- Place your mouse over a corner of the clip region in the QGIS main map window with your mouse. Use your mouse wheel to zoom in close.
- Click the left mouse button to add a point and the X and Y coordinates will be populated.
- Click the *OK* button and dots appear in both the georeferencer and main QGIS map windows.

Repeat these steps for each of the four corners of the clip region.

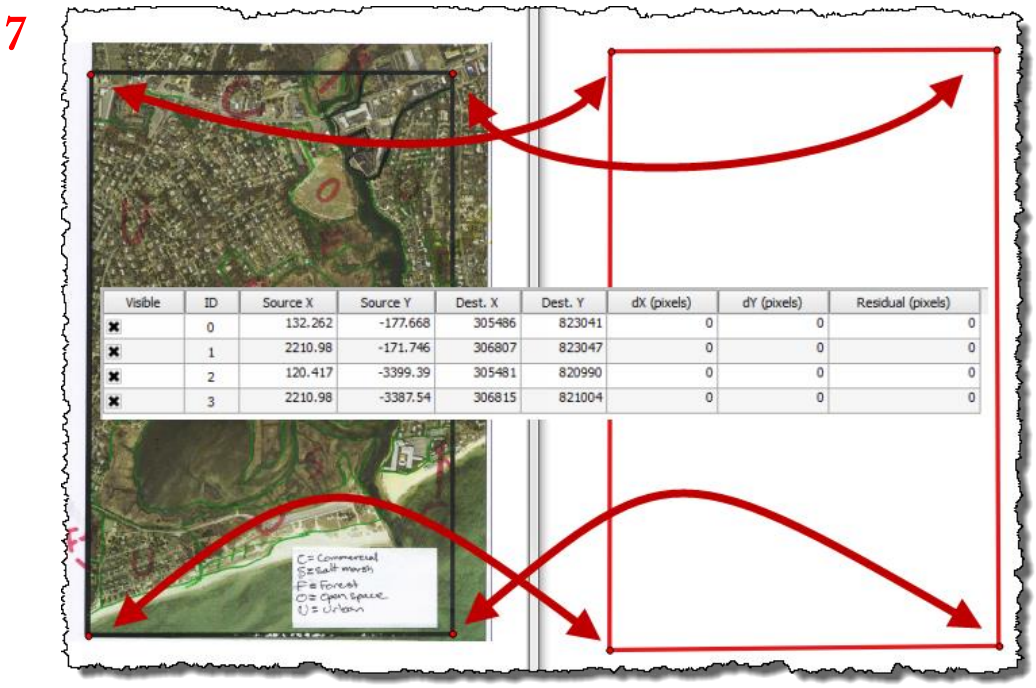


Figure 11: Georeferencing involves mapping a scan's pixel coordinates to GIS coordinates.

You can see our four GCPs and GCP table in Figure 11 as a red dot in each corner of both images. GCPs are simply places in the scan on the left (in pixel coordinates) that you can also find in the GIS map on the right (in the Massachusetts Mainland coordinate system).

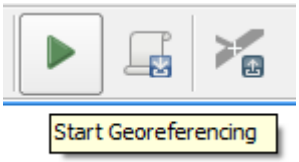
There's some things to note in the *GCP table*…

- The *Visible* checkboxes allow you to enable or disable a GCP. This is important functionality, especially if you accidently digitize one in the wrong place.
- The *id* of the *GCP* starts at zero, not one!
- The *Source X* and *Source Y* columns refer to the **Pixel Coordinates** of the scanned map interpretation.

- The *Dest.X* and *Dest.Y* columns refer to the **Destination Coordinates** in the GIS map on the right. These are in the Massachusetts Mainland coordinate system.
- The *dX (pixels), dY (pixels), and residual (pixels)* columns refer to error. In other words, is one of your GCPs in the wrong place? In this example all are zero so the match is perfect! Zero residuals don't occur all that often. Its common to have errors of two or three (when you've got good control) or up to ten or fifteen when the control is poor such as when your GCPs are trees or other poorly defined features. Depending on your project, you might get away with errors up to say around twenty. There are no hard and fast rules here. There are often many factors in play. You should always test to see if your georeferencing results are acceptable. After I run the geo-referencer, I will overlay cadastral maps. That way I can see how well the GIS property boundaries overlay onto the rectified image.

I could write paragraphs and paragraphs about this stuff, but I really think I'll do a much better job of explaining it in the video.

8 Once you've digitized the four Ground Control Points then click the green arrow to start the georeferencer.



Click the **Start Georeferencing** button again after the settings are loaded

9 Next, the *Transformation settings* dialog box will appear. This looks a bit daunting at first glance, but because we've got a good quality scan to georeference (the basemap and its border was printed from QGIS and was scanned pointing north), all you really need to do is to…

- Set the Transformation Type: Polynominal 1
- Set the resampling method: Nearest neighbor
- Set the target Spatial Reference System (SRS): Massachusetts Mainland. **
- Ensure that you nominate an *Output raster*. Call it *YarmouthLandUseInterpretation_rectified.tif*
- Check the *Load in QGIS when done* box.

The rest will look after itself.

We can take these defaults because we're starting off with a basemap that

- has already been photogrammetrically corrected, and
- has been carefully placed in the scanner so it faces north.

We only need to *geo-reference* our interpretation and we don't need to *geo-rectify* it. Rectification is a far more sophisticated process and is explained in the next section. Click the *OK* button and the settings are loaded. Then click the program runs and the processed image will load in QGIS.

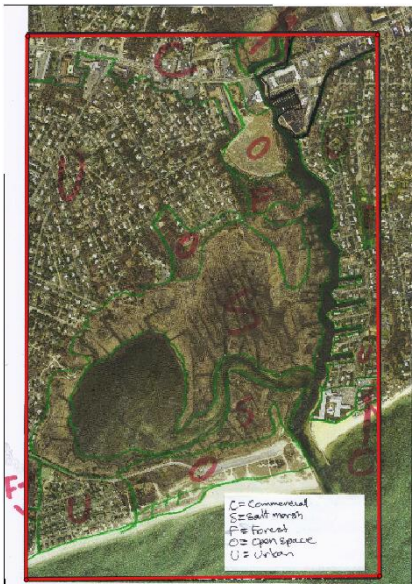
** *It is imortant to choose the same coordinate system as the other GIS maps you're using.*

If you don't then you're just setting yourself up for a disaster!!! It can cause maps to be displaced a few metres, a few hundred metres, or even thousands of kilometres in error.

In this case all our maps are in the Massachusetts Mainland coordinate system (ESPG: 26986). The Filter box in the coordinate reference system selector dialog allows you to refine your search. Find the Massachusetts Mainland coordinate system (ESPG: 26986), select it with you mouse and click the OK button.

10 And, here it is. Done!

As a test you should overlay the clip region onto the processed Land Use interpretation. Shade the GIS clip region pink and with no fill and it should look like this one here!



What's the difference between Registration and Rectification?

If we wanted to bring an un-processed air photo into QGIS, then we would need to...

1. Have a whole bunch of Ground Control Points, and
2. Experiment with the *Transformation type* and *Resampling method* options.
3. Possibly correct the photo in stages.

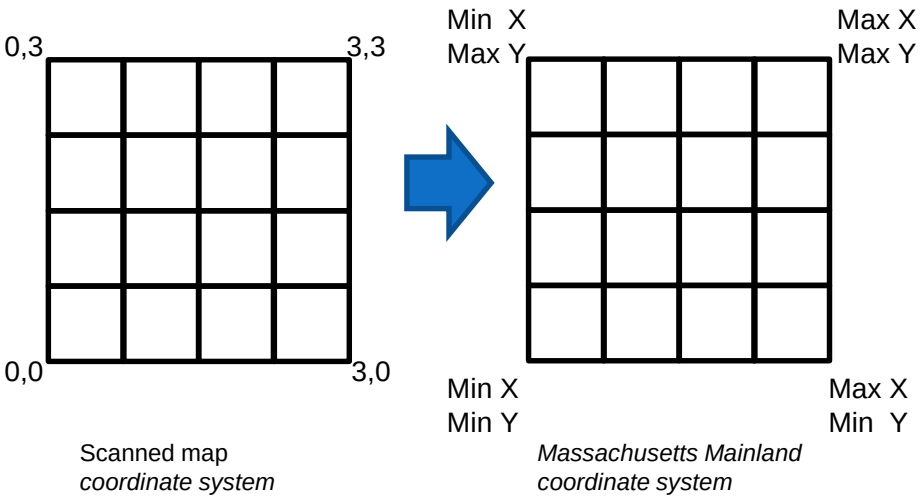


Figure 12: Registration is all that's required because the scan on the left is correctly oriented and not distorted in any way. It only needs to be matched to a coordinate system.

Because the base-map we're using in this exercise has been produced using GIS maps that are already accurate, and I've placed the interpretation squarely in the scanner, the field-interpreted map only needs to be *registered*. By this I mean that the scanned interpretation only needs to be matched to coordinate system. This means that we only need a small number of ground control points and minimum computer grunt to place the interpretation into the Massachusetts mainland coordinate system. Other geographical information systems such as Mapinfo and Arc would only attach a text reference file (such as mapinfo and arcview world files). But, the QGIS geo-referencer seems to do genuine resampling.

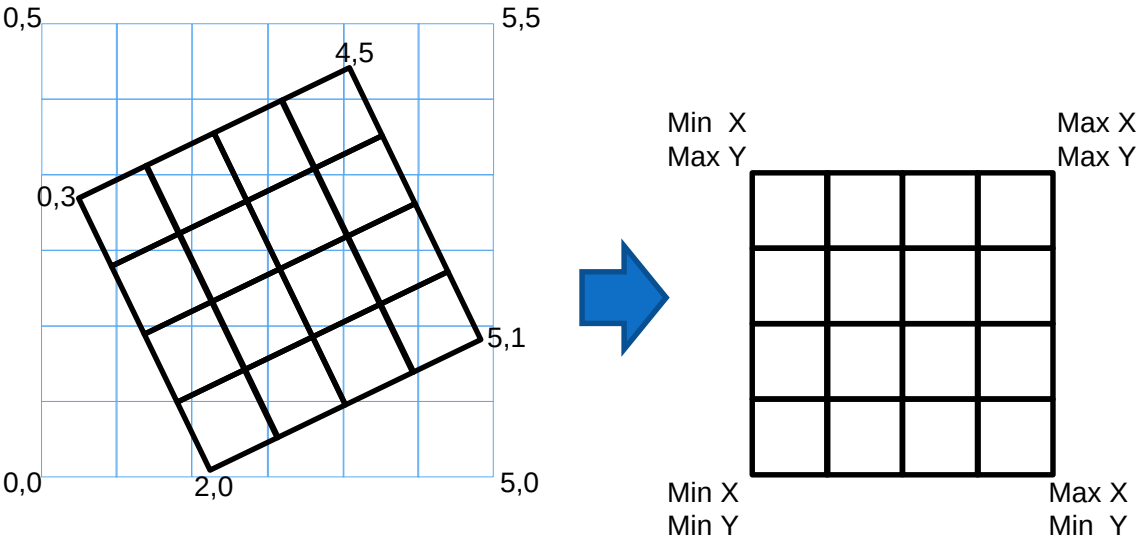


Figure 13: Rectification is required because the scan on the left needs to be rotated so it can fit into the Massachusetts Mainland coordinate system.

Things are not always so easy. The base map where using in this tutorial is ideal for geo-referencing.

Rectification is a process where your scan is digitally re-oriented to face north. It involves using many more ground control points than were used for the registration exercise. In QGIS it's just a matter of using a different algorithm from the drop down box in the *transformation settings* dialogue. If you need to rectify an image for your own project then you should do further reading in the Quantum QGIS manual. However, what I show you in this lesson provides a very good foundation for understanding the process.

PART 3: PREPARE YOUR ON-SCREEN DIGITIZING ENVIRONMENT

A bit of background to digitizing

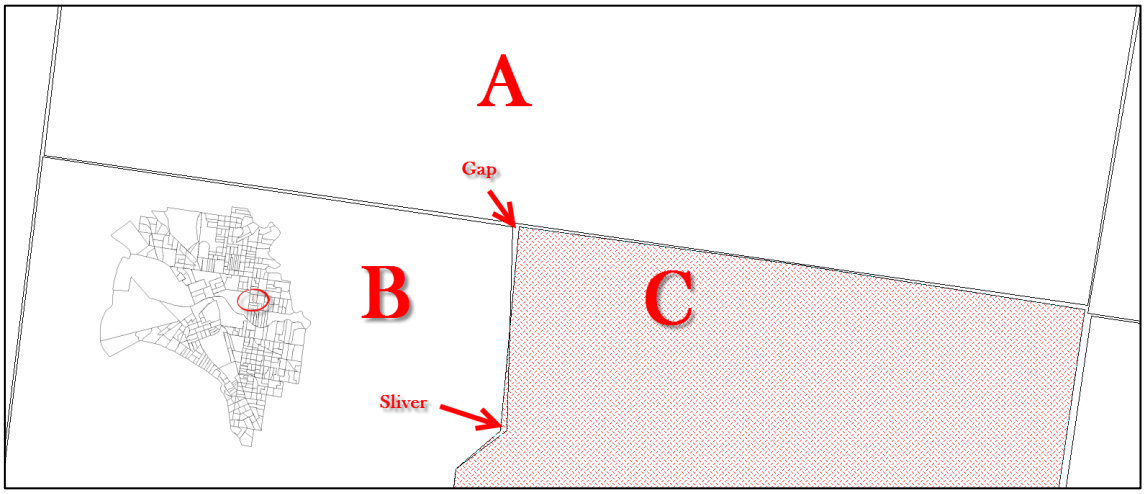


Figure 14: Two digitizing errors we're likely to come across in this exercise are *slivers* and *gaps*. These are often difficult to see unless you zoom in closely.

Digitizing is the process by which we convert hard copy maps into vector GIS maps. There are three main ways to digitize hard copy maps…

1. Use adhesive tape to stick a paper map to a special digitizing tablet. Then use a special mouse called a puck to trace the features into your GIS.

2. Scanning a map and then use advanced GIS processes to convert the scanned features into vector GIS features
3. Scanning a paper map and then on-screen digitizing the GIS features from it. You do this by tracing the features on the scan with your mouse.

In this lesson we'll learn the scanning and on-screen digitizing technique.

Digitizing is tedious work that few people like doing. So, after you've input a few maps of your own, you should feel proficient enough to train someone up to do some of this for you. You should take great care because errors introduced here will flow through to the rest of your project. Two of the errors you're likely to come across when you're digitizing this exercise are shown in Figure 14. Although the map in the inset seems OK, when you zoom in you can see

1. gaps between the polygons and
2. places where polygons overlap.

Although neither are major problems if you're only creating thematic maps, both will cause errors when you're making geographical queries…

1. Because there is a *gap* there's no way to tell that polygon A is next to polygon B.
2. In *topological* GIS maps, the *sliver* between polygon B and polygon C will become a very small unattributed polygon. In non-topological GIS maps, polygon C will report as being larger than it should be.

The more sophisticated spatial databases that QGIS connects to such as Grass, Postgres, and Spatialite are far more intelligent and far less forgiving than the shape file we'll be digitizing in this tutorial. These databases use what are known as *topological* data structures. Topology is where a polygon knows everything about every polygon that adjoins it. Spatial queries (eg. "how many m^2 is 10 Smith St") can be made directly to these databases without the need to involve QGIS. In contrast, for the shape file we're about to create, you have to run a QGIS query to find information about adjoining polygons.

In a little while I'm going to show you a very elementary way to create polygons in the *Shape file* we just created. For most small GIS projects this file structure is more-than-adequate.

In fact, I never use topological GIS files in my consultancy work. The projects I work on are one-offs and are far too focused. Topological files can be a sledgehammer-to-crack-a-nut, and besides, it would take a long time to show you how to use the tools. At this stage I think you'd be overwhelmed. The smallest topological error generally means that a polygon won't create. Such errors can be very difficult (and frustrating) for inexperienced users to trace.

How to create a blank map to Digitize into

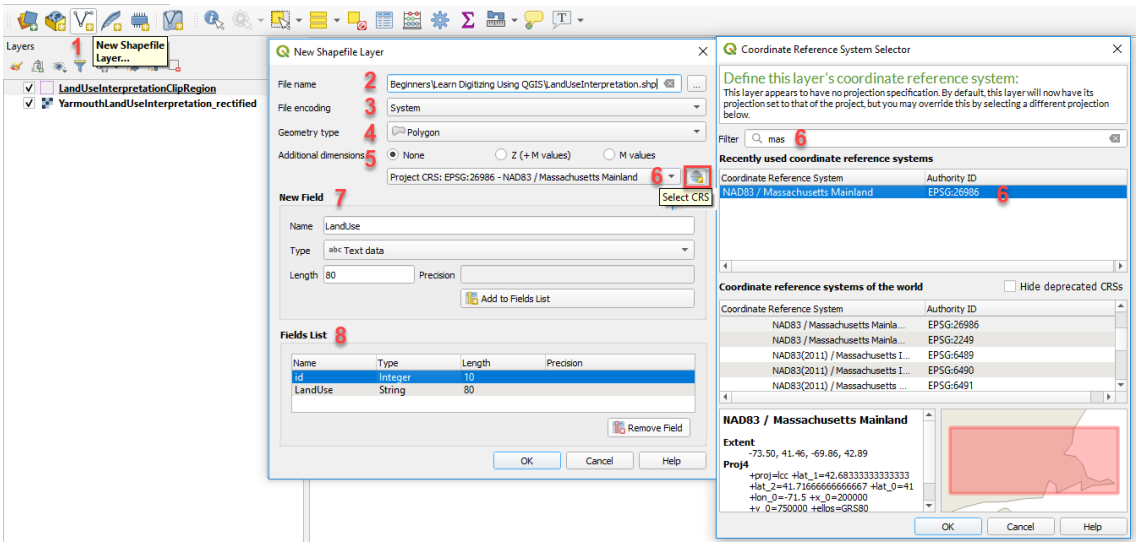


Figure 15: A composite screen capture of the "New Shapefile Layer" dialog boxes.

Let's start with a quick recap of where we are. The Clip Region in our georeferenced scan matches the Clip Region in QGIS perfectly, and we can overlay other GIS maps onto it.

The scan is now a dumb backdrop. It is just a drawing. You cannot query it. You cannot thematically map it. Before we can do either of those things, we need to on-screen digitize the lines that were drawn on the scan, and make them polygons.

1. Click the New Shapefile Layer button to launch the New Shapefile Layer dialog box. Enter the following Information…

2. File Name: In our "Learn Digitizing Using QGIS" folder, add the file "LandUseInterpretation.shp"

..\Desktop\QGIS for Beginners\Learn Digitizing Using QGIS\LandUseInterpretation.shp

3. File encoding: Choose “system”. Another safe option would be UTF-8.

4. Geometry type: Choose Polygon. The other geometry types (Points, Lines and multi-point) are described in the eBook glossary.

5. Additional dimensions: Choose None. Other dimensions (Z and M values) values are described in the eBook glossary.

6. Coordinate / Spatial reference system: Click the “Select CRS” button. In the dialog, choose Massachusetts Mainland system (NAD/83 ESPG 26986). Type “Mas” into the filter area to refine your search.

7. New field: Enter “LandUse” (as one word). This will hold the Land Use the code ('Commercial', 'Salt Marsh', etc.) for each Land Use polygon that we digitize.

Type: Text (text and other data types are described in the eBook glossary).

Length: Make this 80. You really only need to be conscious of column widths for large files.

Click the “add to field list” button.

8. Fields List: Because we’re not going to use the ID column we should delete it. In a corporate situation you would need to be sure that this column was not being used elsewhere in the system first.

Highlight the field name and click the 'Remove attribute' button to delete it.

9. Finally: Before we click 'OK' and create the blank Shape File, you should double-check your dialog box against the one in this video or the eBook.

Click 'OK' and our shapefile will be added as a new map layer.

How to create a donut polygon

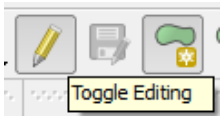
Before we start digitizing from the scan that we just registered, we need to create a donut polygon over our study area. Without a donut, we would not have an edge to digitize against. The steps to do this follow…

Create a polygon that we can cut a hole out of

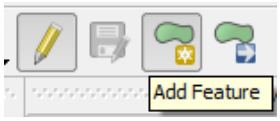
1 Be sure you have the following shape files open …

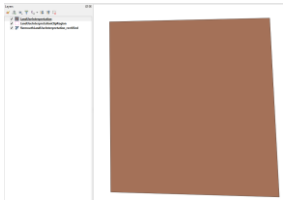
- *LandUseInterpretation*
- *LandUseInterpretationClipRegion*
- *YarmouthLandUseInterpretation_rectified*

2 Use your mouse to highlight the *LandUseInterpretation* shape file and then click the *Toggle Editing* button to make it editable.



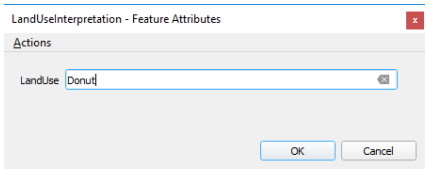
3 Click the *Add Feature* button and then click-click-click with your left mouse button until you have a large polygon over the top of *LandUseInterpretationClipRegion*. Then complete the polygon by clicking your right mouse button.



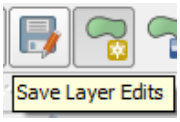


The polygon you have just created will become our donut (polygon with a hole in it). It doesn't need to be perfect because we're going to delete it when we're finished.

4 When you complete the polygon by clicking the right mouse button an *Attributes* box will appear. Enter "Donut" as the LandUse.

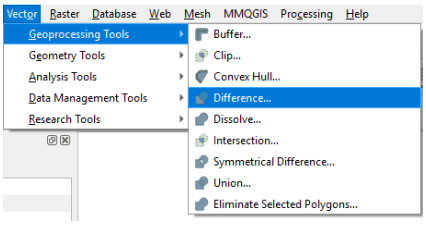


5 Save your changes to the *LandUseInterpretation* shape file



Use the Difference functionality to create a new file with a hole in it

6 From the *Vector -> Geoprocessing Tools* drop-down menu choose the *Difference* option and launch the *Difference* dialog box.



7 Choose the following…

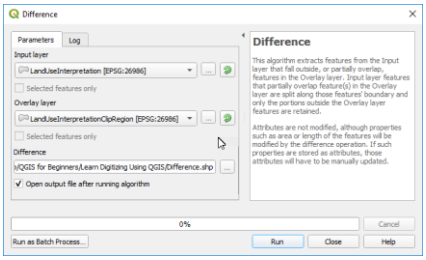
Input vector layer*: LandUseInterpretation*

Overlay layer: *LandUseInterpretationClipRegion*

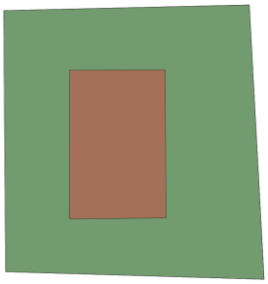
Difference file: *Difference (make sure it's a shape file).*

Check the *Open output file after running algorithm* box.

Click OK.

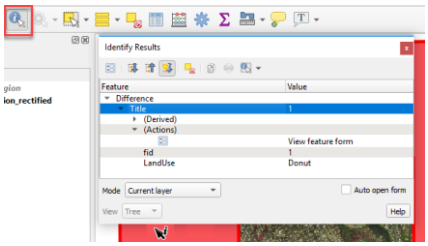


8 Voila! We now have a donut shaped polygon to digitize against.



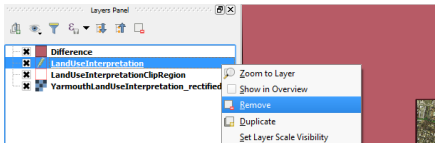
Overwrite the LandUseInterpretation map with the new file

9 Highlight the *Difference* map in the Layers area.



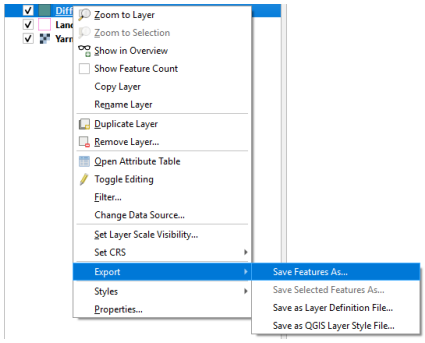
Click on the Identify features button and then on the polygon in the *Difference* layer. Note that it has inherited the LandUse column, and even the *donut* attribute.

10 Now we're going to overwrite the *LandUseInterpretation* shape file with the *Difference* shape file. First we need to close *LandUseInterpretation*. Otherwise we'll get a "file in use" error message.

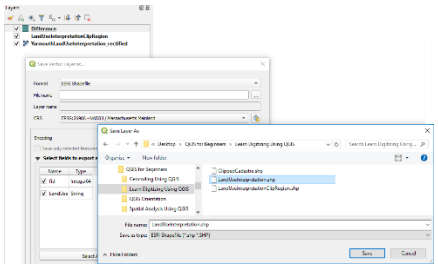


Right-click *LandUseInterpretation* and then left-click Remove

11 Right-click *Difference* and then and choose the "Export -> Save Features As..." menu option. In the "Save Vector Layer As…" dialog…



In the Save vector layer as… dialog



a. Browse to find LandUseInterpretation.shp

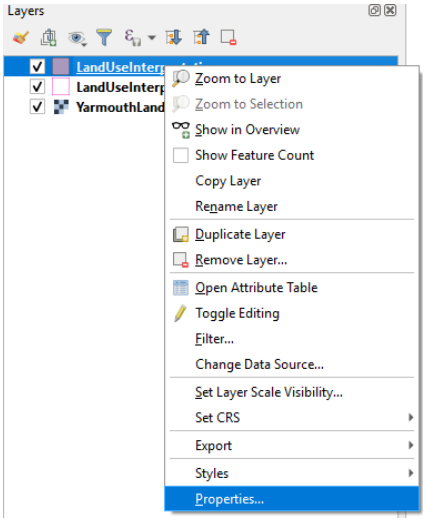
b. Highlight it

c. Check the "Add saved file to map" box.

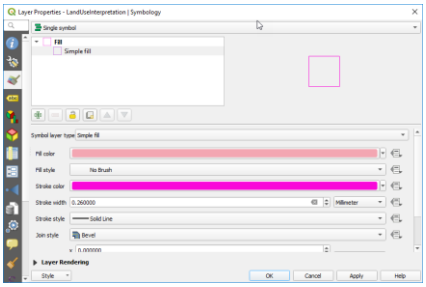
d. Click Yes to Replace.

Change the display style of LandUseInterpretation

12 Right-click “LandUseInterpretation” to launch the Layer Properties dialog.

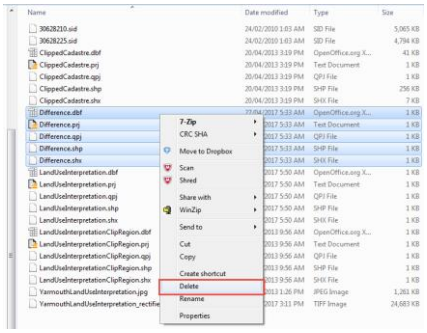


13 Change the style to be pink with no brush. Having the polygons transparent will make it easier for us to digitize in the next section.



Housekeeping

14 Now go to the gis-for-beginners-digitizing folder and delete the *Difference* shape file. We're doing this only for housekeeping purposes. Its very easy to lose track of what files are what if you don't.



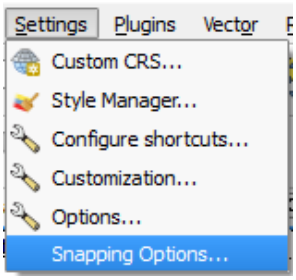
Highlight all the components and either right-click to delete OR depress the Delete button on your keyboard.

How to set the snapping options

Snapping options are common to all GISs. Because adjoining polygons must join each other “exactly” (see Figure 14), snapping options allow you to define how close you need to be to another polygon for the polygon you’re digitizing to automatically snap to it. You need to set these before you start. Otherwise your map will be junk!

I suggest that you begin by following the technique I set out below, and once you become comfortable with that, then experiment using different combinations of the options. You really only get to understand some of these things once you take the time to play with them.

From the settings menu choose *Snapping Options*. This box is where you set all the options that allow you to digitize in a way that’s as topologically correct as you can get with a shape file (shape files don’t have true topology). By this I mean that it allows you to digitize in a way that there are no overlaps in your maps. I explain below…



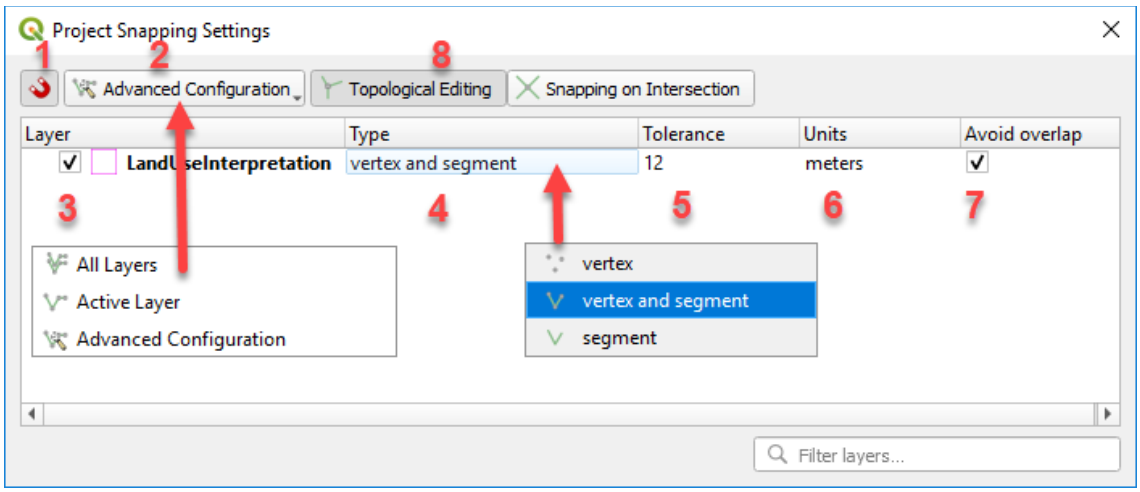


Figure 16: Snapping options

1 Click the horseshoe to enable the snapping options dialog.

2 Choose Advanced Configuration from the drop-down menu. You can choose to edit the Snapping Options for the Active Layer (selected in the Layers Panel), all the layers, or launch this Advanced dialog.

3 Check this box to enable the snapping options for a map. The map you check is the map you're going to "snap" to. So, you can edit one map and snap to a different one!

4 This is where you choose what you're going to snap to. The options are *vertex, segment, vertex and segment.* When you're on-screen digitizing, each mouse click creates a vertex (sometimes called a node), and the bits between vertices are known as segments.

5 & 6 Snapping tolerance options are *pixels* or *map units.* In this example, if a *vertex or segment* is found within *12 pixels* the mouse click is automatically moved to the closest vertex or segment.

7 Clicking this allows you to avoid overlapping adjoining polygons. In the absence of this you would have to digitize the vertices for adjoining polygons in the same place – a very tedious process. If you fail to set this correctly your map could end up looking like the one in Figure 14.

8 This option allows you to more easily maintain shared boundaries. Be sure to click it if you are digitizing polygons.

Click the 'X' button in the top-right corner and dismiss the dialog.

PART 4: HOW TO ON-SCREEN DIGITIZE A MAP

Now go ahead and digitize the polygons using the digitizing tools. Each polygon contains a letter that indicates its Land Use category and you should attribute each one according to the values in Table 1.

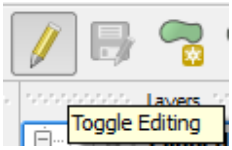
Identifier	Category
C	Commercial
S	Salt marsh
F	Forest
O	Open space
U	Urban
	Water

Table 1: Land Use categories

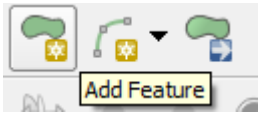
1 Be sure you have the following files open …

- **Shape files:** LandUseInterpretation and ClippedCadastre
- **Raster scan:** YarmouthLandUseInterpretation_rectified
- **Raster air photos:** 30628210 and 30628225

2 If you haven't already, move your mouse to the *Layers* window and highlight the *LandUseInterpretation* shape file. Click the *Toggle Editing* button to make the map editable.

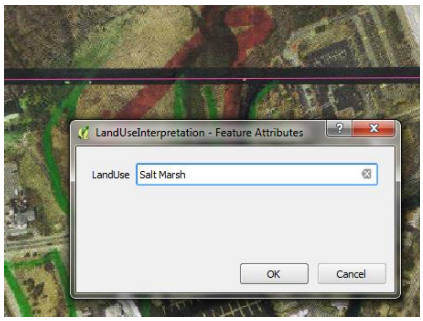


3 Now, on the interpretation, zoom into a polygon you intend to digitize.



Click the *Add Feature* button and then click-click-click with your left mouse button until you have traced a large polygon over the top. Complete the polygon by clicking your right mouse button.

4 An *Attributes* box will appear. You should enter the appropriate LandUse as per the legend at the bottom right corner of the interpretation scan (or Table 1).



5 Here it is. The first polygon. Because of all the *snapping options* we did earlier in this lesson, its neat and tidy against the edge of the donut polygon. If its not neat and tidy, you should check your snapping options against those in Figure 16.

For the purpose of the screen capture, I've elected to show the attribute as a label. I'll show you how to do this later in the lesson.

Continue digitizing until you have finished the entire interpretation. Please don't skip any part of this. I really want you to get some practical experience so you can better understand

1. how tedious this process can be, and
2. the nature of the decisions that the person who created a map, and the

person who digitizes a map must constantly make.

The beautiful neat looking GIS map that's the end result often masks these decisions!

Here's some digitizing issues you should think about…

- GIS lines and boundaries are infinitely thin, but the lines you're digitizing your interpretation are as thick as the Chinagraph pencil that was used to draw them. Use the QGIS *measure* tool to measure the thickness of a Chinagraph line on the field interpretation. You'll find they're 10 metres wide in places.
- Map makers must make decisions relating to scale and detail. For example, for some studies water features are important and for others they're not.
    - Which waterways should be included and which ones left out? And why?
    - How detailed should the digitizing be? Should you digitize just the centre of the watercourse, or both its banks? And if you digitize the banks, how do you define these? Most air photos are taken in summer, so your interpretation will be based on summer water levels. But winter and flood flows are much higher and so the watercourse map would look different. These are important issues because maps often become the basis for legal decisions.
    - Should the interpretation and digitizing tasks be approached with just the current project in mind, or future projects as well?
- Clues in air photos can help you with your interpretation. For example, in our small digitizing example you can tell where a waterway stops and a salt marsh starts because the salt marsh in the air photo has straight drains rather than meandering waterways. Swamps have drains!
- How do you deal with polygons in the field interpretation that have accidently not been attributed?

Note the Chinagraph lines that are crossed out at the bottom of the interpretation. This is a standard editing practice for features that were drawn by mistake.

How to Copy Other People's GIS Maps Into Yours - Geographical Editing

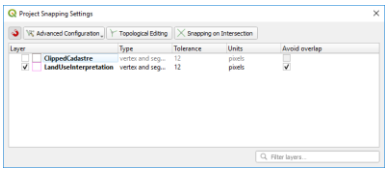
So now to the tricks. These involve using standard copy and paste functionality. We're going to incorporate QGIS map editing functionality such as *split features*  and *merge*  . Don't panic. I'm not going to get you to digitize the entire map again. I just want you to create a couple of polygons to see that there's other ways of going about digitizing.

1 Open…

- YarmouthLandUseInterpretation_rectified.
- ClippedCadastre
- LandUseInterpretation

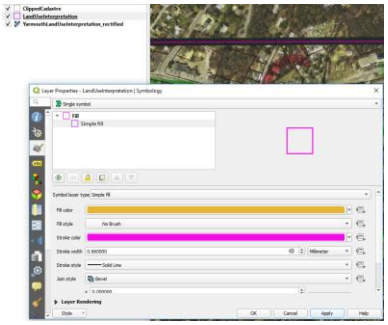
2 Highlight the *LandUseInterpretation* map in the *Layers* area and then click the *Toggle Editing* button to make it editable.

3 Ensure the Snapping Options for *LandUseInterpretation* are identical to the *Snapping options* box on the right. This is a place where beginners can trip-up, so be sure to pay close attention to the details.



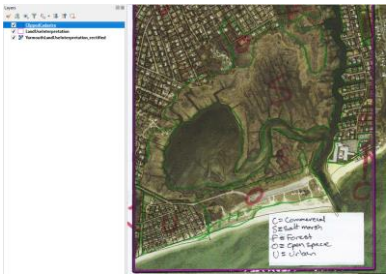
Revise the *How to set the snapping options* section of this lesson if you need to.

4 Right-click on *LandUseInterpretation.* In the *Layer Properties* dialog and make the *fill style* "No Brush". That way you can see through the polygon to the hand-drawn lines underneath.



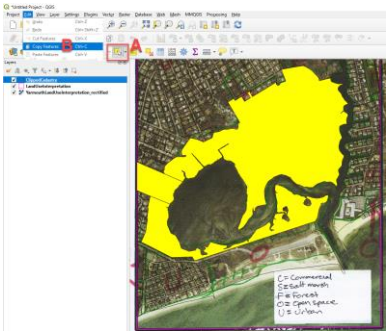
If you're not in a hurry, have a bit of a play with this dialog. The more you play and experiment the more confident you'll get with QGIS.

5 Turn on and highlight the ClippedCadastre map in the Layers Panel. This tells QGIS that we're going to perform some action of the ClippedCadastre map. Now zoom into the area shown here. Rather than digitizing the salt marsh by hand, we're going to make use of boundaries that already exist in the cadastre.



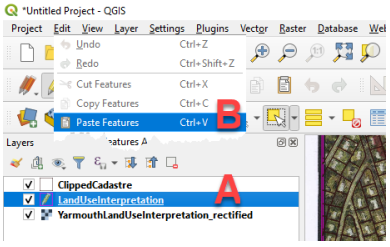
6 **A** Click the *Select* button. Then, while holding down the *Ctrl* key on your keyboard, select the three cadastre polygons shown in the screen capture.

B From the *Edit* drop-down menu, *Copy* the selection.

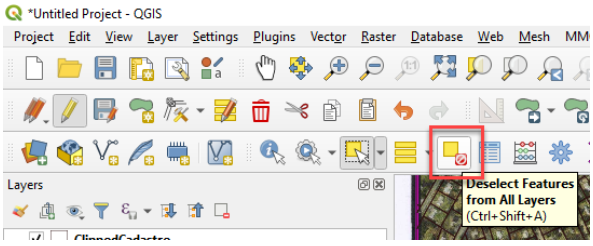


7 **A** Highlight *LandUseInterpretation* in the Layers box on the left (remember that it's still "editable")

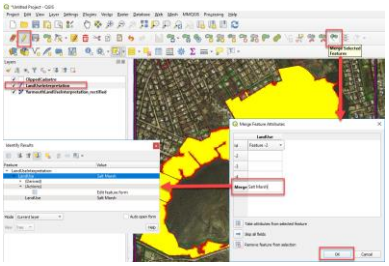
B From the *Edit* drop-down menu, choose to *Paste Features* into *LandUseInterpretation*.



8 Here's what you should end up with after clicking the Deselect Features from All Layers button. Note that you can see the hand drawn interpretation underneath.



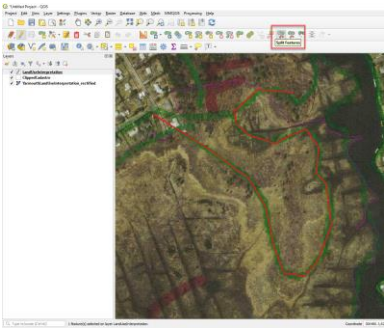
9 The first thing we need to do is to merge the three cadastral polygons we pasted into the *LandUseInterpretation* map, into one polygon.



- Highlight *LandUseInterpretation* in the Layers box on the left and be sure it's editable.
- Click the *Select* button.
- While holding down the *Ctrl* key on your keyboard, select the cadastre polygons shown in the screen capture.
- Click the *Merge Selected Features* button and type "Salt marsh" into the *Merge* field.

Click *OK* and the three polygons are merged.

10 We have a problem to fix. Although the merged cadastral polygons accurately represent the boundary of the salt marsh, they do not represent the Land Use interpretation. Fortunately for us, the Salt Marsh is reflected in the cadastre. However, mostly, this is a coincidence. To fix this we need to use the *Split Features* tool…

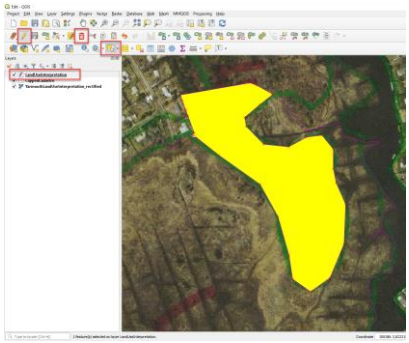


- Zoom into the area shown on the right
- Click the *Split Features* button and using your left mouse key, trace the interpretation as shown on the right. Right-click to split the polygon.

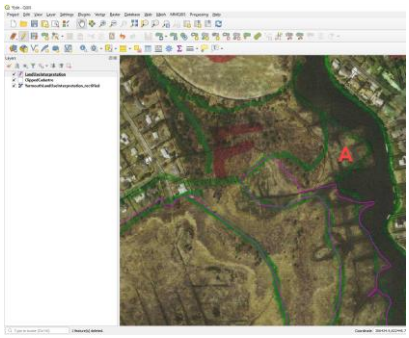
11 Now we need to delete the polygon we just created with the *Split* tool.

A Click the *Select* button.

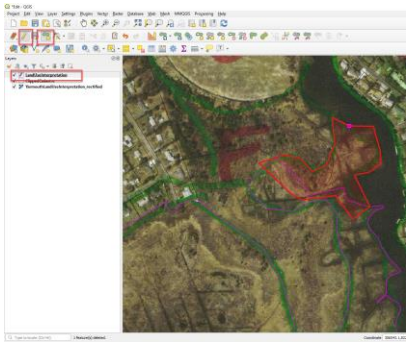
B Click the *Delete Selected* button…and the polygon is deleted.



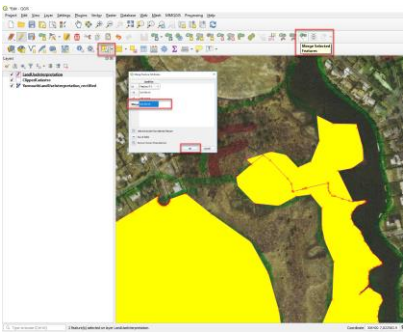
12 We have another problem to fix. The salt marsh polygon should extend into the area at **A**...



Click the Add Polygon Feature button to digitize a polygon along the lines of the one in the screen capture.



13 Now merge the two polygons in the same way you did in step 9.



14 Done!!!

Continue using the Copy, Paste, Merge, Split, Delete techniques I've just shown you to complete the digitizing exercise.

When working on your own projects, you should always start digitizing your map with this technique. Then digitize whatever is left by hand.

Armed with your newly acquired digitizing skills and the bunch of issues that I've asked you to consider, now digitize the polygons for the entire interpretation. As is often the case, there is no right or wrong for how you approach this task. You might choose to be very precise and click-click-click hundreds of times for each polygon, or maybe just tens of times or even a few times. As you're digitizing, I'd like you to think through the issues with each approach. They feed into the scale you nominate your map to be in within its metadata record. How would you describe the scale of your digitized map when you've finished it?

Other Useful Maps

In this exercise we used a boundary from a cadastral map to represent the edge of the Salt marsh. Other types of maps can be very useful sources of boundaries. Often you need to think beyond what maps appear to be at face value. Some examples follow…

- **Contours:** Sometimes a contour can be used as a demarcation line. For example, "use the 12 metre contour as the boundary for a soil"..."or for an excavation", etc
- **Roads:** The oldest roads are usually on the easiest land to build on. They are often on land that's the least susceptible to flooding. I could imagine using an old road to delineate a 1 in 100 year flood level.
- **Railway lines:** The requirements for minimal grade and all weather operation mean that railway lines usually follow high or dry points in the local terrain Often these might give clues to soil boundaries, indigenous vegetation communities, or even burial sites for artefacts.
- **Cadastre (land ownership):** This often demarcates the best land from the poorest, or new housing estates from old housing estates, or swamp land from developable land.

Copying Other People's GIS Maps Into Yours - Intellectual Property Issues

Having digitized this land use map, I think you've done enough digitizing now to understand that it can be a real pain. And that even though it is a pain, it is important because a GIS map that has been properly digitized forms a good foundation for your project. Remember…*Garbage in, garbage out*!

I want to spend a little bit of time talking about a couple of tricks you can use to make digitizing a bit easier. These tricks involve taking boundaries from other GIS maps, so you need to be sure that you're legally allowed to take them. This is a very important point because stealing can get you into a lot of trouble! Maps can cost millions of dollars to create, so you can expect that map producers will be motivated to protect their copyright in the courts…

- Governments usually own most of the GIS maps you're likely to want to use. Some governments use Creative Commons licensing (variants of the term Public Domain) and others use Copyright. You should check the websites you're

downloading from to see if the license conditions allow your intended use of the data. The maps used in this course are from www.massgis.gov, and the Terms Of Use allow me to distribute them to you on the basis that my use of the data involves “teaching”. Here’s an extract from the license…

The Commonwealth holds a copyright interest in most of the material posted on Mass.Gov…With respect to material in which the Commonwealth holds the copyright …the Commonwealth forbids any copying or use other than "fair use" under the Copyright Act. "Fair use" includes activities such as criticism, comment, news reporting, teaching, research, and other related activities.

- Some organizations will “license” maps to you. Some licenses will allow you to copy features from the licensed maps and others won’t. In any case, if you copy bits of licensed maps into your own maps then you’re unlikely to be allowed to keep those bits once your license has expired.
- So, be sure to read the license conditions for any GIS maps you use. The uses least likely to be approved at no cost are commercial ones and the uses most likely to be approved relate to community, teaching and research. You should contact the owner of the map if you are in any way unsure of their terms of use, and preferably you should get written permission from them. Emails are often sufficient.

PART 5: HOW TO VALIDATE YOUR MAP

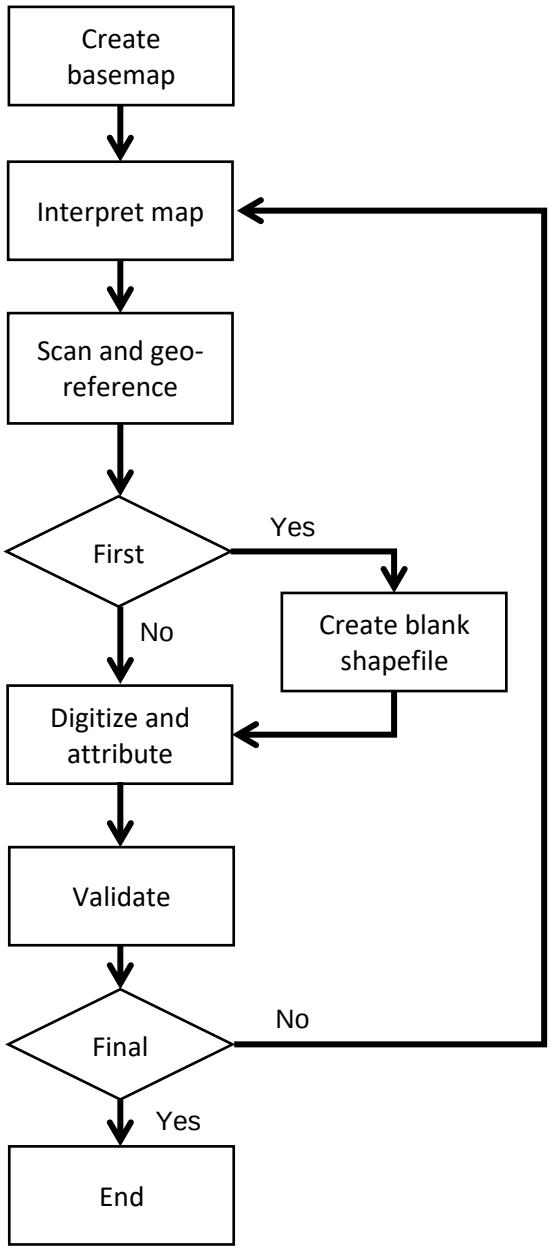
Now that you've digitized the map you need to print it out for the field staff to validate. Have a close look at it yourself first…

- If your map is reinterpretation of an old map, then refer back to the original map to be sure the new map makes sense. Shade the reinterpretation to be the same as the original. Can you see the same shapes?
- Use Google Street View to have a look at any places you're not sure about if its available. In some cases, the absence of photography can say as much as the presence of photography. If is not available then maybe the photography was too hard to collect, or was not worth collecting.

When you're satisfied that you have an understanding of the map, return the draft to field staff for validation and take the time to point out any errors or discrepancies you found. Don't be embarrassed to ask questions. Just be as tactful as you can. Your input to the

project is as a spatial analyst and few people have that skill. Your questions might go along the lines of…

- For a demographic project: "Most of the census polygons you aggregated have populations of around 300 people. There are two polygons that are inconsistent with this - one has a population of 100 and another has a population of 600. Do you want to review these boundaries?"
- For an environmental project: "I noticed that you mapped a number of small hills. When I digitized the map I could see other small hills in the contours that you didn't map (eg. here, here and here). Was that intentional?"



Any corrections to be made at this point will force you to backtrack to the *Interpret map* box in the flowchart. Sometimes you can eyeball the corrections in, and other times you'll need scan and georeference the corrections. Whichever path you need to take, I feel confident that you now have the personal toolkit that will allow you to cope with it.

How to create a thematic map using categorical data

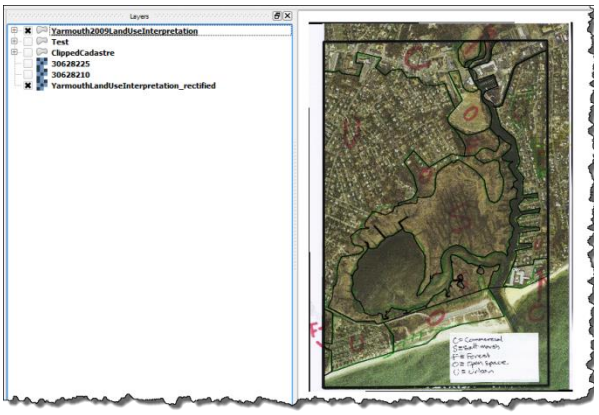
When we looked at the census we thematically mapped *classes* of data. To help us validate our map, we're about to thematically map *categories* of data. Validating our data categories is very important because when our map is topologically sound and our data

is represented by a consistent nomenclature we have a GIS Database rather than a Digital Map.

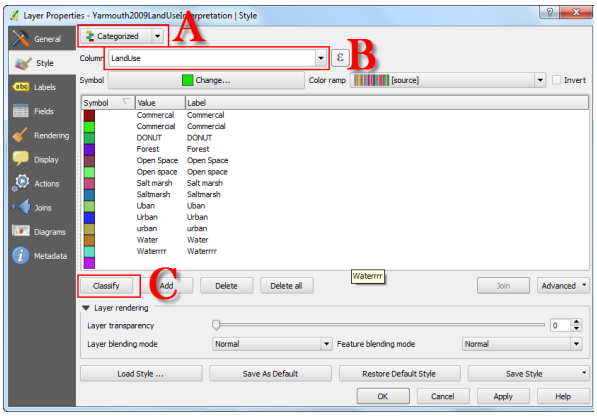
		Suggested color scheme			
Identifier	**Category**	**Color**	**Red**	**Green**	**Blue**
C	Commercial	Light pink	240	217	250
S	Salt marsh	Light blue	153	227	255
F	Forest	Green	97	204	38
O	Open space	Light green	191	255	191
U	Urban	Pink	255	209	204
	Water	Blue	0	85	255

Table 2: Land Use categories and suggested colours. These are here for reference only. Although I give a brief demonstration of these in the video, I intend to discuss colour schemes in a later lesson.

1 Here's the finished map. Now we're gonna shade it.



2 Launch the *Layer Properties* dialog for the *Yarmouth2009LandUseInterpretation* map

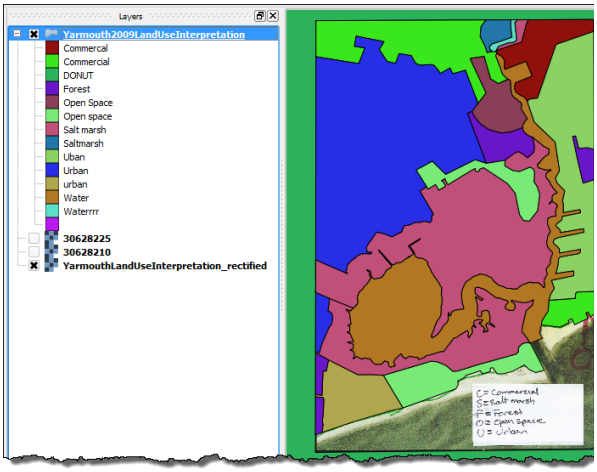


A Choose *Categorized* from the drop down list.

B Choose *LandUse* as the *Classification field*.

C Click *Classify* and every polygon I just digitized will be shaded a different color

3 Here's the shaded map based on just the defaults. But there are some problems that we need to fix…



- The first relates to *nomenclature.* Even though there might be many ways to describe a landuse, to prevent erroneous queries, in your GIS there should be only one way. In our digitizing example, because some attributes are incorrectly spelt there's a number of classes that shouldn't be there. Incorrect spellings are the simplest type of

nomenclature issue. QGIS is also case sensitive, so Urban is different to urban

There's a whole bunch of other nomenclature issues that you'll discover if you ever get involved in projects where you're combining maps that have been created by different people.

- I also digitized multiple polygons because some of the features were so big. These need to be merged.

4 To correct a polygon's attribute you need to…

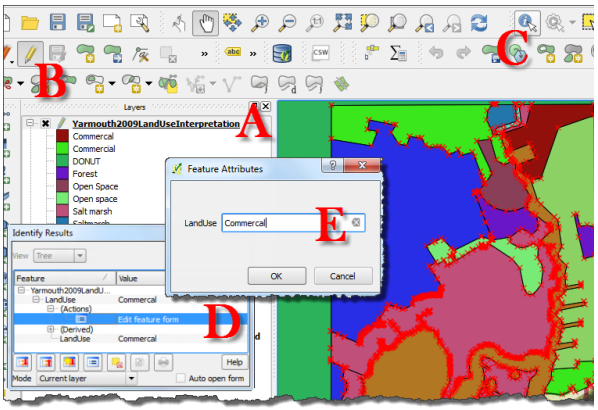
A Highlight the *Yarmouth2009LandUseInterpretation* map.

B Make the map editable.

C Click the information button.

D Click on category polygon to bring up the *Edit feature form.*

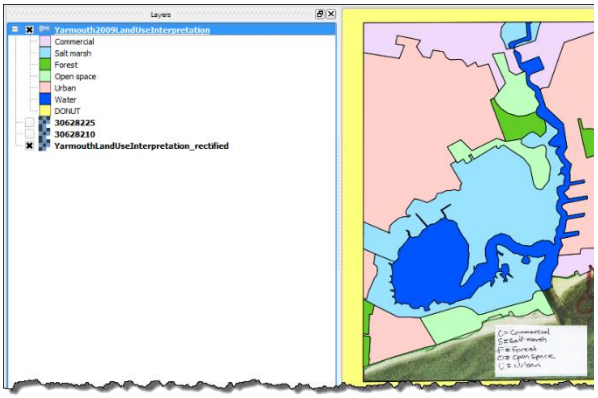
E Change the value of the attribute in the *Edit feature form*



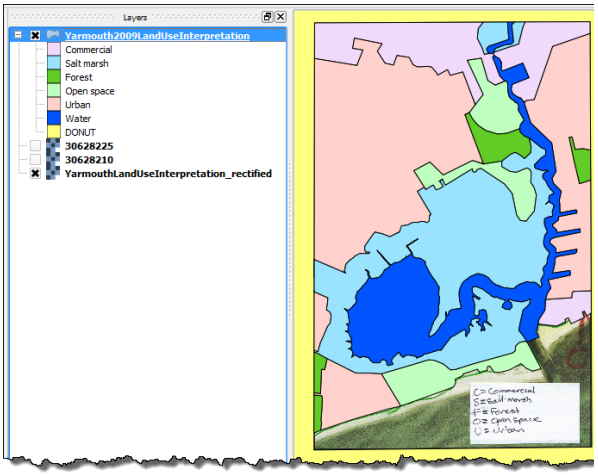
5 Once I'd fixed the nomenclature I was able to produce this map. The thing to note from this is the importance of "standards". In this case…

- Upper case first letter of a label and the remainder of the label as lower case.
- Correct spelling.

This way I was able to reduce fourteen legend categories to be seven.



6 The final thing was to merge adjoining polygons with the same value as I did in step 10 of the Advanced Digitizing section.



PART 6: THE ROLE OF OLD MAPS

In the absence of off-the-shelf maps for your very focused GIS project, you should turn your attention to archival maps. Did you know that some of the most valuable maps are to be found in libraries and in the back sleeve of old books and reports?

I recently used a military map from the 1800s to assist with an urban flood management study. The map showed swamps that were later filled and then built on. For the same survey I used oral history as a tool to discover the long filled-in *Misery Swamp*. I've also used old settlement maps to guide archaeological and vegetation surveys. I've seen studies where old planning maps were used to trace the previous owners of old contaminated industrial sites. This is very important information because brownfield developments are projects where old industrial sites are redeveloped to be residential.

The bad news is that for data quality reasons you can rarely bring old maps straight into your GIS. They often require reinterpretation. Unless you have the appropriate background, you'll need to work in a team to do this. Its common for team members to have no understanding of GIS. It can take some special skills and techniques to extract useful information out of them.

Where to look for old maps

An important issue facing many organizations around the world is the loss of corporate-memory. This occurs when long-time workers retire or are made redundant. When they leave they take the memory of the work they've been doing with them. Often, without realizing it, their work had a spatial component expressed as maps that accompanied the reports they produced.

Major events such as war and environmental disaster, or new ideas like environmentalism, meant that in some decades many reports were written. Prior to GIS and reliable scanning tools, these reports were not digitized, and so over the years many have been lost or forgotten.

In many cases the information contained in these reports would be very expensive or impossible to collect again. The good news is that most old maps can be reinterpreted and brought to GIS with the aid of contemporary maps such as geological maps, water industry maps, and maps produced by engineers and surveyors.

Why GIS engineering maps are so good

Engineers and surveyors have a strong history of inputting spatial data into GIS because much of the work they do is about managing assets. The land ownership and asset position jigsaw puzzle that's required for such management doesn't work well unless all maps are accurately captured and described in a GIS. When the maps are high quality, uses such as the following flow…

- **Utility companies:** They need to find their buried assets (power, water, gas, telecommunications, etc). They also need to know whose land they're burying them on.
- **Contractors:** They need to know who owns the land they're digging up and any pipes or cables they're likely to come across when they dig.
- **Tax departments:** Accurately surveyed land title boundaries allow governments to tax land owners based on the size, locality and value of their holdings.
- **Planners:** Accurately surveyed cadastre ensures that neighbours don't build on each other's land.

Why GIS social and environmental science maps are so bad

In contrast to the strong history of GIS in asset survey, generally speaking there is a poor history of social and environmental scientists creating GIS databases. Part of this is because while profession-specific GIS is taught as a part of an engineering degree, the same cannot be said of all social and environmental science degrees. Also, social scientists and environmental scientists are often the least inclined to sit at a computer

and build GIS datasets. Generally speaking, they are also poor manipulators of data. So, potentially there's a bit of a career edge to be had for scientists with GIS skills!

Traps when digitizing environmental maps

In contrast to surveyed maps, environmental maps are mostly "interpreted" so this is where an understanding of scale is very important. Elsewhere I've made a distinction between the scale of map display and the scale of map interpretation, and made the point that for many environmental maps, scale relates to…

- the number of days spent in the field creating the map, and
- the scale of the maps such as contours, cadastre, etc. that were used to inform an interpretation.

Recognizing treasure where others see trash

An important character trait for people wanting to restore old maps is one that's generally undesirable in the general community - that is the trait of a hoarder. Unfortunately, this comes naturally to me because I was brought up on a farm, and on a farm you never throw anything out because there *might* be a use for it one day! I also spent the second half of my teens working in the antique industry. The upside is that when I entered academia I had the special skill of being able to recognize treasure in everyone else's trash.

When I first used GIS I was doing rural planning research. The missing (and key) dataset in my research was an accurate GIS soils map. This led to the discovery that many organizations had bookshelves full of old reports and maps, most of which had the potential to be related to GIS maps of contours, water features, roads and land ownership, and then reinterpreted.

Traps with old-time makers of maps

For any work you're likely to be doing, it's reasonable to assume that surveyed boundaries are accurate. The biggest data challenge you're likely to come across is coordinating the collection of project specific social or environmental maps into GIS. As a GIS analyst, its often up to you to be the conduit for bringing these maps into a GIS and making them meaningful. To do this you need to develop some special skills to work with non-technical field staff - how to provide useful basemaps and information for the reinterpretation, and also how to extract the maps and data you need from them.

As a GIS analyst, don't be surprised if you find yourself working on a project to upgrade an old map. If you do, you'll probably find yourself working with people who aren't GIS savvy. The sort of people I'm talking about are those eyes glaze over when they sit in front of the computer. They compare GIS maps to the cartographically produced maps that they're used to working with. They don't understand GIS and often they don't understand the implications it has for them. And to be honest, some are simply not interested! When you work with these people some will be afraid to draw on a map lest their interpretation be wrong, others will be afraid of or disinterested in the technology, and others will provide information that's too detailed to be mapped at a scale that's useful to strategic decision makers.

PART 7: HOW TO BUILD A BASEMAP

Because so many GIS professionals are overworked with day-to-day corporate spatial data management, too few really understand how to work with a team of non GIS professionals to build a GIS map - it's more than just using a mouse or a digitizing tablet to input maps. It's also about understanding the geography that lies behind the maps you are creating. And if you don't understand the geography, then knowing how to go about extracting meaningful geographical information from someone who does.

The weekly radio show I used to do was a bit like that. When I interviewed someone, I didn't need to know everything about their topic. I just need to know enough about their topic to know what questions to ask them!

For the remainder of this lesson we'll be guided by the workflow shown in Figure 17. I'll talk about how to work in a team to facilitate a map interpretation, and then how to bring that interpretation into quantum GIS.

How to create a base map

I've discovered that the trick to working successfully with non GIS savvy people is to remove the barriers for working with you by expressing your maps in their terms. Tangibly this means producing paper base-maps to draw their interpretation on. These maps should be compatible with other maps they're familiar with in terms of scale and look, and highly focused in terms of the information you put on the map for them to use. Many field workers find it easier if they can easily compare your map to a local road atlas that they're familiar with. In such cases you should produce your base maps at the same scale as the local street atlas if that's appropriate.

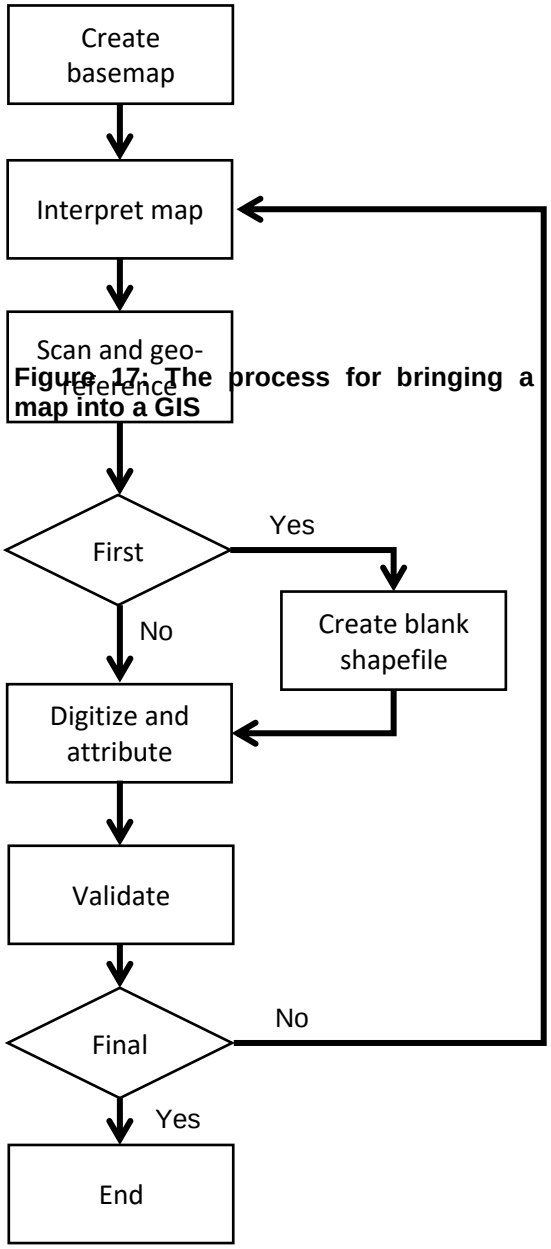


Figure 17: The process for bringing a map into a GIS

There's a bunch of information that people interpreting environmental themes need. It's best if the bottom layer of your basemap is an air photograph. These are generally taken on (or close to) midday on the summer solstice. This is when the sun is highest and shadows are least. The colours and shades on the photography provide clues to the vegetation, soils, land cover, land use, etc. Its counter-intuitive, but black and white photography often shows more information than colour photography.

If you're producing an environmental map, it's a good idea to match the photos with rainfall records from your national weather bureau. Rainfall can have an enormous influence on the sorts of themes you can easily interpret – photos taken during dry periods can be good for interpreting detailed watercourse maps, and during wet periods,

areas that might be susceptible to flooding. Never underestimate the importance of water – depending on how it interacts with the landscape it can influence soil formation and vegetation, and ultimately the level of engineering required to develop an area of land.

Soil and geology maps are often important because they can help map vegetation health and type. Soils and geology have a big influence over what vegetation grows where.

Other information that might be useful to these mapping projects are roads, fence lines, cadastre, slope maps, contours and water features. If you plan to use non-GIS maps as basemaps then in order to print them out at the same scale as other basemaps in your project, you'll need to scan and georeference them as described later in this lesson.

In most cases, if you can produce one single composite map with those themes that are most important to the interpretation, then that's sufficient. Be sure to run your basemaps past your colleagues before they go into the field. Sometimes I produce a couple of options for them to choose from.

If you can, go into the field and try and understand how your maps are being used. Also, look at the maps that your colleagues are used to using, and then format your maps to have a similar look and scale if you can. What I'm talking about here is reducing barriers to the adoption of your maps – once again, this is not about you, it's about your client (ie. your colleagues)!

Old-timers are used to putting maps on top of each other on light tables, so producing your maps at the same scale is very important. For some projects I have even gone so far as producing the maps on transparencies so they can be overlaid onto any map that's the same scale. Be aware that the heat from laser printers can shrink transparencies slightly.

Examples of basemaps

So, what do basemaps look like? The following are examples from three studies I've worked on over the years.

Terrain patterns (Figure 18): Terrain pattern maps are close relatives of soil maps and geology maps. They're another version of many similar systems of land evaluation devised in the second half of the 20th Century, but differ mostly because their intended

audience was engineers. Most land evaluation maps are targeted to agricultural scientists and planners.

Terrain evaluation schemes allow the speedy mapping of large areas at low cartographic detail but with very detailed descriptions (including soils). Hence, in the field, a small scale (eg. 1:250,000) map can still be really useful in the right hands. The Terrain Pattern scheme that was used in this study was well suited to a computing environment due to its numerical representation of landscapes, and importantly, the map provided the ideal framework for bringing together a number of incompatible studies at a consistent scale and nomenclature.

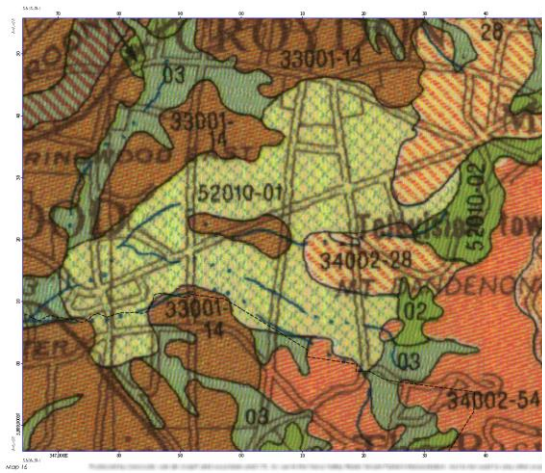
I began this project by printing the maps A, B and C in Figure 18 at 1:25,000 scale. The interpretation was drawn onto the 1 metre interval contour map (C) that had been printed as a transparency so it could be overlaid onto the geology and terrain pattern maps. This was then scanned and digitized in a manner similar to the way I showed earlier this lesson.

An interesting point is that even if detailed geology and contour maps had been available at the time of the original terrain interpretation, it is unlikely they would have been at a compatible scale and so would have been difficult to use. Hence, until recently, most landscape studies were undertaken at regional scales.

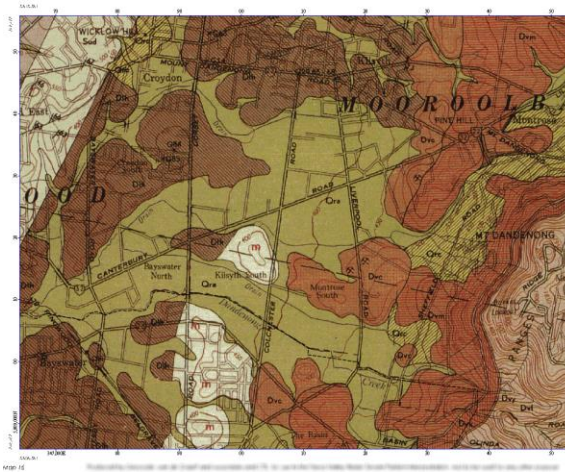
Native Vegetation study (Figure 19): In this study, biologists mapped a number of themes relating to roadside vegetation. In Australia, roadsides are sometimes the only remaining habitat for indigenous plants and animals. The base mapping I produced was designed to complement the local road directory that the biologists were already familiar with. They drove the local streets and used felt tipped pens to mark the basemap with information such as vegetation quality, habitat potential and so-forth.

Census study (Figure 20): This is one of the first GIS studies I was ever involved with. It was the mid 1990s and my lecturer had rescued some census data tapes from the rubbish bin at the census bureau. Data was backed up to tape in the 1980s. Some 10 inch reels could backup a massive 140mb in a half hour or so!

My job was to turn the census boundaries he had drawn onto a local street directory into a GIS map. An important lesson is that my lecturer was most comfortable drawing on a map that he was familiar with. I'll talk more about this map later.

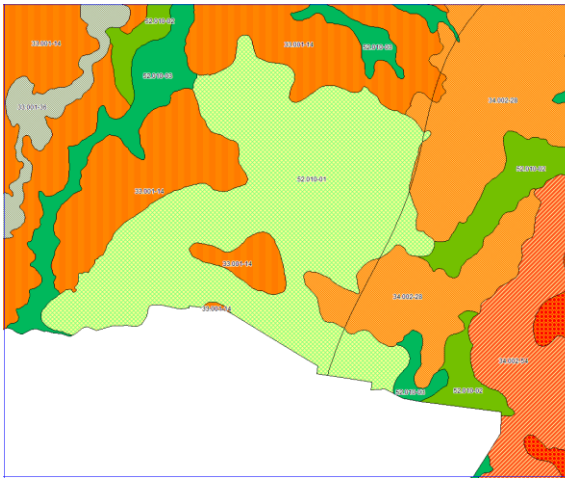


(A) The 1970s 1:250,000 scale terrain pattern map that provided the framework for bringing together a series of incompatible maps.



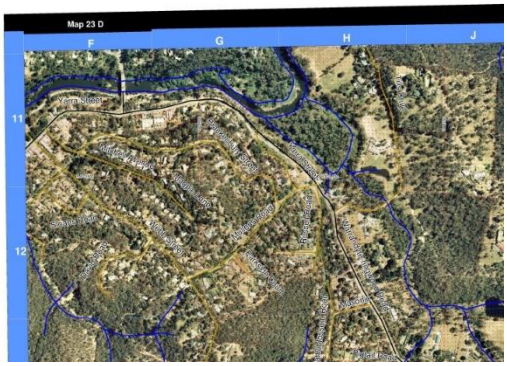
(B) The 1970s 1:63,360 (inch-to-mile) scale geology map that provided much of the detail for the reinterpretation.

(C) The reinterpretation was informed by maps A and B and then drawn onto this transparency of a 1m contour map

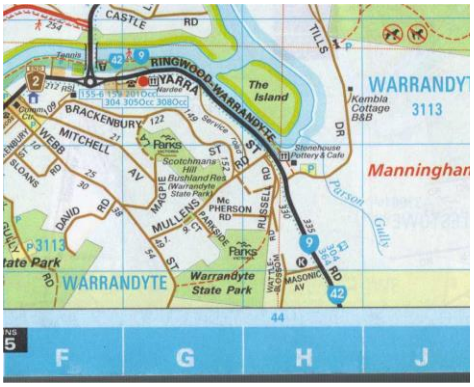


(D) This is the final reinterpreted map.

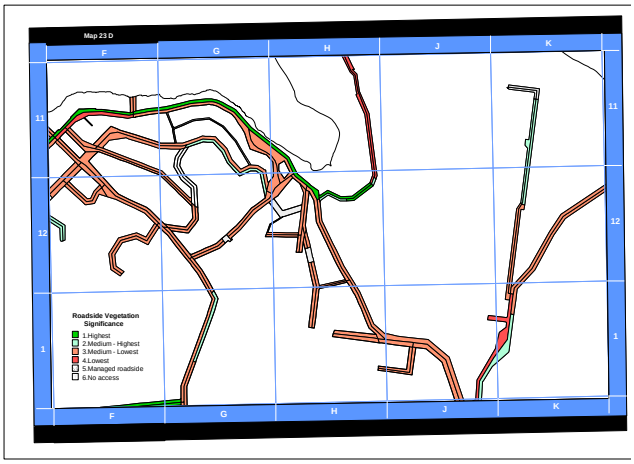
Figure 18: TERRAIN PATTERNS - After printing maps A, B and C out at 1:25,000 scale, the Terrain Patterns were reinterpreted onto the contour map.



(A) This is the map that was given to the field staff. It was at the same scale as map (B), and also has the same grid coordinates on it.



(B) This is the local street map that the biologists used to navigate in the field. The information here complimented that in map A.



(C) This is the resulting interpretation

Figure 19: NATIVE VEGETATION STUDY - In this example I printed streets on top of air photography at the same scale as the local street directory. The two maps complimented each other – air photos on one (A) and parks and other features on the other (B). The interpretation was drawn in felt pen on map (A). It was a very simple approach, but one the biologists raved over.

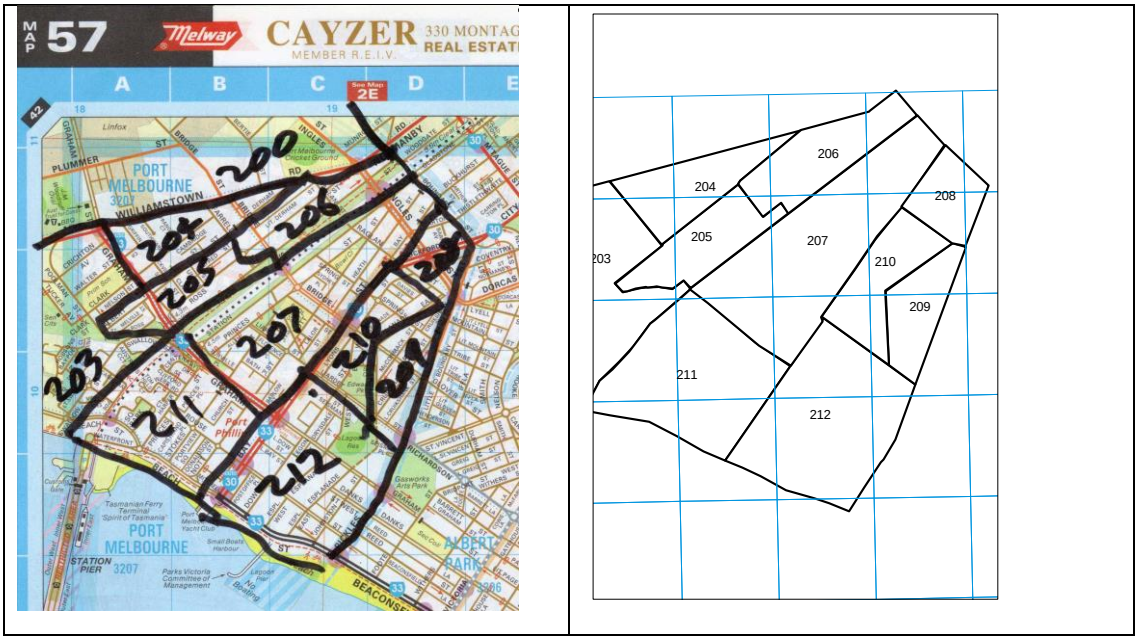


Figure 20: CENSUS: This dataset dates back to when Australia first started using computers for the census. These were the days when our census bureau crunched the data, printed it out and then threw out the tapes (yes, tapes). My lecturer had salvaged some computer tapes from the census bureau. He used descriptions of the geographies provided by the census bureau to draw the census boundaries on to a local street directory. I then digitized these with reference to one of the first GIS maps of roads for my home town.

How to interpret a map

Usually a map interpretation is undertaken on a base map using a Chinagraph pencil. This is a wax based pencil made by the UK company Staetdler and available from artists shops. If you can't buy Chinagraph brand then ask for "grease pencils" or "china markers". These pencils write well on shiny surfaces and you can rub them out with an eraser. I've also used felt tip pens, but these aren't as good because they're indelible.

Don't be surprised if your colleagues are reluctant to draw lines on a map. It can be confronting for them. So, be sure to spread the maps over a car bonnet and encourage them to draw a draft while in the field. Don't be afraid to ask questions and make contributions as they're drawing. Just imagine that they're a guest on your radio show. I've often been surprised at how a simple question can result in fairly major changes to

a map. For example, *there's a bunch of other areas (here, here and here) that look the same as the one you just mapped – shouldn't you map those too?*

Sometimes I get told to use a dashed line because "the boundary is diffuse". To that I respond with "we have to put a boundary somewhere". Dashed lines work well in cartography, but not when you're doing GIS modeling (unless you use some very sophisticated techniques). Occasionally I've even drawn the boundary I intended to digitize. More often than not this is met with a "no, no, no" followed by a willingness to draw a boundary. Along the way you should write notes about any decisions on the map.

Too often your colleague will "promise" to go back to the office and draw the map up there. Some people are true to their word and others aren't. Here's some things to consider. Away from the field…

- context gets lost
- the collegiate discussion about the interpretation is absent
- more often than not the mapping process gets re-prioritized down-the-list.

Everyone involved is worse off when this happens. So, whenever possible, at least complete a draft of the map in the field.

Later on, your mapping options include documenting diffuse boundaries in metadata, creating an accuracy map or assigning an accuracy attribute to each geographical element.

Traps when digitizing old paper maps

Old maps and reports are often still valuable. They can often be restored through a process that involves reinterpretation. You need to be careful when digitizing maps from old books and reports because accuracy can be affected in one or both of two ways…

- Paper is not "stable", so old maps are often spatially distorted.
- The quality of survey control might have been poor at the time the map was interpreted so things, although thematically correct, might have been mapped in the wrong place.

My experience is that old-time map makers were true professionals and even if their maps were not spatially accurate, they were thematically accurate (the shapes were

correct but they were just in the wrong place). I've had this problem only twice, and both times with soil maps. The first map was randomly incorrect by 400 metres in places and the second map by up to 2 kilometres in places. I say only twice because these days I never digitize an archival map without reinterpreting it with reference to accurately surveyed GIS maps such as air photos, roads, hydrography and contours.

CONCLUSION

INSERT CONCLUSION WHEN BOOK IS FINISHED

Please leave a review so you can help others learn how they can benefit from this book and help me learn how I can better serve my readers.

I hope you found this tutorial useful. Perhaps we'll meet again in one of my other tutorials?

Thank you and take care!

Ian

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Find the course at the following web address…

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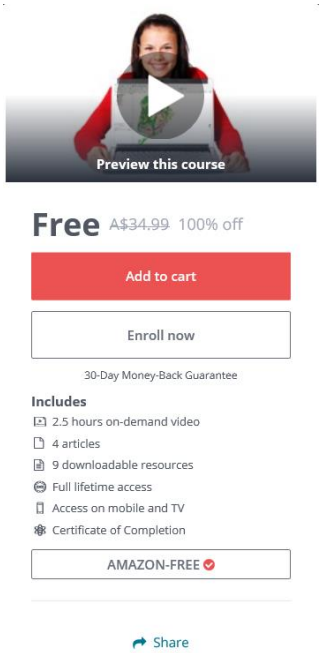
…and enter the coupon code **AMAZON-FREE** at checkout.



GLOSSARY OF TERMS

Attribute data	Data that relates to a map object. For example, two attributes of a dot on a GIS map might be that… 1. It's a fence post 2. It's made of wood.
Base Map	The map you draw an interpretation on. You create this with • all the features that will assist the person you're working with do their interpretation • all the features that you will need to digitize the interpretation. I recommend that your basemap includes a boundary with known coordinates so you can easily scan, georeferenced and then on-screen digitize from it.
Categorical data	Sometimes called Data Classes. Data that can be expressed as groups. For example Land Use (rural, urban, etc), Vegetation Type (forest, grassland, etc), Habitat Quality (high, medium, low)
Clip board	Standard Windows functionality that allows you to highlight, then copy and paste text and pictures from one computer program (eg. a text editor) to another (eg. QGIS).

Column	The vertical collection of cells in a table. In a table, a column normally has a title which is its reference (for example “DATE”). Data follow underneath the heading (for example, October 17…). *See also, field*
Cross tabulation	The joint distribution of two variables. For example, a cross tabulation of “full time employees” and “teenagers” would reveal all those teenagers who are employed full time.
Database	A collection of tables that are used to describe the project you are working on. In a well designed database, each table will contain information about only one aspect of the project. It is very important that information is stored only once within a database, otherwise you can have problems maintaining data validity and integrity. For example, if a someone’s address was stored in two database files and only one file was updated when the person moved house, how would you know which address was correct?.
Decimal number data type:	This data type holds decimal numbers. You can define a field’s Length and Precision. The field length is the total length of the field and the field precision is the number of decimal places. For example, a field length of 4 and a field precision of 2 allocates two places for whole numbers and two places for decimal numbers. Valid entries are 99, .99, 99.99. Invalid entries are 999 and .999.
Digitize	*See Digitizing tablet*
Digitizing tablet	A sophisticated electronic tablet on which you attach maps with sticky-tape and trace features with a *puck*. The puck interacts with a dense grid of wires inside the tablet that detect its position and the map features are digitized into the GIS. Later these features get interrogated by sophisticated software that checks its geographical integrity and then turns linework into enclosed polygons. These are not so common these days. Often you can get by by on-screen

	digitizing. I show you how to do this in my *GIS for Beginners #2: Georeference & Digitize in QGIS* tutorial
DPI	Dots Per Inch. This is scanner speak. The higher the number the more detailed the scan. When I'm georeferencing maps to digitize from, I usually scan them at 300 DPI.
Dynamic map	A map that changes in response to new information. It is always up-to-date. Online weather maps are a good example. Contrasts with a Static map.
Field	A reference to a column of data in a database. Imagine an Excel spreadsheet with a column called "date" and you're some ways to understanding the concept of a Field. However, in a database a field is like a column in an Excel spreadsheet on steroids. Database fields can be referenced by computer programs and GIS queries.
File	*See Table*
Geocode	A text description that can be related to a geographic object (eg. zip codes, addresses, census district names, and local government areas). Imagine you… 1. Have a 300 row spreadsheet. Each row represents a member of a local club. One of the columns contains each member's address. 2. You have a GIS map representing all local addresses You could create a map of your 300 club members by matching the address in each row of your spreadsheet to the GIS map. I show you how to do this in my *GIS for Beginners #4: Learn Geocoding in QGIS 3* tutorial.

Geographical Information System (GIS)	A computer based system for displaying, manipulating and analysing map based information.
GIS	See Geographical Information System.
Ground control point (GCP)	When you're geo-referencing a raster file (ge. a scanned map or an air photo), the scan is in a coordinate system that relates only to itself (ie. row and column numbers), and not to anywhere on the earth (eg. latitude and longitude). In order to relate your scan to an earth position you need to find places on your scan that you can also find in a GIS map. When you digitize these places they become known as *Ground Control Points (GCPs)*. When you've found enough GCPs you run a QGIS program to rectify the image. That turns your scan into an image that can underlay your GIS maps. I show you how to do that in my *GIS for Beginners #2: Georeference & Digitize in QGIS* tutorial.
Key field	A column in a table that contains a unique identifier that allows a row to be related with a row in another table. Customer Number and Student Number are examples. (see also *Field*). In the example below because the customer numbers in both tables are identical it is possible to print a delivery docket that ensures a Large Refrigerator gets delivered to 10 Smith Street.

Customer Number	Sale Item
1234	Large Refrigerator
1235	Small Refrigerator

Sales

Customer Number	Address
1234	10 Smith Street
1235	18 Jones Street

Customers

Line	A GIS object defined by two X and Y coordinates. For example, a section of road.
M value	Refer to horizontal distances (eg buffer widths) in a shape file (see also Z value)
Map layer	A map of a single theme such as cadastre, roads, water features, etc. A GIS maps is created by combining multiple layers. In QGIS, maps can only contain one data type (ie. points, lines, polygons, polylines).
Map object	See object
Mental map	A map that is produced based on someone's understanding of an area. For example, a farmer's mental map of their land will relate to it's productivity and ease of management. An environmentalist's view of the same tract of land might relate to the quality of its wildlife habitat.
Metadata	Information about information. For example, in a census what does employed mean? Working >10, >20, >30 hours each week? Most data custodians have metadata describing their datasets. Often this can be found on the internet or in a library. If all else fails, contact the custodian by email or telephone!
Multi-point	Multiple points that refer to a single row in a table eg a rabbit warren with multiple entrances. Mostly used for sophisticated GIS databases.
Node	*See Vertex*
Numeric data type	This type of data column only holds whole numbers. Numeric columns are defined to have a length. A length of 1 will hold 0-9, length of 3 will hold 0-99, etc. If you enter a decimal number into a numeric column then it will be

	rounded to the nearest number. So, 1.2 will become 1 and 1.7 will become 2.
Object	This most often refers to something that is mapped such as a tree, track or paddock. For an explanation of the four GIS object types, see *Points, Lines, Polylines* and *Polygons*.
Point	A location defined by an X and Y coordinate. For example, a power pole or fence post.
Polygon	An area defined by three or more X and Y coordinates. The final coordinate is identical to the first coordinate. For example, a sports oval or a paddock.
Polyline	A location defined by two or more X and Y coordinates. For example, a power line or a fence.
Post Processing	Computer software is used to compare GPS collection to that of a base-station GPS in order to gain centimeter accuracies
Raster map	Alsp known as a bitmap or a scan. A grid with a different value in each cell. Sometimes cell values can be equated to colours (eg. A photo). Other times, especially in a georeferenced map, the cell values can represent the value of something. For example a height, a slope, or a map category.
Row	The horizontal collection of cells within a table. That part of a table that contains data. In a GIS, each row usually contains information about a map object.
Segment	This is the line between two vertices/nodes.

Select / Selection	You can select a map object by clicking on it with your mouse either on a map, or within a table. Either method will make a selection in both your GIS map and the attached. When you make a selection, you can choose to do things only to the items you've selected. For example, change its color on the map, or change a value in a column.
Sort	A process by which the values in a data column are ordered either alphabetically or numerically from lowest to highest. In a GIS, this is done using Structured Query Language (SQL).
Spatial	Anything that relates to "space" and can be mapped.
Static map	A map that doesn't change once its been produced. It remains fixed at the point of time in which it was produced. Printed maps are static maps. Contrasts with a Dynamic map.
Structured Query Language (SQL).	The language that a GIS uses to summarize data.
Table	A method of storing data. A table has columns with headings that can be referred to by a GIS, and rows containing data that are "used" by a GIS. A table is normally confined to information about one topic.

Item	Date	Crop
PicnicArea	Oct 17 2010	Sprayed
PicnicArea	Nov 17 2010	Mowed
PicnicArea	Dec 17 2011	Fertilized

Field identifier

} *Column*

	Row
	See field
Temporal	Anything that relates to time. If we have two maps of the same theme over the same area that have been created at different times then we can map "change". For example, comparing a land use interpretation through time. I show you how to do this in my *GIS for Beginners #1: QGIS 3.4 Orientation* tutorial.
Text	In GIS this means data that are stored in ASCII format. ASCII format data can be read by text editors and can also be read by QGIS. Variations that you're likely to come across are Comma Separated Value text (.csv), straight text (.txt) and Tab Separated text (normally you check a "Tab" box when importing this). Word processor files and database files are NOT text data.
Thematic map	A map about a theme. A theme might be demographic (total population in each postcode), environmental (habitat quality in each postcode), economic (total number of manufacturing plants in each postcode), etc. As you can see, any area can be mapped for numerous themes.
Topological map	
Vertex	When you're on-screen digitizing, each mouse click creates a vertex (sometimes called a node). See also segment.
Windows Clipboard	See *Clipboard*

Z value	Refer to vertical distances (heights) in a shape file (see also M value)