Exercise: photointerpretation of pastoral structures in a Pyrenean valley

This exercise has been created as a basic introduction to the use of aerial imagery, including on-line services, to remotely detect archaeological features.

For the development of the exercise we will cover some basic GIS functions:

- Download aerial imageries and connect to on-line services.
- Creation and edition of vectorial files.
- Detection of human-made structures.
- Creation and edition of fieldwork maps.

The exercise is based on a research developed in upper valleys of the Pyrenean mountains (modern Catalonia). Situated at 2000-2500 masl, they are dominated by pastures shaped through a long-term interactions of the herding practices with the environment. For more information on the research project in the area:

- Palet, Josep M.; Garcia, Arnau; Orengo, Hèctor, Polonio, Tania (2017). «Els espais altimontans pirenaics orientals a l'Antiguitat: 10 anys d'estudis en arqueologia del paisatge del GIAP-ICAC». *Treballs d'Arqeologia* (núm. 21). <https://www.recercat.cat/handle/2072/307889>.
- Colominas, L., Palet, J. M., & Garcia-Molsosa, A. (2020). What happened in the highlands? Characterising Pyrenean livestock practices during the transition from the Iron Age to the Roman period. *Archaeological and Anthropological Sciences*, *12*(3), 69. https://doi.org/10.1007/s12520-020-01023-3

The exercise has been created in a way that can be completed without any previous knowledge of GIS. We will be using QGIS (the present document has been elaborated using the 3.12 version, note that some inconsistencies might arise due further updates. Contact your instructor if you encounter any difficulty).

For this exercise we will use some files that need to be download and saved in your computer. You can access the files in the Github exercise folder: https://github.com/ArnauArqueo/training_giap/tree/main/e2_photointerpretation_pyrenees.

This exercise is based in a study case situated in the upper valleys of the Pyrenean range. The landscape is dominated by pasturelands heavily influenced by herding practices. Photo: Arnau Garcia Molsosa

Remains of a dry-stone enclosure built for the management of the herds during summer. Photo: Arnau Garcia Molsosa

A herding camp including a hut and an enclosure. The exercise aim is to identify this type of archaeological remains in aerial images. Photo: Arnau Garcia Molsosa

1: Initial setup

Start by opening QGIS and create a new project.

In the initial page use:

Project -> New or Ctrl+N or Icon

It is recommended to save the project and all associated files in a single folder, which might be organised in subfolders. For example: My Documents (or any other location in your PC) */ GIS_exercises / Exercise 1*.

Then download and unzip the *photointerpretation_pyrenees_files*. Start by loading the study area (file *study_area_pyrenees.shp*). Use the main menu

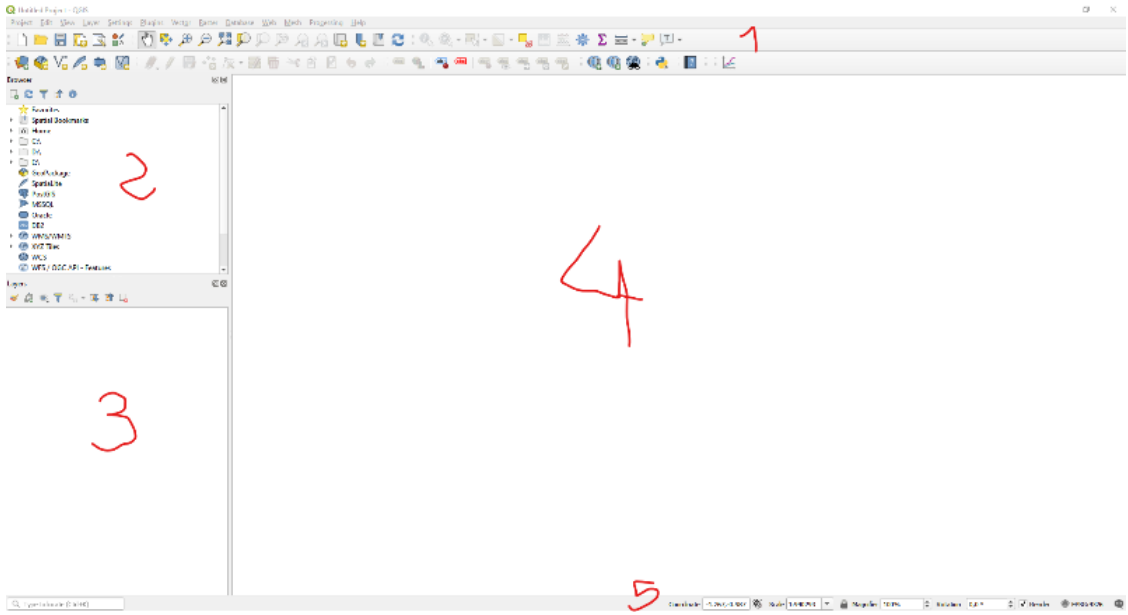
Layer -> Add Layer -> Add Vector Layer or Ctrl+Shift+V or use Data source Layer (Icon)

Finally select the Coordinate Reference System that we are going to use in this exercise.

Click on the EPSG code on the right of the lower bar or access CRS properties or the project property window:

Project -> Properties… or Ctrl+Shift+P

Select CRS ETRS89/UTM Zone 31N or EPSG25831. This is the standard projected system for the region (if you want to replicate the exercise in other geographic areas, check the preferred CRS).



For a detailed description on how to download and install QGIS and set up a new project, check exercise 1: https://github.com/ArnauArqueo/training_giap/tree/main/e1_optical_telegraph.

You will start with a blank project, good moment to review the main "working areas" in QGIS. On **1)** there is a bar which contains the **menu** and icons that give you direct access to the most commonly used tools. **2)** is the **browser panel**, which gives you access to computer folders where the data is stored. The panel below, **3)** is the **layers panel** and will show the datasets used on the project and that will be displayed in **4)** a **canvas** where the data will be visualised based on its spatial information. In **5)** there is the lower bar, with the information about the **coordinate system** and **scale**.

2: Using online map services

In this exercise we will examine aerial imagery and try to extract archaeological information. Nowadays, digital collections of cartographic material, including ready-to-use orthorectified aerial images, have become very accessible. Most of us are familiar to use it in a regular basis in our smartphones.

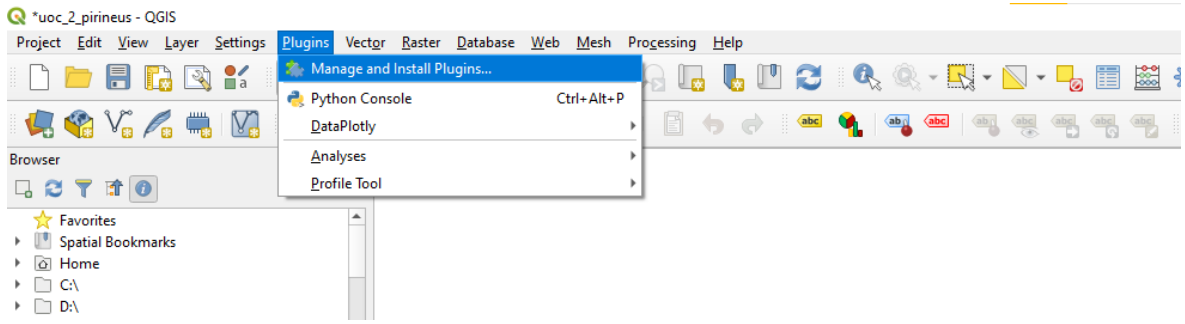
Current geodata repositories include the ones maintained by public administrations (later in the exercise we will work with materials of Catalan Cartographic Institute, but similar institutional agencies existed at local, regional, national or EU levels); also many private companies offer access to geographic datasets (probably the ones we are more familiar are linked to big software companies, for example Google Maps, Bing Maps or Apple Maps); there are also Open Source community initiatives (most known is Open Street Maps, www.openstreetmap.org).

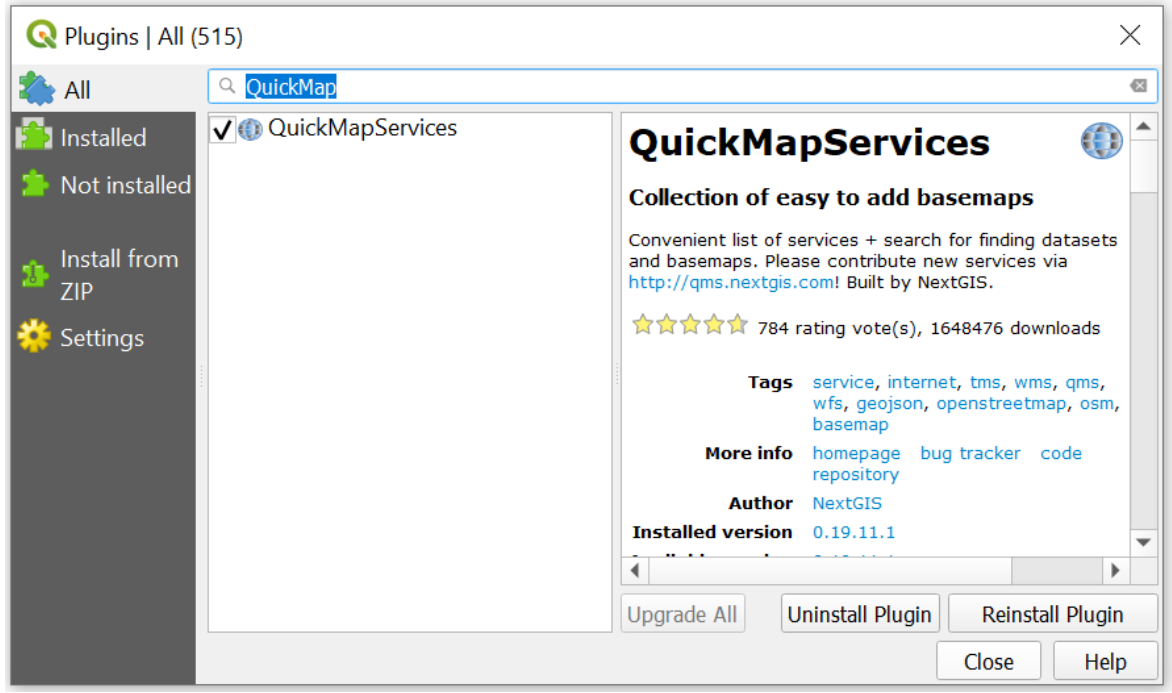
Here we will start by examining different ways to display map services in QGIS, starting by the *Quick Map Services Plugin,* which provide access to a list of services.

First we have to install the Plugin:

Plugins -> Manage and install Plugins

Search **QuickMapServices** and install. Be sure that the plugin is activated (ticked box next to plugin name).

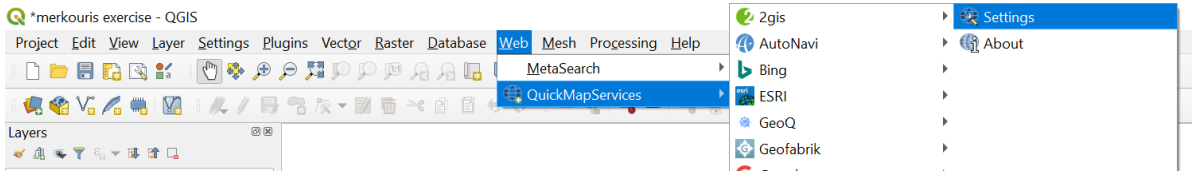




3: Add services in QuickMapServices

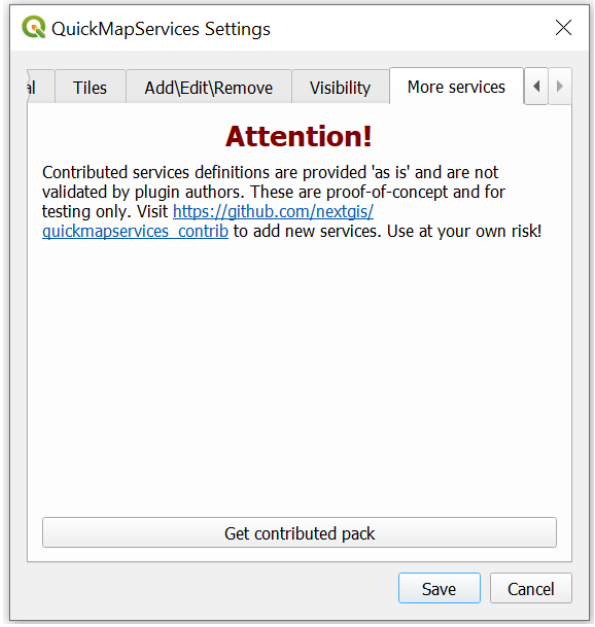
Back to the main Menu the plugin can be access in:

Web -> QuickMapServices



At the beginning only few options are available. To incorporate more services we will select **Settings**. A new window will appear.

In the settings window search for **More Services** and **get contributed pack**.

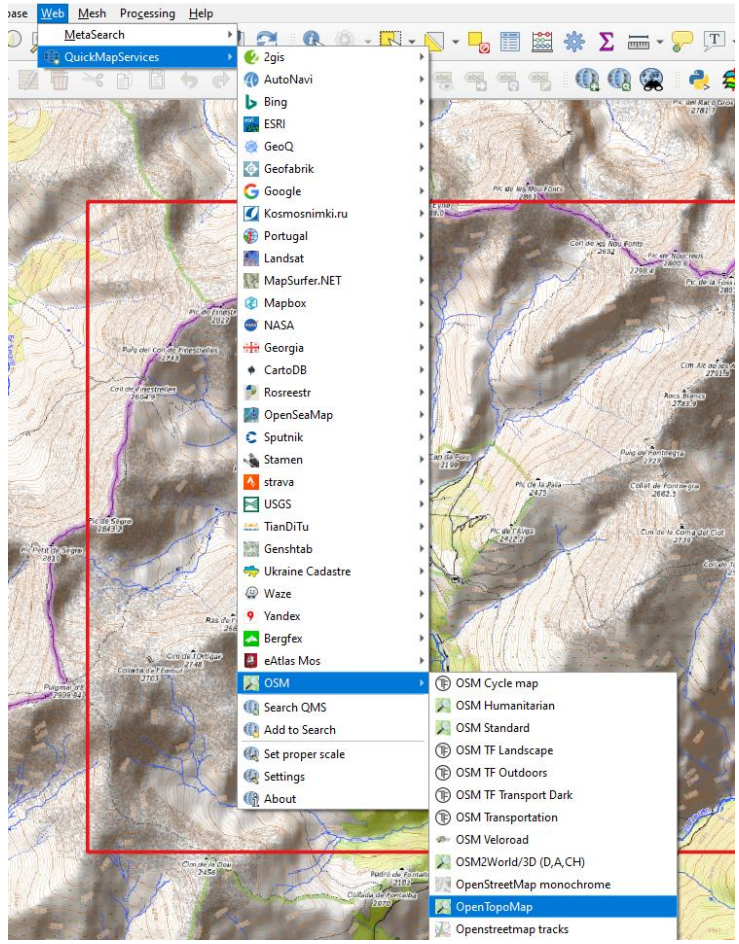


4: Select services

Now more options are available in the **QuickMapServices** Menu.

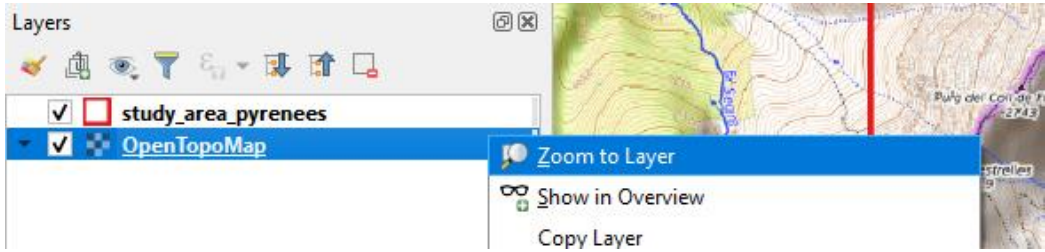
For now, we are interested in a topographic map, which will help us to visualise the relief to understand the broad context.

Select for example **OpenTopoMap** or **Google Terrain**.



5: Observing Coordinate Reference Systems

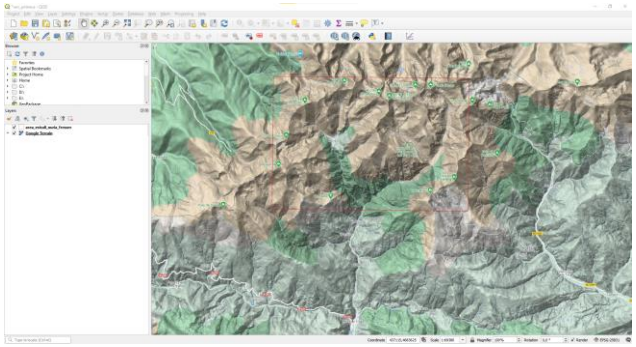
A useful tool to know is the option to **zoom to layer**. Right click on the layers' name in the Layers panel. This will show the total extension of the layer.

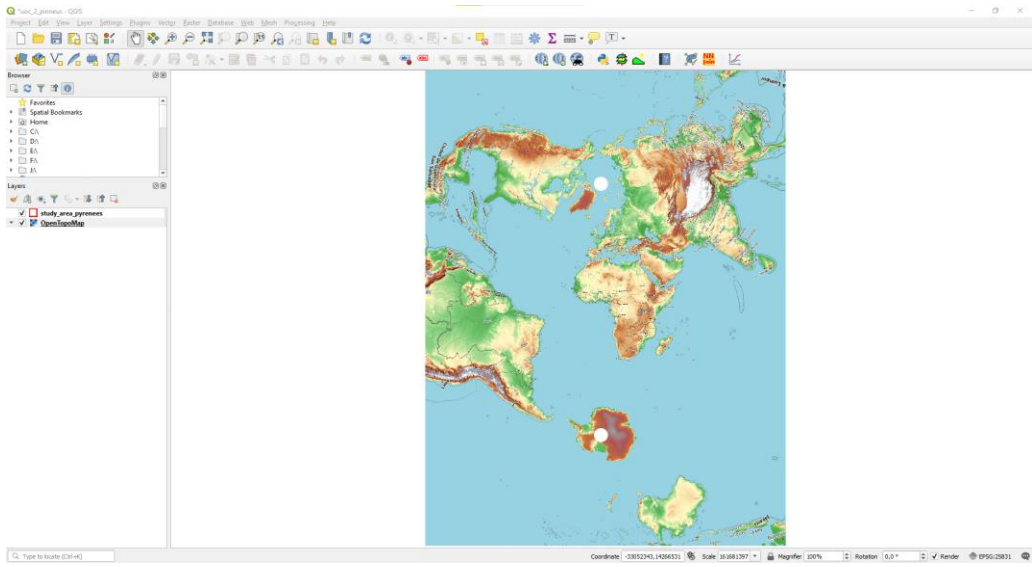


Since we have a world map, we can take this opportunity to have a look on how the earth globe is projected. You can play by changing the CRS (see point 1). Use for example EPSG 4326 or EPSG3857, which are common global projections.

To go back to the exercise, set EPSG25831 as a CRS and **Zoom to layer** to the **study_area_pyrenees** layer.

After that, your screen will look something similar to the following image:





In this example (OpenTopoMap using CRS EPSG25831), we can see how the world is projected around the UTM zone 31N.

6: Download aerial images

For this exercise we will use aerial imagery provided by the *Institut Cartogràfic i Geològic de Catalunya* (https://www.icgc.cat/en/), a public agency of the Catalan Government. It is an example of public administration cartographic services adapted to the international standards defined by the Open Geospatial Consortium (https://www.ogc.org/about).

Although we are going to use an online WMS connection, it is worth to stop a moment in how to download the image files from their webpage.

We can start by having a look at the visualization app:

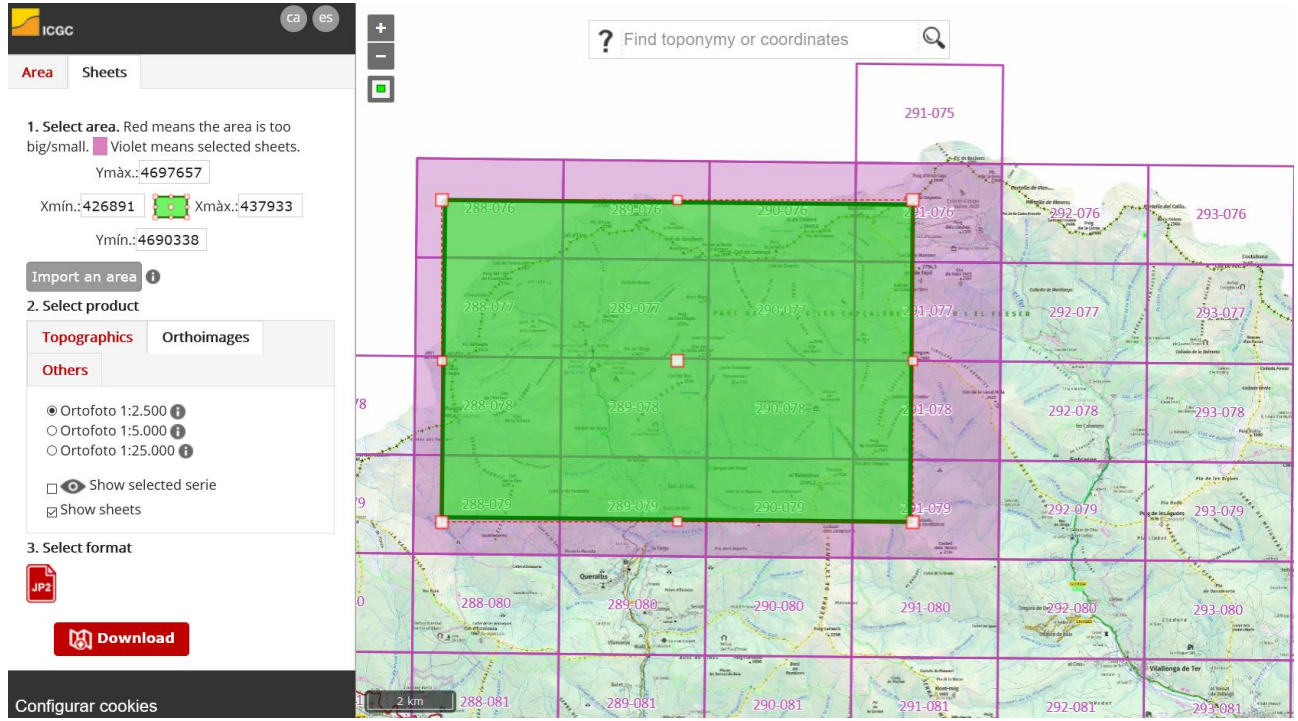
http://srv.icgc.cat/vissir/index.html?zoom=6&centerRnd=true

For obtaining the images we can use also its download app:

http://www.icc.cat/appdownloads/

Choose the higher resolution images: go to **Select product**, select **Orthoimages** and **ortofoto 1:2500**.

Import the study area using **Import an area** and load (*study_area_pyrenees.kml*) to select sheets to download. Since the area is too large to be downloaded in one go, it is necessary to divide it in two ore more groups. You can reduce the size of the area and move it. The app will create a link for downloading the images.



7: Load aerial images to GIS

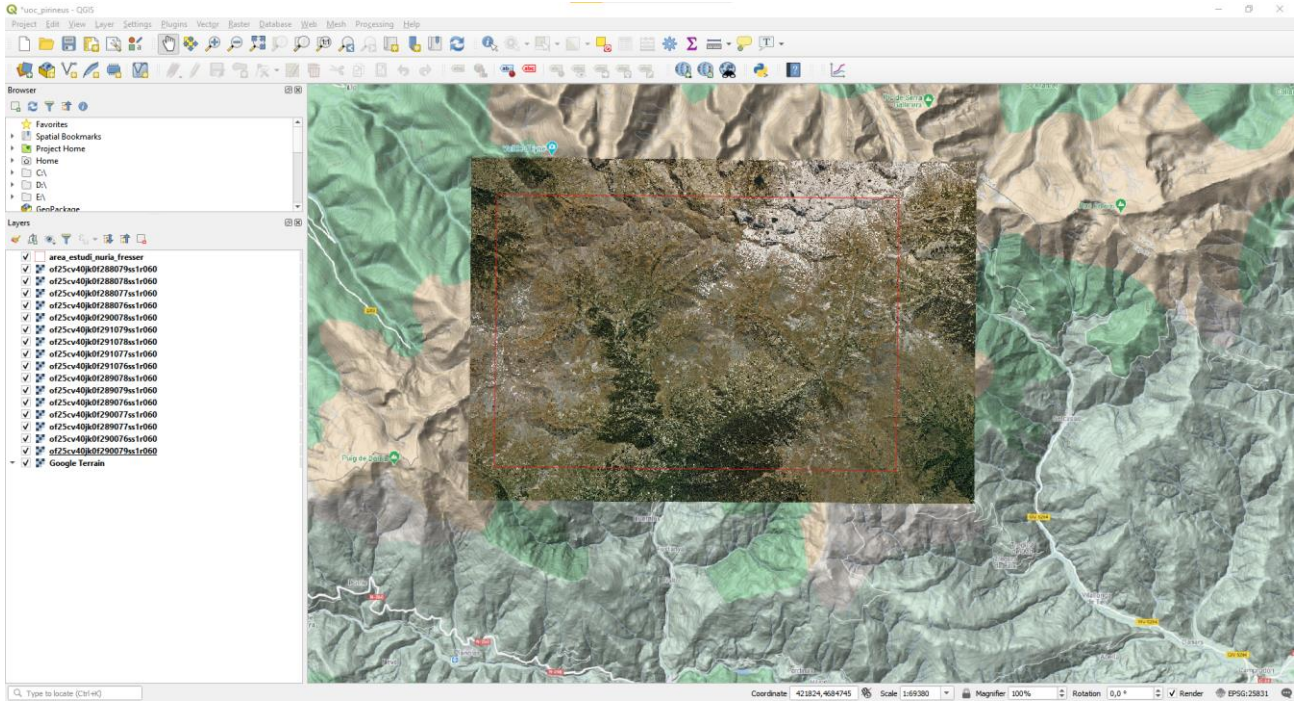
Once the download is complete we can copy the files in the project folder and unzip (note that you may have to unzip first the downloaded file and then each of the images).

To load the images to the QGIS project you can use:

> *Layer -> Add Layer -> Add Raster Layer or Ctrl+Shift+R or use Data source Layer (Icon)*

Select the *.jp2* file.

The images will appear already georeferenced.



Remember: Orthoimages are raster files in which each pixel has 3 bands with information about the colour (Red Green Blue or RGB). In this case, the file contains also information of its geographic position.

It is interesting to note that in the above image, large parts of the area are covered by snow (the image was probably taken around winter). In some cases that might be a problem and so it would be necessary to find images taken in other dates. That is very common when dealing with satellite images, when clouds can cover large parts of the area of interest.

We are not covering the management of image files in this exercise, but it is worth to keep in mind some tools that are useful:
We can merge the images so we don't need to deal with multiple layers (use *Raster -> Miscellaneous -> Merge…*).
For a better performance is recommended to create "pyramids" that will avoid to load all the details when working at lower scales (you can create pyramids in **Layer Properties**).
Finally, you can clip an image using a vector file (e. g *study_area_pyrenees.shp*) to eliminate the areas you are not interested (on the main menu select *Raster -> Extraction -> Clip Raster by Mask Layer*)

8: Online geoservices

An alternative to download cartographic material is to connect to online services.

Online service have the advantage that doesn't require to download an store large quantity of information in your disk. On the other hand, its use is dependent on internet connection and the data cannot be edited. Availability a part, we can use one or the other depending on the type of work.

In our case, since we are going to use it only for visual inspection, is indifferent which one we use.

In the icgc webpage, select **WMS orthoimatges** and **WMS othophotos**

https://www.icgc.cat/en/Public-Administration-and-Enterprises/Services/Online-services-Geoservices/WMS-Ortoimatges/WMS-Orthophotos

We see that the page provides a link plus technical information and a list of the layers that we can access through this service.

Copy the link.

WMS service that includes all the ICGC orthophotos organized by layers, one per year

URL: https://geoserveis.icgc.cat/icc_ortohistorica/wms/service?

Last update: **15/04/2020**

Technical aspects of the service

- Supported OGC: WMS 1.1.1
- Original EPSG: 23031 / 25831
- Supported EPSG: 23031, 25831, 32631, 4230, 4258, 4326
- Supported GetMap formats: GIF, PNG, BMP, JPEG, TIFF
- Supported OGC methods: GetCapabilities, GetMap

Available layers

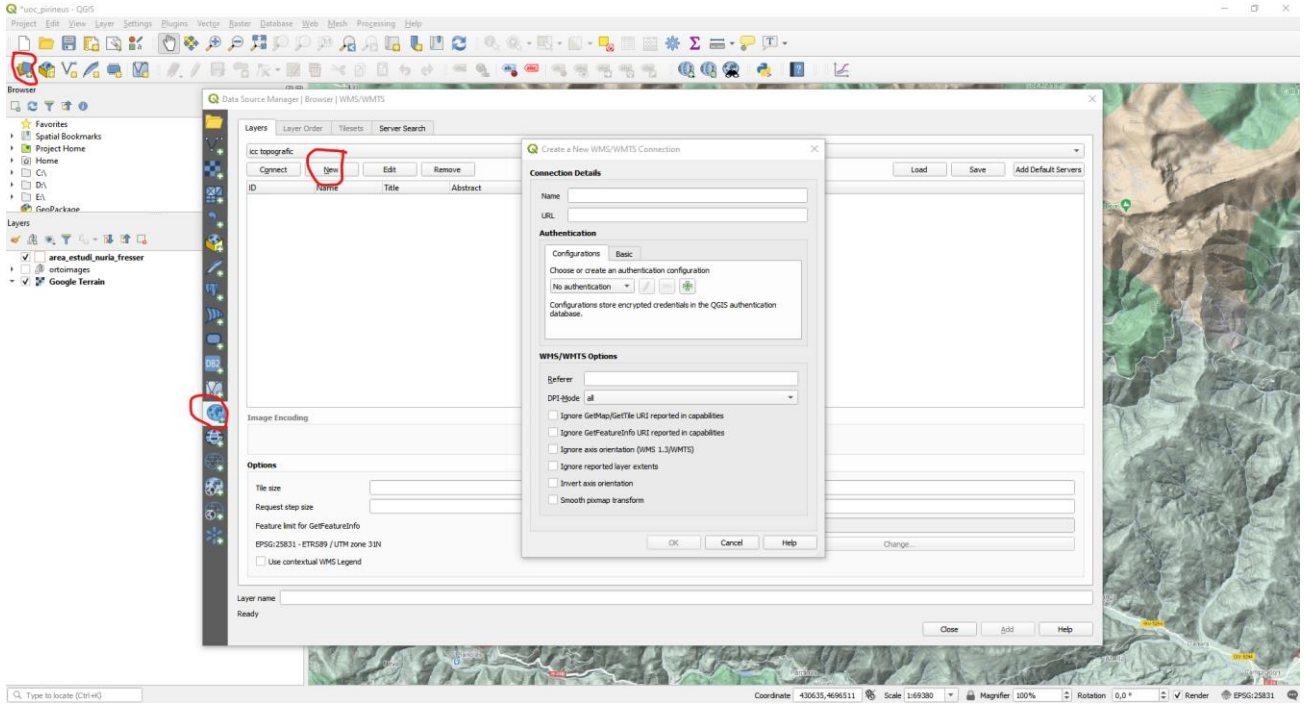
Layer	Layer name	Range of scales
Orthophoto of Catalonia 1:1 000 (annual)	orto10cYYYY	All scales

9: Create WMS connections in QGIS

To link a WMS to a QGIS project we use the Data source manager  .

> *Layer -> Add Layer -> Add WMS/WMTS Layer… or Ctrl+Shift+W*

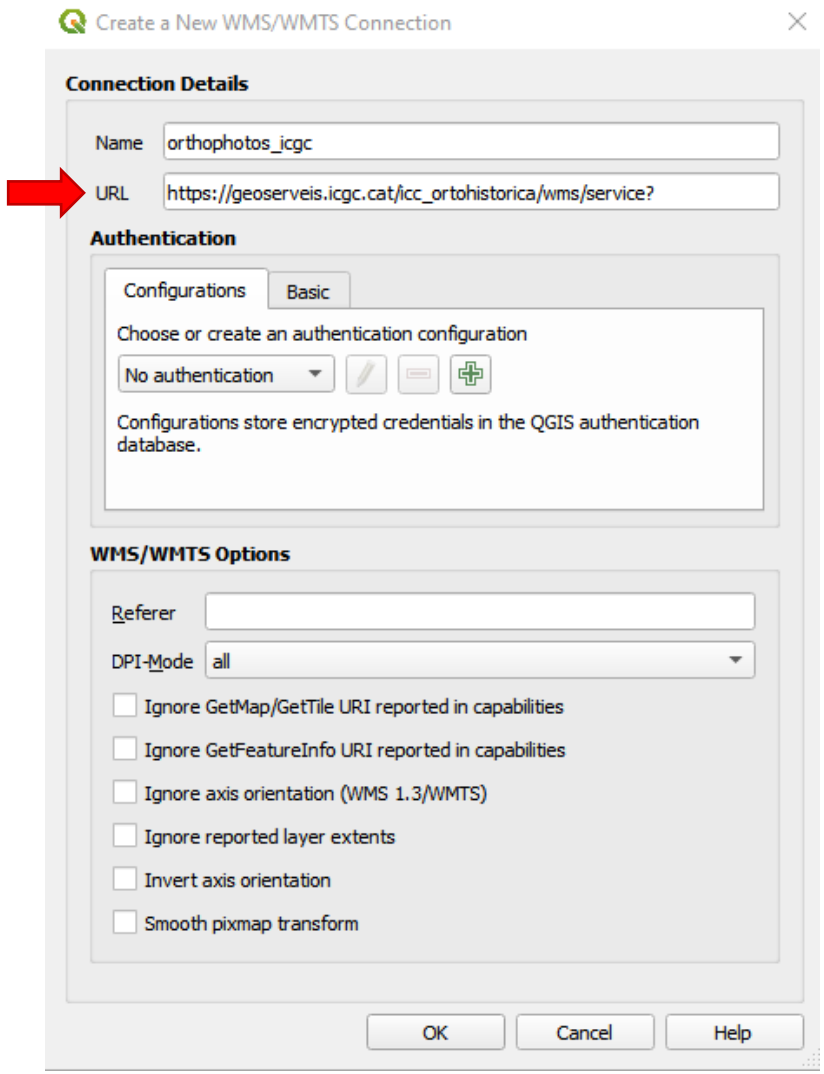
Select **new**.



10: Connection details

In the new window, name the connection and paste the url.

Keep the default options for all the other settings and press OK.

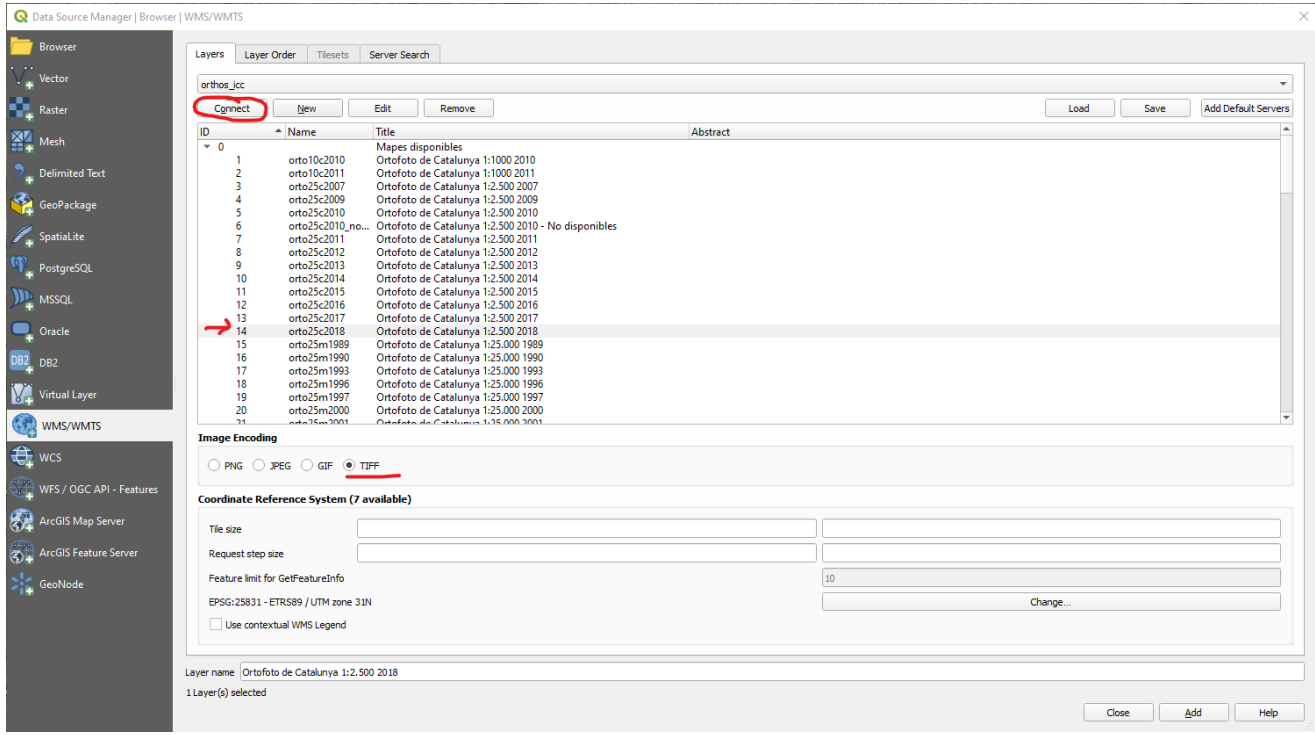


11: Connect to geoservices in GIS

Select **connect** to visualize the layers included in the WMS service.

For this exercise we are interested in the last orhtophotomap of 25cm/pixel (1:2500), which correspond to **orto25c2018**.

Check that **TIFF** encoding is selected and **add** the layer.

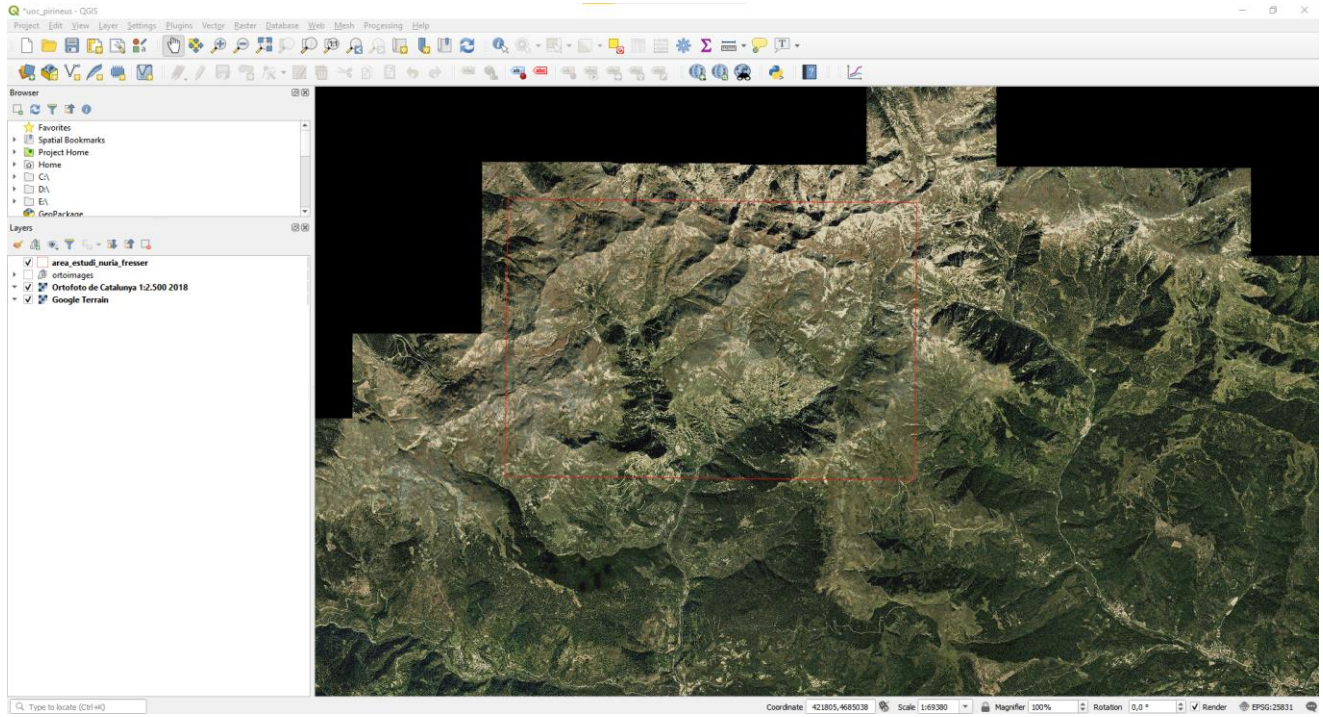


This WMS service give access to the different orthomaps produced by the Cartographic Institute using systematic monitoring. That creates a very interesting tool to see the evolution of the territory during the last years. An easy exercise is to select different products and check the differences.

12: Ready to work

At this point the set up is ready and we are ready to start the photointerpretation.

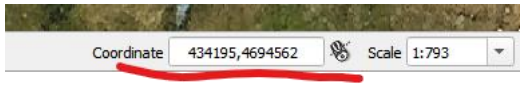
Our objective is to detect human-made structures related to historical herding activity.



13: Example of a herding campsite

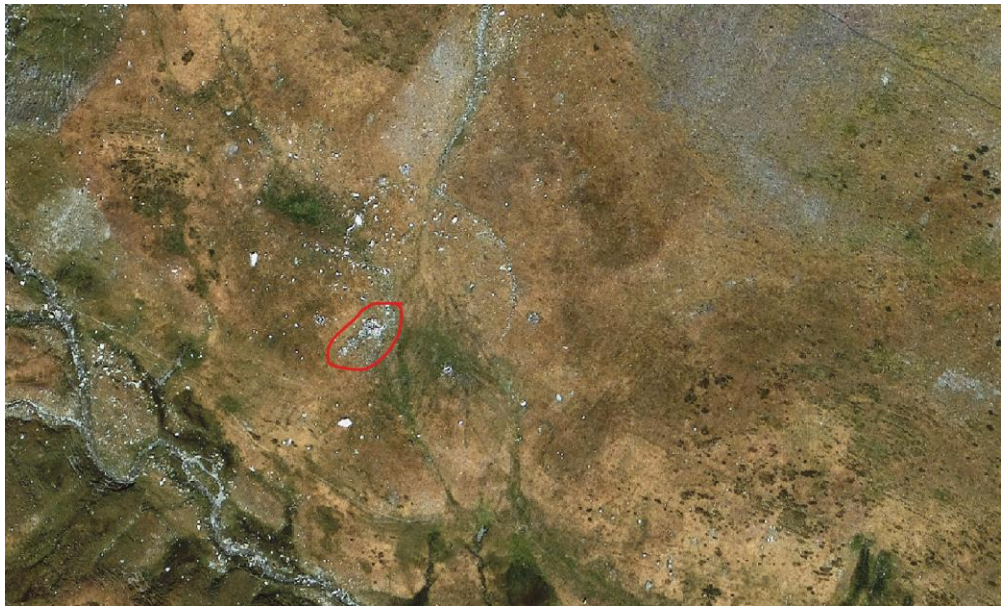
In first place we will examine an example of the type of structures that we are interesting.

We will start by centre the image on the coordinates 434195; 4694562 (remember, the CRS is ETRS89/UTM Zone 31N or EPSG25831). For that, type the coordinates in the coordinate box and 1:1000 in the scale box (centre of the lower bar):



We will take a look at the image and we will realise the presence of different heaps of stones -white/grey- that contrast with the grasslands -green/brown- and the river course -left lower corner-.

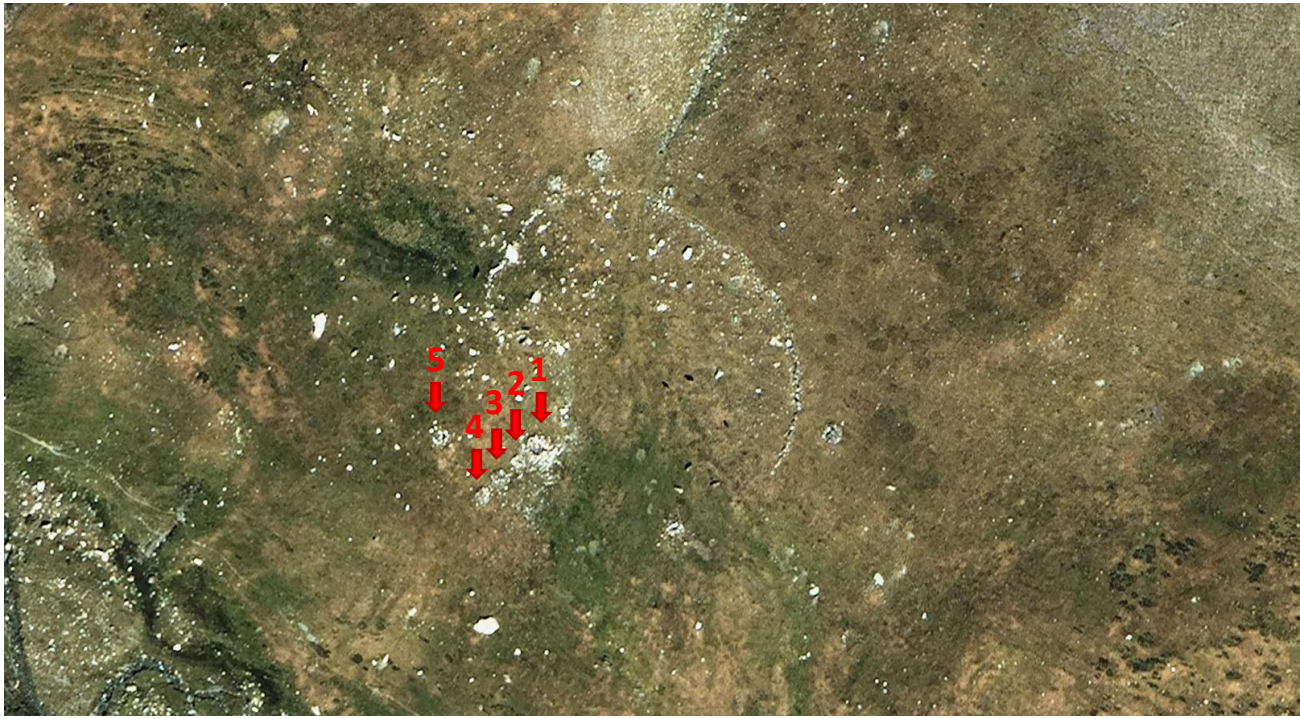
We look first to the group of heaps in the centre and zoom in (red circle in the lower image on the right).



14: Shepherds huts

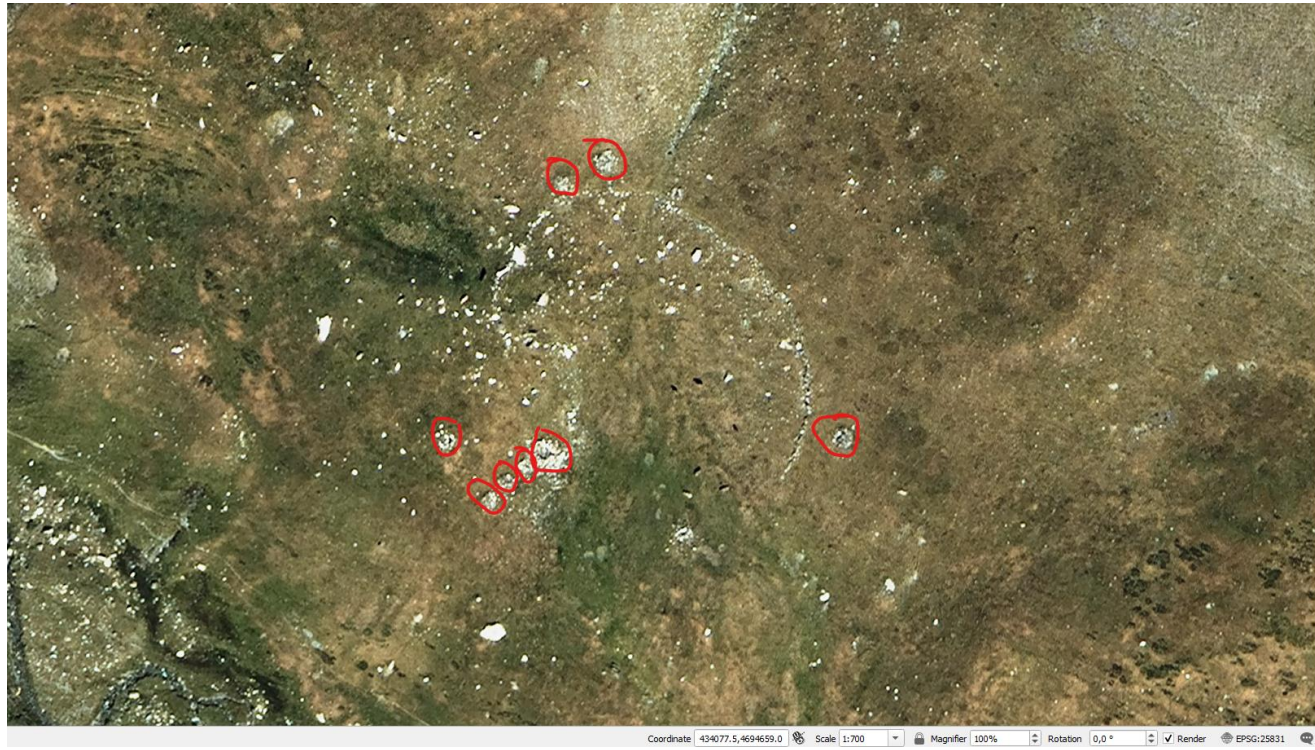
They correspond to a group of shepherd huts.

Those structures were used at the beginning of the 20th century and we are lucky to have a picture of them that can be compared with its state during the archaeological survey.



15: Shepherds huts

We can spot several of this huts around:



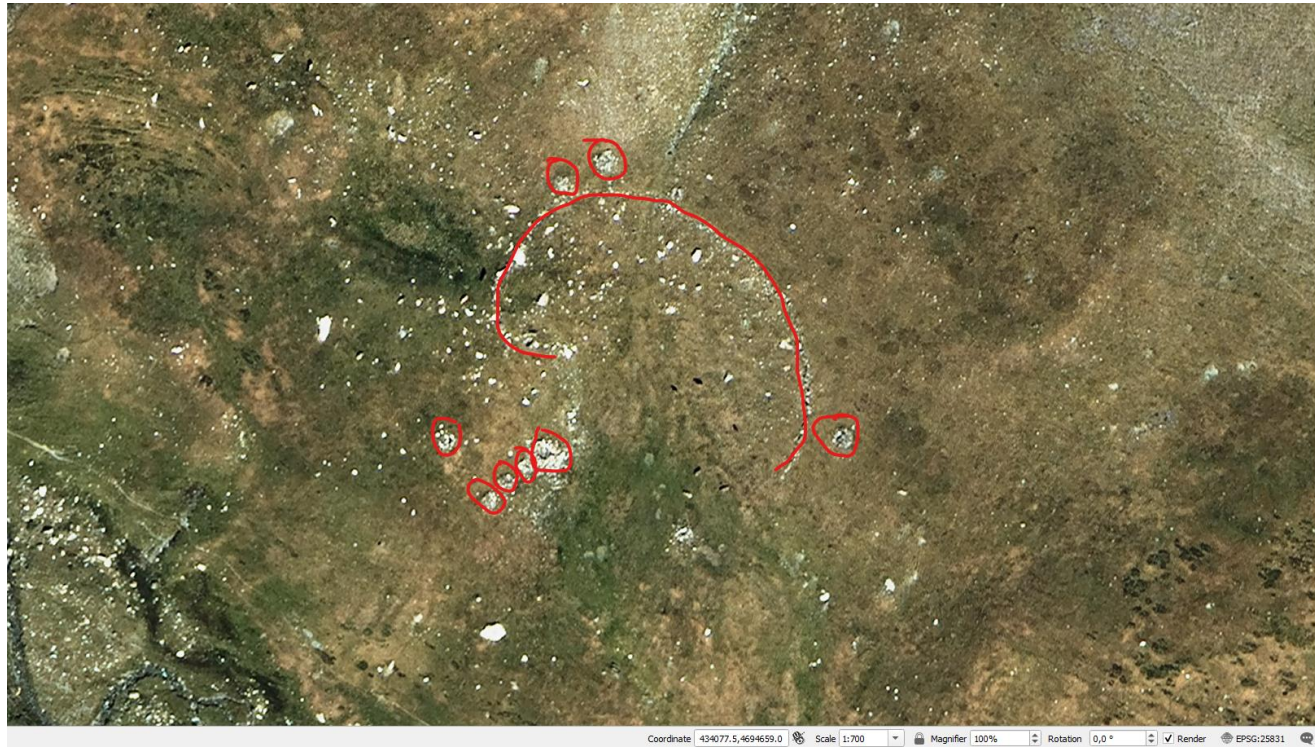
16: Enclosure

Finally, we can spot also the remains of a dry-stone enclosure with a circular shape.

That is an example of a common summer camp.

In this exercise we will try to localise and document similar camps around the valleys.

You can use the limits included in the file *study_area_pyrenees.shp* as the area to analyse.



17: Create vector layers

Once we have located a potential archaeological feature, how can we store the information about its location and character?

In this exercise we are going to create a file containing coordinates for each feature, associated to information about the type of feature (hut/ enclosure) and its chronology (we will address this aspect at the final part of the exercise.

Start by creating a **new shapefile layer**:

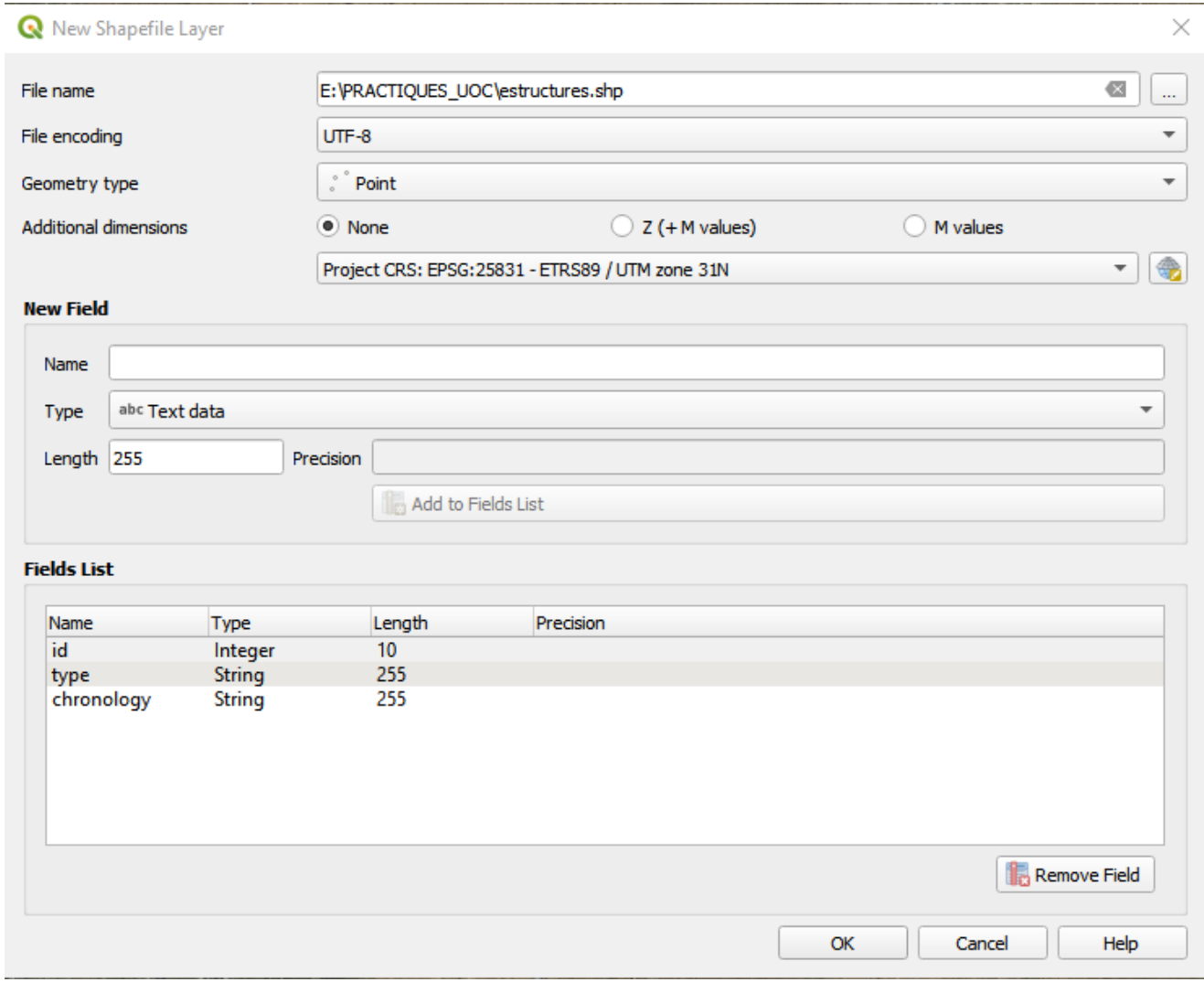
Layer -> Create Layer -> New Shapefile layer or

Define **file name** and folder (use the project folder)

Define Geometry type. To simplify the exercise, we are going to focus only in the location and use points, but we could use lines and polygons to document also the shape and size of the features.

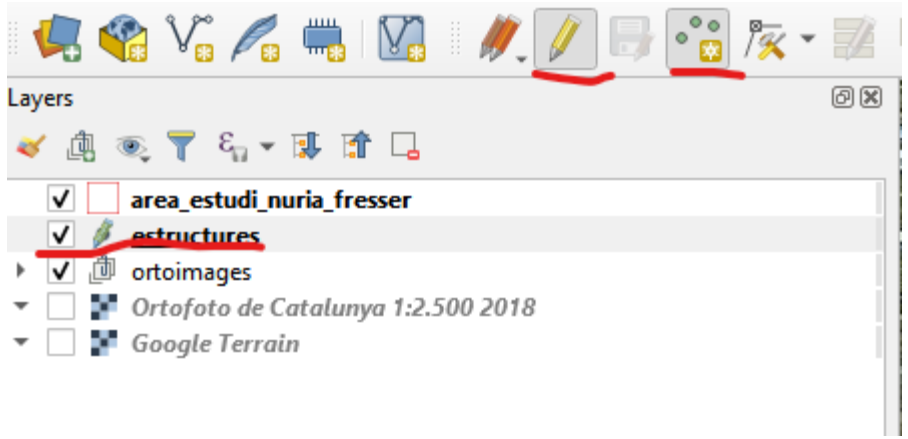
Select the CRS (EPSG 25831, the same as the project)

In this case we have add, a part of the id, two string fields using **New Field**: **type,** to report the type of structure, and **chronology**, which we will use later to include temporal references.



18: Edit vector layer

The new shapefile will appear on the Layer Panel. The layer contain no information. Edit the layer will allow you to add the elements observed.



We will first activate the edition mode, using the pencil icon or

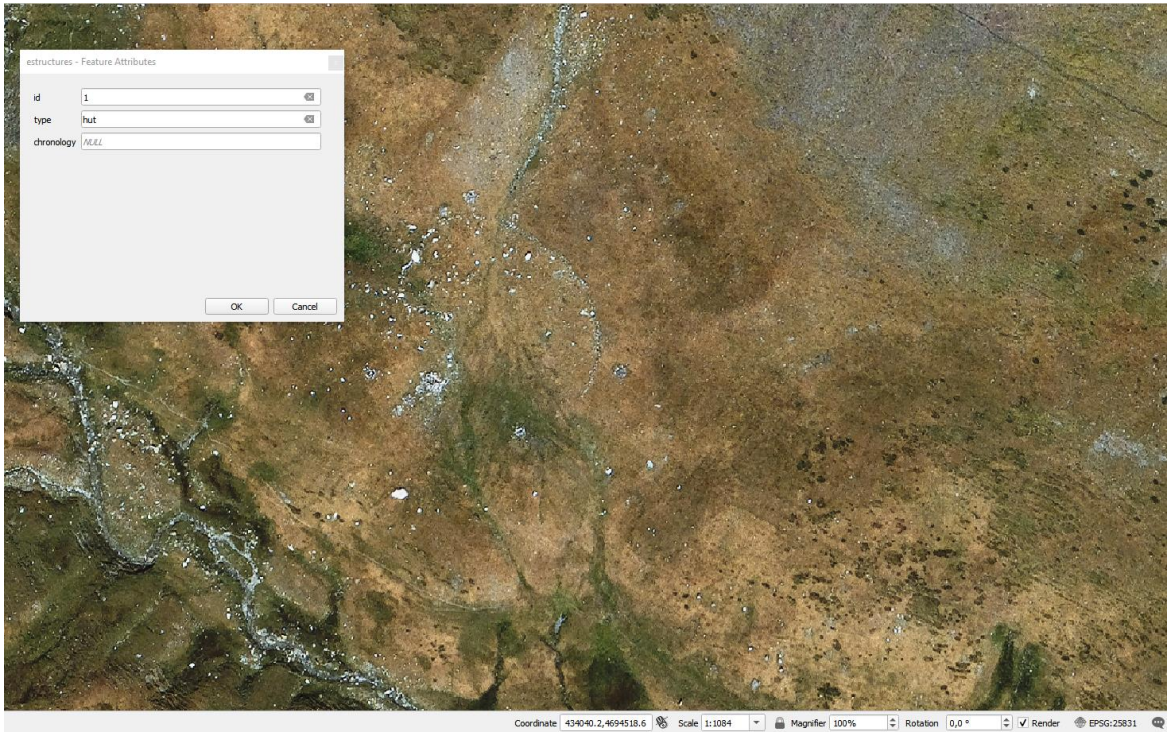
Layer -> Toggle edition

It is important to note that in the layers panel the edition icon will appear next to the layers that are currently under edition.

Use

Edit -> Add point feature or () to add new points and () to edit them.

Click on the feature, add the information on the table (except chronology) and press **OK**



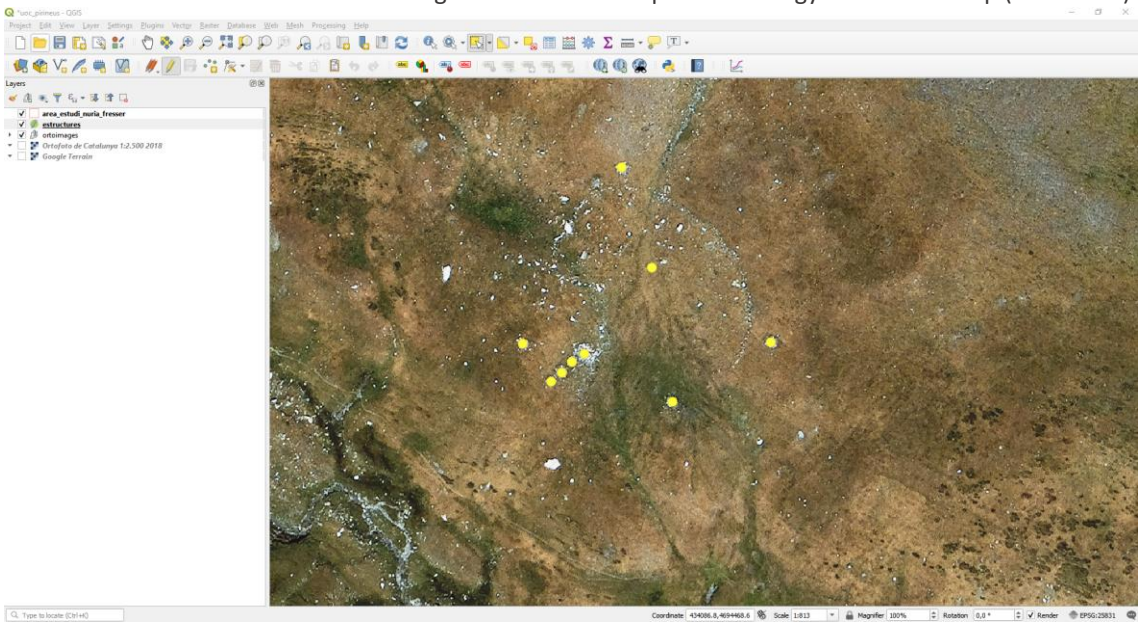
19: Edit vector layer

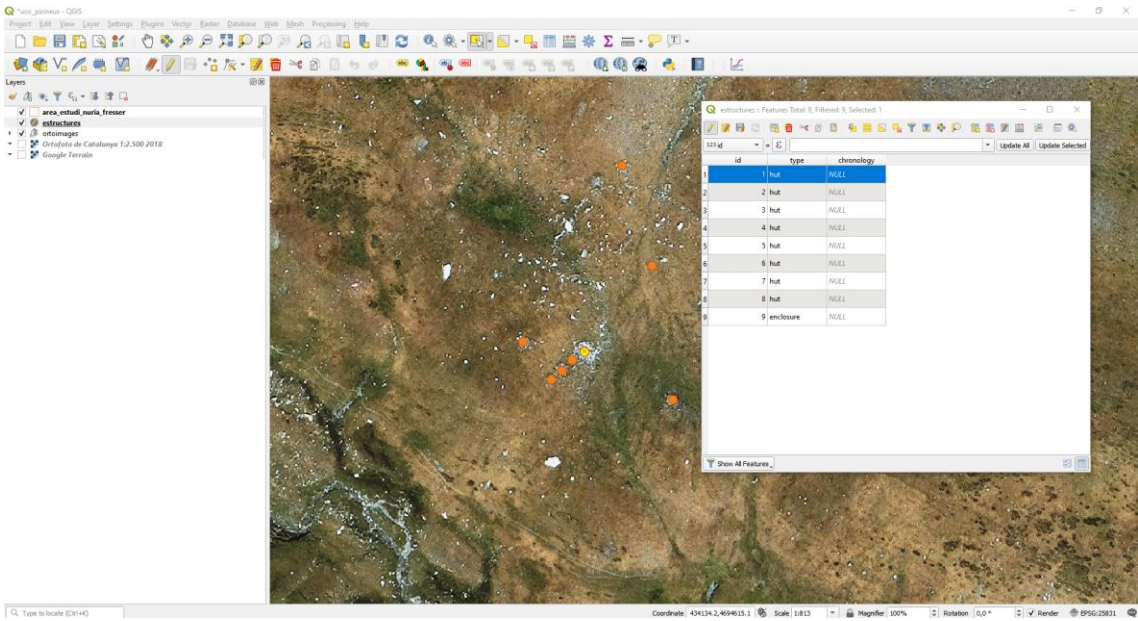
We repeat the process for the rest of the huts and the enclosure.

After that we can check the table

Layer -> Open attribute table or right-click on the layers panel.

Now we can see the table with the attributes.





20: Create a fishnet

When you start to explore large areas, you are forced to move around the map changing the scale. Doing that, you'll realise that is relatively easy to "get lost", not being able to remember which areas had been analysed and which not.

In those case is useful to divide the area in smaller parts, in what we can call a fishnet. In this example you will create a grid of squares covering the study area.

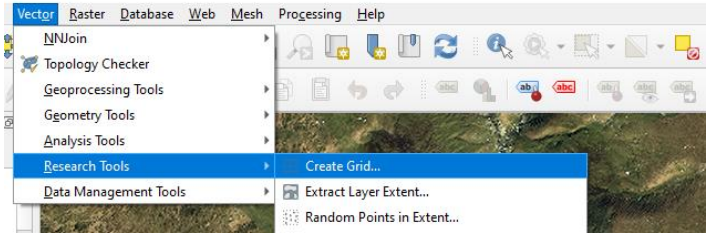
In the main menu, select

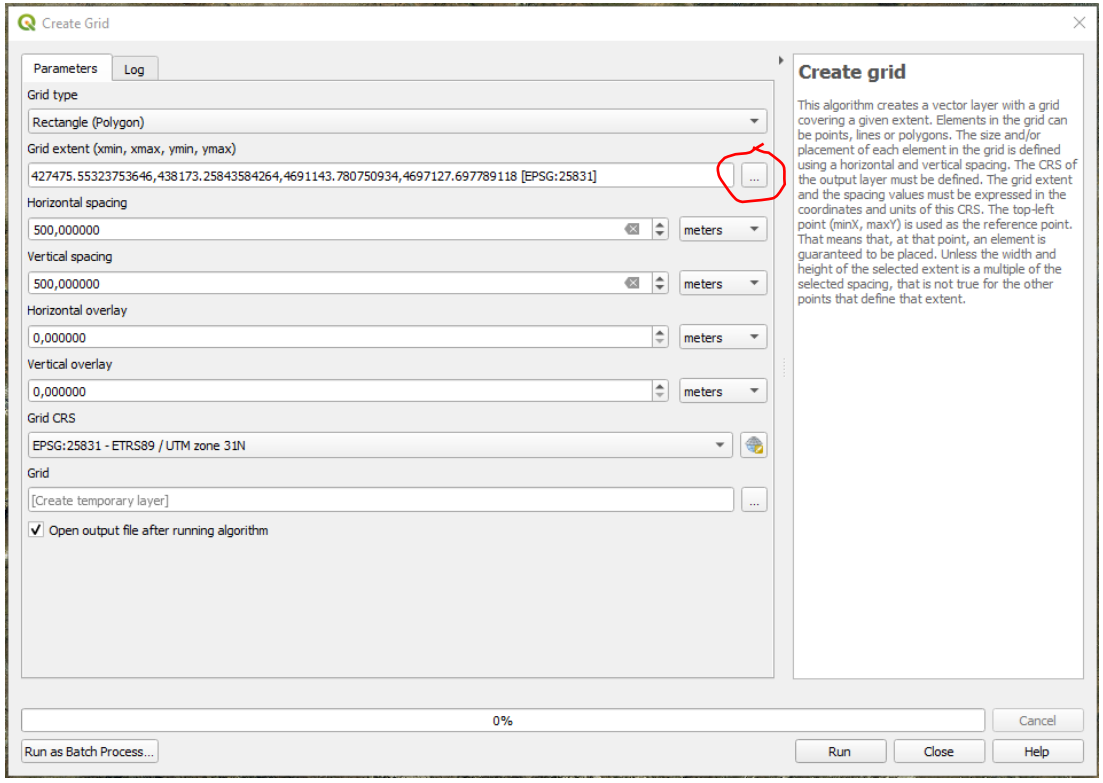
Vector -> Research Tools -> Create Grid…

On the parameters select **Rectangle** and select the … icon **to Use layer extent** as the grid limit. Choose *study_area_pyrenees.shp*.

Define the **spacing** values, here we are using a 500m x 500m grid, which is ok for the resolution, but you can try different options and choose the most comfortable to you.

Define the Grid CRS according to the project (EPSG 25831) and click **Run**.

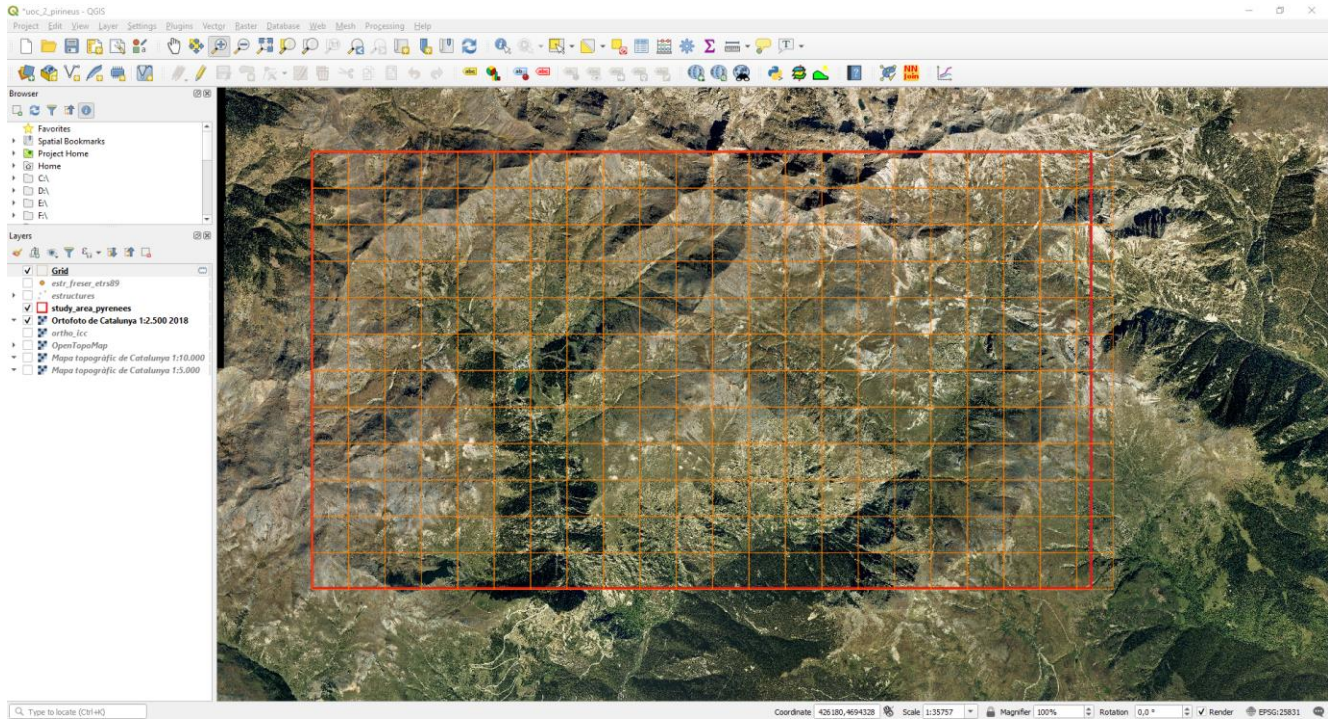




21: Using the “Fishnet”

The tool creates a grid of polygons within the defined limits. The grid is a temporary layer, you can save it in the project folder to keep it for future sessions.

After completing one square you can move to the next one, following a systematic exploration.



22: Identifying features of interest

From this point, move around the study area and try to detect other structures of archaeological interest. Huts and enclosures represent most of the elements of interest and are the most visible ones. Enclosures are in general the easiest to spot, while huts, being smaller, are more difficult. Take in consideration that they tend to appear grouped, so, if you spot an enclosure huts won't be far. Said that, there are cases of enclosures without nearby hut and the other way around.

A particular type of enclosure are what it is known are the "milking corridors". They appear as two parallel dry-stone walls. They where use to control which animals where milked and which ones not. Some times are more difficult to spot by a not-trained eye and some natural formations can look very similar, but you will find few like the one in the example in the study area.

23: Assign symbols to the different elements

To easily distinguish the different types of features, you can assign different symbols.

Right-click the layer and select “properties”. You can also access the window using the main menu:

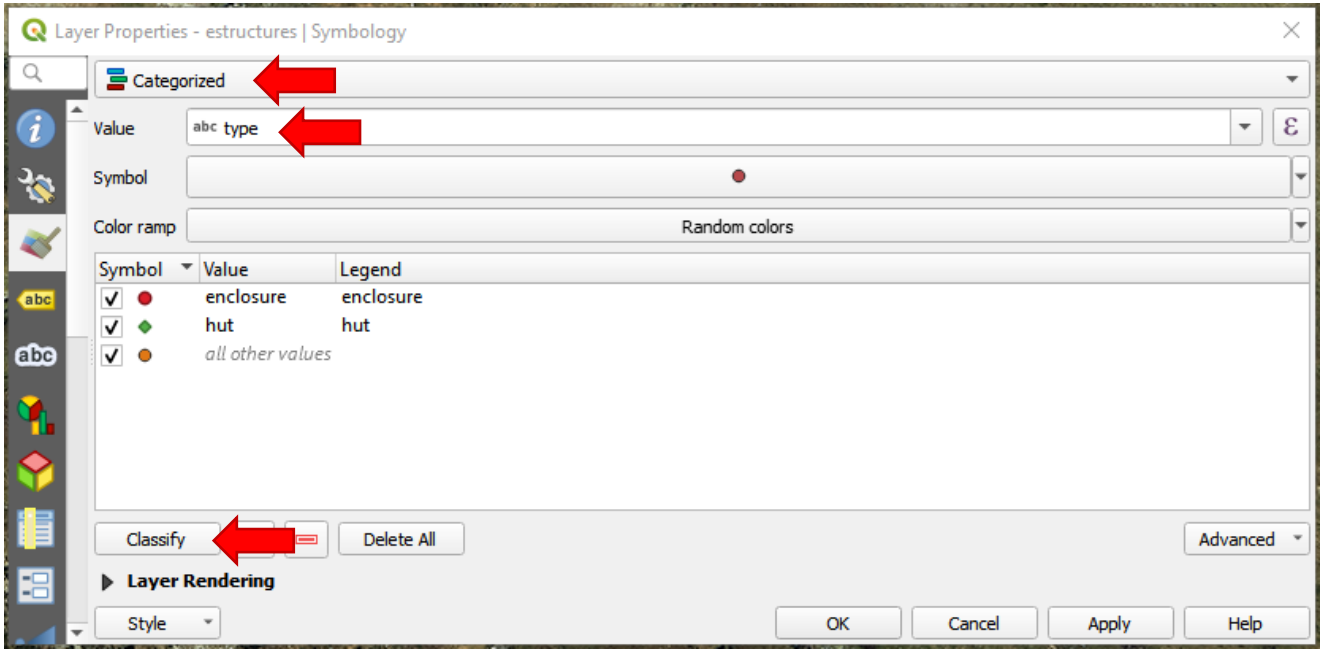
Layer -> Layer properties…

On the properties window, select **symbology** ().

In the symbology window you can select to represent the features by categories (**categorized**) instead of a **single symbol**.

For this example, define **type** as the value and press **classify**. That will create a list with all the values contained in the column. Now you can change the colour and shape of each of the feature types.

You can define a symbol and colour ramp or double click on each symbol individually.



24: Create field map

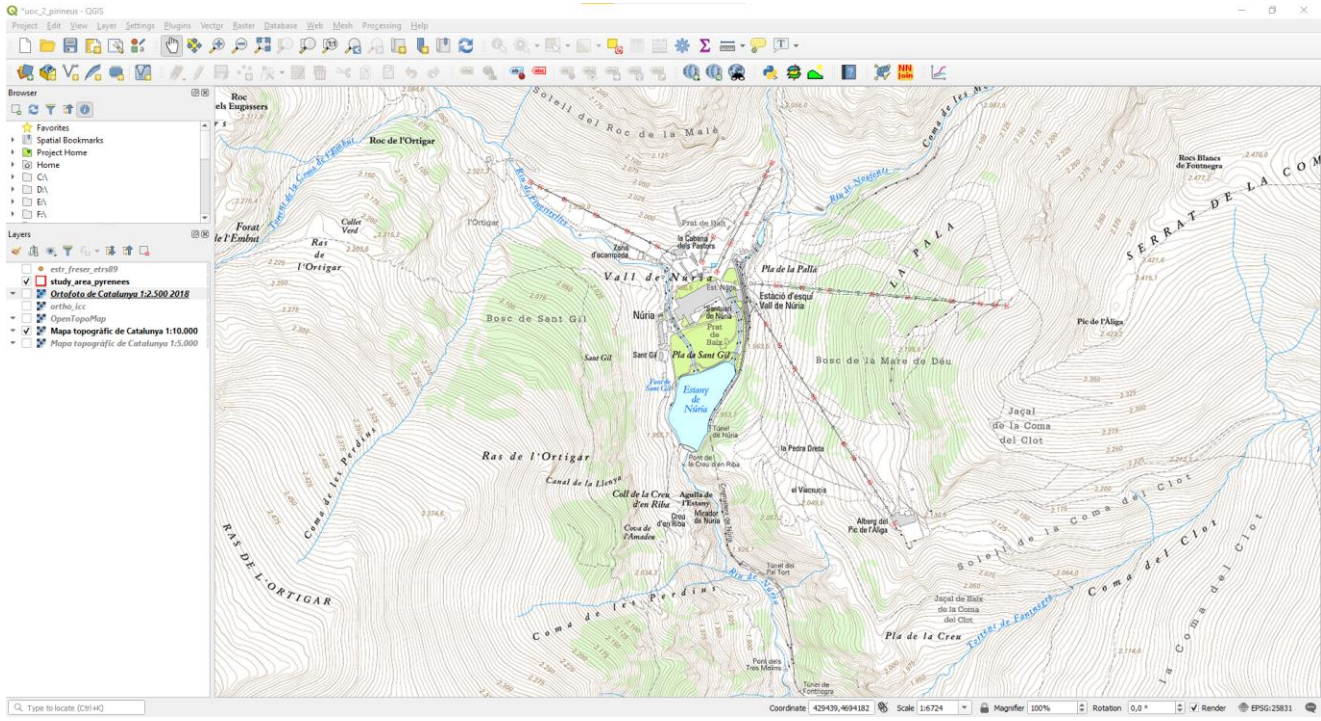
Once the photointerpretation is finished, good research would involve terrain assessment of the data, often referred as “ground-truthing”.

In our case, the objective of ground-truthing would validate that the features identified correspond to the proposed categories.

In an archaeological research, photointerpretation is usually employed as a preliminary work. The dataset would serve to plan and guide field survey, when an evaluation of the archaeological interest of the different features would be carried on.

In the next points we will create a topographical map which will incorporate the results of photointerpretation for field operation purposes.

For that we will select the layer containing the identified features and a topographic map.



This example uses the topographical maps produced by the Catalan Cartographic institute (you can download in different formats at https://www.icgc.cat, or use the WMS connection https://geoserveis.icgc.cat/icc_mapesbase/wms/service? and select the 1:5000 or 1:10000 basemap). You can use other services, like, e.g., *OpenTopoMap* or *Google Terrain*.

25: Create a New Print Layout

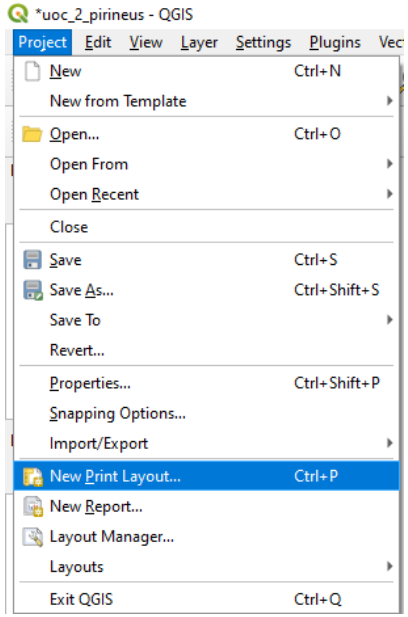
QGIS, as well as many other GIS software, incorporated a second interface for designing cartographic outputs, including figures and printings.

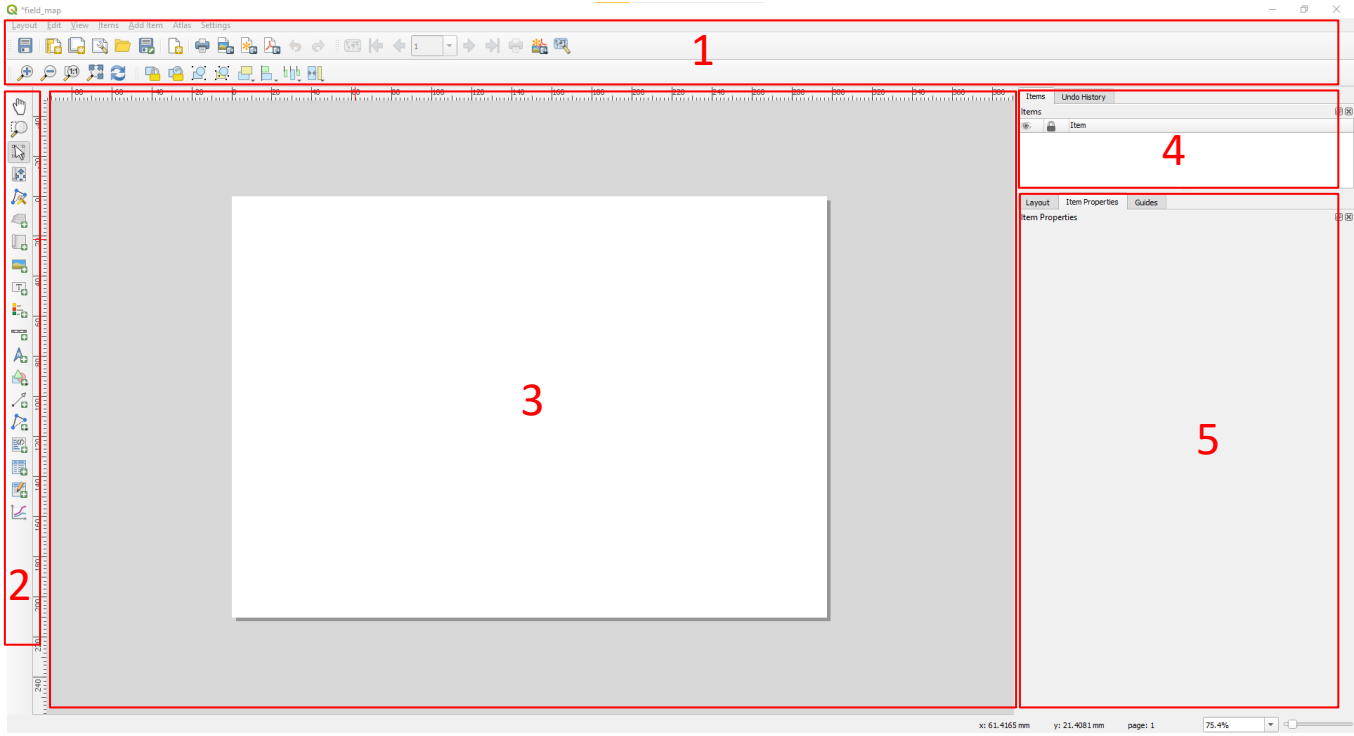
Using the main menu open a **New Print Layout**.

Project -> New Print Layout or Crtl+P

The program will ask to name the Layout with a title (e.g. *field_map* or any other name of your preference).

A new window will show the new interface.





The Layout interface is similar to the main interface we've been using until now, but contains significant differences: On **1)** The bar which contains the **menu** and icons gives access to the tools to manage the layout. **2)** a second bar on the left side give access to the main tools to move around and to add the different **items**. **3)** the **canvas** represents the printing area. **4)** the **items panel** works similarly to the **Layer panel** in the project interface. **5)** the lower right panel give access to the **Item Properties**.

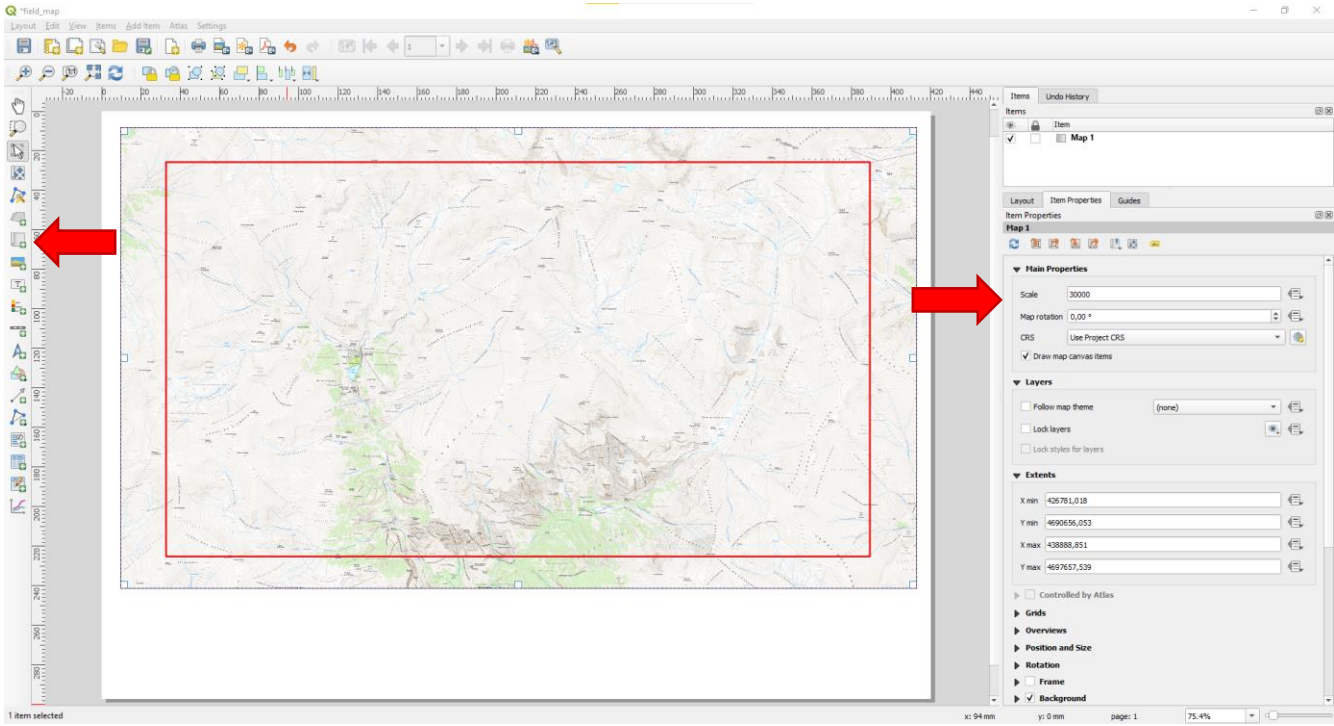
26: Add map

Use **add map** and draw a rectangle, which will create a window to the main project.

Add Item -> Add Map or icon 

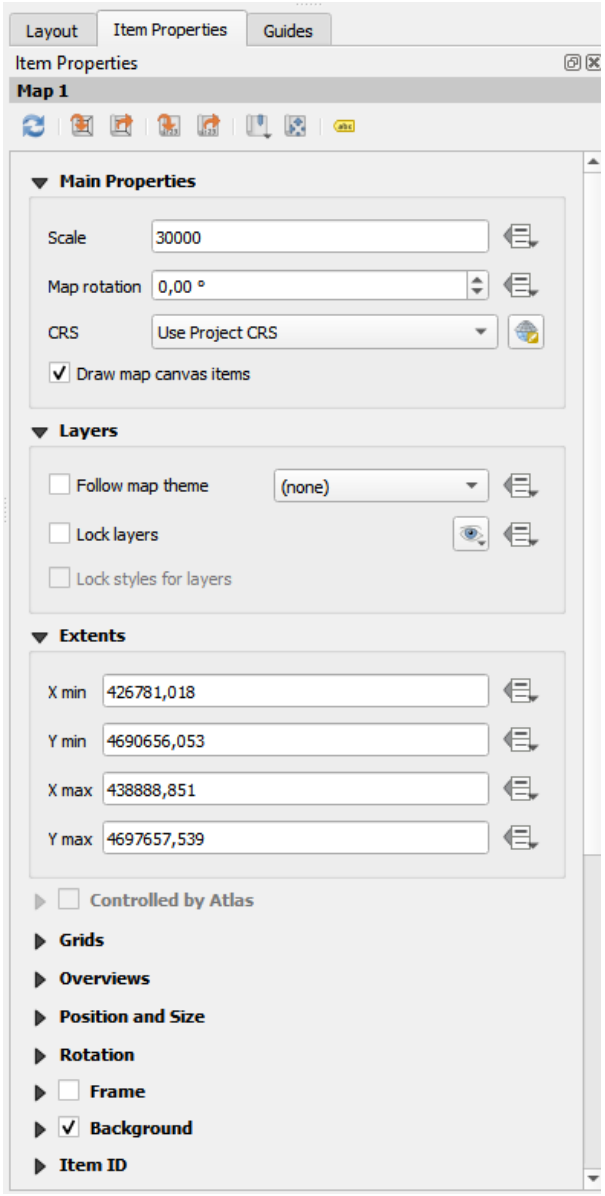
Right-clicking on the blank page we can select the page size.

For the example here we are creating a A4 size page with a map that covers all the study area at scale 1:30000. You can define the exact scale in **item properties**.



In the left menu, you can access several tools to facilitate the movement around the layout. To move around the page, you can use the hand icon (). You can also zoom to a specific area (). The arrow icon () is used to select the item you want to work with. Finally, the four-arrow icon () is used to move inside the map window.

27: Map properties



Select the map window and look at its **item properties**. The panel contains different parts.

In the first line you have different navigation tools, including the possibility to define the frame view using the main project and *vice versa*.

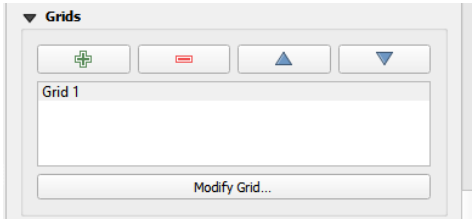
Select the CRS, scale, and rotation, in case you don't want to display the North on top.

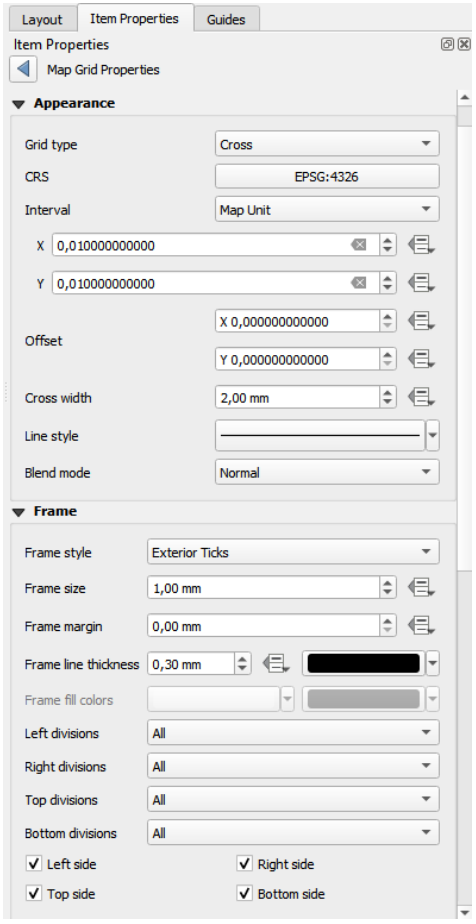
Note that in general the main project and the map are synchronised and the layout will display the layers as they have been defined in the main project. Here you can lock and unlock layers. That is very important when you have several layouts for one project or when you want to work on the main project without changing the view on the map.

Here you can define the area based on coordinates

On the lower part there are several options to manage map the map characteristics (an example in the next point).

28: Define grid properties





To create a printed map to be used on the field, we will start by creating a grid showing the coordinates in the geographic CRS (WGS84, EPSG: 4326) used by most GNSS devices.

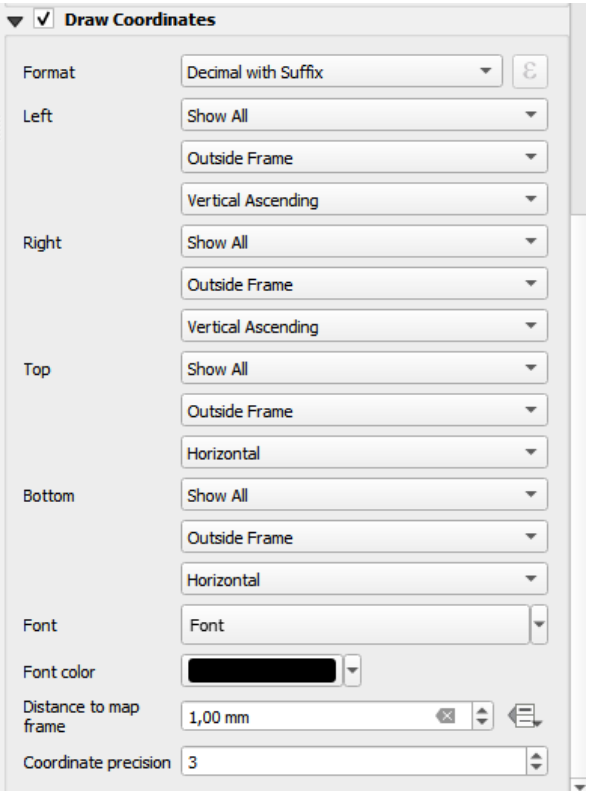
It might sound even exotic nowadays, but having a map with a coordinate grid will allow you to record a location in the field even without having access to GPS or other satellite based geolocation system. Combine it with a compass and you will be able to navigate with a very high precision as well.

Use the **+** icon to add a new grid and open the properties panel by clicking on **Modify Grid…**

Firstly define how the grid will be represented and its precision. The values at the example will produce the result you can see in the next page, but you can try to change the parameters until you fin something practical for you.

Note how the CRS have been changed!

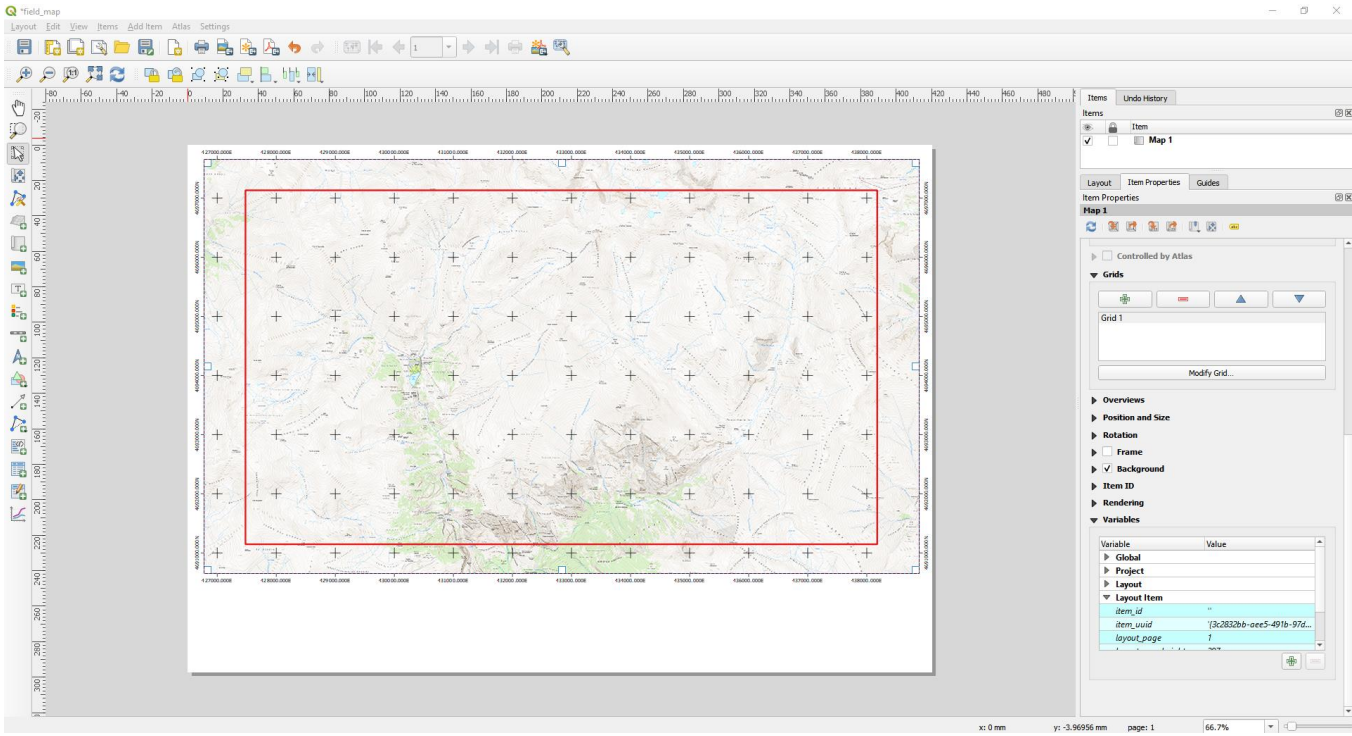
Secondly, define how the coordinates will be displayed at the borders of the map.



29: Grid

You can see the result of the grid in the canvas.

What we have now is a proper map, in the sense that can be printed and used to navigate and geolocate features in the field. But it still misses some information…

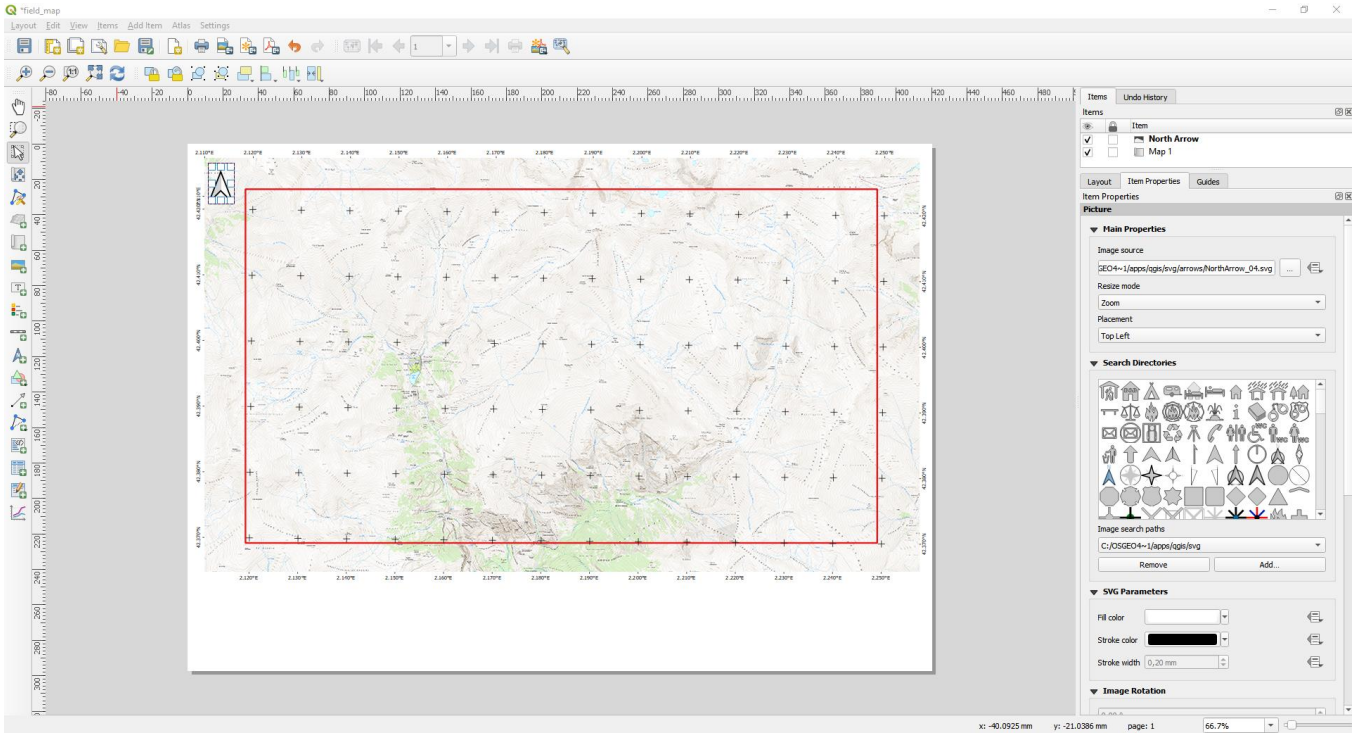


30: North arrow

We will start by adding a North Arrow. Use **add North Arrow** and draw a rectangle.

Add Item -> Add North Arrow or icon 

Using **Item Properties**, you can change its aspect.



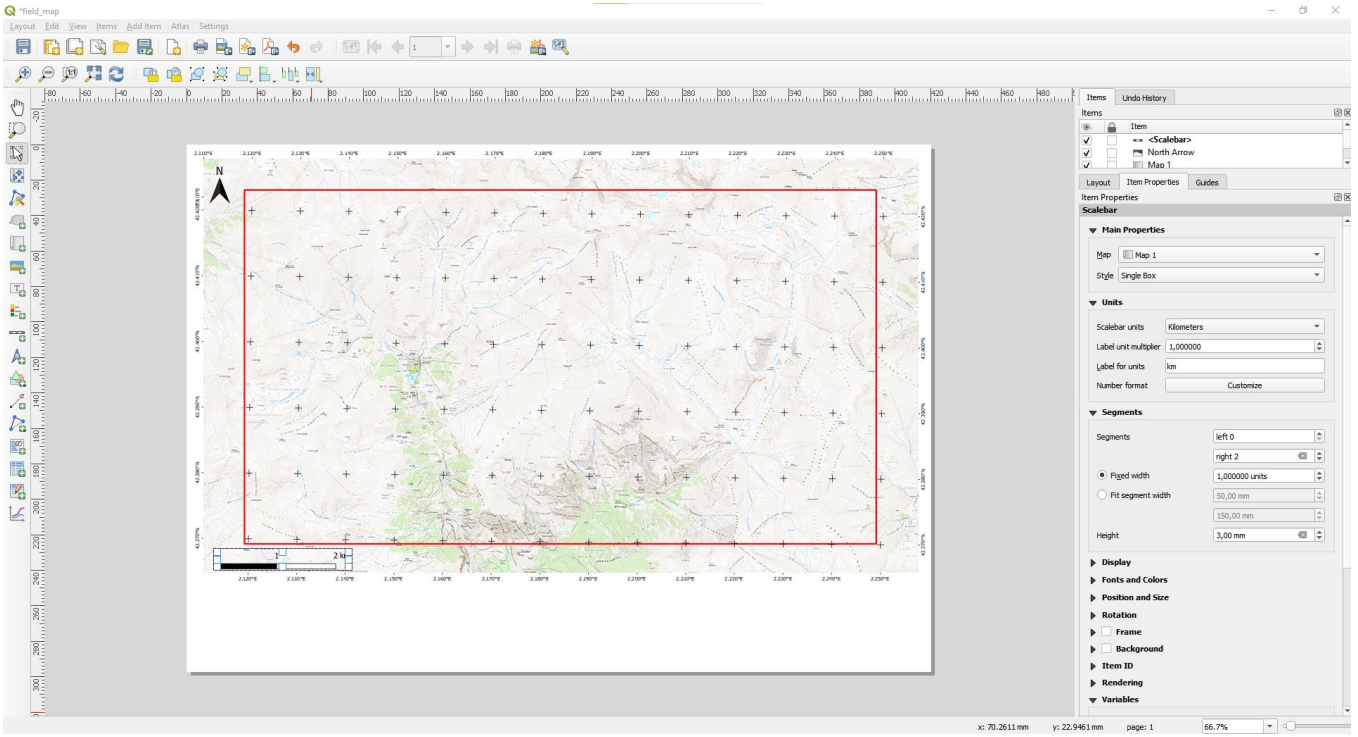
Although there is not a particular reason (and, indeed, there is plenty of examples of alternatives); the present-day more common convention is to represent the maps with the North on top. In any case, maps usually incorporate a visual reference to the directions.

31: Scale bar

Add also an scale bar. Now, use **add scale bar** and draw a rectangle.

Add Item -> Add Scale Bar or icon 

There are many options to define its aspect, you can have a look at **item properties** until you are satisfied.



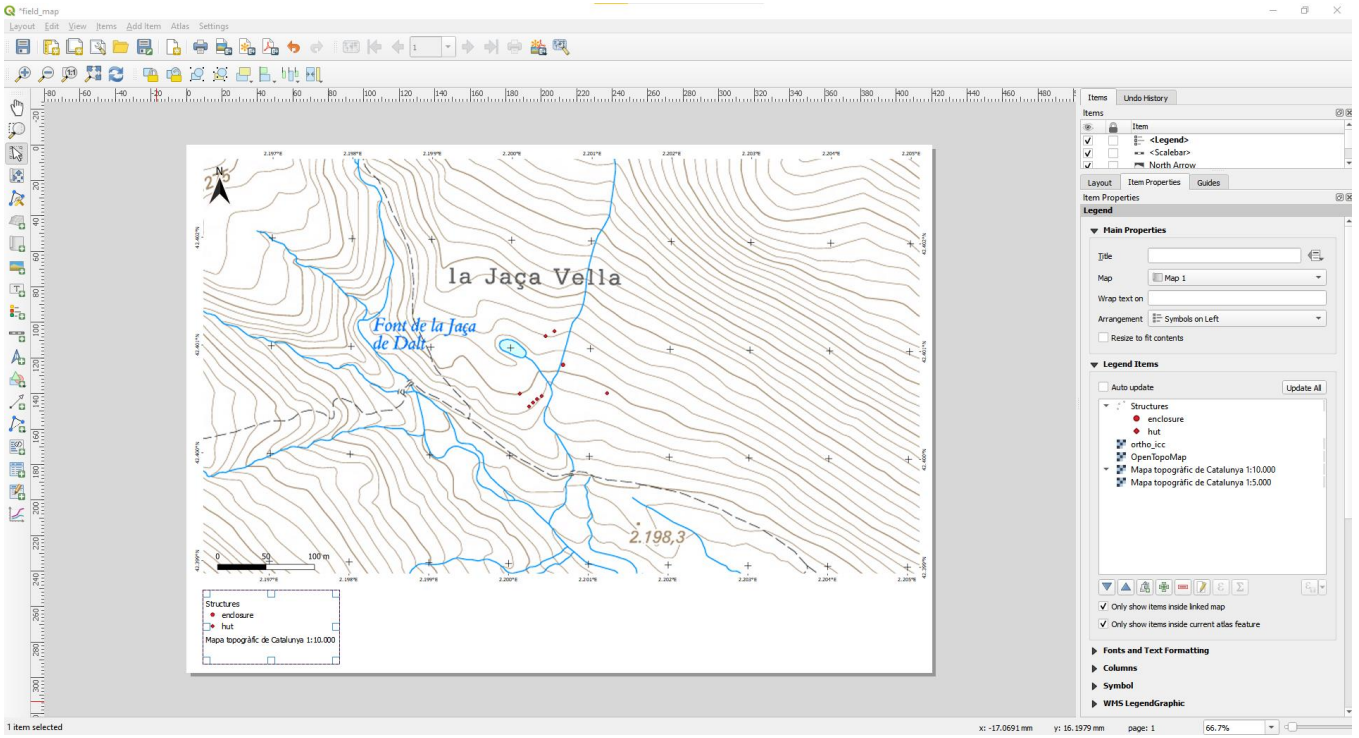
32: Legend

Finally we will incorporate a legend to identify which points correspond to huts and which ones to enclosures or other features. Use **add legend** and draw a rectangle.

Add Item -> Add Legend or icon 

By default the legend will show all the layers from the main project. If you want to change the way it looks (it is usually advisable to do that to present a more clear and tidy view to the reader), go to **item properties**, untick the **Auto Generate** box and you can modify which layers to show and which no, rename them, etc…

With the coordinates, the arrow and the legend you will have a professional map; ready to print and go to the field or to be incorporated as a figure in a report or publication.



33: checking

The next step in a research would be to move to the fields and assess the data obtained remotely by photointerpretation. For some data, to know for example the chronologies of the uses of the different structures, an archaeological excavation would be necessary.

For this exercise, instead of a field trip you can use the information included in the "archaeoroutes", a group of touristic itineraires based on the study case used in this tutorial. Have a look at the webpage (Catalan & Spanish):

http://parcsnaturals.gencat.cat/ca/xarxa-de-parcs/ter-freser/gaudeix-del-parc/equipaments-i-itineraris/itineraris/arqueologics/

You can find a short flyer and a GPS track for each of the routes and a general map. You can use also the files containing the points of interest "link" and the routes "link" included in the exercises.

You can simulate you work along the pre-defined routes: Have you localised some of the structures in the area of the waypoints? You can have a look on the archaeological data of some of the camps. Which structures contain? From which period?