6.1 Creating outline maps

The technical term for a map in which areas are differently coloured is a chloropleth map, MapInfo users will know it as a thematic map. In these cases the colouring is done according to some value. The following example simply constructs a map which allows you to select an area to be filled with a colour you choose. A simple map to construct but one which has a basic functionality for species mapping.

QGIS

6.1.1 A simple QGIS map

QGIS: Introduction

Objective	Map of Europe in which the regions are colour themed and individual countries may be selectively highlighted to indicate a species' presence
Applications	QGIS (also readily carried out in MapWindow & DIVA-GIS)
Maps	TDWG (http://www.kew.org/gis/tdwg/index.html)
Region	Europe
Sample data	Fauna Europaea (http://www.fauna-eu.org/) list of countries for a scarce taxon
Open project	new
Save project	\\Mapdata\World\Europe\Europe.qgs (before the addition of taxon data): \\[Project]\[taxon name]_Europe.qgs

A Set the Coordinate reference system (CRS)

1 Open QGIS and set the CRS:
Project|Project properties|CRS : tick the "Enable 'on the fly' CRS transformations"
The upper panel in this window will be empty on first use of QGIS but will contain your "favourites" as you develop projects. The lower panel has a huge number of entries, narrow this down by typing "etr" in the filter.
Select the ETRS89 / ETRS-LAEA EPSG:3035 within the Lambert Azimuthal Equal Area category (as recommended by Eionet)

B Add a background vector layer

2 Layer|Add Layer|Add Vector Layer : Maps>World>TDWG>Level2>Level2.shp (see ▸4.5.2)

3 Use the Zoom in button to approximately select Europe.
(experiment with the other Pan and Zoom controls)

4 Rename the layer to European Regions (right click|Rename)
Apply a filter (rt-click|Filter) adding "LEVEL1_NAM" = 'EUROPE'

5 Apply rendering to the layer (see Layer rendering below)
With your layer highlighted in the Layers panel, right-click and select Properties|Style, choose Categorised and the field from the table "Level2_NAM"
In the Colour ramp dropdown select Random colours. Select Classify
In the display, there should only be the following regions:(Eastern, Middle,

Northern, Southeastern and Southwestern Europe.
Adjust the colours of these regions either individually or using the colour ramp again (colour ramps can be devised and saved for future use), pale pastel shades are appropriate here, they simply form a background.

6 Save this project in your project folder (not in Maps). It is advisable to save intermediate steps as QGIS doesn't support undo operations to quite the same extent as other applications.

C Add the Country vector layer

7 Layer|Add Layer|Add Vector Layer : Maps>World>TDWG>Level4>Level4.shp (see 4.5.2) - read Brummitt, 2001 to see why we've omitted Level3
Rename the layer to "Countries"

8 Apply a filter to this layer:
Right-click|Filter and enter "Level1_cod" = 1 in the Query builder. This filter prevents all non-European countries from displaying

9 Apply rendering: Properties|Style, choose Column LEVEL_4_NA and use the Colour ramp dropdown to set all the colours the same - the colour you want to use to indicate "present"

10 Expand the "Countries" layer and untick all the boxes individually.

11 Save the project (Europe.prj)

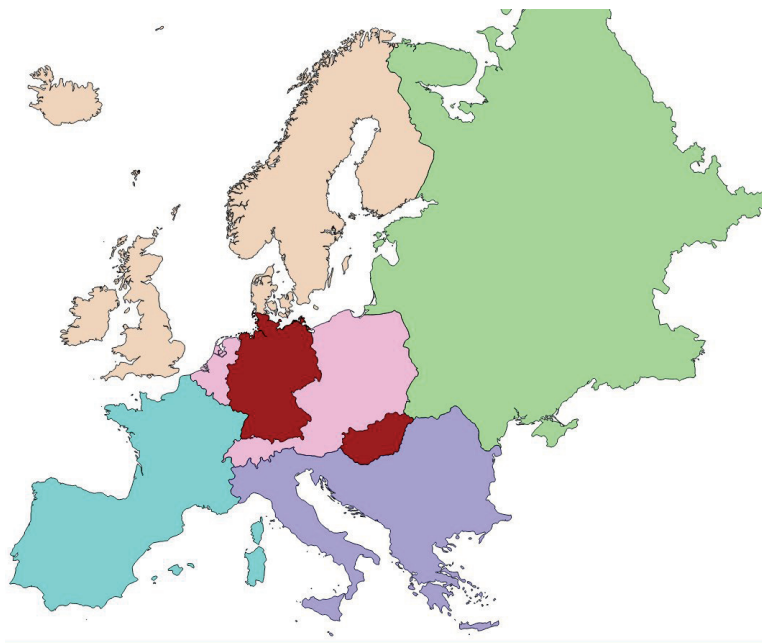


Figure 1. The map should look something like this screenshot. Germany and Hungary have been selected in the "Countries" layer.

D Refinements

The map is usable at this stage but before doing that it is advisable to make several improvements to the appearance:

Background

12 **Colour the seas & lakes**: Project|Project properties|General and set the background colour to a pale blue.

13 **Add non-Europe countries for context:** Add another Level4 layer, filter it with "Level1_cod" != 1 and render it with pale grey, using the transparency slider to fade it. Rename it "Non-Europe".

14 **Add some European country outlines**: Add another Level4 layer, filter it with "Level1_cod" = 1 and render it transparent, use the transparency slider to fade the boundaries. Rename it "European countries"

E Organise layers into groups

The sequence and arrangement of the layers placed in the Layers panel is important. Some of the layers added are masks and so their position in the stack is important, if they find their way to the top then they will mask subsequent work. Correct sequencing is aided by the facility to place layers with similar functions into groups and the facility to turn entire groups on and off as required.

15 **Set up groups**: Right-click in the Layers panel and add the groups: Project & Outline. Drag layers into the appropriate group (Countries into Project, all the others into Outline.
Additional groups for organising other environmental variables (Chapter ▸4.7) such as Climate and Biogeography, and analytical layers such as Grids will be added to this project later.

16 Save the project (Europe.qgs)

F Test the project with real data

Quantitative

? is it possible to do this without resorting to a separate data table, just to introduce the idea without creating confusion

Qualitative

Copying the data from published maps is the simplest approach. The Fauna Europaea distribution maps are an easy and appropriate source for this data as they provide a presence/absence list for all European countries.

1 Open the Fauna Europaea website at the Distribution page, search for a taxon and click the Display on Map (your Java will need to be up to date), use the list from Display in Table button.

2 From the displayed list select the appropriate countries and enable their display in the Countries layer.

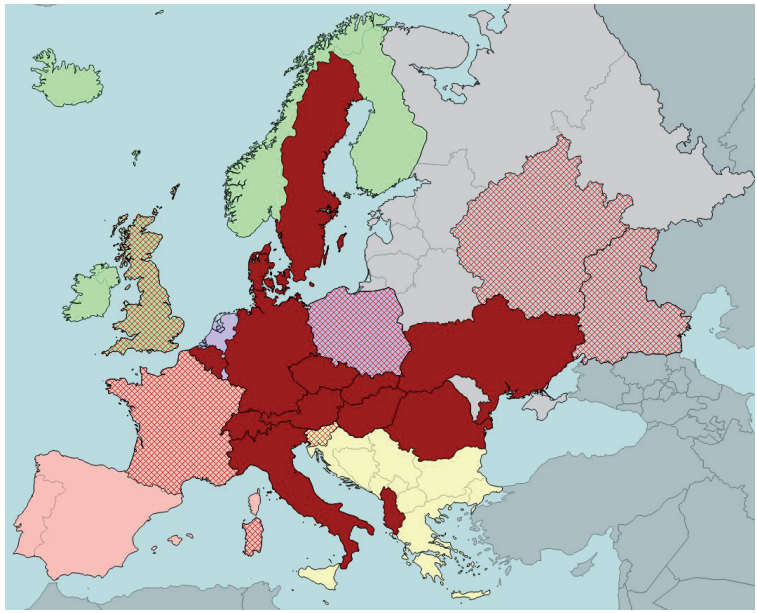


Figure 2. Screenshot map showing distribution of *Rainieria calceata* from Fauna Europaea. Cross-hatching from additional data (a duplicate of the Countries layer with different rendering)

3 Save as "[Taxon name]_Europe" in an appropriate project folder.

Review

At this point a number of techniques have been used in QGIS to achieve the simplest usable QGIS project file for Europe. There is sufficent now for personal desktop investigations of taxa and even enough, using Print Screen, to take a screenshot to create an image suitable for simple publications such as newsletters.

The resulting map is poor at conveying much useful information, suggesting that the taxa are distributed throughout the countries indicated when in fact they occupy small southerly sites in UK and Sweden. This is a question of granularity, for more effective depictions the geospatial objects should be smaller, tiles and points being preferred to provinces (sub-divisions of a country).

Next steps:

1. Principles of layer rendering (▸5.1.1)
2. Improved presentation using QGIS' Print Composer (▸5.2)
3. Points, grids and tiles (▸5.3, also see ▸4.8 for principles)

Alternative treatments:

1. The way you define Europe for your project is important, consult ▸4.2.3 and amend the filters in the various layers to suit.

6.1.2 Layer rendering

Layer rendering & chloropleths

6.1.2.a Principles of Layer rendering

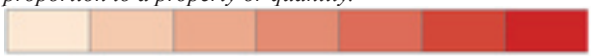
Managing what is and what is not visible amongst stacked map layers under various conditions (e.g. magnifications, ambient light) is an important concept and an integral part of the design process of digital maps whether the user be just ourselves and colleagues on our own desktop or networked systems or other users via designs for interactive web displays, GPS displays, SatNav screens or print.

1 Static layer rendering

This refers to the fixed appearances given to the objects on a single layer. To a degree these are determined by conventions, so UK Motorways will be a certain shade of blue and a certain thickness, A-roads a particular shade of red, Ancient Woodlands will usually be some shade of green and consist of some form of cross-hatching so as not to obscure other objects. In the example above, European regions have been given different shades. Point symbols too have a convention.

Chloropleth (thematic) maps

Chloropleth is the technical term for the thematic maps with which some users may be more familiar. Areas or symbols placed inside defined areas are shaded or coloured in proportion to a property or quantity.



There are some simple rules to prevent us from producing misleading maps,

📖 Wikipedia at http://en.wikipedia.org/wiki/Choropleth_map has a useful set of rules regarding Colour Progression.

📖 Lillethun A., Cryan S., Jessen T. & Steenmans C. 2011. Map Colour Guide. .

Chloropleth maps have static layer rendering conventions too. For example the readability of a map will be destroyed if the colour conventions for hot and cold are reversed.

On a desktop GIS there are many ways to alter the way in which layers render, the colours and thicknesses of lines can be changed as can colours and hatching patterns of fills and symbols for points. Layers can be turned off with a simple tick box or faded out with a transparency slider control. Finally controls can be used which determine the scales through which the layer is permitted to be visible - dynamic layer rendering:

2 Dynamic layer rendering

Layers change dynamically; this could occur in several ways, the perspective may be changed by zooming in and out (a feature of desktop systems), by changing angles of view (e.g. GoogleEarth), position (GPS and SatNavs) or via external influences such as ambient light (SatNavs).

Since the process involves the rendering of individual layers in different ways according to different perspectives (zoom is one perspective, low ambient light levels

on a SatNav causing the layers to change colour is another) the concept can clearly be best described as "layer rendering", qualified where necessary by "perspective"

*The term **rendering** is "*the creating, texturing and shading of an image" *and so is the exact word needed to explain these concepts. It's an artist's word and could be applied to the act of colouring engravings in old Natural History books. Not to be confused with the usage by computer developers to describe the "drawing" of the image onto the screen.*

Using Chloropleths in QGIS

1. In the **Styles** panel of a layer, choose **New color ramp** in the **Color ramp** dropdown box.
2. The dropdown in the **Color ramp type** popup window will allow you to select Gradient, Random or ColorBrewer:
    1. Gradient:

The command in QGIS is **Settings|Style Manager**. For an enhanced set of colour ramps install the ***Color Ramp Manager***, an add-in which can be obtained via **Plugins|Manage and install plugins** and browsing for ***Color Ramp Manager*** and selecting **Install plugin.** Following successful installation an icon will appear on the toolbar, clicking which will present a pop-up window which can be used to select collections of colour ramps from various sources (and permit you to decide where to save them).

The next time you choose **New color ramp** in the **Color ramp** dropdown box in the **Styles** panel of a layer, the dropdown in the **Color ramp type** popup window will allow you to select the collection you downloaded above (*cpt-city*).

Some standards are provided by EEA. A "Map Colour Guide" at http://www.eionet.europa.eu/gis/docs/EEA%20Corporate%20identity%20manual%20Map%20colour%20guide.pdf will be found useful and a guide to the colours used for Biogeographical Regions (see 4.8.2) is contained within their Guide for EEA map layout.

Well worth using those guides to create Colour ramps of your own.

References

Lillethun A., Cryan S., Jessen T. & Steenmans C. 2011. Map Colour Guide. .

Elmer M.E. 2012. Symbol Considerations for Bivariate Thematic Mapping. University of Wisconsin,

Stevens J. 2015. Bivariate Chloropleth Maps: A How-to Guide Available at: http://www.joshuastevens.net/cartography/make-a-bivariate-choropleth-map/.

Review

6.2 Composition and presentation

[Refer to section on visuals etc.]

6.2.1 Extents

Presentation: extents

Application	QGIS
Region	Europe & Pan-Europe
Open project	\\Mapdata\World\Europe\Europe.qgs
Outline map	EEA standards from Eionet (▸4.7.3C)
Save project	\\Mapdata\World\Europe\Pan-Europe.qgs

During the course of this section it is likely that you may make a choice as to the most usable extent for your particular needs. Given the use by Fauna Europaea and LANMAP of the Pan-Europe concept (non-political) we add that to our stock of "no-data" projects.

[more of a preamble]

The EEA standards provide many choices as to the most appropriate set of map **extents** to use:

1. **Extent 1c** clips off the large parts of the western edge of East European Russia and the northern edge of North European Russia. This is the optimum extent for maps depicting non-Russian data, will be generally usable if data from Eastern Europe is poor or absent and not quite adequate for display of country-based presence/absence.

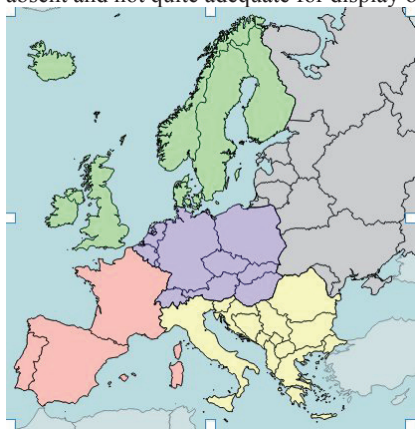


Figure 3. EEA Map extent 1c Projection EPSG:3035

2. **Extent 2c** clips off lesser portions of the western edge of East European Russia and the northern edge of North European Russia. This is optimum for European regions, will be generally usable if data from Eastern Europe is poor or absent and will be better than 1c for display of country-based presence/absence.

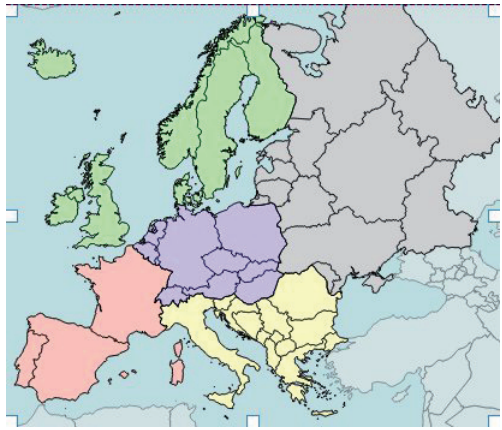


Figure 4. EEA Map extent 2c Projection EPSG:3035 - Plenty of space for legends actually on the image (deprecated by EEA)

3. **Extent 3c_n** will encompass the entire Pan-Europe area but the scale is small.

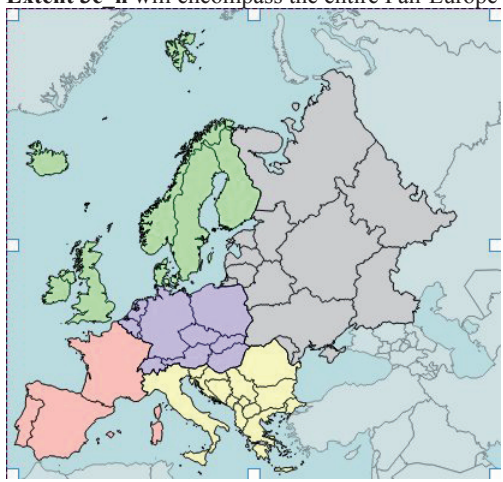


Figure 5. EEA Map extent 3c_n Projection EPSG:3035

In QGIS' Print composer it is possible to save these extents in order to generate graphic output of your work to exactly the same dimensions.

1. Open the QGIS project file saved at step 16 above.
2. Select Project|New Print composer. A new Print composer window opens. Set the dimensions of the page (A4 upright)
3. Click the Add new map button
   Use the cursor to draw a large rectangle on the page
4. Refer to table 1.3. "Specification of map extents by coordinates" in the **Guide for EEA map layout.pdf.**
   In QGIS Print composer select the Item properties tab in the lower right portion of the window.
5. In the Extents boxes of the panel enter the coordinates of your chosen EEA Map

extent as follows:

EEA term	QGIS term	Map extent 1c	extent 2c	extent 3c_n
Bottom	Y min	1350000	1350000	1350000
Left	X min	2555000	2555000	2555000
Top	Y max	5500000	5500000	6650000
Right	X max	6580000	7405000	8100000

Monitor progress by clicking the "View extent in map canvas" after each entry.

6 This action changes the scale which becomes an "odd" number. To achieve the nearest round number (e.g. 25000000) the size of the rectangle must be altered. EEA consider that accurate relationships between the printed image and the real world are considerably less important than having an image which is easily viewed.

Review

Barry Cox C. 2001. The biogeographic regions reconsidered. J. Biogeogr. 28: 511–523. [bypassed by more recent treatments]

Barve V. 2015. Discovering and developing primary biodiversity data from social networking sites. 98.

.

Numerous GIS applications

Huggett R.J. 2005. Fundamentals of Biogeography, 2nd Edition. 441-442 pp.

6.2.2 Legends & outputs

Presentation: legends

adding legends
exporting

Copying styles from other QGIS projects

1. Open QGIS project in which you have a layer with styles you require.
2. Select layer
3. Right click and select Styles|Copy style
4. Open the QGIS project containing the same layer (unstyled)
5. Right click the layer and select Style|Paste style

6.2.3 Multiple map frame layouts

qgis two maps on one composer:
http://gis.stackexchange.com/questions/45174/how-to-handle-multiple-map-frames-with-different-layers-in-one-print-layout
http://gis.stackexchange.com/questions/80182/adding-multiple-maps-in-qgis-composer
http://gis.stackexchange.com/questions/93436/including-two-different-maps-in-one-qgis-print-composer
http://gis.stackexchange.com/questions/140484/how-to-create-several-maps-showing-different-layers-but-the-same-area
http://opensourcegisblog.blogspot.co.uk/2015/08/tutorial-side-by-side-maps-in-qgis.html
Multiple map frame layouts are possible in QGIS by basing Map frames upon different groups. However QGIS is currently unable to support this treatment if the map frame layouts are of different projections (as in the case of British Isles when the Channel Isles are required), the solution here is to compose the final map in some external application (e.g. Desk top publisher or Graphics application) or to use DMAP. ...

6.3 Plotting data on a map

Application	QGIS
Project file	A copy of QGIS project [Europe] from ▸5.1
Region	Europe
Sample data	Data in Excel format as described in ▸3.3.6 (see ▸7.4 for sample data)
Open project	\\Mapdata\World\Europe\Pan-Europe.qgs

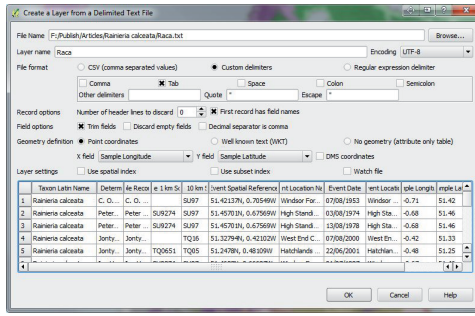
6.3.1 Points

Plotting: points

Like the flags created in geotaggers or Google Earth and similar programs, the ability of a GIS to create a symbol at a point on the map specified by coordinates is one of the most important functions of a GIS. A manual function which creates a symbol via coordinates which are manually entered is possible in QGIS via one of the plugins (Numerical Digitize) but the customary method is via a CSV table which is added to your project via the "Add Delimited Text Layer"

The CSV table may be output from a spreadsheet and needs to contain X and Y coordinates at a minumum, other fields in the table characterising the data can be used to modify the appearance of each point (a point has a position but no magnitude)

1. Open a QGIS project from ▸5.1 and save a copy of it in your project folder
2. Adjust the visibility of any background colours to meet the needs of your project (on/off or transparency slider in the Styles dialogue),
   The more complex the "ecoregion" background used, the more explaining required in your presentation/publication. If you have chosen a Europe map and it is intended solely as an inset accompanying a more detailed distribution map of a single country then the least complex "ecoregion" may be the best choice (no background > country presence/absence > TDWG > EEA), otherwise choose the ecoregion background that best suits a full sized map (EEA > TNC > LANMAP), your scrutiny/analysis and the needs of your project (e.g. Climate, Soils, Forestry)
3. Obtain your points data by exporting from Recorder 6 as an Excel spreadsheet (ensuring that the Sample Latitude, Sample Longitude and Sample Year fields are included) then save the spreadsheet as a text file (=CSV) see 3.3.6
4. In QGIS Layer|Add Layer|Add delimited text layer and select the CSV file, the following dialogue appears:



Choose the CRS which was used to collect the Lat/Long data (WGS 84 in the case of Recorder 6)

5 Rename the layer to that of the taxon. Adjust Styles to make the points a useful size, colour and shape.

The following map is now obtainable through the Composer functions:

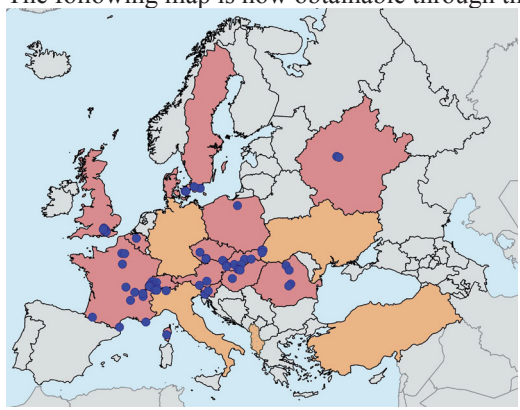


Figure 6. Distribution of *Rainieria calceata* in Pan-Europe (blue dots). Countries in which it is present are in red, Fauna Europaea countries in which the taxon is reported but no occurrences have been discovered by the author are in orange.

This map was used to make enquiries to the Fauna Europaea group coordinators as to their sources of data for those countries marked in orange.

This simple style of map could be considered as a "thumbnail", usable to provide a European context to single-country studies.

For a more analytically useful presentation, choosing a different background layer may be of value (ecoregions, climate, soils, vegetation etc.)

6 Use the Composer manager to create a legend:

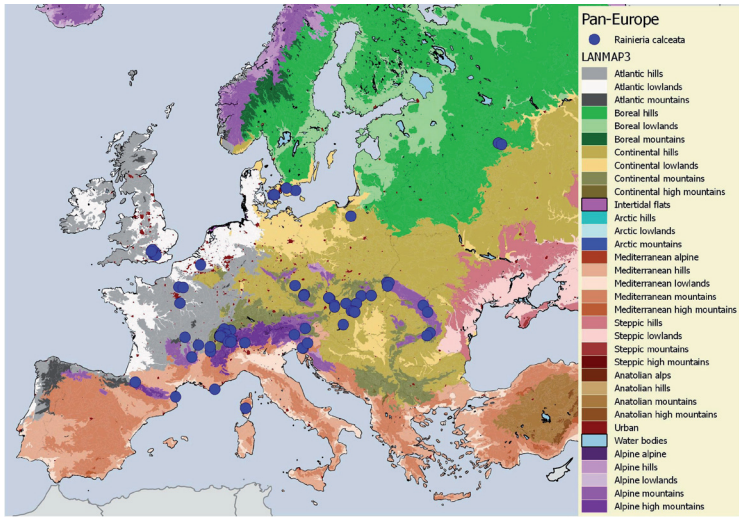


Figure 7. Distribution of *Rainieria calceata* on LANMAP ecoregions (level 3)

This graphic may lead to a first step in postulating the conceptual model as advised in Franklin's SDM elements (4.6.3) - Alpine hills and mountains (it breeds in fungi in Beech trees so the above is just one element of such a model)

7 Save the QGIS file and the Composer file in appropriate project folders

Review

This technique of representing distribution by placing unqualified points or place-markers onto a map is a simple one, used extensively in certain web-based mapping systems such as iNaturalist or Google Earth.

From this point we can now pursue any of the following (see 4.6):

1. Improve the appearance of a distribution map by enhancing the presence/absence points with date ranges (▸5.3.2)
2. Add and utilise appropriate grids or tiles (▸5.3.3)
3. Incorporate some other quantitative data such as abundance which may have been gathered (▸5.5.1)
4. Compare the distribution of our taxa with biotic and abiotic factors (from geospatial datasets obtained via other sources) and begin to build up a conceptual model of distribution. (▸5.5.2)

6.3.1.a Quality of sample datasets:

The nature of data collected through trawling of published papers etc. [?????] precludes a lot of potentially useful quantitative information which could be used to enhance such a display of taxa at points.

6.3.2 Date ranges

Plotting: Date ranges

The observation date is potentially useful data but whilst Recorder 6 is capable of handling a wide range of date formats, as a consequence these formats are not so readily interpreted by QGIS. The information which may be used in QGIS displays (different date ranges shown as different colours) is that of "Sample Year" obtainable

through a Recorder 6 Wizard (see ▸3.3.6)

1. Open the QGIS project from ▸5.3.1 and save a copy of it in your project folder.
2. Add a second copy of the CSV text layer
3. Double click that layer to access the Styles dialogue
4. Select Categorised, Sample Year then Classify
5. Change the type to Rule-based - the dialogue now presents one rule for each year in the table.
   Reduce the number of rule-based categories by deleting most of them. Do not delete the last one - which contains the NULL value for those records which don't have a date, you may delete the first one if you have no use for a date equalling zero. Leave a maximum of 4 or 5 categories in total, anything more becomes unreadable.
6. Adjust the Rule for each of your remaining categories (except the NULL) by double-clicking on the row and entering the Rule into the Filter box thus:
   "Sample Year" >= 1820 AND "Sample Year" <= 1899
   (enclose the name of the field in quotes because the word "year" is a reserved word), change the Label too to something meaningful.
   Repeat for the other 3 or 4 categories using date ranges you prefer (1970 is a key date as many publications compare pre and post 1970 records)
   The last Rule should read "ELSE" because it's a non-numerical value (~NULL), label this with "No date".
7. The Colour ramp has been lost by this process so each category must be hand-coloured. Double-click each category then from the drop-down beside the "Color" box select the Pick option and "steal" the colour from an open copy of the Map Colour Guide pdf (Lillethun et al., 2011.) At the same time adjust the size and type of symbol. A smaller symbol for the "No date" category will prevent the symbol from obscuring coincident symbols that do have a date. Alternatively the rendering order can be changed using the "Rendering order ..." function in the Styles dialogue so that more recent symbols are on top.

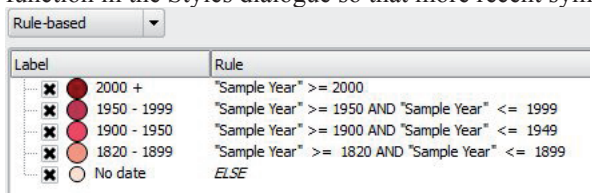


Figure 8. Rule based date range categories in the QGIS Styles dialogue of a points layer.

? can this be saved and used in another project?

Do another example using a green to red range (more critical work to indicate population reduction)

And another pre/post 1970

Systematic errors & point locations

Point symbols placed upon a map in this fashion may be inaccurate due to a variety of causes, any imprecision introduced arise as a result of our incorrect depiction.

This inaccuracy arises from the way in which the location data may have been collected. Thus for example if a number of occurrences are recorded utilising a small scale map and the location is provided simply as a reference to a 10km square (a map usage convention) then the point placed on a map will locate at the lower left corner of a 10km tile which contains the actual location. This methodology has therefore introduced a systematic error which whilst reproducible and therefore precise, is actually inaccurate. Different kinds of systematic errors may be present in the same collection of species occurrences in respect of locations. The point location may be simply judged by the compiler based upon rather vague information such as the name of a site, town or region.

Such levels of systematic error are unavoidable in trawls of historic data and have given rise to problems in modern analyses such as IUCN assessments (Webb & Brown, 2016) and statistical modelling (Engler et al. 2004) but modern accurate means of recording location positions via GNSS devices mean that more recent surveys can be much more accurate in this regard.

There are methods of dealing with geospatial data to depict locations in a more precise way, these methods involve the selection of tiles which are based upon polygons (see Polygon mapping below.)

Granularity

In species occurrence studies of variable spatial accuracy, the choice of cell size (grain) is determined by statistical manipulation designed to eliminate (or reduce) errors. Aggregating all data into cells representing the poorest level of locational accuracy or dropping those with the poorest accuracy are the two extreme approaches but there are means of finding a compromise between the two.

📖 Elith J., Burgman M.A. & Regan H.M. 2002. Mapping epistemic uncertainties and vague concepts in predictions of species distribution. Ecol. Modell. 157: 313–329.

6.3.3 Projections and Grids

Projections & grids

Grids as a visual aid

The use of grids very much depends upon the scale of your map. At large scales such as a Palaearctic map the use of a grid is of debatable value unless one is discussing projections and CRS,

At the European level an overlain grid offers little additional visual assistance to orientation and interpretation but grids are used to gather statistical information, manage large databases (e.g. CORINE, Natura 2000 etc. see Annoni et al. 2001) and process the large scale geospatial datasets (e.g. LANMAP); usage is discussed in Peifer, 2011.

At the level of individual countries however, grids become important as a visual aid to orientation, as a reference to printed maps and as a means of recording and referring to the locations of species occurrences via maps (paper, GIS & other electronic) or GNSS devices.

Projections & their grids in European countries

Different countries prefer different projections and as a consequence utilise different grids. Traditions of recording according to those grids or parcels may be long established. In interpreting published species occurrence data it is important therefore to establish what those grids and parcels are.

The following sources will be of value in determining the preferred system for a particular country:

- Figure 6 of the paper within a paper "*Coordinate Reference Systems used in Europe - Including Map Projections*" by Ihde et al. starting on page 35 of:

  📖 Annoni A., Luzet C., Gubler E. & Ihde J. 2001. Map Projections for Europe. Inst. Environ. Sustain. 1–131.

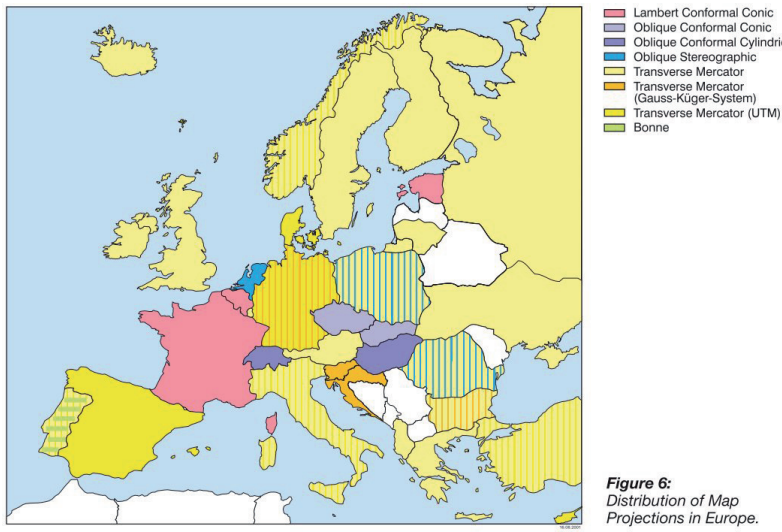


Figure 6: *Distribution of Map Projections in Europe.*

Figure 9. Redo this using QGIS

- Online guides: Websites relating to outdoor pursuits can be informative, for example the Netherlands "Sherpa" site for scouts at http://www.sherpaz.nl/default_all.asp?CAT=Techniques&Sub=Navigation&Sub2=Map tells us about the Dutch Grid.
- Printed maps by the countries mapping agency may provide valuable data. The UK's Ordnance Survey maps have a very clear explanation of the grid system on all printed maps, similarly France's IGN maps (Carte de Randonée 1:25,000) which uses the UTM grid.
- Published distribution maps or lists in books, catalogues or online publications may suggest customary projection and grid system.
  Examples: A catalogue in a book in the Fauna Entomologica Scandinavica series has a table of presence for each taxa against several countries in which Denmark, Sweden, Norway and Finland are divided into short region codes. For a geospatial depiction these codes need to be related to the parcels. Maps may not be feasible in some printed books due to the large number of taxa but online catalogues and atlases are less restricted in this regard.
- A search through the CRS list in QGIS using the name of the country may indicate potential projections.
- Published books and travel guides (e.g. Brotherton, 2011)
- Presets listed as options in a handheld GPS
- EEA reference grids:

EEA reference grid

100 km ETRS89-LAEA grid:

The coordinate reference system (CRS) for this grid is ETRS89 / LAEA Europe, also known in the EPSG Geodetic Parameter Dataset under the identifier: EPSG:3035. The Geodetic Datum is the European Terrestrial Reference System 1989. The Lambert Azimuthal Equal Area (LAEA) projection is centred at 10E, 52N.
Coordinates are based on a false easting of 4321000 meters, and a false Northing of 3210000 meters. (Peifer, 2011)

http://www.eea.europa.eu/data-and-maps/data/eea-reference-grids-1

6.3.3.a Method: Creating a grid in QGIS 5.3.3

By far the simplest approach to using grids is to acquire pre-made grids as above. The next is to use the OSGR tool from the Tom.Bio plugin (see next section).
There are situations however when neither method suit the requirements of a project. The project may require lines rather than tiles so that coordinate labels can be displayed around the edges of a grid, perhaps you wish to create a Lat Long grid or emulate one used in a publication so as to analyse location and other data.
QGIS' own functions are capable of carrying out such tasks but the plugin MMQGIS provides a useful range of tools to simplify the process:

1 Install the QGIS plugin MMQGIS
Plugins | Manage and install plugins scroll down to MMQGIS and select **Install plugin.**
This particular plugin appears as an option on the menu rather than icons on the toolbar.

A detailed example of using this method to create a National Grid and labelling the tiles is described for the Czech Republic & Slovakia later in this chapter. Examples in individual countries ...

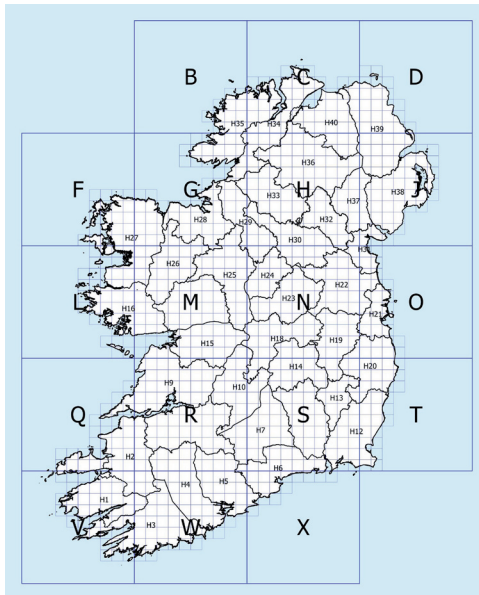
http://gis.stackexchange.com/questions/123444/how-to-create-a-fishnet-grid-shapefile-in-qgis
http://gis.stackexchange.com/questions/30331/how-to-create-a-lat-lon-grid-in-qgis
http://gis.stackexchange.com/questions/30988/how-to-create-a-grid-constrained-within-a-polygon-in-qgis
http://gis.stackexchange.com/questions/50371/creating-vector-grid-using-qgis
http://gis.stackexchange.com/questions/42695/how-to-emulate-a-specific-vector-grid-in-qgis

6.3.3.b Method: Irish National Grid

Irish National Grid

Application	QGIS
Vector data-sets	http://www.arcgis.com/home/item.html?id=ae74a8497a1041669a9d2165a0f450b6 http://www.openstreetmap.ie/irish-vice-counties-the-creation-of-a-specific-dataset-on-openstreetmap/ or search for "Irish Vice Counties - OpenStreetMap Ireland", the link to the data stored on GitHub is on that page
Region	Ireland
Open project	new
Save project	\\Mapdata\\Ireland.qgs & \\Mapdata\\ING100k.shp for the grid

1. Open a new QGIS project
2. Add the first vector layer for Ireland
3. Set CRS to OSNI 1952 / Irish National Grid EPSG:29901
4. Invoke the OSGR tool from the Tom.Bio plugin
5. Select all objects in the Ireland vector layer
6. Select **user specified**, specify a Grid size of 100,000 and click the second OS **Grid squares** button which only creates squares that overlap the selected objects.
7. **Right-click | Save as** and save this vector layer with an appropriate name (ING 100k) in an appropriate folder (e.g. F:\Maps\UK\¬Ireland\Grids)
8. Repeat steps 6 and 7, specifying a grid size of 10,000 and naming the layer ING 10k.



Note that these squares do not contain the grid references (open the attributes table for a look), these can be added manually (editing tools in the attributes table) for the 17 x 100k squares.

To achieve labelling of the 985 x 10k squares refer to the method described under Czech Republic and Slovakia

Thanks to Rich Burkmar for outlining this method.

Figure 10. Ireland with Irish National Grid and Vice Counties [EPSG:29901]

6.4 Polygon species mapping

Polygon species mapping

An improved represention of species distribution is possible through the selection and characterisation of geospatial polygons rather than the simple placing of points at an x,y coordinate. The broad term for this process is "**point-in-polygon overlay**", a spatial function provided by GIS in which the location data in one table (species occurrence) is used to **select** closed-path polygons in a second table. Attributes from one table may then be transferred to the other, for our purposes this transfer is *from* our **species occurrence data table** *to* a **polygon table**.

At **GIS: Introduction** the mapping task was carried out by hand, the species occurrence data table was absent, we simply used external data and made no permanent changes to the data in the polygon table, all that information (as visible/not visible ticks) was stored in the QGIS project file.

The following table characterises a number of methods available for mapping with polygons:

	Input	Output	Type	Granularity	Accuracy	Data stored in:
5.1	external	Polygon	country	poor	poor	QGIS project
5.3.1	CSV table	Points		high	fair	QGIS project
5.4.1	CSV table	Polygon	province	quite poor	good	QGIS project
5.4.2a	CSV table	Polygon	grid tiles 10km	fair	good	QGIS project
5.4.2b	CSV table	Polygon	grid tiles 10km	fair	good	Polygon copy
5.4.2c	CSV table	Polygon	grid tiles 1km	good	very good	QGIS project
5.4.2d	CSV table	Polygon	grid tiles 1km	good	very good	Polygon copy

there are considerable ... by automating the process

6.4.1 Polygons

Available methods

Several methods are available. In the Point on vector intersection method, point locations in the *localities attribute table* intersect with polygons in a *target vector layer*. The **Join attributes by location** method matches up the two tables and creates an *analysed vector layer* which has an amalgam of the fields from both layers.

This method is implemented in QGIS by Rudi von Staden's **Distribution Map Generator** (plugin https://plugins.qgis.org/plugins/DistroMap/)

DIAGRAM

6.4.1.a Method 1: Point on vector intersection

Polygon: point on vector intersection

Application	QGIS
Data (LAT)	CSV of a taxon (e.g. *Rainieria calceata*) see **Data** or use your own One or more polygon layers: a grid consisting of polygon tiles or use the Départements
Region	France
Open project	France.prj (see **European Atlas** for details of how to construct this)
Save project	[Taxon name]_[polygon size/name]_France.prj

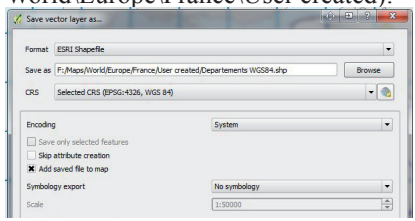
1 Open the France QGIS project and save under a different name in your project folder

2 Add your localities attribute table (LAT): **Layer | Add layer | Add delimited text layer** and adjust its CRS to the one in which it was recorded (WGS84)

A Matching up the CRS of two layers

3 Whilst QGIS will allow layers recorded in different CRS to be displayed on top of one another, it will not permit layers with different CRS to communicate with one another. To achieve our **point on vector intersection** between the *localities attribute table* (WGS84 = EPSG 4326) and the *target vector layer* (EPSG 3035), they must be adjusted to have matching CRS. The former cannot be adjusted (it's a text table and thus hard-wired) but the target layer can, by copying it and pasting it to a version with a different CRS.

Right-click the original of the *target vector layer* (*Départements*), select **Save as** and use the browser to place this copy (named "*Départements WGS84*") in a "User created" folder of your Maps folder for France (e.g. F:\Maps\World\Europe\France\User created):



Note the selection of an ESRI Shapefile format (the original is a MapInfo .tab) and the instruction to place this newly created layer onto your map.

Create a Group in the layers panel (e.g. "Project 1") to contain this new layer (*replica target vector layer*).

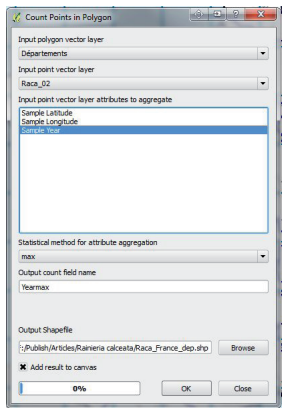
[Repeat for any other non-CRS-matching layers you may require, resulting in a number of new "*xxxxx WGS84*" shapefiles in your "User created" folder (these will be needed again) and those shapefiles loaded into your project, each in its own Group.] [Make a note to backup your Maps folder.]

4 **Vector | Analysis Tools | Point in Polygon**:

This process utilises one of the most useful and distinctive facilities of a GIS, its ability to perform geospatial analyses, making it much more powerful than a mere graphic image display. The *localities attribute table* points are geospa-

tially matched up to polygons in a *target vector layer* and numerical data from the *localities attribute table* processed via a handful of mathematical operators to create a new vector layer (the *analysis vector layer*) with an extra field containing the results of that mathematical operation:

The **points in polygon** dialogue:



Two layers to be selected:

1. The upper one is the *replica target vector layer*, the one that has been derived in order to match the CRS.
2. The lower one is the *localities attribute table*

In the localities attribute table are all fields with a numerical value,

3. Select just one to analyse.

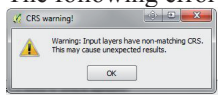
The "Statistical method ..." operators include sum, standard deviation, mean, maximum and minimum.

4. "Sum" is the default choice for a simple exercise.
5. Provide a name for the new field to contain this new figure.
6. Browse to provide a location (your project) and filename for the new *analysis vector layer*
7. Add the resulting new layer to your project
8. OK

A new layer will appear in your project and on the canvas, in the layer panel move it into the group alongside its parent "*xxxxx WGS84*" shapefile.

5 Checking and dealing with errors.

The following error message is frequently encountered:



This doesn't necessarily mean that the process has not worked. Open the attributes table of the created vector layer (**Right-click | Open attribute table**) and scroll across to the newly created field. Click on the header name to that field to sort (ascending and descending) to ascertain whether this field contains data other than null. If so then the process has worked. If not then readdress the CRS matching process, possibly even reloading the original target vector layer (had you altered it at any time it may produce an unexpected result when copied to a WGS84 layer). This topic is discussed at www.qgistutorials.com/en/docs/points_in_polygon.html

6 On this new layer (*analysed vector layer*) select **Properties | Style** then apply **Categories** to the data in your new field. Delete the categories for null and zero as appropriate.

Repeat until a satisfactory output is achieved. It may be necessary to return to the CSV of the *localities attribute table* in order to obtain an attribute field which gives meaningful results.

7 Save project and any temporary layers.

6.4.1.b Method 2: *Join attributes by location*

Polygons: Join attributes by location

Application	QGIS
Data (LAT)	CSV of a taxon (e.g. *Rainieria calceata*) see **Data** or use your own One or more polygon layers: a grid consisting of polygon tiles or use the Départements
Region	France
Open project	\\Mapdata\\France.qgs (see **European Atlas** for details of how to construct this) or continue from the previous project
Save project	[Taxon name]_[polygon size/name]_France.qgs

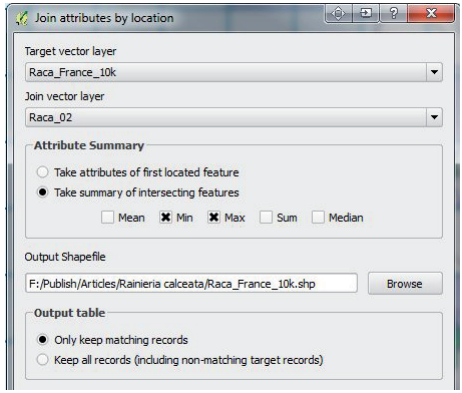
1 Open the France QGIS project and save under a different name in your project folder

2 Add your localities attribute table (LAT): **Layer | Add layer | Add delimited text layer** and adjust its CRS to the one in which it was recorded (WGS84)

3 Replicate the desired *target vector layers* as described in Method 1, step 3 above. Any suitable vector layer can be used, for this example we are dealing with the EEA grid tiles so they must be replicated to WGS84 CRS versions.

4 Select **Vector | Data Management Tools | Join attributes by location** which displays the following dialogue:

The **Join attributes by location** dialogue



Target vector layer is the *replica target vector layer.*
Join vector layer is the CSV *localities attribute table*
Selections in the **Attribute Summary** results in the creation of extra fields ?.
The **Output Shapefile** is your *analysed vector layer*, belongs in your project folder and have a filename that makes sense.
The second option in the **Output table** would copy all polygons to your *analysed vector layer*, not just the ones with your data in. Default choice would be as shown.

This then creates the analysed vector layer specified.

5 On this new layer (*analysed vector layer*) select **Properties | Style** then apply **Categories** to the fields you select. Delete the categories for null and zero as appropriate.

6 Create an appropriate Group to contain it and sequence layers to display appropriately
Repeat for tiles of different scales

7 Save your QGIS project

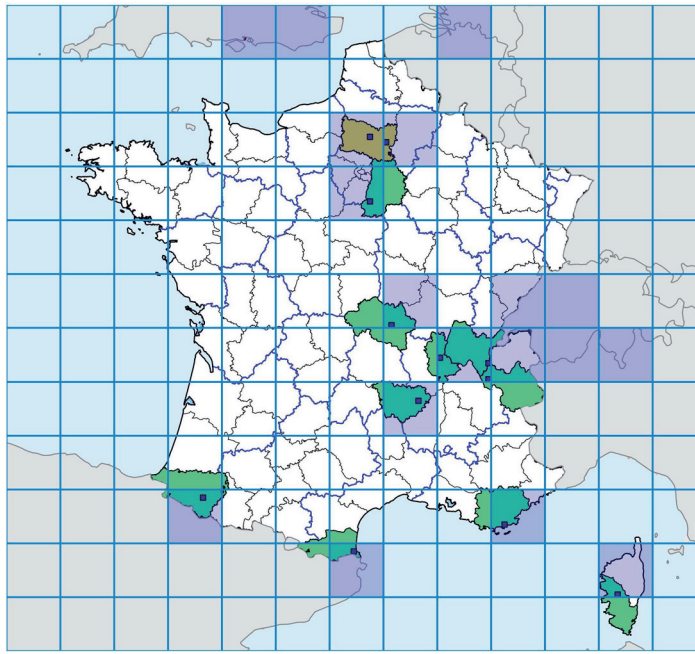


***Figure 11. Rainieria calceata* distribution in France.** EEA grid (100 km ETRS89-LAEA grid) [Lambert EPSG:3035]

The above map is an amalgam of Polygon species mapping techniques, three different representations shown together, any combination may be used to depict distribution.

Départements polygons via the **Point in Polygon** method, single occurrences in green, double occurrences in brown - indicating that the "count" facility was successful. In France the départements are fairly uniform in size so such a map does work and has been used in historic publications.

Tile polygons achieved using the **Join attributes by location** method, both 100km and 10km squares are shown. Chloropleth mapping of these tiles can be incorporated (dates, abundance etc.), such data is present in the polygon layer.

Removal of distribution tiles in adjacent countries can be performed by judicious arrangement of layers in the layers panel or removal of rows from analysis vector layers.

6.4.2 Joins technique

Polygon: Joins

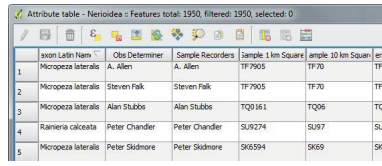
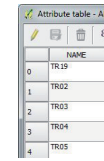
This second principle does not employ the geospatial capabilities of a GIS but instead matches the label in a field describing a specific tile in the *localities attribute table* to a field containing the same label in the *target vector layer*.
This method is readily usable if the source table can be devised to output the appropriate terms (e,g, Recorder 6 output for the British Isles combined with the OSGB reference grid) but becomes somewhat complex for other reference grids, requiring some manipulation of fields in the source table in order to match tile names in the reference grid.

Usage:

1. Recorder 6 will readily output the name of a 10km square such as "SD9034" to a *localities attribute table* and this can be matched with a tile of the same name in a vector layer of similarly named 10km square tiles.
2. Can be used similarly for the Irish National Grid and for other national grids (see Czechoslovakia)
3. The EEA vector grids have a field "CellCode" of the format "100kmE23N29" which can be constructed (using Excel formulae) within the *localities attribute table* from Lat/Long data as described in Peifer H. 2011. ***About the EEA reference grid***
4. Not confined just to grids, this method can be used for countries and provinces provided there is a matching label in a field in both the *localities attribute table* and the *target vector layer* of those countries and provinces.
5. Other techniques in which the data from one layer can be transferred to another layer (e.g. extracting soil types against taxon occurences)
6. This technique brings a GIS close to the capabilities of a vector graphics drwaing application. For example, if a suitable matrix of triangles can be obtained then it can be used to draw a classic soil triangle and apply chloropleths to selected components.

Prerequisites: Matching the output and input labels

Ensure that the *localities attribute table* (CSV) contains a field containing labels which reference the name of a tile in the *target vector layer*:

localities attribute **table**	*target* **vector** *layer*
	
Data in the field "Sample 10 km square" corresponds with "Name" on tiles layer	

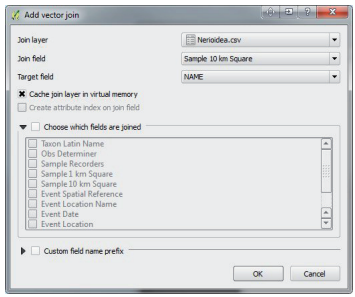
6.4.2.a Method 3: Joins

Application	QGIS
Data (LAT)	??
Region	UK (best because of matching names)
Open project	BI.prj
Save project	??NEEDS A MAP - GOT TO DO THIS ONE

1 **Select** the *target vector layer* in the Layers panel (e.g. a vector grid such as the OSGB 10km square grid), this will not get altered in any way but ensure you have a backup copy if the word "target" causes concern.

2 **Double-click** to bring up the **Properties panel** and select **Joins**.

3 **Click the + button** which brings up the following dialogue:



1. Join layer: *localities attribute table*
2. Join field: the field in the *localities attribute table* containing the labels you wish to link
3. Target field: the field in the *target vector layer* containing the labels you wish to link

4. Cache join layer in virtual memory: By default this tickbox is enabled, leave it that way, this is your reassurance that no changes will be made to the *target vector layer*
5. Choose which fields are joined: If this is disabled, all the fields except the join field will be copied. At least one field is required (do not choose fields that contain any null values)

4 Complete the items in the dialogue as above and select OK.
Re-open the Attribute table of the *target vector layer*. This will now have a number of additional fields, copied across (temporarily) from the *localities attribute table*. Only the unique values however; if there were 20 different records in the source table for TF70 then only one of these would show in this temporary table. Consequently many of the fields chosen in step 5 of the dialogue are therefore valueless, only a random 1 of the 20 records would be copied.
This table still has all its original records, many of them having a null value in the extra join field, some of them with non-null values; it is these latter which we wish to select, these are the records (tiles) that match our *localities attribute table* data*:*

5 In the attribute table, select the "**Select features using an expression**" button and construct a query of the form " "[Field name]" is not null ". The selected tiles will now be highlighted on the canvas map.

6 **Edit | Copy features**. **Edit | Paste features as | New vector layer**, choose the appropriate CRS and save into your project folder using a filename which indicates the tile type e.g. [Taxon]_10km_[date].shp

Review

Once a project has been set up for this method, producing distribution maps to tiles of different resolutions and types can be reasonably rapid. For Great Britain it is considerably slower than the Tom.Bio tools but it will enable a British Isles distribution map to be created by adding the Irish National Grid to a GB one created with Tom.Bio tools. (also see DMAP)
Its main use will be for other grids and other types of vector layers, not just for creating distribution maps but for extracting data for a taxon from other layers (e.g. soil types)

6.4.3 Customised utilities & Automation

Well designed applications permit the addition of customised addons (plugins, addins etc) to facilitate the deployment of various specialist functions. This is particularly true of OpenSource software and is also an element of QGIS.
<- rewrite

6.4.3.a Method 4: QGIS plugin - Tom.bio Biological Records

QGIS Plugin: Tom.bio

Application	QGIS Tom.Bio QGIS plugin, installed into QGIS via menu command Plugins
Data (LAT)	CSV of mixed taxa (Nerioidea)
Region	UK
Open project	BI.prj
Save project	??N

1. Open the British Isles or equivalent EPSG:27700 QGIS project
2. Select the **Plugins | Tombio tools | Biological Records tool** (or command button)
3. Select the **Create new source layer from CSV** button on the dialogue panel to the right of the canvas.
   Browse to a valid *localities attribute table*
   - table must be suffixed ".csv", contain valid OSGB grid references and taxon names (or other categorised objects such as image types or an expedition's recording dates + locations).
   - non-OSGB references will simply be ignored so it is safe if your csv contains "Europe" records.
   - to access a wider range of functions of this tool, the file should also contain more than one taxon.
4. In the **OS Grid Ref column** dropdown, select the field containing the Grid reference (e.g. Event Spatial Reference). In the **Taxon Column** dropdown select the field containing the taxa (e.g. Taxon Latin name) and enable the **Scientific Names** option.
5. Select the **Taxa tab** and click **Load Taxa**, the panel then presents a two-level hierarchical tree starting with Genera
   - if the **Scientific Names** option is not enabled then the list would comprise full binomials
6. Select the required taxa from the list and click the **Create map layer** button. This creates a new layer entitled "TEMP [taxon name]" in the Layers panel and symbols on the Canvas.
7. **Manage layers** thus generated using the command buttons on the toolbar at the bottom of the plugin panel:

Layer		Display		Remove ...	
	Generate		Show all		Last

All the layers generated by this method are temporary and lost when QGIS closes. **Save** the layers you wish to keep.

8 Adjust the **symbology and precision** of layers using the dropdowns:
Experiment with these options, one satisfactory display is a combination of "Records as grid squares" with the transparency set at 50% overlaid with "1km atlas" but choices will very much depend upon the scale of your map.
The attributes of these layers differ from the original CSV, now comprising GridRef, Records, Abundance, Richness and Taxa so if date ranges are required then this information would need to be built into the original *localities attribute table* and designated as "Abundance" at step 4.

Review

needs finishing off

6.4.4 Other applications

DMAP