

Geographical mapping plugin

PLUGINS
VERSION 7.6



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- PIL Python library[®] version 1.1.7 (<http://www.pythonware.com/products/pil/>).
- The SPAdes genome assembler version 3.7.1 (<http://bioinf.spbau.ru/spades>).

Chapter 1

Starting and setting up BioNumerics

1.1 Introduction

This guide is designed as a tutorial for the *Geographical mapping plugin* of BioNumerics. This plugin allows you to plot geographical locations on a map, using the Google Maps API. Locations should be provided either as addresses or as longitude and latitude coordinates, stored as entry information in the BioNumerics database.

In addition, superimposed *graphs* allow the visualization of additional information stored in entry info fields (categories), character values or even dendrograms on top of geographical maps.

1.2 Startup program


When BioNumerics is launched from the Windows start panel or when the BioNumerics shortcut () on your computer's desktop is double-clicked, the **Startup program** is run. This program shows the *BioNumerics Startup* window (see Figure 1.1).

A new BioNumerics database is created from the Startup program by pressing the  button.

An existing database is opened in BioNumerics with  or by simply double-clicking on a database name in the list.

1.3 Installing the Geographical mapping plugin

If a database is opened for the first time, the *Plugins* dialog box will appear by default (see Figure 1.2).

If the database has already been opened previously, the *Plugins* dialog box can be called from the *Main* window by selecting **File > Install / remove plugins...** (.

When a particular plugin is selected from the list of plugins, a short description appears in the right panel.

A selected plugin can be installed with the **<Activate>** button. The software will ask for confirmation before installation. Some plugins depend on functionality offered by specific BioNumerics modules. If a required module is missing, the plugin cannot be installed and an error message will be generated.

Once a plugin is installed, it is marked with a green V-sign. It can be removed again with the **<Deactivate>** button.

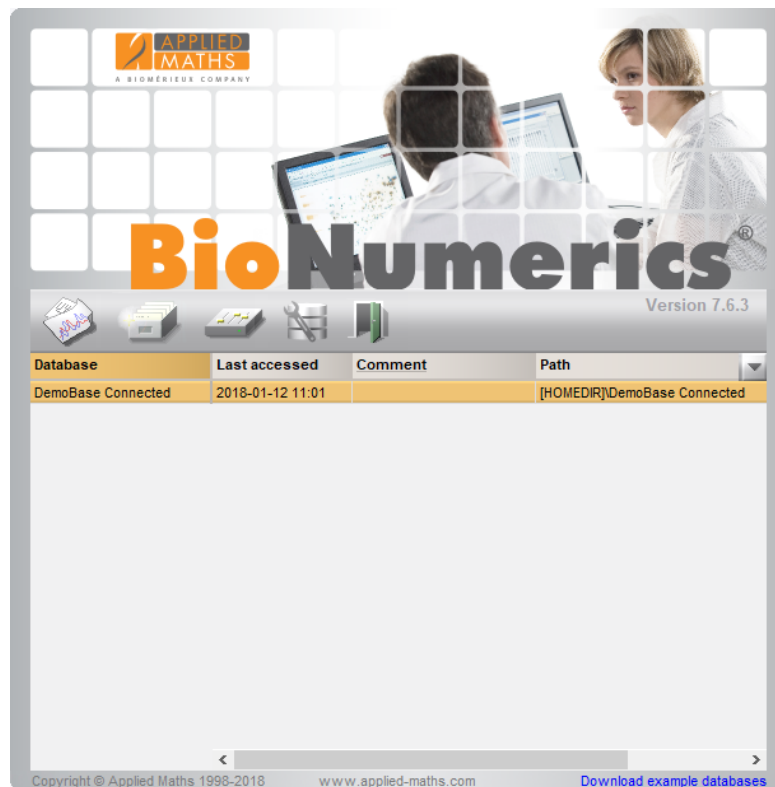


Figure 1.1: The *BioNumerics* Startup window.

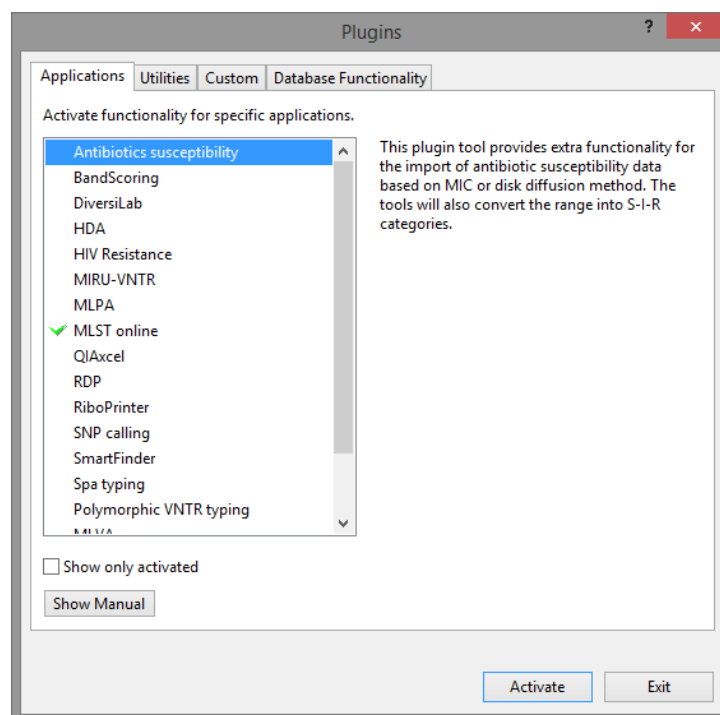


Figure 1.2: The *Plugins* dialog box.

If the selected plugin is documented, pressing **<Show Manual>** will open its manual in the *Help* window.

3.1 Select the *Geographical mapping* plugin from the list in the *Utilities* tab and press the **<Activate>** button.

3.2 The program will ask to confirm the installation of the plugin. Press <**OK**> to confirm the installation.

3.3 Press <**OK**> to continue with the installation of the plugin.

3.4 Close and reopen the database with administrator privileges to activate the features of the *Geographical mapping plugin*.

The plugin provides two additional commands: **Analysis** > **Geo chart...** (🌐) in the *Main* window (see Figure 1.3) and **Statistics** > **Geo chart...** (🌐) in the *Comparison* window.

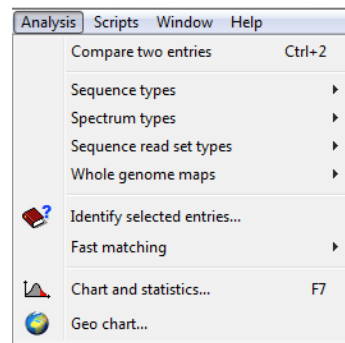


Figure 1.3: Geo chart menu in the *Main* window.

Chapter 2

Geographical data

2.1 Geocoding

The *Geographical mapping plugin* in BioNumerics uses the Google Geocoding API from the Google Maps API Web Service, an HTTP interface to the Google service providing geographic data (<https://developers.google.com/maps/documentation/geocoding/>, <https://developers.google.com/maps/documentation/webservices/>). Geocoding is the process of converting addresses (like "Keistraat 120, 9830 Sint-Martens-Latem, Belgium") into geographic coordinates (like latitude 50.993394 and longitude 3.62993), which can be use as place markers or positions on the map.

Using the *Geographical mapping plugin*, both latitude - longitude information as well as full address information, or both, can be used to plot data on the map. The Google Geocoding results provided by the web service are saved to the database and fully integrated in the BioNumerics user interface. This way, it becomes easy to obtain the envisaged plots, displaying a selection of specific database information plotted on the geographical map.

2.2 Database entries panel

The BioNumerics *Main* window in the default configuration consists of a menu, a toolbar for quick access to the most important functions, a status bar, and various analysis panels Figure 2.1. The *Database entries* panel lists all the available entries in the database, with their information fields and their unique keys. With the *Geographical mapping plugin*, information present in the information fields in the *Database entries* panel can be mapped.

2.3 Information fields

The **DemoBase Connected** either can be downloaded directly from the *BioNumerics Startup* window or restored from the back-up file available on our website:

- To download the database directly from the *BioNumerics Startup* window, click the **Download example databases** link, located in the lower right corner of the *BioNumerics Startup* window. Select **DemoBase Connected** from the list and select **Database > Download**.
- To restore the database from the back-up file, first download the file `DemoBase_Connected.bnbk` from <http://www.applied-maths.com/download/sample-data>, under 'DemoBase Connected'.

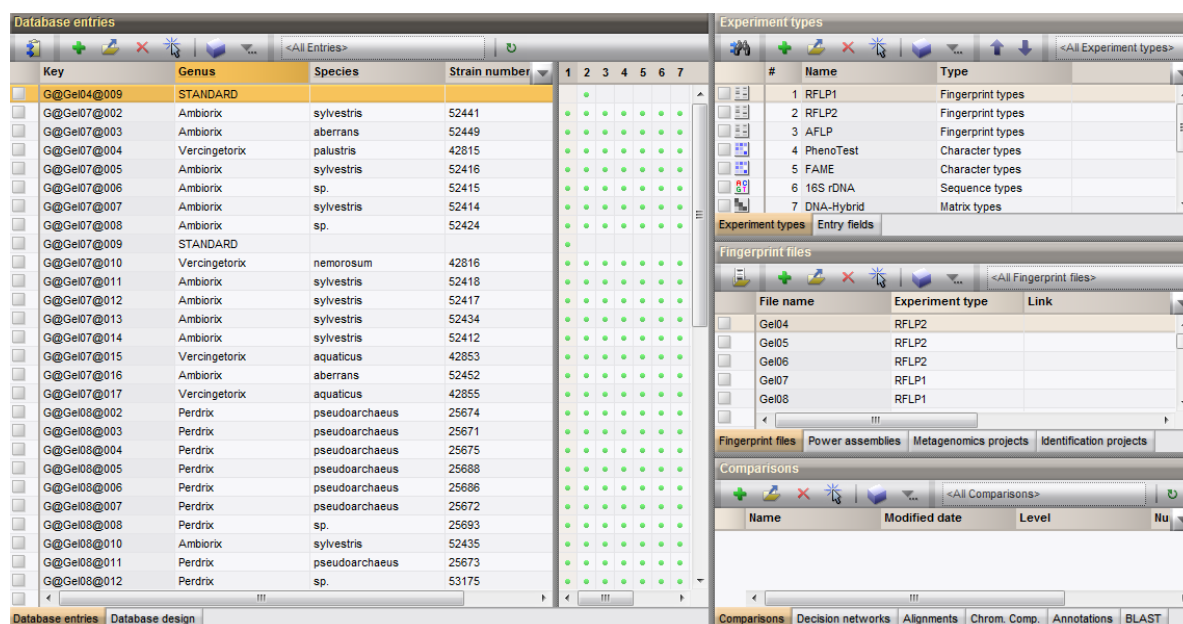


Figure 2.1: The BioNumerics *Main* window.

In the *BioNumerics Startup* window, press the  button, select **Restore database**, browse for the downloaded file and select **Create copy**. Specify a name and click **<OK>**.

- 3.1 Open the demonstration database **DemoBase Connected** and install the *Geographical mapping plugin* (see 1.3).
- 3.2 In the BioNumerics *Main* window select **Edit** > **Information fields** > **Add information field...**. This will open the *Create new entry information field* dialog box.
- 3.3 Enter “Country” in the dialog box that pops up, leave all other settings default and press **<OK>**.

The information field **Country** is added to the list of database fields.

- 3.4 Double-click on the entry with key **G@Gel07@002**. The *Entry* window appears.
- 3.5 Click on the box next to the information field **Country**. The information field is highlighted (see Figure 2.2).
- 3.6 Enter e.g. “France” and press the **Enter** key or select **<OK>** to close the *Entry* window.

The information is now stored in the database. Alternatively to using the *Entry* window, information in the information fields in the database can be edited directly by clicking twice with a short interval (not double clicking) on an information field in the database. The information will appear highlighted and can be edited.

- 3.7 Click twice on the information field **Country** of the entry with key **G@Gel07@003**.
- 3.8 Enter “Spain” in the highlighted information field and press **Enter**. The information is stored in the database.

2.4 Importing geo data

The general BioNumerics import functionality can be used to import information from text files (tab, comma or semicolon separated), MS Excel or from other databases (e.g. MS Access) via an ODBC link.

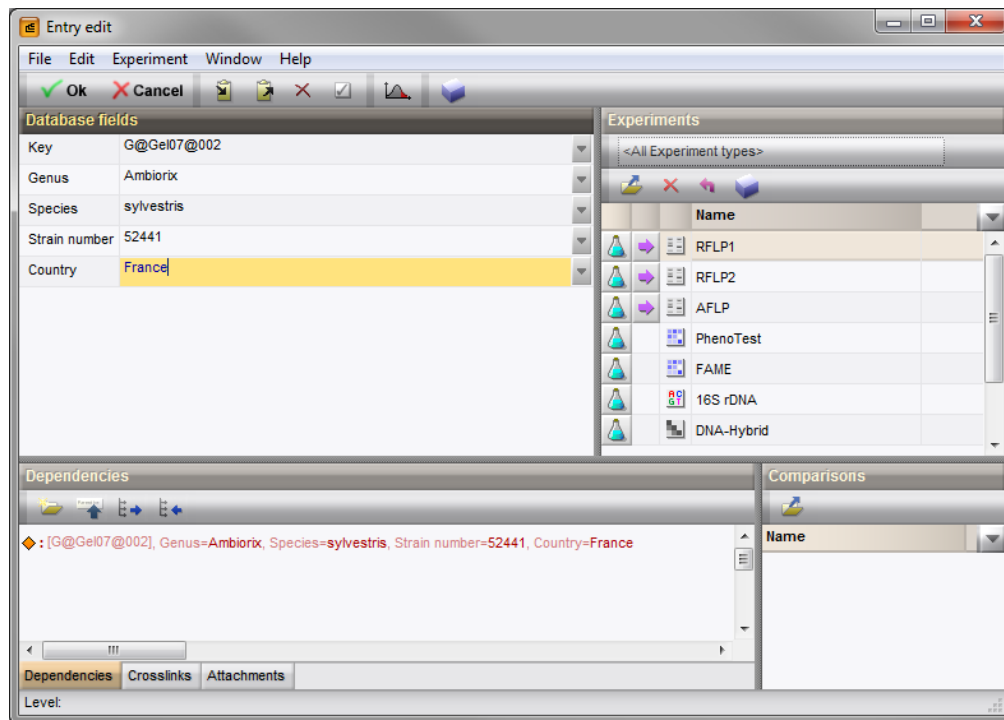


Figure 2.2: The *Entry* window.

As an example, we will import geographical data from a tab-delimited text file. The example data file `Geo_information.txt` can be downloaded as a ZIP archive from the Applied Maths website (<http://www.applied-maths.com/download/sample-data>, click on "Geo data file").

4.1 In the *Main* window, select **File > Import...** (📁, **Ctrl+I**) to open the *Import* dialog box.

4.2 Select **Entry information data > Import fields (text file)** and press **<Import>**.

The *Input* wizard page pops up (Figure 2.3), allowing you to browse to the (unzipped) input text file.

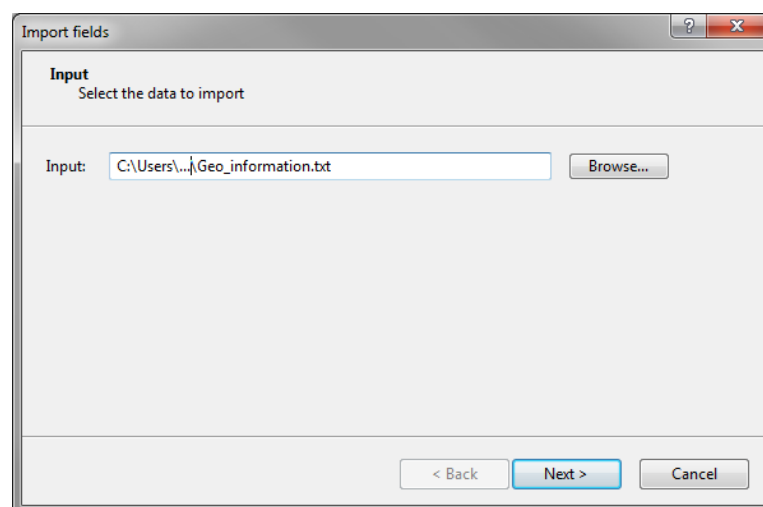


Figure 2.3: Importing geographical data from a text file.

4.3 Browse for the `Geo_information.txt` file and press **<Next>** to continue.

- 4.4 The *Import rules* dialog box lists the columns present in the selected text file as **Source**, their linked **Source type** and the **Destination** component they are associated with (currently all set to <None>).
- 4.5 Select **Key** from the list. Select <*Edit destination...*> and select **Key** as the BioNumerics corresponding field. The import rules are now updated accordingly (see Figure 2.4).

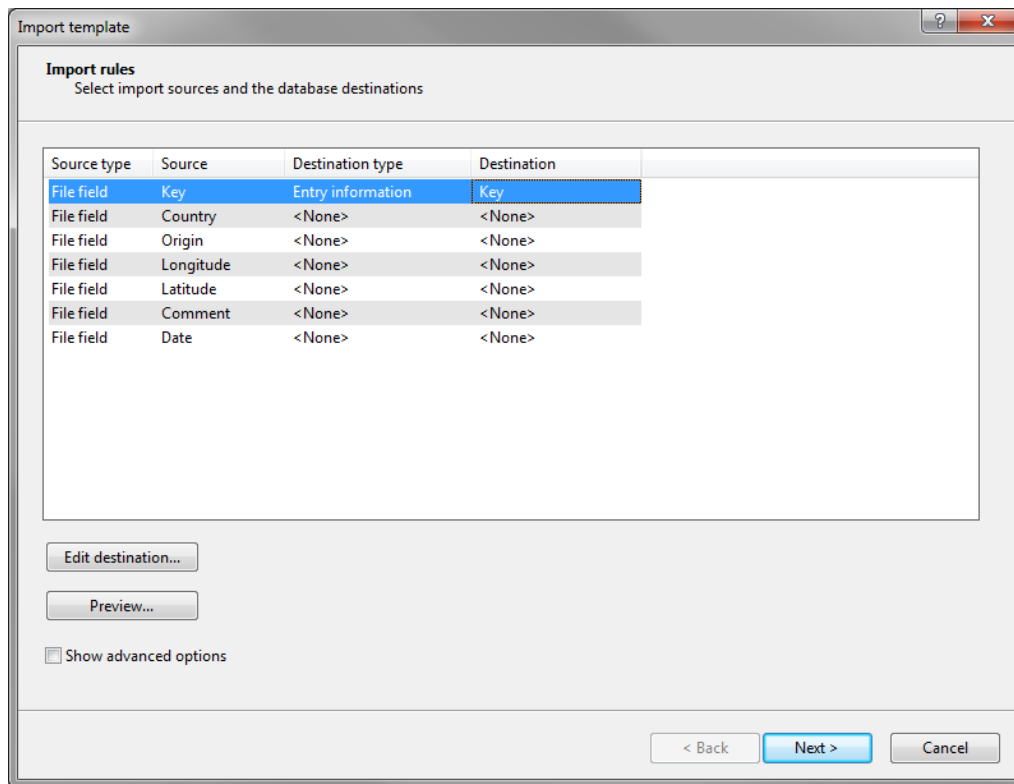


Figure 2.4: The *Import rules* dialog box.

- 4.6 Next, select **Country** from the list and edit this destination by selecting <*Edit destination...*> or double-clicking the **Destination type** on the **Country** row. Associate the information in this column with the BioNumerics entry information field **Country** and confirm by <**OK**>.
- 4.7 Select all the other rows (Origin, Longitude, Latitude, Comment and Date) and edit their destination as a new entry information field by selecting **Entry information field**. Confirm the suggested information field names and the creation of these fields in the database. This will update the *Import rules* dialog box (see Figure 2.5). Note that not all these fields are required to use the plugin. The plugin can function perfectly with just one e.g. “Origin” field.
- 4.8 Press <*Next*> to proceed with the import. This will display the *Import links* dialog box. In this dialog, specify that the **Key** information should be used as linked information field.
- 4.9 Press <*Finish*>.

This completes the creation of the import template and pops up a dialog asking for the template name (see Figure 2.6).

- 4.10 Enter a name (e.g. “Import geo information demobase”) and optionally, also a description for the import template (e.g. “This template imports geographical information from text file, links the Key information and imports longitude, latitude information”) and press <**OK**> to close the *Import template information* dialog box.

The import template is now listed in the *Import template* wizard page. When selecting the template, the description is displayed at the right of the template list.

- 4.11 Press <*Next*> to proceed with the import.

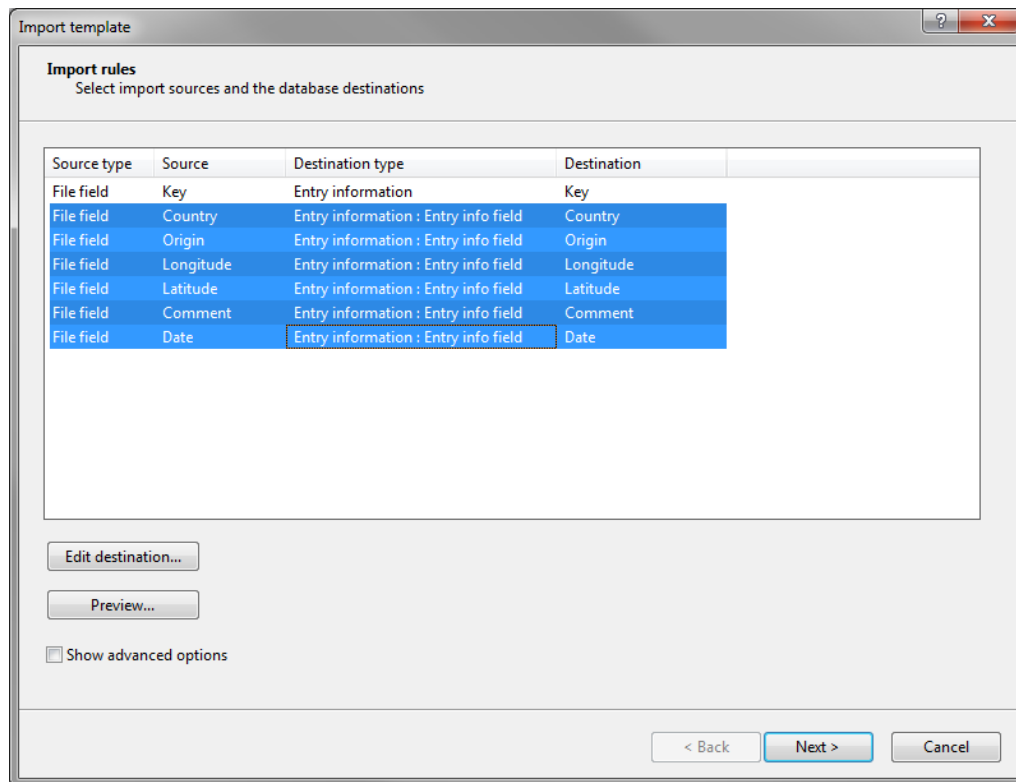


Figure 2.5: The *Import rules* dialog box with all import rules added.

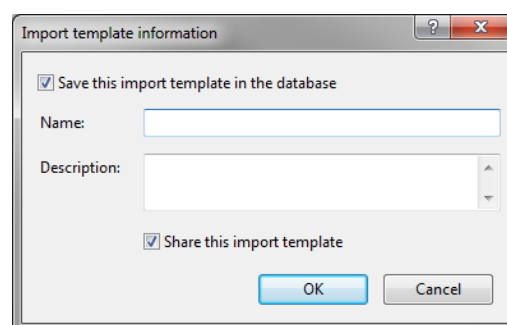


Figure 2.6: The *Import template information* dialog box.

From the database links that are updated, you can verify that the geographical information will be updated for 47 entries.

4.12 Press **<Finish>** to complete the import and update the database.

For all entries, except the standards, the database field information for the columns 'Country', 'Origin', 'Longitude', 'Latitude', 'Comment' and 'Date' is now updated (see Figure 2.7).

Both the imported 'Longitude' and 'Latitude' columns contain numeric information. To allow geographical binning on this information, the field type of these columns should be updated.

4.13 Right-click on the entry field header 'Longitude', and select **Field properties ...** from the pop-up menu that appears. This opens the *Database field properties* dialog box. Change the **Content type** to "Number" and press **<OK>** to close the dialog.

4.14 Repeat the instructions above to change the content type of the 'Latitude' field to "Number".

Geographical binning can also be applied to time information i.e. date information. To use this feature, the

Database entries

Key	Genus	Species	Strain number	Country	Origin	Longitude	Latitude	Comment
<input type="checkbox"/> G@Gel04@009	STANDARD							
<input checked="" type="checkbox"/> G@Gel07@002	Ambiorix	sylvestris	52441	France	Bordeaux	-0.60369	44.826413	Hôpital Pellegrin Tripode
<input checked="" type="checkbox"/> G@Gel07@003	Ambiorix	aberrans	52449	Spain	Madrid	-3.671257	40.419198	Hospital General Gregorio Marañon
<input checked="" type="checkbox"/> G@Gel07@004	Vercingetorix	palustris	42815	France	Bordeaux	-0.60369	44.826413	Hôpital Pellegrin Tripode
<input checked="" type="checkbox"/> G@Gel07@005	Ambiorix	sylvestris	52416	Spain	Madrid	-3.671257	40.419198	Hospital General Gregorio Marañon
<input checked="" type="checkbox"/> G@Gel07@006	Ambiorix	sp.	52415	France	Bordeaux	-0.60369	44.826413	Hôpital Pellegrin Tripode
<input checked="" type="checkbox"/> G@Gel07@007	Ambiorix	sylvestris	52414	Spain	Valencia	-0.362892	39.4795	Hospital Clinico Universitario
<input checked="" type="checkbox"/> G@Gel07@008	Ambiorix	sp.	52424	Spain	Valencia	-0.362892	39.4795	Hospital Clinico Universitario
<input type="checkbox"/> G@Gel07@009	STANDARD							
<input checked="" type="checkbox"/> G@Gel07@010	Vercingetorix	nemorosum	42816	France	London	-0.118532	51.498725	Saint Thomas Hospital
<input checked="" type="checkbox"/> G@Gel07@011	Ambiorix	sylvestris	52418	Spain	Madrid	-3.671257	40.419198	Hospital General Gregorio Marañon
<input checked="" type="checkbox"/> G@Gel07@012	Ambiorix	sylvestris	52417	France	Bordeaux	-0.60369	44.826413	Hôpital Pellegrin Tripode
<input checked="" type="checkbox"/> G@Gel07@013	Ambiorix	sylvestris	52434	Spain	Valencia	-0.362892	39.4795	Hospital Clinico Universitario
<input checked="" type="checkbox"/> G@Gel07@014	Ambiorix	sylvestris	52412	Spain	Valencia	-0.389929	39.483905	Hospital Universitario La Fe
<input checked="" type="checkbox"/> G@Gel07@015	Vercingetorix	aquaticus	42853	France	Lyon			
<input checked="" type="checkbox"/> G@Gel07@016	Ambiorix	aberrans	52452	Spain	Madrid	-3.671257	40.419198	Hospital General Gregorio Marañon
<input checked="" type="checkbox"/> G@Gel07@017	Vercingetorix	aquaticus	42855	France	Paris	2.2228	48.913531	Hôpital Max Forestier
<input checked="" type="checkbox"/> G@Gel08@002	Perdrix	pseudoarchaeus	25674	France	Paris	2.403259	48.879619	Hôpital Robert Debré
<input checked="" type="checkbox"/> G@Gel08@003	Perdrix	pseudoarchaeus	25671	England	London	-0.118532	51.498725	Saint Thomas Hospital
<input checked="" type="checkbox"/> G@Gel08@004	Perdrix	pseudoarchaeus	25675	France	Bordeaux	-0.60369	44.826413	Hôpital Pellegrin Tripode
<input checked="" type="checkbox"/> G@Gel08@005	Perdrix	pseudoarchaeus	25688	Spain	Valencia	-0.389929	39.483905	Hospital Universitario La Fe
<input checked="" type="checkbox"/> G@Gel08@006	Perdrix	pseudoarchaeus	25686	Spain	Valencia	-0.389929	39.483905	Hospital Universitario La Fe
<input checked="" type="checkbox"/> G@Gel08@007	Perdrix	pseudoarchaeus	25672	France	London	-0.118532	51.498725	Saint Thomas Hospital
<input checked="" type="checkbox"/> G@Gel08@008	Perdrix	sp.	25693	Spain	Madrid	-3.671257	40.419198	Hospital General Gregorio Marañon
<input checked="" type="checkbox"/> G@Gel08@010	Ambiorix	sylvestris	52435	France	Paris	2.2228	48.913531	Hôpital Max Forestier
<input checked="" type="checkbox"/> G@Gel08@011	Perdrix	pseudoarchaeus	25673	France	Paris	2.403259	48.879619	Hôpital Robert Debré
<input checked="" type="checkbox"/> G@Gel08@012	Perdrix	sp.	53175	France	Lyon			
<input checked="" type="checkbox"/> G@Gel08@013	Ambiorix	sylvestris	52433	Spain	Madrid	-3.671257	40.419198	Hospital General Gregorio Marañon
<input checked="" type="checkbox"/> G@Gel08@014	Ambiorix	sylvestris	52413	France	Paris	2.2228	48.913531	Hôpital Max Forestier
<input checked="" type="checkbox"/> G@Gel08@015	Perdrix	pseudoarchaeus	25681	France	Paris	2.403259	48.879619	Hôpital Robert Debré
<input checked="" type="checkbox"/> G@Gel08@016	Vercingetorix	palustris	42819	France	Paris	2.2228	48.913531	Hôpital Max Forestier
<input checked="" type="checkbox"/> G@Gel09@002	Perdrix	pseudoarchaeus	25677	France	London	-0.118532	51.498725	Saint Thomas Hospital
<input checked="" type="checkbox"/> G@Gel09@003	Perdrix	pseudoarchaeus	25676	Spain	Madrid	-3.671257	40.419198	Hospital General Gregorio Marañon
<input checked="" type="checkbox"/> G@Gel09@004	Ambiorix	sylvestris	52422	France	Paris	2.2228	48.913531	Hôpital Max Forestier
<input checked="" type="checkbox"/> G@Gel09@005	Perdrix	pseudoarchaeus	25687	Spain	Madrid	-3.671257	40.419198	Hospital General Gregorio Marañon
<input checked="" type="checkbox"/> G@Gel09@007	Perdrix	pseudoarchaeus	25679	France	London	-0.118532	51.498725	Saint Thomas Hospital
<input checked="" type="checkbox"/> G@Gel09@008	Perdrix	pseudoarchaeus	25678	Spain	Madrid	-3.671257	40.419198	Hospital General Gregorio Marañon
<input checked="" type="checkbox"/> G@Gel09@009	Perdrix	pseudoarchaeus	25680	France	Paris	2.2228	48.913531	Hôpital Max Forestier
<input checked="" type="checkbox"/> G@Gel09@010	Ambiorix	sylvestris	52421	France	Paris	2.403259	48.879619	Hôpital Robert Debré
<input checked="" type="checkbox"/> G@Gel09@011	Ambiorix	sylvestris	52420	France	Lyon			

Figure 2.7: Imported information fields containing geographical data.

field properties for the 'Date' field should be changed.

- 4.15 Right-click the entry field header 'Date', select **Field properties ...** from the pop-up menu, and change the **Content type** in the the *Database field properties* dialog box to "Date". Press <OK> to close the dialog.

2.5 Composing addresses from entry fields

The *Geographical mapping plugin* uses location information (i.e. addresses) stored in a single entry information field to submit to the Google Maps API (see 3.2). However, location information will typically be split up over several fields in a normalized database (i.e. Street, City, Country, etc. filled out in separate columns), as this greatly facilitates searching, filtering and sorting on these address aspects. To get round this, we can use a *calculated field* to compose a full address from several address aspects, stored in separate entry information fields. As calculated fields are dynamically calculated, this avoids duplicating the address information in the database.

Here, we will show how to compose location information from the 'Origin' and 'Country' fields in the **DemoBase Connected** demonstration database.

- 5.1 In the *Main* window, select **Edit > Information fields > Add information field...** or highlight the *Entry fields* panel and select **Edit > Create new object...** (+).
- 5.2 In the *Create new entry information field* dialog box that pops up, enter e.g. "Address" as **Name** of the new information field.

5.3 Check the option **Calculate field content from other fields** and press the **<Edit>** button to display the *Calculated database field settings* dialog box.

5.4 Press **<Add information field...>**.

5.5 In the *Add information field* dialog box, select the **Origin** field from the list and press **<OK>**.

Back in the *Calculated database field settings* dialog box, [ORIGIN] is now displayed as part of the "formula" to calculate the field content.

5.6 Press **<Add fixed text...>**.

5.7 In the *Add fixed text* dialog box, enter ", " (i.e. a comma, followed by a space) and press **<OK>**.

5.8 Press **<Add information field...>** again.

5.9 In the *Add information field* dialog box, select the **Country** field from the list and press **<OK>**.

The *Calculated database field settings* dialog box now looks like in Figure 2.8.

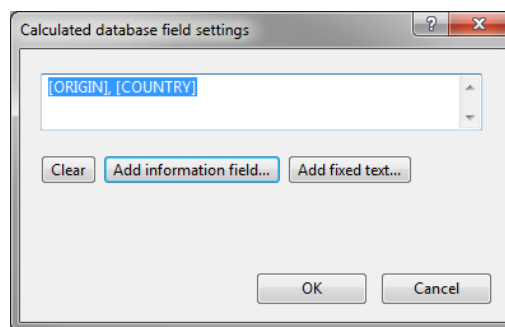


Figure 2.8: The *Calculated database field settings* dialog box, showing the calculated field settings for the Address field.

5.10 Press **<OK>** to accept the calculated field settings and **<OK>** once more in the *Create new entry information field* dialog box.

The new calculated field 'Address' now contains the information from the 'Origin' and the 'Country' fields, separated with a comma and a space (e.g. "Bordeaux, France").



The text address field in the database can also contain street names, house numbers, or names of hospitals, monuments, etc..

2.6 Latitude and longitude

Instead of providing an address and using forward geocoding to find the corresponding coordinates (and plot these on a geographical map), a location can also be specified directly using coordinates. This requires a **latitude** (North-South position) and **longitude** (East-West position) for each location. The expected format for latitudes and longitudes is decimal degrees, with a point as decimal separator.

The example geographical information that was imported (see 2.4) contains latitude and longitude data for most, but not all, entries in **DemoBase Connected**.

Chapter 3

Plotting data on geographical maps

3.1 Deciding which entries to plot

There are two ways to plot entries on a geographical map (see also [1.3](#)):

- Starting from the selected entries in the *Main* window (see below for a brief description).
- Starting from the *Comparison* window. If no entry selection is present, all entries in the comparison will be used. In case a selection is present, only the selected entries in the comparison will be plotted. Character values and dendrograms can only be plotted on geographical maps when starting from the *Comparison* window.

Hence, before we can plot any entries from the *Main* window, we need to make a selection in the database.

- 1.1 Select a single entry in the *Database entries* panel by holding the **Ctrl**-key and left-clicking on the entry. Alternatively, use the **space bar** to select a highlighted entry or click the ballot box next to the entry.

Selected entries are marked by a checked ballot box (☑) and can be unselected in the same way.

- 1.2 In order to select a group of entries, hold the **Shift**-key and click on another entry.

A group of entries can be unselected the same way.


- 1.3 All entries can be selected at once with *Edit* > *Select all* (**Ctrl+A**).

- 1.4 Clear all selected entries with *Database* > *Entries* > *Unselect all entries (all levels)* (, **F4**).

3.2 Plotting locations only

In the following tutorial, it is described to plot locations (stored in entry information fields) on a geographical map, without additional information. In this case, the locations will appear as dots on the map.

As an example, we could plot all entries in **DemoBase Connected** for which location information is available.

- 2.1 Select all entries, except for the standards, in the *Database entries* panel and select *Analysis* > *Geo chart...* ().

The *Basic info* wizard page pops up (see [Figure 3.1](#)).

This wizard page lists the different graph types that can be used and queries for the entry fields which contain the geographical information.

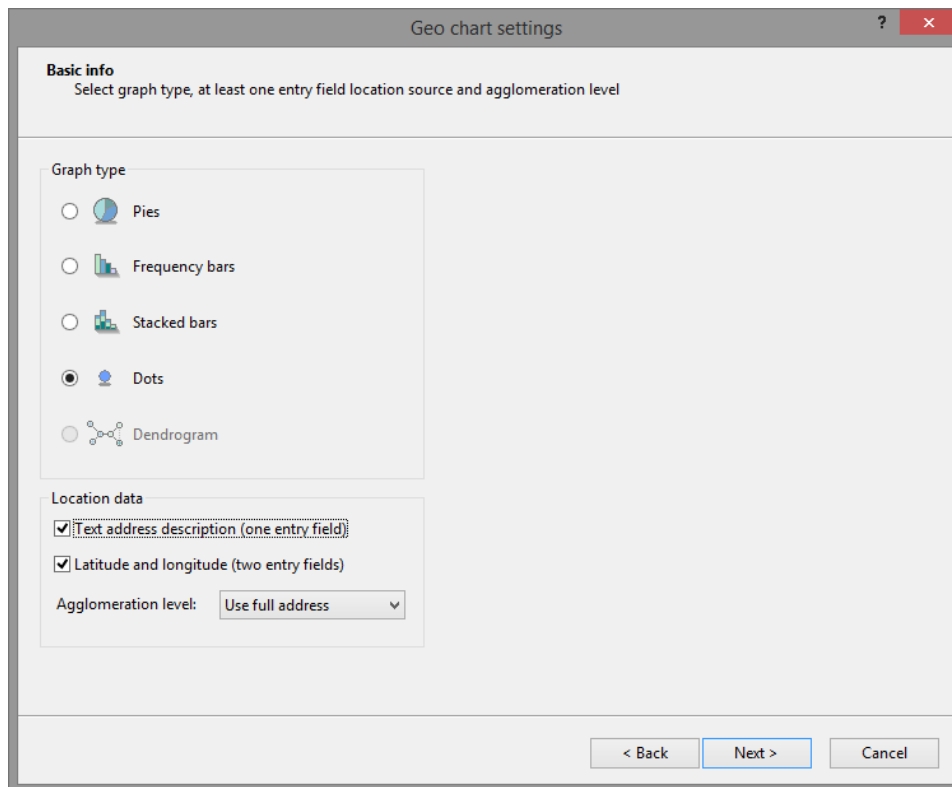


Figure 3.1: The *Basic info* wizard page.

The *Graph type* can be specified. The following types are available:

- **Pies**: The data is plotted in circular pie charts, with the size of the pies proportional to the number of entries per location. Locations, relative number of entries per location (via the pie size) and categories (using colors) can be indicated with pies.
- **Frequency bars**: The data is plotted in vertical bar graphs. The height of the bars will be proportional to the number of entries that have an identical location and category. Similar to pies, frequency bars can indicate locations, relative number of entries per location (via the bar height) and categories (using colors).
- **Stacked bars**: The data is plotted in vertical stacked bar graphs, with differently colored categories stacked on top of one another per bar. In addition, the data can be binned using text categories, numbers or dates. Each bin is hereby represented by a single bar in the stacked bar graph. Note that character values (character type experiments and composite data sets) can only be plotted via the **Stacked bar graphs** option. A stacked bar graphs can indicate location and two different categories *or* a location, a category and a summarized character value per category.
- **Dots**: The data is plotted as discrete data points. Dots can indicate locations only (no extra information, except for the selection state).
- **Dendrogram**: A dendrogram, i.e. the result of a cluster analysis, is superimposed on the geographical map.

Under *Location data* the data used for mapping can be specified:

- **Text address description (one entry field)**: When checking this option, entries will be mapped based on the location information present in one of the database information fields. See 2.5 on how to

compose full addresses using calculated fields. In the next step of the wizard, the information field(s) containing the location information can be specified as **Full address field** (see Figure 3.2).

- **Latitude and longitude (two entry fields):** With this option, entries can be plotted based on latitude and longitude information, present in two separate information fields in the database. When checking this option, the information fields where the latitude and longitude information is stored in the database should be specified as **Latitude field** and **Longitude field**, respectively.
- The results of all the entry locations can be combined according to the **Location agglomeration**. Possible examples of location agglomerations are: “Sublocality”, “Locality”, “Administrative level 2”, “Administrative level 1” or “Country”. A last option is “Use full address”. The latter option implies that only those locations returning exact the same coordinates from Google Maps, will be combined while plotting the data.



When a **Text address description** and **Latitude and longitude** are provided, the latter are used preferentially. The text address descriptions are only used if no coordinate information is available.

Since we only want to plot locations (no additional information), we will use dots in this tutorial.

2.2 Check **Dots** as **Graph type**.

In the **DemoBase Connected** database, coordinate information is available for most, but not for all entries. We will therefore use both the address and the coordinates as location data.

2.3 Under **Location data**, check both **Text address description (one entry field)** and **Latitude and longitude (two entry fields)**.

2.4 Make sure that “Use full address” is selected for **Agglomeration level** and press **<Next>** to proceed.

Figure 3.2: The *Location field* wizard page.

When using a **Text address description** as location data for the entries, the **Full address field** can be entered from this wizard page (see Figure 3.2). The **Full address field** refers to the database information field that contains the address. A drop-down list shows all available entry information fields.

2.5 Select the “Address” calculated field that we created earlier (see 2.5) from the list of database fields.

This information is needed for the mapping of entries that do not have coordinates in the database (no information is present in the ‘Longitude’ and ‘Latitude’ information fields for entries with key **G@Gel07@015**, **G@Gel08@012** and **G@Gel09@011**).

2.6 Press <Next> to proceed to the *Latitude & longitude field* wizard page (see Figure 3.3).

Figure 3.3: The *Latitude & longitude field* wizard page.

The *Latitude & longitude field* wizard page is only displayed when using latitude and longitude as location data for the entries in the *Basic info* wizard page. On this page, the database information fields that contain the latitude (**Latitude Field**) and the longitude (**Longitude Field**) can be selected from the drop-down lists containing all entry information fields.



In case latitude and/or longitude information is missing for one or more entries, a warning message will appear in the *Latitude & longitude field* wizard page.

2.7 Select the database fields “Latitude” and “Longitude” as **Latitude Field Name** and **Longitude Field Name**, respectively.

2.8 Press <Next> to continue to the *Geolocation hint and language* wizard page (see Figure 3.4).

In the *Geolocation hint and language* wizard page, a **Location hint** can be specified. This hint will be used to narrow down the search on the geo server. If all the addresses are located e.g. within the same continent or country, you can enter this information as **Location hint**.

The **Language** setting in the *Geolocation hint and language* wizard page refers to the language of the place names that the Google Maps API returns. Altering this settings has effect on the geocoding results, and thus

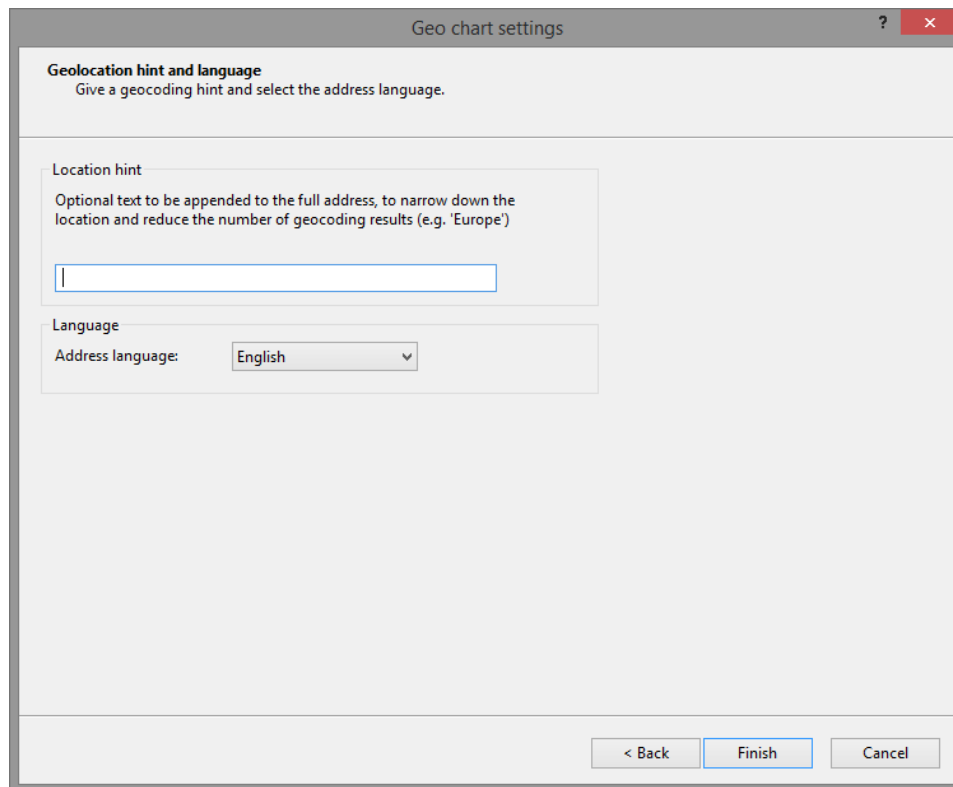


Figure 3.4: The *Geolocation hint and language* wizard page.

on the unresolved locations that are returned.

- 2.9 Enter “Europe” as location hint, select “English” as *Address language* and press <**Finish**> to open the map in the *Geo* window (see Figure 3.5).

To illustrate that coordinates were used, proceed as follows:

- 2.10 Zoom in on the city Valencia by double-clicking the map near Valencia several times.

Because two different sets of coordinates in Valencia are stored in the information fields ‘Latitude’ and ‘Longitude’ in the database, two dots appear in the city Valencia (see Figure 3.6):

Detailed information on available functionality in the *Geo* window can be found in 4.

3.3 Plotting locations and info from a single field

Choosing a graph different from dots in the *Geo chart settings* wizard provides the option to visualize extra information (in addition to location) on a geographical map. This includes the number of entries found per location and optionally categories that are stored in a single entry information field.

For example, say that we want to plot the genera that are found on each of the text addresses that are stored in **DemoBase connected**.

- 3.1 Select all entries, except for the standards, in the *Database entries* panel and select **Analysis > Geo chart...** (🌐).

In case you opened the *Geo* window already (e.g. because you followed the previous tutorial, see 3.2), the *Previous settings* wizard page will appear (see Figure 3.7).

When closing the *Geo* window, the most recently used mapping settings are stored in the database. This

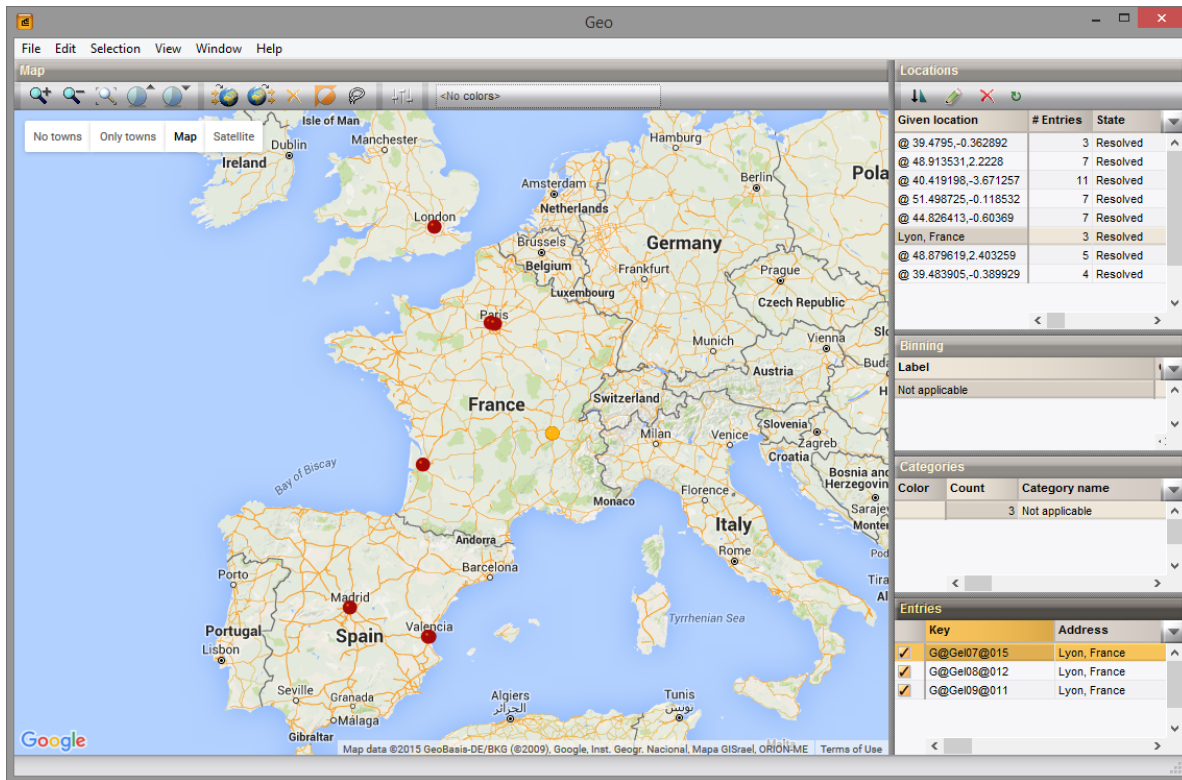


Figure 3.5: The Geo window, displaying locations as simple dots.

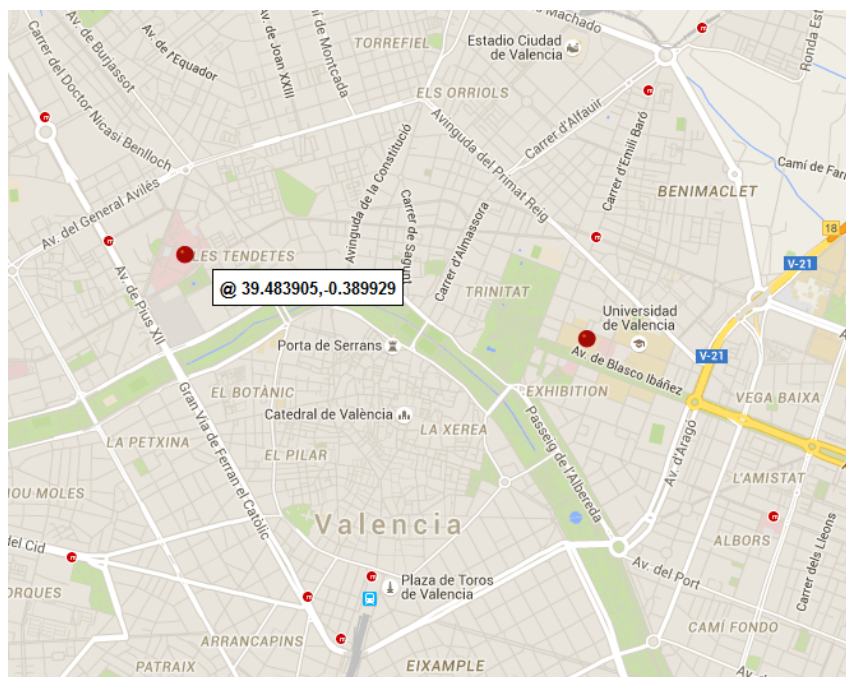


Figure 3.6: Coordinate-based locations can distinguish different places in the same city.

allows you to create a similar geographical map e.g. on another set of selected database entries, without running the wizard again.

The *Previous settings* wizard page displays a summary of the previously used mapping settings.

At this point, you have the option to **Reuse the previous settings**. With this option checked, pressing

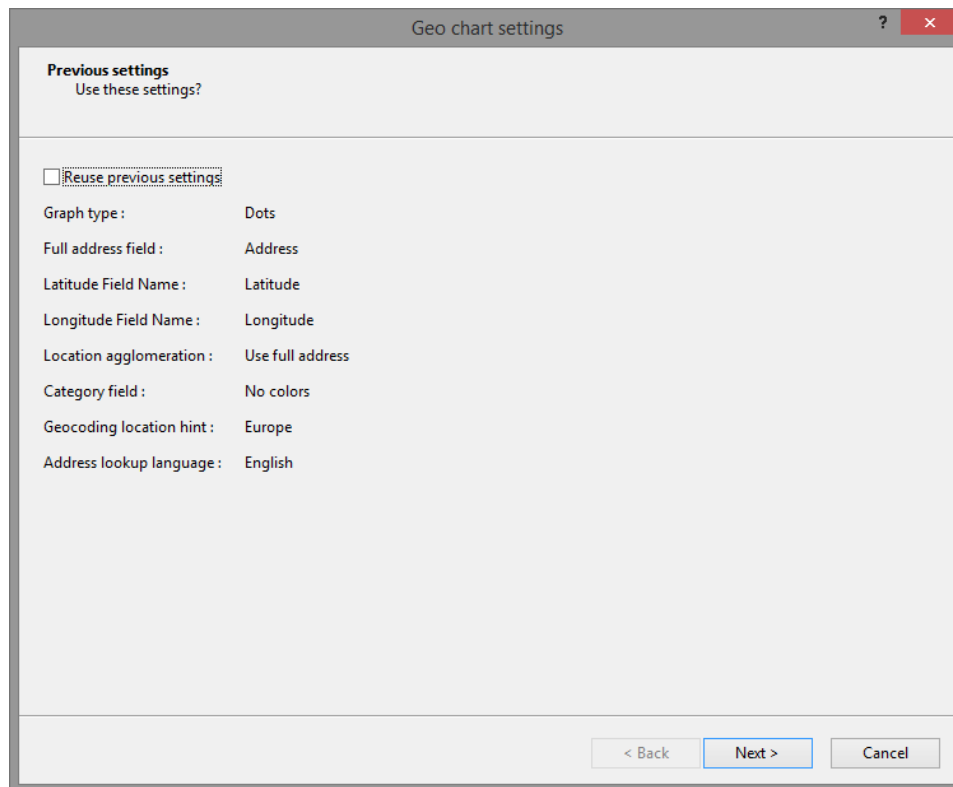


Figure 3.7: The *Previous settings* wizard page.

<Next> will result in the creation of a geographical map based on the settings that are listed in the dialog.

If you leave **Reuse the previous settings** unchecked, pressing **<Next>** will initiate the different pages in the geographical mapping wizard one by one, and allows to change the individual mapping settings to create another customized geographical map.

3.2 Leave the option **Reuse the previous settings** unchecked and press **<Next>**.

3.3 In the *Basic info* wizard page, check either **Pies** or **Frequency bars** as **Graph type**.

3.4 Uncheck **Latitude and longitude (two entry fields)** to use only text addresses and press **<Next>**.

3.5 In the *Location field* wizard page, leave “Address” selected for **Full address field** and press **<Next>**.

This action will display the *Color field* wizard page (see Figure 3.8).

When starting from the *Main* window, only database fields can be selected from the *Color field* wizard page to use as color category in the chart (see Figure 3.8).

When “<No colors>” is selected from the **Categories field** drop-down list, no category colors will be displayed in the graphs. This option can be used to draw graphs (i.e. bars or circles) of the same color, that are scaled proportionally to the number of entries per location.

When selecting an information field as **Categories field** from the drop-down list with none of the options checked, each unique content for the selected information field will be assigned to a different color, and will be plotted in this color in the charts on the map.

The option **Restrict to field states** only becomes available when information field states (see the Reference manual, Chapter Database entries) are present for the highlighted information field. With this option checked, the graph will be limited to those entries having their field state defined in the *Database field properties* dialog box.

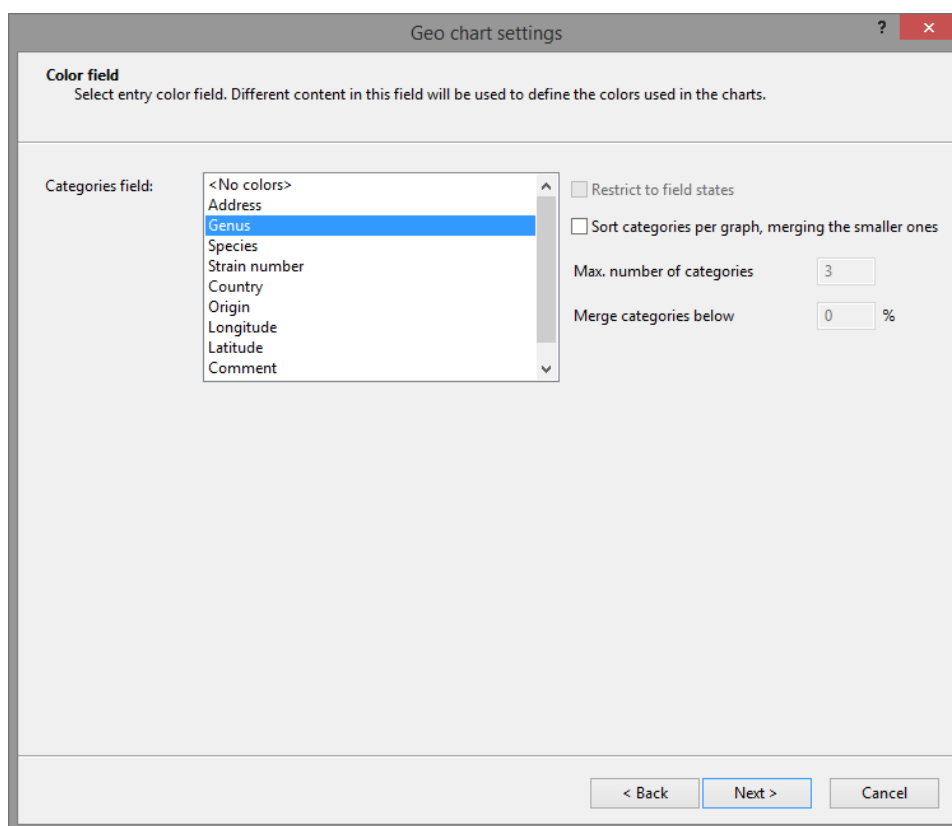


Figure 3.8: The *Color field* wizard page, when the *Geo chart settings* wizard was started from the *Main* window.

When *Sort categories per pie, merging the smaller ones* is checked, each pie chart will start with the largest category on that location, followed by the second largest, etc.. All categories that are below the *Merge categories below* threshold will be merged into a single "miscellaneous" category. With the *Sort categories per pie, merging the smaller ones* option unchecked, the same category order is used for all pie charts and smaller categories are not merged.

3.6 Select "Genus" as *Categories field*, leave the other options unchecked and press <Next> to proceed.

3.7 In the *Geolocation hint and language* wizard page, enter "Europe" as location hint, select "English" as *Address language* and press <Finish> to open the map in the *Geo* window (see Figure 3.9).

Detailed information on available functionality in the *Geo* window can be found in 4.

3.4 Plotting locations and info from two fields

Using a stacked bar graph, categorical information from two entry information fields can be visualized.

For example, say that we want to plot the genera that are found on each of the text addresses and break these down per year of isolation (the latter information is stored in the 'Date' field).

4.1 Select all entries, except for the standards, in the *Database entries* panel and select *Analysis > Geo chart...* (🌐).

4.2 In the *Previous settings* wizard page, leave the option *Reuse the previous settings* unchecked and press <Next>.

4.3 In the *Basic info* wizard page, check *Stacked bars* as *Graph type*, use only text addresses and press <Next>.

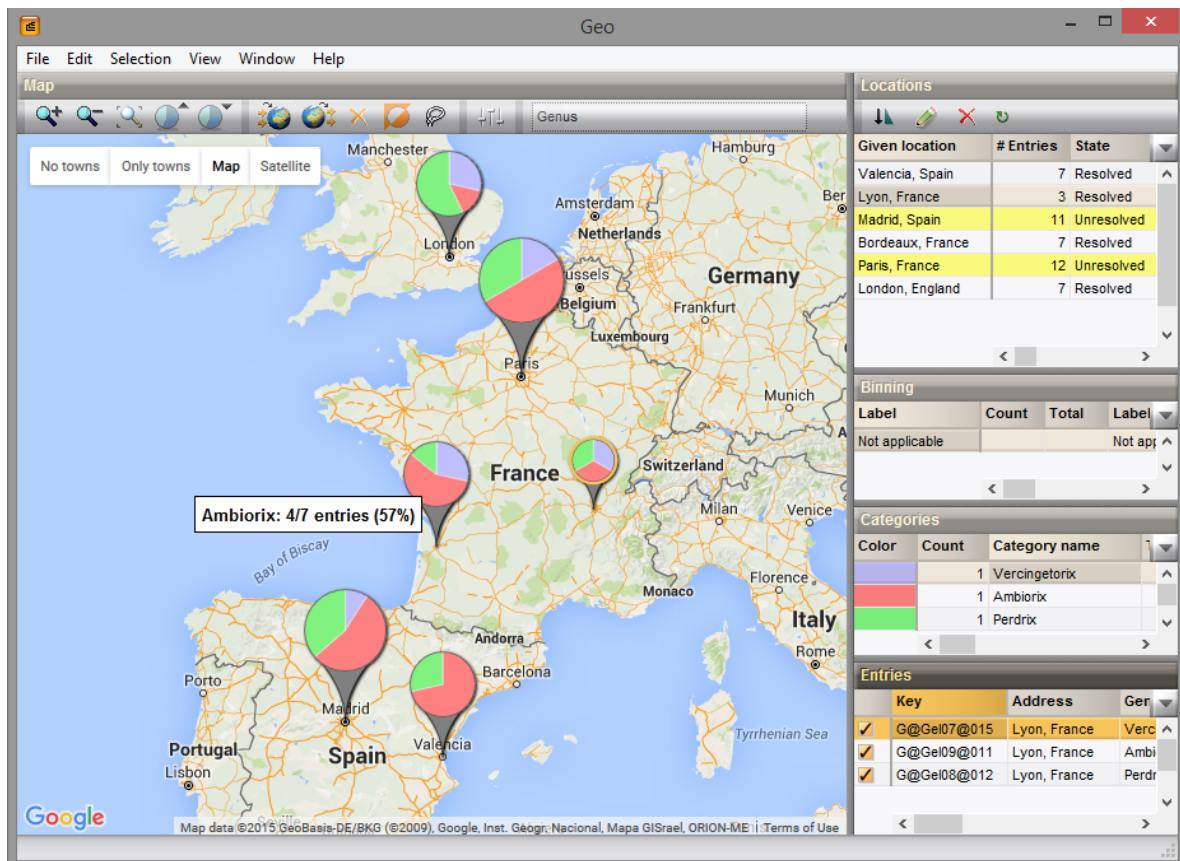


Figure 3.9: The *Geo* window, displaying pie charts with categories defined based on the 'Genus' information field.

4.4 In the *Location field* wizard page, leave "Address" selected for **Full address field** and press <Next>.

4.5 In the *Color field* wizard page, select "Genus" from the **Categories field** and press <Next>.

This action will display the *Binning field* wizard page (see Figure 3.10).

The *Binning field* wizard page is only displayed when stacked bar graphs were indicated as graph type and when categories are created based on an information field or from comparison groups (available when the *Geo chart settings* wizard was started from the *Comparison* window). When both conditions are fulfilled, a **Binning field** can be selected from the corresponding drop-down list.

Any of the user-created information fields (standard properties such as 'Key' and 'Modified date' are not available) can be selected as **Binning field**. The field content will be used to separate the data from the different categories. The type of field (Text, Number or Date) of the selected field will be indicated. A warning will appear in case the field is empty for some of the entries.

When a Date field is selected, an additional **Date grouping span** drop-down list is displayed. This allows binning of the data according to "Year", "Quarter", "Month", "Week" or "Day".

When a Number field is selected, the **Number of bins** can be defined and the bins are created linearly.

When selecting "<No binning>" from the **Binning field** drop-down list, the bars will be created from the original category data, without binning.

4.6 Select "Date" as **Binning field** and use "Year" as **Date grouping span**. Next, press <Next>.

4.7 In the *Geolocation hint and language* wizard page, enter "Europe" as location hint, select "English" as **Address language** and press <Finish> to open the map in the *Geo* window (see Figure 3.11).

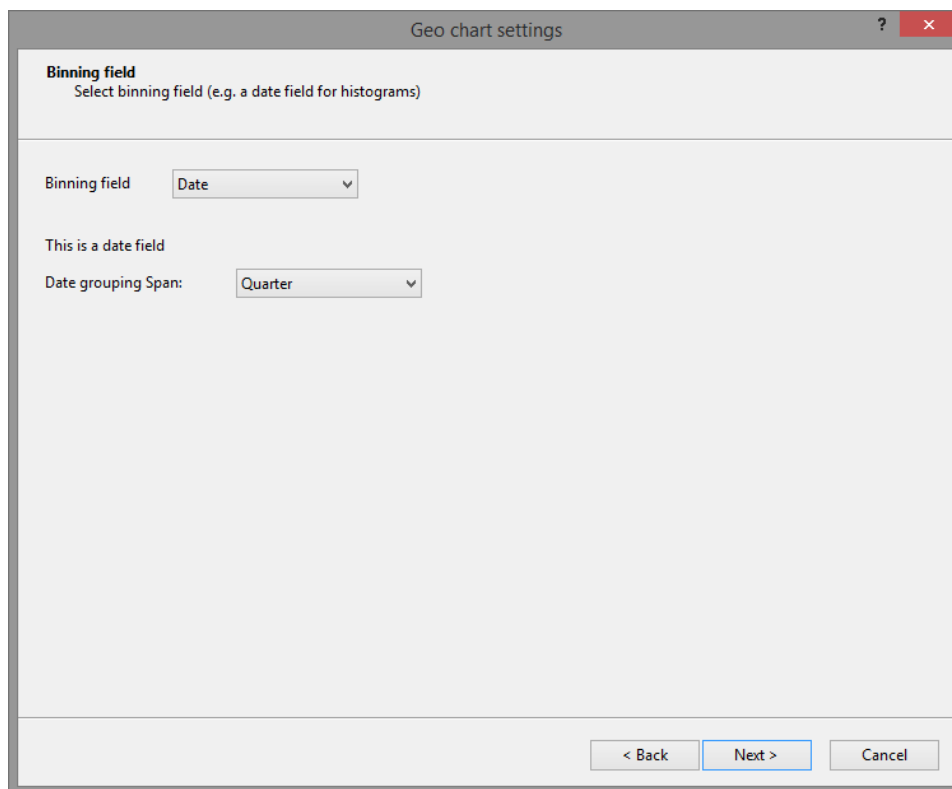


Figure 3.10: The *Binning field* wizard page.

Detailed information on available functionality in the *Geo* window can be found in [4](#).

3.5 Plotting locations and character data

In order to use experimental information (character data and composite data sets) in graphs on a geographical map, one needs to start from the *Comparison* window.

For example, say that we want to create bar graphs with the average composition of the major fatty acids per location.

First, we will create a comparison that contains all entries with address information:

- 5.1 In the *Database entries* panel of the *Main* window, select all entries except for the standards.
- 5.2 Highlight the *Comparisons* panel in the *Main* window and select **Edit > Create new object...** (🛠️).

The *Comparison* window now opens with the selected entries.

The number of bars in a stacked bar graph on a geographical map is limited to 20. Since the **FAME** experiment type contains many more characters, we will make a character selection with the major fatty acids:

- 5.3 In the *Experiments* panel, click on the eye icon (👁️) next to **FAME** to visualize the data in the *Experiment data* panel.
- 5.4 In the header of the *Experiment data* panel, **Ctrl+click** on **14:0** to select this character.
- 5.5 Repeat Instruction [5.4](#) for **16:0**, **Sum in Feature 7**, **Sum in Feature 3** and **Sum in Feature 4**.

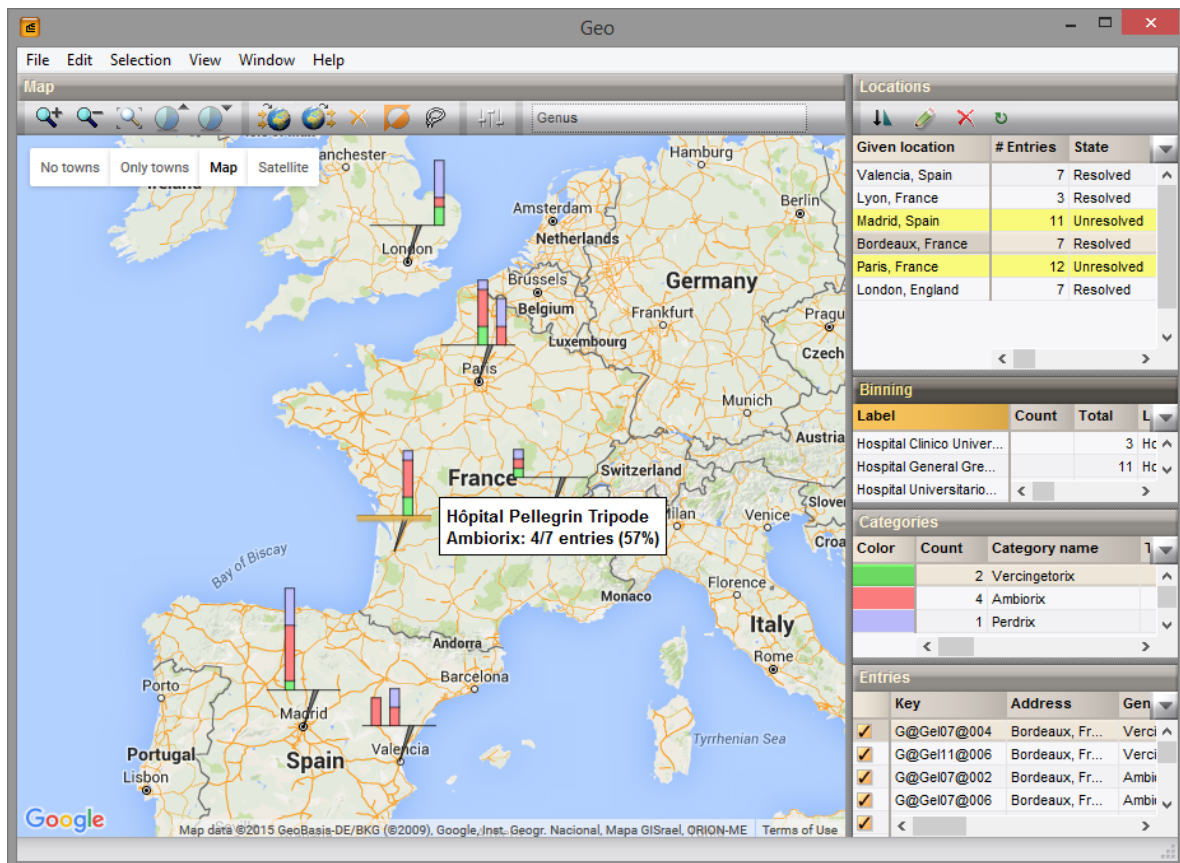


Figure 3.11: The *Geo* window, displaying stacked bar graphs with categories defined based on the 'Genus' information field. The data is binned based on the 'Date' information provided for each sample, creating bins for each year.



If the same set of character is used more than once, it is recommended to create a *character view* for it (see the Reference manual, Chapter Setting up character type experiments).

Now we will plot the information on a geographical map:

5.6 Select *Statistics* > *Geo chart...* (🌐).

5.7 In the *Previous settings* wizard page, leave the option *Reuse the previous settings* unchecked and press <Next>.

5.8 In the *Basic info* wizard page, check *Stacked bars* as *Graph type*, use only text addresses and press <Next>.

5.9 In the *Location field* wizard page, leave "Address" selected for *Full address field* and press <Next>.

This action will display the *Color field* wizard page (see Figure 3.12).

When the *Geo chart settings* wizard is started from the *Comparison* window, additional options are available to use as a color category in the chart:

- Comparison groups: User-defined groups in the *Comparison* window, see the Reference manual, Chapter General comparison functions.
- Character data: Any view (default or user-defined) on character type experiments that contains data. For more information on character views, see the Reference manual, Chapter Setting up character type experiments.

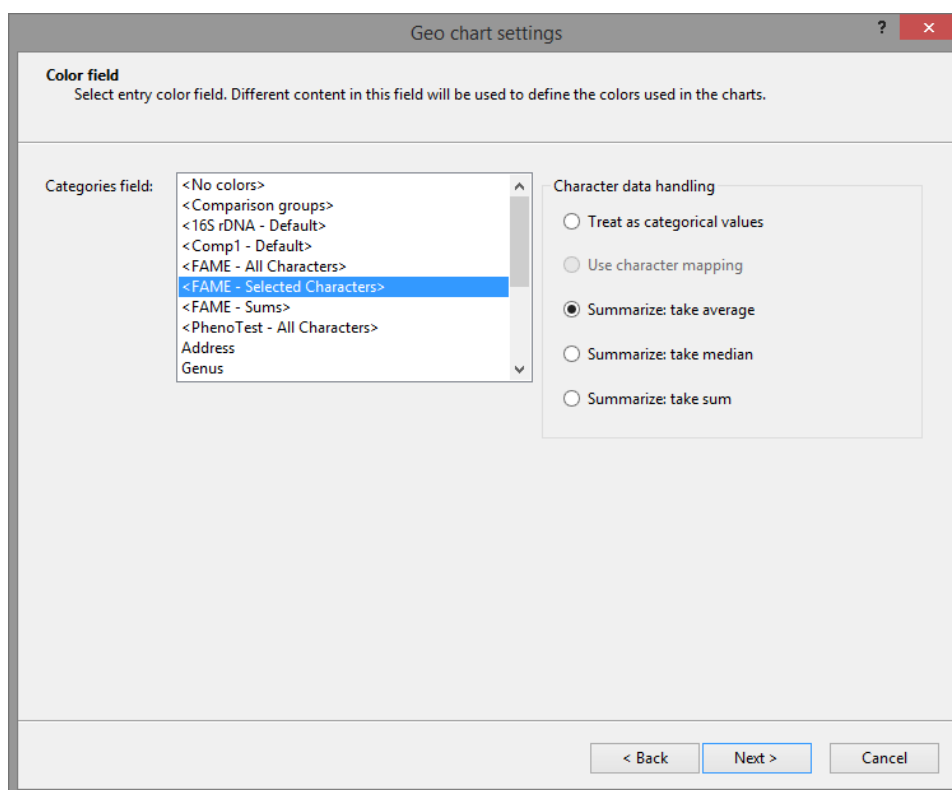


Figure 3.12: The *Color field* wizard page, when the *Geo chart settings* wizard was started from the *Comparison* window. A character view is selected as *Categories field*.

- Composite data sets: Any composite data set (see the Reference manual, Part Composite data sets) that contains data.

When a character view or composite data set is selected as *Categories field*, the *Character data handling* should be specified. Following options are available:

- ***Treat as categorical***: Each character value is considered as an individual state. This is useful for e.g. MLVA, MLST or SNP data sets that are multi-state or categorical by design, but should not be used for quantitative data.
- ***Use character mapping***: Uses the character mapping (see the Reference manual, Chapter Setting up character type experiments) instead of the character values. This option is only available if a character mapping was defined in the *Character type* window.
- ***Summarize: take average***: Calculates for each character the average value per location.
- ***Summarize: take median***: Calculates for each character the median value per location.
- ***Summarize: take sum***: Calculates for each character the summed values per location.

Hence, the first two options treat the data as categorical and produce stacked bar graphs with the colors indicating the fraction of entries that belong to each category. The three latter options generate quantitative values, which will result in the creation of regular bar graphs (i.e., with the height of the bars proportional to the value).

5.10 Select “<FAME – Selected Characters>” as *Categories field*, check ***Summarize: take average*** and press <Next> to proceed.

5.11 In the *Geolocation hint and language* wizard page, enter “Europe” as location hint, select “English” as *Address language* and press <Finish> to open the map in the *Geo* window (see Figure 3.13).

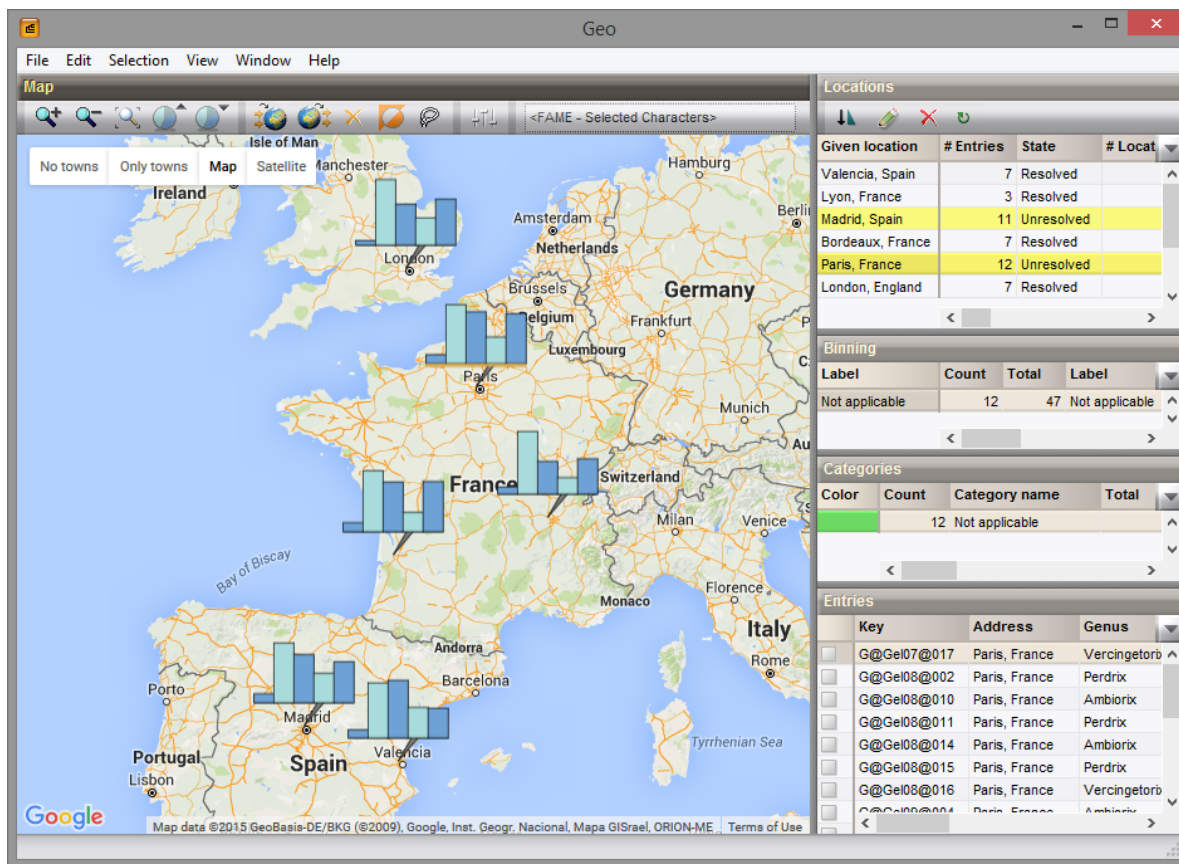


Figure 3.13: The *Geo* window, displaying bar graphs with average relative occurrences of the major fatty acids.

Detailed information on available functionality in the *Geo* window can be found in 4.

3.6 Plotting locations and dendrograms

Another type of graph that can be displayed on a geographical map is a dendrogram. In contrast to other graphs, which visualize additional data per location, a dendrogram connects the locations and indicates similarity between the entries on different locations. Plotting a dendrogram is only possible from the *Comparison* window when at least one cluster analysis is calculated.

Since the combination of similarity and geographical information quickly becomes very complicated, it is best to start with a limited number of entries:

6.1 Select the entries with strain number 42818, 42855, 52414, 52418, and 52420.

6.2 Highlight the *Comparisons* panel in the *Main* window and select *Edit > Create new object...* (+).

The *Comparison* window now opens with the five selected entries. First, we will calculate a dendrogram:

6.3 Click on **RFLP1** in the *Experiments* panel to make this the active experiment type.

6.4 Select *Clustering > Calculate > Cluster analysis (similarity matrix)...*

6.5 In the *Comparison settings* wizard that appears, leave all settings to their defaults, press <Next> and <Finish>.

A dendrogram is calculated and appears in the *Dendrogram* panel. Next, we will plot this dendrogram on a geographical map:

6.6 Select **Statistics > Geo chart...** (🌐).

6.7 In the *Previous settings* wizard page, leave the option **Reuse the previous settings** unchecked and press **<Next>**.

6.8 In the *Basic info* wizard page, check **Dendrogram** as **Graph type**, use only text addresses and press **<Next>**.

6.9 In the *Location field* wizard page, leave “Address” selected for **Full address field** and press **<Next>**.

6.10 In the *Geolocation hint and language* wizard page, enter “Europe” as location hint, select “English” as **Address language** and press **<Finish>** to open the map in the *Geo* window (see Figure 3.14).

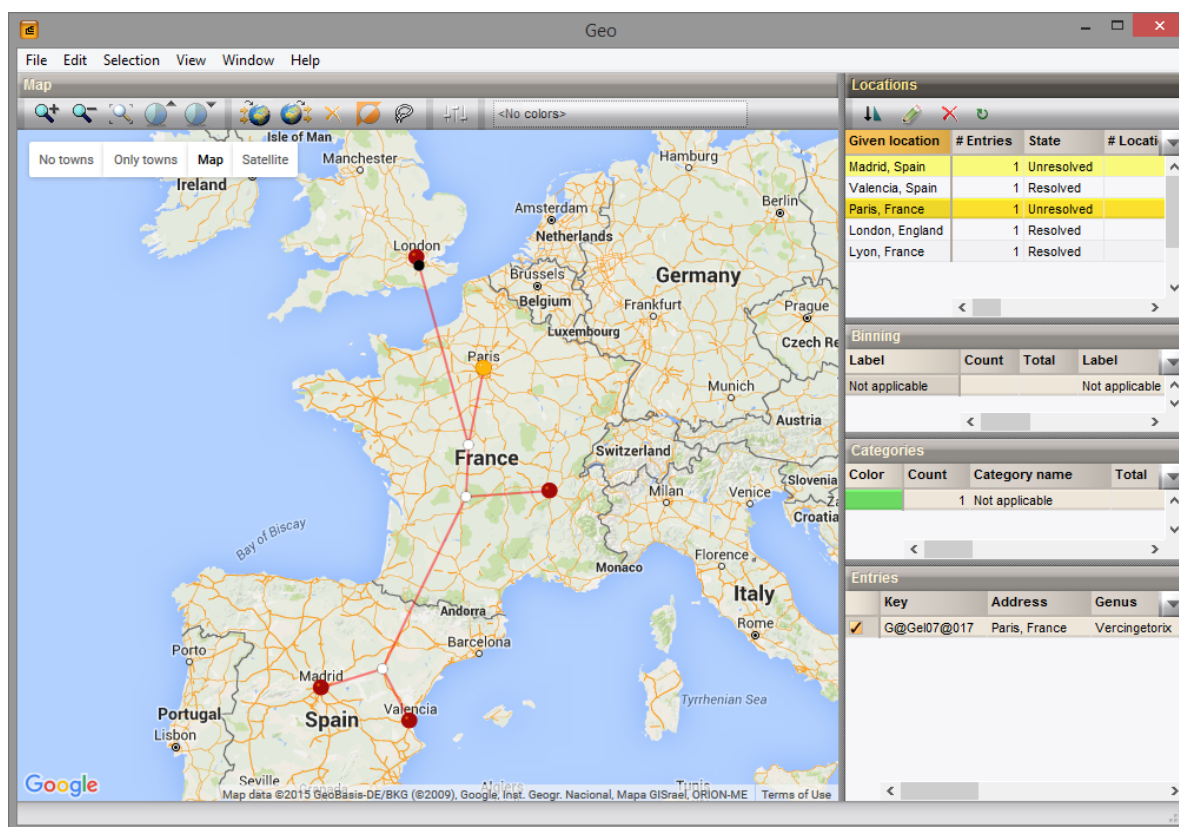


Figure 3.14: The *Geo* window, displaying a dendrogram.

Locations are indicated on the map with colored dots, identical to the ones used in 3.2. Branch nodes in the dendrogram are visualized with smaller, white dots. The dendrogram root is shown with a black dot. When hovering over a location, the path to the dendrogram root is shown in solid black. Likewise, when hovering over a branch node with the mouse, the path to the dendrogram root is drawn in solid black and the corresponding branch is displayed in solid red.



To allow the display of connection lines between entries in case multiple entries have the same location, these entries are spread out in a circle around their actual location.

Detailed information on available functionality in the *Geo* window can be found in 4.

Chapter 4


Functionality in the Geo window



4.1 The Geo window



The *Geo* window displays the geographical map with graphs indicating locations and optional additional information. It also provides feedback on location, category, binning information used and entry selection. The window consists of five different panels:

- The *Map* panel displays the geographical map with dots, pie charts, bar graphs or dendrogram plotted onto the map. Different map views become available by pressing the buttons in the top left of the *Map* panel: the map without town information (<*No towns*>), the map with town information (<*Only towns*>), the map displaying all geographical location information (<*Map*>) and a satellite view (<*Satellite*>).
- The *Locations* panel indicates which locations are plotted onto the map and on which location information this was based. Locations preceded by a '@' refer to longitude-latitude information, while e.g. text like "Lyon, France" indicate that a text address was used to retrieve the location information. Further, the number of entries per location is indicated and the geo mapping state ("Resolved" or "Unresolved"; see 4.2 for more information). For text addresses, the used location as derived from the geo mapping is also indicated in this panel.
- The *Binning* panel provides an overview of the different binning categories that were created based on the specified binning field. For each selected location in the *Map* panel, the number of entries enclosed in this bin is updated in the 'Count' column.
- The *Categories* panel lists all the different categories that are plotted on the geographical map for the current location and bin. Next to the categories, the corresponding plot color and the number of entities enclosed in this specific category are displayed.
- The *Entries* panel lists the entries from selected locations, with all entry information fields.


To move the map in the *Map* panel, click on the map and drag it in the desired direction.

Use **View > Zoom to fit** () to set the position and zoom level of the map so that all graphs fit in the *Map* panel.

Zoom in or out on the center of the map by selecting **View > Zoom in** () or **View > Zoom out** (), respectively. Use the scroll wheel of the mouse to zoom in and out on the position of the mouse pointer. Double-clicking the left mouse button zooms in on the position of the mouse pointer; double-clicking the right mouse button zooms out.

To enlarge or shrink bar graphs, stacked bar graphs or pie charts on the map, use **View > Scale up** () or **View > Scale down** (), respectively.

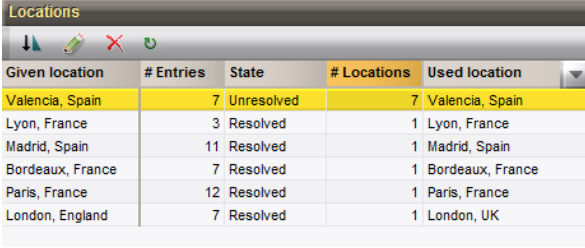
Hovering over a graph will display a "tool tip" with additional information.

With **Edit > Modify settings** () , the current locations can be plot on the geographical map using other settings. This action calls the *Basic info* wizard page again, as described in 3.2.

4.2 Resolving undefined geographical positions


When plotting information based on text addresses, it is possible that more than one location with the same name is retrieved or that the address could not be found by the Google Geocoding web service.

With the example data set, if entries present in the **DemoBase Connected** database are plotted based on their address description, multiple locations are found for "Valencia, Spain", as indicated by the yellow row in the *Locations* panel (see Figure 4.1). One location is the preferred location and is used for plotting.



Given location	# Entries	State	# Locations	Used location
Valencia, Spain	7	Unresolved	7	Valencia, Spain
Lyon, France	3	Resolved	1	Lyon, France
Madrid, Spain	11	Resolved	1	Madrid, Spain
Bordeaux, France	7	Resolved	1	Bordeaux, France
Paris, France	12	Resolved	1	Paris, France
London, England	7	Resolved	1	London, UK


Figure 4.1: Unresolved locations are indicated in yellow in the *Locations* panel of the *Geo* window.


To view the unresolved positions for a location, click on the location in the *Locations* panel and select **Edit > Edit geocoding** () , or simply double-click on the location. This action will display the *Results* dialog box (see Figure 4.2).

This dialog box lists all alternatives which where found for the provided location. In the background, the geographical map is updated with the locations for the alternatives positions. The location that is highlighted in blue in the *Results* dialog box will be selected (shown as an orange dot or halo) on the geographical map, to help deciding on the location.

To select a different location, click on a position from the list to highlight it and press <**Save**>. This action saves the updated geo information links to the database, removes the yellow highlight from the *Locations* panel, and changes the State of the location from "Unresolved" to "Resolved". Once the locations have been resolved and saved to the geo cache, the next time the geo analysis is launched, this updated information will be taken into account and the locations will be listed as "Resolved".

Any location, but especially locations that are listed as 'not found', can be modified or updated in the **Search address** text field of the *Results* dialog box. A new geo search with the updated information is then launched by pressing the <**Submit**> button. The updated results will be displayed in the **Selected location** list. Highlight any of these results and press <**Save**> to save the selected location to the *Locations* panel.

By using **Edit > Clear cache** () , the geo information of the currently highlighted location(s) in the *Locations* panel will be deleted from the cache. When using this command, you will also delete the saved information from the unresolved locations. When performing a new geographical analysis, the locations will appear again as unresolved. This functionality can be used e.g. if you want French instead of English location names: first, modify the address language and then, clear the cache for all locations and resubmit the location searches.

Within the *Locations* panel, the information present in a selected column can be sorted by using **Edit > Sort** () . This can be particularly useful e.g. when searching for all unresolved location states.

A selected location can be removed from the map by selecting **Edit > Remove** () . This action immediately

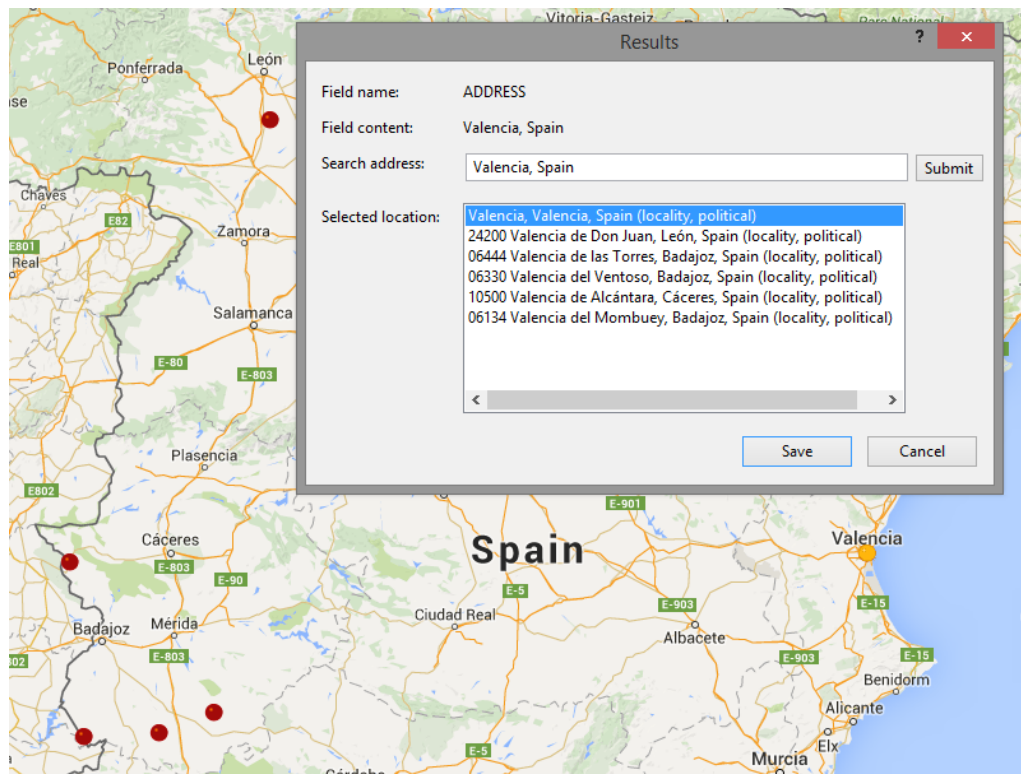


Figure 4.2: The *Results* dialog box, showing all alternatives for the unresolved location "Valencia, Spain". In the background, part of the geographical map is displayed with the highlighted location selected in orange.

updates the map. There is no undo functionality for this action. To restart the analysis with all available information, close the window by selecting **File > Exit (Alt+F4)**, and choose **Analysis > Geo chart...** (🌐) to recreate the original map.

4.3 Selecting locations and entries

Selections of locations and entries provide an interactive way to link geographical information with other analyses in BioNumerics. For example, one could select the entries from nearby locations and check how similar these entries are by observing the position of the selected entries in a cluster analysis or PCA. Conversely, one could select a set of highly similar entries from a branch in a dendrogram and then visualize their geographical spread on a map.

Locations in the *Map* panel can be selected or unselected with **Ctrl+click**. Selected locations are indicated as orange dots (for dots), with an orange halo (for pie charts) or underlined in orange (for bar graphs). In the *Locations* panel, the corresponding rows are highlighted. Locations can also be selected from the *Locations* panel using **Ctrl+click** or **Shift+click** (for complete ranges) and the *Map* panel is updated automatically.

Another very flexible method to select locations in the *Map* panel is via the lasso tool: select **Selection > Lasso select** (🔗) and drag the lasso with the mouse around the locations to be selected. This action adds the locations "captured" by the lasso to the existing location selection.

A selection of locations can be inverted with **Selection > Invert selection** (🔄): The selected locations will be unselected and the unselected locations will now be selected.

To clear the locations selection, i.e. to unselect all locations, use **Selection > Clear selection** (✖).

It is important to realize that a single location can correspond with multiple entries, as indicated in the

#Entries column in the *Locations* panel. Entry selections and selected locations can be synchronized in two ways:

- Entries that correspond to selected locations can be selected in the database with **Selection > Map to database** (🌐). This action is particularly useful to check e.g. the position in a dendrogram of entries that are originating from locations in close proximity. Note that a single selected location can give rise to multiple selected entries.
- To show the locations of selected database entries in the *Map* panel and the *Locations* panel, use **Selection > Database to map** (🌐). This is a convenient action when one wants to check the geographical location of e.g. strains with highly similar patterns. Note that a location is selected as soon as it contains a selected entry.

4.4 Exporting and printing

The geographical map can be printed directly to a printer using **File > Print**. The dialog box that appears is the standard Windows Print dialog box, allowing you to choose a printer and change the properties.

The map can also be exported with **File > Save as**.

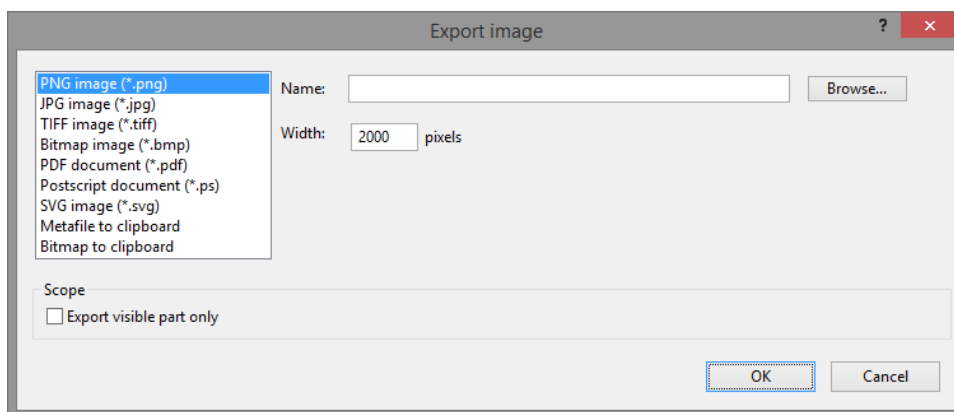


Figure 4.3: The *Export image* dialog box.

This dialog box allows you to export graphical information to a file or to the Windows clipboard in one of several available formats. In case a file is exported, a file **Name** should always be entered or browsed for via the **<Browse>** button. Exported files will open in their default editor. Information on the Windows clipboard can be pasted into other applications. Following export options are available:

- **PNG image (*.png)**: exports to a Portable Network Graphics (PNG) file. PNG is a raster graphics file format that supports lossless data compression. A **Name** and **Width** (in pixels) should be specified; the height will be determined automatically.
- **JPG image (*.jpg)**: exports to a Joint Photographic Experts Group (JPEG) file. JPEG or JPG is a raster graphics file format that uses a lossy data compression. A **Name** and **Width** (in pixels) should be specified, as well as a **Quality** parameter. With the latter, a tradeoff can be obtained between storage size and image quality.
- **TIFF image (*.tiff)**: exports to a Tagged Image File Format (TIFF) file. TIFF is a raster graphics file format with optional lossless data compression. A **Name** and **Width** (in pixels) should be specified.

- **Bitmap image (*.bmp):** exports to a BMP bitmap image or device independent bitmap (DIB) file. BMP is a raster graphics image file format used to store bitmap digital images, independently of the display device. A **Name** and **Width** (in pixels) should be specified.
- **PDF document (*.pdf):** exports to a Portable Document Format (PDF) file. PDF is a file format used to present documents in a manner independent of application software, hardware, and operating systems. A **Name** and the **Orientation** (either Landscape or Portrait) should be specified.
- **Postscript document (*.ps):** exports to a PostScript (PS) file. PostScript is a computer language for creating vector graphics. A **Name** and the **Orientation** (either Landscape or Portrait) should be specified.
- **SVG image (*.svg):** exports to a Scalable Vector Graphics (SVG) file. SVG is an XML-based vector image format for two-dimensional graphics. A **Name** should be specified.
- **Metafile to clipboard:** copies the graphics as Windows enhanced metafile to the clipboard. Enhanced metafile is the standard clipboard exchange format between native Windows applications.
- **Bitmap to clipboard:** copies the graphics as a bitmap to the Windows clipboard. The **Width** (in pixels) should be specified.



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Please contact us for any additional information you might require, we will gladly help you!

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