Till/Tweed Landscape Research Project: visualisation and analysis of Geographical Information Systems (GIS) data

USING ESRI ARCVIEW GIS

DRAFT REPORT FOR CONSULTATION PURPOSES

Prepared by:

Richard Hewitt and Ben Johnson
Archaeology Incorporated
6 Mortimer Terrace
Holywell
Northumberland NE25 0NB

On behalf of:

Dr Clive Waddington
Archaeolgical Research Services
New address line 1
Line 2
Line 3

on behalf of:

Dr CliveWaddington
Archaeolgical Research Services
New address line 1

and

Dr David Passmore
School of Geography, Politics and Sociology
Daysh building
Claremont Rd
Newcastle upon Tyne
NE1 7R

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APPENDICES

1 INTRODUCTION

1.1 The Till Tweed GIS project

Archaeology Incorporated were commissioned by Archaeological Research Services and the University of Newcastle upon Tyne to construct a Geographical Information System (GIS) for dissemination, interrogation, display and analysis of the large quantity of land information generated by the ongoing Till Tweed Landscape Research Project. The aim of this exercise was to provide a distributable end product in digital format for local government archaeology and planning advisors, private developers, and archaeological researchers. This end product takes the form of a CD comprising the following GIS data layers or *coverages*:

1. Study area boundaries for the Till/Tweed project
2. Topographic information expressed as both shaded relief and contours
3. Archaeological finds recovered from fieldwalking during 2003 and 2004 research seasons
4. Location of archaeological trial pits dug on the basis of the fieldwalking results
5. Morphometric land mapping units classified according to Waddington and Passmore (*in press*)
6. Geomorphological landform units classified according to Waddington and Passmore (*in press*)
7. Borehole location and sediment observation information
8. Areas of mining or quarrying within the study area
9. English Heritage (EH) digital transcriptions of archaeological sites and monuments from aerial photographs held in their collection at the National Monuments Record (NMR) , Swindon, Wiltshire. These are supplied with a reference number that corresponds to an individual long report which is stored in a separate folder (see below).
10. EH NMR monument reports for archaeological sites within the study area. These are provided in their original native word document format, as incorporating them into the GIS would prove unnecessarily time consuming given the ease with which they can be opened from the desktop as required.
11. Ordnance survey 1 to 10,000 scale raster greyscale mapping
12. Ordnance Survey map tile boundaries and tile names for the above for ease of reference
13. Ordnance survey 1 to 50,000 scale raster colour mapping

1.2 Provision of data and licensing

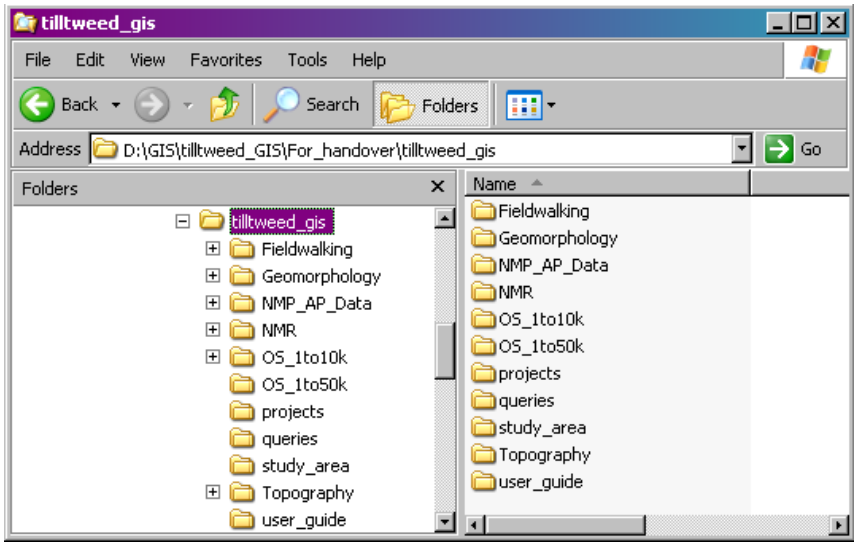
The data described above is provided, with this report, on the understanding that Archaeological Research Services and the University of Newcastle under the umbrella of the Till Tweed project retain joint copyright of this material, except where provided by the Ordnance survey. Ordnance survey data (Topographic mapping, 1:10,000 greyscale raster,

1:50,000 colour raster) is provided on the understanding that this data will be used *for research purposes only* or other permitted purposes under the terms of the recipient's own Ordnance Survey licensing agreement. Neither Archaeology Incorporated, Archaeological Research Services, nor the University of Newcastle can accept responsibility for inappropriate or unlicensed use of Ordnance Survey data once transmitted to any third party.

2 USING THE GIS

2.1 Project Data Structure

This report is supplied along with a CD containing the GIS datasets described above (section 1.1). The data on the CD will appear as follows:



With reference to section 1.1 above, subdirectories within the main **tilltweed_gis** directory contain the following GIS data coverages:

Subdirectory **Fieldwalking**	coverages 3,4 and 5
Subdirectory **Geomorphology**	coverages 6,7 and 8
Subdirectory **NMP_AP_Data**	coverage 9
Subdirectory **NMR**	coverage 10 (not a GIS data layer)
Subdirectory **OS_1to10k**	coverages 11 and 12
Subdirectory **OS_1to50k**	coverage 13
Subdirectory **study_area**	coverage 1
Subdirectory **Topography**	coverage 2

Of the remaining subdirectories on the cd, **user_guide** contains this document in digital format, **projects** is for storing the project file that the user may wish to create according to the detailed instructions in the following section, and **queries** is set up to allow the user to output shapefiles or exported datasets generated as a result of analysis of the data provided. Some examples of simple queries that might be useful are given in Section X towards the end of this document.

2.2 Note on ESRI Terminology

The American Environmental Systems Research Institute (ESRI) is the manufacturer and distributor of ArcView GIS, the software in which the Till/Tweed dataset is intended to be used and for which this user manual is written. ArcView GIS is, however, just part of a larger suite of software which, confusingly, is known by several different names. The following paragraph is given in the hope of clarifying this confusing situation for the first time or novice user of ArcView.

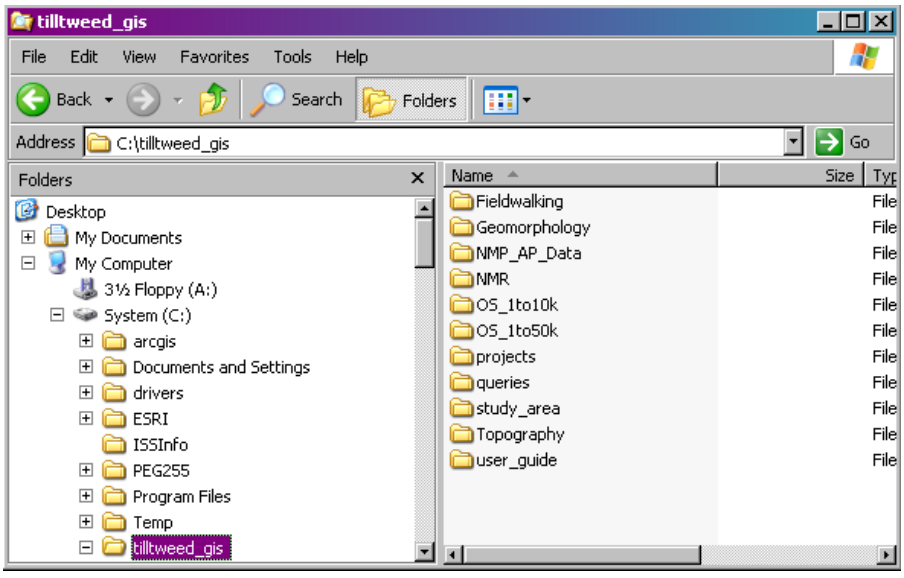
Until 2000, ESRI distributed a powerful but command-line based GIS processing engine named ArcInfo, and a lightweight GIS desktop program with a full windows graphical user interface named ArcView (versions 3.1, 3.2a). This program, first released in 1996, is user-friendly and powerful, but without many of the more complex GIS processing capabilities of its big brother.

In 2000, the new version of ArcInfo was redistributed as a software suite collectively known as ArcGIS along with a new piece of desktop software called ArcMap. ArcMap is effectively an updated version of the now somewhat outdated ArcView, and is fully integrated into the windows environment. Unfortunately, because ArcMap is intended to replace ArcView, it is often referred to as ArcView 8. ArcMap, or ArcView 8, or whatever you wish to call it, is the latest windows desktop GIS software from ESRI. Unfortunately this new desktop software has been slow to take off, and many users, particularly in local government or academic sectors, prefer to continue to use the original ArcView 3.2a, mainly because ArcView 3.2a tends to be easier to use than ArcMap/ArcView 8.

Fortunately, ESRI datasets are all interchangeable anyway. For the purposes of this guide, all you will need to know in advance is whether you have the older ArcView GIS 3.2a, or ArcMap, also known as ArcView 8. This manual has been written so that the user can view and perform basic analysis with either system.

2.3 Locating ArcView GIS and creating a blank project

First, copy the whole of the **tilltweed_gis** directory into a suitable folder on your computer or server. Aim to place the folder as high up the directory structure as possible, because ArcView does not deal well with long file paths. Ideally, place it directly onto the C: or D: drive, or one step down. (below)

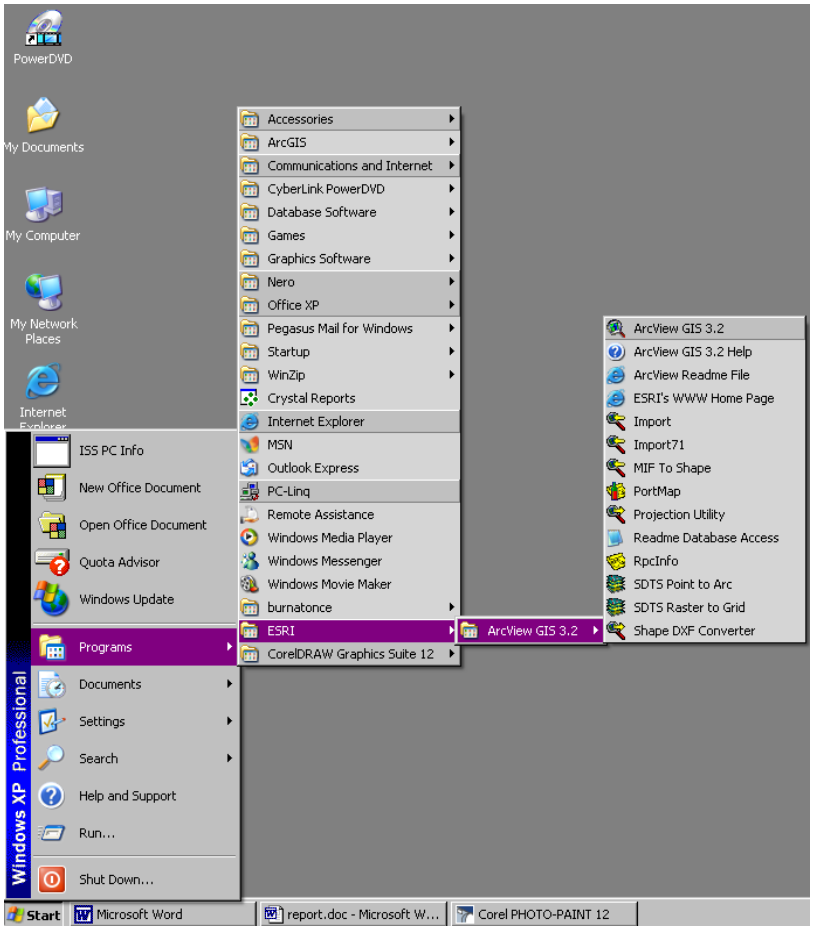


If you have **ArcView GIS 3.2a**, launch the program from the desktop icon

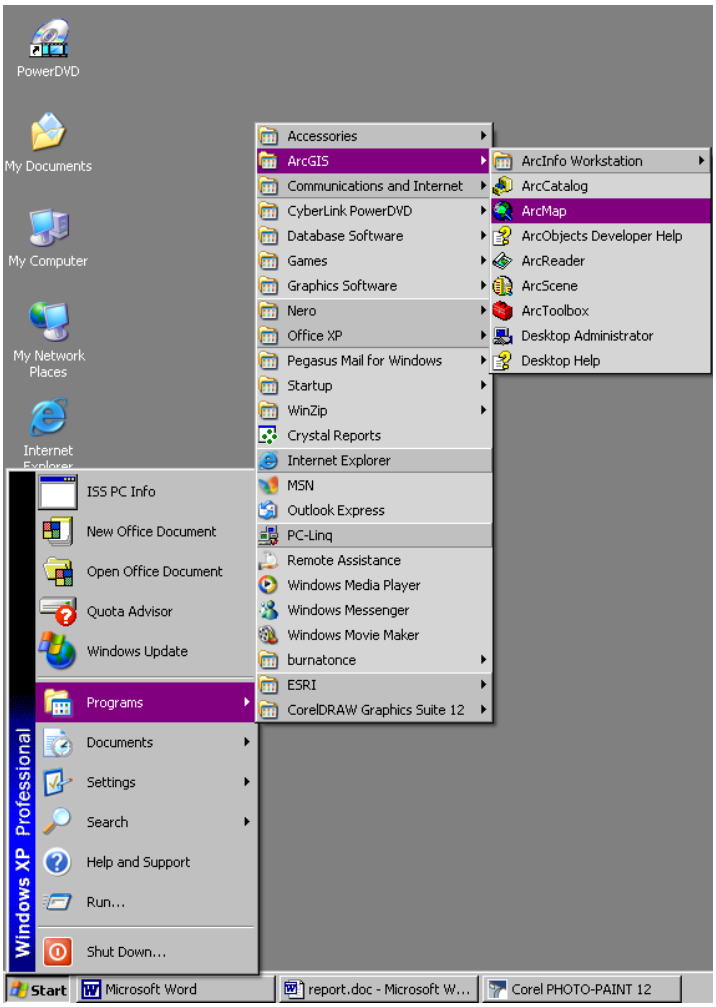
likewise if you have **ArcMap**:

If you do not have the program on your desktop, look in the start menu:

ArcView GIS 3.2a

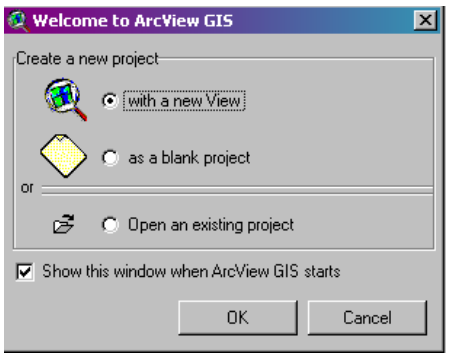


ArcMap:

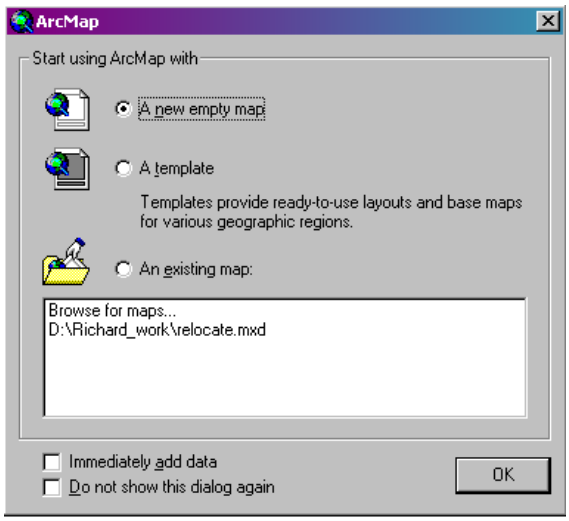


If it isn't in either of these places, browse to C:\ESRI\AV_GIS30\ARCVIEW\BIN32 **(ArcView 3.2)** and double click the arcview.exe icon, or browse to C:\arcgis\arcexe83\bin **(ArcMap)** and double-click the ArcMap.exe icon. If you still can't find it may not yet be installed on your system.

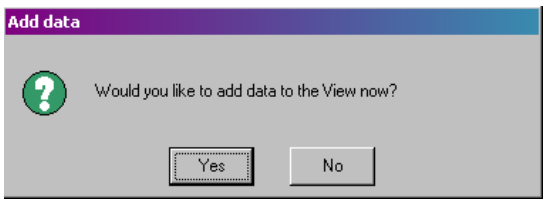
Once the program opens, pick the uppermost radio button in the dialog box "create a new project with a new view" (below), and then click "OK".



The ArcMap startup dialog is similar. In this case, the uppermost radio button "a new empty map" should also be selected. The click OK.



In ArcView 3.2, you will also be asked if you want to add data to the new view immediately (below). For the time being, select No.



2.4 The ArcView Project

In this way, whichever software version we are using, we will have created what ArcView calls *a project*. In ArcView 3.2 project files are recognisable by their .apr (ArcView Project) extension. In ArcMap, just for the sake of being different, projects have a .mxd (ArcMap Document) extension. GIS data can be added to a project in various ways, usually either as data tables to which a map can be attached later on, or as maps or images in various formats which already have attached tables or are to have tables attached to them later on.

If we want to view geographic data on screen as a map (we usually will), it is necessary to create *a view*, or in ArcMap *a data frame*, which controls how our data is displayed. In ArcView 3.2, we have already created a blank *view* by picking the first radio button option. In ArcMap, the new empty map option we have selected will create a blank *data frame*

automatically. In other words, we have already created a blank *project*, into which we can bring our data, and a blank *view* or *data frame*, so we can display the maps.

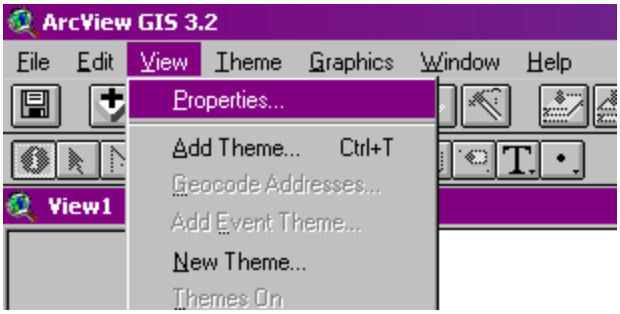
Once data has been imported into the project, it may be desirable to save the project, particularly if many different datasets have been imported. This can easily be accomplished using file > save project (ArcView), or file > save (ArcMap) from the main toolbar. It is important to remember that a project is *not a separate entity*, just a container that tells the program where to find the maps. An ArcView project or an ArcMap document is not in any sense like an AutoCAD drawing or a CorelDraw graphic, in which all the information that will be displayed, including colour, layers and position in the model or on the page is stored in the one file. A project file simply records the location and status of the data that was inserted into the frame, and, if any data have been prepared for plotting in *layout* tabs, these will also be preserved in a project file. This has two important implications:

1. If the path to the various datasets comprising a project is moved, then the project will not open the datasets automatically. Likewise if the dataset is renamed, the project will not find it.

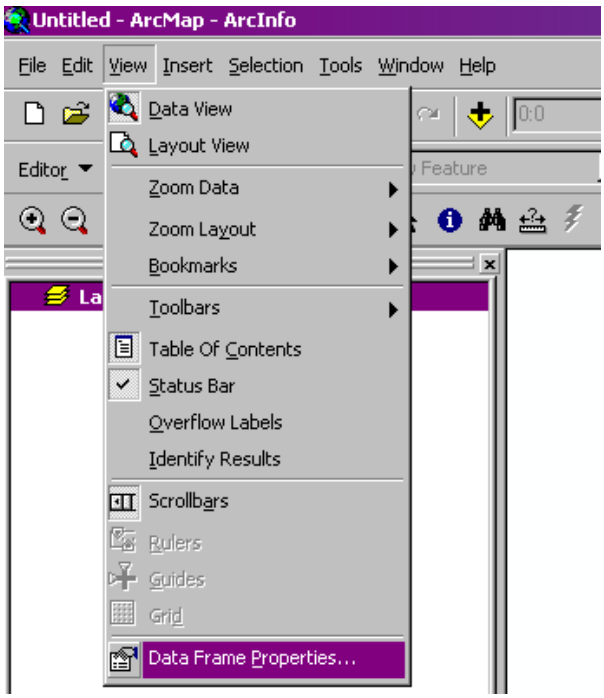
2. simply copying only the project file to another location will not successfully move the GIS dataset which has been imported into it. This is like copying an address written on an envelope stuffed with important documents onto another envelope and travelling across town with the new envelope in the expectation that it will have become filled with copies of the documents in the original envelope.

2.5 Preparing the new view/data frame

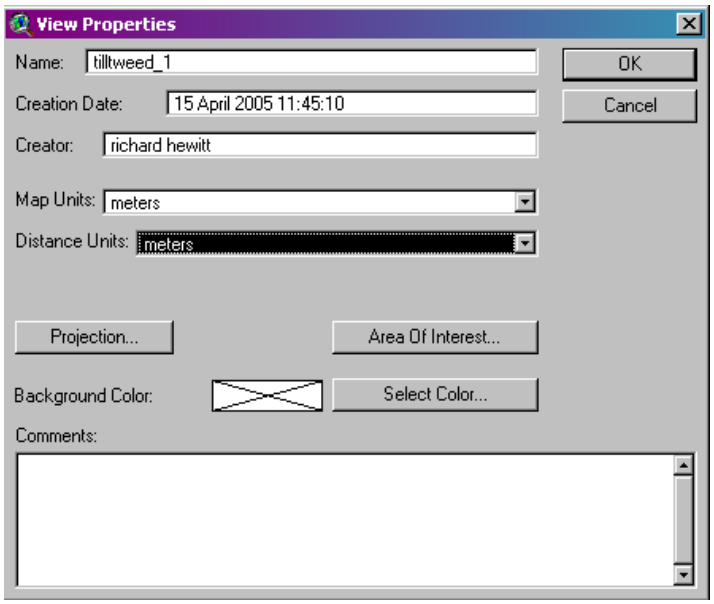
Now a new empty project, with a new geographic view/data frame has been created, we can prepare the view/data frame for the data to be inserted. All of the Till/Tweed GIS dataset is metric, and uses the Ordnance Survey National Grid (OSNG) coordinate system, a straightforward rectangular coordinate system expressed as a flat plane with the x axis (Easting) is of equal scale to the y axis (Northing), with the z axis (Height) being considered exactly perpendicular to the xy plane. In the Till/Tweed GIS dataset, and for most non-specialist terrestrial land surveying applications within the British Isles, the effects of the curvature of the Earth can be ignored. We can therefore simply add the Till/Tweed mapset directly into the infinite mathematical space provided by the GIS software. The only thing we need to do first is to set the units that the new project is using to metres, so that we are able to measure distances across the map surfaces and correctly view the OSNG coordinate system. In ArcView this is accomplished in the view properties dialog:



In ArcMap, this is also found in the view menu, but under data frame properties (over):

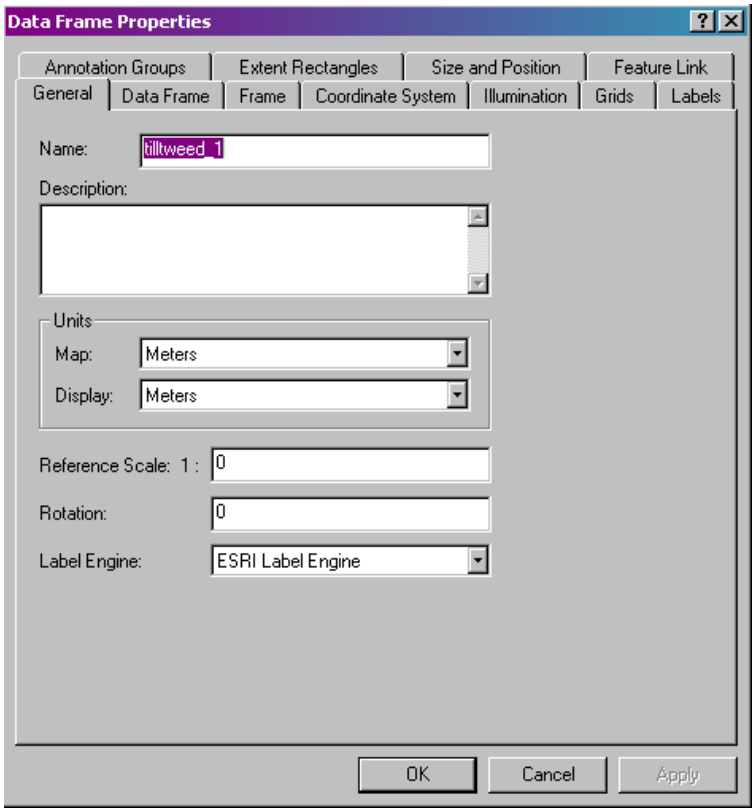


In ArcView 3.2a, the view properties dialog is comparatively simple:



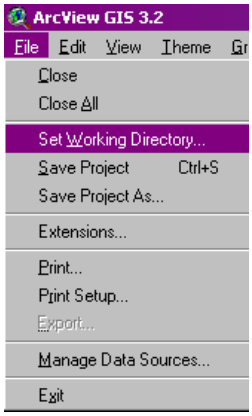
Type a new name for the view in which you will display the geographic data, and if necessary set the data and the creator of the current view. In the drop-down boxes below, for Map Units select “meters” and for Distance Units also select “meters”. All other options can be ignored. Now hit OK.

In ArcMap, the data frame properties dialog is similar, but has many more options. Only the first of the option tabs, “general”, will be needed at present. As with ArcView 3.2a, give the data frame a name, a description if necessary, and set the both of the units in the “Map” and “Display” dialogs to “meters”.

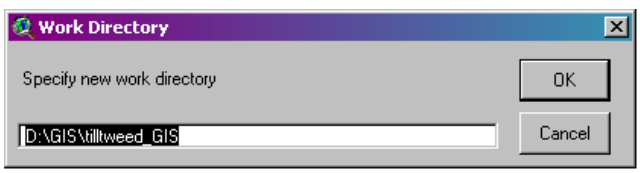


2.6 Setting the working directory

Before adding data to the view frame, it is necessary to set the directory path that we want to add data from. In ArcView 3.2, this is done through the file > set working directory dialog:

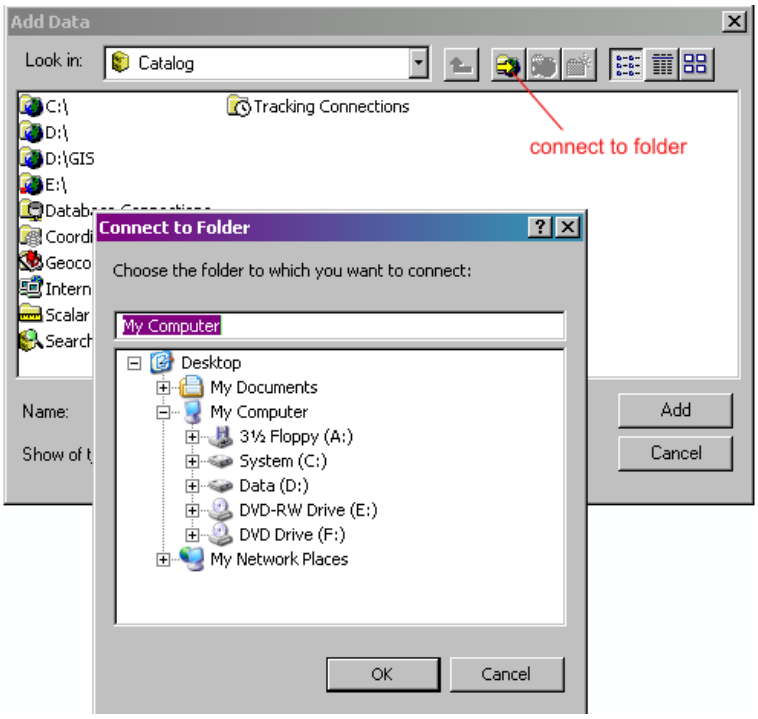


which brings up the set working directory dialog (below). The path you wish to insert data from can be entered by hand, or pasted from the windows explorer address bar.



In ArcMap, the procedure is slightly different. Rather than setting a single file path for the project to which we always expect to return for our data, we have the option of setting up

many different paths or "connections" as ArcMap calls them. These are activated through the "connect to folder" dialog (below):



it is then possible to browse to the **tilltweed_gis** directory in the normal way, which is then stored as a new connection.

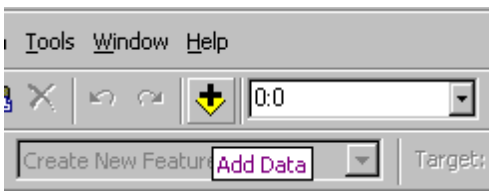
The new view/data frame that has been created is now ready to receive the GIS data.

2.7 Adding data and moving around in the view

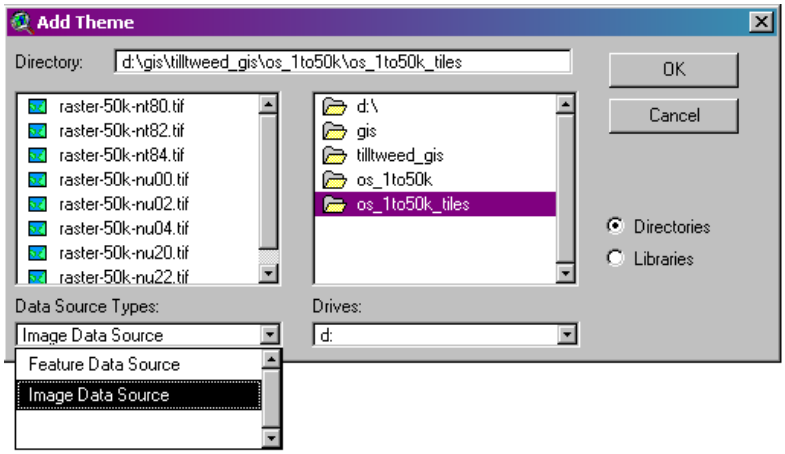
In both ArcView 3.2 and ArcMap the easiest way to bring up the add data dialog is to click on the plus icon at the top of the taskbar (below). In ArcView 3.2 this operation is called "add theme", while in ArcMap it is called, more accurately, "add data".

ArcView 3.2

ArcMap



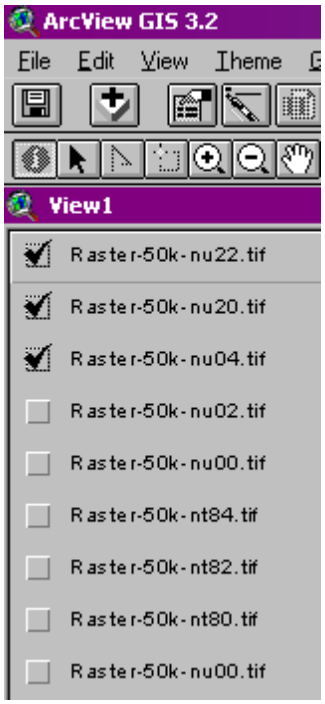
To begin adding data to the project, navigate to the subdirectory inside "tilltweed_gis" called "OS_1to50k" (see section 2.1, above). In ArcView 3.2, ensure that the drop-down box reads "Image Data Source" for this dataset, not "Feature data Source", or the OS raster tiles that are available for import will not be displayed.



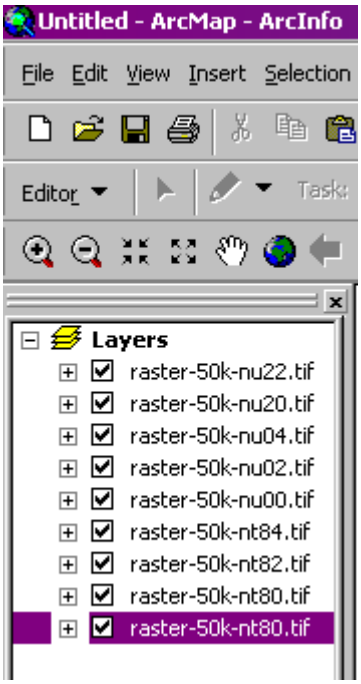
Using the *shift* key, all the OS 1:50,000 mapping can be selected at once. One all the tiles have been selected, click "OK". The OS 1:50,000 scale images will be added to the left-hand menu, though initially they are not visible on the screen.

To view the images, click each button corresponding to an image tile on the left menu, and a black tick will appear signifying that the data set is visible in the current view (below).

ArcView 3.2



ArcMap



The images may not yet be fully visible, so select "full extent" from the view menu (ArcView 3.2, or "Zoom data", and then "full extent" from the view menu (ArcMap). This

will redraw the entire display with the extent of the view area zoomed to show the entire dataset within the view window. This is a useful command to use after adding each GIS coverage to the project. To zoom into the project, use the "zoom in" icon (below). By left-clicking once at the top left of the area you wish to view, moving the mouse down to the top-right of the area, and then left-clicking again, it is possible to draw a window. The adjacent icon allows you to zoom out.


zoom in


zoom out

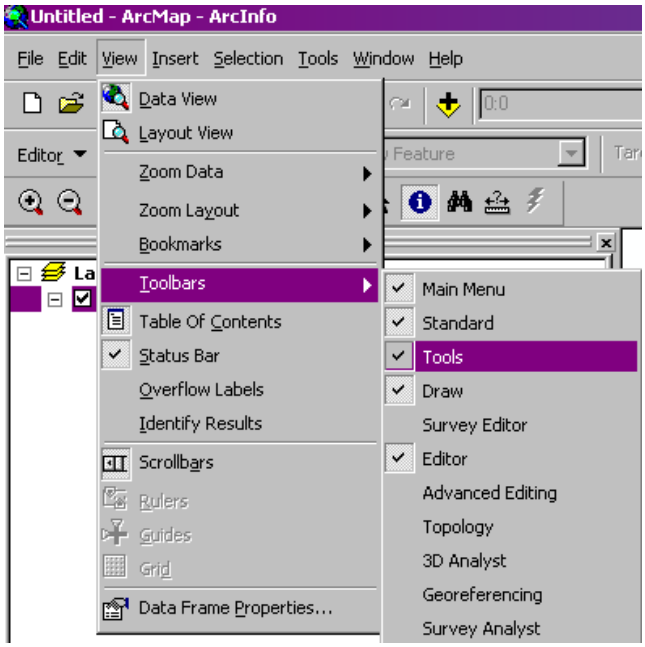

zoom previous (ArcView 3.2)


zoom previous (ArcMap)


Zoom extent (ArcMap)

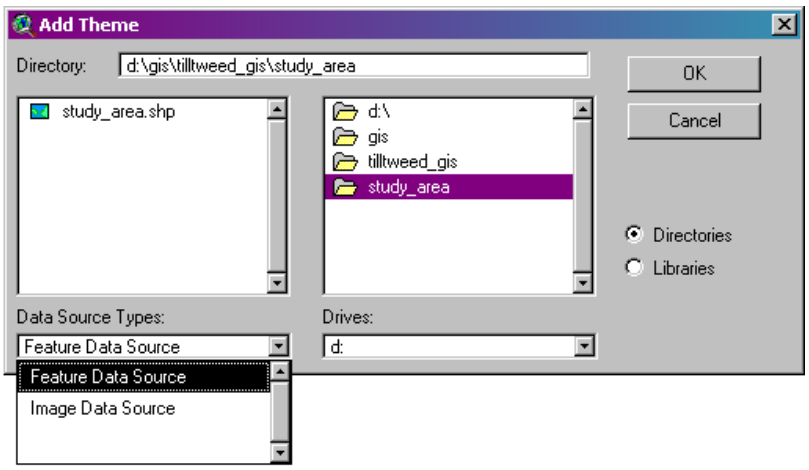
To return to the previous view, click the "zoom previous" icon (above). If you are using ArcMap, Zoom "Full extent" which was previously activated from the toolbar, also has an icon (above).

If you are using ArcMap, and none of these icons are visible, the "tools" toolbar may not be active. Add it to the display menu as below:



2.8 Adding the Till/Tweed study area and using the legend editor

Further data layers can be added in succession, using the method described above. It is suggested that the OS 1 to 10,000 grayscale maps are added next, from the subdirectory "OS_1to10k". Once these are added and turned on, the study area layer can be imported, from the subdirectory of the same name. If you are using ArcView 3.2, it will be necessary to change the Data Source Type to "Feature Data Source" in the drop down box (below).

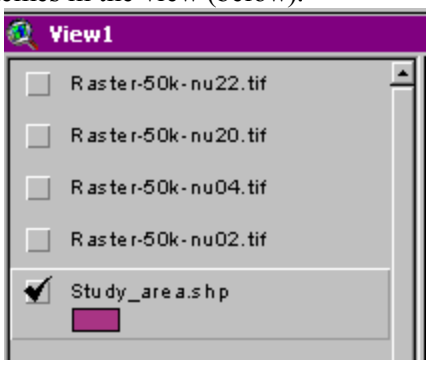


Initially the study area, which is a polygon, will appear filled with a colour randomly selected by ArcView, which will obscure the map tiles beneath. In order to modify this so that the study area is displayed as an open outline, follow the following instructions, depending on the system you have.

For ArcView 3.2:

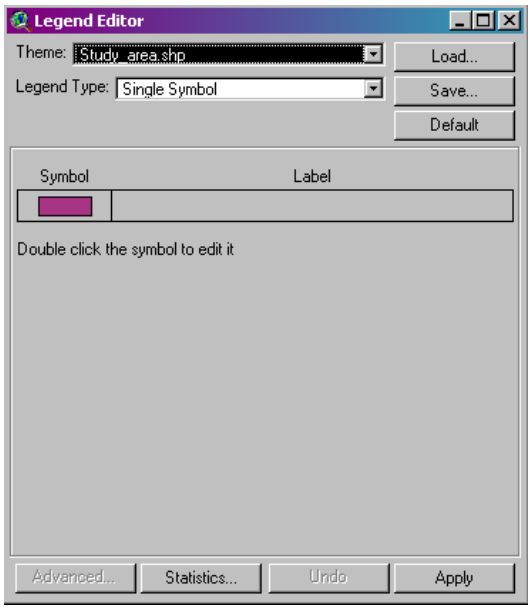
Double click with the left mouse button on the centre of the study_area legend bar (below).

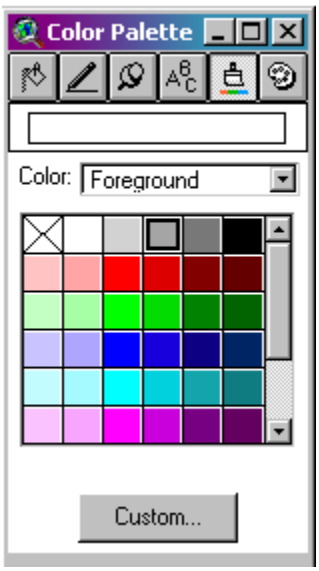
This will open the "legend editor" dialog, which is a very important tool for editing the way data is displayed in ArcView.
Note that a single click on each dataset inserted into the current view does not open the legend editor. Instead, it can be seen that the legend bar for the dataset (or theme, as ArcView 3.2 likes to call it) that has been clicked will appear slightly more prominent than other themes in the view (below).



this means that this theme is now *current*. Operations, such as viewing the attached data tables, will only be applied to the current theme. Inexperienced users of ArcView 3.2 often have trouble viewing the tables or requesting information for the dataset they are interested in because the desired theme is not the current one. It is important always to ensure that the correct theme has been made current before attempting to perform a GIS operation on a particular theme.

At this point, we should have been able to open the legend editor for the "study_area" theme by double clicking it. The legend editor is displayed below left:

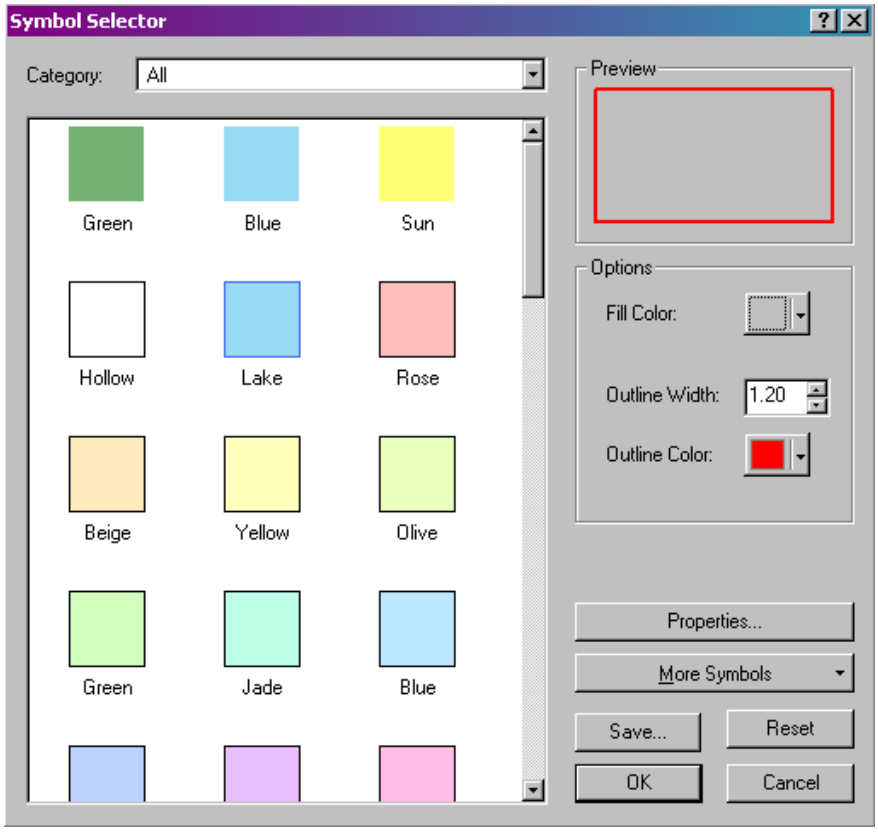




Double-clicking on the filled rectangle below the words "symbol" opens the symbol editor (above right). Select the paintbrush icon on the symbol editor menu to change the fill colour. The drop-down box entitled "Color" controls the property that is to be changed. In this case, we want to make the foreground colour of the study area theme transparent, which will be selected by default. To do this, click once on any other colour in the palette (grey is selected here), and then once on the box containing the diagonal cross at the extreme top left of the colour palette. Note that the symbol colour on the legend editor will be updated to show that the fill is now transparent. Click "Apply" in the bottom left corner of the legend editor before exiting this dialog, otherwise the changes to the fill colour will not be saved.

The study area will now appear as an unfilled outline. To modify the outline colour repeat the steps above, choosing "outline" instead of "foreground" in the color dropdown box of the symbol editor (above right).

In ArcMap, the procedure for changing the way a coverage is displayed is almost identical, although the legend editor is different in appearance (below). In ArcMap, be careful to double click on the dataset symbol, not the name of the dataset, which will bring up a different dialog. Unlike ArcView 3.2, "foreground" is referred to as "fill colour", and has a separate drop-down box.

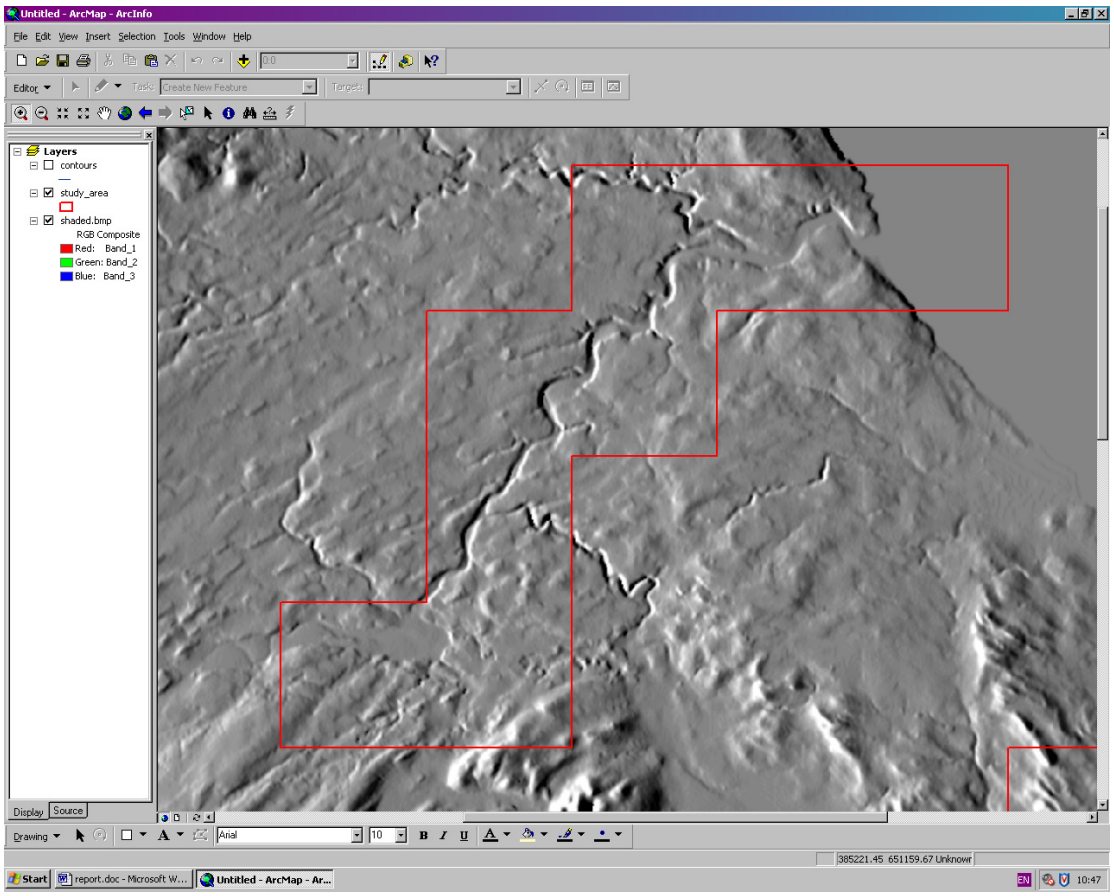


2.9 Adding topography to the view

So far we have imported ordnance survey data at 1:50,000 and at 1:10,000 scale, which can be viewed as required. The larger scale data tiles may take some time to display after each change in view, so it may be helpful to turn these off for the time being.

Both these datasets will provide all the detailed background mapping information we require; for topographic data, we need to import two more coverages, the 1:50,000 grayscale shaded relief map, and the 1:50,000 scale contour lines. These can be added to the view frame in the usual way from the subdirectory Topography. The shaded relief map is presented here as an image, for viewing only. Queryable topographic information, in ascii or grid data format is available, but requires additional program modules or extensions which do not come as standard with ArcView software unless specifically requested.

The shaded relief map, shown here zoomed into the Tweed study area, will look something like this (over)



Contour lines can be added on top of the shaded relief map. To change the order in which the datasets are to appear, hold the left mouse button down over a theme/dataset to move it above or below other datasets. In this way, the contours can be moved on top of the shaded relief map. It is usual practice for images, such as the OS map tiles and the shaded relief map, to be moved to the bottom of the view, with polygon or area coverages displayed next, followed by line coverages such as roads or rivers, with point coverages on top.

2.10 Adding archaeological data transcribed from aerial photographs

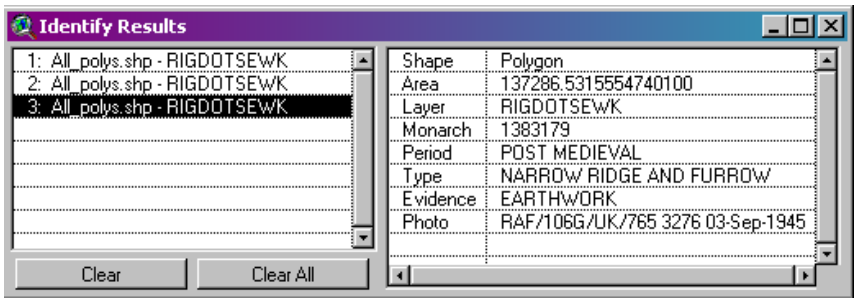
One of the most important components of the Till/Tweed GIS dataset is the archaeological site information transcribed from aerial photographs held by English Heritage at the National Monuments Record (NMR). This data has been transcribed and digitised by English Heritage on behalf of the Till/Tweed project to a very high level of accuracy and detail, and surpasses the standard record of archaeological sites and monuments for the region held by either the NMR or by the local government Sites and Monuments Record (SMR). This data is stored in the subdirectory NMP_AP_Data (National Mapping Programme Aerial Photographic data).

This dataset, NMP_polys, can be added to the view in the usual way. Initially all the features within the coverage will be displayed identically. The map is not annotated, nor do archaeological features have monument numbers next to them. This is because all of this information is contained in a data table which ArcView stores out of sight behind the view. However, it is important to be able to see this data when required, and ArcView provides two ways of doing this. The first involves selecting a feature of interest, and then viewing the records associated with that feature in a pop-up window on top of the view. This is a very

useful way to check the name and ID of a particular feature without leaving the view window.

In ArcView 3.2 select the identify button from the left hand end of the toolbar (below)

Then click on an object on the map. It is important that the theme/dataset containing the features you wish to identify is made *current* (see above, Section 2.8) otherwise the data table shown may not be the one you are expecting. Using the identify command on features within the NMP_polys dataset will cause a table similar to that shown below to appear:



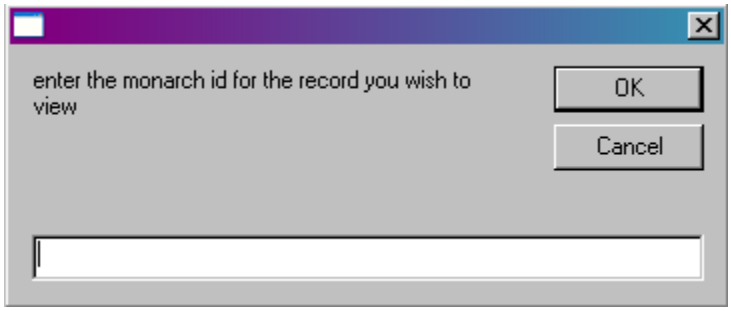
The identify function is virtually identical in ArcMap, though you may need to activate the "tools" toolbar from the view menu (see section 2.7, above).

Note the list of fields that the dataset contains. The only fields we are likely to want to consider for the time being are *Monarch, Period, Type* and possibly *Evidence*. The *photo* field is useful for reference, but we are unlikely to want to classify the data according to photo number. The first important field, *Monarch*, is the single unique identifying number within the National Monuments Record, and it is this field that we will need if we wish to consult the detailed National Monument Record description for this record.

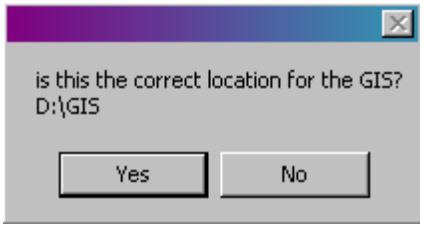
2.11 Using the script program to view the full NMR record

Full National Monument Record descriptions are stored by monarch ID in the subdirectory **NMR**. These records can of course be opened as usual in microsoft word. However, to make this process quicker, a script routine has been written using Microsoft Visual Basic Scripting language (VBScript) to open the required NMR record without the need to scroll through a long list of documents.

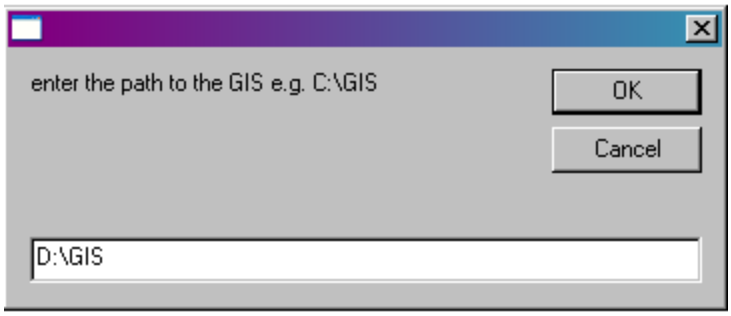
To view the full NMR record for any given feature in the NMP_Polys dataset, first identify the required feature as above. Minimise the GIS program, and navigate to the NMR directory using windows explorer or by right clicking on the "My Computer" icon and selecting "explore". At the bottom of the NMR directory, after several hundred word documents, will be a file called "NMRopen.vbs". Double click on this to open the NMR script program (below)



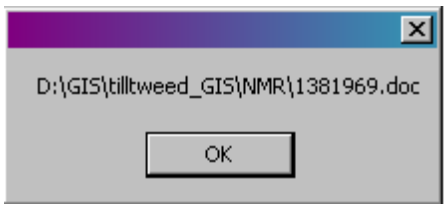
Enter the identifier from the Monarch ID field for the feature you have queried, and click "OK". In order to locate the NMR directory and open the relevant record, the script program needs to know where exactly the main "tilltweed_GIS" directory is located on your computer or server (below).



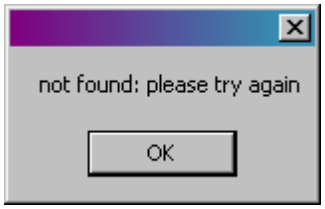
The first time you run this script, it will most likely suggest an incorrect filepath, or no filepath will be listed at all. You will need to select "No" to enter the correct location for the dataset (below):



The "tilltweed_GIS" directory and subdirectories is supplied on the CD accompanying this report, but you will need to have copied it into a particular location on your computer, for example onto the D drive, within a folder called "GIS". The script program already knows the path to the data from "tilltweed_GIS" downwards, but it needs to know whereabouts you have put this directory, so if, for example, you have copied the "tilltweed_GIS" directory into "D:\GIS", then enter "D:\GIS". **You do not need to enter the rest of the filepath, just the path up until "tilltweed_GIS".** If you have a more complex system, and the data needs to be stored on a central server, for example \\server1\Z:\archaeology\projects\northumberland\GIS, then you will need to enter the whole of this information. You only have to enter this information once, however, and a text file containing this path will be written to your C:\Temp\ directory to be used in future. (If you have no directory called Temp on the C drive of your machine, you should create one). Once you have entered the location of the GIS data, a dialog box displaying the whole path to the record you have selected will be displayed (below). Just click OK to proceed.



In the event that the path is incorrect, or if the number is mistyped, a dialog will appear informing you that the record could not be found (below).



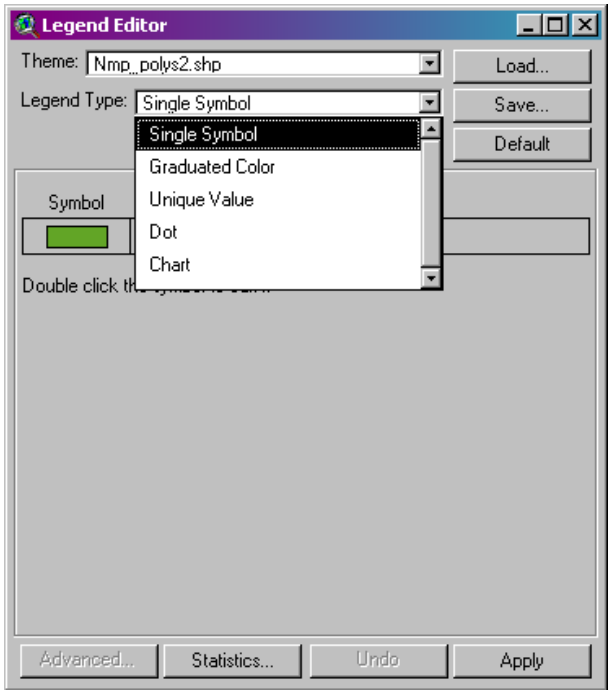
In this event simply click OK and the program will return to the original dialog so the Monarch ID can be entered again. When the record is found, it will be opened in Microsoft Word, and the dialog box will return, prompting for a second Monarch ID. Though it is possible to cancel at any time, there is no need to, as simply clicking anywhere on screen outside the script dialog will minimise it. In this way the full NMR records can be viewed quickly and easily, one after another, without the need to exit the GIS or scroll through directories.

2.12 Basic analysis: reclassification

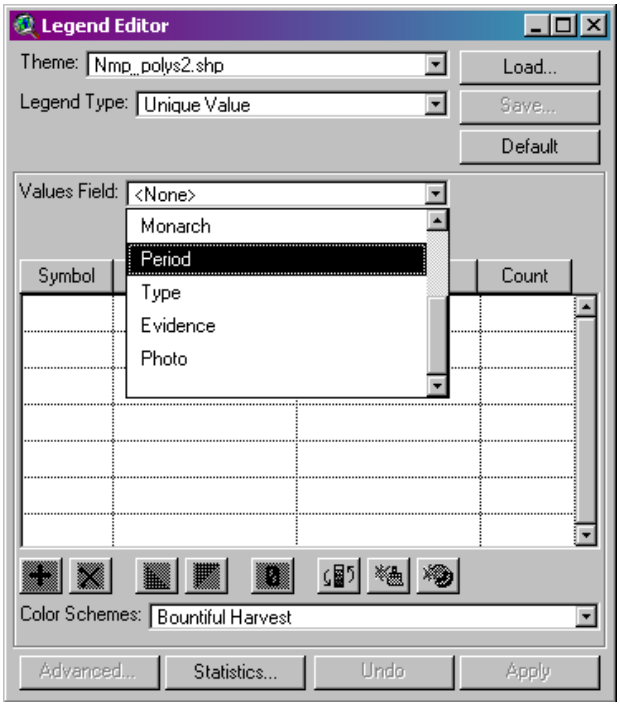
Simply viewing all of the digitised aerial photographic data as a single symbol filled in one colour does not tell us much about the data. We wish to ask questions such as *where are prehistoric sites, relative to roman sites or medieval sites?*

To do this is very straightforward, but requires use of a basic GIS technique called *reclassification*, which is described as follows. A good understanding of how to reclassify datasets according to their constituent attributes is essential if the GIS is to be used effectively as an investigative tool.

For ArcView 3.2a, double-click, as described in section 2.8, on the NMP_Polys dataset on the legend bar to the left of the view window. This will activate the legend editor dialog. Note the drop down box second from the top, entitled “Legend Type”, which will read “single symbol” (below)

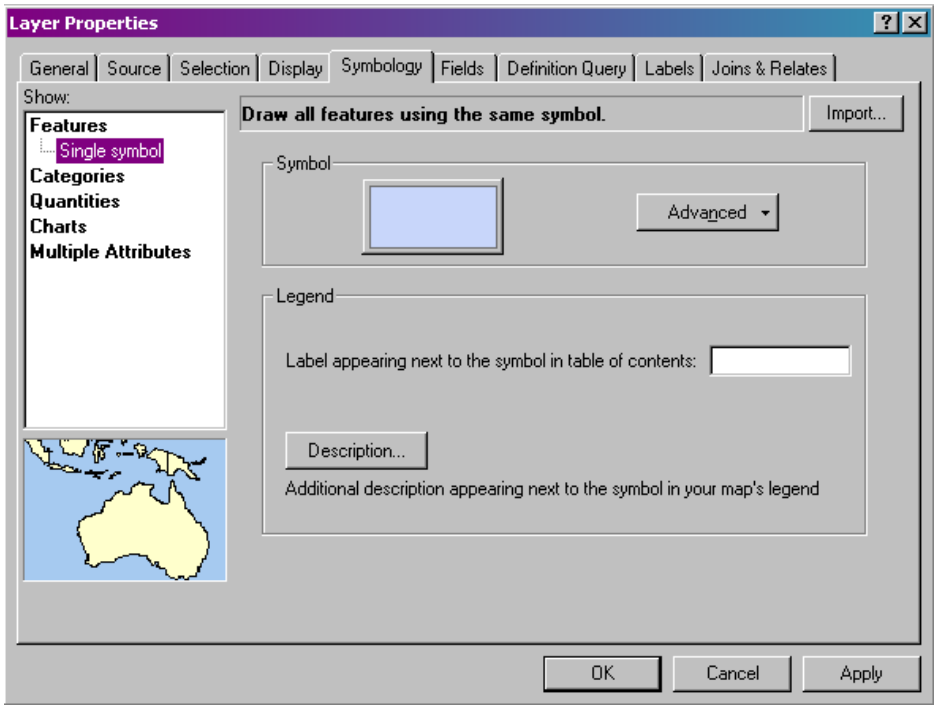


open the drop-down list within the "Legend Type" box, using the arrow at the end of the box, and select "Unique Value" (above). In the "Values Field:" box, which will have appeared below the "Legend Type" box, select "Period". Note how all the fields present in the NMP_Polys dataset are listed here (below).

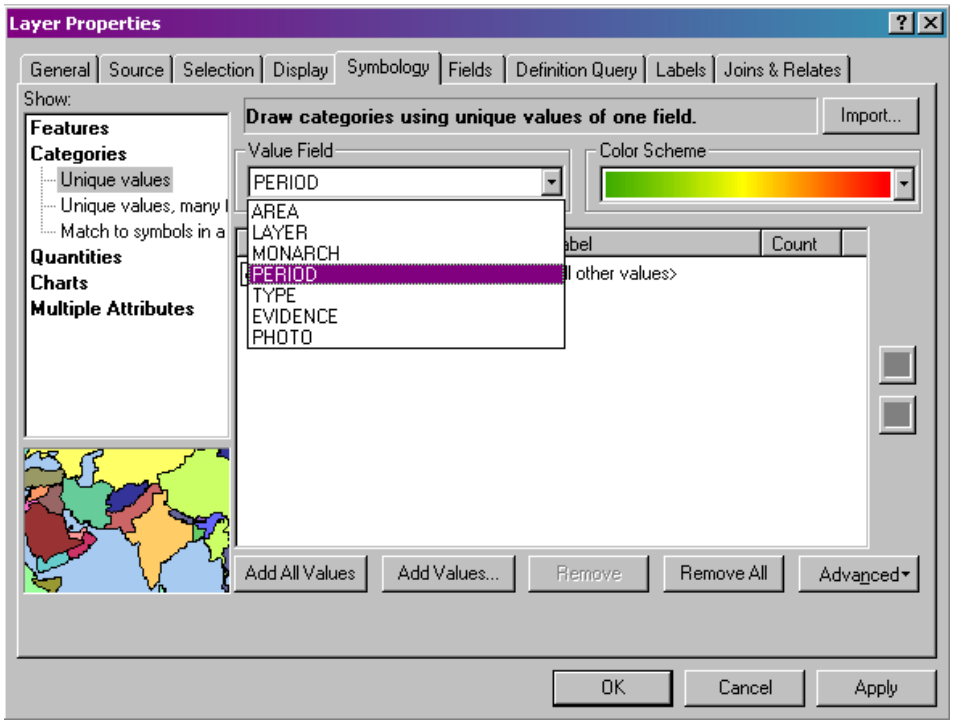


When period is selected, the dataset will be displayed using the default colour scheme, which can be changed in the "Color Schemes" box at the bottom of the dialog. Once you are satisfied, click "Apply", and the digitised sites and monuments will be displayed according to period.

To perform the same operation using ArcMap, double-click on the **name** "NMP_Polys" on the legend-bar at the left-hand side of the screen. This will launch the *layer properties dialog* (below)



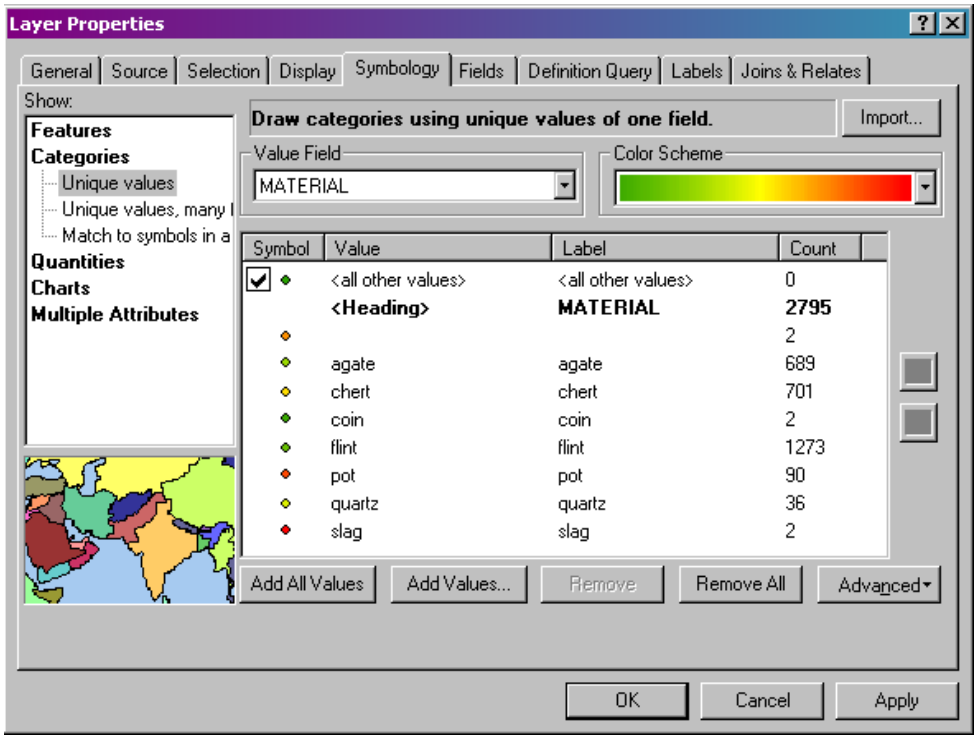
On the left-hand side of this dialog, select "categories", and beneath this, "unique values" (below). Under "Value Field", in the centre of the display, select "Period". At the bottom of the box, select "Add All Values". The colour scheme can be changed in the "Color Scheme" drop-down box to the right. By double-clicking on the colour box beside the individual categories, colours can be selected individually if required. Once the dataset has been reclassified as required, click "Apply" at the extreme bottom right of the dialog.



If desired, under "Multiple Attributes", it is possible to classify the data according to more than one characteristic, for example bronze age cairns, iron age hillforts, etc.

2.13 Adding archaeological data from fieldwalking

Fieldwalking data from the 2003 and 2004 research seasons can be added in the normal way (see section 2.7), from the "Fieldwalking" subdirectory. The "finds" subdirectory contains points with attached tabular data representing the location and characteristics of finds made during fieldwalking. Subdirectory "testpits" contains points representing the locations of the test pitting exercise. In addition, surveyed fields have been classified according to their most prominent morphological characteristic, for example, an area of depression, or a gentle slope. This information is contained in the subdirectory entitled "Morphometric". The theme "morph_hach" contains lines and hachures representing the surface topography at each location, whereas theme "morph_polys" comprises polygonal units within the surveyed areas classified according to their morphometric characteristics. All of these data can be reclassified as detailed in section 2.11 (above), so that each dataset can be viewed as required according to its characteristics, for example, to show all fields according to morphometric unit, or fieldwalking finds according to material (below):



2.14 Adding Geomorphological data

The final remaining coverages to be added comprise Geomorphological information within the Till and Tweed site catchments. Subdirectory "Sediment_Observation" contains borehole information, as points, and polygon coverages representing the boundaries of Hedgeley and Powburn Quarries, where sediment samples were taken. Subdirectory "Landform_Elements" contains polygons representing the geomorphological classification scheme applied to sedimentary units within the Till and Tweed catchments, such as "Holocene Alluvial Fan". This coverage is most usefully classified using the "unique values" method to apply a different legend to each landform element.

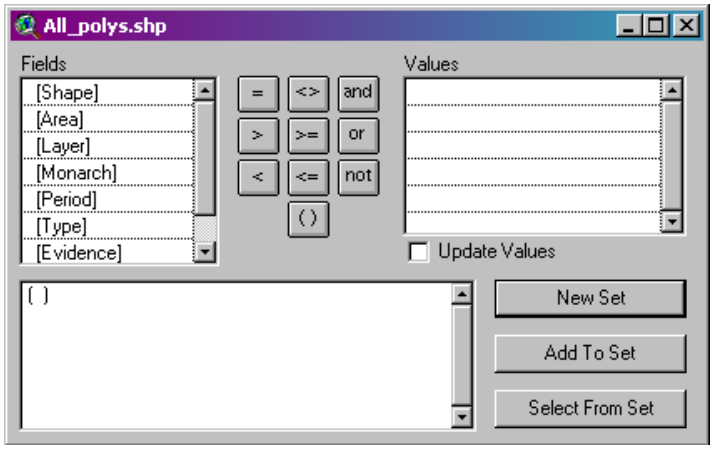
3 BASIC ANALYSIS

Now all the coverages comprising the Till/Tweed GIS project have been added and are available for use. The following section is intended to introduce the new user of GIS to some basic techniques, with the intention of illustrating the power and utility of the ArcView and ArcMap software.

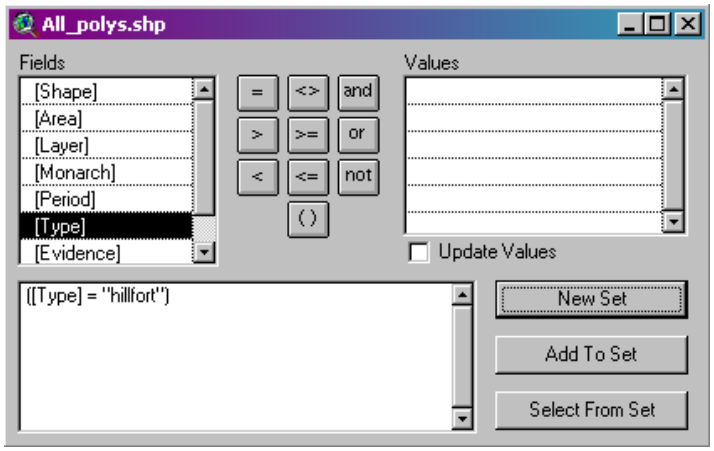
3.1 Building a simple query to select features according to their attributes

Section 2.12 (above) detailed the process of reclassification, that is re-ordering the data so that it is displayed according to one of its attributes. For the NMP dataset it might be useful to reclassify the data according to its period, or for the fieldwalking finds, according to the material from which the artefact is made. Reclassifying the data using the legend editor in this way allows us to view the different categories using different colours, shades, or symbols. However, if we wish to extract one of the categories, for example, hillforts, from the many other categories, we need to search through the characteristics, or attributes, of the dataset and select all the features that match the hillfort criteria. The following example demonstrates how easily this can be accomplished.

For ArcView 3.2a, first highlight the NMP_Polys dataset on the left hand menu by clicking it once with the mouse. Then click the hammer icon:  , which denotes the query builder tool, to bring up the dialog below:



Double click [Type] within the “Fields” box. Click “=”, and then select “hillfort” from the drop down list that will appear in the right hand box entitled “Values”. For larger lists, the Values box may remain empty, in which case, simply enter “hillforts” by hand. The query you have built should appear as below. If it does not, then you can either edit it manually, or delete it and try building the query again.



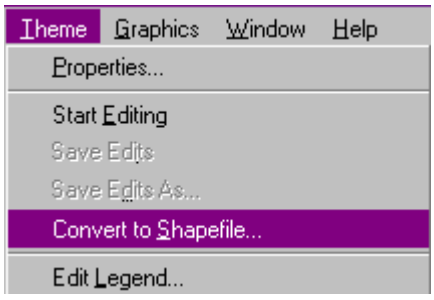
Note that if the query is not exactly correct, a syntax error will be displayed. If the type (e.g. "hillfort") does not exactly match the record name in the field (e.g. hill_fort), then the query will run without error, but no results will be returned.

Once the query is correct, click "New Set". You will notice that nothing happens! This is because the query-builder is very literal minded. You have asked it to select all records with {Type} having entry "hillfort", and it has done exactly that. If you want to actually view the records it has selected, then it is necessary to look at the data a little bit more closely. To do this, close the query builder, and open the attribute table for the NMP_Polys dataset using the button on the toolbar: 

To view the selected records, click the "promote" button on the toolbar: 

This has the effect of temporarily raising the records to the top. It has not affected the order of the table, and once the table is closed the records will return to their proper position. The hillfort records we have selected will appear selected in yellow (or the project selection colour):

Close the attribute table, once you are happy that the query has been successful. The records will remain selected until they are deselected, whether we are viewing them or not. To generate a separate map layer containing only these records, select "Theme → convert to Shapefile" from the tool bar menu (below):

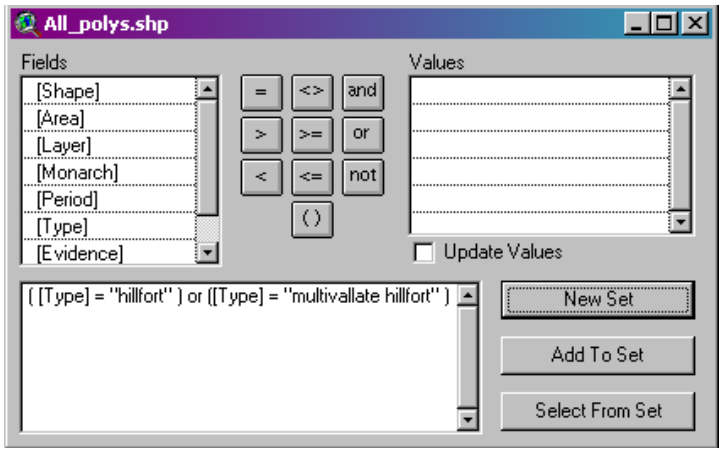


save the Shapefile in the empty "queries" directory with a suitable name, and add the theme to the view when prompted. Turn off all themes and view full extent (see Section 2.7).

Something does not seem quite right. There are only five individual hillforts in the new theme, when we know that there should be many more. What has gone wrong?

3.2 Building more complex queries

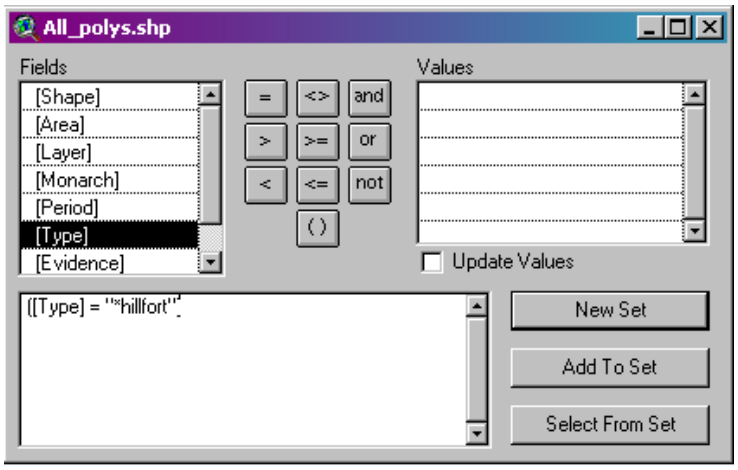
If we reclassify the NMP_Polys theme using "unique values" using the "Type" field, we can see what went wrong. Towards the bottom of the long list of categories "multivallate hillfort" can be found. It is clear that using the query builder to select Type "hillfort" will not select Type "multivallate hillfort" as well. In order to extract all hillforts, we need to be more careful. Return to the query builder, and construct the query below.



Note that it is important to use "or" rather than "and", as using "and" will search for records which satisfy both qualifying statements, e.g. records which have Type BOTH "hillfort" and "multivallate hillfort".

3.3 Using the wildcard character

The queries we have been building are constructed in a common programming language called Standard Query Language or SQL. Much more powerful queries can be built in SQL by using the wildcard character "*", the asterisk. The query we have just constructed could be expressed much more simply using the wildcard character (below)



3.4 Querying features based on their location

One of the simplest ways to perform basic analysis on archaeological data utilises the ability of the GIS software to select features within one map layer or coverage on the basis of their location within another. This is a fairly simple map overlay technique that land scientists have performed without the aid of computers for many years. However, using GIS software, this very laborious and time-consuming work can be accomplished very quickly. In the

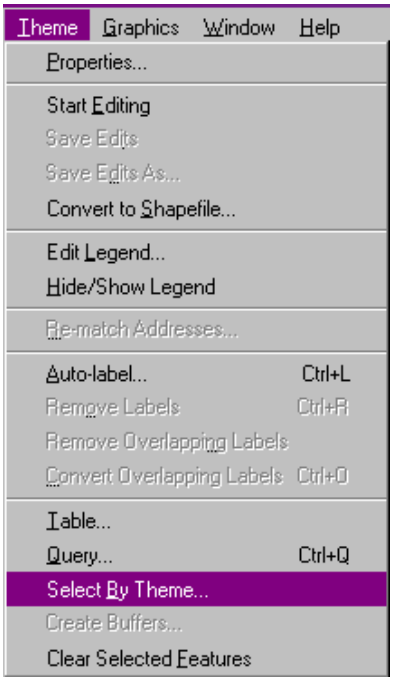
following example, we will extract chert and flint finds from the fieldwalking dataset, and then select finds from the dataset according to the morphometric categories into which they fall; steeply sloping, gently sloping, flat etc. We would expect finds to gradually migrate downslope according to gravity, and we might therefore expect to see significantly higher find counts within areas mapped as flat than in areas mapped as gently sloping. In areas mapped as steeply sloping, we would expect to see lower find counts than in either of these categories. We are therefore able to construct the following hypothesis on the basis of the commonsense observation of the behaviour of objects under the influence of gravity:

"The quantity of finds in a given location is likely to be influenced by the gradient of the slope in that location. More finds will be located on flat or gently sloping areas of land than on steep slopes"

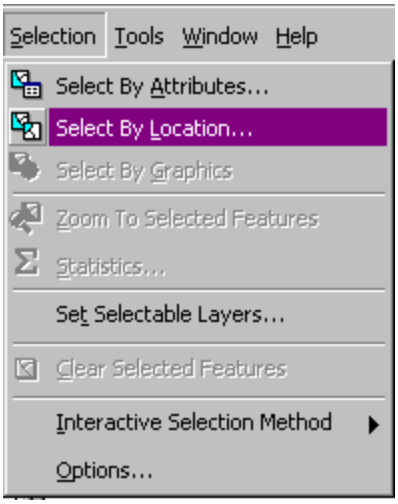
To test this hypothesis, first extract all flint and chert finds from the fieldwalking finds dataset, using the query builder and the category "material". Create a new Shapefile called "lithics", or something similar. Use the same technique to generate four separate categories from the morphometric mapping polygon layer, steep, gentle, medium and flat.

Make this new "lithics" theme current by clicking on it once in the left hand menu. Then go to the "Theme" menu, and choose "Select by Theme", or in ArcMap, go to the "Selection" menu, and choose "Select by Location" (below)

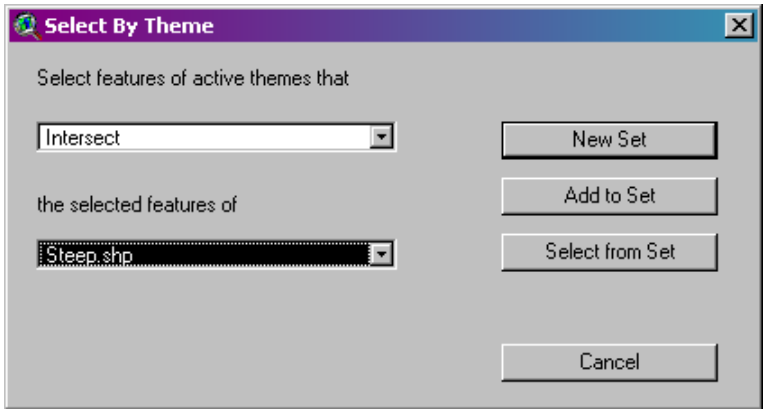
ArcView 3.2A



ArcMap



The next part of the process is virtually identical in both programs, so only the routine for ArcView is described. In order to select the features of the active theme (lithics) that occur on steep slopes, select theme "steep" in the lowest drop-down box, and then "intersect" in the uppermost one. Click "New Set".



Once the selection has been made, we can view the records selected in the attribute table of theme "steep". In the attribute table view, the number of records that have been selected, i.e. the number of lithics that were discovered on steep slopes, is listed. A new Shapefile can be created from the selection set and added as a theme to the view (see section 3.2, above) if required.

This process can be repeated with all the other morphometric categories. The results (below) confirm the hypothesis, as only 11% of the assemblage is located on steep slopes, compared to the 43% discovered on flat ground.

Morphometric category	No. of lithics	percentage
Steep	222	11.25
Medium	397	20.11
Gentle	495	25.08
Flat	849	43.01
Depression	3	0.15
Other	8	0.41
Total	**1974**	**100.00**

3.5 Conclusions

Clearly, the examples given in the preceding section are quite basic, but it has hopefully been possible to demonstrate the utility, simplicity and power of the Till Tweed GIS dataset in conjunction with the ESRI GIS software.

ESRI's ArcView 3.2a and ArcMap are powerful desktop GIS systems which can offer virtually limitless potential to answer useful questions and provide objectives for future research. However, computing power and data quality alone cannot achieve this, and a detailed research framework for analytical GIS needs to be defined if the potential of the system is to be fully realised.

REFERENCES