RELMA
REGIONAL LAND MANAGEMENT UNIT

GIS Exercise
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# Introduction to GIS and Satellite Data Analysis – Lake Nakuru, Kenya

**Requirements**
This exercise requires a PC with Windows 95/98/2000, Windows NT, or later and the freeware ArcExplorer 2.0. To download and install ArcExplorer see appendix 1. The necessary data are available on the RELMA_GIS1.0 CD. The necessary data are available on the RELMA_GIS1.0 CD. Sources of internet available data are given in appendix 2, and in the document Spatial Data and Applications for Environmental Studies in Africa.

**Recommended prerequisites**
It is recommended that you do the exercise Introduction to GIS and digital cartography using ArcExplorer before doing this exercise.

**Objectives**
This exercise will give an introduction to GIS and satellite data analysis using the ArcExplorer freeware. To illustrate the exercise different freely available data over the Nakuru catchment in Kenya will be used. The objective of the exercise is that the students should gain basic insight into using GIS and satellite images for analysing natural resources. After completing the exercise students should understand the usefulness of GIS and (RS) sensing for natural resources management.

**Task**
To pass this exercise a thematic map over the Nakuru region in Kenya showing important aspects of natural resources should be handed in.

## Start the GIS freeware ArcExplorer and add data

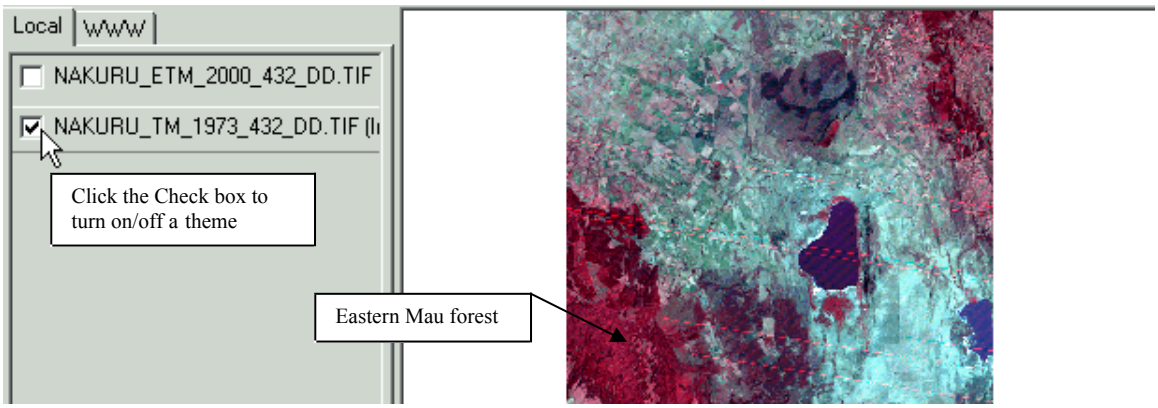
Start ArcExplorer and Save,  the ArcExplorer project, preferably in your home directory. Change the name into something logical. Remember to save the project frequently in case you should cause the program to crash or loose power supply.

The first step is to have a look at two satellite images over the Nakuru catchment in central Kenya. The older image is from 1973 and is taken by Landsat TM (Thematic mapper), the second is from 2000 and is taken from Landsat ETM (Enhanced Thematic Mapper).

The two images are in the directory **…data/spatial/nakuru/images**. Use the Add Theme button,  and add the images by either double clicking or select them and click 

button in the Add Theme(s) dialogue box. The images are both composites of three individual bands, composed to show dense vegetation as red (much like an infrared aerial photograph). Toggle between the images by clicking the Check box for each image. Use the Zoom in tool,

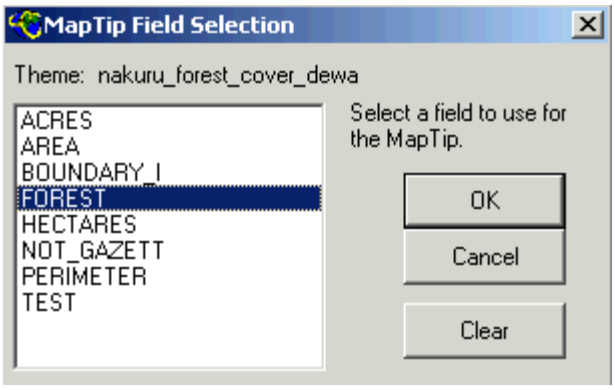
 to zoom to the Eastern Mau forest (see next page). Position the cursor in one corner of the forest, click and hold down the left mouse button and drag over the area you want to zoom in to. The stripes in the 1973 image is due to sensor distortions, do not worry about them. What else do you see when you toggle between the images?




Zoom in until you can see the individual **pic**ture **el**ements ('pixels', rasters or cells) that compose the satellite image. Measure the resolution ('size') of a single pixel by making use of the Measure tool,  . Remember that for using the Measure tool you must define both the Scale bar Properties (under View in the menu) and the Measure unit (under Tool in the menu). The pixel resolution is 30 m in both images, but the distortions in the 1973 make it appear to be double that. The image data is a continuous dataset with values representing 'fields' of color (or reflections as the jargon goes). Most maps, however, display object classes – instead of 'redness' we rather talk about discrete objects like forests, towns etc. Compare the satellite image over the Nakuru area with an 'object' map of the forests the area. Use the Add Theme button,  to add the Kenya map of forests over Nakuru – you find two maps in the **…data/spatial/nakuru/landcover** directory. One map shows the 'official' extent of the forest (**nakuru_forest_cover_dewa**), the other is a more recent update (**nakuru_forest_cover_excisions_dewa_rev3**) done by UNEP.

Put the forest themes above the satellite images by dragging them to the top of the Legend with the mouse (or point at them, right click the mouse and use the Move theme option in the pop-up menu). Click the Check box for each forest theme. By default a polygon object theme is filled with a single color, and hence covers any theme below in the Legend. To see the satellite images 'under' the forest theme you must use the Theme Properties dialogue, which you reach either double clicking on the name label of the theme, or making the theme active by clicking once on the name label (it then appears lifted) and then click on the Theme Properties tool,  . In the Theme Properties dialogue set Style to be Transparent Fill, set Size (for outline) to 2, and select to different colors that will match the satellite background image for each forest theme. Zoom in using the Zoom in tool,  and then Pan,  around to check the accuracies of the object forest maps.

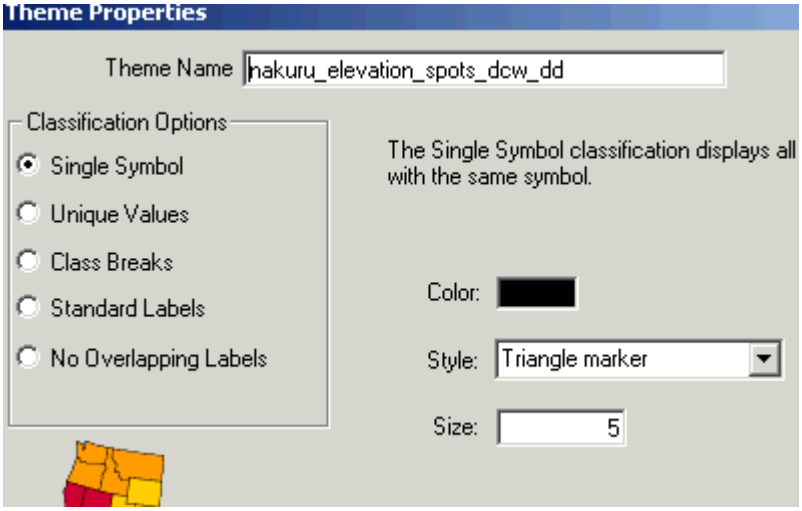
The different forests in the map have different names, and we want those names to appear. Make sure that the 'official' forest map is the active theme (i.e. appears lifted) and click the MapTips tool,  , select Name to be the field to use for MapTips.




## Add a Digital Elevation Model (DEM)

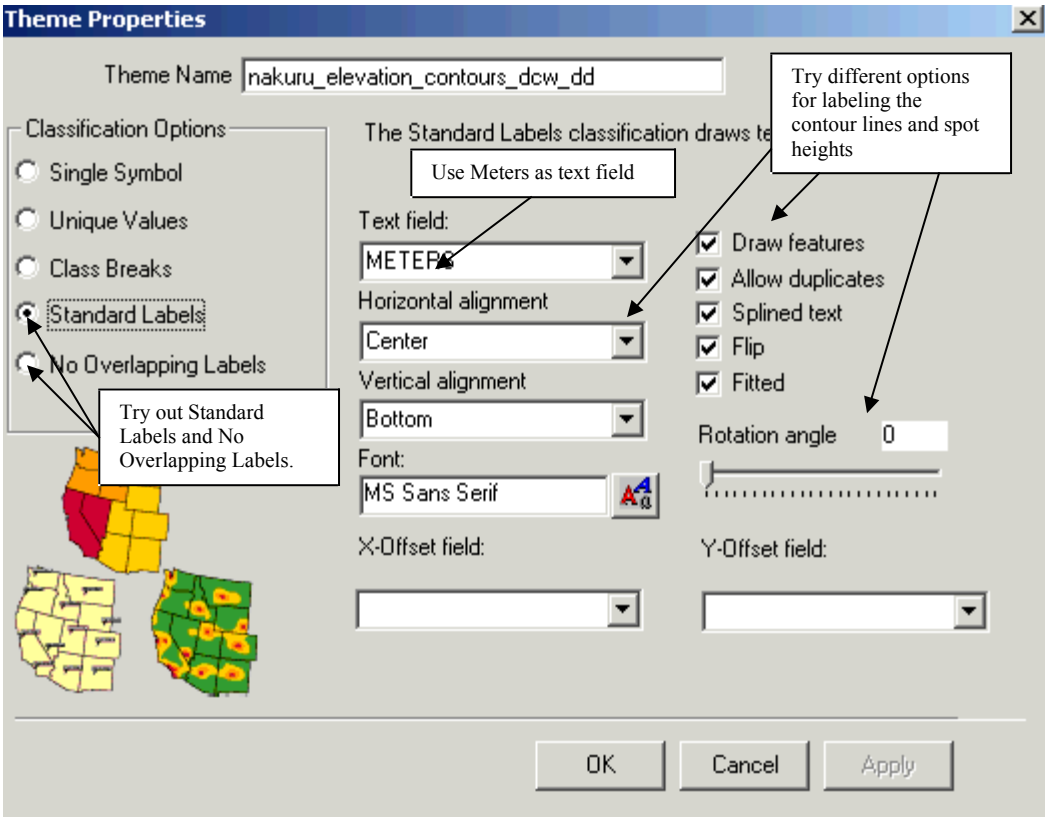
Elevation data in GIS can be in three different formats, as contour lines and spot heights, as triangular irregular networks (TIN) or as raster data. Contour lines is how elevation is usually presented on topographic maps (sometimes with additional hillshading). TIN is the format elevation data is collected from trigonometric surveys. Raster is the preferred data model for doing mathematical analyses and map algebra.

Start by adding contour lines and spot heights. Again make use of the Add Theme button,  , and navigate to the directory **…data/spatial/nakuru/DEM**, add both the spot heights and the contour lines. Put them at the top of the Legend. Change the symbolizing of the spot heights so that they appear as black triangles and make the contour lines black as well.




Because we have the satellite image as a backdrop it is quite easy (but not totally clear) to see which contours are higher and which are lower. But if you turn off the satellite images by deselecting their Check boxes it becomes much more difficult, or impossible rather. Hence we must add text to the contours and spot heights. Text on a contour line should always be on the 'upper side' of the line.

ArcExplorer is a simple GIS, so the options for labelling are not great. But try to put some text on both the contour lines and the spot heights. As the symbols are not unique (both respective themes are symbolized using a single setting for all records) we do not need to duplicate the themes (which is needed if the symbolising is uique). Try to find a symbolizing that looks OK, by selecting various options related to either Standard Labels or No Overlapping Labels.




The contour lines were originally done in feet, so the elevation in meters is a bit unlogical. But it should be obvious that one of the forests is situated in a depression whereas the others are in high areas and on steep slopes. That is also the reason why the spectral properties (i.e. colors in the satellite images) are differs.

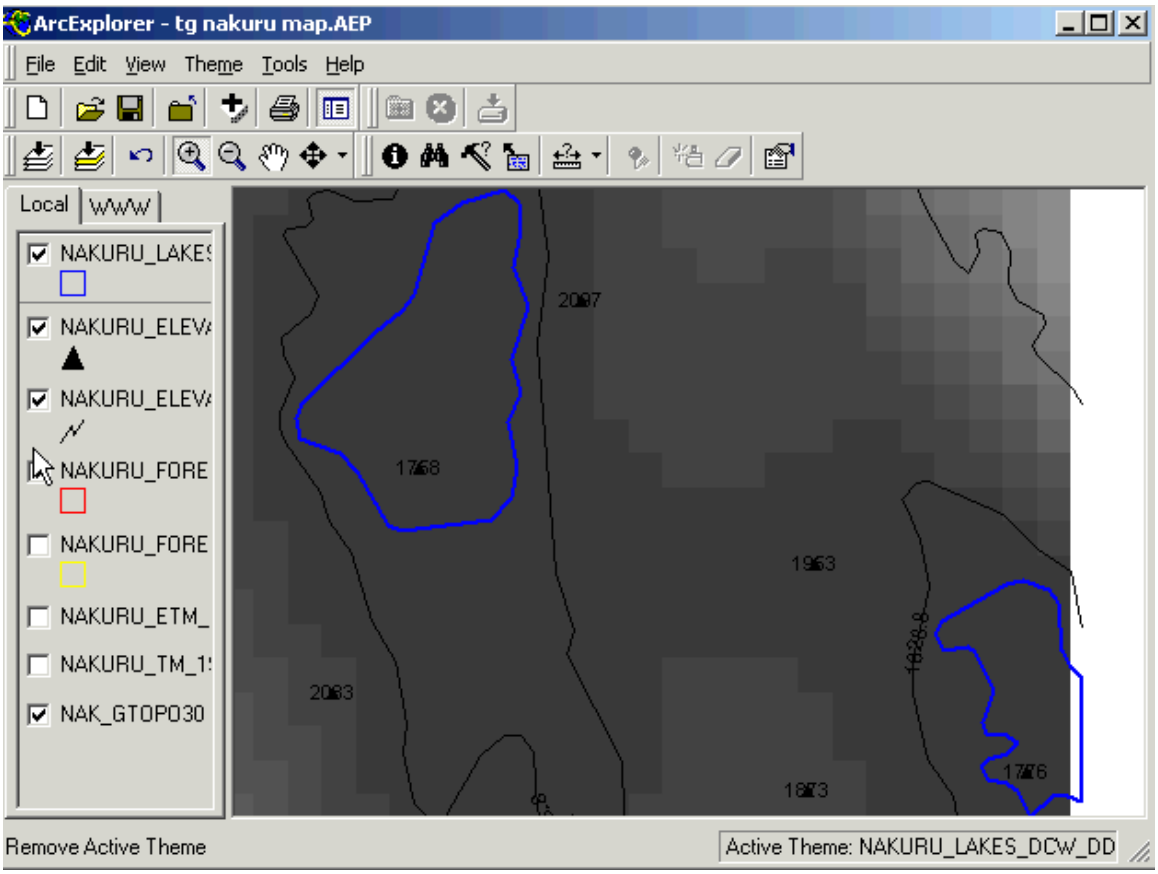
What is the name of the forest in a depression? To find that out you can either make the 'offical' forest theme active and drag the moue over that forest, in which case the MapTips tool should give the answer as a small pop-up text, or you can activate that theme and use the Information tool,  and click in that forest. The correct answer is the Menengai forest.

Now it is time to add the raster DEM. A raster DEM is also a field data set with continuous variation in space. Most GIS systems, however, separate between image data (where the actual values in raster has no physical meaning, it only relates to a color scheme) and grid data (where the field values of the raster have a direct physical meaning). The way images and grids are stored is hence different. To add the grid DEM over Nakuru make use of the Add Theme button,  , and navigate to **…data/spatial/nakuru/DEM/nak_gtopo30**. Nak_gtopo30 is the name of the theme (but it is not a file), but to get hold of the actual raster we must go down to the level of the actual grid related to that theme – the grid has a standard name – **hdr.adf** (regardless of content). Add this grid. As you see the name in the Legend becomes nak_gtopo30. Make sure the DEM grid is at the bottom of the legend and turn it on by clicking the Check box. ArcExplorer can only display (continuous field) grids in black and white, with

white representing high values and black low values. It is now very apparent which forest is a lowland forest. What is the spatial resolution of the grid DEM?

Zoom to Full Extent, and note the flat area (area with homogenous gray color) in the center of the map. This flat area is where Lake Nakuru is situated. To check out the extent of Lake Nakuru turn on one of the satellite image themes by clicking the check box. You can not see the Lake and the DEM at the same time as both themes cover the whole area. In order to see both the Lake and the DEM simultaneously we must add the Lake as an object. Use the Add Theme button, and navigate **to …data/spatial/nakuru/hydro**, the lake is in the theme **Nakuru_lakes_dcw_dd**.

Open the Theme Properties dialogue to make the Style a Transparent Fill, change the color of the outline to blue and Size to 2. Make sure that the Lake theme is Active (i.e. appears lifted) and Zoom to Active Theme, . Your ArcExplorer project should now look like the image below.



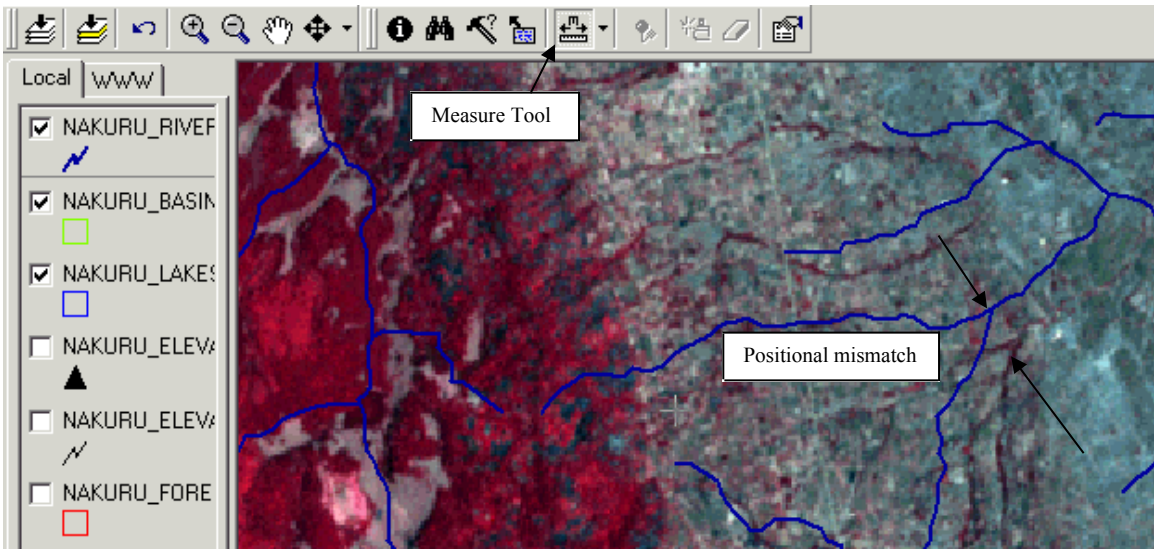

Apart from Lake Nakuru, there is also part of another lake in the view. Use the Information tool, to find out the name of this second Lake (make sure that the lake theme is the Active theme). You can see that the data does not fit perfectly; there are geometrical errors. The Lake theme and the DEM themes are, however both captured from datasets with global coverage. This means that for any part of the globe you can get this kind of information. Also the satellite images used are

globally available. The best part of it is that all this data is for free (the satellite images only for Africa) via the internet (see appendix 2).

Zoom to Full Extent,  . Add the other themes available under **…data/spatial/nakuru/hydro** (**nakuru_basin_dewa_dd** and **nakuru_rivers_dewa_dd**) to the project. Change the symbolizing to better colors and set the Style of the basin to Transparent Fill (done via the Theme Properties dialogue, accessed via double clicking the Theme menu item or from the tool bar,  ).

Notice anything peculiar with Lake Nakuru? It has no outlet!

To check the geometrical accuracy of the different themes, turn on the 2000 satellite image by clicking its Check box. Zoom in to region between the Eastern Mau forest and Lake Nakuru – there is positional mismatch between the satellite image and the river theme. How large is this mismatch? Use the Measure Tool,  to find out.

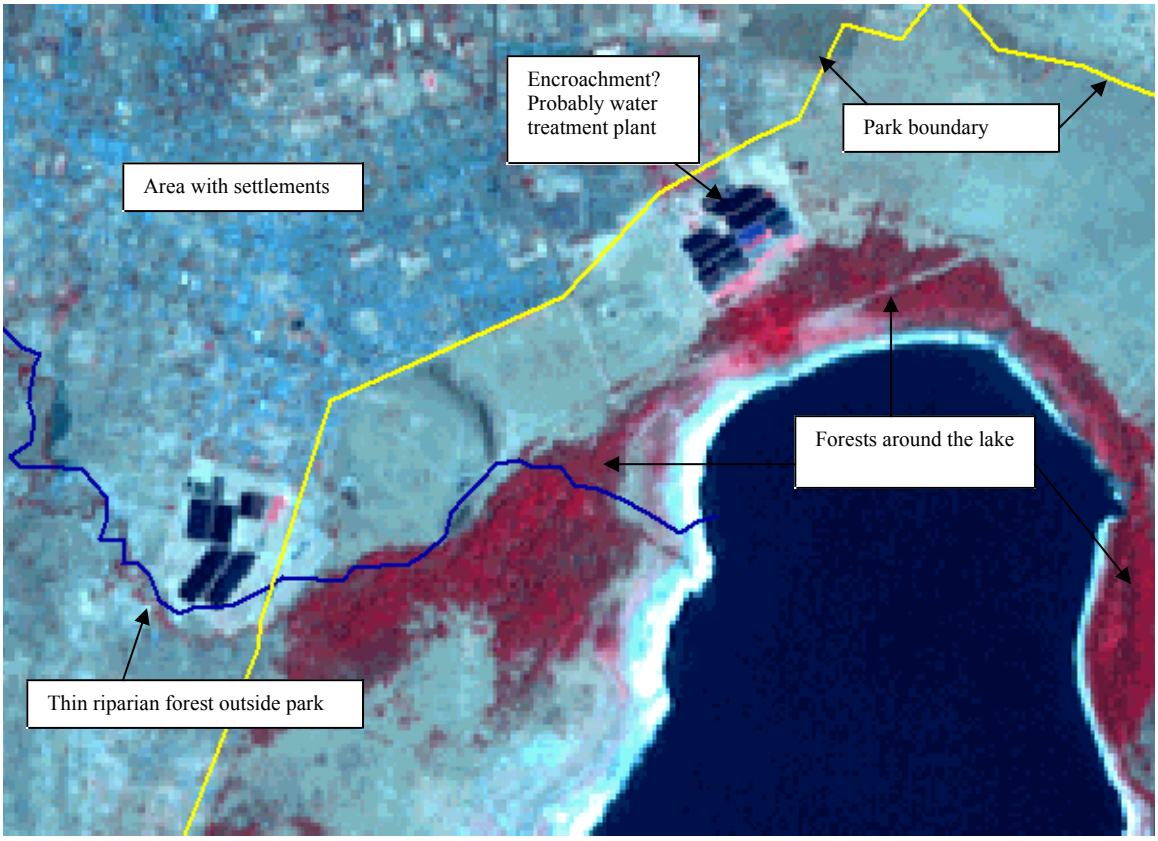



Zoom to Full Extent,  and turn off all themes except the grid DEM, the river and the basin. From a regional perspective it is clear that the datasets fit quite nicely. The rivers drain the mountains surrounding Lake Nakuru, and the basin delineates an internal drainage basin.

## Socioeconomic aspects

The two satellite images quite strongly suggest a substantial loss of forest in the upper parts of the Nakuru basin. Let us have a closer look around the Lake itself before turning to some socio-economic data.

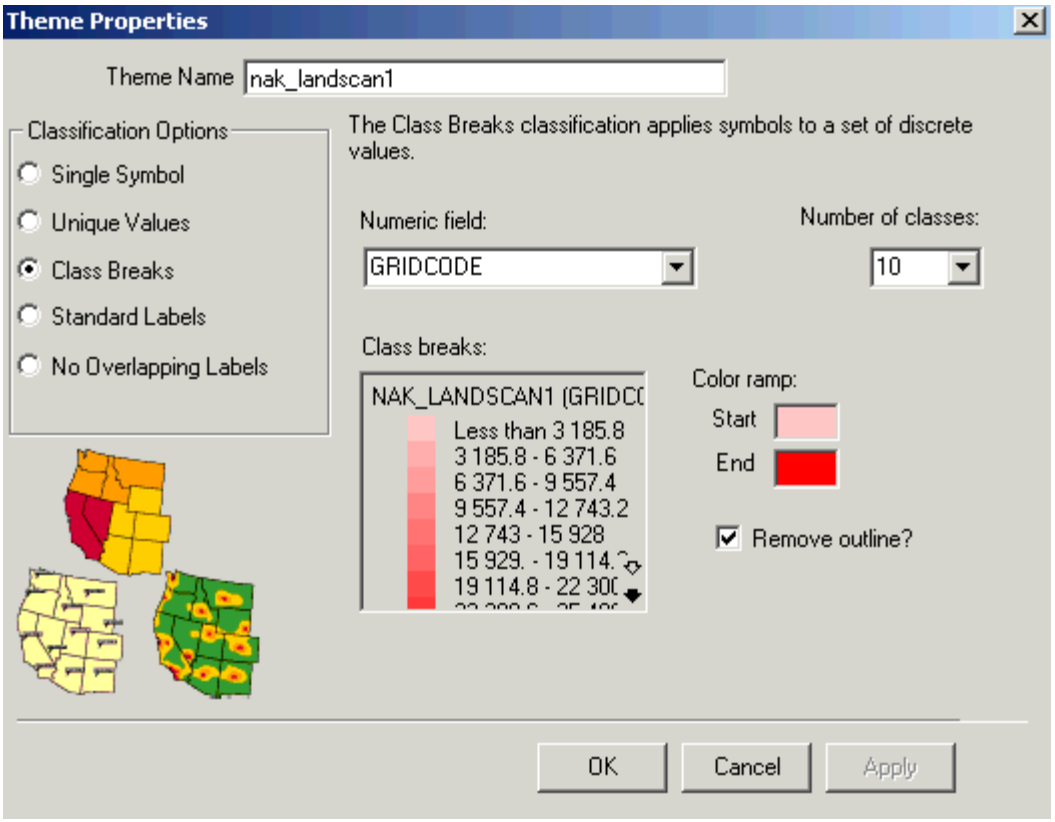
The lake and its near shore area is a protected area, add the theme for this area, **nakuru_limitnaku_lake_dd**, that you find under **…data/spatial/nakuru/nat_parks** (use Add Theme,  ). Use the Theme Properties dialogue box to set Style to Transparent Fill, and select a suitable color for the outline. Make sure the theme is active and Zoom to Active Theme,  . Turn on the satellite image from 2000. There is a distinct difference in tone and texture in the satellite image between the inside and outside of the park boundary. If you toggle between the 1973 and 2000 satellite images, the changes does not seem to be severe – only an apparent encroachment north of the Lake – which looks like a series of water filled squares; my best guess is a water treatment plant. If you look just outside the park boundaries there are only very small remnants of forests (i.e. red areas) left along the rivers as narrow strips of riparian strips. Also note how the settlements north of the lake seems to be much more dense in 2000 compared to 1973.




Now it is time to have a look at some infrastructure and socio-economic datasets to see what we can learn.

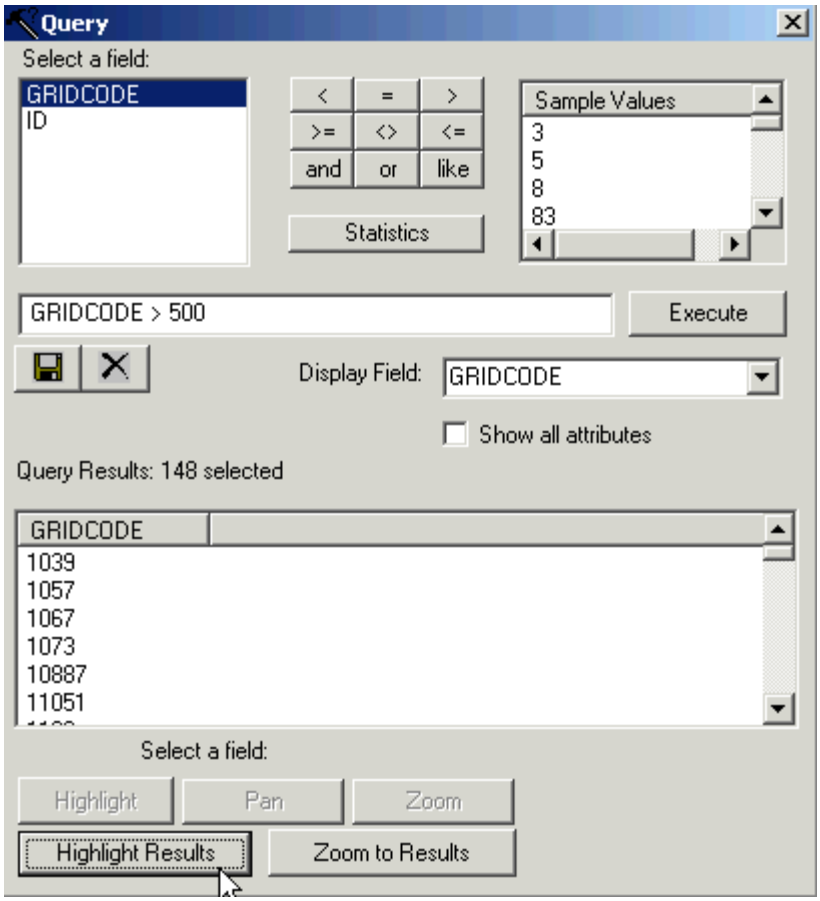
Start by adding the themes for roads (**nakuru_roads_dcw_dd**) and the theme showing the area of the town of Nakuru (**nakuru_nakuru_town_dcw_dd**). Both themes are in the directory **…data/spatial/nakuru/infrastructure**. The dense settlements north of the Lake are obviously there because it neighbors the town of Nakuru. The water treatment plant must be for the town, and was obviously built sometimes between 1973 and 2000.

A recent population dataset with global coverage is the Landscan 2000 dataset (see appendix 2), it is a grid theme and the part of this dataset covering our study area is available under **…data/spatial/nakuru/population\nak_landscan**. Add this theme, put it below the satellite image themes and make it active. Have a look at it by turning off the satellite image themes (deselect the Check boxes) and turn the Landscan population theme on. Use the Theme Properties dialogue to create a Color ramp for the population density. Remove the outline (as shown below) to make it easier to see the population density.



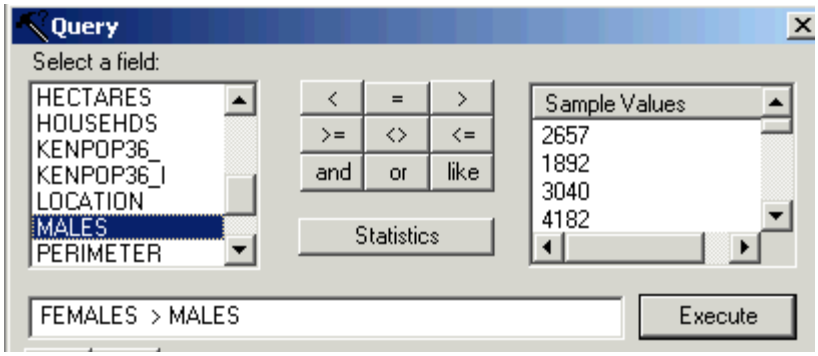

Turn off the Landscan population theme and turn on the satellite image from 2000 by clicking the Check boxes for those themes.

Make sure the Landscan population theme is active and use the Query tool, to see where the population density is higher than 500 persons per $km^2$. The population figures are in the field GRIDCODE. The cells fulfilling the query should now be displayed on top of the satellite image. Zoom in to see how well the settlements you see on the satellite image and the population data corresponds. Use the Statistics button on the Query menu to see what the average population density is in the region.




On the RELMA_GIS1.0 CD there is more socio-economic data available on a ward level. The polygon theme containing the wards is under **…data/spatial/nakuru/population\political\ nakuru_wards_depha_dd**. Put the theme on top of the Legend and use the Theme Properties dialogue to make the fill transparent and the outline black with thickness 2. Then use the Information tool, to look at the data records for some of the wards.

The database contains around 20 records, including the number of males and females in each ward. Use the Query tool, to find the wards with more females than males (good to know if you want to find a spouse).




Save, the ArcExplorer project that you have created, preferably in your home directory. Change the name into something logical.

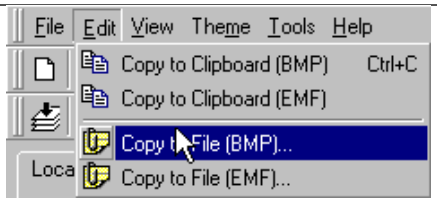
## Your turn

To complete the exercise you create a thematic layout of your own choice with at least one theme contributing to labeling the map.

When you are satisfied with your cartographic product it is time to transfer to another media.

Either print it,  , if you are connected to a printer. Or export the map as a bitmap –found under Edit in the menu bar as shown to the right.

If the map is only built from vectordata copy it to EMF format, **Copy to File [EMF].** If the map contains images copy it to BMP format, **Copy to File [BMP].**



## Appendix 1: How to get ArcExplorer from the internet

Use a web-browser (Netscape, Internet explorer) and navigate to ESRI´s homepage (http://www.esri.com) and to the page with free resources (in the blue field to the left, you have to scroll down get to Free Resources), select ArcExplorer (you should then be transferred to the site http://www.esri.com/software/arcexplorer/index.html). Read about ArcExplorer and then press Download (version 2.0 is the latest at the time of writing this instruction). You should then be transferred to the page http://www.esri.com/software/arcexplorer/aedownload.html. Download the file **ae2seup.exe**, also download the User Guide, **arcexplorer.pdf**.

Close all windows applications that are running on your PC and install ArcExplorer by executing the program **ae2setup.exe** (the program that you downloaded). To be able to install ArcExplorer you must have administrative rights on the computer you are using – if you do not have that you must ask your system administrator to help you. To install and run ArcExplorer the user should have full access (read and write) to the archive C:\Esri\ (not only for installation – also for running). When you install the ArcExplorer the default path for installation is "**Program files\ ESRI\ArcExplorer**". It is recommended that you accept that.

If you get stuck or do not understand a command, please refer to the User Guide that you downloaded (**arcexplorer.pdf**). This document is in pdf format, which you can read using Adobe acrobate reader. If you do not have acrobat reader on your computer you can download it from http://www.adobe.com. Installation is done in a similar manner as the ArcExplorer installation described above.

## Appendix 2: Free data from the internet used in this exercise

For more comprehensive information on data available over the internet see the document Spatial Data and Applications for Environmental Studies in Africa. The exercise GIS Data Mining on Internet introduces using ArcExplorer for direct linking to map resources on the internet. It also includes examples of how to find and download other datasets, including Digital Chart of the World (DCW), which is a comprehensive dataset with global coverage. DCW data covering the RELMA countries (Uganda, Ethiopia, Eritrea, Tanzania, Kenya and Zambia) is available on the RELMA_GIS1.0 CD (under **…data/spatial/DCW**). To import the DCW to ArcExplorer you must use special software (Import71), which is also supplied on the RELMA_GIS1.0 CD. It is however not trivial to import this data, but you can find the instructions in the exercise Data Mining on Internet.