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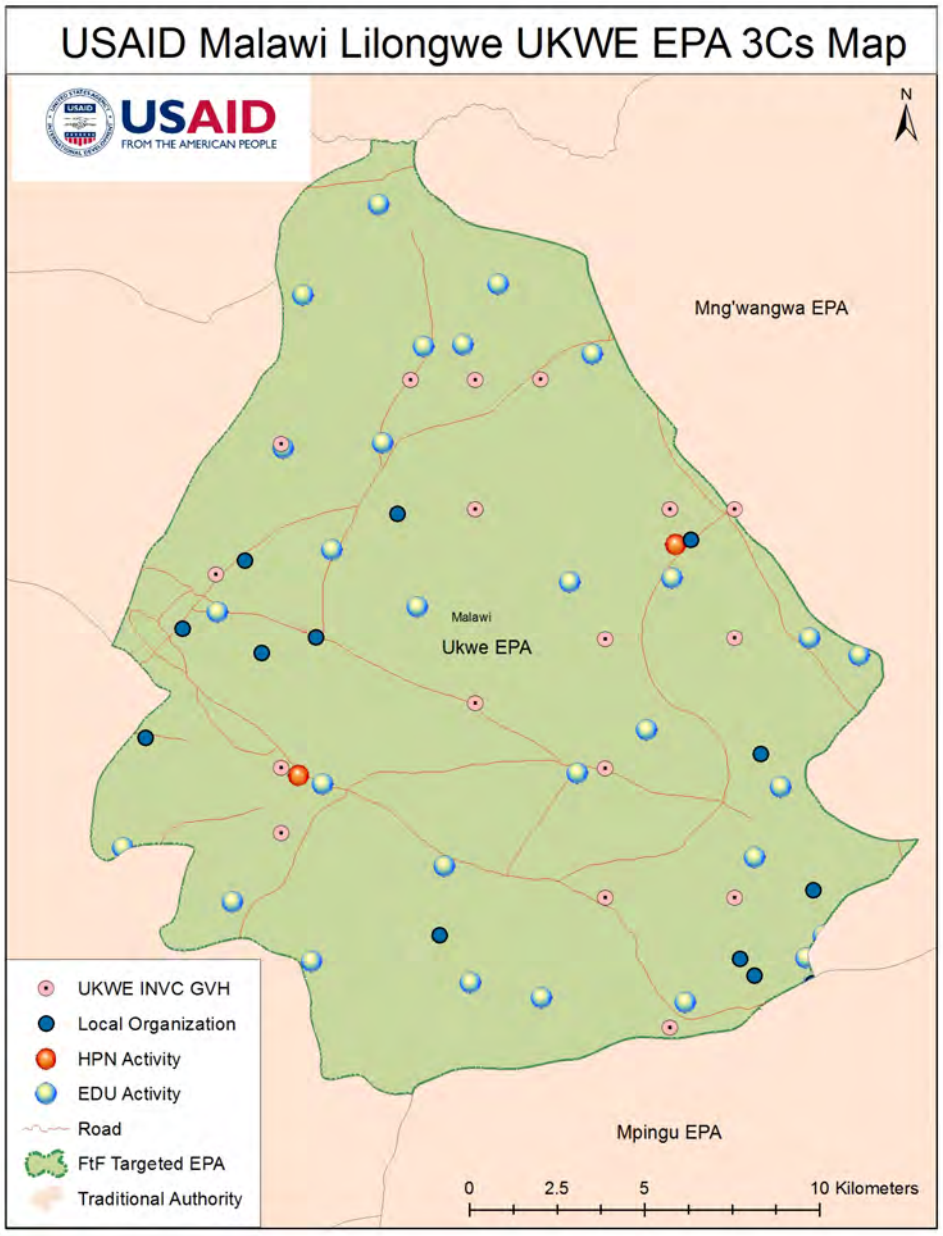
Geographic Information Systems Training Module I through 4



ARC GIS 10.x Geographic Information Systems and GPS Training Guide

Developed by Stephen P. Menard Jr, USAID/Malawi
Program Officer - Original training modules for ArcGIS
9.3 completed in March, 2009
Revised for ArcGIS 10.2 by K. Kuhn, February 2014

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Geographic Information Systems Training Module I

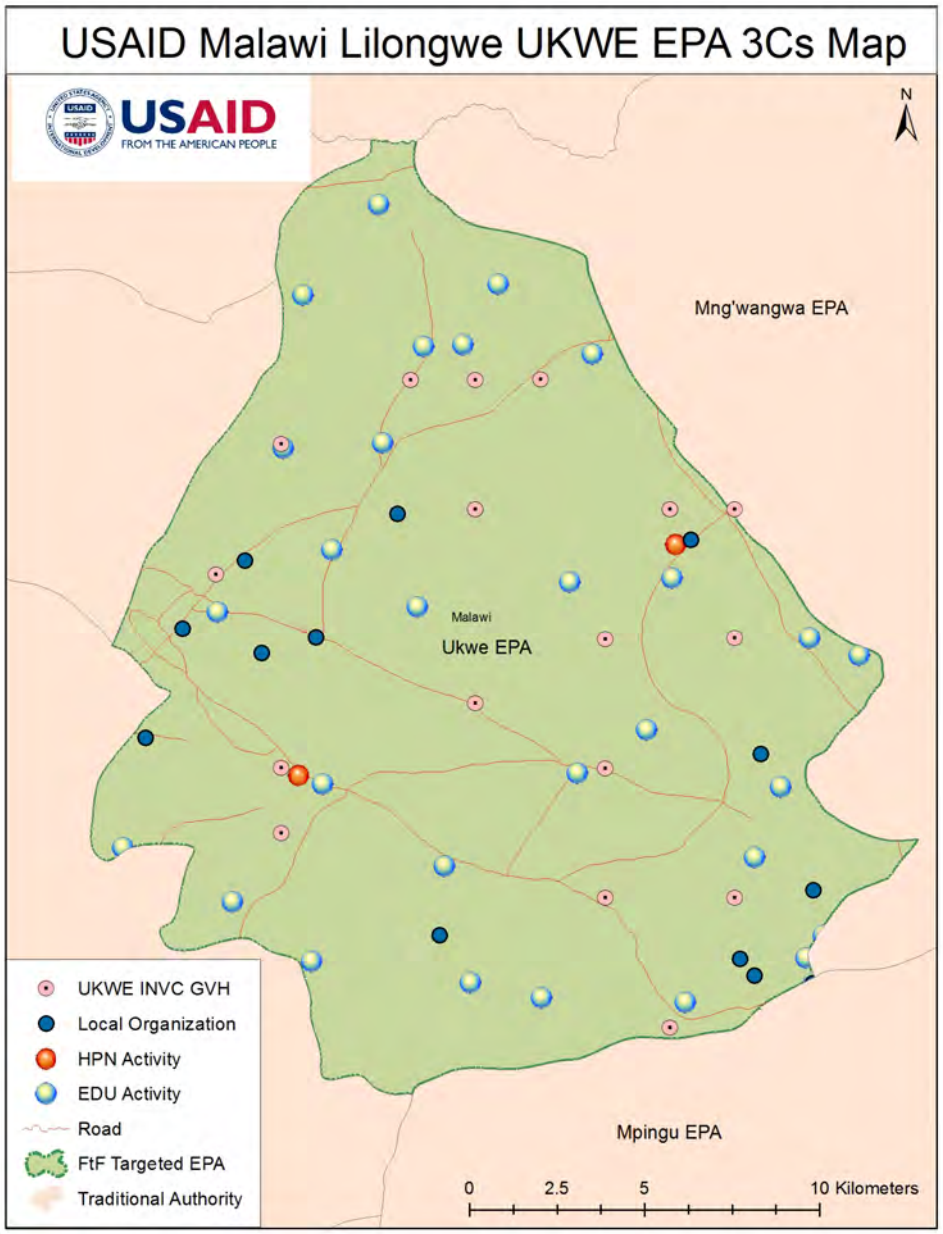

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Table of Contents

Purpose

Provide Geographic Information Systems (GIS) support to USAID/Malawi staff, USG Agencies, Ministry Counterparts and implementing partners through hands on training in GIS concepts, methodologies and software specific applications to build local project capacity. Initial training will build the foundation for more complex future efforts to support project objectives and facilitate donor specific deliverables including reporting, impact analysis, data development and performance monitoring.

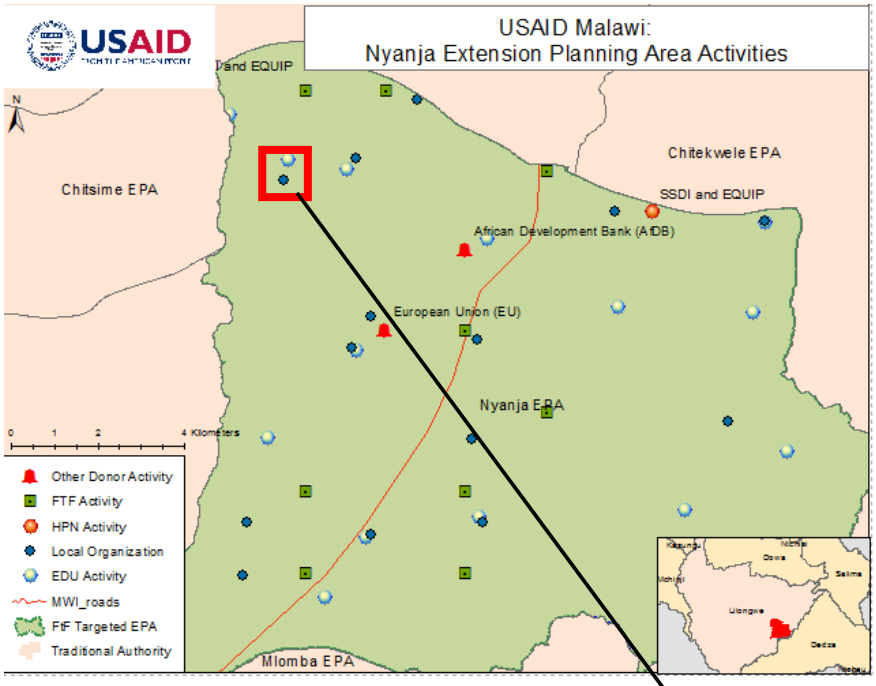
Concepts

What is a GIS?

USAID/Malawi GIS provides user friendly applications as well as training that facilitates the understanding of local project staff with GIS tools and methodologies. USAID/Malawi tries to define GIS in the most simplest of manners:

GIS definition: **GIS links data attributes to features on a map**

Figure 1: GIS Example



Local Organization

FID	Shape *	OBJECTID	type	ident	Latitude	Longitude	altitude	GPS_ident	ORG_Name	Interviewe
48	Point ZM	55	WAYPOIN	LLCHKALSENJ	-14.172996	33.970249	1228.76	LLCHKALSENJ	Senjele	Thokozile Chisala
49	Point ZM	56	WAYPOIN	LLFUKALFUNA	-14.152194	34.021382	1204.34	LLFUKALFUNA	Funachina	Thokozile Chisala
50	Point ZM	57	WAYPOIN	LLKAKALTADA	-14.09753	33.944067	1145.57	LLKAKALTADA	Tadala	Thokozile Chisala
51	Point ZM	58	WAYPOIN	LLKAKALCHIN	-14.110731	34.028879	1224.39	LLKAKALCHIN	Chingoma	Thokozile Chisala
52	Point ZM	59	WAYPOIN	LLKAKALMADA	-14.108753	33.997802	1249.92	LLKAKALMADA	Madalitso	Thokozile Chisala
53	Point ZM	61	WAYPOIN	LLCHKALKAPU	-14.102033	33.928947	1101.03	LLCHKALKAPU	Kaputu	Thokozile Chisala

Though there are many definitions of GIS which all vary to some degree there are several common themes inherent to each of these definitions:

1. GIS technology relies upon computer technology

2. GIS is concerned with spatial or geographic data which refers to data that that has a location upon the Earth's surface.

3. GIS technology emphasizes analysis rather than map-making.

A typical GIS Combines:

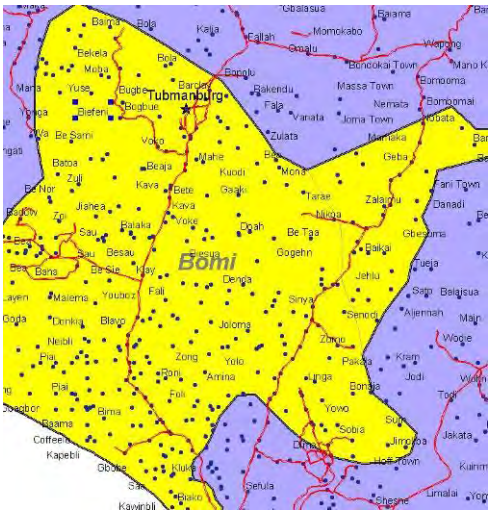
- Hardware
- Software
- Data
- Database Operations
- Analytical Methodologies
- Trained Analysts
- End Users
- Graphic maps

What is Spatial Data?

GIS is a tool to display, analyze and illustrate spatial data. Lines, points and polygons with associated databases represent spatial data. Each line, point or polygon represents a feature that exists at a specific location and is linked to a database containing information about that feature(s). Lines, points and polygon data are referred to as Vector data.

For example spatial data might be represented as:
Points (airports, cities),
Lines (roads, rivers) or,
Polygons – National parks or provincial, district or international boundaries.

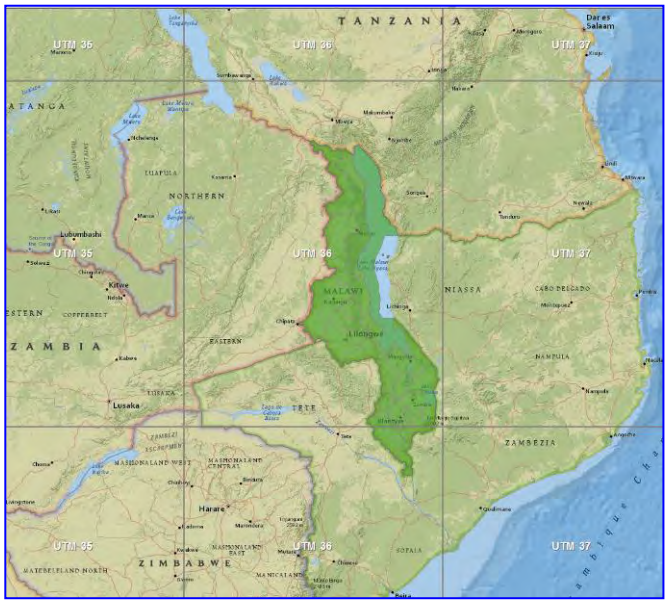
Figure 2: Example of Spatial Data



In this example of Bomi County, Liberia, the highlighted yellow province boundary is a polygon, the red lines are roads and the red blue circles are towns. Each shape (polygon, line and point) represents a different spatial feature and has an associated database with attributes for each feature.

When combined into a GIS these spatial data features are displayed together and represent various data features or **themes**. Each feature or theme is defined both by its location in space (**with reference to a coordinate system**), and by its characteristics (typically referred to as attributes). There are a variety of reference systems that are used to represent these coordinates - we are most familiar with **latitude and longitude** however there are many others reference systems such as UTM (Universal Transverse Mercator, Zone 36 N for Malawi), and Lambert-Azimuthal etc. Each reference system allows a user to project data differently, as maps are flat, it is necessary to fit data onto a 'circular' feature – the earth. Different map projections allow users to display GIS data differently and certain map projections should be used depending upon your location and analytical scale to facilitate data viewing and analysis.

In the country of Malawi the UTM projection, Zone 36 N is used for the entire country.



For our purposes we will be using GIS base data developed from two sources:

1. Malawi Spatial Data Portal Masdap.ithacaweb.org
2. Data developed by USAID through GPS (Global Positioning Systems), and partner data specific to USAID Programs

Why use GIS?

One of the major benefits of GIS is that it provides a platform to integrate complex and diverse information into a simple and illustrative format, a map. GIS facilitates the synthesis of project information (data) into a mapping environment with complementary ancillary data sets such as census information, demographics, livestock, studies performed by various organizations such as the WFP or FAO, etc.

A GIS can be used to do the following:

- **Merges** diverse data sources – project specific information, socio-economic, census, statistical and spatial base data such as administrative boundaries, roads, cities, infrastructure, etc.
- **Manage critical data**
- Inform the decision making process
- Reporting
- **Analyzes** data, **illustrates** trends, growth, and generates value added outputs.
- **Develop, validate, integrate, analyze and disseminate data**
- Reveals important **spatial** relationships that facilitate understanding.
- Provides a platform for project **planning**, **monitoring, reporting and data sharing**
- **Visualizes** and **disseminates** information.

USAID uses GIS as a tool to:

1. Facilitate field data collection (GPS) to add a spatial dimension to our program data (activity locations, road data collection, agriculture fields, etc);

2. Predict Outcomes – using spatial analysis for scenario modeling we can demonstrate how policy might impact land use change- GOANNA;

3. Plan Strategies – a strong analysis we can allocate project resources with sound rationale.

4. Monitor and Evaluate Project Impact – uses spatial analysis to monitor the success of its alternative development program - Spatial analysis provides for project reporting, monitoring and data access at various scales that gives USAID/Malawi a relative advantage.
5. Derive New Information from Existing Data – Derivative mapping: We take existing spatial information and add to it something new (knowledge of relationships between database elements). For example, we can create a soil erosion potential map using information on elevation, soils and rainfall, if we know the relationships between those factors and the new map we are creating.

6. Informed Decision Making – we can incorporate multiple criteria evaluation and multiple objective land use allocation models for decision support.

7. Visualization - Graphical Impact

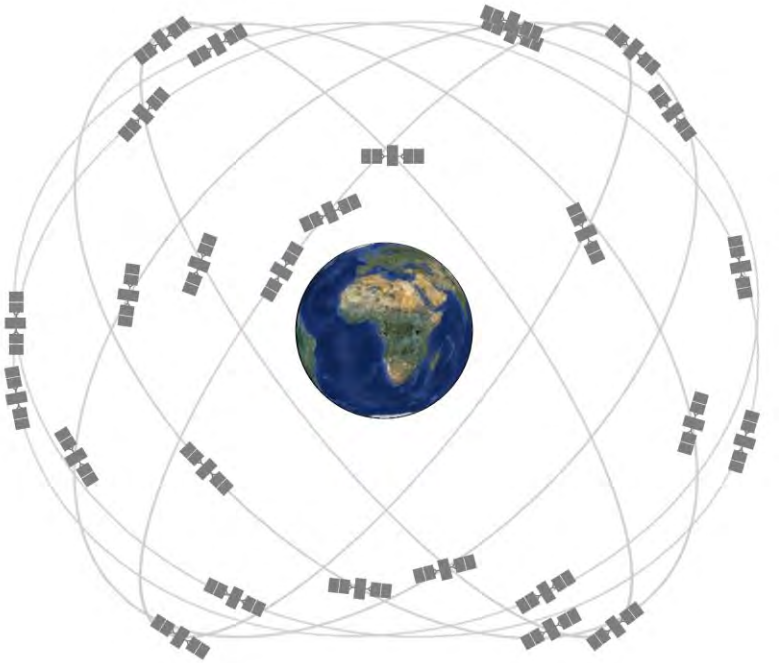
In some instances people are reluctant to use GIS as there are many incorrect assumptions about the technology. People are intimidated by GIS because they believe that GIS is an expensive and technically complex tool that most people will not understand or be able to readily use.

The reality of GIS:

- **GIS is affordable** and does not have to require a large capital investment;
- **GIS is about data and analysts** not hardware or software;
- GIS facilitates the **Integration, Analysis, Visualization** and **Dissemination** of **project information;**
- **GIS provides transparency** to clients, project staff and stakeholders through simple applications; and
- The appropriate **GIS response** should be assessed for each program differently based upon program needs and applied in a responsive manner.

What is GPS?

The Global Positioning System (GPS) is a satellite-based navigation system made up of a network of 24 satellites placed into orbit by the U.S. Department of Defense. GPS was originally intended for military applications, but in the 1980s, the US government made the system available for civilian use. Prior to 1990, GPS signals were deteriorated so a user could not achieve accuracy better than 10 meters. However, this has been changed and now any standard GPS unit can provide a precision of 4 to5 meters or 12- 15 feet.



GPS works in any weather conditions, anywhere in the world, 24 hours a day. There are no subscription fees or setup charges to use GPS. However, tall building s or thick forest cover may block the GPS signal and result in a less precise accuracy.

The 24 satellites that make up the GPS space segment are orbiting the earth about 12,000 miles above us. They are constantly moving, making two complete orbits in less than 24 hours. These satellites are traveling at speeds of roughly 7,000 miles an hour.

GPS satellites circle the earth twice a day in a very precise orbit and transmit signal information to earth. GPS receivers take this information and use triangulation to calculate the user's exact location. **Essentially, the GPS receiver compares the time a signal was transmitted by a satellite with the time it was received.** The time difference tells the GPS receiver how far away the satellite is. Now, with distance measurements from a few more satellites, the receiver can determine the user's position and display it on the unit's electronic map. As GPS receivers track satellites and calculate your position this process is referred to as Triangulation.

Any organization or agency that requires accurate location information can benefit from the efficiency and productivity provided by GPS technology.

GPS units are used to collect point, line or polygon data on program activities by recording the latitude and longitude of activity sites, or tacking roads or walking/driving perimeter locations. The type of GPS unit used by USAID/Malawi does not provide data measurements necessary for land tenure processes and data collected should not be used for any legal purposes or land dispute as it is not to the required accuracy.

ArcGIS 10.x Training –

Module I: The Interface

BACKGROUND

ArcGIS is a suite of applications for creating, using, sharing and managing GIS products. ArcGIS 10.2 is the latest software release from the US based company ESRI (Environmental Systems Research Institute) and provides a comprehensive and complete GIS analytical software package. The ArcGIS suite of software has had many released versions. Major updates are signified by a change in the first numeric designation, such as from 9.x to 10.x. The ".x" sub release signifies a new release of the software with less changes than a major release. ESRI has begun to add sub "." (dot) numeric designators, such as 10.2.1. These signify integrated patches and bug fixes within the software sub release and users should not notice any significant changes to the interface. This training manual was revised for ArcGIS 10.2, but should be applicable for all 10.x releases.

The ArcGIS suite of application has many uses, however for this training we will focus on the following:

1. Facilitate the development/creation of program data and improved base data into a spatial environment for program data management, analysis, validation and to facilitate reporting processes;
2. Provide information to support project planning and inform the decision-making process; and
3. Develop project maps for information dissemination on program results, activity data, etc to illustrate program impact throughout the zone of intervention.

GETTING HELP

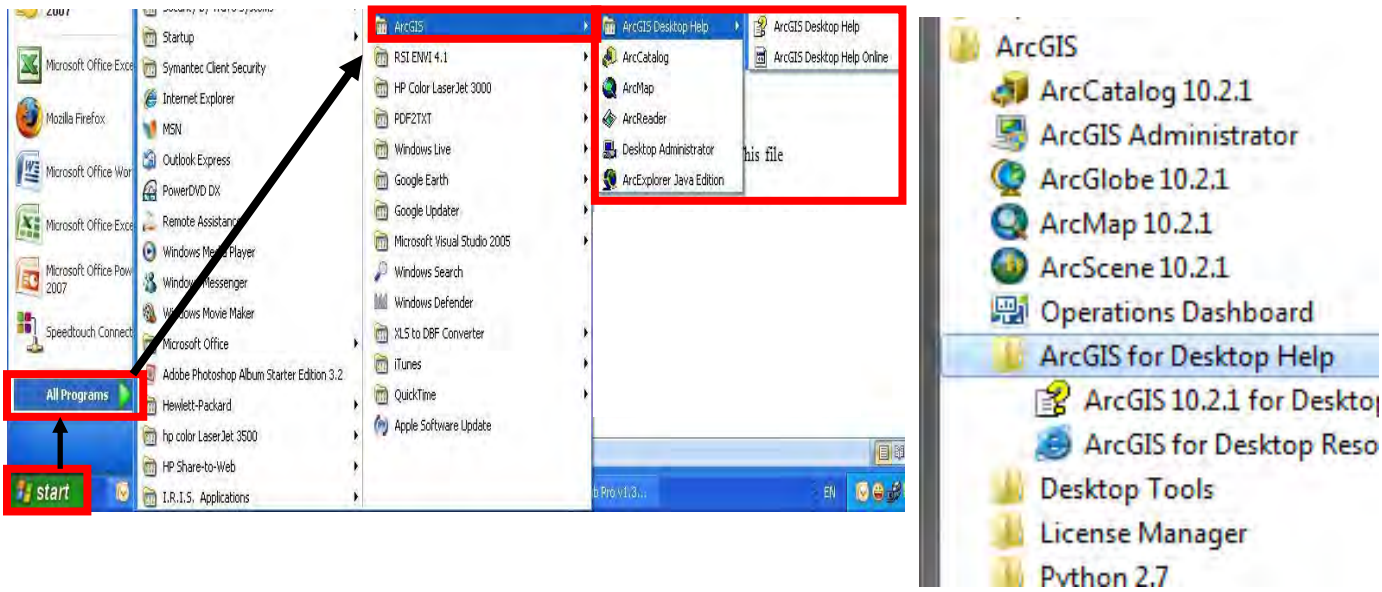
This guide has been designed to walk you through several days of training which will introduce you to the most basic and necessary features of ARCGIS 10.x which will facilitate your ability to use the software to perform basic analysis, data development and maps for reports. ArcGIS also has a comprehensive on line help function as well as a user manual to facilitate and guide your understanding of the software. The comprehensive and online 'HELP' function can be accessed by clicking 'Help' on your windows Programs/ARCGIS menu items or from the software itself from the icon located on the toolbar. The table of contents is broken into common operations and the chapters provide easy to follow, step by step instructions. Please reference the ArcGIS Help feature if you find you have a question outside the scope of this user guide.

START UP

Install the ArcGIS 10.x program on your operating system; it will be required to have the proper license numbers at time of installation to register your single user license.

After installation has completed, you will find shortcuts on your desktop, in addition to the START/Program Menu (See below).

Figure 3: Location of software in Microsoft Programs



Under your ArcGIS folder in the Start menu, you should see the following programs. You may have more, depending on your software license and installed extensions.

- Arc Catalog
- Arc Map
- ArcGIS for Desktop Help and
- ArcGIS for Desktop Resources
- Desk Top Administrator

Both the online and desk top help for ArcGIS 10.x can be accessed from the program menu screen. For this training we will be primarily concerned with using ArcMap and ArcCatalog.

Desktop Administrator is used to manage the software license. We will not cover these functions in this training, please ask your instructor for additional information.

ArcGIS Online

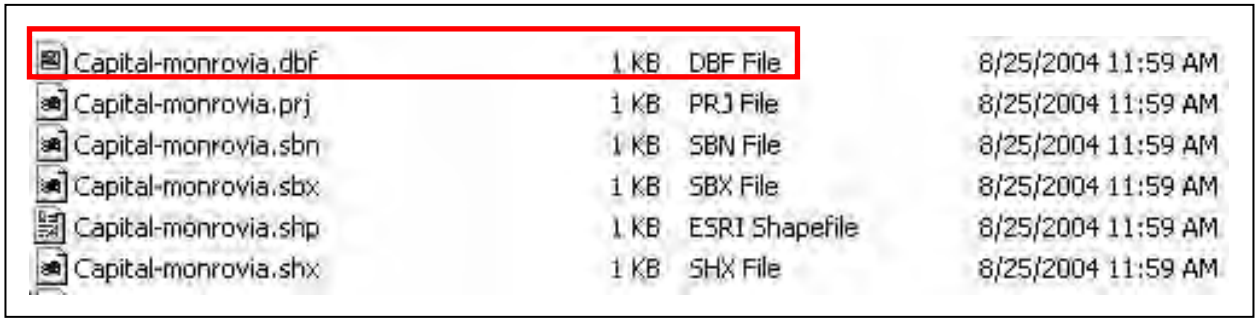
In addition to ArcGIS for Desktop, there is an online application called ArcGIS Online, which can be accessed at www.arcgis.com . This application is subscription based, but may be included with your desktop software. In addition, individuals were able to gain free use with a personal account, as of this writing.

Data Format

SHAPEFILES - The most common data format that you will encounter is the ESRI shape file. A SHAPEFILE consists of multiple files, all have the same name but use different extensions. For a shapefile to be formatted correctly it must consist of at lease these three extensions all with the same name:
.shp
.shx
.dbf (database)

Without these three file extensions your shape file will not be viable, therefore you should be very careful when copying and moving files.

Figure 1: A shape file for the capital city of Monrovia, Liberia



Sometimes the following extensions will also accompany the shapefile:
.prg
.sbx
.xml (metadata – information about our data)
.sbx
.avl (legend)

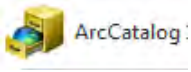
In addition to Shapefiles, ArcGIS can utilize many other data formats, including Geodatabases, jpgs, tiffs etc. Please note; while there are similarities between formats, various data formats provide differences in permitted data structures and workflows. We will primarily be using shapefiles for this training.

When copying or moving a shapefile from one location to another it is necessary to ensure that all extensions are included in the move, otherwise the data will be corrupted and the shapefile will not load properly into ArcGIS. For this reason, it is recommended that you use ArcCatalog to move, copy or rename your GIS data.

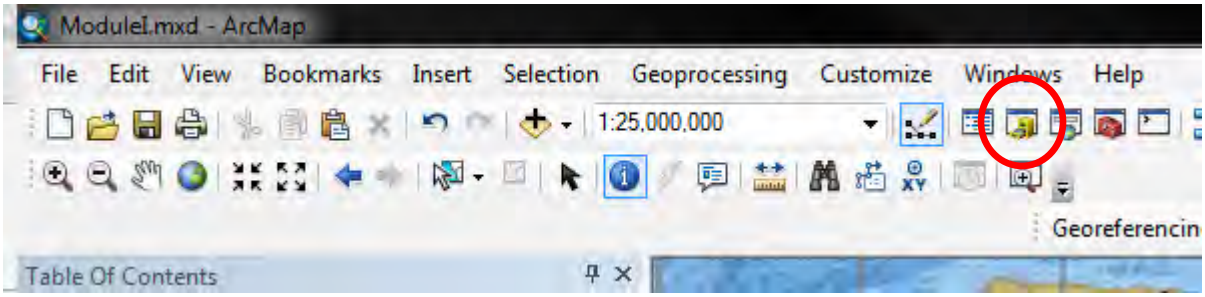
ArcCatalog

ArcCatalog is used for GIS Data management tasks such as; creating new shapefiles, copy shapefiles, delete shapefiles and others. Using ArcCatalog will ensure that all required information is transferred from one location to the next when moving or copying GIS data.

There are two ways to access ArcCatalog: as a stand alone application from the start menu or your desktop. (look for the Arc Catalog Icon)…



And from within ArcMap…(look for the icon circled in red).



ArcCatalog is also used to develop metadata for our GIS data. Metadata is information that explains your data to people who may want to use it and understand the different field attributes associated with the data set, the data projection, how the data set was created, any analysis performed on the data set, etc.

Please note that ArcCatalog is primarily used as a file manager, and not specifically used to edit your GIS data or to create maps, for those types of tasks you will use ArcMap.

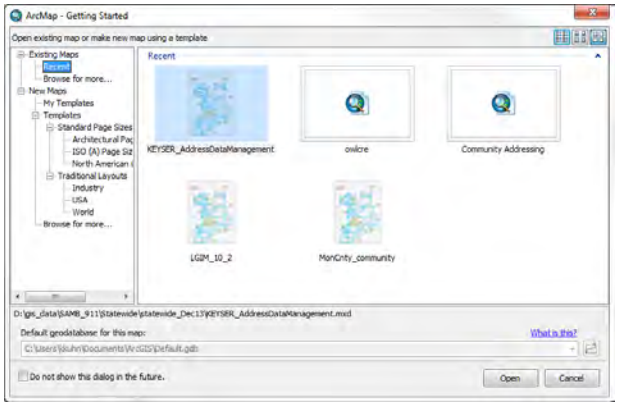
ArcMap, is where we can add data, make maps, perform analysis, access Arc Catalog and ArcToolbox, use geoprocessing tools, build and develop and use geoprocessing models, perform spatial analysis, integrate GPS field data etc. In other words, most of your day-to-day operations will be performed using ArcMap.

ArcMAP - Introduction

ArcMap is the primary application and interface associated with the ArcGIS software. The ArcMap application is accessible by clicking on the ArcMap Icon in your Start Menu or as a desktop short cut.

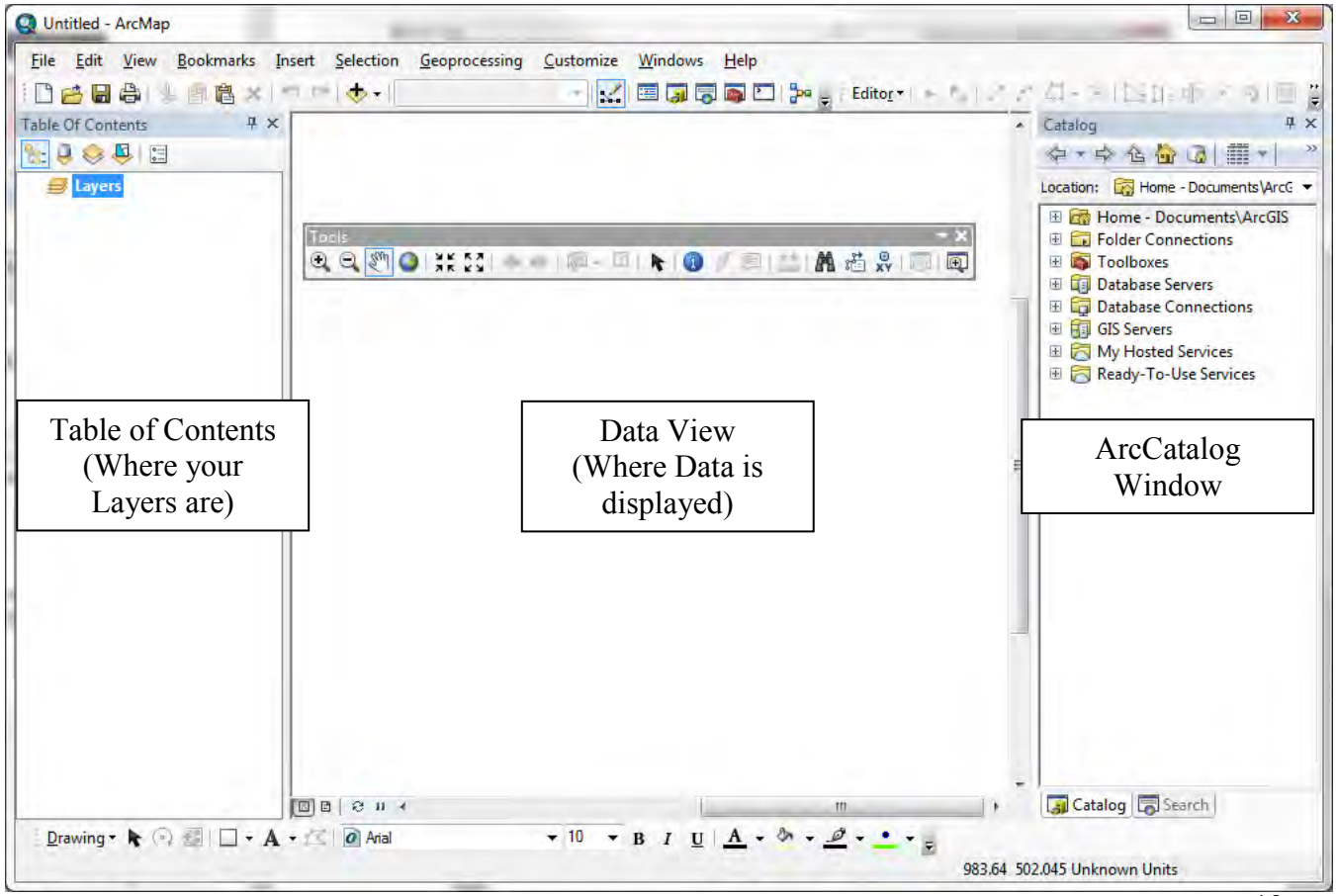
1. Single click the ArcMap icon to open the software. This will begin a new ArcMap document. Each ArcMap document has a .mxd file associated.

   Note: your ArcMap session may begin with a "Getting Started" window. You may cancel this window, which will start a new (blank) ArcMap session.



In **Figure 2** below we will examine the ArcMap basic interface and explain the various menu items and features found throughout the viewer interface.

Figure 2: Arc Map Interface

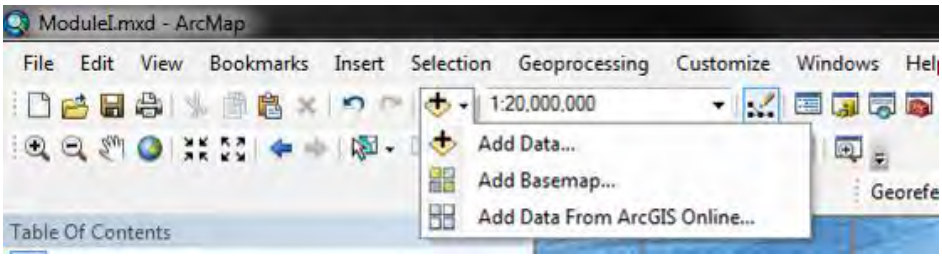


ARCMAP Menus

ArcGIS uses menus at the top of the application t, these menus collect command accruing to their functions.

1. **New Project** – Opens a new (blank) ArcMap Document. (This creates a new .mxd file)
2. **Open Project** – Opens an existing document.
3. **Save project** – Saves the current ArcMap document. Please note the mxd does not contain any data directly, rather it only links to the data being used. This may be important when sharing your .mxd file with others who may need internet access for base data.
4. **Print** –Print the map view.
5. **Cut, Copy, Paste, Undo, and Redo** – facilitates graphic edits and undo/redo graphic edits

6. **Add layers** – This tool allows a user to add GIS data to the document. This data may be stored locally, accessed through a network or provided as a service over the internet. This will also be covered at a later point in the training.



7. **Previous Extent** – Allows a user to immediately zoom back to their previous map view.

8. **Next extent** – Allows a user to zoom forward to an extent they just zoomed away from when using previous extent.

9. **Zoom to Global Extent** – Allows a user to expand the map view to the full geographical extent of the data located within the project.

10. **Zoom to Active layer** – Allows a user to highlight a data theme and zoom to the full extent of that particular geographical layer.

11. **Zoom in** – Allows a user to zoom into an area either by clicking on the desired location or by holding the right mouse button and drawing a rectangular box over the desired area of interest.

12. **Zoom out** – Allows a user to zoom out of an area either by clicking on the desired location or by holding the right mouse button and drawing a rectangular box over the desired area of interest.

13. **Pan** – Select the hand and pan the map view in the desired direction.

14. **Add X,Y –** This button allows a user to drop a point and generate the X,Y coordinate for a specific location in a map.

15. **Identify** – Select the identify button, and then select a data theme by clicking on that theme and making it active. Use the identify tool to query the active data theme.

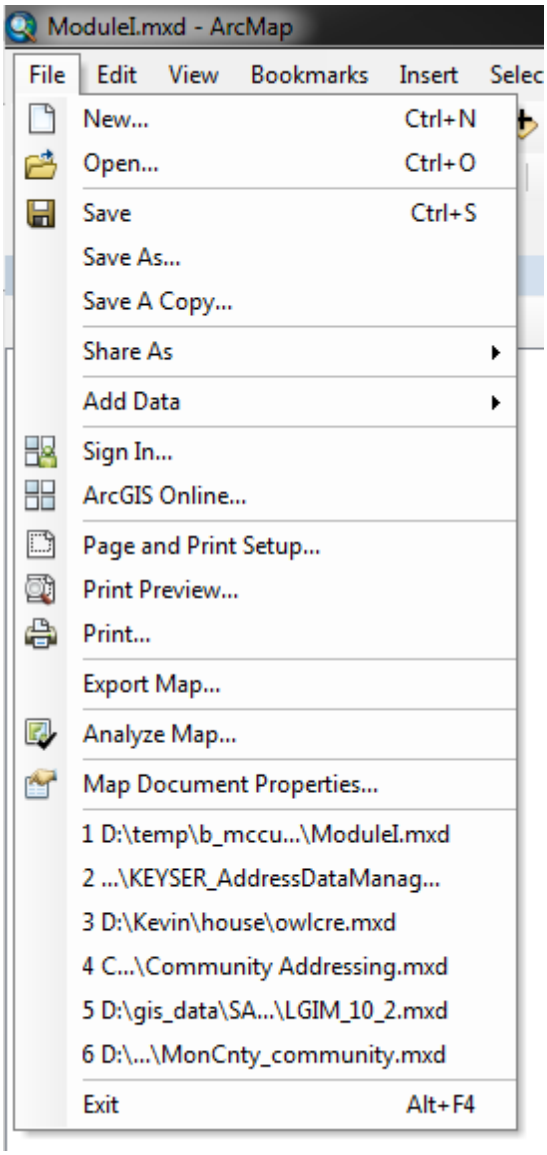
16. **Find** – This tool allows a user to perform a string query on any data theme located within the map view.
17. **Measure** – The measure tool measures distance in specified units from one location to another.

18. **Clear All Selection** – This tool allows a user to clear (un-select) any features that have been selected.

19. **Select Features** – This tool allows a user to choose a selection shape (circle, rectangle, line or polygon) to select features of an active data theme.

File Menu

The File Menu has basic document commands and controls properties related specifically to the open document.



FILE MENU

NEW – Starts new ArcGIS project
OPEN – Opens ArcGIS project

SAVE – Saves Current ArcGIS document
SAVE AS – Saves the current ArcMap document as another name
SAVE A COPY – Saves a copy of the current document. This is useful to save mxd documents compatible with previous software versions.

SHARE AS – shares the map document as a map package or as a map service

ADD DATA – Allows a user to add GIS data to the Project View.

SIGN IN - Allows the user to sign into the ESRI Global Account. This allows access to certain internet functions.
ArcGIS Online – Launches the ArcGIS Online web based application

PAGE and PRINT SET UP – Sets the Page properties for printing and map size (A4, A3, Landscape, etc)
PRINT PREVIEW – See your map before you Print
PRINT– Prints the current document

EXPORT MAP – Exports a version of your map document using various formats, such as jpg, or pdf. Useful for printing or sharing with others.

ANALYZE MAP – Identifies broken data links and optimizes drawing speed issues.

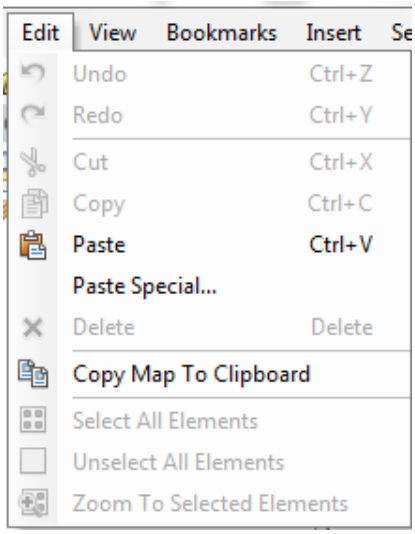
MAP DOCUMENT PROPERTIES – Set properties for the project document (author, date, etc)

RECENT DOCUMENTS - Lists previously opened Arc GIS projects for quick open.

EXIT – Closes Program

Edit Menu

The edit menu contains some commands that should be familiar to most computer users. One aspect to note, is that the commands such as copy and paste work in conjunction with other commands while editing GIS Data. This will be explained in detail later in the training.



EDIT Menu

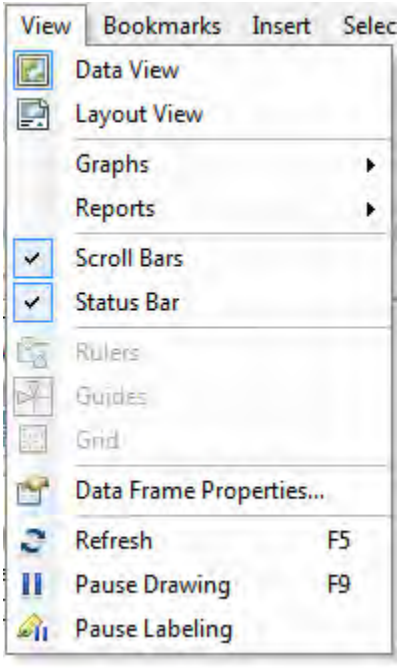
UNDO – Undoes the last action
REDO – Redoes the last action

CUT – Cuts the selected elements
COPY – Copy the selected element to the clipboard
PASTE – Pastes the clipboard content into the map
PASTE SPECIAL – Pastes the clipboard contents using the format you specify.
DELETE – Deletes the selected elements

COPY MAP TO CLIPBOARD – Copies the map in layout view to the clipboard to be pasted in another program or document

SELECT ALL ELEMENTS – Selects all graphics in layout or Map View
UNSELECT ALL ELEMENTS – Deselects all selected graphics
ZOOM TO SELECTED ELEMENTS – Zooms to Selected graphic elements

View Menu



View Menu – Contains options related to the map document

DATA VIEW – Goes to DATA VIEWER
LAYOUT VIEW – Goes to layout View (map view)

GRAPH – Opens the graph menu, allowing you to load or create graphs
REPORT – Opens the report menu, allowing you to create reports

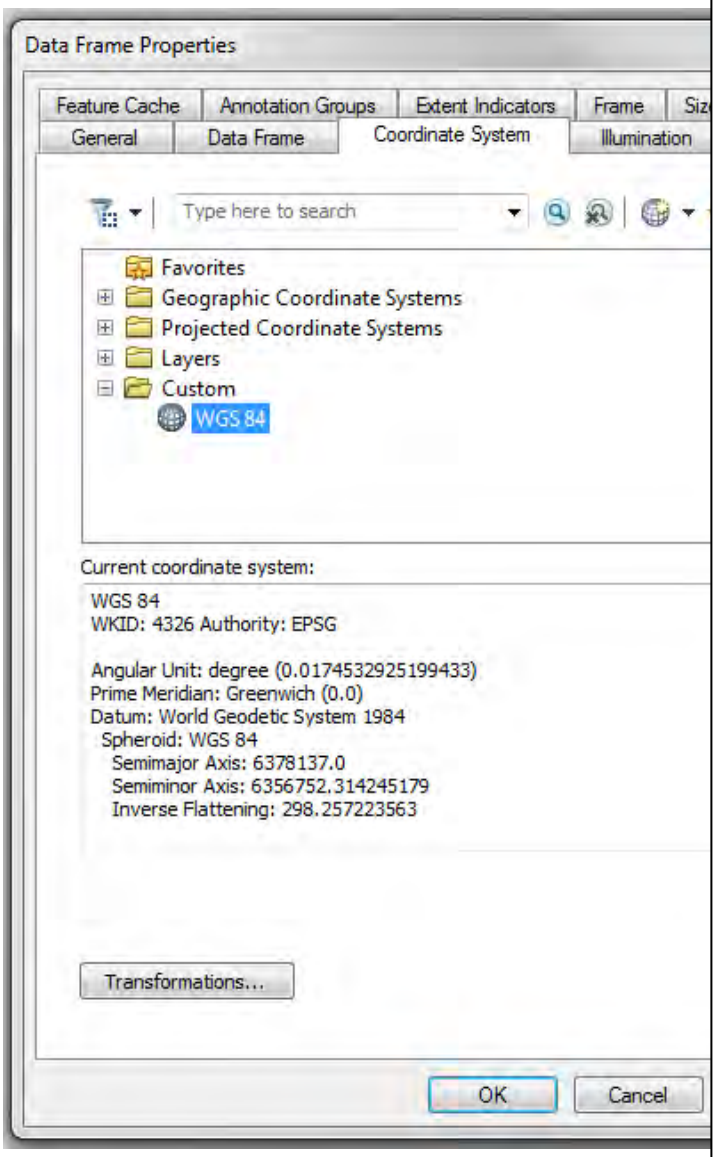
SCROLL BARS, STATUS BARS – make the scroll and status bars visible in the interface

RULERS, GUIDES, GRID – makes the rulers, guides and grids visible in the page layout.

DATAFRAME PROPERTIES –Permits user to set data frame properties for each data frame. (See following figure)

REFRESH- Refreshes the display for data view and layout view
PAUSE DRAWING – pauses all drawing operations
PAUSE LABELING – pauses all labels from being drawn

Data Frame Properties



DATA FRAME PROPERTIES

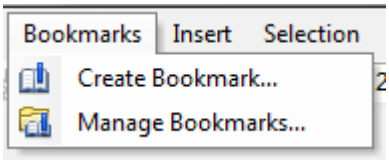
The Data Frame Properties dialog controls many aspects of the data frame, including setting the coordinate system for the data frame itself. This tab controls ArcMap's projection-on-the-fly, and allows data in various projections and datums to be displayed simultaneously. By default, the data frame assumes the coordinate system of the first dataset loaded into the ArcMap document.

This is very important when working with data from latitude and longitude coordinate system and data from a projected coordinate system. Data layers that do not have the same coordinate systems will not display in the same map view unless the Data Frame has a coordinate system defined.

For example, Malawi uses UTM ZONE 36N, WGS 84 Datum. When working with Malawi data, all projects are set to this coordinate system. Having a projected view facilitates the ability to display GPS collected data (typically in latitude and longitude) within the same data view as your projected data.

Bookmark Menu

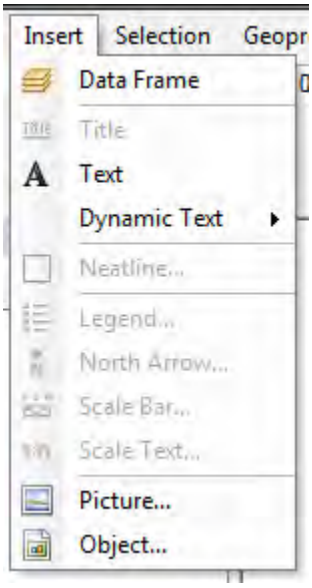
Bookmark Menu–used for creating and managing bookmarks used in your ArcMap Document. Bookmarks are used to mark a place, extent or specific scale for later recall.



CREATE BOOKMARK – Permits user to Bookmark different scales or extents. Bookmarks are unique for each data frame within a ArcMap document

MANAGE BOOKMARK – This opens a dialog that allows you tos save and load bookmarks. You are able to save bookmarks as a bookmark file and then share or import that bookmark into other ArcMap Documents.

Insert Menu



INSERT MENU

This menu permits a user to add specific elements to a map layout in the layout view.

DATA FRAME – Allows a user to add a new data view frame to the map layout to create sub map elements in a layout (For example a regional map)

TITLE – Facilitates the addition of a Map layout Title.

NEATLINE – Facilitates the placement of a box around graphics or the map layout.

LEGEND – Permits a user to add a legend to the Map layout.

NORTH ARROW – Permits a user to add a North arrow to the map layout

SACLE BAR, SCALE TEXT – Permits a user to add a scale bar and text to map layout

PICTURE – Permits a user to add a picture to map layout such as NGO logo, etc.

Selection Menu

This menu provides the user with the ability to select data (features) based on either specific data attributes or the location of features within another feature. For example SELECT all the villages that fall within a given District, etc.

SELECTION MENU

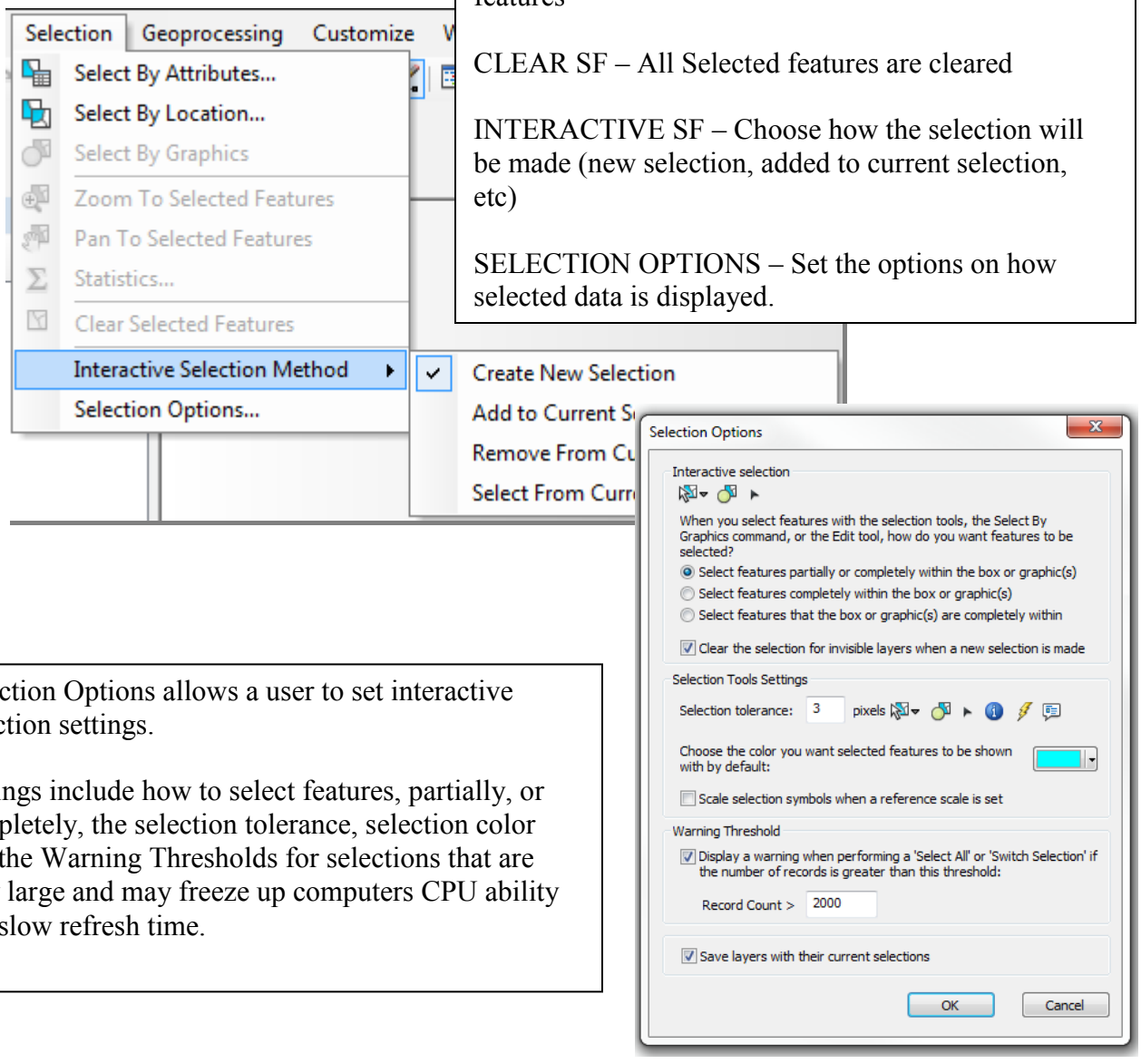
SELECT BY ATTRIBUTES – Select a feature based upon its data attributes and data table.
SELECT BY LOCATION – Select a feature based upon its location to another feature.
SELECT BY GRAPHIC – Select features based upon a currently selected graphic element

ZOOM TO SF – Map will zoom to features that are selected
PAN TO SF – Map will pan to selected features
STATISTICS – Displays statistics for the selected features

CLEAR SF – All Selected features are cleared

INTERACTIVE SF – Choose how the selection will be made (new selection, added to current selection, etc)

SELECTION OPTIONS – Set the options on how selected data is displayed.

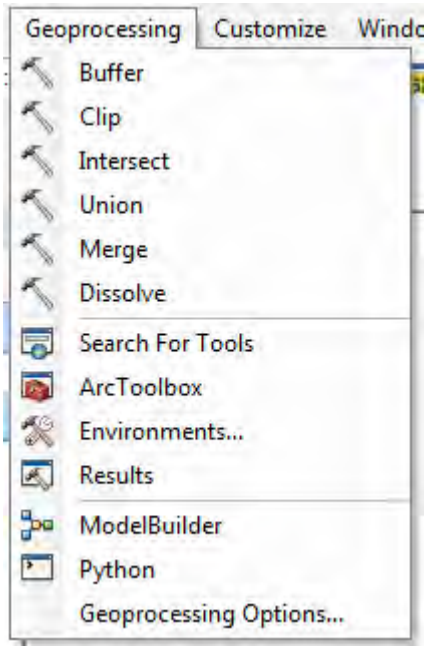


Selection Options allows a user to set interactive selection settings.

Settings include how to select features, partially, or completely, the selection tolerance, selection color and the Warning Thresholds for selections that are very large and may freeze up computers CPU ability and slow refresh time.

Geoprocessing Menu

This menu provides the user with quick access to the most commonly used geoprocessing tools and settings. Tools available in this menu are also available in ArcToolbox.

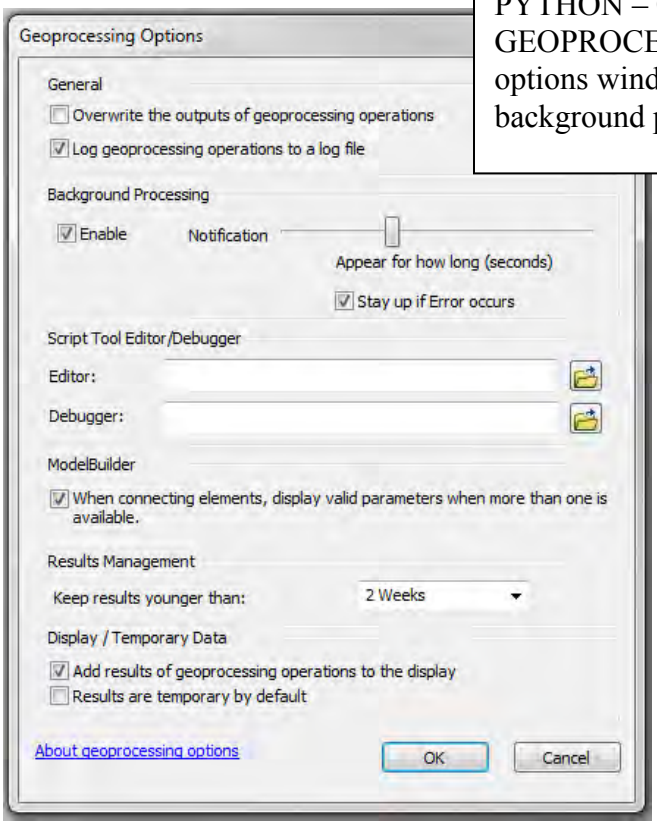


GEOPROCESSING MENU

GEOPROCESSING TOOLS – Opens a the specific geoprocessing tool. See the help documentation for additional information.

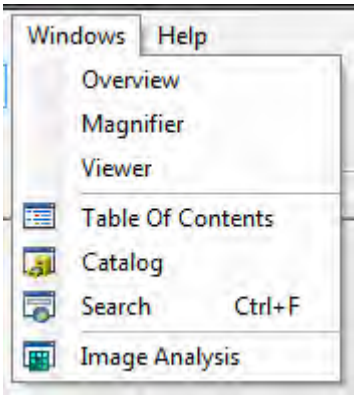
SEARCH FOR TOOLS – initiates a search function focused on finding a tool based upon a keyword
ARCTOOLBOX – Opens the ArcToolbox interface with access to data and analytical GIS tools.
ENVIRONMENTS – Opens the environments settings. These options control many aspects of how or where geogprocessing functions are performed
RESULTS – Opens the results dialog box, which displays the previous geoprocessing steps, allowing you to track progress on current processes or repeat them.

MODEL BUILDER – Opens the ModelBuilder application, which uses a graphical interface to assemble geoprocessing tasks.
PYTHON – Opens the python command line shell.
GEOPROCESSING OPTIONS – opens the geoprocessing options window, allowing for changes to settings such as the background processing option.



Window Menu

This menu provides the user with the ability to open a small viewer window to look at detail at a specific portion of the data view.



WINDOW MENU

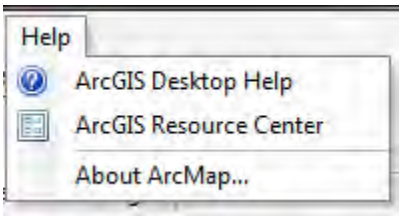
OVERVIEW – Opens a small viewer that displays the data view.
MAGNIFIER – Allows a user to magnify and zoom in and out and pan through the overview display
VIEWER – Opens multiple views of your data, allowing simultaneous views of different scales and extents.

TABLE OF CONTENTS – Adds or removes the TOC from the ARCGIS interface. TOC is where added data resides
ARCCATALOG – Opens the ArcCatalog window within ArcMap.
SEARCH – Opens the search window. Used to search for data, tools etc within ArcGIS and your computer

IMAGE ANLAYIS – Opens the Image Analysis window for working with raster datasets such as aerial photography.

Help Menu

The Help menu interface provides comprehensive Desktop and Internet based help functions for users. The ESRI ArcGIS suite has a rich help section within each desktop application, most help sections include definitions and some tutorials or step by step instructions on how to use the tool. Tools within ArcGIS also have help documenting each option or variable fields within the dialog. You are encouraged to explore some help topics to become familiar with the help section.



HELP MENU
ArcGIS Dektop Help – provides help within the application
ArcGIS Resource Center – provides help linking to ESRI website and online based reference material.
ABOUT ARCMAP – this opens a dialog that displays the versions of the ARCGIS Suite currently installed.

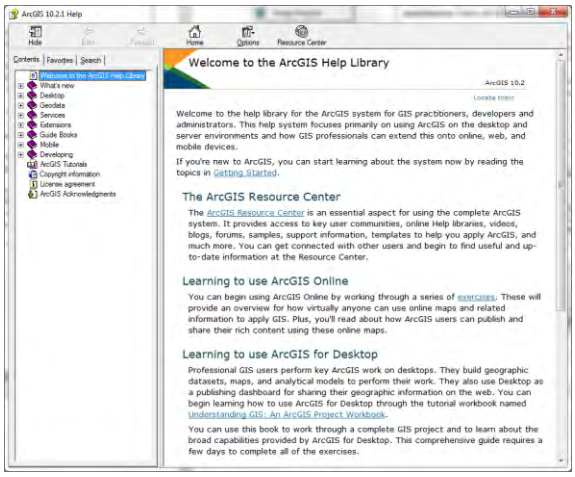
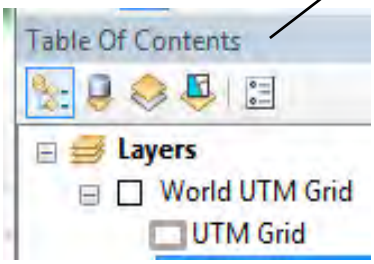


Table of Contents

The Table of Contents window has several icons at the top. These control how you view and control the layers in your map document.



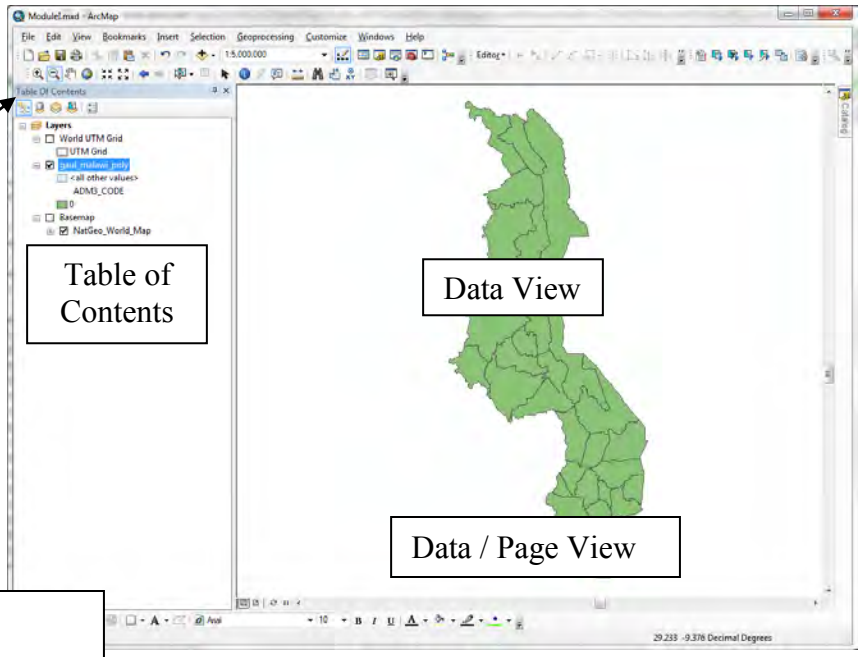


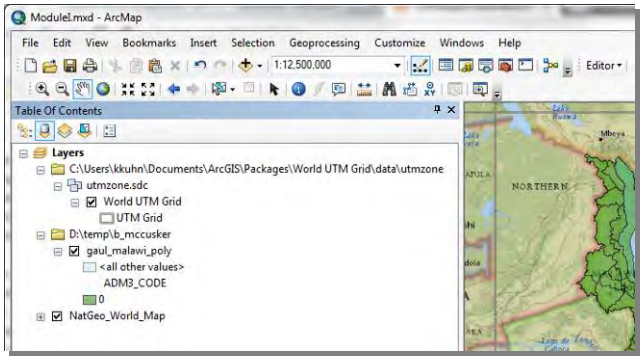
Table of Content

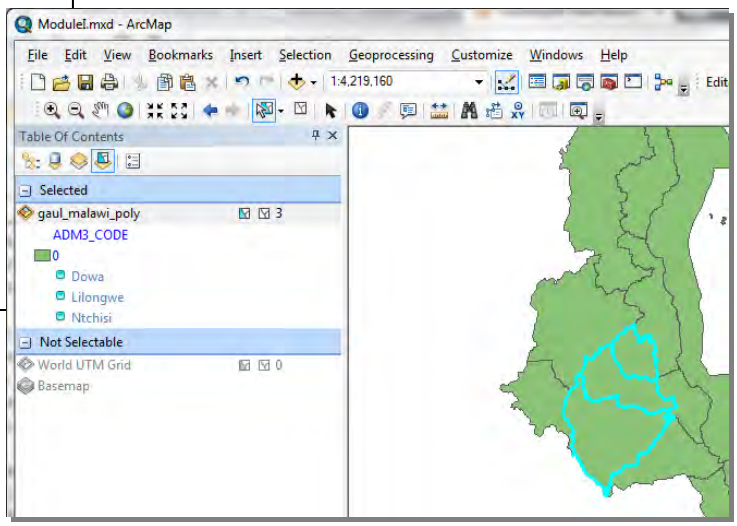
List by Draw Order – shows the layers according to the drawing order displayed in your map. This is the default and most commonly used.

List by Source – shows the layers according to their source workspace. This is useful when editing, to determine which layers share a workspace. (shown to the right)

List by Visibility – shows layers according to their current visibility. This is useful when you are using scale dependent layers.

List by Selection – shows the layers according to whether their features are selectable, and illustrates how many features per theme are selected. (show to the right).





Adding Data

ArcMap begins with a new document, the data view area will be blank. One of the first steps performed when creating a new map document is to add GIS data. This data could be local data that you have previously created, or have been provided, these formats could include shapefiles, geodatabases, tabular data, or others. In addition, data can be sourced from the internet through data providers, or streamed through online data services.

There are two primary methods of adding data to your ArcMap Document.

ArcCatalog: The first method is to use the ArcCatalog Window, browse to your data, and drag and drop the file into your project.

Add Data: The second method is to use the Add Data button.

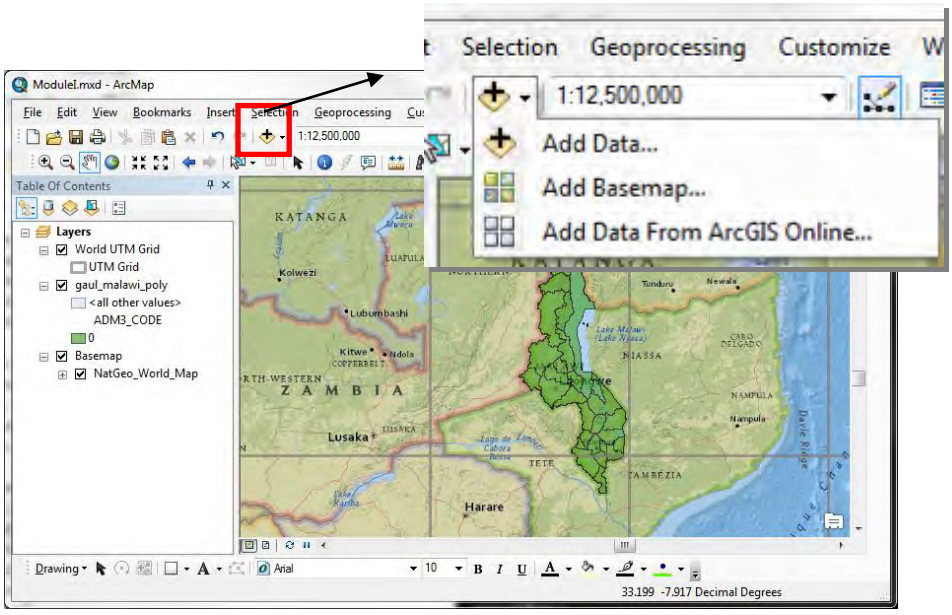
Adding Data:

To add data we use the add data pull down menu which has three commands.

Add Data – opens the add data dialog box, where you can add local data, or connect to a known data server or service.

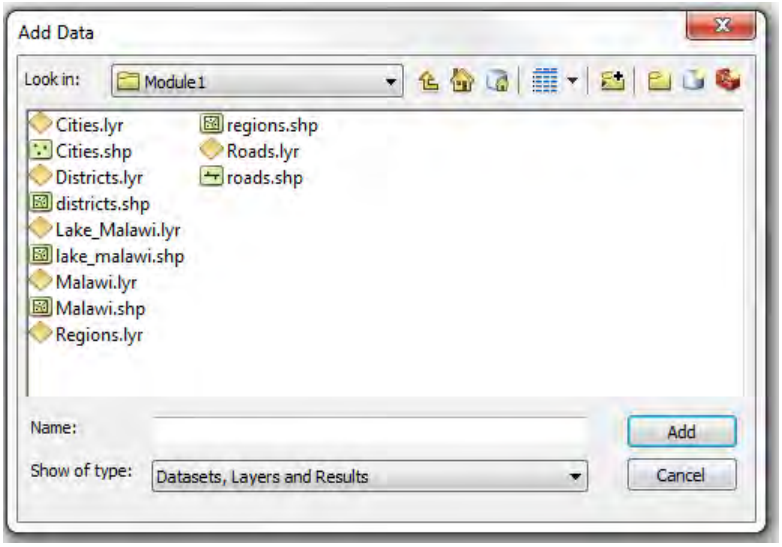
Add Basemap – opens the basemap dialog box, where you can select from a variety of pre-made basemaps published by ESRI and other groups.

Add Data from ArcGIS Online – opens the ArcGIS Online portal, allowing you to browse through numerous basemaps and data services provided by any number of groups.



Hands On Exercise

At this point the user can browse to the GIS data and begin the exersize. Please verify with your instructor the location of your data. For this material, our data will be located on our local C:\training\ folder.



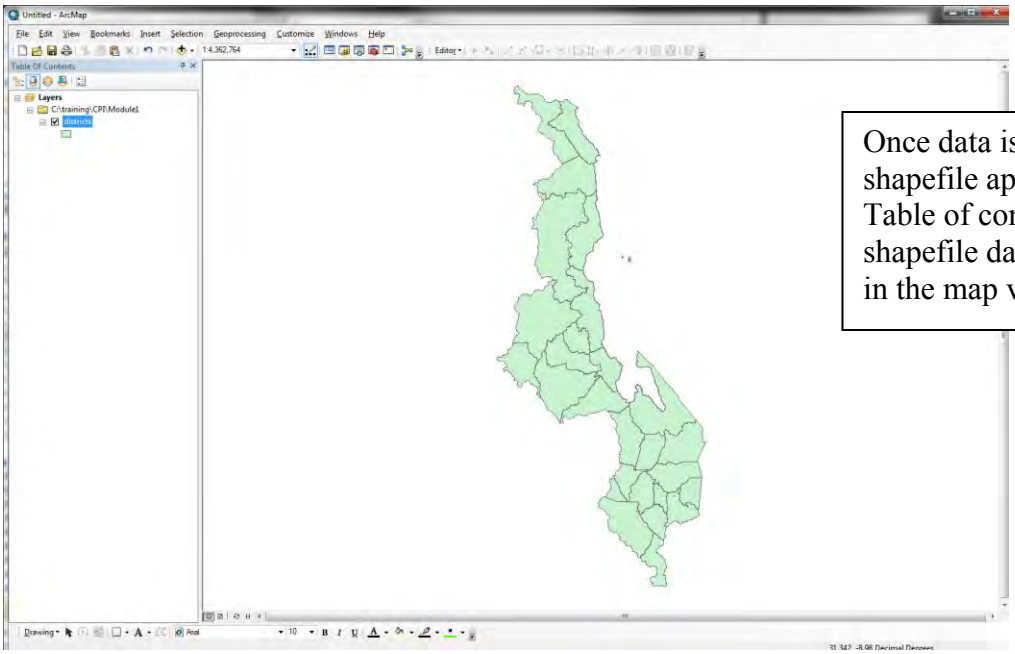
1. Click on the ADD DATA button and browse to the following location:

   C: \training\module1

   Once here we see many different files and symbols that represent Points, Polygons and Lines. Note that the icon representing each geometry type is displayed. Examples for points data is the cities.shp, districts.shp is represented by polygon data and roads.shp are represented as lines. Please note that there are also layer files in this group such as cities.lyr. A layer file contains the information used by ArcMap to represent (symbolize) your data, and cooresponds to the data. It is not specifically required to have, but is a good shortcut when sharing information.

2. Please select the districts.shp file then click ADD (in the lower right hand corner of the dialog box) this will add the data and the dialog box will close.

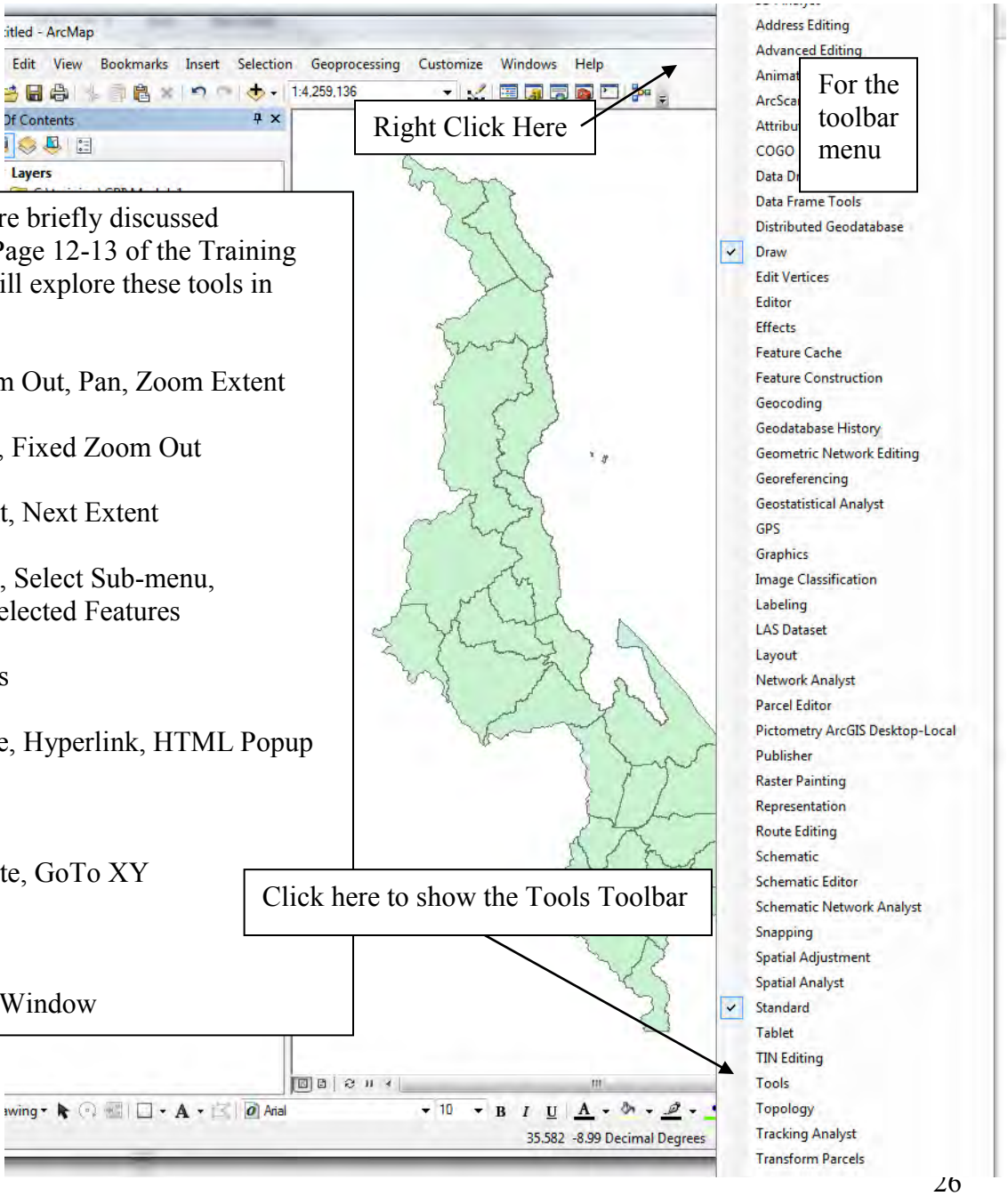
Please note that by holding the SHIFT key down it is possible to select multiple files to add to the ArcMap.



Once data is added the shapefile appears in the Table of contents and the shapefile data is displayed in the map view.

Tools

Now that data is added within our view we can explore the ArcMap interface using the Tools Toolbar (shown below). If you need to add a toolbar, you can always right click on any blank area in the top of the application window, which will access all the toolbars available. The toolbar menu is also available under the Customize>Toolbars menu. ArcMap provides a Tooltip, which gives you the tool name and a brief description of each tool as you hover your mouse over the tool icon.



These tools were briefly discussed previously on Page 12-13 of the Training manual. We will explore these tools in greater detail.

Zoom In , Zoom Out, Pan, Zoom Extent

Fixed Zoom In, Fixed Zoom Out

Previous Extent, Next Extent

Select Features, Select Sub-menu,
Clear Selected Features

Select Elements

Identify Feature, Hyperlink, HTML Popup

Measure Tool

Find, Find Route, GoTo XY

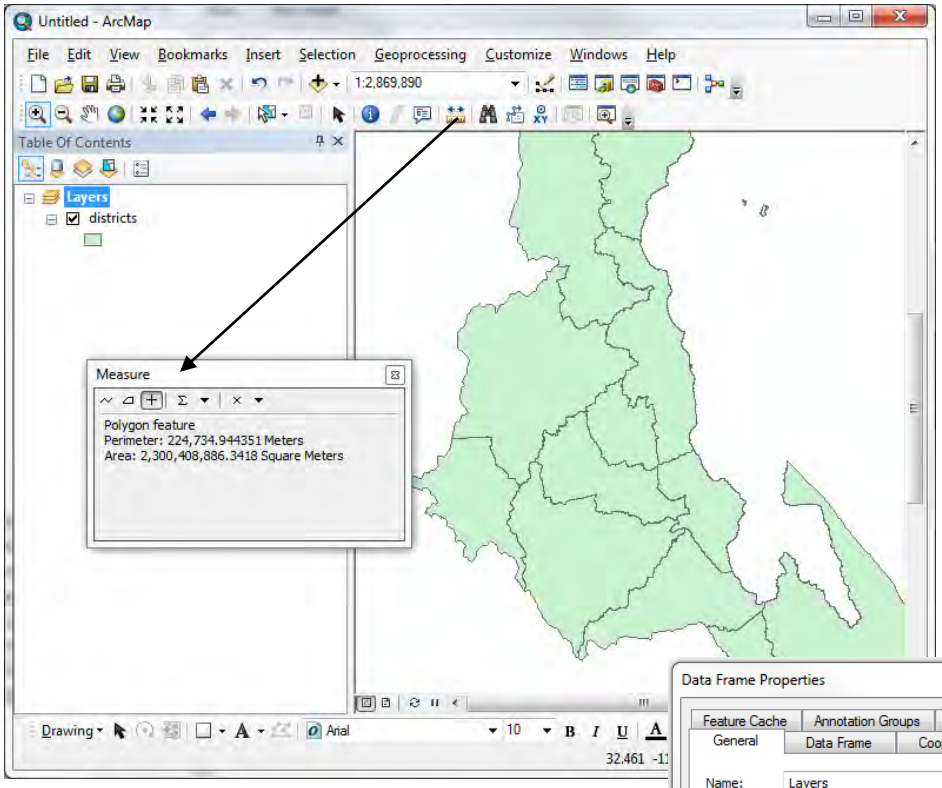
Time Slider

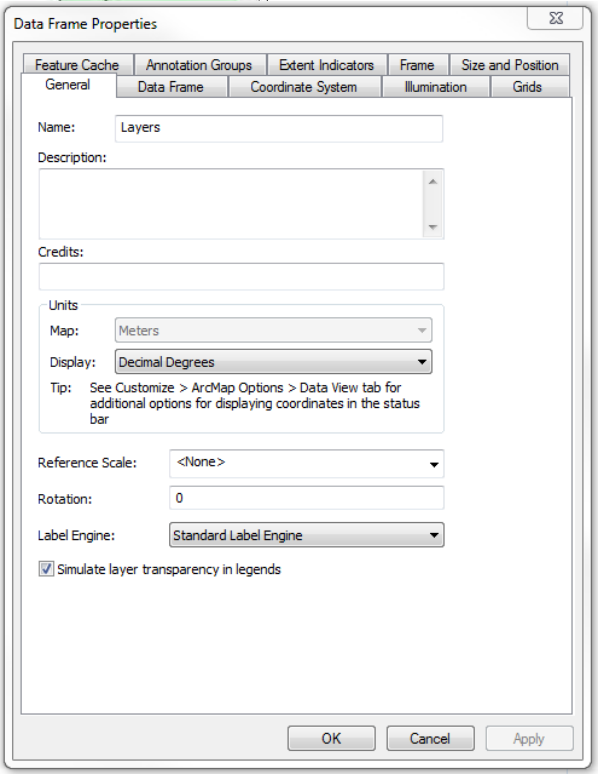
Create Viewer Window

Click here to show the Tools Toolbar

Measure Tool

ArcMap has several ways to measure features. One common way is with the measure tool found on the Tools toolbar. Click on the Measure Tool and it opens a small dialog box, which includes several measure tools. Explore the functions of the measure tools. Note that the results of your measure are displayed in the measure tool dialog. There are ways to measure linear distances, polygon areas or directly measure features. Note, the measure tool depends on having a data frame coordinate system assigned.



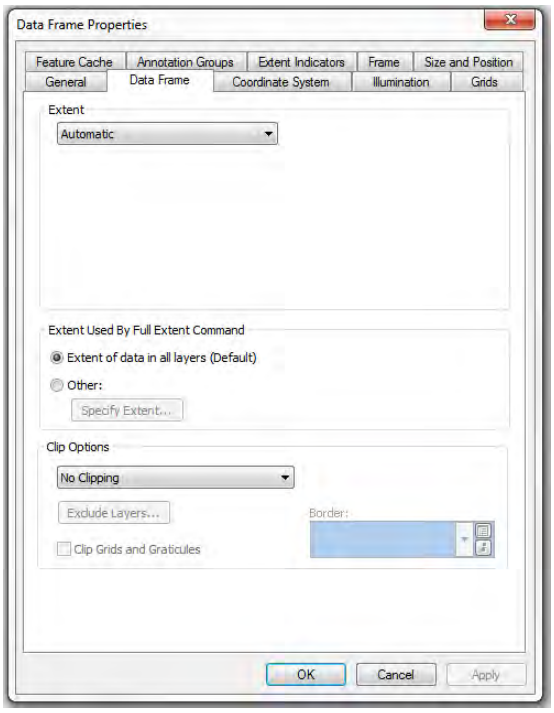


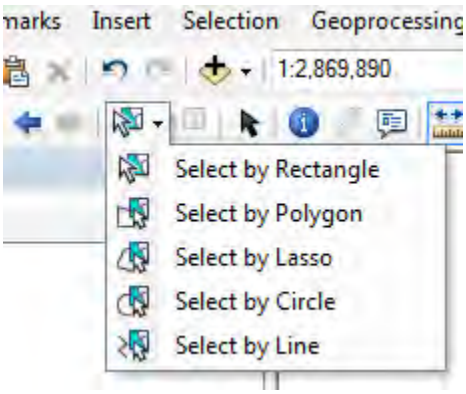
Location Tools

ArcMap has several ways of displaying your location. You will notice that there are coordinates at the bottom right of your main window. These coordinates are displayed according to the projection of your data frame. The Data Frame Properties dialog also has settings to change the display coordinate under the General tab.

Full Extent

The full extent tool permits a user to ZOOM OUT to the fullest extent of the data added into your view. The full extent is also controlled under the Data Frame Properties, Data Frame tab. Here you can specify what you would like the full extent to use, such as a specific layer or custom setting.



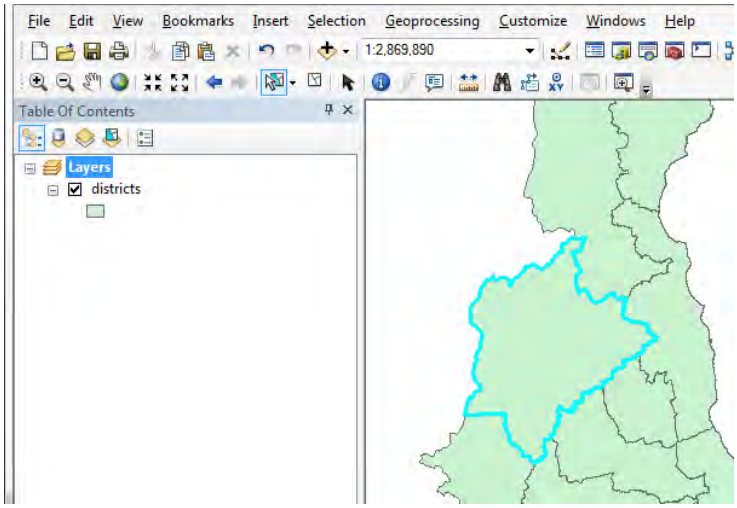


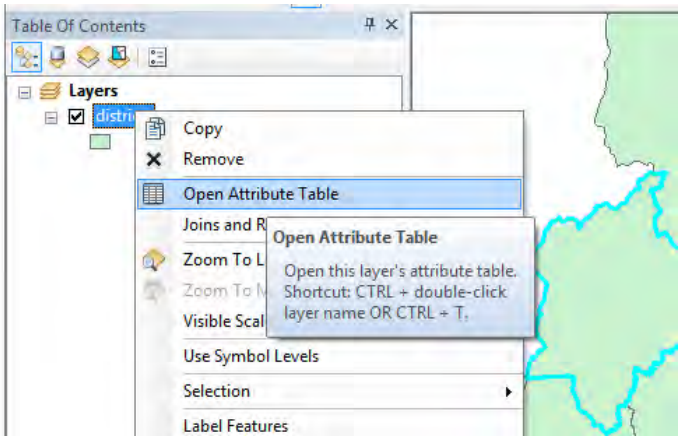
Select

The Select tools are very important to using the tools of spatial data analysis. These tools allow a user to be creative on how they select features. Once a single feature or multiple features are selected, they can be exported as a subset, or be the target of specific geoprocessing operations and many other actions.

3. Choose "Select by Rectangle" and click one of the features on your map.

Note, the feature's shape is now highlighted in cyan.

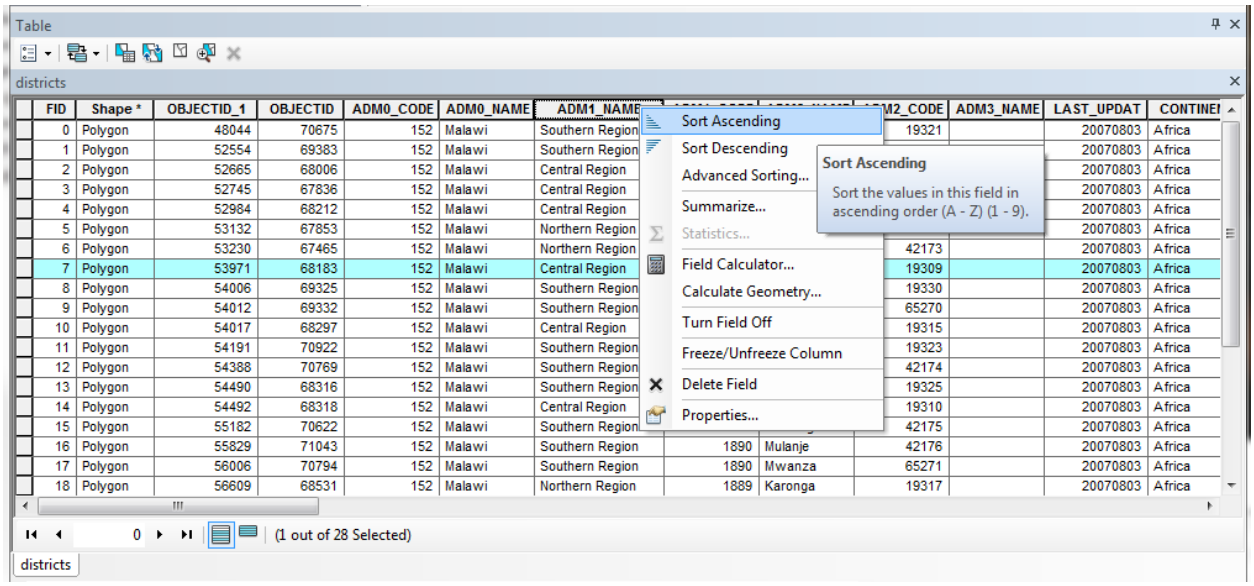




Attribute Table

4. Right click on the "districts" layer in the TOC and click the Open Attribute Table. This will open the districts data attribute table.

Note, the same feature is show selected in the attribute table as was shown in the data view. (as shown in the graphic below). In this table we see the name of the attribute fields (columns) and the associated attribute data values for each feature (rows) within the table.

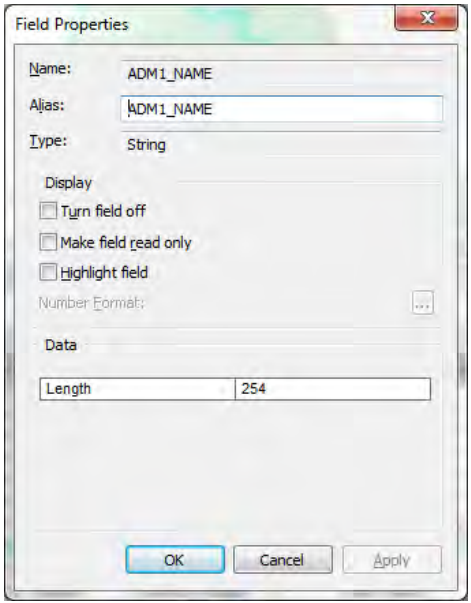


FID	Shape *	OBJECTID_1	OBJECTID	ADM0_CODE	ADM0_NAME	ADM1_NAME			M2_CODE	ADM3_NAME	LAST_UPDAT	CONTINE
0	Polygon	48044	70675	152	Malawi	Southern Region			19321		20070803	Africa
1	Polygon	52554	69383	152	Malawi	Southern Region					20070803	Africa
2	Polygon	52665	68006	152	Malawi	Central Region					20070803	Africa
3	Polygon	52745	67836	152	Malawi	Central Region					20070803	Africa
4	Polygon	52984	68212	152	Malawi	Central Region					20070803	Africa
5	Polygon	53132	67853	152	Malawi	Northern Region					20070803	Africa
6	Polygon	53230	67465	152	Malawi	Northern Region			42173		20070803	Africa
7	Polygon	53971	68183	152	Malawi	Central Region			19309		20070803	Africa
8	Polygon	54006	69325	152	Malawi	Southern Region			19330		20070803	Africa
9	Polygon	54012	69332	152	Malawi	Southern Region			65270		20070803	Africa
10	Polygon	54017	68297	152	Malawi	Central Region			19315		20070803	Africa
11	Polygon	54191	70922	152	Malawi	Southern Region			19323		20070803	Africa
12	Polygon	54388	70769	152	Malawi	Southern Region			42174		20070803	Africa
13	Polygon	54490	68316	152	Malawi	Southern Region			19325		20070803	Africa
14	Polygon	54492	68318	152	Malawi	Central Region			19310		20070803	Africa
15	Polygon	55182	70622	152	Malawi	Southern Region			42175		20070803	Africa
16	Polygon	55829	71043	152	Malawi	Southern Region	1890	Mulanje	42176		20070803	Africa
17	Polygon	56006	70794	152	Malawi	Southern Region	1890	Mwanza	65271		20070803	Africa
18	Polygon	56609	68531	152	Malawi	Northern Region	1889	Karonga	19317		20070803	Africa

By looking at the bottom of the table we can see that we have selected 1 out of 28 Selected (referring to 28 total features in the district dataset, and 28 corresponding records in the table). As well, we can look at either ALL the records or just those SELECTED by using the toggle.

Sort Field - right clicking on the column Field (Attribute) name we can Sort data either Ascending, Descending, or the Advanced Sorting will allow you to sort using multiple columns. The field context menu also will allow you to quickly Summarize the data in a field, hide an attribute field by turning it off, freeze columns to facilitate large table viewing, delete selected attribute fields and calculate new values for attribute fields.

Field Properties – The Properties button permits a user to see the Properties for the selected attribute field (Length, type including short or long integer or text field, etc). Note that each field has a Name and Alias. The Alias can be used by the user for a more descriptive field name, that is more restricted in the actual Name Field.



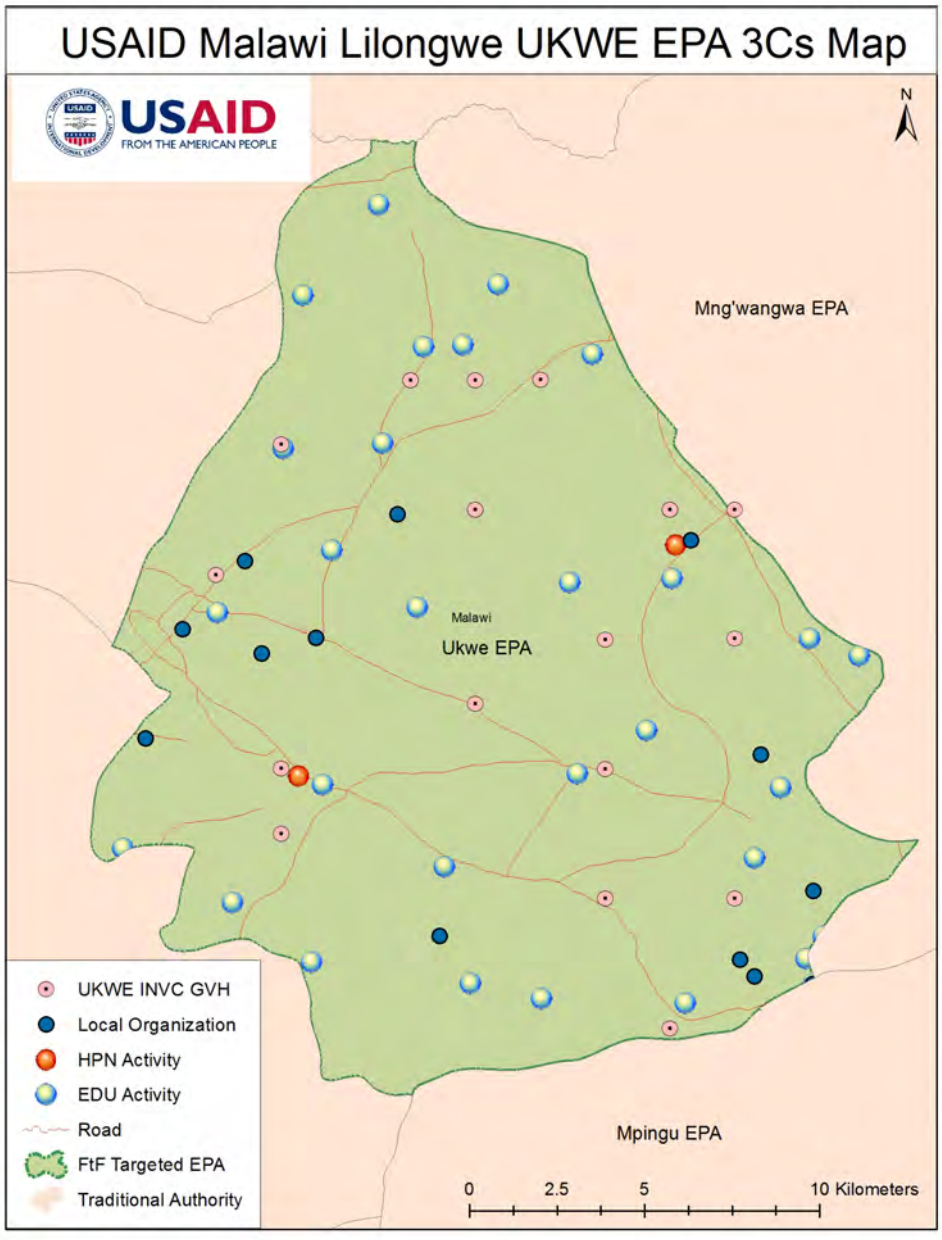
Module 1 Wrap Up

Now that we have gone through the ArcCatalog and ArcMap interface, you have seen the basic functions and locations of menu items. You should feel familiar with the general application commands, but do not need to remember all functions. Rather, it is important to know how to access the help and use ToolTips until you are very familiar with the software.

Please note it is important to be patient while using the software. Be proactive and start to explore different utilities on your own as you begin to learn the ArcGIS environment. Use a copy of real data to experiment with. Becoming familiar with the ArcGIS software, its tools and functionality, as well as the data structure will facilitate your understanding of not only the software, but the data you will be working with. In the end, your ability to use GIS will enable you to be more productive, efficient and effective in your data analysis and visualization.

Looking Ahead
Module II which will work in depth to explore adding national and regional datasets and working with data symbology. We will create both an ArcMap document using a map to illustrate socio, political and program activities, and link program activities with monitoring and evaluation indicator data.

Geographic Information Systems Training Module 2



ARC GIS 10.x Geographic Information Systems and GPS Training Guide

Developed by Stephen P. Menard Jr, USAID/Malawi
Program Officer - Original training modules for ArcGIS
9.3 completed in March, 2009
Revised for ArcGIS 10.2 by K. Kuhn, February 2014

Module II: Working with ArcMap

In order to build capacity and understanding of ArcGIS and its functionality, Module II will focus on adding data, changing symbology and discussing some of the important aspects behind cartography required to produce professional maps for projects.

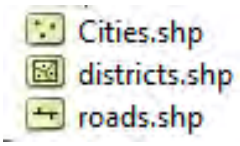
PLEASE NOTE: DATA PROVIDED IS FOR TRAINING PURPOSES ONLY and SHOULD NOT BE USED OUTSIDE THE SCOPE OF THIS TRAINING MATERIAL.

Basic Terms: Shapefiles, Datasets, and Layers -

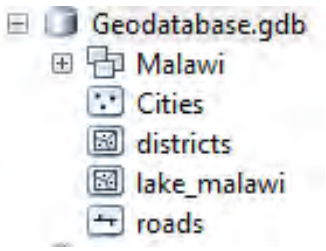
Learning to use ArcGIS depends upon using and understanding the correct terminology. It is important to try to distinguish between the above terms. This will aid in communication between instructors and students, as well as allow you to look up problems in the help section. While there will be many new vocabulary words associated with using GIS, the following key terms will help get you started. It is important to understand the difference between shapefiles, datasets and layers.

Dataset: a generic term that describes a single or multiple data formats that share a common theme. This could refer to a shapefile or geodatabase, with one feature class or many. An example could be the dataset used in this training, which includes roads, cities, regions of both shapefiles and geodatabase feature classes, where all have a common theme of Malawi.

Shapefile: a specific format used to store data consisting of a single feature geometry type. This is generally referred to as a featureclass or dataset. An example may be the roads.shp Shapefiles are symbolized in ArcGIS by the green icons, as shown on the right. Note that the geometry type is also shown, points, polygons and lines.



Geodatabase: a specific format used by ESRI to store data of all types. Geodatabases can store both vector Feature Classes, Feature Datasets, raster data, tabular data and much more. These are symbolized by an icon that resembles a silver tin can…shown as "Geodatabase.gdb"

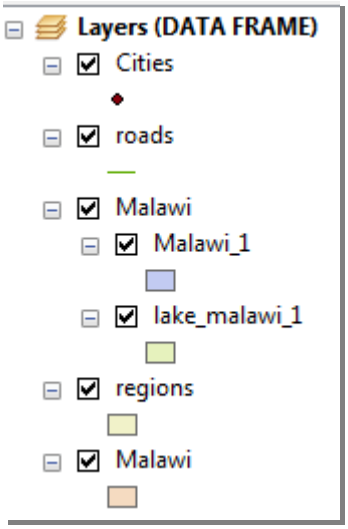


Feature Dataset: a specific term used to describe a collection of feature classes within a geodatabase that shares a common coordinate system. (Shown to the right as "Malawi"

Feature Class: a specific term used to describe a dataset specific to one format, specific to one geometry type. Often shorthand for a Geodatabase Feature Class, however it is correct to use feature class to refer to a single shapefile. It is represented by the silver icons, like the shapefile, representing points, polygons and roads.

Data Frame: a specific term, which is the way in which ArcMap organizes and contains all of your maps layers. You may add multiple data frames to your map to create inset or overview maps. By default, it is called "Layers". (yes, that is slightly confusing). It is shown to the right as "Layers (DATA FRAME)".

Layer: a specific term used in ArcMap to denote a reference to a single dataset. This is used to set all properties of how a specific dataset is represented in ArcMap. A Layer can only reference a single featureclass, but a single featureclass can be represented by multiple layers. There are many layers shown to the right, such as Cities, roads…



Create a New Map Document

You will create a new ArcMap Document and load some data that has been provided to you.

1. Open a new session of ArcMap. (You can click cancel to close the "Getting Started" dialog, if it opens.) By default, ArcMap begins with a new, empty Map Document.

2. Once your new document has opened, click on the ADD DATA Button: 

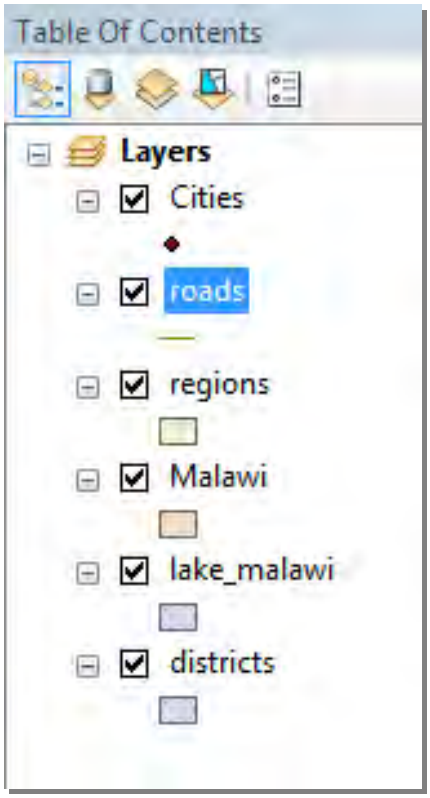
Then navigate to the following location: **C:\Training\Module2**
(Hint, use the connect to folder button if necessary.)

3. Add the following data layers:
   a. regions.shp
   b. Cities.shp
   c. malawi.shp
   d. roads.shp
   e. lake_malawi.shp
   f. districts.shp
   g. Eas_bnd.shp

Working with Layers

Once the layers are added, you will notice that the layers are placed into the table of contents (TOC) in a specific order: They are organized in the TOC by geometry type: Point features are on top of Line features, which are on top of Polygon features (and would be on top of raster datasets).

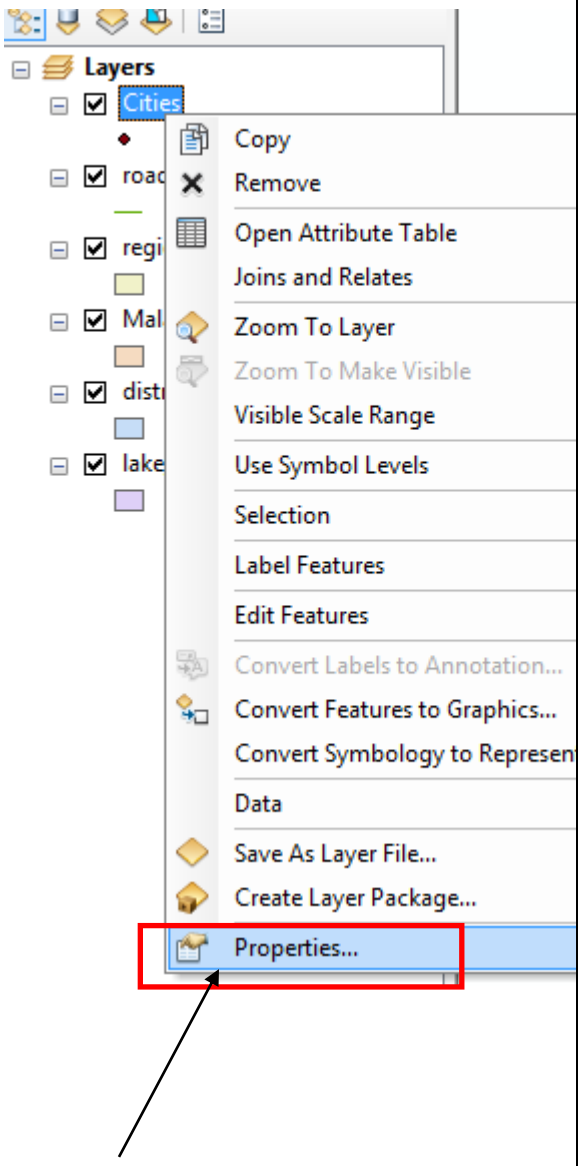
This is important to understand, because ArcMap draws the layers according to their position in the TOC. Experiment by dragging the layers above each other and notice the change in the maps appearance.



Note that your ArcMap document does not contain or store data, rather it only refers to the data you are using. When you "Add Data" to your map document, you are only adding a reference to the original data source.

Context menu: ArcGIS uses both left and right mouse buttons for a variety of commands. A common command used throughout ArcMap and ArcCatalog is the use of a context menu. A context menu is a menu that changes dependent upon where you click the mouse. This applies to both the application interface and within the Data View /Page Layout View. You will notice different options in context menus, including differences between vector and raster datasets.

4. RIGHT CLICK on the Cities layer to bring up the context menu. (as shown below)



1. CLICK on Properties

Layer Context Menu

COPY – Copies the layer
REMOVE – removes the layer– (does not delete the data permanently).
OPEN ATTRIBUTE TABLE – opens the attribute table of a layer
ZOOM TO LAYER- will zoom to the full extent of the layer
ZOOM TO MAKE VISIBLE – will allow you to zoom to a layer depending on the scale dependancy
VISIBLE SCALE RANGE allows a user to set a scale range for a layer to be visible at certain scales and turned off at others
USE SYMBOL LEVELS – allows for advanced control of the layer symbology displayed (please see the HELP for additional information).
SELECTION- Provides functions for selected features
LABEL FEATURES – Toggles the layers labels on and off, according to the label properties (set in the layer properties menu)
Edit Features- begins an editing session targeting the selected layer's data.
Convert Labels to Annotation – converts dynamic labels to static annotation.
CONVERT FEATURES TO GRAPHICS – allows a user to save the layer features as graphics.
CONVERT SYMBOLOGY TO REPRESENTATIONS -
DATA – Provides several options for exporting data into a new shapefile, creating metadata, etc.
SAVE AS LAYER FILE – Allows a user to save a shapefile symbology that has been edited and changed.
PROPERTIES – By far the most important function. To be discussed in detail below

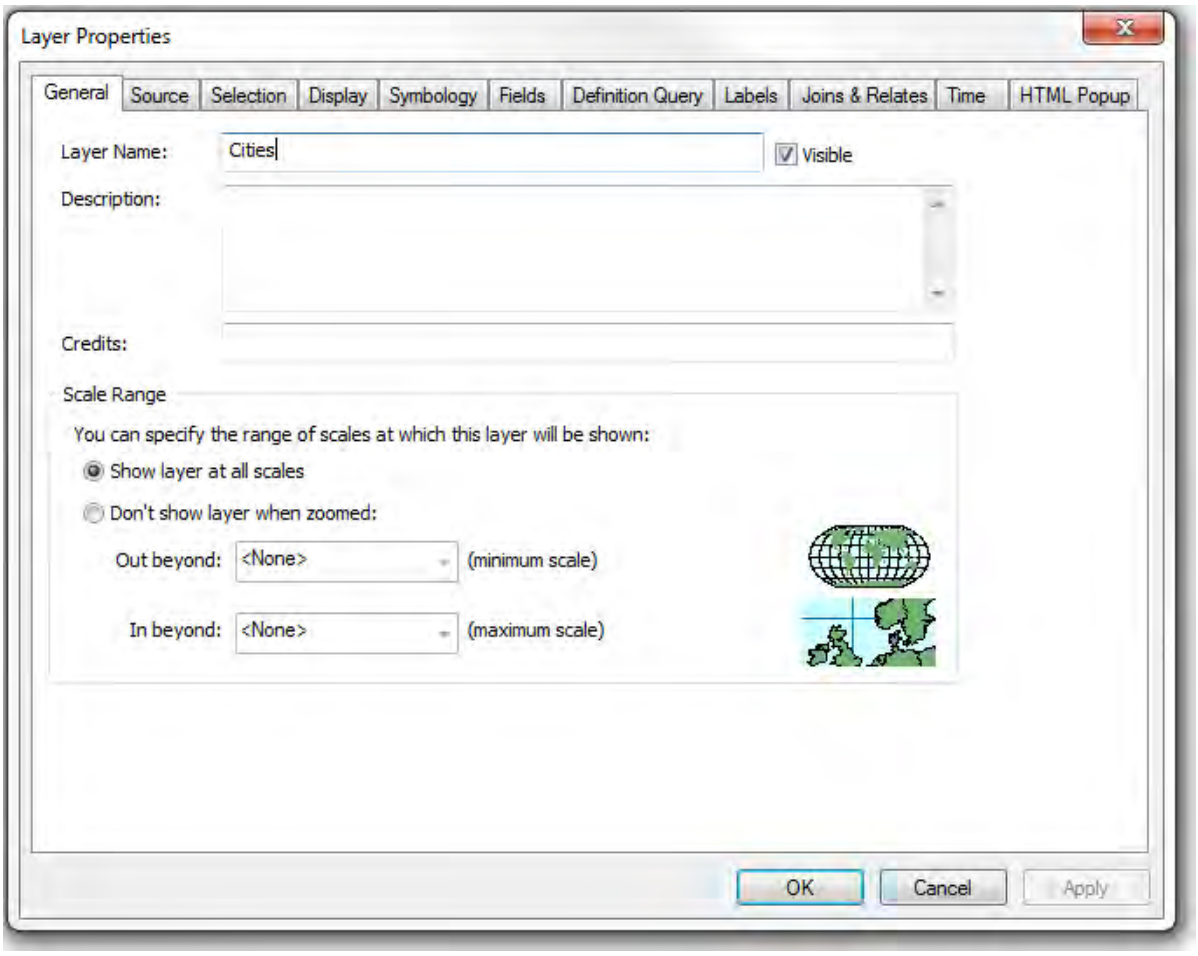
Layer Properties –

The Properties command opens up the Layer Properties dialog box. This dialog box (very important) controls many aspects of the layer properties, such as appearance, it's symbology, transparency, scale dependency, labeling and many others. Being familiar with this menu and it's main tabs will be helpful when creating a map.

Layer Properties – General Menu

This menu controls; the layer name of the dataset, turn the layer on or off (Visible), provides space for Description and Credits, Sets a scale range (makes the layer scale dependent)

Note that changing the layer name here is the same as in the Table of Contents, and does not change the name of the source data.

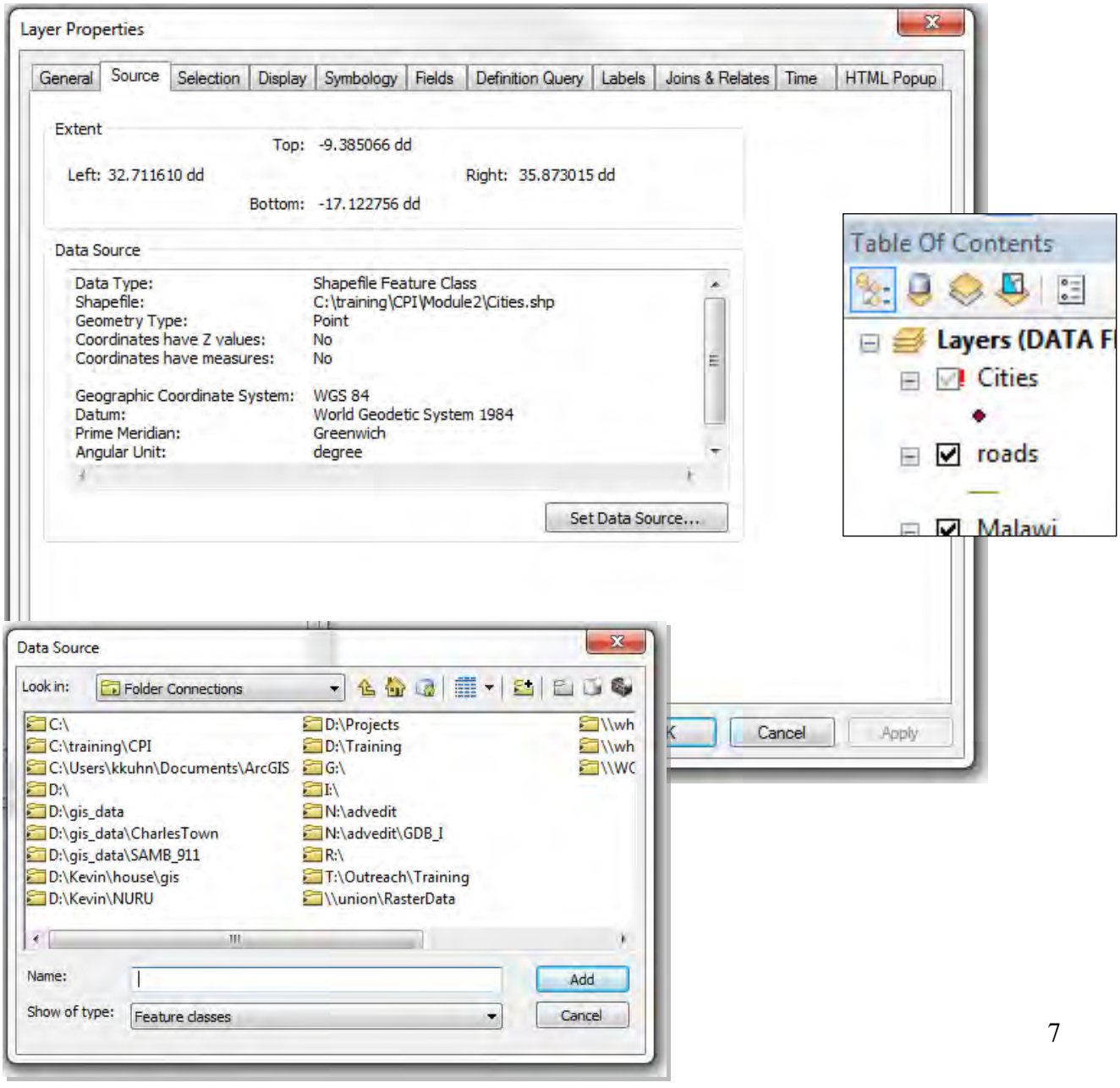


Layer Properties – Source Menu

The Source menu allows a user to see the bounding extent of the layer. It provides information on the location of the data on the user's hard drive or server. It provides information on the geometry (point, line or polygon) and the Coordinate System. In the example below, the coordinate system is defined as WGS84, which is World Geodetic System, which is a geographic (un-projected) coordinate system.

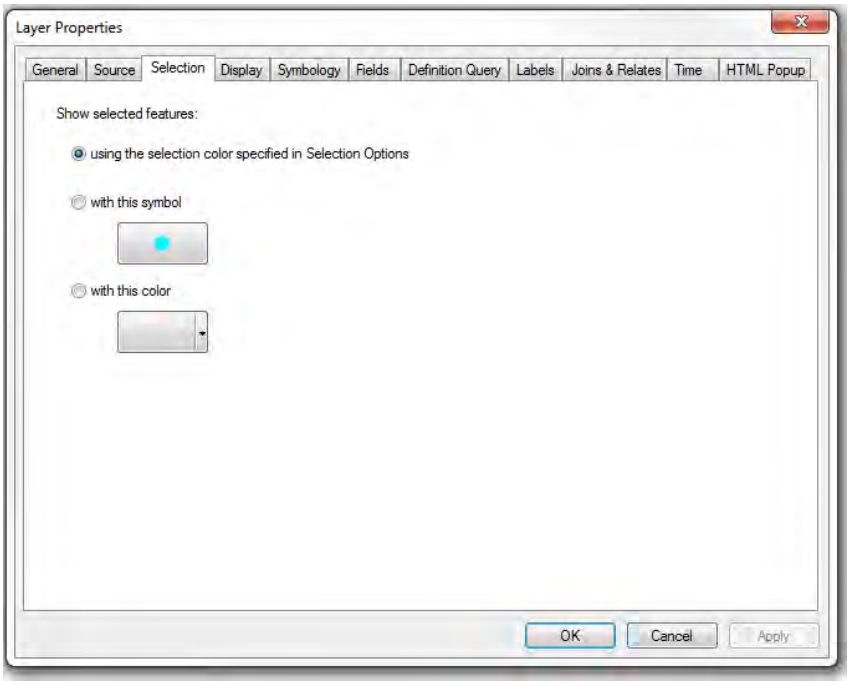
Repair Data Source: The Source menu permits a user to set the data source for the layer. For example; if the layer references a shapefile that is moved or deleted, it will no longer display in the map.

This is referred to a broken link and is symbolized by ! adjacent to the layer name in the table of contents. (as shown below and right). The SET DATA SOURCE command allows a user to browse to the shapefile and repair the link between the layer and shapefile.



Layer Properties – Selection Menu

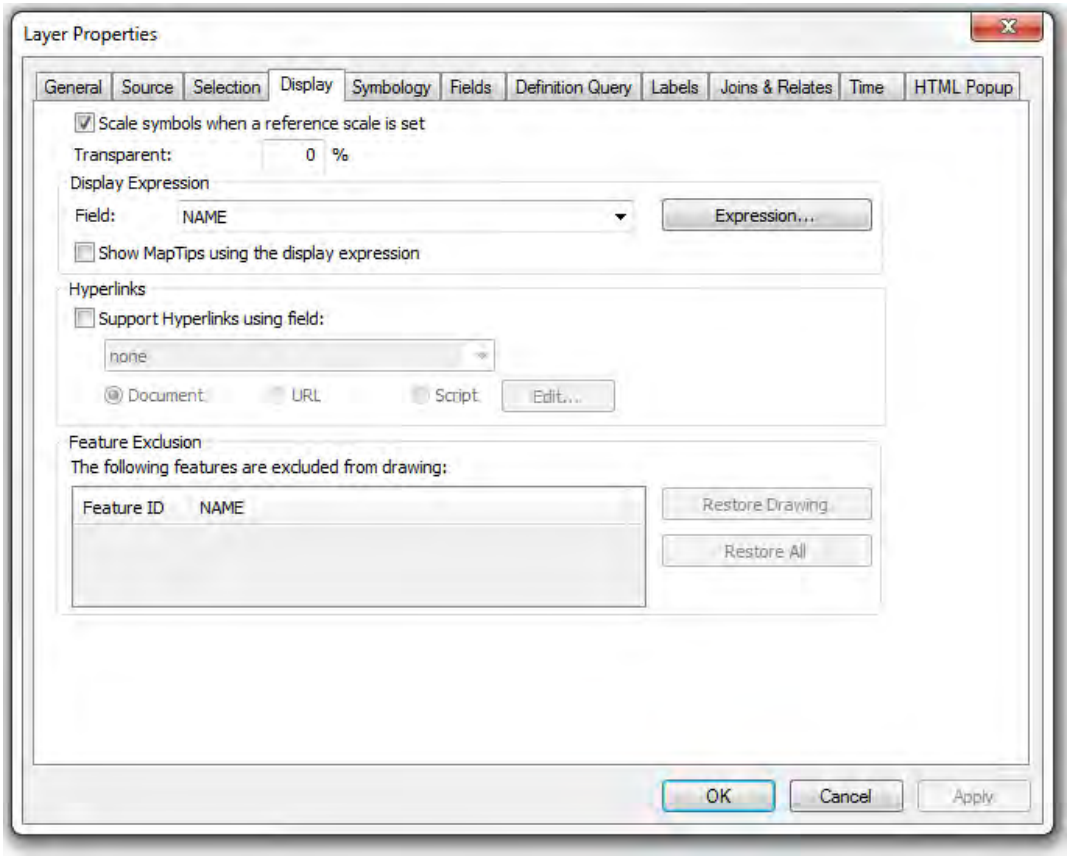
This menu permits a user to change the symbol and color used for displaying selected data



Layer Properties – Display Menu

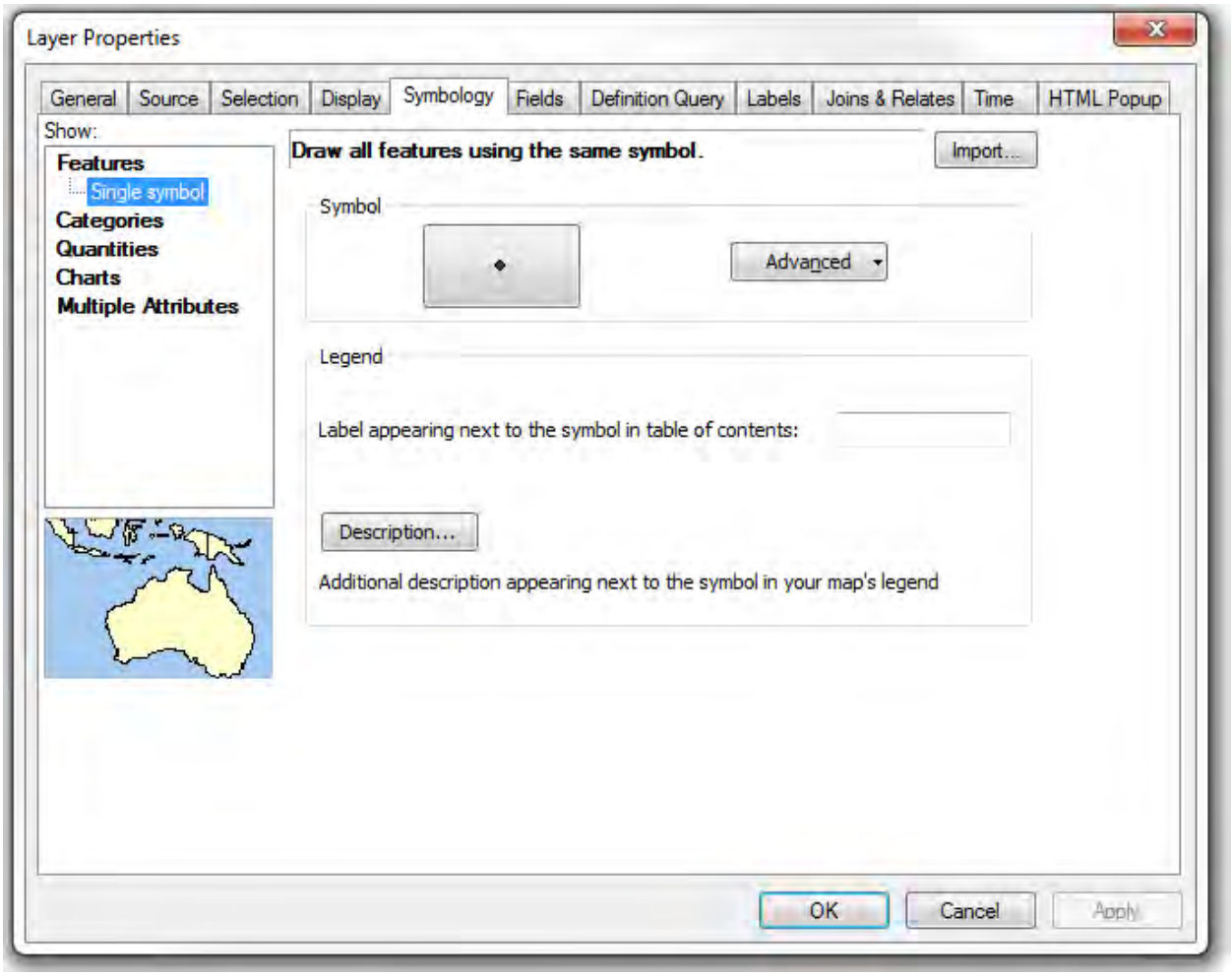
The Display menu controls the scale symbols for a reference scale, as well as the layer Transparency.

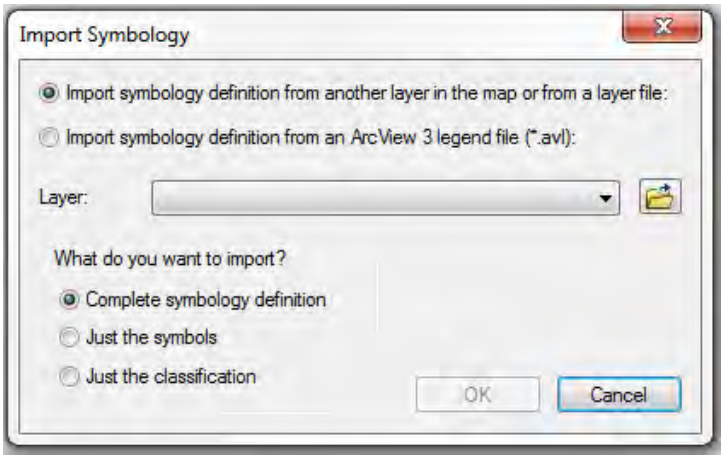
The Display menu allows you to use **Map Tips.** Map Tips function similarly to Tool Tips, but target the data layers, not tools. Turn on Map Tips for a layer and hover over a participant feature and a small label will be presented until you move the cursor. You can also set **Hyperlinks** to allow a field in your data to be used to open hyperlinks, using the hyperlink tool. and allows a user to make data layers transparent up to 100% or use a query function to exclude specific data from display.



Layer Properties – Symbology Menu

The symbology menu is one of the most important menus that will be used. This menu provides various methods for representing your data such as a SINGLE FEATURE, CATEGORIES or UNIQUE DATA, which can be based on attributes, QUANTITIES (ranges of data) based on numeric attribute field, as CHARTS or to display multiple data at one time.

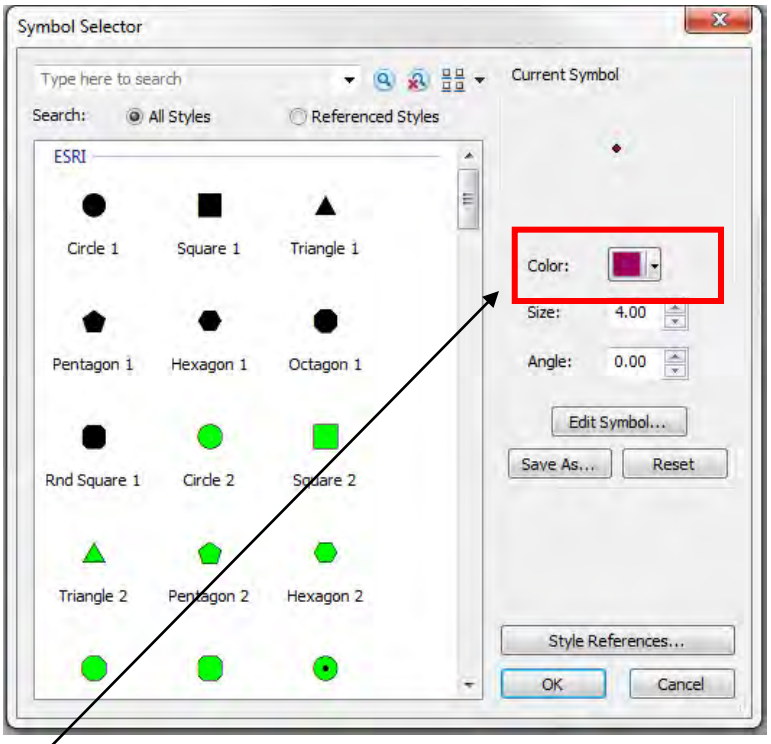




The IMPORT symbology button allows the user to import an Arcview 3x legend file .avl or can apply the symbology from a layer within the TOC or can use symbology from a Layer file.

Above on the SYMBOLOGY menu we see that the **SINGLE SYMBOL** is selected. By clicking on the symbol, a new dialog box will open.

2. CLICK on the SYMBOL



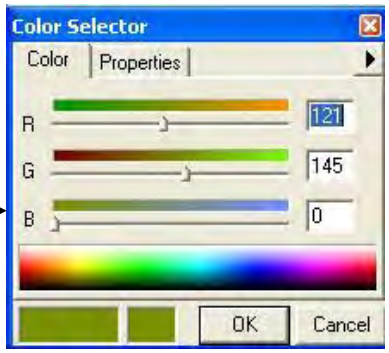
Here a user can select from many different types of symbols and colors.

New symbols can be added through the MORE SYMBOLS button which prompts a user to select different symbol themes which will then populate the symbols with new symbol layers.

PROPERTIES allow a user to change the properties of symbols that are a combination of shapes or colors and to create new symbols.

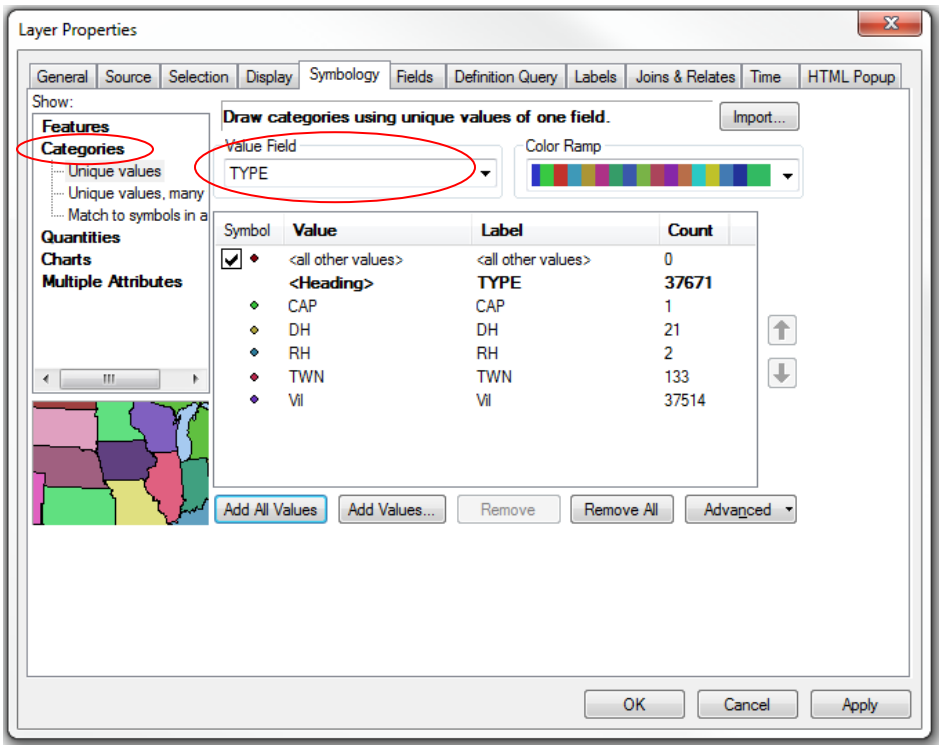
As well the color of symbols can be changed by clicking on the color option, as well for Polygon fill and outline colors can be changed and there are many different types of symbols for points, lines and polygons that can be chosen.

Select the color you want or use the MORE COLORS function to create a new shade based on actual RGB values.



3. CLICK on the show **CATEGORIES** option

The Categories option permits a user to display data based on the unique attributes available in the associated data attributes.



4. Choose **Unique values** under CATEGORIES
5. Under the Value field choose a data attribute field to base the unique value – in this case we chose the field called [TYPE].
6. Now we can Add All Values –When you push this button, ArcMap searches for unique values and adds them to the list to be symbolized. Note that the you are able to specific a label for each group of features. In addition, you have a count of the number of features that are in each group.
7. Note; Adding all values can slow down your computer if you are working with a large dataset.
8. We can apply a color scheme to use for our unique symbols by selecting an option from the color ramp.
9. There are additional options here in this dialog and you should experiment with them to see their effect on how it represents your data, or changes your table of contents.

10. After you are satisfied with a symbology, CLOSE the symbology box.

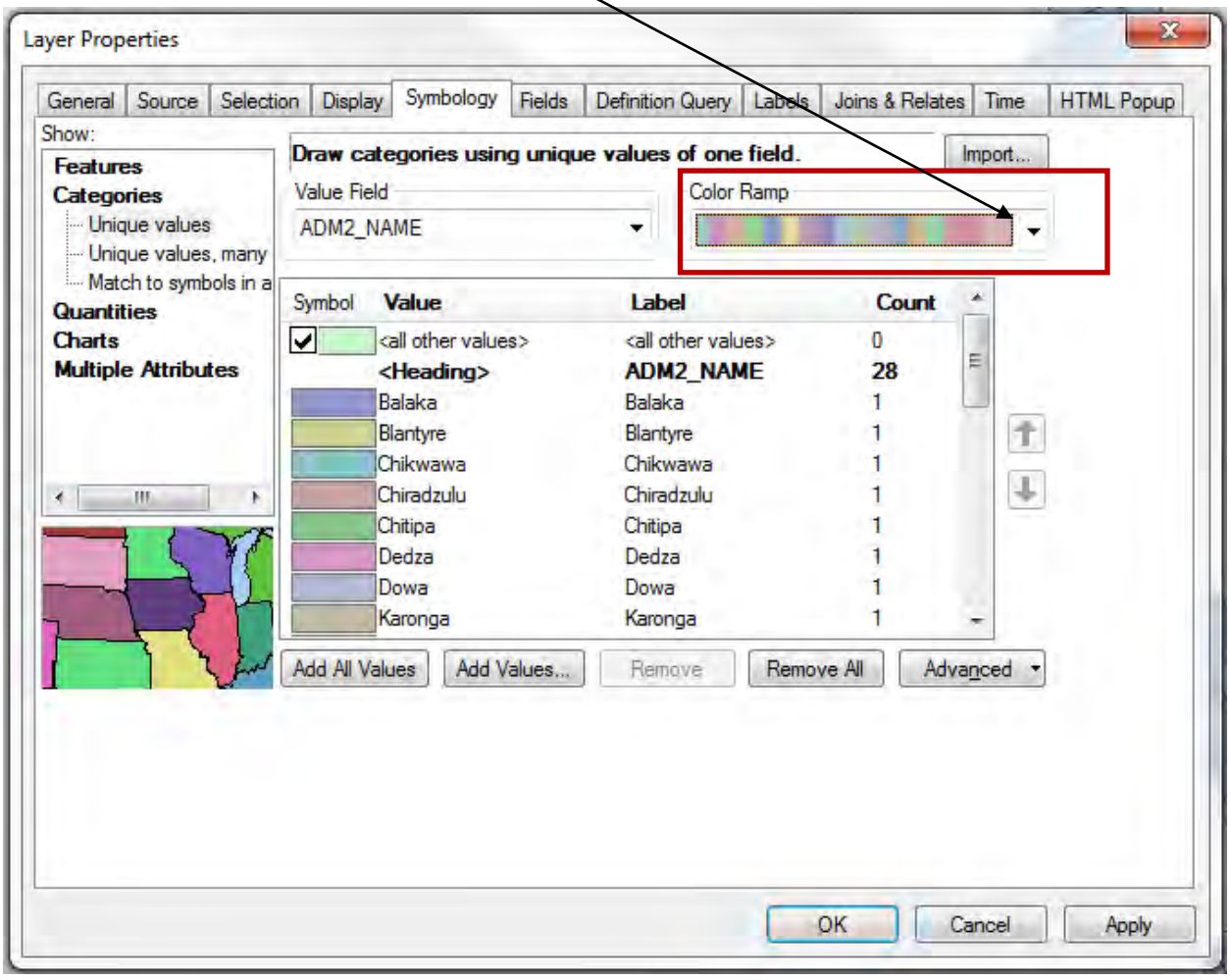
We will now symbolize the districts layer.

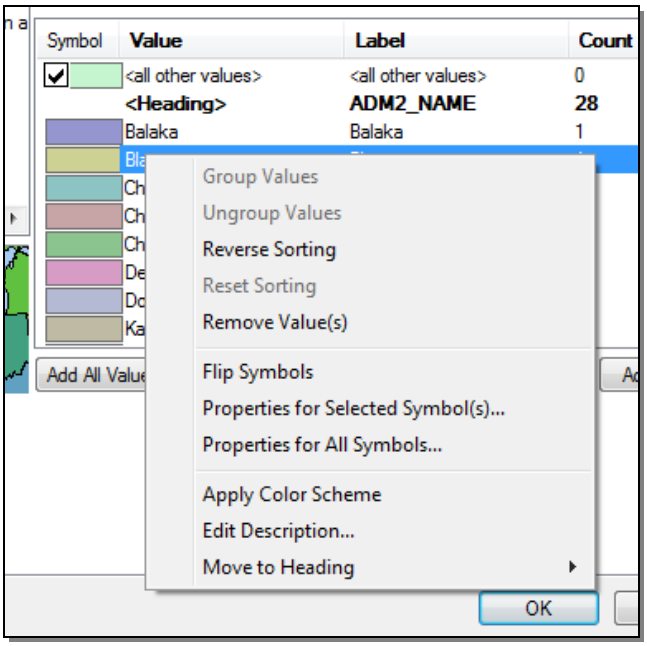
11. Go to the districts layer symbology menu (in the Layer Property menu)

    a. Open the Layer Properties dialog
    b. Select the Symbology Tab
    c. Select Categories – UNIQUE VALUES
    d. Under the Value Field choose ADM2_NAME
    e. ADD ALL VALUES

Your dialog box should now look something like the image below:

    f. Click on the Color Ramp



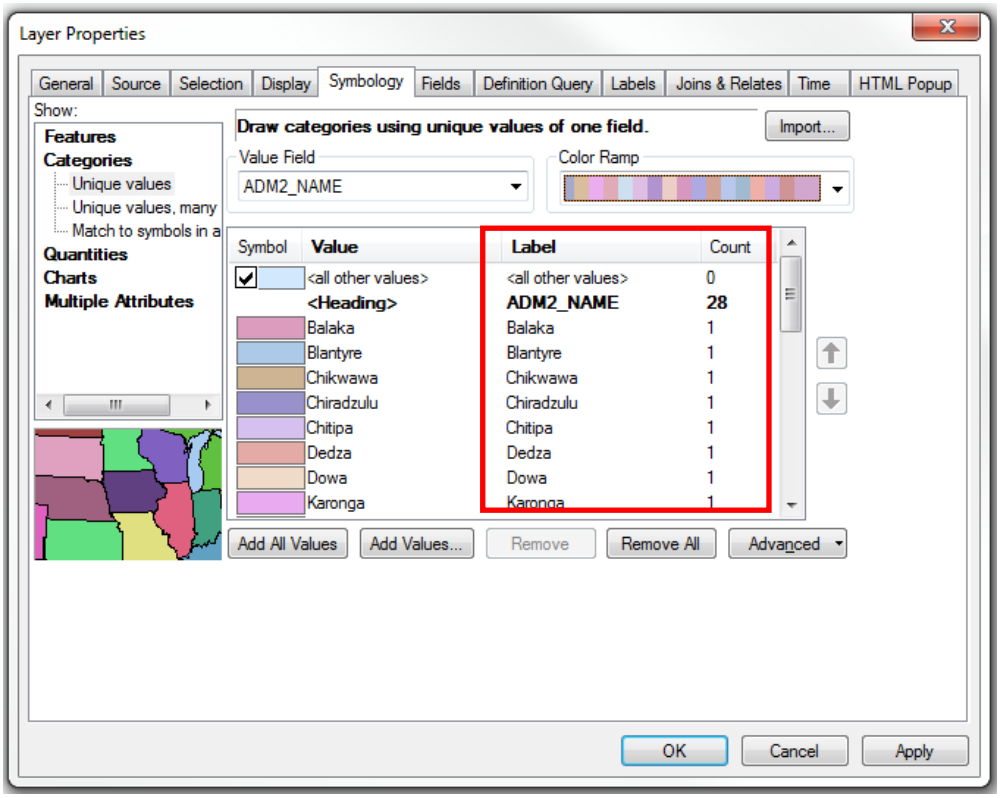


Once you CLICK on the Color Ramp you will be able to select from a variety of color patterns or color ranges.

By right clicking on a symbol another dialog box will open that allows a user to reverse the order of sorting, remove a data attribute value, flip the symbol order and set the Properties for selected or all symbols at once.

Once done hit the OK button to see changes take effect or to continue to edit hit APPLY to apply changes and exit the dialog box.

Under the Label section a user can change the label value that will be presented in the TOC and in the Map legend. (this will be created later on in the Map layout). The count tells a user how many polygon features are (in this case one per district name).



Don't forget, unique symbols allow a user to vary the color of the symbol for each record based upon a given attribute. For example, you could assign different colors to display each administrative unit by Region, Department, Arrondisement or Rural Community.

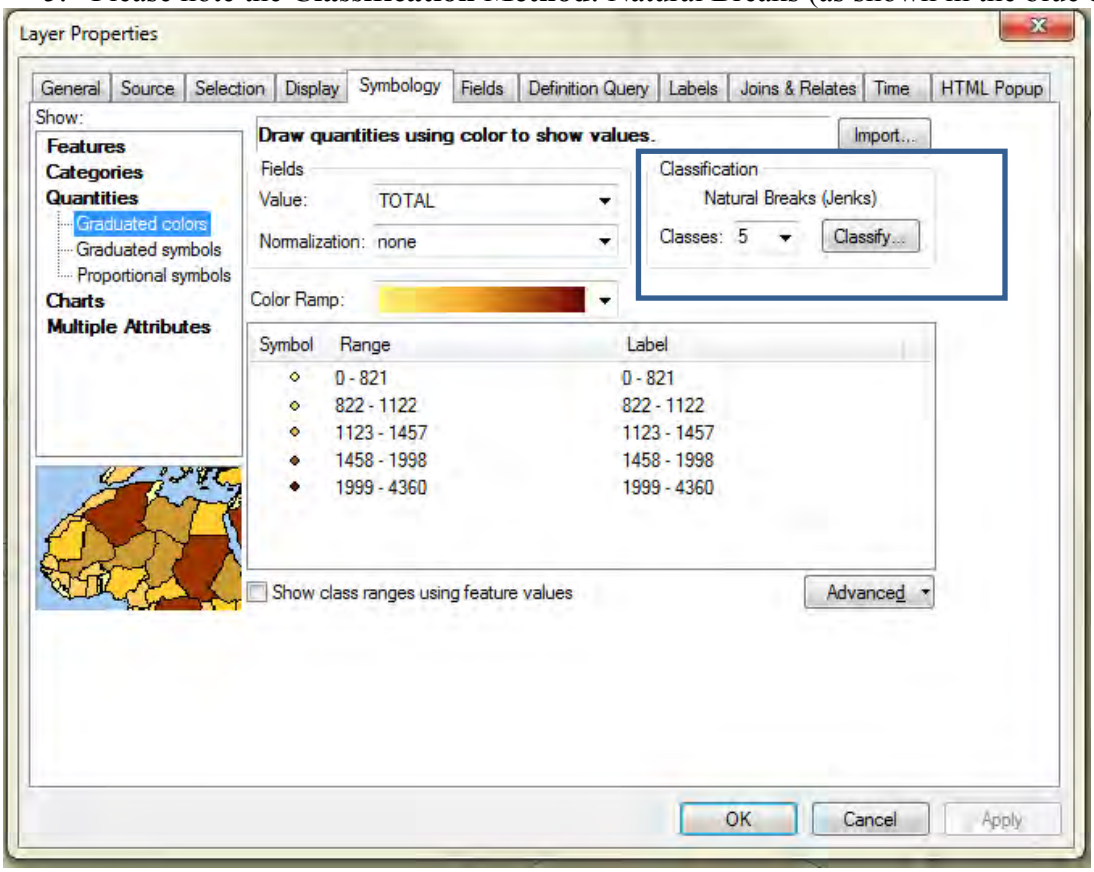
12. Select a color palette and close the layer properties menu.

Quantities allow a user to display data through a graduated display function. Graduated symbols allow you to vary the color and size of the symbol based upon one of the attributes associated with the layer. For example, you could use this feature to label activity grants to show grant value, or to display the numbers of beneficiaries per activity site, teachers or students per school or to show population ranges for villages, or quantities of food in warehouses. As you can see there are many different uses for this display function.

In the example below we will look at displaying population data for cities.
(PLEASE NOTE: THIS DATA IS FOR TRAINING PURPOSES ONLY, and MAY BE SAMPLE DATA CREATED ONLY FOR THIS TRAINING)

Symbolize Points - Cities

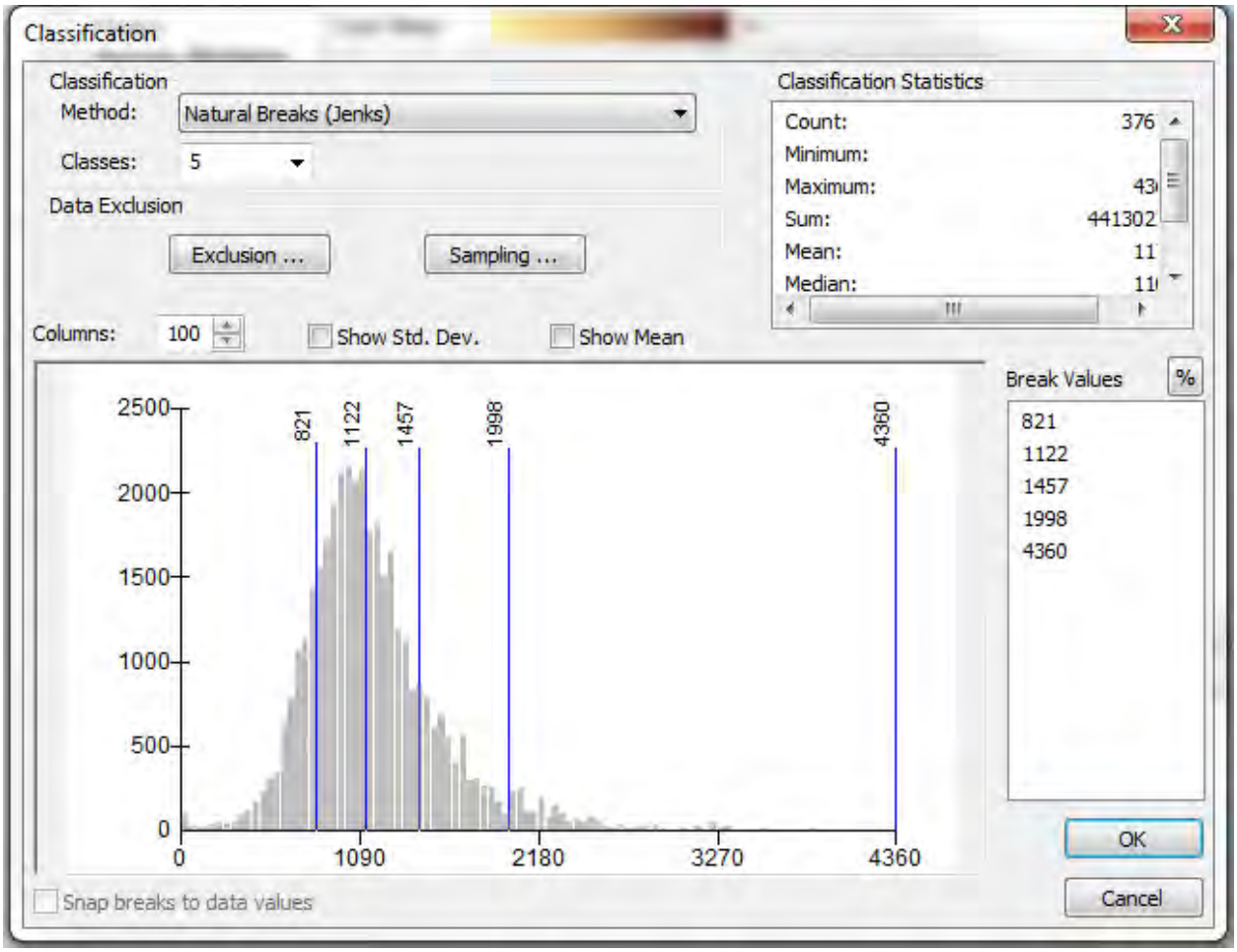
1. Open the cities Layer Properties menu
2. Choose the Symbology Tab
3. CLICK on Quantities and SELECT Graduated Colors
4. Under the Fields, Value: select Total (represents both male and female population fields).
5. Please note the **Classification Method**: Natural Breaks (as shown in the blue box)



By using the COLOR RAMP a user can choose how to display the symbol data – the attributes are automatically displayed using a Natural Breaks (JENKS) classification scheme based on 5 classes.

To change the manner in which data is classified via the distribution of attribute values a user can Select the CLASSIFY button (above in Blue box – see graphic below). This function allows a user to select the method of data classification 9Equal interval, Defined Interval, Quantile, Natural Breaks, standard Deviation, etc.)

Under the classification Statistics general information on data breakdown is provided for the selected attribute and the current data BREAK values for graduated colors or symbols are provided on the lower right hand box.



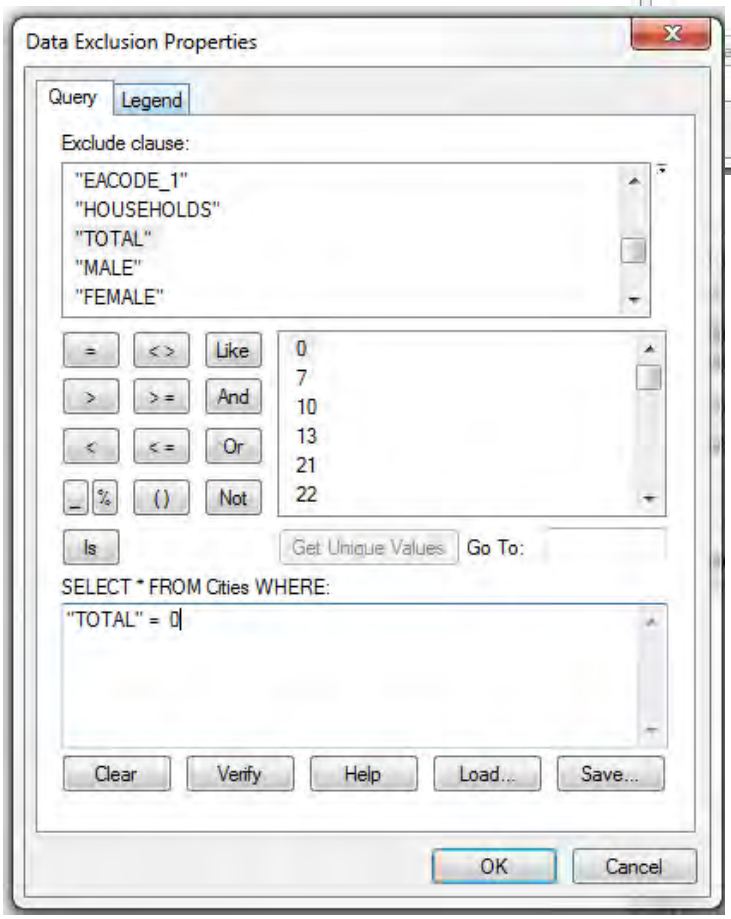
A user can determine which data classification to use and control how many data classes are present.

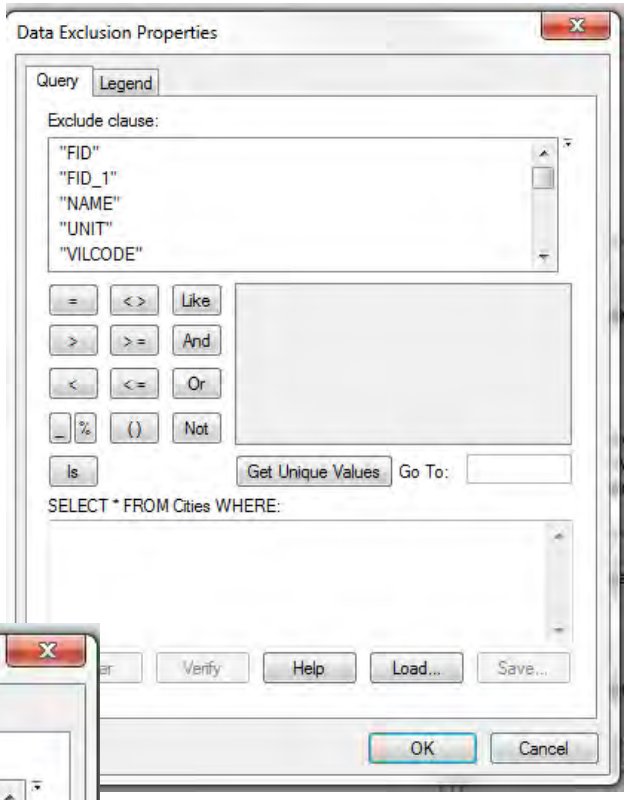
As well through the Data Exclusion function a user can use a query definition to exclude specific data values form the data classification such as 0 or null values.

Simple query logic is used to build a logarithm to define criteria for data exclusion. We want to exclude data that has a population of "0".

6. Under the Classification menu, choose the Exclusion command
7. Under the Data Exclusion Properties, Select the field "TOTAL"
8. Choose the "=" operator
9. Click GET UNIQUE VALUES, this will populate the unique values from the field previously selected (TOTAL).

Your query window would look like the one below:



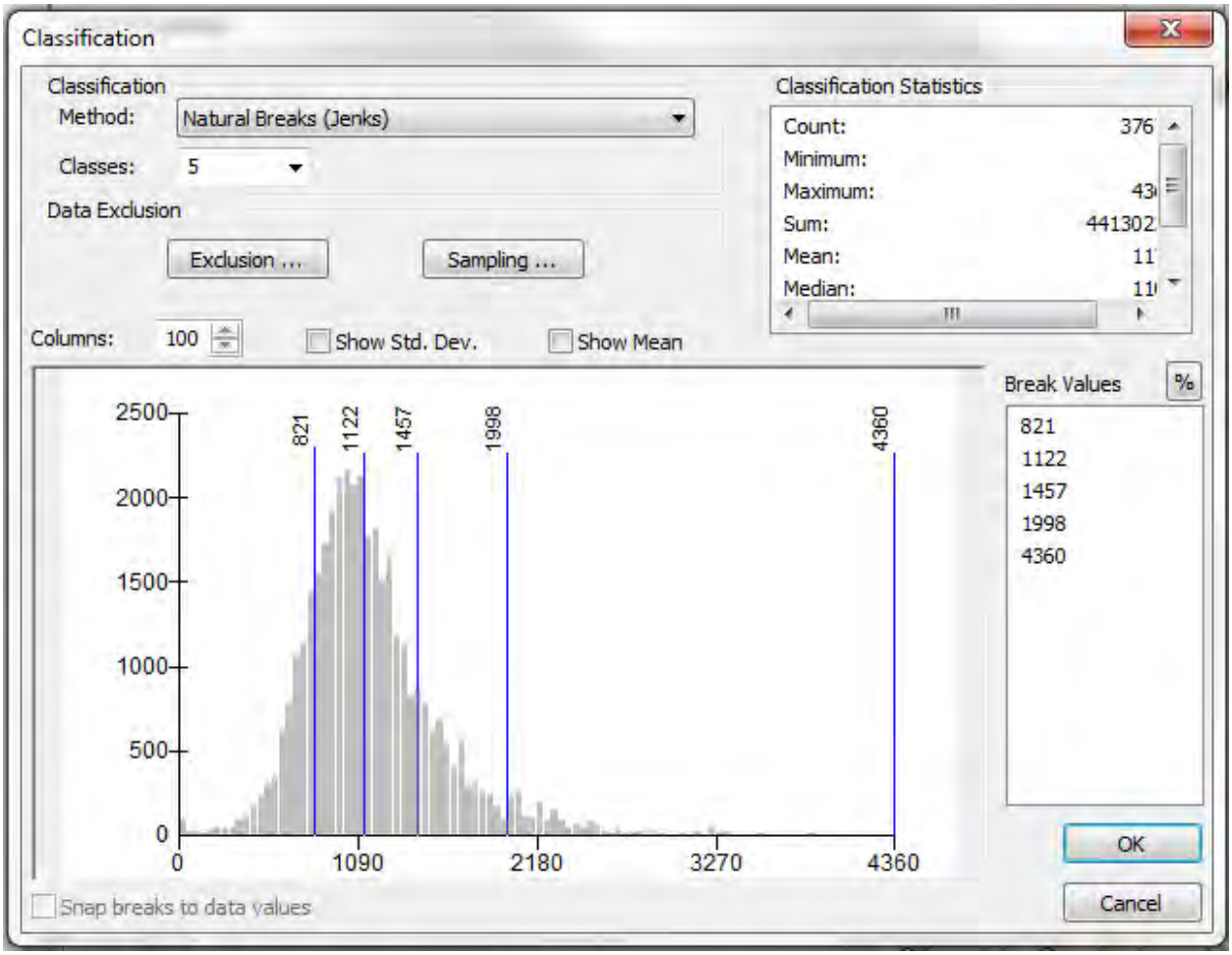


This type of defined query process that uses logical operators to define relationships between data variables is very common in GIS. It is a similar process we will use when we want to select specific field attributes from a data set using both simple and complex logic.

The end result of this exclusion is that data records with an attribute value of 0 will be excluded from the data classification.

10. Click Verify, this will ensure the equation is valid.
11. Click OK

Data Breaks
Sometimes the classification methods that allow a user to display data do not realistically portray the spread of data.



The graph above demonstrates the break points being used to classify the data. You should become familiar with the various classification methods available to use, as they can greatly affect the way in which your data is represented. You are encouraged to test various methods and view your data to understand the impacts of classification.

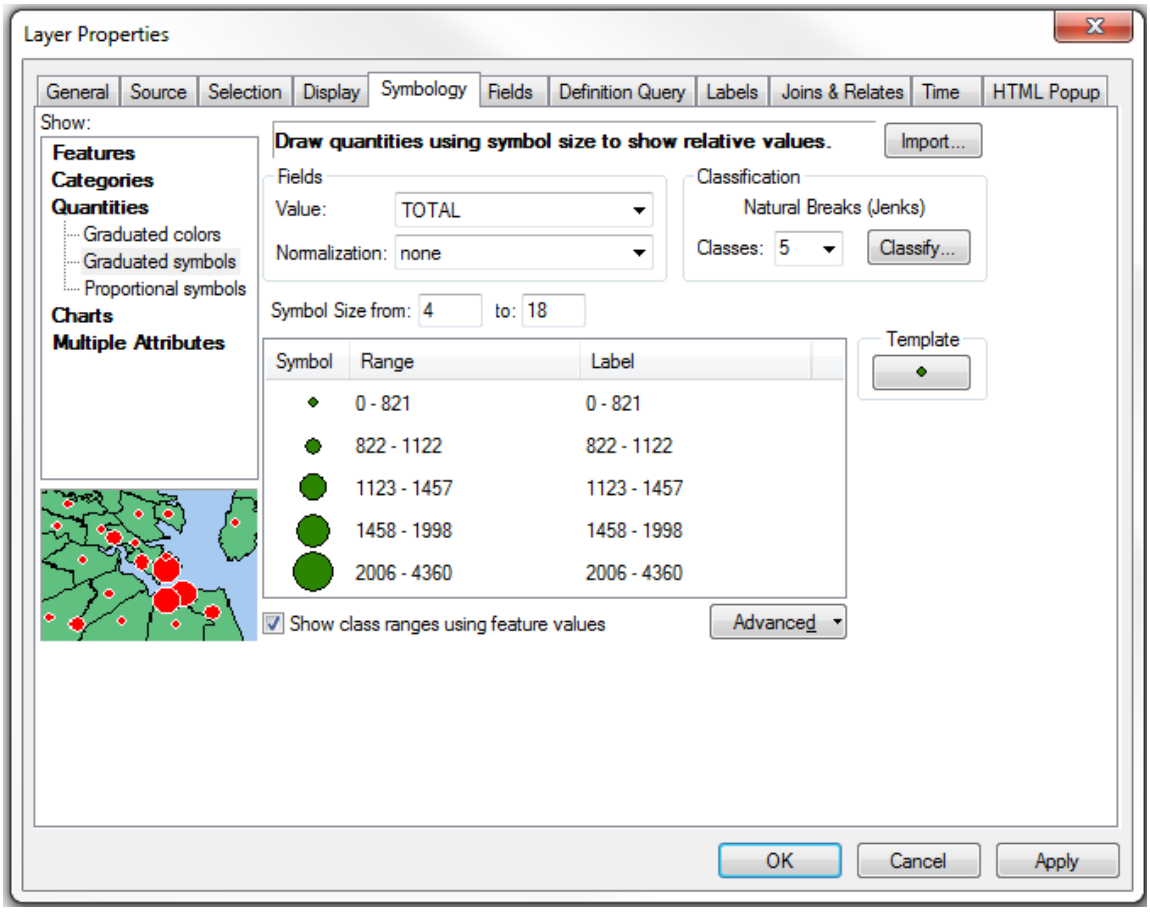
12. Click OK to Close the Classification dialog and return to the Symbol Menu

We have been using graduate colors to represent your population, let us now visualize the data using the same data, but a different method, such as graduated symbols.

13. CLICK on the Graduated Symbols option

Graduated symbols like graduated colors allows a user to display shapefile data basedon a numeric range, instead of by grduation of color, symbols are displayed by graduation of symbol

size. Graduated symbols should be used when you want to highlight the variance of one attribute of a feature among the records of that feature. For example, if the 'Total' field in our data represents population of villages, we can show this with large circles for the more populated areas and smaller circles for the less populated areas. This helps to create a map that really illustrates population over a given area.

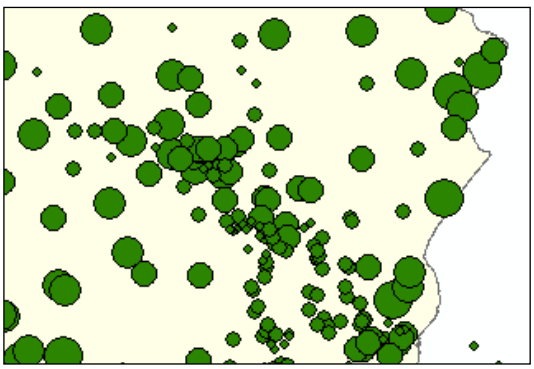


14. Under the Value Field Select TOTAL which represents population

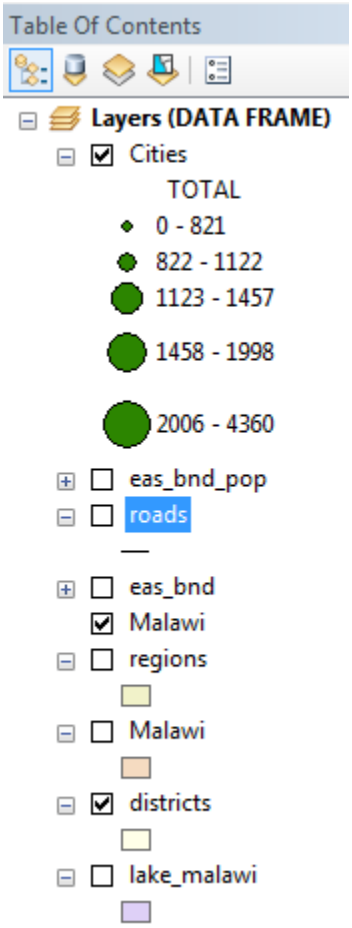
Notice now we can change the variation of size for the symbols in question as well as the type of symbol used. As with the Graduated colors we can use the CLASSIFICATON function to change how data is grouped and classified as previously discussed above.

15. Click Apply and OK to close the Symbology Menu
16. Zoom to a part of your map, at a scale of around 1:400,000

Your image may look like this:



17. Go to the TOC, ensure the following data layers are present:



Please note that the TOC is set to List By Drawing Order

Your symbology may be different than what is shown, that's OK, we will begin to symbolize the layers.

By now, you may have noticed that the check box controls the layer visibility. You can turn on and off the layers, and change the layer order so that your Cities layer is on top, and the roads are on top of the other layers.

Rename Layer

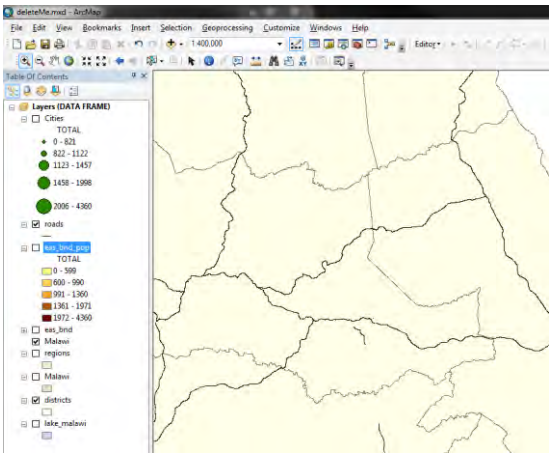
1. You will rename the layer eas_bnd_pop. There are several ways to do this. One method is to use the General menu in the Layers Properties. You can also use the context menu "Rename", and you can also slow double click on the name and you will be able to rename the layer.

2. The eas_bnd_pop refers to the "Population of Enumeration Areas from the National Statistical Office" lets use a shorter name such as "Enumeration Areas"

Symbolize Lines - Roads

Check the box for the roads to turn them on – you will notice that the roads are now displayed in your map, however they are symbolized as one color (single symbology). Currently the roads are difficult to distinguish from the other layers, so we will symbolize them appropriately for the map.

1. go to the Symbology menu,
2. Select Categories, UNIQUE Values
3. Value Field select ROADTYPE
4. Add All Values



Let us symbolize the roads to reflect the Main and Secondary heirarchy.

5. Click on the colored line with VALUE 0 this will open the Line Symbol Selector you see below

6. Scroll through and see which options exist for lines, there are many types to choose from and no matter the option we can always cahnge the thickness of the line, the color and other line properties to meet our needs.

7. Set your Road symbology for each level that represents the road heirarchy;

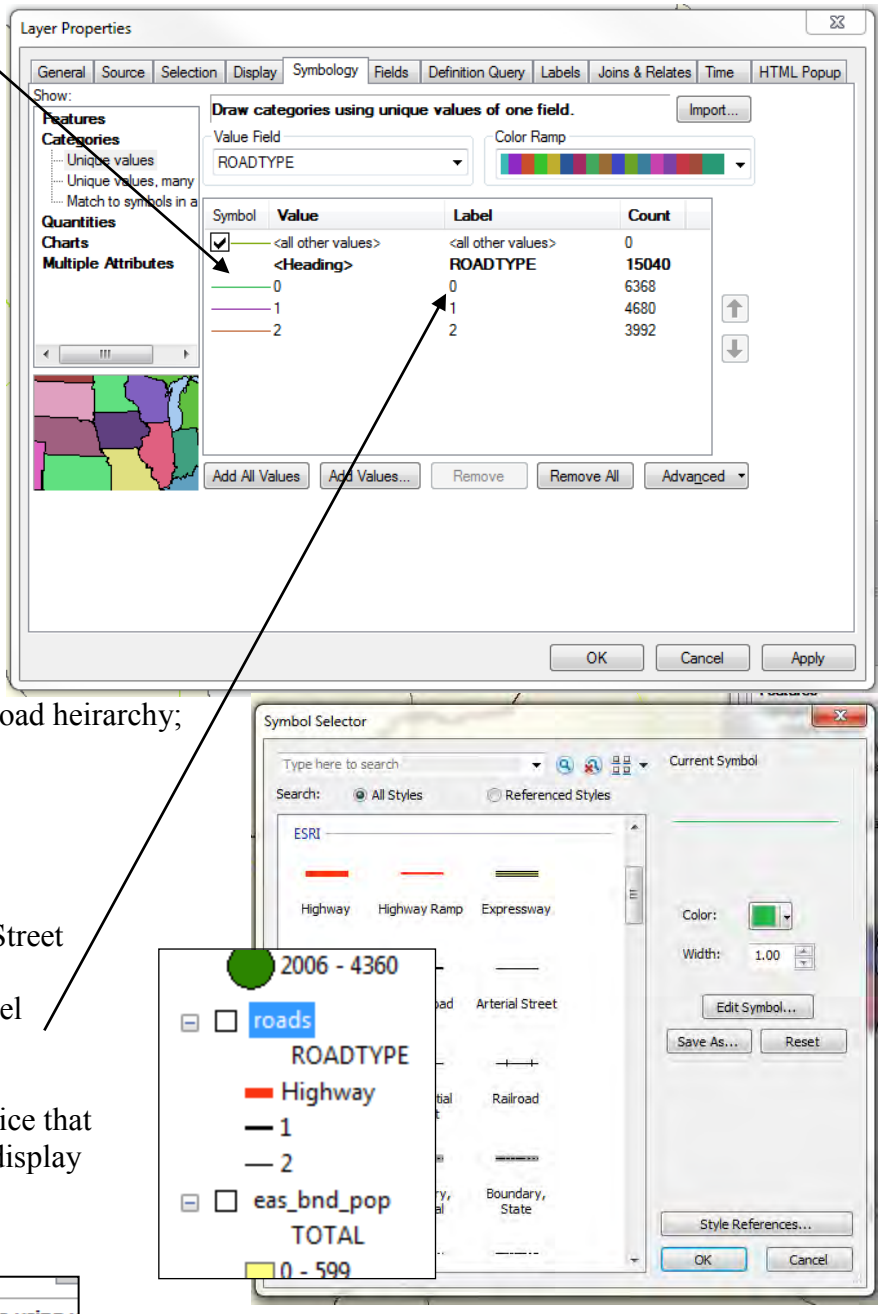
8. Value 0 is a Highway

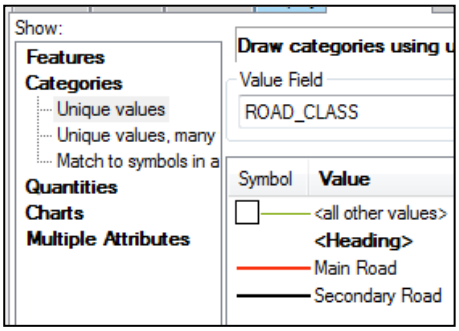
9. Value 1 is a Major Road

10. Value 2 is a Residential Street

11. Change the roadtype Label of 0 to “Highway”

12. Apply your changes, Notice that the TOC has updated to display

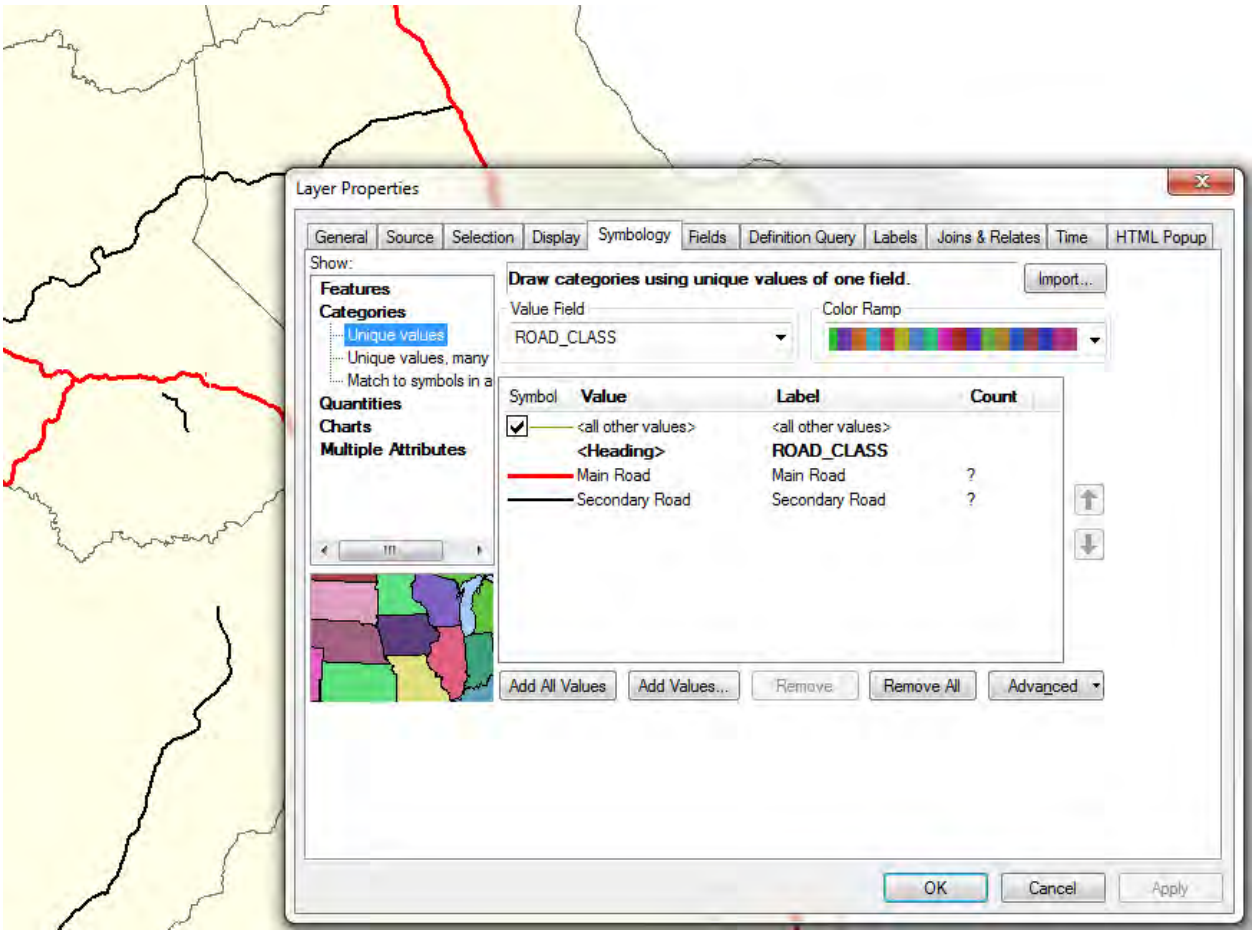




13. You will not change symbols for roads again.

14. Now using what you have learned, change the road symbolgy categories to use the Road_Class Symbol, which has two classifications, Highway and Secondary Roads.

Your map may look something like this:



Symbolize Polygons – Districts, Regions

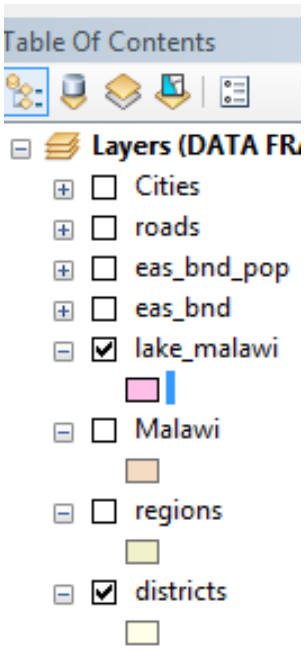
Now we will work with the 3 main ploygon themes (Malawi Country Boundary, Regions, Districts) each of which represent a differnet administrative unit and boundary. In Malawi, there are 3 Regions, within each Region we have Districts.

We will set the Symbol properties for these three polygon features. However, before we do, it is important to set the layers in the correct order in the table of contents. Larger adminstrative units should be followed by medium units then smaller units, you shall see why in a moment. We will want ot place the The Malawi Country boundary on top of the Regions, which are above the districts. Please Note, the order your data will be drawn is determined by the layer order in the TOC.

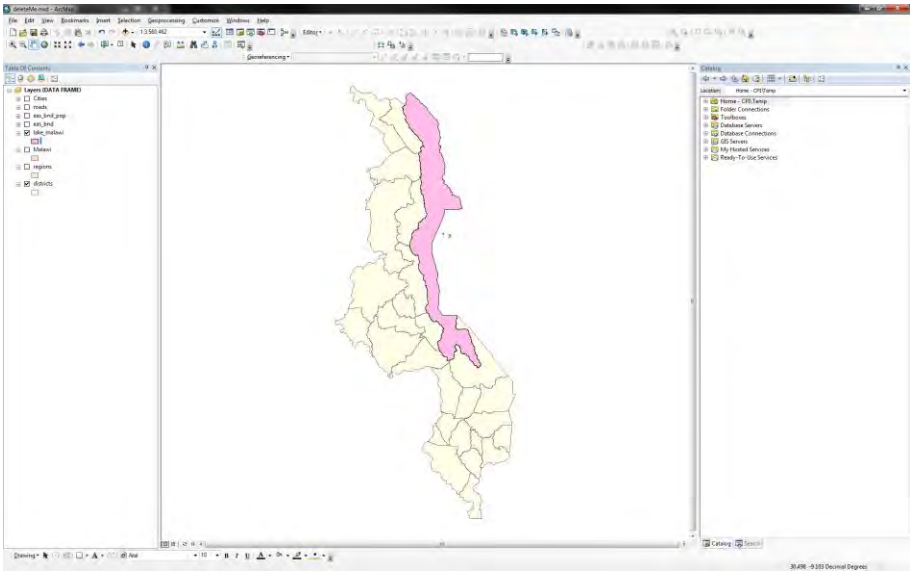
1. If necessary, arrange your layers in the Table of Content to the optimum position. (Polygons on bottom, lines, then points). You can use the sample to the right for a guide.

2. Turn off all layers except lake_malawi and districts (this will reduce clutter on the map while we are working)

3. Zoom to the Malawi layer usiing the layer context menu



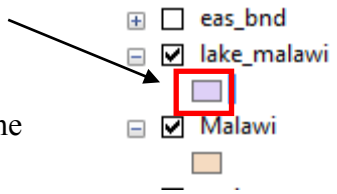
Notice that the map view zooms out to the full extent of the data layer Malawi. Your map should look similar to this:



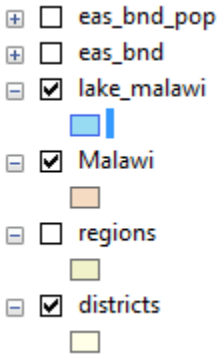
Once all the data is correctly ordered we can start to change the layer properties of each polygon theme. Change the default appearances of the layers to appropriate colors and sizes. (For example, Administrative units should be clearly represented and distinguishable as different data layer boundaries so the end user who views the map clearly understands what data is being presented.

For the lake_malawi, we will be using a SINGLE SYMBOL display function. Therefore it will not be necessary to open the Layer properties and go to the symbology menu. We can directly change the layer symbol by left clicking on the current symbol in the Table of Contents.

4. LEFT CLICK on the lake_malawi symbol in the TOC
5. Take a moment and scroll through and look at the different Polygon options that are available
6. In the symbol selector, choose the "Lake" symbol from the pallet.



7. Turn on the Malawi layer.

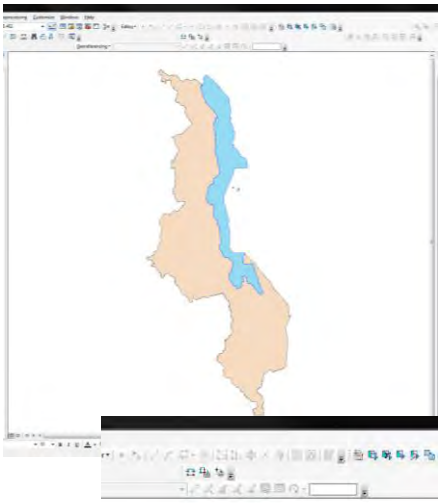


You will notice that you can no longer see the districts, because the Malawi layer is on top. Though we could change the layer order to fix this, we want to have both layers visible. To do this, we will use a polygon with no fill color.

8. CLICK on the Malawi symbol
9. CLICK on the FILL COLOR and choose NO COLOR

This will result in only the Outline being Displayed

10. For the OUTLINE COLOR choose Gray 80%
11. CLICK on the OUTLINE WIDTH and Choose a value of 2
12. CLICK OK and take a look at your Map



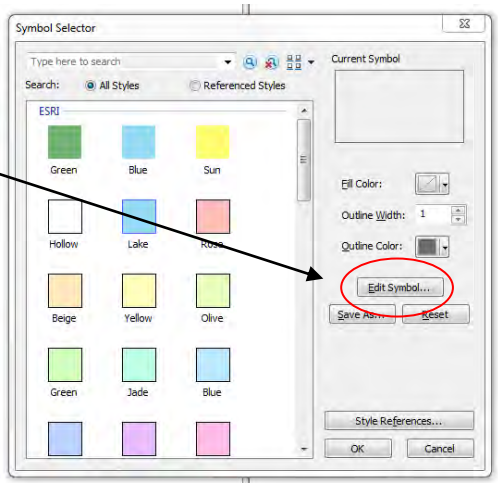
In the graphic to the right we can now clearly distinguish our Malawi Country boundary and we can see our districts layer below in grey/yellow.

We will now turn on and symbolize the regions layer.

13. Turn on the regions layer
14. Click on the regions symbol
15. Choose No Color for the Fill
16. Choose 60% gray

We will now use a different symbol for the outline. This requires going further into the menu options.

17. Click on the Edit Symbol…

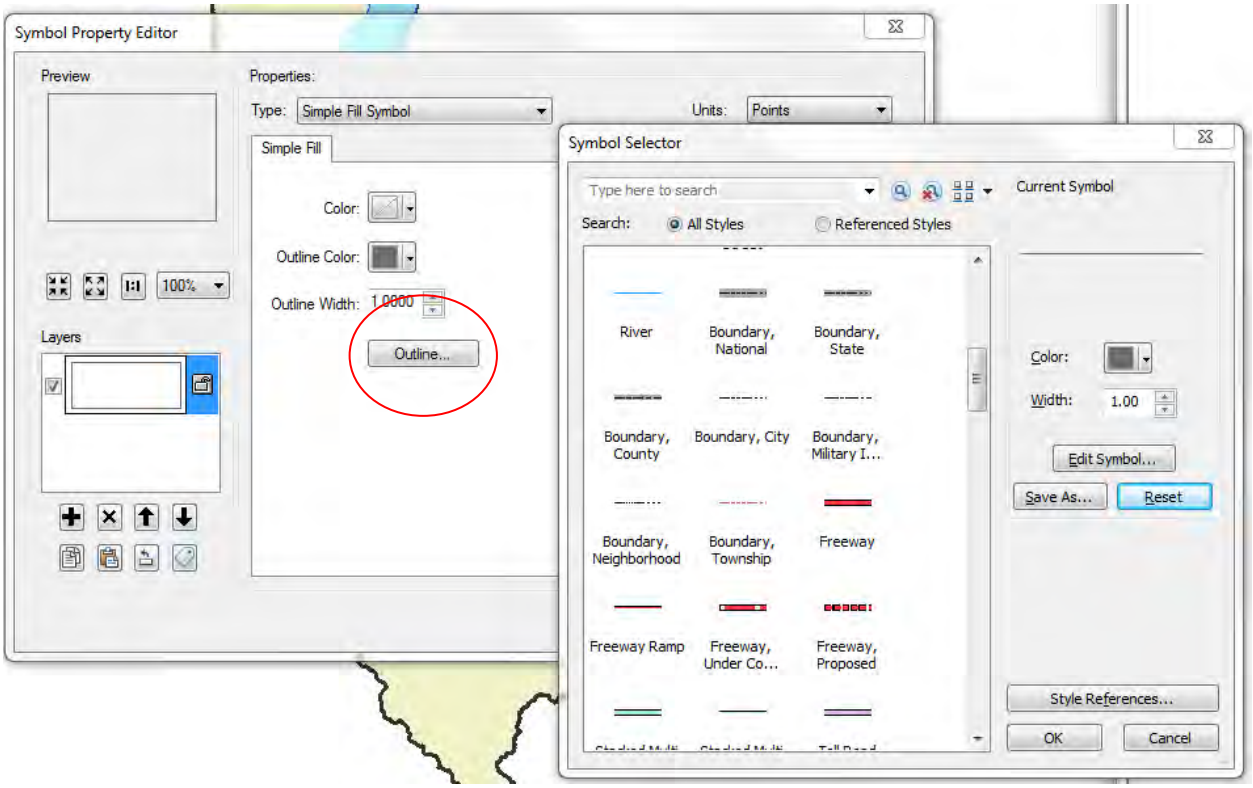


The Symbol Property Editor dialog now appears.

18.

18. Click on Outline

A new Symbol Selector menu will open. This menu now controls the symbology, color and line type of the polygon border. Here we will choose a cartographic symbol, such as a dashed line to represent our boundary.



19. Scroll down in this menu to choose "Dashed 1 Long 1 Short"
20. Set the width to 1
21. Set the Color to Gray 70%
22. CLICK OK and take a look at your Map

In the graphic to the right we can clearly distinguish our Malawi Country boundary and we can see our districts layer, but our regions boundaries are very difficult to see. How can we correct this?

23. Open the districts Symbology
24. Set the Line to .2

25. Set the Outline color to Gray 20%
26. Click OK and take a look at your Map

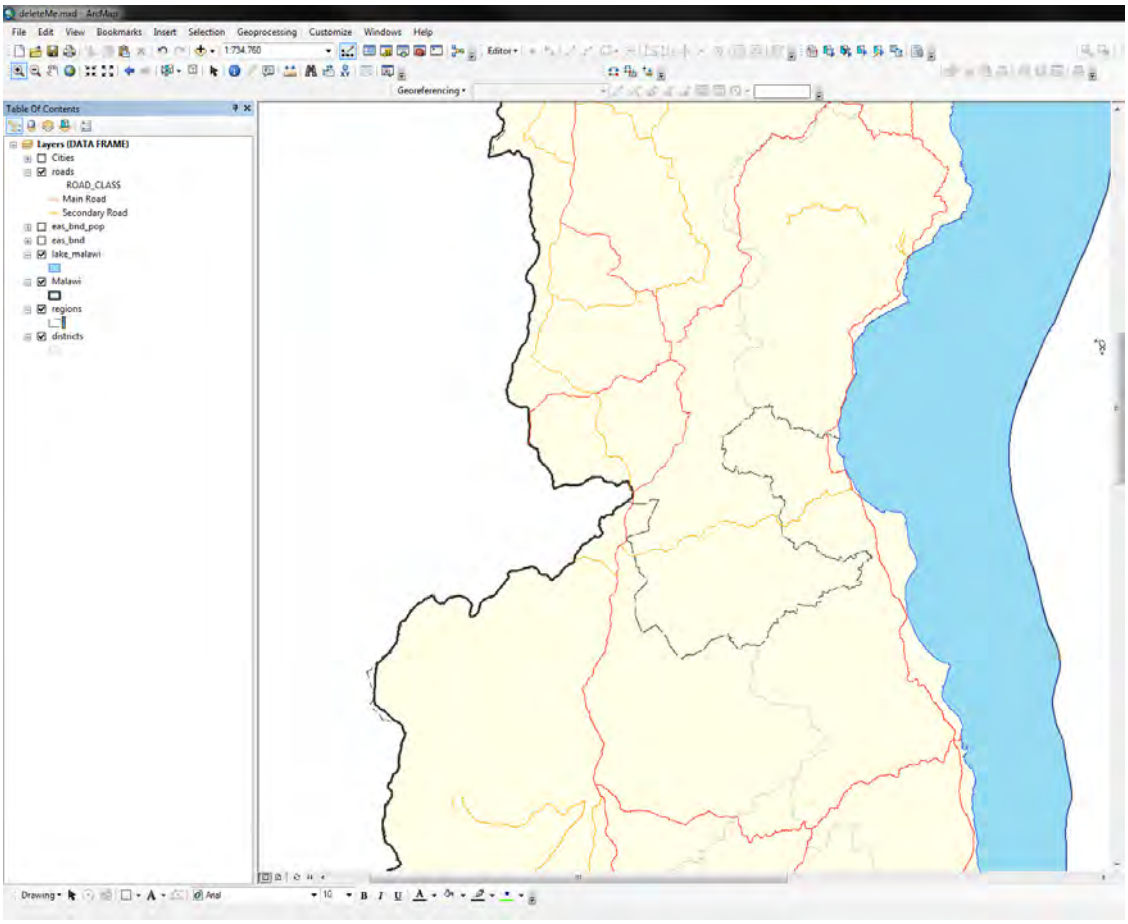
In the graphic to the right we can now see the Malawi Country boundary, our region boundary and districts layer.

You should note that even though we were having problems seeing the regions layer, we altered the symbology of the districts. It is important to understand that good representation relies on the ability of the cartographer to create a visual hierarchy. This may mean that you have to view the layers in context of the map as a whole (with the other layers) and make alterations to each layer according to the map as a whole, in order to properly display your data and information.

27. Turn on your Roads layer (Don't worry about the cities, we will come back to that layer)

See if the map is cartographically pleasing, and the layers have a good hierarchy.

28. Use what you have learned to make adjustments.
29. When you have finished, your map should be similar to the one below.



MAP Projection:

What is Map Projection – paper maps are flat, but in reality the world is round and to view places on a paper maps we must 'project' them. There are many types of map projections, each one functions a bit differently with an end result of displaying data differently. Each projection has a specific property that fits varying purposes, such as maps used to demonstrate general reference, or maps used to navigate. A projection inherently distorts the data in order for it to be displayed, and there are four main forms of the distortion, SHAPE, AREA, DISTANCE and DIRECTION. Think of peeling an orange and trying to lay the peels flat… what happens? Each projection turns a 3D surface into a 2D map, and introduces some distortion. However, certain projections may preserve some aspects of the data better than others.

For example if we are working with data at the Continental level, global level or national level then there are various map projections used that are 'best fits' for displaying data at various scales or levels.

1. Go to the HELP MENU and click on ARCGIS desktop help and then type in Map projection systems. Here you will find a wealth of information on map projections and systems.

FROM the ESRI HELP MAP COORDINATE SYSTEMS

Within ArcGIS, every dataset has a coordinate system, which is used to integrate it with other geographic data layers within a common coordinate framework such as a map. Coordinate systems enable you to integrate datasets within maps as well as to perform various integrated analytical operations such as overlaying data layers from disparate sources and coordinate systems.

What is a coordinate system?

Coordinate systems enable geographic datasets to use common locations for integration. A coordinate system is a reference system used to represent the locations of geographic features, imagery, and observations such as GPS locations within a common geographic framework.

Each coordinate system is defined by:

- *Its measurement framework which is either* ***geographic*** *(in which spherical coordinates are measured from the earth's center)* ***or planimetric*** *(in which the earth's coordinates are projected onto a two-dimensional planar surface).*
- ***Unit of measurement*** *(typically feet or meters for projected coordinate systems or decimal degrees for latitude-longitude).*
- *The definition of the* ***map projection*** *for projected coordinate systems.*

- *Other measurement system properties such as a spheroid of reference, a **datum**, and projection parameters like one or more standard parallels, a central meridian, and possible shifts in the x- and y-directions.*

Types of coordinate systems

There are two common types of coordinate systems used in GIS:

- *A global or spherical coordinate system such as latitude-longitude. These are often referred to as geographic coordinate systems.*
- *A projected coordinate system based on a map projection such as transverse Mercator, Albers equal area, or Robinson, all of which (along with numerous other map projection models) provide various mechanisms to project maps of the earth's spherical surface onto a two-dimensional Cartesian coordinate plane. Projected coordinate systems are sometimes referred to as map projections.*

Coordinate systems (either geographic or projected) provide a framework for defining real-world locations. In ArcGIS, the coordinate system is used as the method to automatically integrate the geographic locations from different datasets into a common coordinate framework for display and analysis.

ArcGIS automatically integrates datasets whose coordinate systems are known

All geographic datasets used in ArcGIS are assumed to have a well-defined coordinate system that enables them to be located in relation to the earth's surface.
If your datasets have a well-defined coordinate system, then ArcGIS can automatically integrate your datasets with others by projecting your data on the fly into the appropriate framework—for mapping, 3D visualization, analysis, and so forth.
If your datasets do not have a spatial reference, they cannot be easily integrated. You need to define one before you can use your data effectively in ArcGIS.

What does this mean to our work?

Well, first it is important to know at what scale you will be working, national, regional, global, etc, in most cases your GIS work will be at the local level.

Consider the following steps in your work:

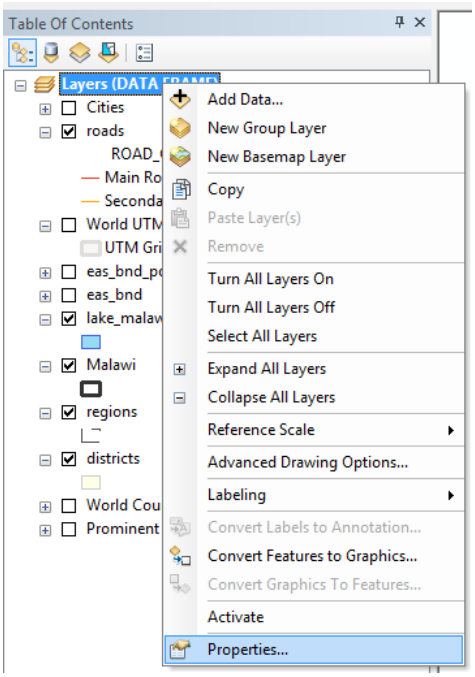
A. Know where your data has originated from (National Mapping or Geographic institute, etc). This information can be found in metadata associated with the data.
B. Discuss with Counterpart's at these locations to understand what Project Coordinate system is used for your specific area.
C. Use a coordinate system for your data frames and for the development of new data.

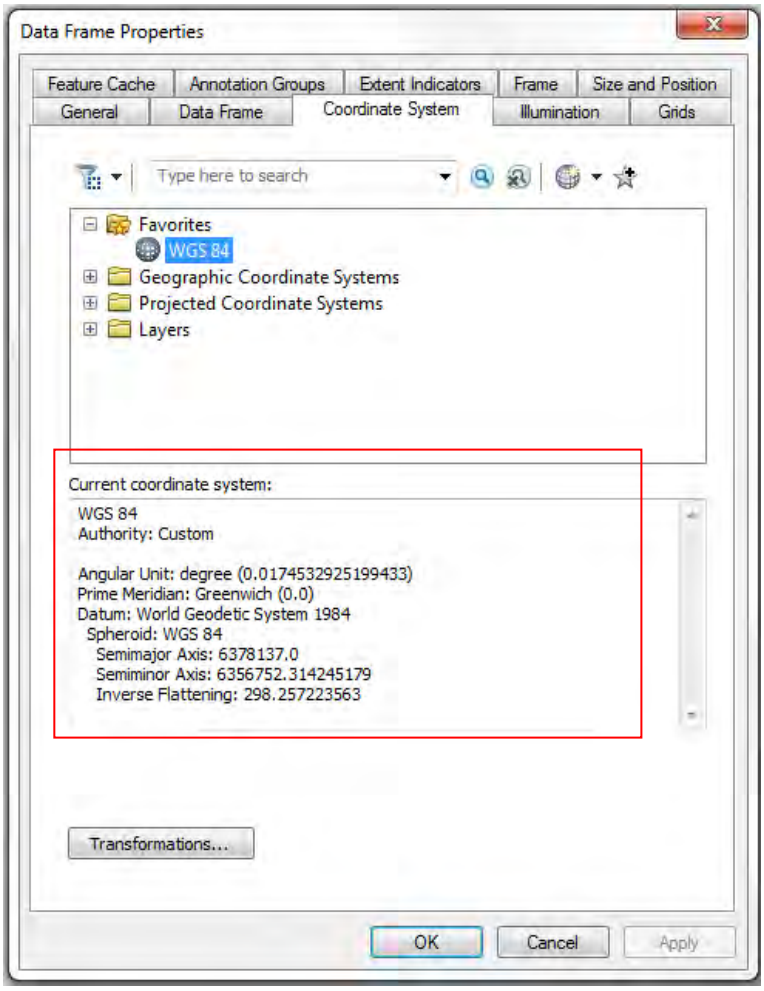
For example in Malawi, the entire country falls within Universal Transverse Mercator (UTM) Zone 36 North. UTM is a common map projection used throughout the world and splits the world into different zones. Some country boundaries may straddle multiple UTM zones. It is important to discuss which map projection is used at the national level with local specialists.

Coordinate Systems in ArcGIS

It is important to note that there are two separate coordinate systems that you will need to be aware of while using ArcMap; those of the **Data Frame** and the **data**.

1. Open your Data Frame Properties Menu
2. Open the Coordinate Systems tab





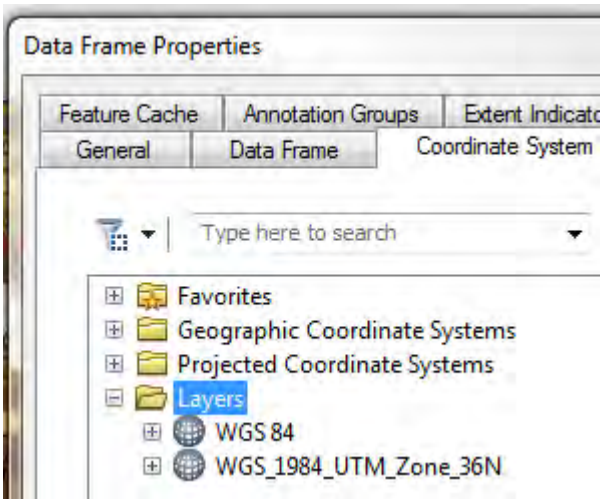
You can see that the "Current coordinate system:" is listed as WGS 84.
This is the World Geodetic System, 1984. As the name implies, this is a geographic coordinate system, *which is not projected*.

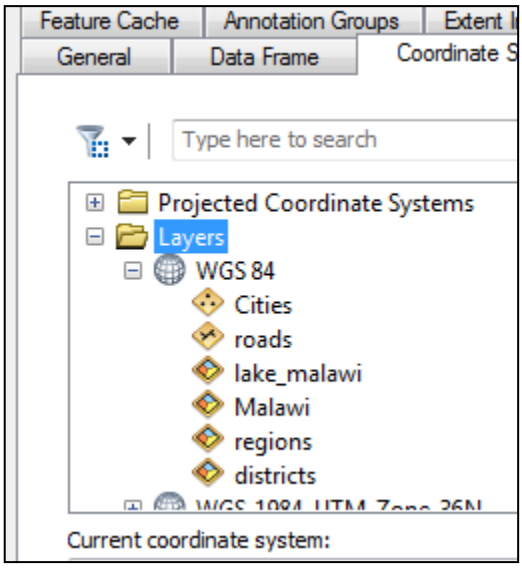
3. Click on the plus by the folder "Layers" in the top box

You should now see two projections under this folder. These are directly associated with the layers coordinate systems.

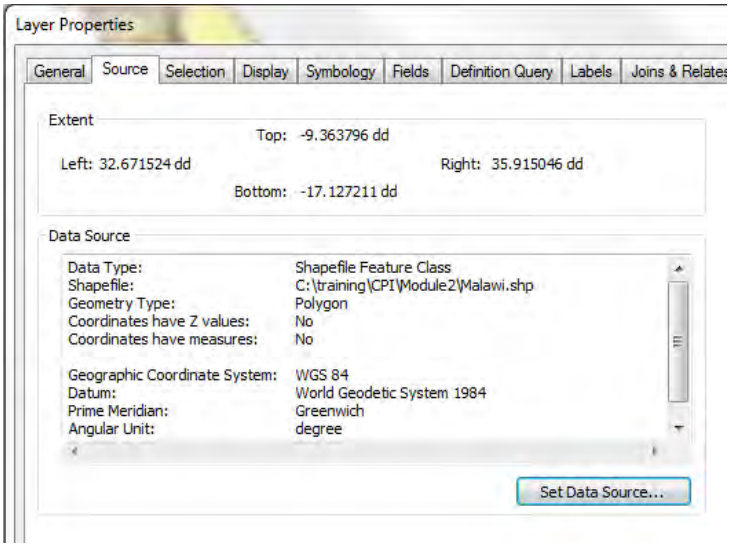
4. Click on the plus by the WGS84

You should now see the layers that all use the WGS84 Coordinate System.





5. Note that roads is under WGS84, and Enumeration Areas is under the WGS_UTM36N
6. Close the Data Frame Properties menu
7. Open up the Malawi Layer properties menu
8. Open the Source Tab



Notice that the coordinate system is also listed as part of the data information. Please note that the coordinate system associated with the layer *IS* the coordinate system of the source data, and will be reflected in all Map document that use that data, it is not controlled by the Layer.

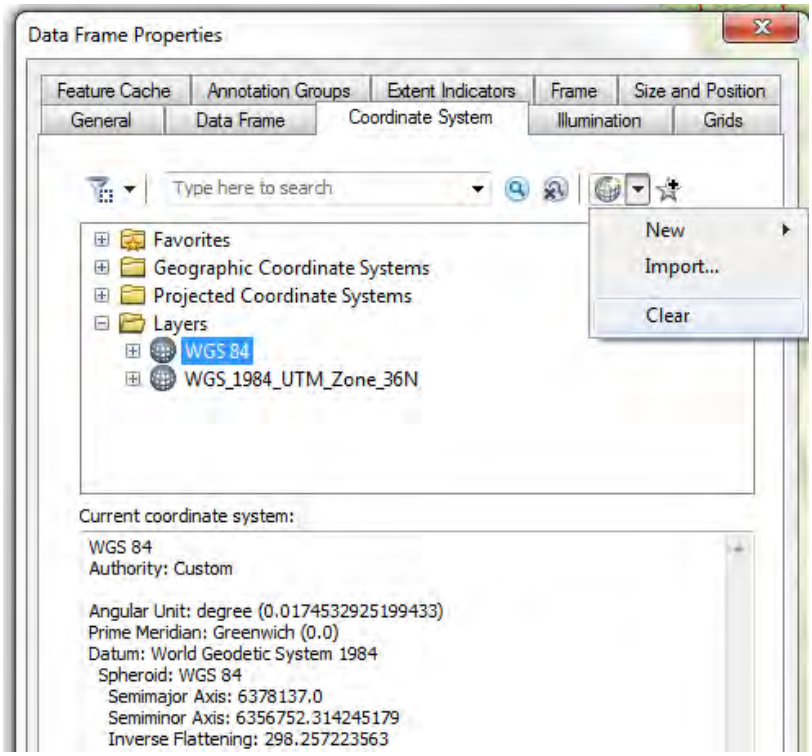
Projection On The Fly

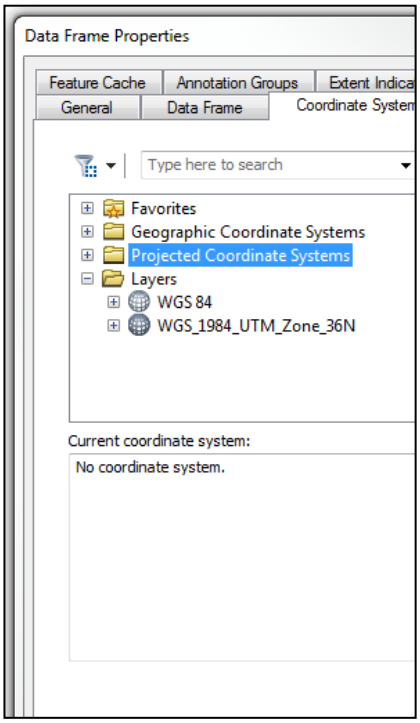
The next concept we will look at is Projection-on-the-fly. The basic concept is that two data sets that use different projections and datums could not be displayed together without projection – on-the-fly. This is because the features use different coordinate values. Projection-on-the-fly in arcgis is controlled by the Data Frame, and is "on" by default. However, we can demonstrate what happens when you turn it "off".

9. Close the properties menu
10. Turn on the Enumeration Areas and Roads in your TOC
11. Turn off all other layers
12. View your map. You should see the enumeration area and roads.

As noted, roads is under WGS84, and Enumeration Areas is under the WGS_UTM36N. These two layers are currently visible.

13. Go to your Data Frame Properties, Coordinate System menu.
14. Click on the pull down menu to "add coordinate system" (next to the Globe icon)
15. Click on Clear

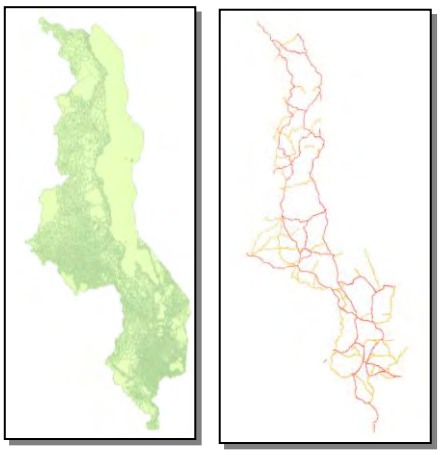




Note that previously our Data Frame was using WGS 84, and after clearing, the Data Frame does not list a Coordinate System.

16. CLICK OK and take a look at your Map

What do you notice about your map? Where did the roads go?



17. Zoom to roads Layer

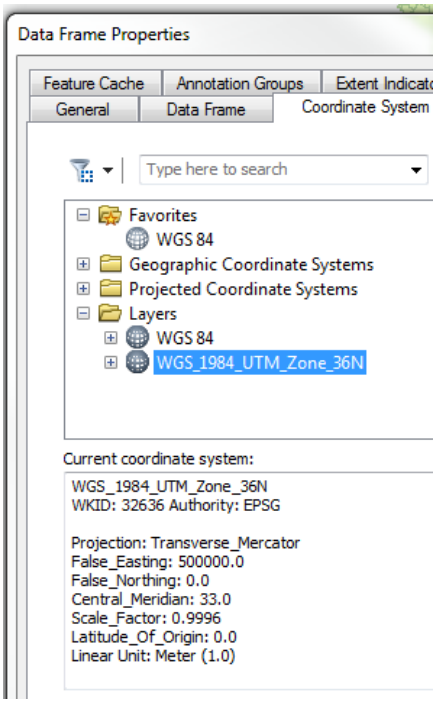
You see the roads? However, they are not in the same extent as the other datasets.

18. Zoom to the extent

Let us correct the situation by setting a Coordinate System for the Data Frame again.

19. Open the Data Frame Properties, coordinate system menu

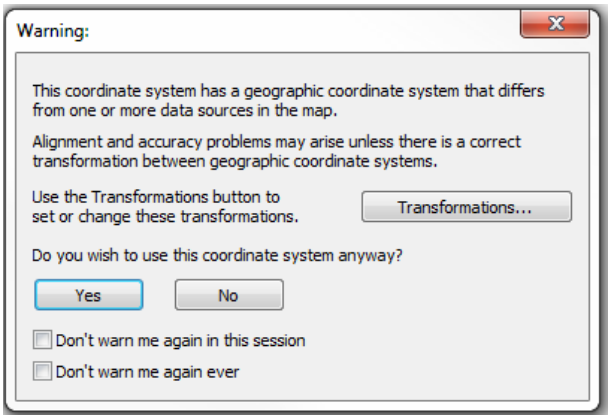
You can set any projection at this point for your projects, again, the Data Frame coordinate system is the common coordinate system that all data in your projects, and is projected-on-the-fly to.



20. Open the Layers folder,
21. Select WGS_1984_UTM_Zone_36N (It should appear in the "Current coordinate system" window.
22. Click OK

Datum and Transformations

Depending on the data you are using, you may get a Warning message such as below. This message is to let you know that a Transformation is required to align the data properly. Though the Projection-on-the-fly can align different projections, data that uses different Datums need to undergo a transformation. This can also be set within the data frame, or within the warning dialog box. ArcMap usually makes a suggestion as to which transformation, but if you are unsure please see the help section or ask your instructor for further information on setting transformations.

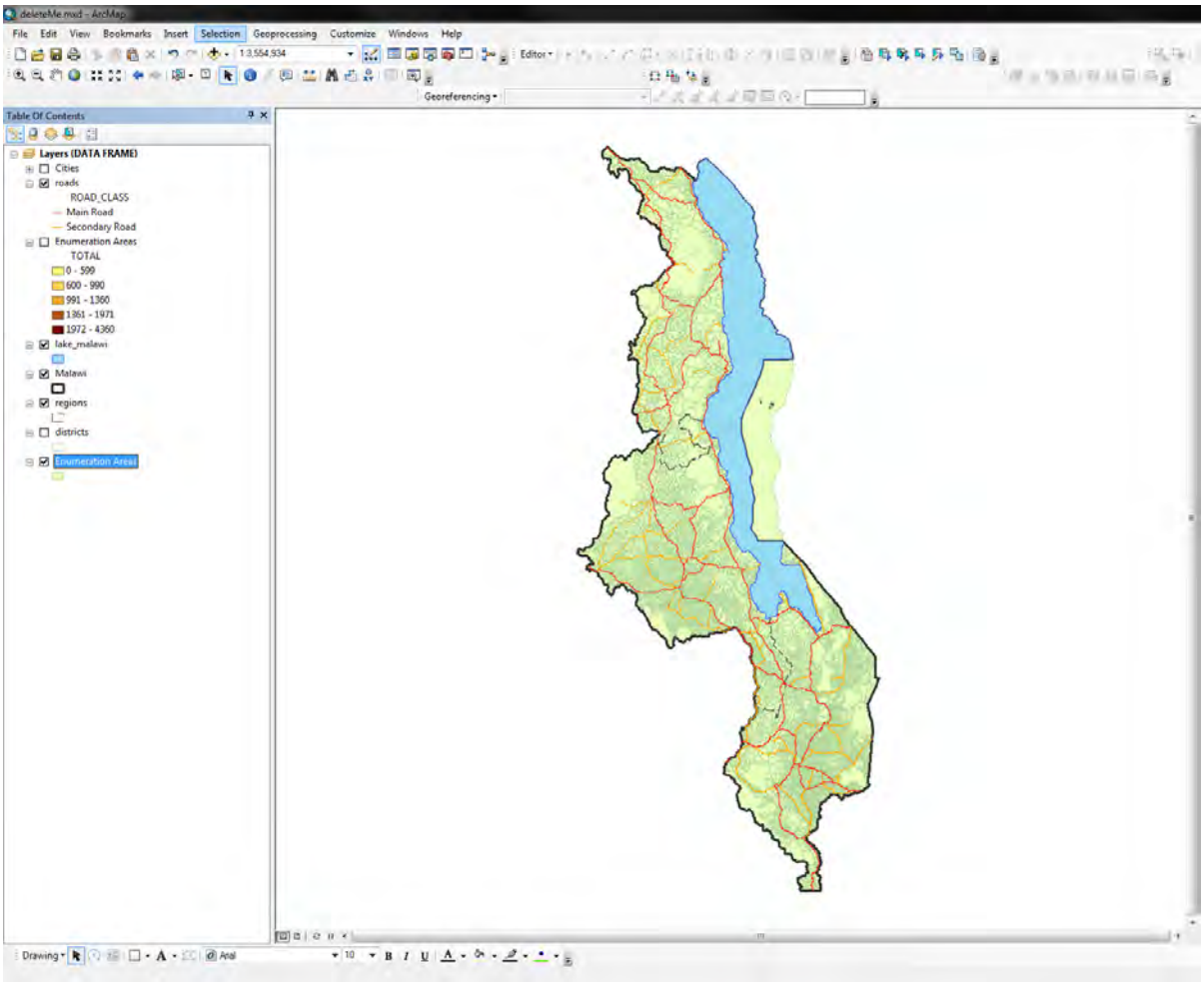


Though understanding the Datam and Transformation tools are important, for the purposes of our training, you may dismiss and ignore any of the transformation warnings.

You should now see that the map is “fixed” and the road and Enumeration Areas line up again.

23. You can turn on the Lake, Malawi and regions layers.

Your map should look similar to this one below:

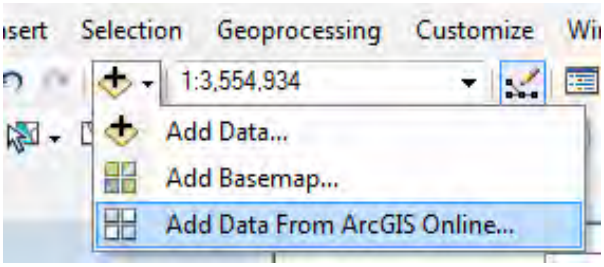


Map Projections and ArcGIS Online

You may skip this part of the exercise if you do not have an internet connection.

We will next experiment with data from ArcGIS ONLINE using a geographic and projected coordinate system. Because you will be working with data that is ONLINE, you may need to be patient while the data is drawn, please keep this in mind as you pan and zoom within your map.

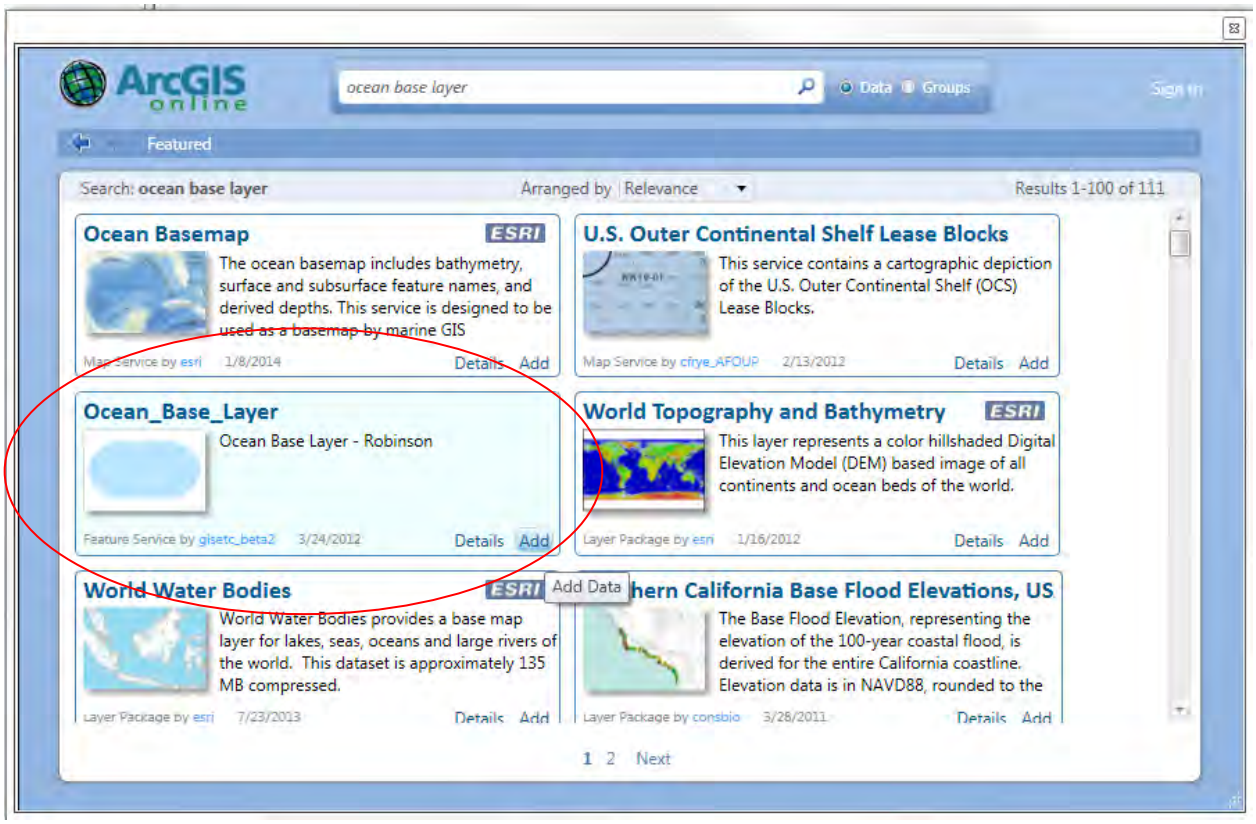
1. Turn Off all layers
2. Turn On Malawi
3. Use what you have previously learned to symbolize Malawi as a solid color, (such as bright yellow)
4. Add Data From ArcGIS ONLINE



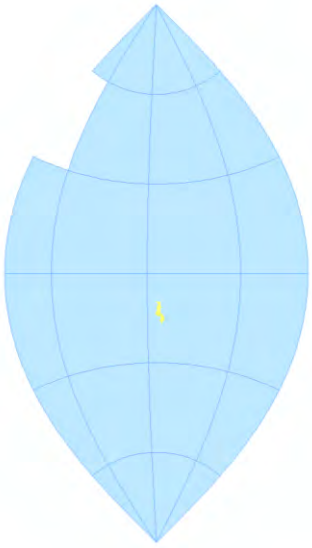
You will see a new data gallery that contains data services being served from all over the world! You can browse through the gallery for a minute.

We will use the search to look for a few specific data services to use in this exercise.

5. Use the search box for "ocean base layer".
6. Briefly browse through the results, you will notice there are over a hundred of results. (though your results may look different)
7. Add the Ocean_Base_Layer – Robinson Feature Service by gisetc_beta2

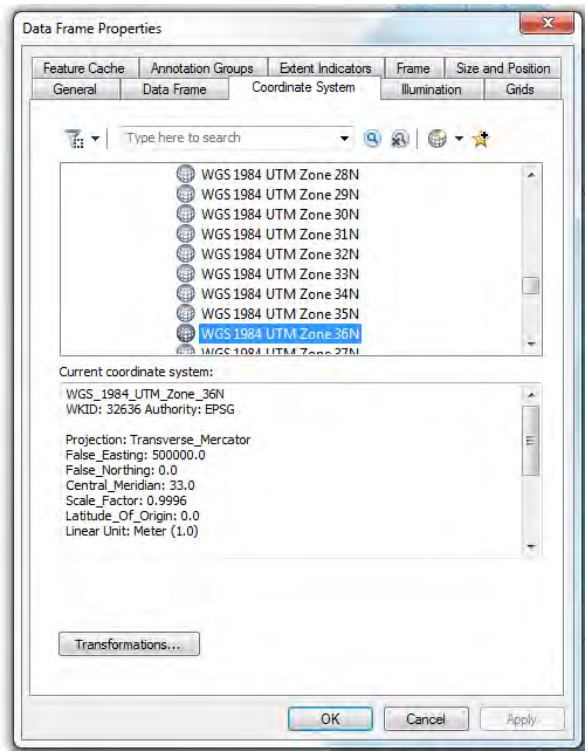


8. Once the Layer has loaded, Zoom to the full extent.



Your map should look similar to the one on the right:
What is wrong with the oceans?

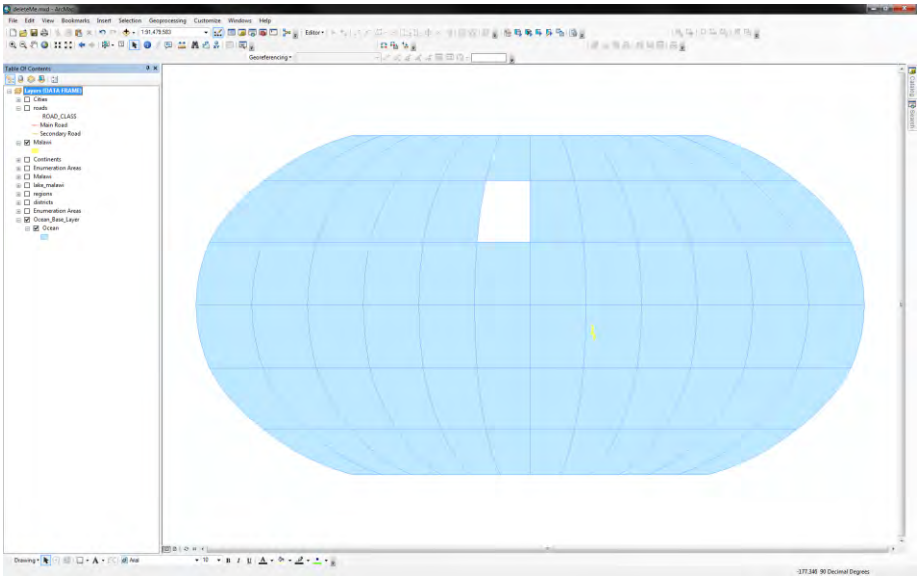
Lets check our maps Data Frame Coordinate System.
We last left our Coordinate system as UTM zone 36N



Though the UTM projection is suitable for working with data in Malawi, it does not appear to be suitable for a global map. Lets choose a different projection.

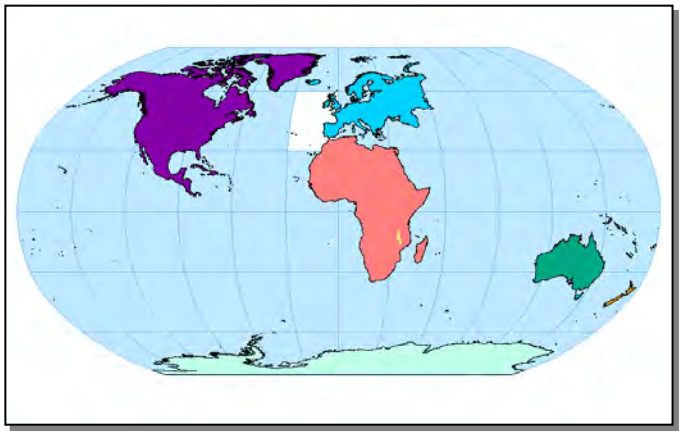
9. Open the Layers Folder in your Coordinate System menu,
10. Click the World Robinson Coordinate System, you will see the Ocean Layer.
11. Choose World Robinson
12. Click Apply and look at your map

What has changed about your Ocean layer?



In the above map we now see our data overlaid with the oceans data. The oceans dataset is really just a backdrop that facilitates illustrating the projections.

13. Add Data from ArcGIS Online
14. Search for a continents dataset
15. Add a suitable layer. (there will be many suitable layers, you may pick one,



Once your data loads, you should have a map that looks similar to the one on the right. We will now experiment with a few projections.

16. Go to your Data Frame Coordinate systems menu

We have previously been using projection data that has been directly associated with one of your dataset. ArcGIS has an extensive listing of projections, and you are able to choose one independently of your layers.

17. Open the Projected Coordinate Systems folder
18. Scroll down to the "World" subfolder and expand it
19. Select the Azimuthal Equidistant (world)
20. Click OK and view your map

As the name suggests, this projection minimizes projection distortions that effect distance, however, as you can see the area, shape and direction suffer.

21. Return the Data Frames coordinate systems menu
22. Open the World folder (Under the Projected Coordinate systems folder)
23. Select the Fuller (world) Projection
24. Click OK and view your map

What does your map now look like? What use would this projection have? If we exclude the Ocean and continent data, what projection data would you use for our training purposes? Why?

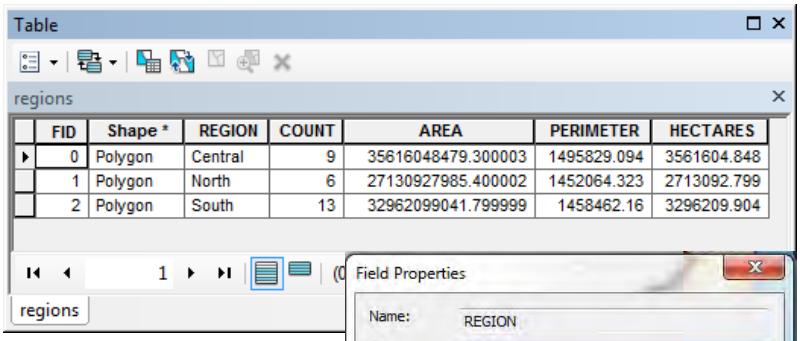
25. Remove the Continents and Oceans layers
26. Set your Data frame projection back to UTMz36 (HINT: Return to the data frame coordinate system menu, and select the WGS 1984 UTM zone36n projection (it is under your layers folder, assigned to your Enumeration Areas)
27. Click OK and view your map
28. Zoom to the Malawi layer

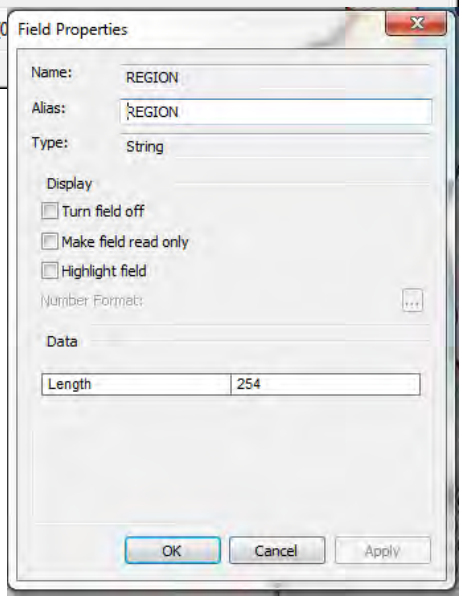
Layer Properties –Field Menu

In module 1 you learned how to open the attribute table, we will look more closely at the data structure for attributes. The structure of your data is known as the data schema, it can also be referred to the data model. You can think of this as the skeleton and the data is everything around the skeleton.

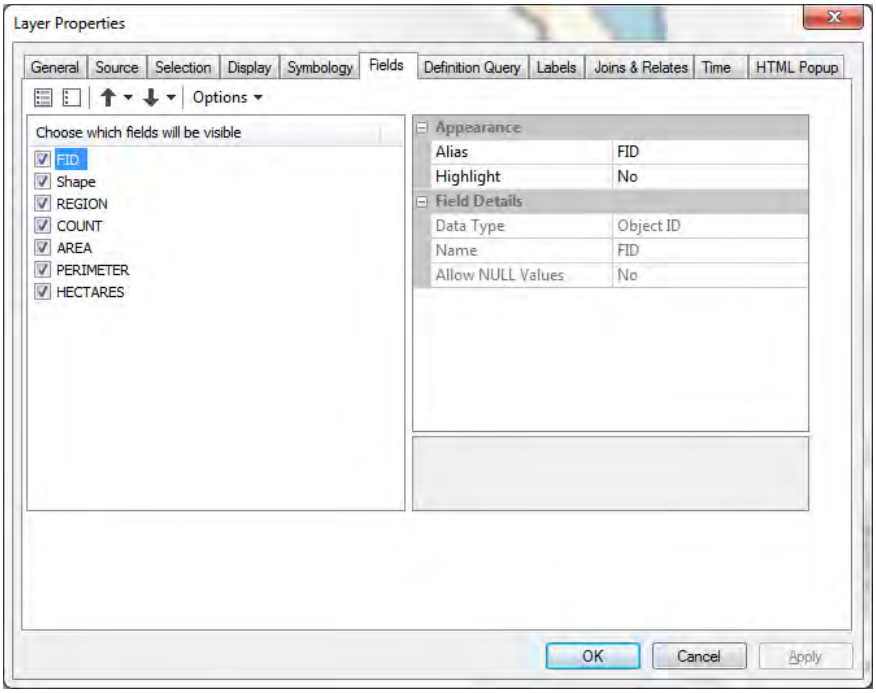
1. Open the regions attribute table (hint: it is under the layer context menu)

You can see the various fields, represented as columns in the regions data, FID, Shape, Region, Count, Area, Perimeter, Hectares.





2. Right click on the Region field header, to access the fields context menu.
3. Click on Properties to open the Field Properties dialog.
4. Notice that the name and alias of the Regions Field.
5. Also notice the field type is “String”, and the length is “254”
6. Click OK
7. Open the region layer properties menu
8. Click on the Fields Tab



This Menu provides information on all the data attribute fields within the data table. It provides the name, any alias, type of field length, precision and numeric format. It is a quick reference for users when working with data tables.

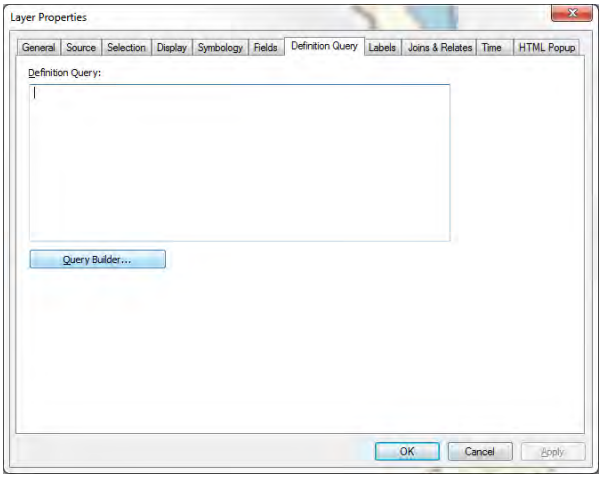
9. Click OK to close the menu.

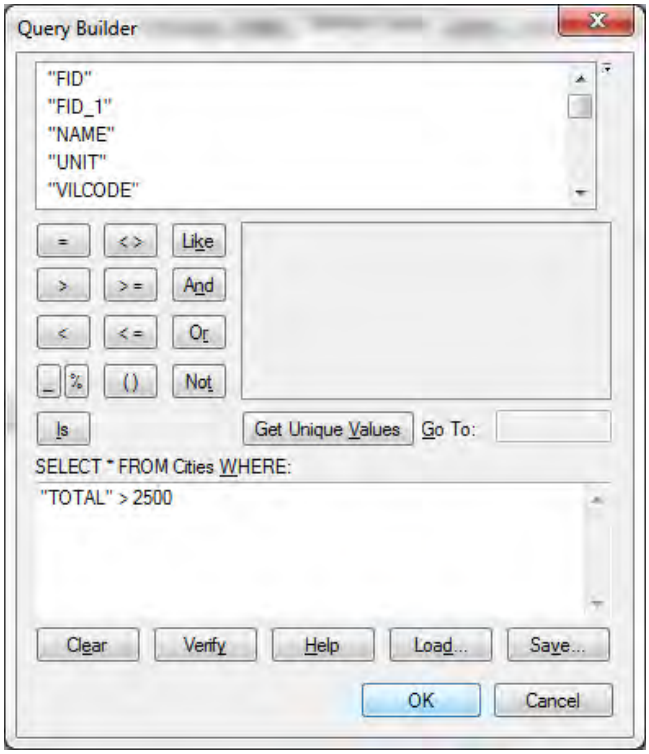
Layer Properties –Definition Query

Definition Query provides a tool that permits a user to display only features that meet certain criteria. This function is similar to the Data exclusion function under Graduated symbols we have previously discussed, however, the definition query allows a user to define a simple or complex query function on a data attribute that affects the entirety of the dataset. The result is only that data that meets the query is displayed in ArcMap, both the Map view and in the attribute table. It is helpful to remember that the layer is only a reference to the dataset, so another way to think of a definition query is that it can be used to subset a portion of a larger dataset.

We will subset our cities data to help clarify our map

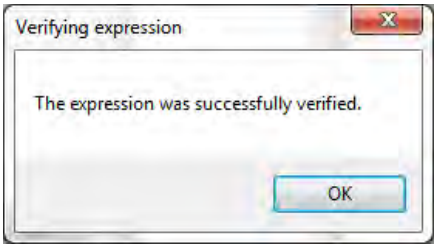
1. Turn on your Cities layer, view your map
2. Open the layer properties menu for the Cities
3. Click on the Definition Query tab
4. CLICK on the QUERY BUILDER button, the following dialog opens



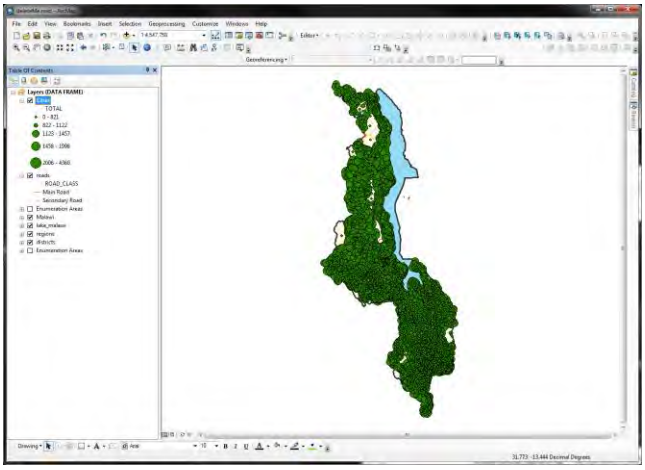


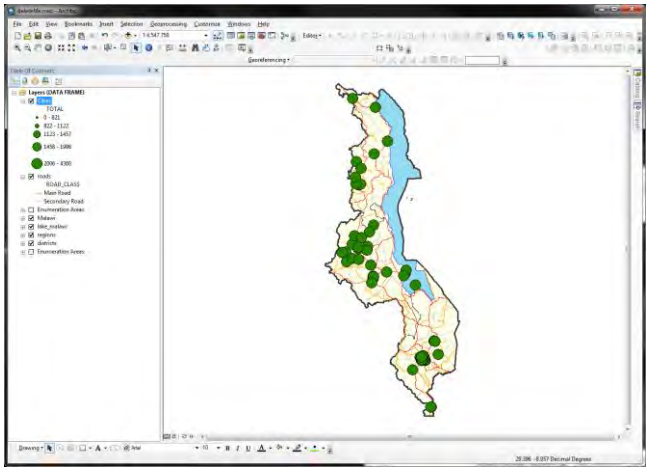
We will subset only cities that are larger than 2500population.

5. Select the field “TOTAL” from the top menu, (hint: double click will enter it in the equation box.
6. Select your > operator
7. Type 2500
8. Your equation should look like the one above.
9. Click Verify
10. If your expression is successfully verified click OK
11. Click OK on the query builder
12. Click OK on your layer properties and view your map



What does your map look like now?





Here we can use the QUERY BUILDER tool to define a specific query. Perhaps we are interested only in display villages whose populations are between 1,000 and 2,500 inhabitants. By defining the appropriate complex query we can easily implement this function.

13. Open the Definition query, query builder menu
14. Clear the existing Query
15. Use the Query where: "TOTAL" > 1000 AND "TOTAL <2500

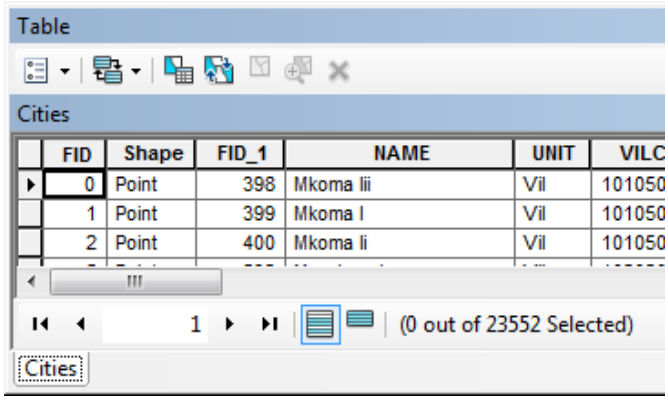
Our first query which is a simple query looks like this: "TOTAL" > 1000
This in itself is a simple query, however by using another logical operator in this case AND we can join it to another simple query to create a complex query.

"TOTAL" > 1000 AND "TOTAL <2500

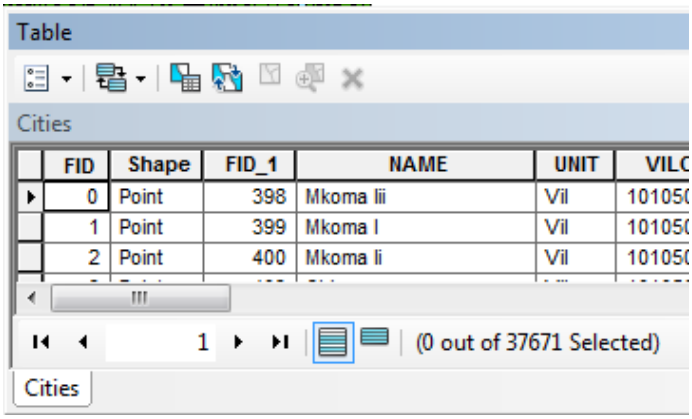
16. CLICK on VERIFY to run the query
17. Click on OK and look at your map

If we compare the map prior to the Query vs. after the query we will see a big difference in the number of features present. This should be very apparent in the map, which now shows results for cities with populations between 1000 – 2500 inhabitants. One additional way to see the effects of the definition query is through the attribute table.

18. Open your cities attribute table
19. View the bottom left, which lists the total number of features present. You should have 23,552 features.



20. Close the attribute table
21. Now clear you definition query (hint: return to your definition query menu under the layer properties)
22. Close your layer properties menu
23. Open your cities attribute table



How many records are there?
Please Note: the definition query is used to change what records are displayed for this particular layer, it does not alter or change the source dataset. It is a common practice to have multiple layers in the same map document that uses the same dataset. This can help symbolize your data with a bit more control.

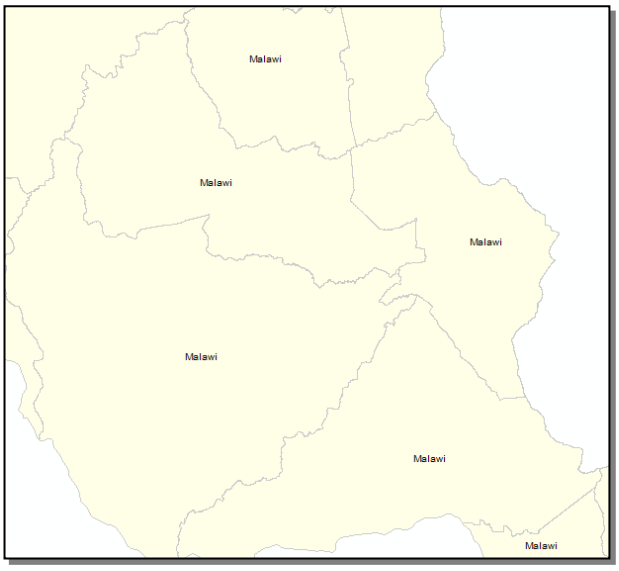
24. Close your attribute table.

Layer Properties –Labels

ArcMap provides a user with advanced tools for creating professional cartographic text labels for illustrating the names of places, countries, rives, and any other features within the map view. An important note in ArcGIS: labels are considered dynamic elements. Labels are drawn and redrawn each time the map scale and extent changes. Users are not able to manipulate labels, rather all labels are controlled by the label settings per layer. In order to manually manipulate a label, it must first be converted to annotation, which is a static text element. We will not cover annotation in this training, but you are encourage to experiment with annotation, as it allows for greater control when producing a cartographic product.

You have previously learned that you can turn labels on and off from the layer context menu. We will now learn some of the settings used to control how the features are labeled, to do this, we will use the Labels menu in the Layer Properties.

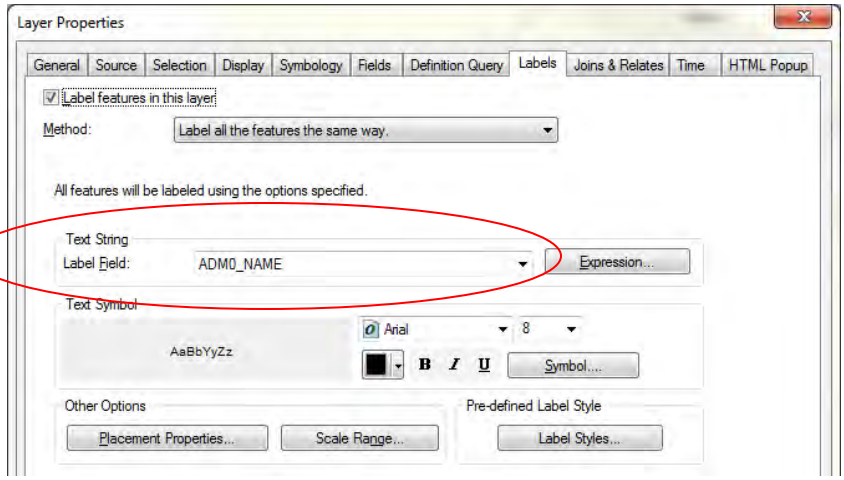
1. Turn off all layers except the districts
2. Zoom to a scale of 1:1,000,000
3. Turn on the labels for districts using your layer context menu
4. View your map



You should note that each district is labeled as "Malawi". This is not very helpful, so we need to change what ArcMap is using to label the districts. To do this, we will use the Layer menu in the layer properties menu.

5. Open your districts label menu (in the layer properties)

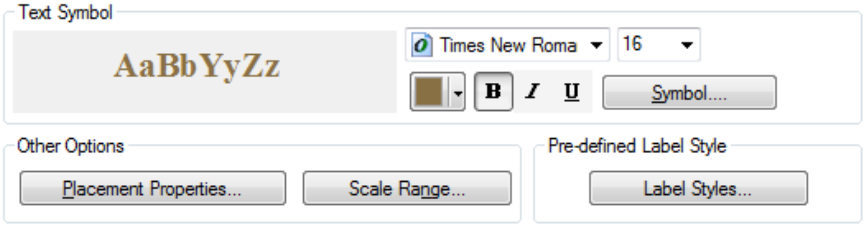
Currently, ArcMap is using a default field to label features, which is not correct for our layer.



6. Use the Label Field menu to select the "ADM2_NAME" field
7. Click OK, view your map

You should now see that your districts are correctly labeled. However, the labels are not very cartographically pleasing, so let us change some additional label settings.

8. Open the label menu
9. Set the font to "Times New Roman"
10. Set the font size to 16
11. Set the text color to leather brown (4th column, bottom row).
12. Click OK and view your map



As you can see, you can change the font type, size, color, etc as well as the placement of labels. ArcMap has an extensive list of controls for labeling.

This menu function will be revisited in more detail towards the end of Module II and in Module III, when we are ready to insert labels into our map.

Layer Properties –Joins and Relates

One of the great functions of ArcGIS is data integration, the ability to join one data table to another. This can be accomplished through two principal methods; a join based on an attribute and a spatial join. A spatial join is performed by ArcMap between to spatial datasets, and is based upon their location to each other. We will not cover a spatial join in this training, rather, see the Help section to learn more about spatial joins. We will focus on joining tables based on an attribute (which we will simply refer to simply as a join). In order to perform a join, each data set must share a common identifier (the primary Key).

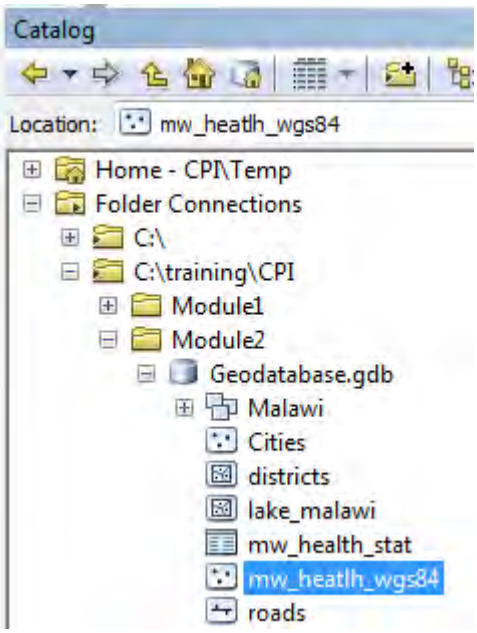
For this exercise, we will be working with two new data layers, loaded from a geodatabase, one is a featureclass the other is a table.

1. Add Data, Browse to the C:\Training\Module2 folder

(Hint: you can use the Catalog window to drag and drop the files onto your map)

2. Open the Geodatabase.gdb
3. Add the wv_health_wgs84 point featureclass and the mw_health_stat

Note, ArcMap added the point dataset with the other points in your TOC, but it added the table at the bottom.



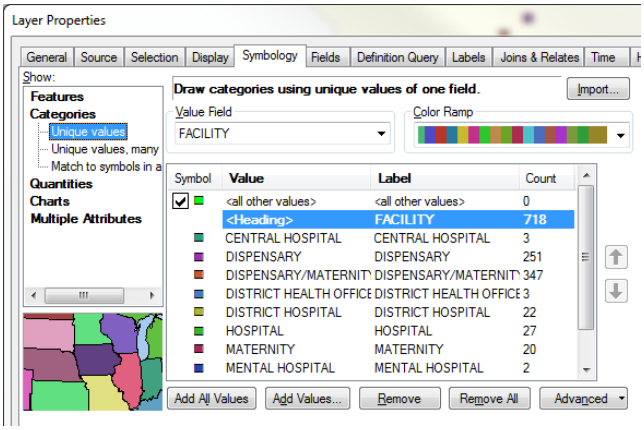
Please note, that your TOC automatically switches to List By Source. This is because your table does not appear in the List By Drawing.

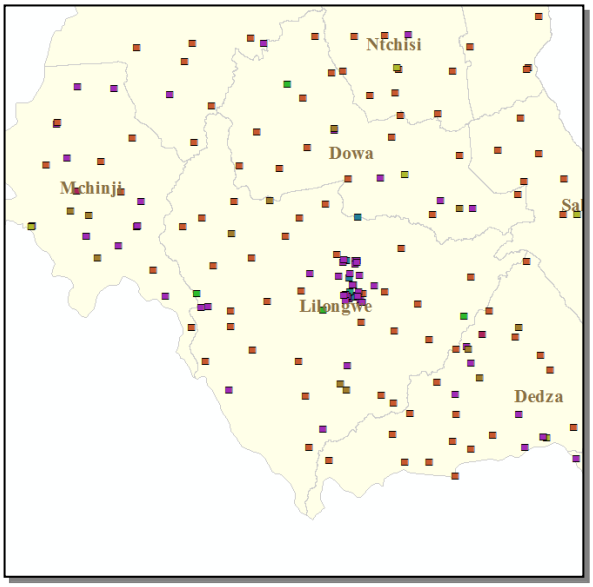
The mw_health_wgs84 dataset contains location information for hospitals and health clinics in Malawi. The mw_health_stat table contains health statistics that correspond to the hospitals and health clinics.

Let us rename our new layer and symbolize the points

4. Rename mw_health_wgs84 to Health Centres
5. Set the symbology to Categories, using the Facility field
6. Set the symbology to a square, 8pt
7. Apply any random color ramp

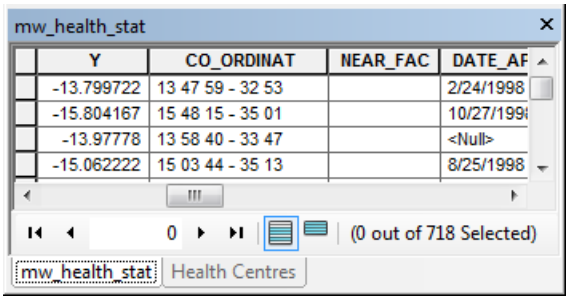
This dialog box informs a user if any tables have been joined or related to the table of the data layer in question.





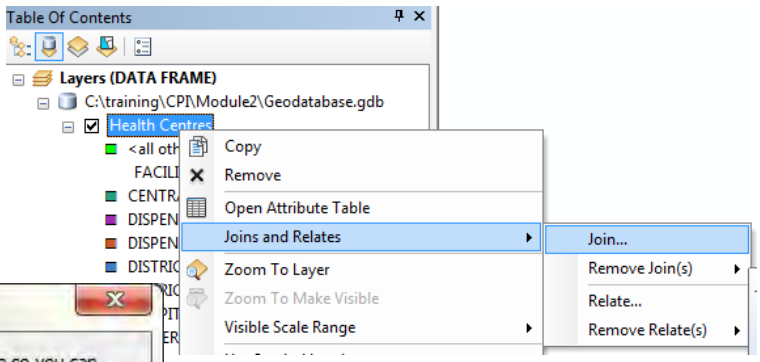
Your map should now look similar to the one on the right. Currently, the map is hard to distinguish important health centres. We will want to symbolize these health centres based on the number of operations they perform. This data is not available though directly in the feature attribute table. However, this data is available in our mw_health_stat table. We will need to perform a JOIN. In order to join the data, we must first identify the primary key, or the common identifier used in both datasets.

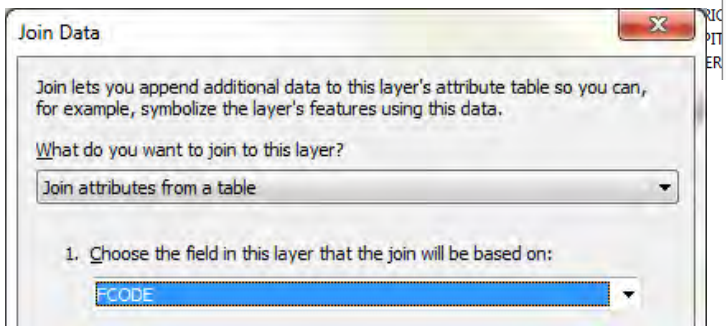
8. Open the Health Centre's attribute table.
9. Leaving the attribute table open, Open the mw_health_stat table. Note: both tables are not visible, however, there are tabs on the bottom of the table window.
10. You may switch between tables using those tabs.



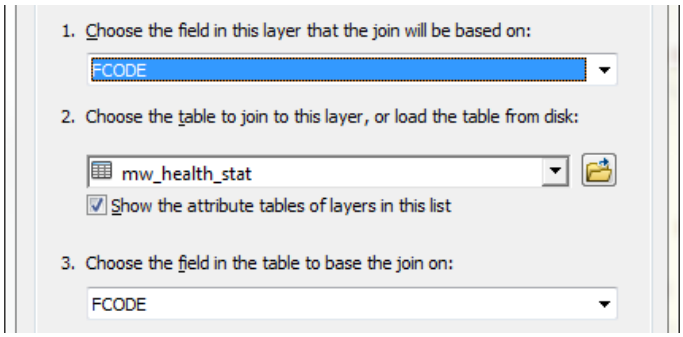
Look carefully between the tables. Which common field is available to use as the primary key?

11. Go to the Health Centres Context menu, and select Join.
12. Choose the FCODE field that this join will be based



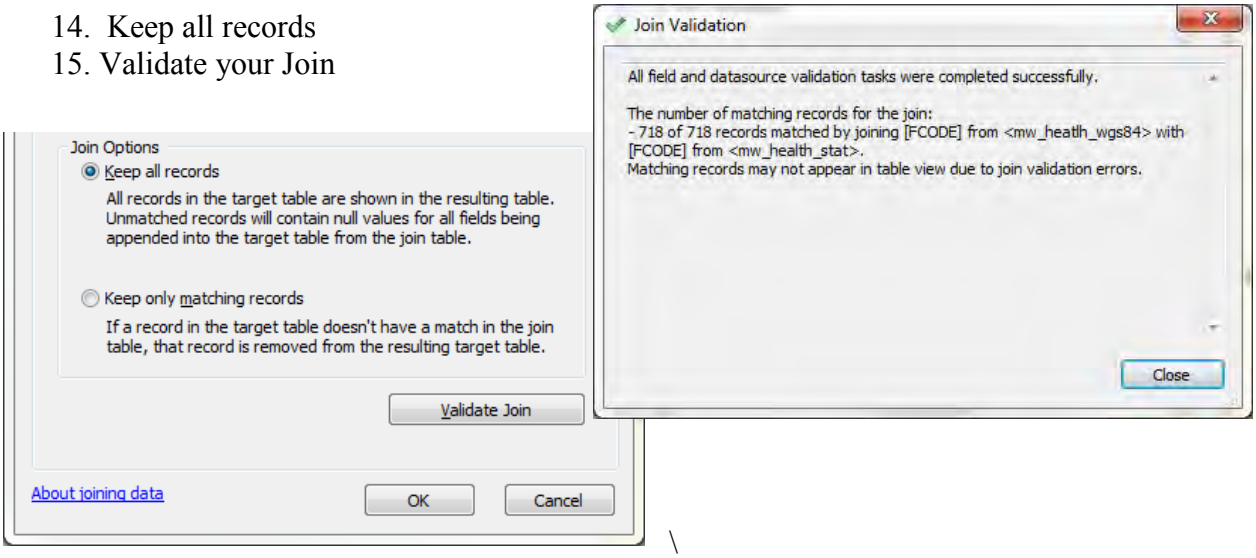


13. Choose the mw_health_stat table that will be joined to the Health Centres.



Note that once a primary key is identified for the layer, and a join table is selected, ArcMap looks for that same primary key field and will automatically fill in the FCODE field for you. This will only happen automatically when the field names and field types are the same, otherwise you will have to specific which field to use manually.

14. Keep all records
15. Validate your Join



\

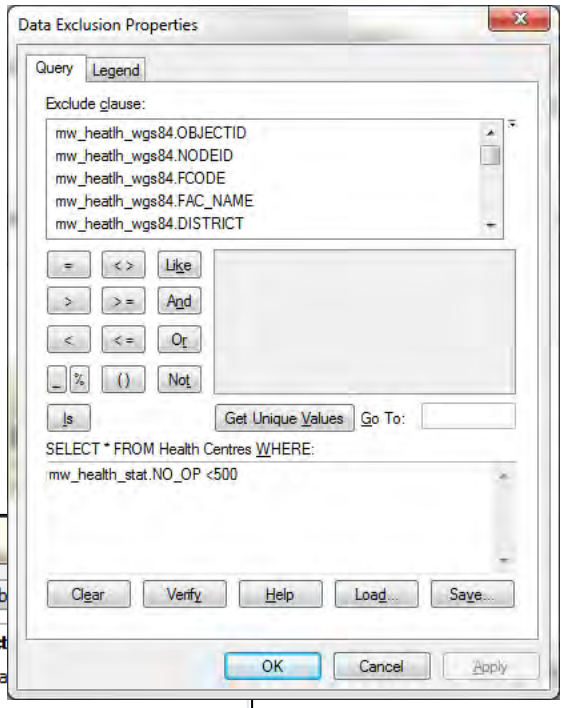
You should have 718 of 718 records join.

16. Close your Join Validation
17. Click OK and view your Health Centre attribute table

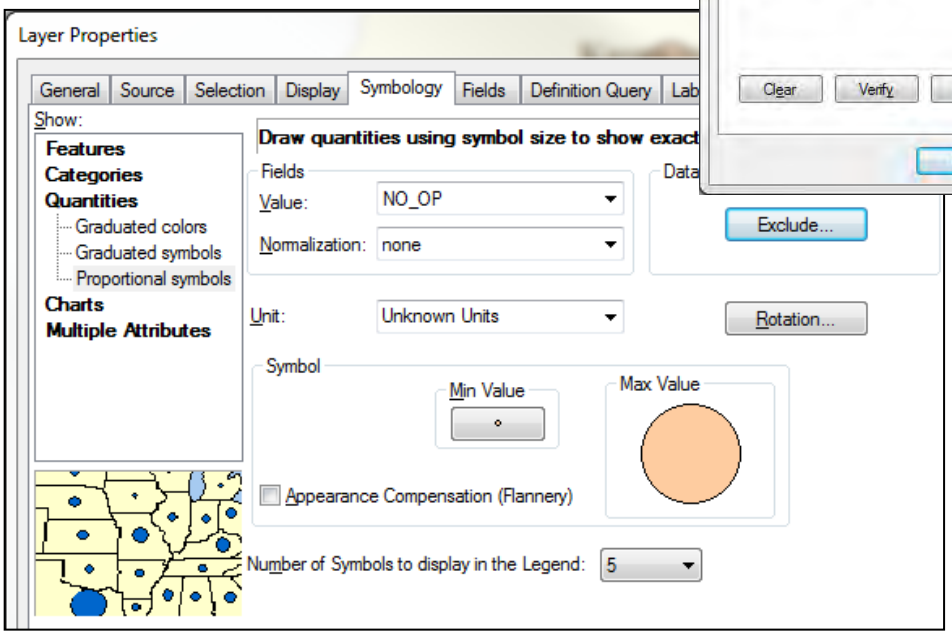
Note: you now have additional fields that have been appended to your Health Centres Dataset. These new fields are temporary, and only persist as long as the join is in place. You may remove the join at any time, and a join does not alter your data. If you wish to make a join permanent, you may export your data (while joined), into a new dataset.

Let us now symbolize the Health Centres by the number of operations.

18. Symbolize Health Centres by Quantity
19. Use Proportional symbols
20. Use the NO_OP field for the value
21. Exclude all NO_OP < 500
22. Set the Number of Symbols to display in the Legend: 5

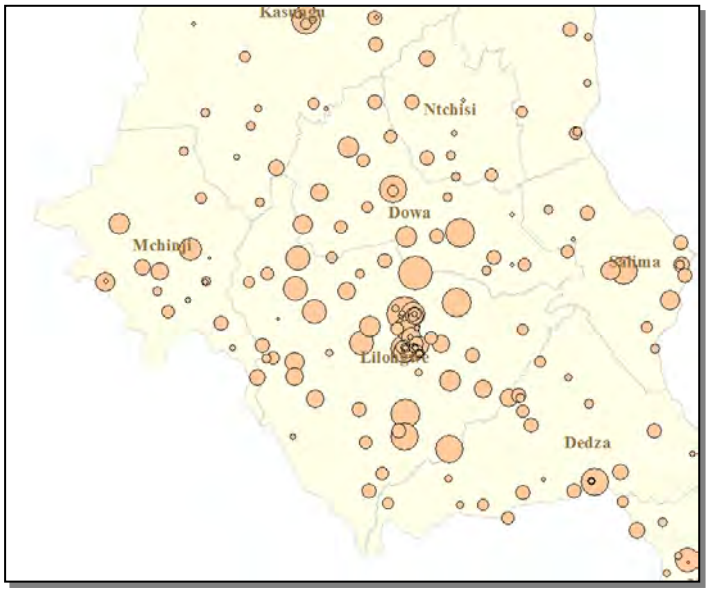


Your symbology should look similar to the one below:



23. Click OK and view your map

While cartographically, this map may need some further work, it does convey new information about the Health Centres.

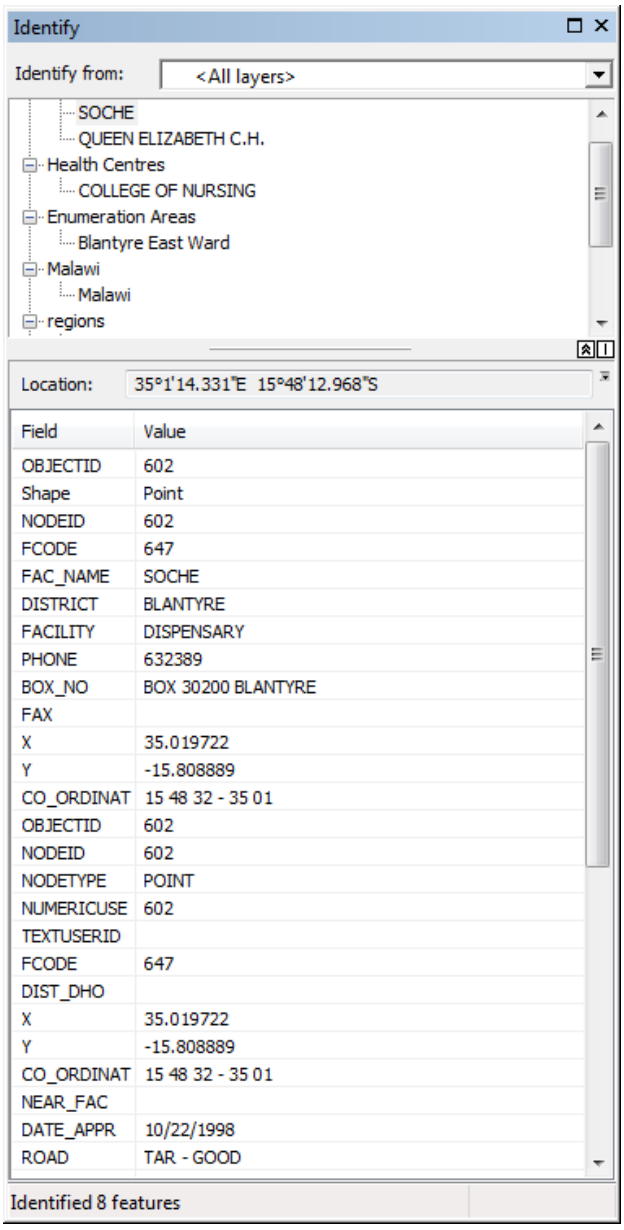


Identify Tool

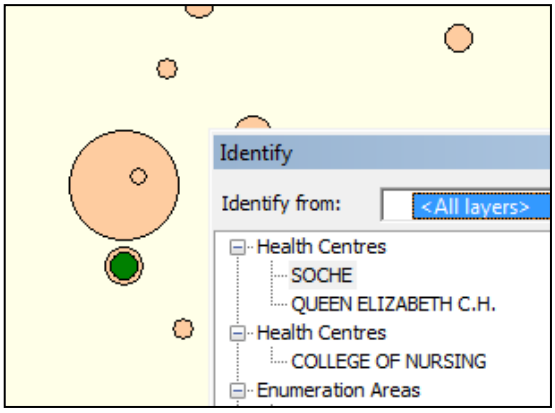
The Join will allow us to explore new data that has been associated with our Health Centre features. Lets look at using the Identify Tool.

24. Zoom into an area of density of Health Centres in your map
25. Use the Identify Tool to identify a feature. (hint; it is on your tools toolbar)

You will see an Identify Dialog box open. Note that the top of the box controls which layers you will be identify. If it is set to all layers, you will Identify any feature that is present where you click. In this instance, you can see that we have identified many layers, including several Health Centers.



When you identify a feature in your dialog box, it will briefly flash green, as a guide for you to locate it on your map.



26. Identify the first feature in your list and view the fields.

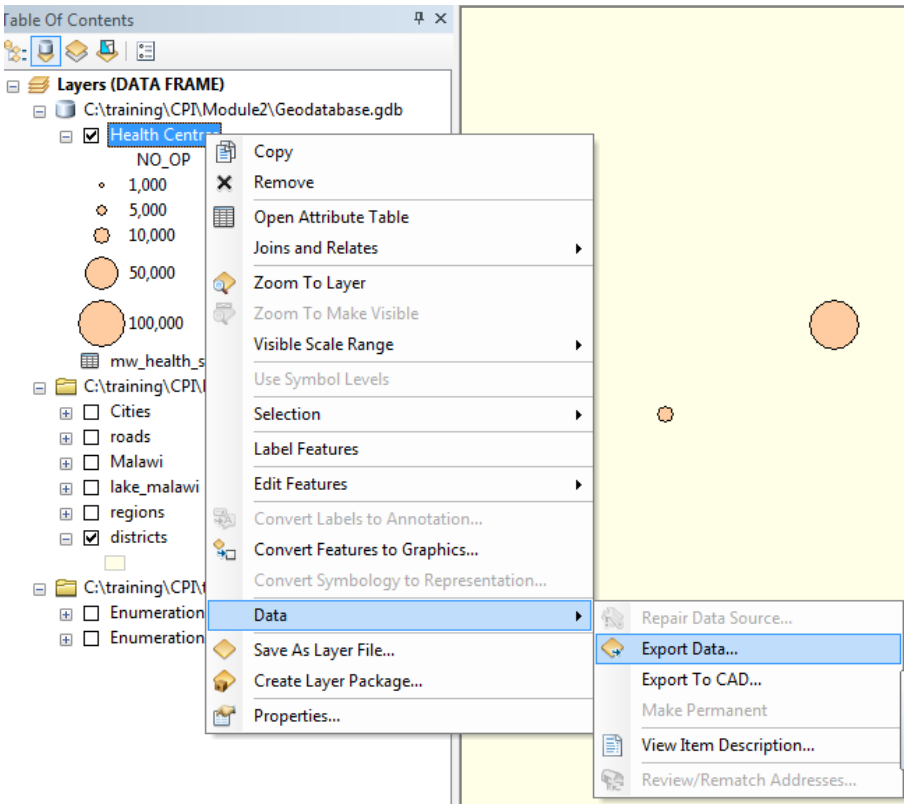
Note that the coordinates are available of the feature.

Note the attributes are available, including the attributes of the Join Table as well.

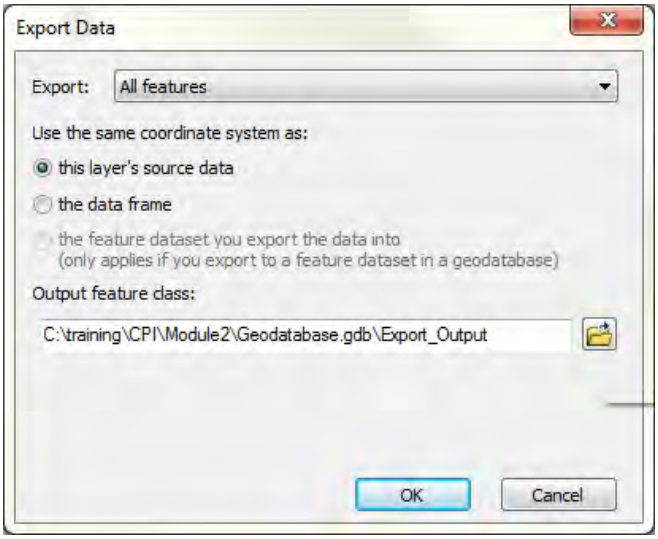
The last step we will perform is to export our joined data to create a permanent version of the Health Centre dataset.

27. Go to your Health Centre Layer context menu
28. Select Data
29. Select Export Data…

The Export Data window will open, allowing you to browse to the location you want to place your data. We will place the data in our C:\training\Module2 folder, and save the new data as a featureclass inside our geodatabase.



30. Name your export file "mw_healthstat_wgs84"
31. Click OK



We will now move on to summarize everything we have discussed to produce a cartographic map.

Module 2- Wrap Up

Take a moment to study the map below. What do you notice about the map?

What Layers are present?

How is each layer symbolized?

What is the drawing order?

What is the Hierarchy?

What are the labels? (This will be covered in Module 3)

Using what you have learned, create a map that is similar to the one on the previous page. This will mean you will determine what layers to turn on and off. What features you may want to include and exclude.

In order to produce a map such as this you will need to:

Use a Definition Query on a layer (or more)
Symbolize by category
Symbolize using a visual hierarchy (color and line thickness for example)
Label features using classes (Module 3)
Label using different Fonts (Module 3)

You can experiment and have fun! Though there are solid cartographic principles to follow, cartography is part art, and appeals to the design of the individual cartographer. The point of creating a map is to convey ideas about spatial relationships, or in other words, to tell a story.

Now that we have our map view set up we will start to create our map layout.

At this point Please SAVE the project under the name ARCGIS training. Note that the file extension for ArcGIS projects is .mxd

Map development or cartographie will be done in Module III which will cover the following:

- Addition of labels our map
- Addition of other graphic elements to our map (North arrow, legend, regional data view, scale and supporting data text, etc).

Please open Module III – Map Layout Development

ArcGIS 10.1 Training – Module III: Cartographic Development

In order to build capacity and understanding of Arc GIS and its functionality Module III will focus on creating a map layout based on the ARCGIS project developed in Module II and build on the basic skills learned so far.

Module three will focus on:

- Map layout development
    - Print set up
    - Labels
    - Graphic element insertion
        - Legend, north arrow, scale bar, regional data frame, source data information, logos, etc.
    - Exporting maps

Table of Contents

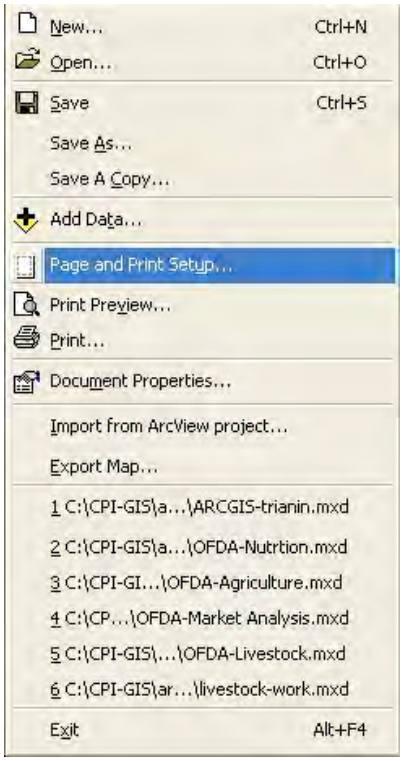
PAGE SET UP

1. Open the Arc GIS Project saved during Module II.

Once we have our data symbology developed we can start to think about our map design.

The first step before we set up our map layout view is to look at our current PAGE Set up.

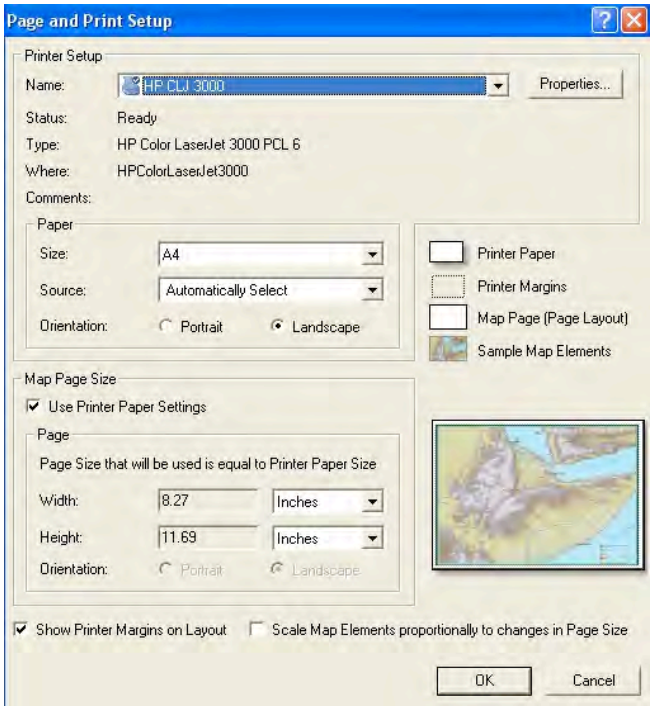
2. Go to the FILE menu then Page and Print Set up



Depending on your map size and the actual geographic area represented a user will need to select the appropriate map set up – either Landscape or Portrait.

As well, here a user should define the size of the map that will be generated A4 (letter) or another custom size for specific printing purposes.

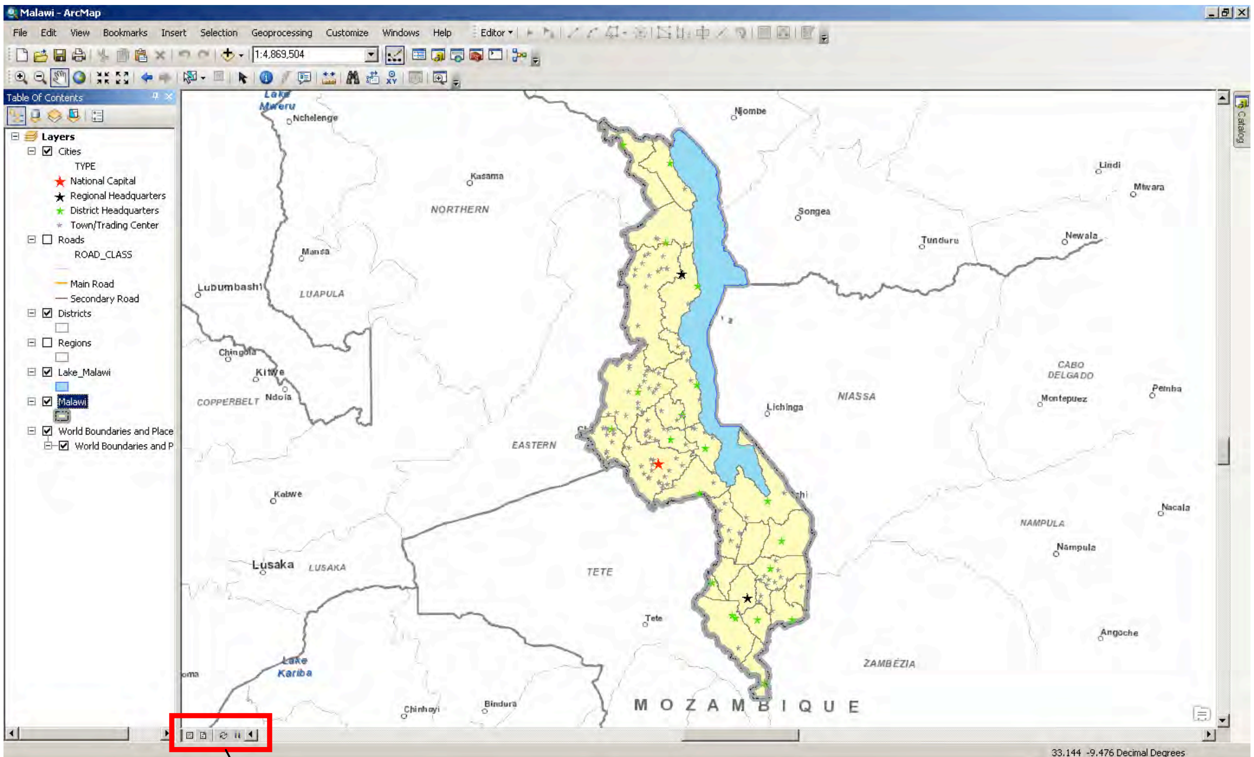
For this map, select Landscape and click OK.

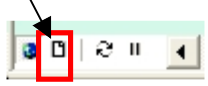


MAP LAYOUT VIEW &TOOLS

Once the Page Properties are set we need to switch from our TOC- Data View to our Map Layout View.

This is done by clicking on the Map Layout View button. Alternatively, you can use the VIEW menu and select Layout View from there.





When you CLICK on this button – we enter into the Map layout View.

The Map layout has specific tools that will allow us to navigate within the Layout environment.

From Left to Right the Layout tools are as follows:

- Zoom in
- Zoom out
- Pan in layout
- Fixed Zoom in
- Fixed Zoom out
- ZOOM to map page
- Zoom to 100% (print display)
- Toggle Draft Mode
- Focus
- Template change

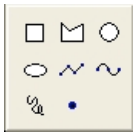
It is important to note that layout tools should be used to navigate within the Map layout environment. If Data View zoom in, zoom out and pan tools are used it will change the map display and scale.

3. CLICK on ZOOM to MAP Page 

Some of the other critical tools you will use include:

The SELECT Graphics tool 

This toll is used to select graphics within the Map layout, to move them around, etc.

Other commonly used tools include insertion of text in different formats and insertion of shapes, lines or points.  

As well we have FONT and shape/text tools that allow a user to set the font type, color, size as well as shape fills and colors for polygons, lines and points before we add them to the map

If you are missing or close out the Layout Tools or the Draw tools, you will need to go to the CUSTOMIZE menu, select TOOLBARS and turn on your tools.

It is important to remember that all elements within the map layout are graphics including the Map itself and can be deleted if selected and deleted. Please be careful when you are working in the Map Layout environment.

However if do accidentally delete an important graphic element by mistake you can always use the UNDO and REDO buttons to correct this error.

These buttons are accessible after adding a graphic element to the map layout or after deleting or changing graphic elements.

Before we start to add our graphic elements to the map we will work to insert our text Labels that will assist our map audience to better understand the map through providing information on features within the map such as principal locations, administrative units, countries, oceans, etc.

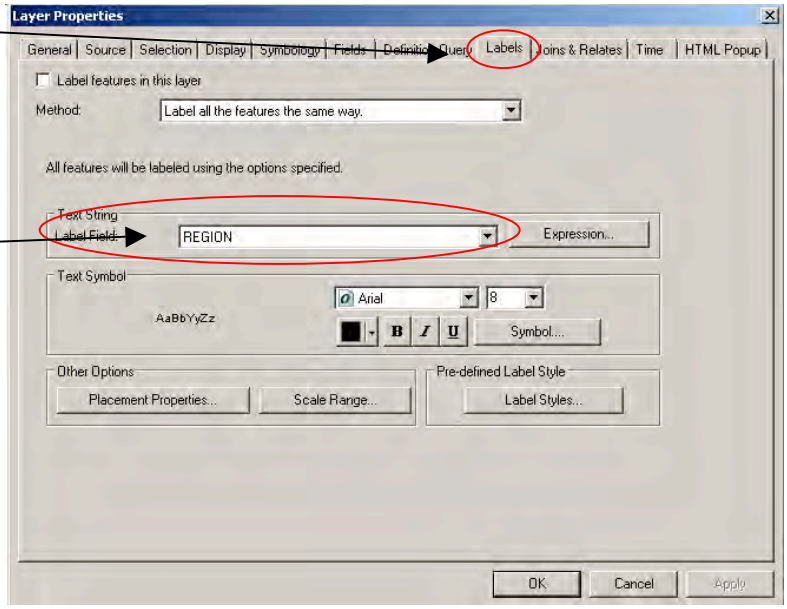
LABELS

In Module II we discussed the various TAB properties found when we RIGHT CLICK on a shapefile data them in the Table of Contents (TOC). In Module II emphasis was placed on defining and displaying symbology for our various data themes. One important aspect that was left out that will be examined now is LABELS for data themes.

Labels are important aspect of any cartographic product and provide crucial information to anyone who maybe using or looking at a map. Remember we use maps because they are visual sources of information that can provide an abundance of data on a given theme. Labels will inform a map audience what they are looking at through descriptive text.

Let's start the LABEL process: We will start with our largest features and work our way down to the finer features and by creating and applying labels we will be able to determine at what level to stop labeling and how much information we can actually include in a map so that is informative and still reads well and is not overly populated with either data or label features.

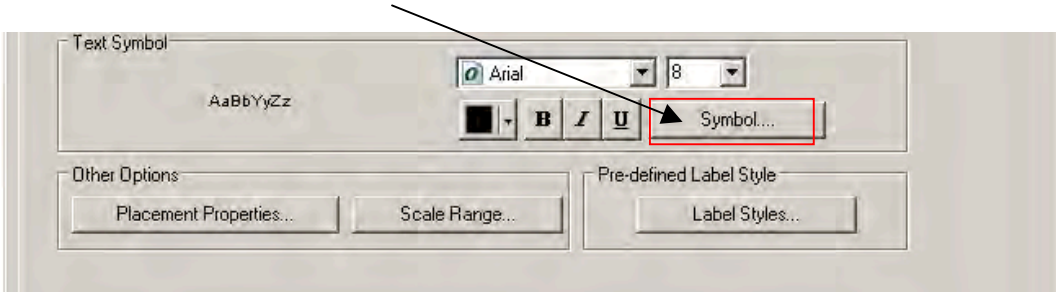
4. In the TOC, RIGHT CLICK on the Regions Layer.
5. Select PROPERTIES.
6. Go to the LABELS Tab to bring up the Label properties.

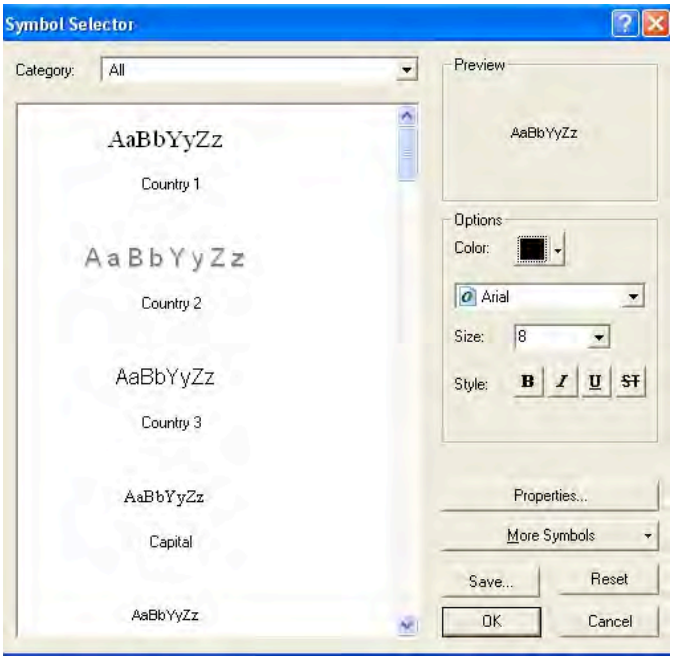


What data field should we use to Label our Regional Countries?

7. Choose REGION.

8. Now CLICK on the SYMBOL button to select from different TEXT styles.

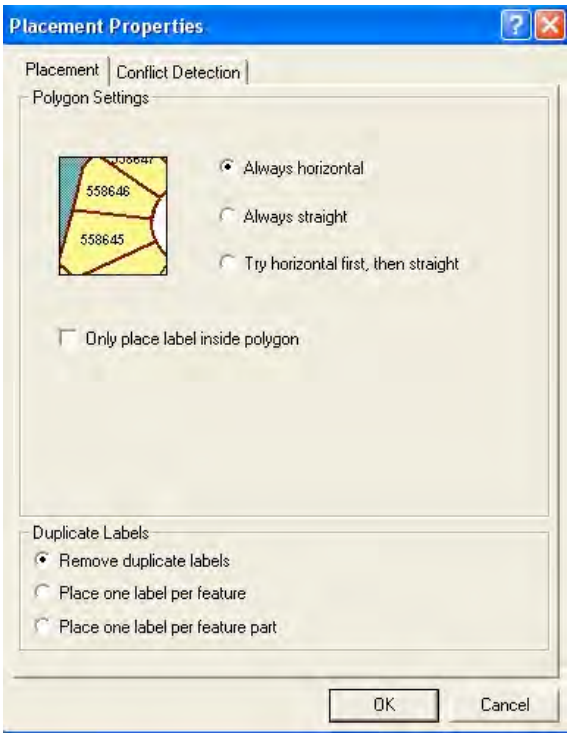




9. Scroll through and have a look at the prefabricated text styles available for use.
10. Select HISTORIC REGION and increase the font SIZE to 18.

11. Click OK and Return to the main Label Tab.
12. Now Click on PLACEMENT Properties in the Label properties box.

Placement properties is used to determine how features will be labeled, direction of text and how many labels per feature part – for example a country like Indonesia has many different islands which would consist of many different polygons, do we need to label each feature part with the name Indonesia or just the Country as a whole? Placement Properties allows a user to choose how to label features whether it is polygon, point or line, as you can imagine point features have more options.

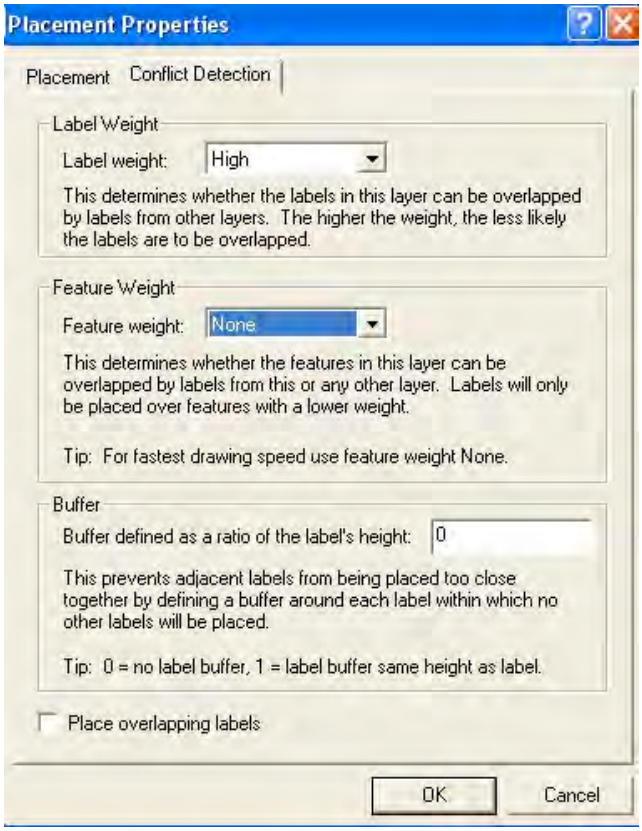


On the placement Properties choose the following:

1. Always Horizontal
2. Remove Duplicate Labels

Now go to the CONFLICT DETECTION tab.

Conflict Detection Settings allow a user to determine how Labels will display in proximity to other labels within the map layout and to give weight over 1 data feature over another and to ensure that maps are not overlv crowded with text labels.



Label weight permits a user to weigh how labels are overlapped –

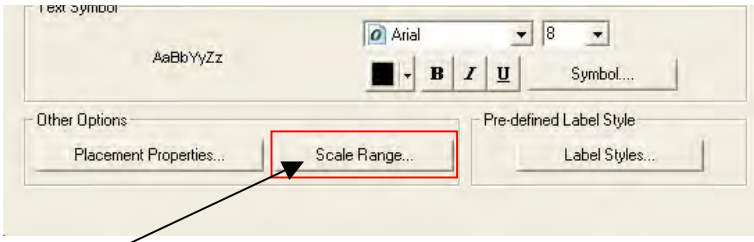
1. Select High here as we do not want labels to overlap or touch

Feature weight defines how labels from different layers overlap with features of this layer

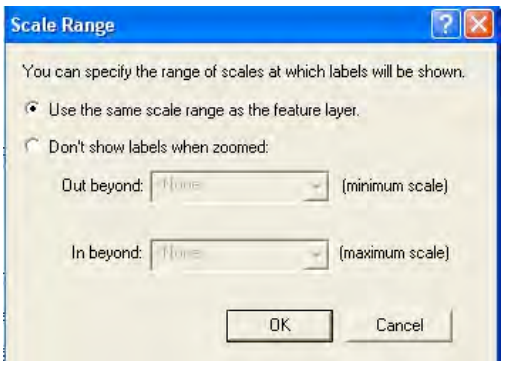
2. Select NONE for feature weight

Leave Buffer as 0 and leave Place Overlapping Labels – toggled off as we do not want labels to overlap.

13. Click on OK when finished here.
14. Now click on the SCALE RANGE button found in the Label properties.



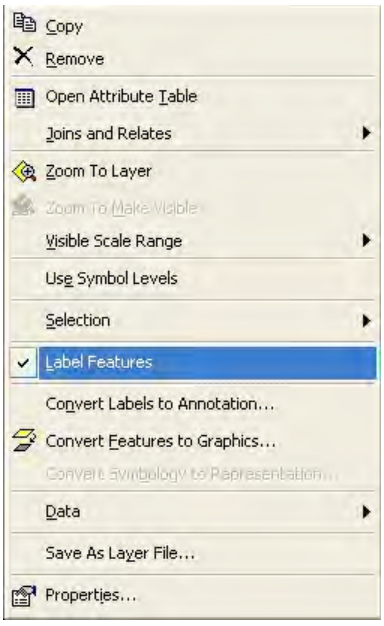
This button opens a dialog box that permits a user to determine the scale range for feature text labels within a map layout.

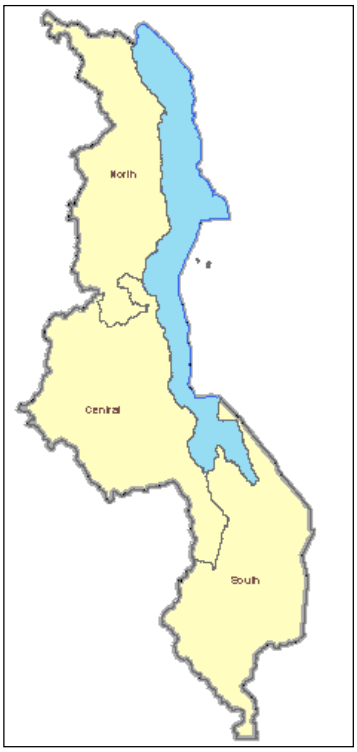


By Choosing Don't Show labels when zoomed a user can define when labels will appear in a map.

This function is commonly used with village databases. For example, with over 10,000 villages in Senegal applying village feature labels at a national scale where we see the entire country is not feasible. However, when a user starts to zoom into a map or given area it is useful to have this text to inform users, therefore the Scale Range function allows a user to set the scale range for when labels should and should not appear.

15. Click OK and close the SCALE RANGE dialog box.
16. Now that we have set up our labels, let's look at them.
17. Click on APPLY on the Layer properties dialog – Do you see your labels in the Map? The answer is no – Even though we set up all the criteria for our labels they are not yet present or 'turned on' in the map layout.
18. RIGHT CLICK on the Regions layer in the TOC.
19. Toggle on LABEL FEATURES.





Once Toggled, we can see the Labels appear in our map layout.

Now define labels for the Malawi Districts data feature: Follow the same steps we used above except define a text style that is different from the Regions layer.

Try different colors and fonts to see how your map will look.

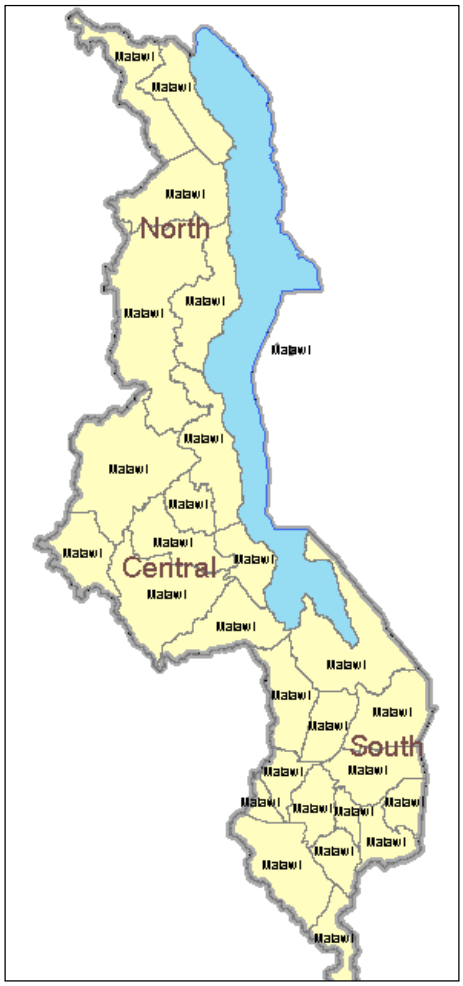
Use the MAP LAYOUT tool 1x1 to zoom into the map at its print resolution to see how different map aspects from labels to features will look.

The 1 to 1 tool button will be useful when we insert our various graphic elements into the map layout such as logos, legend, north arrow, etc to make corrections and fine tune our map before exporting a final product to .jpeg format for printing.

Use the MAP layout PAN tool to pan around your image without changing the current scale or focus area.

20. Now use the zoom to map tool to zoom back out to your entire map layout

Your map should resemble the one below to some degree:



Personally, I feel that the text color in the above map is too harsh, please go back and change the text color so it is not black but a dark shade of gray.

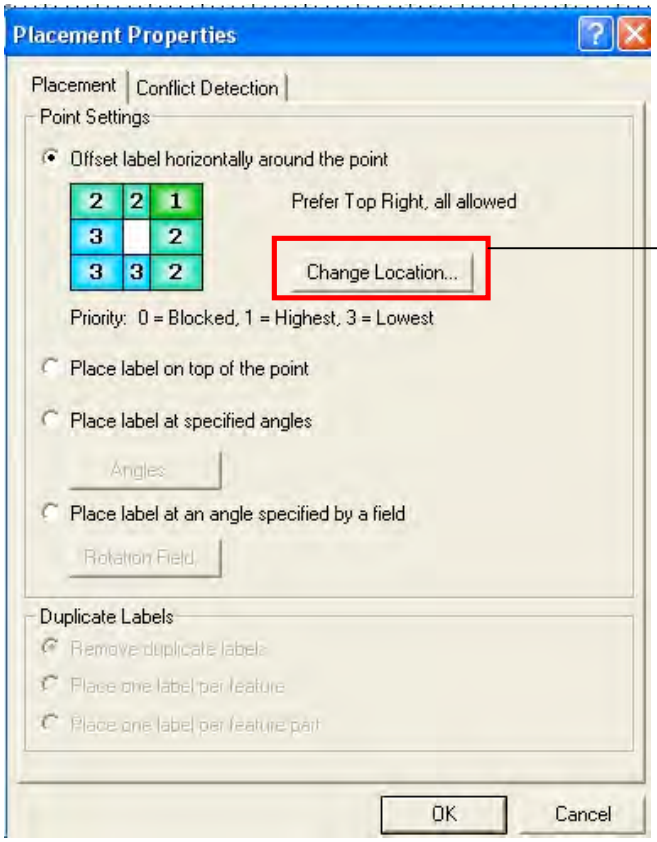
21. Right Click on the Region layer in the TOC.
22. Select PROPERTIES.
23. Select the Labels TAB.
24. Change the current Color from brown to a shade of grey (GREY 30%).

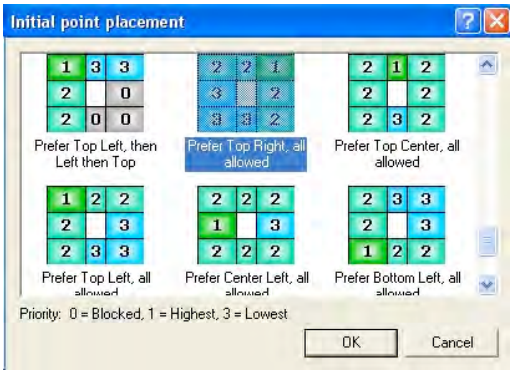
25. Click OK when you are done to see the change, if not satisfied, choose another color.

Now, let's label the cities. Right click on the CITIES layer to open the PROPERTIES and go to the LABELS tab. Under the field value choose – NAME which is the name.

Notice for point placement properties we have several different options since we are now labeling a point feature.

26. Click on PLACEMENT OPTIONS.





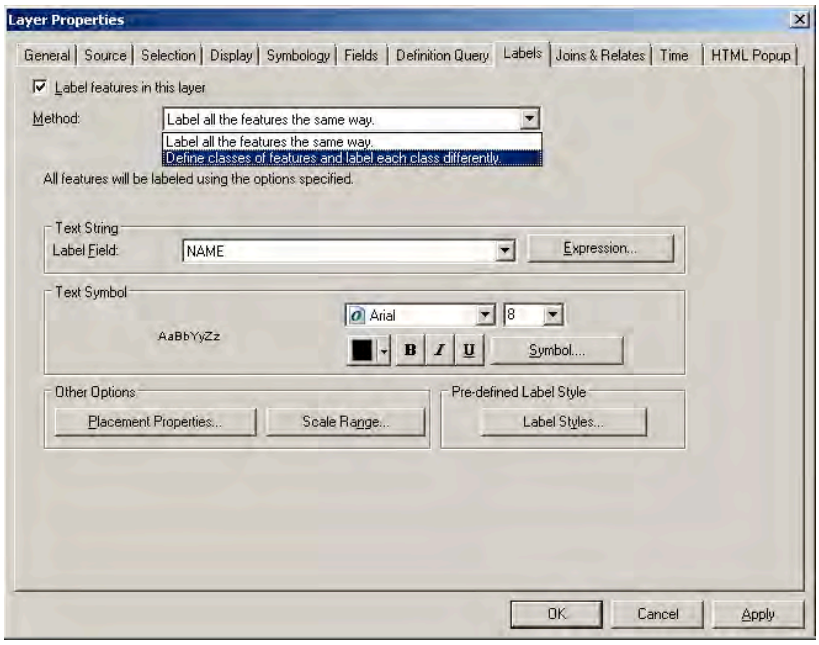
First, it is possible to change the location of the text as per its location to the point feature. Click on CHANGE LOCATION and examine the various choices for where point text can be placed.

As well it is possible to place text directly on top of a point or at a specified angle

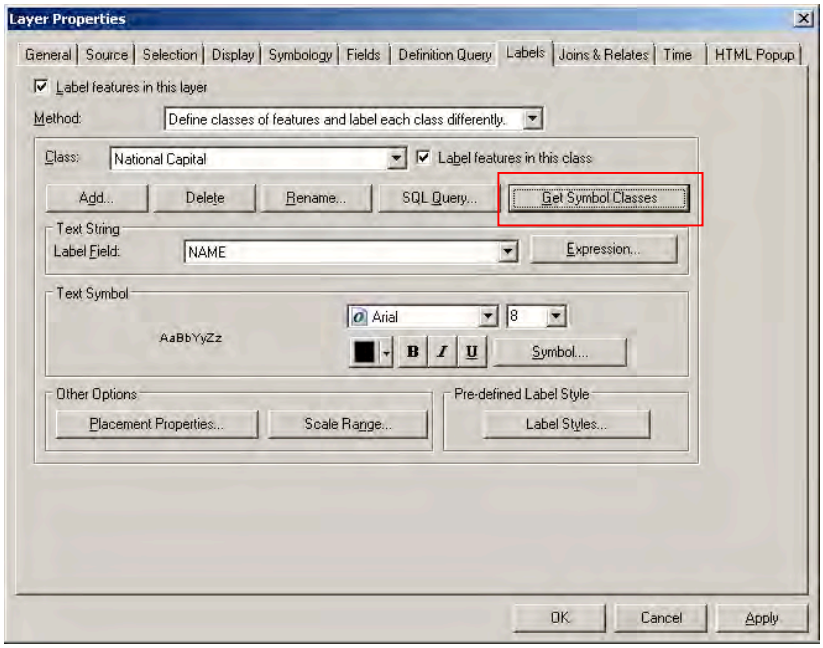
Go ahead and choose a text location, font, color, size, etc and apply your properties.

Since we are dealing with four different types of cities, perhaps we want to display our text for each symbol with the symbol's color. This is easily done in the Label Tab Properties.

Instead of choosing LABEL ALL FEATURES THE SAME WAY choose DEFINE CLASSES OF FEATURES AND LABEL EACH CLASS DIFFERENTLY.

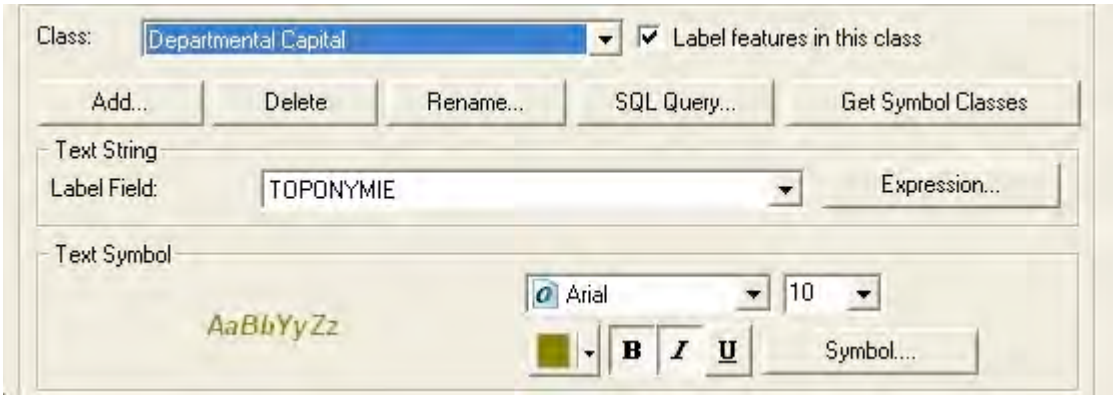


Once selected several new options become available.

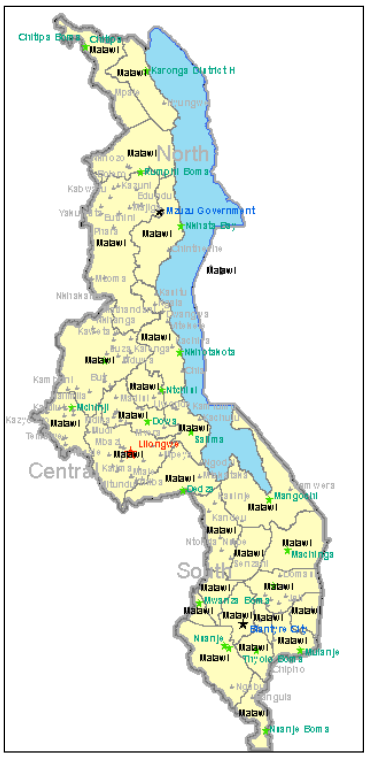


27. Click on GET SYMBOL CLASSES. If it asks you if you want to override the current class features –accept this option and now you will see under the CLASS it has pulled in the different symbol classes we defined earlier.
28. Select NATIONAL CAPITAL – since our symbol is a red star choose a RED color and BOLD the font.
29. Do the same for REGIONAL HEADQUARTERS – choose a BLUE color and BOLD FONT.

30. Do the same for DISTRICT HEADQUARTERS – Choose a DARK GREEN COLOR and BOLD the font.



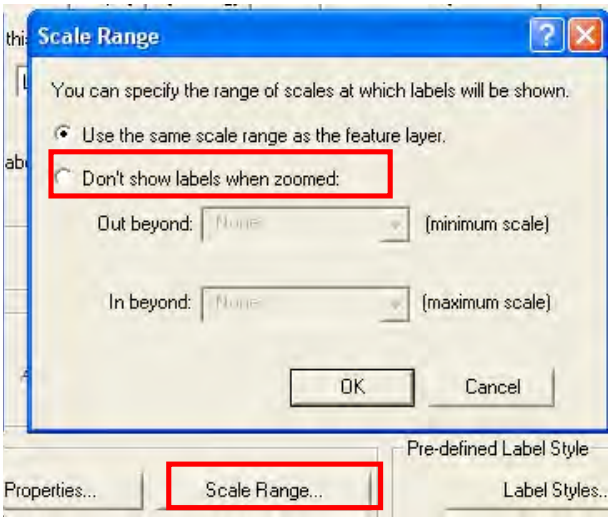
31. Finally, do the same for TOWNS/TRADING CENTERS- Choose a LIGHT GRAY COLOR and BOLD FONT. When finished click apply, look at your new labels and click OK and close the Layer Properties box when finished. Your map may now resemble the map below.



It is clear when we see this map that the labels inserted for towns/trading centers saturate the map. However, it is still good to have these labels but perhaps only when at a scale that is zoomed in more when we are interested at viewing information at the local level. It is possible to set the label properties so that label appear or disappear at a certain scale. This is done using the scale range.

Let's set the scale range for Community rural:

32. Right click on the Cities layer in the TOC.
33. Select PROPERTIES.
34. Select the LABEL tab.
35. Change the CLASS option to DISTRICT HEADQUARTERS.
36. Click on SCALE RANGE.



Here we do the following:

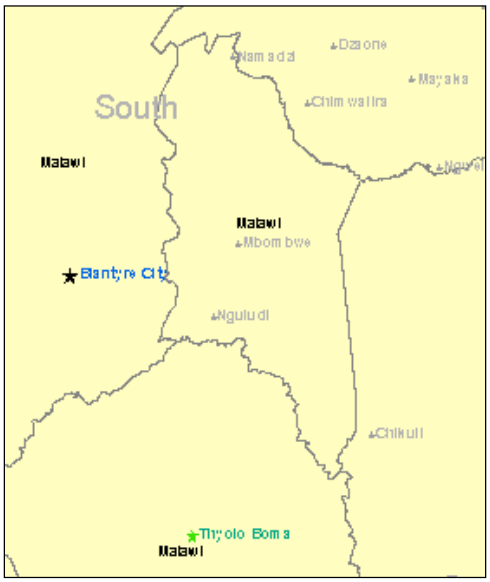
1. Toggle on "Don't show labels when zoomed"
2. For OUT BEYOND choose 750,000
3. And IN BEYOND choose <None>
4. Repeat for TOWNS/TRADING CENTERS
5. CLICK OK, on the SCALE RANGE box
6. Then CLICK OK on the Layers properties and examine your map.

When you look at your map you will notice your labels for District Headquarters and Towns/Trading Centers have disappeared.

However, when we zoom into a scale that is under 750,000 our labels will reappear.

37. Use the ZOOM tool and zoom into the map until you are under a scale that is less than 1:750,000.

Do you see the labels that appear in the map below?



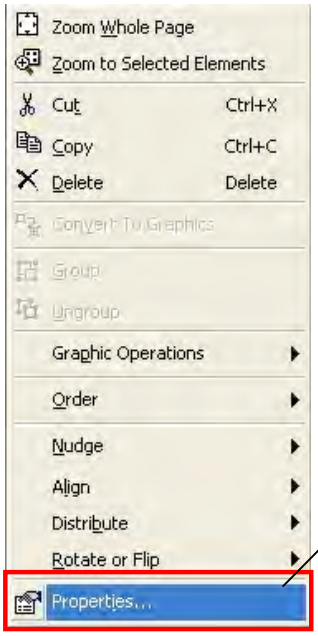
Use the BACK arrow to zoom back to your previous extent. 

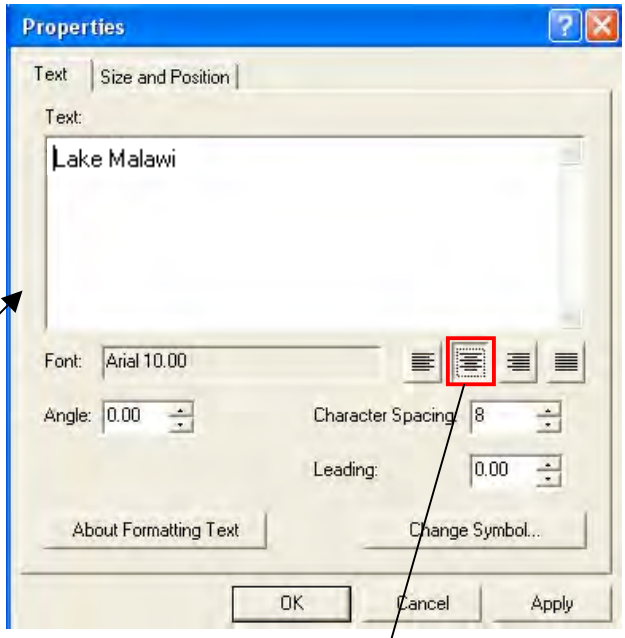
The final text that we will add to this map will be a text insertion to mark Lake Malawi. To do this we will use the text tools mentioned in the beginning of Module III.

Select the A and Click inside Lake Malawi

A small text box will appear in the spot where you clicked. 

38. Right Click on the text box and Select PROPERTIES to open the Text box Properties.





39. Type in the words Lake Malawi – change the spacing to be centered

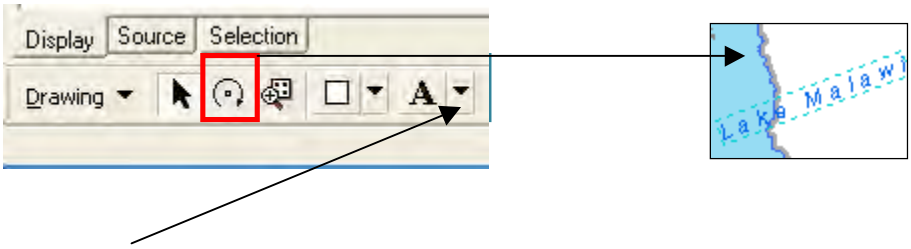
In the properties box a user can also change the Angle of the text, the spacing between characters and the leading.

40. Click APPLY to see what your text looks like – Make sure the Font size is not too large.

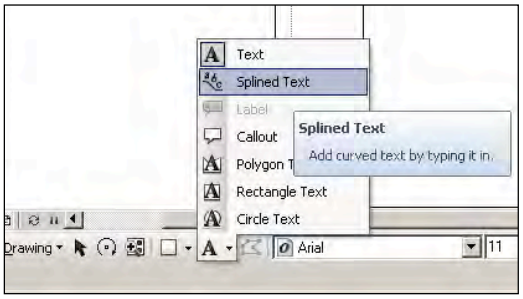
As well, predefined text styles exist for oceans, lakes, rivers and streams. Press the CHANGE SYBMOL button to bring up the symbol selector.

41. Select the SEA text, Click OK, and then APPLY to see how it looks.
    Perhaps it is too large and needs to be reduced – Change the font size. Once you are satisfied, press the OK button to close the Label properties box.

    Once you have inserted a text element into the map layout another tool becomes available. The Rotational tool allows a user to select and change the direction of text within a map layout.



Other text tools allow a user to create different text such as Call outs or riverine text.



Select the SPLINED TEXT tool.

42. Go to the Area in the map where you want to place the text and Click several times in an arc or line direction you would like the text to follow.
43. Right Click on the TEXT
44. Select PROPERTIES – Type Lake Malawi – Click APPLY to see what your Text looks like.
45. Change the color, font and size of the text.
46. Delete one of the Lake Malawi Texts and leave one in the map.

Now that we have Labels covered we will finish our map layout by adding in the various graphic elements that will complete our map layout. These graphic elements will include:

- Map Title and Neat line
- North Arrow
- Source Text box and Neat line
- Logos
- Scale bar
- Legend and
- Data Frame Insert

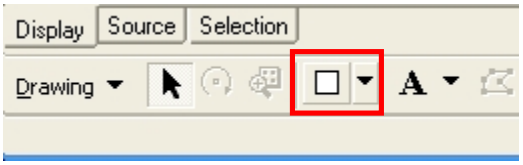
GRAPHIC MAP ELEMENTS

Map elements help provide additional and critical information in map layouts such as data on scale, map titles, north arrows, source information and a map legend which explains to the intended audience what the various colored polygons, lines and point symbols refer to in the map. Therefore the addition of map graphics is an important task and should be performed meticulously and validated to ensure that errors are not made in spelling and that the map itself is a professional looking map. The first item that we will add to our map is a Neat Line Box and a map title.

Neat Box

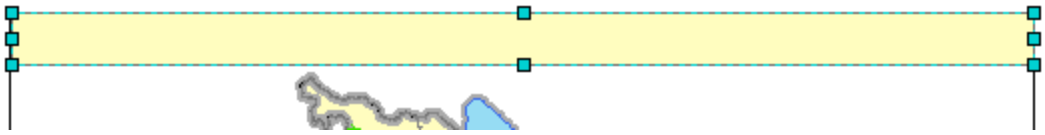
All graphic elements can be found under the INSERT MENU on the main ARCGIS interface on the top of the map and data viewer.

1. Make sure the layout view is toggled and you are working in the layout and not the data view.
2. In the lower right hand corner select the new rectangle box to draw a rectangle that the Map Title will rest upon.



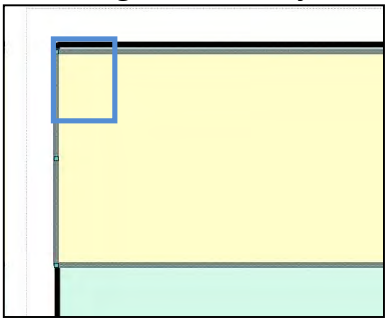
3. Starting in the upper left hand corner of the map inside the layout map border, hold down the LEFT mouse button and draw a rectangle across the top of the map.

Once drawn, release the mouse button and you will see your rectangle in the map layout.

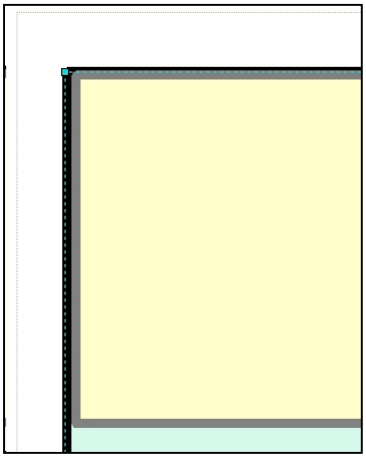


Now it is necessary to ensure the neat box corners are correctly aligned with our map frame.

4. Using the MAP Layout Zoom tool Zoom into the left corner of the map



5. Select the Black arrow element/graphic selector 
6. Select the neat box
7. Using the arrow adjust the corners of the neat box so they align correctly with the map frame
8. There should <u>not be</u> any visible gap or overlap between the Neat box and the map frame



9. Now perform the same steps on the right hand corner of the map to ensure everything is aligned correctly.

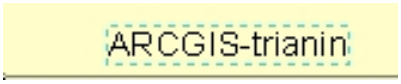
10. Use the Zoom to map button and zoom back out to your map layout view 

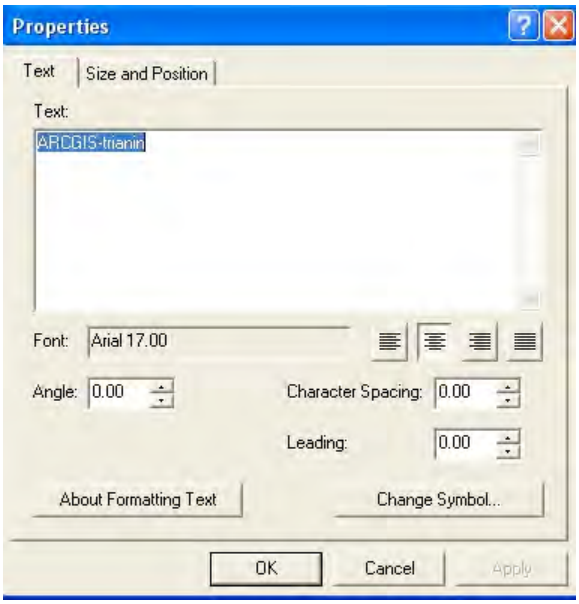
Map Title

Once done we will now add our TITLE to the map

11. Go back to the INSERT MENU and Select TITLE

From here you will see a Text box appear in the upper middle portion of the screen, most likely just below the neat box we just created. The Title will default to the beginning name of your ACGIS project.





12. Right Click on the text
13. Scroll down and select PROPERITES this will open the text dialog box.
14. Type in an appropriate name for your map title. In this case let's write:

<u>Malawi Political Administration Map</u>

15. Please set the font color, font size, etc for your Title so it fits appropriately within the neat box and is not too small or too large.
16. Hit OK when Finished

17. Look at your title and resize the neat box so it is not too large but holds the Map Title text within the area of the box.

Please note that when we use the Title option on the INSERT menu it will automatically center the Title text.

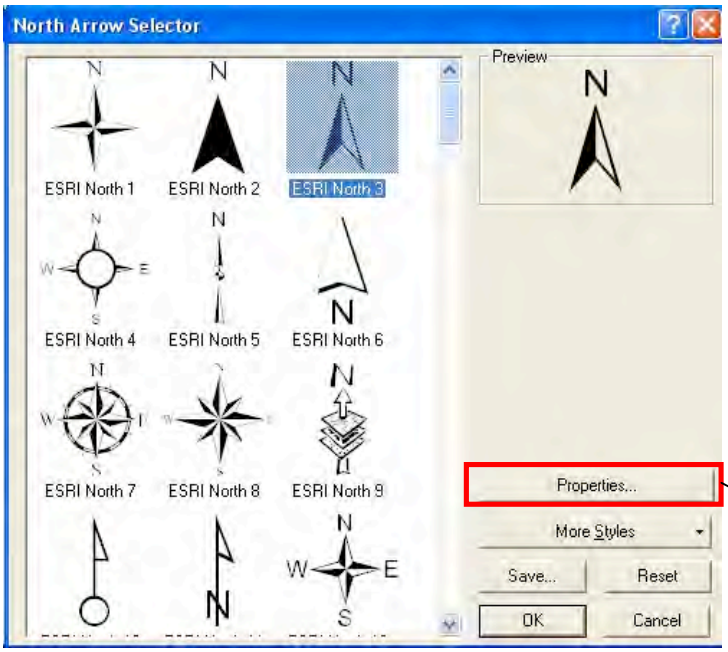
To move the Title text we can either use the Black element selector arrow or we can select the element and use the up, down and left and right keys on our keyboard to move graphic elements in the desired direction.

18. Use the keys to reposition your text
19. Use the black selector arrow to reduce the size of the neat box
20. Save your project

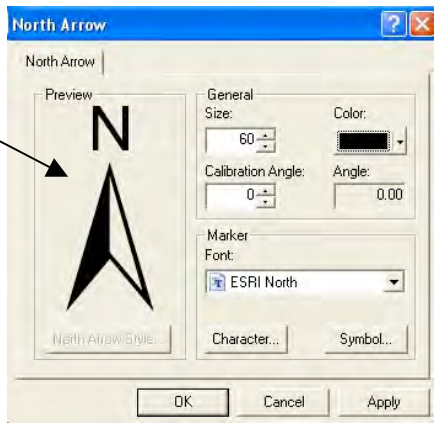
North Arrow

North Arrow placement is simple:

1. Click on the INSERT menu
2. Click on NORTH ARROW
3. When the North Arrow dialog box appears select the North arrow you would like to use



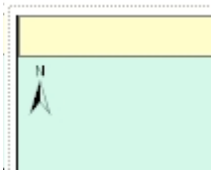
4. CLICK on PROPERTIES to change the North arrow properties.



5. Click on OK on the properties box
6. Click OK on the North Arrow box.

This will place a north arrow in your map layout.

7. Use the Black Arrow Selector to move and resize the north arrow
8. Move the North Arrow to the upper left hand corner of the map layout



9. If we use the Zoom to 100% button we will be able to look at our graphics at the size they will print. 

10. Click here and zoom into the map.

11. Now use the Map pan to pan to the corner and look at the North arrow size? 
12. Determine if it looks appropriate at the given print scale, if not please change.
13. Save your project.

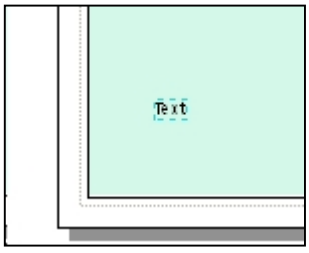
Source Text Box and Neat Box

Whenever we create a cartographic product (a map) we should always include information on the different data sources, where they were obtained from as well as information on the map projection, units, and datum and when the map was created and by who it was created.

This is relatively easy to do. First, we will create text box then we will create a neat box that will hold our source information, like our map title.

1. Select the New Text Tool from the DRAW toolbar. 

2. Click in the lower right hand corner and start writing your text
3. If necessary use the Black Element arrow, select the text.
4. Right Click on the text.
5. Select PROPERTIES to bring up the text properties.

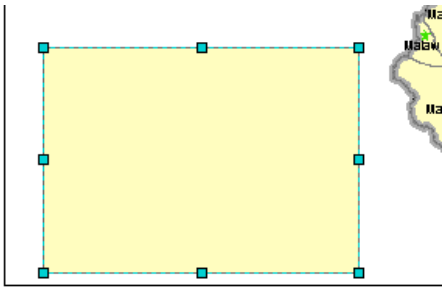


6. Type the following ⟶
7. Click OK when finished.
8. Select the Black Arrow tool and move your text into the corner
9. Click on the RECTANGLE tool in the DRAW toolbar and create a box, just larger than your text that covers your text.

Source:
Administrative data provided by:
Malawi Spatial Data Portal (MASDP).
URL: http://http://masdap.ithacaweb.org/

Projection: UTM Zone 36S
Datum: WGS 84
Units: Meters

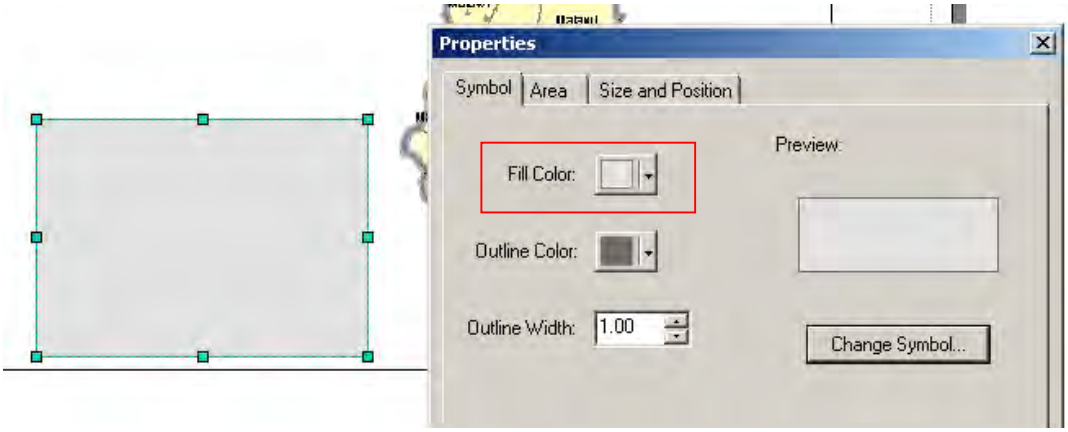
Map created by YOUR NAME
on TODAYS DATE.



10. Right Click on the neat box.

11. Select PROPERTIES.

12. Change the fill color from beige to Gray (10%) and press APPLY.



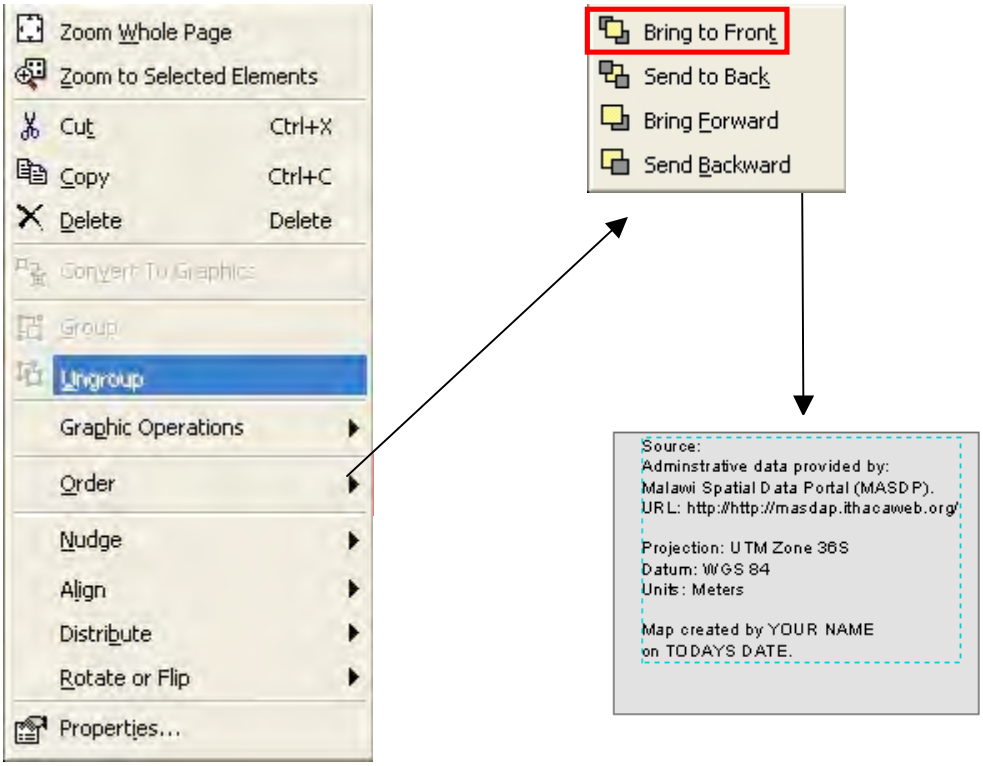
Now you can see that our neat box now covers our text, which is behind the box. What must be done now is to change the ORDER of the graphic elements so that our text element we just created is in front of the neat box.

13. Close the PROPERTIES box.
14. Using the Black Arrow tool, CLICK within the neat box to select the text box.

15. Once Selected (indicated by blue highlight), Right Click on the selected graphic.

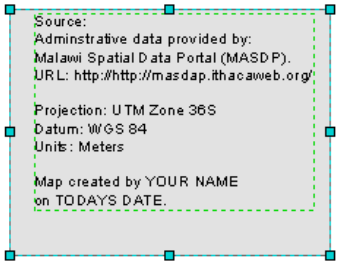
16. Choose ORDER
17. Then Choose BRING TO FRONT

This will bring the selected element (the text box with our source data to the front.



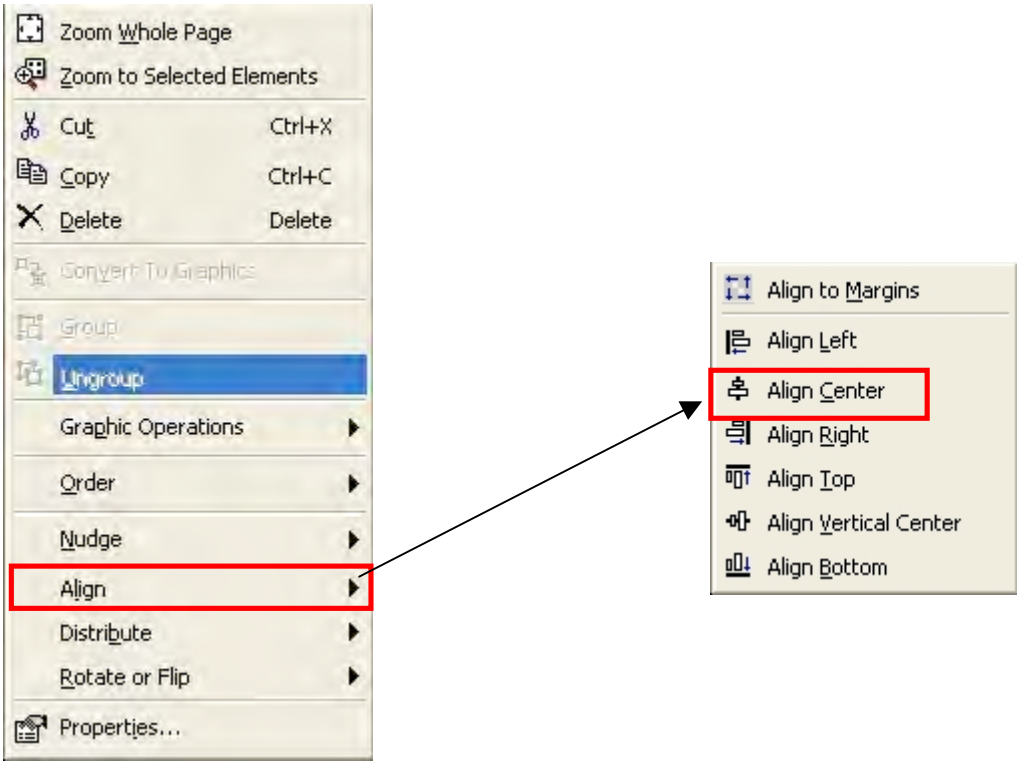
Since our text box will live within the neat box we should ALIGN these two graphic elements so they fit together nicely and resemble professional graphics.

18. Using the black select elements arrow, draw a box around both the neat box and text box to select both graphic elements

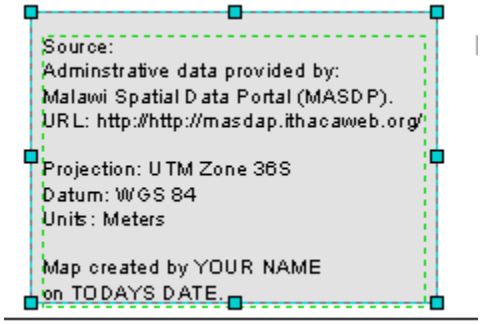


19. Right Click on both selected elements.

20. Choose ALIGN CENTER.



21. Notice how the two elements are now aligned?



22. Select both graphic elements again.
23. Right Click
24. Choose GROUP

By choosing group, the user can combine multiple graphics into 1 graphic layer.

Once grouped, resize the source text and neat box to fit into the lower left hand corner.

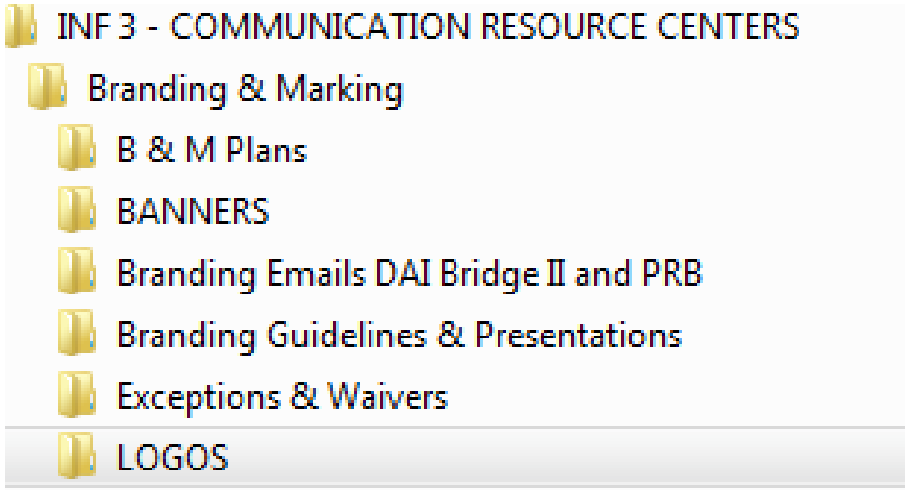
25. Select the grouped elements
26. Grab the top right hand corner and carefully diminish the size of the grouped graphic element.
27. Use the 1 to 1 zoom button to zoom into the map and examine how the source box looks. When you are satisfied with how it will print you can stop adjusting.
28. Select the grouped graphic again
29. Now using your keyboard up/down and left/right arrows move the graphic so it fits squarely in the lower left hand corner and so that the neat lines match those of the map layout.
30. Save the project.

The map should look resemble the one below:

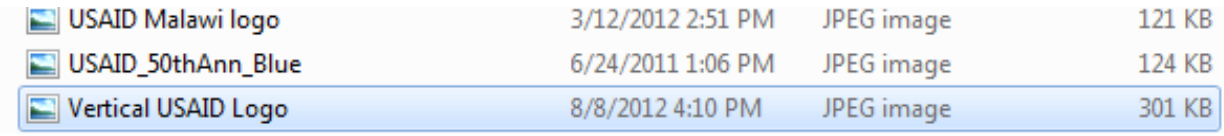
Logos

Organization Logos are very easy to place into your map. In USAID maps, the USAID logo will be used. Other logos may also inserted including such as other donor or USG Agency logo (World Bank, WFP, FTF, PMI, USDA, CDC, U.S. Embassy, partners, etc.).

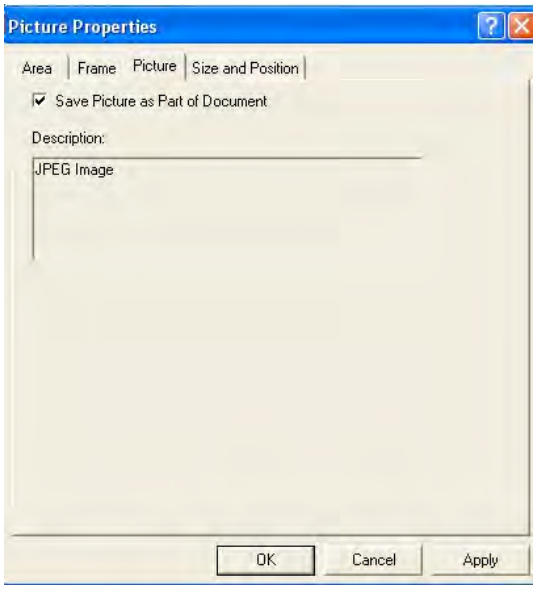
1. Go to the INSERT menu
2. CLICK on Picture
3. Browse to the location where your desired logo is located



In this case we are just selecting the USAID logo. Open the USAID logo folder and select the following logo:

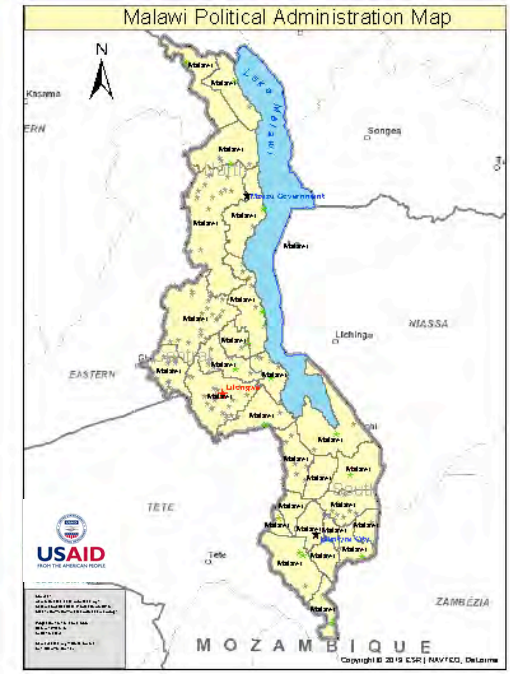


4. Hit OK when done
5. Most likely you will have to resize your logo
6. Use the black arrow element select tool to resize the logo
7. Move the logo to just above the source text box
8. Use your keyboard arrows to adjust the final spacing of the logo
9. Right click on the logo and open the Properties



10. Toggle on the Save Picture as Part of Document option – this will save your logo as part of the map, which will assure that the logo is always present in the map.

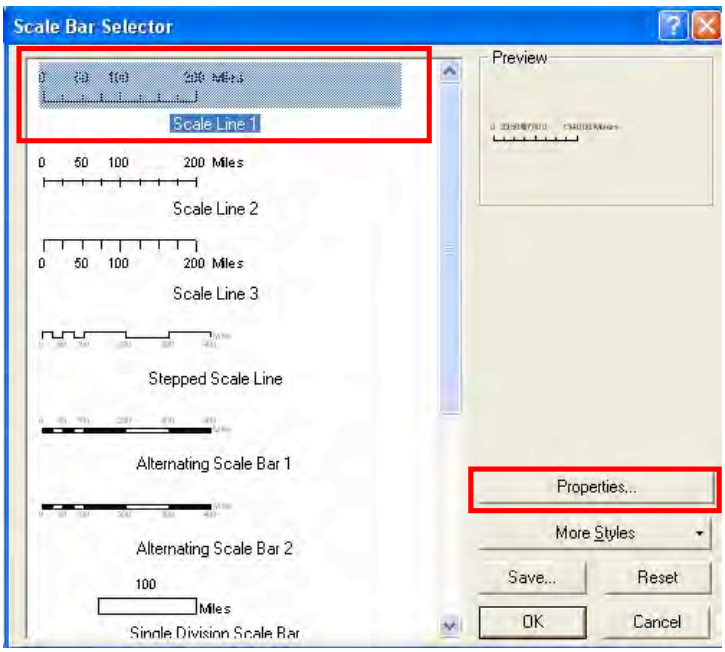
Our map should now resemble the map below:

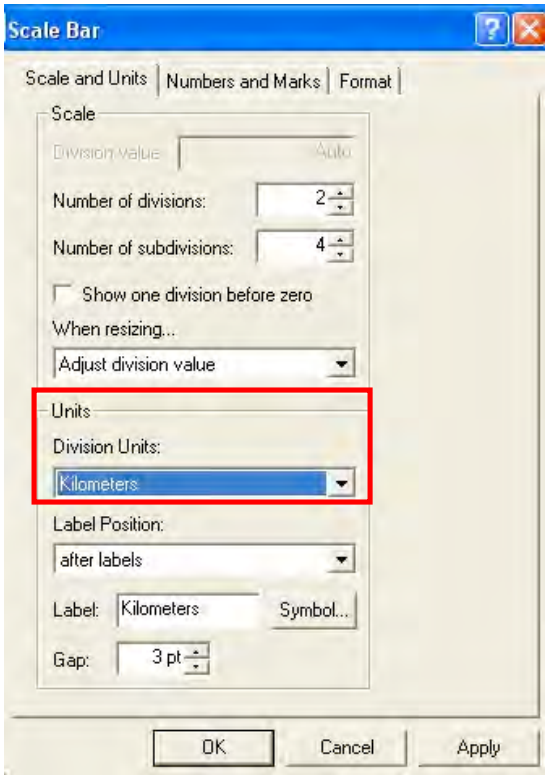


Scale Bar

Now we will insert a scale bar. Scale bars are important features in any map as they provide information on the map scale and associated distances.

1. Go to the INSERT menu.
2. Select SCALE BAR. This will open the scale bar selector.
3. Select the type of scale bar you prefer.
4. Click on Properties to adjust scale bar properties.





Under the scale bar properties a user can adjust the scale and unit settings, how numbers and marks on the scale bar are displayed and how the scale bar is formatted.

Usually, I leave in the default settings and change only the Division units to be in Kilometers or miles depending upon the system of distance measurement used in the country (metrics or standard system).

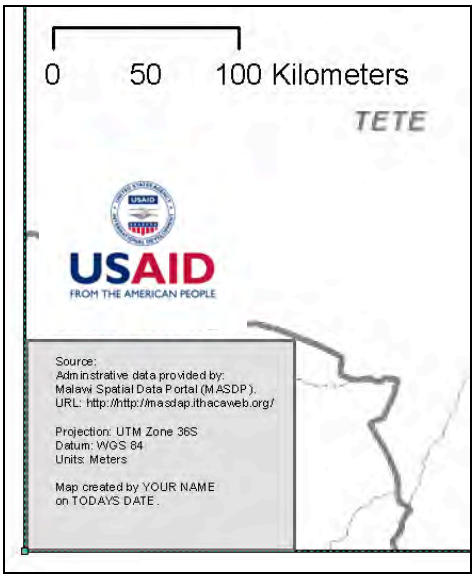
5. Under the Division Units, please select Kilometers.
6. Click OK when finished
7. Click OK on the scale bar selector

From here you will see a rather large scale bar appear in your map layout.

8. Resize the scale bar, shorten it to 100 kilometers and then diminish its size to an appropriate dimension given the Print/scale 1 to 1 ratio/
9. Move the scale bar above the logo.

10. Make sure the scale bar text and numbers do not overlap with the map – country borders and that the spacing between the three graphics (source text box, logo and scale bar) is sufficient.

11. Use your key board up, down, left and right keys to make slight adjustments.



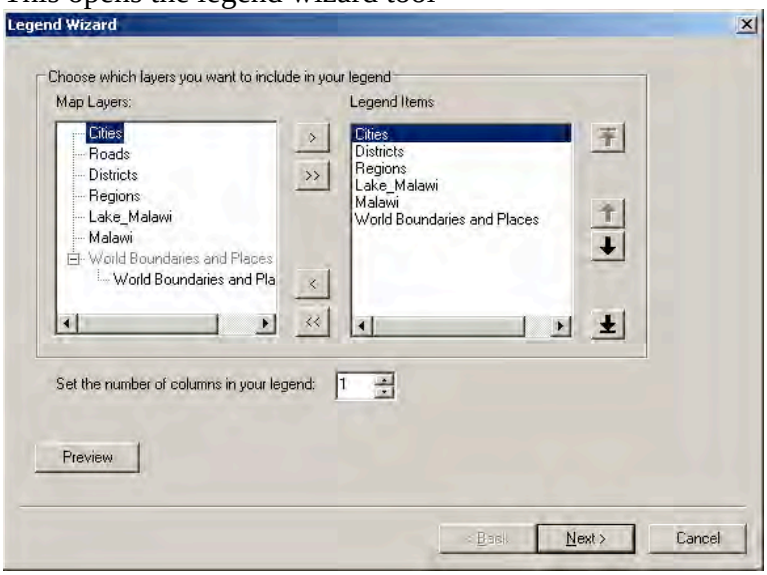
Legend

Legends are most likely one of the most critical graphic aspects that you will ever include in a map. Legends provide map users with an important 'key' that informs the map reader what he/she is looking at on the map. Legends tell us what different color, points, polygons and line features represent.

Arc GIS 10.1 provides a wonderful legend tool that allows a user to create quite professional, high quality maps and their respective legends. The differences between Arc View 3.x and ARCGIS 10.1 in this regard are immense and clearly ARCGIS 10.1 provides improved functionality that cannot be matched in the 3.x series.

1. Go to the INSERT menu
2. Select LEGEND

This opens the legend wizard tool



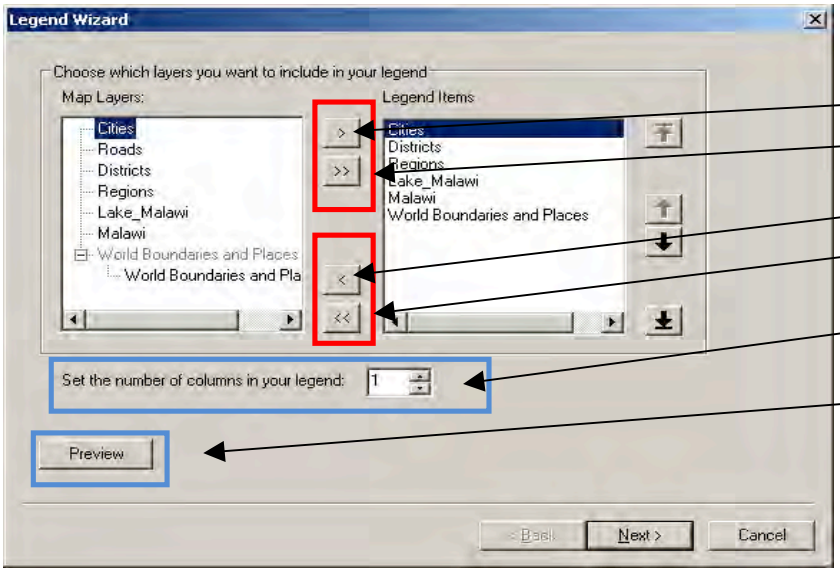
On this first screen we will choose which data layers will be included in the legend as well as their order in the legend (points, lines polygons). Take a good look at the names of the shape files here in the legend items; these are how your names will be displayed in the Legend.

The good thing about the legend and the data files in the TOC is that they are linked, changes you make in the TOC will also occur in the Legend.

From the dialog box above do the following:

3. Look at your map and remove any shapefiles that are present in the Legend items but not in your map layout. We only want to present information for data layers present in the map layout.
4. As well, once you are done with the legend wizard remember to go back and change the names of data layers in your TOC so they present correct and informative names, for example Lake_Malawi should be changed to Lake Malawi.
5. Close the Legend Wizard and go back to the TOC and rename all relevant data files now.
6. Reopen the Legend Wizard from the INSERT menu.

As well please note that the Legend wizard automatically includes data layers in the legend items that are toggled on and visible in the TOC. Unchecked items will not appear in the Legend items just under the Map Layers section, however they can be added to the Legend items or legend items can be removed by selecting the layer and using the to and from arrows on the legend wizard.



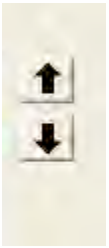
7. Add one selected layer
8. Add all layers at once under Map layer section
9. Remove 1 selected layer at a time
10. Remove all added layers at one time
11. Set the number of columns you would like to have in your legend
12. Allows a user to preview the legend at any time to see what it looks like.
13. Try using 2 or 3 columns and PREVIEW the legend to see the differences

Notice the ROADs data is not located in the Legend Items.

14. Select the Road Layer under map layer and add it to the Legend Items.
15. Make sure to use the UP and DOWN arrow to move the ROAD layer to be situated between the Points (Cities) and polygon data layers.

As well we will want the make certain the Polygon administrative units to go from smallest to largest.

16. Use the up and down arrow to make sure that the polygon layers are by size:

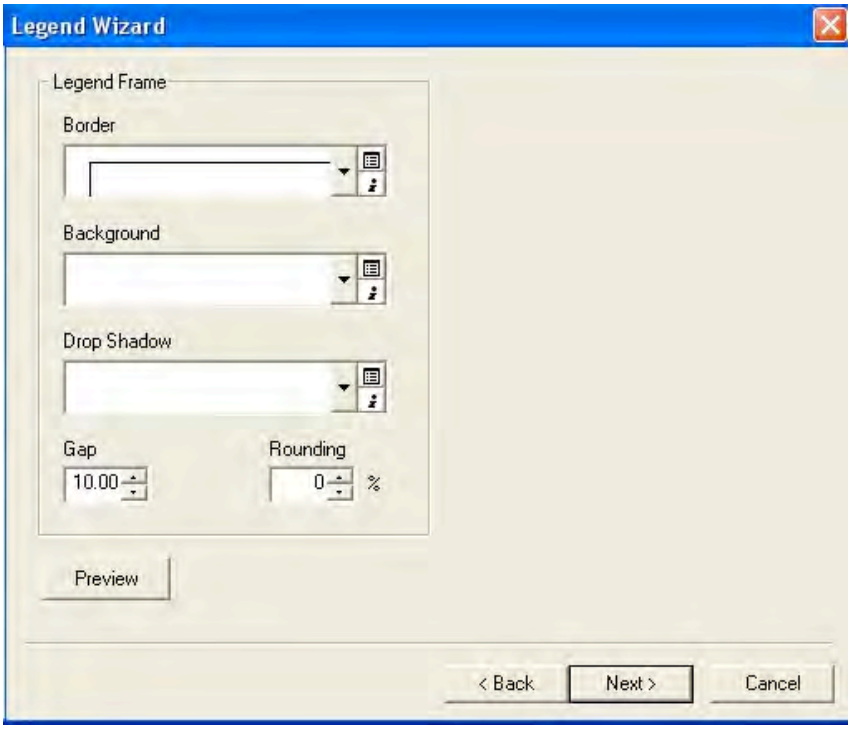


17. Click on NEXT to proceed with the Legend Wizard

The next dialog box allows a user to set the font and text for a Legend title. Personally, I do not use a legend title, and delete the text here as it takes up more space which is sometimes required.

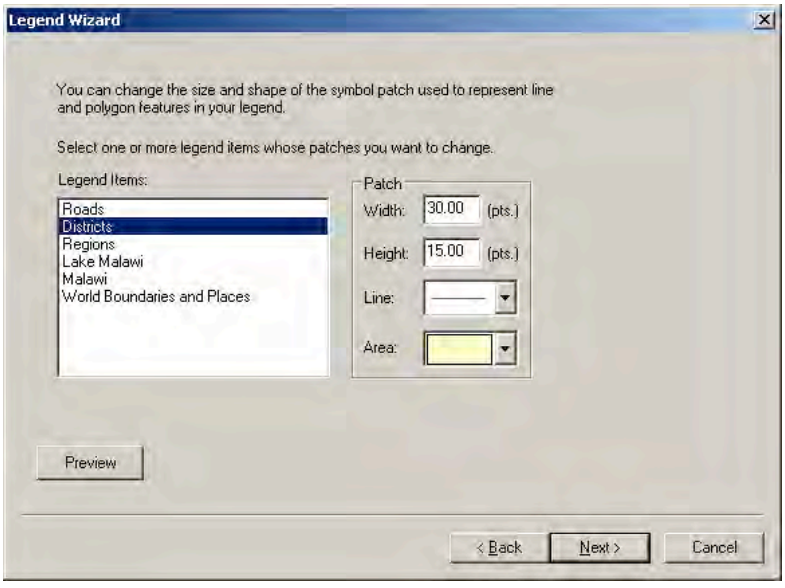
18. Delete the word LEGEND form the text box
19. Click next to proceed

The next screen allows a user to add a neat box, background and frame (neat line) to the legend as we did for the Map title and for the Source Box.

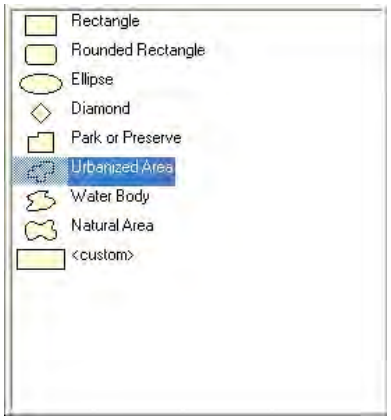


20. Under Border Select 0.5 frame, leave the default color
21. Under Background Scroll all the way to the bottom and select WHITE
22. We will not use a drop shadow ,but please select one, Click on PREVIEW and preview your legend, then remove the drop shadow
23. Click NEXT to proceed

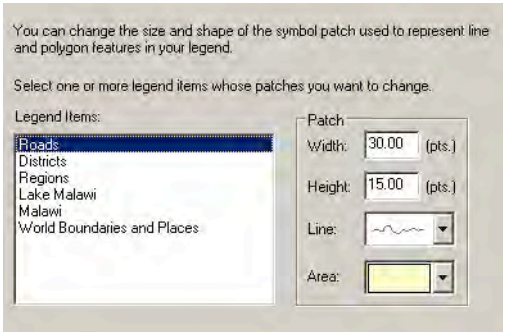
The next box allows a user to select how polygon and line element legend key shapes will be displayed. There are several options to choose from.



For Polygons, select the Legend item in the list. Next use the AREA drop down options to choose an Area patch shape to represent the polygon. There are several different types to choose from.



24. Choose Urbanized Area for DISTRICT, REGION, and MALAWI,
25. For LAKE MALAWI choose Water body
26. For ROADS select the Flowing Water



27. Click NEXT to continue to the next screen
28. The below screen allows a user to change the spacing options between the various items in the legend such as text, labels, columns, patches, etc.

29. Leave the defaults and Click FINISH.

This will create/add the legend just developed into the map layout. Your legend should resemble the legend below:

Notice in this legend that roads are not displayed. You may have roads displayed but missing other layers.

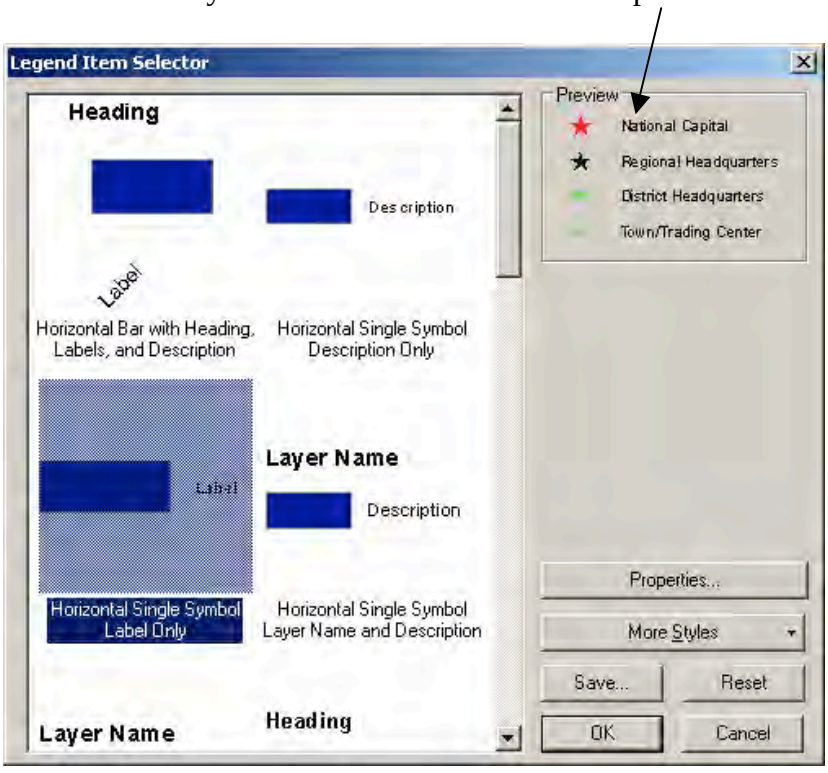
30. In the TOC, toggle on the layer that is not displayed in the legend. If it is not drawn on the map then it will not be displayed in the legend. You will notice the legend automatically refreshes to include changes made in the TOC.

Now you can see that in both in the TOC and the Legend that Cities are referred to by TYPE and Roads are referred to as ROAD_CLASS, both in capital letters. Let's fix that in order to make a more professional looking legend.

We will change the STYLE of the Cities and Roads to remove the words (TYPE and ROADS_CLASS) and still keep our labels.

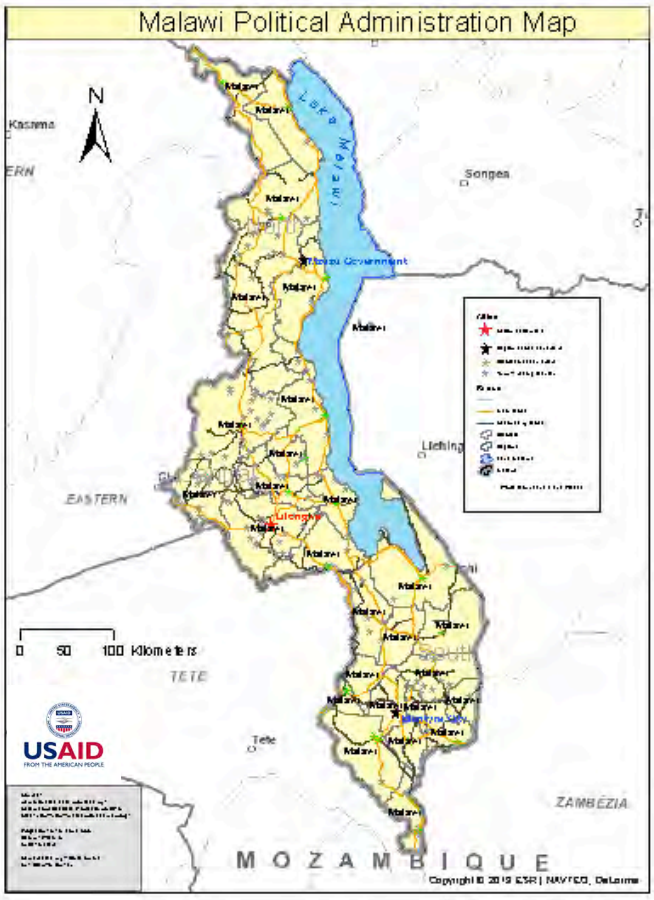
31. Right Click the legend and select PROPERTIES to open the properties of the legend.
32. Under the Items Tab Select Cities.
33. Click STYLE located at the bottom of the properties box.
34. Choose a style that removes the sub- heading TYPE but keeps the heading Cities and the symbol labels (3rd selection down from the left)

Note that when you choose a STYLE selection a preview is available.



Once Selected: Click OK, choose Roads, and change the STYLE of Roads. When finished, close the Legend Properties box. Your Legend should resemble the legend below.

Now find an appropriate spot to place your legend within the map layout. Resize (diminish) the legend box and place on the left hand side. Your map should resemble the map below.



Use the 1 to 1 zoom button to zoom into the map and then use the map layout pan hand to pan to the legend and make sure that the legend size is adequate for the map to print properly on A4 (8.5 x 11 inch) scale.

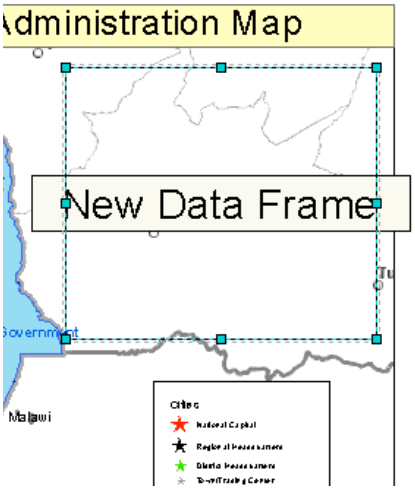
Data Frame Insert

The last graphic element we will add to our map is a data frame insert. A data frame insert is effectively another map layout that we can insert into our map and populate with data layers to display a map subset. In this case we will use the data frame insert to illustrate the regional location of Malawi within Africa. This type of graphic element provides additional – regional information to the person who is using the map or viewing the map, especially if they are unfamiliar with the region or data presented in the map.

1. Go to the INSERT MENU
2. Select Data Frame Insert

A data frame will appear in your map as well as under the TOC just below the last data layer.

3. In the map layout, Select the data frame, resize it and fit it between the legend and the title neat box.



Now we will need to copy and paste the necessary data layers into the new data frame that is under the TOC.

This will be done layer by layer.

4. In the TOC Select WORLD BOUNDARIES
5. Right CLICK
6. Select COPY
7. CLICK on the New data frame in the TOC
8. Right CLICK
9. Select Paste layers

This will paste the World Boundaries layer into the new data frame insert. You will see the World Boundaries data layer in both the new data frame on the map layout and in the TOC.

10. Do the same for the following Malawi.

Now it will be necessary to enlarge the World Boundaries layer to a regional extent. First we have to display World Boundaries when zoomed out past 1:10,000,000.

11. Right Click on the new World Boundaries data layer in the NEW Data Frame within the TOC.
12. Select PROPERTIES and the GENERAL tab.
13. Activate the SHOW AT ALL SCALES button and press OK.
14. Use the Zoom in and Zoom out Tools within the new data frame in the layout view to show a larger area of Africa. Be sure Malawi is still visible.

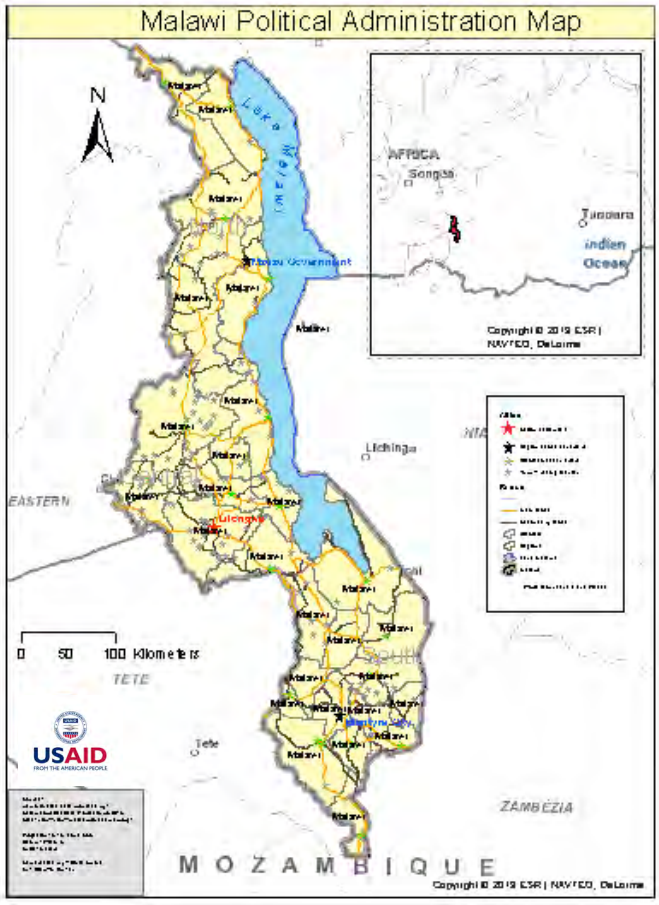
To highlight Senegal do the following:

15. Click on Malawi data layer fill in the TOC under the new data frame to open the symbol selector
16. Choose a red fill and red line color (width 1)
17. Click OK and close the symbol selector box

Now Malawi should be highlighted in red. Resize and reposition any elements until you are pleased with the final map.

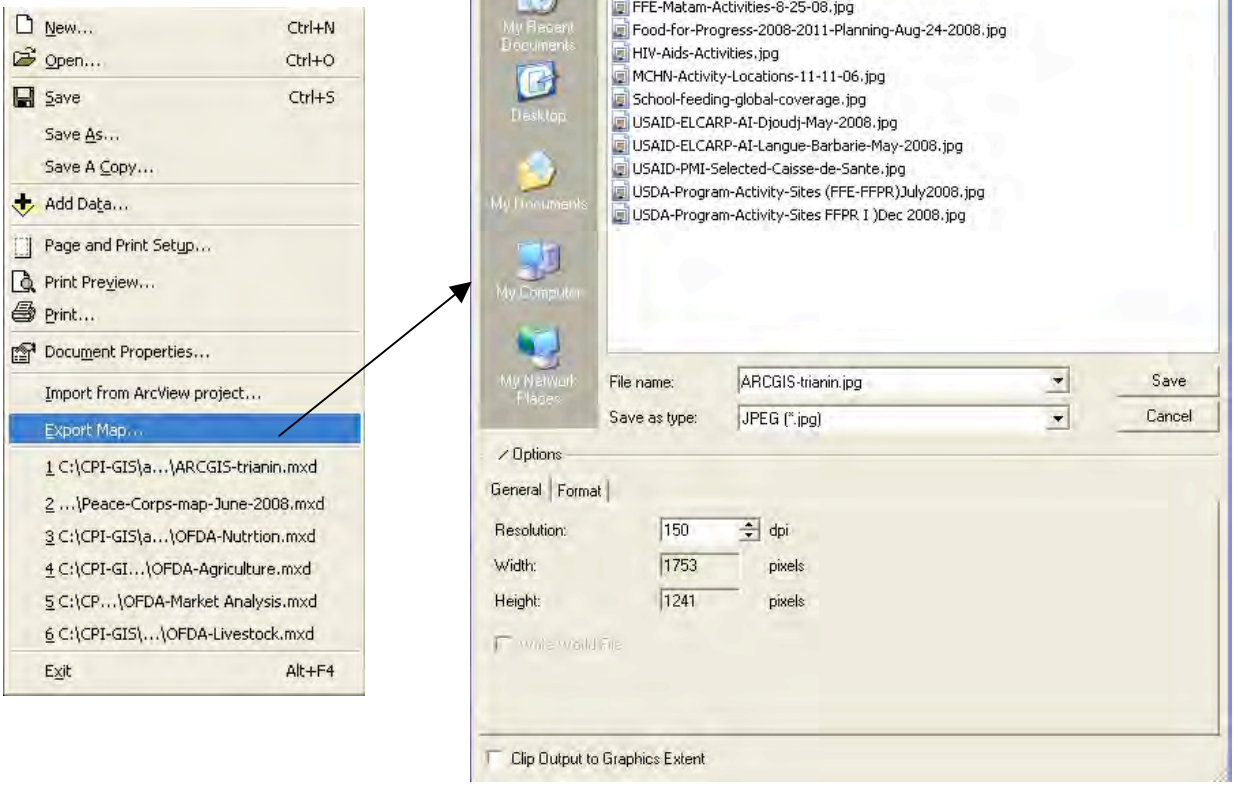
18. Save your project once finished

Your map should now resemble this map.



The last step to take is to export your map as a .jpeg for printing.

19. Go to FILE.
20. Select Export map.



21. Browse to the location where you would like to save the /jpeg map
22. Provide an appropriate file name
23. Select an appropriate file type - .jpeg is a good format to use
24. Adjust the resolution – the higher the resolution the larger the file you will create. Typically between 150-200 dpi is good, use 150 dpi.
25. Click SAVE
26. Open Windows Explorer, browse to the location of your map
27. Open it
28. Print it and have a good look a t it for potential errors or changes you should make
29. Have your colleagues look at it and provide comments

This ends Module III.

ArcGIS 10.1 Training – Module IV: Data Development

In order to build capacity and understanding of Arc GIS and its functionality Module IV will focus on the integration and development of external and internal data sources, working with tables, global position systems (GPS), geo-processing and data analysis and selection of data by attributes or location.

Module four will focus on:

- GPS use and GPS data integration into the ArcGIS 10.1 environment
    - Importing and Exporting GPS data into the GIS (waypoint, track, polygon)
- Adding X,Y data
- External Table development, internal table development (importing)
    - Normalized data creation, standards, unique identifiers, etc
- Internal Table Development
    - Data development, calculation, attribution
- Editing Shapefiles – creating new lines, polygons, points, etc
- Development of value-added data – Selection by attributes/location, etc
- Geo-processing tools – Arc Tool box

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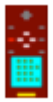
GPS DATA INTEGRATION – DNR GPS

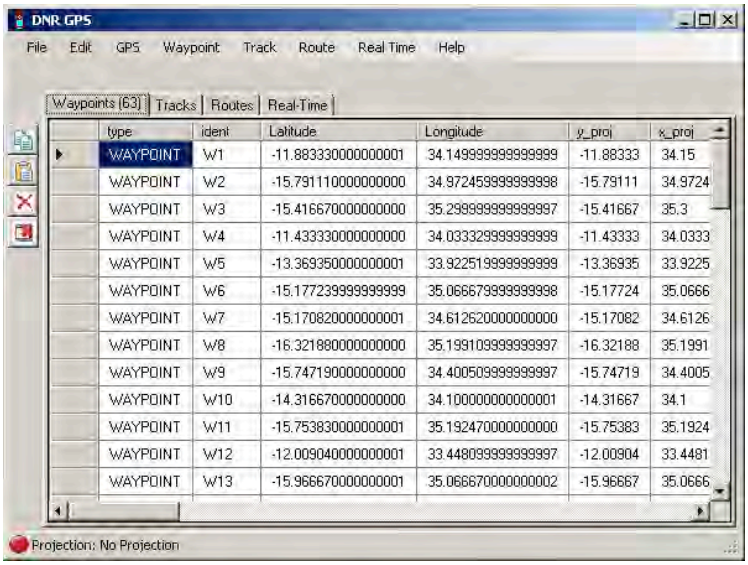
In ArcGIS 10.0/10.1 environment we can use free software available from the University of Minnesota called DNR GPS (version 6.0.x). This software is a standalone application that easily allows data transfers between a Garmin GPS and GIS software such as ArcGIS. When you download the DNR GPS application, it comes as a compressed .zip file which must first be extracted. The application is extracted to a folder called dnrgps.

From here, we will connect the GPS to the computer and explore the functionality of DNR GPS.



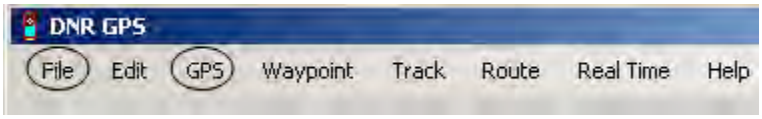
After you have connected the GPS to the computer and ensured it is turned on, run DNR GPS. To run the DNR GPS application, open the dnrgps folder and double click the dnrgps application icon.

The application will start and present the user with the following user interface (GUI).



type	ident	Latitude	Longitude	y_proj	x_proj
WAYPOINT	W1	-11.883330000000001	34.149999999999999	-11.88333	34.15
WAYPOINT	W2	-15.791110000000000	34.972459999999998	-15.79111	34.9724
WAYPOINT	W3	-15.416670000000000	35.299999999999997	-15.41667	35.3
WAYPOINT	W4	-11.433330000000000	34.033329999999999	-11.43333	34.0333
WAYPOINT	W5	-13.369350000000001	33.922519999999999	-13.36935	33.9225
WAYPOINT	W6	-15.177239999999999	35.066679999999998	-15.17724	35.0666
WAYPOINT	W7	-15.170820000000001	34.612620000000000	-15.17082	34.6126
WAYPOINT	W8	-16.321880000000000	35.199109999999997	-16.32188	35.1991
WAYPOINT	W9	-15.747190000000000	34.400509999999997	-15.74719	34.4005
WAYPOINT	W10	-14.316670000000000	34.100000000000001	-14.31667	34.1
WAYPOINT	W11	-15.753830000000001	35.192470000000000	-15.75383	35.1924
WAYPOINT	W12	-12.009040000000001	33.448099999999997	-12.00904	33.4481
WAYPOINT	W13	-15.966670000000001	35.066670000000002	-15.96667	35.0666

The software registers that the GPS unit is connected and automatically displays the data collected. You also have the ability to use the GPS menu if you experience problems. From the GPS menu, you can Find your GPS or install the latest Garmin USB drivers for your GPS device.



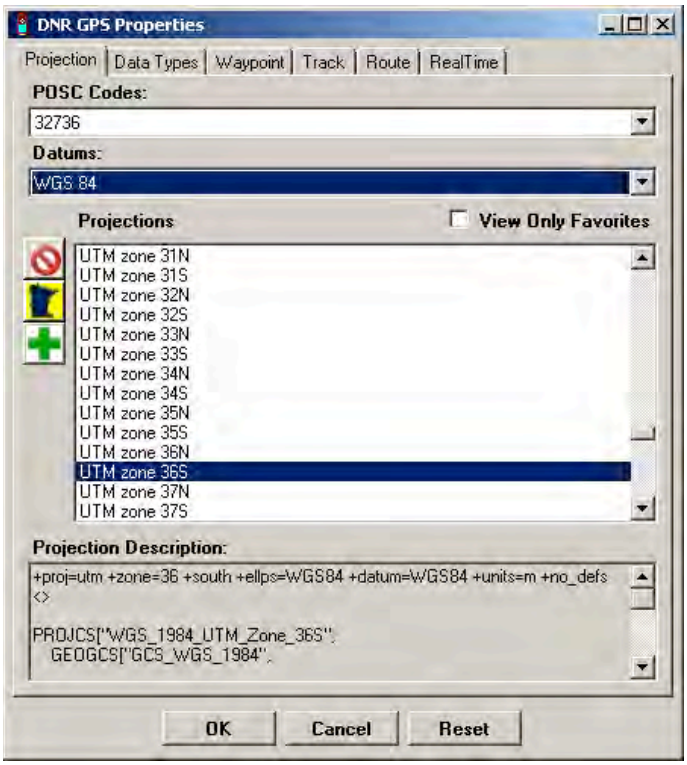
Under the FILE MENU a user can import or export data, set the projection units, etc. Let's begin with setting a projection. Under the FILE MENU, select SET PROJECTION. The DNR GPS Properties dialog box will open.

Here we want to set the projection properties for our GPS data so when it is downloaded we have coordinates in our desired projection. Note that the GPS captured coordinates will not be altered and will still be available in the attributes of the waypoints after they are added to ArcMap. We are simplying defining which projection we want to use when importing or exporting data to DNR GPS.

Since we do not know which POSC Code we want, we will change the Datums and Projection options. The POSC Code will automatically change based on our selection.

Change the DATUMS option to WGS 84.

Scroll down and select UTM zone 36S. Do not selet "OK" just yet.



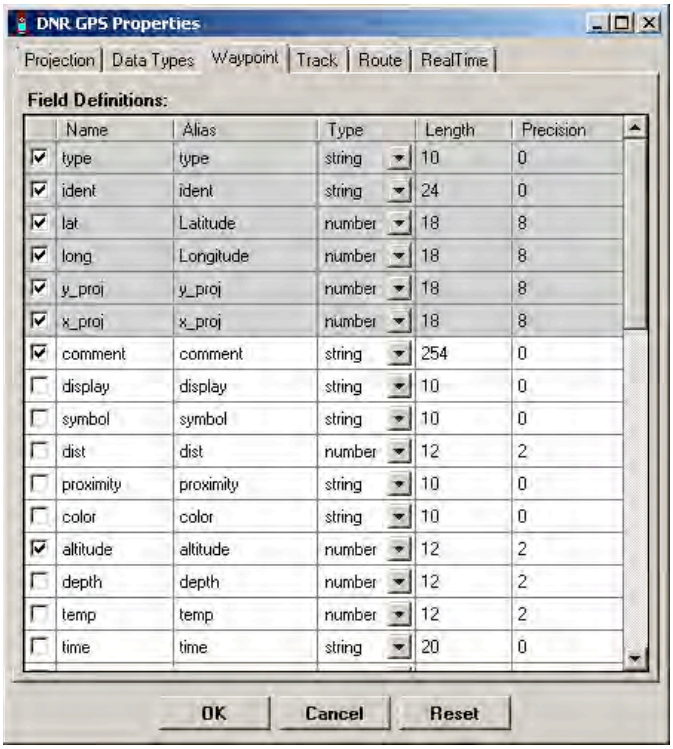
From the DNR GPS Properties dialog box, we can also select which attribute fields we would like to keep within the extracted GPS table. Since we already have the Properties dialog box open, we will go ahead and select which attribute fields we would like to keep.

From the DNR GPS Propeties dialog box, select the WAYPOINT TAB.

Uncheck any attribute fields you find useless. Be certain to keep all the attribute fields that are highlighted in gray. The additonal attribue fields you select to keep may be blank when you export the data to ArcMap. However, the attributes you select to keep can later be edited in ArcMap. For example, you can choose to keep the "Link" attribute and later type in a URL or path to a picture of the feature associated with that record.

Next, select the TRACK TAB and determine which attributes you would like to omit.

Once you have defined the projection and chosen the attributes for you waypoints and tracks to keep, press the OK button to save your preferences.

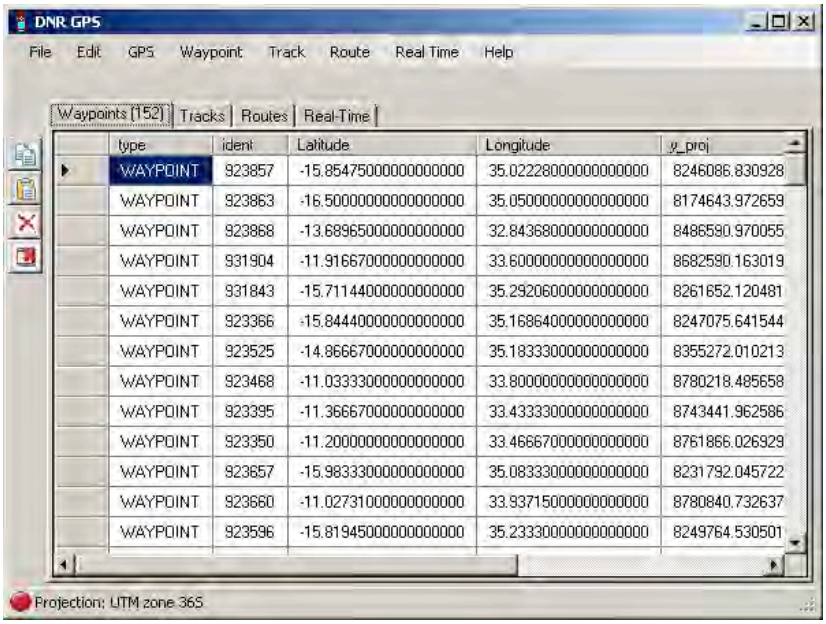


You will notice the DNR GPS GUI now has your new projection displayed in the lower left corner.

Uploading Waypoints

Often times you may collect waypoints with your GPS and save them to your computer for later use. When the waypoints you want to work with are no longer stored within the GPS, you will have to upload them to DRN GPS.

From the FILE MENU, choose LOAD FROM and select FILE. Navigate to the data folder and choose the WAYPOINTS file. The waypoints will then populate themselves in DRN GPS. You may notice the data was collected with latitude and longitude coordinates but there are also x_proj and y_proj attributes which have our defined UTM 36S coordinates.

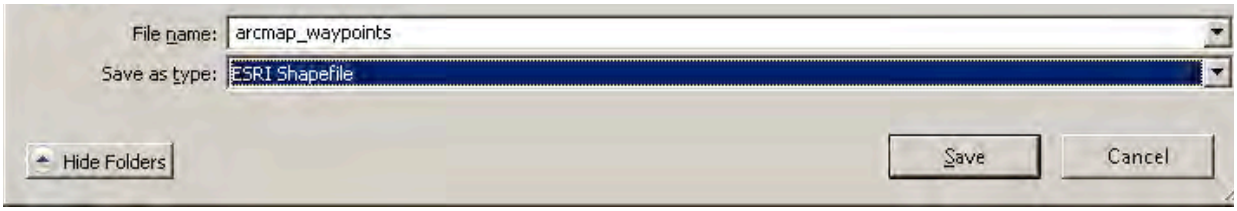


Downloading Waypoints

If you have your own waypoints, you can use them or continue with the provided waypoints file you just uploaded. DNR GPS provides you with the option of downloading your waypoints to files, databases, webservices, and ArcMap. The objective of this exercise is to place our waypoints in ArcMap.

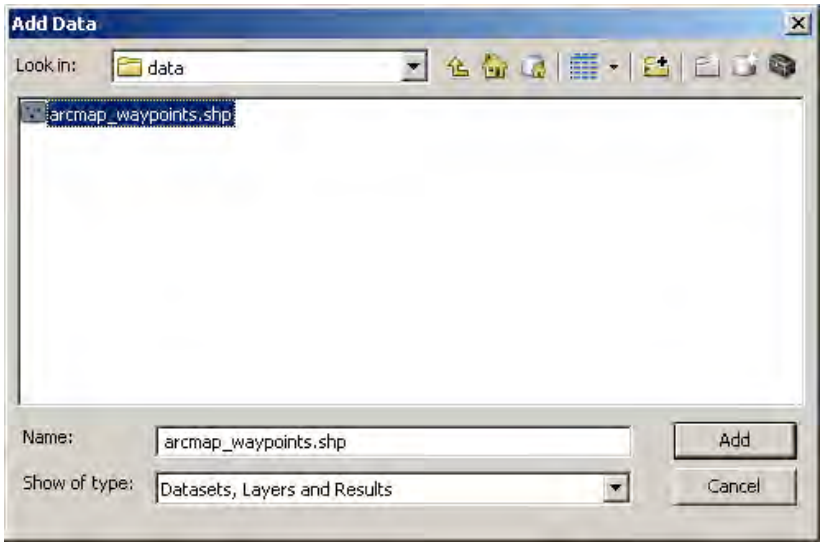
From the FILE MENU, choose SAVE TO, select ARCMAP and then select FILE.

From here you will be prompted to browse and save your waypoints in a specific folder. When the "Save To File" dialog box opens, navigate to your data folder and name the new file you are about to save. The example below uses the name arcmap_waypoints. Next, change the SAVE AS TYPE option to ESRI SHAPEFILE and press SAVE. The waypoints are now stored in your data folder and ready to be added to ArcMap.

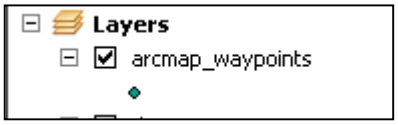


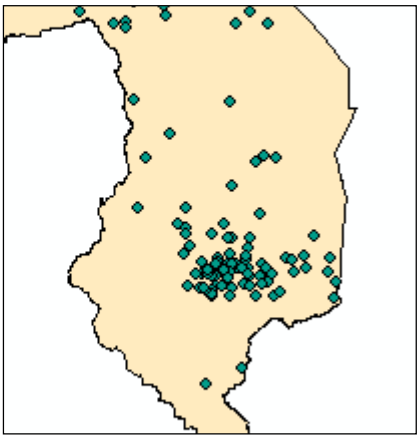
Next, we want to add the waypoints to ArcMap. Do not exit out of DNR GPS since we will continue to use it.

1. Open the Arc GIS Project saved during Module III.
2. Press the ADD DATA button 
3. Navigate to your data folder and choose the file you just saved (arcmap_waypoints). Press ADD.



The data will be automatically added to your Arc Map data view TOC.





The data will also display in your map view. Leave the ArcMap project open as you continue this exercise.

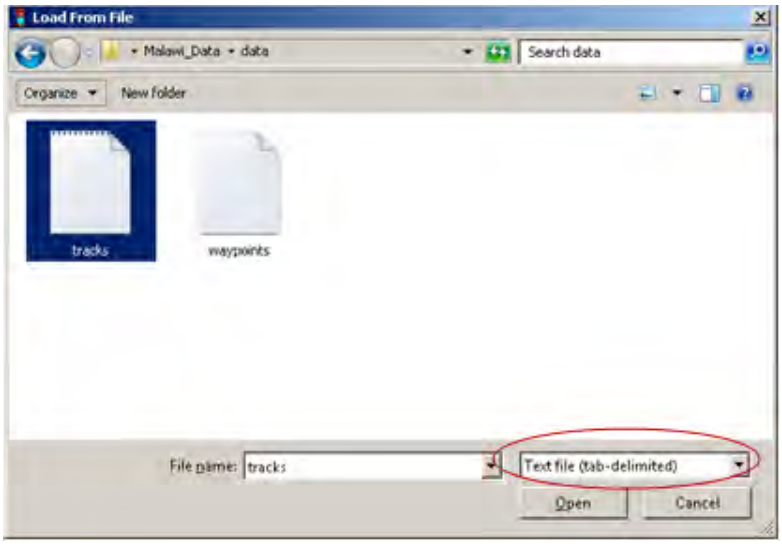
Uploading Tracks

When you collect waypoint data, you may go to a certain feature, turn on the GPS, save the coordinates, turn off the GPS, travel to another location and repeat the process. When you collect track data, you keep the GPS turn on at all times and save your coordinates as you move. Track data is downloaded as a series of points which can then be generalized into a line or polygon feature. This information is useful for creating data on road networks, or any other linear features. In general you will notice the accuracy of GPS generated line data (for roads) is much greater than that of the road data typically available through government data agencies throughout the developing world. It is recommended to capture road data with your GPS whenever possible. If a user wants to generate polygon data such as agriculture field perimeters, this is possible as well and highly useful. Simply mark a starting point and commence walking with your GPS on, once the perimeter is complete, turn off the GPS unit prior to starting another perimeter.

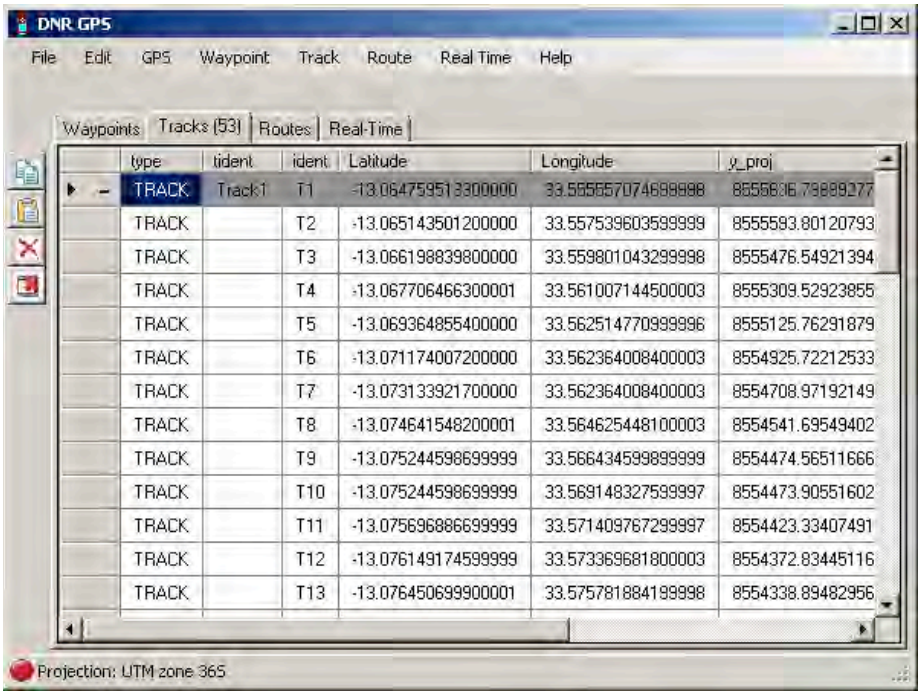
The procedure for adding Tracks to DNR GPS is identical to the procedure you used to add waypoints. From the FILE MENU, choose LOAD FROM and select FILE. Navigate to the data folder and choose the TRACKS file.

You may not see the TRACKS file. If that is the case, DNR GPS changed the options to only show ESRI Shapefiles after you selected that option when you saved your waypoint data.

Simply change the options back to TEXT FILE and you should be able to then open the TRACKS file.



DNR GPS has now been populated with 53 records representing the track we followed.



type	tident	ident	Latitude	Longitude	y_proj
TRACK	Track1	T1	-13.064759513300000	33.555557074699988	8555836.79899277
TRACK		T2	-13.065143501200000	33.557539603599999	8555593.80120793
TRACK		T3	-13.066198839800000	33.559801043299998	8555476.54921394
TRACK		T4	-13.067706466300001	33.561007144500003	8555309.52923855
TRACK		T5	-13.069364855400000	33.562514770999996	8555125.76291879
TRACK		T6	-13.071174007200000	33.562364008400003	8554925.72212533
TRACK		T7	-13.073133921700000	33.562364008400003	8554708.97192149
TRACK		T8	-13.074641548200001	33.564625448100003	8554541.69549402
TRACK		T9	-13.075244598699999	33.566434599899999	8554474.56511666
TRACK		T10	-13.075244598699999	33.569148327599997	8554473.90551602
TRACK		T11	-13.075696886699999	33.571409767299997	8554423.33407491
TRACK		T12	-13.076149174599999	33.573369681800003	8554372.83445116
TRACK		T13	-13.076450699900001	33.575781884199998	8554338.89482956

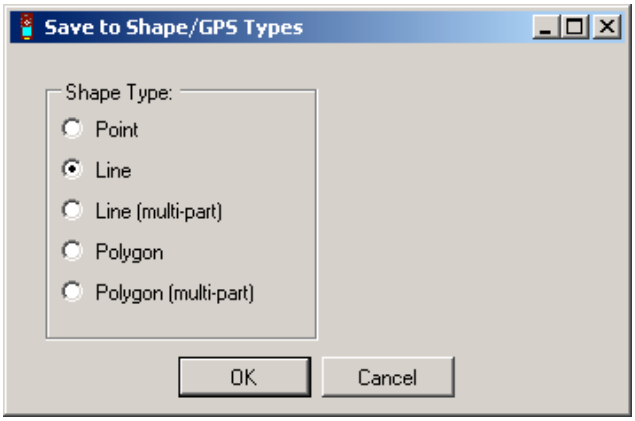
Downloading Tracks

If you have your own tracks data, you may use that or continue with the provided track data you just uploaded. Downloading tracks is also similar to downloading waypoints with one small exception which allows you to specify if data represents a linear feature or a polygon.

From the FILE MENU, choose SAVE TO, select ARCMAP and then select FILE.

From here you will be prompted to browse and save your waypoints in a specific folder. When the "Save To File" dialog box opens, navigate to your data folder and name the new file you are about to save. The example below uses the name arcmap_tracks. Next, ensure the SAVE AS TYPE option specifies ESRI SHAPEFILE and press SAVE.

You will then be prompted to specify whether the tracks are points, lines, or polygons. Choose the LINE option and press OK.

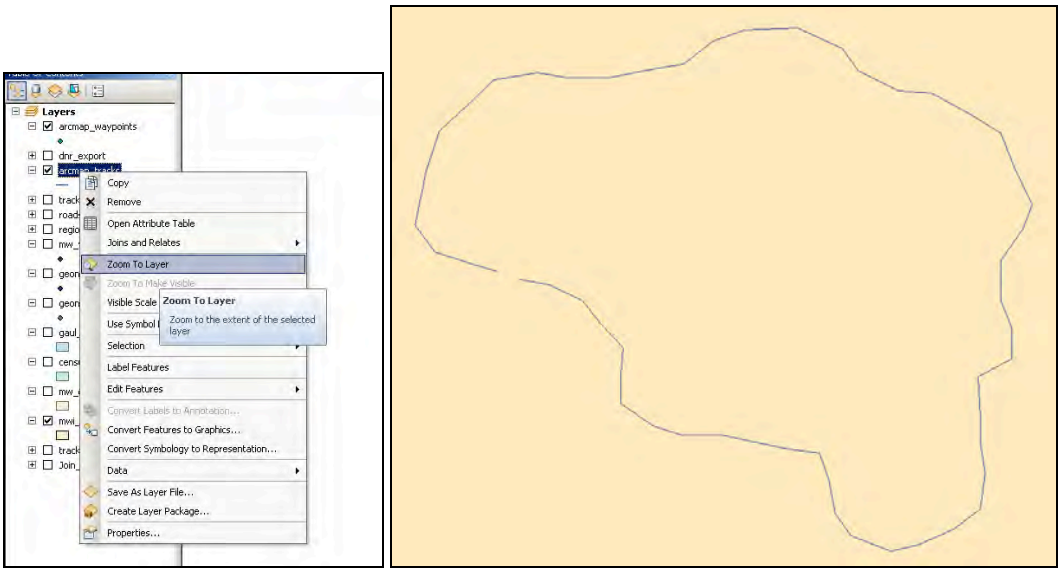


The tracks are now stored in your data folder and ready to be added to ArcMap.

Next, we want to add the tracks to ArcMap.

1. Return to ArcMap and press the ADD DATA button 
2. Navigate to your data folder and choose the file you just saved (arcmap_tracks). Press ADD.

The data will be added to your Arc Map data view TOC and also displayed in your map view. Because the track is very small, it may not be noticeable on the map when zoomed out. In order to zoom in on the track, locate arcmap_track in the TOC and RIGHT CLICK on it. A flyout window will appear and you can select ZOOM TO LAYER. You should then be able to see the track which is displayed as a line. Notice the small gap which exists in the left portion of the track. By definition, lines are not closed features. If this was a closed feature, we would have chosen to download the data as a polygon. By definition, the beginning and ending coordinates of a polygon are the same and will therefore be connected.



Notice the small gap which exists in the left portion of the track. By definition, lines are not closed features. If this was a closed feature, we would have chosen to download the data as a polygon. By definition, the beginning and ending coordinates of a polygon are the same and will therefore be connected. See example below:

This is a polygon representing the rehabilitated perimeter of a community garden in the village of Dioude Diabe in Northern Senegal located in the Department of Podor, community rural of Mboumba along the Senegal River. In this example there are two polygon records one for the Men's garden and one for the women's garden. This illustration denotes the Women's Association Garden. Coupled with the ability to calculate acreage or hectare size of perimeters Arc Map provides interesting and adaptive tools.

To zoom back out to the entire country, press the FULL EXTENT button  or the BACK TO PREVIOUS EXTENT button  .

ADDING X, Y DATA

Besides importing data from a GPS unit, users will find the availability of point data (village locations, health or school facilities, etc) available in a tabular format that includes longitude and latitude data (x and y data) where X signifies the westerly or easterly coordinate (longitude) and Y signifies the Northern or southern coordinate (latitude). Arc Map facilitates the import of X, Y coordinate data in tabular format which can be added to the TOC and then mapped directly into the Map view. This then allows a user to export the tabular reference data into a shapefile format.

In the example below we have received a list of trading centers. This data includes both projected and geographic location coordinates.

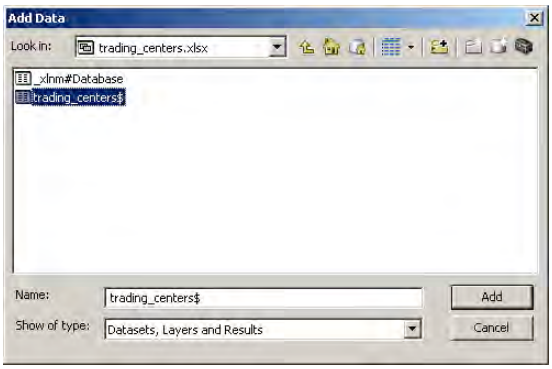
Before we start we should first discuss an important aspect of data development and table creation as well as importing tables into a GIS. The default data table file format for shapefiles is a database (.dbf) file, which under all earlier versions of Microsoft Excel was supported as an output extension, allowing a user to save an Excel .xls file as a database .dbf(IV) table. Under Microsoft Excel 2007 this save as option was removed. Excel will open and read .dbf files but not save them in database format. Conversely, ArcMap will read and open Excel .xls/.xlsx files but will not save in the same format. Furthermore, ArcMap encounters difficulty editing Excel files. Therefore, it will be necessary to first open an Excel files in ArcMap, and then export it as .dbf files which can be opened in Excel. After making any changes in Excel, save the file again as an .xls/.xlsx file which should be opened and saved as a .dbf file in ArcMap. While this procedure is sounds complicated, the best advice is to avoid sharing files between ArcMap and Excel. That is, if you plan to use Excel data in ArcMap, make sure it is in final form prior to adding it to ArcMap.

When importing tables into ARCMAP and using the ADD XY data feature it is important to ensure the following:

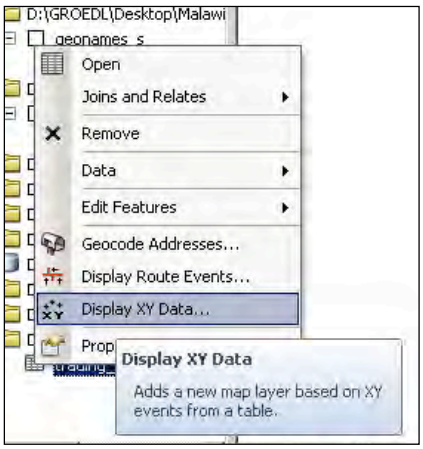
- There are no data errors in XY coordinates – this will be illustrated with points that do not fall within the anticipated coordinate zone or tables that do not add correctly. A review of table fields should be undertaken if errors are found or importation fails.
- Ensure that numeric field and decimal points carry over from the conversion from .xls to .dbf
- Note that data attribute column names cannot exceed 12 characters in length.
- Prior to adding your table make certain you know which coordinate system the XY coordinates use.

In the first example below we will ADD XY data from an Excel file that has already been cleaned and made ready for importation. If you have a .dbf file, the procedure is identical.

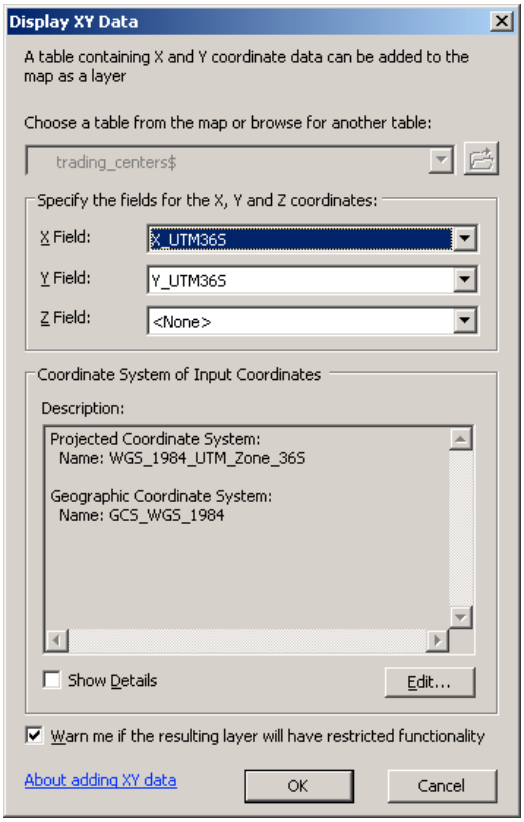
1. Add the tabular data to ArcMap using the ADD DATA button  .
2. Navigate to your data folder and open trading_centers.xlsx
3. Select the training_centers$ file and press ADD



4. The table listing trading centers is now added to the TOC. Right click on the trading centers in the TOC. A flyout window will present you with several options. Choose DISPLAY XY DATA.

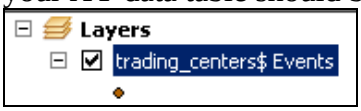


This opens up the DISPLAY XY DATA dialog box:



5. Choose the fields that represent the X (X_UTM36S) and Y (Y_UTM36S) data that will be used to map the point locations.
6. Once chosen, verify the description states the projected coordinate system is WGS_1984_UTM_Zone_36S. If not, press the EDIT button and define the coordinate system as UTM Zone 36S.
7. CLICK OK once finished. You may be notified of restriction errors. You may notice the DISPLAY XY DATA dialog box has this option checked at the bottom. If you do not get the message, continue with the next step. Read the message and press OK. This message box is warning you of the issues we just discussed on the previous page when utilizing Excel data in ArcMap.

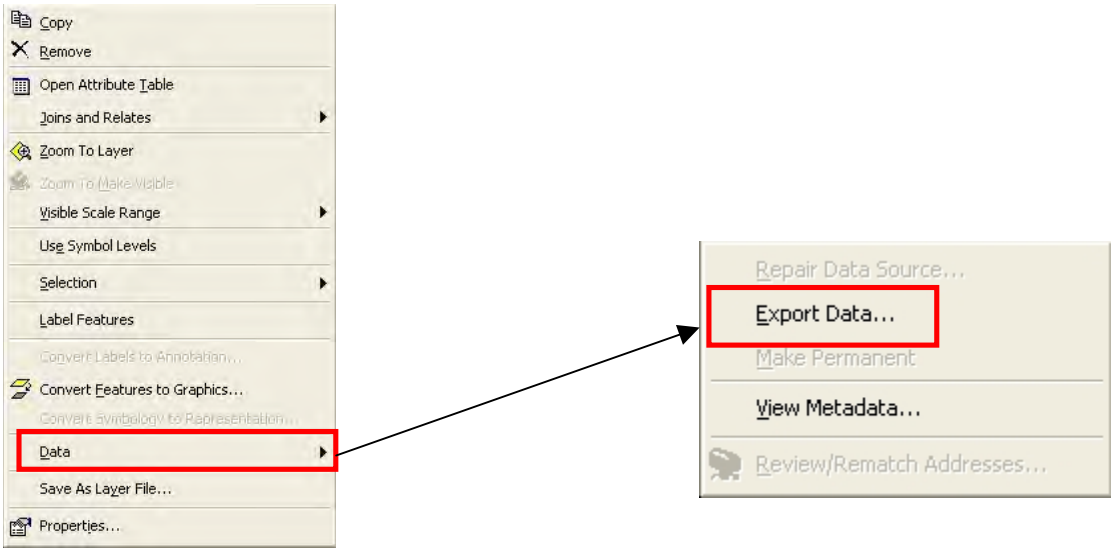
Once done, and if no major problems exist in the data your XY data table should be added to your TOC as an EVENT file.



The data should be displayed in your map view as well. For clarity, all other data layers have been turned off for the illustration.

Now export the data into a new shapefile.

8. Right CLICK on the trading_centers$Events file
9. Proceed to DATA
10. Export the data as a new shapefile
11. Use the data layer Projection properties NOT the data view properties
12. Save in your data folder as a file named MARKETS.



EXTERNAL TABLE DEVELOPMENT

Now that we have used our ADD XY data tool to import and map an external data table that has already been 'CLEANED' and readied for importation into a GIS we will take the table in its original format and see what steps are required before we can successfully import the table.

During this exercise you will start to see how important it is to understand table development from a GIS perspective. This is especially important when we want to integrate M&E data or other external data sets or indicators into a spatial environment for mapping and analysis. Keeping GIS in your mind and its requirements will facilitate you to build indicator and monitoring tables that are GIS friendly from and which will save a lot of time as cleaning data tables for fluid integration into a spatial environment can be quite time consuming if the tables are not prepared correctly or with a GIS end product in mind from their conception.

Prior to starting we should discuss table structure and data 'Normalization' procedures. Working with Data intended for a GIS and collected in the field or imported from various external or internal sources requires a strong understanding of tables and data normalization. Normalization of data facilitates 'clean data' with emphasis on standard spellings, field attribute names, table development procedures, etc.

Normalized Data and Table Structures

When looking at a map, it is helpful to know more about the features represented in it than simply where they are. For example, when looking at a map of rivers and streams, we have limited information usually just the names of the features.

A hydrologist may want to know even more, such as the slope of the river, the roughness of its bed and banks, and the shape of its cross-section, because these qualities are important in being able to define the velocity of water flow in the river.

This type of descriptive information about a geographic feature is called its **attribute data.** Attributes can be stored as numbers or character strings in a data record. A *collection of data records makes up a data table*.

There are two descriptions available for each geographic feature: its **spatial location** and its **descriptive attributes**. *It is essential for a GIS that these two descriptions be connected*. To do this, a **unique identifying number** must be associated with each geographic feature. That number is then stored both with the spatial description and with the attribute description.

A GIS is essentially a spatial database. The power of GIS comes from its ability to link a geographic feature on a map with its related descriptive attributes. The descriptive attributes are stored in the attribute table of the graphic feature.

Arc Map allows for the development and management of spatial data and it s associated attributes. In the case of shapefiles this data is stored in the *.DBF file. The following ideas hold true for all GIS data:

- Each table, is identified by a unique table name, and is organized by *rows* and *columns*.
- Each column within a table also has a unique name.
    - Columns store the values for a specific attribute, e.g. Type, Code, Toponimi.

- A Row represents one record in the table. In a GIS each row is usually linked to a separate spatial feature, e.g. a regency capital location.
    - Accordingly, each row would be comprised of several columns, each column containing a specific value for that geographic feature.

The following table illustrates recently imported village location data for Mauritania. This table displays 25 rows and 14 columns. That is 25 data attribute records with 14 columns of information (data) for each record providing specific information about that record.

COLUMN – Data Fields for Each Attribute Record →

ROW DATA RECORD

Attributes of Village-data-fixed Events

OID	NOM_DE_LA_	AUTRE_APPE	WILAYA	MOUGHATAA	COMMUNE	CODE_LOCAL	LONG-W	LAT-N	LONG-PR	LAT-PR	POP_LOCALI	CODE	Shape *
0	KAEDI		04	1	01	001	-13.50412	16.14683	659944	1785757	31052	1	Point
1	BELINABE		04	1	01	002	-13.55749	16.14265	654240	1785254	1394	2	Point
2	PIMPEDIEL		04	1	01	003	-13.53049	16.14952	657122	1786035	100	0	Point
3	RINDIAO		04	1	01	004	-13.5722	16.14243	652667	1785219	836	0	Point
4	NERE WALO		04	1	02	001	-13.64013	16.11217	645424	1781822	1124	1	Point
5	BIR EL BARKA		04	1	02	002	-13.5946	16.15091	650265	1786141	392	0	Point
6	DIAWOUT		04	1	02	003	-13.65453	16.11194	643884	1781786	77	0	Point
7	DIOKE		04	1	02	004	-13.6152	16.14663	648065	1785652	488	2	Point
8	KAGNADI		04	1	02	005	-13.71238	16.14609	637673	1785525	378	0	Point
9	SINTHIOU BOUMAKA		04	1	02	006	-13.61084	16.12101	648551	1782821	949	0	Point
10	SINTHION TAIBA		04	1	02	007	-13.59362	16.12888	650386	1783704	205	0	Point
11	SYLLA		04	1	02	008	-13.59057	16.13134	650711	1783978	937	0	Point
12	WOLOUM NERE		04	1	02	009	-13.64947	16.19183	644368	1790629	983	0	Point
13	GANKI		04	1	03	001	-13.23914	16.21377	688220	1793389	327	1	Point
14	DAFOR		04	1	03	002	-13.33345	16.30632	678053	1803546	51	0	Point
15	DAR NAIM		04	1	03	003	-13.41281	16.22477	669643	1794455	101	0	Point
16	DAR SALAM		04	1	03	004	-13.42941	16.20761	667883	1792542	644	0	Point
17	GOUDIOUMA		04	1	03	005	-13.43538	16.19828	667252	1791505	265	0	Point
18	MARHANA	WOURO SIRENABE	04	1	03	007	-13.58295	16.29999	651397	1802644	59	0	Point
19	MBIDENNE ALAMBE	WOURO SAMBA KED	04	1	03	008	-13.48989	16.25945	661374	1798230	50	2	Point
20	MBIDENNE GOLOMBE		04	1	03	009	-13.47248	16.28546	663214	1801122	291	2	Point
21	MBIDENNE LEDYAK	WOUNDOU SANGHRE	04	1	03	010	-13.4174	16.3388	669054	1807069	94	2	Point
22	MIFTAH EL KHAIR		04	1	03	011	-13.36897	16.2772	674283	1800293	99	0	Point
23	SEYENNE GABABE		04	1	03	012	-13.37466	16.20872	673735	1792711	428	0	Point
24	SEYENNE WOURO MOLO		04	1	03	013	-13.36168	16.21231	675120	1793119	398	0	Point
25	THIOUTH DEGUEJMOLE	BELENDENDI	04	1	03	014	-13.20028	16.23912	692351	1796230	389	0	Point

Record: 1 Show: All Selected Records (0 out of 1086 Selected) Options

To facilitate the development of proper data tables and structure across organizations and within countries data development should follow government coding systems. Standardization of information is key to data management and can be referred to as data normalization.

Normalized data is essential to data management. The use of government recognized data standards including spellings, map projections; etc will facilitate data development and the ability to share data between organizations. The use of recognized government standards for village names and codes will help to reduce data entry errors associated with village name spellings and provide a standard and recognized base on which to build program data. By using standards that are already in place and accepted at the national level an organization can save time and justify the reasons behind data.

For example, different program officers working on different activities in the same village may write the name of the village quite differently. The use of a normalized and standardized data set provided by a nationally recognized source will take this error away from program officers and provide a name that can be used by all and that is justifiable. In the end this will also reduce confusion and data entry errors and the time required to determine which village is being discussed.

For example, what if every government unit in Malawi had their own spelling for cities and towns? Everyone would spell names differently and no one would be able to share information. The development and integration of government standards addresses this problem.

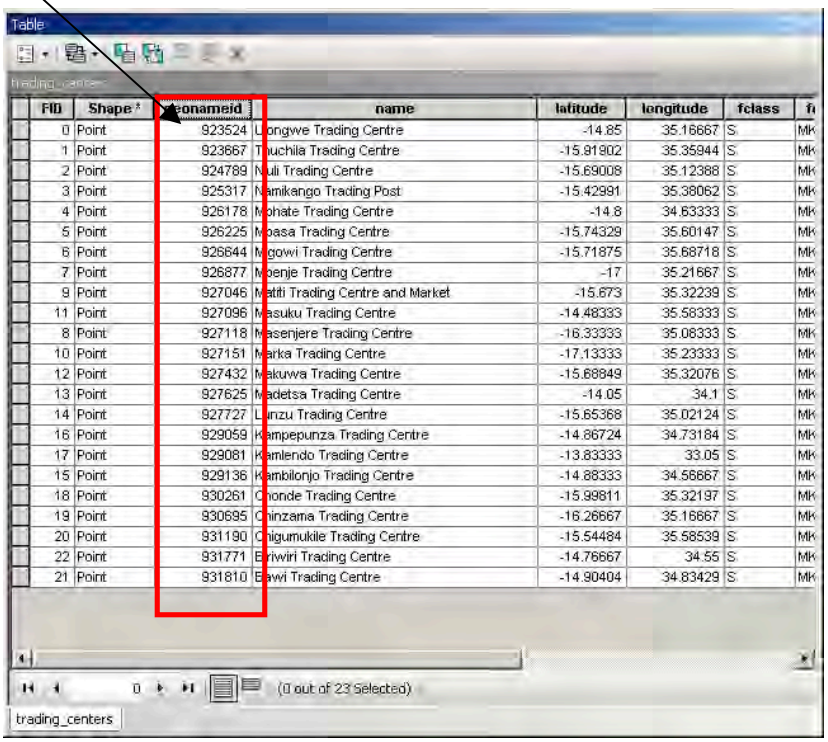
Another major part of data standardization is the development of a code or primary key that serves to identify data records: Any GPS point, polygon or line data record should have a unique identifier.

Primary Key/Unique Identifiers: Are data that create a unique identity for each record, much like a social security number that uniquely identifies every American Citizen. The primary key field contains unique values (i.e., there can only be one occurrence of each value), which serve as unique identifiers for each record in the table.

Examine the table below to get a better idea of primary keys used to identify trading centers in Malawi.

In this example the primary key is a text sequence starting from 92xxxx. Primary keys could also be a combination of numbers/text. Notice how each record has its own Primary Key or unique numeric identifier?

Primary Key



The primary key is used as a link for other tables. Without a common link field (Primary Key) we would be unable to associate or link related databases. For example, think of your social security number. It is unique to you a link to your credit score, bank accounts, driving records, taxes, payroll and so forth.

In the table below we can see an example spatial GIS points for primary schools in Senegal and a table of 2008 indicator data. Both tables contain the primary key which facilitates the ability to join or relate these tables and thus map, analyze and integrate program indicator data into a spatial environment.

On the left is the spatial GIS point shape file and the right our 2008 indicator data.

Attributes of sf-fin-8-07-update

FID	Shape *	TOPONYMIE	ID
58	Point	Abdallah	SF118
50	Point	Adji bali	SF13
51	Point	Aere Poste	SF1
84	Point	Agnam Townguel	SF80
124	Point	Alingo Ganina	SF34
76	Point	Alvar	SF57
123	Point	Belel Bogal	SF35
86	Point	Belele Kelle	SF81
63	Point	Belly Thiowy	SF14
25	Point	Bewedji	SF58
20	Point	Biddi	SF82
0	Point	Binguel Bolo	SF9
59	Point	Bitto	SF119
52	Point	Bode	SF2
95	Point	Boguel Belly Edy	SF46

Attributes of SF-total-Food-08-final

OID	COMRURALE	ID *	ECOLE	FILLES	GARCONS	TOTAL
117	MBOUMBA	SF118	ABDALLAY	77	44	121
12	DODEL	SF13	ADJI BALI	34	20	54
115	MADINA NDIATBE	SF116	AERE BOULBEL	60	39	99
0	AERE LAO	SF1	AERE POSTE	95	37	132
79	GUEDE VILLAGE	SF80	AGNAM TONGUEL	138	113	251
56	GAMADJI SARE	SF57	ALWAR	85	53	138
33	FANAYE DIERI	SF34	BA KARNABE(GANINA)	26	25	51
34	FANAYE DIERI	SF35	BELEL BOGAL	37	15	52
80	GUEDE VILLAGE	SF81	BELELE KELLE	76	18	94
13	DODEL	SF14	BELLY THIOWI	94	22	116
57	GAMADJI SARE	SF58	BEWEDJI	50	14	64
81	GUEDE VILLAGE	SF82	BIDDI	65	46	111
8	AERE LAO	SF9	BINGUEL BOLO	25	21	46
118	MBOUMBA	SF119	BITO	58	52	110
1	AERE LAO	SF2	BODE	182	92	274

Notice how the indicator data on the left school names may in some cases differ greatly from the names in our GIS point file? The file on the left uses the standardized spelling why the indicator data on the left uses the program officer's spelling convention. Sometimes it is necessary to carefully look for other possible spellings based on pronunciation differences such as Vordou and Wordou.

Note in a GIS there are many ways to approach data and resolve analytical problems. While you could correct the spelling differences after importing the data into the GIS, it is always better to ensure clean data is imported prior to use. Users who are new to GIS are often much more comfortable and proficient with Excel and prefer to clean data within the Excel environment.

INTERNAL TABLE DEVELOPMENT

Now we will examine how database tables can be built within the Arc GIS environment. First we will work with an existing, spatially referenced table and add data fields to the table. Then we will create a new table and a new shapefile and start to build data attributes.

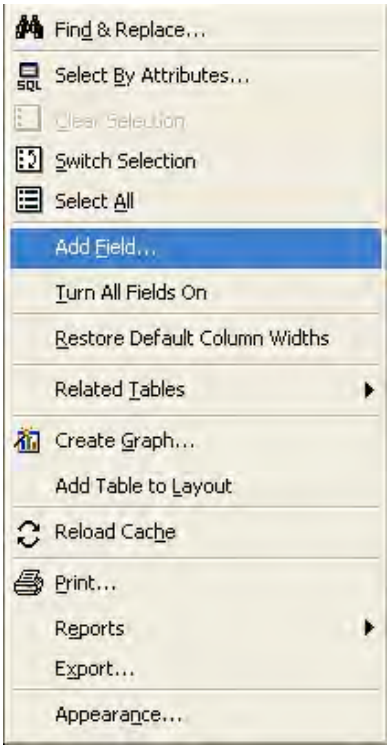
Spatial Editor

Editing data is quite easy in ArcGIS. New attribute fields for existing spatial data can be created and populated in the ArcGIS environment. Before a user can edit data, one of the first required steps is to ensure that the Editor tool is loaded into the map view. Until you begin editing, data is read only and cannot be modified. If you do not see your Editor tool, you will have to turn it on by going to the CUSTOMIZE menu, select TOOLBARS, and check EDITOR.

The Editor tool bar is now loaded in your map view.

One quick point of clarification which is very important to note is that in the ArcGIS new data fields cannot be added when an editing session has been started. Therefore if you anticipate adding new data field columns to a data set this must be done before initiating an EDIT Session.

Prior to starting a data edit session we will add a new data field to the waypoints data you imported earlier.

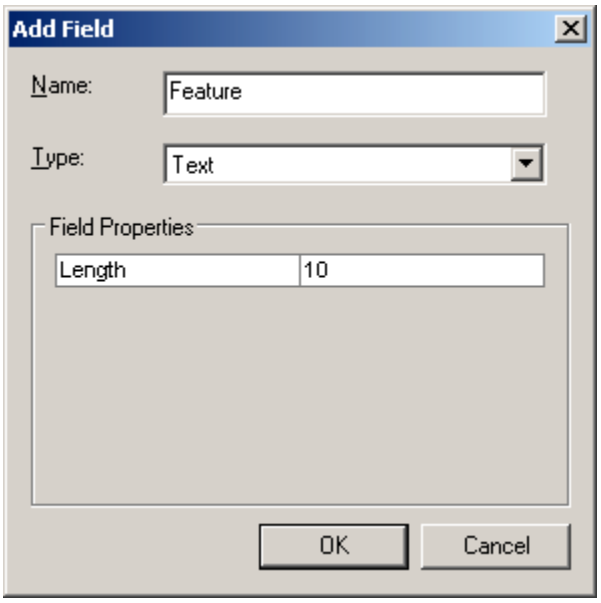


1. Right Click on the arcmap_waypoints file in the TOC.
2. Select OPEN ATTRIBUTE TABLE.
3. At the top of the table (left hand side) you will see an OPTIONS button click on this button

4. Choose the ADD FIELD

Note: that a user CANNOT add a new data field once in editing mode, therefore it is required to add a field or fields prior to data editing.

These waypoints are actual locations of schools throughout Malawi. When you view the table, you have no idea where the school is, what the name of the school is, or that they are even schools. Therefore, we are now going to add some of this information to the table.

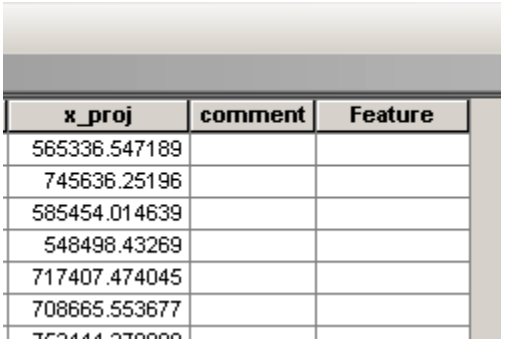


Once you select ADD field the ADD field dialog box will appear. First, we want to add a column indicating these records are schools.

Here you will provide a Field NAME, select the type of field and the column width.

5. Name the Field FEATURE
6. Under Type chose TEXT
7. Set the length to a value large enough to contain the word feature. The default is 50 which is extreme.
8. Click OK when finished

You will notice that a new field at the end of your data table has been added.



x_proj	comment	Feature
565336.547189		
745636.25196		
585454.014639		
548498.43269		
717407.474045		
708665.553677		

For more information on Field types and Properties I have included a description taken directly from the Arc GIS Help Guide built into the software.

When you create feature classes and tables, you select a data type for each field. The available types include a variety of number types, text, date, binary large objects (BLOBs), or globally unique identifiers (GUIDs). Choosing the correct data type allows you to correctly store the data and will facilitate your analysis, data management, and business needs.

Numbers

You can store numbers in one of four numeric data types:

- Short integers
- Long integers
- Single-precision floating point numbers, often referred to as *floats*
- Double-precision floating point numbers, commonly called *doubles*

In choosing the data type, first consider the need for whole numbers versus fractional numbers. If you just need to store whole numbers, such as 12 or 12,345,678, specify a short or long integer. If you need to store fractional numbers that have decimal places, such as 0.23 or 1234.5678, specify a float or a double.
Secondly, when choosing between a short or long integer, or between a float or double, choose the data type that takes up the least storage space required. This will not only minimize the amount of storage required but will also improve performance. PLEASE refer to the ARCGIS HELP function for more information on number field formats and limits.

Text

A text field represents a series of alphanumeric symbols. This can include street names, attribute properties, or other textual descriptions. An alternative to using repeating textual attributes is to

establish a coded value. A textual description would be coded with a numeric value. For example, you might code road types with numeric values by assigning a 1 to paved improved roads, a 2 to gravel roads, and so on. This has the advantage of using less storage space in the database; however, the coded values must be understood by the data user. If you define your coded values in a coded value domain in the database and associate the domain with the integer field storing your codes, the database will display the textual description when the table is viewed in Arc Map or Arc Catalog.

Once you have created your data fields you will want to attribute data records with values. A user can attribute data within an editing session or prior to starting an editing session by using the FIELD CALCULATOR.

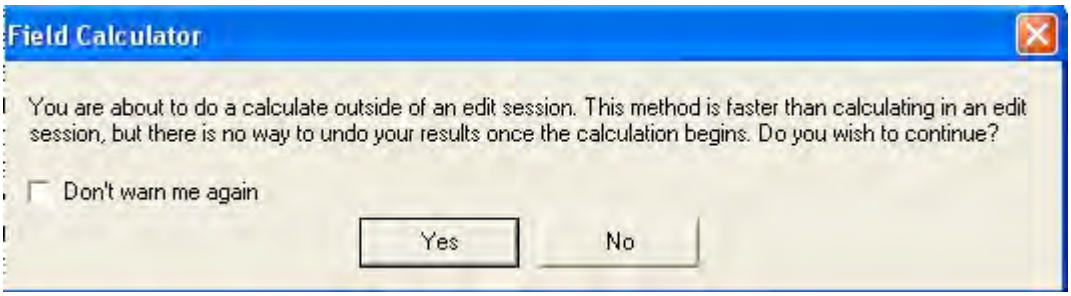
Attributing Data outside an Editing Session

Calculating data outside an EDIT session is easy, but cannot be automatically reversed (undo), so a user must be careful to assure the edits made are correct.

Now we will use the field calculator to populate the newly created FEATURE field to be equal to the word “School”.

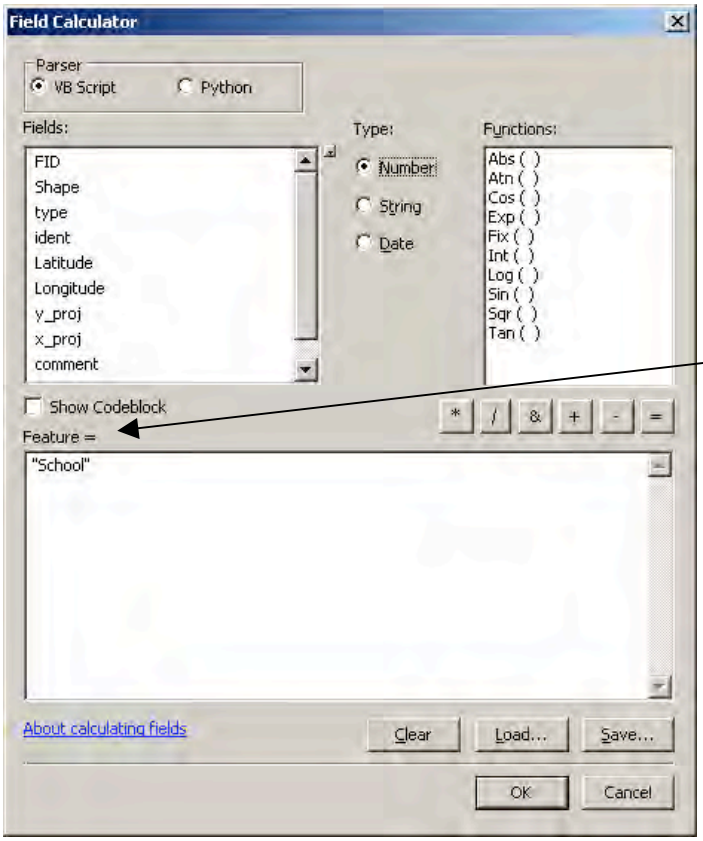
1. Right Click on the FEATURE field
2. Select FIELD CALCULATOR

A message box may pop up once you select the field calculator:



3. Select YES

Notice the Field Calculator Dialog box will open (as below)



The field calculator allows a user to quickly calculate data fields for all or a select group of data records.

4. CLICK on the HELP button to read on the functions of the FIELD CALCULATOR
5. In the FEATURE Box, type "School". You want to enclose text in parenthesis so the field calculator knows you want your new feature to be exactly what you typed. You could also set it equal to another field in your table.
6. The equation now reads Feature = "School"
7. Click OK, you will see all your FEATURE Data records should now be designated as a School. Leave the attribute table OPEN.

If you only wanted to change select records, you would first select them in the attribute table. When you utilize the field calculator, it will change the values for all records if none are selected but will only change the value of selected records if you have records selected. If you plan to have unique values for each record, the field calculator is time consuming and tedious. In that case, you will want to directly edit within the table which is explained later.

Joining Data to an Attribute Table

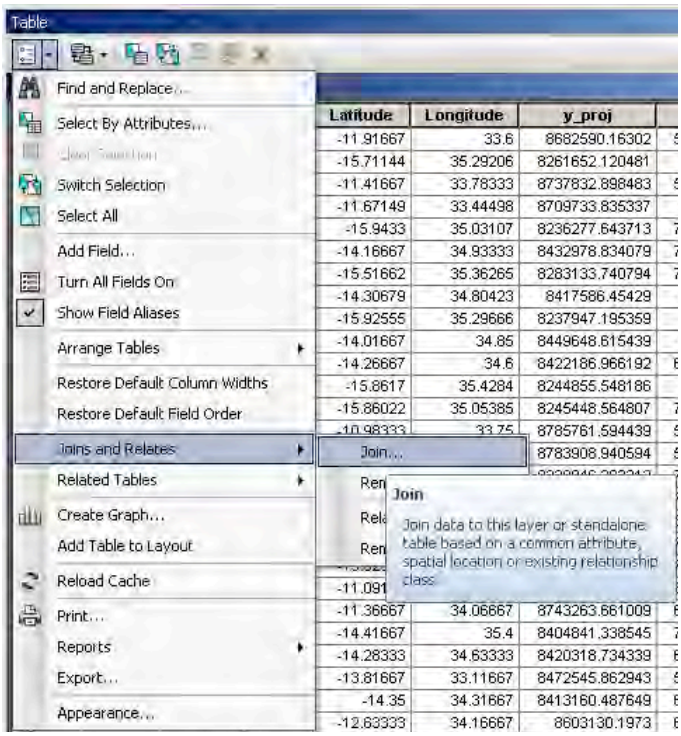
In this section, we will take a list of school names and join that list to your attribute table.

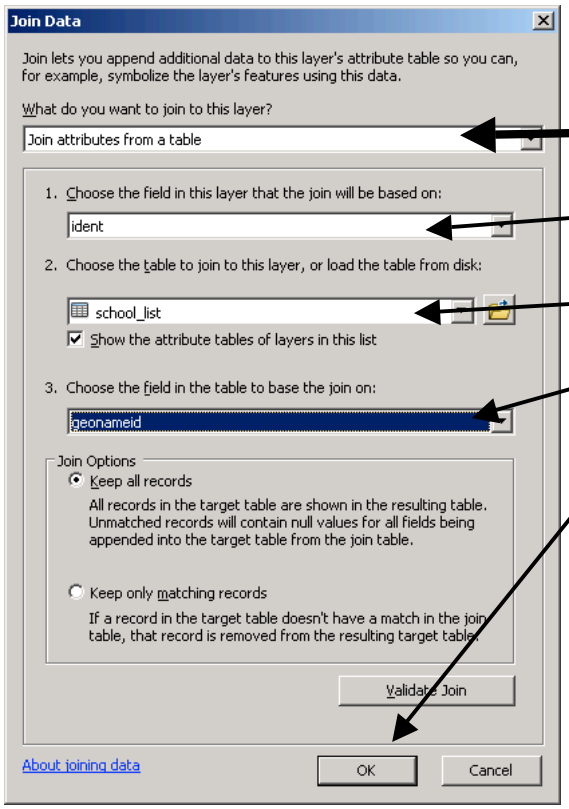
1. Add a NEW field to the arcmap_waypoints attribute class. Do you remember how? OPTIONS, ADD NEW FIELD. Name this new field SCHOOL NAME. The new field will need to be TEXT and the length around 30.
2. Add the list of school names to the TOC. Use the ADD DATA button and add the .dbf file named SCHOOL_LIST.
3. Open the attribute table for school_list and examine it. You will notice the unique primary key and a list of names.

4. Since the arcmap_waypoints attribute table also contains a primary key, we will join the two tables together by the primary key. The primary key in the school_list is GEONAMEID and the primary key in the arcmap_waypoints table is ident. Can you spot some matches?

geonameid	name	pe	ident	Latitude
923857	Soche School	POINT	931843	-15.7114
923863	Snambenje School	POINT	931809	-11.4166
923868	Sitoro School	POINT	931709	-11.6714
931904	Alick Cisi School	POINT	931681	-15.943

5. We want the list of schools to go in our arcmap_waypoints attribute table. Therefore, go to the attribute table for arcmap_waypoints.
6. Use the OPTIONS button to find JOINS AND RELATES. Select JOIN.





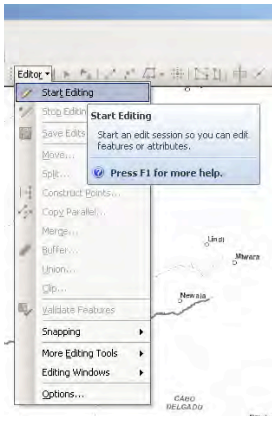
7. Starting from the top of the JOIN DATA box. Choose JOIN ATTRIBUTES FROM A TABLE
8. The field the join is based on is the IDENT field we identified in the attribute table.
9. Select SCHOOL_LIST as the table that contains the data to join to this table.
10. The field from the school_list table is the GEONAMEID field.
11. Keep all records and press OK.
12. If prompted to Create and Index, Select NO.
13. Open the attribute table for arcmap_waypoints.
14. Do you see the list of schools appended to the right end?
15. Joins are only temporary. To make the join permanent, you will need to export the shapefile.
16. In the TOC, Right Click arcmap_waypoints. Choose DATA, then EXPORT DATA. Save the new file as SCHOOLS in your data folder. When asked if you want to add it to the map, select YES.

	Feature	OID	name
	School	3	Alick Cisi School
	School	4	Bandawe School
	School	147	Bawula School
	School	143	Bulala School
	School	142	Bvumbwe School
	School	141	Bwadzulu School
	School	146	Camanga School

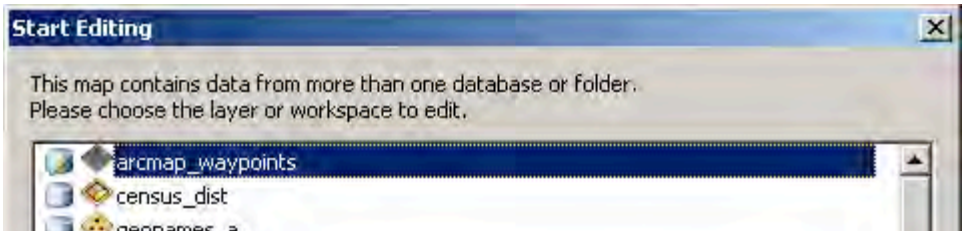
Attributing Data and Creating New Data inside an Editing Session

Now we will work within an editing session to create new data – a new point location for a new school and attribute this new data record within an editing session.

1. Go to the EDITOR Menu
2. Select Start Editing



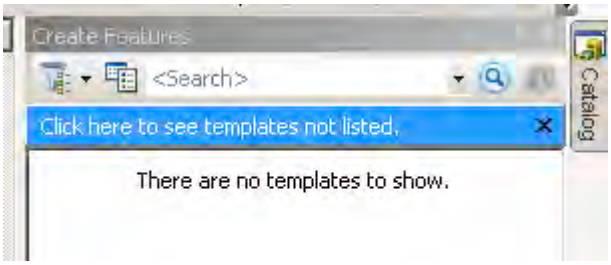
3. Select the feature you would like to start editing data. We want to edit our arcmap_waypoints to include a new school



A secondary message box may appear to inform you that you are editing a data file which is in a different coordinate system than your data frame. If so, acknowledge it to continue with the editing.

Now you will see the EDITOR tool is no longer grayed out. Press the CREATE FEATURES button to create a new school feature on your map.

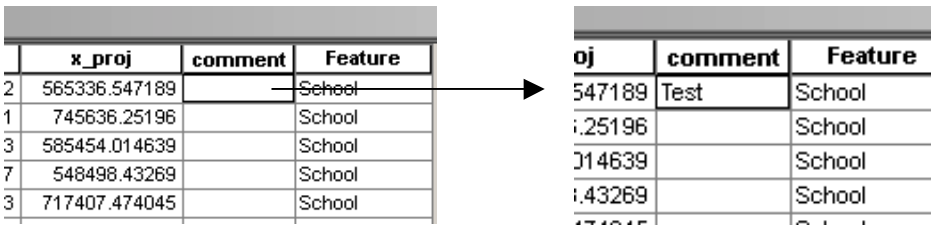
On the right side of your data view window you will notice a new window for creating features. Notice in the example below that there are no TARGET features listed. This is because I turned off the arcmap_waypoints feature in the TOC. Turn the arcmap_waypoint feature class on and off in the TOC and notice how it appears and disappears from the create features window. Leave it turned ON so we can continue.



In Arc GIS it is possible to edit several shapefiles at the once by changing the target shapefile when necessary. Always be careful that you are editing the correct TARGET shapefile.

Now that we have started editing if we go to our data table we will see that if we click with in a cell we can edit attribute values.

4. Click in first record under the COMMENT field and type in TEST.

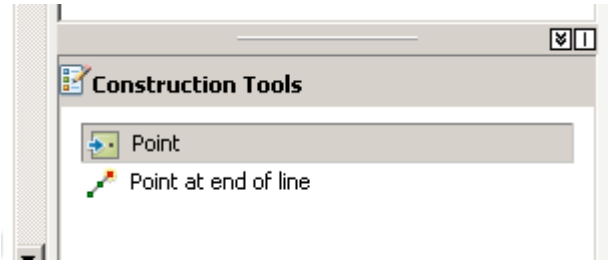


	x_proj	comment	Feature
2	565336.547189		School
1	745636.25196		School
3	585454.014639		School
7	548498.43269		School
3	717407.474045		School

oj	comment	Feature
547189	Test	School
.25196		School
014639		School
.43269		School

5. Save your Edits once completed
    a. Click on the EDITOR MENU
    b. Select SAVE EDITS
    c. Close the attribute table

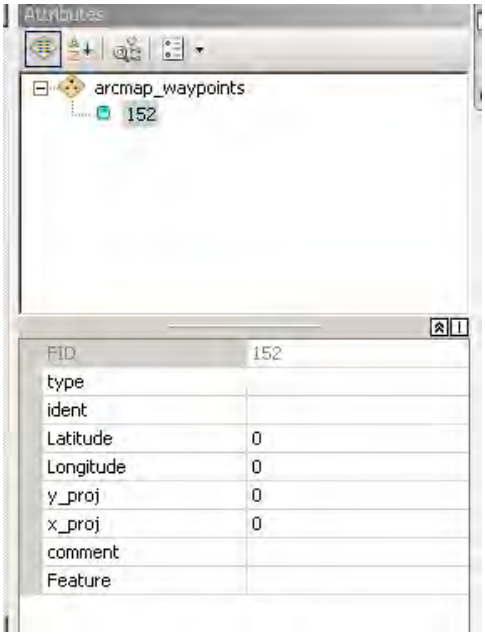
6. Select your TARGET feature class (arcmap_waypoints) in the CREATE FEATURES window. You will notice the Construction Tools become activated at the bottom of the Create Features window. Since the arcmap_waypoints feature class is point data, we can create only points.



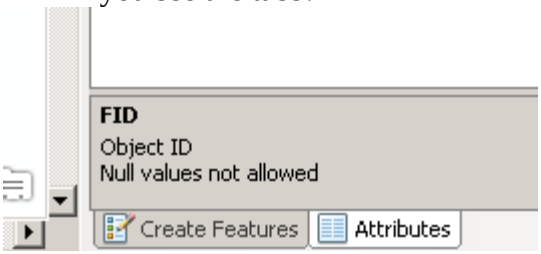
7. Left Click on POINT to construct a new point on the map.
8. Now go to your ArcMap data view window. You will notice a small point located on top of your mouse arrow. Find a location on the Malawi map to place this new school. Any location will suffice as this is only a learning exercise. Left click where you want the point.

9. You see the point shows up on your map highlighted. Also notice you still have the point attached to your mouse arrow which allows you to continue adding more points. We will just add the one.
10. Now we would like to add some attributes to the newly created school. We could open the attribute table and everytime we created a new feature and make changes. To save on monitor window space, we will now utilize a different technique.
11. Select the ATTRIBUTES button on the EDITOR Tool.

This replaces the Create Features window with and Attributes Window. Notice that all the fields from the attribute table are in this window. However, the only record is 152, the point feature we just created.



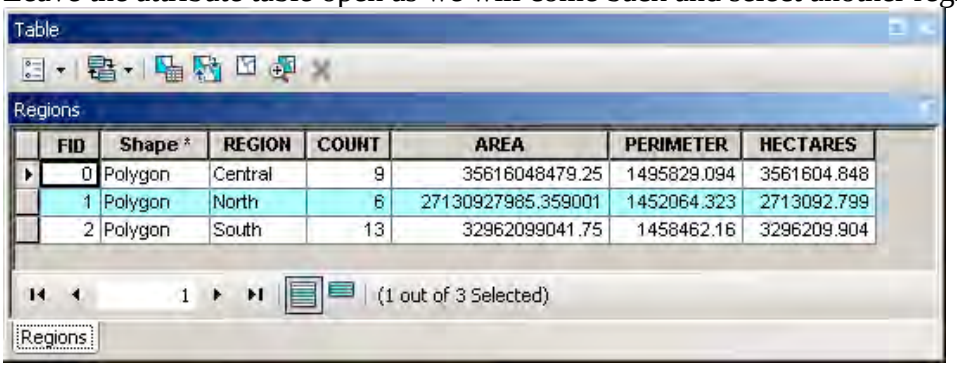
12. Click in the cell next to the FEATURE field and type in School.
13. Next, open your attribute table and look at the last record, FID 152. What do you see in the Feature field? The edits are linked between the map, attribute table, and editor.
14. Save your edits in the EDITOR Tool.
15. To return to the Create Features window, look at the lower left corner of the Attribute window. Do you see the tabs?



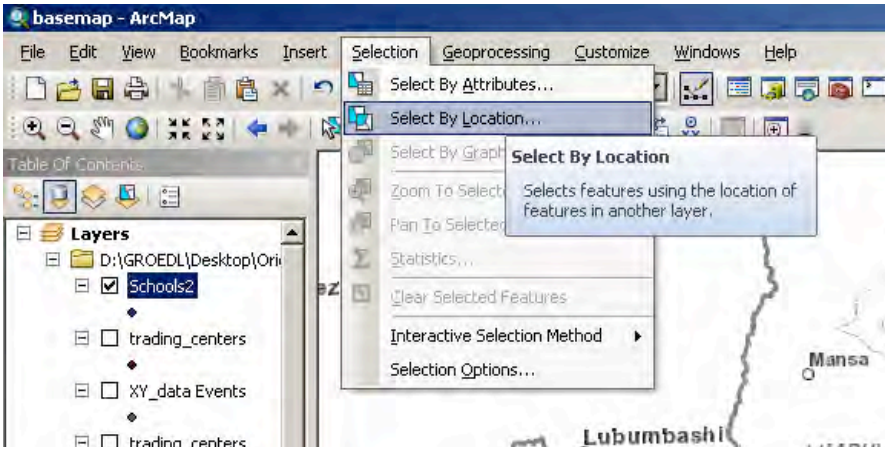
Developing Data by Location

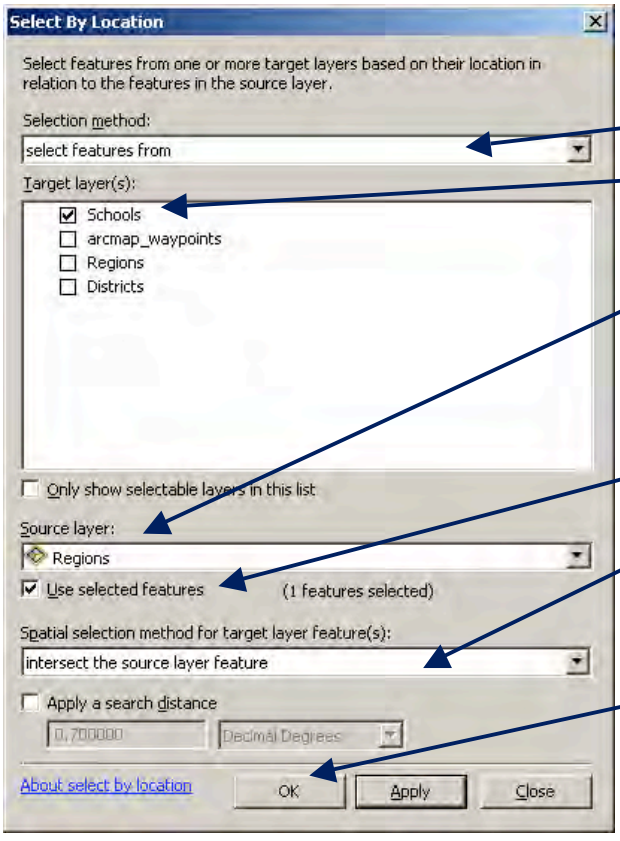
As another Data development exercise we want to identify schools by the region they are located in so we can provide this data to the appropriate authorities. There are three districts: Northern, Central, and Southern. Trying to "figure" out which schools are in which district is tedious and time consuming. Luckily, ArcMap can do this for you.

1. First, since we are only looking for schools within a single region and our Region feature class contains three regions, we will need to select which region we want to search.
2. We will first select schools in the NORTHERN region.
3. Open the attribute table for REGIONS.
4. Select the record for the NORTH region. Click in the gray box to the left of the FID field to select a record.
5. Leave the attribute table open as we will come back and select another region later.



6. From the SELECTION Menu, choose SELECT BY LOCATION.





7. The Selection method is SELECT FEATURES FROM
8. Check Schools as the Target Layer since we want to select schools in the North Region
9. REGIONS is the source layer since the different regions of Malawi are contained in that shapefile.
10. Be sure you Check the USE SELECTED FEATURES box or else all the schools will be selected.
11. For the Spatial Selection Method, choose INTERSECT THE SOURCE LAYER FEATURE. That will select all schools that are contained within the North Region.
12. Press OK and view the results on your map. Notice the schools in the North Region are highlighted but no schools in the Central or Southern Region are highlighted.
13. Go back to your Schools shapefile in the TOC and export (Select Data – Export Data) the selected schools to a new shapefile named NORTH SCHOOLS. When prompted, Add the Data file to the View.
14. Repeat steps 1-13 for the Central Region and for the Southern Region. When you export the data, name them appropriately.

Once finished you should have three new files North Schools, Central Schools, South Schools.

The next step will be to 'merge' these three files into 1 file. Although the originated from one file, this lesson is intended to instruct you on how you can take many different files and combine them into a single shapefile and attribute table.

The ArcGIS Help function provides the following information on the MERGE tool.

Combines input features from multiple input sources (of the same data type) into a single, new, output feature class. The input data sources may be point, line, or polygon feature classes or tables.

Use Merge when there are features from multiple input sources that need to be combined into one feature class.

- *Input data sources need not be adjacent; overlap is allowed.*
- *The type of input data, such as polygons or tables, must be the same for all inputs.*
- *If no coordinate system is specified in the Environment Settings, the output feature class will be in the coordinate system of the first feature class in the input features list.*
- *Current map layers may be used to define input features. When using layers, only the currently selected features are used in the Merge operation.*
- *Merge cannot use multiple input layers of the same name. Although ArcMap allows for the display of layers with the same name (from different directories) these may not be used in the Merge tool. For example, although c:\roads and d:\redlands\roads are two distinct datasets (located in different workspaces), both will appear in ArcMap with the same name (Roads).*
- *Output fields and their contents can be controlled by the Field Map option.*
- *The order in which you select fields determines the order in which their values will be displayed in the output field. When joining several input fields into a single output field, the output fields' values will be generated based on the order the input fields were chosen.*
- *A new output field can be added to the output feature class or table, composed of user-specified input fields.*
- *A single output field can be generated from multiple input fields. This happens, if more than one input feature class or table contains a field of the same name, or it can happen, if a new field is created and the contents of the output field are generated from multiple (differently named) user-selected fields.*
- *The first input feature classes' or tables' fields will appear first as sub fields in the Field Map.*
- *Merge identifies fields based on their name, not on their data type. Input fields are identified by their name and grouped into an output field of the same name.*
- *The data type of an output field will default to the same as the data type of the first input field (of that name) it encounters. The data type may be changed manually at any time to any valid data type. All valid data types will be listed if the tools dialog box is used.*

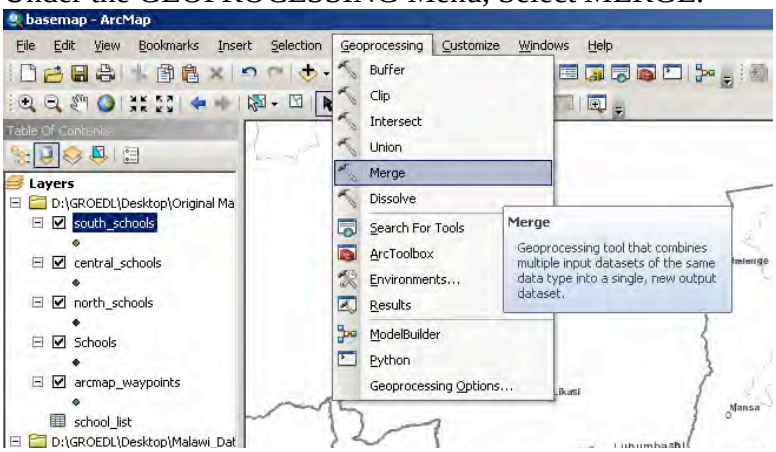
- *Merge does not perform edge matching. There will be no adjustment to the boundaries of features. Edge matching can be performed in ArcMap or ArcINFO Workstation only.*
- *Unlike the Union function, Merge does not planarize the input features into a single output. Input features from all the input feature classes remain intact in the target feature class.*
- *When performing a Join (Merge rule), you can specify your own delimiter such as a space, comma, period, dash, and so on. If you want to use a space, make sure your mouse pointer is at the start of the input box and click the space bar once.*
- *Concatenation can happen only if the fields chosen are from the same input feature class or table.*
- *There are a number of Merge rules available: first, last, join, sum, mean, median, min, max and standard deviation.*
- *Format options are only available on input fields of type text (and in conjunction with the Join merge rule). You can specify start point, end point, and so on. Format allows you to apply your changes to the selected input field or to apply them to all occurrences of the same input field.*

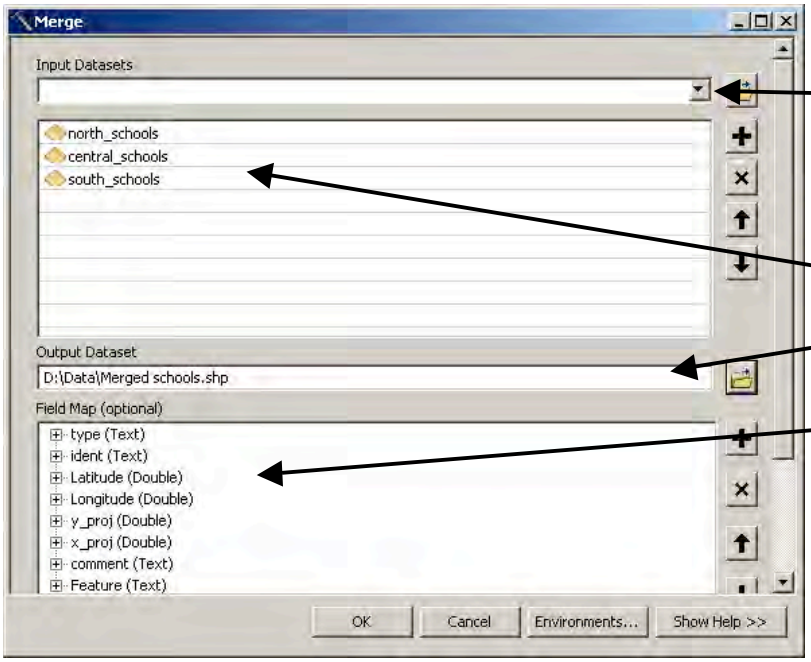
As discussed under the MERGE Usage tips, if we want to merge several GIS files together, in this case the regional school, files the merge function will use data attributes from the first file selected.

What does this mean? It means that only matching attribute field names (based on the first selected file) will be used. For example if one file has the field attribute Name and the second file has School_Name the records with School_Name will be blank after merging. Data will not be present as the attribute field name is not the same as the first file used.

Therefore, it is important to look at all the tables for the data layers you wish to merge, identify the key fields you want to keep across the shape file and then in tables which do not have the same field attribute names ADD a new Field with the same name as the first shape file so data is not lost. Then when merged the data will be present. However, for now, we know all our attribute tables are identical.

1. Under the GEOPROCESSING Menu, Select MERGE.





2. Because all the files we want to merge are in the TOC, use the drop down arrow to select each regional school
3. Select one school then repeat step 2 to add another school to the list.
4. Specify the output folder and name to save the new merged schools in.
5. For now, leave the optional field map options alone. However, if you wanted to exclude fields from your new merged field, you could use the field map to select which fields you wanted to include and which fields you did not want to include.
6. Press OK. Be patient, at first it will seem as though nothing is happening.
7. Open the attribute table for your merged schools and examine the results. Were you successful? Hopefully YES!

The Geoprocessing Menu has several other options that are frequently used in any GIS application. You will notice a dissolve tool, clip tool, intersect, union, and buffer. It is also worth pointing out that these tools are also available on the Editor Toolbar with one significant difference. When you use the Geoprocessing menu, you typically want to perform operations on entire features. When you use the Editor Too, you can perform the operations on a single record. For example, take the records of two property parcel and merge them or conversely, split one record into two new ones while keeping the associated attributes.

This ends Module IV