ArcMap Tutorial 1.0

1.1 – Loading the Landsat and SAMB Images
1.2 – Adjusting Image Contrast and Changing Band Combinations
2.1 – Digitizing the MUC Land Cover Classes
2.2 – Attributing the MUC Land Cover Classes

Tutorial Objectives: *Become familiar with several important ArcMap features, and create a digital GLOBE Land Cover Map.*

ArcMap is the ArcGIS tool used to create and visualize various types of geographic data, including maps and map features (Fig. 1). ArcMap is also used to resolve basic geographic questions of location, size, juxtaposition, and can even answer "what if?" questions - geographic modeling scenarios. One of ArcMap's most powerful features is its ability to be customized for specific, unique types of analyses, via its customizable interface.
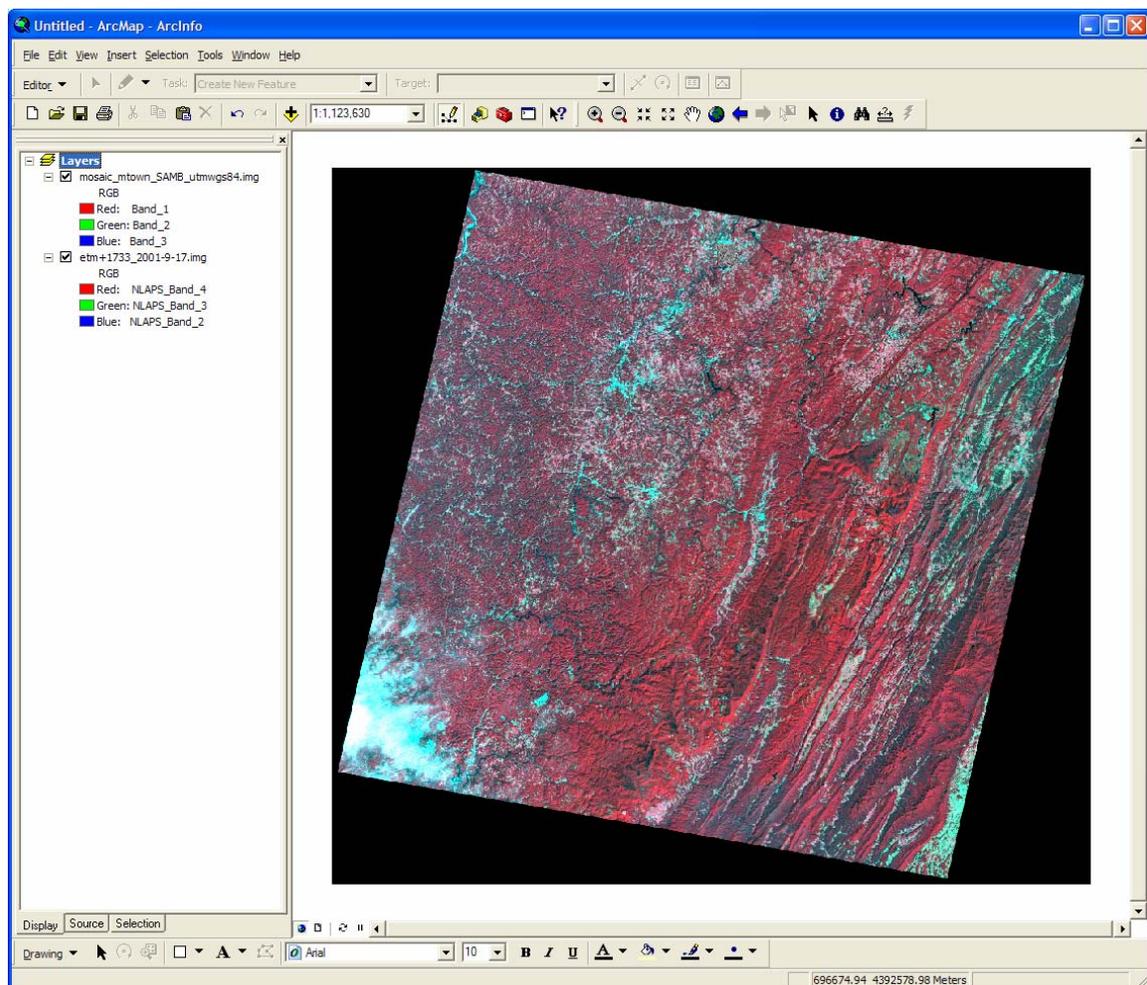

Figure 1. ArcMap, showing the *Table of Contents* in the left pane and the Landsat image etm+1733_2001-9-17.img in the *Display Window*.

Lesson 1. Viewing Digital Geographic Data in ArcMap

1.1) Loading the Landsat and SAMB Images

Browse to and boot ArcMap using the Start button (Start/Programs/ArcGIS/ArcMap). A small dialog box will appear, asking you to make a selection (Fig. 2). We will click the radio button to select "A new empty map".
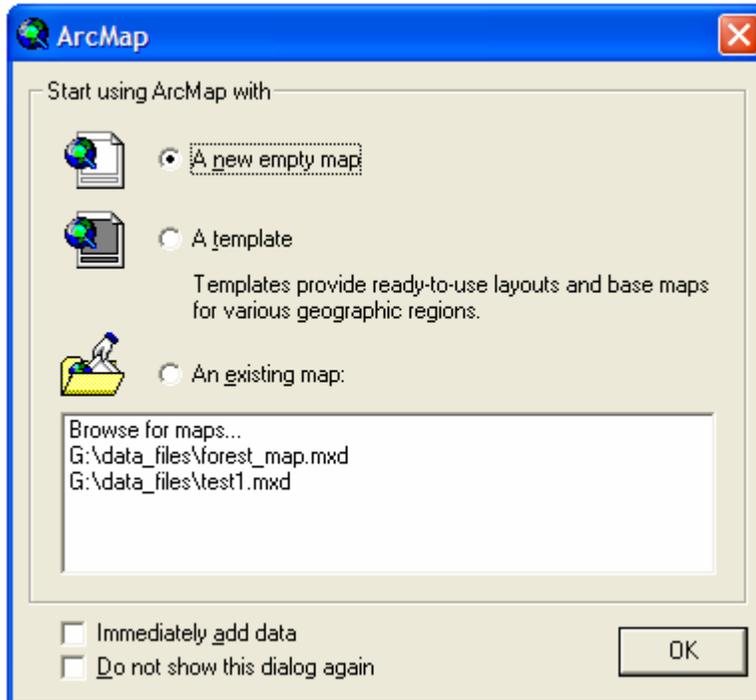

Figure 2. The *ArcMap Start* dialog box.

Once we've created a new map file by clicking 'OK', we can browse to our images. To do this, we click on the "Add Data" icon ⬇ , opening the Add Data dialog box that permits browsing to our data files. Notice that ArcMap uses ArcCatalog *Connections*. Browse to the Landsat image etm+1733_2001-9-17.img and add it. The Display Window should resemble Figure 1.

Before we learn about image enhancement, let's add the GLOBE 15km x 15km subscene and the 5km x 5km subscene that we'll ultimately be using for our MUC land use map. These will help us understand how image contrast enhancement works.

Click the Add Data icon and add south_middle_globe.img, followed by the image named south_middle_5x5_km.img. All three images should now show up in the *Table of Contents*.

Let's arrange them by size, with the entire scene underlying the 15km by 15km scene, with the 5km by 5km scene as the "top" layer. This is done simply by selecting and dragging the files in the *Table of Contents*.

Notice that if you click the small box immediately to the right of the '+' sign for each image, you can turn the image display on or off. If you click the '+' sign, it will display ('-') or hide (''+'') the image's band numbers and *display* assignments (Fig. 3). Note that these are only the three bands that are displayed on the screen, not the total number of bands that could be used in a display. We'll learn more about the latter idea in the next section.
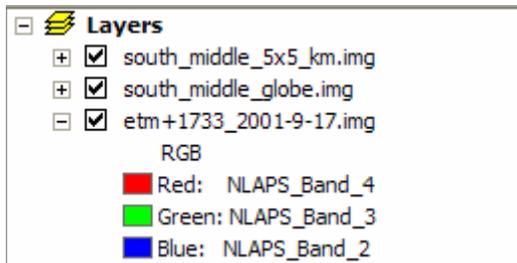

Figure 3. The ArcMap Table of Contents showing the color display assignments for the near-infrared band (4), the red band (3), and the green band (2).

1.2) Adjusting Image Contrast and Changing Band Combinations

Now that all three Landsat images are added, let's force the computer to display them so we can view them as individual, subsetted files. To do this, we'll need to represent the pixel data values, the DN's or "digital numbers", differently. We do this by altering the DN's as they are displayed by the computer (but we don't actually alter the pixel values in the data, just their *display* value on the compute screen – this is an important point). We do this by "mapping" the underlying (original) DN values to "new" display values.

First, select the underlying scene (etm+1733_20019-17.img), right-click and draw down to "Properties…", click the "Symbology" tab (Fig. 4).
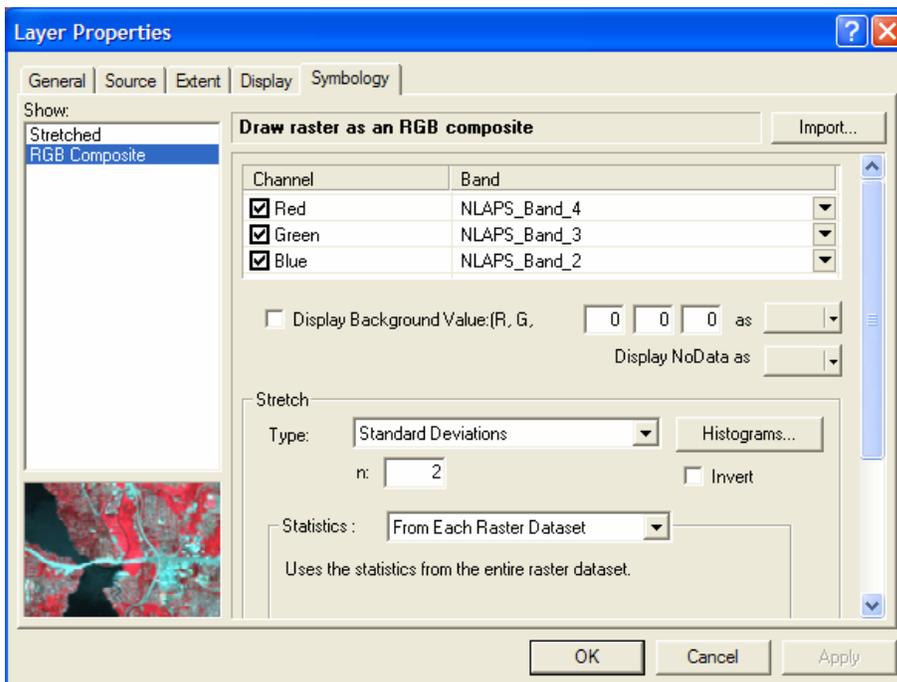


Figure 4. The Symbology dialog box in the Layer Properties menu.
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West Virginia GLOBE, West Virginia View

Note that the Layer Properties Symbology shows our image as a 4,3,2 color-IR image (the small image in the lower left always shows a color-IR example, regardless of the band combinations). What we'll do is view how ArcMap displays the image, by noting the type of stretch (Standard Deviations) and 'n' value. Click on the 'Type' menu and you'll a variety of choices (None, Custom, Standard Dev., etc.), representing the various types of functions one can apply the selected image DN values for each band. The frequency distribution of the DN values of the data in the Near IR band, displayed using the red color gun on the computer monitor, looks like this:
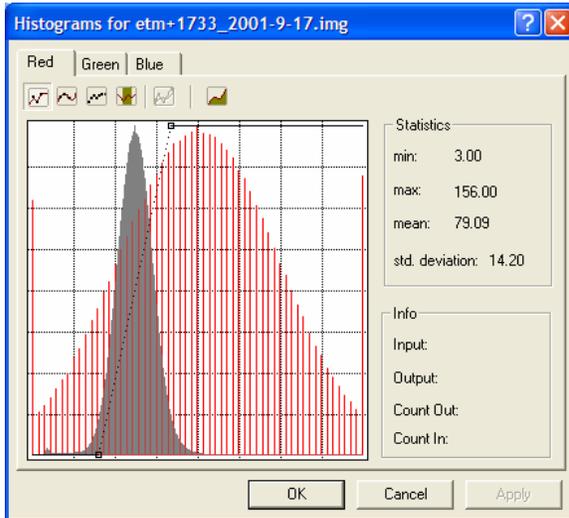
All that has been done here is a simple *remapping* of the original pixel values to 'new' values for display purposes (the new values are being written to what's called a "Look Up Table", or LUT). We'll manually set them back to their original, "unstretched" values. But first, let's examine the stretch on the green and blue bands.

Since we know that the x-value is the original pixels value and the y-values are the 'new' or stretched values, let's map the y-values back to the original values using a 1:1 mapping.

Figure 5. The frequency distribution of DN values in the near-IR band, band 4, displayed using red.

Click on the small box on the x-axis and drag it t the origin. Now, select the small box at the top, and drag it to the upper right corner. What you've jus done is created the function x=y. The two frequency distributions should overlap. Let's do that for all three bands and view the image as it looks without a contrast stretch. Now, let's change the contrast on all three images so we can see each clearly (Fig. 6).
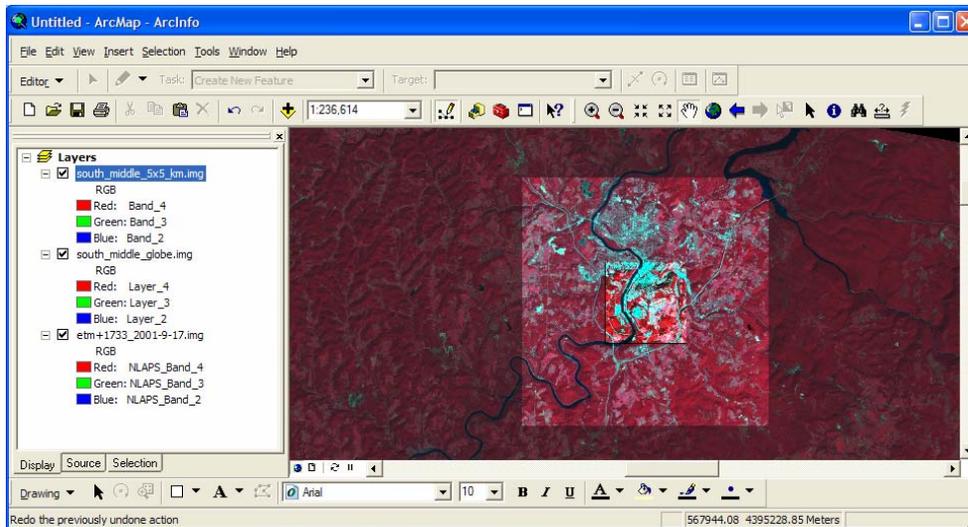

Figure 6. All three Landsat images, each displayed using a different contrast stretch.

Contrast stretching is useful for a variety of visual analysis techniques. Another technique we can use extract information from a Landsat scene is changing the band combinations. Whereas the existing color-IR image shows the vegetation quite well, there are other bands and band combinations that help to distinguish other features. A common combination is 5,4,3. Landsat band 5, the mid-infrared band (1.0 to 1.9 Ium, micrometers) is set to red, and near-IR is set to green. This is an effective combination for distinguishing grasslands (agricultural hay fields, in our area) from forest. The visible, or 3,2,1 is also useful for this distinction. We can try these combinations on urban land uses and assess how effective they are at distinguishing, for instance, bare soil from asphalt.

2.1 Digitizing the MUC Land Cover Classes

After we've examined the GLOBE Landsat image and we've begun to see some of the ways we can extract information about surface features, it's time to begin our Land Cover Mapping exercise. The idea is to create a digital version of the manual land cover map described in the Land Cover – Biology investigation (see Manual Land Cover Mapping Protocol in the 2003 Land Cover / Biology Investigation manual). We'll use the Landsat subscene and the SAMB aerial photographs to map MUC land cover classes.

First, add the index (Mon_Co_index_projected.img) so that we can see the aerial images we'll need for accurate mapping. Then add the GLOBE 15km x 15km scene, then add the six SAMB images over it, finally add the 5km x 5km scene. The display window should look like this (Fig. 7):
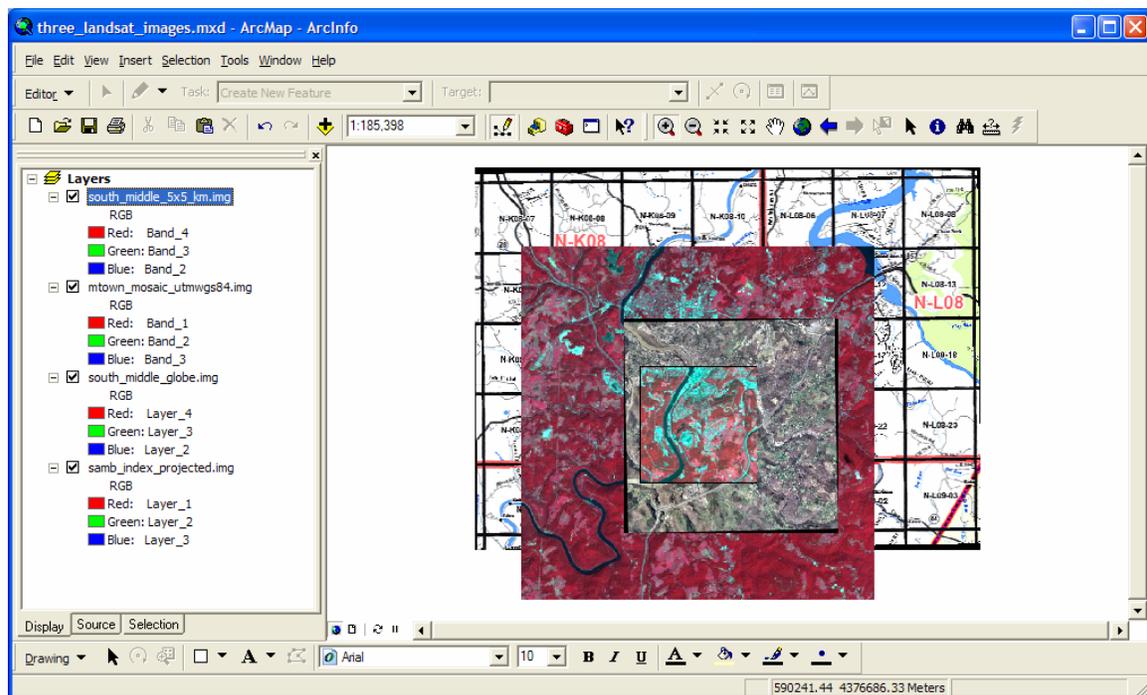

Figure 7. The ArcMap Display window showing all four data sets, ready for MUC class digitizing.

We begin our digitizing exercise by adding the shape file that we created in ArcCatalog. Click the 'Add' button and browse to the shape file directory. Locate LandCover.shp and double-click; it should then show up in the Table of Contents window.

Under the main ArcMap menu there should be a secondary menu showing 'Editor' in the upper left (if not, add it by browsing to View > Toolbars and selecting Editor so that the Editor tem is checked). Notice that, although you've added the shape file, nothing shows up in the Display window – that's because we've essentially opened an empty file; it has the required associated files (the .prj, .dbf, and .shx files), yet has no polygon features and associated geographic reference data. That's what we'll be creating in this exercise.

Now let's begin digitizing our land use cover classes (to review the cover classes, see the MUC Guide). Begin by selecting 'Create New Feature' in the Task drop-down menu (Fig. 8). Ann altenative is t use Auto-Complete-Polygons (we'll try this in a moment).
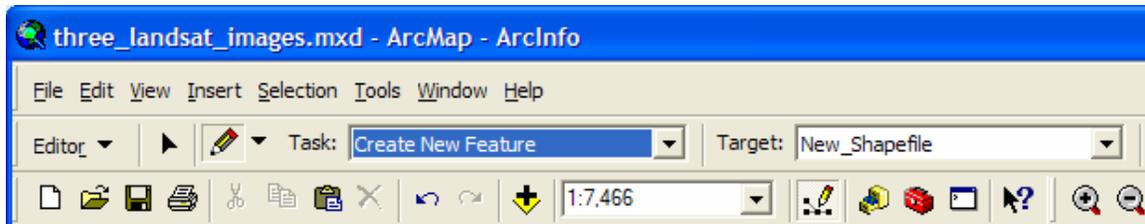

Figure 8. Begin digitizing the MUC classes using the Editor's 'Create New Features' task.

Grab the pencil icon [pencil icon] and note that your pointer becomes a small crosshair symbol. Pick a homogeneous area (for instance, a patch of forest), and create the vertices of your polygon by 'tracing' the boundary and clicking at each vertex. Finish the polygon feature at it's natural ending point / beginning point by either double-clicking or right-clicking and selecting 'Finish Sketch', or hitting t F2 key (you can "undo" the most recent vertex by clicking the Undo button on the toolbar [undo icon]). Now, pick a more complex shape and digitize it… don't create more than a single polygon by crossing your lines (even though ArcMap allows this). Note that these features are 'isolated', and don't share a common boundary.

Another neat editing trick is creating polygons that bound each other. First, create a polygon as described above. Then, under the 'Task' menu, draw down to Auto-Complete Polygon. This will allow you to create a set of vertices using the adjacent feature. Before you can start sketching, select the 'Editor' tool > 'Snapping…', and notice that a window appears between the Table of Contents and Display windows (Fig 9) (Note - If you have more than one Shapefile loaded in the table of Contents window, you'll need to tell the editor what file's polygons you want 'auto-completed' by selecting that file and it's vertex, edge, and end). Also click the 'Edit Sketch' box, below the 'Layer' box, and select all three choices (vertices, edges, and perpendicular).
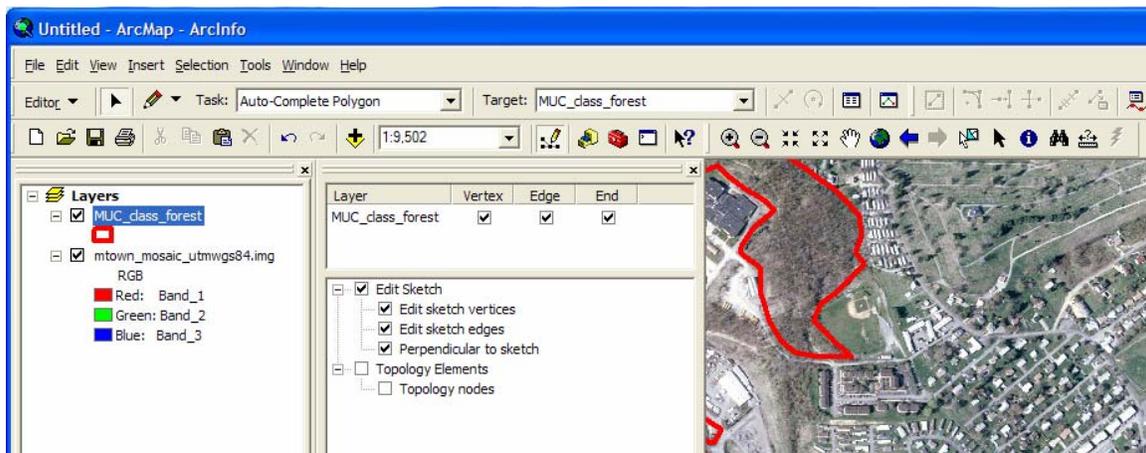
Figure 9 . The Editor > Snapping settings necessary for Auto-Complete Polygon and both edge and vertex snapping.

Try it. Notice that the crosshair pointer wants to 'snap' to the adjacent feature. We can set this 'snapping tolerance' by selecting 'Editor' > Options > general tab, and filling in the box labeled 'Snapping Tolerance'; set it to 10 pixels for the SAMB photos, and fewer for lower resolution data.

Modifying and Deleting Polygon Features

To delete an entire polygon feature, grab the 'Edit' tool, click on the feature (the boundary will become highlighted), right-click and draw down to delete; you can also use the Edit menu and perform the same task on the highlighted feature.

To modify a polygon, simply double click on it and the boundary will change color, and the vertices will become evident. Bring the pointer over a vertex and notice that the pointer changes to a four-pointed star. Now you can move the vertex to a new location.

To add a vertex, select 'Modify Feature' in the 'Task' menu, select the polygon that you'd like to modify, place the mouse pointer over the location where the new vertex is needed, and right-click the mouse and select 'insert vertex'. This is very useful for adding complexity (detail) to simple polygons.

2.2 Attributing the MUC land Cover Classes

A. Calculating the area of each MUC polygon

Once we're done creating our digital land cover map, let's add 'area', the area (in square meters) of each MUC polygon, and the MUC class code. Are there any other attributes that you think are important? If so, we can add those too. To add area, we either need to run an Arctoolbox wizard, or we can d it 'manually' (we'll do both just for practice).

Open Arctool box. Select the 'Spatial Statistics Tools' at the bottom. Open utilities, select 'Calculate Areas'. Enter the existing shape file name, and a new name for the output. This will run a script that automatically calculates the area of each polygon.

Another way is to create our own script to calculate polygon area (actually, copy a script that someone already wrote in Microsoft Visual Basic (VBA) -- Search Desktop Help for Add Field > Data Management).

First, click Editor on the Editor toolbar and click Start Editing. Right-click the shape file layer you want to edit and click 'Open Attribute Table'. Right-click the field heading for area and click 'Calculate Values...' (if there is no field for area values, you can add a new field for area by clicking the Options button and selecting Add Field - however, to add a new field, you need to exit the editing session). Check 'Advanced'. Type the following VBA script in the first text box:

Dim dblArea as double
Dim pArea as IArea
Set pArea = [shape]
dblArea = pArea.area

Type the variable dblArea in the text box *directly under the area field name*. Click OK. That should add all the polygon areas automatically. Make sure you check the area numbers to see if they make sense.

B. Adding MUC Class Codes

Adding MUC Class codes (attributes) to your polygons is simple and can (like many of these exercise elements) be accomplished in a number of ways. Initially, let's try coding our land cover classes "on the fly", as we digitize. First, clear the polygon fill so the underlying imagery is visible under the polygon, and show the polygon boundary in a high contrast color. Now, using the 'Editor' toolbar, draw down to 'Start Editing'. Right-click file, open attribute table, select the polygon of interest, and fill in the appropriate MUC class code. Save edits when you're finished. In this way you can select and code quickly.

Another way to add attribute codes is while you're digitizing the polygon features. Simply open the attribute table as you digitize, thus highlighting the active polygon (Fig. 10), and fill in the MUC code when the polygon is completed.
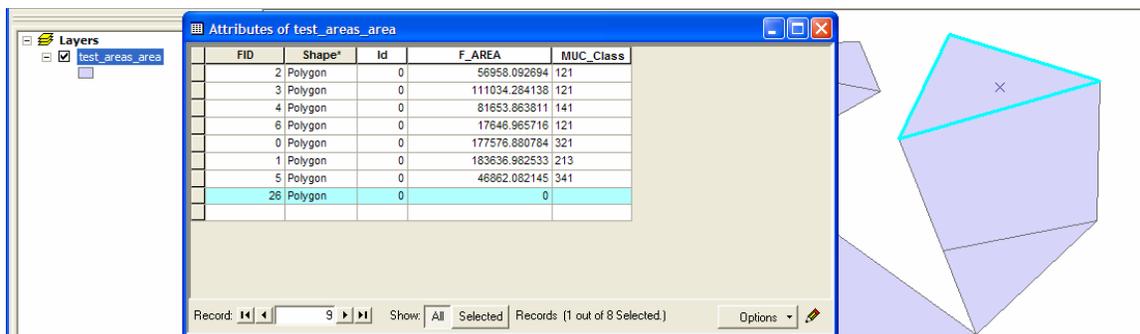

Figure 10. The attribute table showing the active polygon, selected and visible to the right, in the display window.

Apparently this does not work if you're using the Auto-Complete polygon task.

GLOSSARY

Aerial Photograph (also air photo) – typically a nadir-looking photograph taken from either a fixed-wing or rotor aircraft. Aerial photographs are typically orthorectified and georeferenced and thus can be used like a map.

ArcMap – one of several ArcGIS programs, used primarily to organize digital geographic data.

ArcGIS – the current ESRI flagship Geographic Information System (GIS) software that includes a series of integrated programs to manage, create, process, analyze, and report geographic data.

ArcMap – the ArcGIS mapping program, also includes some data creation and analysis features.

ArcView – the suite of GIS programs that includes ArcMap, ArcMap and ArcToolbox.

Bands (also channels) – bands or channels are wavelength locations within the electromagnetic spectrum. Visible light is typically divided into three bands (because the human eye is only sensitive to these three colors). The "blue band" exists between approximately 450 to 550 nanometers (or .45 to .55 microns); the "green band" exists between 550 and 650 nm, and the "red band" exists from 650 to 750 or so.

Coordinate System – a geographic reference system, such as Universal Trans Mercator or Geographic Lat/Longs.

Datum (also geodetic datum) – a geodetic datum is a model of the earth. Datums define both the size and the shape of the earth, as well as orient coordinate systems that are used to map the earth. Referencing geodetic coordinates to the wrong datum can result in significant spatial error. See also **Map Projections** and **Coordinate Systems**.

Ellipsoid – a 3-dimentional surface, such as the earth, defined mathematically (can be a sphere, cigar-shaped, or pill-shaped). Think of it this way… take an ellipse and "spin it" about its major axis, and the resulting 3-D "object" is the ellipsoid (see http://en.wikipedia.org/wiki/Ellipsoid).

Georeferencing – the process of providing a coordinate system to an (orthorectified) image or map.

GLOBE – **G**lobal **L**earning and **O**bservations to **B**enefit the **E**arth. A educational program sponsored by NSF, NASA, NOAA and other organizations designed to teach science and environmental understanding to K-12 students.

GIS – Geographic Information System. Hardware (computers, GPS receivers, etc.), software (e.g. ArcView), and people (you and I) that work together as an integrated system to create, management, and disseminate digital geographic data for decision-making.

GPS – Global Positionaing System. A system of satellites, receives, and software that uses trigonometry to determine locations on the earth's surface.

Ground Reference Data – information on a surface feature or features gathered either on-site, from nearby, or from another trusted source such as a recent, high-quality aerial photo.

Land Cover / Biometry Protocol – The GLOBE protocol designed to teach remote sensing, land use ecology, and elements of biometry (quantitative biology, measuring vegetation).

Landsat – Land remote sensing satellite program dating back to 1972 and currently managed by the USGS. Landsat 5 (launched in 1984) and 7 (in 1999) are still operational. **For a Landsat-specific glossary, see** http://landsat.usgs.gov/glossary.php

Orthorectified – ortho means 'straight, correct, right', Orthorectification is the process of removing distortions in the image due to interactions between the camera, lens, aircraft orientation, and the ground surface. Orthorectification is the process of removing these distortions and making an image or photograph geographically "correct", like a map.

Projection (also map projection) - the process of transforming (*projecting*) features such as points, lines, and areas or polygons, from a *spherical* (3-D) surface to a flat (map, 2-D) surface, with minimal distortion.

Raster (see also Vector) – a two dimensional array of pixels, typically expressed either as columns and rows or as x,y coordinates; any data structure expressed as a grid. A "black and white" digital photograph is an example of a panchromatic or grey-scale raster image. A natural color digital photographic is an example of a 3-band raster image (R,G,B or red, green, and blue).

Remote Sensing – the process of acquiring information on the earth's surface from a distance (usuall aircraft or satellite), processing that information, and analyzing the information for decision-making.

Satellite Image – a remotely sensed (usually digital) image of the earth's surface acquired by a sensor onboard a satellite.

Vector (see also Raster) – a geographic data structure using the point, or node and respective connecting segment, as the basic building block for representing geographic features. Points, lines, and polygons are the three basic types.

WGS 84 (also **WGS84**) - an earth-centered datum used by the Global Positioning System called the World Geodetic System 1984 or WGS 84. WGS84 was adopted as a world standard from a datum called the North American Datum of 1983 or NAD 83. For all practical purposes there is no difference between WGS 84 and NAD 83.

For a more general remote sensing glossary, see the Canada Centre for Remote Sensing web page at:
http://www.ccrs.nrcan.gc.ca/ccrs/learn/terms/glossary/glossary_e.html