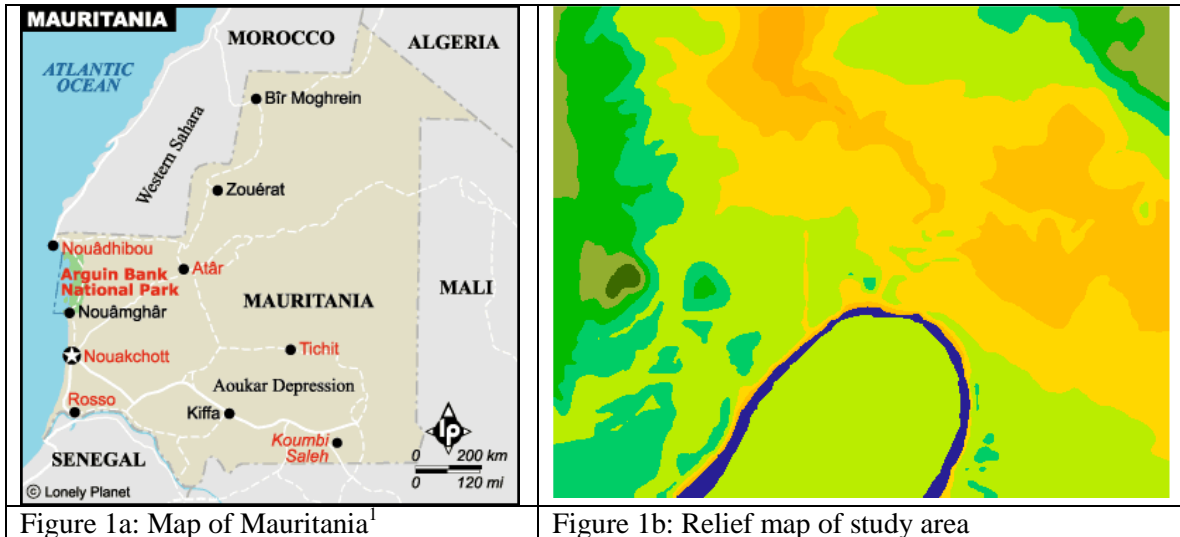


GIS Lab: Sorghum Exercise – ArcMap 10

1.0 INTRODUCTION

The location of the data set is western Africa, more specifically in the south of Mauritania, adjacent to Senegal (see figure 1a). In the study area you will notice a river bend in the southern portion of the relief map (see Figure 1b). The river itself is the Senegal River; the small area contained within the bend is in Senegal; and the rest of the area is in Mauritania.



The analytical aim of this tutorial is to determine the area suitable for growing sorghum, a cereal crop originating in the subtropics of Africa. It is the fifth most important crop cereal in the world and now the southern US states are the greatest producers. Its primary uses are livestock feed and ethnic foods (e.g. porridge, grits & beer ☺). Traditionally it is grown in areas prone to flooding and is planted after the floods recede.

In our exercise two criteria for growing sorghum have to be met:

- clay soils (as they hold water better than other soils), and
- an elevation of 9 metres or less (i.e. subject to annual flooding).

Thus the two data sets provided are of soils (*Dsoils*) and elevation (*Drelief*).

The educational aim of this tutorial is to introduce students to the process of:

- setting up a GIS project in ArcMap (note that it is properly known as an ArcMap document),
- examining the data provided and
- conducting a few basic raster functions (specifically: the use of reclassify, map query and map calculator).

A bullet indicates that action is required on your part, i.e.

- Turn the page and begin the tutorial.

¹ Source: Lonely Planet. <http://www.lonelyplanet.com/mapshells/africa/mauritania/mauritania.htm>

Estimated time to complete this lab: 50 minutes

We interrupt this tutorial for an important news flash:

Hey, some of you have been running into problems in past labs because you have skipped some of the steps. In a word ... Don't. Please ensure you do all the steps marked by bullets. Call if you need help; the cost is \$1 per visit.

And now back to our regularly scheduled tutorial.

2.0 INITIAL PROJECT SET-UP

This section covers the basic housekeeping chores of starting a map document. It is essential that you do these steps correctly.

2.1 Copy Data

- Copy the *Sorghum* folder from the G: drive to your U: drive.

2.2 Creating a Geodatabase and Adding Existing Data

- Start **ArcCatalog**, browse to the *Sorghum* folder on your U: drive
- Right-click on the *Sorghum* folder, select **New**, then **File Geodatabase**

You now have an empty geodatabase. You will now rename it and then import the 2 raster layers.

- Rename the file to **MySorghum**
- Right-Click *MySorghum.gdb*, select **Import**, then **Raster Datasets**
- Add *drelief* and *dsoils* to your geodatabase **** this may take a couple of minutes to process, please be patient ****
- Once the 2 raster files are included in *MySorghum.gdb*, you can delete the original raster files (*drelief* and *dsoils*) that you copied to your U: drive that are not in the geodatabase
- Close ArcCatalog

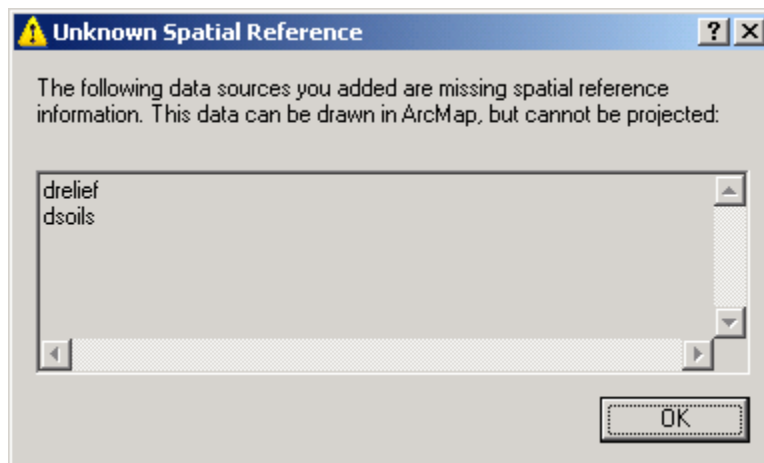
So thus far you have copied the existing folder with the data to your U: drive. Then you created your very own geodatabase and named it MySorghum. At that stage it is simply an empty container where all your data for this project will reside. The next step was to add (import) the 2 raster files (drelief and dsoils) into the geodatabase.

It is important to distinguish between the data set (MySorghum.gdb) and a map document (*.mxd). Remember the map document “points” to the data and remembers how you want it drawn (symbolology). The next step is to create the map document.

2.3 Starting a New Project and Adding Data

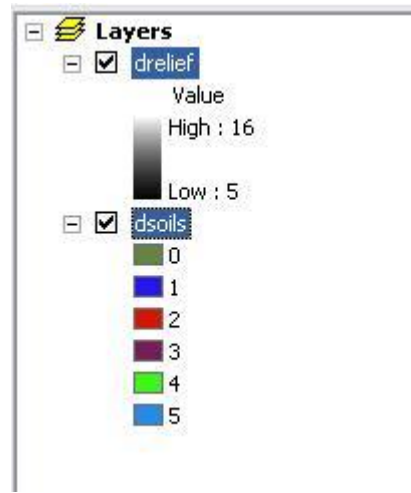
- Start ArcMap
 - Ensure **New Maps** is selected in the left column
 - Ensure the **Blank Map** is selected in the box on the right
 - Click OK
- Click the *Add Data* button, browse to MySorghum.gdb and add the layers drelief and dsoils to your map document

These data lack some spatial reference information and therefore cannot be converted to different projections. An error message appears. But we don’t really care about re-projecting anyhow so we can blissfully ignore this.



- Click OK

The *Table of Contents* section on the left side of the window should look similar to the following (although colours for dsoils may vary – that’s OK for now):



It is OK if the order of dsoils and drelief are reversed. However, you can *click-and-drag* layers to be in the same order if need be.

2.4 Enabling *Spatial Analyst*

As we will be working with raster grids we will need to ‘turn on’ the *Spatial Analyst* module.

- From the *Customize* menu select *Extensions* and select *Spatial Analyst* (ensure the little box has a tic) and then click Close

Even though we have loaded the *Spatial Analyst* extension, its toolbar may not be activated. To activate the *Spatial Analyst* toolbar ...

- From the *Customize* menu select *Toolbars* and select *Spatial Analyst*

The *Spatial Analyst* toolbar will appear. If it is ‘free floating’ you may wish to anchor it.

- drag and drop the toolbar on the gray toolbar section at the top of the screen

2.5 Setting the Working Directory

By default the working directory for a new project in ArcView is set to *\Temp* and all newly created files are stored here. To ensure new files are saved to your drive we will set the working directory to the same directory as our data (e.g. *U:\Sorghum*).

- Under the *File* menu select *Map Document Properties*
- set the default geodatabase to **MySorghum.gdb**
- ensure “Store relative pathnames...” is selected
- Click OK

Reminder about full path vs. relative path:

Full path name “starts” with the drive and the exact path (set of folders) for the data.

Thus, if you copied the *Sorghum* folder to U:/GIS, then ArcGIS would use the path

U:/GIS/*Sorghum*

to find the data. So if you then copied the folder to your C: drive on your laptop, ArcGIS would not be able to “find” your data as your laptop is not connected to the U: drive.

Relative path name “starts” in the same location as the map document. Most often the data is simply stored in this folder (or a sub-folder). Thus, it would not matter if you copied to any other drive (laptop, flash drive, etc.) as ArcGIS would simply look in the same folder as the map document for the data (in this case, the *Sorghum* folder).

2.6 Saving the Map Document

- From the *File* menu select *Save*
 - Navigate to your *Sorghum* directory
 - Type in a project name that includes your first name (i.e. *DougSorghum*)

The map document has now been created and the source data added. That ends the housekeeping chores.

Oh oh, another news bulletin:

These were the steps to follow to create a new geodatabase. They may come in handy when you do the deer winter range lab.

3.0 EXPLORING THE DATA

When first starting out on a map document it is a good idea to explore the data and alter how it is displayed in order to better understand the information in the various layers.

3.1 Examining the Attribute Data and Altering Display of Data

The first task is to quickly examine the attribute data for each map layer.

- At the moment both map layers are selected. Click once in the white area of the *Table of Contents* to clear the selection.
- Drag *dsoils* above *drelief* if it is not on top already
- Right click on *dsoils* and *Open Attribute Table*

OBJECTID *	VALUE	COUNT	SOIL
1	0	65417	No Data
2	1	12581	Heavy Clay
3	2	58365	Clay
4	3	9931	Sandy Clay
5	4	49355	Levee
6	5	11411	Stony

Make a note of the following:

1. The soils map is divided into **discrete** soil types (e.g. clay, sandy clay, etc.). Note the pixel **values** associated with each soil type (e.g. clay = 2).
 2. The *Count* field provides the total number of pixels for each category; the total for clay is 58,365 pixels.
 - Close the *Attributes of dsoils* window.
- Right click on the *drelief* map layer.

You will notice that you cannot access the *Open Attribute Table* option (it should be inoperable and 'grayed out'), indicating there is no table to be accessed.

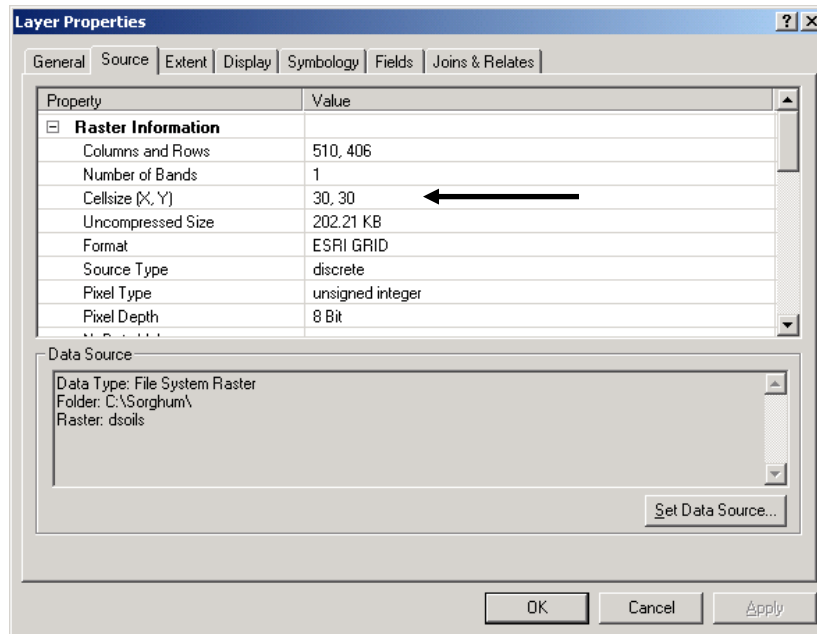
The reason why there is no table to open is that *drelief* is a **continuous variable** that depicts elevation. Since the data set is truly continuous (i.e. continually varies across the landscape) it is conceivable that no two pixels would contain exactly the same number. Thus the data table would need a record (row) for each and every pixel – there is nothing to be gained from looking at such a table.

3.2 Pixel Resolution and Quick Calculation of Area

One of the common metadata items is pixel resolution.

- Right click on *dsoils* and select *Properties* from the drop down menu
 - Click on the *Source* tab at the top

Note the cell size is 30 by 30. The units, although not specified, are metres. Thus a square pixel measuring 30m on edge would occupy 900 square metres.



- Click OK to close the window.

Remember that the clay soil type was composed of 58,365 pixels. An estimate of area would simply be:

$$\text{Area} = 58,365 \text{ pixels} * 900 \text{ m}^2/\text{pixel} = 52,528,500 \text{ m}^2$$

$$\text{Area} = 52,528,500 \text{ m}^2 = 5,253 \text{ ha}$$

- Add a field to the dsoils table called area, type is long integer and figure out a way to calculate area in hectares ☺

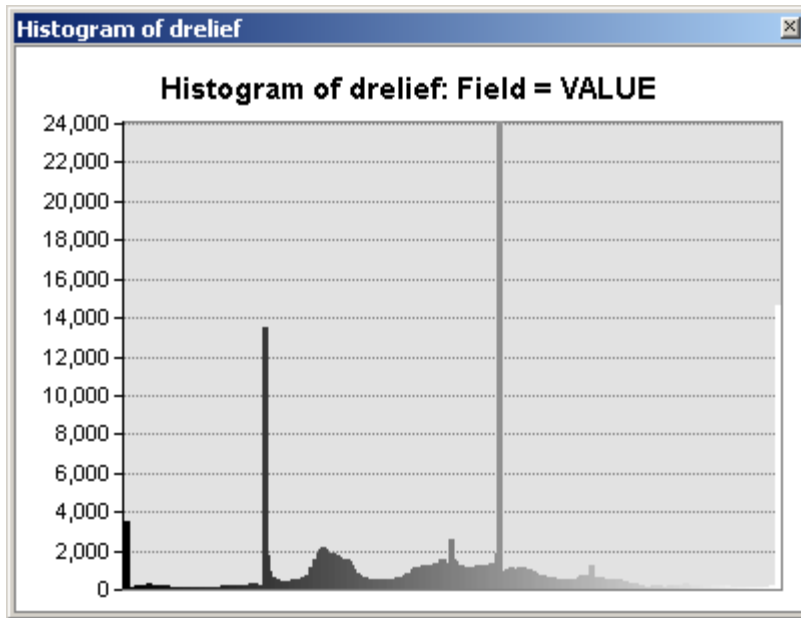
3.3 Viewing a Histogram of Pixel Values

You will recall that we could not open an attribute table for the theme *drelief*. We can, however, look at the frequency distribution of the pixel values.

- In the *Layer* drop down box on the *Spatial Analyst* toolbar select *drelief*.
 - Then click the histogram button

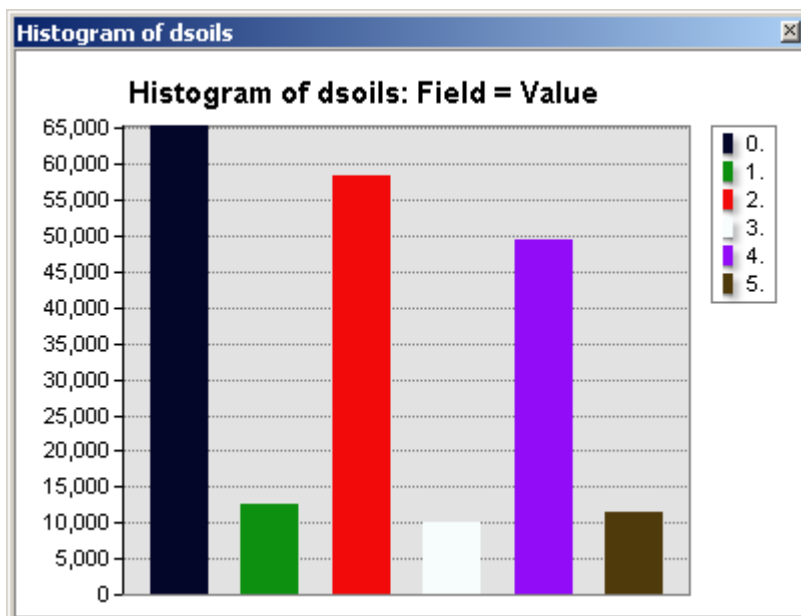


Note the distribution is shaded with the same gray scale colours as used in the legend.



Notice the large grey spike. Note that spikes such as these usually indicate something “unusual” about the data – in this case it is because the area across the river is in another country with no data available – so an arbitrary value of 10m was used.

- Close the histogram
- Change the layer to *dsoils* and look at its histogram. Compared to the histogram for the continuous variable (*drelief*) it is obvious that the data set for *dsoils* is discrete.

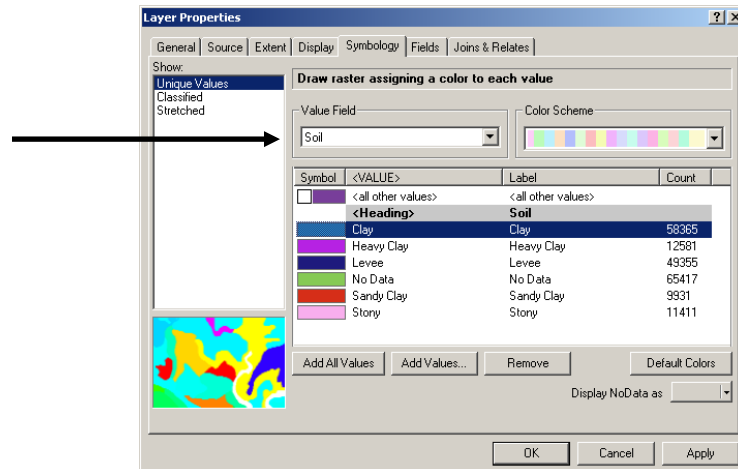


- Close the histogram when you are done

3.4 Altering the Display of the Data

Remember from section 3.1 that the data table had values for soils types (e.g. 2 for clay) and a soil description. It would be more informative if the legend (Table of Contents) displayed the soil descriptions rather than the numbers.

- Right click *dsoils* and then select *Properties*
- On the *Layer Properties* window click *Symbology* tab
 - Select *Soil* from the *Value Field* combo box



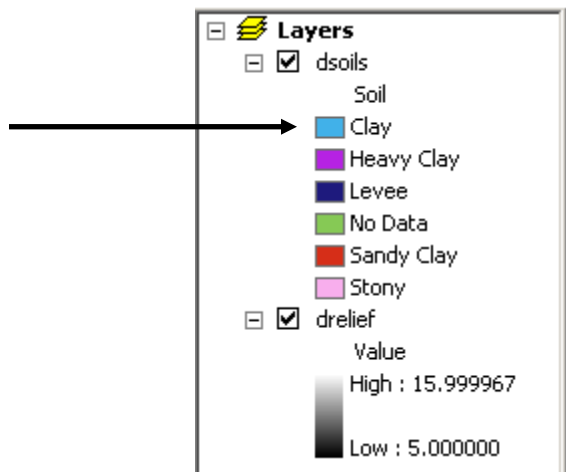
Notice that the Labels have descriptions instead of numbers. Your colours will likely vary from what is shown above – that's OK as we will change them momentarily.

- Click OK

Note the change in the legend.

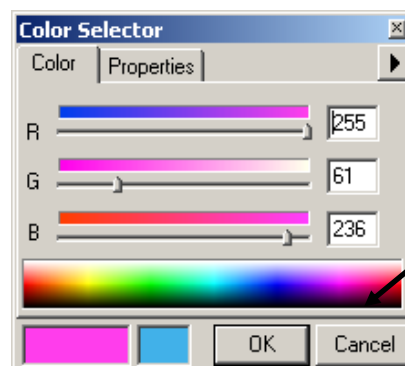
Colours for discrete data sets are chosen at random. Controlling colours can highlight data types of interest – in our case we are interested in clay soils.

- Click on the colour box to the left of 'clay' in the Table of Contents



A *Color Selector* box will appear.

- Click on the **pink** color in the 'rainbow bar'



- Click OK

Using the same procedure set the colours as follows:

Heavy Clay – purple

Levee – brown

No Data – black

Sandy Clay – medium green

Stony – dark green.

Next we will alter the display of *drelief*.

- Click the box next to *dsoils* to turn off its display (i.e. no tic)
- Ensure the box next to *drelief* is turned on (i.e. there is a tic)
- Click on the black & white colour bar under *drelief*



- Select the colour scheme that ranges from left to right: green-yellow-brown-purple-white. It is 15th from the bottom.



- Click OK

Can you identify the highlands and valleys?

4.0 DETERMINING THE COINCIDENT AREA

The analytical task is a simple one: find the area where both of the following conditions occur:

- clay soils, and
- elevation ≤ 9 meters.

This is known as constraint mapping. The following is a brief overview of the steps required.

Phase 1: Create Boolean (Logic) Layers

The first phase is creating *Boolean* (or logic) layers from the raw data layers. A *Boolean* layer contains pixels with values of only 0's and 1's, whereby the 1's indicate areas that meet our criteria and 0's do not. A *Boolean* layer is created for each parameter of interest. In our case we would create two *Boolean* layers:

1. one from *Dsoils*, where 1's would indicate clay and 0's would indicate all other soil types, and
2. a second from *Drelief*, where 1's would indicate an elevation of 9 or less (i.e. the flood area) and 0's for all higher ground

Phase 2: Combine Boolean Layers

The second phase involves combining the *Boolean* layers in such a way that the resultant layer would have 1's only where all the parameters are satisfied. In our

case this means that the soil type is clay and the elevation is less than or equal to 9 meters.

We will now determine the area that is suitable for growing sorghum. We have a few options for conducting this analysis. As **the objective of the exercise is to learn about raster functionality and become familiar with the *Spatial Analyst* interface**, we will conduct the analysis two different ways. Luckily each method will only take a couple minutes.

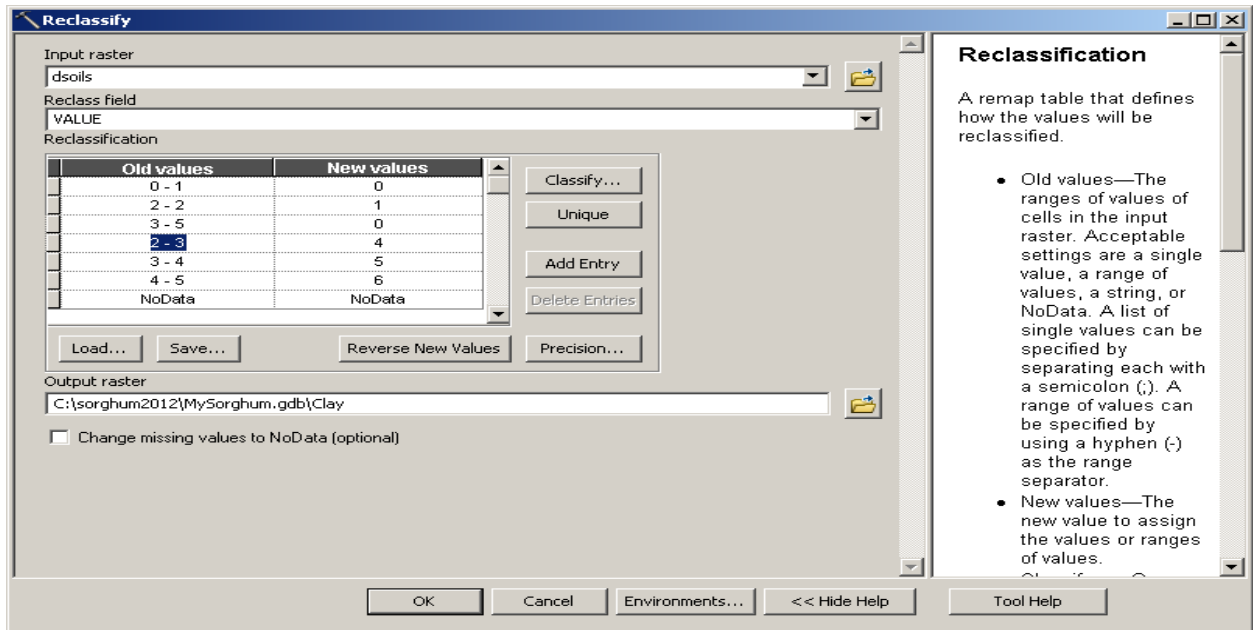
4.1 Creating Intermediate Data Layers

Sometimes it is necessary to create the intermediate layers along the way. In our case that would be creating a “clay map” and a “flood map”. Then these two intermediate map layers are combined to create our final “sorghum map”. To complete this task we will use the *Reclassify* function. When we reclassify in raster we create a new map layer that is a simplified version of the original.

- Ensure **ArcToolbox** is open and click *Spatial Analyst Tools*, then *Reclass*, then double-click *Reclassify*
 - For the *Output Raster* (bottom box) type **Clay**
 - From the *Input Raster* drop-down box select *dsoils*
 - From the *Reclass Field* drop-down box select *Value*
 - For the Output Raster change the filename

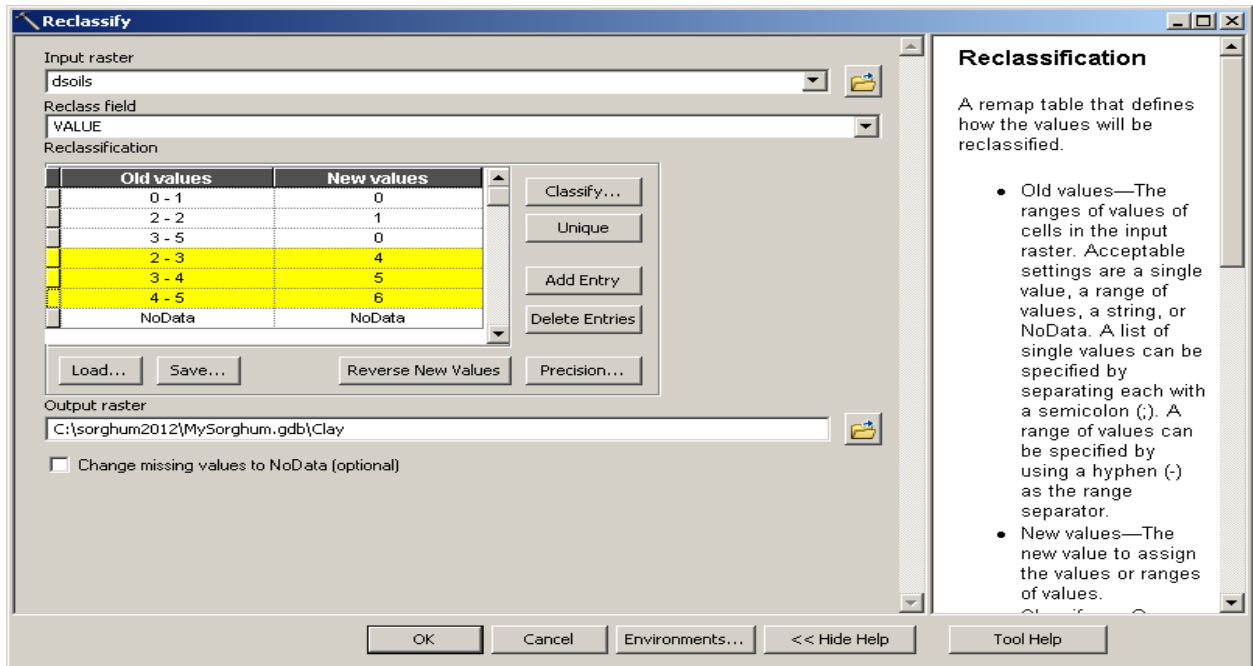
Remember that the pixel value for clay was ‘2’. As we are making a *Boolean* layer for clay we want to create a new layer where the pixel locations that had 2’s will now have 1’s and all else will have 0’s.

- In the first row type **0 - 1** under *Old Values* and **0** under *New Values* (pixels with a value of 0 or 1 in the *dsoils* layer will have a value of 0 in the new layer). **** Be sure to enter as “0 - 1” and not “0-1” (i.e. spaces are important)**
- In the second row enter 2 - 2 and 1
- In the third row enter 3 - 5 and **0**



We have now reclassified our data so that on the new layer clay will be indicated with 1's and all else will be 0's. But we have some excess rows that need to be deleted.

- Click the small grey box to the left of the row with “2 – 3”. The row should be highlighted in yellow. Then drag down until the 3 rows with numeric values are highlighted yellow. Use the *Delete Entries* button to delete these rows.



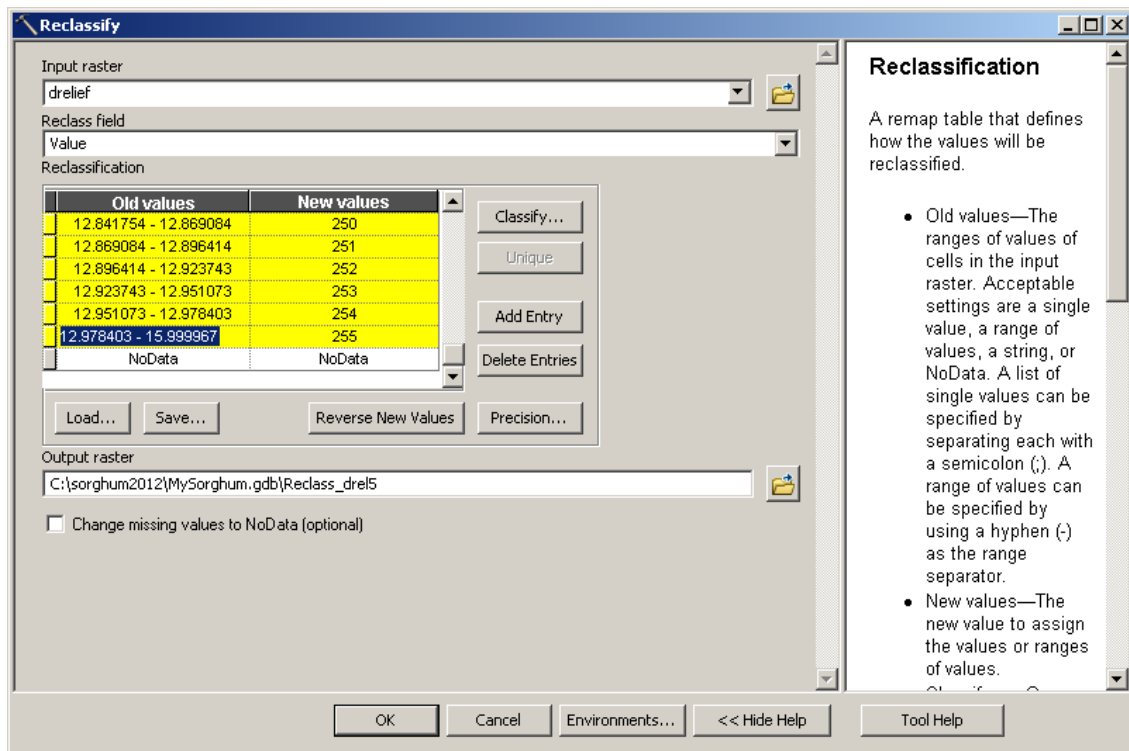
- Click OK. **** Note that it may take a couple of minutes to process – wait until a new map layer appears.**

A new layer is added to the project, where 1's indicate clay and 0's indicate all else. Compare the new data layer to the Soils map – does it make sense? Next reclassify elevations to create a “flood map”.

- Double-click on the *Reclassify* tool again.
 - For the *Output Raster* (bottom box) type **Flood**
 - From the *Input Raster* drop-down box select *drelief*. Note that *Value* is automatically selected for the *Reclass Field*.

Remember that the pixel values less than or equal to 9 are subject to annual flooding and are suitable for sorghum. Notice that the list for “Old values / New values” is very long. We will need to delete many rows from the table.

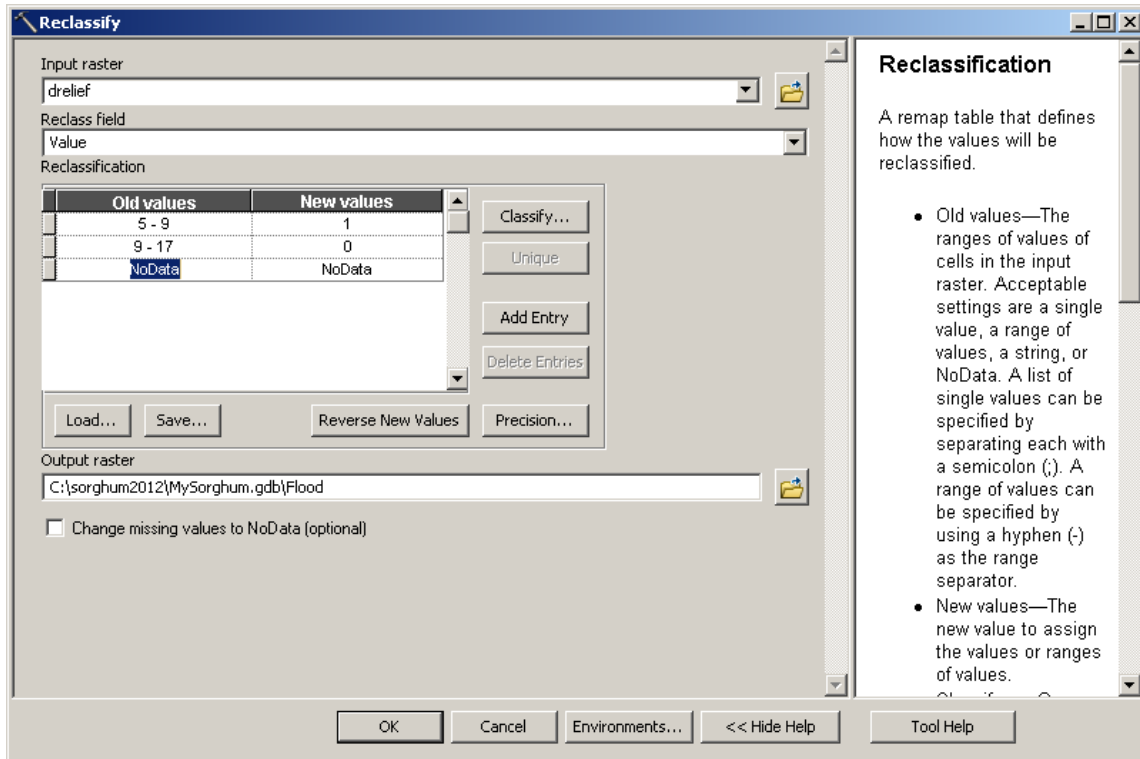
- Click the small grey box to the left of the third row – it should be highlighted in yellow. Then drag down until the rest of the rows are highlighted in yellow except for the NoData row. It should not be coloured yellow.



- Click the *Delete Entries* button

There are now only two rows in the “Old values / New values” list.

- In the first row, under *Old Values*, type **5 - 9** (remember the spaces are important, it's 0 - 9, not 0-9) and, under *New Values*, type **1**
- In the second row enter **9 - 17** and **0**



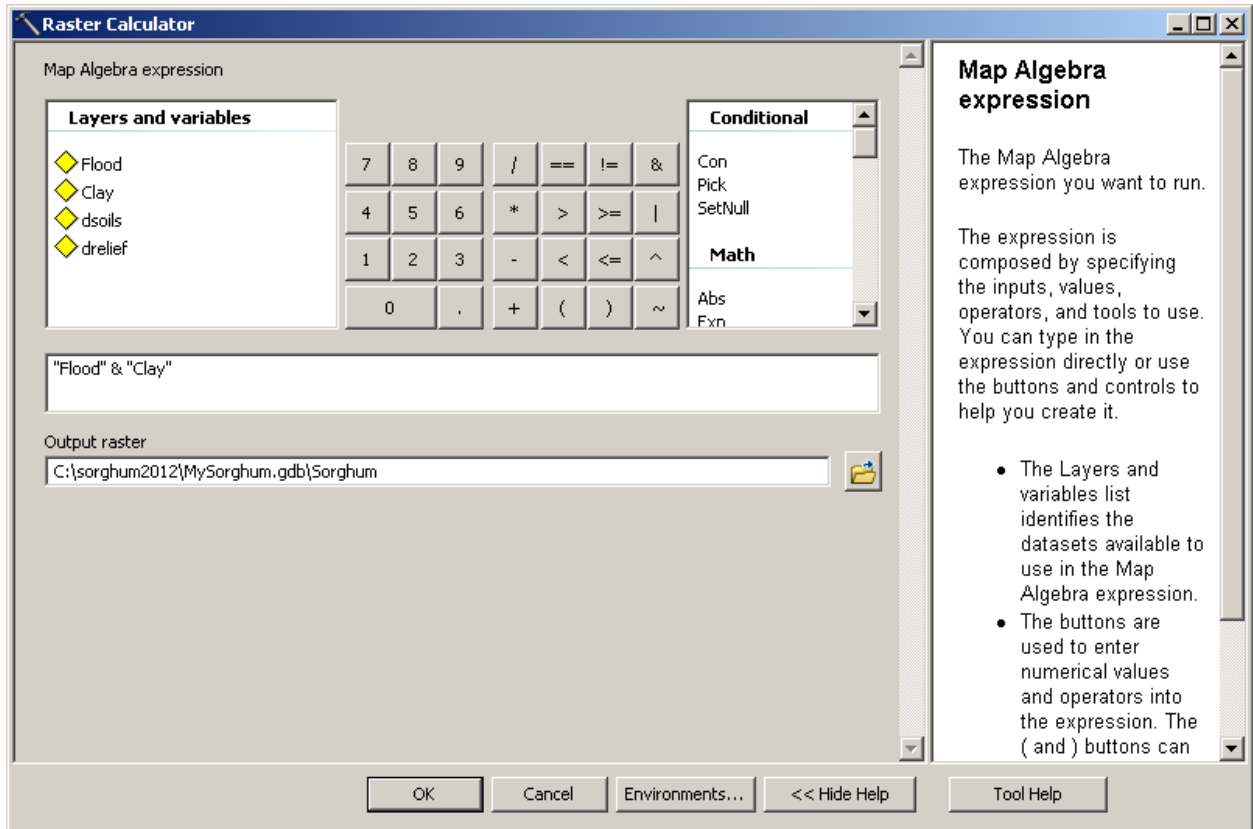
Two points to note:

- There is no problem repeating the '9' for the minimum value in row 2 as all of the exact values of '9' will have been allocated to the value of '1' (as per row 1), and now any value ever so slightly higher than '9' will receive a value of '0' – this way we ensure there are no missed values (i.e. if we entered 9.1 - 17 and there was a pixel with a value of 9.001 it would be missed in the reclass and remain as 9.001 in the new raster layer).
 - We enter '17' as the maximum value just to be sure to capture all the data (note the legend had '16' as the highest value, thus we need to enter any value higher than this – I often use 9999 for the upper value).
- Click OK **** again, wait for the processing to finish**

A new layer is added to the project, where 1's indicate flood area and 0's indicate higher ground).

Now we need to combine these two *Boolean* layers to delineate areas where both criteria are met (i.e. where the 1's overlap).

- In the *Spatial Analyst* toolbox click on *Map Algebra* and double-click *Raster Calculator*
 - Change the Output Raster name from “rastercalc” to “Sorghum”
 - From the *Layers and variables* list double click *Flood*
 - Click the “&” button
 - Double click *Clay*



It is understood that

Flood & Clay is equivalent to saying

On the new map put 1's only where **Flood = 1 and Clay = 1**

What this means is that the new map layer will have 1's where the soils were clay and flooded.

- Click OK

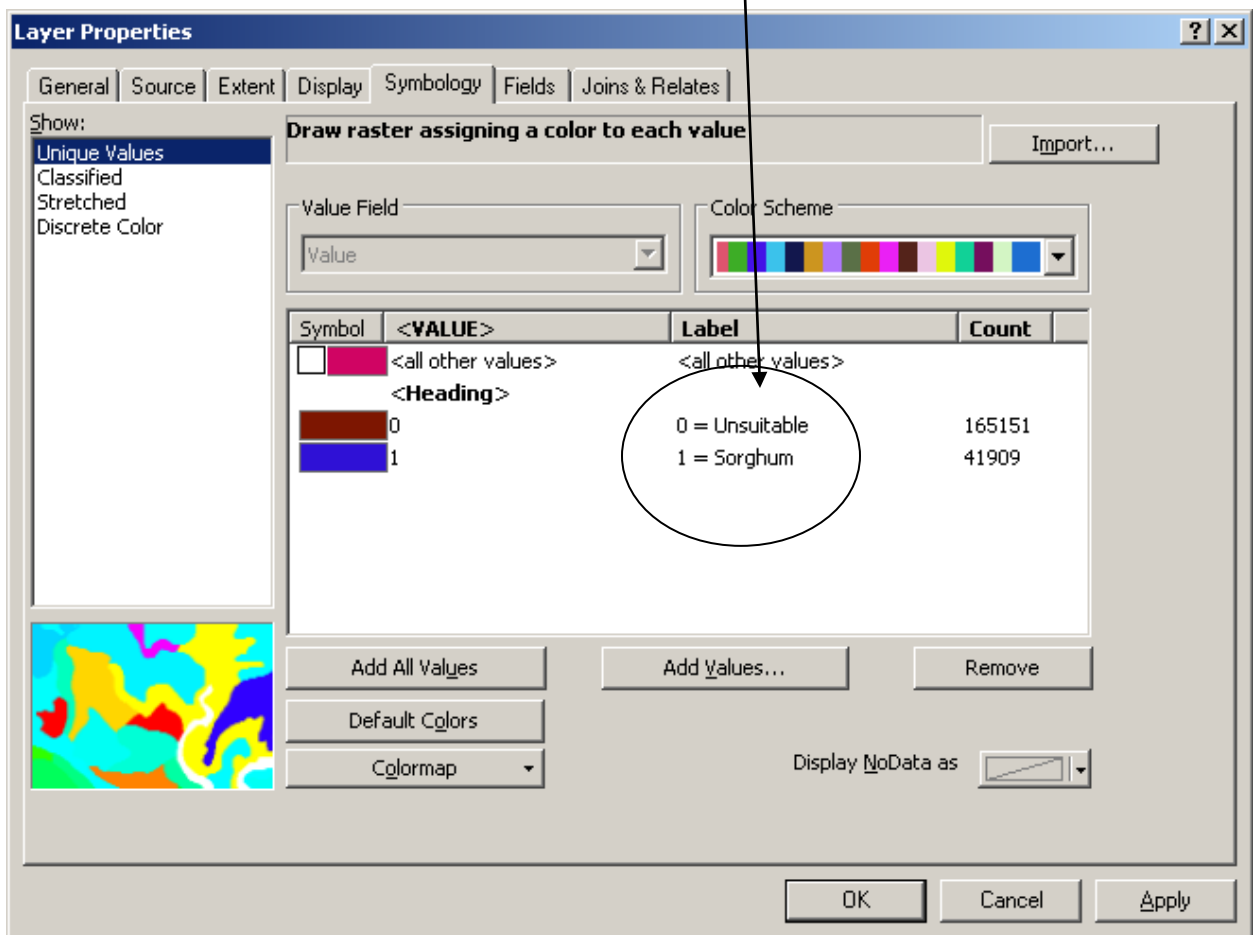
A new raster layer is added to the project, entitled *Sorghum*. On this layer the 1's represent areas suitable for growing sorghum, where clay soils and elevations ≤ 9 metres coincide.

As we only had two criteria, the process requires only 3 steps: the creation of two *Boolean* layers and the overlay of these two layers. This process exposed us to two functions:

- **Reclass**: which is used to **simplify** a raster data set; can be into *Boolean* with only 1's and 0's, or it could also be used to put continuous data, such as elevation, into classes (e.g. 0-100m, 100-200m, 300-400m, etc.)
- **Raster Calculator**: which was used to **combine** layers.

To further aid in understanding the results let's add to the legend

- o Double-click Sorghum and click on the *Symbology* tab
 - In the Labels type **0 = Unsuitable** and **1 = Sorghum**



- Click OK

Do the same to the other two layers

- legend entries for *Flood* should be “**Unsuitable**” and “**Flood Area**”
 - legend entries for *Clay* should be “**Unsuitable**” and “**Clay Soils**”
- Examine the 3 layers (*Clay*, *Flood*, and *Sorghum*) and see if the results make sense.

4.2 One Step

We can by-pass the creation of the two initial *Boolean* layers and simply use the *Raster Calculator* to conduct this analysis in one step. This is useful if we are familiar with what the functions do and have no need for the intermediate map layers. We will utilize only the two original raster layers. Also, remember that on *dsoils* clay has a value of 2.

- From the Spatial Analyst toolbox double-click on the *Raster Calculator*

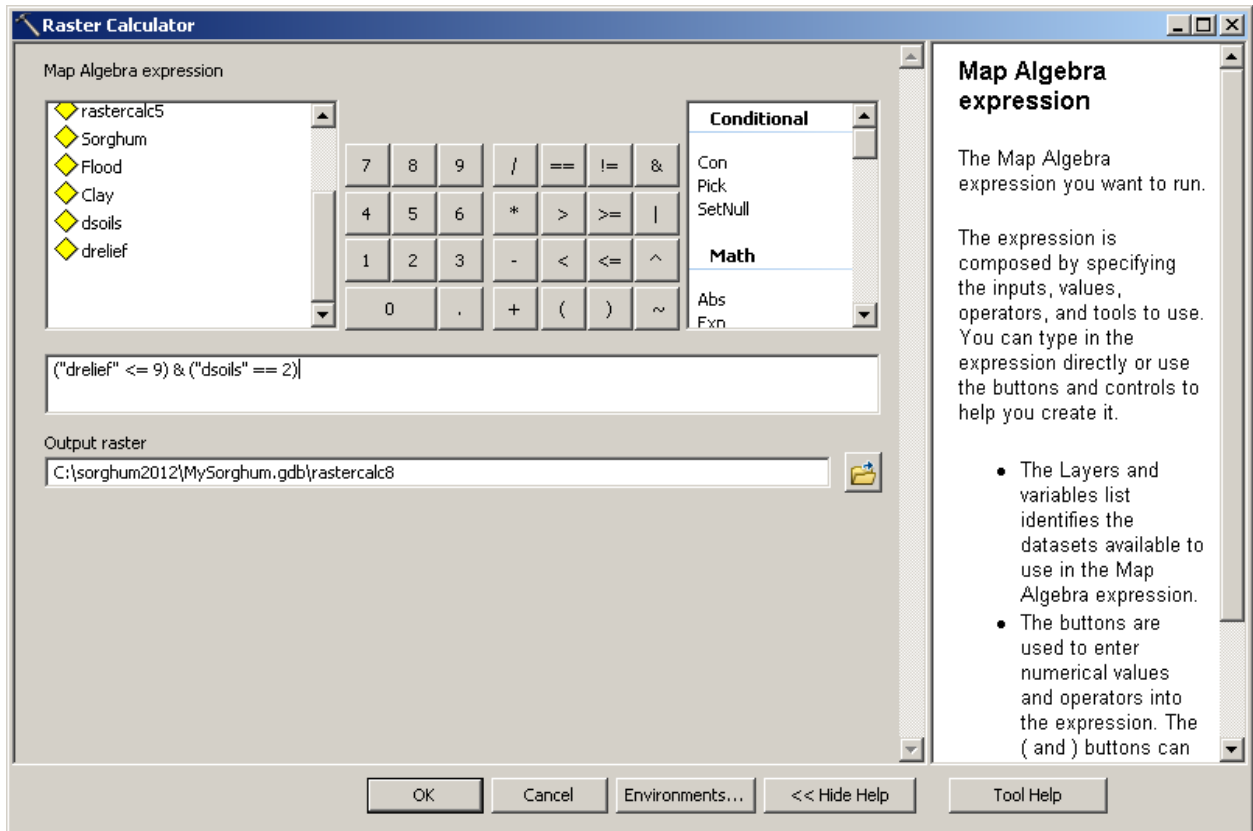
Note, you will be entering the following formula

`("drelief" <= 9) & ("dsoils" == 2)`

into the calculator. The individual keystroke instructions are given below:

- Click “(“
- Double-click *drelief*
- Click the `<=` button
- Click 9
- Click “)”
- Click the “&” button
- Click “(“
- Double-click *dsoils*
- Click the “==” button
- Click 2
- Click “)”

Refer to the image below to ensure the formula has been entered correctly.



- In the Output Raster change the filename from *rastercalc* to *Sorghum2*
- Click OK
- As before, edit the legend entries (e.g. 0 = Unsuitable, 1 = Sorghum)

You will notice the results are the same. So once we understand the process the intermediate steps can be by-passed and this operation can be conducted in only one step.

Now, you are ready to perform the assignment portion of this lab. Good luck!