

Forest Management Using DEMs: Managing Forest Fire Hazards using the Model Builder Facility in ArcView

Scenario

In some areas of the world forest fires are a regular occurrence and often perceived by humans as damaging to the forest. There are 3 categories of forest fires: ground, surface and crown.

In many ecosystems regular ground and surface fires are actually essential for the survival of many species.

A ground/surface fire can:

- Release nutrients back into the soil
- Initiate germination
- Remove pathogens
- Create gaps and stimulate diversity

A crown fire is the most destructive fire usually killing the tree and is much harder to control [\[See reference 1\]](#).

A forest manager has the challenge of managing the forest in a way that is in harmony with the natural ecosystem but minimising the risk of intense crown fires and danger to the local human population.

In this exercise you are a forest manager using a DEM and vegetation dataset to predict the potential fire hazards of a region in the USA. You will be using a generalised standard created by the National Fire Protection Association (NFPA). This simple standard predicts fire hazards based on a relationship between slope and forest fuels.

After we have developed our simple fire hazard model, we will then use a facility within ArcView called Model Builder to

Data used in exercise

This exercise is supplied with several datasets and you will use these to create a new fire hazard layer. The supplied data are:

- DEM (30m resolution with altitude in metres), held in ESRI floating point format
- Vegetation: this shape file contains several attributes that describe the vegetation according to two systems, known as the Holland and FBO classifications. The **hollandtex** file indicates the vegetation in each

polygon, **holland95** is a standard code for vegetation type and **FBOModel** is another standard code for vegetation type, according to a different classification system.

- Roads, rivers and historical fires (vector shape files)

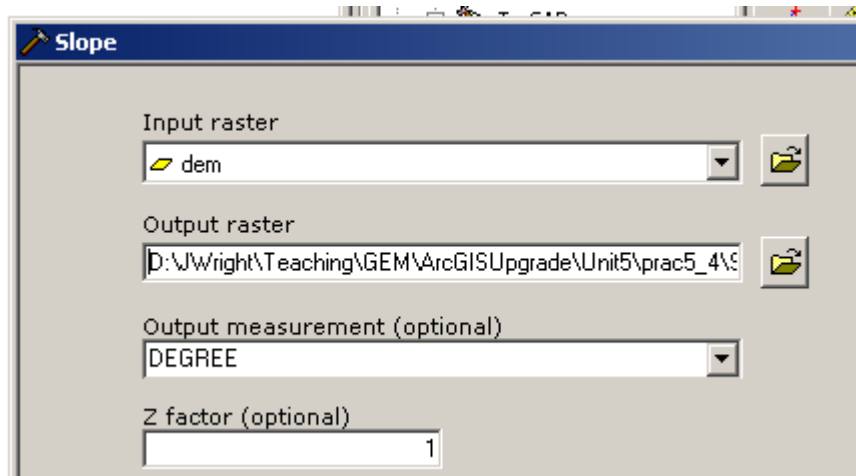
Setup

This exercise comes with zipped data. It is suggested that you unzip the data to a single location such as **C:\eLearning\Unit5\FireRisk**. The output you create can go into this directory.

Exercise

1 Calculating slope and reclassifying it into a risk layer

- Import the raster map layer **DEM** using *conversion tools / to raster / float to raster* in the ArcToolBox, calling your new raster grid **DEM**.
- Calculate slopes (in degrees) from this elevation model by choosing *spatial analyst tools / surface / slope* from within the ArcToolBox

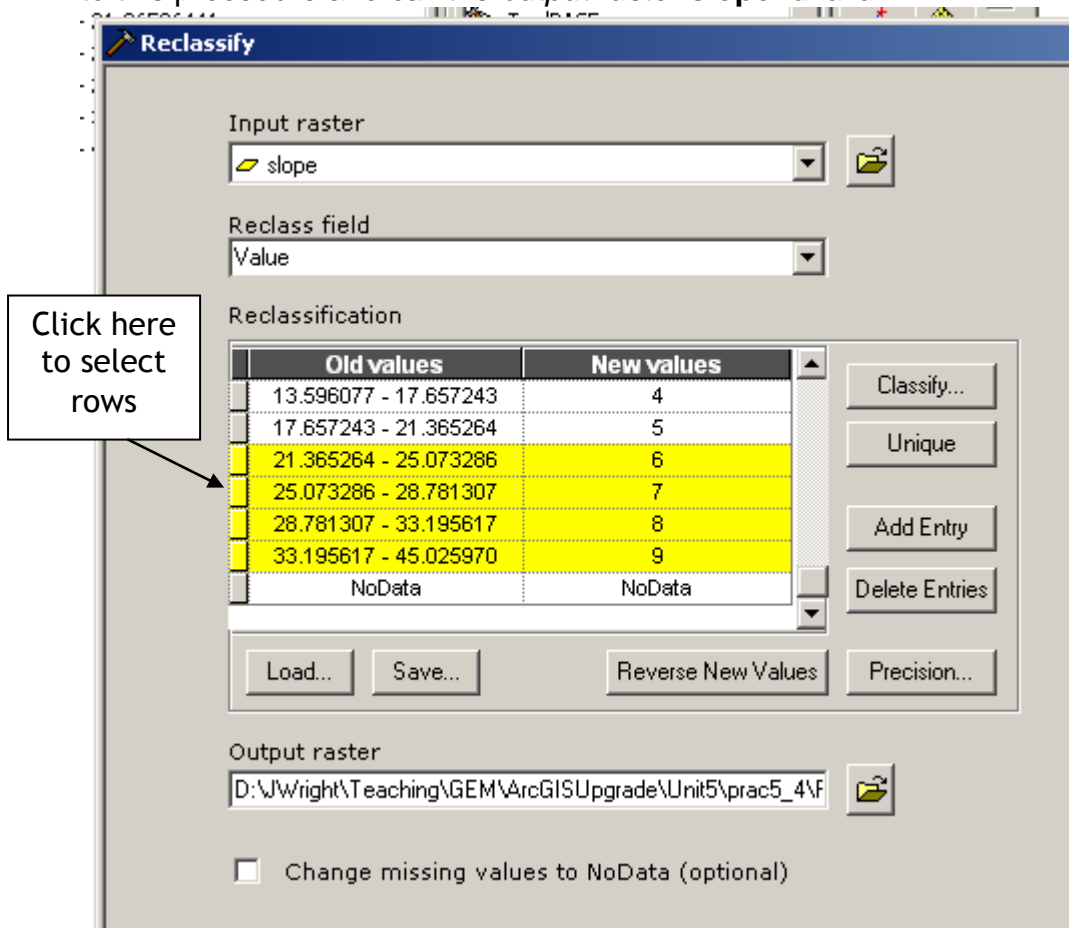


You can now reclassify the slope into the NFPA risk point scale. You are simply creating a new dataset where you say what was the old value is now a new value. Using this method you can group many values into a single value. The old ranges of slopes (measured in degrees) and the associated fire risk scores are shown in the table below. According to this table, slopes that are less than 10 degrees will have a fire risk score of 1, slopes of 10-20 degrees a fire risk score of 4, and so on.

New value	From	To
1	0	10

4	10	20
7	20	30
8	30	40
10	40	999

To reclassify slopes, go to the ArcToolBox and select *reclassify* from *spatial analyst tools / reclass*. Choose your new **slopes** map layer as the *input raster* to this procedure and call the *output raster* **slopehazard**.



From the table above, you will see that you need to reclassify five different ranges of slopes (the table above contains five rows). You may therefore need to delete some entries from the *reclassification* box by clicking at the left edge of the reclassification box and then pressing *delete entries*.

When you have five entries left (excluding the 'nodata....nodata' entry), you can start typing over the entries that remain and replacing them with the information in the table on the previous page (see illustration below). Before you do this, you may wish to click on the *precision* button and reduce the number of decimal places that are displayed for the *old values*.

Reclassify

Input raster
slope

Reclass field
Value

Reclassification

Old values	New values
0 - 10	1
10 - 20	4
20 - 30	7
30 - 40	8
40 - 999	10
NoData	NoData

Buttons: Classify..., Unique, Add Entry, Delete Entries, Load..., Save..., Reverse New Values, Precision...

Output raster
D:\Wright\Teaching\GEM\ArcGISUpgrade\Unit5\prac5_4\F

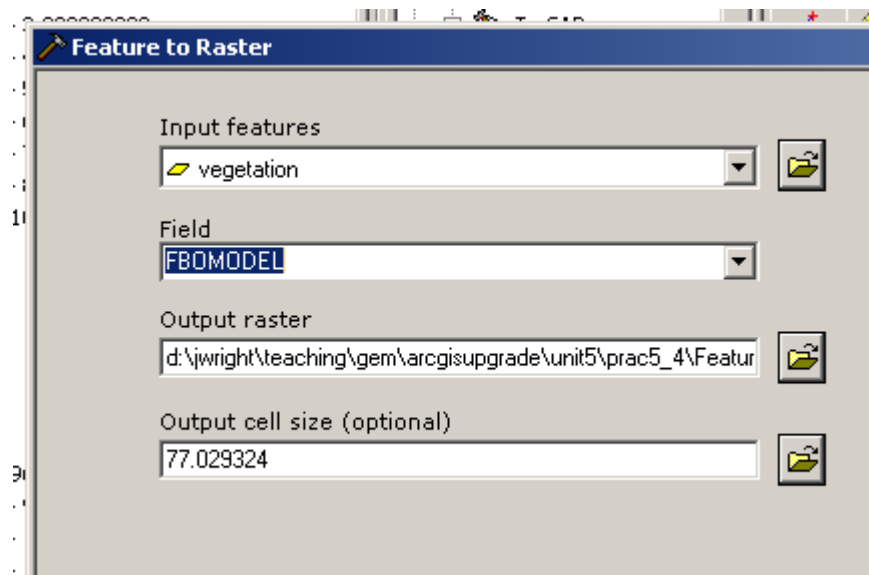
☐ Change missing values to NoData (optional)

If you now run *reclassify*, you should find that your fire hazard scores for slope are displayed.

2 Converting the vegetation data to raster format

For vegetation, we have available the NFPA fire point hazard scores for the FBO vegetation classification. To use these, we will first need to convert our vegetation shape file to raster format. To do this:

- Go to the ArcToolBox and choose *conversion tools*, then *to raster* and then *feature to raster*.
- Choose **vegetation** as your *input features* and then select **fbomodel** (the field with the FBO vegetation classification codes) as the attribute from this map layer that will be rasterised – see below). Call the *output raster* **veg_FBO**.



3 Reclassify raster FBO types into a NFPA hazard point scale.

A dataset you need to create is a reclassification of the **Veg_FBO** dataset you just created (the raster dataset you built from rasterizing the polygon dataset and recoded with FBO values you exported from the database) into the NFPA hazard point scale.

The table below shows NFPA fire hazard point scores (under *new value*) for the different FBO vegetation types (in the *from...to* columns). For example, vegetation with FBO code 4 has a fire hazard score of 20. Based on this table, reclassify the **veg_fbo** and create a new raster output called **veghazard**.

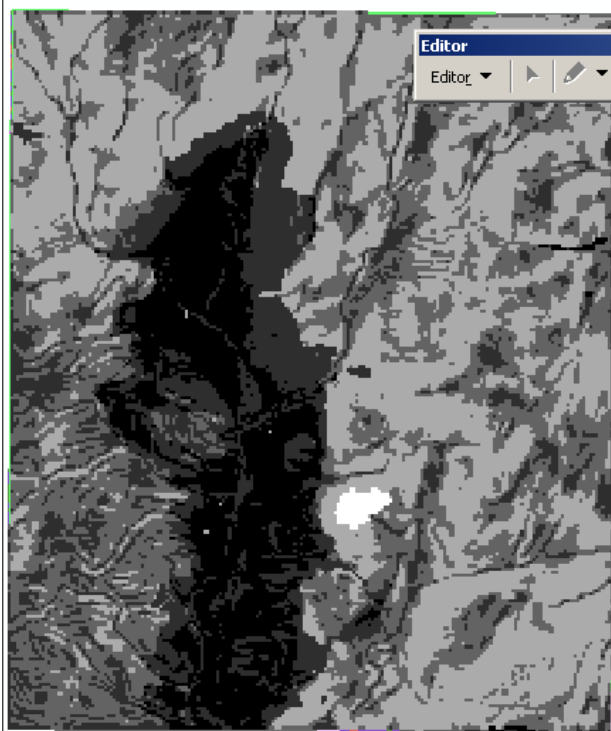
New value	From	To
0	0	0
5	1	3
20	4	4

10	5	9
20	10	10
25	11	13

4 Creating a composite slope/fuel model

You will now create a composite slope / fuel layer. The NFPA Standard is a numeric scale for assessing fire risk and severity. It makes use of slope and vegetation type. Slope was a point scale of 1 to 10 whilst fuel type is a scale from 5 to 25. By summing the two grids you will create a single grid which you can use to identify areas where fire risk is greatest:

- Go to the ArcToolBox and go to the *spatial analyst tools* and then choose *math*. From within *math*, choose *plus* and then use this tool to add **veghazard** and **slopehazard** together, to create a new raster output called **firehazard**.
- After you have run *plus*, you may wish to change the way your output raster is displayed. If you right-click on the **firehazard** map layer and choose *properties* and then select the *symbolology* tab, you may wish to display this map layer using the *classified* option rather than as *unique values*. Your output raster should look something like the illustration below, in which dark areas represent low hazard and light areas represent high hazard (though note that this depends on how you display it...):



5 Adding context to your fire risk layer

Add the **rivers**, **roads**, and **historic_fires** map layers to your map display, if you have not done so already.

Questions:

Q1 Examine your fire risk map, identify the obvious area at risk just south east of the centre of the map. What vegetation is it and why does it have such a high risk?

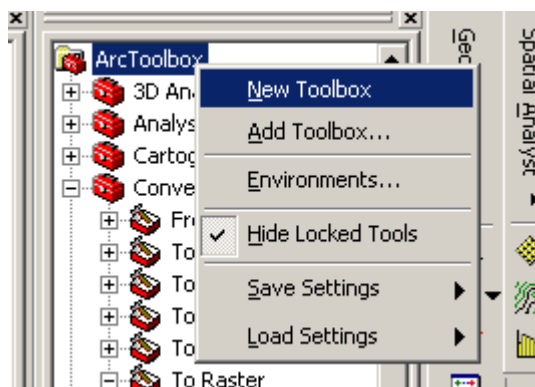
Q2 If this area did start as a forest fire then the fire fighting team would need access to the area. What is the approximate distance from the nearest road ($\pm 50\text{m}$) to this fire risk area? The resolution of your grid data is 30m.

Q3 Historically, have fires occurred in the areas you would have expected?

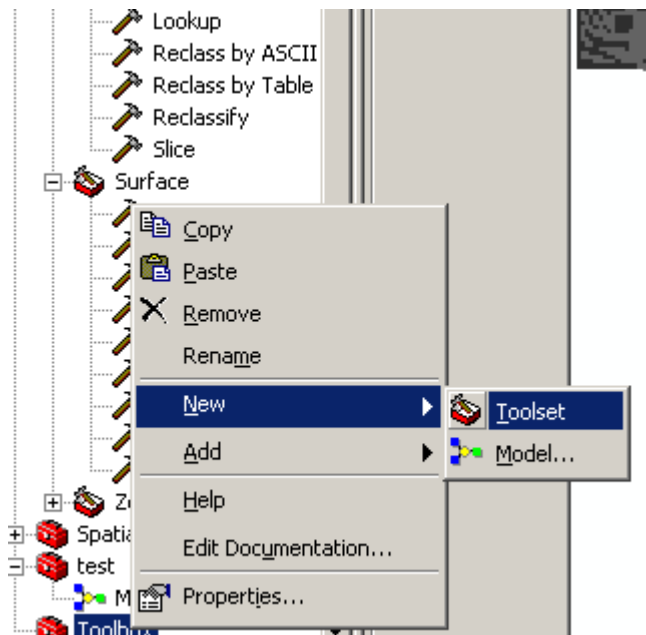
6 Creating a tool that predicts fire hazard – introducing Model Builder

It is possible for us to ‘bundle’ together the logic that we used to create our fire hazard model and create a graphical representation of our fire hazard calculation. We can do this as follows:

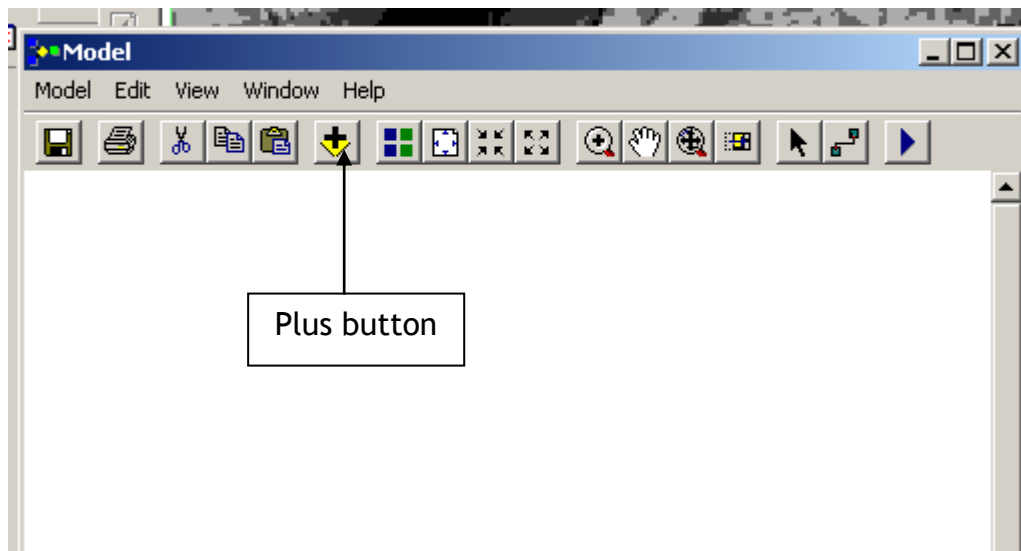
- right-click on the ArcToolBox and choose *new tool* from the menu that pops up.



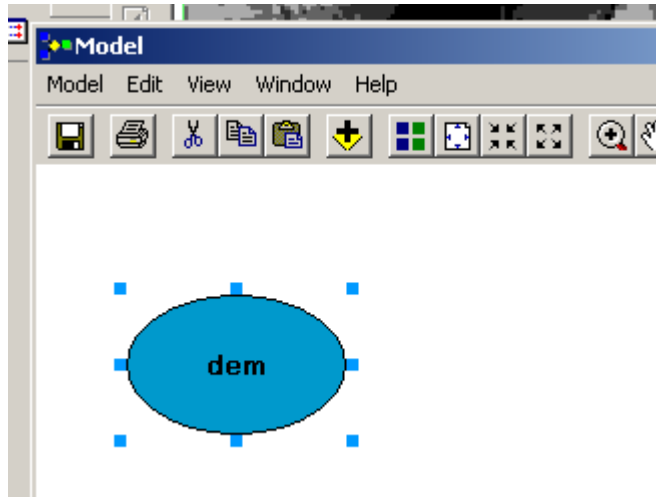
- You should now find that you have a new tool (called simply ‘toolbox’) if you scroll down to the bottom of the ArcToolBox window. You can click once on the name of this tool and rename it to something more sensible, such as ‘firehazard’.



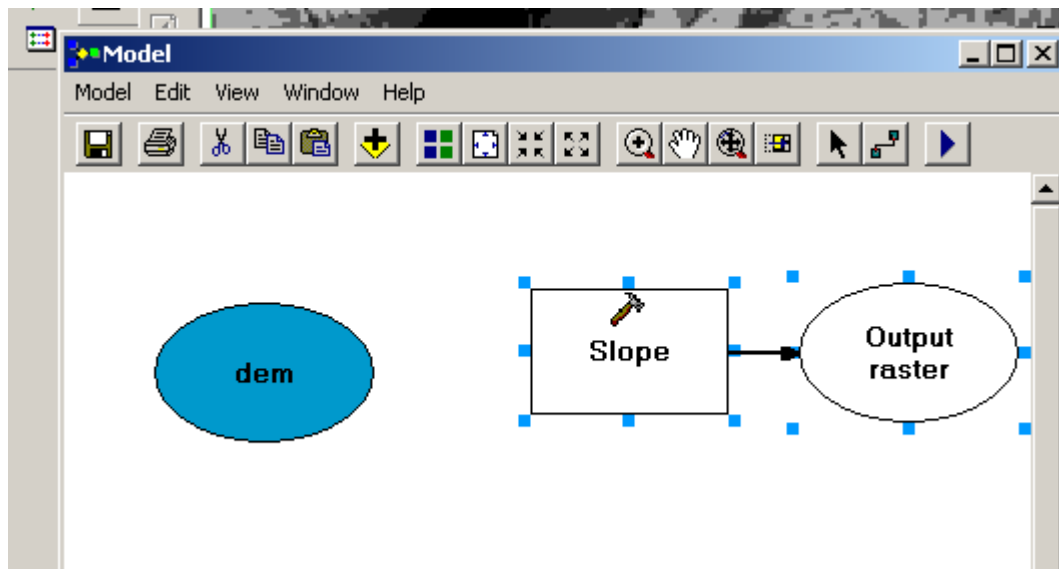
- Right-click on your new 'firehazard' tool and another pop-up menu will appear.
- Click on the *new* option and then select *model...*
- This will open up the ArcView Model Builder – a graphical tool for designing analytical operations. Model Builder in effect has an 'empty canvas', onto which we can add the names of map layers or ArcView tools



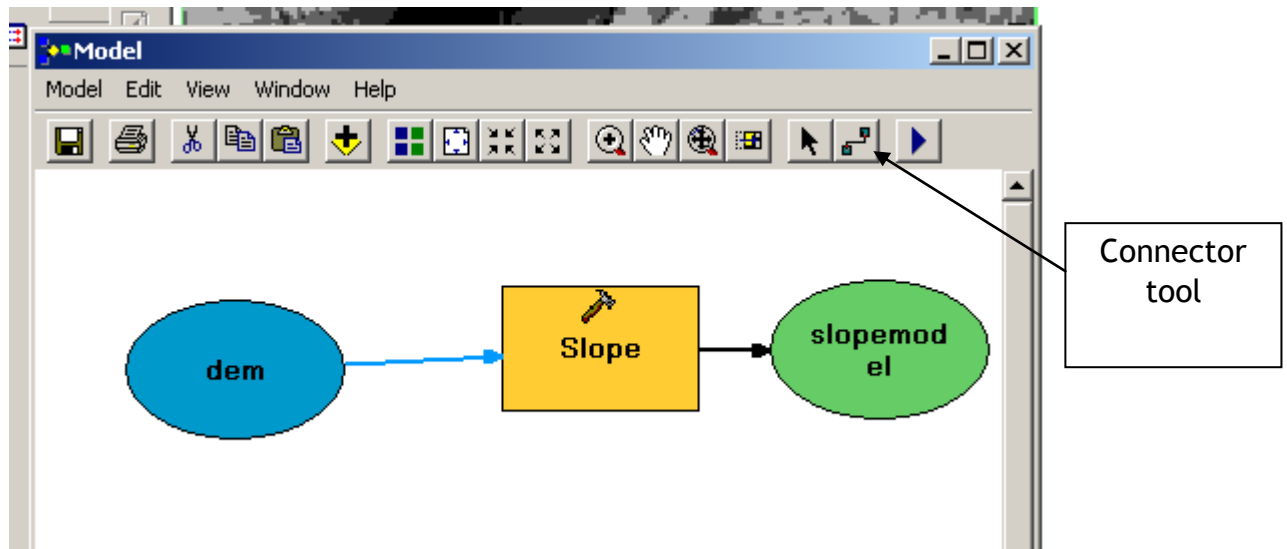
- To start with, we will add in the **dem** map layer. To do this, click on the 'plus' button within the Model Builder window and choose your **dem** map layer
- A graphical representation of this map layer should now appear in your Model Builder window:



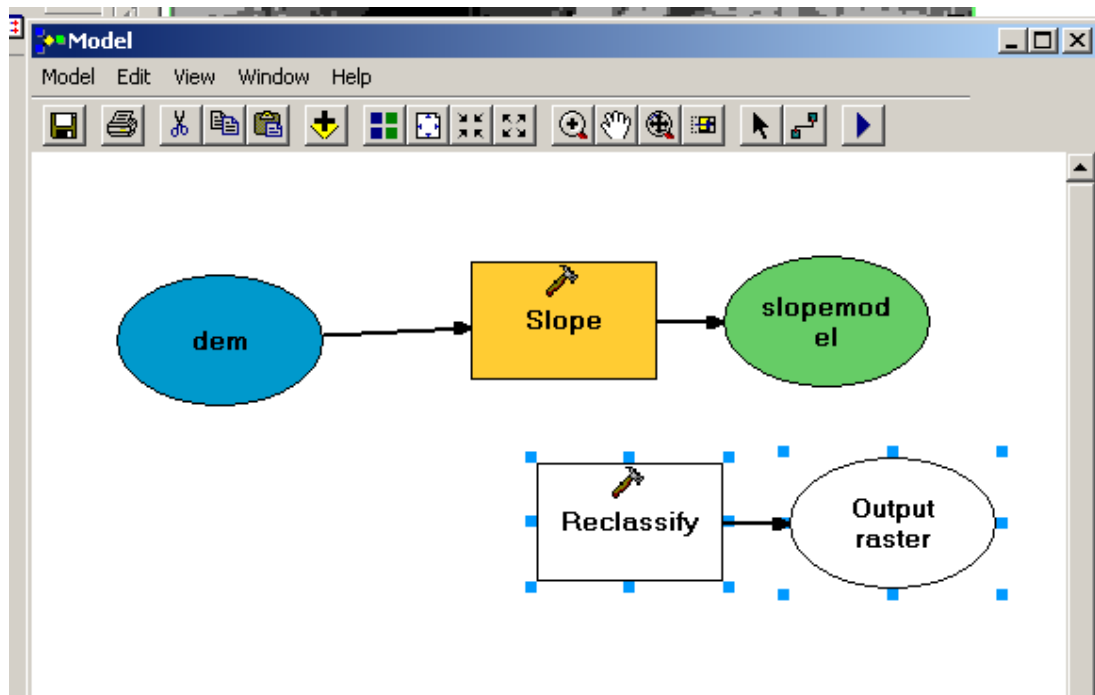
- Next, make sure that you can see the *slope* tool in the ArcToolBox. Click on this tool and (holding down the left-mouse button) drag and drop this tool into the Model Builder window.



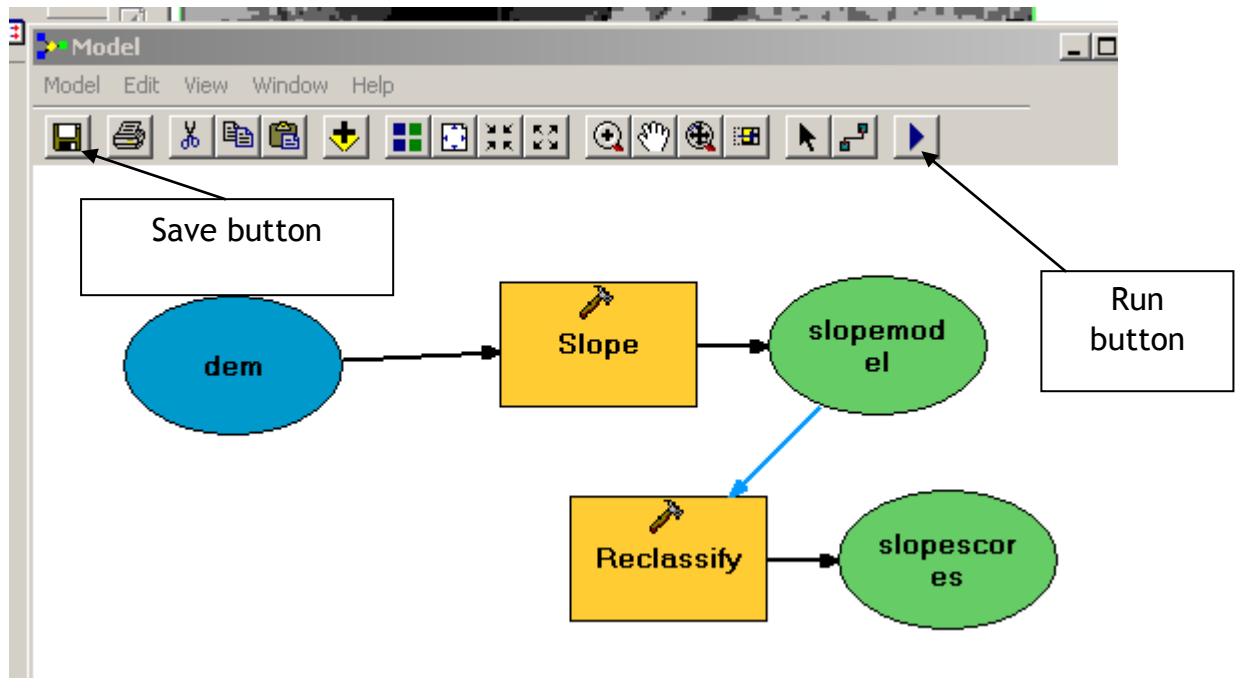
- The slope tool should now be displayed graphically in our Model Builder window, together with an *output raster*. If you double-click on the *output raster*, you can give your output raster an appropriate name by entering this in the *output raster* box, such as **slopedmodel**.
- Click on the connector tool (see below), then hold down your mouse button within the **dem** oval, then move your mouse across and over the **slope** box, and release the mouse button again. You should now see that the **dem** oval is now connected to the **slope** box and these change colour.



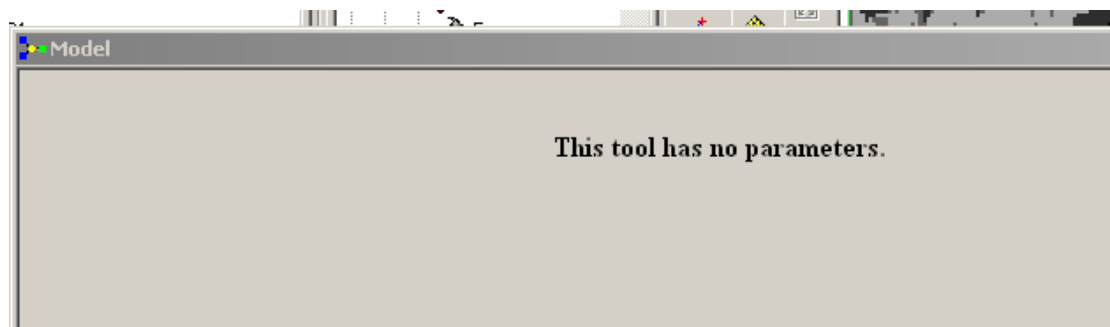
- You can now double-click on the slope box and have a look at the options for running the command. You should see that the input has been set to **dem** and the output set to **slopemodel**. If you needed to, you could change other options for running slope at this point (we do not need to here).
- Now drag and drop the *reclassify* tool into the Model Builder box.



- Again, much the same thing happens. You can double-click on the *output raster* and change this to a more sensible name, e.g. **slopescores**. You can also use the connector tool to link up **slopemodel** with the reclassify tool.



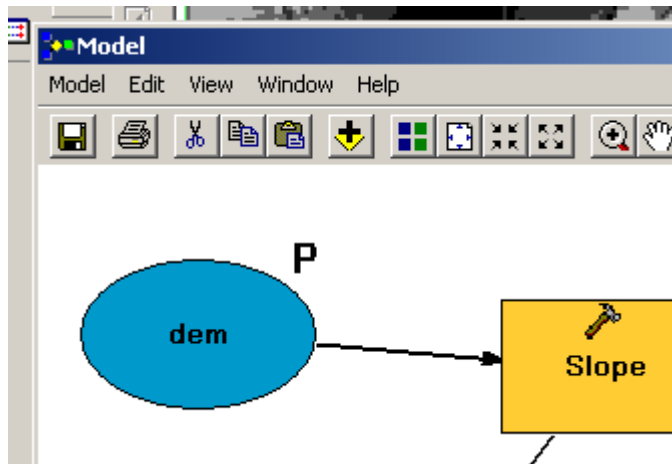
- Double-click on the *reclassify* tool, and you can enter in the ranges for reclassifying slopes, in much the same way as we did earlier. We could continue adding in more of the steps that we followed earlier, but for simplicity, for now we will stop with these two steps.
- Now try pressing the run button (see above). Your model should execute and work through the logic of the diagram.
- Note that you can see the results of the model execution by right-clicking on **slopescore** and choosing *add to display*.
- Note also that you can export your model as a diagram by going to the *model* menu and choosing *export* and then *to graphic...*
- If you now save your model using the save button (see above), you can close down the Model Builder window.
- If you now save your work as a Map Document (via *save* on the *file* menu), your new model will be saved along with your map display and can be reopened subsequently.
- If you wish to run your model again, you can do so by double-clicking on it in the ArcToolBox. You should see an empty box with the statement 'this tool has no parameters' and an *ok* button. Click on *ok* and your model will run again.



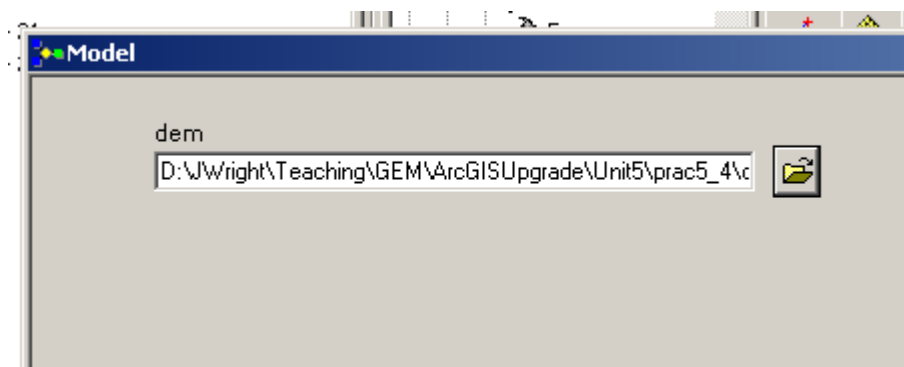
What are parameters and how do they work?

To answer this question, we need to re-open our model once again. To do this:

- right-click on your new model and choose *edit*.. This should open up the Model Builder window once again.
- Right-click on the **dem** oval in your model and check the option that says *model parameter*. You should now see a P appearing next to the **dem** oval, meaning that this is now a parameter.



- To understand what this means, save your model once again and close down the Model Builder window.
- Run your model again by double-clicking on it.
- This time, because **dem** has been specified as a parameter, when you run the model you will be prompted for a raster grid to use as the **dem**. In other words, the model's user specifies input map layers that are defined as parameters, rather than the person building the model in the first place. Re-enter the name of your dem, and run the model one more time.



From this fairly simple demonstration, it is clear that the Model Builder is a potentially very useful facility for developing environmental models. We have used it here to develop a simple forest management tool, but you can imagine that it has potential uses in many sectors of environmental management.

References:

- [1] United States Department of Agriculture - Rocky Mountain Research Station (2001), Assessing Crown Fire Potential by Linking Models of Surface and Crown Fire behaviour, http://www.fs.fed.us/rm/pubs/rmrs_rp29.html
- [2] Mike Price (2003), Modelling the wild land/urban interface, ArcUser (April – June), 46 – 50.