

GEO 465/565

Lab 6:

Modeling Landslide Susceptibility

This lab will give you more practice in understanding and building a GIS analysis model. Recall from class lecture that a GIS analysis model is a sequence of geoprocessing steps or functions used as part of a GIS analysis. These steps can also be represented in ArcGIS with ModelBuilder, also mentioned in class. You will work with ModelBuilder at the end of the lab.


The study area for this lab is in San Bernardino County, California, a region prone to mudflows and landslides due to several factors. It is also an area that has been affected by wildfires – the most recent of which occurred in October 2003. We would like to see if we can determine what parts of the study area are more susceptible to slides. The lab uses real-world data and methods to look at some possible analysis models to determine landside susceptibility using slope, aspect, vegetation, and other possible factors. In this project you use a digital elevation model (DEM) to derive slope and aspect datasets. These datasets will be combined with other data to find areas with high slide susceptibility. The values and GIS analysis models for determining landslide susceptibility are for educational use only and should not be used to determine slide hazards or areas safe from landslides, as there are many other factors that are not considered in this exercise.



Step 1: To become more familiar with the file structure and the data used in this project we will begin by opening ArcCatalog and looking at the datasets and data structure for the project.

- a. Copy the folder **EdUC_Landslides** from the data folder to your student data folder. [For Distance Ed students](#), you'll need to download the **lab6_data.zip** file (306 Mb!!) from Blackboard, and when unzipped, should reveal the folder **lab6_data**.
- b. Open ArcCatalog

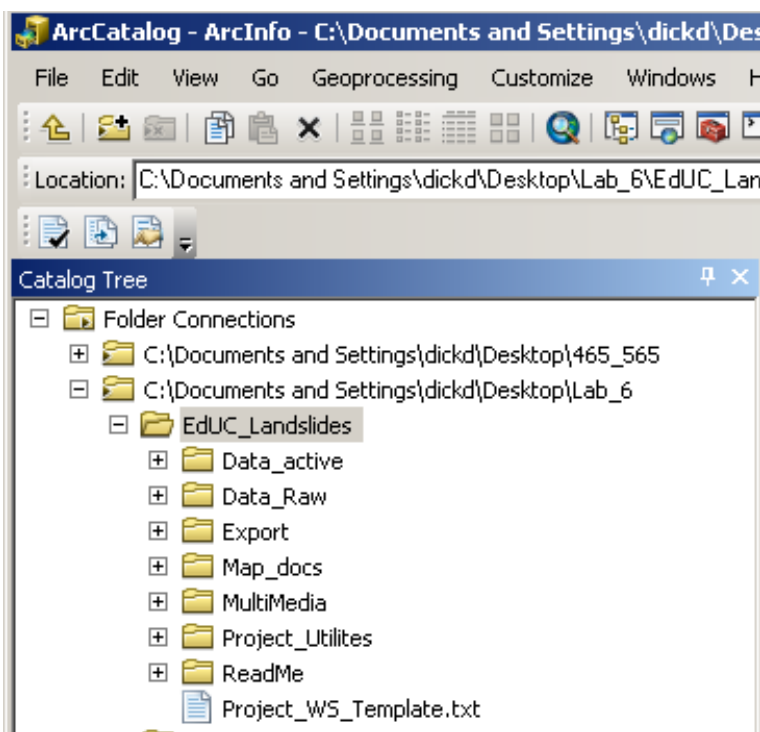
- c. Make a direct connect to the **EdUC_Landslides** folder (or for Distance Ed students, the

lab6_data folder) by clicking on the Connect to Folder  button and browsing to your student folder.

Then click on the name of the folder **EdUC_Landslides** (or **lab6_data**). Click OK.

Step 2: Look at the data structures within **EdUC_Landslides** (or **lab6_data**). NOTE: when opening grid datasets you may be prompted to create pyramids – click “yes” if this prompt is displayed.

- a. Click on the + by **EdUC_Landslides** (or **lab6_data**) to expand the folder – note the names of the subfolders.




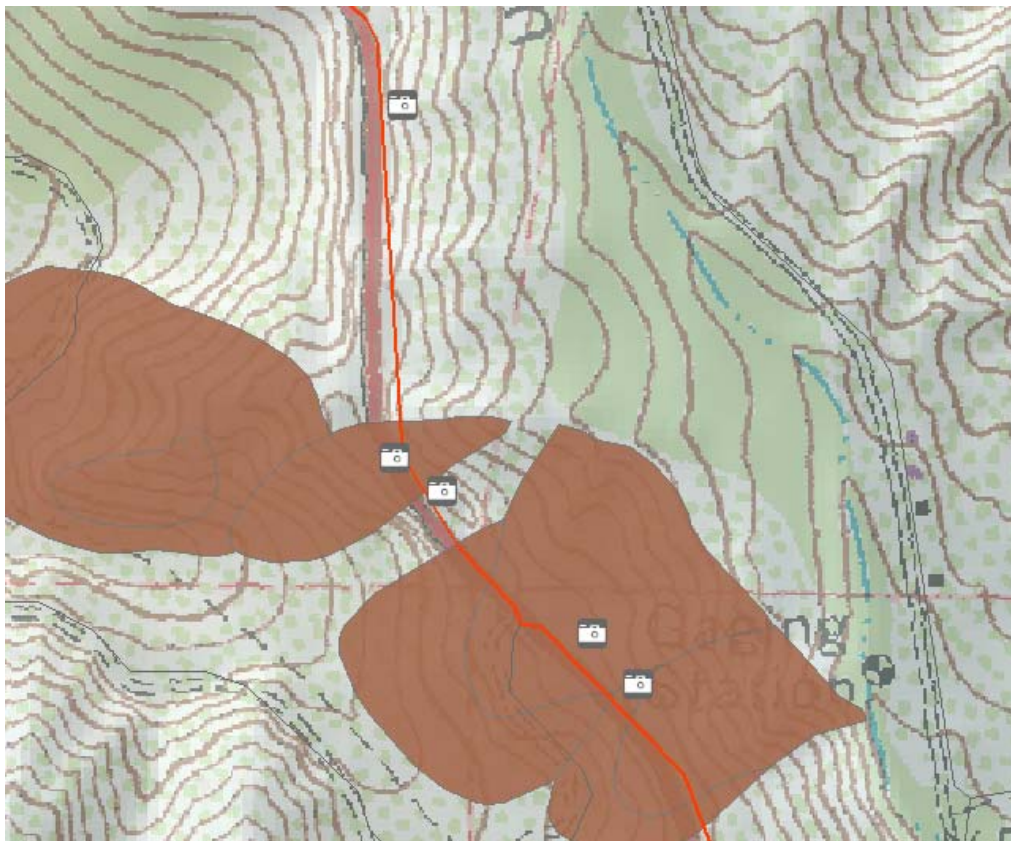
- b. Expand the subfolders (click on + by a subfolder) and look at the names of the files under each subfolder. Click on the minus “-“ by each folder if you want to close them.
- c. Let’s look at some of the data. Expand the “**Grids**” subfolder in the **Data_Active** folder and click on the “**geol**” layer in the Table of Contents. Click on the “Preview Tab” and select “Geography” in the Preview window. Switch the Preview to “Table” by clicking on the down arrow and clicking on the Table.



Question 1: What is the geology of the first entry in the “Summary 1” column? (3 pts)

- d. Now expand the “**Layers**” subfolder. Click on the “**burn_severity.lyr**”. Note in the Table that there are three attribute classes in the VEGBURNSEV field (Low, Moderate, and High). Change to Geography for the Preview window.
- e. Now click on the + by the geodatabase file named **SB_landslides_UTM_NAD27.mdb**. Pick one of the datasets and click on its name. Look at the Table and Geography for that dataset. Note: the geodatabase includes raster and vector feature datasets.
- f. Expand other Folders in the Table of Contents and see what type of icons you see. Note the different color for shapefiles, layers (cartographic), and geodatabases.
- g. Expand the Export folder and click on **Landslide.png** – note that this image is a “Layout” of some of the data from this project. Click “yes” to create pyramids.
- h. Collapse all of the folders by clicking on the “-” by expanded folders.


Step 3: Now that you have seen what data is available we are ready to open ArcMap and begin determining what areas are most susceptible to Landslides. We have taken a short field trip and acquired some digital photos of rock types and hyperlinked them to the project. And we will look at a remotely sensed image taken during the 2003 fires.

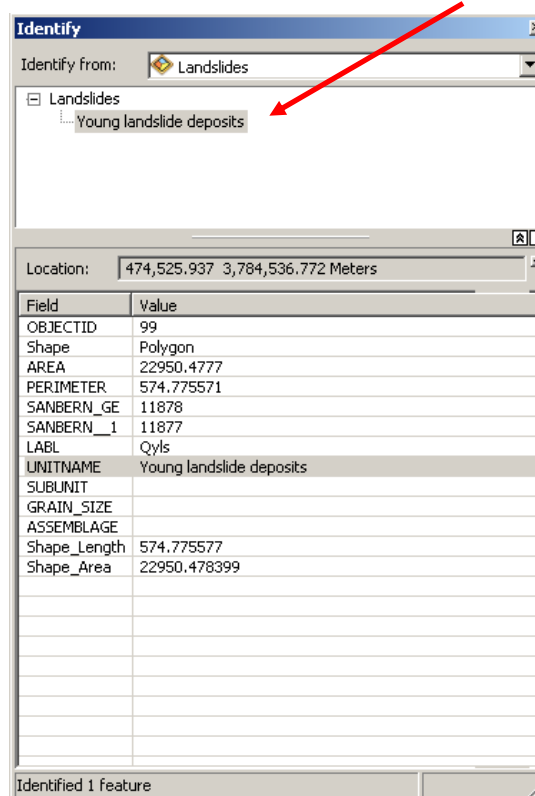
- a. Open **ArcMap**.
- b. You are going to open an “Existing Map”. Click on “Browse for more...” and browse to **EdUC_Landslides\Map_docs** and open **Landslide_analysis.mxd**.
- c. Zoom In  to the region where the Photos symbols are located on the map. The dark brown polygons are previously mapped landslides.



- d. We may want to return to this map extent so we are going to create a Bookmark, which we can use to return to this region. Click Bookmarks on the menu bar and click Create. Name the Bookmark “**Photo Extent**” and click OK. Now click on Zoom to Full Extent  and then return to the **Photo Extent** by using the Bookmark dropdown menu.
- e. Look at the rock types by clicking on the hyperlink symbol  (which highlights the camera symbol with a blue dot) and hovering near a photo. The name of the photo will appear. Click on the blue dot and a picture of the site will open in a new window. After inspecting the location, close the window (click on the X in the upper right corner). Now repeat this for the other rock type photo locations.

Question 2: Two pictures show expansive stretches of land (i.e., are taken at a distance). What are the names of these two photos? (3 pts).

- f. We are now going to hyperlink the fire image to the center of one of the landslide polygons in the center of the study area.
- g. Go to your bookmark, “Photo Extent”. Open the Identify tool  and click anywhere in the map. When the Identify Box pops up, set the Target Layer to “Landslides”. Click on one of the landslides in the middle of the study area. Right Click on the name of the Landslide highlighted in the Identify Results dialog box and click on Add Hyperlink.



Browse to the folder: `\EdUC_Landslides\Data_Active\RS_Images`, click on **fire-631.jpg** and click Open. NOTE: Make sure you are hyperlinking to a picture (should be the first choice). Then Click OK in Add Hyperlink window.

- h. Close the Identify Results dialog box and click on the Hyperlink tool. You will see that the landslide you picked is now outlined in blue. You may need to Zoom in to see the polygon. Using the Hyperlink tool, click on that landslide and the Remotely Sensed image will open. You can zoom in to the image and see the region covered by the study area. Close the image and the Identify Results dialog box and Zoom to Full Extent.


Step 5: It has been suggested that landslides can occur in different types of rock formations and near or further away from faults. We will now think about those datasets that we have access to that can help us find areas that may be susceptible to slides. ***While these data are real-world data, this exercise is not meant to be scientifically accurate or a true predictor of mud or rockslides, and should not be used to determine slide hazard or safe areas.***

This exercise is “data-driven” in that there are many models for slide susceptibility and each uses data that may or may not be easily obtainable. We will use the data that are available to create other datasets useful for modeling slide probabilities. The original and derived data include:

* Digital elevation data to derive Slope and Aspect datasets. Moderate to steep slopes can be more susceptible to slides. Aspect in an arid environment can be a surrogate for vegetation density. Generally, south-facing slopes (compass direction 90 to 270 degrees) have less

vegetation than north-facing slopes (compass direction 0 to 90 and 270 to 360 degrees). Generally slopes that have little or no vegetation are more susceptible to slides.

* Burn severity data will be used to find areas that have had their vegetation removed by recent wildfires, which may increase susceptibility to sliding.


- a. Close your current ArcMap Project. If you wish, you can save you project in your Map_docs folder.
- b. Open ArcMap and open a New Blank Map.
- c. Click on the **Add Data** button  and browse to the folder **EdUC_Landslides\Data_active** and double click on the **SB_landslides_UTM_NAD27.mdb**. Hold down Ctrl and click on **DEM_elev**, and **Sb_BAER_Burn_Severity**, then click Add.
- d. Save this document with an appropriate name in the **Map_docs** folder in the **EdUC_Landslides** project.
- e. Setting “relative path names” is usually important for projects you want to share. Click **File** menu, pick Map Document Properties and click “Store relative pathnames to data sources”. Click OK.
- f. It is also important when working with temporary files and rasters to specify where they will be saved so you can easily delete them. Click on the **Geoprocessing** menu, then click **Environments...**. Click on Workspace and fill in:
 - a. *Current Workspace* -- browse to your student folder, **EdUC_Landslides** and select **Data_Active**
 - b. *Scratch Workspace* – browse to your folder **EdUC_Landslides\Data_active** and select **Scratch_Temp**
 - c. Click OK and then OK.

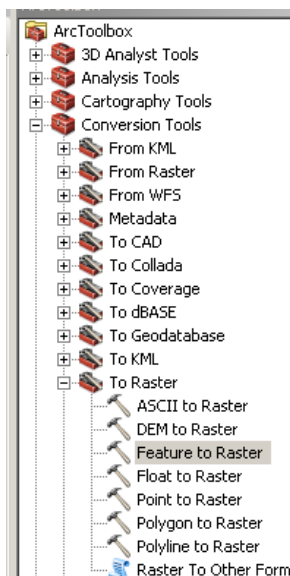
Step 6: We are now going to begin to create the datasets we need in order to do our analysis. We will use several different methods and tools to complete the analysis including the **Spatial Analyst Tools** found in **ToolBox** to create datasets for Slope, Aspect and Burn Severity. You will use the **DEM_elev** grid to create Hillshade, Slope and Aspect datasets, and you will convert the Burn Severity polygons to a Grid. We will then use these new layers to do the analysis.

- a. Go to Customize → Extensions and check “Spatial Analyst” and close the dialog box.
- b. Go to Geoprocessing → ArcToolbox. The ArcToolbox window will open. Expand the Spatial Analyst Tools toolbox (click on the + next to it) and then click on the + to open the Surface toolset. Double click on Hillshade. A new dialog box opens. Be sure the **DEM_elev** in the input raster. For the Output Raster, browse to you folder **Ed_UC_Landslides\Data_active\GRIDS** and name it **Hillshade** and click Save. Leave the rest of the fields as the defaults, and click OK. This will create a **Hillshade** of **DEM_elev** for our study area to help in visualizing the analysis.
- c. Now return the Surface tools and double click on Slope.
- d. In the dialog box be sure the **DEM_elev** is the Input Raster. For the Output Raster, browse to your student folder **EdUC_Landslides\Data_active\Scratch_Temp** and name it **Slope**, click Save. Leave the rest of the field as the defaults, and click OK.
- e. Repeat step d above only click on **Aspect** rather than Slope. Name it **Aspect**.

- f. *Save your project* (do this often during raster analysis).
- g. We will now convert the Burn Severity dataset to a Grid. You can look at the Burn Severity dataset by right clicking on the **Sb_BAER_burn_severity** and clicking on Open Attribute Table. Answer the question below, and close the table.

Question 3: VEGBURNSEV has three categories. What are they? What do you think they represent? (4 pts).

- h. Open the **Toolbox** if it is not open by clicking on the **Toolbox** . Scroll and expand (click +) the **ArcToolbox** to see the **Conversion Tools**, expand the **To Raster** toolset and then double click on **Feature to Raster** tool.



- i. In the Dialog box, select **Sb_BAER_burn_severity** from the dropdown box for the Input Features. Then in “Field” pick **VEGBURNSEV**, and for the Output raster click on the browse button and browse to **EdUC_Landslides\Data_active\Grids**. Name the output **sb_burn_sev**, then click save (accept defaults) and OK.

Step 7: There are now four new datasets: **Hillshade**, **Slope**, **Aspect** and **sb_burn_sev**, in the Table of Contents. Look at each dataset in the Table of Contents and the values for **Slope** (0 to > 80), **Aspect** (compass direction of the slope) and **sb_burn_sev** (Low, Moderate and High, indicated by the “1”, “2” and “3”). We will reclassify the **Slope** and **Aspect** to reflect the probability of slides. Again, this exercise will make some assumptions about slope stability and use the available data sets, which may not truly reflect true slope stability. In general, the greater the slope is, the more unstable the location. In general, well-vegetated slopes are more stable. Aspect will be used as a substitute for vegetation density with the assumption that in the arid southwest, south facing slopes tend to be dryer and have lower vegetation density due to high evaporation rates. We will then consider the severity of burning to suggest the increased instability of a slope with High burn severity relative to low or moderate burn areas.

- a. First Reclassify **Slope**. In **ArcToolbox**, expand the **Spatial Analyst Tools** and then expand the **Reclass** toolset. Double click on **Reclassify**.
- b. In the Input raster field, pick **Slope**. Click on the **Precision** button and set “number of decimal places shown” to 0, and then click OK. Click on **Classify** button, pick “Natural Breaks (Jenks)” and type in 6 classes. In the Break Values table to the right, highlight each value and change the values to 5, 10, 15, 25, 33, and 81 and click OK. Click on the “New Values” field, and change the values in the Reclassify window for each listed below (Note: category “2” left out on purpose):

Old Value	New Value
0-5	0
5-10	1
10-15	3
15-25	4
25-33	5
33-81	6
NoData	NoData

- In the Output raster, browse to **EdUC_Landslides\Data_active\Scratch_Temp**. Name it **Reclass_of_Slope**, click Save. Click OK.
- c. Right click on the **Reclass_of_Slope** and click **Properties**. Click on the **Symbology** tab and pick a color ramp in the **Color Scheme** with the darkest color for the highest values. Click the **Display** tab and set **Transparent** to 40 to 50% (try each and determine which is more effective). Click OK.
 - d. You may need to reposition the layers to see the **Hillshade** beneath the **Reclass_of_Slope**. Clean up the Table of Contents by collapsing the un-needed symbology for the other layers (click on the – button for all layers besides **Hillshade** and **Reclass_of_Slope**).
 - e. Uncheck the boxes beside all layers besides **Hillshade** and **Reclass_of_Slope**. This will turn off drawing on all data. You should see that the steepest slopes are the darkest colors (depending on your color scheme).
 - f. Now we will reclassify **Aspect**. In the **Reclass** toolset of the **Spatial Analyst Tools**, double click **Reclassify**. Set the Input raster to **Aspect**. Click on the **Precision** button and set to 0 decimal places, click OK. Click on **Classify**, choose “Defined Interval” and type in 30 for the interval size then click OK. You will now set “New Values” in the Reclassify dialog box so that the directions are “weighted” according to their susceptibility to landslides, and the numbers 0, 1, 2, and 3 represent the weights.

Follow the metric below:

For all interval values -1 to 90: "0"
 90 to 120: "1"
 120 to 150: "2"
 150 to 180: "3"
 180 to 210: "3"
 210 to 240: "2"
 240 to 270: "1"
 270 to 360: "0"

This will suggest that south facing aspect will be more susceptible to slides than north facing slopes. In the Output raster, browse to

EdUC_Landslides\Data_active\Scratch_Temp. Name it **Reclass_of_Aspect**, click Save. Click OK.

- g. Inspect the **Reclass_of_Aspect** to see what the reclass does by making it 60% transparent and turning all layers off except the **DEM_elev**. Right click on **Reclass_of_Aspect**. Click **Properties** and then the **Display** tab and set **Transparency** to 60%. Click OK. You may have to reposition the **DEM_elev** layer so it's right below your **Reclass_of_Aspect**. Zoom in on the map to see the different portions, and observe how aspect has been reclassified.

Step 8: You will now use **Raster Calculator** and the three reclassified grids to find areas of least to greatest susceptibility to slides. You will also be able to weight the influence of Slope more by multiplying the three factors with 60% of the influence for **Slope**, 20% for **Aspect**, and 20% for **Burn Severity**. This will be done by multiplying the reclassified values by **.6 for Slope** and **.2 for Aspect and Burn Severity**.

- a. Expand the **Map Algebra** toolset of the **Spatial Analyst Tools**, double click on **Raster Calculator**.
- b. Double click on **Reclass_of_Slope** and click on * and click .6 then click on +
- c. Double click on **Reclass_of_Aspect** and click on * and click .2 and then click on +
- d. Double click on **sb_burn_sev** and click on * and click .2
- e. Your expression MUST look like the one below:

"Reclass_of_Slope" * .6 + "Reclass_of_Aspect" * .2 + "sb_burn_sev"*.2

- f. In the Output raster, browse to **EdUC_Landslides\Data_active\Scratch_Temp**. Name the output **Temp1** and click Save. Click OK. A newly calculated raster grid named **Temp1** will be added to your Table of Contents. There is a range of values for this raster calculation, which suggest slide susceptibility (low to high).
- g. You will now use the values in **Temp1** and **Raster Calculator** to create a grid of only values greater than 4.2. This should represent areas that are highest in susceptibility to slides.
- h. In the **Map Algebra** toolset of **Spatial Analyst Tools**, double click on **Raster Calculator**. Double click on **Temp1** then click > then click in **4.2**. In the Output raster, browse to **EdUC_Landslides\Data_active\Grids**. Name the output **High_sus** and click

Save. Click OK. The new grid is added to your map and listed in the Table of Contents. Uncheck **Temp1** and reduce it (click -).

- i. You will now symbolize this dataset so that only those values with 1 are in the legend. Right-click on **High_sus** and the **Properties, Symbology** tab. Click on the 0 Value and click the **Remove** button. Click on the value of 1 in the **Label** column and type in *Highest Susceptibility*. Double-click on the symbol and pick a bright color. Click OK.

Question 4: Turn on just the High_sus and the DEM_elev layers (make sure the DEM is underneath the High_sus). Where do the high susceptibility areas occur? Does this make sense to you? Why or why not? (5 pts).

Step 9: You will now clean up your project, add streams, roads, faults, and remove unneeded datasets. (Make sure all other layers besides your created grid, **High_sus**, are turned off).

- a. Click **Add Data** and browse to the **SB_Landslides_UTM_NAD27.mdb** geodatabase. While holding down Ctrl, click on **Sb_roads**, **Sb_streams**, and **Sb_faults** then click **Add**.
- b. Re-symbolize the above datasets by right clicking on the symbol and picking an appropriate color for each one (i.e., dark gray for roads, blue for streams, and red for faults).
- c. Click **Add Data** and browse to **SB_Landslides_UTM_NAD27.mdb** geodatabase and add the **DRG_Clip**. This dataset can be set to transparent, but it might be more effective to change the values for “white background” to no color. Right click on the symbol for white with the value of 1 in the Table of Contents legend for this dataset. Select no color. Right click on **DRG_Clip**. Click on the Properties and Display tabs and try setting transparency to 30% (you may want to try different values).
- d. Move the **High_sus** dataset to the top of the Table of Contents (click and drag on the name).
- e. Zoom to full extent and view the areas that are more susceptible.

Question 5: Where is the high landslide susceptibility in the region? Describe the relationship between susceptibility and the roads, faults, and streams. (5 pts).

Question 6: What agencies or interested citizens would be interested in a map such as this? How could a landslide susceptibility map help inform these groups in decision making processes? (5 pts).

Question 7: What are some other types of data that could be added to the project in order to better pinpoint where landslides could occur? (5 pts).


Step 9: Create a “Layout” view *with all the map elements*, and save your map as a jpg file. Insert this jpg file into your lab report. **(12 pts)**

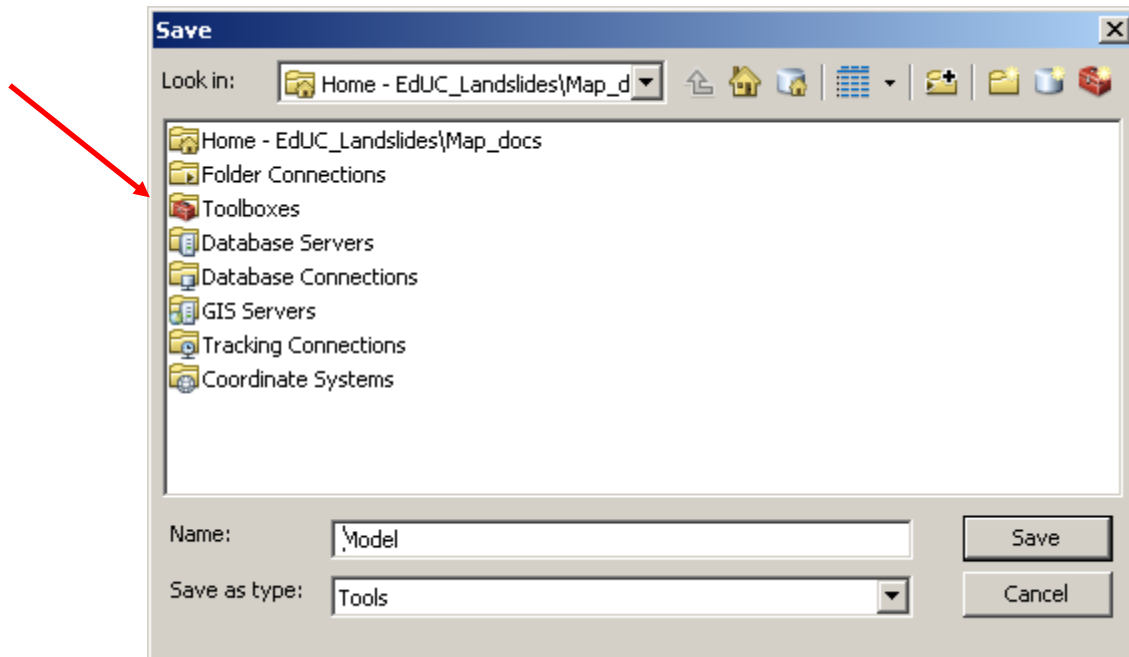
Step 10 - Using ModelBuilder: ArcGIS ModelBuilder provides an interface that you can use to visually create analysis models in ArcGIS.



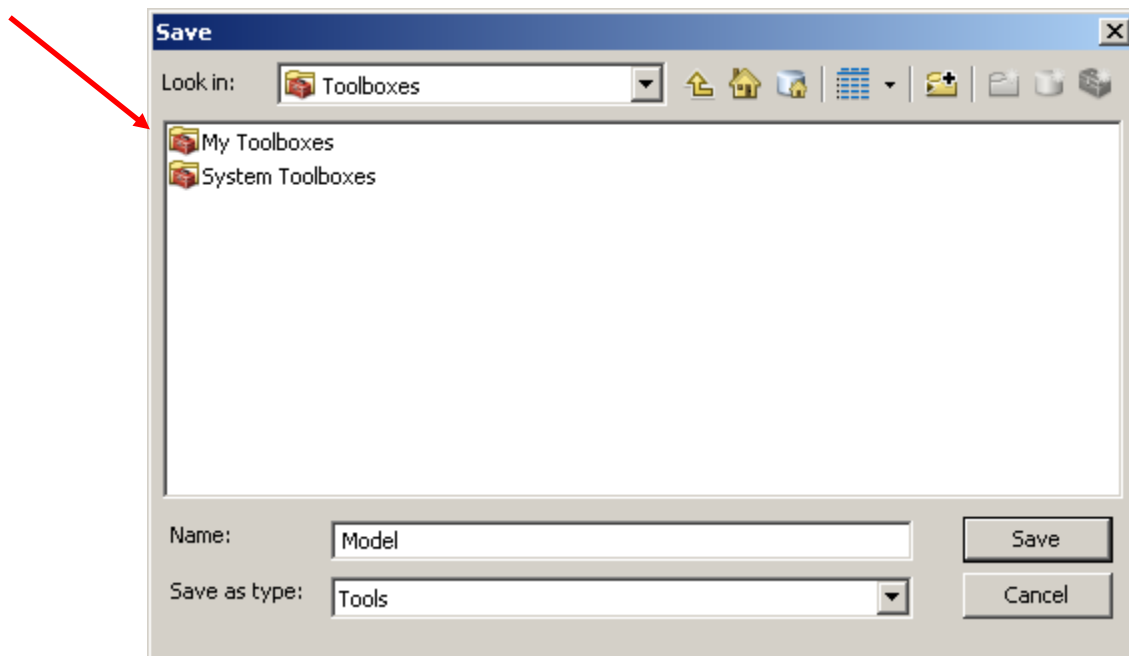
The ModelBuilder window consists of a display window in which you build a diagram of your model, a main menu, and a toolbar that you can use to interact with elements in your model diagram. You can run a model from within the ModelBuilder window or from its dialog box.


We will now repeat the creation of your landslide susceptibility analysis model using ModelBuilder. **Your mission will be to re-create Steps 6-8 above, but this time using ModelBuilder instead of Raster Calculator.** To begin, we need to create an empty model within a new Toolbox. Make sure the ArcToolbox is visible. Click on the **ModelBuilder**

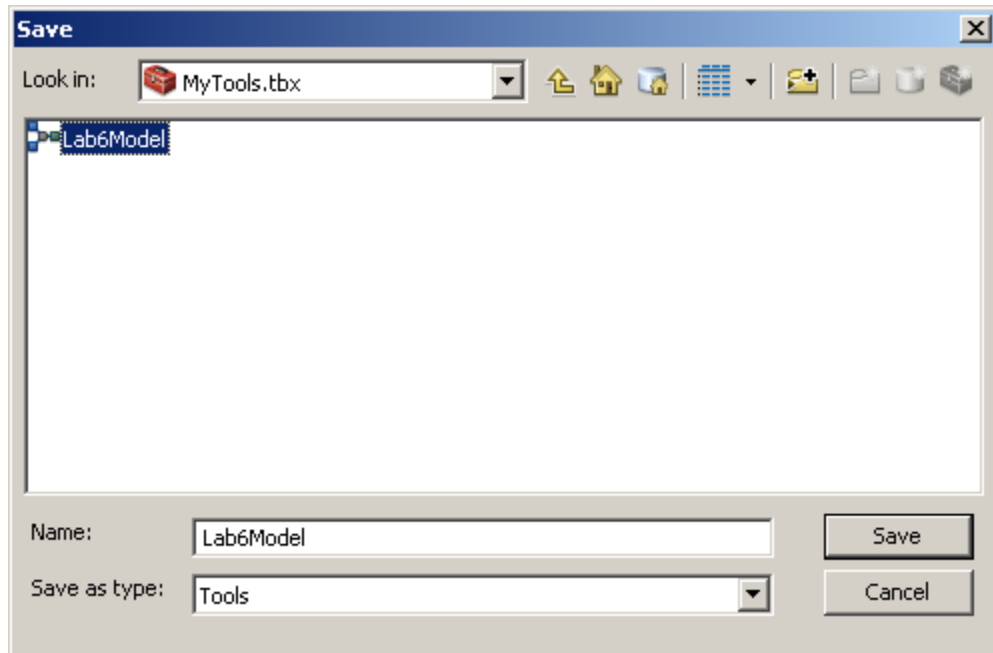
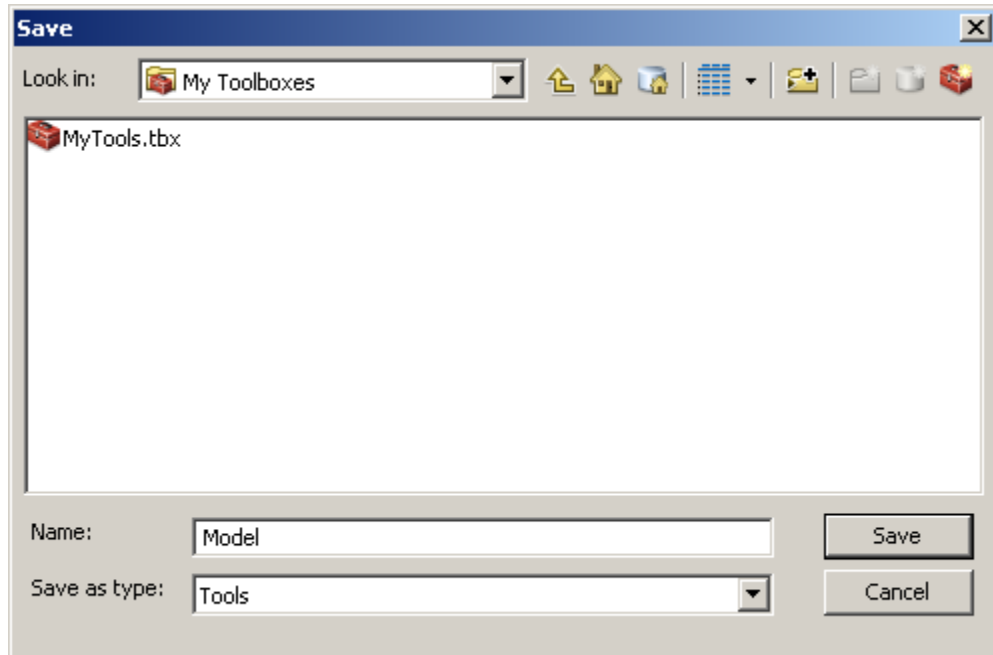
window icon . A new Model window in which you will build your model will appear. Next you will save the model. When the **Save** dialog box opens, use the pull down (Look in) and navigate to **Toolboxes**.



Double click on Toolboxes and then double click on **My Toolboxes**.



In the upper right hand corner of the window, click New Toolbox . Name the Toolbox **MyTools**. Double click on **MyTools** and name your model. Click save.



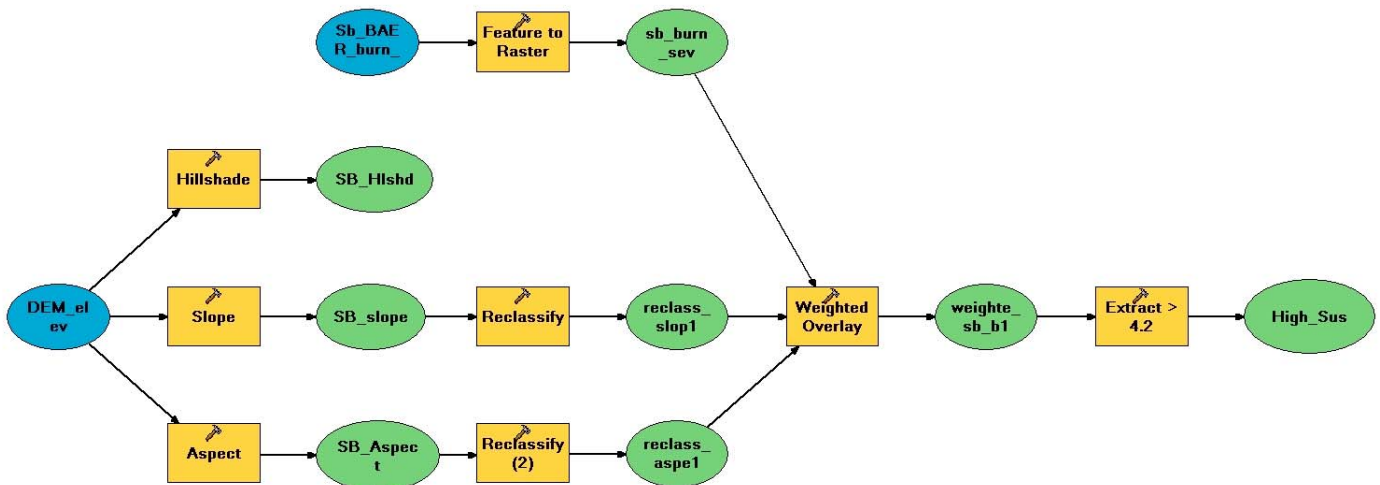
Close your Model window. In the ArcToolbox window, right click on **ArcToolbox** and select **Add Toolbox...** Navigate to **Toolboxes → My Toolboxes → MyTools.tbx** and click Open. Your Toolbox, MyTools, will now appear in ArcToolbox. Click on the + next to MyTools, right click on your model and select Edit.

Now add the data that you want to use in the model. Since you are replicating Steps 6-8, you'll want to start with the **DEM_elev** and **Sb_BAER_burn_severity** layers again. Click on the **Add Data** icon and add them. They will appear as blue shapes (Note: they may be added one on top

of the other, so use the select tool (black arrow) to move them around so they are both visible). From there you'll want to add the *Hillshade*, *Slope*, and *Aspect* functions to the model (which will appear as yellow shapes). These will help you to re-create the grids that you derived from **DEM_elev** in Step 6, and you'll want to add the *Feature_to_Raster* function to use on **Sb_BAER_burn_severity**, and so on. Don't forget to save your model from time to time.

Note that you can make connections between datasets and functions by clicking on the connection icon (two little boxes connected by a red line), which will change the mouse arrow to a magic wand. You can then click on each layer individually, and draw a line from that layer to a function. You can also rename the results of a step in the model by left clicking on the oval and going to "rename." In general, you'll have to work a bit more independently on this part of the lab (i.e., hand-holding, step-by-step instructions are not provided here on purpose). But learn to use the ArcGIS Desktop Help (a valuable skill), as well as the assistance of your teaching assistant and discussions among yourselves.

To give you a hint, here is what your final model should look like:



Now run your model, and compare the results to what the Raster Calculator came up with earlier in the lab. Click on the "run" icon, which is the blue arrow on the far right of the dialog box. When the model is finished running, click "ok" on the progress dialog box. To see the results, right-click on the **High_Sus** green oval and choose "Add to display". Take a screen-shot of the landslide susceptibility model that you re-created in ModelBuilder, as well as the final **High_Sus** layer that was produced. Include the screen-shots in your lab write-up along with the ANSWER to:

Question 8: Consider the two main GIS analysis model building tools used in this lab (Raster Calculator vs. ModelBuilder). Were the results the same? Was one easier to use than the other? Explain why by comparing and contrasting the GIS analysis model building methods. (6 pts).