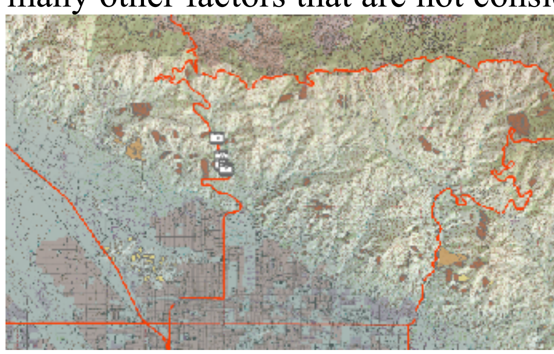
GEO 465/565
Lab 6:
Modeling Landslide Susceptibility

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.



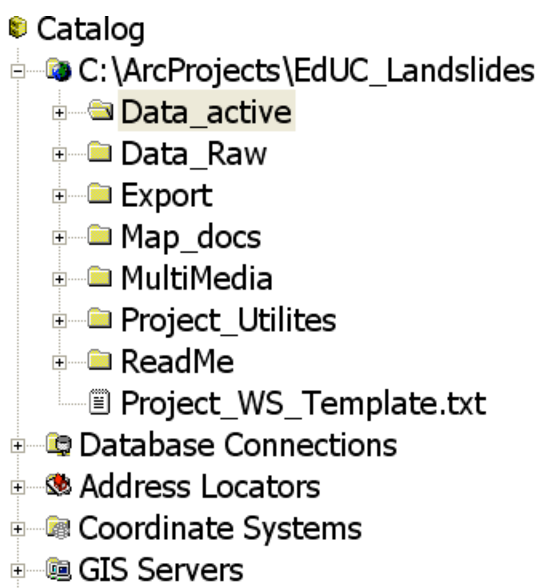
Step 1: To become more familiar with the file structure and the data used in this project we will begin by opening ArcCatalog and looking at datasets and data structure for the project.

a. Copy the folder **EdUC_Landslide** 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 **EdUC_Landslide.**

b. Open ArcCatalog
c. Make a direct connect to **EdUC_Landslide** folder by clicking on the Connect to Folder  button and browsing to your student folder. Then click on name of folder **EdUC_Landslides**. Click OK.

Step 2: Looking at data structures within **EdUC_Landslides**. Note: when opening grid datasets you may be prompted to create pyramids – click "yes" if this prompt is displayed.

a. Click on the + by the **EdUC_Landslides** project to expand the folder - note the names of the subfolders.



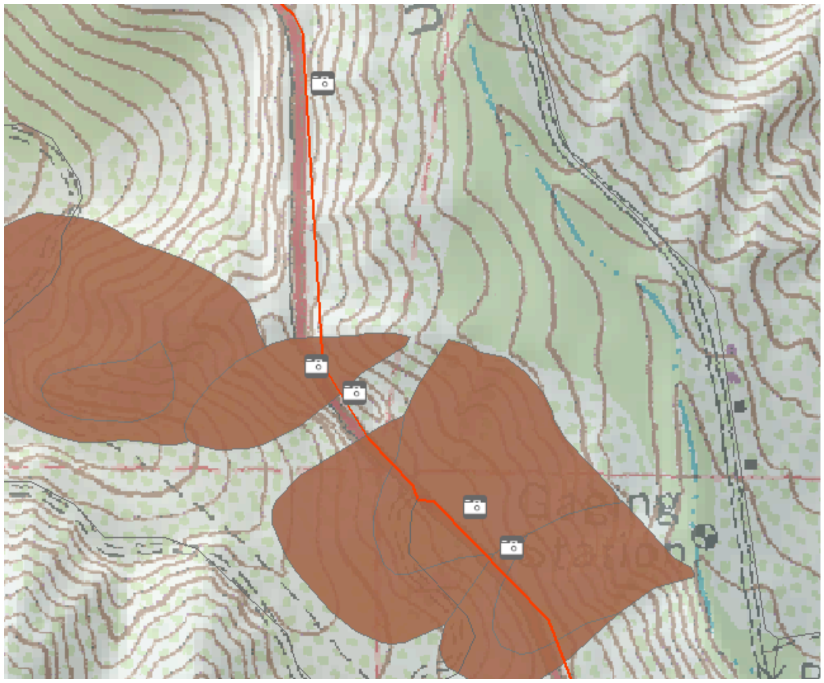
b. Expand the subfolders (click on + by subfolder) and look at the names of the files under each subfolder. Click on the minus "–" by each folder if you want to close them.
c. Let's look at some of the data. Expand the "**Grids**" subfolder in the **Data_Active** folder and click on the "**geol**" layer 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 Table.

Question 1: What's the geology of the first entry in the "Summary 1" column?

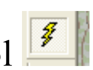
d. Now expand the Layers. Click on the "**burn_severity.lyr**". Note in the Table that there are three attribute classes in the VEGBURSEV field (Low, Moderate and High). Change to Geography for the Preview window.
e. Now click on the + by the geodatabase file named **SB_landslides_UTM_NAD27.mdb**. Pick 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 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. Close the Layout by clicking on the X.
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 remote sensed image taken during the 2003 fires.

a. Open **ArcMap**.
b. You are going to open "An Existing Map". Browse to **EdUC_Landlides\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 on View menu, Bookmarks 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 in the View 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 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?

f. We are now going to hyperlink the fire image to the center of one of the landslide polygon in the center of the study area.

g. Go to your bookmark, "Photo Extent". Open the Identify tool and 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 and 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 in now outlined in blue. You may need to Zoom in to see the polygon. Using the Hyperlink tool, click on that landslide and the Remote Sensed image will open. You can zoom in on 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 this data is 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 hazards 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 subrogate for vegetation density. Generally south facing slopes (compass direction 90 to 270 degrees) have less vegetation then north facing slopes (compass direction 0 to 90 and 270 to 360 degrees). Generally slopes that are 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 your project in your Map_docs folder.
b. Open **ArcMap** and open a new empty 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 Properties and click on "Data Source Options" button and click on "store relative path names." 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 Tools menu, click Options. Select the Geoprocessing Tab and click on the Environments button. Click on the General Settings 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 Analysis** extension and **Tools** in **ToolBox** to create datasets for Slope, Aspect and Burn Severity. You will be using the **DEM_elev** grid to create a Hillshade, Slope and Aspect datasets and convert the Burn Severity polygons to a Grid. We will then use these new layers to do the analysis.

a. Go to Tools→Extensions and check "Spatial Analysis". Then go to View→ Toolbars and make sure the spatial analysis toolbar is checked. This should make the Spatial Analyst toolbar pop up on the screen.
b. Click on the dropdown menu for Spatial Analyst toolbar, pick Surface Analysis and click on Hillshade (be sure the **DEM_elev** is the input surface), for Output Raster Browse to your folder **EdUC_Landslides\Data_active\GRIDS** and name it **Hillshade** then click save, and OK. This will create a **Hillshade of DEM_elev** for our study area to help in visualizing the analysis.
c. Click on the Spatial Analyst toolbar, pick Surface Analysis and click on Slope.
d. In the dialog box be sure **DEM_elev** is the input surface leave the defaults and for Output Raster browse to your student folder

EdUC_Landslides\Data_active\Scratch_Temp and name it **Slope** and click SAVE and OK.

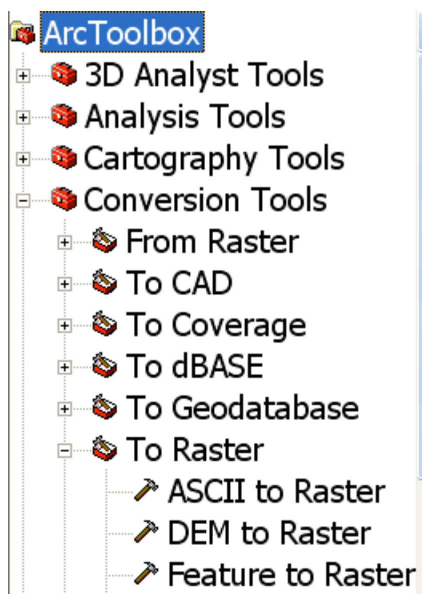
e. Repeat steps B-D above only click on **Aspect** rather than Slope as the Surface Analysis (again, you are making two aspect files, and saving them in different places). Name it **Aspect** and click SAVE and OK.

f. ***Save your Project*** (do this often during raster analysis).

g. We will now convert the Burn Severity dataset to a Grid.

h. You can look at the Burn Severity dataset by right clicking on the **Sb_BAER_burn_severity** and clicking on the 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?



i. Open the ***ToolBox*** if it is not open by clicking on the ***ToolBox*** GUI . Scroll and Expand (click +) the ***ArcToolBox*** to see the ***ConversionTools***, Expand the ***To Raster*** toolset and then Double

Click on the ***Feature to Raster*** tool (see graphic above). In the Dialog box, Browse for the Input Feature to the **Sb_BAER_burn_severity** Feature Class from the geodatabase. 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** Raster and Feature Class datasets 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 A**spect** 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 being less stable then low or moderate burn areas.

a. First Reclass **Slope**. Click on the Spatial Analysis dropdown menu and click Reclassify. In the Input raster field, pick **Slope**. Click on 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:
b. 0 – 5 put "0"; 5 – 10 put "1"; 10 – 15 put "3", 15 – 25 put "4" and 25 – 33 put "6" and 33 – 81 put "6" [category "2" left out on purpose]. Leave as Temporary. Click Okay.
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 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

unneeded symbology for the other layers (click on the – button for all layers besides **Hillshade** and **Reclass of Slope**).

e. Uncheck the boxes besides 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 **Reclass Aspect**. Using the Spatial Analyst Menu, click on Reclassify and set the Input raster field to **Aspect**. Click on Precision button and set to 0 decimal places, click OK. Click on "Classify", choose "Defined Interval" and type in 30 for the interval value 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 weights are represented by the numbers 0, 1, 2, and 3. 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 then north facing slopes. Leave as Temporary and 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,** Properties and click 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 the Raster Calculator and the three reclassed grids to find areas of least to greatest susceptibility to slides. You will also be able to weigh the influence of Slope more by multiplying the three factors with 60% of the influence for **Slope**, 10% for **Aspect** and 10% for **Burn Severity.** This will be done by multiplying the reclassed values by .6 for **Slope** and .2 for **Aspect and Burn Severity**.

a. Click on the Spatial Analyst toolbar and 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

h. Then click Evaluate. A **Calculation** will be added to your Table of Contents. There is a range of values for this raster calculation, which suggest a slide susceptibility (low to high).
i. You will now use these values 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.
j. Click Spatial Analyst toolbar, then Raster Calculator. Double Click on **Calculation** then click on > then click in 4.2. Click Evaluate. You will make this **Calculation** layer permanent.
k. Right click on the **Calculation2** in the Table of Contents and click Make Permanent. Save in the Grids folder and name **High_Sus** and click Save. Uncheck the old **Calculation** (check –)
l. Add this new Grid to the project. Click Add data and browse to the **High_Sus** dataset. You will now symbolize this dataset so that only those values with 1 are in the legend. Right click on **High_Sus** and Properties, Symbology tab. Click on the 0 Value and click Remove button. Click on the value of 1 in Label column and type in Highest Susceptibility. Double click on the symbol and pick a bright color.

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?

Step 9: You will now clean up your project, add streams, roads, faults, and remove unneeded data sets. (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**. Holding down Ctrl click on **Sb_road, 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 road, blue for streams, red for faults.)
c. Click Add Data and browse to the **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 null color. Click on the symbol for white with the value of 1 in the Table of Contents Legend for this dataset. Click Properties Tab and check Color is Null click OK. Right click on **DRG_Clip**, Properties and Display tab and try setting transparency to 30% (you may want to try different values).
d. Move **High_Sus** dataset to the top of the Table of Contents (click and drag on name).
e. Zoom to Full extent and view the areas that are more susceptible.

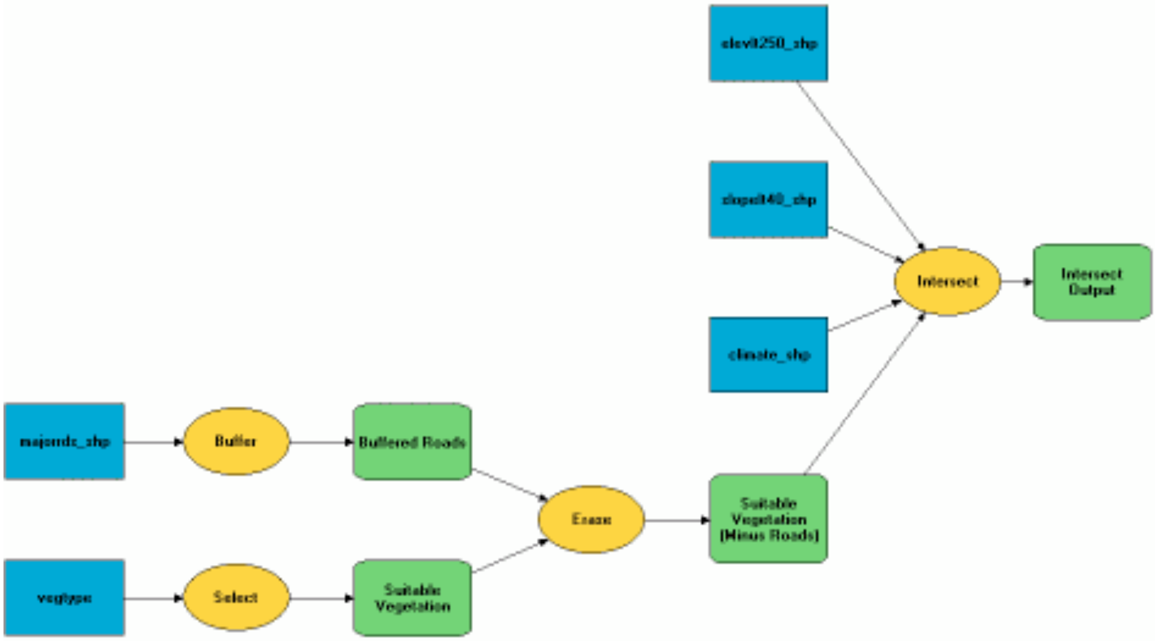
Question 5: Where is the high landslide susceptibility in the region? Describe the relationship between susceptibility and the roads, faults, and streams.

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?

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?

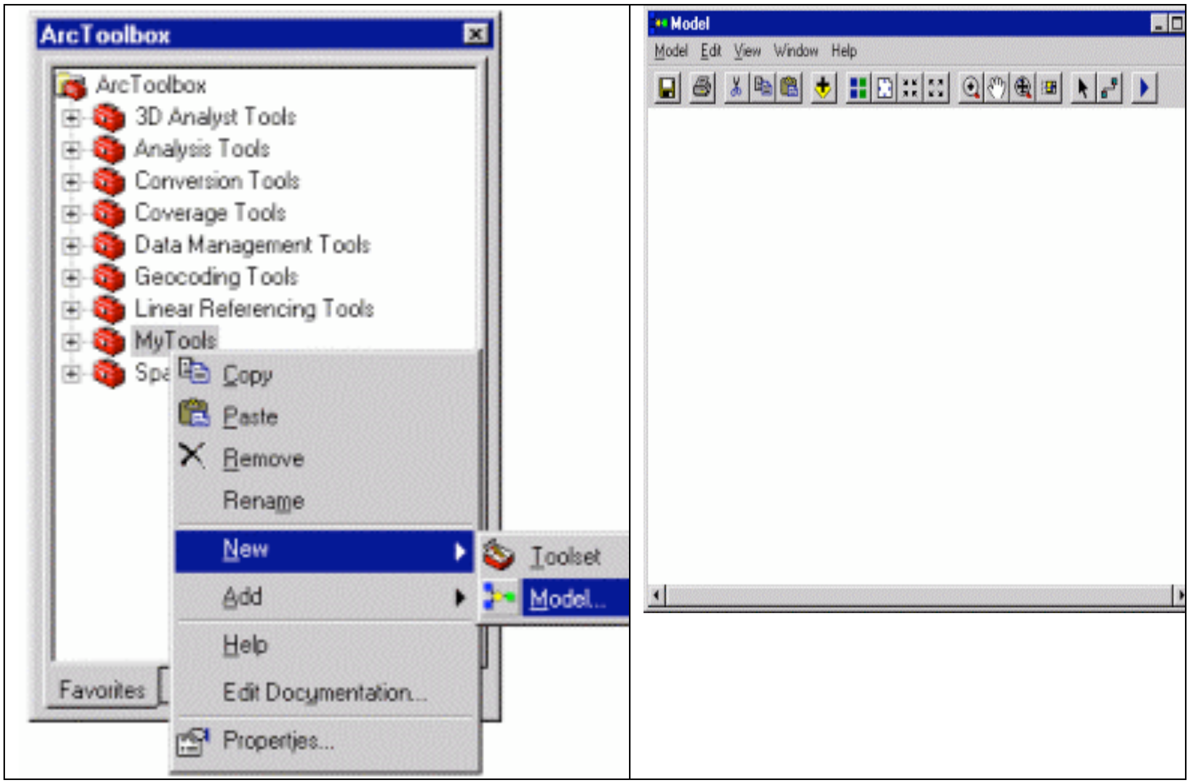
Step 9: Create a "Layout" view with all the map elements, and save your map as a jpeg file. Insert this jpeg file into your lab report.

Step 10 - Using ModelBuilder: ArcGIS ModelBuilder provides an interface you 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.

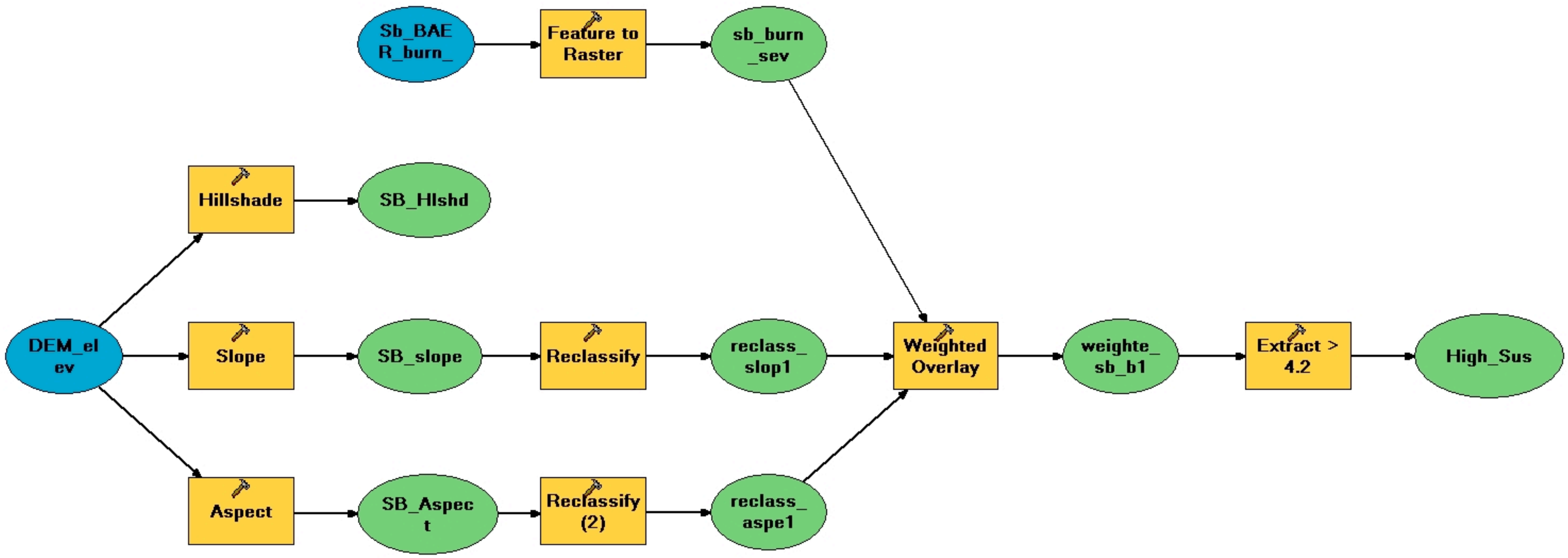
We will now repeat the creation of your landslide susceptibility analysis model using ModelBuilder. **<u>Your mission will be to re-create Steps 6-8 above, but this time, using Model Builder instead of Raster Calculator.</u>** To begin, we need to create an empty model. Make sure the ArcToolbox is visible in the center of the display, right-click on the word "ArcToolbox" at the top, and select "New Toolbox". Name your toolbox "MyTools". Now right-click on this new toolbox, point to new, and select "Model". A new model is created in the toolbox, and a default window is opened so you can build your model.



Next, add the data that you want to be 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 these. They will appear as blue ovals (note: they may be added one on top of the other, so use the select tool (black arrow) to move them around so all three are visible). From there you'll want to add the *Hillshade*, *Slope*, and *Aspect* functions to the model (which will appear as yellow ovals). 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.

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, 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 writeup 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.**