

FNR 65 Introduction to GIS

Lab 10: Raster Analysis - Sea Level Rise Around Humboldt Bay

Introduction

This lab will introduce raster processing by examining the potential impact of sea level rise around Humboldt Bay. This lab was originally developed by James Graham and later modified by Jason. R. Patton

Note: this is a simplified analysis of sea level rise, the real implications of sea level rise, when we incorporate storm surge, tsunamis, and tidal variability, will be different and include factors beyond what we can consider in this simplified model.

There is additional information and maps available at:

- [Global Sea Level Rise](#)
- [Surging Seas](#)
- [National Geographic: If All the Ice Melted](#)
- [NOAA: Sea Level Trends](#)
- Houston, J. (2013). Sea Level Rise. Coastal Hazards. C. W. Finkl, Springer Netherlands. **1000**: 245-266.

Learning Outcomes

- Be able to use the following tools in raster analysis:
 - Resample
 - Raster calculator
 - Vector to raster
 - Reclass
- Be able to describe the basic advantages between raster and vector data types.

Data

[DEM for Humboldt County](#)

The DEM is from the National Elevation Data set and has been mosaicked together from a number of TIFF files from the National Elevation Data set.

Walk Through: Lab Preparation

To set up for this assignment:

1. Create a folder structure on "D:" as we have done before, within a folder called, "lab_10":
 - 01_Originals
 - 02_Working
 - 03_Final
2. Download the data into the "Originals" folder, unzip it, and make sure the spatial references are defined correctly.
3. The spatial reference system for this lab is "North American Datum 1983, Universal Transverse Mercator Zone 10 North" or "NAD 83, UTM Zone 10 North". Copy data sets that are in this spatial reference from the "Originals" folder to the "Working" folder and "Project" any data sets that are not in this spatial reference to the "Working" folder.

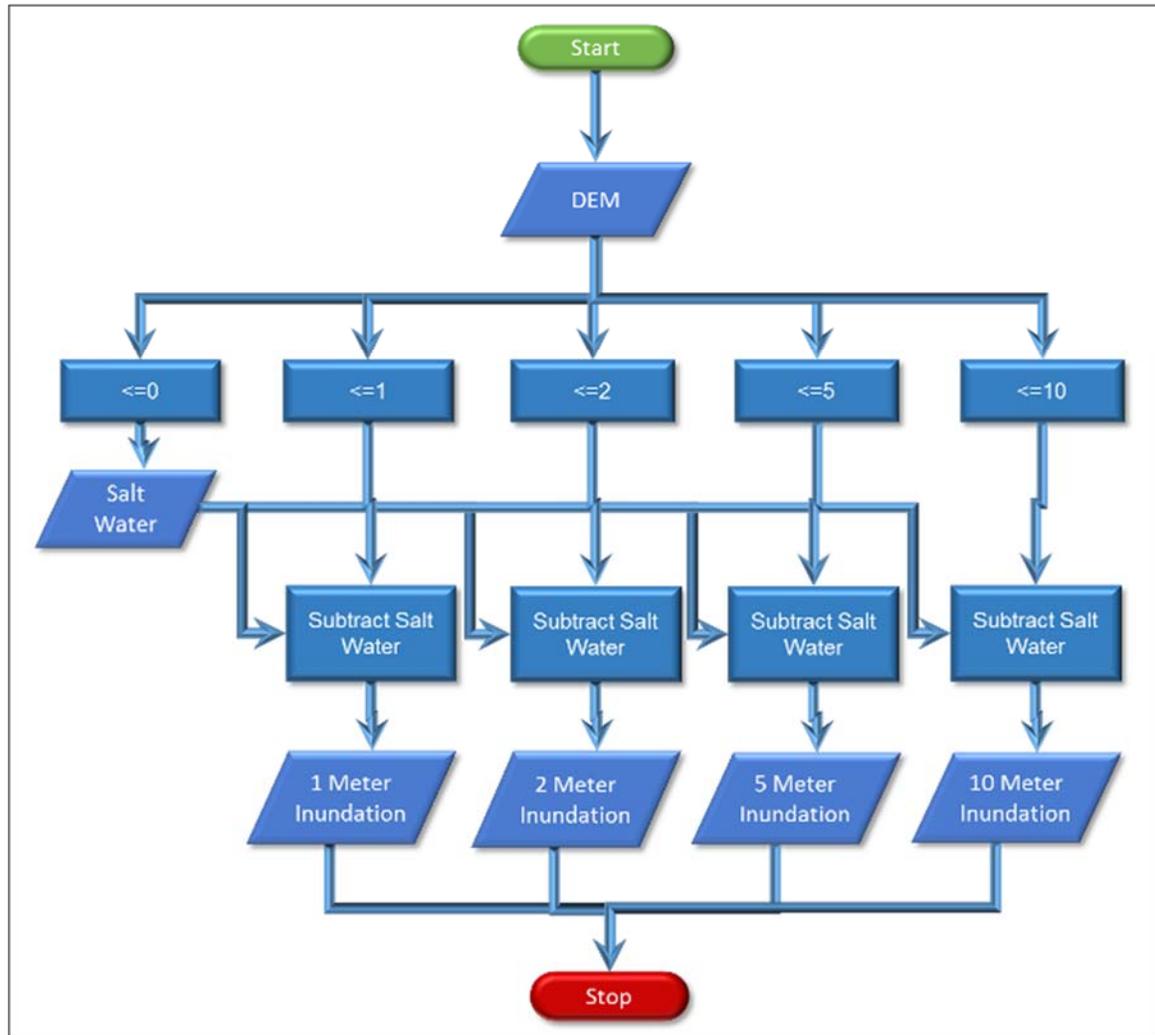
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Walk Through: Creating models for various levels of sea level rise

Like many tasks in GIS, once we have the data setup correctly, doing analysis flows relatively easily. Here, we will create rasters representing the land that might be inundated by water as the level of the ocean rises. This is a first order estimate and the results have large uncertainty. The uncertainty is based on the limitations of the assumptions made with this analysis (that it is simplified).

4. Open the "DEM" in ArcMap.



When you open raster files, ArcMap will typically ask if you want to create "Pyramids" unless they are already available. You'll want to say "Yes" if you are going to use the raster data repeatedly as this will greatly speed up the rendering of raster data. For elevation rasters, I select "bilinear convolution." Read the help about this.

5. To check the spatial reference for a raster, you need to scroll down in the "Source" tab in "Properties" as it is toward the bottom.
6. At the top of this list are some very important information about the raster.

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- Columns and Rows: Number of pixels horizontally (columns) and vertically (rows)
- Number of Bands: 1 for most rasters, 3 for RGB (one for red, one for green, one for blue)
- Cell Size (X,Y): the width (X) and height (Y) of each pixel in the raster in the units defined in the spatial reference
- Uncompressed Size: The size of the raster if it was all loaded into disk at one time
- Format: File format
- Pixel Type: floating point or integer
- Pixel Depth: 8-bit, 16-bit, 32-bit, and 64-bit.
- NoData Value: This numeric value is used to represent "no data" or null values. Pixels that are not valid will be set to this value and will appear transparent.

The data types have different names from the ones for attributes. The table below gives the characteristics of the types and both names. The "Pixel Depth" refers to the number of bits that each pixel will require and determines the possible range of values. The "Pixel Depth" is given in the names in the first column which you will see in raster-based tools in ArcMap such as "Create Raster Dataset."

Pixel Name	Type	Attribute Name	Minimum	Maximum	Precision
1_BIT	Integer	-	0	1	<1 digit
2_BIT	Integer	-	0	3	<1 digit
4_BIT	Integer	-	0	15	1 digit+
8_BIT_UNSIGNED	Integer	-	0	255	2 digits+
8_BIT_SIGNED	Integer	-	-127	127	2 digits+
16_BIT_UNSIGNED	Integer	-	0	65535	4 digits+
16_BIT_SIGNED	Integer	Short Integer	-32767	32767	4 digits+
32_BIT_UNSIGNED	Integer	-	0	4294967296	9 digits+
32_BIT_SIGNED	Integer	Long Integer	-2147483648	2147483648	9 digits+
32_BIT_FLOAT	Floating Point	Float	Big negative number	Big positive number	7 digits+
64_BIT	Floating Point	Double	Huge negative number	Huge positive number	15 digits+

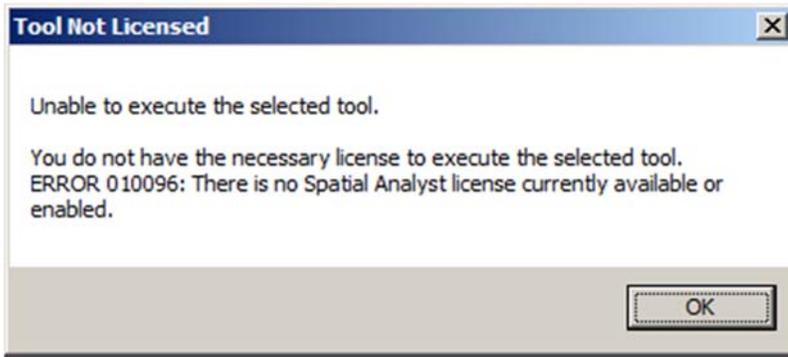
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Question 1: List the "Pixel Type," "Pixel Depth," and "Cell Size" for the DEM.

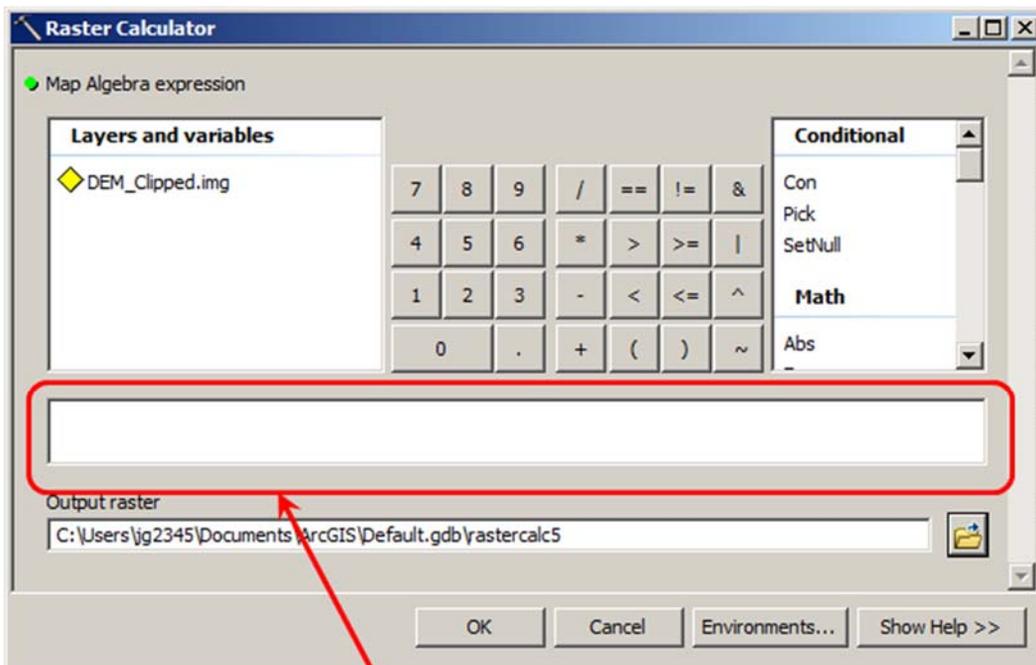
7. In the Toolbox, select "Spatial Analyst Tools → Map Algebra → Raster Calculator." This is a powerful tool that allows you to "do math" on entire raster images as if you were just doing math on a regular calculator.

Chances are you will get the following error:



Since Raster Calculator belongs to a special extension within ArcMap, we must first turn on the extension to use its functions. Choose "Customize -> Extensions... ->" Then check the box next to Spatial Analyst.

Raster Calculator is similar to the field calculator. On the left is a list of the raster layers you have open in ArcMap. On the right is a list of the "functions" that you can apply to rasters and in between these two are numbers and "operators" that you can use to operate on two rasters to produce a new raster.



Equation Box

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8. Double-click on the DEM to have it added to the equation as you did in the Field Calculator. Then click on " \leq " and then "0" to find the elevations that are at or below sea level.
9. Give the new raster an appropriate name like "SeaLevel2010.img." Make sure it ends in ".img" for the "IMAGINE" file format and click "OK". The new raster should appear and you should be able to see the outline of the existing Humboldt Bay.
10. Take a look at the legend and you'll see that there is "0" and "1." Raster Calculator has created a new raster that contains 0s where the equation you entered was "false" and 1s where the equation was "true." This is a powerful tool to create new rasters that contain the areas you are really interested in for different types of analysis.
11. Repeat the process above for areas that are less than one or equal to 1 meter and call it "SeaLevelPlusOneMeter.img". You now have one raster that contains 1s for everything at or below zero meters and one that has 1s where everything is at or below 1 meter.
12. Let's subtract the "SeaLevel2010.img" raster from the "SeaLevelPlusOneMeter.img" raster to find the areas that are above zero meters (sea level) and below 1 meter.
 1. Subtract the sea level raster from the raster with elevations below or at 1 meter in the "Raster Calculator" and saving them to a new raster, called something like "1minusDEM."
 2. Take a look at the raster you just made. Cell values will be 1s where the elevations are between sea level and 1 meter and 0s everywhere else. This raster will theoretically show the area of land that will be covered by water or "inundated" if we have a 1 meter sea level rise.

Question 2: How much land appears to be between 0 and 1 meters? You may need to zoom in and toggle between the two layers to see the pixels that are between 0 and 1.

13. The problem with the image above is that the ocean level moves up and down and there really isn't a "0" elevation. "Mean Sea Level" has been selected as the 0 elevation but this actually varies quite a bit over time and in different regions. Local data is required to improve these estimates and this becomes very involved, we're going to continue with this dataset to see what we can learn.

Skill-Drill: Additional Sea Level Rise Rasters

14. To have a more interesting model, repeat the steps above to produce rasters that show the potential areas of inundation for 2, 5 and 10 meters. Remember one may re-run the raster calculator from the geoprocessing/results window. Your file names should be:
SeaLevelPlusTwoMeter.img
SeaLevelPlusFiveMeter.img
SeaLevelPlusTenMeter.img
And
2minusDEM
5minusDEM
10minusDEM

Walk Through: Creating a land use raster

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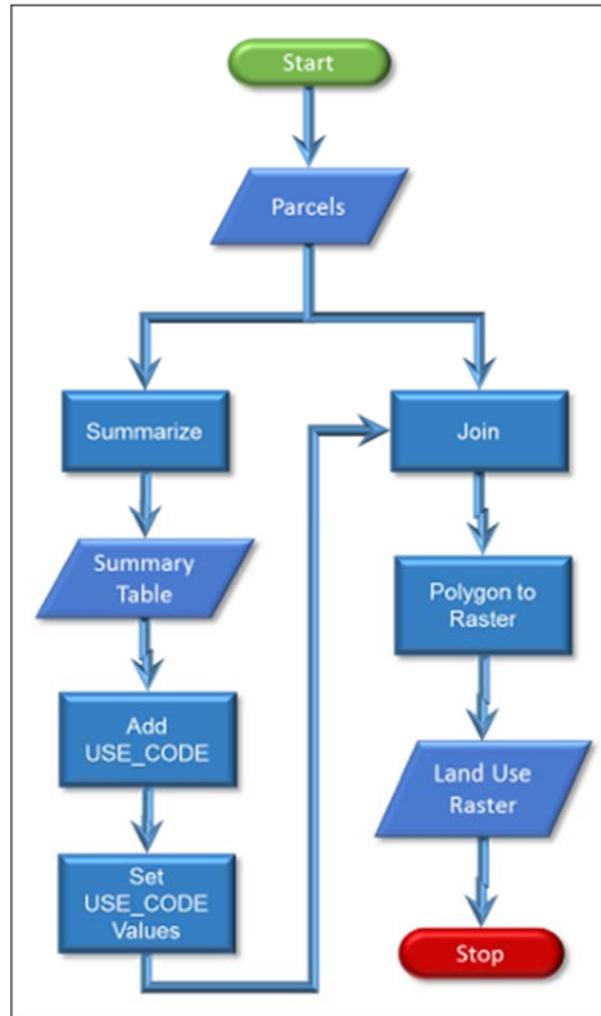
15. To evaluate the impact of sea level rise, we need some data on the various land uses in the Humboldt Bay area. In other words, the impact of sea level rise on a residential area would be very different from an area of range land.

1. Go to the Humboldt County GIS web site and download the "parcel" shapefile or use the parcel file from a different lab.
2. Un-compress, define, and project as needed.
3. Load the data in ArcMap and you'll see that it covers the entire county and contains a number of attributes including the type of land use (column "EXLU4").
4. We can reduce the number of values in the "EXLU4" column to make it easier to use the data so first, "Summarize" the "EXLU4" value into another table.
5. We need to group the large number of categories in the EXLU4 table into a smaller number of categories and convert them to numbers so we can use them in a raster. So, add another integer attribute/field to this the new table, call it "USE_CODE", and give each of the rows an appropriate numeric value as below.

1. City
2. Agriculture: include timber production
3. Residential (all categories of residential)
4. Commercial
5. Industrial: include mining
6. Recreational: include camp, golf courses, open space
7. Tribal
8. Public
9. Other: all others including blanks

You will need to start and end an "Edit" session to type into the attribute columns.

16. The next step is to "Join" the new table back into our original table.



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1. Select the apn table.
2. Select "Join Attributes from a table" in the "Join Data" dialog.
3. Select "EXLU4" as the field for item "1."
4. Select your table as the "table to join to" in item "2" and the "EXLU4" as the field.
5. You don't need to worry about the "Join Options" because all of the records will match. Click "OK"
6. Return to the attribute table for the parcel data and you'll see the new attribute for land use type has been added.

Now we want to convert our polygon land uses to a raster

7. From the Toolbox, select "Conversion Tools -> To Raster -> Polygon to Raster".
8. Select your attribute (USE_CODE) with the new land use types for the "Value field" and give the file an appropriate name, like "apn_raster," that ends with ".img".
9. Specify the "Cellsize" to be the same as our DEM.
10. When you click "OK" a new raster should be added to your map that contains the land use type in each pixel based on the polygons that overlap with the raster. Check the attribute table to see if your new values appear.

Question 3: Zoom in to an area of Arcata and examine the differences between the raster and polygon version of the parcel layers. What impact do you think this difference will have on the analysis?

Question 4: What "Pixel Type" is the new raster?

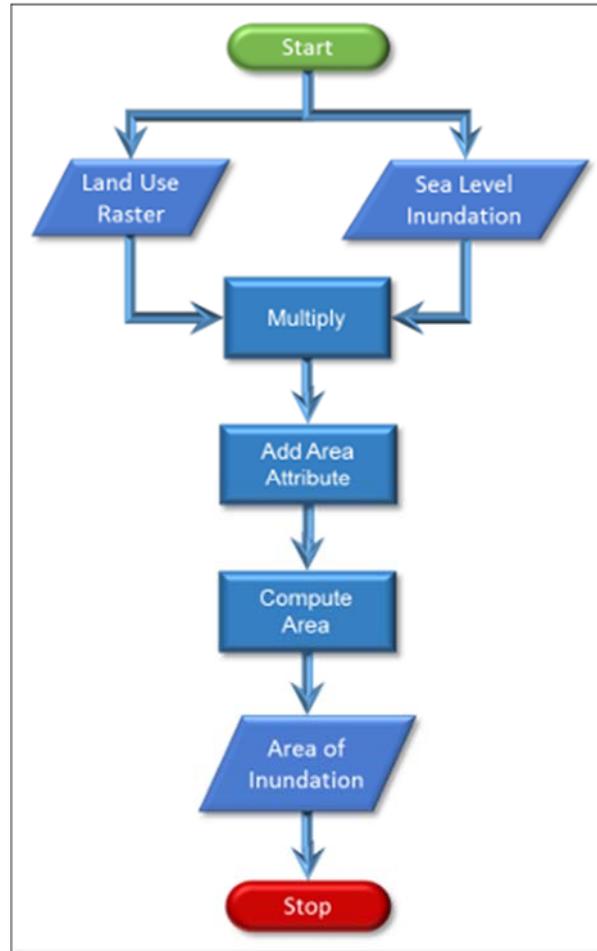
Skill Drill 1: Finding the change in areas of inundation

For the final step, we'll be computing the amount of area of each land use type that could be inundated by different levels of sea rise.

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17. Our sea level rise rasters contain 1s where there will be sea level inundation and 0s (or null values) elsewhere. Because of this, we can just multiply this raster by our land use raster and we'll just have the land uses where there will be inundation by sea water.
18. Examine the new raster and you'll see that it contains non-zero values only where there will be inundation.
19. If you open the attribute table for the new raster, you'll see the "Count" field. This is the number of pixels that contain each land use value.
20. Create a new field in the attribute table for the "Area" of inundation for each land use type and then use Field Calculator to compute the area in hectares. Since a hectare is 100x100 meters (10,000 meters squared), and the pixels are 10x10 meters (100 meters squared), you can just divide the number of pixels by 100.
21. Repeat this for the 5 and 10 meter sea level rise rasters, and one for 1 meter sea level drop. Your file names should be something like, landuse_inundated_2m.img, landuse_inundated_5m.img, and landuse_inundated_10m.img
22. Create a table that shows the hectares of land that could be inundated by different levels of sea rise.



Question 5: What happened when you tried to model a sea level drop? (Hint: how was the data in the DEM collected?)

Question 6: What type of data would we need to model a drop in sea level?

Walk Through: Creating an inundation risk map

We also want to create a map that shows the various levels of sea rise.

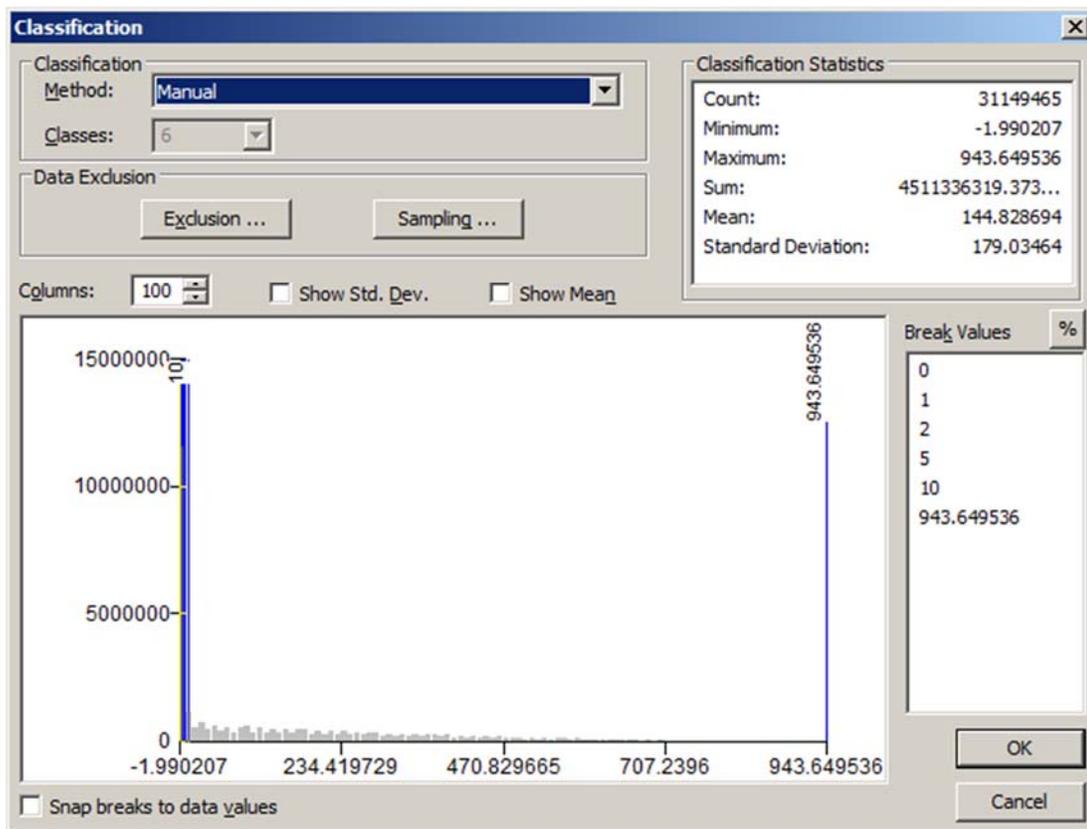
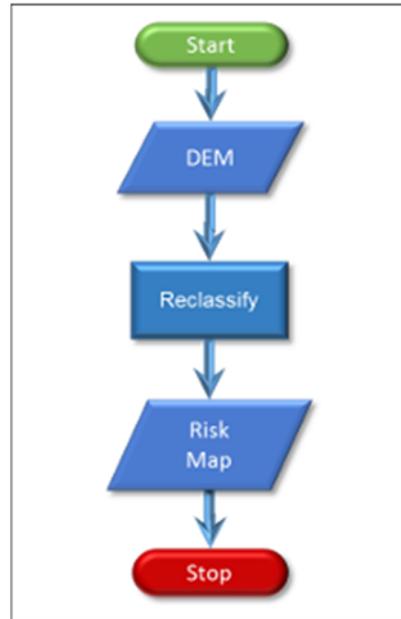
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23. In the toolbox, select "Spatial Analyst → Reclass → Reclassify." This is a tool that lets you change the values in a raster based on ranges of values or individual values.
24. Select your original "DEM_Clipped" raster for the "Input raster."
25. For multi-band rasters, you'll need to select a "Reclass field" but since this raster only contains one band, you don't need to change this setting.
26. Click on the "Classify..." button
27. In the dialog that appears, select "6" for the number of "Classes."
28. Select "Manual" for the method as we want to specify our own ranges of values.

For some reason, once you select "Manual," you cannot change the number of "classes" so you have to change this value first.

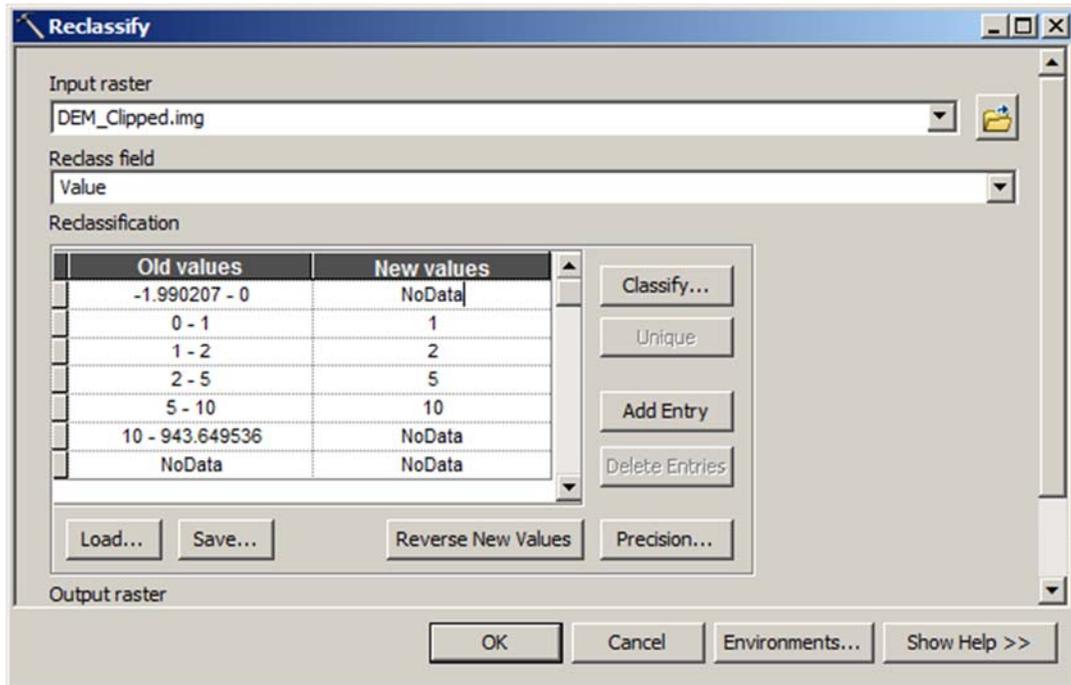
29. Click on each of the "Break Values" on the lower right and enter the values 0, 1, 2, 5, and 10 as below. Leave the last value as the maximum value in the raster or you will receive an error.



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30. Click "OK" and you'll see the "Break Values" appear as in the "Old values" column. This shows that the "old values" in your "Input raster" will be "reclassified" to the "New values" on the right of the "Reclassification" box.
31. Click on the "New value" for the first row and change it to "NoData". This will make the pixels at or below sea level transparent.
32. Do the same with the other "New values" so they match the image below. Give this dataset a name like "DEM_reclass.img." When you click "OK" you should see a new raster appear that has separate sections of pixels for each of the potential levels of sea rise.



33. Click on the colored boxes next to each different entry to give it an appropriate color. You might make the pixels that are within 1 meter of sea level red to show they are at greater risk and those at 10 meter green to show less risk. You'll also want to change the numbers to appropriate text for your legend.

Reference the Supplemental Learning Module to [Create a Hillshade as a Background](#) for this lab.

Deliverables: A short report that includes your results from the exercises:

- Turn in your answers to the 6 questions.
- Include a shaded relief map that gives the user an ideal of the topography around Humboldt Bay.
- Include maps showing the potential impact of at least two sea level rise distances, and sea level fall of 1 meter around the bay.
- Include a table that shows the area of different land use types impacted by different levels of sea rise.

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- Remember that this is a hypothetical study and include some verbiage in your report that mentions the results have uncertainty and should not be used to make immediate decisions (other than reducing our use of fossil fuels!).

Make sure all the text in your maps is readable and above 9 point. You do not need to include your name or the data in the map as your name and the date will be on the overall document. You can also move the information on spatial reference and data sources to the caption to simplify the map. Also remember to define all acronyms before using them and spell check your document before turning it in. We will begin deducting more points if these items are not addressed in this and future labs.