COA 690 / 790 GIS in Marine Science
Lab 7
Instructor: Wei Wu
Due date: 4/3/2017

We are going to work with raster data analysis and practice the spatial operations we have learned on Tuesday.

What you need to turn in is three maps described in Exercises 4 and 5.

1. Projecting raster data

Open the **Map Document**, **Rasters.mxd**, by ***Double-Clicking*** on it.
In the **Table of Contents**, ***Right-Click*** on the **ned_91749882 Layer** and ***Open*** its **Properties**.
Click on the **Source Tab** and ***Scroll Down*** to examine the **Spatial Reference Information**.

Note that this dataset is currently using the Geographic Coordinate System (Lat/Lon) and the North American Datum 1983. We want to project this data to another Projection/Coordinate System.

Close the **Layer Properties Dialog.**
Click on the **Search Tab** on the right of ArcMap and ***Search*** on the term "**Project Raster**".
Click on the **Project Raster** tool to ***Open*** it.
Select the **ned_91749882 Layer** as the **Input Raster.**
Browse to the folder where you want to save the data and ***Save*** the **Output Raster** as "**Elevation**".
Click the symbol for Output Coordinate System, expand "Layers", and select "NAD_1983_UTM_Zone_18N".
Click **Ok** twice to ***Apply*** the **UTM Projection** to the **ned_91749882 Layer.**
The resulting **elevation Layer** in UTM projection will be added to your map document.

2. Clipping a raster dataset to a vector layer

Raster datasets can be very large, and consequently, calculations based upon those datasets can be quite processor intensive. To minimize the processing time needed to work with raster data, as with all data formats, it is always desirable to subset to only the area of direct interest.

Return to the **Search Tab** and ***Search*** on the term "**clip**".
Click on the **Clip** from the **Data Management Tool** to ***Open*** it.
Select the **elevation Layer** as the **Input Raster**.
For the **Output Extent**, ***Select*** the **Study_Area_polygon.shp** layer.
Save the **Output Raster Dataset** as **elev_clip** (be sure you remove any file extension, which determines the type of raster dataset).
Click **Ok** to ***Apply*** the **Clip**.

3. Creating isometric contours from raster data

One of the more familiar ways of depicting elevation is with the use on isometric contour lines. They are the concentric lines visible on USGS Topographic maps that visually indicate changing elevation. These lines can likewise be applied to any raster data, and where appropriate can create striking visual representations of changing values in the variable of interest. Here you will create contours based upon the elev_clip dataset.

Click **Search Tab** and ***Search*** on the term "**Contours**".
Click on the **Contour** from the **Spatial Analyst Tool**, to ***Open*** it.
Select the **elev_clip Layer** as the **Input Raster**.
Name the **Output Polyline Features** '**contour_5m**' and ***Save*** it to the **\Shapefile**\ folder**.**
Set the **Contour Interval** to **5** (this will create 5 meter contours).
Click **Ok** to create the **contour_5m Layer**.
Close ArcMap.

4. **DEM filtering, and updating**

We often obtain DEM data with various errors, a cell size different that we wish to have, or at different resolutions for different parts of our study areas. We may use raster operations, or functions, to improve our DEM data.
Here we will mosaic data of two different resolutions. We often have data from various sources, for example, DEMs at approximately 10 m resolution have been developed for nearly all of the lower 48 US states. In addition, higher resolution DEMs are currently under production, typically 1 to 3 m, for many portions of the US. We may have part of our study area in each of these zones. Our first task here will be combining two DEMs, *Valley3*, at 3 meter resolution (cell size), and *Valley9*, with a 9 meter resolution. We want to use the higher resolution data where we have it, but use the lower resolution data elsewhere.

Start ArcMap and add both data sets: Valley3 and Valley9.
Calculate the hillshade for both data sets (**Spatial Analyst – Surface – Hillshade**).
Inspect these hillshades carefully, and note the enhanced detail with the 3 meter DEM. Note the greater definition of the small streams and streambanks.
Remove the two hillshades from the data view to reduce clutter.
We can use the **Spatial Analyst – Raster Calculator** to join these two data sets. Note that we want to use the *Valley3* data where we have it, and the *Valley9* data everywhere else.
Our first step is to convert the 9 meter data to a 3 meter cell size. This does not make the 9 meter data better, but in ArcMap, and in most GISs, we must have all data at the same cell size. Basically, we are making copies of the data to create a finer resolution.
The simplest way is to resample the *Valley9* DEM.
Use **ArcToolBox – Data Management Tools – Raster – Raster Processing - Resample**
In the resultant window, specify the *Valley9* as input, an output file, a 3 meter cell size, and a bilinear resampling.
After the resampling is done, load the new data set, and verify that it has a 3 meter resolution.
We can now combine the two data sets.

Although there are many ways to do this, perhaps one of the simplest is with clever use of two raster functions – IsNull and Con. We talked about these in class, but in short, the IsNull returns True whenever a cell comparison or value is Null. The con function takes three values, the first is a true/false test, and second is the value to assign to a grid if the test is true, and the second is the value to assign if the test is false.

Open Spatial Analyst – Map Algebra – Raster Calculator. We can nest these functions using "raster calculator:

Con(IsNull([valley3]),[valley9_3],[valley3])

This function first applies the test, is the cell of *Valley3* equal to Null? This is true everywhere in our study area outside the data region of *Valley3*. When the value is Null, the con function assigns the value found in *Valley9_to3* to the cell in the output data set. When the value is not Null, the con function assigns the value found in *Valley3*.

Look at the combined data that comes from this calculation. Compute and inspect the hillshade, and verify that it has the higher detail contributed by the *Valley3* data set.

We'd now like to introduce filtering as a tool to fix "noisy" data. This is often used with interpolated surfaces, particularly LiDAR data, and similar tools are used near edges for mosaiced DEMs and other continuous surfaces.

Load the DEM named Shasta. Calculate the slope (**Spatial Analyst – Surface – Slope**). Pick either percent or degrees.
Examine the slope surface. Notice the "speckled" appearance in the northwest and southeast, flatter portions of the DEM.
Now calculate a hillshade surface for the Shasta DEM. Leave the Azimuth as is, set the Altitude to 25, and check the model shadows box.
Again, inspect this, and notice the funny artifacts, in the locations of the anomalous slopes. These are both data "spikes," white points with a long thin shadow trailing to the southeast, or "pits," dark areas on the northwest with a white "edge" on the southeast.
How do we remove these?

As we have talked in class, we may use a low-pass filter to identify and get rid of this speckle. We may apply a low-pass filter with the **ArcToolBox – Spatial Analyst – Neighborhood – Filter** command.
Specify the Shasta DEM as the input, and a filter type of LOW, and specify an output name, like *lowpass*.
Run the filter, and inspect the output. It is probably easiest to see the effects by calculating the hillshade of the output, and looking at the areas that have spikes and pits. The result shows the reduction in the size of the spikes and pits, although they are still visible.
We could stop here, and just accept the filtered data layer. But if we look carefully at the filtered and unfiltered hillshade, we'll see we pay a cost for filtering. We lose some of the fine detail, apparent in the image of the unfiltered hillshade compared to the filtered hillshade.
We'd like to keep both, and we can.
First we should subtract the filtered layer from the original Shasta layer. Hint: use the Raster Calculator then make the data layer permanent by right clicking "Calculation", then Data -> Make Permanent, naming it *Difference*.

We can then only replace the cells where the difference is large. Here, large is a relative term, but after a few trials, and looking at the difference histogram, a threshold of about 15 works fairly well.
We want to replace the cells in the Shasta image when they are more than 15 meters different from the filtered surface. Otherwise, we leave the Shasta surface alone, and hence, we don't get any of the degradation in detail in otherwise good data.
We can open the Spatial Analyst – Raster Calculator, and apply the following function:

Con(Abs([difference]) > 15,[lowpass],[Shasta])

If the absolute value of the difference is greater than 15, we write the filtered value to the output. Otherwise, we write the original data value.
Make the resulting calculation permanent, name it *smoothed*.
We can verify that this is helpful by viewing the hillshade of the output raster, and comparing it to the original, and the filtered surfaces. Note that we have removed most of the speckle, but maintained the detail.

We could apply the filter successively, and average the local points further, and apply the con function to a difference layer again.

You need to turn in the map of the shaded relief (that is the *hillshade_of_smoothed*): making it semi-transparent (50%) over the *smoothed* elevation data. Make sure you model shadows in the shaded relief surface (points will be deducted if you do not – we need it to evaluate how well you've applied the filtering). Add a legend, name, north arrow, title, and scalebar.

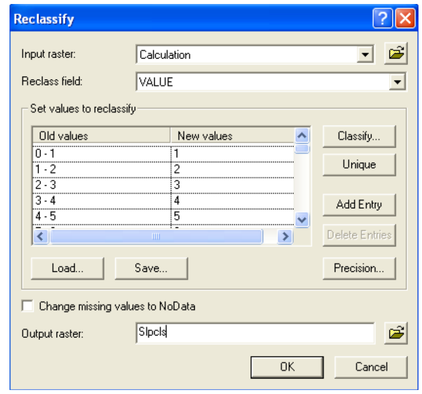
Close ArcMap.

5. **A Cost Surface**

We will create a cost surface for locating a building. Our cost surface will depend on slope and distance to existing roads. In our problem, we will assign a road construction cost of $25 per meter of road required. We have a vector data layer of roads, digitized from USGS maps, and we will use grid functions to convert this to a cost data layer.
Slope also affects access costs, because roads on steeper terrain are more expensive. The cost is nonlinear, increasing slowly at first for low slopes, then more rapidly at steeper slopes. We will derive slope from a DEM data layer. To reflect the nonlinearity in slope costs, we will apply the trigonometric sine function to model this increase in cost. We will then add these two cost layers. Finally, we wish to apply an upper threshold of $5,000 to consider only those areas that are within our budget.

Start ArcMap.
Create a new map project, add the raster ***mardem*** to the view, and inspect it.
Inspect the layer **Properties**. What are the units of the elevation? What are the highest and lowest elevation values? Does it make sense?
Derive the slope for *mardem***.** *S*elect **Spatial Analyst – Surface – Slope**. Specify degrees units for slope. Name the output file *mar_slope*.
To keep the view uncluttered, remove the *mardem* grid from the map.

Examine the slope layer. This should be values from 0 to about 33 degrees.
Select Spatial Analyst – **Reclass - Relassify.**
The Old values to New values list should reflect the reclassification of using an interval width of 1 for the old values, as illustrated in the figure on the right.



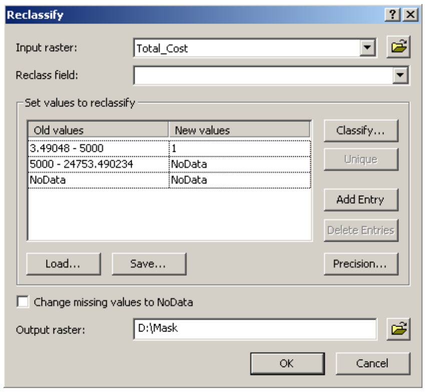
Also note that you can save this reclassification table, for example, if you wish to use it again in the future, and you can load saved tables.
Also note you can specify how missing data are assigned, and you must specify the name and optionally the directory of your output file.
Name the output grid something like *Slpcls*.
Now remove the original slope layer, it just clutters your display.

Next we will apply a formula that determines the cost of building on slopes.
Left click on **Spatial Analyst – Map Algebra – Raster Calculator**
Type the following function into the center window: Sin(slpcls/57.2958) * 200.
Note that it is better to use the calculator buttons than to type the equation using the keyboard – generally, you'll see fewer syntax errors.
Name the output *Slope_Cost*, left click on OK.
Verify the cost layer makes sense, and that they are highest where slopes are steep.

Next, we need to display and generate our distance costs from the roads layer.
Add the *Mar_rd83.shp* file.
Left click **Spatial Analyst – Distance – Euclidean distance**.
Select *Mar_rd83* as the source data. Set the cell size to 30 and store output with a name *Distance*.
Examine the result layer, and make sure it is reasonable.
Now, multiply the distance layer you just produced by the cost per unit distance to estimate distance cost.
Left click **Spatial Analyst – Map Algebra – Raster Calculator** and enter the equation: [Distance]*25, name the output *Dist_Cost*, then left click **OK**. If all goes well you will get an additional layer named *Calculation*.

Our next step is to combine the two sets of costs. Open the Raster map calculator again, and add the two cost layers: [Dist_Cost]+[Slope_Cost].
This should result in our new layer, name it *Total_Cost*.
Examine the *Total_Cost* layer and make sure it makes sense.
Think a minute about what you've just done. You first calculated a slope, and then a cost associated with building a road per unit distance across the slope. Then you calculated a distance, and then a cost associated with building a road to that distance from an existing road. Both of these were calculated for every grid cell in your study area. You then added these two together for an estimated total cost to build a road to any portion of the mapped area. A real problem would include many other factors, like soils, surface vegetation, slope constraints over minimum segments, etc., but this would only lengthen the analysis, and not change the basic way you are applying the tools.

Our job now is to select those areas below the $5,000 threshold. We will do this by creating a mask grid. This grid will have 1 at all locations where the costs are below $5000, and 0 where the costs are above $5,000. We will then multiply this with our total cost grid, to zero out those areas we don't wish to consider.

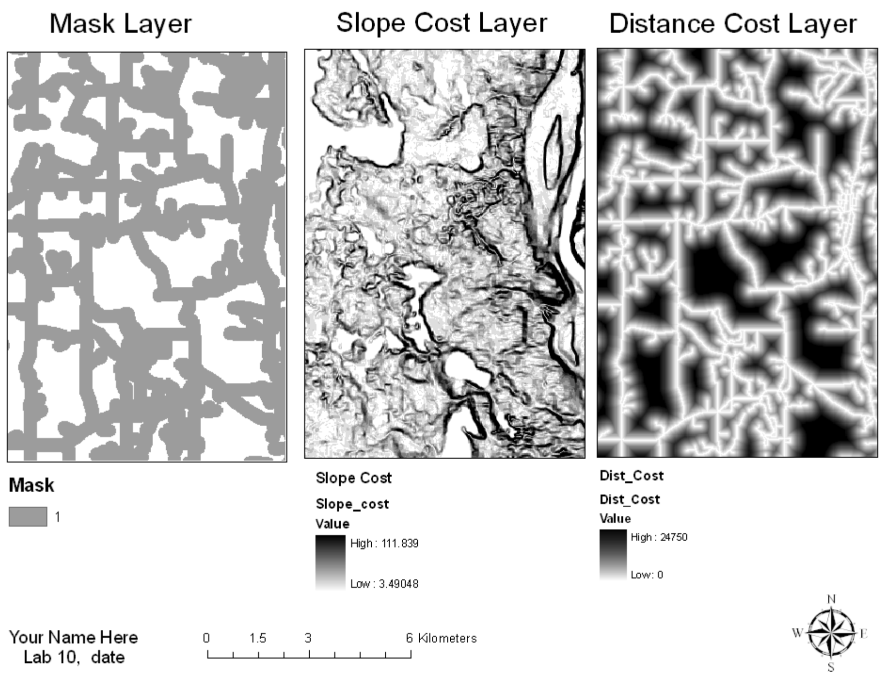


Reclassify Total_Cost by **Spatial Analyst – Reclass – Reclassify**.
The reclassification table is shown at right.
Make sure you have NoData for the New value of the 5000 to 24753.49024 category.
Make sure you specify the output raster name, here shown as *Mask*.
Multiply the Total Cost raster by the Mask raster using **Raster Calculator** and name the output *Final_Cost*.

You need to hand in the map: Display the *Final Cost* layer in your data view. Add the roads layer, *mar_83.shp*, and create a layout with appropriate legend, titles, name, north arrow, etc.

You also need to hand in the map: Create a composite layout with three separate data frames on the same layout, with 1) a data frame with the *mask* layer, 2) another data frame (Insert -> Data Frame) with the *slope_costs* layer, and 3) a data frame with the *dist_cost* layer. Color the mask as gray and white, and color the distance and slopes costs as graduated colors, with a gray monochromatic color set. Include the appropriate legend for each map. An example is shown as below.

Title



Acknowledgement

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