Lab Report

Title: Lab 2
Notice: Dr. Bryan Runck
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Date: Oct 27, 2021

Project Repository: https://github.com/cavaz020/GIS5571/
Google Drive Link: N/a
Time Spent: 15 hrs

Abstract

The problem being addressed in this report was to create a cost surface and to find an optimal path between Dory's location from her farm to her fly fishing spot in Whitewater State Park. I was given the coordinates of the starting point and the location of her destination of which I mapped and found the coordinates. I was also given conditions that dictate Dory's preferred path and these conditions dictated which data I decided to use. Because she only mentioned preferences for not walking in water or farms and a preference for the most gradual path in terms of slope, I only included a Landcover layer and a DEM layer. I cropped these layers to the area of interest for faster manipulation. I created a slope raster of the DEM and then conducted a rescale of the slope. I reclassified the landcover data. I created a cost layer based on the slope and reclassified landcover data. Finally, I created an optimal path based on the points and on the cost raster. I tried some variations on the process to see other possible resulting paths.

Problem Statement

The tasks within this report were to create an ETL for data to go into a cost surface model, to create a cost surface model, and then to justify how Icreated the cost surface. Then, the main question I am trying to answer is: what is the optimal route for Dory to take to get to her fly fishing spot near Whitewater State Park in SE Minnesota?

Table 1. Qualitative elements for the analysis.

#	Requirement	Defined As	(Spatial) Data	Attribute Data	Dataset	Preparation
1	NAIP Imagery via Earth Explorer	National Agriculture Imagery Program (NAIP) captures this aerial imagery during the agricultural growing seasons in the continental United States. NAIP imagery is acquired at a one-meter ground sample distance.	N/a	N/a	N/a	Added to a mosaic
2	MN Geospatial Commons	National Land Cover Database (NLCD) released by the U.S. Geological Survey (USGS).	NLCD Landcover Data (2016)	Focused on avoiding both 'bodies of water' (class 11) and 'cultivated crops' (class 82)	Landcover Shapefile	Clipped to the study area (NAIP files)

3	County DEMs	DEMs for the counties involved in the focus area	DEMs Wabasha County, Winona County and Olmstead County	1 meter DEMs		Clipped to the study area (NAIP files)
4	Conditions for Dory's Path	Dory prefers to not walk through any farm fields because they can be muddy in the spring. She also doesn't like crossing water bodies if there isn't a bridge, though sometimes she doesn't mind if she's wearing her waders. Other than that, she just wants to take the path that is the most gradual in terms of slope.	N/a	N/a	N/a	These conditions dictated which datasets I incorporated.

Input Data

This data is what I input for this project. I was given the coordinates of the start point and the location of the end point and I created a point feature layer based on their coordinates. The NAIP imagery was more just for visualization and for clipping the other layers.

Table 2. Data used in this cost surface modeling work.

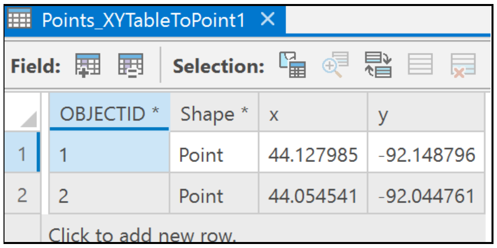
#	Title	Purpose in Analysis	Link to Source
1	Points of interest	The points are useful in creating the optimal path (start and end points).	N/a (point coordinates from the instructions)
2	NAIP Imagery	Images I got from Earth Explorer that I mosaiced to create a rough study area.	Earth Explorer
3	LiDAR Data	Data from the three counties within the rectangular study area	MNDNR FTP (Counties>Wabasha, Winona and Olmstead)
4	Landcover Dataset of MN	National Land Cover Database data released in 2016 of Minnesota	Landcover Shapefile

Methods

Points

First, I created the two points by creating a table with the coordinates of each point and then using the 'XY Table to Point' tool via arcpy.

Image 1. Attribute table of the two points of interest.



Points_XYTableToPoint1

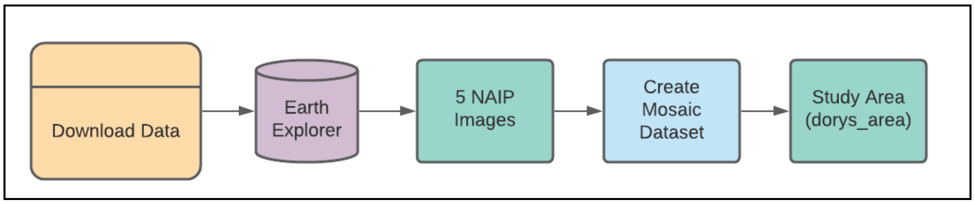
Field: Selection:

	OBJECTID *	Shape *	x	y
1	1	Point	44.127985	-92.148796
2	2	Point	44.054541	-92.044761

Click to add new row.

Study Area

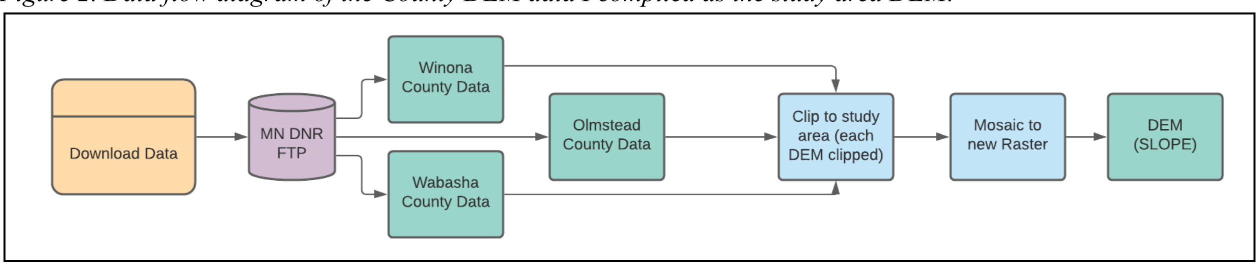
Figure 1. Data flow diagram of the NAIP Imagery I compiled as the study area.



I downloaded NAIP imagery from Earth Explorer based on the coordinates of the start and end points. I entered the two location coordinates to ensure that the imagery I downloaded was encompassing the entire area of interest. I then added the five NAIP raster files to the geodatabase and used the ‘Create Mosaic Dataset’ tool and then I used the ‘Add Rasters to Mosaic Dataset’ tool to join all of the rasters into one layer.

Elevation Data: Preprocessing

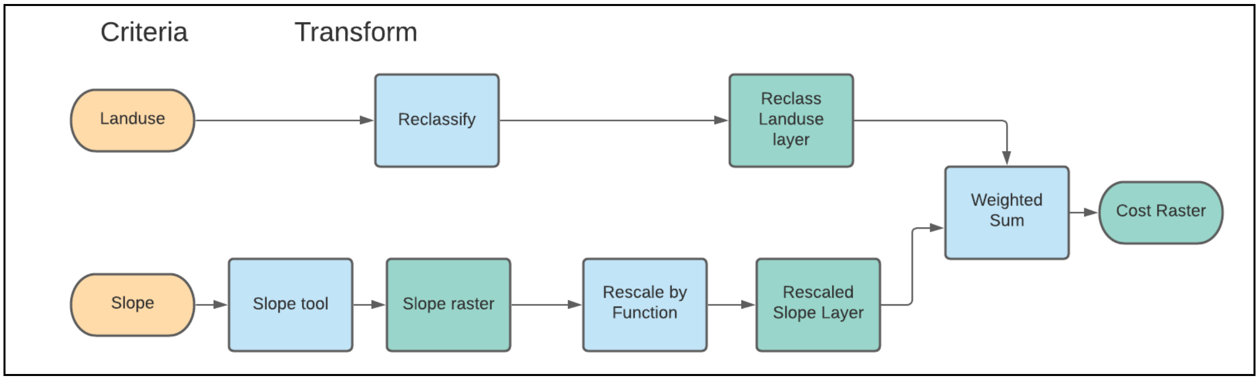
Figure 2. Data flow diagram of the County DEM data I compiled as the study area DEM.



Using the study area, I clipped the rest of my data so that I wouldn’t be wasting any time looking at much outside of my focus area. For the elevation data of the area, I downloaded DEMs from the three counties encompassing the two points (start and end point) from the MNDNR FTP. The three counties that were involved in the study area were Wabasha County, Winona County and Olmstead County. I then clipped each of these rasters to the study area. Finally, I used the ‘Mosaic to new Raster’ tool via arcpy to meld them into one, contiguous DEM encompassing the study area.

Elevation Data: Creating Cost Raster

Figure 3. Data flow diagram of the process leading to creating a cost raster.



Within the conditions, it is stated that Dory, “just wants to take the path that is the most gradual in terms of slope”. Going off of this information, I decided to use the slope tool via arcpy and create a raster layer of the slope in the area. I decided to use **‘Percent rise’ in the output measurement** because it groups the slope into 0-100 which sounded like a good way to summarize the slope versus having an output of degrees of the slope. I also was trying to decide between **geodesic and planar for ‘Method’** but ultimately landed on ‘planar’. These are some entries that could be switched up to test out how they affect the creation of different outcomes for the final path.

Image 2. DEM layer and using the Slope tool.

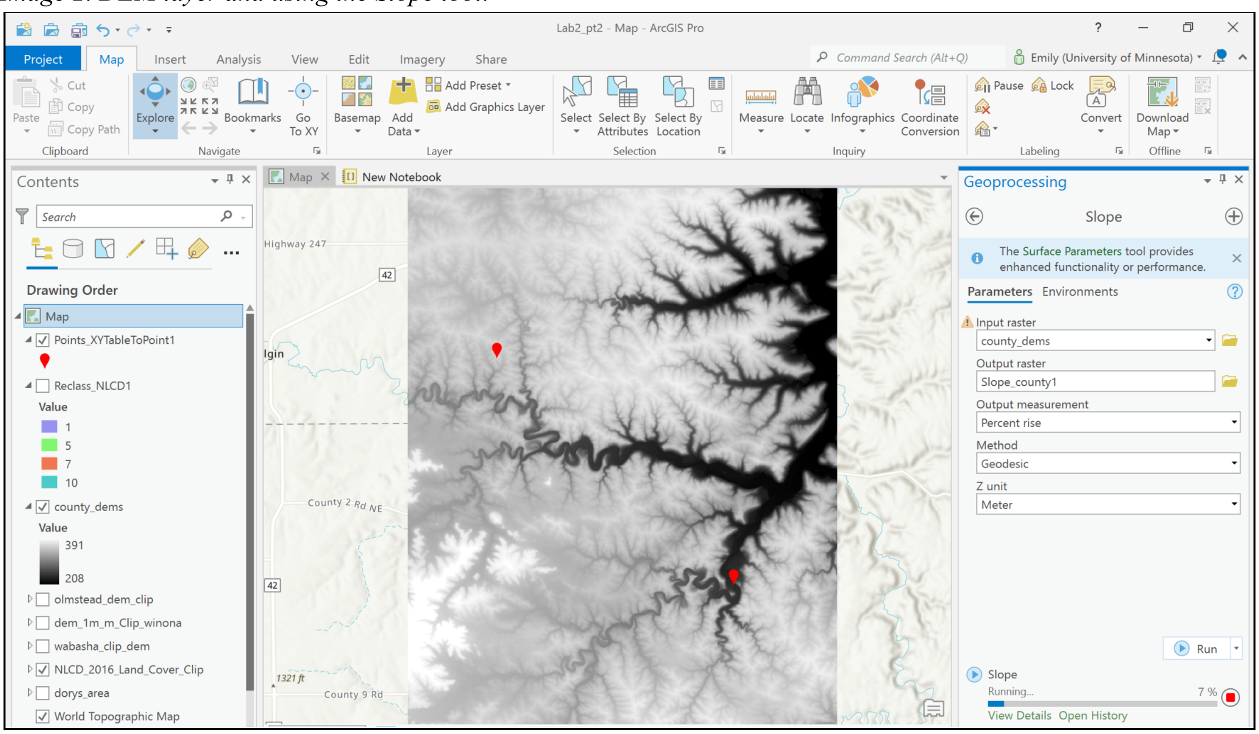
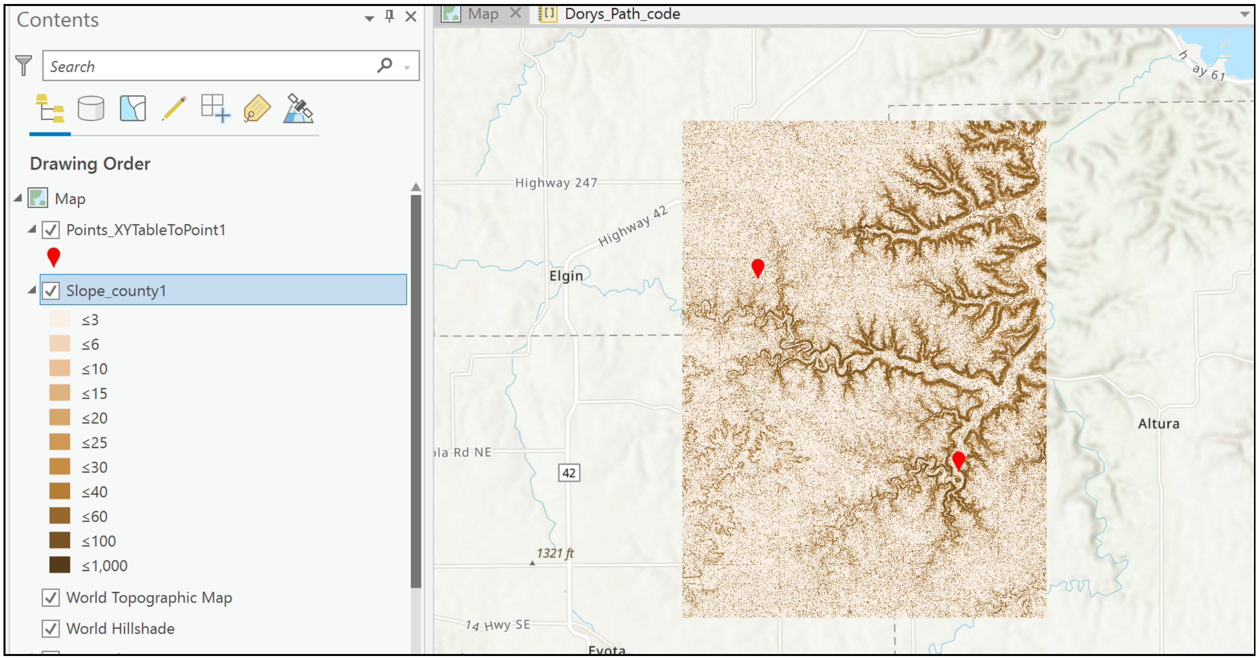
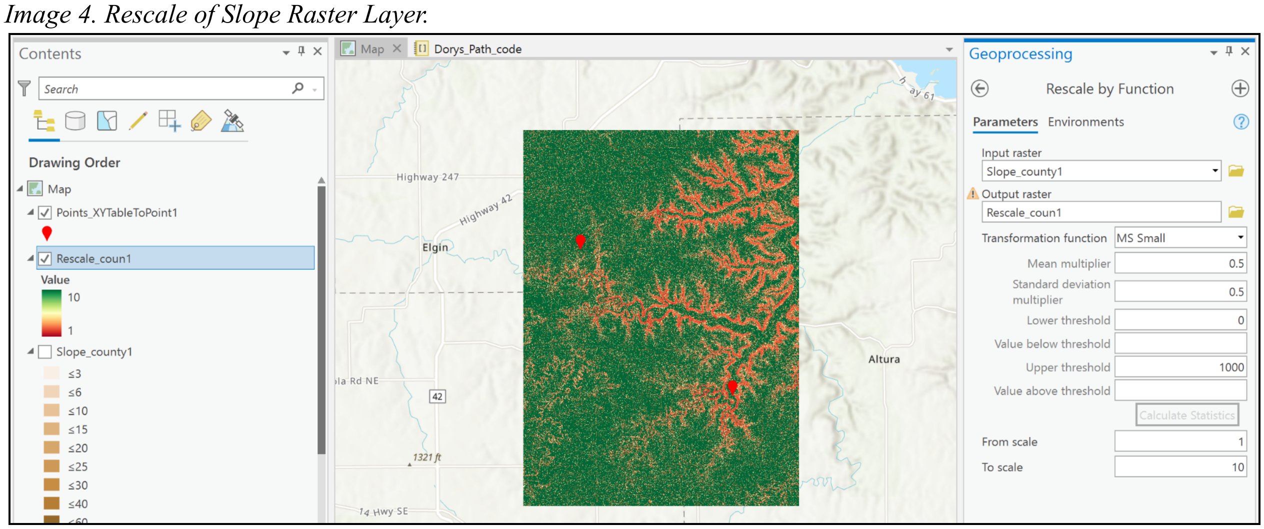


Image 3. Resulting slope raster layer.



The final step of creating an elevation layer to be added to the cost surface involved using the 'Rescale by Function' tool. I used **0.5 for the Mean multiplier and for the Standard deviation multiplier**. I changed the lower and upper thresholds to 0 and 1000, respectively, to encompass all of the values in the slope raster layer. This might be something to fine tune in future studies.

Image 4. Rescale of Slope Raster Layer.



Land Use Data

As I stated earlier, using the study area, I clipped the rest of my data so that I wouldn't be wasting any time looking at much outside of my focus area. This also applied to the Landcover layer. The conditions stated that, "Dory prefers to not walk through any farm fields because they can be muddy in the spring. She also doesn't like crossing water bodies if there isn't a bridge, though sometimes she doesn't mind if she's wearing her waders". These conditions dictated how I reclassified the land cover data. I used the Reclassify tool to do so. I put in a 7 for the bodies of water (class 11) because the condition said she could possibly go through water but I thought it would be harder to walk through bodies of water just because they might be deep. Alternatively, I put in a 5 for the wetland categories because she could still walk through those areas easier than bodies of water. I put a 1 for all of the urban, forest and grass classes and a 10 for the cultivated crops layer and the layer meant for grazing cattle since she doesn't want to walk through 'farm fields'. **These reclassifications** could be switched up a lot and could create varied results for the cost surfaces.

Image 5. Reclassifying Land Cover Classes.

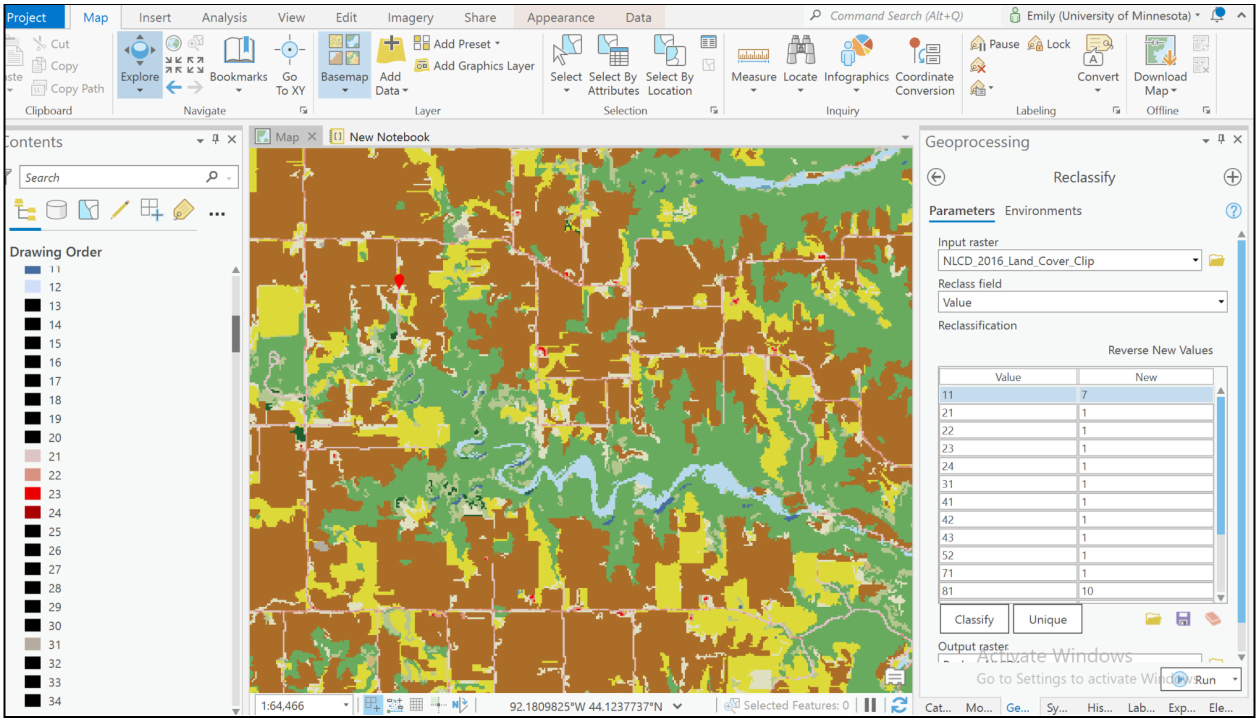
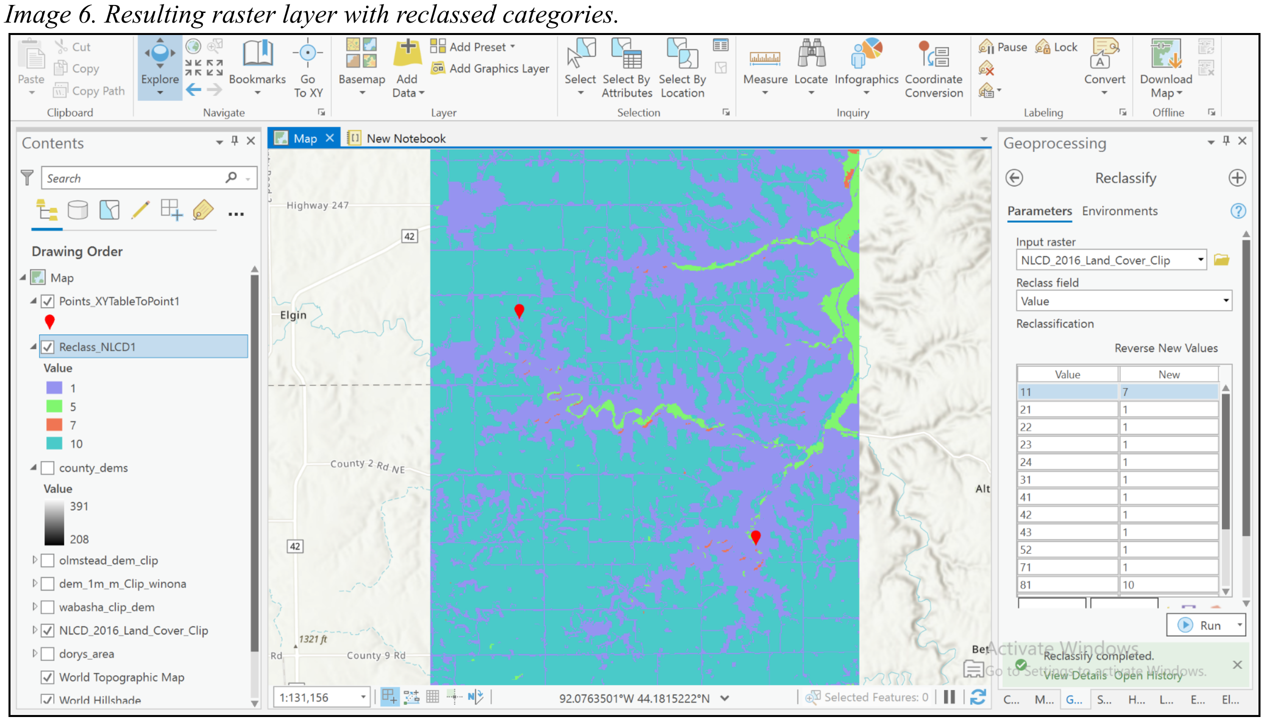
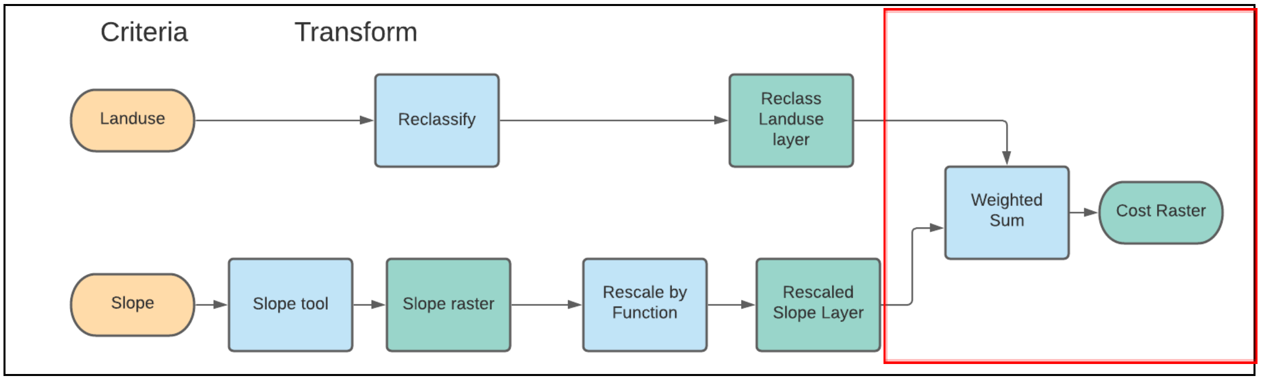


Image 6. Resulting raster layer with reclassed categories.



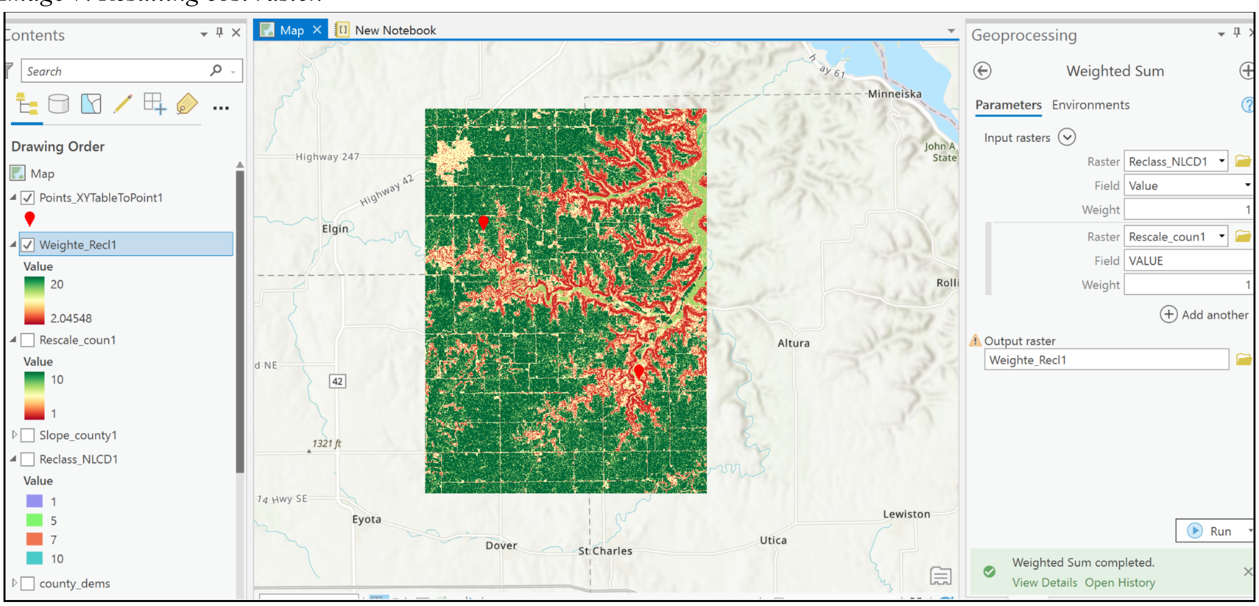
Cost Raster

Figure 5. Data flow diagram of the creation of a cost raster focused on the final steps.



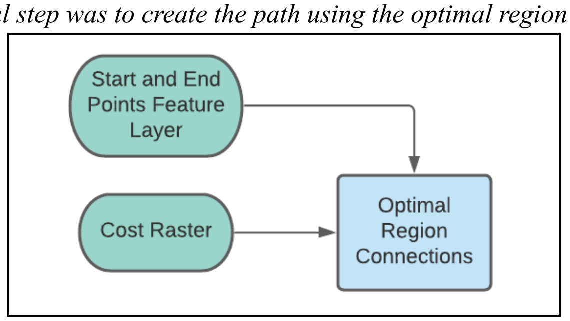
I created a cost raster based on the two layers of interest - landcover and slope. I weighted each layer equally. This is something that could be changed in future studies to possibly alter the outcome of the final path.

Image 7. Resulting cost raster.



Optimal Connection

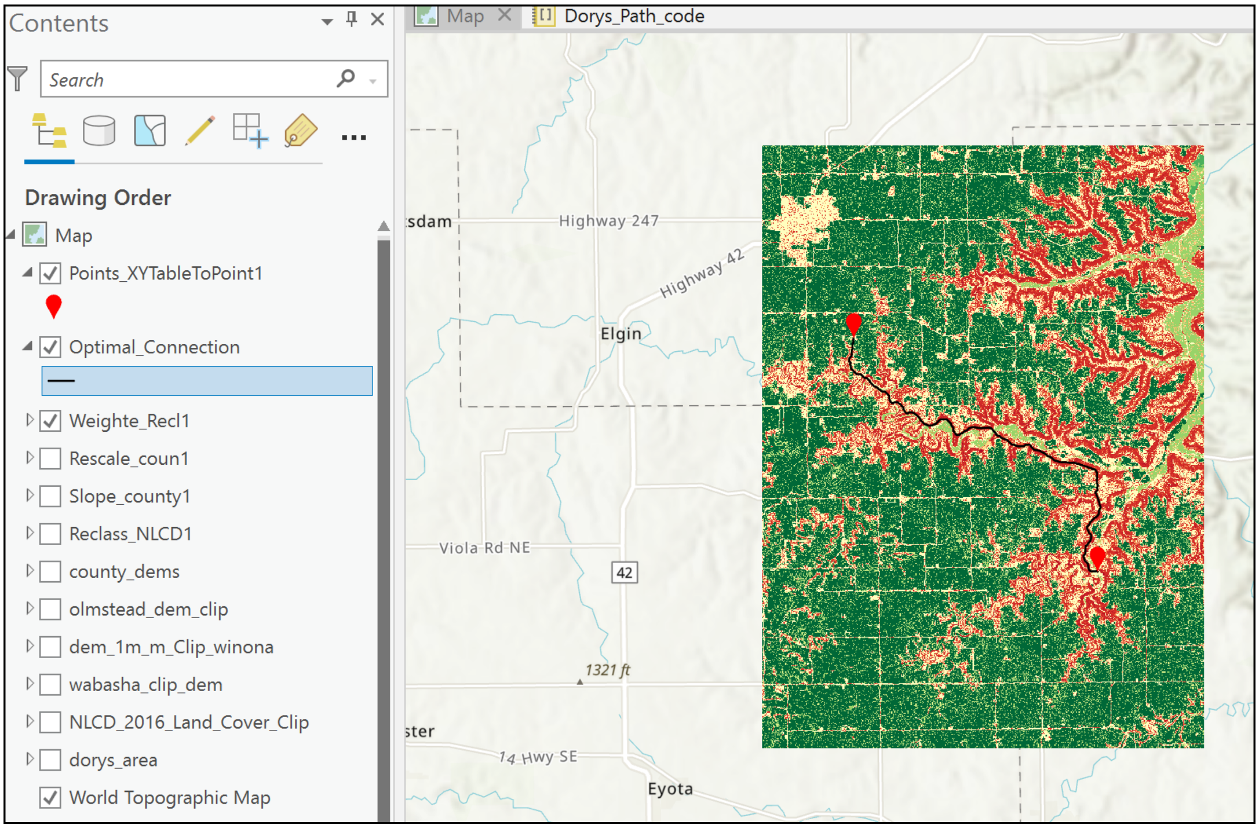
Figure 6. The final step was to create the path using the optimal region connections tool.



I used the 'Optimal Region Connections' tool via arcpy as there is a start region and an end region between which Dory often travels. The required inputs are the start and end regions and the cost raster created previously.

Results
All of this work produced a path that Dory could take to go fishing and then back home. I tried out different variations and they did not result in a line that looked viable for various reasons. This line looked viable because it wasn't just straight across (bird's-eye path) and it avoided a lot of the farmland which, in the picture below, is located in the dark green areas.

Image 8. The resulting optimal path.



Results Verification
The results verification is difficult for this task because some of the inputs are up to the user or the creator of the cost raster. I tried out some other variations as pictured below.

When I change the cost of bodies of water up to 10 rather than having them as a 7, the line that is output is very similar if not exactly the same. To me, this means that the route I chose is already ideal enough that the change in cost doesn't affect the result.

Image 9. Reclassification with bodies of water as a 10 (high cost) rather than what I used (7).

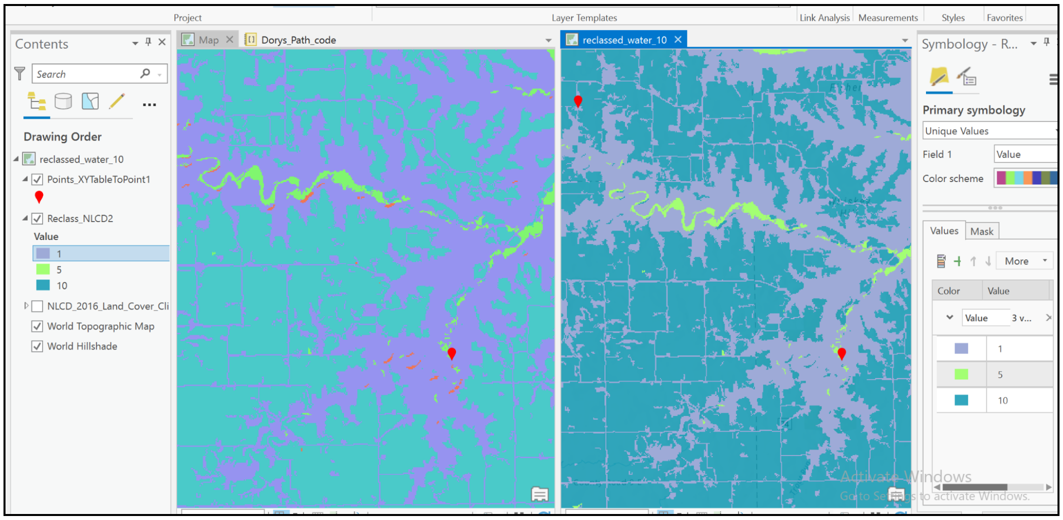
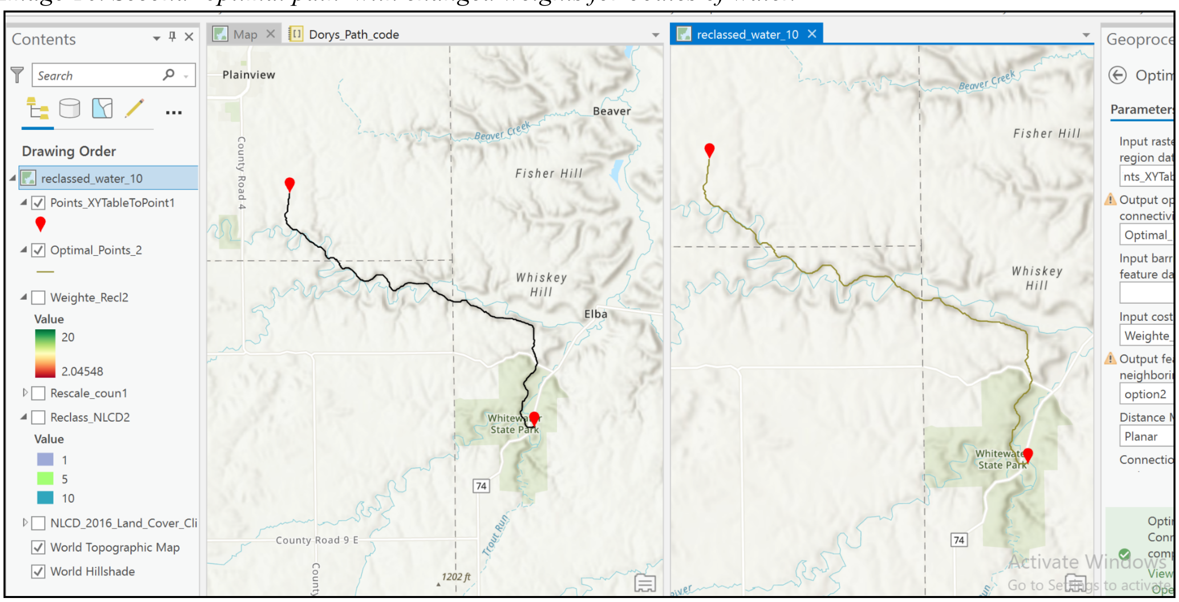
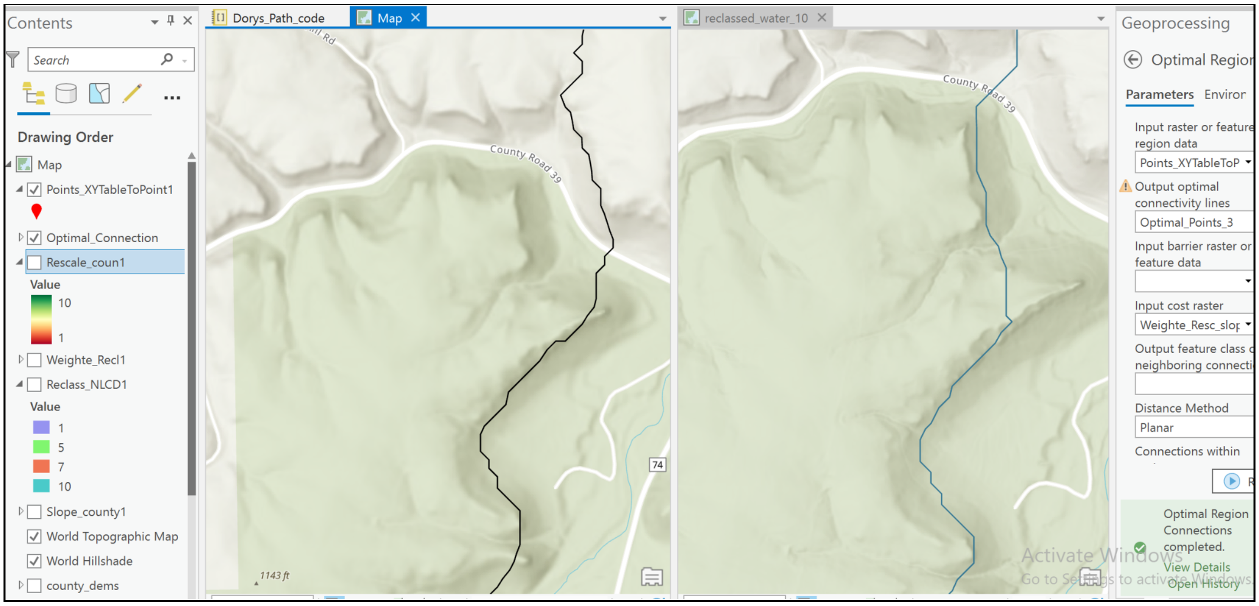


Image 10. Second 'optimal path' with changed weights for bodies of water.



I also tried to change calculating slope differently. This didn't make a huge difference but it seemed to me like the line I chose where I calculated slope using percent rise was a bit more complicated (more curves) and to me that made me think it was more accurate and detailed.

Image 11. Zoom in on curve of third 'optimal path' with slope calculated using 'degree' rather than percent rise.



Discussion and Conclusion

I learned how to create a cost raster and how to create an optimal path based on my input for each layer. I thought this part of the lab was a lot more fun than the previous part and I wished that I had had more time to focus on it and not rush it because I had been using up all my time on the space time cube. I also think that this part of the lab is a lot more applicable in the real world or for purposes that I could see myself working on. This analysis seems to be something that most GIS technicians will have to produce at some point in their career. I also learned that there are a lot of ambiguous points that may affect the outcome as I have stated throughout the report. However, if the project is more strenuous or has more conditions that must be met, these ambiguous points may be solidified.

References

1. "Mosaic To New Raster—Help | ArcGIS for Desktop." n.d. Accessed October 27, 2021. https://desktop.arcgis.com/en/arcmap/10.3/tools/data-management-toolbox/mosaic-to-new-raster.htm.
2. "Slope (Spatial Analyst)—ArcGIS Pro | Documentation." n.d. Accessed October 27, 2021. https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/slope.htm.
3. "Add Rasters To Mosaic Dataset (Data Management)—ArcGIS Pro | Documentation." n.d. Accessed October 24, 2021. https://pro.arcgis.com/en/pro-app/latest/tool-reference/data-management/add-rasters-to-mosaic-dataset.htm.
4. "Create Mosaic Dataset (Data Management)—ArcGIS Pro | Documentation." n.d. Accessed October 24, 2021. https://pro.arcgis.com/en/pro-app/latest/tool-reference/data-management/create-mosaic-dataset.htm.
5. "NAIP Imagery." n.d. Page. National-Content. Accessed October 24, 2021. https://fsa.usda.gov/programs-and-services/aerial-photography/imagery-programs/naip-imagery/index.
6. "NLCD 2016 Land Cover, Minnesota - Resources - Minnesota Geospatial Commons." n.d. Accessed October 24, 2021. https://gisdata.mn.gov/dataset/biota-landcover-nlcd-mn-2016.
7. "Distance Analysis: Identifying Optimal Paths Using Rasters Video | Esri." n.d. Accessed October 24, 2021.

https://www.esri.com/videos/watch?videoid=qO1LIFwbgDI&title=distance-analysis-identifying-optimal-paths-using-rasters.

Self-score

Category	Description	Points Possible	Score
Structural Elements	All elements of a lab report are included **(2 points each)**: Title, Notice: Dr. Bryan Runck, Author, Project Repository, Date, Abstract, Problem Statement, Input Data w/ tables, Methods w/ Data, Flow Diagrams, Results, Results Verification, Discussion and Conclusion, References in common format, Self-score	28	**28**
Clarity of Content	Each element above is executed at a professional level so that someone can understand the goal, data, methods, results, and their validity and implications in a 5 minute reading at a cursory-level, and in a 30 minute meeting at a deep level **(12 points)**. There is a clear connection from data to results to discussion and conclusion **(12 points)**.	24	**20**
Reproducibility	Results are completely reproducible by someone with basic GIS training. There is no ambiguity in data flow or rationale for data operations. Every step is documented and justified.	28	**24**
Verification	Results are correct in that they have been verified in comparison to some standard. The standard is clearly stated **(10 points)**, the method of comparison is clearly stated **(5 points)**, and the result of verification is clearly stated **(5 points)**.	20	**18**
		100	**90**