Lab Report

Title Lab 2-Part 2
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Project Repository: https://github.com/mmarsole/GIS5571
Google Drive Link: NA
Time Spent: 10hrs ?

Abstract

Part 2 of this lab concentrated on making a Cost Surface map (image/raster) and finding Optimal Paths for an imaginary person to use to walk from their home to another location, based on select preferences. These preferences included: avoiding crop fields, walking on 'gradual slopes', and avoiding streams when possible.
Based on my calculations, I have found several paths that could be used based on varying preferences. My first result confirmed that I couldn't avoid streams (I'd have to manually edited the stream data to show where bridges were located in order to use the data, as it's current depiction of streams made it impossible to avoid a streams crossing in my study area). Other paths favored roads more than unpaved surfaces depending on their 'weight' in the Cost Surface map.

Problem Statement

"To create a surface that shows places where Dory would more or less prefer to walk in order to get to the park, provided that (1) Dory prefers to not walk through any farm fields, (2) She also doesn't like crossing water bodies, and (3) wants the path that is the most gradual in terms of slope." (from lab 2 assignment doc)

Table 1. Desired data

#	Requirement	Defined As	(Spatial) Data	Attribute Data	Dataset	Preparation
1	Land Cover classification	Numerical values assigned to each cell within the tiff, that designates land as crops, impervious, wetlands, water, or grasslands, etc.	Tiff file	NA	Mn GeoSpatial Commons	Cropped to a smaller spatial extant
2	Elevation data	DEM, a tiff file that records the elevation in each cell	Tiff file	NA	Mn GeoSpatial Commons	Cropped to a smaller spatial extant
3	Stream data	Line data that provides the locations of streams/bodies of water in MN	shapefile	NA (only needed the	Mn GeoSpatial Commons	Cropped to a smaller

				location of the streams)		spatial extant
4	Start and End points	Had to make a shapefile that designated Dory's Start and End points for her walk	Shapefile	Description (field that indicated if it was the start of end point)	NA	Made in ArcPro interface

Input Data

As stated, we want to create a cost surface for where Dory will prefer to walk to get from her home to her favorite fishing spot. Based on her preferences, I have downloaded data from MN Geospatial commons (Land Cover, Elevation, and Streams data), and created data (Start and End points for Dory's walk). Both the Land cover data and elevation data are tiffs, while the other two files are shapefiles. The spatial resolution of the elevation data is 30 meters while the Land cover is 15 meters. Although not the same spatial resolution, both will be sufficient to conduct a cost surface map for Dory's walk.

Before the data could be used for the cost Surface, it had to be 'reclassified' or 'rescaled' depending on whether it was discrete or continuous data. This step ensures that we can directly compare the values to different data. See Table 2 for the scale parameters.

The following optimal paths rely heavily on elevation data and land cover and for the most part ignore the streams data (it was still considered within the Land cover data, where all cells classified as 'open water' were assigned a High cost values to avoid its use). If given more time, I'd consider using road data to identify bridges over streams as another preference input.

Table 2. Obtained Data

#	Title	Purpose in Analysis	Link to Source
1	Minnesota Land Cover Classification and Impervious Surface Area by Landsat and Lidar: 2013 update - Version 2	Reclassified to a scale of 1-10, where 10 was the highest cost (less desirable), and 1 the lowest cost (more desirable). I decided the values/scale for each land type as follows: **Urban/Developed**: (org. value) 1-100: (new value) **2** **Wetlands:** 101,102: (new value) **8** **Open Water:** 103: (new value) **10** **Extraction**: 104: (new value**) 9** **Forest**: 105,106,107: (new value) **1** **Managed Grass/Natural Grass**: 108: (new value) **1** **Agriculture:** 109,110: (new value) **9**	Mn GeoSpatial Commons
2	Minnesota Digital Elevation Model - 30 Meter Resolution	Used to calculate slope. I chose that Dory would only walk on surfaces between, -10 and 10 degrees. (to ensure a more gradual path).	Mn GeoSpatial Commons
3	Stream Routes with Kittle Numbers and Mile Measures	Tried to used as a 'barrier' (an impediment that Dory is not allowed to cross), but found it was impossible to calculate an optimal path using it as a barrier (this	Mn GeoSpatial Commons

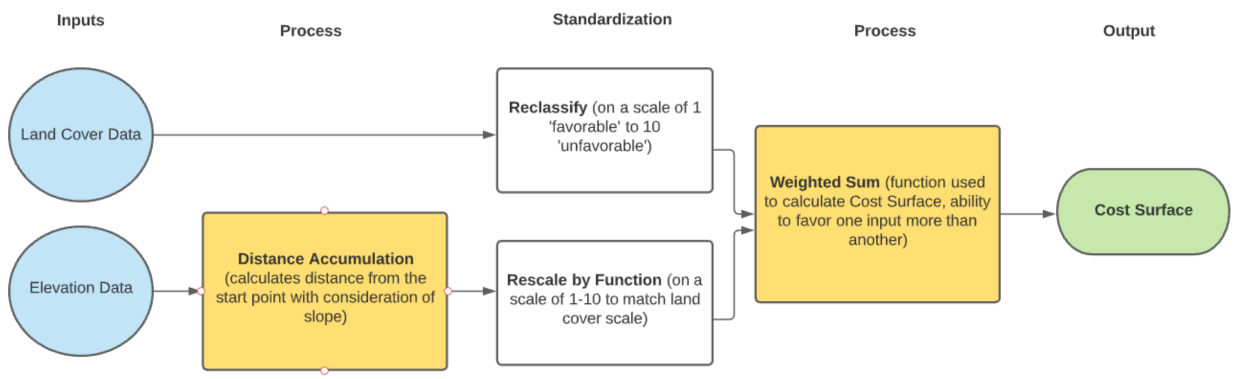
		means, Dory must cross water at some point in her trip, although this could be via a manmade bridge)	

Methods

Once the appropriate data has been obtained, we can build a Cost Surface. As displayed in Figure 2, the cost surfaces for this lab were based upon land cover and elevation. The elevation was first processed using the "Distance Accumulation" Tool. This tool gave me the opportunity to calculate a raster whose cells' values were based on the distance from the starting point and the slope. In this tool I chose to use a Binary function to calculate values for areas where slope was between 10 and -10 degrees (thus removing the possibility of walking over steep terrain). As a result, any cells where the slope was steeper, were then classified as 'No Data' values and could not be crossed later during Dory's walk. This method is less forgiving and favors Dory's preference for gradual slope. The values for the binary function could be altered to be more inclusive, or another function could be used to calculate slope preference.

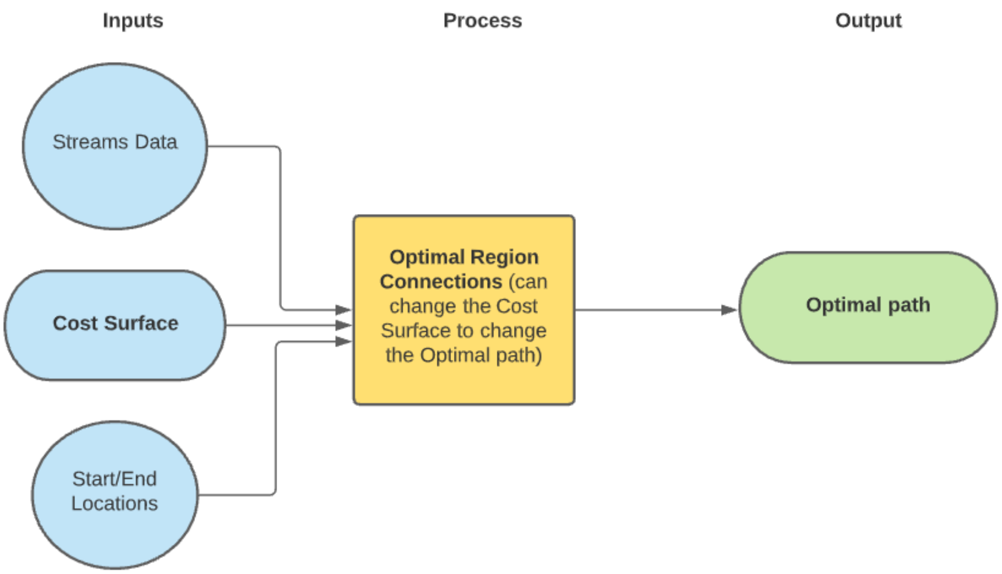
Once the raster from the "Distance Accumulation" has been calculated, this raster needs to be rescaled to values between 1 and 10, so it can be comparable with the land cover preferences. Then we can create a Cost Surface that considers all of our preferences (Land Cover reclassified and Elevation Rescaled) to calculate the walkability of surfaces for Dory. Using the "Weighted Sum" Tool, you can favor a preference over another by increasing its weight (I did two versions, one where each input's weight was equal and another where the land cover weight was higher than the elevation input, see the Results section to read more about these outcomes).

Figure 1. Creating a Cost Surface



From the Cost Surfaces we can compute Optimal Paths. These paths will vary if you change the cost surface (which are altered by either your choice of weights or inputs). In this lab I created 3 optimal paths, based on three different inputs. Using the "Optimal Regional Connections" tool you can select your start and end point data as well as your cost surface to calculate the best path for Dory. See figure 2 for better understanding of the inputs for the "Optimal Regional Connections" tool. Alternatively, you can use "Optimal Path as Line" tool, but you will only be able to consider the slope as the input for your path (this method is less preferable since it will ignore our desire to avoid crop fields).

Figure 2. Creating Optimal Paths



Results

Based on the methods described I created two Cost Surface rasters. Image 1is a Cost Surface with a stronger preference for Land Cover (the spatial weight of 5 was assigned to land cover while 1 was assigned to the elevation. While Image 2 displays a Cost Surface where the inputs elevation and land cover are equal (their weights were both 1), and thus the scale ranges from approximately 2 to 20 (since each of the inputs were scaled to values between 1-10). In both cases the higher the values, the less favorable the walking surface.

Based on these Cost surfaces, I calculated optimal paths (see image 3). Note that the blue path (called 'Optimal_path_favored_weights_py1') tends to follow the roads while the green path (called 'Optimal_path_equal_weights_py1') seems to be on the river (a good option if Dory had a boat). The blue path was based on Image 1 (which favors land cover type) while the green path was based upon image 2 (equal weight distribution). Each path offers pros, the blue path will likely provide less water crossings, but the green path will probably be more scenic.

Lastly, you'll notice there is a third path, (called 'Optimal_Path_slope_py1'). This path was created with only slope preference in mind via the "Optimal Path as Line" tool and does not consider Dory's Land cover preferences. You'll notice it mostly avoids the river, since much of it is surrounded by steep terrain, but it does recklessly traverse through crop fields.

Image 1: Cost_Surface 1 (equal weights)

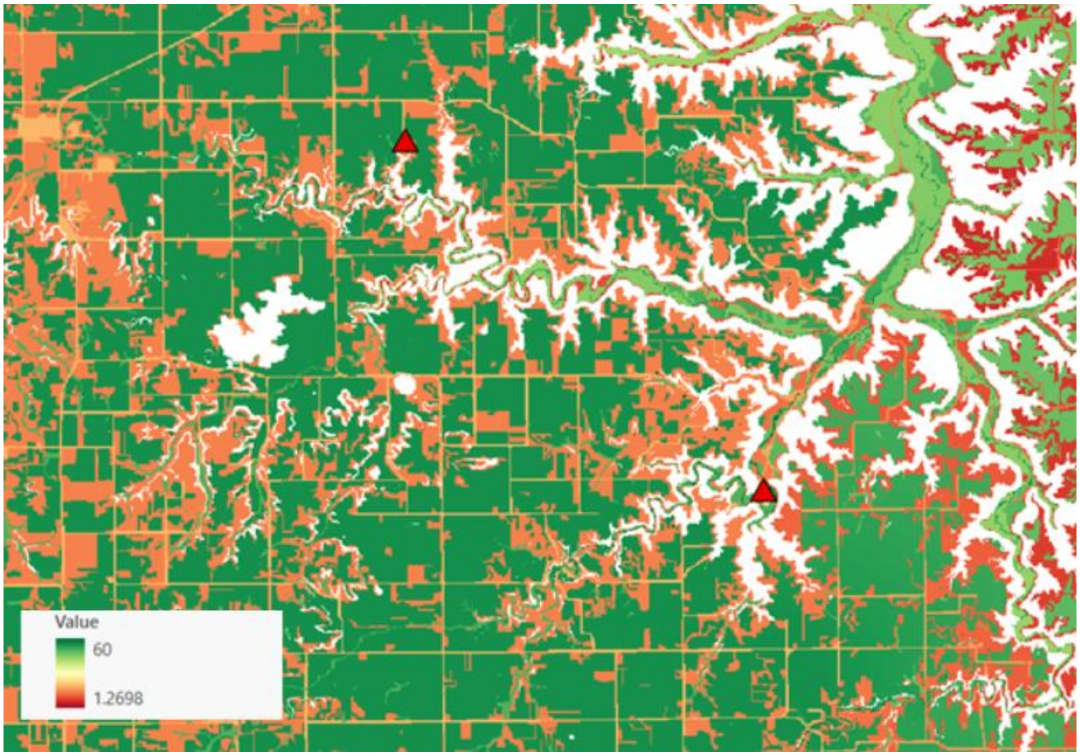


Image 2: Cost Surface 2 (favors Land cover type)

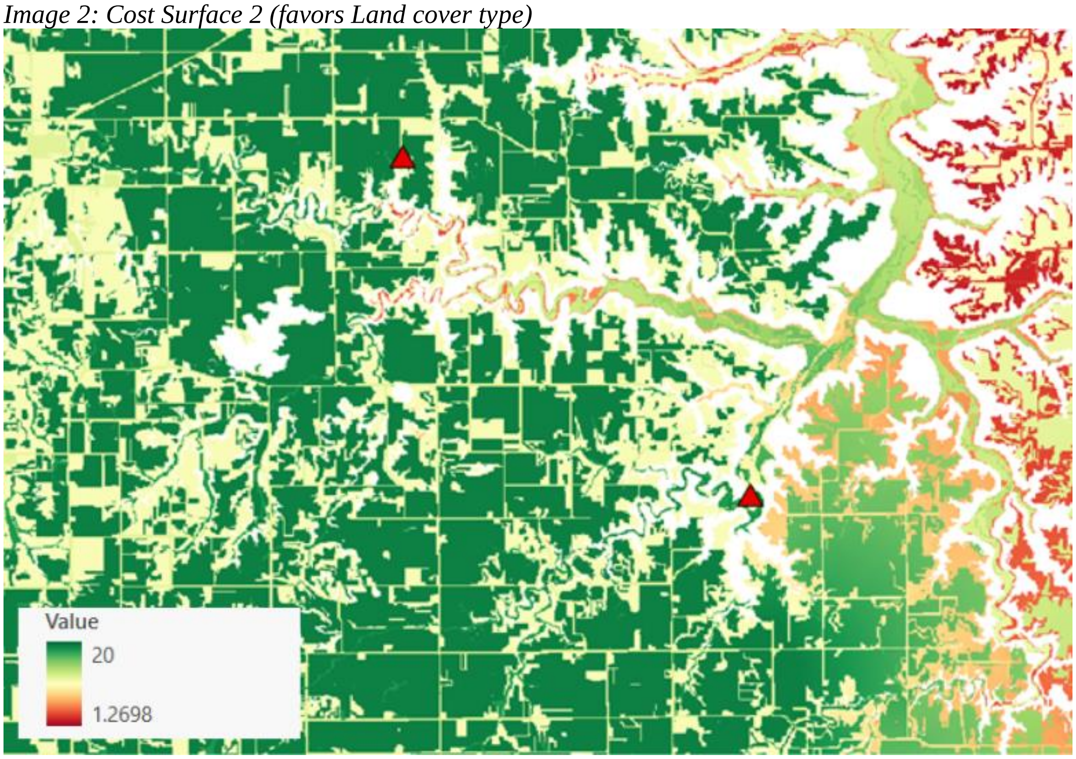


Image 3: Optimal Paths (see three examples based on three varying inputs)

Results Verification

These results were a result of code from my Jupyter Notebook and were compared to their GUI calculated counterparts. I can also make sense of these results through some critical thinking and deduce that seem plausible with visual inspection.

Discussion and Conclusion

Based on my calculations, I think better results were obtained with the 'Optimal Region Connection Tool" since it is based on the Cost Surface file which in turn is based on several different variables, while the "Optimal Path as Line" tool works with only slope input. Going forward, I think its would be worthwhile using road data in order to identify bridges (or alter the stream data to convey breaks where there are bridges, and then using it as a barrier).

I would like to play around with Dory's preferences a little more and see if there are other ways to incorporate the stream data. For example, it might be possible to buffer the streams, then rasterize the data and feed in this raster (rescaled to values between 1 and 10) to make a new cost surface with this as an additional weighted preference.

At this point I'd like to extend my gratitude for the online tutorial published by Esri, which made this whole lab doable.

References

Distance Analysis: Identifying Optimal Paths Using Rasters. (2021, March 29). Www.esri.com; esri. https://www.esri.com/videos/watch?videoid=qO1LIFwbgDI&title=distance-analysis-identifying-optimal-paths-using-rasters

Self-score

Fill out this rubric for yourself and include it in your lab report. The same rubric will be used to generate a grade in proportion to the points assigned in the syllabus to the assignment.

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	**22**
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	**26**
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	**94**