Part 02

Abstract

A cost raster identifies the cost of traveling through each cell in any study extent. In this lab, an optimal path between two points is determined after taking subject preferences into consideration using cost surface raster. Initially, all the input datasets, including roads, streams, land cover and DEM, were downloaded from the MN Geospatial and then imported to ArcGIS Pro. The reclassify tool is then used to standardize the criteria layers, which are then overlayed after assigning them equal weights. Subsequently, two spatial analyst tools, namely cost distance and *cost path as polyline* tool, were used to get the desired optimal path between the defined two points.

Problem Statement

Map algebra and cost modeling are used to create cost surfaces. In this lab, an imaginary person named Dory wants to travel from her farm location (44.127985, -92.148796) to the North Picnic area (44.049801, -92.050226) but there are some specific preferences while selecting a route. Dory doesn't prefer to walk through any farm fields, cross water bodies if there is no bridge, and take a steep path. The cost surface that represents these preferences using map algebra is created. Uncertainty analysis is done by incrementally altering each model weight and re-running the model to learn how different choices might impact the map outcomes.

Table 1. Required Data for the cost surface.

#	Requirement	Defined As	(Spatial) Data	Dataset	Preparation
1	MN Counties	Shapefile of all counties in the state of Minnesota	Vector (Polygons)	Mn GeoSpatial Commons	No
2	Road network	Raw vector data to locate all roads in the study extent.	Raster	Mn GeoSpatial Commons	Yes (Reclassification)
3	Streams	Raw vector data to locate all streams in the study extent.	Vector (Lines)	Mn GeoSpatial Commons	Yes (Reclassification)
4	Digital Elevation Model	Raster data to determine slope in the study extent.	Raster	Mn GeoSpatial Commons	Yes (Reclassification)
5	Land cover	Raster data to determine landuse in the study extent.	Raster	Mn GeoSpatial Commons	Yes (Reclassification)
6	Starting and End Points	CSV file containing coordinates of Dory's starting & end point.	CSV	-	Yes

Input Data

The input datasets required to create the cost surfaces using map algebra and cost modeling are tabularized below. There are, in total, six datasets considering all of the subject's route preferences and starting and end points of the route.

Table 2. Input datasets.

#	Title	Purpose in Analysis	Link to Source
1	MN Counties	For study extent	https://gisdata.mn.gov/dataset/bdry-counties-in-minnesota
2	Road network	The subject (Dory) prefers to cross water bodies as long as there is a bridge. This layer will represent all the roads that cross the streams in the study extent.	https://gisdata.mn.gov/dataset/trans-roads-mndot-tis
3	Streams	The subject (Dory) prefers to cross water bodies. This layer will represent all the streams in the study extent.	https://gisdata.mn.gov/dataset/water-strahler-stream-order
4	Digital Elevation Model	One of Dory's preferences is not to take the route that has a steep slope. This dataset will provide information about the slope in the study extent.	https://gisdata.mn.gov/dataset/elev-30m-digital-elevation-model
5	Land cover	One of Dory's preferences is not to walk through the fields. This dataset will tell how the study extent is covered by forests, wetlands, impervious surfaces, agriculture, and other land and water types.	https://gisdata.mn.gov/dataset/biota-landcover-nlcd-mn-2019
6	Starting and End Points	CSV file containing coordinates of Dory's starting & end points.	-

Methods

Since Dory doesn't prefer to walk through any farm fields, cross water bodies if there is no bridge, and take a steep path, four datasets were used to find the cost surface path. Initially, all the input data were downloaded from the MN Geospatial and then imported to ArcGIS Pro. Considering Dory's starting and end points, only three counties, namely Winona, Olmstead, and Wabasha, were selected from the MN counties layer using the geoprocessing tool select by attribute. Subsequently, the dissolve tool was used to merge the three counties and define the study extent. The methodology to perform said task is summarized in the data flow diagram, shown in Figure 1.

In order to get road network streams, digital elevation model, and land cover data within the study extent, extract by mask tool was used on the said input datasets. The next step in producing the cost raster is to combine the reclassified datasets. The reclassify tool is then used to standardize the criteria based on a scale of 1 to 10. The score one is given to the most preferred choice while ten is for the least preferred choice. The reclassified input raster layers are overlayed in this lab by multiplying each raster cell's suitability value by its layer weight and then combining the values to produce a suitability score. For this lab, all four inputs were given equal weights i.e., 0.25 or 25%.

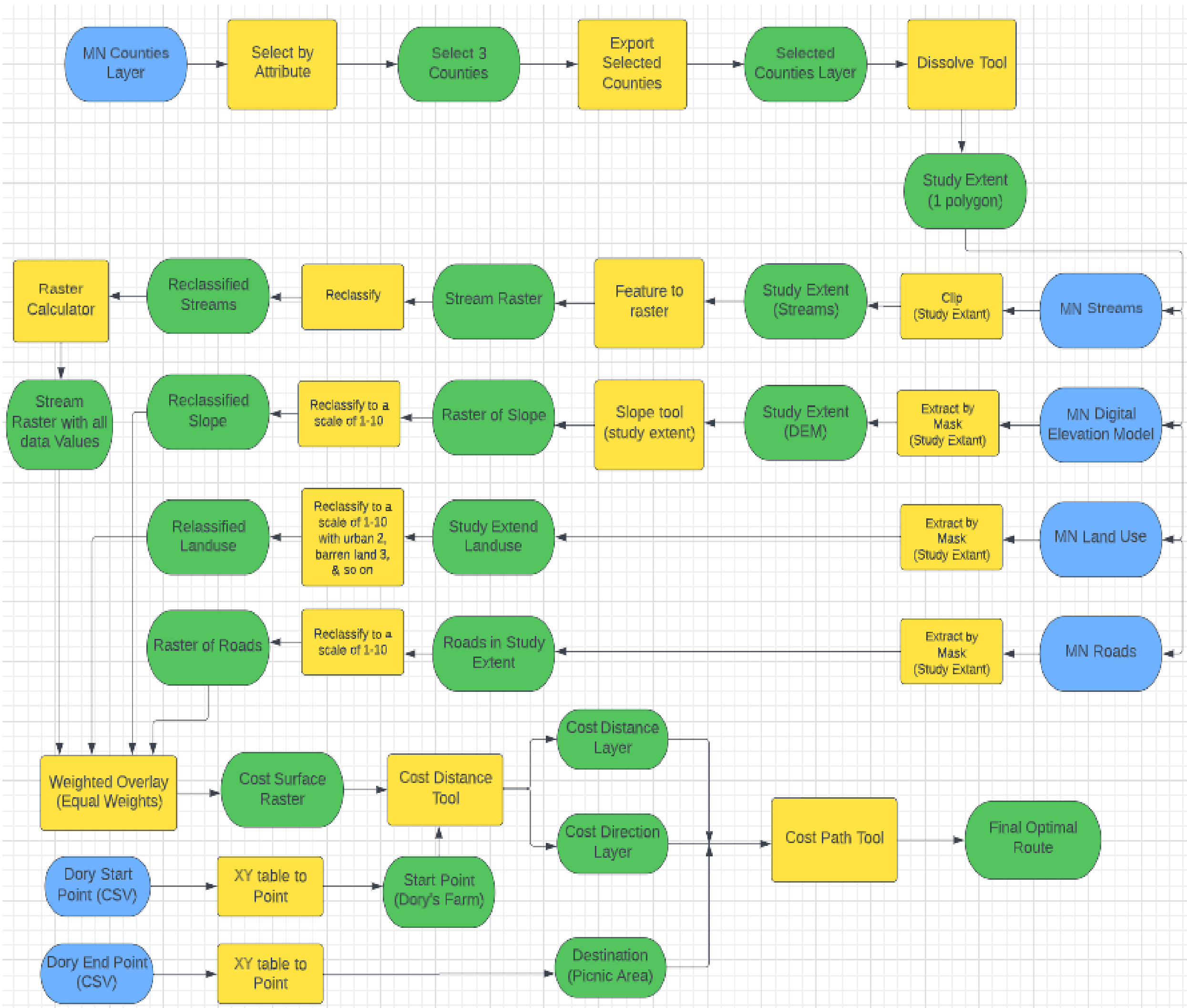

Figure 1: Flow Diagram of the entire Methodology.

After the weighted overlay analysis, the cost distance tool is used to get the cost distance layer and cost direction layer. The inputs for the said tool are Dory's starting point and weighted overlay. Subsequently, the *Cost Path as Polyline* tool is used to get the optimal path between Dory's starting and end (North Picnic area) points.

Results

The aim of this lab was to perform a cost surface analysis in a defined study extent after taking subject preferences into consideration using map algebra. The methodology described in figure 1 is followed to get all the outputs. The reclassified layers of *Stream, Roads, slope and Land Cover*, and weighted overlay analysis are shown in figures 2, 3, 4, 5, and 6.

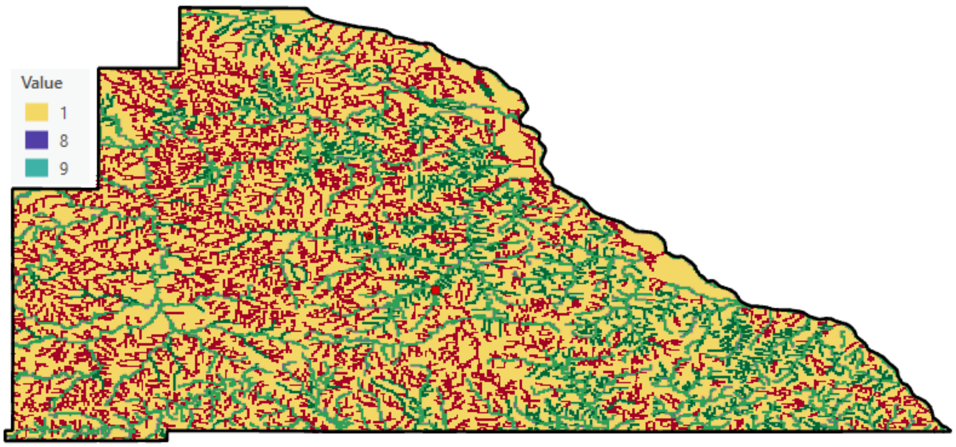

Figure 2: Reclassified Stream Layer

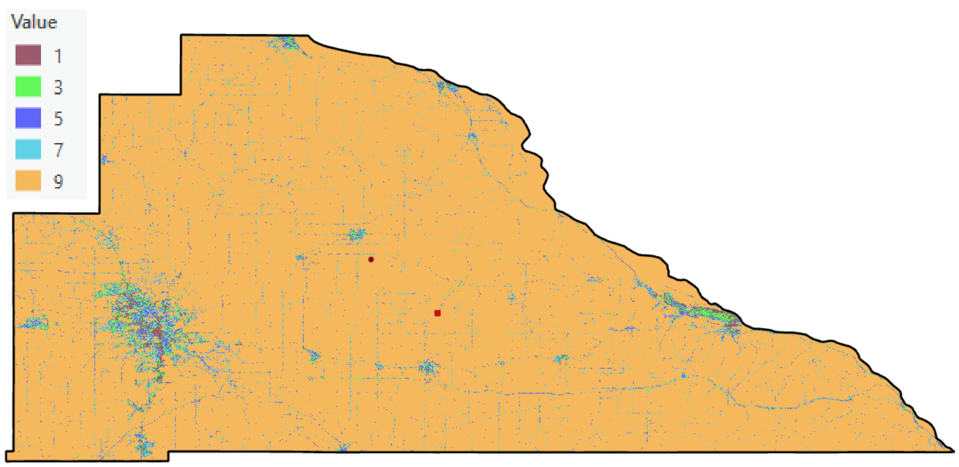

Figure 3: Reclassified Roads Layer

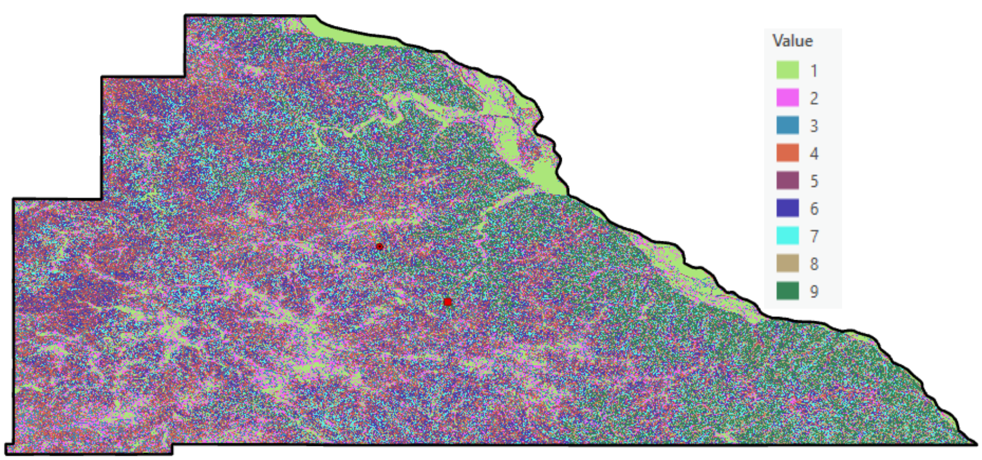

Figure 4: Reclassified Slope layer

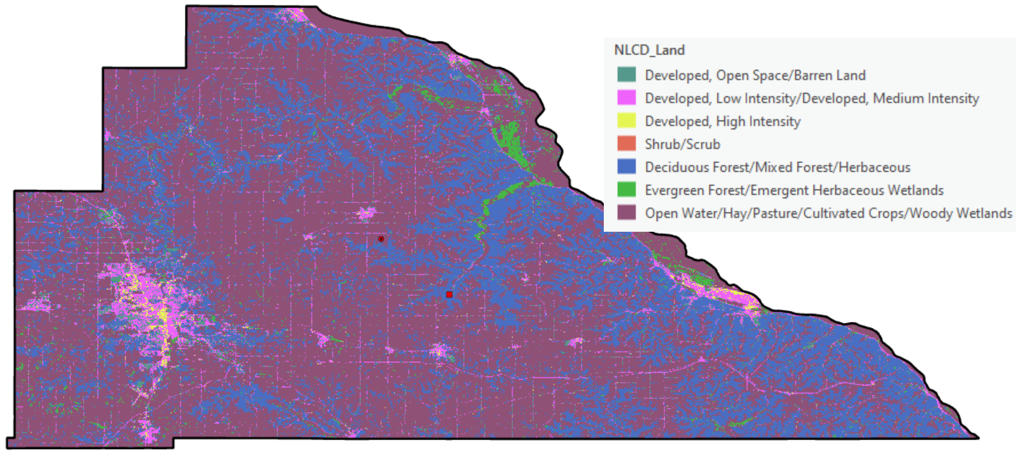

Figure 5: Reclassified Land Cover layer

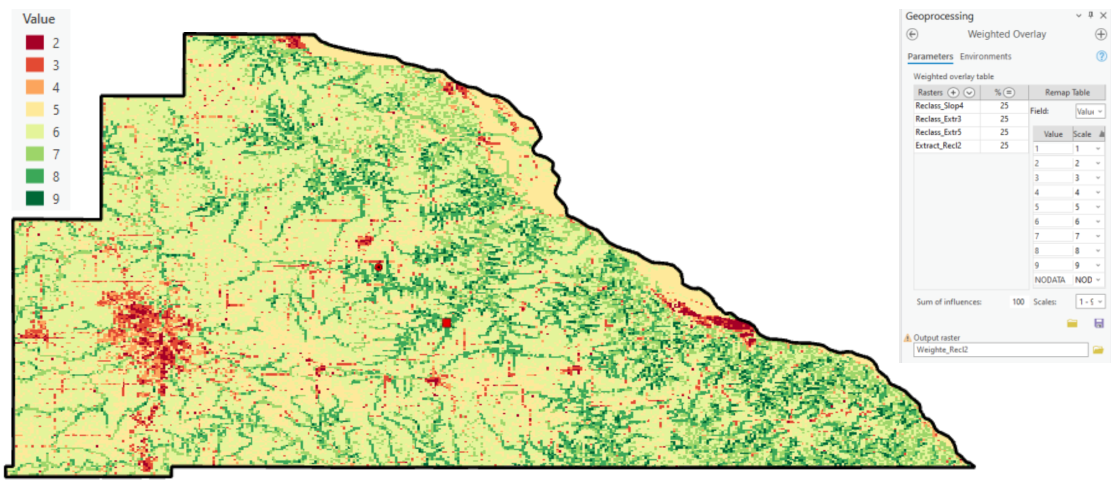

Figure 6: Weighted Overlay

The outputs of the cost distance tool are the cost distance surface and cost direction layer, as shown in Figures 7 & 8. The inputs were a CSV file containing information about Dory's starting point and weighted overlay.

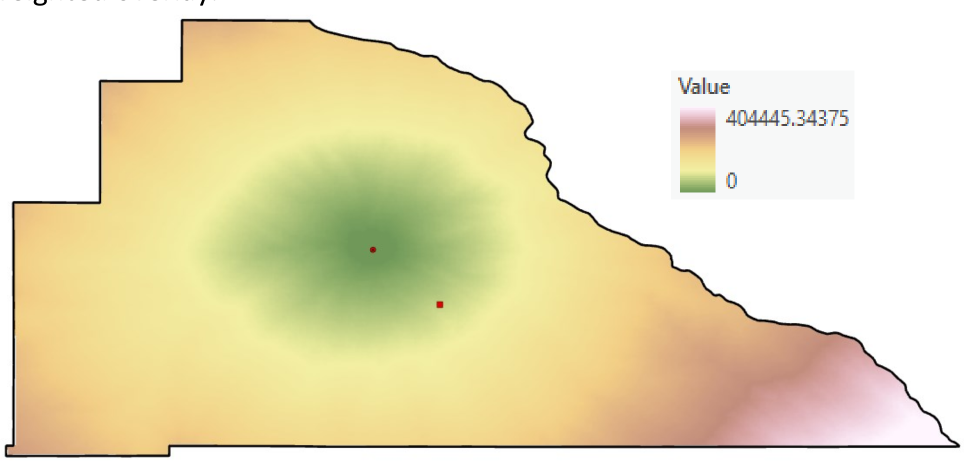

Figure 7: Cost Distance layer

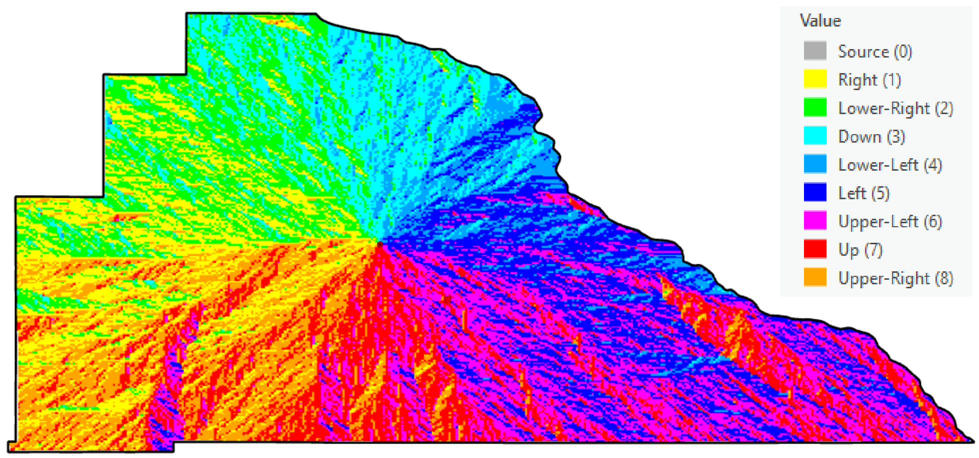

Figure 8: Cost Distance layer

The *Cost Path as Polyline* tool used to find the optimal path between Dory's starting and end (North Picnic area) points gave the route that is shown in figure 9. The inputs of the said tool are Dory's endpoint, cost distance, and cost direction layers.

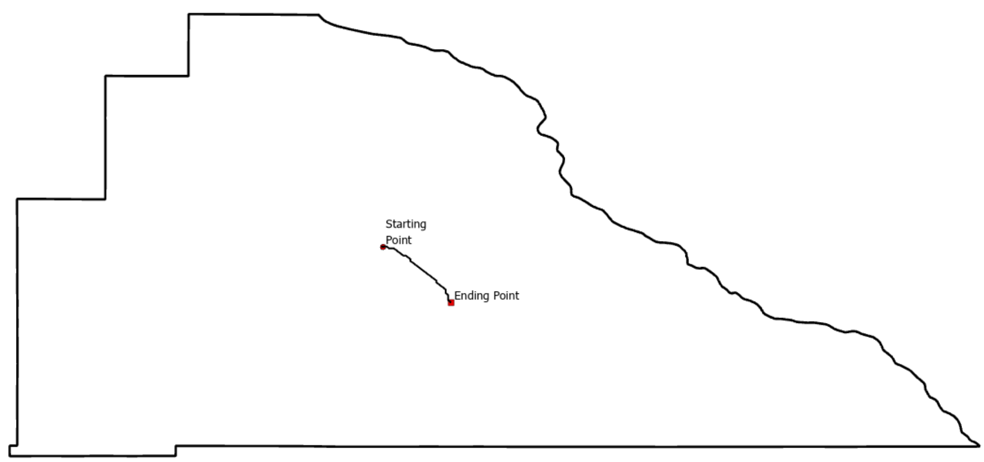

Figure 9: Optimal path between Dory's starting & end points.

Results Verification

The results were verified after altering each criteria's weight and re-running the cost path tool several times. There were few changes in the path from starting to end points were observed, which is an indication that the model was working perfectly fine. Moreover, it was visually verified by mapping the path in google earth and observing the features it has been crossing. In a nutshell, I would say that the optimal path justifies all of Dory's preferences.

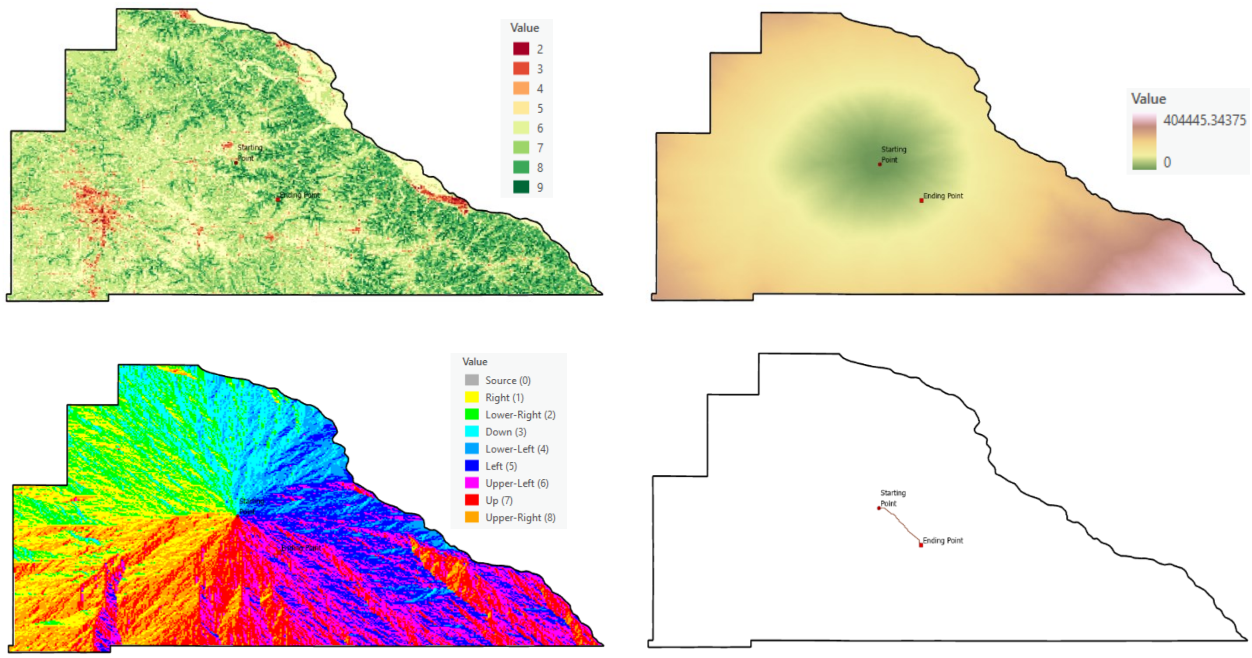

Figure 10: Optimal path determined when input weights were altered and set not equal.

Discussion and Conclusion

For this part of the lab, I learned how Map algebra and cost modeling are used to create cost surfaces and how to create an ETL for input data to go into a cost surface model. Moreover, I learned about the use of different geoprocessing tools and working with raster and vector datasets. The second part of lab 02 was something I enjoyed working on.

References

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2. County Boundaries, Minnesota. MN Geospatial Commons. Website. October 27, 2022. https://gisdata.mn.gov/dataset/bdry-counties-in-minnesota
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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	24
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	28
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	20
		100	100