Lab Report

Title: <Lab 3 Report >
Notice: Dr. Bryan Runck
Author: Rongxuan Zhu
Date: 11.30.2021

Project Repository: < https://github.com/zhux0474/GIS5571/tree/main/Lab3>
Google Drive Link: <N/A>
Time Spent: <24 Hours>

Abstract
Lab3 instructs me to compare and contrast three different weighting approaches to generate cost surface and optimal paths for Dory in the notebook of ArcGIS Pro to answer the question of what the optimal route is for Dory to take to get to her flyfishing spot near Whitewater State Park in Southeast Minnesota. The cost surfaces and optimal paths are created to represent places where Dory would prefer to walk to get to the destination.

Problem Statement
Lab 3 is developed based on the work from Lab 2. Three different weighting approaches for creating cost surfaces and optimal paths are compared and contrasted to answer the question for Dory that what the optimal route to take to get to the fly fishing place near Whitewater State Park in Southeast of Minnesota. Dory prefers to not walk through any farm fields, she does not like crossing water bodies without bridges or waders, and she wants to take the most gradual path in terms of the slope. Three different cost surfaces and optimal paths will be built to represent the preferences for Dory.
Table 1 shows the broken-down elements of the problem statement.

Table 1. < Table of Elements Break Down from Problem Statement >

#	Requirement	Defined As	(Spatial) Data	Attribute Data	Dataset	Preparation
1	Minnesota Stream	Raw stream input dataset for cost surface	Vector Data	Stream Geometry	Mn GeoSpatial Commons	Download from MNGeoSpatial Commons
2	Minnesota Land Cover 2016	Raw raster input dataset for cost surface	Raster Data	Land Cover	Mn GeoSpatial Commons	Download from MNGeoSpatial Commons
3	Minnesota DEM	Raw raster input dataset for cost surface	Raster Data	Elevation	Mn GeoSpatial	Download from MNGeoS

					Common s	patial Commons
4	Jupyter Notebook	Tool to build ETL pipeline	N/A	N/A	N/A	N/A

Input Data

The Land cover and DEM raster data and trails shapefile are all downloaded from Minnesota Geospatial Commons. They are used to create cost surface and optimal path for Dory.

Table 2. <Table of Input Data Downloaded from Websites with Links>

#	Title	Purpose in Analysis	Link to Source
1	Minnesota Stream	Raw stream input dataset for cost surface	Mn GeoSpatial Commons
2	Minnesota Land Cover 2016	Raw raster input dataset for cost surface	Mn GeoSpatial Commons
3	Minnesota DEM	Raw raster input dataset for cost surface	Mn GeoSpatial Commons

Methods

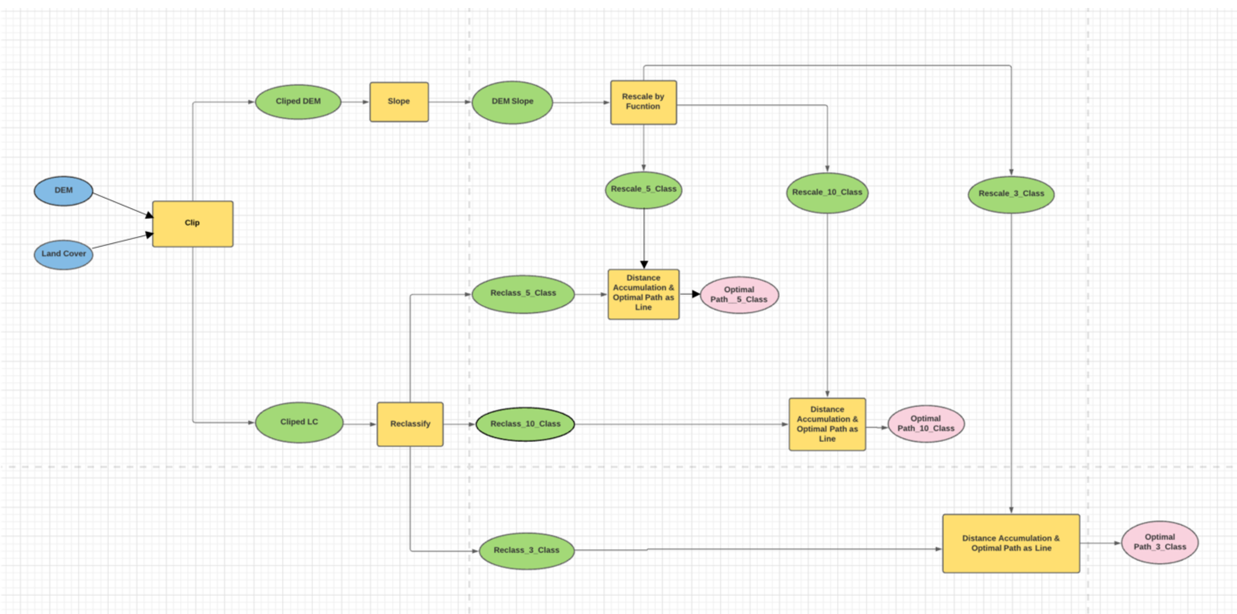

Figure 1. Data flow diagram.

The general methods are summarized into Data Flow Diagram(Figure 1) and the code can be found under the notebook folder on GitHub.

This lab is developed based on the work from Lab2. Three different weighting approaches for creating optimal paths are compared and contrasted. Lab2 generated optimal path based on a reclassification of the land cover raster of 5 classes with the lowest value assigned to easiest crossing surface and the highest value assigned to hardest crossing surface based on Dory's preference. In Lab 3, two more weighting approaches are tested for creating optimal paths with the reclassification of the land cover raster of 3 classes and 10 classes.

The clipped land cover raster was reclassified based on Dory's preference in two different ways with fewer (3) and more (10) classes than 5. The model weight is adjusted manually in the reclassify tool to find the better optimal path result.

In the fewer classes weighting approach, the open water is classified as 3 which is the highest because it is almost impossible to cross. Wetland and cultivated crops are classified as 2 which is the second difficult area to cross. All the developed area and forest area is classified as 1 which is the easiest to cross.

In the more classes weighting approach, the NLCD lands are classified into detailed categories. Open water and wetland are classified as 10 which is the highest, cultivated crops are 9, the forest is classified as 8 while shrub and scrub are 7, herbaceous is 6, Hay and pasture is 5, the developed area with open space are 4, the developed area with low intensity is 3, the developed area with medium intensity is 2 while the developed area with high intensity and barren land are 1 which is the easiest to cross.

The clipped DEM raster is used to calculate the slope using the Slope tool. And it is rescaled using MS Small transformation function from 1 to 3 and 1 to 10 separately to match the number of classes in the Land Cover reclassification raster for different weighting approaches which allow the smaller values in the input data to have higher preference over larger values and to match the number of classifications of land cover data (Figure 3).

The rescaled dem slope with 3 classes (10 classes) is used as a cost raster and reclassified land cover with 3 classes (10 classes) is used as the surface raster, and the start point is used as input feature source data of the Distance Accumulation tool to create the distance accumulation raster and back direction raster. The optimal path as line function is run use the output from distance accumulation tool which are distance accumulation raster and back direction raster with the endpoint (as input feature destination data). A line from the start point to the endpoint is generated as the optimal path that Dory could take.

Results

Figures 2, 3, and 4 are the results of three different weighting approaches by running Distance Accumulation and Optimal Path as Line tools in ArcPro between the start and endpoint with 3, 5, and 10 reclassification classes of land cover raster with back direction raster

Figures 5, 6, and 7 are the comparisons of optimal paths between the start and end points with 3, 5, and 10 reclassification classes of the land cover raster.

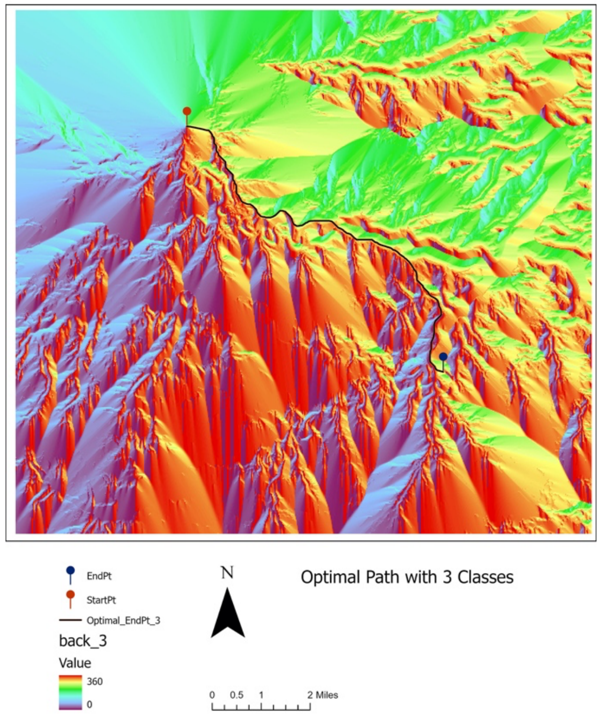

Figure 2 – Optimal Path between Start and End Point with 3 Reclassification Classes of Land Cover Raster with Back Direction Raster

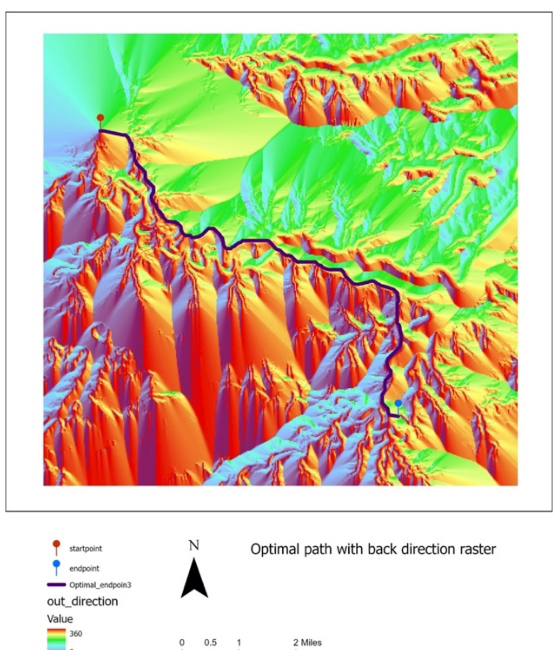

Figure 3 – Optimal Path between Start and End Point with 5 Reclassification Classes of Land Cover Raster with Back Direction Raster

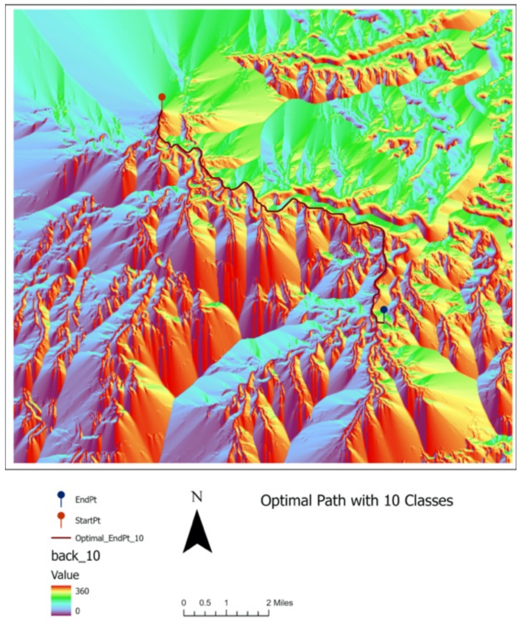

Figure 4 – Optimal Path between Start and End Point with 10 Reclassification Classes of Land Cover Raster with Back Direction Raster

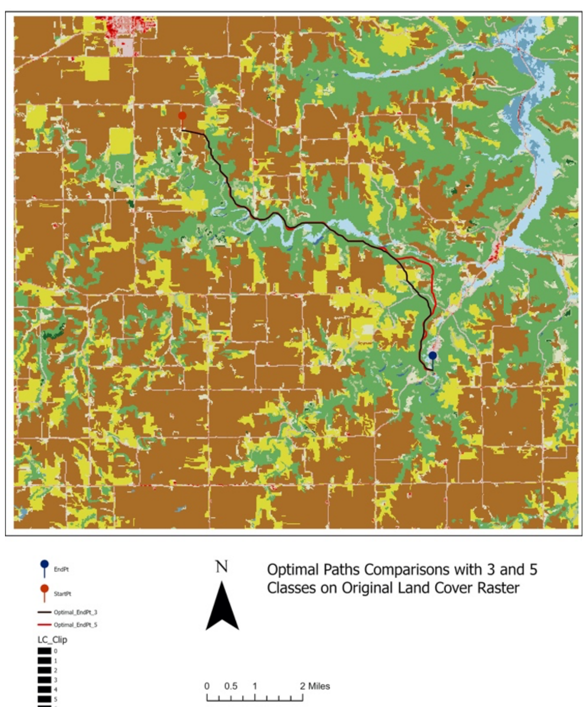

Figure 5 – Optimal Paths Comparisons between 3 and 5 Reclassification Classes of Land Cover Raster

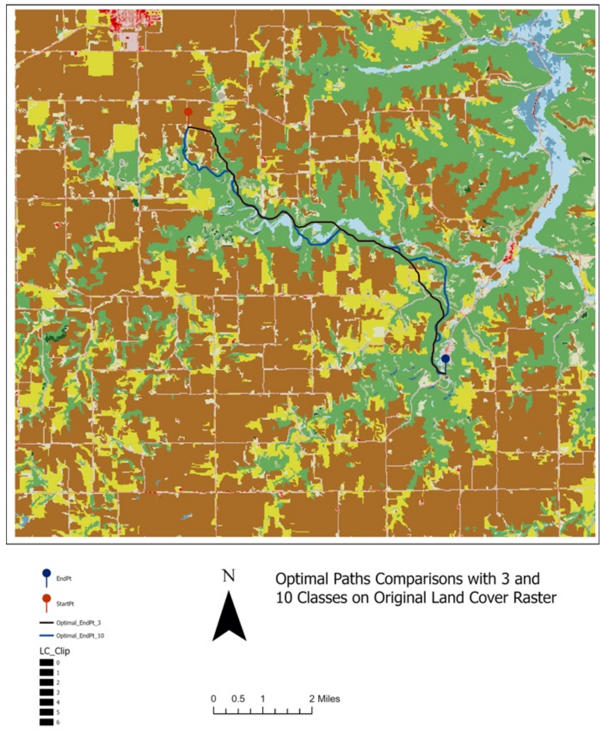

Figure 6 – Optimal Paths Comparisons between 3 and 10 Reclassification Classes of Land Cover Raster

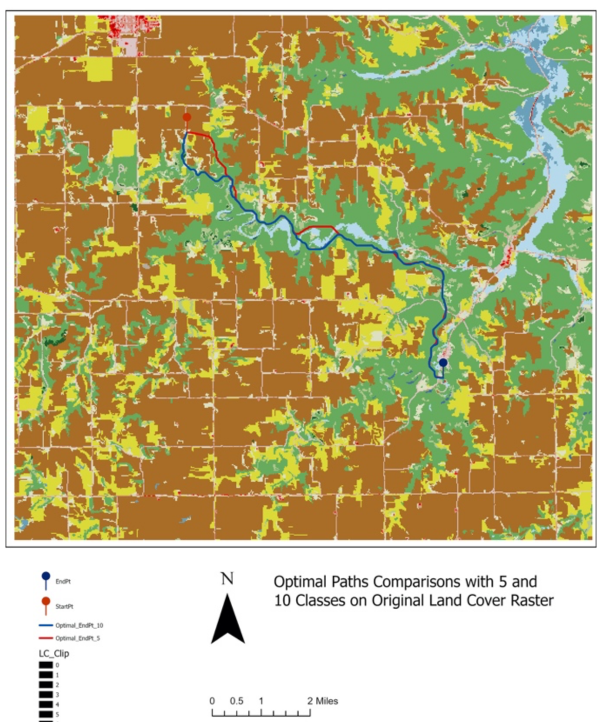

Figure 7 – Optimal Paths Comparisons between 5 and 10 Reclassification Classes of Land Cover Raster

Results Verification

The line feature class generated in figures 2, 3, and 4 visually looks different but reasonable based on their different reclassification methods as optimal paths for Dory to travel from start point to endpoint based on her preference as the line follows the area that has a lower value on the raster, and it tries to avoid the area with high value. Figures 5, 6, and 7 compare two optimal paths at a time and they provide a clear comparison and help us choose the most optimal path for Dory between different weighting approaches.

Discussion and Conclusion

The reclassification of land cover raster with 3 and 5 classes generates a similar optimal path (Figure 5) and the biggest difference is that 5 classes prefer deciduous forest while 3 classes prefer developed with high intensity when it gets to the area near the endpoint

The reclassification of land cover raster with 3 and 10 classes generate less similar optimal paths (than with 5 classes) (Figure 6) and they choose different directions from the start point with 3 classes goes east cross crop and reach developed area and 10 classes goes south and follow the developed area which is closer to dory's preference. These two paths follow the forest area and avoid wetlands and they cross the woody wetlands at different locations. When it gets to the area near the endpoint, 10 classes prefer deciduous forest while 3 classes prefer developed with the high-intensity area (which is similar to the differences of 3 and 5 classes).

The reclassification of land cover raster with 5 and 10 classes generate less similar optimal paths (Figure 7) at the beginning near the start location(similar to the difference between 3 and 10 classes since 3 and 5 classes generate similar optimal path) and these two paths merged and overlapped after they cross woody wetland at different locations and reach the endpoint.

In my opinion, the reclassification of land cover raster with 10 classes generates the most optimal path for Dory based on her preference which follows the developed area and forest and tries to avoid open water and wetland. 3 classes group too many different land types into the same class which can cause the error, 5 classes have slightly more specified categories than 3 classes but it is still not enough to generate a better path for Dory.

References

Distance analysis: Identifying optimal paths using rasters. Esri. (2021). Retrieved October 25, 2021, from https://www.esri.com/videos/watch?videoid=qO1LIFwbgDI&title=distance-analysis-identifying-optimal-paths-using-rasters.

Distance accumulation (spatial analyst). Distance Accumulation (Spatial Analyst)-ArcGIS Pro | Documentation. (n.d.). Retrieved October 25, 2021, from https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/distance-accumulation.htm.

Optimal path as line (spatial analyst). Optimal Path As Line (Spatial Analyst)-ArcGIS Pro | Documentation. (n.d.). Retrieved October 25, 2021, from https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/optimal-path-as-line.htm.

Rescale by function (spatial analyst). Rescale by Function (Spatial Analyst)-ArcGIS Pro | Documentation. (n.d.). Retrieved October 25, 2021, from https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/rescale-by-function.htm.

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