Lab 2 Part Two

Title: Create a Cost Surface with ArcGIS Jupyter Notebooks to Find Dory's Optimal Fishing Route
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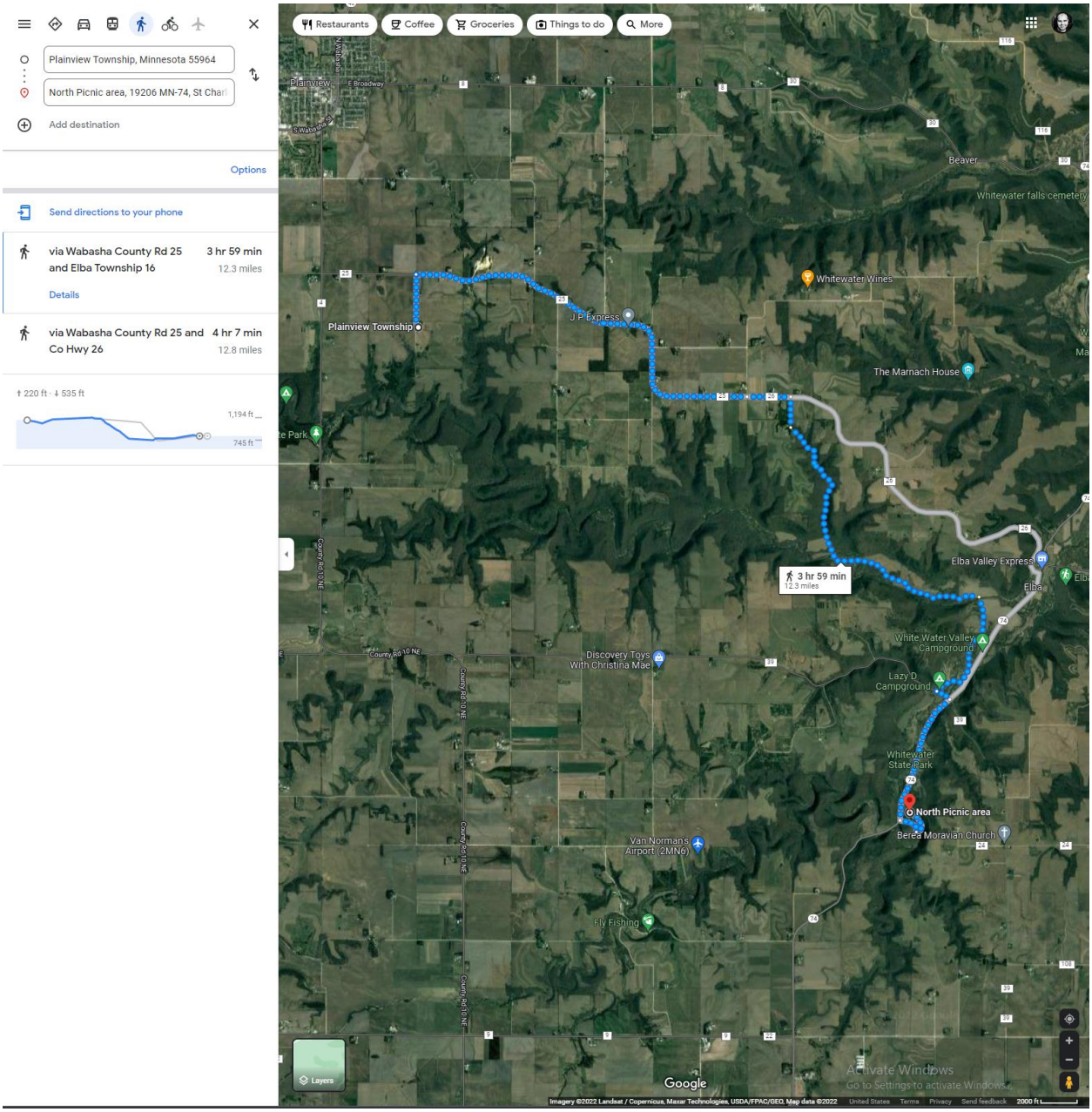
Project Repository: https://github.com/ardumn/GIS5571/tree/main/Lab2
Google Drive Link: https://drive.google.com/drive/folders/1XVw91c_9BcQHZ44FHaGDDLJkGu-QY3sB
Time Spent: 24 hours

Abstract

How do I find the best fishing location in Mary Lake (Itasca State Park) from my home in Lake Alice Township? Though it may have been solved, this hypothetical question can be applied to a cost surface analysis in finding the best cost-effective path and minimizing factors based on user preference. In the case of Dory, who is enamored with fly fishing, and moved to Plainsview Township solely for this purpose, but has bias for her preferred route to the Whitewater State Park. These preferences being she prefers spring season to fish but doesn't like to attempt walking muddy farm fields or maneuvering water bodies (unless she's has her waders) to that of a bridge. Slope is preferable depending on graduality, with the confines of the area she's leaving in. Giving all these factors, the study extent is established by using three counties and ancillary data extracted from MN GeoSpatial Commons to mask, clip, and reclassify then make weights. These weights assess the cost surface based on each of the parameters (data) that have been calculated then produce a cost-effective distance (which Dory's Farm is inputted). This then is assessed on cost surface from all sources and a back link for each neighbor (North Picnic Area destination). This than should result in the final optimal route and can be reassessed many times to find different paths and is applicable to many other applications.

Problem Statement

Dory's predicament is to find an optimal route for fly fishing in Whitewater State Park from her farm (44.127985, -92.148796) in Plainsview Township, MN to the North Picnic Area (44.0544° N, 92.0448° W). The preferences outlined for her are that she enjoys spring hiking but disapproves of walking in farm fields of muddy terrain and crossing into water bodies if there is not a bridge (unless she has her waders). Additionally, she wants a to have a gradual path in terms of slope (incline). Using a cost surface model and analysis, her preferences are inputted to find her most optimal path within the study area and given terrain. (See Map 1)



Map 1. Google Maps clip of network analysis estimate.

#	Requirement	Defined As	(Spatial) Data	Attribute Data	Dataset	Preparation
1	County Boundaries, Minnesota	The standard Minnesota State County Boundary dataset that is used by MNDNR and many other state agencies. It is maintained by the	County Geometry	Vector Boundary	MN GeoSpatial Commons	Numerous preparatory operations and extractions. First create an ETL, then

		MNDNR Lands and Minerals Division.				establish study extent for which Dory's Farm and North Picnic area reside in two different counties (using attributes and dissolve tool) This being the extent for cursory operations for Cost Surface creation.
2	NLCD 2019 Land Cover, Minnesota	Minnesota NLCD layer is derived from the full NLCD dataset. The national raster is clipped and projected to UTM Zone 15N.	Raster Classes	Pixel	MN GeoSpatial Commons	Used as a weight for Cost Surface analysis in optimal route. Once Counties have been Dissolved, NLCD is used to by Land Use and Impervious surface to implicate suitable paths(some being wetland and water).
3	Minnesota Digital Elevation Model - 30 Meter Resolution	30 Meter Digital Elevation Model (DEM) is a copy of the USGS 1:24,000 scale Level 2 DEMs for the State.	Raster Elevation	Pixel	MN GeoSpatial Commons	Used as a weight for Cost Surface analysis in optimal route. Once Counties have been Dissolved, DEM is used for Slope for rigidity/uphill areas.

4	Stream Routes with Strahler Stream Order	Stream segments with Strahler stream order values assigned.	Stream Line Geometry	Vector	MN GeoSpatial Commons	Used as a weight for Cost Surface analysis in optimal route. Once Counties have been Dissolved, Strahler Streams is Clipped to study extent, Rasterized amd used for Reclassificati on and Raster Calculated to mitigate areas potentially wet.
5	XY Data.CSV		Aspatial	Tabular	N/A (Google Maps for coordinates)	XY Data CSV to convert XY Data to Point in ArcGIS Pro to display Dory's Farm and North Picnic Area

Table 1. Enumeration of the steps to establish the Cost Surface model in relation to Dory's preferences.

Input Data

The data used is in line with the preferences and area that Dory's farm and Whitewater State Park reside in respectfully, all the county boundaries aren't necessary for this analysis, only three within the extent of the farmstead and state park. The counties act as the extent for all other layers which the ancillary data will be masked and clipped to, (after Olmstead, Wabasha, and Winona are exported). The NLCD 2019 data contains 12 classes ranging from Pasture, Bare Land, and Grassland to Developed land and is a subset of a larger NLCD dataset. Likewise, to that of the MN DEM originating from the USGS for elevation and rigidity of surfaces. Strahler Stream routes is unique, in that each stream is denoted with ordinal ranking from 1 to 4 each number denoting sallowness of the stream 1 being deepest and 4 being sallowest.

All data is inputted into a cost surface model and analysis and suitable for the preferences outline in the problem statement.

#	Title	Purpose in Analysis	Link to Source

1	County Boundaries, Minnesota	Study area by which the Optimal route for Dory will be investigated and extent for inputting extracted masks for Landcover, DEMs, and Streams for Cost Surface operations.	MN GeoSpatial Commons
2	NLCD 2019 Land Cover, Minnesota	Classify Land Use features (Urban, Bare Land, Forest, Water, etc.) and Impervious Surfaces (Bridges and Roads) as a weight in the Cost Surface analysis for Dory's preferences to the North Picnic Area.	MN GeoSpatial Commons
3	Minnesota Digital Elevation Model - 30 Meter Resolution	Using the Slope tool to assess areas of uphill/downhill as a wight in the Cost Surface analysis for Dory's preferences to the North Picnic Area.	MN GeoSpatial Commons
4	Stream Routes with Strahler Stream Order	Rasterization of feature and Reclassification for further evidence and weighting for Cost Surface analysis for Dory's preferences to North Picnic Area.	MN GeoSpatial Commons

Table 2. Data requirements that are applicable to the study extent of Dory's Farm and the North Picnic Area (Whitewater State Park).

Methods

As described in the input data, the methodology used for lab was to construct the study area by which the locales of Dory's farm and the Whitewater State Park reside in. By using the coordinates of Dory's farm and locating the coordinates of North Picnic Area via Google Maps, the data was tabulated into a Excel file and exported as CSV, for better functionality in ArcGIS Pro. Utilizing the XY to Point tool the points were displayed into the Map on ArcGIS Pro as a vector point in which the study area (as stated) was surmised. Once the three counties were selected, and dissolved by the points, with further extraction of the NLCD, DEM, and clipping of the streams, the raster analytics phase proceeds.

This extent, the reclassification of each raster dataset is confirmed to Dory's preference stated in the problem statement, bridges and roads from impervious surfaces, land use of fields, baren land, water bodies, etc. slope for the DEM and finally streams. Each are classified uniquely, especially that of Streams for NODATA values, since they have surplus of these values, and need Raster Calculator to populate these values with 0s in order to have weights registered correctly. Then the Cost Surface can analyze multiple times from Dory's Farm and the Picnic Area based on the Distance to nearest source (NPA) and each neighborhood and least-accumulative cost for Back-Link. Thus, producing the optimal final route for Dory for her to find to fly fish.

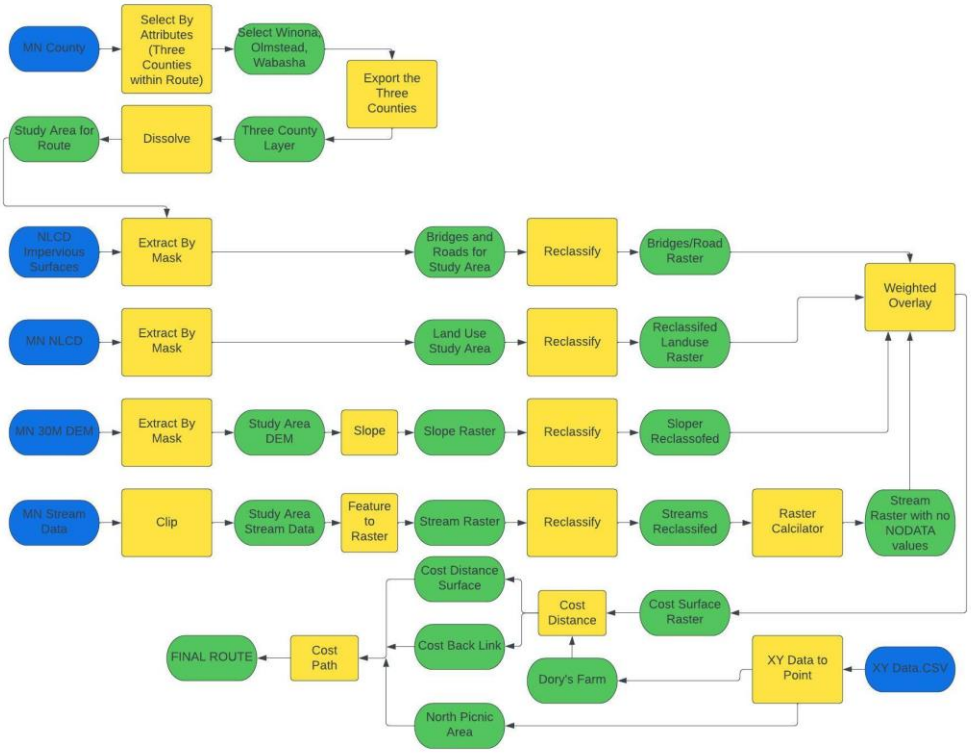
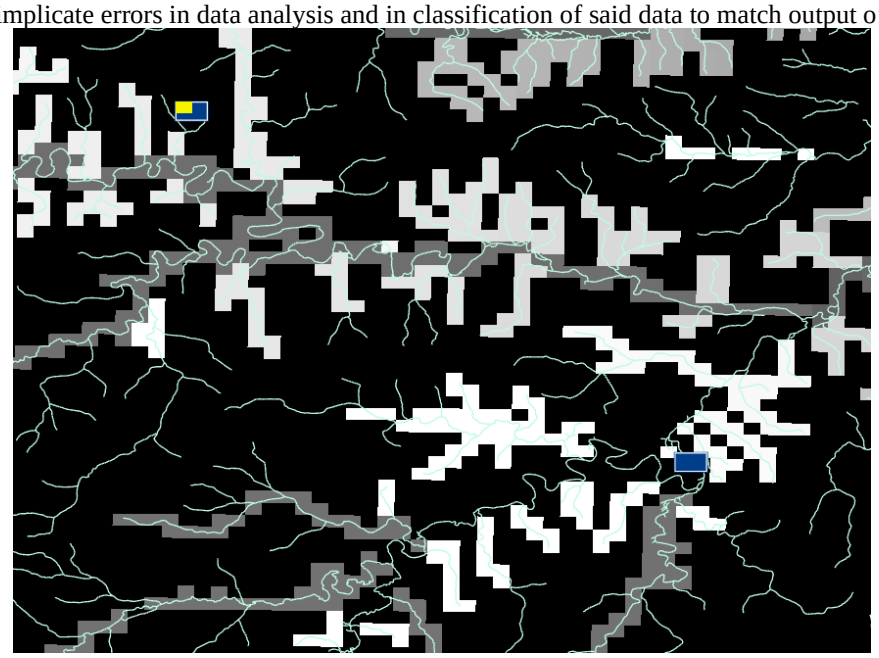


Figure 1. Enumeration of Cost Surface model steps and end result for final route for Dory's Path to North Picnic Area..

Results

Despite no route being generated in Map 2, the process for running the Cost Surface model proved resourceful and is reliable, it is the matter of classification and enumeration units that are used. Likewise, the number of weights that are used and ran multiple times to find many potential routes, not just one fixed path is the point of a cost surface analysis and the predicates that are inputted into the model. It can assume that if you were to apply Cost Surface techniques to a similar procedure in finding the least cost path that using a plethora of other raster products and tools would implicate errors in data analysis and in classification of said data to match output of routes.



Map 2. Rough Optimal Route from Dory's Farm (top left) to North Picnic Area (bottom right).

Results Verification

As depicted in the first map, there are no definitive routes displayed, so there is bias in the classification and error in how each class was produced. The model itself is reliable and can be used to be reproduced for other purposes and analysis not just applicable for Dory's purposes, but also in slope and watershed analysis in this part of the state and others.

Discussion and Conclusion

Using Cost Surface analysis is almost parallel to that of a Network Analysis in finding the least cost path to a route, instead of vector analysis we are performing raster analysis and minimizing/mitigating preferences on a cell basis with time travel basis. In juxtaposition, the cost surface model seems to take more factors into account than network analysis, or about the same amount of factors, for real world implications if you have more weights and products to be inserted into your model. To minimizing the amount of bias and error is to use most reliable data sources, code correctly, have same cell sizes to other classifications and weights, and run multiple analysis to find best route based on study you're training to perform

References

Create a network analysis layer. (n.d.). Arcgis.com. Retrieved October 30, 2022, from https://pro.arcgis.com/en/pro-app/latest/help/analysis/networks/new-network-analysis-layer.htm

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Understanding cost distance analysis. (n.d.). Arcgis.com. Retrieved October 29, 2022, from https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/understanding-cost-distance-analysis.htm

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	**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	**98**