Lab Report

Title: Lab 2 part 1 and part 2
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Date: 11/1/2022

Project Repository: *https://github.com/Samikshya036/GIS5571/tree/main/Lab2*
Time Spent: Around 20 hrs

Lab report Part 1

Abstract
This lab required me to develop ETLs to download lidar and PRISM data, and then build Python Notebooks that showed the data using Python code. I built a DEM and TIN file from the lidar data. Both Pdf are available on GitHub and examined the various visualization options for lidar data with ArcGIS Pro which supports both 2d and 3d presentations. I converted the PRISM data to Space Time cubes after downloading it to summarize the average monthly precipitation readings for the continental US.

Problem Statement

1. To build an ETL in ArcPro Jupyter Notebooks and arcpy that downloads .LAS files from MN DNR, converts .LAS files into both TIN and Dem file and export pdf of DEM and Tin with correct visualization.
2. To build an ETL in ArcPro Jupyter Notebooks that downloads the annual 30-Year Normals .bil files for precipitation from PRISM, converts data into a spacetime cube and export to disk and export animation to timeseries.

Table 1: Table showing data requirement from MNDNR and PRISM Climate Group

#	Requirement	Defined As	(Spatial) Data	Attribute Data	Dataset	Preparation
1	Elevation data	.LAS files from MN DNR	Point (lidar) data	Point (lidar)	MNDNR	NA
2	Precipitation data	Annual 30-Year Normals .bil files for precipitation from PRISM	Raster	Precipitation value (inches)	Prism Climate Group	NA

Input Data

Las data includes various other features (intensity, classification, return, etc.).St. Paul, Minnesota, is covered by the region that is currently available and may be used to produce a DEM, and TIN model.

The PRISM data set covers the whole continental United States and has a cell raster size of 4km. This statistic describes monthly precipitation over a specified area over a 30-year period. As a result, an analysis should be able to detect seasonal precipitation fluctuations throughout the year.

Table 2: Table showing purpose in analysis for .las file and bil.zip file.

#	Title	Purpose in Analysis	Link to Source
1	4342-12-05.las	To convert .LAS files into both TIN and Dem file and export pdf of DEM and Tin with correct visualization.	MNDNR
2	PRISM_ppt_30yr _normal_4kmM2 _01_bil .zip	To convert data into a spacetime cube and export to disk and export animation to timeseries.	Prism Climate Group

Methods

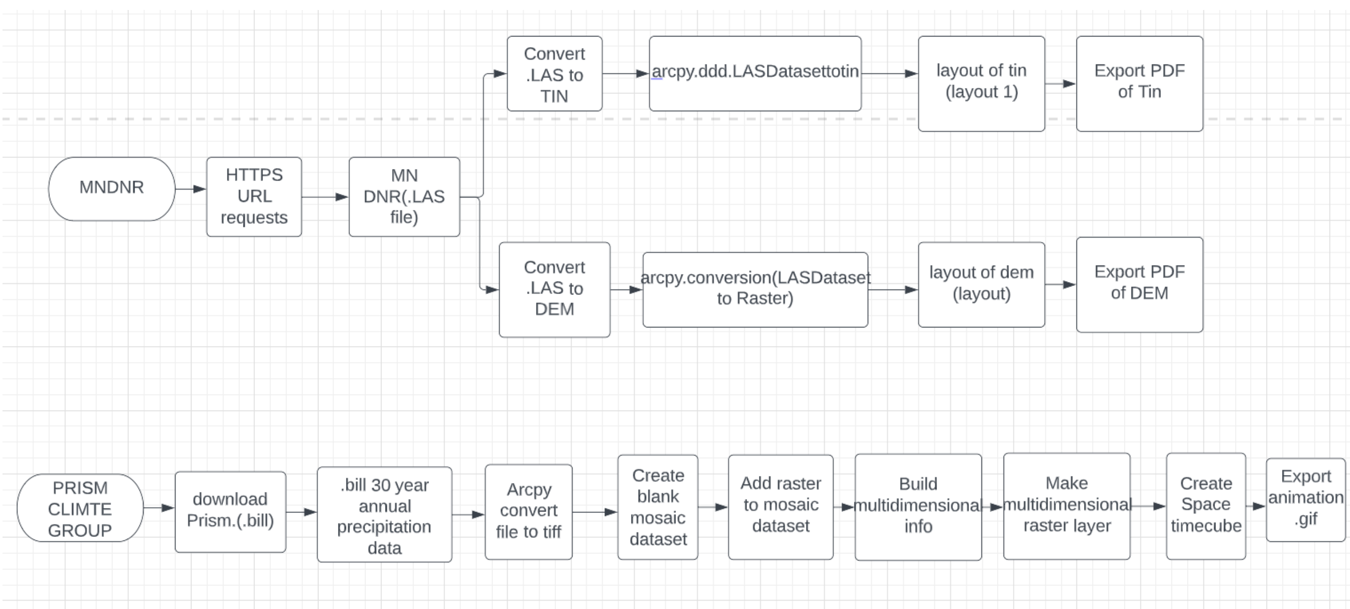

Figure 1. Data flow diagram.

MNDNR . Las file Methods

-
- Download .las file using url from MNDNR in Jupyter notebook
- Convert .LAS into both .tin and DEM
- arcpy.conversion.LasDatasetToRaster
- arcpy.ddd.LasDatasetToTin
- Exports PDFs of the DEM and TIN with correct visualization
- lyt.exportToPDF
-

Converts the .LAS file into both a DEM and a TIN

```
In [132]: with open(path_to_las,'wb') as f:
              f.write(las_file_obj.content)

In [137]: arcpy.conversion.LasDatasetToRaster(r"C:\Users\subed036\Desktop\LAB02\outputlas.las", r"c:\users

Out[137]:
          Messages

In [163]: arcpy.ddd.LasDatasetToTin(r"C:\Users\subed036\Desktop\arcgislab2\outputlas.las", r"C:\Users\sube

Out[163]:
          Messages
```

```
+  ✄  ⎘  ⎗  ↑  ↓  ⏯ Run  Code

In [90]: print(aprx.filePath)
         C:\Users\subed036\Desktop\LAB02\LAB02.aprx

In [1]: aprx = arcpy.mp.ArcGISProject(r"C:\Users\subed036\Desktop\LAB02\LAB02.aprx")

In [121]: arcpy.server.GetLayoutTemplatesInfo(r"C:\Users\subed036\Desktop\LAB02\RasterFunctionTemplates")

Out[121]:
          Messages

In [176]: lyt = aprx.listLayouts('Layout')

In [165]: lyt.exportToPDF(r"C:\Users\subed036\Desktop\LAB02\DEM.pdf")

Out[165]: 'C:\\Users\\subed036\\Desktop\\LAB02\\DEM.pdf'

In [171]: lyt = aprx.listLayouts('Layout1')

In [172]: lyt.exportToPDF(r'C:\Users\subed036\Desktop\LAB02\Tin1.pdf')

Out[172]: 'C:\\Users\\subed036\\Desktop\\LAB02\\Tin1.pdf'
```

Figure 2: Figure showing Python codes for .LAS file (MNDNR)

Exploratory 2D and 3D visualization:

- Open the project file to start visualizing the scene. In the Insert tab, select "New Local Scene" by performing a right-click on "New Map." Onto the scene, drag the LAS file
- Open the project file to start creating a map visualization. In the Insert tab, select "New Map." Onto the map, drag the LAS file. To view the visualization, go to the new Appearance Tab and select symbology > elevation.

Prism Climate Group

- Download .bill 30 year annual precipitation data file from Prism climate group using url in Jupyter Notbook
- Convert file to tif (raster to other format)
- Create mosaic dataset (arcpy.management.CreateMosaicDataset)
- Add raster to mosaic dataset (arcpy.management.AddRastersToMosaicDataset)
- Build multidimensional info (arcpy.md.BuildMultidimensionalInfo)
- Make multidimensional layer (arcpy.md.MakeMultidimensionalRasterLayer)
- Create space time cube
- Export animation.gif

Convert to tif

```
In [2]: arcpy.conversion.RasterToOtherFormat(r"C:\Users\subed036\Documents\ArcGIS\Projects\LAB2\bils\PRISM_ppt_30yr_normal_4kmM3_01_b
Out[2]:
```

Messages

```
In [37]: arcpy.management.CreateMosaicDataset(r"C:\Users\subed036\Documents\ArcGIS\Projects\LAB2\LAB2.gdb", "mosaic", 'PROJCS["WGS_198
Out[37]:
```

Messages

```
In [3]: arcpy.management.AddRastersToMosaicDataset(r"C:\Users\subed036\Documents\ArcGIS\Projects\LAB2\LAB2.gdb\mosaic", "Raster Datas
Out[3]:
```

Messages

```
In [4]: arcpy.management.CalculateField(r"C:\Users\subed036\Documents\ArcGIS\Projects\LAB2\LAB2.gdb\mosaic", "Timestamp", "$feature.C
Out[4]:
```

Messages

Build Multidimensional Info

```
In [5]: arcpy.md.BuildMultidimensionalInfo("mosaic", "Variable", "Timestamp # #", "mosaic # #")
Out[5]:
```

Messages

 # Make Multidimensional Raster layer

```
In [4]: arcpy.md.MakeMultidimensionalRasterLayer(r"C:\Users\subed036\Documents\ArcGIS\Projects\LAB2\LAB2.gdb\mosaic", "mosaic_Multidi
Out[4]: 'C:\\Users\\subed036\\Documents\\ArcGIS\\Projects\\LAB2\\mosaic_MultidimLayer_1.nc'
```

, Figure3: Figure showing Python codes for .bill file (PRISM)

Results

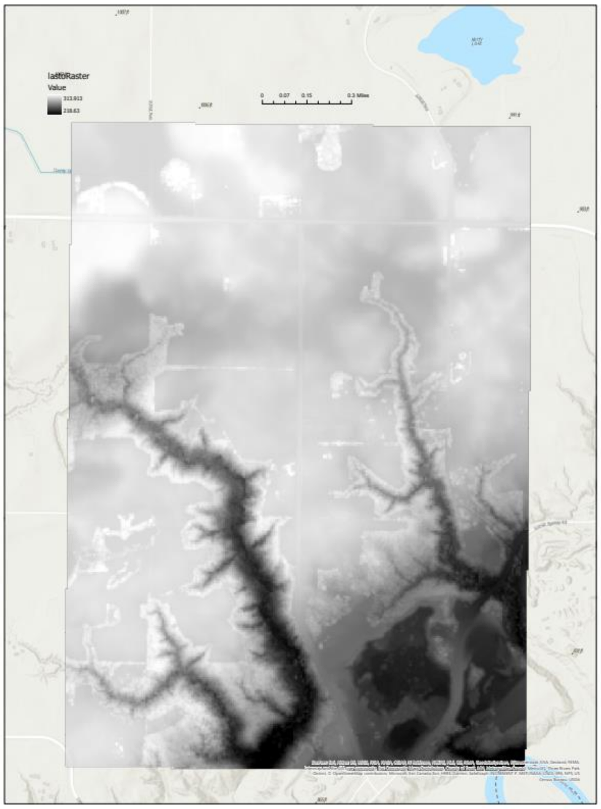

Figure 4: Figure showing Screenshot of exported PDF of DEM

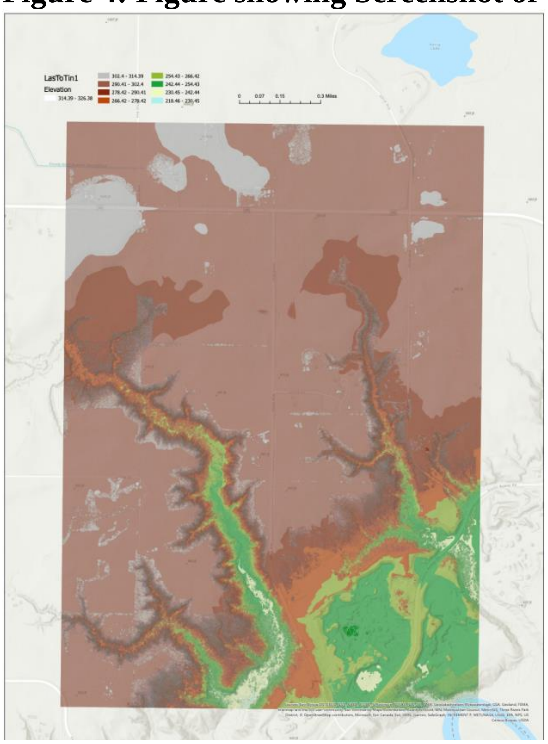

Figure 5: Figure showing exported PDF of TIN.

Exploratory 2D and 3D visualization:

The 3D and 2D representations of the downloaded LAS file are shown in Figure 6. Both visualization options display the LAS data as a gradient of elevation or elevation-related attributes. The Scene version includes the unique ability to move about a 3D version of the landscape, which makes it easier to observe in space than a 2D surface but requires more processing power.

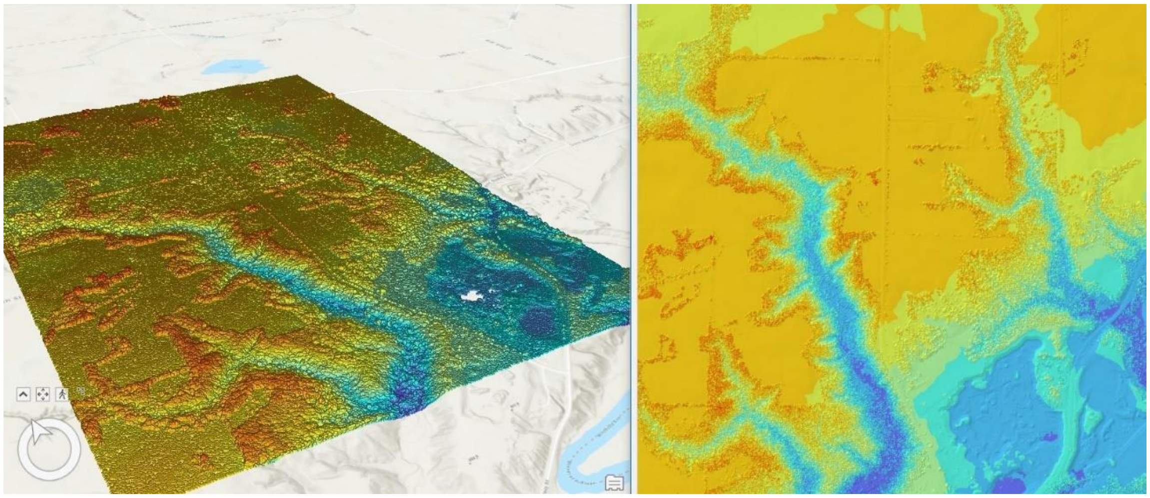

Figure 6: 2D and 3D visualization of LAS data

Time cube results:

Figure 7: Mosaic multidimensional layer.

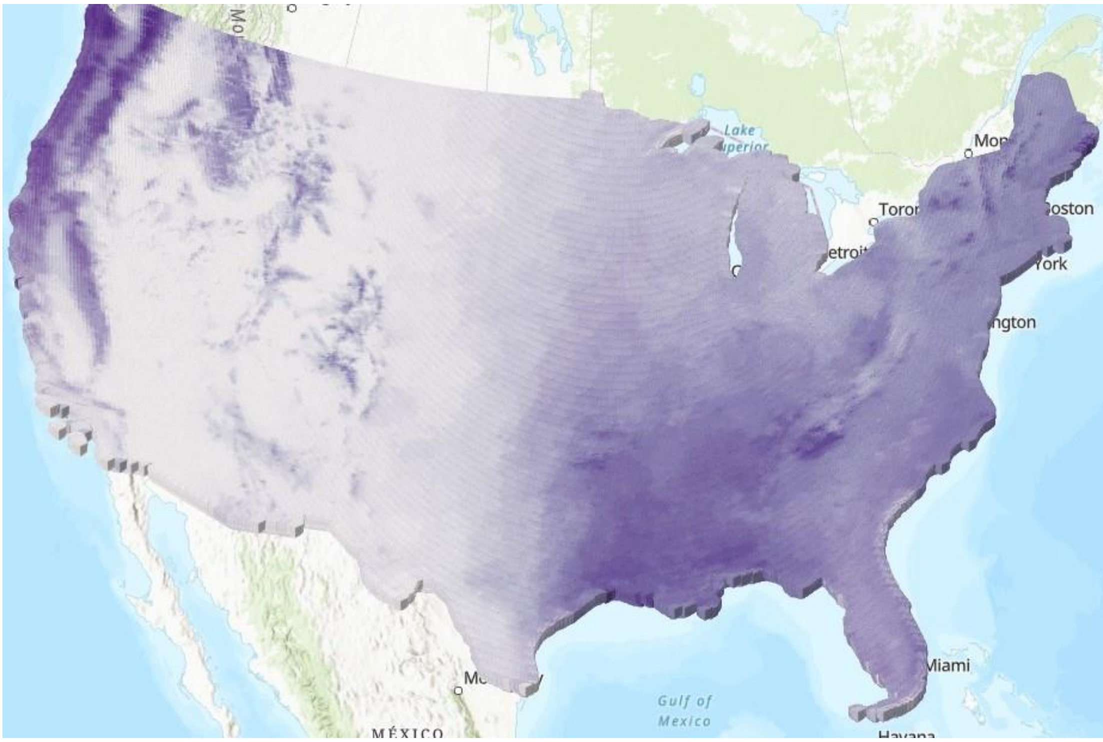

Figure 8: Figure showing time cube results of visualization of 30-year precipitation normal.

Results Verification

For LAS results I verified if the code is retrieving the correct file is to manually download it and compare it to the automatic download. These documents appear to be identical. Run the same tools in the GUI to test the LAS to Raster/Tin conversions. The GUI and code yield the same results when the parameters are the same.\

For 2D/ 3D LAS I verified it if visualizations match with the TIN version from the LAS, and each other.

For Space timecube, By visually inspecting the raster files within the ArcPro interface, I was able to validate the monthly raster pictures produced. This confirmation validated my output. The Space Time cube was more difficult to verify because I couldn't quickly evaluate the result visually.

Discussion and Conclusion

I learnt about rasters in this lab. I learnt to convert them in different files I also learned about space time cube but visualization was little tough for me. I learnt to download .LAS files from MN DNR, convert .LAS files into both TIN and Dem file and export pdf of DEM and Tin with correct visualization and to build an ETL in ArcPro Jupyter Notebooks that downloads the annual 30-Year Normals .bil files for precipitation from PRISM, converts data into a spacetime cube.

References
https://pro.arcgis.com/en/pro-app/latest/arcpy/mapping/introduction-to-arcpy-mp.htm

https://pro.arcgis.com/en/pro-app/latest/tool-reference/space-time-pattern-mining/createcubefrommdrasterlayer.htm

Lab Report (Part 2)

Project Repository: *https://github.com/Samikshya036/GIS5571/tree/main/Lab2*

Abstract
A cost raster shows the price associated with traversing each cell within any research extent. In this lab, a cost surface raster is used to find the best route between two points while accounting for subject preferences. All of the input datasets, including the DEM, streams, land cover, and highways, were initially acquired from the MN Geospatial and imported into ArcGIS Pro. The criteria layers are then given identical weights and standardized using the reclassification tool before being overlaid. To find the ideal path between the specified two places, two spatial analyst tools: cost distance and cost path as polyline tool were then applied.

Problem Statement
To Create an ETL for data to go into a cost surface model, Create a cost surface model and Map the range of cost surfaces given uncertain preferences and model weights.

Table 1. Table 1 shows data requirement for the cost surface.

#	Requirement	Defined As	(Spatial) Data	Dataset	Preparation
1	MN Counties	Shapefile of counties in Mn	Vector (Polygon)	Mn GeoSpatial Commons	-
2	Streams	Raw vector input data	Vector	Mn GeoSpatial Commons	Reclassify
3	Road Network	Raw input data (vector)	Raster	Mn GeoSpatial Commons	Reclassify
4	DEM	Raster data for slope determination	Raster	Mn GeoSpatial Commons	Reclassify
5	Starting and ending points	.CSV file of Dory's coordinates	CSV	-	Reclassify
6	Land Cover	Raster data for land use determination	Raster	Mn GeoSpatial Commons	Reclassify

Input Data

The datasets needed to generate the cost surfaces using map algebra and cost modeling are listed below. There are six datasets in total that take into account all of the subject's route preferences as well as the starting and ending locations of the route.

Table 2: Table showing purpose of analysis for input dataset

#	Title	Purpose in Analysis	Link to Source
1	MN Counties	For study extent	MNcounties
2	Streams	This layer will represent all the streams in the study extent.	Stream order
3	Road Network	This layer will represent all the roads that cross the streams in the study extent.	RD network data
4	DEM	This dataset will contain information about the slope in the study area.	MN DEM
5	Starting and ending points	Dory's starting and ending coordinates are stored in a CSV file. final point	-
6	Land Cover	This dataset will show how forests, wetlands, impermeable surfaces, agricultural, and other land and water types cover the study area.	ncld

Methods

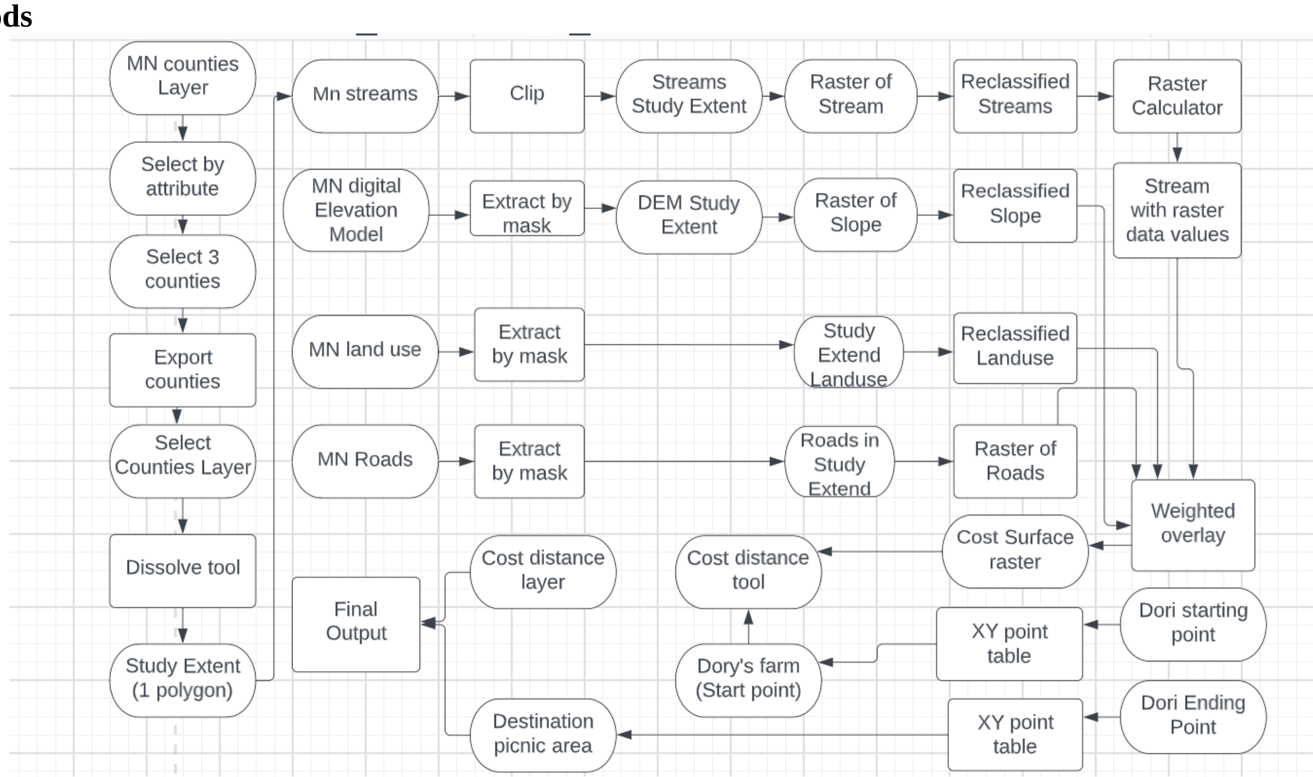

Figure 1. Data flow diagram.

Method steps

- Four datasets were used to determine the cost surface path of a bridge and a steep path.

- All input data were obtained from MN Geospatial and then imported into ArcGIS Pro.
- Dory's starting and ending points are exclusively in three counties: Winona, Olmstead, and Polk.
- Using the geoprocessing tool select, and Wabasha were chosen from the MN counties layer as an attribute .
- The dissolve tool was used to join the three counties and define the study extent
- The data flow diagram summarizes the methods used to complete the task as illustrated in Figure 1.

The extract by mask technique was applied to the above input datasets in order to obtain digital elevation model and land cover data for the road network streams inside the study area. Combining the classed datasets is the next stage in creating the cost raster. The criteria are then standardized using the reclassification tool using a scale from 1 to 10. The most favored option receives a score of 1, while the least preferred option receives a value of 10. In this lab, each raster cell's suitability value is multiplied by its layer weight to give a suitability score, which is then added to the values to form the classed input raster layers overlay. All four inputs in this lab received the same weights, or 0.25 or 25%.

I used cost distance tool to obtain the cost distance layer and cost direction layer following the weighted overlay analysis. The weighted overlay and Dory's beginning point serve as the tool's inputs. I then used Cost Path as Polyline to determine the best route between the starting and ending places of the Dory (North Picnic area).

Results

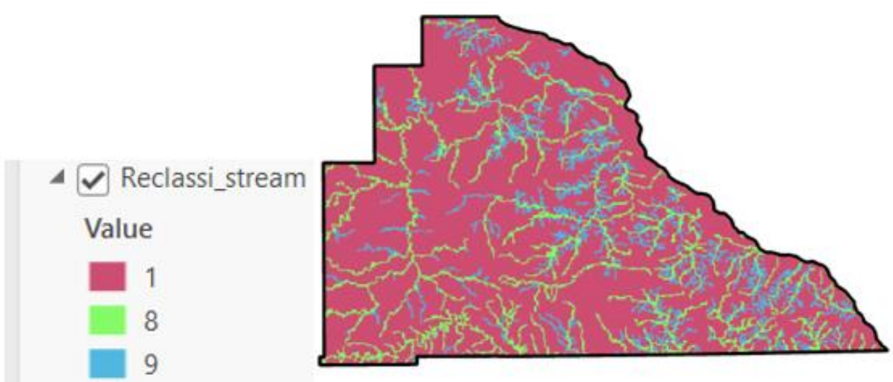

Figure 2: Reclassify Stream

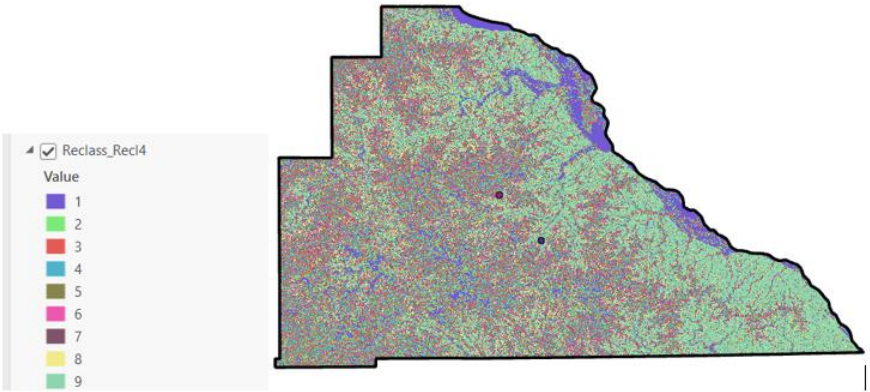

Figure 3: Reclassify Slope

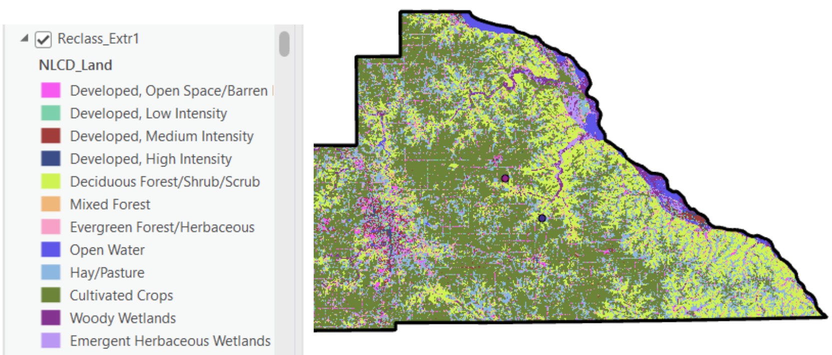

Figure 4: Reclassify Land cover

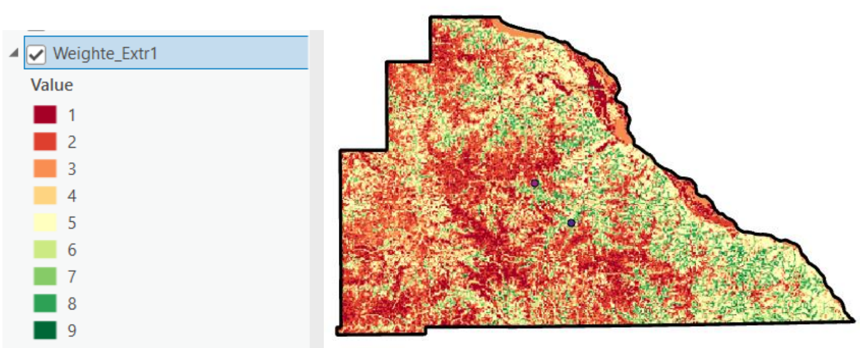

Figure 5: Weighted overlay

The cost distance tool produces the cost distance surface and cost direction layer that are depicted in figures 6and 7 The inputs were a weighted overlay and a CSV file with information on Dory's starting point.

Figure 6: Cost distance layer

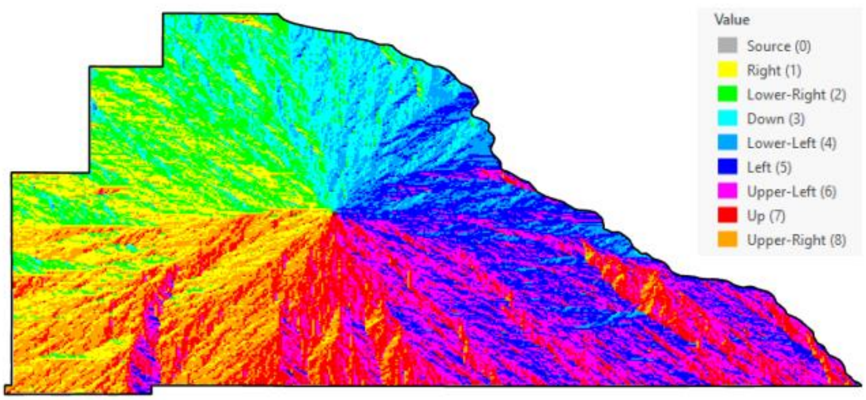

Figure 7: Cost distance layer

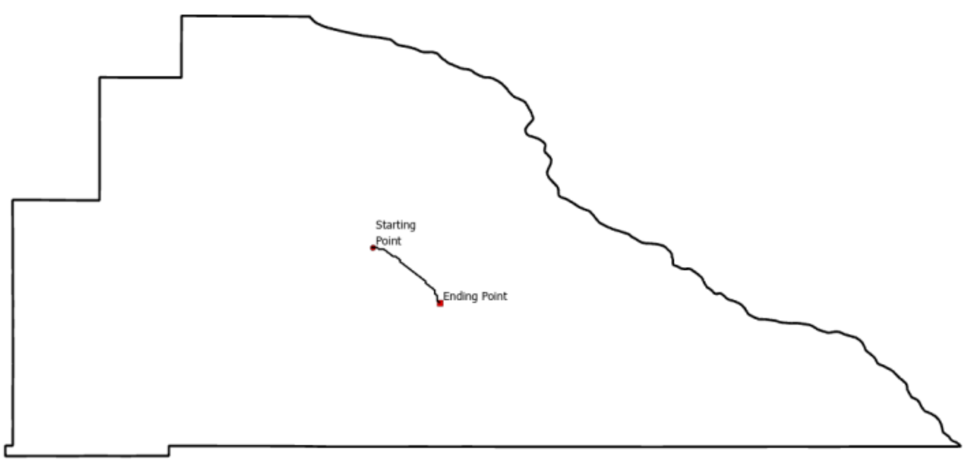

Figure 8: Optimal path line

The route illustrated in figure 8 was determined by the Cost Path as Polyline tool, which was used to determine the best route between Dory's beginning and ending points (North Picnic area). Dory's end point, cost distance, and cost direction layers are the inputs for the aforementioned tool.

Results Verification

These outcomes were from code in my Jupyter Notebook, and they were compared with the map outcomes. I can also develop explanations for these results using some critical thought and visual observation.

Based on my calculations, I believe the "Optimal connection Tool" produced better results because it is based on the Cost Surface file, which is based on multiple distinct variables, as opposed to the "Optimal Path as Line" tool, which only requires slope input.

Discussion and Conclusion

I believe that using road data to identify bridges might be beneficial in the future. Dory's preferences are something I want to experiment with a bit more and see if there are any other ways to use the stream data.

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	**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	**20**
		100	**96**