

Creating New Hiking Trails with Hazards in Mind

1. The Problem

California has an impressive number of state and national parks located throughout the state. Most of these parks were established between 1902 and 1980 and typically host a combination of hiking trails, mountain-biking trails, and campgrounds. In the early days, one can imagine that trails were necessary for travel and communication by horseback as well as firefighting endeavors. It was only until the 1920's that hiking became a recreational activity and a need for hiking trails arose (US Forest Service, 1922). Many of the trails existing today are quite old, and while they are well-maintained, they may not have been constructed with many of California's natural hazards in mind. A common natural hazard which typically occurs in the late-winter to spring months is land-sliding. As the climate continues to change, more frequent extreme weather events have been causing more frequent land-sliding throughout California. Landslides are often found spilling out onto hiking trails as one goes out hiking in the spring. As landslides become a more frequent phenomenon, I think it will become increasingly important to reevaluate the locations and paths of existing state and national park trails.

The Standish-Hickey State Recreational Area was established in 1921, making it one of the oldest state parks in California. It is prone to land-sliding and now has many mapped landslides throughout the small park. My hypothesis is that a new hiking trail going through Standish-Hickey SRA can be generated using the ArcMap "Least Cost Path" tools to avoid landslide prone areas while still finding the least strenuous path through the park.

2. Data Collection

For this analysis, I required a digital elevation map (DEM) of the area of interest in a resolution reasonable for slope and landslide area. I was able to download a 10-meter resolution DEM from the USGS National Map project (<https://viewer.nationalmap.gov/basic/>). Digitized USGS topographic maps were also available for the region, which I downloaded for potential point and line shapefiles related to the state park. I also needed the Standish-Hickey SRA boundary, which was part of a massive park boundary dataset that I found on ArcGIS Online. Image PNG landslide data was also found on ArcGIS Online, which was offered by the California Geological Survey. Lastly, I added a NAIP 4-band aerial imagery layer to use as a background for the map.

3. Data Processing

Since the datasets added from ArcGIS Online were streaming, I first exported the datasets to have a permanent copy for myself. While doing this, I changed the coordinate system of these datasets to UTM NAD 1983 Zone 10 by using my data frame coordinate system, which I had set to NAD 1983 through the data frame 'Properties' tab. I chose to switch to NAD 1983 as the ArcGIS Online datasets were originally in WGS 1984 Web Mercator Auxiliary Sphere and I

wanted something better to work with. I used the ‘Project Raster’ tool on the DEM to project to UTM NAD 1983 Zone 10.

After adjusting the data for coordinate system and projection, I began to clip some of my larger datasets. I wanted to do this early on to avoid slowing down the program with the large state wide datasets that I had added.



Figure 1. At a step during my data processing, showing the distribution of mapped landslides in Standish-Hickey SRA.

4. Workflow

First, I open the ‘Cost Path’ tool to see what data it requires. To run the tool, I need to input a ‘cost distance raster’ and a ‘cost back link raster’, both of which have their own tools to create them. The ‘Cost Path’ tool also requires a feature destination, which is essentially the end point of my trail.

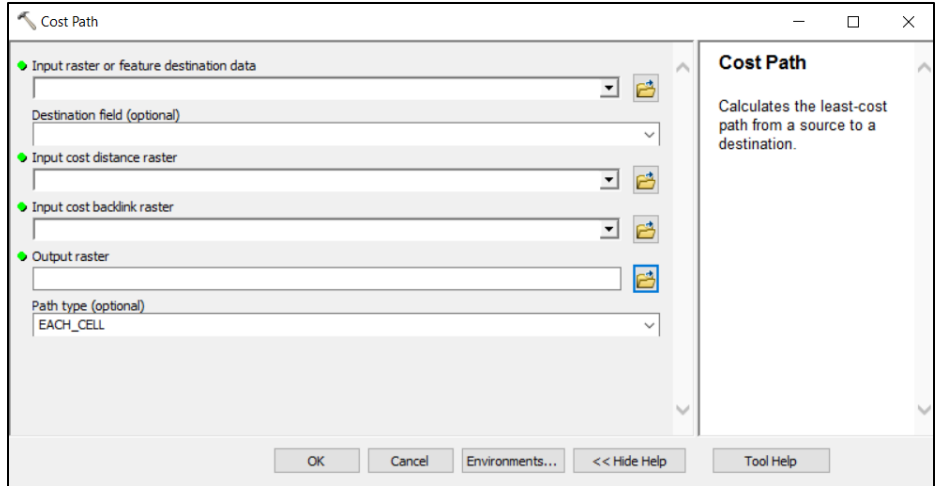


Figure 2. ArcMap ‘Cost Path’ tool showing required inputs.

The ‘Cost Distance’ tool requires a ‘cost raster’ and a feature source datum, which is the start point of my trail. The ‘Cost Back Link’ tool requires the same inputs as the ‘Cost Distance’ tool.

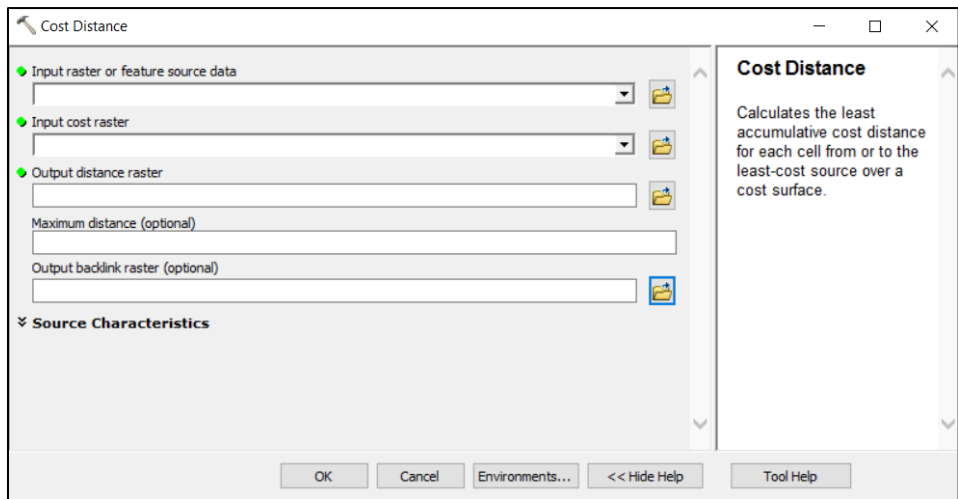


Figure 3. ArcMap ‘Cost Distance’ tool showing required inputs.

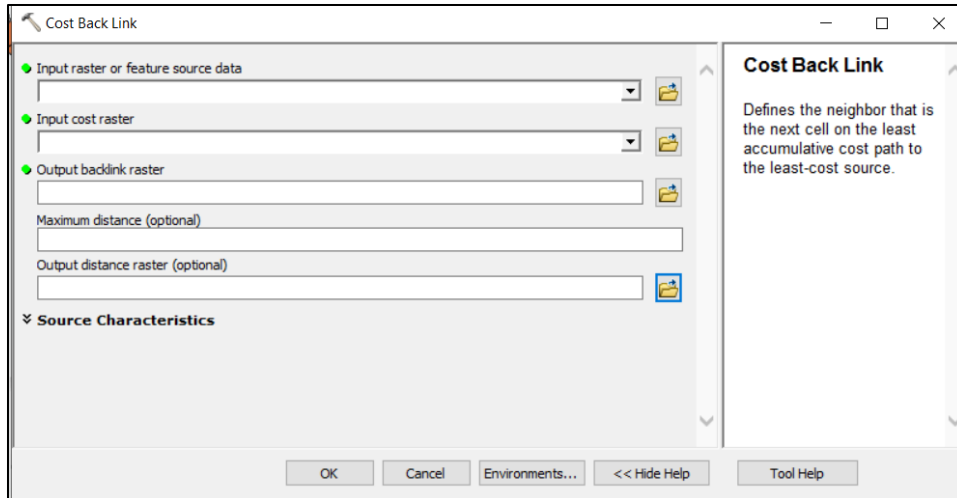


Figure 4. ArcMap ‘Cost Back Link’ tool showing required inputs.

I have decided to use slope and landslides as my “cost” where I want the least amount of slope for easy hiking and no previously mapped landslides for safe hiking on my new trail.

- **Create Trail Start/End**

I created two new shapefiles to place my trail start and end, which will be needed for my cost path analysis.

- **Create Landslide Raster**

The mapped landslides were in image PNG format, so I made a new shapefile of polygons to trace each landslide within my area of interest and added a “Value” field in the attribute table to make each landslide have a value of ‘1’. I included the river as well as I don’t want my hiking path in the river. I then used the ‘Feature to Raster’ tool to make a raster of my landslides. I set my attribute field to “Value” and use the same cell size as my DEM raster, which I set in ‘Environments’. I then use the ‘Raster Calculator’ to give an ordinal value to my landslide and non landslide area by using the following statement:

Con(IsNull(“landslides”), 0, “landslides”)

- **Cut DEM using Landslide Raster:**

This allows me to now use the ‘Set Null’ tool to clip my mapped landslides from my DEM. My ordinal landslides raster is my ‘Input Conditional Raster’ and my DEM is my ‘Input False Raster or Constant Value’. I type in ‘Value = 1’ in the expression box to select my landslides with their value of 1 and run the tool.

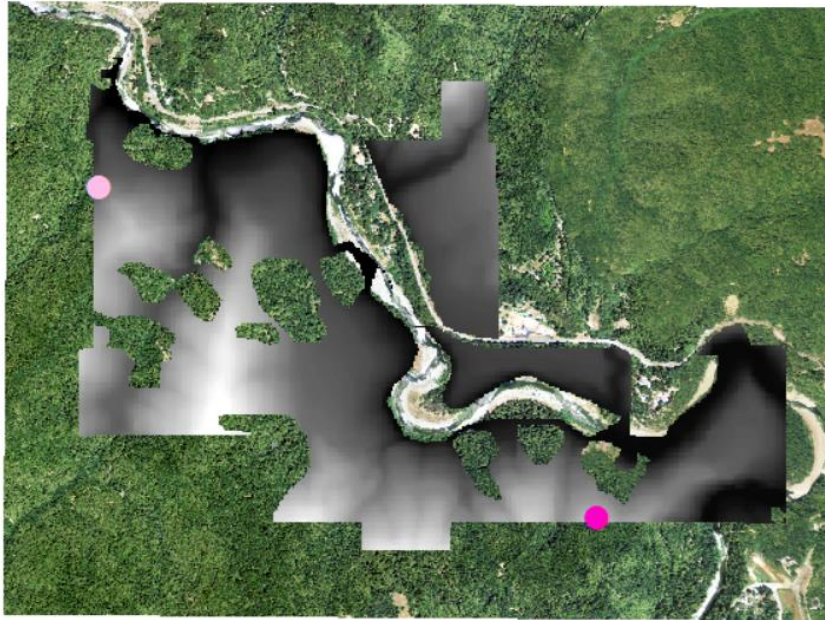


Figure 5. The result of using the ‘Set Null’ tool. Trail start is indicated by the dark pink circle while the trail end is symbolized by a light pink circle.

- **Create Slope Raster**

I now have a DEM with landslides cut out. I use the 3D Analyst ‘Slope’ tool to create a slope raster with my landslide “holes”. This becomes my “cost raster” that I will use when executing my cost path analysis.

- **Create Cost Distance**

I open up the ‘Cost Distance’ tool and select my Trail Start as my feature source and my slope raster as my cost raster.

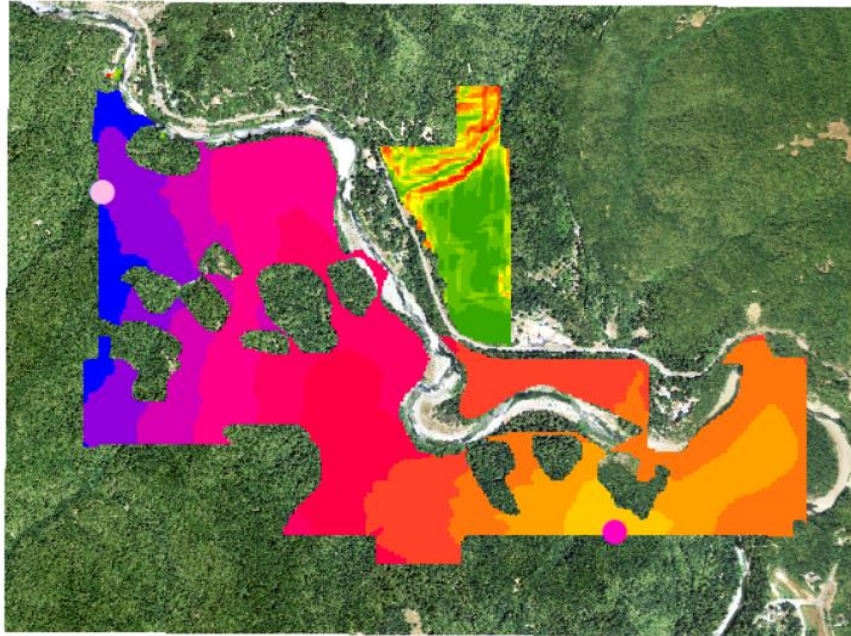


Figure 6. Cost distance output raster.

- **Create Cost Back Link**

Next, I open the ‘Cost Back Link’ tool using the same inputs as my cost distance raster.

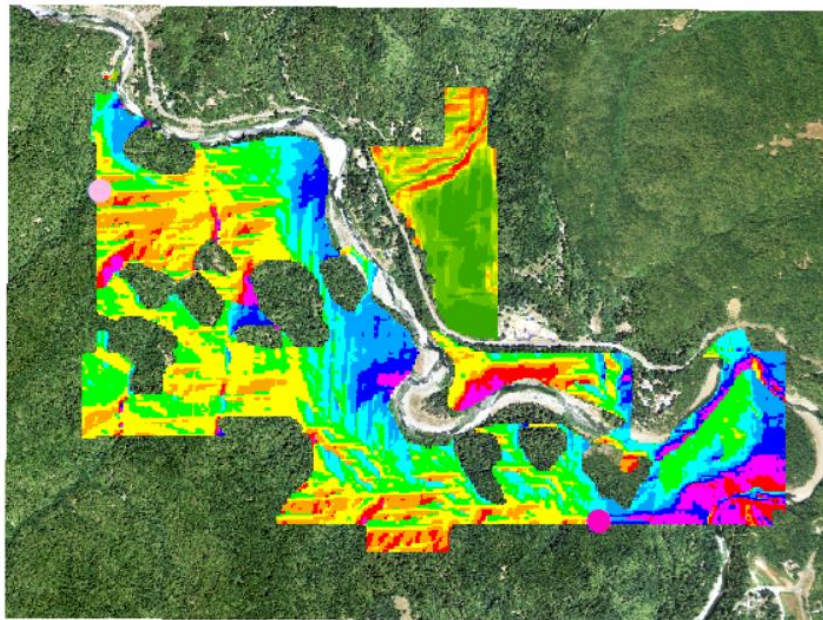


Figure 7. Cost back link output raster.

- **Calculate Cost Path**

Now I can calculate my least cost path through this state park. My feature destination is my trail end point and I select my new cost distance raster and my new cost back link raster as my other inputs and let the tool run. The output is a raster line.

- **Raster to Polyline**

My last step is to convert the raster line to a polyline. I use the 'Raster to Polyline' tool to do this.

5. Map Result

The process of combining the cost of slope with the cost of avoiding landslides was not as easy as clipping shapes out of a raster but was still reasonably straight forward. I am certain that there are other methods of combining costs, but this seemed to do a fine job for the simple analysis that I had chosen. The problem could have been made more complicated by assigning different levels of risk associated with different types of landslides.

The Cost Path tool was easy to use and the result was a new trail which avoids landslides and also keeps hiking easy.

Works Cited

US Forest Service. Trail Construction on the National Forests. (Washington, DC: U.S. Department of Agriculture, 1922), 6.

Standish-Hickey State Recreational Area, California

Emily Carreno, 11-27-19

