Using GIS to Create Geology-Based Educational Trails in Glacier National Park

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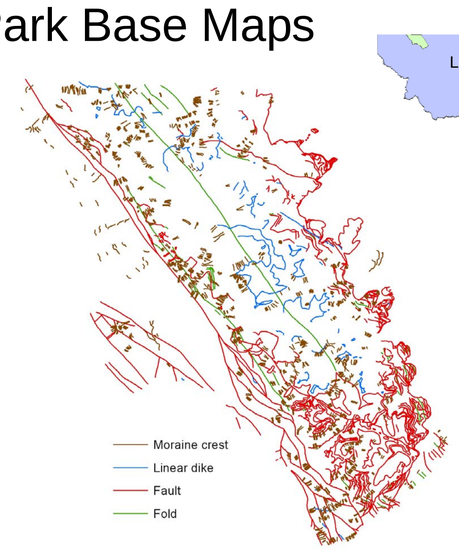
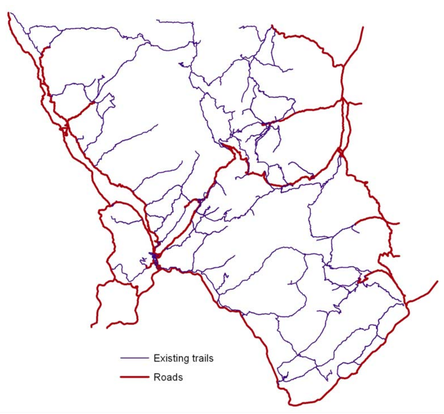
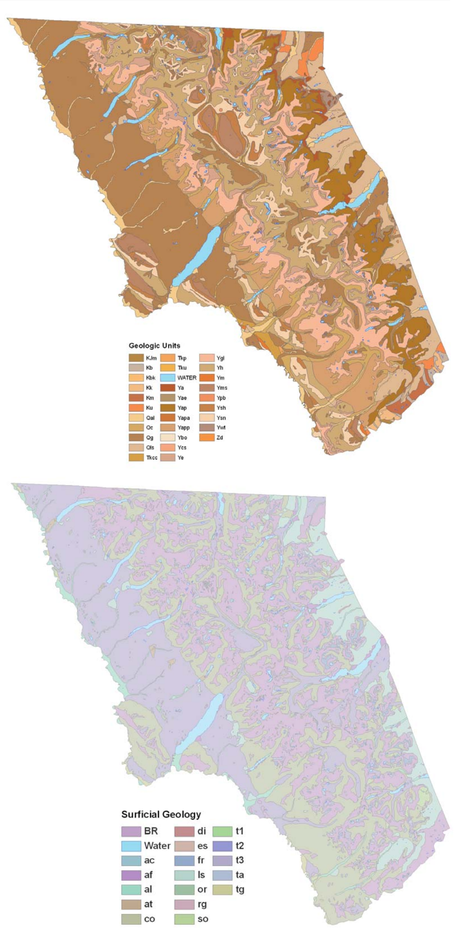
Introduction

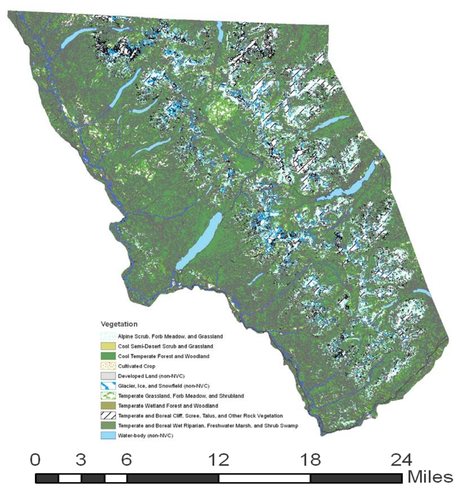
Our nation's national parks are home to a wealth of outdoor education opportunities, especially geologic features. Existing trail networks may not have been designed with this purpose. This project proposes a new method to create new trails which would bring visitors to various points of interest that could be explained by a interpretive ranger or a pamphlet. Data already available can be used in a GIS to analyze and display multiple attributes and has a built-in tool for generating the optimal path between points of interest. In this project visitors will be directed towards folds, faults, dikes, glacial moraine crests, and geologic contacts.

Park Base Maps









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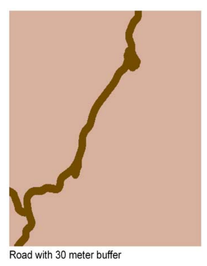
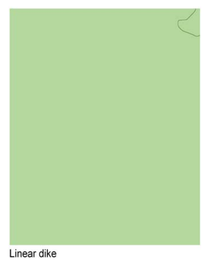
Methods

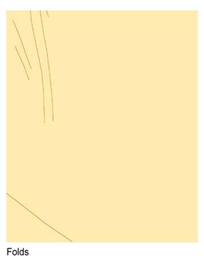
Data from online National Park Service sources were collected for Glacier National Park. A study area was chosen by looking at compiled layers and finding an area with road access, gentle terrain, a number of geologic units, and a variety of surficial geology and vegetation cover types. All maps were clipped to within study area. All vector layers were converted to raster and reclassified so that places of highest interest are lowest value. For geologic units, polygons were converted into lines so that boundaries would be emphasized in the analysis. Vegetation layers were classified by ability to see geologic features through it and suitability as a trail surface. All reclassified rasters were summed to create a total cost raster layer. Start, mid, and end point layers were created to identify trailheads. The Path Distance and then the Cost Path tools were then employed to have ArcGIS plot the best trail between points of lowest cost, according to the input cost raster.

Reclassified Study Area Maps


Road with 30 meter buffer


Moraine crests


Linear dike


Folds

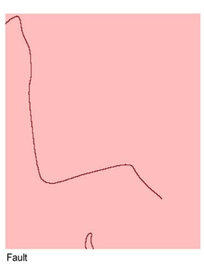

Geologic unit contacts


Vegetation by type

Forest, scrub, meadow, and rock vegetation are least cost and darker blue. Snow, wet areas, and developed land are less desirable areas for trails.


Vegetation by density

Vegetation with a canopy density of 10-60% is least cost and darker green.


Fault

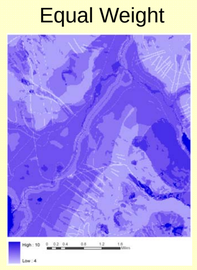

Surficial geology

Bedrock is least cost, lightest green. Alluvium, colluvium, and till are mid values. Water, talus, & landslides are highest cost, darkest green.

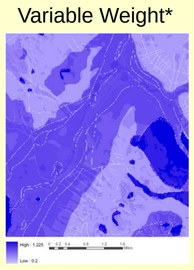
0 0.2 0.4 0.8 1.2 1.6 Miles

Total Cost Rasters

Equal Weight



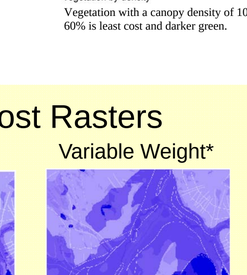
Variable Weight*



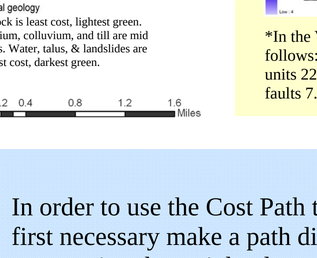
*In the Variable Weight Raster the inputs were weighted as follows: geologic unit contacts 37.5%, surficial geologic units 22.5%, vegetation density, moraine crests, folds, and faults 7.5%, vegetation type 5%, and roads and dikes 2.5%.

In order to use the Cost Path tool, it is first necessary make a path distance raster using the weighted cost raster, start point, and Digital Elevation Map. This produces a backlink raster which is like a slope aspect map but shows what direction of movement is the easiest/least cost for each cell. Then the path distance raster and backlink layers are inputted into the Cost Path function to make a "best single" pathway.

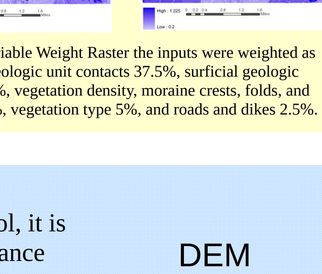
DEM



Path Distance Example*



Backlink Example

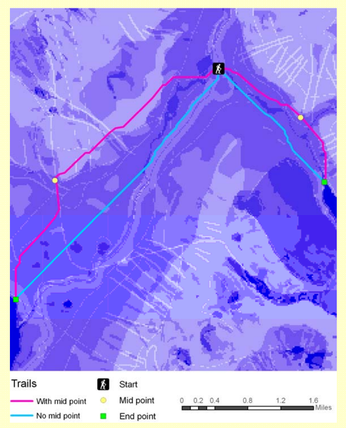


*Lighter values represent lower costs to start point.

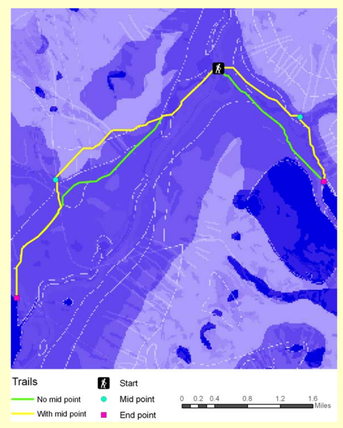
Results

Using the Cost Path tool, four trail systems were created that passed through or near sites of geologic interest. The first two systems used the raster in which all input features were equally weighted. The second two systems used the raster in which input features had variable weights. A trail was created on each raster using a beginning and end point. In order to direct the path towards features of interest, additional trails were plotted using a mid point placed so that the path would be forced to intersect or pass close to these features. To do this, the Path Distance function and then Cost Path function were run from the start to the mid point and from the mid point to the end point.

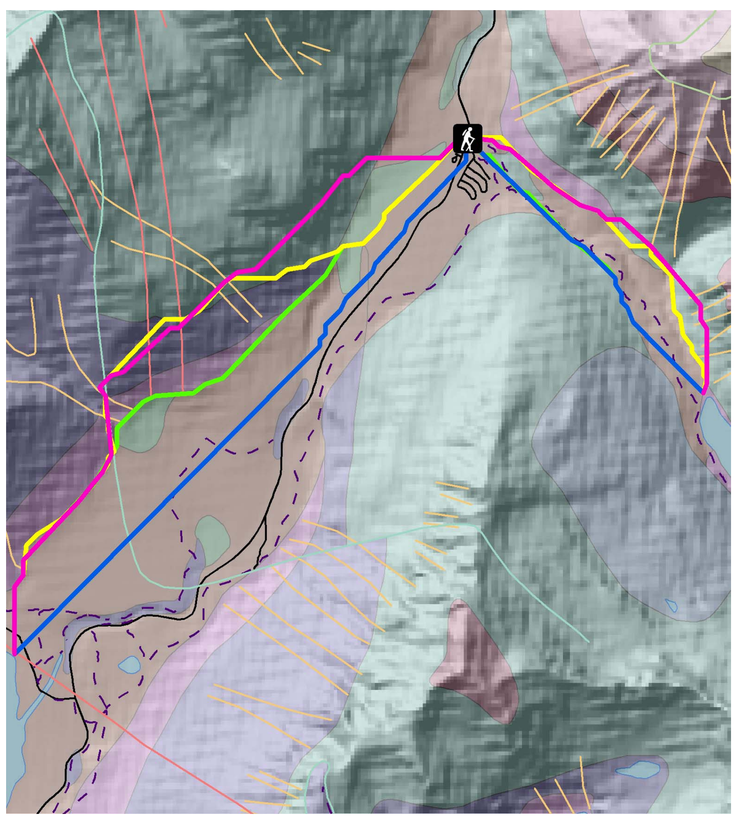
Trails on Equal Weight Raster

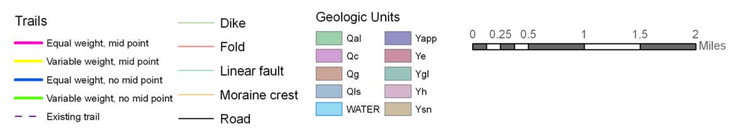


Trails on Variable Weight Raster



Final Trail Map





Conclusion

Based on the specifications we were able to give it, the Cost Path tool created good trails. The new trails pass by or intersect more points of geologic interest than the trails currently in existence and would therefore be better for educational hikes about park geology. Trail creation was not perfect though. For future application of this tool, it will be necessary to provide more specific inputs, perhaps with a different weighting scheme. For example, it would be better for visitors to see as many geologic units as possible instead of just following contacts.

Sources

Snyder, Stephanie A., et al. (2008) Ecological criteria, participant preferences and location models: A GIS approach toward ATV trail planning. *Applied Geology, 28*, 248-258.

NPS Data Store. http://science.nature.nps.gov/nrdata/ *Accessed April 6, 2009*

National Map Seamless Server. USGS. http://seamless.usgs.gov/index.php *Accessed April 6th, 2009*

Acknowledgments

Thank you to Jacob Benner and Kipp Callahan for assistance with the ArcGIS program.

NOTE: All maps are oriented with the top of the poster as North.