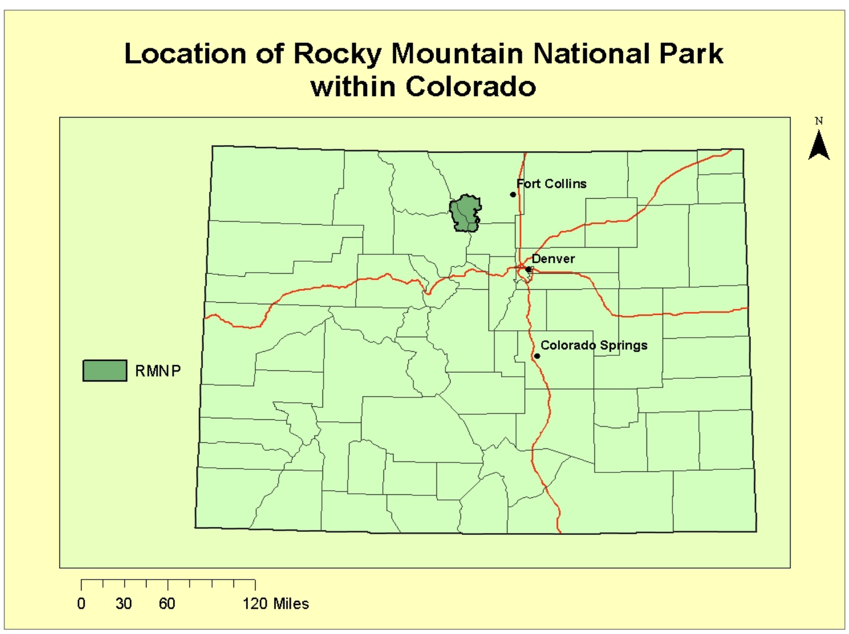
Cost Distance and Cost Path Modeling in Rocky Mountain National Park

Daryoosh Ardalan

11/29/09

GEOG 4080

Rocky Mountain National Park is a very popular tourist destination for many people across the nation as well as the globe. It is home to a diverse and extensive trail system which provides access to its thick forests, high altitude plains, and even higher peaks. The broad range of terrain contained within the park system requires a detailed process of modeling and exploring in order to make good a good decision as to where to carve a trail. Of course most of this work is done on the ground by personally surveying and examining the terrain. However, increases in technology now allow this type of analysis to be completed digitally. ESRI's Spatial Analyst tools in ArcMAP make it possible to combine land cover type, vegetation density, and slope to estimate the path of least resistance from one place to another. In this case, the Cost Path function has been used to determine the easiest path from each campground to the nearest trailhead based on a Cost Distance raster. **Map A** shows the location of Rocky Mountain National Park in Colorado.



Map A

The Cost Path is the estimated "most probable path for a process or a phenomenon to take" (Xu, 1994) According to Xu and Lathrop, the Cost Path function tracks the back link raster through the path with least cost, acquired from the cost distance raster. The back link and cost distance rasters are created from a friction surface and a source layer. In this case, the source layer is Trailheads and the friction surface was created by overlaying slope, vegetation density, and land cover friction surfaces. A requirement for creating a friction surface is that all input friction surfaces must be on the same scale, in this study the friction scale ranges from 0 to 10. In the case of land cover, "The resistance value of each cell in the grid is based on the resistance value of the land cover type attributed, but can be refined in many different ways if necessary" (F. Adriaensen, Et. Al. 2003) For this study I used a layer containing vegetation cover type from the National Park Service and reclassified many different types of land cover into more general groups. The original classifications can be found in the Rocky Mountain National Park Vegetation Classification Polygons document. My reclassified groups and their assigned frictions are displayed in **figure 1**.

Value	Veg Type	Friction
1	herbacious	2
2	glacier/rock	7
3	shrub/ribbon forest	5
4	aspen	4
5	fir/spruce/juniper	7
6	pine	4
7	cliff/water	ND
8	mixed conifer	6
9	road/paved	4

FIGURE 1: VEGETATION FRICTION

Areas where there are cliffs, rivers, lakes, or other impassible features are considered absolute barriers and given NoData values to restrict paths. Ribbon forest is defined as consisting of "strips (or forest) oriented perpendicular to prevailing winds." (Bekker and Malanson 2008) and are predicted to exist in areas also containing shrubbery. The slope friction values are based on the Digital Elevation Model split into three groups and are displayed in **figure 2** below.

Value	Slope	Friction
1	0-15%	3
2	15-30%	7
3	>30%	10

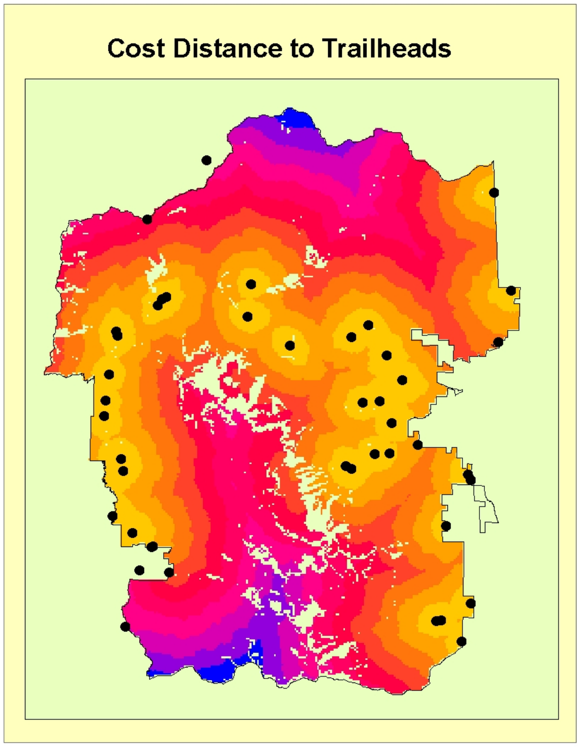
FIGURE 2: SLOPE FRICTION

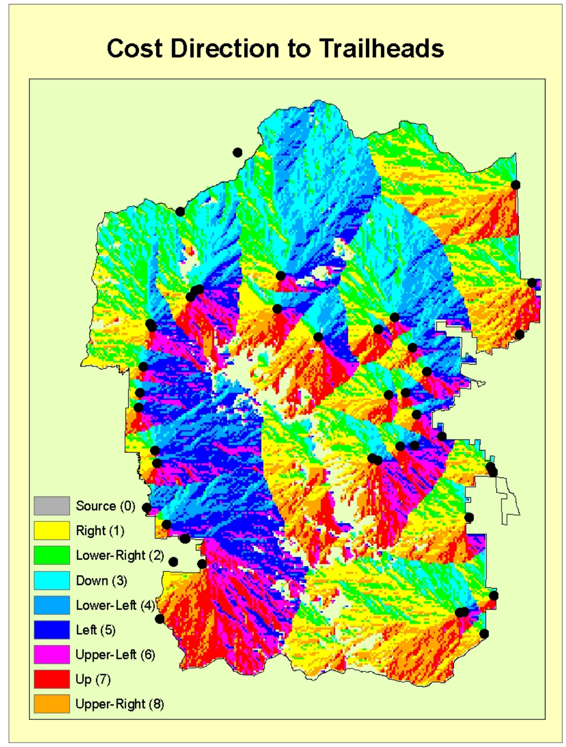
The vegetation density friction values are also provided by the Rocky Mountain National Park Vegetation Classification Polygons document. They did not require simplification; however their assigned friction values are displayed in **figure 3** below.

Value	Density	Friction
0	0	0
1	>75%	8
2	50-75%	6
3	25-50%	4
4	<25%	2

FIGURE 3: DENSITY FRICTION

These three surfaces were combined to create a total friction surface that is used to create the cost distance raster grid. The cost distance raster displays the weighted distance from the source (trailheads) to the extent of the analysis (Rocky Mountain National Park). Along with the Cost Distance raster, a Cost Direction raster is also created which shows the direction from any cell in the park to its nearest source. The Cost Distance and Cost Direction rasters are used together along with the destination layer (campgrounds) to determine the least cost path. Cost Distance and Cost Direction are displayed in **Map B** and **C.**

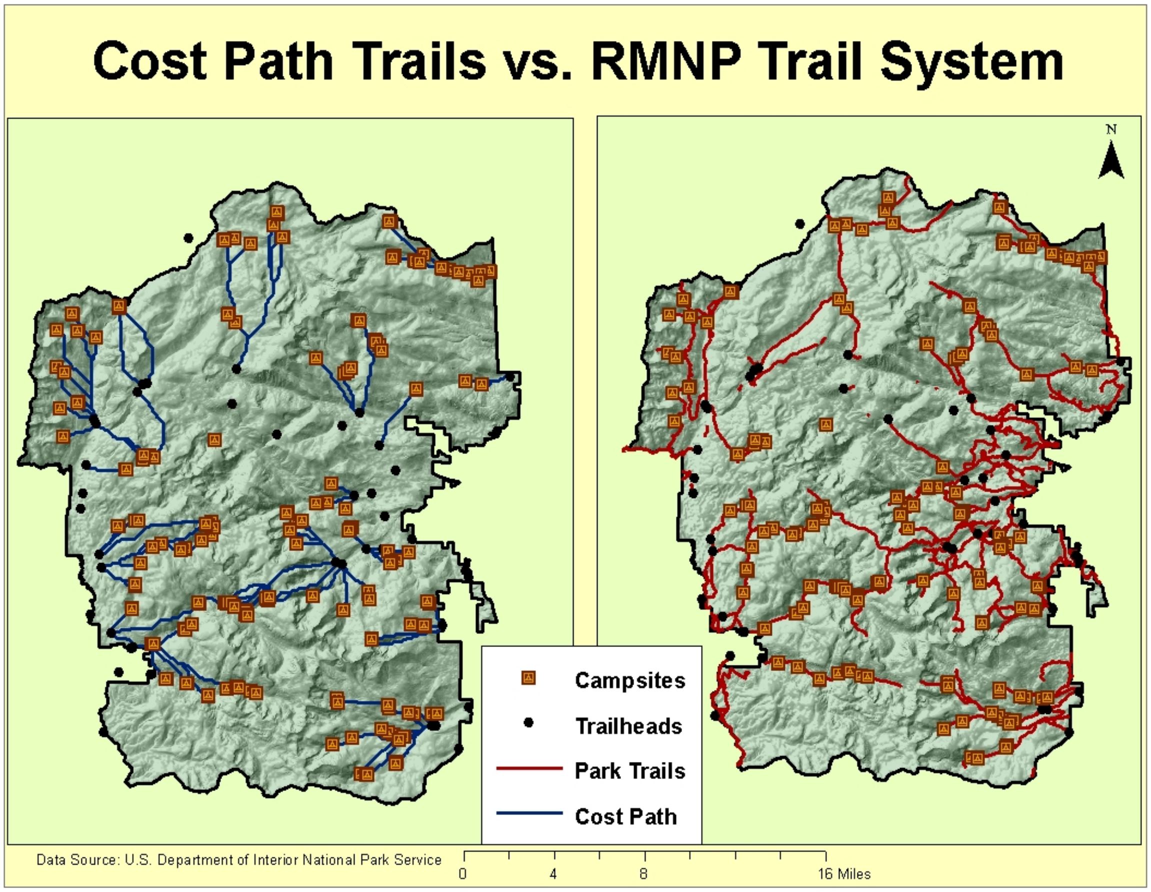




Map B

Map C

The results of this study are surprising in the regard that many of the cost paths fall almost directly above the existing trail system within Rocky Mountain National Park. One way that the two paths differ is that existing trails often follow ridges instead of valleys to give the trail user a better view during use. **Map D** displays the comparison of Cost Paths generated and the existing trail system.



Map D

By comparing the output maps in the presentation, it is clear that the cost path analysis is a fair method of creating or predicting trails in an environment with diverse vegetation types, land cover, and altitude changes. These results could also be used to help decide where to create new trails within the park system. If more accurate friction data is used, along with viewshed analysis, further studies like this can very easily and accurately aid in the construction of new trails within the large and important National Park system.

Bibliography:

Linear forest patterns in subalpine environments
Bekker and Malanson *Progress in Physical Geography.*2008; 32: 635-653

Rocky Mountain National Park Vegetation Classification Polygons

Bureau of Reclamation Remote Sensing and Geographic Information Group, 2005
biology.usgs.gov/npsveg/room/index.html

The application of ‘least-cost’ modeling as a functional landscape model
F. Adriaensen, Et. Al. 2003 *Landscape and Urban Planning* Vol. 64 Issue 4

Improving Cost-Path Tracing in a Raster Data Format

Xu and Lathrop Jr. *Computers and Geoscience* Vol. 20 No. 10 1994


ROMOVEG
Clip:
To BNDRY2006
VEGCLIP
Dissolve:
Veg_Type
VEGCLIPDIS
Edit Veg_Type:
Veg. Class
Table
VEGCLASS
Convert:
Polygon to
Raster
VEGRAS
Reclass:
Friction from
Veg Class
Tablle
VEGFRIC
Dissolve:
Density
VEGDENSE
Convert:
Polygon to
Raster
VEGDENSERAS
Reclass:
Density Fric
Table
DENSEFRIC
DEM
Extract:
To BNDRY2006
EXTRACT_
DEM2
Slope
SLOPE
Reclass:
Slope Fric
Table
SLOPEFRIC
Hillshade:
315deg
HILLSHADE
CAMPSITES
VEGFRIC
DENSEFRIC
SLOPEFRIC
Map Algebra:
Plus
FRICSURF
TRAILHEADS
Cost Distance:
Direction
allocation
FRICDIST
FRISDIR
FRICALL
Cost Path:
Each Cell
FRICPATH