Raster Analysis

Cost Distance Analysis

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I. Basics of Distance Analysis

In previous topics and exercises we used the Euclidean Distance tool to create a continuous distance surface using specific features such as roads, water bodies and urban areas. The calculated surfaces were nothing but a straight distance measurement from the object to the defined extents of the dataset.

The Euclidean distance tools are very useful when a straight-line distance is what is needed for analysis such as in the case of defining service/delivery areas from a set of source centers, or calculating a travel distance along a straight line from a source starting point. The direct relationship between a variable (e.g. suitability of location) and its proximity to a certain feature could also use a Euclidean distance measurement (e.g. proximity to water bodies). But when this distance is affected by certain barriers such as a steep slope, a large water body or any natural or man-made feature, the route from the source location to the destination might not be a straight line, instead, in many cases, the shortest distance may not be the fastest one. This is called an "overland" path. An example to this would be the path of a hiker from one point on a rugged, open land area to another; this might involve crossing streams at their lowest water level, typically choosing the less steep grounds, avoid densely forested patches and so on. So, the path of the hiker would take a more or less indirect direction between the two points. Another example is a spill of a pollutant on the landscape; calculating the free flow of this fluid on the landscape would involve the slope as well as the soil types and land cover that would re-direct the fluid from one point to another until it reaches the lowest point or a stream. In those cases, the cost-distance analysis methods are applied; where cost surfaces would be involved in modifying the straight-line path between source and destination points. The cost surfaces are nothing but raster datasets that would include values that would impede the direct flow and would deflect the path to the best cell values between the points.

You can create a single least-cost path or a corridor that presents multiple potential paths between the locations. You can also use the same method to create a layer showing the spread of a phenomenon (e.g. wildfire) where the model creates the least-cost path across the surface in all directions from the origin.

A. Euclidean Functions

The Euclidean method has 3 main functions: Euclidean Distance, Euclidean Allocation and the Euclidean Direction. The Euclidean Distance function calculates the straight line shortest distance between the center of each cell in the raster dataset to the center of the source cell(s) using the Pythagorean theorem for hypotenuse calculation. The Euclidean Direction calculates the direction of each cell to its closest source using a 0-360 degrees measurement moving east from the 0 degree (north). Finally, the Euclidean Allocation calculates what I refer to as the "service area" around a source; so having multiple source points (e.g. stores), the Euclidean

Allocation would assign each cell to a specific source according to its Euclidean distance (e.g. identifies the area served by each store). The following help link explains all three functions in more details:

> https://desktop.arcgis.com/en/arcmap/latest/tools/spatial-analyst-toolbox/understanding-euclidean-distance-analysis.htm

B. Cost Distance Analysis

On the other hand, Cost Distance analysis takes into consideration factors that would affect the travel from a source point to a destination location, such as the difficulties or barriers that might affect the route direction between the two points. Those factors can be steep slopes, unpaved roads, specific inaccessible land cover types (water, swamps, dense vegetation …etc.), danger zones, or any other factors that would typically increase the travel time between the points. In the Cost Distance analysis, those factors are included in what is called a Cost Surface.

Read about the general concept of the Cost Distance analysis here:

> https://desktop.arcgis.com/en/arcmap/latest/tools/spatial-analyst-toolbox/cost-distance.htm

A Cost Surface is a raster continuous dataset where cell values are coded from low to high cost, a relative scale that the user defines but typically, higher cell values are more difficult to travel through while lower cell values are the easiest or most convenient. This surface could be a combination of multiple factors that have been weighted according to their relevance. The combination method could be determined according to the nature of the original as well as the reclassified data.

Simple mathematical functions (addition, subtraction, division and multiplication) could be used to combine those factors, but also, other Combinatorial functions could be applied as well.

Read about the Cost Surface calculation here:

> https://desktop.arcgis.com/en/arcmap/latest/tools/spatial-analyst-toolbox/creating-a-cost-surface-raster.htm

Once the source, destination and cost surface are defined, the least cost path could be created using the Cost Path tool. The Cost Path tool uses the inputs to calculate the path that uses the lowest possible combination of values to link the source to the destination cell(s). Read more about the Cost Path tool here:

> https://desktop.arcgis.com/en/arcmap/latest/tools/spatial-analyst-toolbox/cost-path.htm

Generally the main steps that the Cost Distance Analysis requires are as follows:

1- Define the origin point(s)
2- Define the destination point(s) or location(s)
3- Calculate the cost surface
    a. Evaluate each variable that would contribute to the cost surface
    b. Combine all variables into the cost surface raster
4- Using the origin (source) and destination locations, calculate the Cost Distance surface (a raster dataset that calculates the distance from the source to every point in the study area extents) and the direction surface (or "Backlink" raster; which basically shows how each cell in the study area extents links back to the source point(s) using directions)
5- Calculate the least cost path; which creates connected series of cells that links the source point(s) to the destination(s).

Raster Analysis

Cost Distance Analysis

SUMMARY

In an effort to manage the Cook Forest State Park trails, the park officials are considering extending the current trail system. The major driving force in this project is to include a trail segment that connects the current trails to an area with cellular phone coverage using the existing cell-phone towers that surround the area. One important requirement is that this trail has to fall mostly in the existing boundary of the park. It is understandable that most of the cell-phone coverage areas fall outside those boundaries and the park officials are willing to entertain the option of extending the trails beyond the park's limits.

II. Introduction

Download the exercise data from the corresponding link.

Most of the raster data handling and analysis will rely on the use of a software extension (i.e. plug in) called Spatial Analyst. It comes bundled with ArcGIS Pro, but the proper licensing should be acquired/assigned.

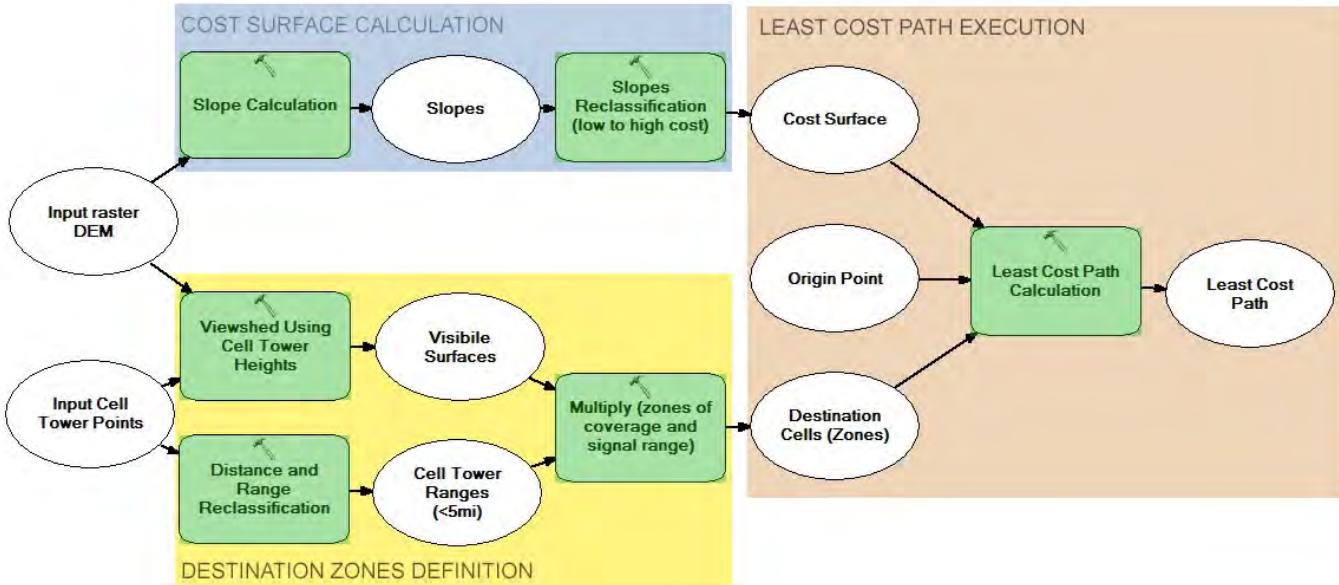
III. Problem

The new trail should take into consideration the optimum path from a suggested starting point to the nearest area with cell-phone service according to least slope conditions.

IV. Action Plan

There are a couple of problem that we need to solve in order to reach the final objective of defining the optimum least cost path to a cell phone coverage area. First, we need to define the coverage area of each cell tower; those are going to be considered as the destination cells. Second, we need to create a cost distance layer that is going to be used as the determining factor of the path calculation using the slopes of the study area. A "backlink" surface will also be created in the process in order to link back to the origin point from each of the possible destinations.

The following flow chart summarizes the main steps that will be adopted in solving this problem.



A flowchart that shows the main steps for the least cost path calculation which will lead to the creation of suggested trails according to their shortest distancefrom a defined point on the existing trail system to areas of cell-phone coverage in a nearby location, the path would chose the cells with the lowest slope va slope value according to the calculated cost surface.

In summary, we are going to start by defining the destination zones; or areas of good cell phone coverage, using the cell tower point data in conjunction with the DEM of the area. Then we are going to calculate the cost surface based on a calculated slope dataset. Finally, we are going to combine all of those results with the a defined origin point on the existing trail lines in a least cost path calculation to produce a dataset with all the possible path lines that lead from the origin to a cell coverage zone using the most gentle possible slopes.

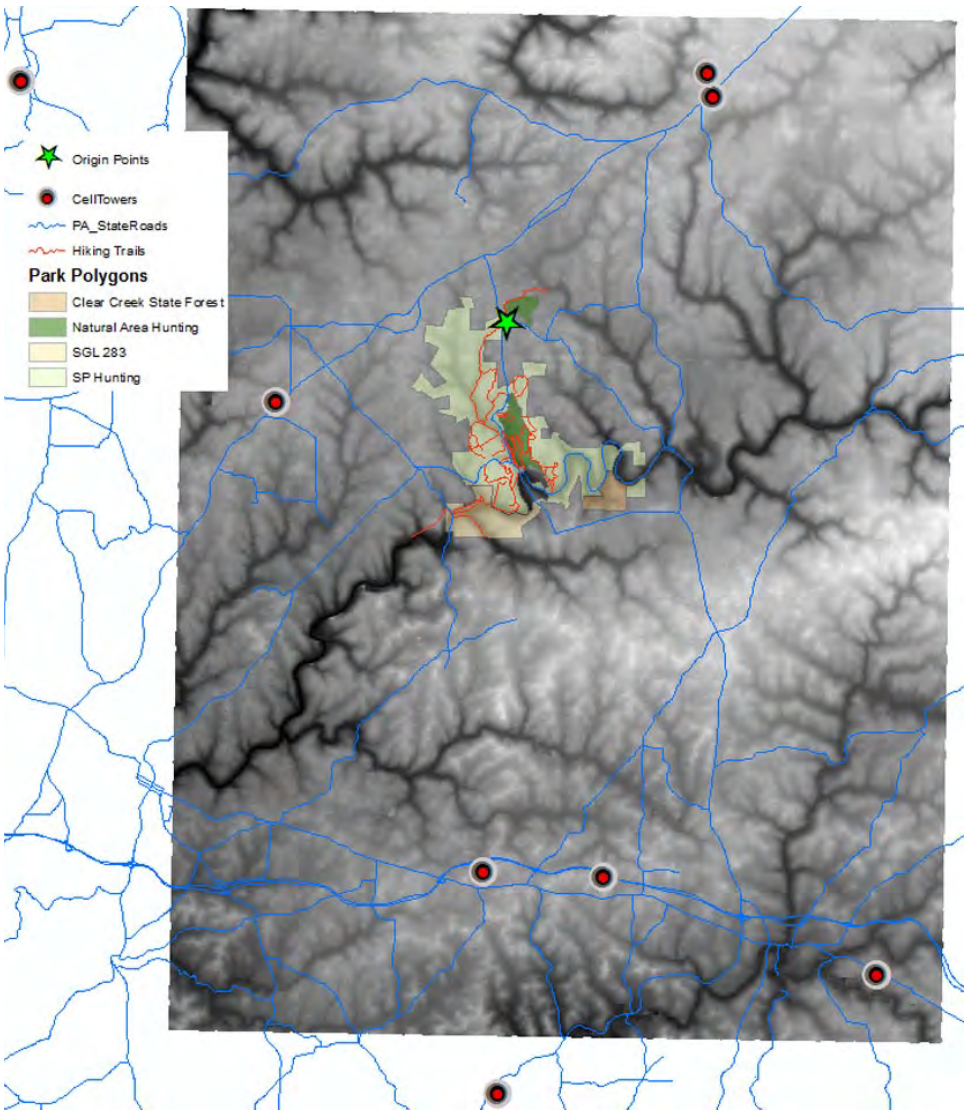
V. Source Data

The data required for this exercise can be summarized in the following table:

Dataset	Type	Notes
CookForest_DEM	Raster	The DEM will help in calculating the cost surface based on the slopes
CellTowers	Vector	Cell tower points are essential to determine the cell signal coverage
OriginPoints	Vector	A defined starting point on the existing trail system
ParkPolygons	Vector	Polygons of the park boundaries – will help identify the best path that falls mostly within those polygons in the final result assessment stages
HikingTrails	Vector	The hiking trail lines would be helpful at the final result assessment stages where final recommendations on which calculated paths would be best attached to the existing trail lines.

In order to define the destination points (zones of cell signal coverage) we need to use both the cell tower locations together with the DEM in order to calculate the "Viewshed" or the areas on the surface that are visible from each tower. An estimated maximum distance of 5 miles is assumed as the active direct (Euclidean) distance range of each of the cell towers.

Add all available data to a new project; observe the attribute tables and change the symbology in order to familiarize yourself with the data. The data should be similar to the following figure:



This figure shows all of the data that is going to be used in this exercise either as analysis input or as a final output illustration. It shows the Cook Forest State Park boundaries as it is located on top of the available 30 meter resolution (98.425 ft) DEM constructed (mosaic) from 9 USGS 7.5' Quadrangles.

VI. Defining the Destination Zones

Before you start your analysis steps, we need to set a "mask" for the Analysis Environment; setting a mask would restrict the analysis to our study area boundaries. In this exercise, we are going to make the extents of the given DEM dataset as the bounding coordinates for all of our outputs by default (Analysis tab >> Geoprocessing Group >> Environments >> Raster Analysis >> Mask, then browse and select the CookForest_DEM dataset).

The cell phone signals can generally cover around 5 miles from the transmission towers, this distance vary depending on many factors. Among the major factors is the topography and direct visibility of certain parts of the landscape from the original tower point. The visibility areas from each of the transmission towers can be calculated using the Viewshed function either in Spatial Analyst (Toolboxes >> Spatial Analyst Tools >> Surface >> Viewshed) or 3D Analyst (Toolboxes >> 3D Analyst Tools >> Visibility >> Viewshed).

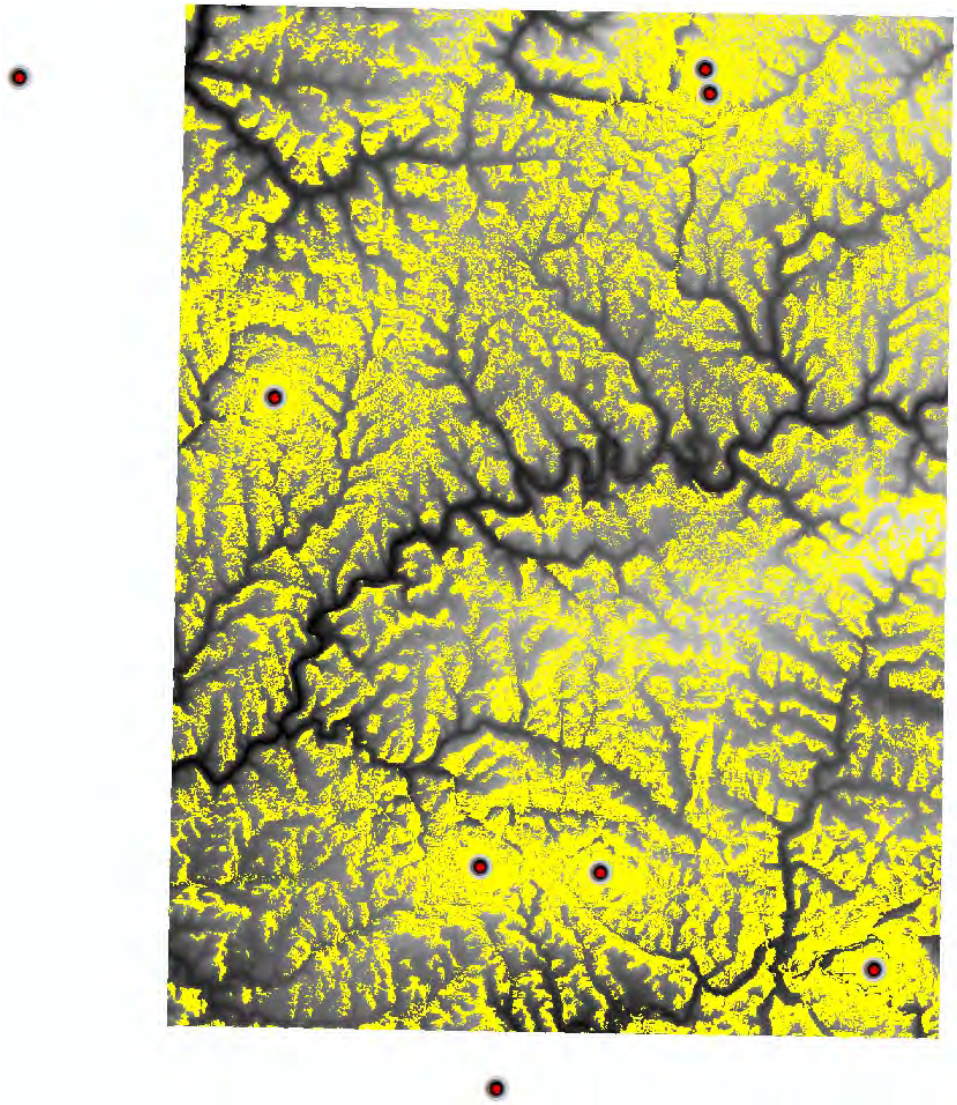
Read about the Viewshed tool and the visibility analysis here:

> https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/using-viewshed-and-observer-points-for-visibility.htm

Run the Viewshed tool from Toolbox >> Spatial Analyst Tools >> Surface >> Viewshed

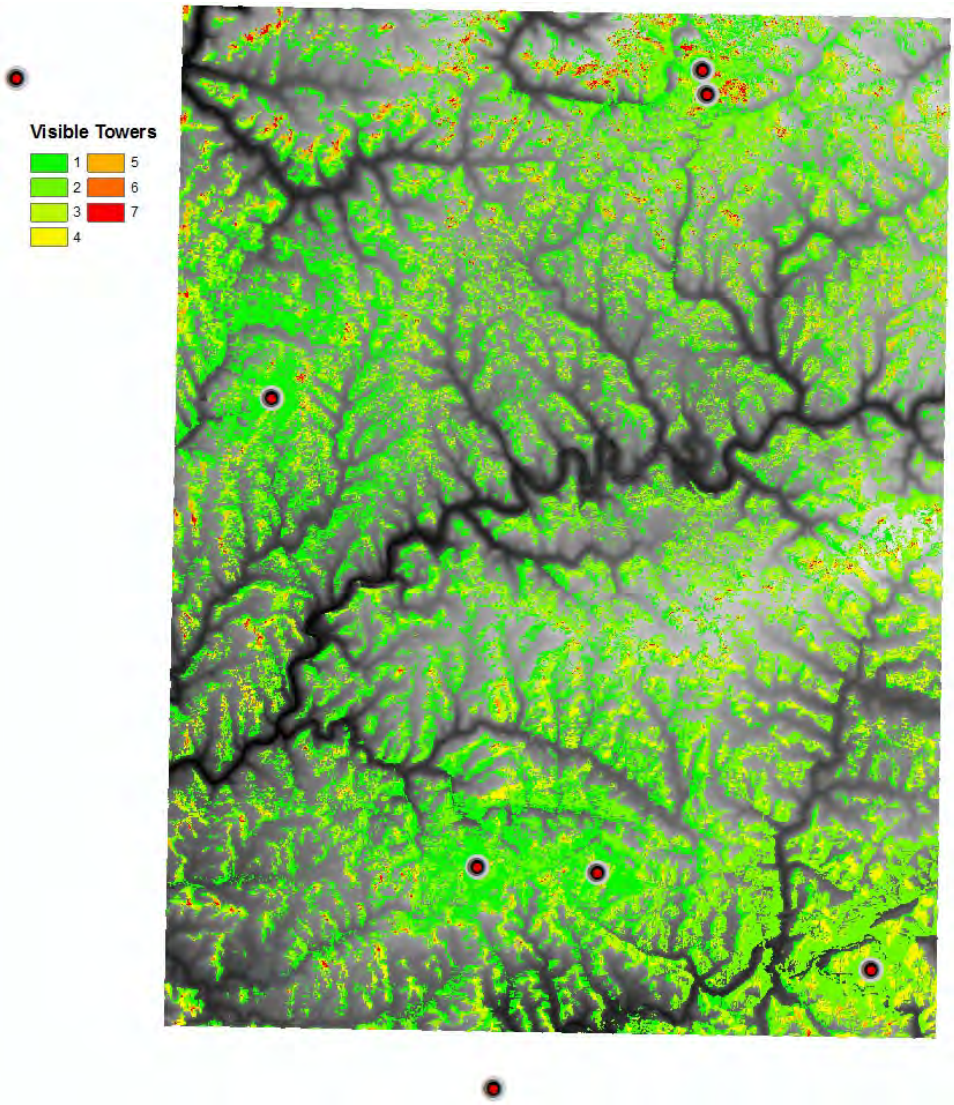
Use the COOKFOREST_DEM as the input raster, CELLTOWERS as the Input point or polyline observer features, and browse your exercise geodatabase and store the Ouput raster as **CELL_VIEWSHED**. Accept all the other defaults. By default the viewshed tool uses the field OFFSETA from the CELLTOWERS feature class as an offset value measured above the earth surface (Tower height) in feet.

A new raster data will be created and added to the table of contents. The output should look similar to the following figure:



The resultingvisible areas (yellow) of the earth surface from each of the available cell phone towers (red with gray halo points). By default, ArcMap will show the result as visible/Not visible only, a closer look in the attribute table of the resulting viewshed dataset would show, for each cell, how many cell phone towers are visible.

The attribute table of the resulting viewshed dataset would show 8 different values with cell Count for each. Each value indicates how many of the 7 available cell phone towers are visible. The Value “0” means none of the towers is visible while “7” means that all 7 towers are visible from the specified location. Using a quick symbology change, we can visualize this information in a more effective way. The following figure shows the use of the existing values to symbolize the viewshed dataset:

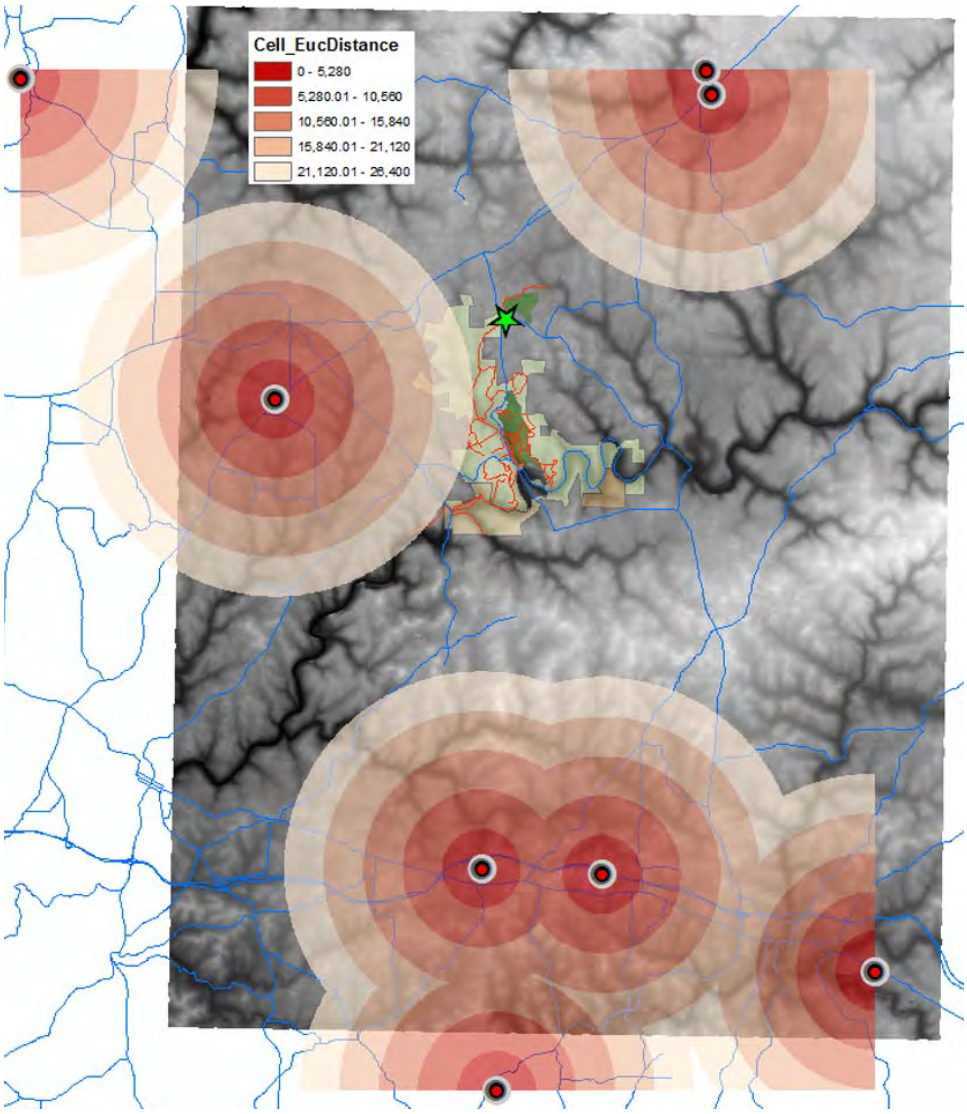


Using the value attribute table of the CELL_VIEWSHED dataset we can determine which areas has a higher likelihood of being covered by cell phone signals using the number of cell phone towers visible from each cell. Bright green cells are visible from only one tower while bright red ones are visible by all 7 towers in the study area.

Visibility is not the only factor that would affect the cellular phone signal strength; the proximity to the transmission tower is also a factor. Therefore, measuring a Euclidean distance from each of the towers is the following step.

Using the Euclidean Distance tool, use the CELLTOWERS as the Input raster or feature source data, store the Output distance raster in the exercise's geodatabase and name it **CELL_EUCDISTANCE**, change the Maximum distance to 26400 (5 miles x 5280ft), then browse and select the COOKFOREST_DEM for the Output cell size.

The CELL_EUCDISTANCE should be similar to the following figure:



Restricting the Euclidean distance calculation to 5 miles around each cell tower reveals that only one cell tower have partial coverage to the north western edge of the Cook Forest State Park. Eventually, the subsequent analysis of the least cost distance would lead to a location with the defined distance range of this tower only.

The next step is to find a way to combine the information from the Euclidean distance and the tower visibility datasets. In order to do that we are going to reclassify the continuous data presented in the Euclidean distance dataset (CELL_EUCDISTANCE) into 5 classes according to the following table:

Distance (ft)	Class
0-5280 (1mi)	5
5280-10560 (2mi)	4
10560-15840 (3mi)	3
15840-21120 (4mi)	2
21120-26400 (5mi)	1

Run the Reclassify tool and save the output as **CELL_EUCDISTANCE_RECLASS** inside the exercise geodatabase.

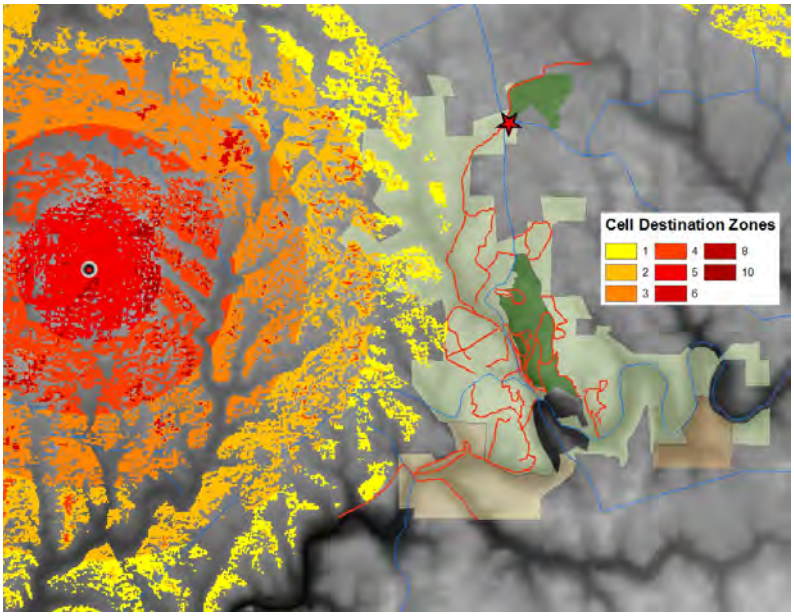
The reclassify the CELL_VIEWSHED dataset according to the following table, save the output as **CELL_VIEWSHED_RECLASS**:

# of Towers	Class
4-7	2
1-3	1
0	0

If we multiply both of the reclassified datasets (**CELL_EUCDISTANCE_RECLASS** and **CELL_VIEWSHED_RECLASS**), the resulting raster would be defining cell zones of cell tower coverage quality (it is not going to be perfect since those are not the sole parameters in signal strength calculation).

Using the **TIMES** function (Toolboxes >> Spatial Analyst Tools >> Math >> Times), multiply both datasets (CELL_EUCDISTANCE_RECLASS and CELL_VIEWSHED_RECLASS), save the output as **CELL_DESTINATION_ZONES**, which is going to work as the destination input in the least cost path calculation.

The **CELL_DESTINATION_ZONES** dataset should look similar to the following figure:



This figure shows a zoomed in view of the defined cell phone coverage destination zones in relation to the boundaries of Cook Forest State Park as well as the designated origin point on the trail. Dark red colors (larger numbers) indicate zones that are assumed to be with better cell phone coverage while brighter red and yellow colors are lower quality; both are taking into consideration the number of visible cell towers as well as the proximity to them.

VII. Cost Surface Calculation

In this exercise demonstration we are going to consider only the slope as the main "cost" factor for traveling between the origin point and the calculated destination zones.

Fist, calculate the slopes (degrees) using the Slope tool (Toolboxes >> Spatial Analyst Tools >> Surface >> Slope) using the COOKFOREST_DEM, name the slopes output as **COOKFOREST_SLOPES**.

Then reclassify the **COOKFOREST_SLOPES** into 10 classes using the Natural Breaks (Jenks) method, where 10 is the steepest slope. Name the output as **COST_SURFACE**.

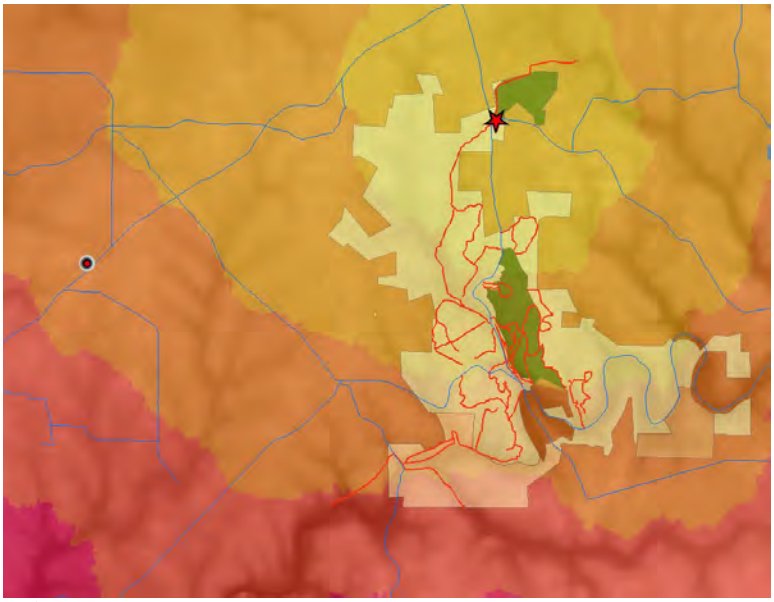
VIII. Cost Distance Calculation

The cost distance tool calculates not only the cost of travelling from an origin (source) point through a predefined cost surface, but also creates a "backlink" dataset that computes the series of cells that connect back to the source from any location within the study area. Both cost distance and cost distance backlink are required for further least cost path calculations.

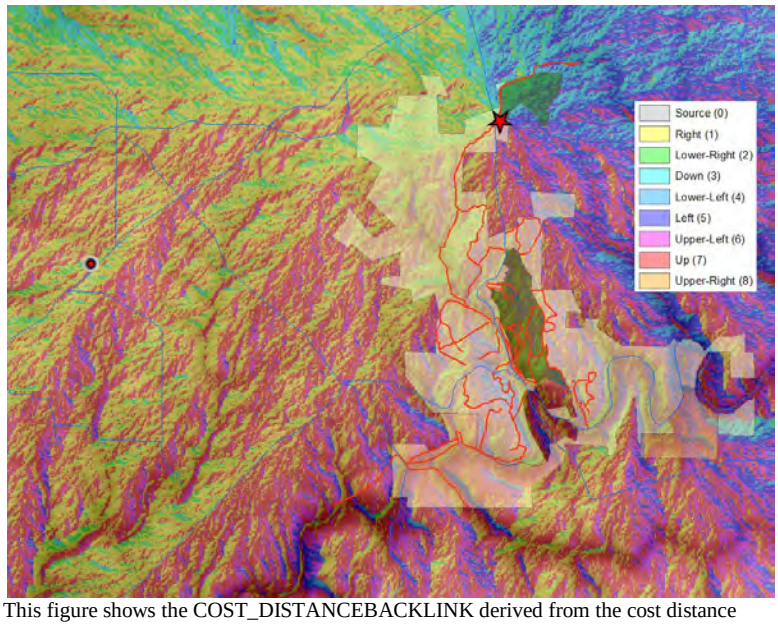
In this step, run the Cost Distance tool from the Toolboxes >> Spatial Analyst Tools >> Distance >> Legacy >> Cost Distance. Use the following parameters to fill in the dialogue box:

- Input raster or feature source data: **ORIGINPOINTS**
- Input cost raster: **COST_SURFACE**
- Output distance raster: **COST_DISTANCE**
- Output backlink raster: **COST_DISTANCEBACKLINK**

The outputs should look similar to the following figures:



This figure shows the COST_DISTANCE raster created using the cost distance tool. Lower values (bright reds and yellows) indicate closer distance to the point of origin (source).



This figure shows the COST_DISTANCEBACKLINK derived from the cost distance calculation. It indicates the direction of each cell as it connects back to the cell of origin (source point marked as a red star). This dataset in conjunction with the cost distance raster would work as the core calculation of the least cost path from the source point to any destination in the study area.

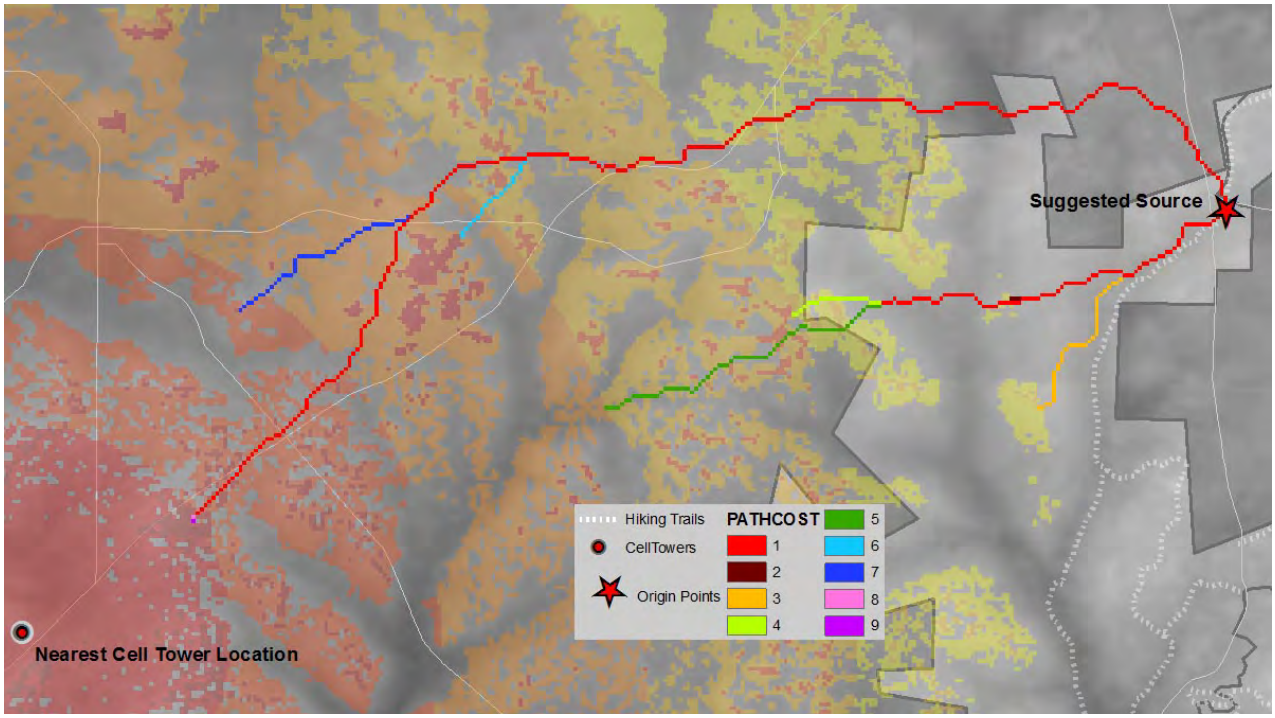
IX. Least Cost Path Calculation

Now we have all the elements that are needed to calculate the least cost path from the origin point (source) to the destination zones (CELL_DESTINATION_ZONES).

Launch the Cost Path tool from Toolboxes >> Spatial Analyst Tools >> Distance >> Legacy >> Cost Path. Change the parameters in the dialogue box to match the following table:

Parameter	Value	Notes
Input raster or feature destination data	CELL_DESTINATIONZONES	Those are the cells that qualified as having cell phone coverage close to the State Park boundaries
Destination field (optional)	Value	
Input cost distance raster	COST_DISTANCE	Created in an earlier step and defines the Euclidean distance/cost of travel from the source point to all points in the study area
Input cost backlink raster	COST_DISTANCEBACKLINK	Created earlier and defines, for each cell in the study area, the direction of travel back to the source point.
Output raster	LEAST_COST_PATH	Make sure to store the output in your exercise geodatabase
Path type (optional)	EACH_ZONE	Specifying EACH_ZONE as the path type would restrict the calculation to those possible paths that link the source point to each of the defined zones of the destination dataset (zones are defined by the group of cells that belong to the same class value, in this case it will be each zone of specific signal strength).

After running the tool, the output would be a raster dataset that has the different suggested paths according to the given parameters. You may symbolize the output based on the **PATHCOST** field instead of the values, and display it on the **CELL_DESTINATIONZONES** layer to see the connection between the source point to each of the defined destination zones. The final output should be similar to the following figure:



The least cost paths are classified according to their "cost" of travel between the source point and each of the previously defined cell phone coverage zones. The red suggested path that is mostly located inside the park polygon would probably be the most appealing to the park officials since it passes through the existing park boundaries and would invlove the least amount of negotiation and land purchases. It also can be linked to the existing trail at an earlier point (where the orange and red paths cross close to the existing trail).

X. Result Assessment

The results of this study need a closer look since there are a group of assumptions that were given at the beginning of the assignments that might not be accurate. For example, defining the cell phone coverage destination zones based on just the visibility of the tower together with the proximity to it would be questionable, since the signal strength from each tower might be different at the transmission point, also the types of signals can be affected by different environmental conditions such as weather and/or tree cover.

It is suggested that those defined areas of cell phone coverage to be tested prior to launching the least cost path analysis. Park officials might be advised to use longer paths (green on the previous figure) but closer to the cell tower, or consider even refining this result by adding some other criteria to the cost surface, such as the possibility for using the existing trail lines

instead of roaming non-trail paths, or even consider using some of the paved roads as quick and easy shortcuts to lead to cell phone coverage areas.

XI. Report the findings

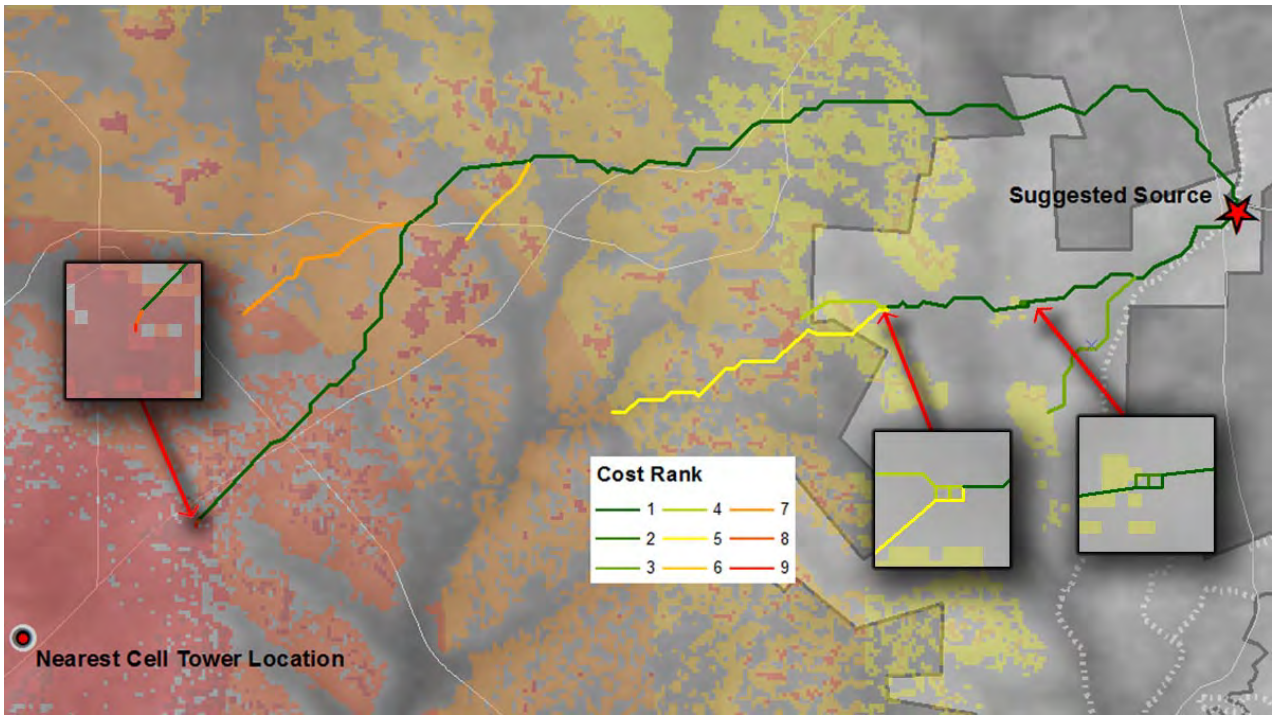
You may elect to display the last figure as the final result, but in order to make the results more usable by the park officials I would convert those paths into vector lines, measure their lengths and possibly prepare them for budgetary handling.

Before conversion, the LEAST_COST_PATHS raster layer needs to be reclassified according to the PATHCOST field. So, run the Reclassify tool, and chose a sorted (ascending) classification of the PATHCOST field, the new value field should start from 1 and ends at 9. Name the output as **LEAST_COST_PATHS_RECLASS**.

Then run the Raster to Polyline tool from Toolboxes >> Conversion Tools >> From Raster >> Raster to Polyline. Fill the dialogue box according to the following table:

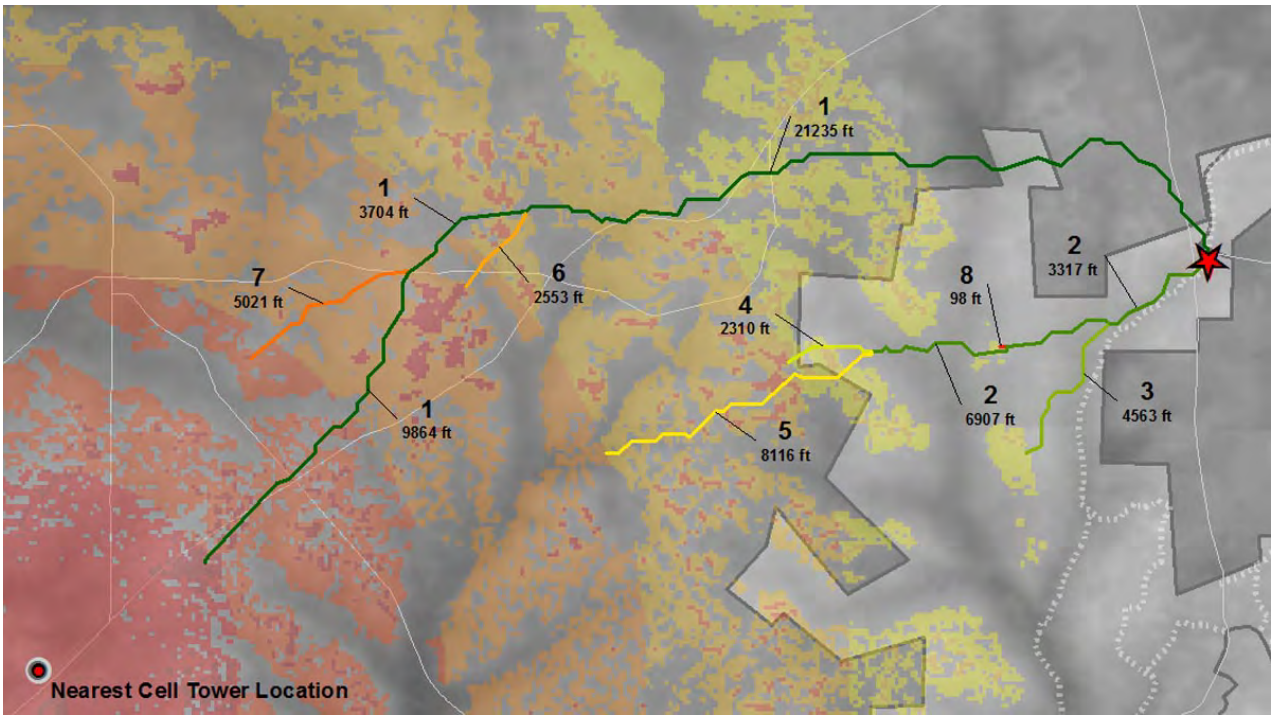
Parameter	Value	Notes
Input raster	LEAST_COST_PATHS_RECLASS	
Field (optional)	Value	
Output polyline features	PATHS	Since PATHS is going to be a vector feature class, store it inside the FEATURES dataset inside the exercise geodatabase
Background value (optional)	NODATA	NODATA specifies the areas that have no cell values as the background data
Minimum dangle length (optional)	0	
Simplify polylines (optional)	Checked	

This will create a new feature class (PATHS) and adds it to the table of contents. You may change the symbology to reflect the GRID_CODE field (unique values). You'll find that the output has a couple of problems and needs to be cleaned up before including it in the report. The following figure shows the problem areas in this output:



The output vector layer (PATHS) will have several problem areas due to the vectorization of a raster dataset. Among those, are pixel-like vector lines at two locations (the two highlighted boxes on the right side of the figure), as well as segments of the paths that were classified as high cost (highlighted at the far left of the figure), due to the slope constraints,, both of them combined do not exceed 160 feet in length (check the PATHS attribute table).

So, this data needs to be cleaned up. Those unneeded lines should be deleted (Edit tab), and linear segments that should belong to separate trails, such as the dark green lines, should be split and merged to form unique entities. With this data, I merged many segments together in order to facilitate reporting, and I did split the dark green path at the Suggested Source point in order to make two separate lines. I also added a TRAIL_ID (short integer) field in the attribute table and assigned each connected group of segments that would constitute a whole trail system a unique ID. I also labeled the result using the TRAIL_ID as well as with the SHAPE_LENGTH field (in feet). The final result would look similar to the following figure:



Each connected series of lines were merged to form only one line segment, it was assigned a TRAIL_ID, then labeled with both the TRAIL_ID as well as the length of the trail in feet (using the SHAPE_LENGTH field).

You may take an extra step of suggesting your recommendation about the shape and location of the trail, together with reporting the total length and how long the portion of the trail that falls outside the park boundaries. Also, you may calculate and report the average slope on each trail segment; this information could be extracted using the LEAST_COST_PATHS and the COOKFOREST_SLOPES datasets.

XII. Your Turn

According to the preliminary results that we achieved in this exercise so far, we can refine our search to include other factors which can improve our findings. For example, we need to include the existing trail lines as a weighting factor for the cost surface calculation instead of just the slopes; i.e. an existing trail would be preferred over open land for travel. Also, the slopes should be classified with a hiker in mind, the automatic natural breaks classification that we used in the exercise might not be the best for a pedestrian, therefore, we need to reclassify the slopes while giving a higher cost for any land that is more than 10% in slope. Furthermore, the origin point location has been modified according to the earlier findings; it has been moved further south closer to the suggested light-green path segment in the previous figure. Those suggested changes might improve the results according to the park official's needs.

Using similar procedures, organize your analysis steps using the "YourTurn" Geodatabase. In this part, you'd need to calculate a new cost surface layer that adds not only the slope as a

factor. Refer to the reading section about Creating a Cost Surface in order to give you an idea about a typical multi criteria cost surfaces creation method:

https://desktop.arcgis.com/en/arcmap/latest/tools/spatial-analyst-toolbox/creating-a-cost-surface-raster.htm

Here are a few hint steps on how to create the cost surface using 2 variables for this exercise; the slopes and the trails (feel free to use other methods to combine the two variables but include an explanation of why did you pick your method):

- First of all you have to set the "Processing Extent" in the "Environment Settings" to the DEM raster dataset (COOKFOREST_DEM).
- Use "Polyline to Raster" tool (Toolboxes >> Conversion tools) to convert the Trails to TRAILCOST_LINES (using the TRAVELCOST field, and the spatial resolution (cell size) of the COOKFOREST_DEM); this will create a raster dataset that has cells with a value of 1 for the trail lines and NoData for everything else within the defined Processing Extent.
- Convert all NoData in the In the TRAILCOST_LINES raster, Convert all NoData to 0 using the Conditional "Con" function in conjunction with the "IsNull" within the "Raster Calculator" (Toolboxes >> Spatial Analyst Tools >> Map Algebra >> Raster Calculator), set the output to TRAILCOST:

  Con(IsNull("TrailCost"), 0, "TrailCost")

- Calculate Slopes and reclassify them to 1 smoothest to 6 steepest (0-2, 2-4, 4-6, 6-8, 8-10, 10>) – SLOPE_RECLASS
- Combine the slopes with the trail data using the Raster Calculator Conditional Con function in order to create the COSTSURFACE:

  Con("Trailcost", "Trailcost", "Slope_reclass", "Value = 1")

  Basically, the conditional Con function evaluates each cell in TRAILCOST, if a cell value in TRAILCOST is 1, it will be copied as 1 in the output, otherwise (value of 0), it will be replaced with the SLOPE_RECLASS cell values

Now, using similar procedures, and using the same given datasets, you are asked to perform a similar analysis to find the best (least cost) paths from the given origin (source) point to each of the destination zones of cell phone coverage using the COSTSURFACE raster dataset.

You are required to create a PDF report (start in any word processing software (e.g. Word), then save it as PDF) of the procedures and results. Also, include your geodatabase with only the main steps that you followed in order to reach the final result. Create a ZIP file for your geodatabase and submit the zipped geodatabase as well as the separate PDF report to the

corresponding assignment dropbox (total 2 files). DO NOT submit multiple PDFs as your final report (do not also submit any other formats (DOCX, DOC, XML …etc.).

A. Report Content

- Include a cover page with a selected title "Finding the Least Cost Path to Cell Phone Coverage Areas in Cook Forest" or something similar, your name, class number and date of the report.
- Figure captions of every step you make during the analysis is required to show the different steps of analysis preparation and procedures.
- Make sure to save all of the essential steps using the same raster dataset file naming convention used in the demonstration exercise.
- Add a flowchart to summarize the steps with explanation of details for each step.
- Extract all of the missing information from the given data.
- Take screen snapshots (Alt + Prnt Scrn) of your ArcGIS Pro window every time you make a step or an action that changes the result on the screen and paste the resulting clipboard image in your word processing software (e.g. Word), **DO NOT** crop or resize the pasted image, I would like to be able to see your table of contents organization of layers. You may create a 1 column 2 rows table; past the image inside the top cell and insert your text in the lower one. if you can't see the details of the snapshot screen capture images very well... I won't either!
- Under each pasted image, type in a brief description on how did you reach this step and what does it show.
- In the Results Assessment section of your report you should discuss your reflection on which path the park officials should consider as well as any other factors that you see essential in this analysis for future refinements. Suggest any other optional/required criteria and/or methods that would be beneficial to improve the results.

XIII. Grading Rubric

Grading for this exercise will be according to the following rubric:

Criteria	Score From
Cover Page	5
Destination Zones Identification	20
Cost Surface Preparation	20
Least Cost Path Analysis	20
Result Assessment	15
Final Results Reporting (Map/Table/Graph)	15
Overall Report Presentation Quality	5
TOTAL	**100**

Partial completion of any of the grading criteria will be graded according to the level of completeness/quality based on the following scheme for every criterion:

Level	%
Excellent	100
Very Good	75
Good	50
Fair	25
Absent	0

XIV. Readings

- Understanding Euclidean distance analysis: https://desktop.arcgis.com/en/arcmap/latest/tools/spatial-analyst-toolbox/understanding-euclidean-distance-analysis.htm
- Understanding Cost Distance analysis https://desktop.arcgis.com/en/arcmap/latest/tools/spatial-analyst-toolbox/understanding-cost-distance-analysis.htm
- Creating a Cost Surface https://desktop.arcgis.com/en/arcmap/latest/tools/spatial-analyst-toolbox/creating-a-cost-surface-raster.htm
- Creating the Least Cost Path https://desktop.arcgis.com/en/arcmap/latest/tools/spatial-analyst-toolbox/creating-the-least-cost-path.htm
- Using Viewshed and Observer Points for visibility analysis https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/using-viewshed-and-observer-points-for-visibility.htm
- Conditional Evaluation with Con https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/conditional-evaluation-with-con.htm
- Raster Calculator https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/raster-calculator.htm