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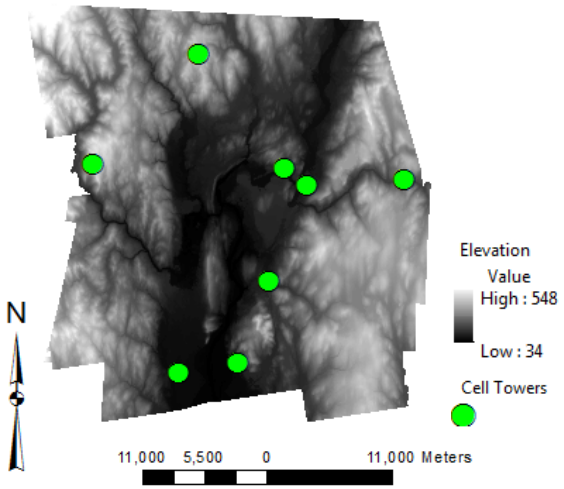
Environmental Studies

Determining Sunset Obstruction from a New Cell Tower

"Please use (only) the several datasets that have been distributed to generate a new grid on which values ranging from 0 to 5 indicate the likelihood that any given pixel will have its future sunset views affected by a soon-to-be-sited cell phone tower"

In the following exercise, (1) I first identify areas that have high servicing needs based on current cell service, distance to the closest cell tower, and inferred population density. (2) I then site potential towers by finding locations on shallow-sloping land that would service these high-priority areas. (3) Next, I establish a ranking of these potential new towers by summing together total benefit that would result from the construction of each. (4) Finally, I create a grid showing probability of sunset obstruction from a newly constructed tower.



Add Field

1) Create a new field, “OFFSETB” in preparation of the observer points operation. The specified values here indicate that each pixel will be deemed visible to the cell towers if the height 2 meters above the elevation surface is visible. Cell service determination should be based slightly above ground level!

Table

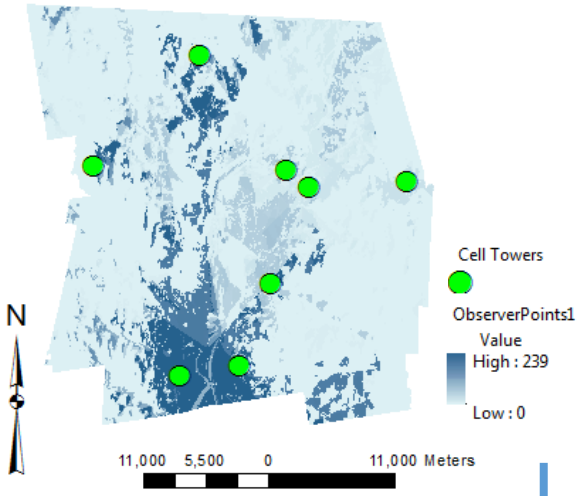
CellTowers

FID	Shape *	Id	OFFSETA	OFFSETB
0	Point	1	86	2
1	Point	2	24.3	2
2	Point	3	39.6	2
3	Point	4	45	2
4	Point	5	61	2
5	Point	6	51.8	2
6	Point	7	45.7	2
7	Point	8	53.9	2

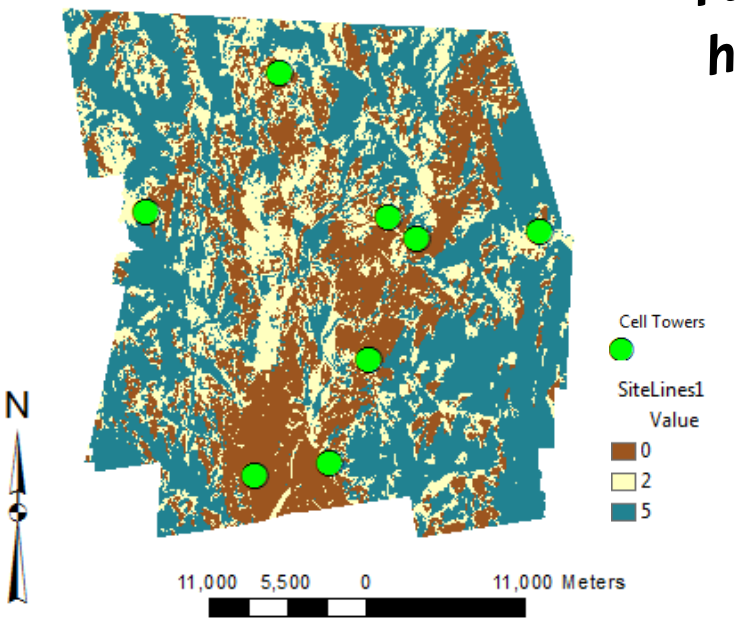
Observer Points

2) Outputa a grid, “ObserverPoints1” in which each pixel knows which cell towers it can be seen from.

OBJECTID *	Value	Count	OBS1	OBS2	OBS3	OBS4	OBS5	OBS6	OBS7	OBS8
1	0	20162385	0	0	0	0	0	0	0	0
2	1	4156945	1	0	0	0	0	0	0	0
3	2	3109459	0	1	0	0	0	0	0	0
4	3	2171724	1	1	0	0	0	0	0	0
5	4	252788	0	0	1	0	0	0	0	0
6	5	365050	1	0	1	0	0	0	0	0
7	6	110184	0	1	1	0	0	0	0	0
8	7	379254	1	1	1	0	0	0	0	0

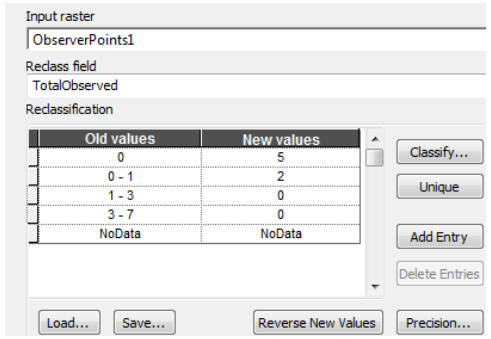


Factor 1: Which locations do not currently have a clear line of site to a cell tower?



Reclassify

4) Outputs a new grid that assigns a 5 to pixels that are not visible to any cell towers, a 2 to pixels that are visible to only 1 tower and a 0 to pixels that are visible to more than one cell tower

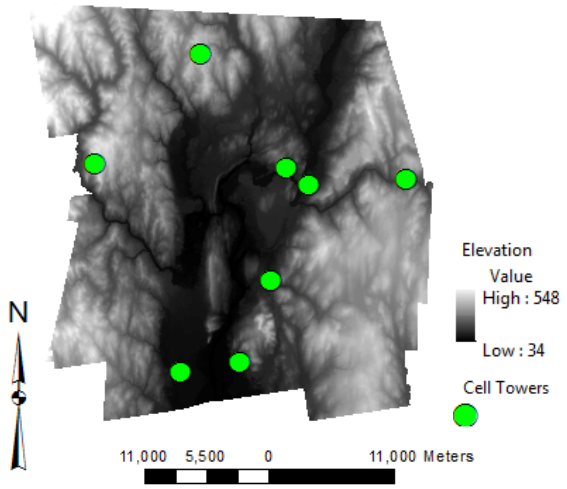


Calculate Field

3) Creates a new field, “TotalObserved” in the attribute table of “ObserverPoints1” equal to the total number of cell towers that are visible to a single pixel (TotalObserved = [Obs1] + [Obs2] + [Obs3] + [Obs1] + [Obs1] + [Obs1] + [Obs1] + [Obs1])

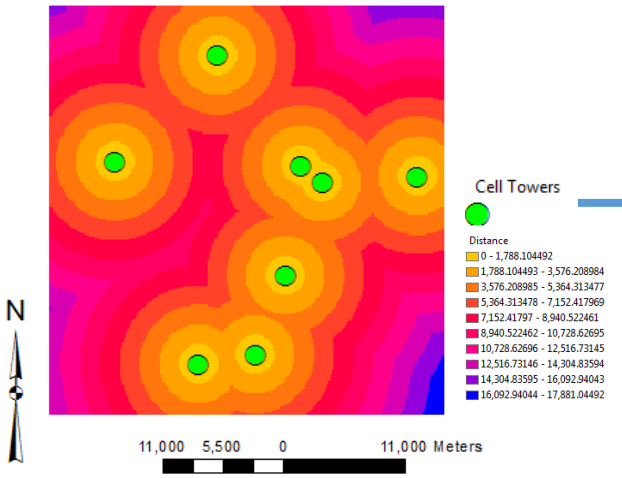
OBJECTID *	Value	Count	OBS1	OBS2	OBS3	OBS4	OBS5	OBS6	OBS7	OBS8	TotalObserved
1	0	20162385	0	0	0	0	0	0	0	0	0
2	1	4156945	1	0	0	0	0	0	0	0	1
3	2	3109459	0	1	0	0	0	0	0	0	1
4	3	2171724	1	1	0	0	0	0	0	0	2
5	4	252788	0	0	1	0	0	0	0	0	1
6	5	365050	1	0	1	0	0	0	0	0	2
7	6	110184	0	1	1	0	0	0	0	0	2
8	7	379254	1	1	1	0	0	0	0	0	3

Factor 2: Which locations are farthest away from the nearest cell tower?



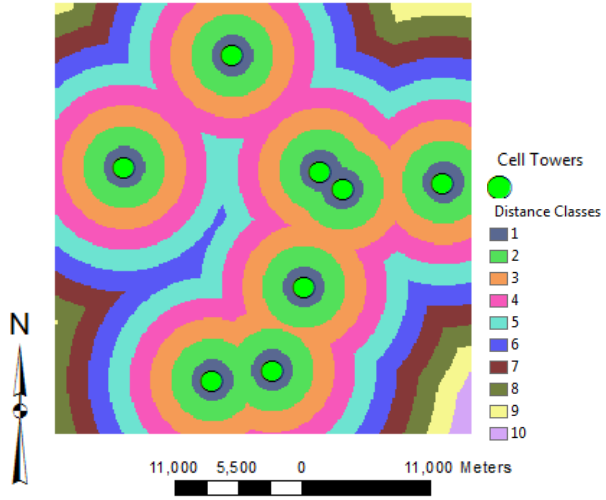
Euclidean Distance

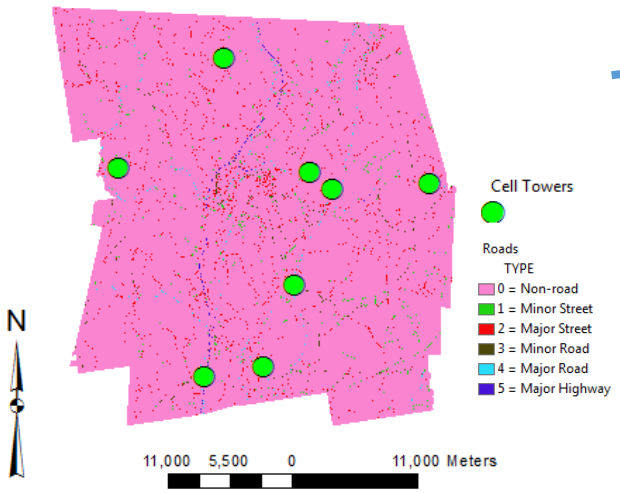
1) Generates a grid showing the distance (as the crow flies) from the nearest cell tower



Reclassify

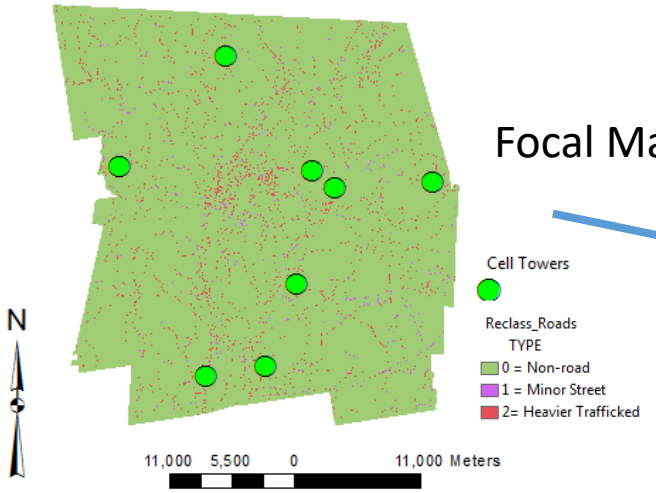
1 Outputs a new grid that assigns a low score to pixels closest to a cell tower





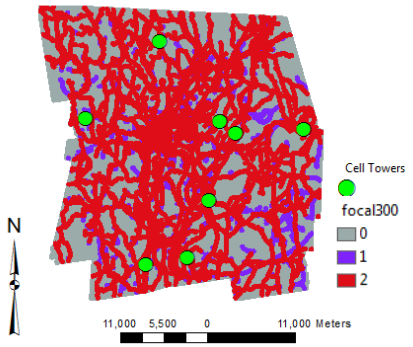
Reclassify

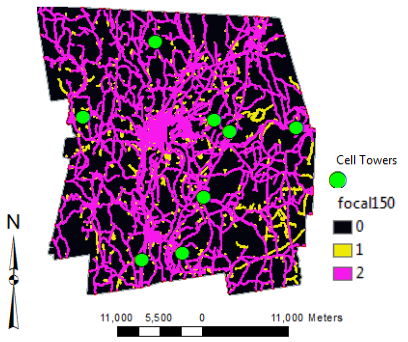
1) Reassign Values to the roads data so that "non-road" receives a value of 0, "Minor Streets" receive a value of 1 and heavier trafficked roads receive a value of 2.



Focal Maximum (*2)

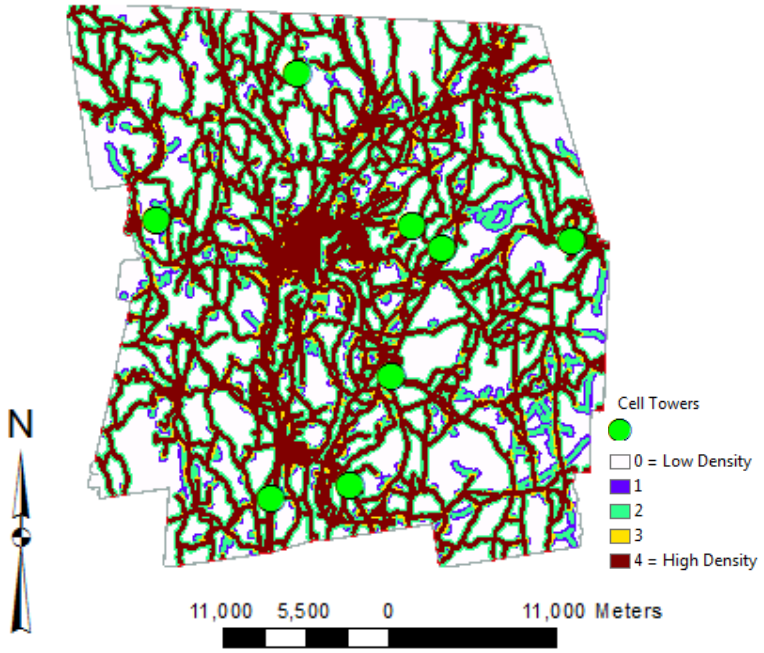
2) Complete this operation twice. In the first, pixels in the output raster take on the maximum value in a 300 meter radius of the original grid. In the second, pixels in the output raster take on the maximum value in a 150 meter radius of the original grid. In both, higher values are assigned to pixels closer to highly trafficked roads.





Raster Calculator

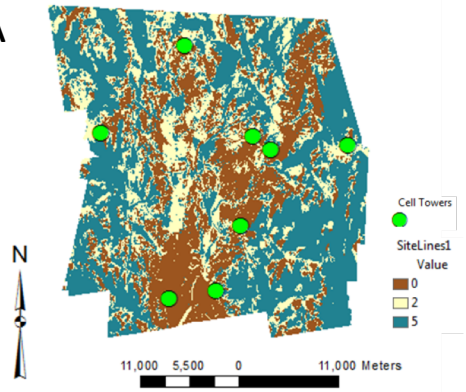
3) Combine these grids to form a new grid whereby higher values are assigned to pixels closest to major roads, lower values are assigned to pixels closest to minor roads, and 0 is assigned to pixels far away from both. This serves as a proxy for population density



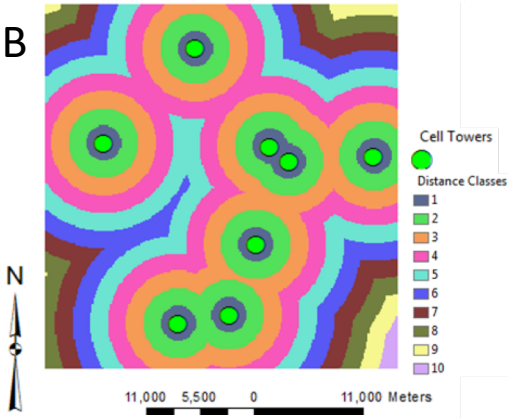
Factor 3: Which locations are the most densely populated?

Finding Areas of "Service Need" Based on Factors

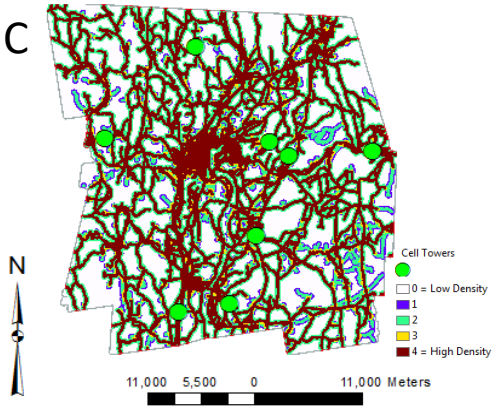
A



B

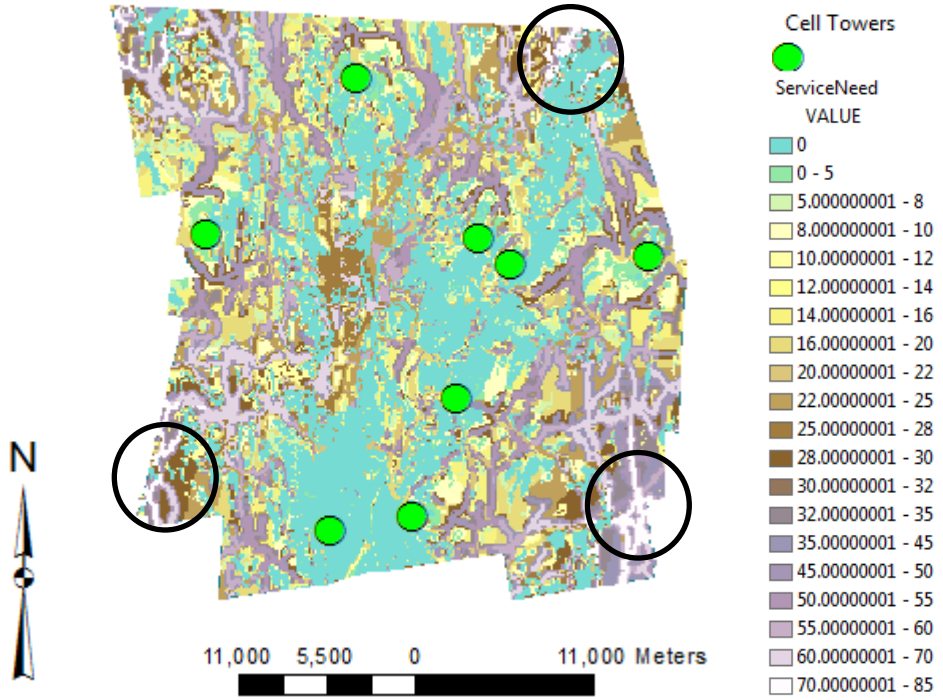


C

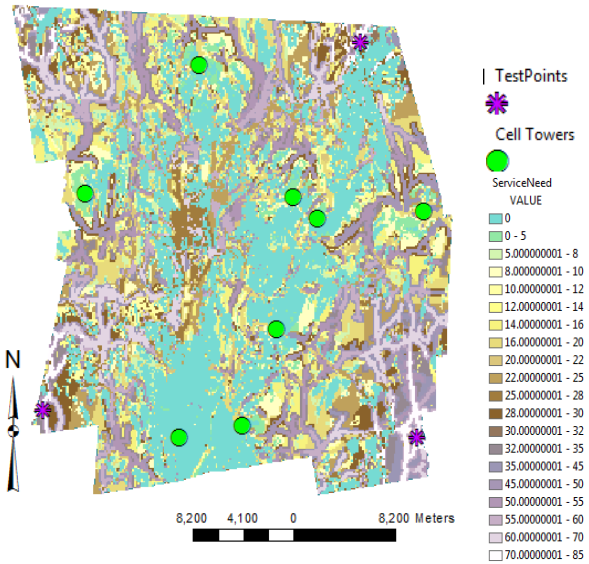


Raster Calculator

1) Combine data to form a new grid, "ServiceNeed" according to the equation ServiceNeed= A*(B + 2C). The coefficient of 2 in front of C normalizes the data ranges so that population density and Euclidean distance from the nearest cell tower are weighted equally. A is multiplied against the sum of (B + 2C) so that pixels with more than 1 cell tower in view are automatically assigned a score of 0, altogether removing them from consideration of tower placement.



The output raster shows areas in highest need of service. Circled in black are 3 locations I'll use to test cell tower placement.

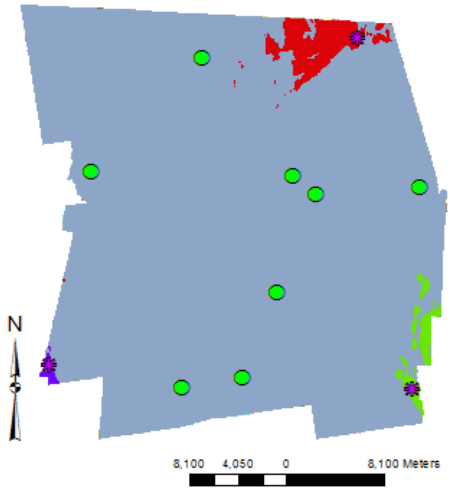


CellTower2

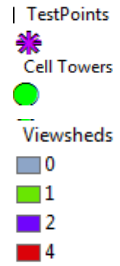
FID	Shape *	Id	OFFSETA	OFFSETB
0	Point	0	2	40
1	Point	0	2	40
2	Point	0	2	40

Observer Points

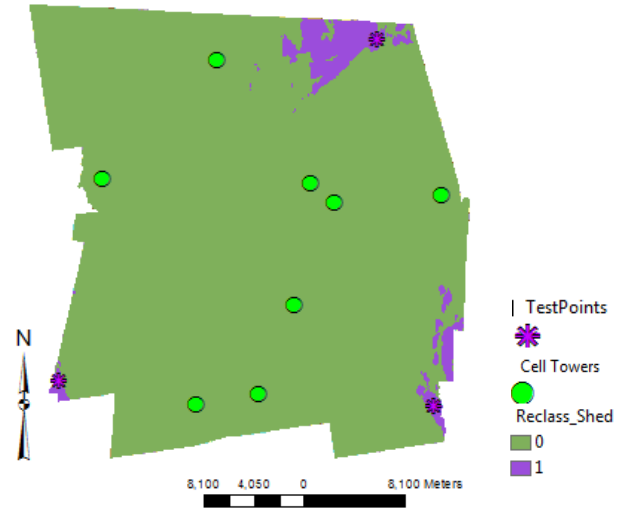
Create a new points shapefile, "TestPoints" and place points in spo of high service need. I've located three points to test. In the attribute table of the new shapefile, create a new field "OFFSETA" and populate with 2 (meters). Create a new field "OFFSETB" and populate with 40 (meters). This step is in preparation for the Observer Points operation. I will be looking for pixels which (at 40 meters above) are visible to (2 meters above) the test points.



The viewsheds displayed in green, purple, and red show the locations for which newly positioned cell towers will be in direct site lines to locations of high service need.

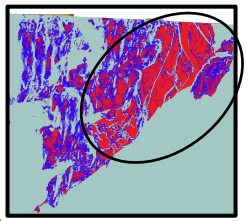


Reclassify

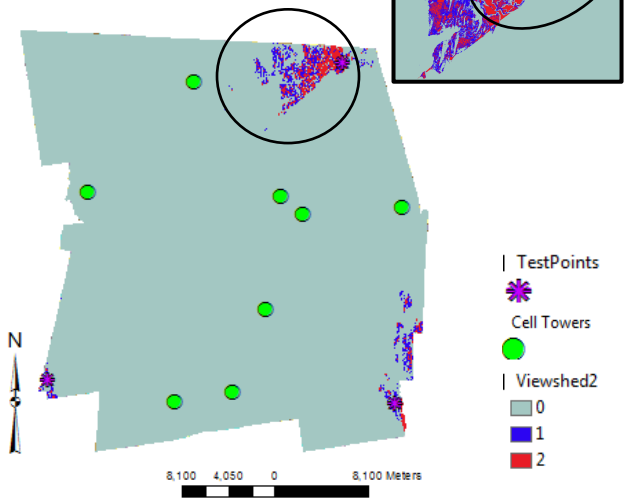


New Tower Siting

Raster Calculator

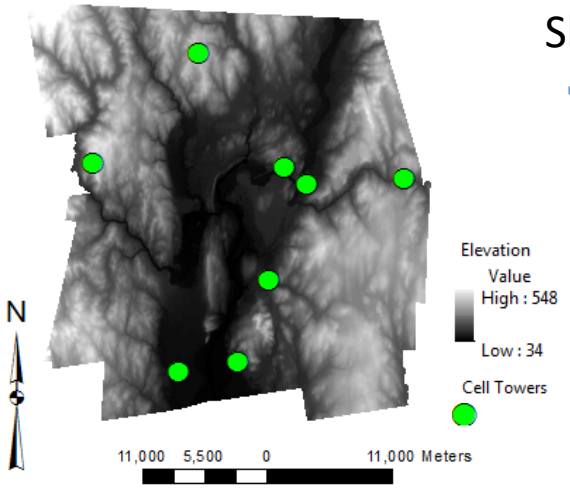


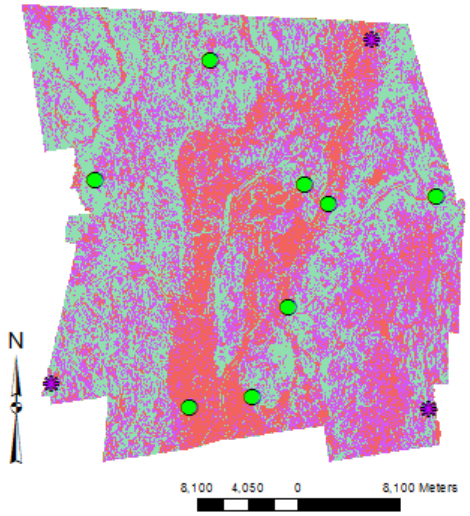
Reclass Slope * Reclass Viewsheds… high value (red) outputs give possible locations where next cell tower should be tested (within the previously determined viewsheds). Shallower slope = less costly construction!



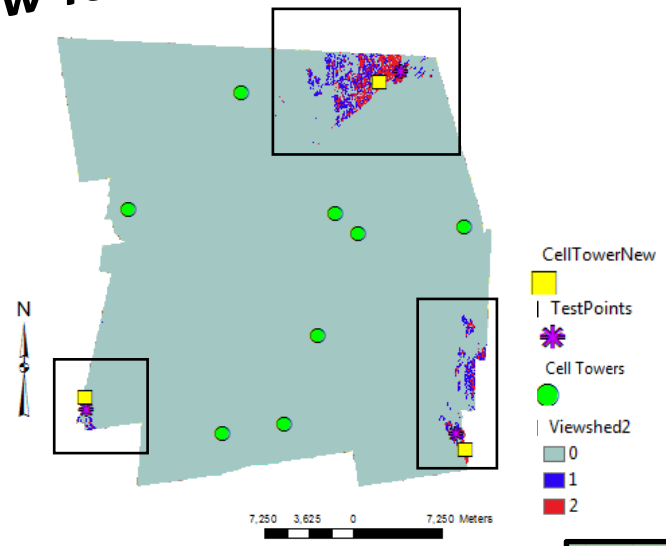
Slope + Reclassify

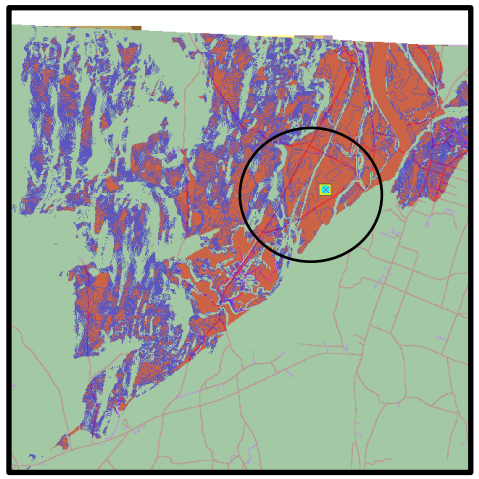
Create a grid of slopes from the elevation raster. Then reclassify to give a score of 2 to slopes between 0 and 2 degrees (shallow), a score of 1 to slopes between 2 and 8 degrees and the rest a value of 0.

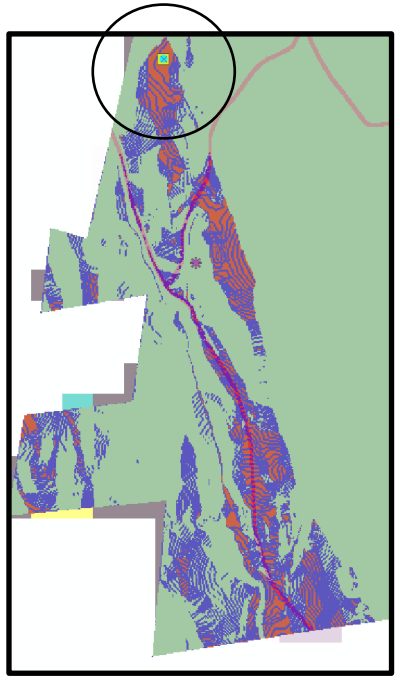


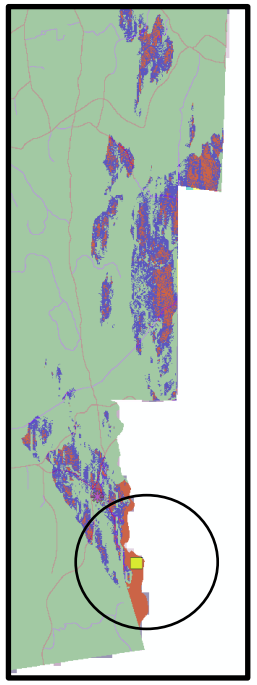


New Tower Siting (Cont…)



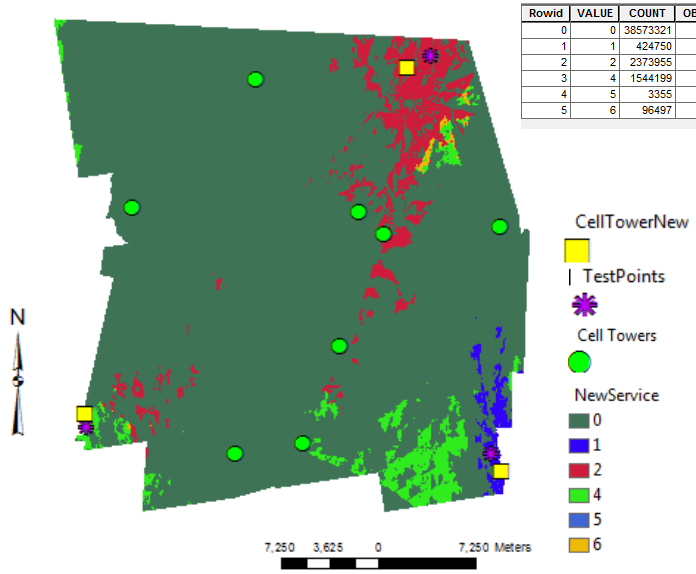






The output layer includes shows all of the pixels that would be visible from these new cell tower locations, color coded by the cell tower(s) that are responsible for coverage

Rowid	VALUE	COUNT	OBS1	OBS2	OBS3
0	0	38573321	0	0	0
1	1	424750	1	0	0
2	2	2373955	0	1	0
3	4	1544199	0	0	1
4	5	3355	1	0	1
5	6	96497	0	1	1

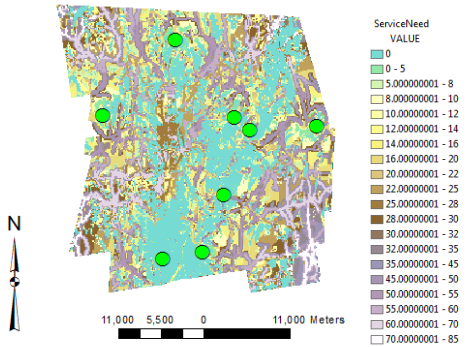


Observer Points

CellTowerNew

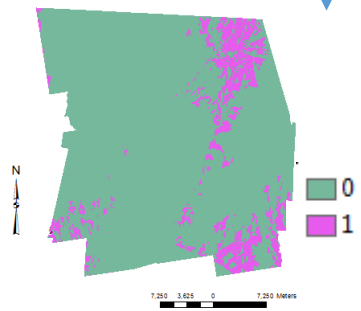
FID	Shape *	Id	OFFSETA	OFFSETB
0	Point	0	40	2
1	Point	0	40	2
2	Point	0	40	2

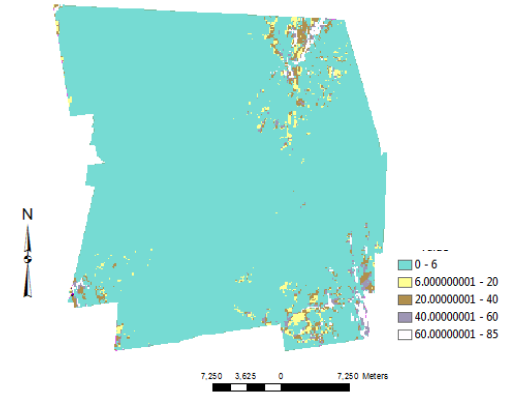
Now, create a new shapefile, which includes points for potential new cell towers. I've located these points in shallow-sloped locations (which do not fall on top of roads!) within the viewsheds of high service need areas. Populate the attribute table for this new shapefile with "OFFSETA" (40 meters)- the height of the new tower- and "OFFSETB"- the height at which a pixel can be seen by the tower.



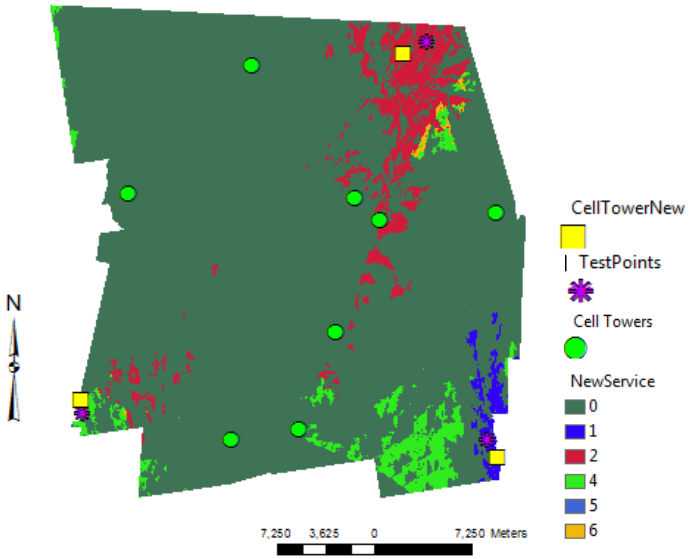
Reclassify

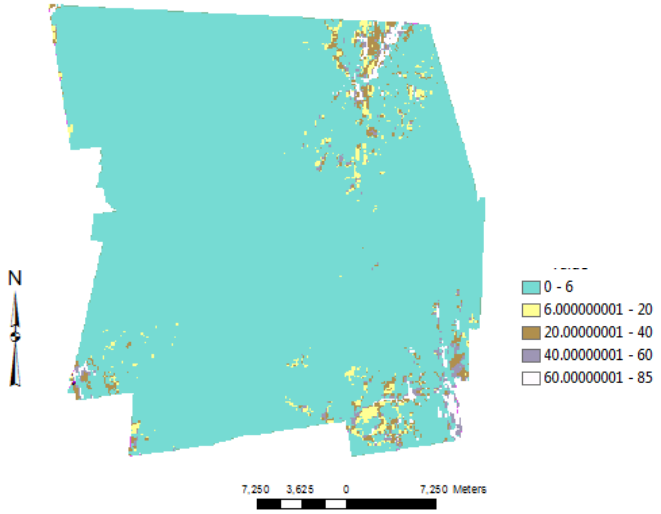
Raster Calc





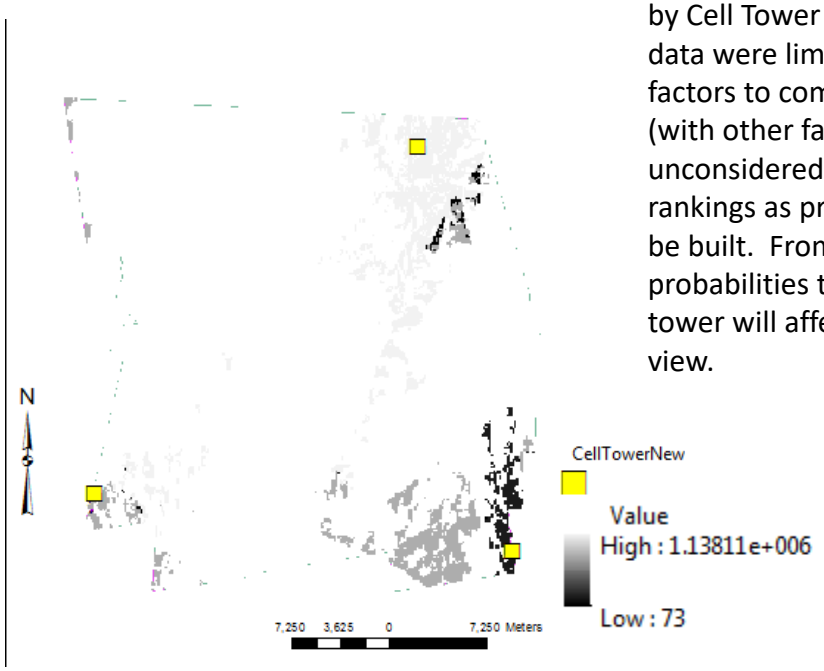
Assigning a Likelihood Hierarchy to Potential Cell Towers





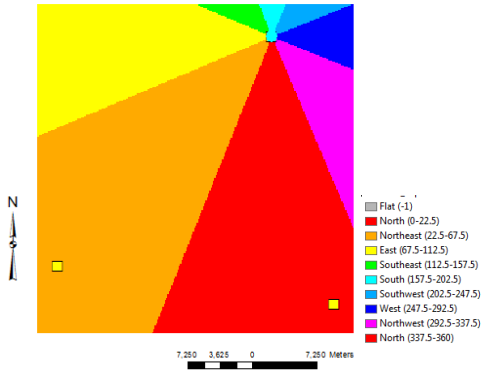
Zonal Sum

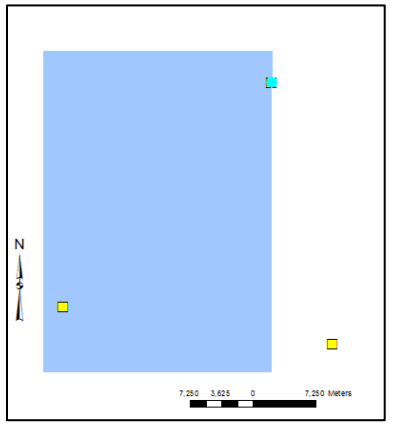
I approximate the most beneficial tower by summing together service need for each cell tower coverage zone. This will give me a ranking of the tower that is most likely to be built.



Cell Tower North has the highest value, followed by Cell Tower West, followed by Cell Tower East. Because the given data were limited to merely a few factors to come to this determination (with other factors likely left unconsidered), I'll consider these rankings as probabilities that each will be built. From this, I can extract probabilities that a soon-to-be-built tower will affect a given pixel's sunset view.

Determining Sunset Obstruction Likelihood

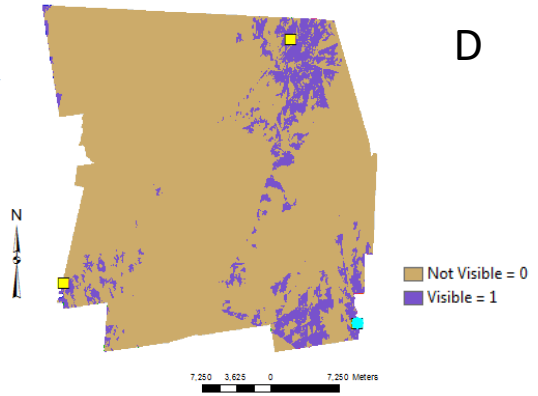




A

CellTowerNorth
(Most Likely)

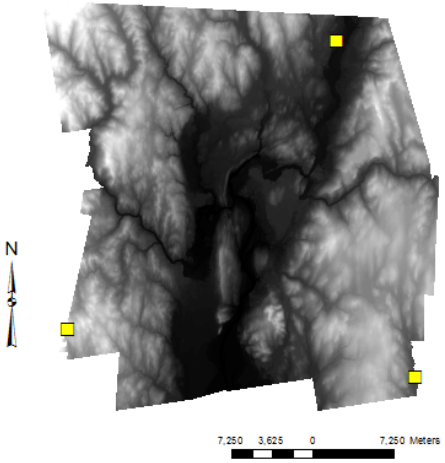
5 = obstruct
0



D

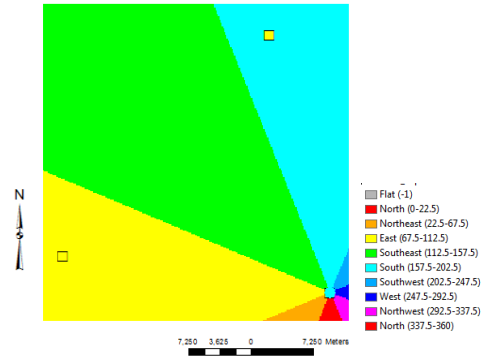
Raster Calculator

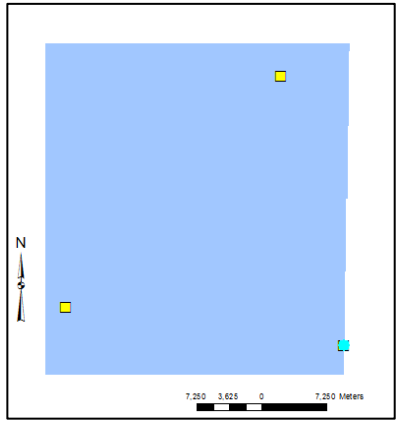
FinalLikelihood = D(A+B+C)



Euclidean Direction +
Reclassify

0 if west
1 if east

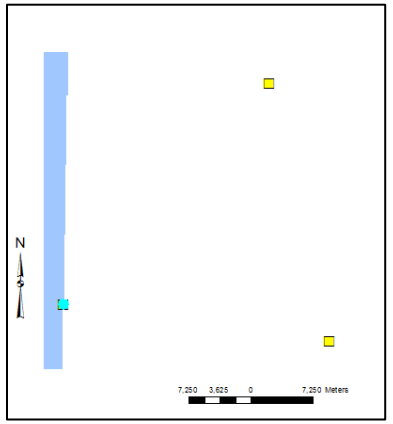




B

CellTowerEast
(Least Likely)

1 = obstruct
0



C

CellTowerWest
(Middle Ranking)

2 = obstruct
0