

FINAL

WIND FARM SITE EVALUATION – WESTERN NORTH CAROLINA, USA

Introduction

The aim of the final assignment is to determine the best location for a wind farm in Western North Carolina. I was given ten sites to examine against six main criteria: airspace restrictions, bird species restrictions, elevation limitations, wind potential, cost of connecting to the closest transmission line, and obstruction of scenic overlooks on the Blu Ridge Parkway (BRP). The conclusion is that parcel 8 (Figure 1) is best suited for a wind farm.

Methods

Guided by the spreadsheet (Figure 2), I took three main approaches. Firstly, the elimination of airspace and bird species has given binomial answers to the question of whether wind farms can be constructed. As such, I eliminated sites 7 and 10 but kept them along the work in case the initial criteria or regulations would change. Secondly, after eliminating unsuitable parts of each parcel due to the elevation, the approach of determining wind category as some areas have more wind, hence better suitable. Therefore, all ten sites received a rating and the number of megawatts of wind energy they could potentially generate. Thirdly, the cost-effective approach to quantify the cost of constructing a powerline to connect to the grid. Cost was determined by land use, elevation slope, and visibility of scenic overlooks on the BRP. I'll describe the steps one by one.

Airspace restrictions

The Federal Aviation Administration (FAA) sets the restrictions that within 7 nm around any major airport, there should be no wind turbines. The same radius for airports is 4 nm, and for all other FAA sites (e.g., helipads), it's 1 nm. I used a buffer tool to identify the necessary radius around these objects. I didn't save the model builder environment to depict those processes, but the result is in Figure 3.

Avian species restrictions

I established a 1.5 km buffer around each site and analyzed the potential number of avian species within the wind parcel together with the buffer. The model is attached as Figure 12. Lanes 4 and 5 of the spreadsheet (Figure 2) depict the results of determining avian species-restricted sites.

Elevation limitations

Not all the area within a parcel could be used for erecting wind turbines. The North Carolina Mountain Ridge Protection Act of 1983 provides two conditions (elevation above 914m and

steepness of the slope around, which suggests a ridge). Therefore, I identified such sites and produced a raster that only includes areas where wind turbines can be constructed (Figure 4). Parcels 4, 8, and 10 are also shown in a closer look. Line 9 of the spreadsheet provides a suitable area, model details are under Figure 13.

Wind potential

Due to the variation in elevation, specific landscape features and surroundings, I was given a map of wind categories in North Carolina. It spans from 'poor' to 'excellent', with the latest having the largest generation potential (0.75 MW/turbine). Each hectare can fit three turbines, and as such, in line 29 (Figure 2), I provided a total generating capacity with a ranking below. Site 1 can potentially generate the largest amount (722 MW), followed by parcel 8 (535 MW), which was eventually selected as the best.

Cost of connection to the closest transmission line

Two elements influence the cost of constructing a new powerline from the wind farm parcel to the existing grid: land use and slopes. Certain categories of land use can't be used for the power line (e.g., open water), while others bear a high price (e.g., pasture/hay costs \$65/m). Therefore, the best landscape for the powerline is a developed area, which costs \$10 or barren land (\$15). The second critique is a slope with any elevation change less than 10% costing nothing extra, while the elevation change above 40% costs \$16/1 m. There were no elevation changes above 80% within the given area. The total costs are depicted in Figure 5 and summarized on line 32 of the spreadsheet.

Obstruction of view

Due to the potential view obstruction, we have an agreement for a settlement (\$15,000) for every scenic overlook from which a wind farm can be seen (Figure 6). Therefore, it significantly altered the cost determination on top of the grid connection. As such, the remediation cost for site 12 is the highest (\$180,000) due to the 12 overlooks obstructed while sites 2, 3, 5, 6 and 8 have no view obstruction. Despite calculations, this site may have view obstruction, which I elaborate on in the results.

Results

Parcel 8 is the most suitable site given the lowest cost of connection to the grid (Figure 1 and Figure 2), no settlement cost with the Blue Ridge Parkway Tourist Network (BRPTN) and a high production capacity (535 MW).

Site 8 considerations

The method of determining the view obstruction is based on centroid – a single spot in the middle of the parcel. Many parcels, including parcel 8, are located across the hill where the

center spot lies on one side (zoom in map on the Figure 1). Therefore, anything visible from that spot will only be visible on one side. In the case of site 8, it is north with a slight direction to the west. The view technically crosses no BRP overlooks, but three things should be considered in the final decision-making process.

Recommendations

Parcel 8 is best suited with the parcel 3 being the second alternative. While making the final decision, it is important to consider two elements that can further hinder the litigation process with the BRPTN and one that can expand the opportunities:

- While calculated in the center, a significant portion of the site can still be visible from the BRP. As such I recommend repeating the calculation with multiple points per parcel depending on the landscape and testing the view on the ground.
- CadaAire has rotor blades 45 m in diameter. Though we weren't given the height of such turbine, a similar model [Vestas V90](#) (a model, which is also very close to the CadaAire turbine) with the same blade length is 125 m high. Therefore, this height is a critical consideration in determining scenic views. To mitigate this challenge, I recommend considering the height of turbines and providing a field work examination of their visibility.
- At the same time, during the calculation, the curvature of the Earth wasn't considered, along with the obstruction of air particles view. Therefore, certain wind turbines may be barely visible from the BRP, and litigation costs should not be paid.

Overall, to conclude the analysis of the study, it is necessary to start from the viewpoint of obstruction. The Nicholas School of the Environment student will gladly accept further work from the Wind Power Consortium of NC and will recommend suitable turbines.

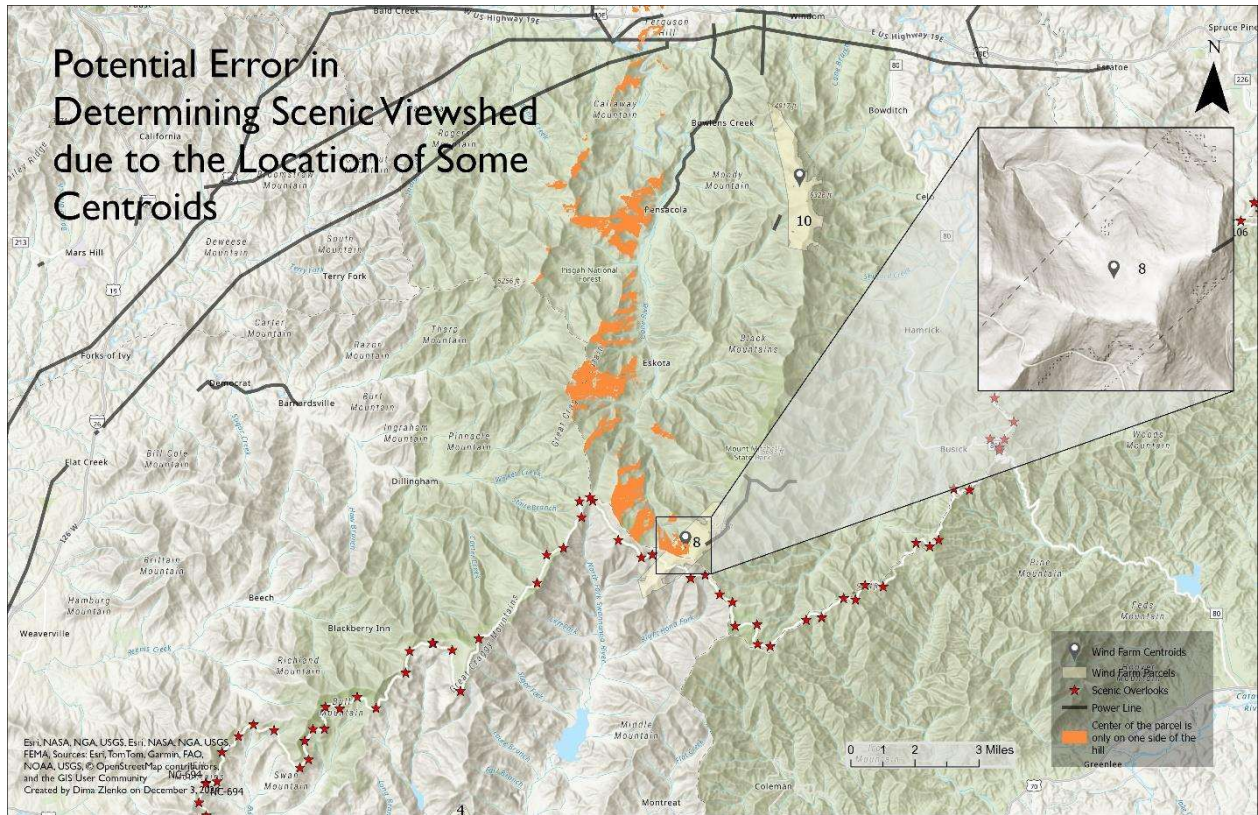


Figure 1 Most suitable parcel 8 and its potential flaw as the centroid is located on one side of the hill and possibly does not obstruct the view to major viewpoints, which potentially leads to high litigation cost

	PARCEL #	1	2	3	4	5	6	7	8	9	10	
2	FAA restricted?							X			X	
3												
4	# birds w/in 1.5km	714.4	677.1	687.6	875.0	897.5	995.6	809.7	801.5	931.5	1,092.1	
5	Bird restricted?										X	
6												
7	Total Area (HA)	221.4	220.2	237.6	287.8	348.5	332.1	298.1	440.2	416.3	593.5	
8	Protected Ridge area (HA)	4.5	38.4	2.4	9.7	15.4	59.6	17.1	52.6	0.5	123.1	
9	Available Area	216.9	181.7	235.2	278.1	333.2	272.5	281.0	387.7	415.8	470.4	
10												
11	AREA(HA) IN... 'poor'	0.4	0.0	0.0	86.6	59.6	122.4	11.3	15.0	28.6	4.1	
12	'marginal'	8.6	3.7	5.5	32.8	47.1	37.4	83.3	29.2	40.6	15.7	
13	'fair'	14.8	9.2	23.7	24.1	57.2	30.0	42.7	33.9	61.7	31.9	
14	'good'	18.8	9.4	13.7	14.8	13.9	42.6	56.2	35.6	56.0	32.6	
15	'very good'	25.4	8.0	31.9	25.4	31.2	17.6	48.4	28.0	50.6	39.8	
16	'superior'	47.0	15.6	41.7	56.3	80.7	18.1	39.3	76.3	93.0	128.9	
17	'excellent'	101.1	136.2	118.7	39.8	42.7	4.4	0.0	169.0	84.8	212.1	
18	total	216.0	182.0	235.1	279.7	332.3	272.5	281.2	387.0	415.3	464.9	
19												
20	# TURBINES IN... 'good'	56	28	41	44	41	127	168	106	167	97	
21	'very good'	76	24	95	76	93	52	145	83	151	119	
22	'superior'	140	46	125	169	242	54	117	228	278	386	
23	'excellent'	303	408	356	119	127	13	0	507	254	636	
24												
25	MW FROM... 'good'	8.4	4.2	6.2	6.6	6.2	19.1	25.2	15.9	25.1	14.6	
26	'very good'	19.0	6.0	23.8	19.0	23.3	13.0	36.3	20.8	37.8	29.8	
27	'superior'	72.8	23.9	65.0	87.9	125.8	28.1	60.8	118.6	144.6	200.7	
28	'excellent'	227.3	306.0	267.0	89.3	95.3	9.8	0.0	380.3	190.5	477.0	
29	TOTAL MW	327.5	340.1	361.9	202.7	250.5	69.9	122.3	535.5	397.9	722.0	
30	RANK	6	5	4	8	7	10	9	2	3	1	
31												
32	Cost to link to grid (\$)	\$127,166	\$160,290	\$67,120	\$59,997	\$136,768	\$28,891	\$114,598	\$24,631	\$224,971	\$41,225	
33												
34	# of scenic overlooks w/in viewshed	10	0	0	6	0	0	10	0	12	5	
35	Remediaton costs (\$)	\$150,000	\$0	\$0	\$90,000	\$0	\$0	\$150,000	\$0	\$180,000	\$75,000	
36												
37	Total cost (\$)	\$277,166	\$160,290	\$67,120	\$149,997	\$136,768	\$28,891	\$264,598	\$24,631	\$404,971	\$116,225	
38	Below budget?	No	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	
39												
40	Additional: Cost \$ per MW	\$846.4	\$471.3	\$185.5	\$739.9	\$546.0	\$413.4	\$2,163.7	\$46.0	\$1,017.9	\$161.0	
41	Disqualified?	Budget						FAA		Budget	FAA & Birds	
42	Recommendation		Second choice						Yes			

Figure 2 Spreadsheet to determine the most suitable site for the wind farm

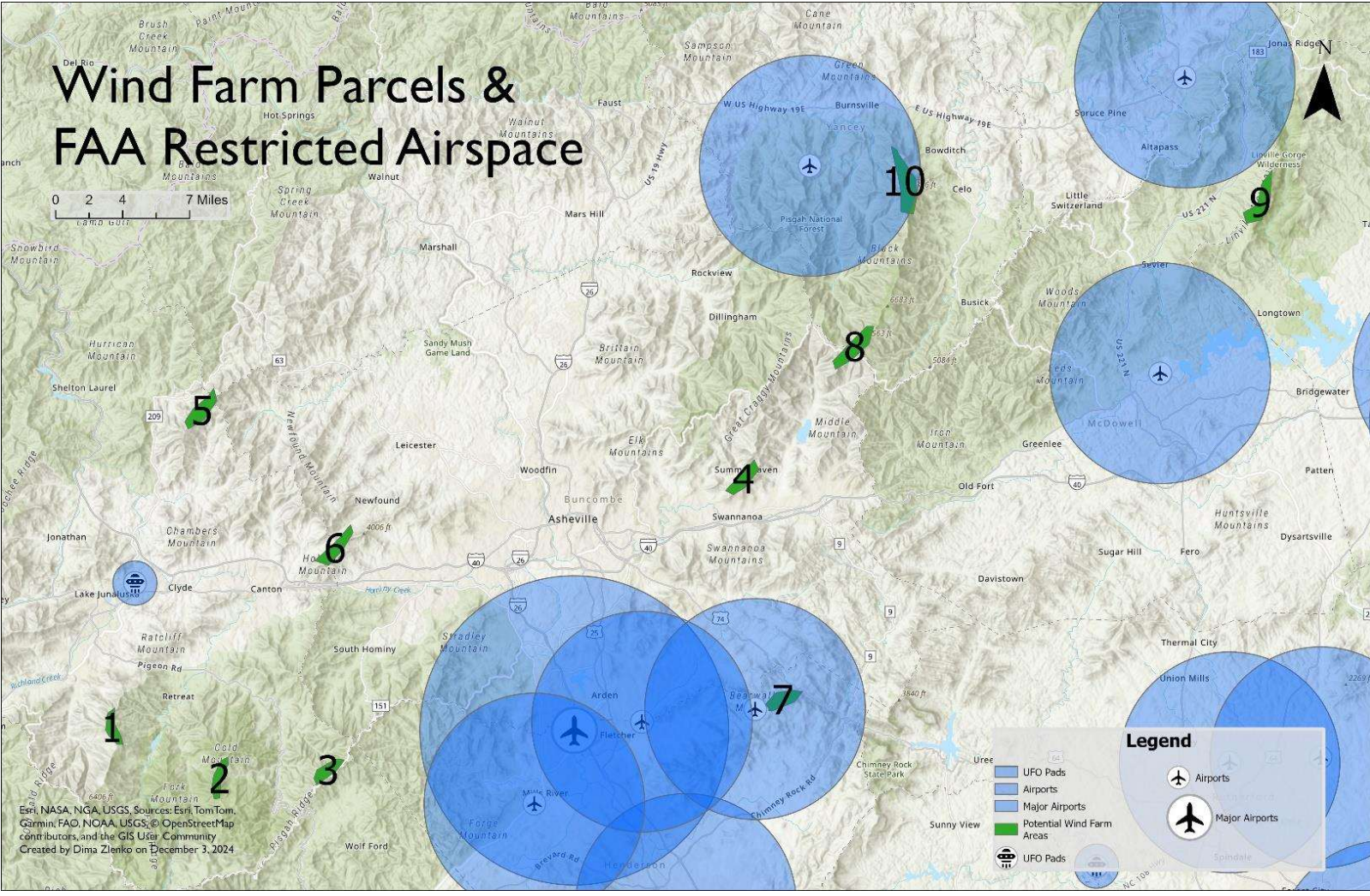


Figure 3 Areas around the FAA objects: major airports, airports, and others

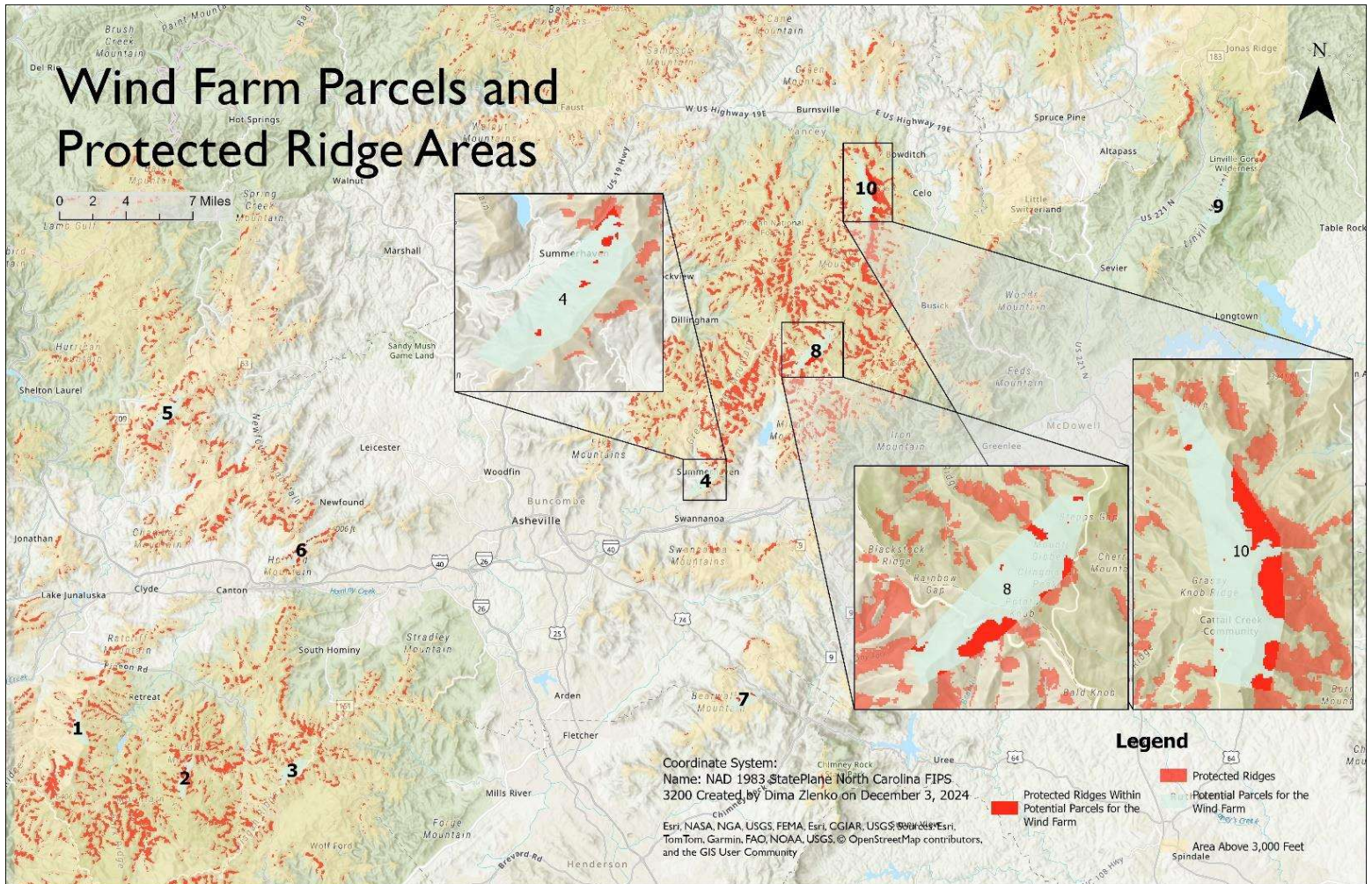


Figure 4 The overlap of elevation and ridges

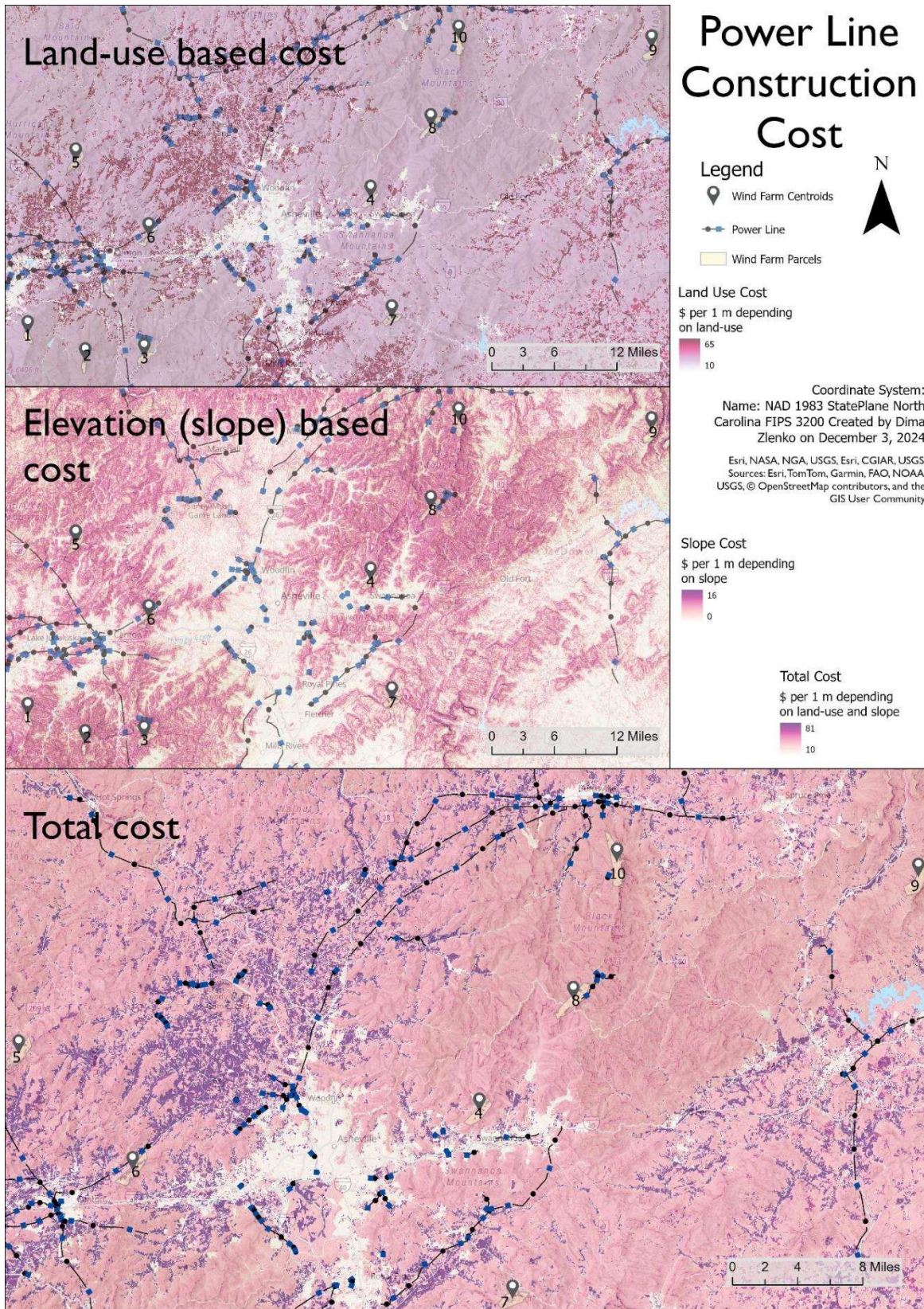


Figure 5 Cost determination

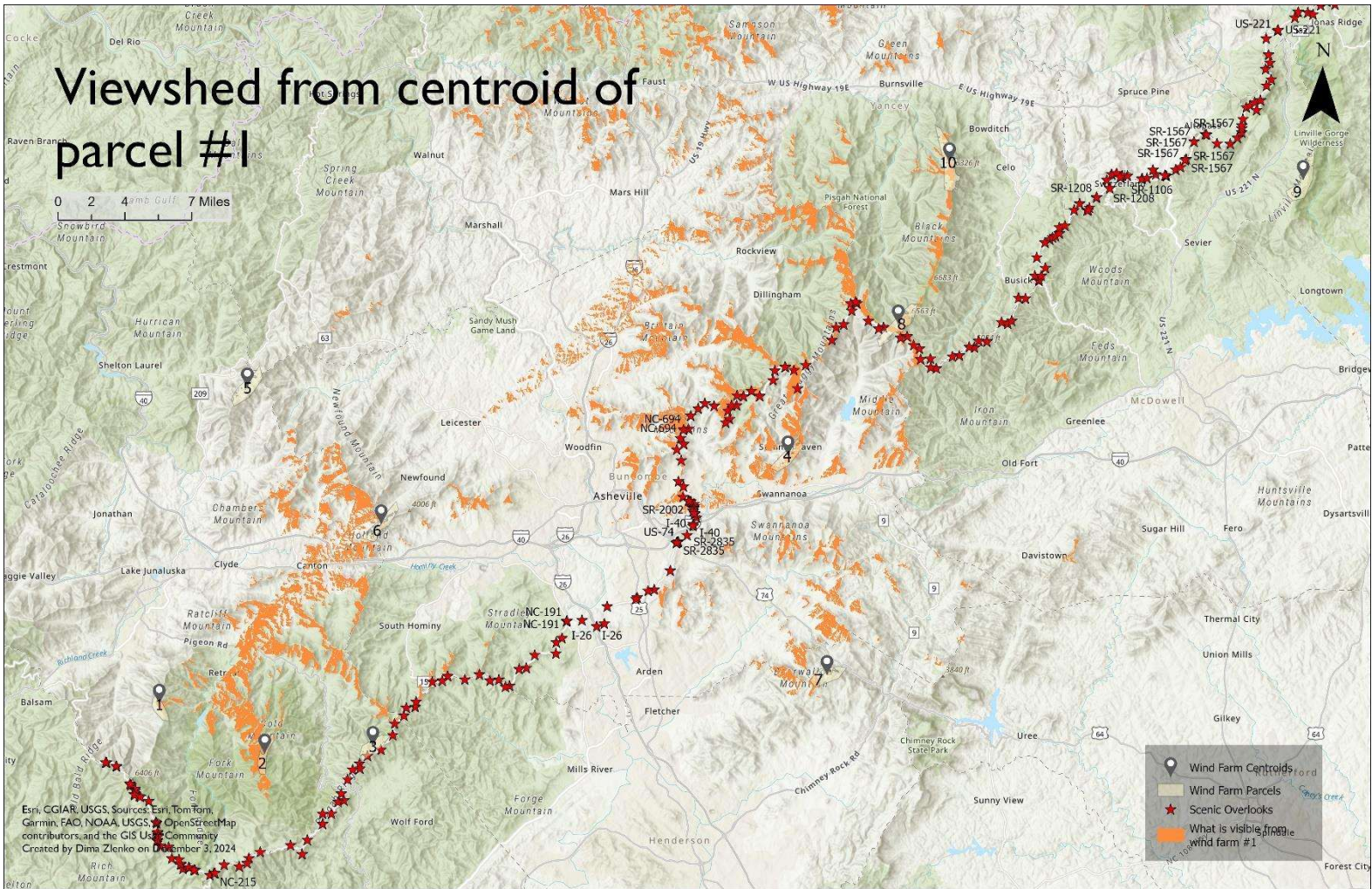


Figure 6 Closer view of the potential viewshed from one of the wind sites