Suitability Analysis of Wind and Solar Farms in Oregon, USA

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May 2019

Abstract

Renewable energy such as wind turbines and solar panels create a lower environmental impact than traditional energy sources. Oregon has pledged 50% of its' energy production will come from renewables by 2040 and to completely phase out electricity produced by coal by 2030 ("Energy in Oregon", n.d.**).** This study used the following datasets to evaluate the ideal locations for solar and wind farms: solar insolation, wind speeds, land cover, slope, national and state parks, transmission lines, highways, and cities. PostgreSQL database and GIS software were used to intersect the parameters and create final solar and wind potential maps of suitable areas. Wind and solar suitability were highest in the southeastern, south central and north central portions of the state. Gilliam and Sherman counties showed the best overall values for solar potential, while Harney and Gilliam counties had the highest wind potential. Further analysis should be conducted on cost and review of established solar and wind farms to determine the best locations to expand renewable energy production in Oregon.

Introduction

Renewable energy sources, such as wind turbines and solar panels, create a lower environmental impact than traditional energy sources, such as fossil fuels, which are finite and often imported at a high cost. Renewable energy can be produced domestically, which enhances energy security. Furthermore, there is a global movement to combat climate change by reducing emissions caused by burning fossil fuels ("Why is Renewable Energy Important?", n.d.**).**

In order to achieve this goal, the most ideal locations for new solar and wind farms must be identified. Factors such as installation and maintenance cost, distance from cities, proximity to existing power and transportation infrastructure, as well as reliable energy generation, need to be evaluated. GIS tools and databases are a powerful way to compare and analyze these spatial questions. Several studies have focused on finding ideal locations for solar and wind farms. For example, Ignizio (2010) used solar insolation values, roads, ownership lands(excluded), powerlines, hydrography information, existing solar facilities, and a DEM (slope) to evaluate if solar farms in the southwestern United States existed in the most suitable areas. Meanwhile, J.R. Janke (2010) evaluated ideal locations for wind and solar farms in

Colorado using wind speed, solar insolation, distance to transmission lines, distance to cities, population density, distance to roads, land cover, and non-federally protected lands.

In order to assess maintenance and installation costs, this study chose to look at distance from cities, highways, and transmission lines. Protected land, such as national and state parks, and areas with a slope greater than 5% were eliminated from the study area for solar because such areas inhibit the ability to generate energy and install panels. Areas with a slope greater than 10% were excluded for the wind potential study since slopes greater than that are not suitable for wind turbines. Land cover was evaluated for ideal land type to build on. Lastly, average wind speeds and solar insolation across Oregon were used to assess areas for potential energy production. Each of these parameters was reclassified from 0 to 1, with 1 being most ideal, and assigned a weight (Table 1) to calculate the final solar and wind potentials (Formula 1). Due to lack of funding existing solar and wind farms were unable to be included in the study for comparison.

The goals of this suitability analysis are to determine which areas have the greatest potential for generating energy from solar or wind in Oregon. Additionally, we evaluated which counties have the best potential for solar or wind energy development.

Table 1.

Criteria used to model solar and wind potential

Variable	Ideal Conditions	Possible Values	Weight
Solar Insolation	Maximum	[0-1]	3
Wind Speed	NREL Class 7	[0-1]	3
Distance to Transmission Lines	Close to Transmission lines	[0-1]	2
Distance to Highways	Close to Highways	[0-1]	1
Distance to Cities	Further from cities	[0-1]	1
Land cover	SEE Table 2	[.33, .66, 1]	1
Slope	Less than 5% for solar Less than 10% for wind	0 or 1	n/a
National and State Parks	Outside of Park boundaries	0 or 1	n/a

Methodology

The methodology for this study is based on Janke's modeling of wind and solar farm potential in Colorado (2010) and Brewer et al.'s analysis of solar power site suitability throughout the American southwest (2015). The study area for this project is all locations in the state of Oregon. Two Boolean parameters, protected lands (Janke, 2010, p. 2229-31) and slope percent (Brewer et al., 2015, p. 827-8), were used to identify potential solar and wind production sites. These areas were then evaluated for proximity to cities, existing transmission lines, and highways, as well as suitability of land cover. Wind speed measured at 50m above the ground, and annual solar GHI (global horizontal irradiance) were used to quantify potential for wind and solar energy generation, respectively (Janke, 2010, p. 2229-31). Each of the non-Boolean parameters was reclassified on a 0-1 scale, with 1 being the most ideal (ibid., 2231). Spatial analysis was performed using ESRI ArcGIS Pro 2.2, PostgreSQL 11, and PostGIS 2.5.3.

Polygon layers were created for each parameter, and the raw suitability values for each layer were reclassified from 0 and 1, with 1 being most ideal, using ArcGIS. Each of these shapefiles were then imported into our PostgreSQL database as a table for spatial analysis (Appendix A). As geometric intersections were calculated between tables, additional tables were created to store the results of the SQL queries (Appendix B). GIST indices were used on the geometry column of each table to expedite intersections and spatial joins (Appendix B).

Oregon state park polygons and polygons of national parks within Oregon were merged to create the protected lands layer. The Identity tool was used with an Oregon state polygon and the protected land layers as inputs to create a layer containing polygons for both protected and non-protected areas within Oregon. Protected areas were reclassified with a value of 0 and non-protected areas were given a value of 1 (Table 1).

There is no consensus on what slope value is too steep to install large-scale wind or solar energy generation infrastructure. Brewer et al. (2015, p. 827-8) found 85% of solar facilities in the southwest were located on land with a slope less than 3.1 degrees, or 5.4%. Watson and Hudson (2015, p. 23), as well as Kamholz (2008, p. 6) used a slope less than 10% to identify potential sites for wind energy production in Texas and the UK, respectively. Palmer et al. (2019, p. 1138) discovered the maximum slope used for solar studies in various countries ranged from 11% in Iran to 2% in India, with a common US technique using 3% as the cutoff for studies measuring slope as a Boolean parameter. This study used 5% slope as our maximum slope for solar analysis and 10% for wind, which fit within the ranges used by previous studies.

Slope was calculated using a DEM with 10m cell size. It was resampled to a 1-mile cell size to make the scale more appropriate for a statewide site suitability analysis, and then a slope raster was created using the Slope tool in ArcGIS. That raster was then converted to a polygon shapefile (Figure 3).

Highway, city, and transmission line GIS datasets were downloaded from the Oregon Spatial Data Library as shapefiles. The city layer was polygon and the highway and transmission line layers were polyline. A distance raster was created from each of these three vector layers using the Euclidean Distance tool in ArcGIS. The resulting rasters were of type floating point and had a cell size of 5 miles, with the value of each cell recording the distance to the nearest feature. The Int tool in ArcGIS was used to convert floating point cell values to integer values in order to build the raster attribute table. Once this was completed, the Raster to Polygon tool in ArcGIS was used to create the final polygon layers for each parameter (Figure 3) that were imported into the database.

When measuring proximity to highways and existing transmission circuit, areas that were closer to features in each respective layer were most ideal. Therefore, to calculate the reclassified values between 0 and 1 for the highway and transmission circuit layers, the minimum distance value in each respective layer was divided by the distance value for each feature (Janke 2010, p. 2231). For example, with a minimum distance value of 1, an area 50 miles from the nearest highway would have a reclassified value of 1/50 = 0.02, whereas an area 1 mile from the nearest highway would have a reclassified value of 1.

Locations farther from cities were considered more ideal for solar and wind production (Brewer et al. 2015, p. 827; Janke 2010, p. 2231), meaning the areas farthest from cities would have reclassified distance values of 1. Therefore, to reclassify distance values for the cities layer the distance value for each feature was divided by the maximum distance value in the layer (Janke 2010, p. 2231). For example, with a maximum distance value of 50, an area 1 mile from a city would have a reclassified value of 1/50 = 0.02, whereas an area 50 miles from the nearest city would have a reclassified value of 1.

Land cover data was downloaded from the Oregon Spatial Data Library as a 30m categorical raster. The raster was resampled to 5-mile cells to match our other non-Boolean datasets, and then values were reclassified into integer categories from 0 to 3, with 3 being most ideal and 0 being water bodies (Table 2). These integer values were then reclassified between 0 and 1 by dividing the value of each cell by 3, producing values of 0.0, 0.33, 0.67 and 1.0 (Table 1). This layer was then converted to a polygon layer so it could be uploaded into the PostgreSQL database (Figure 3).

Table 2.

Reclassification of landcover values

Suitability	Reclassification	Original Value
Most Ideal	3	Barren Land, Shrub/Srub, Herbaceous
Adequate	2	Forest, Crops
Least Ideal	1	Snow/ice, Developed, Wetlands
Not Suitable	0	Open Water

Wind and solar GIS datasets were downloaded from the National Renewable Energy Laboratory (NREL) as vector polygon shapefiles. For wind, each feature had a wind power class (WPC) integer value ranging from 1 to 7. These values were reclassified by dividing each by 7. Annual global horizontal irradiance values were used for solar analysis. GHI values ranged from 3.21 to 4.82. These values were reclassified between 0 and 1 by dividing each value by 4.82.

After preparing all data as polygon shapefiles in ArcGIS (Figure 3), the shp2pgsql data loader was used to produce SQL queries to create each table and load the spatial data into them:

```
shp2pgsql -s 2992 -I Hwy_Dist Hwy_Dist > Hwy_Dist.sql
```

Psql was then used in the terminal to run the SQL queries which resulted from the above command:

```
psql -d final_project574 -U postgres -f Hwy_Dist.sql
```

All shp2pgsql and psql code used to create tables and load data can be found in Appendix A.

In ArcGIS, the Intersect tool could have been used to intersect all polygon layers at one time. PostGIS, however, does not offer a spatial analysis function that computes the geometric intersection of more than two layers. Because of this, a series of spatial joins was performed using the ST_Intersection function. First, the *hwy_dist* and *trans_dist* tables were joined and an ST_Intersection was calculated on their respective geometries. The results of the SELECT query were inserted into a temporary table called *hwy_trans*:

```
INSERT INTO hwy_trans (hwy_gid, hwy_val, trans_gid, trans_val, geom)
(SELECT
        h.gid AS hwy_gid,
        ROUND(h.dist_val::numeric, 3) AS hwy_val,
```

```
                    t.gid AS trans_gid,
                    t.dist_val AS trams_val,
                    CASE
                        WHEN ST_Within(h.geom, t.geom)
                        THEN h.geom
                        ELSE ST_Multi(ST_Intersection(h.geom, t.geom))
                    END AS geom)
    FROM hwy_dist AS h JOIN trans_dist AS t ON ST_Intersects(h.geom, t.geom);
```

The WHEN/ELSE construction with the ST_Within() condition was used to expedite the processing of the ST_Inersection() function. If the first geometry, h.geom, is within the second geometry, t.geom, then the geometry of the current record in table *hwy_dist* can be inserted into the results table since its entire geometry forms an intersection with a feature in table *trans_dist*.

The same query as above was used to intersect the *hwy_trans* and *city_dist* tables and the results were inserted into the *hwy_trans_city* table. A similar query was performed until the GID and reclassified value between 0 and 1 had been joined and the intersection between the geometries had been calculated for tables *hwy_dist*, *trans_dist*, *city_dist*, and *landcover* (Appendix B). The resulting table was *hwy_trans_city_lc* (Appendix B).

Two tables containing all the non-Boolean parameter values for wind and solar were created in which we calculated the final potentials for wind and solar production (*all_vals solar, all_vals_wind*). An intersection was performed between *hwy_trans_city_lc* and *solar_potntl* to create *all_vals_solar*, and the same intersection was calculated between *hwy_trans_city_lc* and *wind_potntl* to create *all_vals_wind* (Appendix B). The final value for solar potential was created using this formula (see Table 1 for weights and layers):

((3*sol_val) + (2* trans_val) + city_val + hwy_val + lc_val) / 8

Formula 1. Weighted formula for calculating final solar/wind potential

This formula was also used to calculate wind potential by replacing 'sol_val' with 'wpc_val'. This formula results in values between 0 and 1.

A similar query was used to create the *potntl_site_solar* and *potntl_site_wind* tables, the geometry of which represented the possible area where either solar or wind development could occur. Rather than having a classified value between 0 and 1, these two tables were Boolean layers. As part of the spatial join, only records with a slope percent equal to or less than 5 (slope_pct <= 5) were selected for solar and only those with a slope percent equal to or less than 10 (slope_pct <= 10) for wind. Records that were not part of a national or state park (protected = 0) were selected from the *or_park* table in the spatial join (Figure 3). The results of these spatial joins were inserted the *potntl_site_solar* and *potntl_site_wind* tables, respectively. Finally, the geographic intersection was calculated between the *potntl_site_solar* and *all_vals_solar* to create the *solar_potntl* table (Figure 2), and between the p*otntl_site_wind* table and *all_vals_wind* table to create the *wind_potntl* table (Figure 3).

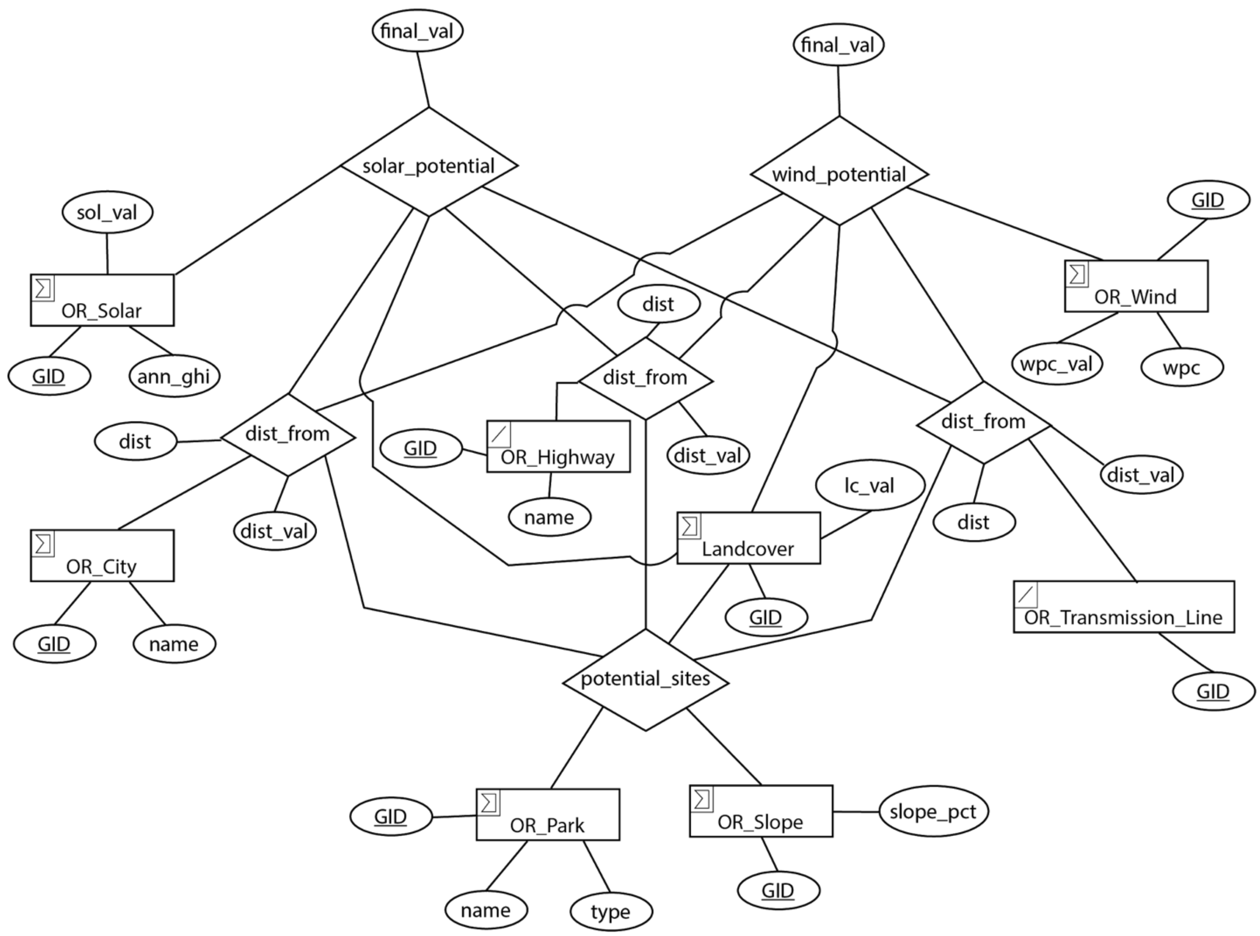


Figure 1. ER Model

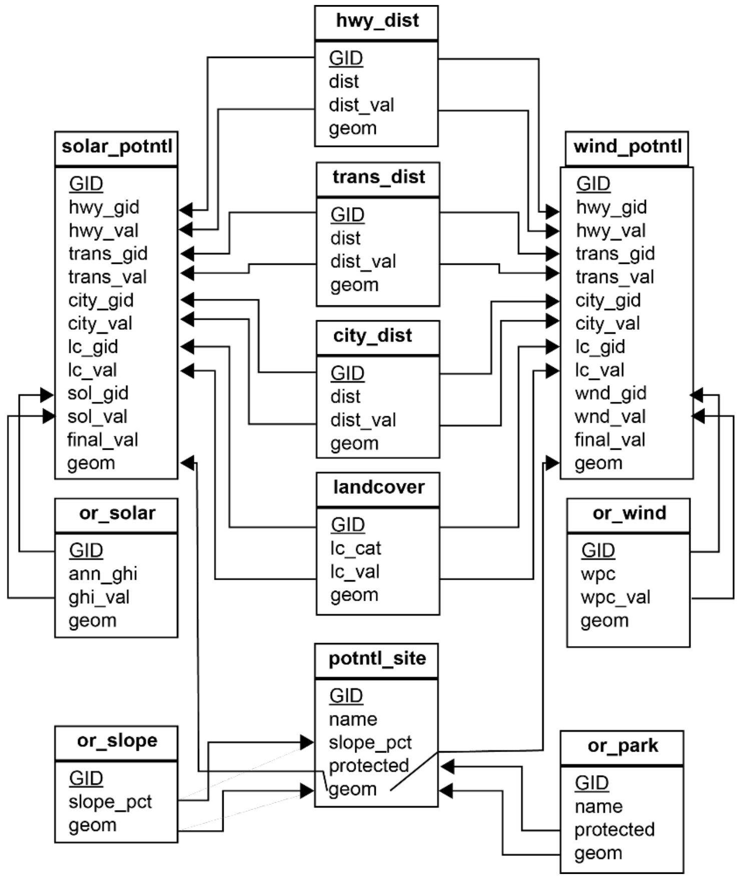


Figure 2. Logical Model

Suitability Analysis of Wind and Solar Farms in Oregon, USA

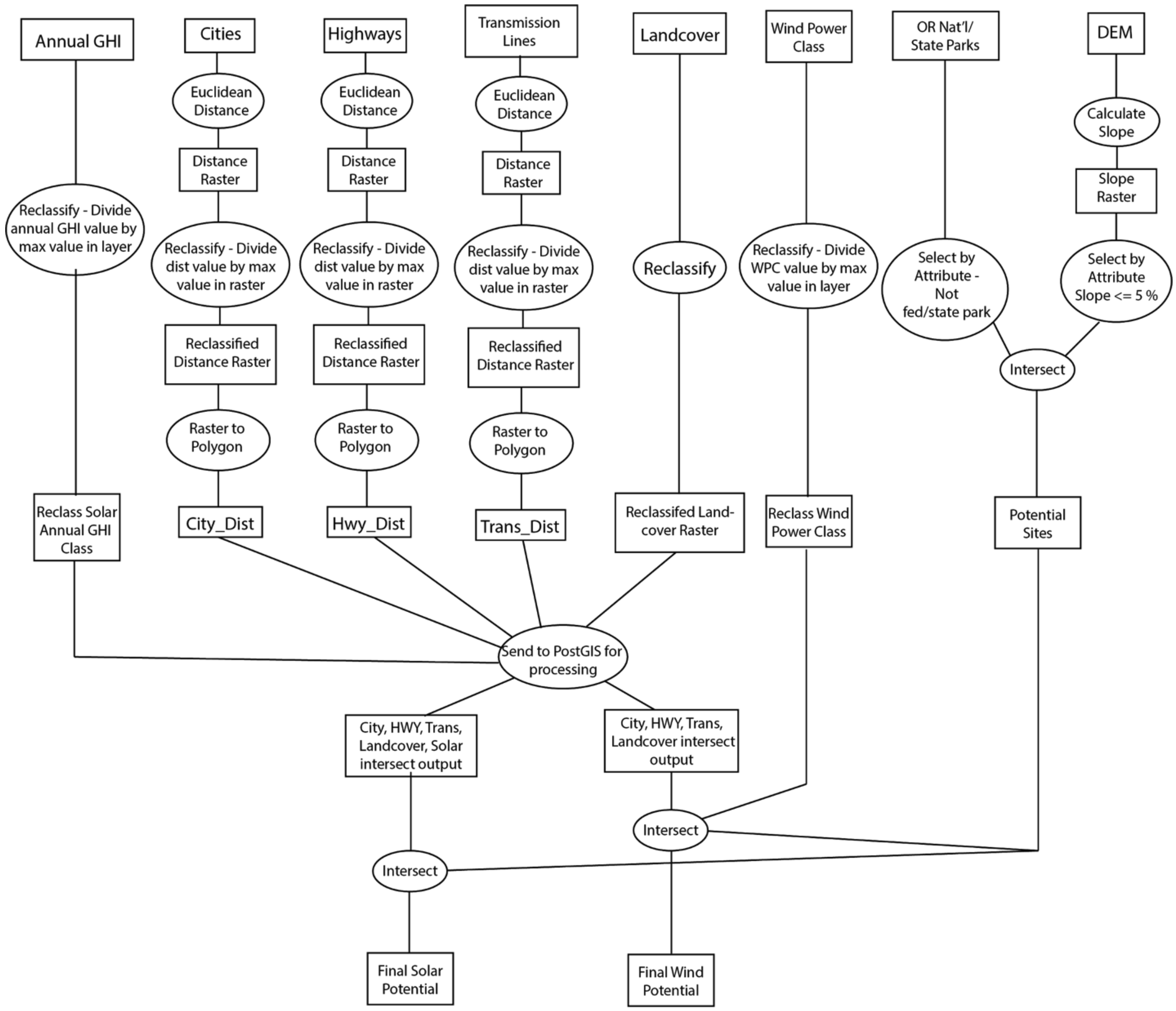
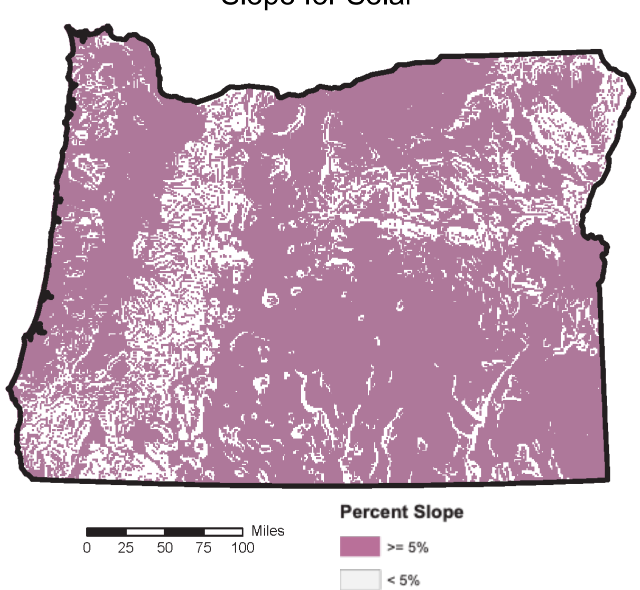


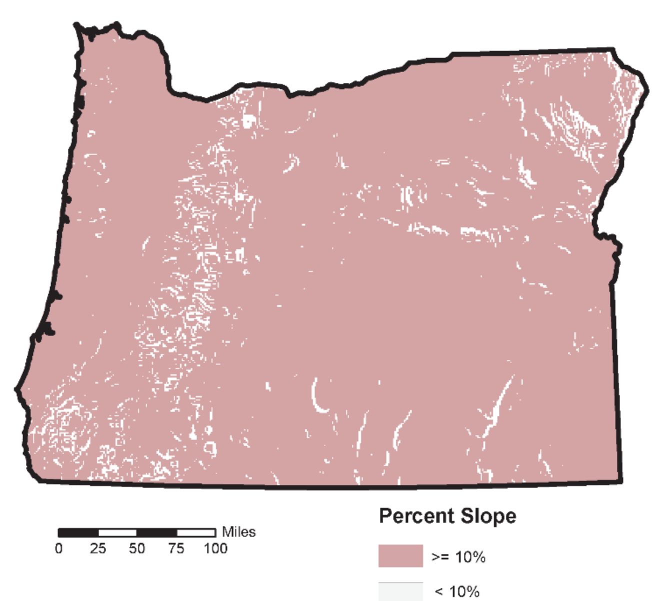
Figure 3. GIS Model

Results

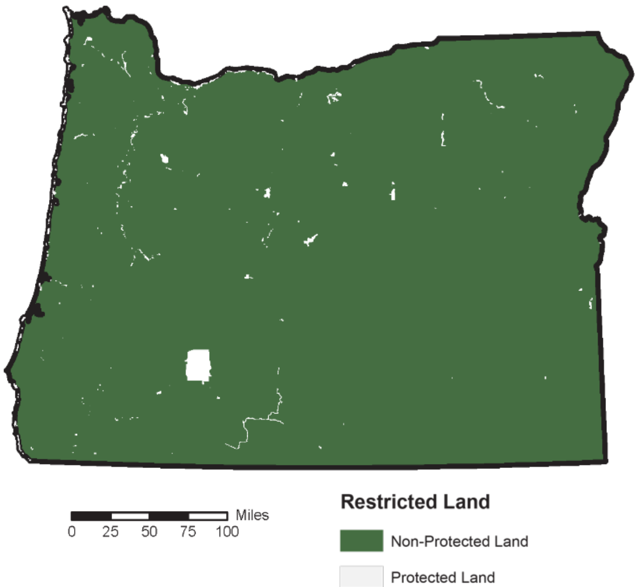
Slope for Solar



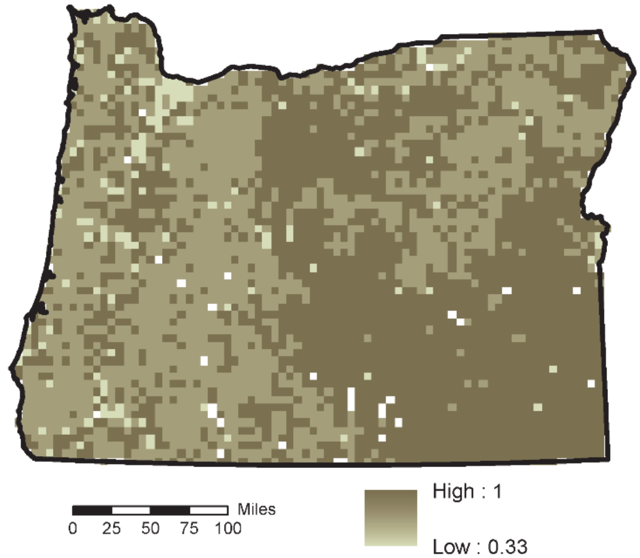
Slope for Wind



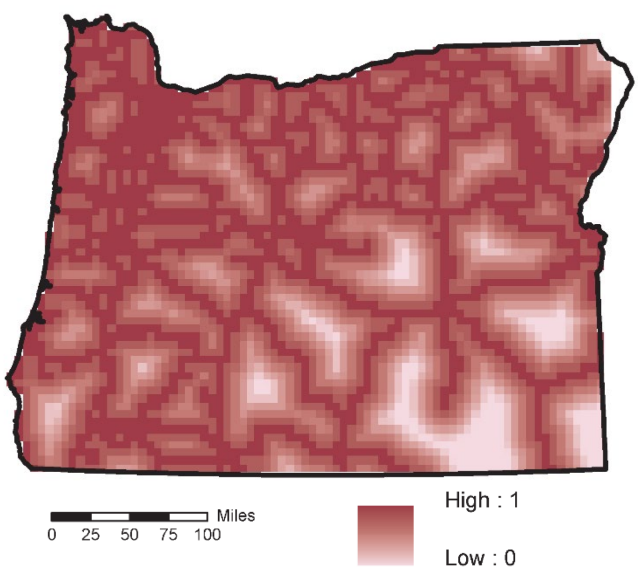
National and State Parks



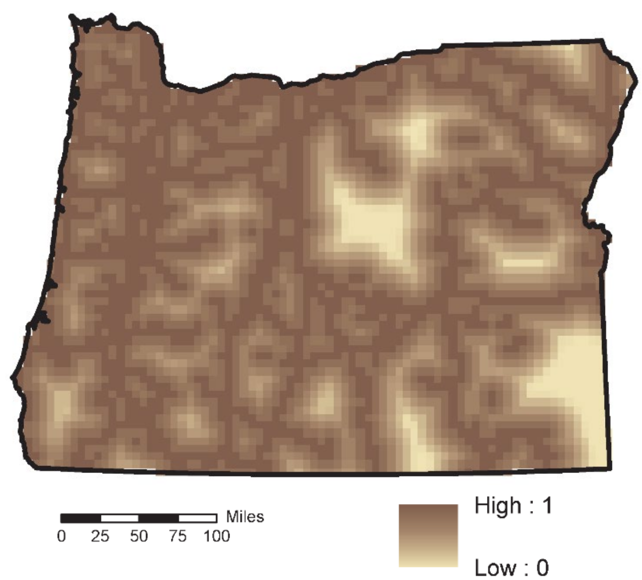
Land Cover



Distance from Highways



Distance from Transmission



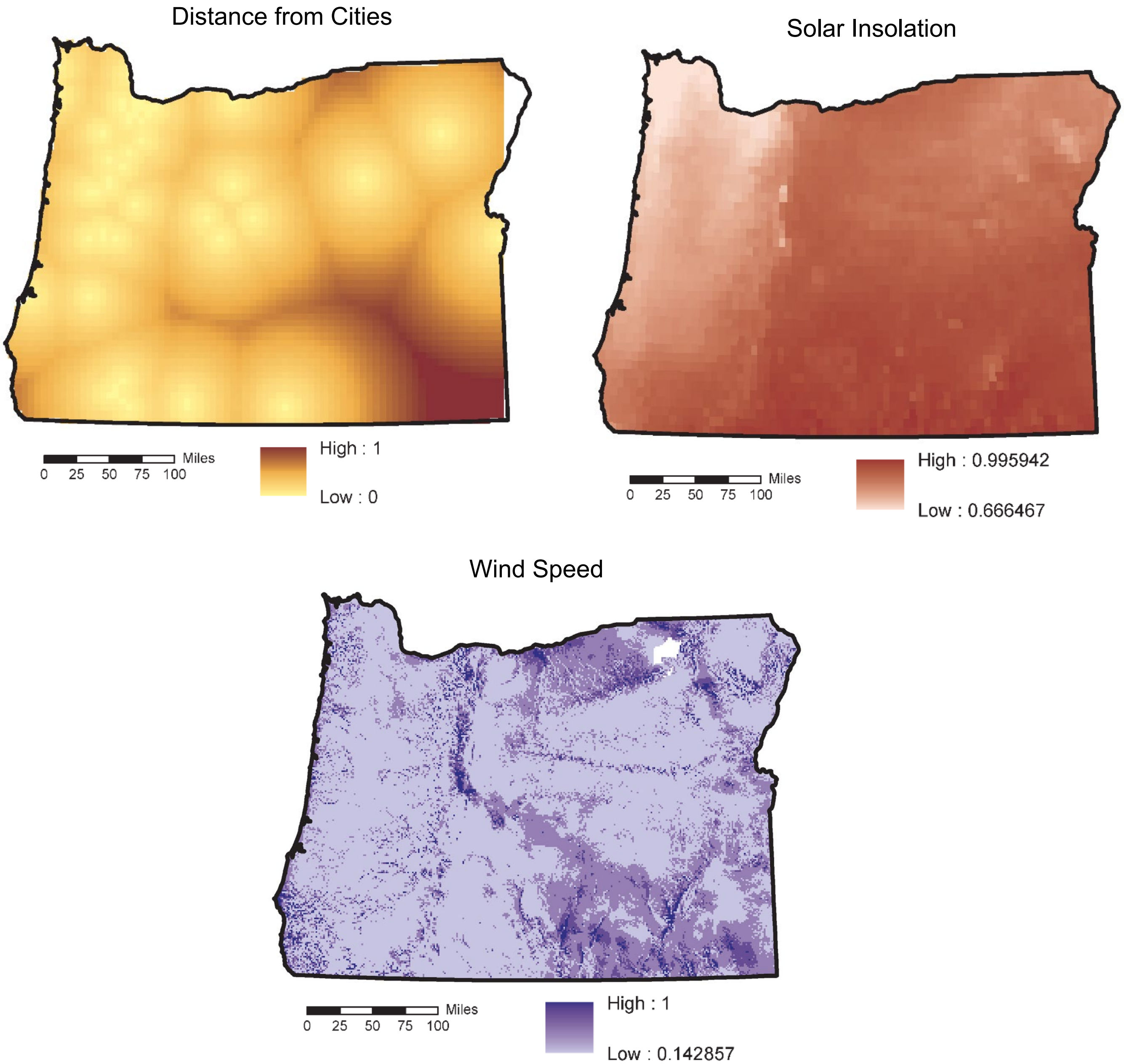


Figure 4. Geospatial parameters used for suitability analysis.

The slope and national and state parks maps show areas excluded in the analysis. On the solar slope map there is a substantial area of unsuitable land on the west side of Oregon due to the Cascade Mountain Range. Similarly, the wind slope map shows a limited region of the Cascade Mountain Range omitted. In general, the national and state park map did not eliminate large areas but rather several small and fairly spread out with the exception of Crater Lake National Park in the southwest portion of the state. Ideal land cover is in the southeast and north central part of the state. Highways are generally spread out with a concentration in the north west and several gaps throughout the southeast. Transmission lines are concentrated in the western half of the state with a few gaps of no coverage in the central and southeast regions. The cities map shows the ideal area in the southeast portion of the state. Solar insolation reclassified values do not go below 0.66 across the entire state. However, the lower values are grouped west of the mountain range and the highest are in the south. Wind has the largest values in the north central and south eastern part of the state. Lastly, there are scattered areas along the coast with high wind values as well (Figure 4).

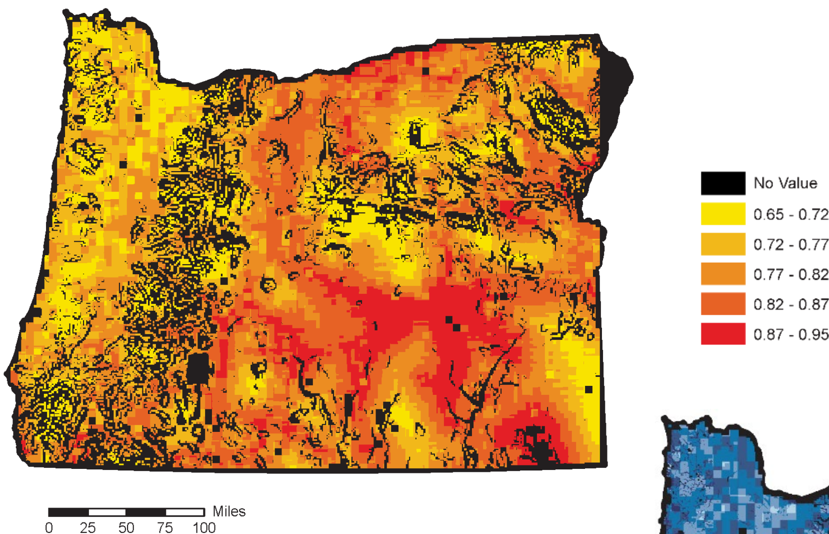


Figure 5. Solar Potential

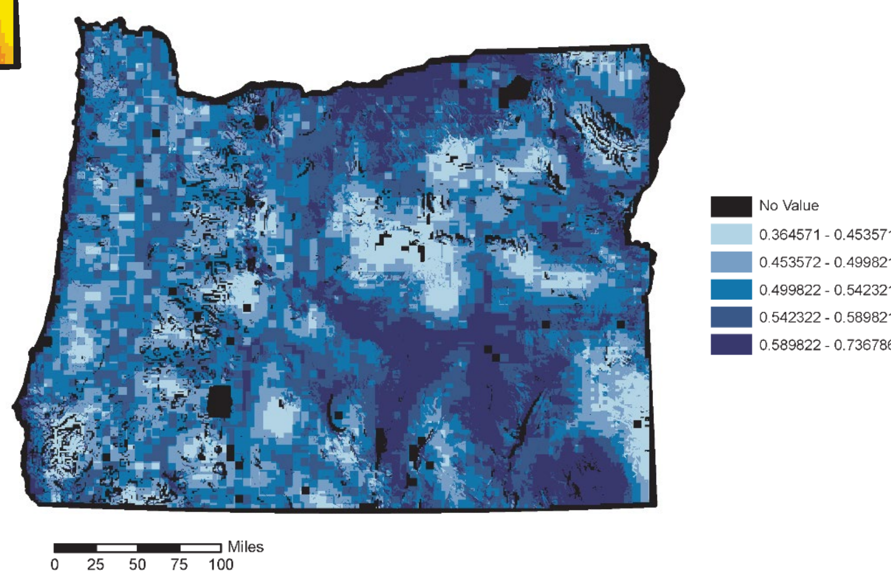


Figure 6. Wind Potential

The range for solar potential across the state is 0.65 to 0.95. The highest values are clustered in the southeast portion of the state and a few dispersed along the north central region. West of the mountain range are primarily low potential values (Figure 5). Morrow county had the greatest area of land suitable for solar panel installation at 94.33%. However, only

64.59% of that land was above the mean value, 0.77. Sherman county had 85.25% of its area classified as suitable and 99.25% of that land is above the 0.77 threshold (Table 3, Figure 7).

The wind potential has values ranging from 0.36 to 0.95 on the reclassified scale. Highest values are seen in the north central and south eastern part of the state. There is a small cluster of high values in the south western coast of the state as well. The lowest values are seen in a central region and the south eastern edge. (Figure 6). Washington county had 99.34% of its area suitable for wind turbine installation. However, only 2.29% of that land is above 0.60 value threshold. Whereas, Gilliam county had 94.84% of its area suitable and 47.40% above the threshold of 0.60 (Table 4, Figure 8).

Table 3

Top 10 counties for overall suitable land for solar potential

County	Total Area (Square Miles)	Suitable Area (Square Miles)	% Suitable Area	Average Value	% Suitable Land Above Value 0.77*
Morrow	2048.4096	1932.3332	94.33%	0.7903	64.59%
Washington	726.4063	642.1818	88.41%	0.7390	21.92%
Harney	10226.9350	8960.0690	87.61%	0.8549	91.96%
Gilliam	1222.7423	1069.4522	87.46%	0.8353	98.31%
Yamhill	718.2192	616.9679	85.90%	0.7568	30.61%
Deschutes	3053.5046	2605.972359	85.34%	0.8137	74.92%
Sherman	831.2027	708.58132	85.25%	0.8301	99.25%
Crook	2986.0155	2517.2085	84.30%	0.7723	54.79%
Malheur	9929.9532	8320.9570	83.80%	0.8090	69.65%
Lake	688.6017	6914.9825	82.71%	0.8313	85.22%

**Average solar potential value*

Table 4

Top 10 counties for overall suitable land for wind potential

County	Total Area (Square Miles)	Suitable Area (Square Miles)	% Suitable Area	Average Value	% Suitable Land Above Value 0.60*
Washington	726.4063	721.592424	99.34%	0.5214	2.29%
Crook	2986.0155	2954.46104	98.94%	0.4895	4.36%
Morrow	2048.4096	2000.6957359	97.67%	0.5596	34.64%
Yamhill	718.2192	698.247983	97.22%	0.5275	2.09%
Deschutes	3053.5046	2958.5789031	96.89%	0.5431	21.33%
Harney	10226.9350	9850.9204	96.32%	0.5848	41.05%
Benton	678.6557	652.7848	96.19%	0.5122	1.81%
Wasco	2394.8045	2289.6067	95.61%	0.5521	10.56%
Gilliam	1222.7423	1159.6525	94.84%	0.5983	47.40%

Jefferson	9929.9532	1696.9328	94.78%	0.5195	8.40%

**Average wind potential value*

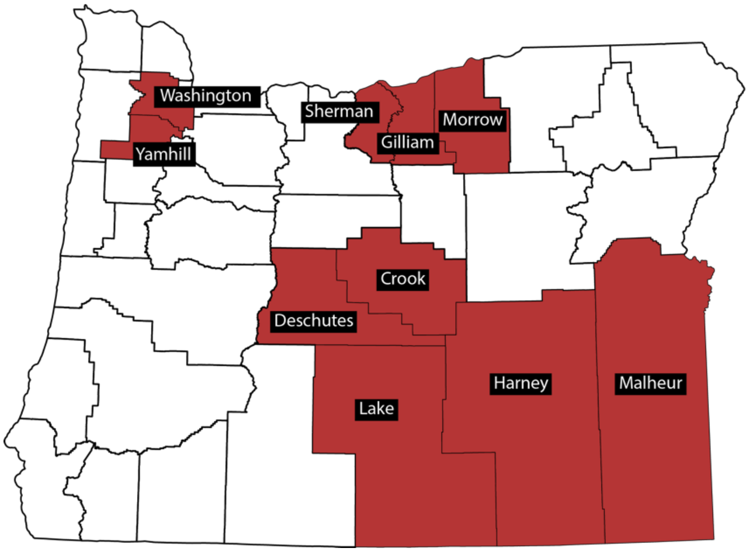


Figure 7. Top 10 Counties for Solar Potential

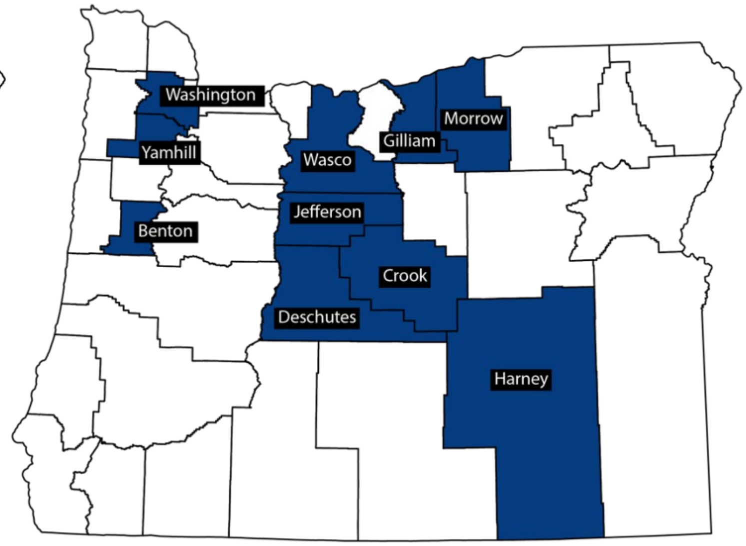


Figure 8. Top 10 Counties for Wind Potential

Discussion

Overall, solar potential had higher values across the state than wind potential indicating solar farms may be a better investment than wind. However, further study into cost and maintenance of each form will need to be conducted in order to assess that conclusion. Wind potential had a higher percentage of suitable area per county (Table 4) due to a less exclusive slope standard. However, none of the top 10 counties in Table 4 had an average value above the total average value of wind potential indicating a less concentrated region of high values. Additional studies could narrow down the best location for wind by utilizing city boundaries or census blocks instead of counties.

Surprisingly, wind values were not highly concentrated along the coastal line where sea-breeze wind is near constant between ocean and land (“Sea and Land Breezes”, n.d.). Considering this study’s extent was the state boundary of Oregon, wind power off the coast might be stronger than on land.

Southeastern, south central and north central proved to be an ideal location for both wind and solar. The counties Crook, Deschutes, Harney, Morrow, and Gilliam were included in the top 10 counties for both wind and solar (Table 3 and 4) and reside in these regions. Development is recommended there. However, it is worth noting that the southeastern region is part of the Oregon High Desert which could prove a challenging area to build. The transmission lines and highways maps had large gaps in the southeast which means development will need to include transmission and road builds. Future studies can evaluate the cost effect to build a road or water line to the area as seen in a study of solar power site suitability in the southwestern part of the U.S. (Brewer et al, 2015). Whereas, the north central region is less concentrated but has existing infrastructure.

Washington and Yamhill county are not in the regions recommended for development (Figure 7 and 8) but were included in the top 10 counties for both wind and solar (Table 3 and 4). The majority of land in those counties is viable, but the percentage of land above the threshold for wind does not reach 3% and for solar the values does not exceed 31%.

The counties with highest values in both suitable land and percent of suitable land above threshold for solar are Gilliam and Sherman (Table 3). For wind the counties with highest values in both are Harney and Gilliam (Table 4). Per the second objective of this study the listed counties have the best potential for wind and solar development. Conversely, further research is recommended to evaluate if higher potential value or more area in viable locations is more significant.

Conclusion

Altogether, this study utilized GIS-based software and databases to give a recommendation of several regions to expand development of solar panels and wind turbines throughout Oregon. Future studies can narrow down these regions through adding parameters such as additional restricted land (100-year floodplains, federal land), population density, and current solar and wind farm locations. Thus, continued research into viable locations and expanded development of renewable energies will aid Oregon in reaching its renewable energy goals.

Appendix A

```
--create SQL files
shp2pgsql -s 2992 -I Hwy_Dist Hwy_Dist > Hwy_Dist.sql
shp2pgsql -s 2992 -I Slope_Pct_1mi Slope_Pct_5mi > Slope_Pct_1mi.sql
shp2pgsql -s 2992 -I Trans_Dist Trans_Dist > Trans_Dist.sql
shp2pgsql -s 2992 -I City_Dist City_Dist > City_Dist.sql
shp2pgsql -s 2992 -I OR_10m OR_10m > OR_10m.sql
shp2pgsql -s 2992 -I OR_Solar OR_Solar > OR_Solar.sql
shp2pgsql -s 2992 -I OR_Wind OR_Wind > OR_Wind.sql
shp2pgsql -s 2992 -I landcover landcover > landcover.sql
shp2pgsql -s 2992 -I potntl_site potntl_site > potntl_site.sql

--load SQL into db
psql -d final_project574 -U postgres -f Hwy_Dist.sql
psql -d final_project574 -U postgres -f City_Dist.sql
psql -d final_project574 -U postgres -f Slope_Pct_1mi.sql
psql -d final_project574 -U postgres -f Trans_Dist.sql
psql -d final_project574 -U postgres -f OR_10m.sql
psql -d final_project574 -U postgres -f OR_Wind.sql
psql -d final_project574 -U postgres -f OR_Solar.sql
psql -d final_project574 -U postgres -f landcover.sql
psql -d final_project574 -U postgres -f potntl_site.sql
```

Appendix B

```
INSERT INTO hwy_trans (hwy_gid, hwy_val, trans_gid, trans_val, geom)
(SELECT
        h.gid AS hwy_gid,
        ROUND(h.dist_val::numeric, 3) AS hwy_val,
        t.gid AS trans_gid,
        t.dist_val AS trams_val,
        CASE
            WHEN ST_Within(h.geom, t.geom)
            THEN h.geom
            ELSE ST_Multi(ST_Intersection(h.geom, t.geom))
        END AS geom)
FROM hwy_dist AS h JOIN trans_dist AS t ON ST_Intersects(h.geom, t.geom);

INSERT INTO hwy_trans_city (hwy_gid, hwy_val, trans_gid, trans_val, city_gid city_val, geom)
(SELECT
        ht.hwy_gid,
ht.hwy_val,
        ht.trans_gid,
        ht.trans_val,
        c.gid AS city_gid,
```

```
		c.dist_val AS city_val,
		CASE
			WHEN ST_Within(c.geom, ht.geom)
			THEN c.geom
			ELSE ST_Multi(ST_Intersection(c.geom, ht.geom))
		END AS geom)
FROM hwy_trans AS ht JOIN city_dist AS c ON ST_Intersects(c.geom, ht.geom);

INSERT INTO hwy_trans_city_lc (hwy_gid, hwy_val, trans_gid, trans_val, city_gid, city_val,
lc_gid, lc_val, geom)
(SELECT
		htc.hwy_gid,
htc.hwy_val,
		htc.trans_gid,
		htc.trans_val,
		htc.city_gid,
		htc.city_val,
		l.gid AS lc_gid,
		l.lc_val AS lc_val,
		CASE
			WHEN ST_Within(l.geom, htc.geom)
			THEN l.geom
			ELSE ST_Multi(ST_Intersection(l.geom, htc.geom))
		END AS geom)
FROM hwy_trans_city AS htc JOIN landcover AS l ON ST_Intersects(l.geom, htc.geom);


INSERT INTO potntl_site_solar (name, slope_pct, protected, geom)
(SELECT
		p.name,
		s.slope_pct,
		p.protected,
		CASE
			WHEN ST_Within(s.geom, p.geom)
			THEN s.geom
			ELSE ST_Multi(ST_Intersection(s.geom, p.geom))
		END AS geom)
FROM or_slope AS s JOIN or_park AS p ON ST_Intersects(s.geom, p.geom)
WHERE s.slope_pct <= 5 AND p.protected = ‘N’;

INSERT INTO potntl_site_wind (name, slope_pct, protected, geom)
(SELECT
		p.name,
		s.slope_pct,
		p.protected,
		CASE
			WHEN ST_Within(s.geom, p.geom)
			THEN s.geom
			ELSE ST_Multi(ST_Intersection(s.geom, p.geom))
		END AS geom)
FROM or_slope AS s JOIN or_park AS p ON ST_Intersects(s.geom, p.geom)
```

```
WHERE s.slope_pct <= 10 AND p.protected = 'N';


INSERT INTO all_vals_solar (hwy_gid, hwy_val, trans_gid, trans_val, city_gid, city_val, lc_gid,
lc_val, geom)
(SELECT
        htcl.hwy_gid,
htcl.hwy_val,
        htcl.trans_gid,
        htcl.trans_val,
        htcl.city_gid,
        htcl.city_val,
htcl.lc_gid,
        htcl.lc_val,
        CASE
            WHEN ST_Within(p.geom, htcl.geom)
            THEN p.geom
            ELSE ST_Multi(ST_Intersection(p.geom, htcl.geom))
        END AS geom)
FROM hwy_trans_city_lc AS htcl JOIN potntl_site_solar AS p ON ST_Intersects(p.geom,
htcl.geom);

INSERT INTO all_vals_wind (hwy_gid, hwy_val, trans_gid, trans_val, city_gid, city_val, lc_gid,
lc_val, geom)
(SELECT
        htcl.hwy_gid,
htcl.hwy_val,
        htcl.trans_gid,
        htcl.trans_val,
        htcl.city_gid,
        htcl.city_val,
htcl.lc_gid,
        htcl.lc_val,
        CASE
            WHEN ST_Within(p.geom, htcl.geom)
            THEN p.geom
            ELSE ST_Multi(ST_Intersection(p.geom, htcl.geom))
        END AS geom)
FROM hwy_trans_city_lc AS htcl JOIN potntl_site_wind AS p ON ST_Intersects(p.geom,
htcl.geom);


INSERT INTO solar_potntl (hwy_gid, hwy_val, trans_gid, trans_val, city_gid, city_val, lc_gid,
lc_val, sol_gid, sol_val, final_val, geom)
(SELECT
        a.hwy_gid,
a.hwy_val,
        a.trans_gid,
        a.trans_val,
        a.city_gid,
        a.city_val,
```

```
a.lc_gid,
                    a.lc_val,
                    s.gid AS sol_gid,
                    s.sol_val,
(((3*htcls.sol_val) + (2 * htcls.trans_val) + htcls.city_val + htcls.hwy_val + htcls.lc_val)/8),
                    CASE
                              WHEN ST_Within(s.geom, a.geom)
                              THEN s.geom
                              ELSE ST_Multi(ST_Intersection(s.geom, a.geom))
                    END AS geom)
FROM all_vals_solar AS a JOIN or_solar AS s ON ST_Intersects(s.geom, a.geom);

INSERT INTO wind_potntl (hwy_gid, hwy_val, trans_gid, trans_val, city_gid, city_val, lc_gid,
lc_val, wnd_gid, wnd_val, final_val, geom)
(SELECT
                    a.hwy_gid,
a.hwy_val,
                    a.trans_gid,
                    a.trans_val,
                    a.city_gid,
                    a.city_val,
a.lc_gid,
                    a.lc_val,
                    w.gid,
                    w.sol_val,
(((3*htcls.sol_val) + (2 * htcls.trans_val) + htcls.city_val + htcls.hwy_val + htcls.lc_val)/8),

                    CASE
                              WHEN ST_Within(w.geom, a.geom)
                              THEN w.geom
                              ELSE ST_Multi(ST_Intersection(w.geom, a.geom))
                    END AS geom)
FROM all_vals_wind AS a JOIN or_wind AS w ON ST_Intersects(w.geom, a.geom);
```

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