The Land Policy Institute Wind Prospecting Tool Prototype

Preliminary Summary

Introduction

Despite its unique location and exceptional assets (see Figure 1), Michigan embarrassingly lags behind many other states in the nation in installed wind generating capacity. According to the American Wind Energy Association, while Michigan ranks fourteenth in the nation in wind resource capacity, of the thirty one states that have installed systems, Michigan ranks twenty sixth. The estimated onshore potential wind resource capacity for the state of Michigan is about 16,000 megawatts, but fewer than 3 megawatts have been installed. In contrast, Texas has installed a total of 2,768 megawatts of its capacity. Michigan is very near the bottom in terms of the ratio of installed to potential capacity despite our greater need for energy independence due to our relative isolation as a peninsula state.

This gap in realized capacity offers tremendous opportunity for business growth. Nationwide, states are increasingly pursuing renewable energy sources and many with wind energy potential are pursuing such potential as a matter of policy. According to Michigan's 21st Century Energy Plan, approximately 5,200 to 9,200 GWh of additional renewable energy is needed by December 31, 2015. Wind energy development offers a new economic opportunity for Michigan. Renewable energy development has been a boon for some of the progressive nations in

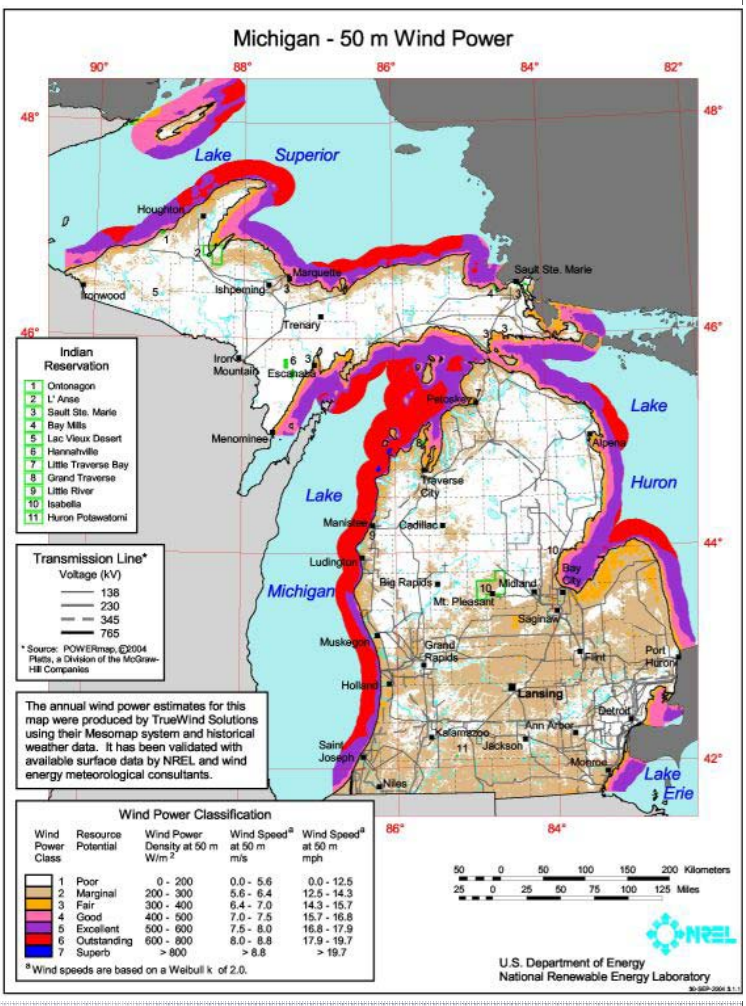

Figure One: National Renewable Energy Lab (USDOE) 50m wind density resource map for Michigan

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Europe -- resulting, for example, in the creation of tens of thousands of jobs in both Germany and Denmark.

Michigan currently relies on coal and nuclear fueled baseload generation units for about 83 percent of its annual electricity production. Most raw material costs are out-sourced to other regions of the US, not Michigan. Annual dollar exports for coal-based electric energy were over $1 billion in 2006. Our vast untapped wind resource gives wind energy an edge, provided that some of the key constraints to wind energy development are removed. Critical steps must be taken not only to identify those barriers, but to strategically eliminate them. Barriers for wind in Michigan appear to be causing existing firms and investors to work in other states by creating developer risk associated with inadequate site specific information about wind potential, contract opportunities, connectivity opportunities, and pricing strategy.

The key objective of this initiative is to reduce the transaction costs associated with deploying wind systems in the state, thus fostering viable market function, where feasible, for the benefit of Michigan. Working together, we envision the installation of 2,000 to 3,000 megawatts of suitably sited wind power generation over the next eight years, putting us well on the way to meeting the state goal of ten percent renewable energy by 2015. Capital expenditures alone would be $200 to $300 million per year. This will invigorate the new energy economy.

As a component of this initiative, the MSU Land Policy Institute (LPI) has developed the Wind Prospecting Tool Prototype to help foster an enabling environment for the development of wind energy in the state of Michigan. Michigan is competing on a global stage for investment by wind energy developers. Michigan needs an easily understood, integrated framework that can:

- Filter out areas of low potential for wind energy development.
- Focus efforts of stakeholders on high quality areas, and provide critical analysis of policy gaps in those areas and the state level to enable wind energy development.
- Target statewide policy and the wind development community investment toward those areas that are most conducive for wind energy development.
- Help communities understand their own wind development potential.

There are barriers to competition, but none that are insoluble. Michigan has the wind resources; with the proper policies and incentives, Michigan can compete for global wind energy development.

Factors Affecting Wind Development

Wind energy will not develop in Michigan without an enabling environment. Communities need to understand what wind energy companies need. A comprehensive site assessment in the state will be valuable. The identification of Michigan communities with wind potential, land, enabling zoning, and incentives such as wind renaissance zones will also be valuable. Supportive state policies and active recruitment of wind energy companies will also help. The WPT was conceived to focus on locational choice to be of assistance to the wind power industry, and to provide policymakers with clear science based information. When fully funded and mature, the WPT will include:

- Targeted education for policy makers local and statewide to create an enabling environment.
- Economic impact analysis.
- Environmental assessment rubric.
- Small scale development information.
- Comprehensive site assessment.

The prototype tool focuses on finding and assessing the capacity of the best areas for wind development in Michigan and assessing community by community the potential for local development. The WPT will help filter, focus and target information on wind energy development in Michigan by providing information on four receptivity factors:

- Geophysical Factors.
- Land/Economic Factors.
- Environmental Concerns.
- Local Policy.

The presence of these factors and their interaction can make a community an excellent place for wind power development or present transaction costs so high as to preclude it entirely. Articulating these factors allows communities and the state to understand its benchmark and address policy and educational efforts to reduce or eliminate those transaction costs.

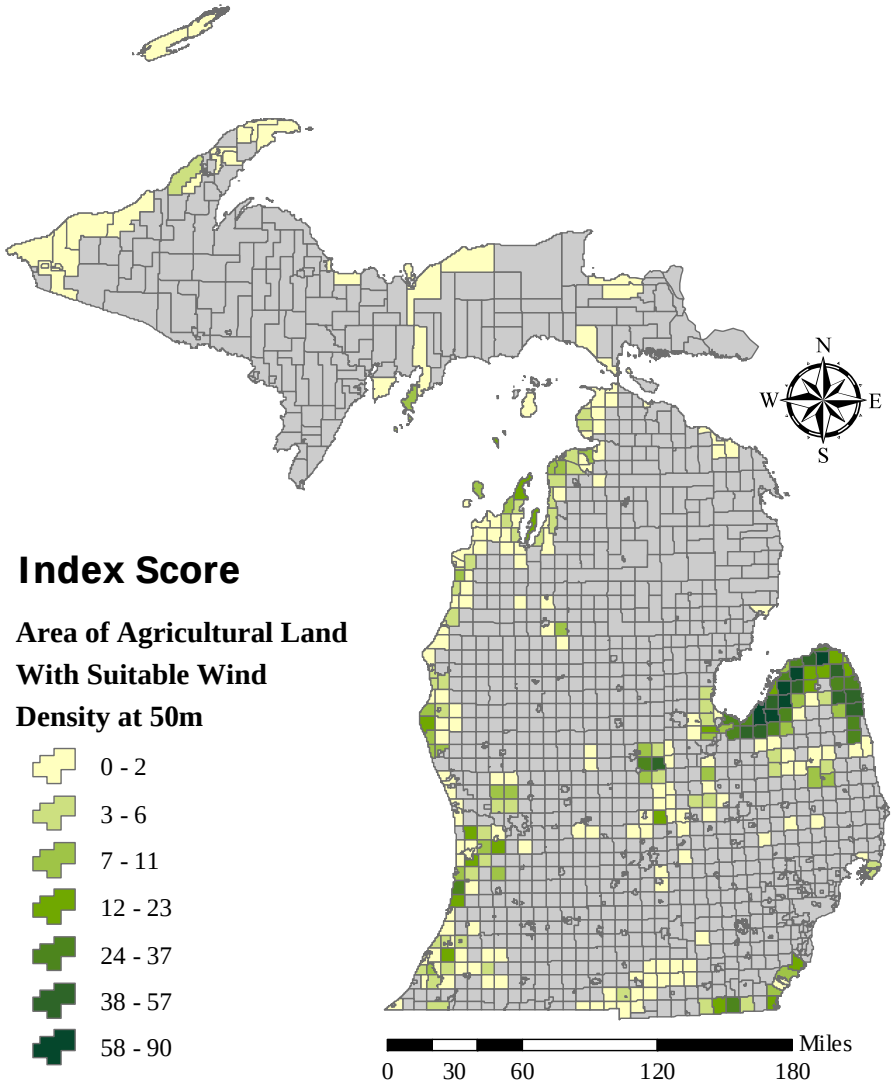
The Wind Index

The suitability index was developed primarily to determine the top areas of Michigan for utility scale wind development, considering the four factors. Each factor was represented by indicators at the community level. Various datasets were used in this analysis, including US Census for demographic information, USGS National Land Use and Land Cover data for Landscape characteristics, Michigan State Tax Commission reports for valuation, the Michigan Geographic Data Library for community mapping, and the fundamental wind resource map used was the National Renewable Energy Lab (USDOE) 50m wind density map for Michigan. These indicators were then ranked and scaled to produce an additive index with a maximum value of 1000. The higher the score, the more appropriate an area is for utility scale wind development. The data used and the processes they represent are shown in Table one.

Data	Proxy For	Possible Index Score
Wind Speed Score	Wind density for power generation	350
Agricultural Land Contiguity and Area	The number of towers that can be strung together in a reasonably compact setting	180
Forest Land Contiguity and Area	The number of towers that can be strung together in a reasonably compact setting	130
Per Acre Value of Agricultural Land	Land Costs	130
Population Density: 2000	Possible local resistance to wind farm installation	130
Population Density Change: 1990 - 2000	Pressure for residential and other types of development	80
Total Possible		**1000**

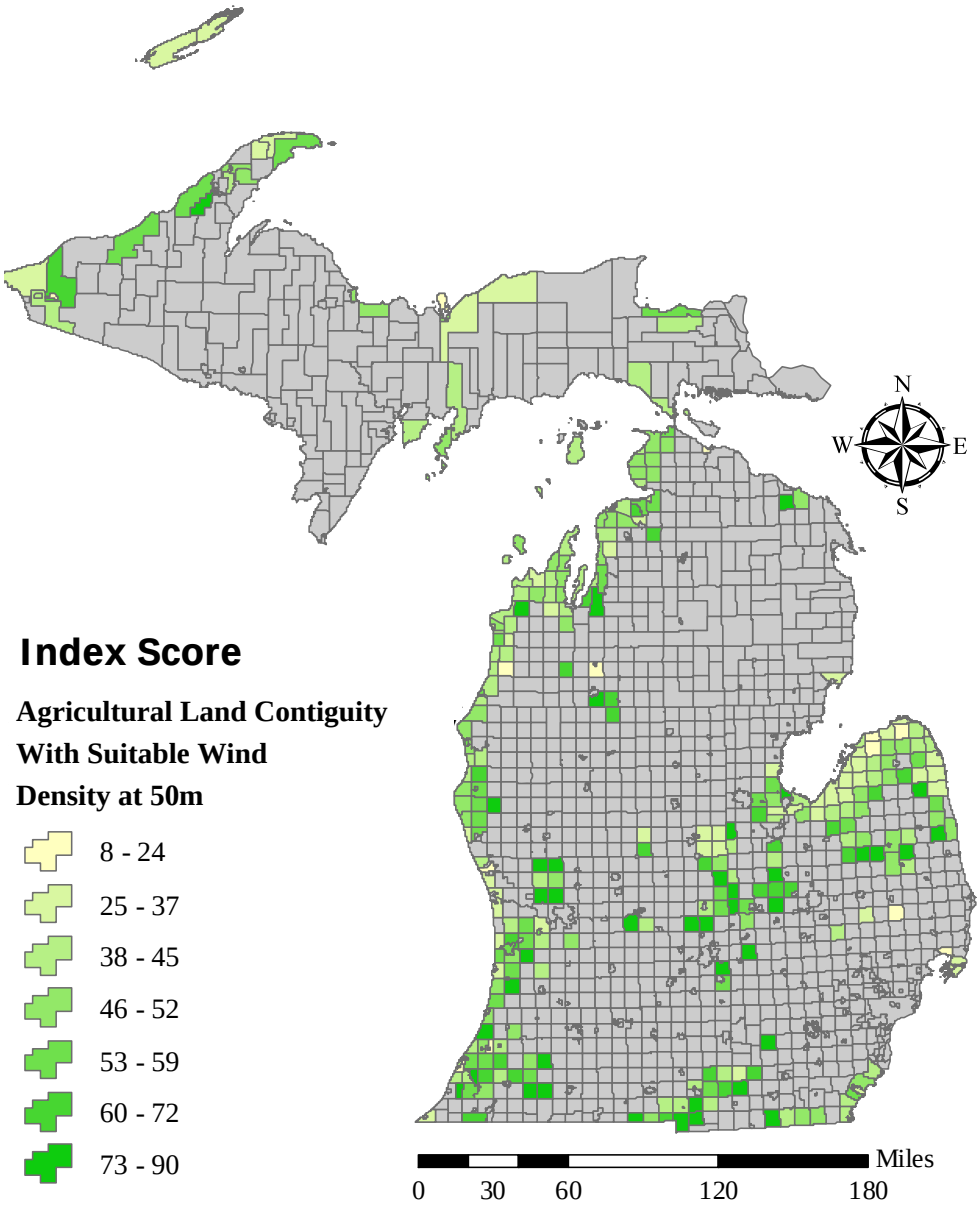
Table One: Data used in the wind index and what it represents.

The Index Components



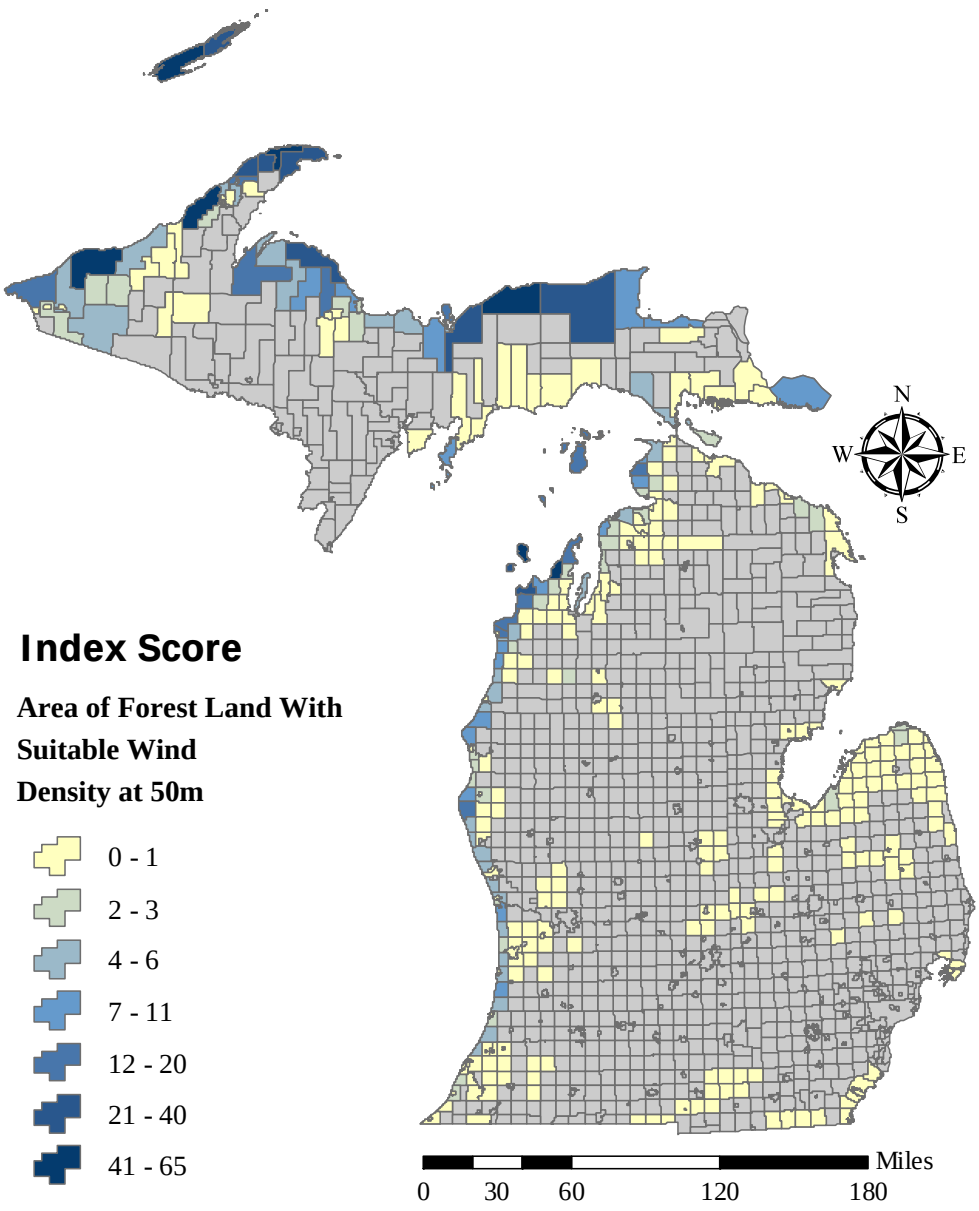
Area of Agriculture with Wind

Agricultural land has proven to be one of the most important land types for the installation of wind turbines. The installation of wind turbines on agricultural land allows a farmer to continue farming the land because of the minimal footprint of each tower, and the income generated for the farmer by the leases is far greater than the minimal loss in capacity to produce crops where the turbines are installed. Another added benefit of installing wind turbines on agricultural land is that it preserves the agricultural land for future food production. The more area of agricultural land within a community, the greater the amount of towers that can be installed within that community. In addition, the ability to assemble coalitions of landowners interested in hosting turbines is increased.



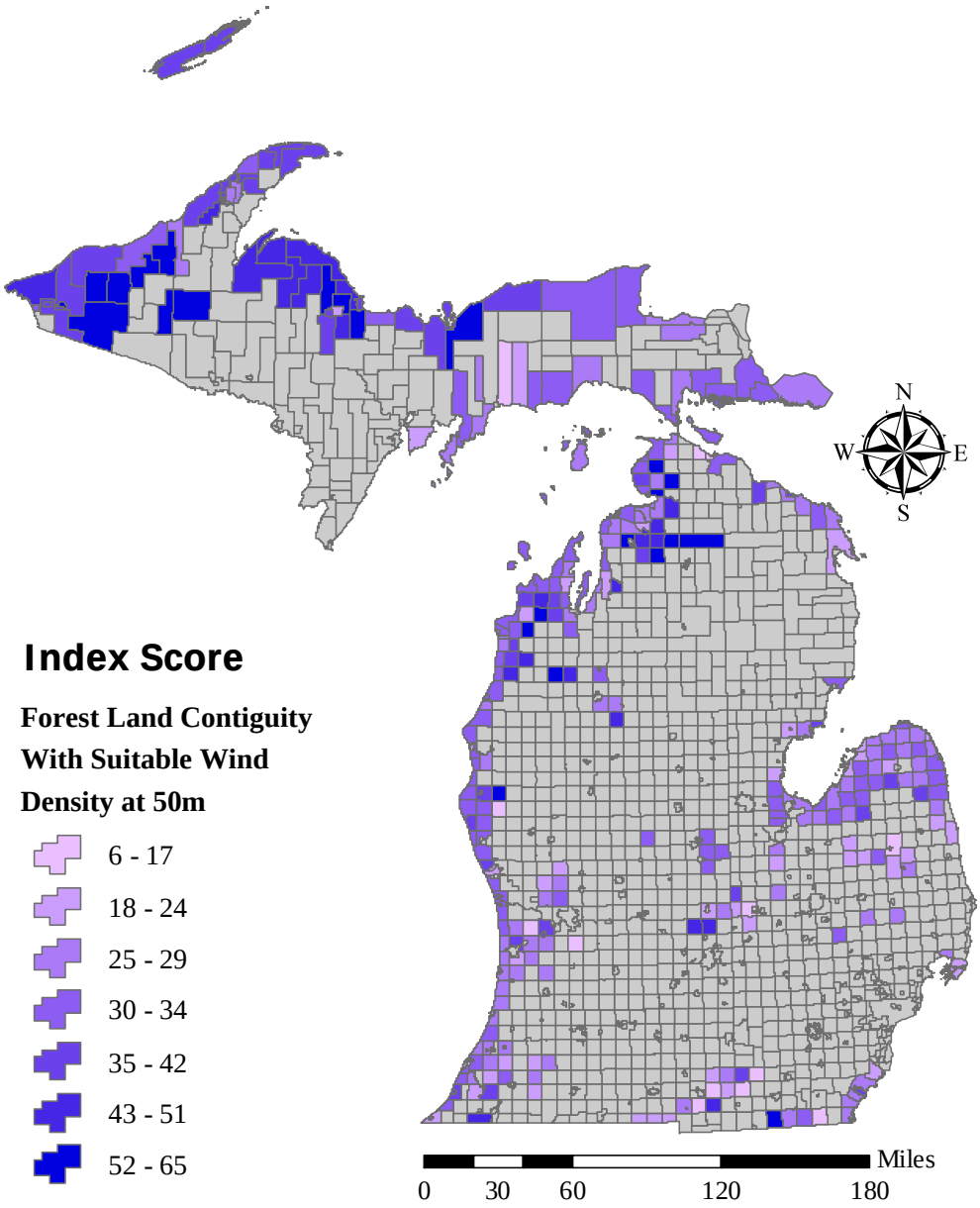
Contiguity of Agricultural Land with Wind

The cost of an installation and the ease of interconnection are partially decided by the compactness of the entire wind farm. Some communities have large areas of agriculture that is scattered throughout the landscape while others have agriculture that is densely packed. Contiguity is a measure derived from the discipline of landscape ecology that is a direct measure of how connected or separated agriculture is in the area in question. Scores are determined within each community using the Fragstats analysis environment.



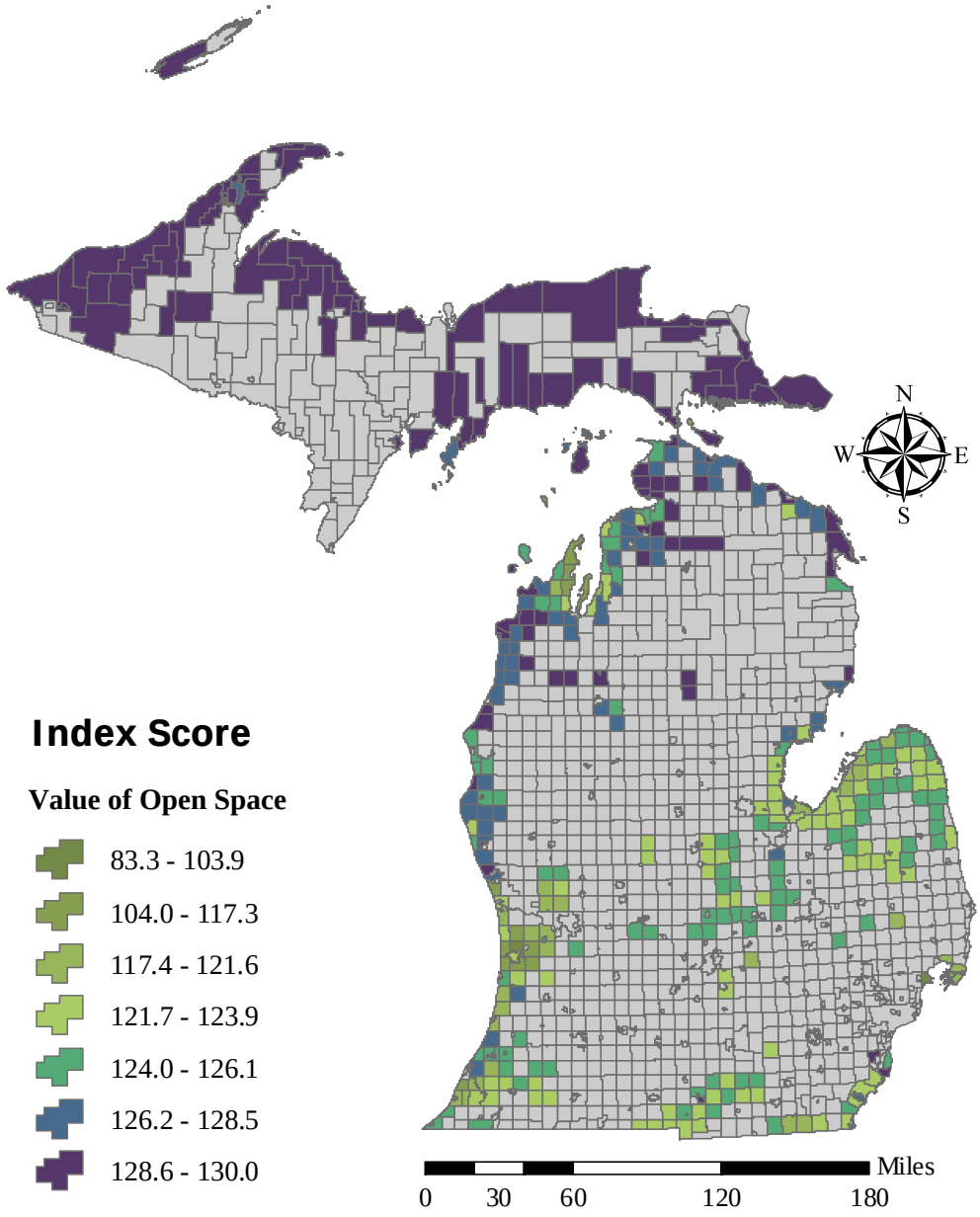
Area of Forest with Wind

Forest area with wind is important to wind energy development, while possibly less desirable than agricultural land for wind development due to siting concerns. The NREL map models the effect for land cover so some of the forested area of Michigan have high wind resources. As with agriculture, the more area of forest within a community, the more potential towers a wind developer can concentrate in an area. With high interconnection costs to the grid, it is important to wind developers that there be enough installed power capacity and wind turbines in an area to be able to offset the cost of interconnection into the grid.



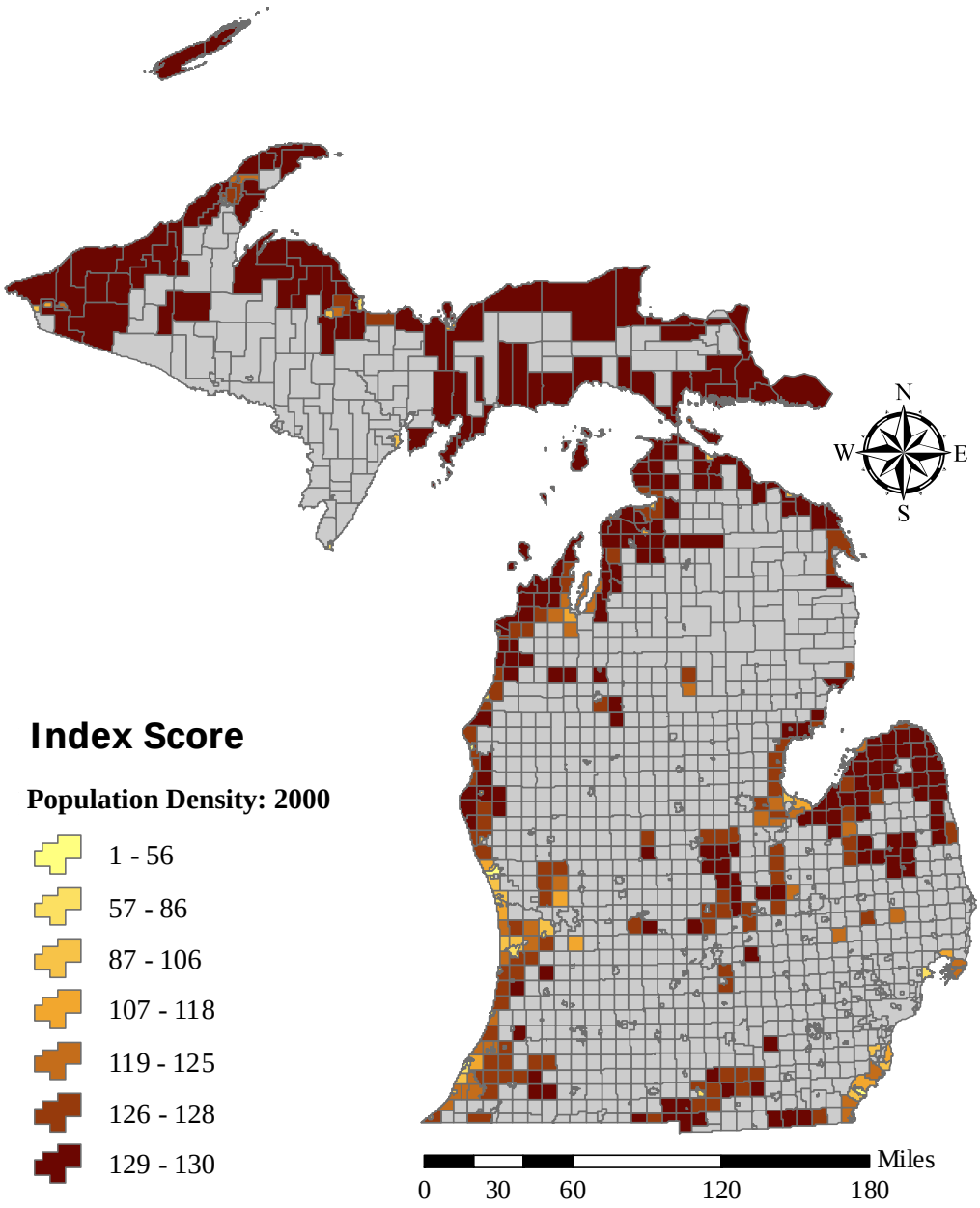
Contiguity of Forest Land with Wind

As with agricultural landscapes, the cost of an installation and the ease of interconnection are partially decided by the compactness of the entire wind farm. Some communities have large areas of forest that is scattered throughout the landscape while others have largely connected tracts. Contiguity is a measure derived from the discipline of landscape ecology that is a direct measure of how connected or separated forest is in the area in question. Scores are determined within each community using the Fragstats analysis environment.



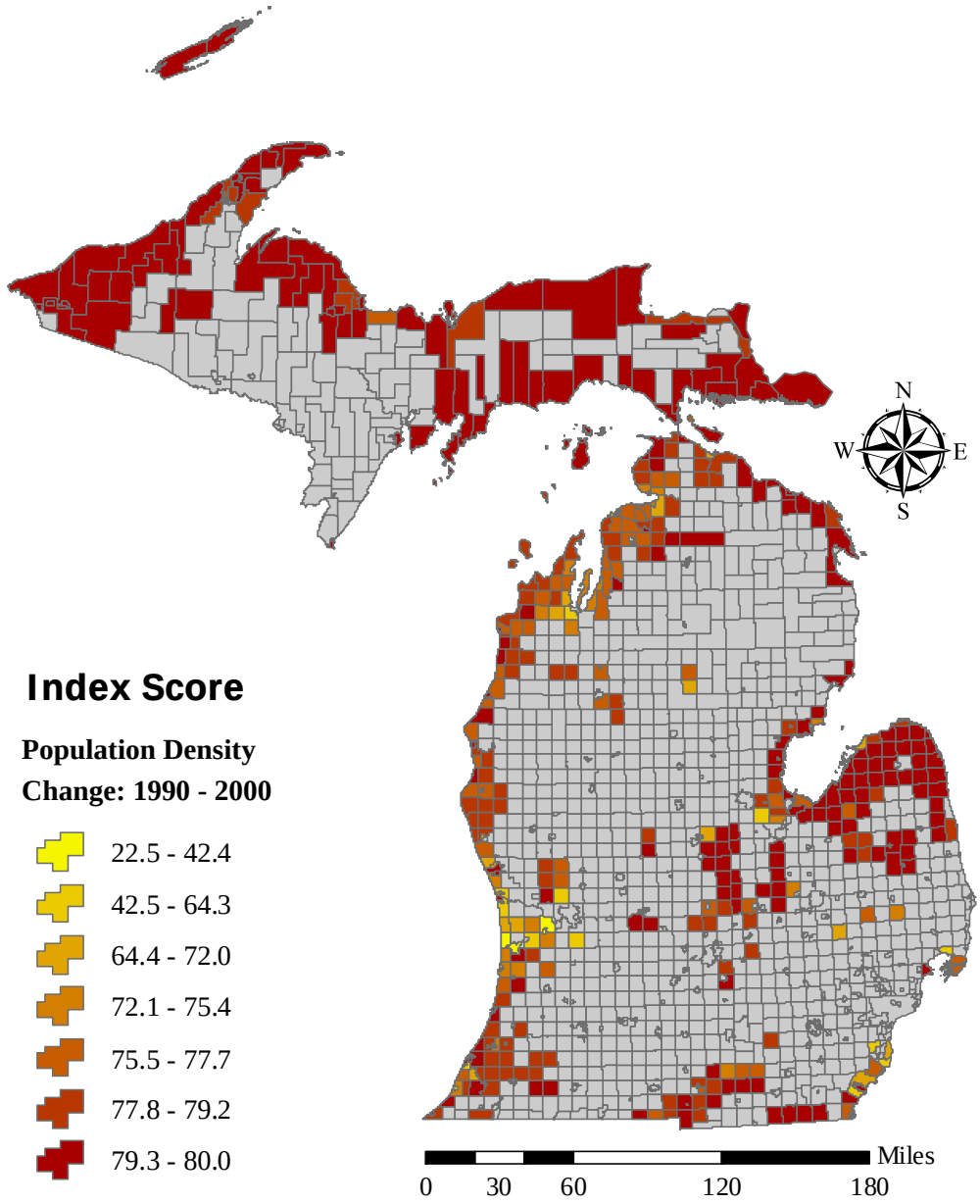
Open Space (Agriculture and Forest) Land Value

Land value is a fundamental metric in determining lease rates, local taxes, and also serves as an indicator measure of other development pressures. As the value of open landscapes increases, the cost of wind instillations also increases; therefore, low land values score high on the index. Agricultural value as defined by the state tax commission also includes forest land value.



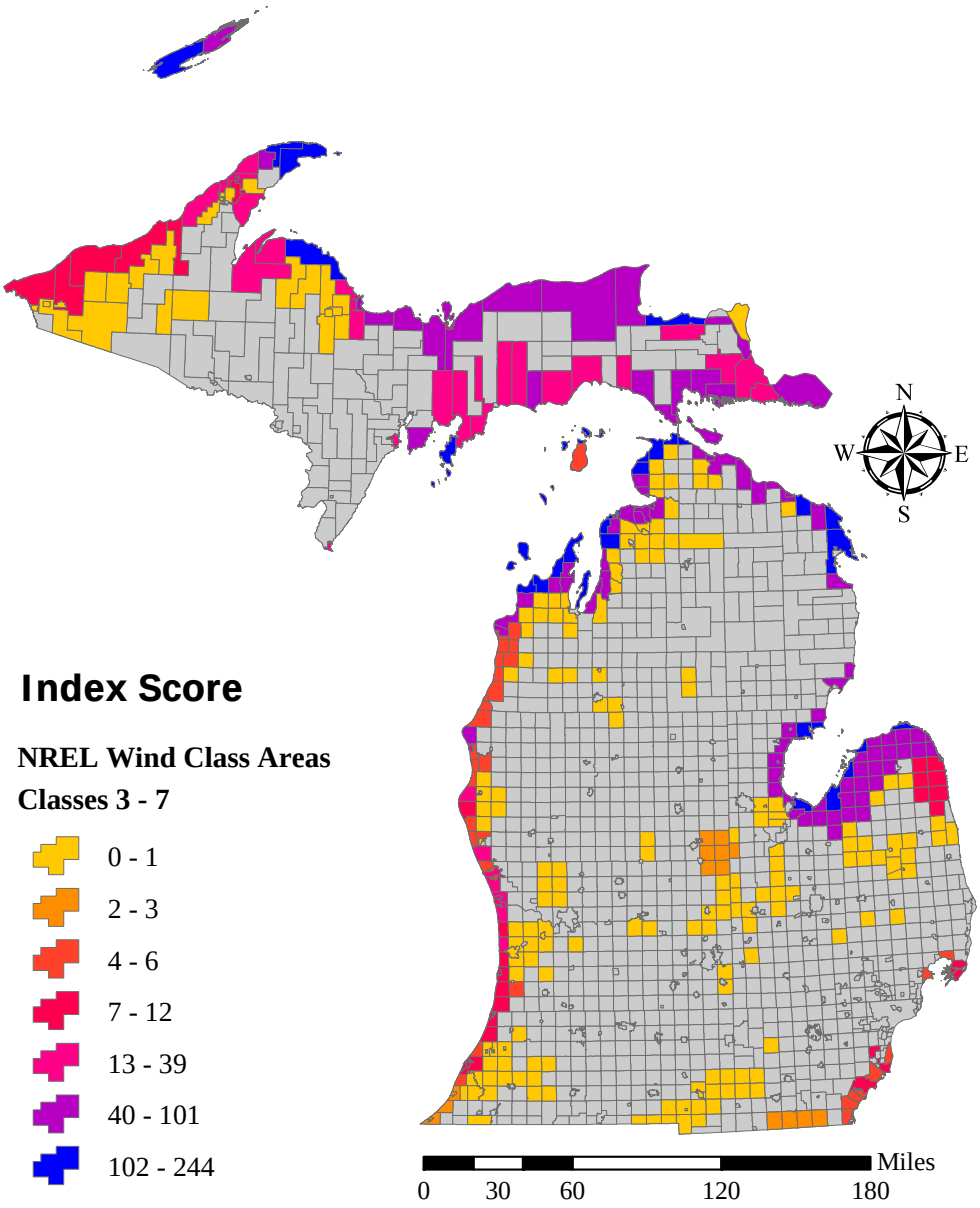
Population Density: 2000

Population density in this index is used to measure the potential for local resistance in a community to wind development. The greater the population density within a community, the more likely there are going to be individuals with concerns about issues such as view shed impingement, ice throw, flicker fusion, and bird strikes. In communities with low population density, there is less chance of creating these issues.



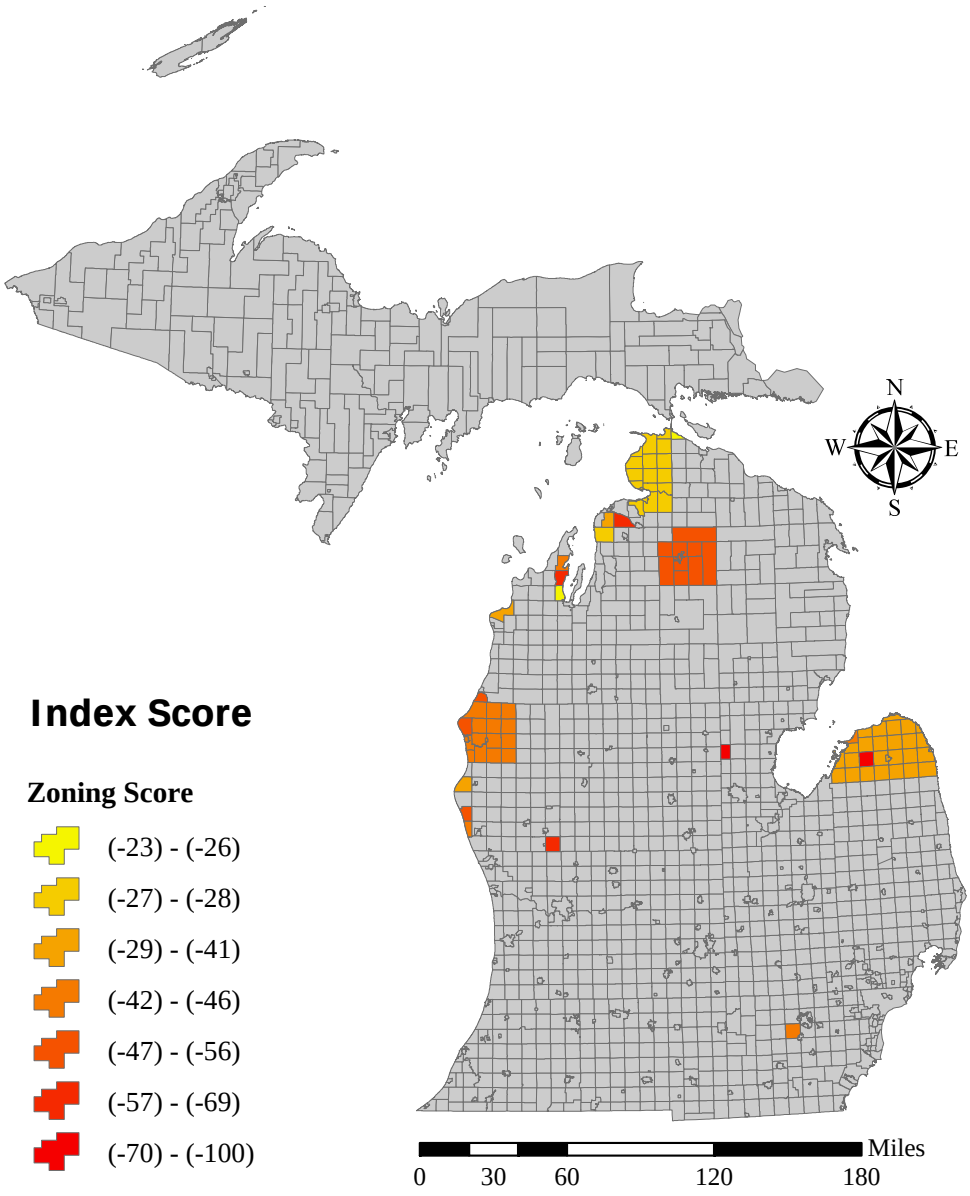
Population Density Change: 1990 – 2000

Population Density change measures a community's potential for other types of development pressures such as residential development or commercial which may be more financially rewarding than wind leases. This metric is used to capture willingness on the part of land holders to enter into long term leases vs. the potential payoff from a sale to other types of development. Communities with low population growth are given high index scores; all negative values were given a value of 100.



Wind Score

Class three or better wind, as modeled by NREL, is generally considered to be the threshold for utility scale wind development. The wind score is a result of filtering the NREL original 50m wind density data to produce a map of only class three to seven wind resources in Michigan. Area in each class was scaled and added to produce the final wind resource score for a community.



Zoning Score

One of the key factors in determining the suitability for wind energy development is local zoning laws applicable to wind turbine and energy development within a community. A review of the zoning language in Michigan applicable to wind power development was conducted, and the level of barrier presented by zoning was assessed ranked and scaled. This final value was then subtracted from the final score. Unfortunately, zoning scores have the only potentially negative values as there are no communities that have passed enabling ordinances that reduce barriers for wind development. Positive score are possible. Also communities with no language pertaining to wind were assigned a zoning score of zero.

Initial Results

The scores were summed and a final Community map was produced. This map was then intersected with the NREL class three an up areas to clip out the areas without documented wind resources. Results are shown in the tables below.

Top

Minor Civil Division Name	County	Agricultural Area Score	Agricultural Contiguity Score	Forest Area Score	Forest Contiguity Score
Leland Twp	Leelanau	8	48	50	31
Leelanau Twp	Leelanau	21	45	19	31
Eagle Harbor Twp	Keweenaw	1	34	65	39
Glen Arbor Twp	Leelanau	1	44	27	30
Akron Twp	Tuscola	90	30	2	27
Grant Twp	Keweenaw	0	52	40	37
Fairbanks Twp	Delta	7	51	8	28
Sims Twp	Arenac	0	0	0	42
Bliss Twp	Emmet	1	50	4	31
Fair Haven Twp	Huron	17	33	1	19

Bottom

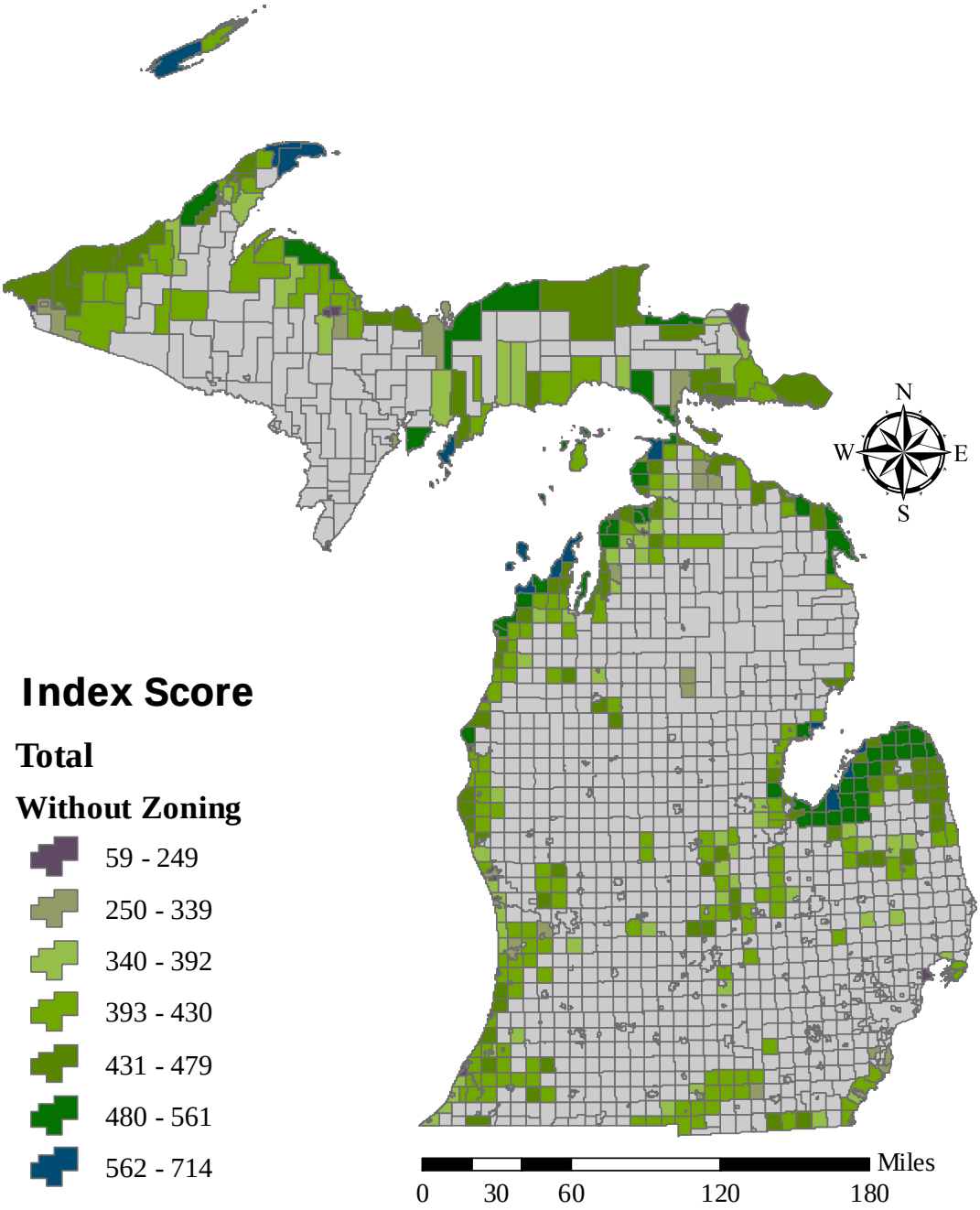
Minor Civil Division Name	County	Agricultural Area Score	Agricultural Contiguity Score	Forest Area Score	Forest Contiguity Score
Village of Douglas	Allegan	0.0	18.7	0.5	33.3
Roosevelt Park	Muskegon	0.0	0.0	0.0	0.0
Muskegon Heights	Muskegon	0.0	0.0	0.0	0.0
Coloma	Berrien	0.0	16.6	0.0	0.0
Menominee	Menominee	0.0	0.0	0.0	0.0
Manton	Wexford	0.0	8.3	0.0	0.0
Ludington	Mason	0.0	56.8	0.2	19.0
North Muskegon	Muskegon	0.0	0.0	0.1	18.8
St Joseph Twp	Berrien	0.0	10.0	0.1	32.7
St Joseph	Berrien	0.0	41.5	0.2	22.7

Ten

	Land Costs	Possible local resistance to wind farm installation	Pressure for residential and other types of development	The need wind of appropriate density for power gen-			
	Open Space Value Score	Population Density Score	Population Density Change Score	Wind Resource Score	Zoning Score (subtracted)	Wind Index Score	Wind Index With Zoning sub-
	125	129	79	244	0	714	714
	117	129	78	243	0	682	682
	130	130	80	160	0	639	639
	130	129	79	187	0	627	627
	123	129	80	128	0	608	608
	130	130	80	115	0	584	584
	128	130	80	139	0	572	572
	127	127	75	198	0	569	569
	125	130	79	172	28	591	563
	121	128	80	198	41	597	556

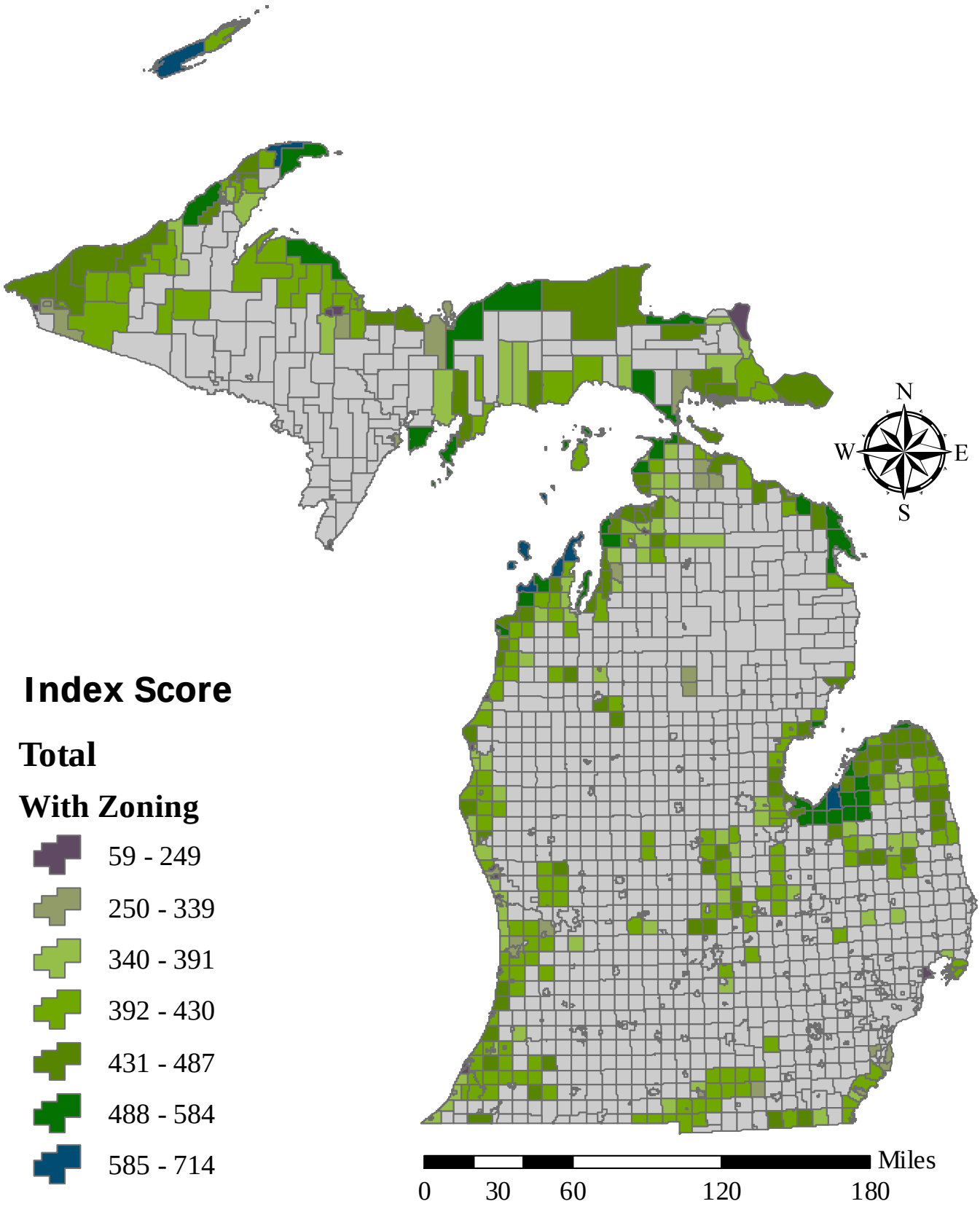
Ten

	Land Costs	Possible local resistance to wind farm installation	Pressure for residential and other types of development	The need wind of appropriate density for power generation			
	Open Space Value Score	Population Density Score	Population Density Change Score	Wind Resource Score	Zoning Score (subtracted)	Wind Index Score	Wind Index With Zoning subtracted
	0.0	0.0	0.0	7	0	59.5	59.5
	0.0	0.6	79.0	4	0	83.6	83.6
	0.0	0.0	80.0	4	0	84.0	84.0
	0.0	67.8	80.0	0	0	164.4	164.4
	0.0	72.4	80.0	31	0	183.4	183.4
	0.0	103.6	74.7	0	0	186.6	186.6
	0.0	54.0	80.0	22	44	232.0	188.4
	0.0	96.0	71.4	4	0	190.3	190.3
	0.0	80.0	63.9	7	0	193.8	193.8
	0.0	49.0	80.0	7	0	200.4	200.4



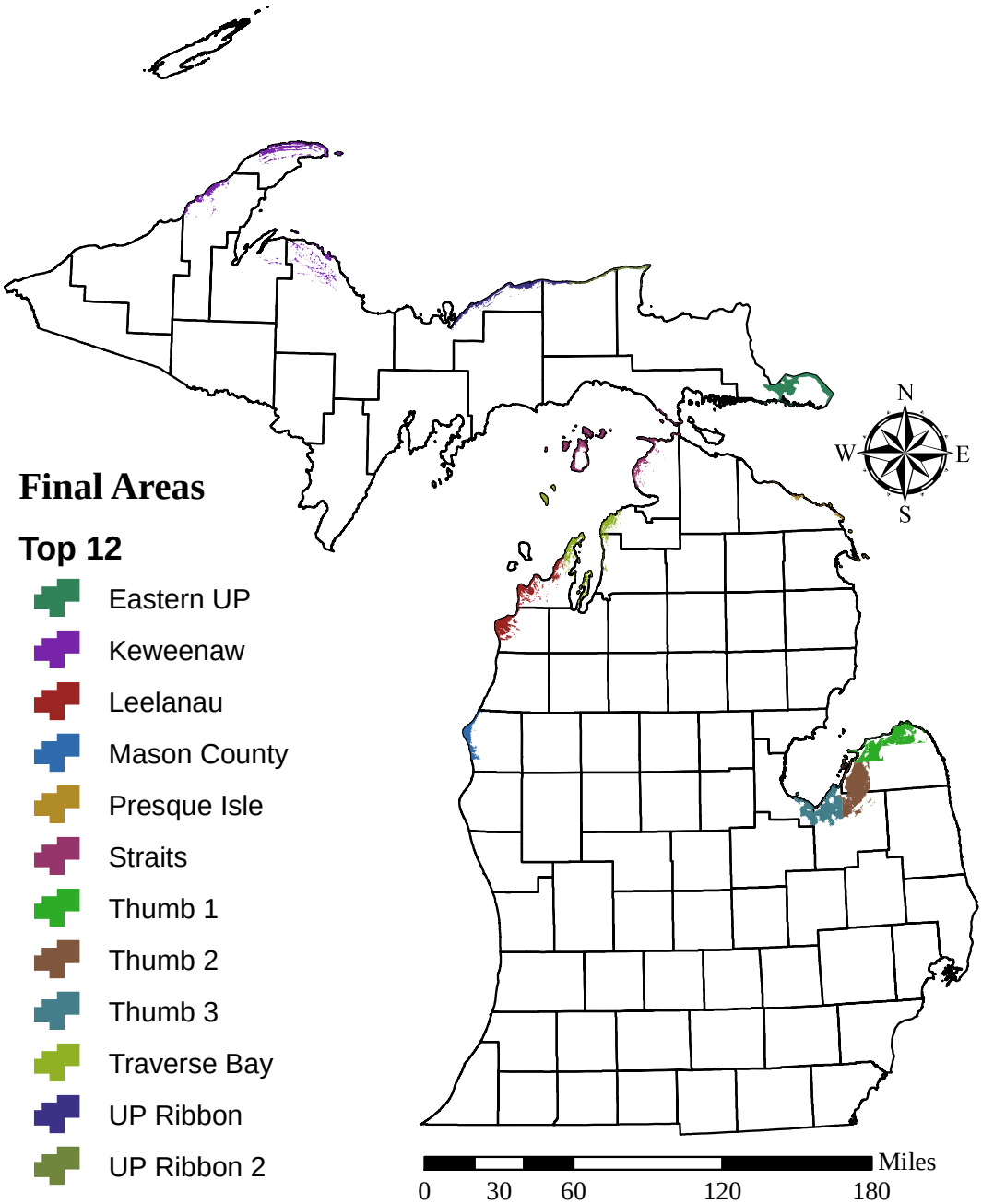
Total Index Score

The total index score represents the addition of all index values by community. The map above shows the index score without the influence of the zoning score, and the map on the right shows the index score for each MCD with the zoning score's influence. Though high index scores are most often found in coastal communities, but it is important to note that there are a number of inland communities with relatively high index scores.


N
W
E
S
Index Score
Total
With Zoning
59 - 249
250 - 339
340 - 391
392 - 430
431 - 487
488 - 584
585 - 714
Miles
0
30
60
120
180

Final Results

The highest scoring communities in Michigan (index scores of 500 or better) were then selected and aggregated into the top 12 wind utility scale wind development areas in the state. It is important to note that the grid and transmission issues have not been addressed yet so some of these areas will possibly be later determined to be impractical. The table on the right shows the townships that make up each of the top 12 areas for utility scale development.



Townships That Fall Within Michigan's Top 12 Areas for Wind Energy Development (Townships at the top of the table have the largest area of wind)											
Eastern UP	**Keweenaw**	**Leelanau**	**Mason County**	**Presque Isle**	**Straits**	**Thumb 1**	**Thumb 2**	**Thumb 3**	**Traverse Bay**	**UP Ribbon**	**UP Ribbon 2**
Drummond Twp	Eagle Harbor Twp	Lake Twp	Hamlin Twp	Presque Isle Twp	St James Twp	Dwight Twp	Brookfield Twp	Akron Twp	Leelanau Twp	Burt Twp	Whitefish Twp
Detour Twp	Stanton Twp	Glen Arbor Twp	Pere Marquette Twp	Pulawski Twp	Peaine Twp	Chandler Twp	Windsor Twp	Gilford Twp	Norwood Twp	Munising Twp	McMillan Twp
	Grant Twp	Leland Twp	Grant Twp	Alpena Twp	Readmond Twp	Hume Twp	Columbia Twp	Fairgrove Twp	Peninsula Twp	McMillan Twp	
	Powell Twp	Crystal Lake Twp	Ludington	Rogers Twp	Bliss Twp	McKinley Twp	Sebewaing Twp	Hampton Twp	Charlevoix Twp	Munising	
	Houghton Twp	Empire Twp		Krakow Twp	Cross Village Twp	Port Austin Twp	Elmwood Twp	Merritt Twp	Banks Twp		
	Ishpeming Twp	Cleveland Twp		Rogers City	Friendship Twp	Lake Twp	Almer Twp	Wisner Twp	Marion Twp		
	Champion Twp	Gilmore Twp			Moran Twp	Huron Twp	Fair Haven Twp	Portsmouth Twp	Suttons Bay Twp		
	Hancock Twp	Benzonia Twp			Wawatam Twp	Caseville Twp	Ellington Twp	Bangor Twp	Torch Lake Twp		
	Arvon Twp	Centerville Twp			St Ignace	Pte Aux Barq Twp	Elkland Twp	Juniata Twp	Central Lake Twp		
	Michigamme Twp	Kasson Twp			Mackinaw Twp			Essexville			
	Adams Twp	Frankfort			Center Twp						
	Bohemia Twp	Platte Twp									

Development Scenario Results

The top 12 areas in the state were then further examined to determine the possible number of towers they can accommodate as well as estimating power output, lease values, and maintenance and upkeep jobs as well as construction job creation. Wind turbines are generally spaced no closer than five times their rotor diameter. Using this rule, 450m spacing was determined to be a reasonably conservative estimate of tower density as it represents a 90m rotor diameter, and the largest turbines commissioned for instillation in Michigan have an 80m rotor diameter. The power possible was calculated by assuming a 1.65 megawatt turbine (the size slated for a recent Michigan development) at 28% efficiency. Job creation was estimated by a literature review which indicates approximately .08 FTE maintenance and upkeep jobs are created per megawatt installed and 1.23 construction jobs per megawatt in large instillations. To present reasonable estimates of impacts, several scenarios were calculated using 5%, 10%, 15%, and 20% of the wind resource area. The results of this analysis are shown in the table on the next page.

Development Scenario Results for Michigan's

Area Name	Towers possible if 5% of the resource area is used	Power production possible if 5% of the resource area is used	Potential land lease value if 5% of the resource area is used	Potential maintenance and upkeep jobs created if 5% of the resource area is used	Potential construction jobs created if 5% of the resource area is used
Eastern UP	60	27.7	$119,800	8	122
Keweenaw	83	38.6	$166,900	11	169
Leelanau	64	29.8	$128,900	9	131
Mason County	23	10.7	$46,200	3	47
Presque Isle	8	3.6	$15,800	1	16
Straits	48	22.1	$95,800	6	97
Thumb 1	89	41.2	$178,500	12	181
Thumb 2	104	48.2	$208,800	14	212
Thumb 3	89	41.3	$178,600	12	181
Traverse Bay	49	22.7	$98,100	6	100
UP Ribbon	35	16.2	$70,300	5	71
UP Ribbon 2	14	6.4	$27,600	2	28
Area Name	Towers possible if 15% of the resource area is used	Power production possible if 15% of the resource area is used	Potential land lease value if 15% of the resource area is used	Potential maintenance and upkeep jobs created if 15% of the resource area is used	Potential construction jobs created if 15% of the resource area is used
Eastern IP	183	84.7	$366,588	24	372
Keweenaw	255	118.0	$510,714	34	518
Leelanau	197	91.1	$394,434	26	400
Mason County	71	32.7	$141,372	9	143
Presque Isle	24	11.2	$48,348	3	49
Straits	147	67.7	$293,148	19	297
Thumb 1	273	126.2	$546,210	36	554
Thumb 2	319	147.6	$638,928	42	648
Thumb 3	273	126.2	$546,516	36	555
Traverse Bay	150	69.3	$300,186	20	305
UP Ribbon	108	49.7	$215,118	14	218
UP Ribbon 2	42	19.5	$84,456	6	86

Top 12 Areas for Utility Scale Wind Development

Towers possible if 10% of the resource area is used	Power production possible if 10% of the resource area is used	Potential land lease value if 10% of the resource area is used	Potential maintenance and upkeep jobs created if 10% of the resource area is used	Potential construction jobs created if 10% of the resource area is used
120	55.3	$239,600	16	243
167	77.1	$333,800	22	339
129	59.6	$257,800	17	262
46	21.3	$92,400	6	94
16	7.3	$31,600	2	32
96	44.3	$191,600	13	194
179	82.5	$357,000	24	362
209	96.5	$417,600	28	424
179	82.5	$357,200	24	362
98	45.3	$196,200	13	199
70	32.5	$140,600	9	143
28	12.8	$55,200	4	56

Towers possible if 20% of the resource area is used	Power production possible if 20% of the resource area is used	Potential land lease value if 20% of the resource area is used	Potential maintenance and upkeep jobs created if 20% of the resource area is used	Potential construction jobs created if 20% of the resource area is used
240	553.5	$479,200	32	486
334	771.1	$667,600	44	677
258	595.5	$515,600	34	523
92	213.4	$184,800	12	188
32	73.0	$63,200	4	64
192	442.6	$383,200	25	389
357	824.7	$714,000	47	725
418	964.7	$835,200	55	848
357	825.1	$714,400	47	725
196	453.2	$392,400	26	398
141	324.8	$281,200	19	285
55	127.5	$110,400	7	112

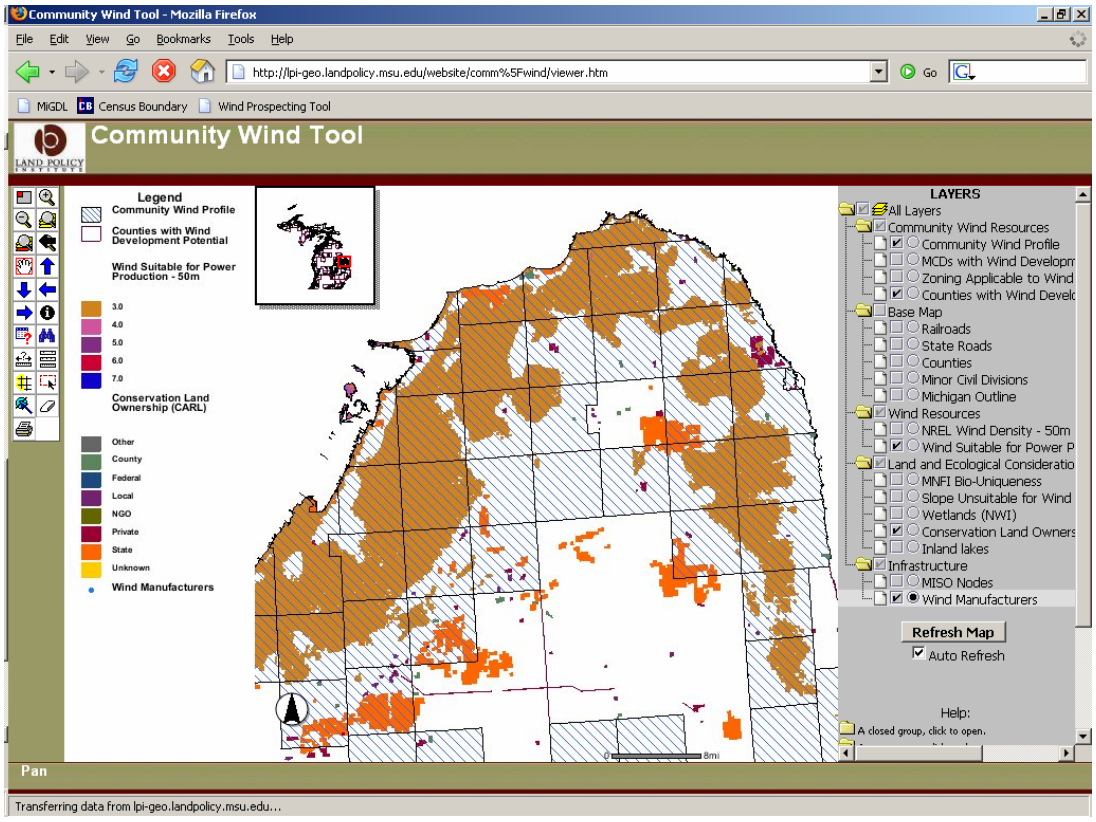
Community Tool

The community level wind tool includes information on a community's potential for wind development. Each community has a customized and printable report that includes information on the community's LPI wind index score and the potential number of towers, jobs, and revenue the community can receive with wind development. The tool also includes zoning laws applicable to wind energy development in each community allowing residents and policy makers within the community to find out whether or not local zoning is making their community less attractive to wind. There will also be examples of how communities can pass zoning laws to make their communities attractive to wind developers.

Community Wind Profile

Grant Twp

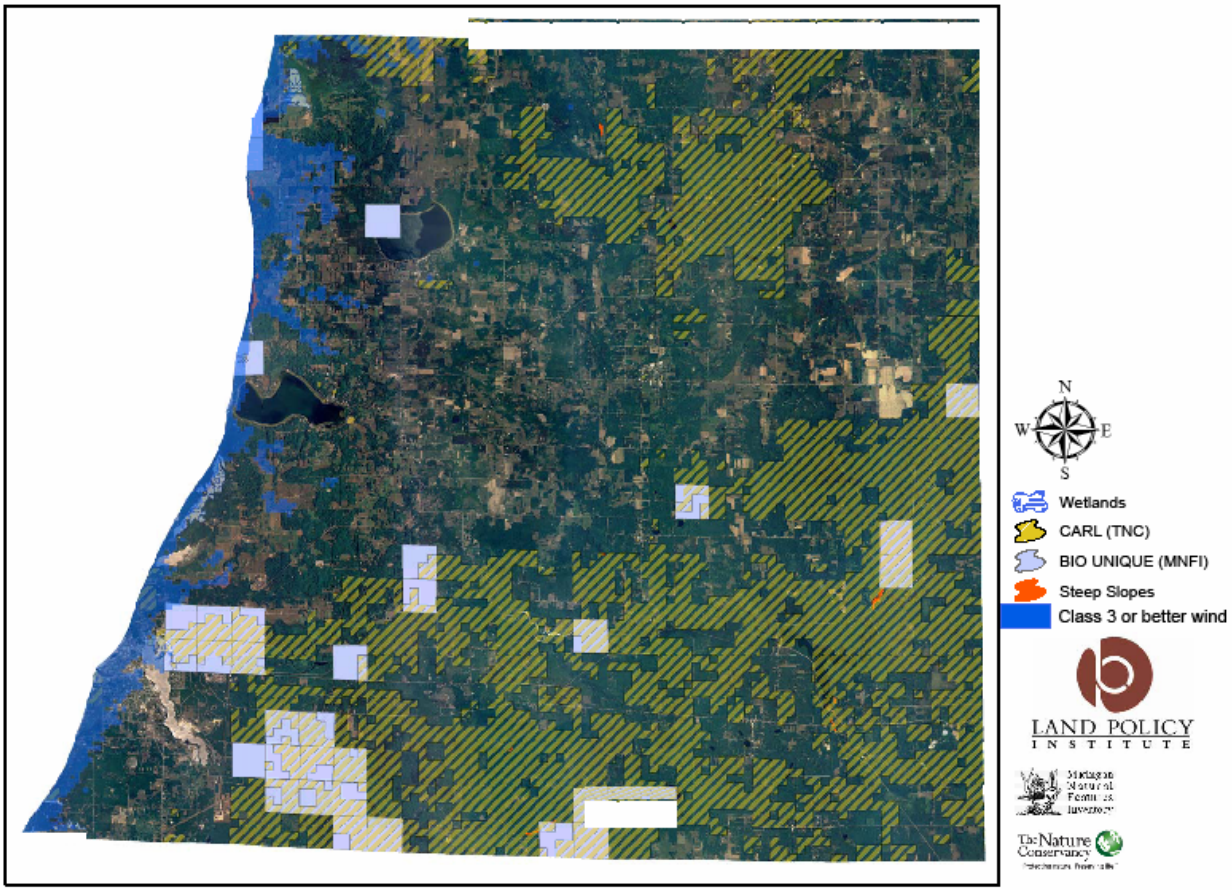
Field Name	Field Value
NAME	Grant Twp
Total possible number of towers if all Area is built	468
Total possible power generation if all Area is built	131.04
Towers Possible on 5% of resource area	23.4
Power generation possible on 5% of resource area	6.552
Potential land lease value on 5% of resource area	46800
Potential Maintence and upkeep jobs on 5% of resource area	3.0888
Potential construction jobs on 5% of resource area	47.4903
Towers Possible on 10% of resource area	46.8
Power generation possible on 10% of resource area	21.6216
Potential land lease value on 10% of resource area	93600
Potential Maintence and upkeep jobs on 10% of resource area	6.1776
Potential construction jobs on 10% of resource area	94.9806
Towers Possible on 15% of resource area	70.2
Power generation possible on 15% of resource area	32.4324
Potential land lease value on 15% of resource area	140400
Potential Maintence and upkeep jobs on 15% of resource area	9.2664
Potential construction jobs on 15% of resource area	142.4709
Towers Possible on 20% of resource area	93.6
Power generation possible on 20% of resource area	43.2432
Potential land lease value on 20% of resource area	187200
Potential Maintence and upkeep jobs on 20% of resource area	12.3552
Potential construction jobs on 20% of resource area	189.9612
Acres of Class 3 Wind at 50m	1796.32
Acres of Class 4 Wind at 50m	0
Acres of Class 5 Wind at 50m	0
Acres of Class 6 Wind at 50m	
Acres of Class 7 Wind at 50m	
Total Area of Class 3 or Above Wind	1796.32



Additional Information/Value added to map server

Beyond the factors already addresses there are a host of environmental and landscape issues that affect wind power sighting and development. These factors include areas of critical habitat for threatened and endangered species, conservation land, wetlands, lakes, and steep slopes. With the help of project partners, this information was included in the tool as well. These areas were not subtracted from the total area available for development because they serve as indicators that as part of comprehensive site assessment are areas of concern. For example, a conservation easement for agriculture may or may not eliminate the possibility of wind turbine instillation; the location of the easements is shown to indicate this must be investigated. Similarly, the presence of an endangered species may eliminate an area or simply require special construction considerations. If future funding is secured, these issues will be examined in more detail. In addition with follow on funding, the Land Policy Institute would like to model migratory flyways and examine avian habitat to minimize bird strike potential. An Example of a county's exclusionary areas is shown below.

Manistee County Land and Environmental Consideration Areas



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Next Steps

The Land Policy Institute is actively seeking feedback and information that will help us refine this tool. Based in an initial industry review, we will repeat the analysis. Once this is complete and the generation estimates are calculated, we will forward the results to ITC for initial review and approximation of interconnection costs and wait times.

Please visit the tool on the web at:

www.landpolicy.msu.edu/WPT

Partners

The Land Policy Institute would like to thank our partners in this project for their assistance and willingness to share data and experience.

DL&E Michigan Department of Labor & Economic Growth

ITC Transmission

Michigan Natural Features Inventory

The Nature Conservancy
Protecting nature. Preserving life.™

The Great Lakes Renewable Energy Association

Information Resources:

Wind Power and Economic Development: Real Examples from the Pacific Northwest. Jesse Jenkins and Troy Gagliano. Renewable Northwest Project.

Wind farm construction to start soon. Frounfelter, Megan. Huron Daily Tribune. June 6, 2007.

Industry experts were consulted to determine 28% wind turbine efficiency for electricity production.

Landowners' Frequently Asked Questions about Wind Development. Haley, Jay. US Department of Energy. http://www.eere.energy.gov/windandhydro/windpoweringamerica/pdfs/wpa/34600_landowners_faq.pdf