UTILITY-SCALE SOLAR SUITABILITY MODELING

An analysis of site suitability and land conversion for large-scale solar development in Wisconsin

By Ryan Michalesko

Introduction

As Wisconsin has no substantial in-state fossil fuel resources, reliance on a non-renewable-based energy profile leads to an energy spending deficit of $14.4 billion[1]. This profile is rapidly shifting, however. There is increased development of utility-scale (greater than 100 megawatts) photovoltaic production, including several projects under construction and in the queue.

Through an executive order in 2019, Wisconsin Governor Tony Evers pledged that all electricity consumed in Wisconsin be 100 percent carbon-neutral by 2050. Utility companies are beginning to follow suit. Wisconsin-based provider Alliant Energy announced plans in 2020 to eliminate coal from its generation portfolio by 2040 and achieve net-zero CO2 emissions by 2050. In doing so, they have simultaneously set about increasing their solar production. They are on track to add over 1,000 megawatts of solar power by the end of 2023 with the creation of 12 solar farms across nine Wisconsin counties. WEC Energy Group, the state's largest utility, plans to add approximately 800 megawatts of solar.

A recent study by the Center on Wisconsin Strategy (COWS) suggests that development of utility-scale photovoltaics (UPV) could supply 31.7% of energy in a proposed 100% in-state energy profile[2]. If all else remains constant, this projection translates to the offset of 20.2% (260.9 Trillion BTU) of the current end-use consumption.

Geospatial analysis was conducted to model the capacity of Wisconsin's landscape to meet the COWS projection. Suitability analysis was conducted to identify areas suitable for UPV development and estimate the implied land conversion.

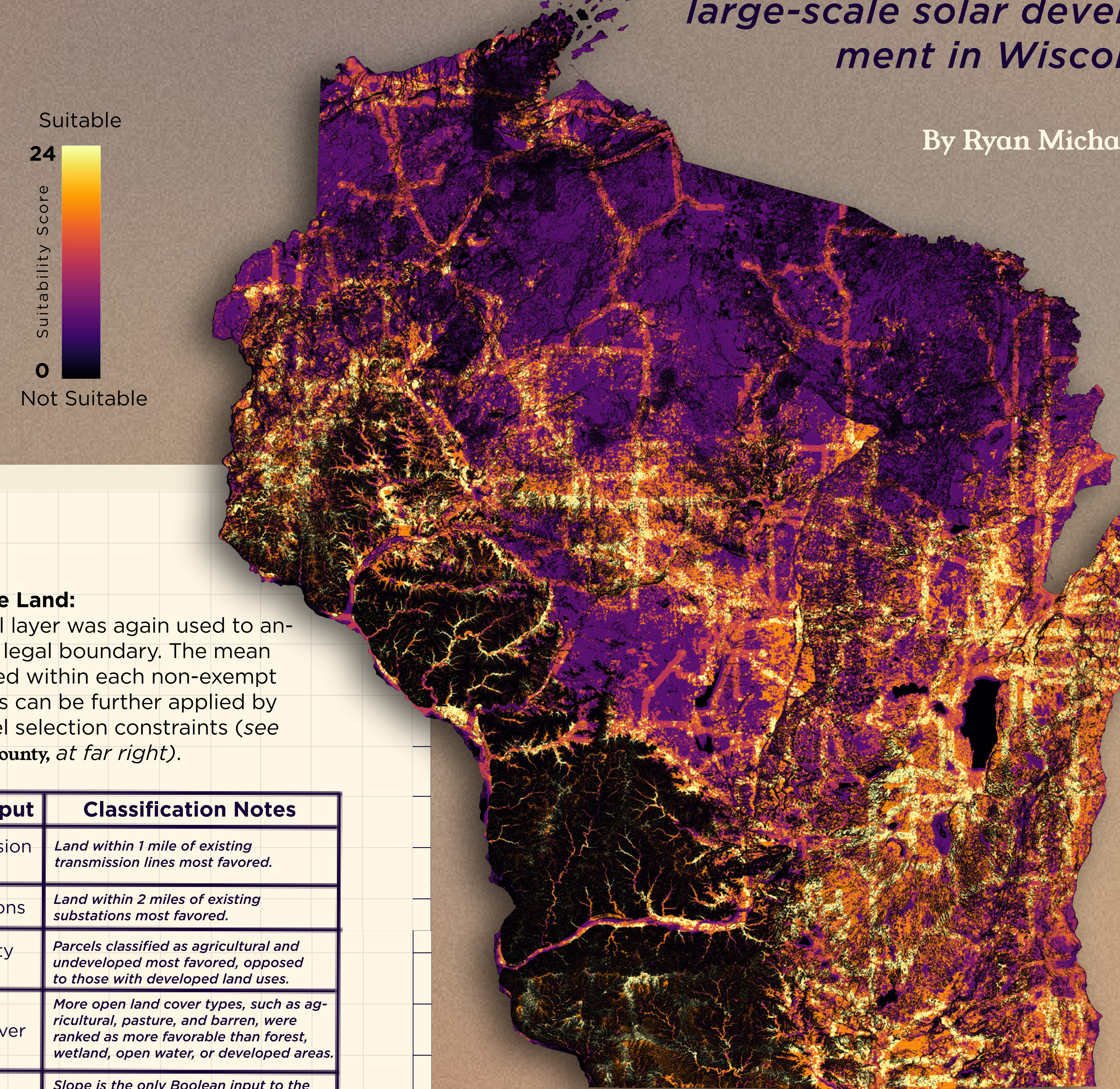

Figure 1.1

Methods

This methodology is based, in part, off the work of Janke[3], and Zarby and Grandstrand[4]. The flow chart (**Figure 2.1**) illustrates the GIS suitability modeling process, completed in ESRI ArcGIS Pro software. Several input datasets were considered.

Proximity to Infrastructure: Line and point features of current electric power transmission lines and substations were sourced from Homeland Infrastructure Foundation-Level Data (HIFLD). While the HIFLD data may contain some inaccuracies, the most current data are retained as confidential due to security concerns by the Public Service Commission of Wisconsin (PSC) and individual utilities. The Euclidean Distance geoprocessing tool was utilized to create distance rasters of these two features. Each was reclassified with rankings to favor land within one mile of existing transmission lines and within two miles of substations[x].

Land Use & Cover: Parcel polygons and assessor-assigned property classes were retrieved from the Wisconsin Statewide Parcel Map Initiative. Property classes are one way to help account for potential human interests within the suitability model (e.g., NIMBY). Areas designated as exclusively agricultural or undeveloped were ranked most favorable. All "exempt" parcels were excluded from analysis, which accounts for protected lands, such as state parks, and other public land.

Land cover was classified from the National Land Cover Database (NLCD). Agriculture, pasture, and barren lands were ranked most suitable. Grasslands, while generally favorable terraine-wise, were assigned a lower ranking to account for their significance as a natural resource. Forests, wetlands, open water, and developed areas were ranked lowest.

Terrain: Lastly, a percent slope raster was derived from the U.S. Geologic Survey's 10-meter resolution National Elevation Dataset as compiled by the Wis. Department of Natural Resources. Given its ability to hinder, or entirely prevent, a solar development, terrain was given significant consideration. While there is no consensus on what is too steep for large-scale solar, some studies have addressed this question[5]. The slope model was reclassified into two classes: areas less than or equal to 5% rise and areas greater than 5% rise. The terrain of the latter class is not suitable for solar development and was assigned a suitability score of 0.

Weighted Analysis: The group of reclassified input data were subsequently weighted and combined using Weighted Sum Analysis. The assigned weights (**Table 2.1**) serve as multiples of the assigned individual suitability ranking. For example, an area ranked as 3 (most suitable) given its proximity to transmission lines, is multiplied by a weight of three. As transmission lines are considered of the most important considerations in identifying suitable land.

Measuring Suitable Land:
The polygon parcel layer was again used to analyze suitability by legal boundary. The mean score was calculated within each non-exempt parcel. This analysis can be further applied by adding other parcel selection constraints (*see* **Case Study: Portage County,** *at far right*).

Weight	Data Input	Classification Notes
3	Transmission Lines	*Land within 1 mile of existing transmission lines most favored.*
1	Substations	*Land within 2 miles of existing substations most favored.*
2	Property Class	*Parcels classified as agricultural and undeveloped most favored, opposed to those with developed land uses.*
2	Land Cover	*More open land cover types, such as agricultural, pasture, and barren, were ranked as more favorable than forest, wetland, open water, or developed areas.*
N/A	Slope	*Slope is the only Boolean input to the suitability model. Areas with slope greater than 5% rise were excluded.*

Table 2.1

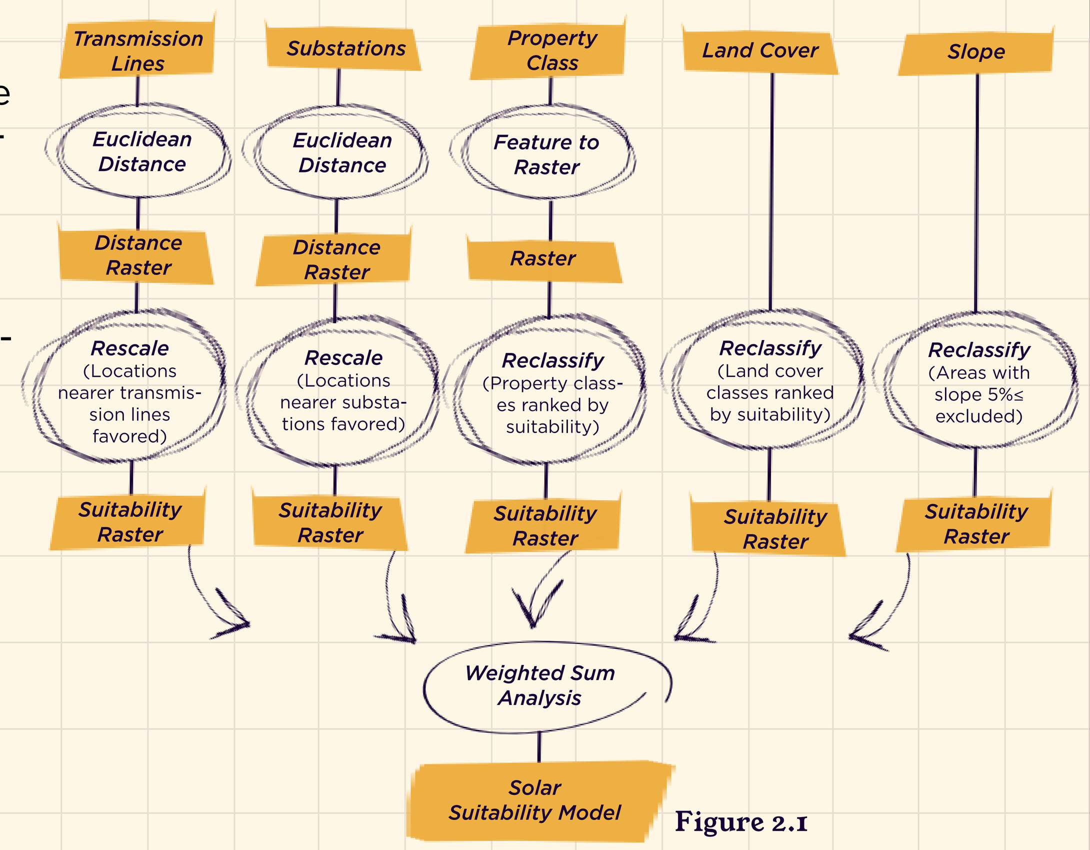

Figure 2.1

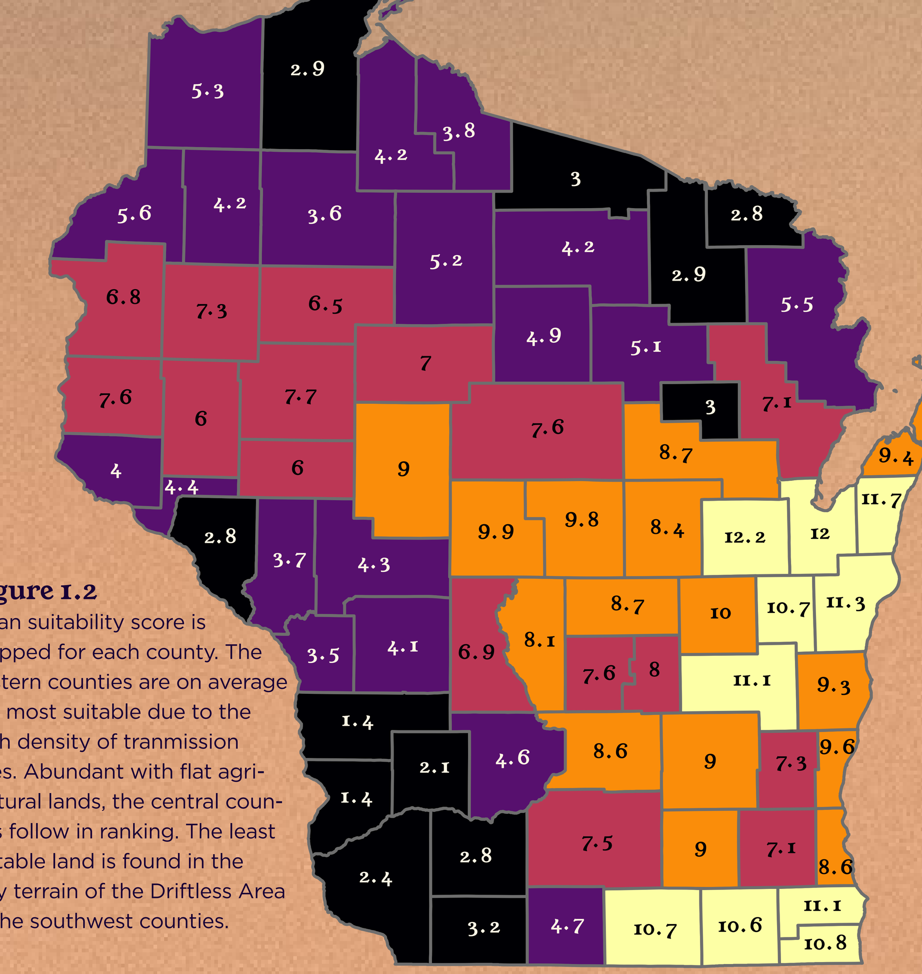

Figure 1.2
Mean suitability score is mapped for each county. The eastern counties are on average the most suitable due to the high density of tranmission lines. Abundant with flat agricultural lands, the central counties follow in ranking. The least suitable land is found in the hilly terrain of the Driftless Area in the southwest counties.

Case Study: Portage County

One application of the suitability map (**Figure 3.1**) is to examine the relationship with legal boundaries.

This case study considers this suitability model in Portage County, where development of a 250-megawatt solar project on 2,584 acres has been proposed[6].

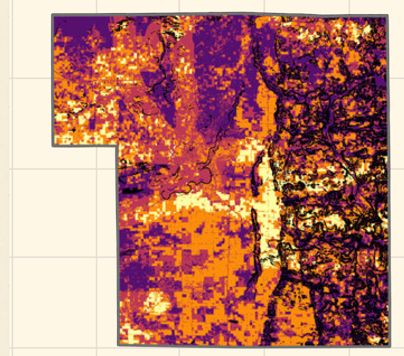

Figure 3.1

Workflow

- *Parcels merged by primary ownership attribute*
- *Single-owner land units greater than 100 acres selected*
- *Location query for land in the above selection that comprise area of at least 500 acres retained*
- *Zonal Statistics tools used to average raw suitability scores within these boundaries* (**Figure 3.2**)

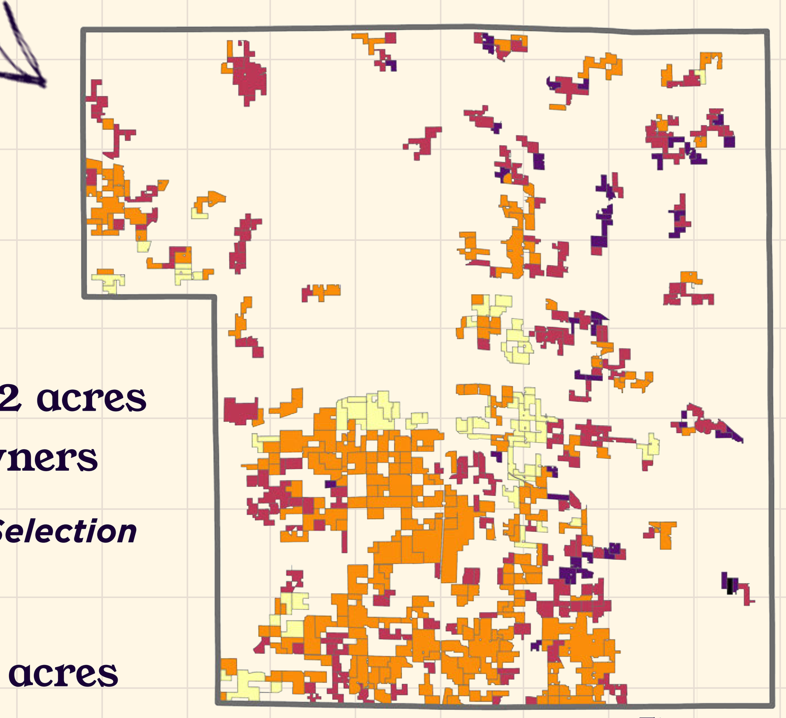

Figure 3.2

119,922 acres
398 owners
Total of Selection Criteria

13,867 acres
53 owners
Highly Suitable Land from Selection
(FIGURE 3.2 *in Yellow*)

1,000 to 3,000 MW
Potential Solar Production of Highly Suitable Land
(5-7 acres per 1 MW)

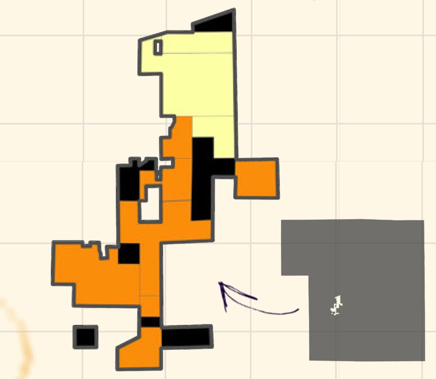

Figure 3.3
Suitability of a proposed solar site. Black areas show land not captured by the test criteria. This underscores the role of suitability models as often accurate, but not always precise, estimation tools.

Conclusion

Given a capacity factor of 18% in Wisconsin[7], a 1MW solar farm produces 1,576.8 megawatt hours (MWh) annually. Therefore, to meet the COWS projection **necessary development totals 48,494 MW solar capacity converting 242,470 to 339,458 acres of land** (5-7 acres per MW)[8].

In considering several land characteristics as criteria in this study, **896,137 acres were found to be highly suitable** for UPV solar development **supporting 128,019 to 179,227 MW capacity** (263% of that required by the projection).

While suitability analysis proves a valuable tool for modeling, the output results remain estimations. Further in-depth analysis is critical to determine true suitability on more local levels. For example, consideration of areas of cultural and natural significance may prove decisive for a specific site.

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