

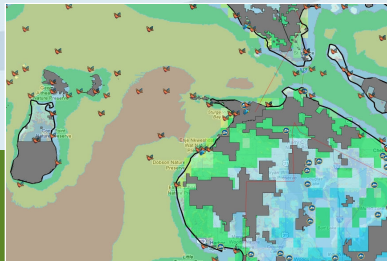
A Review of Approaches to Assessing Appropriate Placement of Wind Development

April 2013

Prepared by Greg Chernoff



MIISTAKIS
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FINAL REPORT

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INTRODUCTION

Wind power development is a fledgling and fast-growing industry in Alberta, particularly in Grassland and Parkland Natural Regions. In contrast to oil and gas development, the Surface Rights Act of Alberta does not apply to wind development. Specifically there is no "right of entry"; landowners have the authority to approve development and grant access rights through legal instruments such as a contract, easement or lease. There is no requirement under existing Conservation and Reclamation Regulations to reclaim surface disturbances caused by wind energy projects.

The Government of Alberta seeks to regulate the wind industry in a way that is fair, sustainable, and aligned with regional plans arising from the Provincial Land Use Framework. There is currently a moratorium prohibiting wind development on Crown lands.

There are ecological impacts associated with wind power infrastructure. A broad range of wildlife species are impacted in various ways, from collision fatalities, to avoidance or altered migratory behaviour. Impacts on native vegetation and wildlife habitat can occur during wind facility construction; there are also permanent additions required to existing road and power transmission networks. The current regulatory process requires that the Wildlife Management Branch of Alberta Environment and Sustainable Resource Development review and sign off on any proposed wind power development projects as part of the approvals process administered by the Alberta Utilities Commission, the provincial regulator.

Industry wants to take advantage of the abundant wind resource in Alberta's Prairie and Parkland regions, and would like to develop their industry on a "level playing field", where the regulator's expectations and protocols are transparent, equitable, and consistent.

Municipal governments and local communities want to balance economic opportunity with the desire to preserve landscape, social, and aesthetic values. Municipalities have authority over wind development through Land Use Bylaws, and can direct development according to this policy.

The Prairie Conservation Forum (PCF) is preliminarily exploring opportunities to help create this "level playing field" of wind suitability assessment in Prairie and Parkland Alberta, and is interested in learning what has been done in other jurisdictions to address these complex land-use challenges.

The purpose of this report is three-fold:

1. To conduct a detailed review of two recent GIS-based modeling applications aimed at assessing the appropriateness of wind development: the Nature Conservancy's Ecological Risk Assessment of Wind Energy Development in Montana (Martin et al, 2009); and the Conservation Biology Institute's Decision Support System for Conservation in the Tehachapis and Southern Sierra Nevada (CBI, 2013).
2. To identify and review other similar efforts, using a broad-ranging suite of criteria and a GIS-based approach, to the assessment of wind development potential and suitability.

3. In consideration of the learnings from steps 1 and 2, to offer some initial thoughts on what could be done in Prairie and Parkland Alberta to create tools and/or processes that would facilitate informed and balanced discussion on where wind development is appropriate, and where it may not be.

At the outset, it is important to note that the review described in this report is not exhaustive. Doubtless there are approaches to mapping and assessing appropriate wind development alternatives, and other valuable resources, which have not been included in this review. The goal is to present a cross section of current approaches and resources, with a focus on those that have the most potential value and relevance to the Prairie and Parkland Alberta context.

REVIEW OF THE NATURE CONSERVANCY (MONTANA) APPROACH

In 2009, The Nature Conservancy (TNC)'s office in Helena, Montana, published a report entitled "An Ecological Risk Assessment of Wind Energy Development in Montana" (Martin et al, 2009). The following factors contributed to the need for the type of analysis presented in the report:

- The rapid growth, and relative lack of regulation, over the wind power industry in Montana;
- The lack of significant study of the cumulative ecological effects of wind development in the state (previous research having been limited to impacts on individual species, e.g. birds or bats); and
- The need, as perceived by TNC and others, for a resource that would illuminate some important considerations if wind development is to be sited in a way that preserves (or minimally disrupts) ecological integrity.

The objective of TNC's research was to make the best use of freely available spatial data describing both the potential for wind power development and areas of ecological significance to map areas of high ecological risk within the state of Montana. High-risk areas are those parts of the state where there are both high ecological values and favourable conditions for wind power development.

Areas with high wind development potential were mapped using a data set from the US National Renewable Energy Laboratory (NREL). Areas of potential wind development were selected as those with "good or better" conditions for wind power, which are primarily located in the eastern "half" of the state (i.e. east of the Rocky Mountains). Jurisdictions that do not permit wind development (e.g. National Parks, Wilderness Areas, urban centres) were excluded from further analysis.

TNC identified 4.4 million acres of "low-risk lands" - areas that the NREL data suggests are suitable for wind power development, which are situated on lands with low ecological value such as cultivated croplands and highly fragmented landscapes like high-density oil and gas fields. They recommended that proponents of future wind power developments consider these low-risk lands first.

Areas of high ecological value were then identified as those that met any one of the following criteria:

- "Relatively intact habitats", identified by selecting areas classified as "Native Vegetation" in the US National Land Cover Classification (NLCC) data set.

- Habitat for numerous important wildlife species, predominantly birds and bats with a focus on those found in eastern Montana. Species were selected based on the availability of spatial data describing their habitat and range, on documented sensitivity of the species to wind power infrastructure, and on the importance of the species at a larger (state or regional) scale. Selected species included:
 - Sage grouse, mapped using buffered lek locations;
 - Grassland endemic birds (several species), mapped using predicted species abundance and sensitive/threatened habitats;
 - Piping plover and interior least tern, mapped using known breeding grounds;
 - Waterfowl, mapped using known migratory concentration areas, specifically high-quality wetlands;
 - 13 bat species, mapped using a model predicting species abundance;
 - Grizzly bears, mapped using a habitat suitability model; and
 - Ungulate winter range, mapped from existing range data.

These data came from various government and other sources, and were of varying accuracy and currency, but were the best freely available data.

- High-value landscapes (rare ecosites, landforms, etc.), as previously mapped by TNC.

For each of the ecological values listed above, TNC individually mapped regions that satisfied the criterion, both across the entire state, and also only in areas with high potential for wind power development. Areas where development potential and ecological value were both high were considered “high ecological risk”. “Low risk areas” were those where high ecological value exists, but conditions are not favourable to wind power development.

Finally, TNC developed a summary Ecological Risk Assessment map. In this map, any area that had wind development potential, that also met any one of the ecological criteria above, was considered a High Risk Area (see Figure 1).

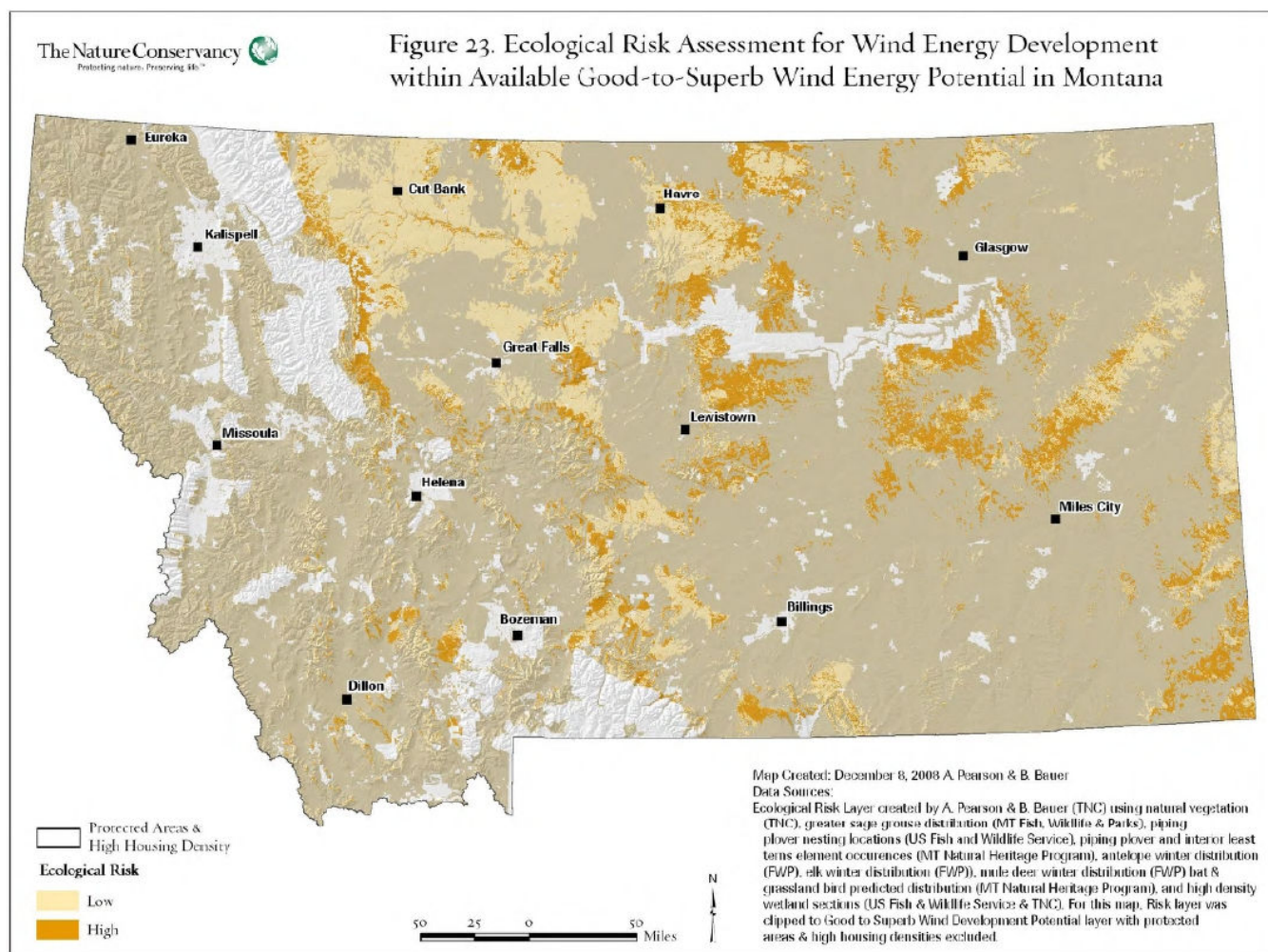


Figure 1: Final Map of TNC Ecological Risk Assessment Project.

REVIEW OF CONSERVATION BIOLOGY INSTITUTE APPROACH

The Corvallis, Oregon-based Conservation Biology Institute (CBI) recently produced a report entitled “Decision Support for Conservation in the Tehachapis and Southern Sierra Nevada” (CBI, 2013). Based on a collaborative research project originally titled “Wind, Wings & Wilderness”, the objective was to plan and propose conservation reserves around existing and approved wind farms in the Tehachapi Mountains east of Bakersfield, California. The study area is a narrow chain of mountains, 4.8 million acres in size, which serves as a linkage zone between four ecoregions: Mojave Desert, Sierra Nevada, South Coast, and Central Valley. The Tehachapis are attractive to wind power developers, but are also of critical ecological value at regional and local scales.

The CBI approach only considered current and approved wind farms in the mapping of areas with potential for wind power development. Conservation priorities were mapped using a sophisticated, non-proprietary (i.e. shareable) platform called the Environmental Evaluation Modeling System (EEMS). EEMS is a user-defined hierarchical fuzzy logic model that can be run either from ESRI ArcGIS software, or

from within the CBI's [Data Basin](#), a web-based conservation tool for mapping, modeling, and sharing data (Data Basin web site). Fuzzy logic GIS models allow for the consideration of a non-binary range of values for input factors in a decision support system. In this case, CBI synthesized over 250 spatial data sets into a single conservation priority layer using a 50+ step decision tree constructed on the EEMS platform. The CBI Tehachapis decision tree is shown in Figure 2. The minimum mapping unit for the CBI analysis was one section (i.e. one square mile).

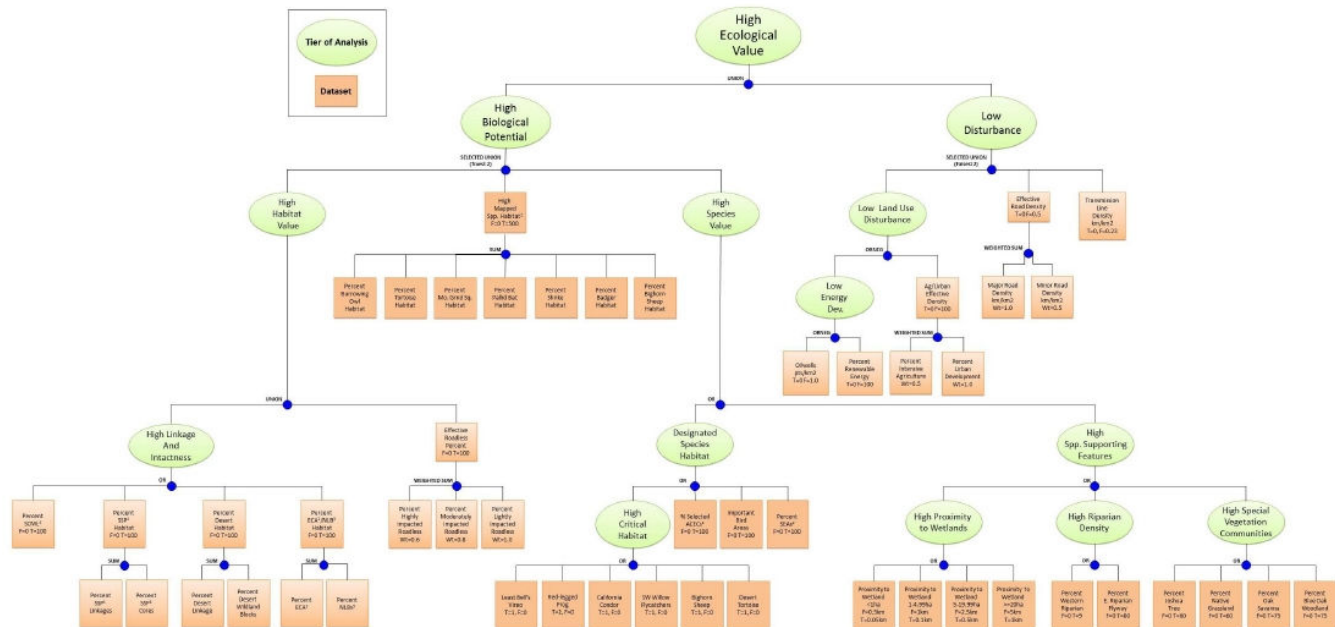


Figure 2: Conceptual Framework for CBI Approach.

When deployed from Data Basin, EEMS allows for instant viewing of any input or intermediate data sets in the decision tree. It also allows the user to query individual polygons in the data set for their values in every layer that inputs to the final calculation of ecological value. This facilitates understanding not only of the end result of the analysis, but an appreciation for the most significant contributing factors to that end result.

CBI used a public consultation process, engaging a diverse group of stakeholders, to identify conservation priorities in the Tehachapi Mountains. Priorities included the following thematic areas:

- High degree of ecological intactness/integrity;
- Landscape-scale (i.e. region- or state-wide) importance to ecological connectivity;
- Low levels of anthropogenic disturbance, low road density;
- Special plant communities and landscapes (habitats) supporting rare species; and
- Areas designated or legally protected for wildlife (especially bird or bat) conservation.

As mentioned above, the CBI model did not assess the technical suitability or requirements favourable to wind power development within their study area.

The output of the CBI Tehachapis modeling process is a map showing recommended conservation areas, where wind development should not be considered. This map is presented in Figure 3.

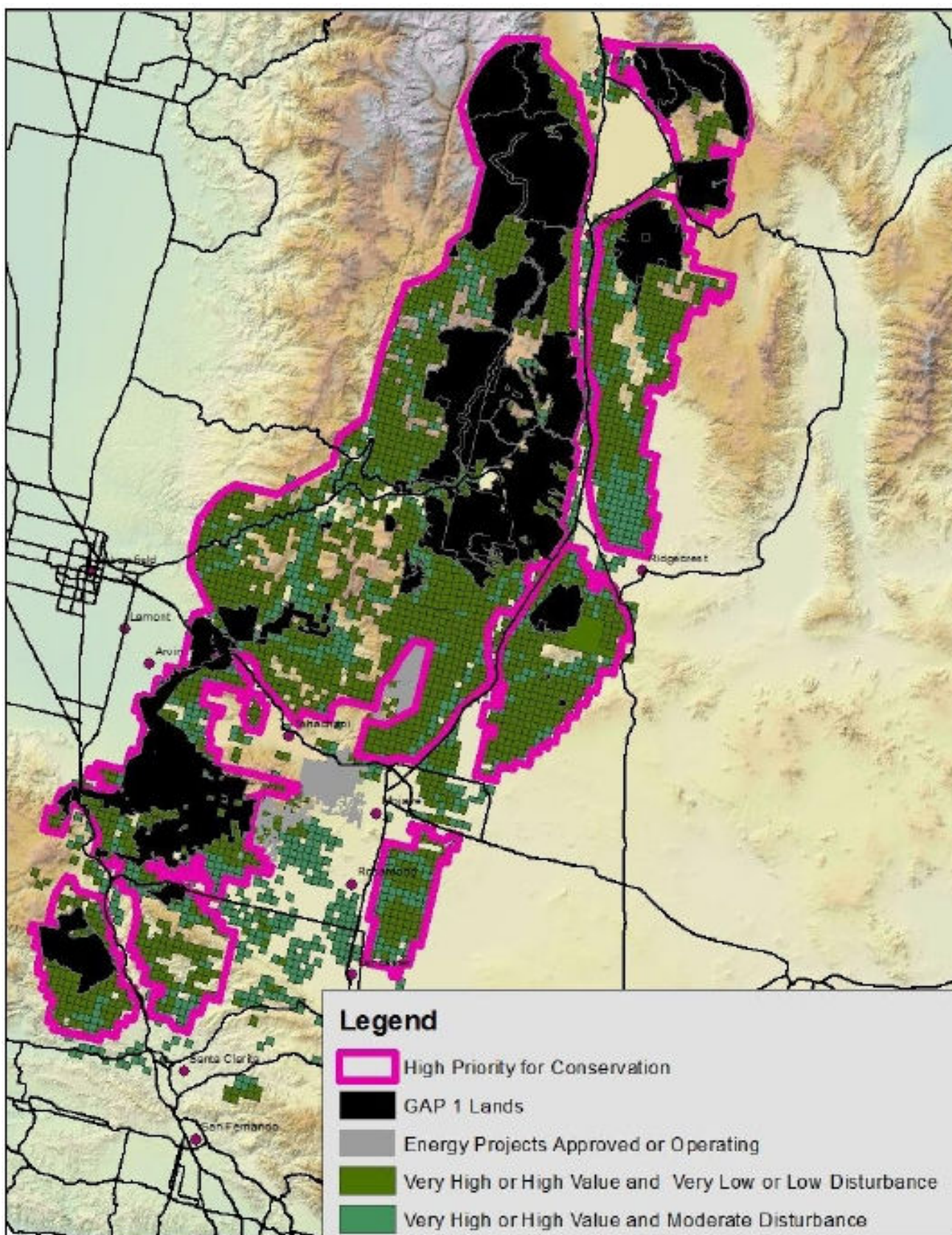


Figure 3: Final Map of CBI Tehachapis Report.

OTHER GIS-BASED APPROACHES TO ASSESSING APPROPRIATE WIND DEVELOPMENT POTENTIAL

To date, much of the documented GIS analysis of wind power siting has focussed exclusively on the technical, geographic, and economic factors influencing the viability of wind power development (e.g. Schillings et al 2012, Toke et al 2008, Voivontas et al 1998). Since the PCF is interested in more comprehensive ways of evaluating wind development options, analyses focused on only part of the assessment have been omitted from this review.

It is only relatively recently that researchers and decision-makers have begun to consider a more balanced assessment of wind development potential that incorporates ecological factors and conservation priorities. This may be due to evolving science and knowledge around the ecological effects associated with the wind industry, the rapid growth of wind power in many parts of the world, or changing public perceptions toward wind power. In any case, there seems to be a growing need for a broader perspective when considering wind energy options.

A wide range of approaches to assessing suitability and mapping wind development potential have been reviewed from various jurisdictions, including the US State of Maine (Graham et al, 2012), northern Spain (Ruiz et al, 2012), western Turkey (Aydin et al, 2010), and South Africa (Belfiore et al 2012, Moilola 2009). The suite of environmental factors considered by each modeling approach ranges from simple exclusion of “no-go” jurisdictions (e.g. Belfiore et al, 2012), through consideration of habitat for endangered or threatened species (e.g. Graham et al, 2011), to consideration of more complex measures of ecological value (e.g. Moilola, 2009). Some studies also include spatial analysis of factors such as aesthetics and other cultural values in their assessment of development potential (e.g. Aydin et al 2010, Ruiz et al 2012).

The fuzzy logic model is popular among researchers assessing the suitability of wind power development to various landscapes (e.g. Aydin et al 2010, Moilola 2009, Ruiz et al 2012). This is likely a reflection of the complexity of the research questions being asked; simple Boolean metrics (e.g. yes/no, in/out, presence/absence) are insufficient when one seeks to understand complex factors that affect ecological, social, and economic values around wind development.

Along with academic researchers, decision-makers, industry associations, and conservation groups are interested in broadening the discussion regarding the appropriateness of wind power development across their areas of focus (Fehily Timoney & Co 2012, ASRD 2011, GLWC 2011, Weis et al 2010). Numerous organizations have developed best practices and recommended guidelines - including environmental considerations - for wind facilities (Fehily Timoney & Co 2012, GLWC 2011, OMNR 2011, Gipe & Murphy 2005, EWEA 2002), some focused on wind development in Alberta (ASRD 2011, Bradley & Neville 2011, Weis et al 2010).

Many regions are developing web-based mapping tools to help stakeholders better understand the factors affecting wind development potential, see the extent of current and planned development, and assess the trade-offs between development and conservation. One of the best current examples is the Great Lakes Wind Atlas (<http://erie.glin.net/wind/>), an initiative of the transboundary Great Lakes Commission. The GLWA is an interactive, web-based mapping tool for wind siting in the Great Lakes

region, comprised of eight US States and two Canadian Provinces. The tool allows for the simple (visual only) overlay of data layers related to technical, social, and environmental considerations for wind development. A screenshot of the GLWA is presented in Figure 4.

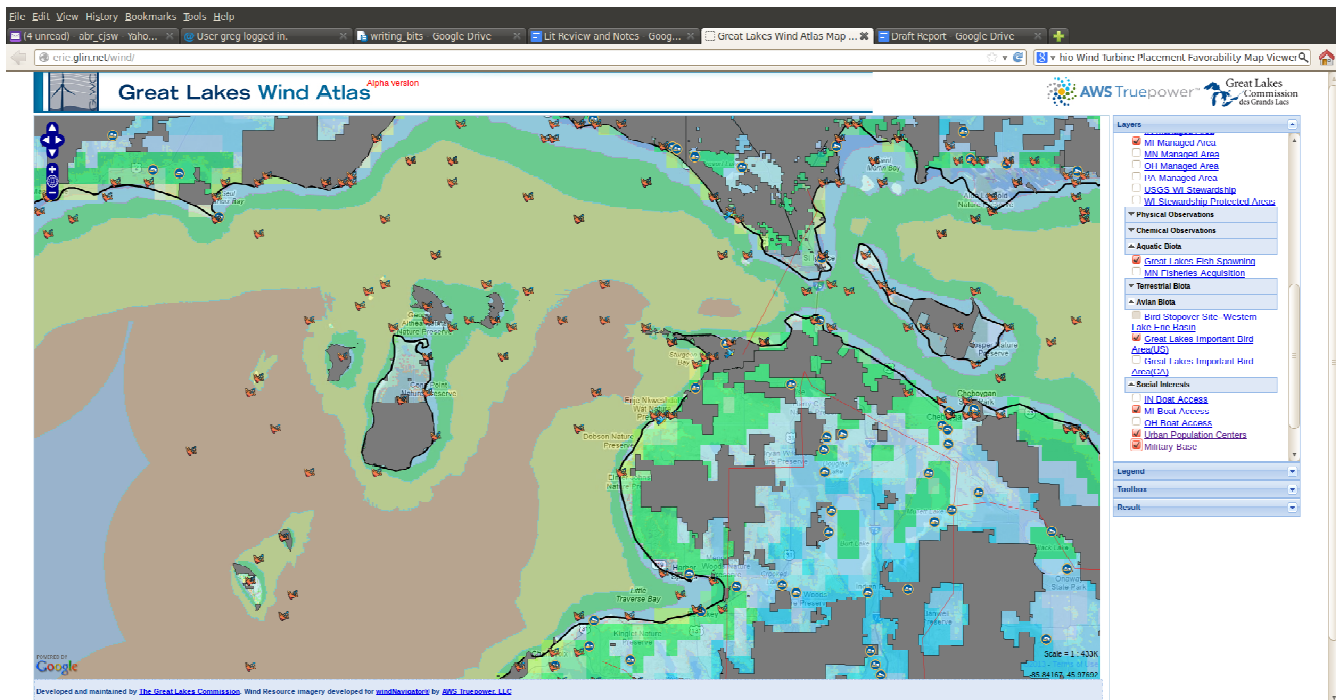


Figure 4: Screenshot of the Great Lakes Wind Atlas.

The State of Vermont has also created a web-based mapping tool that may be helpful in assessing wind development potential. The Renewable Energy Atlas of Vermont (<http://www.vtenergyatlas.com/>) is a tool for siting of wind and other renewable energy options (e.g. solar, biofuels) throughout the state. The wind module currently only considers geographical/technical factors, and allows users to view and query existing or planned wind power facilities. A screenshot of this tool is presented in Figure 5.

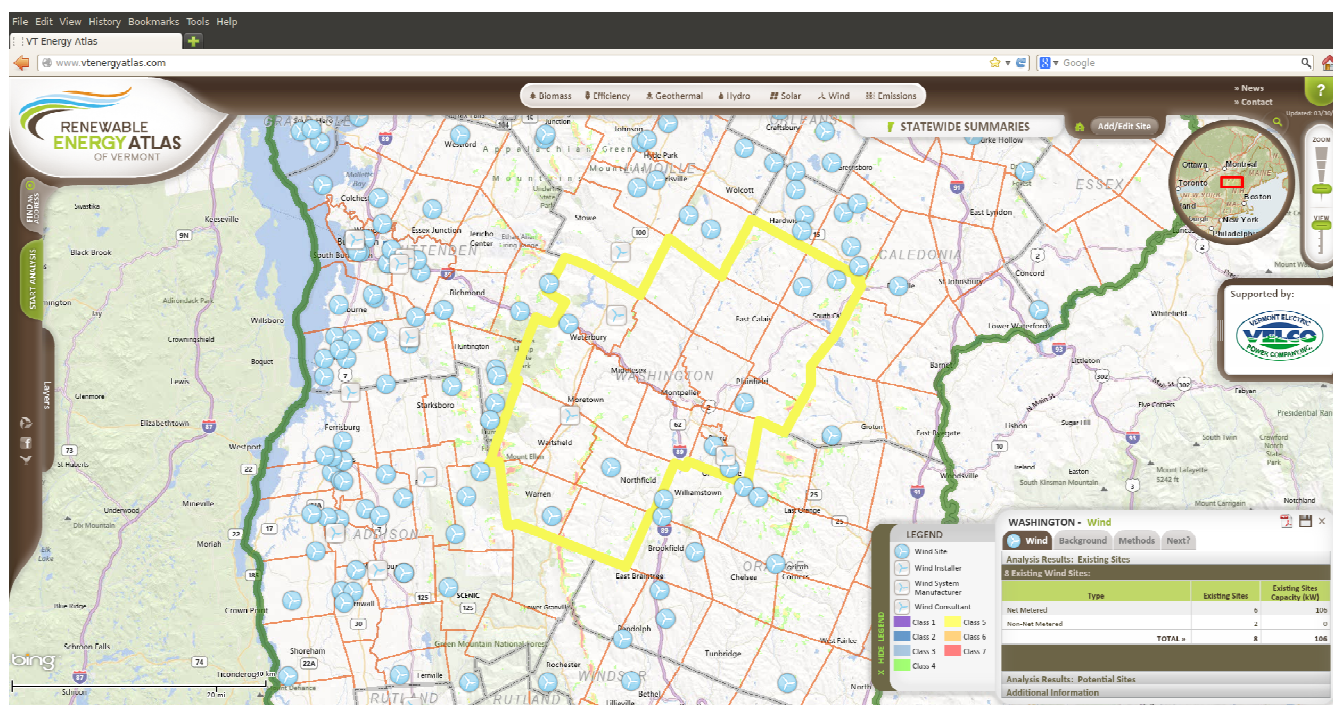


Figure 5: Screenshot of the Renewable Energy Atlas of Vermont.

The Ohio Department of Natural Resources has also created an online tool called the Wind Turbine Placement Favorability Map Viewer. The methodology for creating the tool is well-documented (ODNR, 2009), but the tool itself cannot be found online at time of writing.

DISCUSSION

COMPARISON OF TWO APPROACHES

Both approaches to assessing the ecological risk of wind development that are reviewed in detail above have their strengths, and their weaknesses. The TNC approach (Martin et al 2009) is more balanced, acknowledging that the wind industry is likely to grow in coming years, and mapping opportunities for growth in areas where ecological risk is minimized. Another strength is its methodological simplicity, which would allow for intuitive understanding by a broad range of users. Furthermore, since the model can accommodate a wide range of data accuracy and currency, it is scalable to whatever data may be available and could likely incorporate new data as it comes available with relative ease. It would be quite feasible to find spatial data for Prairie and Parkland Alberta that is comparable to those datasets used to calculate risk in Montana, especially if data access were coordinated through an organization with the diversity, reputation and representation of the PCF. Lastly, Since the TNC model was developed for Montana, there may be benefits to adopting an approach that has already been followed in an adjacent jurisdiction to Prairie and Parkland Alberta. If the PCF could find suitable data in Alberta to replicate the TNC Montana approach, there is the possibility of creating a uniform, seamless layer across the Canada-

US border. Future possible efforts could be directed at conducting a uniform ecological risk assessment across the entire Northern Sagebrush Steppe.

The main strengths of the CBI Tehachapis approach (CBI, 2013) are in the sophisticated modeling method that was employed, and in the inclusion of public consultation in the identification of conservation priorities. The EEMS is sophisticated and allows for the modeling of complex interactions between different components, but the interface it employs is graphical, user-friendly, and would facilitate the explanation of a complex 50-step hierarchical model to someone with little prior modeling or mapping experience. The ability to interact with the entire decision tree of the model and see the results of intermediate steps would be valuable in assessing model performance, and in determining which input factors are the strongest drivers of model results. Public engagement at the outset of the process ensures buy-in of stakeholders and alignment of conservation priorities. Furthermore since the model is driven by public opinion, it can be configured to reflect changing public opinion over time. A parallel model could also be developed based on consultation with a different stakeholder group, and the two models could then be used as the basis for facilitated discussion and consensus-building in the development of a future land use plan or conservation strategy.

One of the greatest strengths of the TNC approach - its simplicity - is also one of its biggest shortcomings. The final map of the report presents two basic options over every area in Montana with potential for wind development: those that are "high environmental risk", and those that are "low environmental risk". One would assume that all high-risk areas are not equally high, and with a few basic alterations, the model could be designed to show the degree of risk as a continuous variable, rather than a comparison of polar opposites. The simplest way to achieve this would be to count the number of environmental criteria present at each location, and assign higher value (and therefore higher risk) to areas in which more criteria are fulfilled. A similar approach could be employed to represent wind development potential as a continuum: Rather than mapping regions as "suitable" or "not suitable", why not take advantage of the range of available data? The final map that would result from this approach may be slightly less intuitive, but it would be vastly more meaningful. Moreover, this model modification would require no different data than those that TNC already used.

Two main challenges are observed in the CBI Tehachapis approach. Firstly, the more sophisticated EEMS model would require more expertise and more time to build, both translating to a higher cost to perform the analysis. It is a subjective determination whether this added cost is acceptable, given the results that EEMS is capable of producing.

The other shortcoming to the CBI approach is the failure to accommodate any future wind development in the conservation design. This was likely a deliberate decision, but it renders the model a poor representation of reality in most jurisdictions where there is a wind power development interest. Incorporating a wind power suitability map would require another "branch" on the EEMS decision tree adding to model complexity, but it would also add some balance to the final design of conservation reserves. Despite the complex and fuzzy-logic methods pursued by CBI, the output presented in the final map reverts to a binary choice between "recommended for conservation", and "not recommended for conservation". Presenting the model outcomes as such may allow for easy interpretation, but it understates the complexity and potential value of the modeling process.

The goal of this report is not to decide unequivocally that one approach is better than the other, but more to highlight the benefits of either approach and identify opportunities to build on one or the other in the context of wind development assessment in Prairie and Parkland Alberta. Both of these approaches are entirely valid, and neither of them is universally “right”. Choice of the correct model to apply depends on available resources and data, and on a clear articulation of the questions being asked.

IDEAS FOR A PCF WIND SUITABILITY ASSESSMENT TOOL

As discussed above, elements of both the TNC and CBI approaches could be applied to a map-based wind suitability assessment tool for Prairie and Parkland Alberta. Based on a review these two approaches and of current literature on planning appropriate wind development, the following ideas should be considered in the potential development of future tools and processes:

1. **Interactive Mapping Tools:** Web-based mapping tools like those described above can be powerful means by which to show overlapping priorities, track changes, understand trade-offs, and encourage discussion. An interactive model like EEMS allows for the demystification of complex modeling approaches, and makes science and land use planning more accessible to all participants.
2. **Public Consultation:** Meaningful consultation with a diverse group of stakeholders allows consensus-building to start at the beginning of the process, improves understanding of both model methods and outputs, and increases the likelihood of buy-in to strategies that are developed through any conservation planning process.
3. **Access to Data:** Regardless of what modeling approach is chosen, success is heavily underpinned by the quality of data, both spatial and non-spatial, that goes into the model. The best data sources are current, accurate, transparent, and freely accessible. With its cross-sector, multi-agency reach, the PCF is ideally positioned to facilitate access to the best data for Prairie and Parkland Alberta.
4. **Incorporation of Best Practices:** Best practices have relevance in a site-specific context, but they can also be incorporated into broader landscape-scale planning processes. For example, an interactive mapping tool may be designed to include “sliders” or “toggle switches” that would allow the user to understand the difference between future development patterns with and without best practices in place. The best practice and responsible development guidelines referenced in this report, both from Alberta and from other jurisdictions, could prove useful to an assessment tool or conservation planning process.
5. **Meaningful Engagement and Insertion:** Public and stakeholder engagement are critical, but most land use or conservation planning processes are designed with the further objective of informing the way that decisions are made. Since the PCF does not have authority over land use in Prairie and Parkland Alberta, any tools or processes that are developed should aim to find appropriate nodes of engagement with, and points of insertion to, the decision-making process.

CONCLUSION

Around the world and across a broad range of stakeholders - from government, industry, conservation groups, concerned citizens and local communities - the benefits and impacts of wind power are being assessed according to a wider range of criteria than ever before. Stakeholders are asking questions like:

- Is wind power appropriate here? How much?
- Is it socially desirable (aesthetics, health concerns, etc.)?
- How might wind development impact on local or regional ecology?
- How might ecological or social impacts be minimized?
- What is the appropriate balance between the environmental benefits of wind energy (reduced emissions/pollution) and the environmental impacts?

Matching pace with this broadening perspective, scientists are asking and answering a broader range of research questions, and everyone is looking for innovative and useful ways to communicate and illustrate this new knowledge and to use it to engage stakeholders in informed, meaningful discussion around the future of wind energy - and, indeed, all forms of energy and land use.

This report has reviewed some current approaches to addressing questions, engaging in dialog, and making decisions with respect to wind power development around the world. In consideration of these learnings, the PCF can now turn its attention to Prairie and Parkland Alberta, develop its own list of questions, and discuss how they might be answered.

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INTERNET RESOURCES:

Data Basin / Conservation Biology Institute: <http://consbio.org/products/categories/data-basin>

Great Lakes Wind Atlas / Great Lakes Commission: <http://erie.glin.net/wind/>

Renewable Energy Atlas of Vermont / State of Vermont: <http://www.vtenergyatlas.com/>