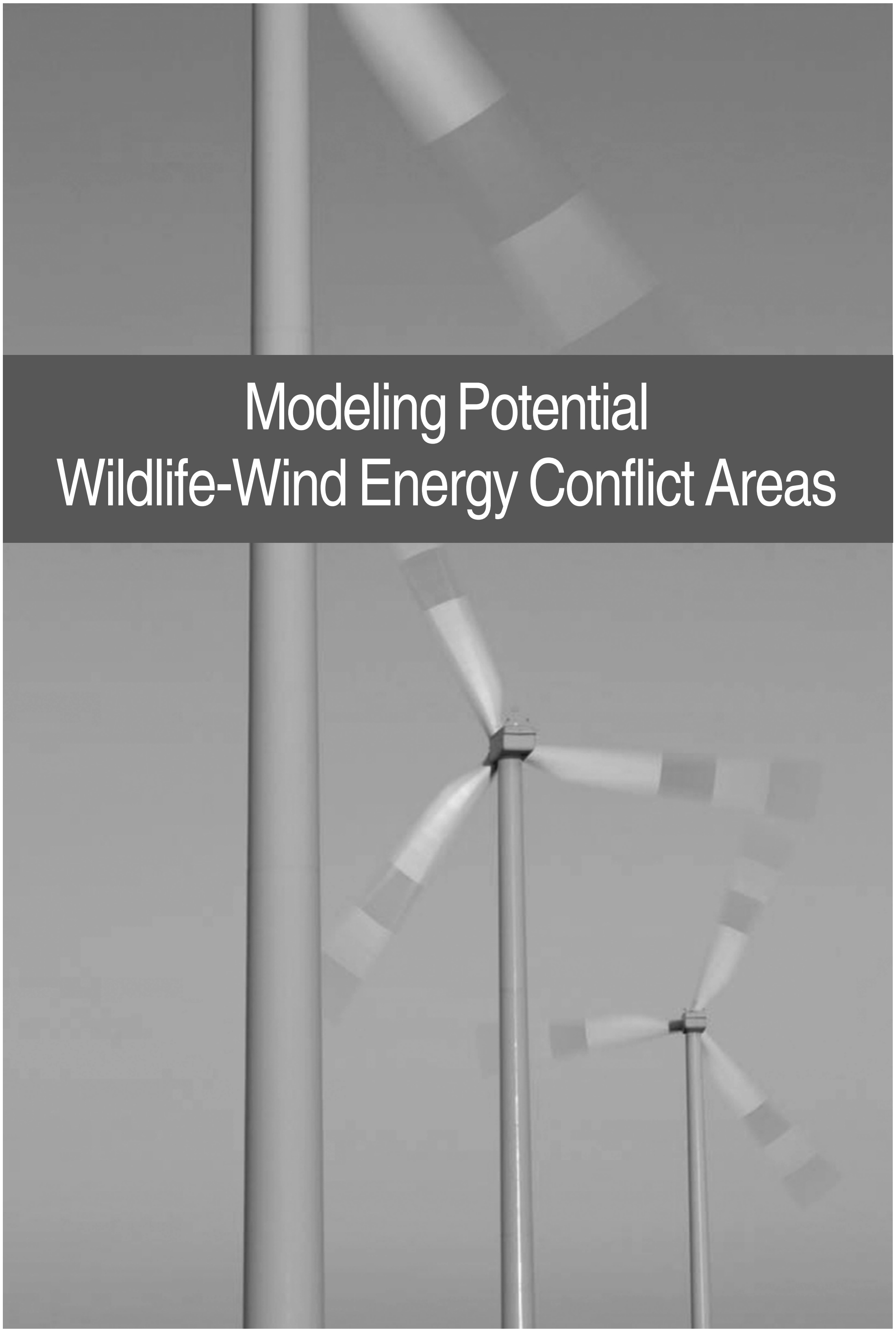
Modeling Potential Wildlife-Wind Energy Conflict Areas



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Modeling Potential Wildlife-Wind Energy Conflict Areas

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Executive Summary

Renewable energy policies and Appalachian ridges combine to make Pennsylvania a favorable setting for wind energy facilities. But a proliferation of proposals and developments has created new challenges for local governments, which are ultimately responsible for permitting commercial installations on private lands. Rows of wind turbines bring the promise of emissions-free energy, but the tall, moving structures possess a broad development footprint encompassing hundreds or thousands of acres. Their unique form and site requirements threaten some of the state's most significant wildlife habitats in upland areas. In Somerset County and elsewhere, for example, grassroots resistance to commercial wind proposals has grown, in part, due to environmental concerns.

This research aimed to provide a tool to more comprehensively address land use decisions involving commercial wind energy. The researchers developed an approach to highlight areas where competing demands of wind development and wildlife protection are likely to emerge.

Commercial wind energy is a new and largely unregulated land use in the state. Other than federal stormwater or wetlands permitting requirements, few policy mechanisms exist to ensure that ecological considerations are addressed in wind development proposals. For example, a Pennsylvania Department of Environmental Protection model ordinance offers a template to address public health and welfare but offers no guidance on wildlife concerns. Consequently, municipal officials may lack the information and resources crucial to the siting of wind turbines. Wind energy facilities have a potential for direct and indirect threats to wildlife—particularly bats and birds—in the airspace swept by the turbine blades and along the forested ridges cleared to permit service roads and other associated infrastructure. In some cases, rates of bird and bat mortality inflicted by wind turbines have caused alarm over the vulnerability of species populations.

The researchers used a statewide geographic information systems database, compiled by the Pennsylvania Natural Heritage Program (PNHP), to produce township-scale maps for use by municipal officials. PNHP data highlight areas of outstanding importance to the state's wildlife. The researchers combined this data with wind speed data to model likely areas of conflict between wildlife habitat and commercial development interests. In all, 235 townships in 39 counties were found to contain areas of potential conflict.

The research findings and conclusions are presented in two publications. The information in this report describes the work completed to identify likely areas of conflict. The companion manual, *Using Pennsylvania Natural Heritage Program Data for Wind Energy Planning: A Manual for Townships,* includes the maps that show likely areas of conflict. It also may aid local officials in using the maps to create restricted zones or ordinances to reduce wildlife risks and steer development proposals to locations more appropriate for wind energy generation.

While they are not substitutes for detailed site reviews in proposed development areas, these publications are proactive tools that may better ensure the coexistence of wind energy and wildlife populations in Pennsylvania.

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Introduction

Against the backdrop of rising energy demands and concerns over the contribution of fossil fuel combustion to climate change, it would appear that wind energy's time has come. Societal concerns have shaped federal and state renewable energy policies, creating a favorable environment for the wind energy industry. While wind generation remains small as a percentage of electrical output in the United States, it is growing rapidly, with more than 19,500 MW of installed capacity as of June 2008 (AWEA, 2008). This growth is manifested in clusters of turbines that must cover many acres, as each turbine generates relatively little power compared to conventional sources. Wind "farms" have a broad footprint and thus are highly susceptible to the sorts of land use conflicts evident among other forms of development. Community reactions to wind energy proposals in Pennsylvania and other states are not all positive, and include fears over impacts to birds and other wildlife. Scientific research to date, although in need of more consistent methods and a greater understanding of migratory and other species behavior, confirms that these concerns are warranted (GAO, 2005). While "green" in terms of air quality, wind energy installations are no different from other human structures in the sense that they modify habitat and create obstacles for wildlife. Currently there is a pressing need to understand and predict the ecological consequences of transforming Appalachian landscapes for wind power generation (GAO, 2005). This region, with its remote ridges, powerful updrafts, and surrounding large population centers, is especially vulnerable to conflicts.

This research provides a tool, in the form of a manual and township-level maps, to better anticipate wildlife impacts and facilitate desirable outcomes in local planning and permitting decisions. The research used geographic information systems (GIS) technology and data from Pennsylvania's Natural Heritage Program (PNHP).

The Context for Wind Energy in Pennsylvania

Pennsylvania currently ranks 16th overall among states in terms of installed wind generation capacity (AWEA, 2008), but is a leader among northeastern states. Growth has been facilitated by Act 213, signed into law in 2004. This requires that 8 percent of the state's energy sold for retail consumption come from "Tier I" renewable energy sources, including wind, by 2021. It is worth noting that surrounding states have also instituted renewable standards—some more aggressive than Pennsylvania's—that will further fuel the market for renewable electricity generated in Pennsylvania.

Wind energy facilities comprised of several turbines began operating in Pennsylvania in 2000 (Table 1). Spurred on by state initiatives for renewable energy and topographic advantages in the form of ridgetops where winds are strong and reliable, the industry has developed rapidly and growth is expected to continue. In August 2008, the Associated Press reported that the Pennsylvania Department of Environmental Protection (DEP) had approved plans for the state's largest wind power development on the border of Tioga and Bradford counties; as has become somewhat routine, the project was challenged by a local group (AP, 2008).

Wind energy projects in the state are increasing in size, and can encompass thousands of acres. Turbines themselves occupy a small percentage of the area used. For example, the National Renewable Energy Laboratory website features a Windfarm Area Calculator[1] that assumes an individual turbine footprint of between 0.25 and 0.5 acres. The majority of project areas are consumed by inter-turbine spacing, land use buffers, access roads, and other infrastructure. Turbine heights are also on the rise, and now commonly exceed 300 feet from the base to the tip of the vertically extended blade.

With few exceptions, such as wetlands, the regulation of wind energy facility siting on private lands in Pennsylvania falls under local jurisdiction (DCNR, 2006). Local governments possess the power and responsibility to plan for land use and its regulation under the Munici-

Table 1: Existing wind power developments in Pennsylvania, 2008 (Adapted from AWEA, 2008)

Development	Year Online	County	Municipality(ies)	Turbines	Power Capacity (MW)
Humboldt Industrial Park	1999	Luzerne	Hazleton	2	0.13
Green Mountain Wind Farm	2000	Somerset	Summit Twp., Garrett	8	10.4
Mill Run Power Project	2001	Fayette	Springfield Twp., Stewart Twp.	10	15
Somerset Wind Power Project	2001	Somerset	Somerset Twp.	6	9
Meyersdale	2003	Somerset	Summit Twp.	20	30
Waymart Wind Farm	2003	Wayne	Canaan Twp., Clinton Twp.	43	64.5
Locust Ridge Wind Farm	2006	Schuylkill	Mahanoy Twp.	13	26
Bear Creek	2006	Luzerne	Bear Creek Twp.	12	24
Casselman Wind Project	2007	Somerset	Summit Twp., Black Twp., Addison Twp.	23	34.5
Allegheny Ridge Wind Farm	2007	Cambria / Blair	Portage Twp., Washington Twp., Cresson Twp./ Greenfield Twp., Juniata Twp.	40	80

[1] http://www.nrel.gov/analysis/power_databook/calc_wind.php.

palities Planning Code. However, local officials may be ill-equipped to manage the unique challenges of wind energy proposals. DEP issued a model ordinance for wind energy facilities intended to protect public health, safety, and welfare, but the model ordinance does not address wildlife considerations (DEP, 2006). Prompted by a growing awareness of the potential for conflicts between wind energy and wildlife, the U.S. Fish and Wildlife Service issued a set of guidelines (USFWS, 2003); however, the document lacks regulatory authority on private lands where Pennsylvania's existing commercial wind turbine developments are located. Although some local jurisdictions in Pennsylvania have adopted ordinances addressing wind energy safety, nuisance, and decommissioning issues, none had targeted wildlife interests during the time of this research.

State agencies have taken steps to address wind power and wildlife conflicts but they do not fully address local planning needs. The Pennsylvania Game Commission issued wind energy review guidelines for state game lands to ensure that recreational and habitat values receive highest priority and "better than equal" compensation if projects are approved. In April 2007, the Game Commission signed a voluntary agreement with 12 companies to help safeguard wild resources on private lands (Pennsylvania Game Commission, 2008). The Pennsylvania Wind and Wildlife Collaborative (PWWC), spearheaded by the Pennsylvania Department of Conservation and Natural Resources (DCNR), seeks to develop principles and practices to address risks to wildlife and habitat from wind power development; as of the publication of this research, however, it has not produced guidelines applicable by local governments.

Local officials lacking the resources to manage wind turbine developments in a comprehensive and consistent manner are heavily reliant on advice given by project proponents. Greatly needed are tools accessible to the nonspecialist to quickly screen for potential wind energy-wildlife conflicts and plan accordingly. More informed, objective decision-making regarding appropriate areas for wind turbines would ultimately improve the prospects for wind energy in Pennsylvania. Indeed, current grass roots resistance to proposed wind energy developments in the state is arising, in part, out of environmental concerns not addressed by local regulatory structures (Bourg, 2007 and SOAR, 2008).

Threats to Wildlife from Wind Energy Developments

Wildlife—notably migratory birds and bats—is vulnerable to collisions with turbine blades (USGAO, 2005). Furthermore, habitat fragmentation and loss affect a broad spectrum of plants and animals. Pennsylvania's north central forested areas support the highest diversity of birds and mammals (Yahner, 2003), and much of the state's remaining intact forest is found along ridges avoided by previous forms of land development. Wind energy brings new and novel risks to more natural and often isolated landscapes that play a critical role in supporting Pennsylvania wildlife.

Bird Impacts

Multiple studies (Hunt, 1997; Orloff and Flannery, 1992, 1996; and Smallwood and Thelander, 2004) at the Altamont Wind Resources Area (AWRA) in California have reported a high number of raptor deaths per year, including 75 to 116 Golden Eagles, 209 to 300 Red-tailed Hawks, and 73 to 333 American Kestrels. Constructed during the 1980s, the facility predates design features incorporated elsewhere to address aesthetic and ecological concerns. AWRA serves as a worst-case scenario and has helped spark close scrutiny of wind energy facilities. In a contrasting example (Osborn et al., 2000), researchers observed less evidence of harm to birds at the Buffalo Ridge facility in southwest Minnesota; here only seven fatalities from collisions were found during a 20-month period. Evidence at Buffalo Ridge suggests that birds adjust their flight patterns to avoid turbines (Osborn et al. 1998). However, true comparisons among existing studies remain problematic due to inconsistent methods (Kulvesky et al., 2007). Bird mortality rates from wind turbines generally lag behind those caused by collisions with vehicles, windows, communication towers, and power lines (Erikson et al., 2001). Yet it is important to note that concerns over avian mortality reflect quality as well as quantity; any loss of neotropical migrants or protected birds is cause for concern because these populations are already stressed by habitat loss and other impacts (Johnson et al., 2002). Numerous factors, such as bird abundance, presence of migration corridors, areal extent, topography, and prey abundance, can all influence the potential for avian mortality at a wind power facility (Nelson and Curry, 1995).

For raptors, the specific relationship among flight behavior, topography, and wind movement is central in determining potential fatalities at any wind energy facility (Hoover and Morrison, 2005). The mortality of griffon vultures within wind energy facilities in the Strait of Gibraltar in Spain was found to be related to the interaction between wind and topography (Barrios and Rodriquez, 2004). At AWRA, topography, wind patterns, and prey at the site were all contributors to red-tailed hawk fatalities (Hoover and Morrison, 2005). In Appalachia, it is known that raptor migration is often concentrated along higher elevations, such as ridge-tops and the edges of plateaus, where updrafts from deflected surface winds are present (Mueller and Berger, 1967). These favorable locations for wind energy, if developed, pose a potential hazard for migrating raptors. Use of Appalachian ridges during spring and fall migration is poorly understood, however, and more research is needed.

Bat Impacts

Bats account for nearly a quarter of all mammal species, yet they are poorly studied. They are exceptionally vulnerable because of their low reproductive rates and limited ability to recover from population clashes (Barclay and Harder, 2003). Bat collisions with television towers and other human-made structures are well documented (Crawford and Baker, 1981), but clear evidence of collisions at wind energy facilities emerged more recently (Osborn et al., 1996). Migratory and tree-roosting bat species appear to be most at risk (Horn et al., 2008). The cumulative impacts of wind energy development could significantly increase bat mortality, particularly along the forested ridges of Appalachia (Tuttle, 2004). Arnett et al. (2005) studied two ridge-top wind energy facilities, the Meyersdale Wind Energy Center in Pennsylvania and the Mountaineer Wind Energy Center in West Virginia, for impacts to bats. A total of 262 and 398 bat fatalities were recorded in a six-week period at the Pennsylvania and West Virginia sites, respectively. These numbers are among the highest ever recorded and support the researchers' contention that forested ridges are locations of especially high risk for bat fatalities at wind facilities, where bats may be attracted to the turbines. The mechanisms behind turbine-related bat fatalities are poorly understood; Kunz et al. (2007) identified 11 different variables worthy of investigation, including attractive prey and habitat features at turbine sites, wind speed effects, and physiological traits of bats that leave them vulnerable or unable to detect threats from turbines. Very recent evidence suggests trauma related to air pressure changes is a factor (Baerwald et al., 2008).

Forest Fragmentation and Habitat Impacts

Habitat impacts specifically resulting from the construction of wind energy facilities have not been extensively studied. However, the ecological significance of habitat pattern and its alteration through fragmentation by human activities has been widely researched (Forman, 1995, provides a comprehensive overview). For example, in a recent study, Chambers (2008) observed a preference among salamanders for breeding sites away from a logging road in south-central Pennsylvania. While turbines themselves are the most prominent features of a development, they rest on pads and are linked by roads and power lines that alter the landscape. Indeed, habitat fragmentation from this associated infrastructure is potentially more damaging than direct impacts from turbine collisions (Kuvlesky et al., 2007).

Fragmentation by roads and other activities causes several "edge effects" that can extend hundreds of yards into the interior of a habitat (Forman and Deblinger, 2000). These include greater light intensity, increased temperature, decreased moisture, decreased leaf litter accumulation, altered species abundance and composition, and a decreased nesting success rate among some songbirds (WPC, 2005). Additionally, roads can serve as pathways for the spread of invasive exotic species (Trombulak and Frissell, 2000).

Legally Protected Species

Apart from ecological concerns are legal concerns for municipalities and developers stemming from the federal Endangered Species Act (ESA) and Pennsylvania's own Wild Resources Conservation Act (WRCA). Under both the ESA and WRCA, lists of species deemed to be endangered or threatened are maintained. Endangered species are those in danger of extinction throughout most or all of their range. Threatened species are those likely to become endangered. The ESA was passed in 1973, and shortly thereafter, the Pennsylvania General Assembly empowered the Game Commission to adopt and expand the federal list as the state list. Damage caused to species ("taking" in legal terminology) on either list carries the potential for fines and/or imprisonment. It should be noted, however, that no wind energy facility has been prosecuted for violation of these acts (GAO, 2005).

Today there are far more state endangered and threatened species than federal ones. Only nine federally listed species are presently known to occur in the state, including three mussels, two plants, two mammals, one reptile, and one fish. Of these, the Indiana Bat is of most concern with respect to wind power facilities. Bald eagles were recently de-listed from the federal list, but remain on the state list; they are also subject to additional protection under the Bald and Golden Eagle Protection Act. The state list includes hundreds of species, the majority of which are plants. Casual inspection of distribution maps for protected species indicates that the general ranges occupied by many of the listed flora and fauna overlap areas of commercially viable winds along the state's ridges.

A GIS Approach

A computer-based geographic information system (GIS) possesses mapping and database management capabilities that enable rapid analysis and presentation of spatial information. Geographically-referenced data, such as road segments, local government boundaries, and elevation points, are stored in layers that may be displayed in maps or related mathematically to generate new variables, such as roads crossing steep slopes in a specific county. GIS techniques are employed in a variety of land use contexts, including wind energy development (Wisconsin Department of Natural Resources, 2004; and Rodman and Meentemeyer, 2006). GIS data representing wind speeds and natural habitat in Pennsylvania do not currently exist together in a format readily accessible by local officials, hampering effective planning and increasing the likelihood of conflicts arising from wind development proposals.

PNHP data collected through the state Natural Heritage

Inventory (NHI) are publicly available in GIS form as Natural Heritage Area (NHA) polygons. The polygons represent habitat buffers surrounding species point observations. (The original points and the species they represent are restricted information.) They carry four general designations (WPC, 2005):

- Biological Diversity Areas (BDAs) containing plants or animals of special concern at state or federal levels, exemplary natural communities, or exceptional native diversity.
- Landscape Conservation Areas (LCAs), large contiguous areas that are important because of their size, open space, habitats, and/or inclusion of one or more BDAs. These typically have not been heavily disturbed and thus retain much of their natural character.
- Important Bird Areas (IBAs) meeting one of several criteria developed by the Ornithological Technical Committee of the Pennsylvania Biological Survey. The Pennsylvania Audubon Society administers the state's IBA Program and defines an IBA as "a site that is part of a global network of places recognized for their outstanding value to bird conservation."
- Important Mammal Areas (IMAs), nominated under the Important Mammal Areas Project (IMAP) being implemented by a broad alliance of sportsmen, conservation organizations, wildlife professionals, and scientists. These must fulfill criteria developed by the Mammal Technical Committee of the Pennsylvania Biological Survey.

The county-based NHIs are undertaken by scientists, including volunteers and employees of the Western Pennsylvania Conservancy (WPC) and the Nature Conservancy, with the purpose of "provid[ing] current, reliable, objective information to help inform environmental decisions," and "guid[ing] conservation work and land use planning, ensuring the maximum conservation benefit with the minimum cost." The inventories cover nearly all of the state's counties, including those with wind speeds sufficient for commercial development. The data are frequently historical in nature, and often originate from public lands—participation by private landowners is voluntary. The NHIs offer the best available body of current ecological data, and are used by state agencies for tasks, such as National Pollutant Discharge Elimination System (NPDES) stormwater permit reviews. Natural heritage information, when combined with wind speed data, can provide a means of assessing the potential for conflicts between wildlife management and wind energy land use objectives.

Goals and Objectives

This research, conducted in 2008, was undertaken to model where conflicts between ecologically significant areas and wind energy developments in Pennsylvania are likely to occur. Furthermore, the model was intended to function as a means of prioritizing concerns among these areas of conflict. Objectives centered around the application of GIS techniques to develop township-level maps usable for planning purposes by local officials, and around the acquisition and use of natural heritage and wind speed data.

Data Acquisition and Preparation

The first general objective was to compile a database for use in the GIS analyses. This required the purchase of wind speed data from a private vendor (AWS Truewind, LLC) and coordination with the WPC to obtain NHA data. Because the two data sets were in different, general purpose formats, they needed to be standardized and modified to serve the specific demands of the project. The U.S. Department of Energy classifies wind speed on a scale ranging from one through seven; wind speeds below Class 4 are not generally desired for commercial purposes, and were removed from the dataset.

Analysis: Data Overlays and Index Development

To relate commercial and wildlife interests displayed by the map data layers, thereby identifying areas of potential conflict, the researchers superimposed (overlaid) wind speed and NHAs. This overlay process was also needed to show the coexistence of NHAs. The researchers used the numbers and types of NHAs at a location as a basis for attributing ecological significance.

To develop an index usable for setting land use priorities, they ranked areas of overlap among wind speeds and different NHAs in a new map layer. The resulting "conflict" index was intended to communicate the level of ecological importance of areas featuring commercially desirable wind speeds.

Generation of Township Maps

To present the results from the analyses in a format suitable for use by local officials, the researchers selected Pennsylvania townships containing areas of conflict, and constructed separate map files scaled to the individual townships. They designed a legend scheme to clearly present the conflict index and added reference features to orient map readers.

User's Manual

Given the technical nature of the information presented, and the specialized procedures employed, the researchers documented their steps in creating the maps and developed a user's manual to help local officials interpret them. The manual also provides recommendations on how local officials can use the maps for planning purposes. The manual, *Using Pennsylvania Natural Heritage Program Data for Wind Energy Planning: A Manual for Townships*, is available as a separate document.

Methods

The researchers assessed the vulnerability of ecological features to wind energy development by creating an index that assigned ordinal ranks to different classes of NHA polygons and summed the intersections of the different polygon types in areas of Class 4 or higher wind speeds. The researchers used ArcGIS 9.2 software, produced by the Environmental Systems Research Institute (ESRI) and licensed to the Indiana University of Pennsylvania Department of Geography and Regional Planning SEAL Laboratory, to analyze data and create the maps.

The maps were designed as a screening tool to proactively highlight areas of concern or opportunity. They are not a substitute for more detailed site analyses once a permit application has actually been submitted.

Data

The researchers purchased the wind speed data for Pennsylvania from AWS Truewind, LLC. The data were originally developed for the U.S. Department of Energy in 2002 and revised in 2006. They represent predictions based on a model incorporating terrain and historical weather data, and have a standard error of 7 percent or less. The researchers reclassified the wind dataset to identify areas of wind speeds of 15.7 mph or greater at 164 feet (50 m) above ground. These are areas of at least Class 4 sought by wind energy developers. (For convenience, "Class 4" is used to refer to all of the reclassified areas.)

The researchers obtained the NHA polygon data from the WPC. Information concerning precise points of species occurrence is restricted; however, NHAs are corresponding habitats delineated by ecologists and suitable for land use planning. They are organized into data files as Biological Diversity Areas (BDAs), Landscape Conservation Areas (LCAs), Important Mammal Area (IMAs), and Important Bird Area (IBAs).

BDAs and LCAs are updated on an ongoing basis through county NHIs; all PNHP data used were current as of April 2008. NHAs originate from field observations by different researchers and organizations, and the above categories are not mutually exclusive. Areal overlap among different types of polygons occurs in many cases, emphasizing the importance of some locations.

Within the county-level NHI reports, NHAs are further distinguished by their level of significance, such as exceptional, high, or notable status. However, the researchers could not include these rankings in the analyses. Significance rankings for polygons were not consistently provided among the GIS files, and the size of the database prohibited manual entry of missing information from the original natural heritage inventory reports.

Table 2: Values used in conflict index rankings

Layer	Value
Core Biological Diversity Area + Class 4 wind area	100
Support Biological Diversity Area + Class 4 wind area	10
Landscape Conservation Area + Class 4 wind area	1
Important Bird Area + Class 4 wind area	1
Important Mammal Area + Class 4 wind area	1
Class 4 wind area only	0

File Conversion and Conflict Index

The researchers combined the NHA polygons with the wind data and made additional modifications to the NHA files to develop the index.

They later combined six "layers" or types of map polygons to generate the conflict index. Polygon cells were assigned values based on the layer to which they belonged (Table 2). The index was produced by summing all cell values occupying the same map space. Higher values represent a greater concentration of ecological resources, and corresponding risk if developed for wind energy.

The layer values are weightings developed under the following assumptions:

1) The information contained in the NHAs and the qualities they represent may allow one to assign higher priority to some categories than others, but they do not allow the true assessment of how much more sensitive or noteworthy one polygon type is than another. For example, habitats that are more rare or unique can be interpreted as more significant, but no all-encompassing unit of measure exists to compare value among different habitats used by birds, mammals, or other organisms. Attributing mathematical significance beyond the ordinal level is not appropriate.

2) Overlaps among the different NHA polygon types signify that some areas have been deemed significant under multiple approaches and objectives, such as bird conservation or mammal conservation. These areas should be weighted accordingly in the index.

3) A potential problem when adding multiple criteria in an index is that areas that are truly exceptional in one respect may achieve lower sums than areas that simply avoid low scores among the different critieria (Smith and Theberge, 1987). Because of their transcending importance to many species and their often undisturbed character, BDAs represent the highest conservation priority. As a generalization, the presence of a BDA should outrank any other ecological considerations when using the township conflict maps. (In practice, critical IBA and IMA features are typically captured in BDAs.) Further, Core BDAs are of higher conservation priority than Support BDAs, which act more to enhance the functions of core areas.

Following this rationale, layer values used in generating the index are intended to highlight the significance of BDAs in the map overlays. A value of 1 is assigned to map cells belonging to LCAs, IBAs, and IMAs; however, values of 10 and 100 are applied to Support BDAs and Core BDAs, respectively. Summed layer values – the index – summarizes information about the number of overlapping conservation polygon types and the presence or absence of BDAs. For example, a map area possessing a value of 102 represents the overlap of a Core BDA and two lower-ranked polygons (LCA, IMA, or IBA). A map area with a value of 13 represents the overlap of Support BDA cells with cells of the LCA, IMA, and IBA categories. A value of "0" indicates the presence of Class 4 or greater winds but no NHAs.

Map Preparation

The researchers refined the maps to show only index values for areas possessing Class 4 winds. This removed potentially useful information, as commercial wind developments also encompass roads and other infrastructure not tied to wind speeds. However, this information is available in the county-level NHI reports, and its inclusion on the maps would detract from the presentation.

Map files showing PNHP polygons (drawn from BDAs and LCAs) that contained endangered or threatened species (federal or state listing) were obtained from the WPC by special request and added to the maps in unconverted form for visual reference. They are not part of the index and are shown wherever they occur within the townships (for example, they were not edited to exclude areas outside locations of Class 4 winds).

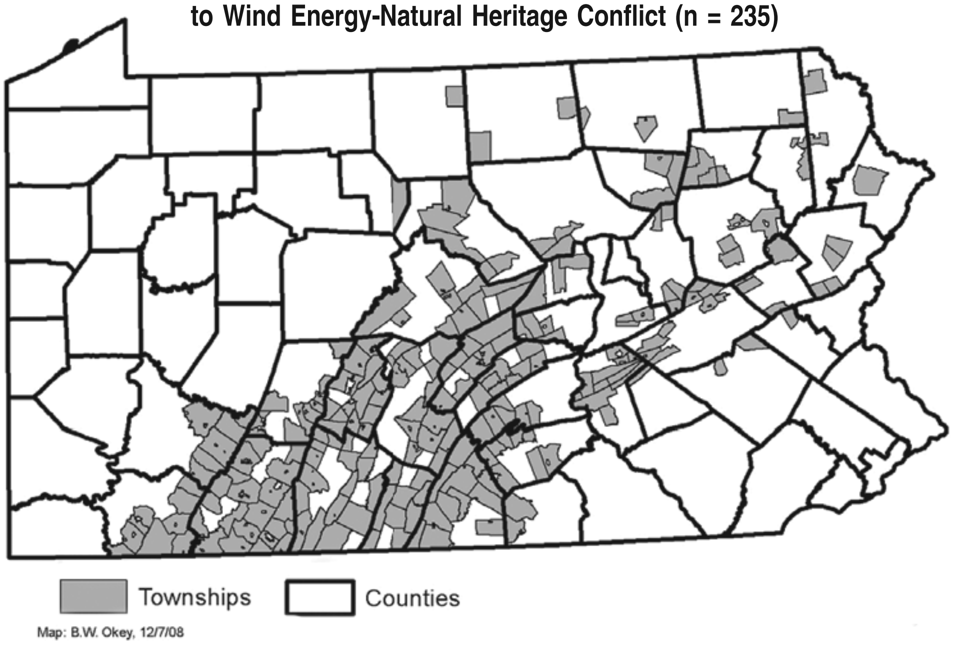
Township boundaries determined the focus of each map (areas outside were "masked"). ArcGIS map files for local government boundaries, roads, and surface water features were downloaded from Pennsylvania Spatial Data Access and incorporated. Selected prominent roads and/or streams were labeled for orientation purposes, and standard cartographic components were added. For the conflict index legend, it was possible to obtain a count of cells by index value, allowing, after conversion from square meters, the inclusion of acreages corresponding to each value on the map.

Results

The researchers identified 235 townships in 39 counties that possessed conflicts between Class 4 or greater winds and PNHP conservation areas (Figure 1) (See the Appendix for the list of townships). A description of the approach taken in creating the maps, recommendations for their use, and the maps are included in the manual, *Using Pennsylvania Natural Heritage Program Data for Wind Energy Planning: A Manual for Townships*.

More than two-thirds (158) of the mapped townships possessed no conflict-free (index value of 0) Class 4 acreage. This highlights the significance of ridges and upland areas as repositories of much of the state's remaining intact wildlife habitat. In spatial terms, both the greatest commercial potential and the greatest likelihood of ecological risks lie in the southwestern portion of the state. Of the top 20 townships in terms of total Class 4 land (range = 1,435-3,993 acres), eight are in Somerset County (Table 3). Of the top 20 townships in terms of conflict-free (index value of 0) Class 4 area (range = 376-2,241 acres), half are in Somerset County (Table 4). Neighboring Westmoreland County, however, contained six of the top 20 townships ranked by acreage of Core BDA conflict (range = 295-1,471 acres)—i.e., index values of 100 or greater (Table 5).

Figure 1: Pennsylvania Townships Vulnerable to Wind Energy-Natural Heritage Conflict (n = 235)



Conclusions

Wind speeds alone are an imperfect predictor of commercial energy sites, and this study focused on a subset of Class 4 or greater wind areas exhibiting natural heritage overlap. The researchers emphasize that no model can completely replace case by case evaluations of proposed sites. A finding of no conflict (index = 0) pertains only to overlap with habitats designated through the NHIs; other concerns, such as storm water runoff and erosion and areas impacted to access the site, also require consideration. A more sophisticated analysis would require inclusion of electric grid access, road networks, land ownership, and a host of other factors that ultimately influence location choices. The area occupied by the Green Mountain Wind Farm (Summit Township, Somerset County), for example, did not appear as Class 4 in the wind data

Table 3: Top 20 townships ranked by total Class 4 wind area (index = 0 to 103)

Rank	County	Township	Acres
1	Somerset	Allegheny	3993
2	Somerset	Shade	3815
3	Somerset	Elk Lick	3795
4	Somerset	Brothers Valley	2955
5	Blair	Antis	2878
6	Somerset	Ogle	2584
7	Somerset	Stoney Creek	2491
8	Perry	Toboyne	2305
9	Westmoreland	Ligonier	2263
10	Somerset	Greenville	2204
11	Franklin	Fannett	1989
12	Blair	Logan	1967
13	Westmoreland	Fairfield	1917
14	Bedford	Cumberland Valley	1730
15	Perry	Jackson	1687
16	Fulton	Brush Creek	1617
17	Mifflin	Armagh	1595
18	Somerset	Southampton	1571
19	Cambria	Adams	1476
20	Huntingdon	Shirley	1435

while the location of the neighboring Meyersdale facility did. However, the conflict index did highlight 16 of 17 townships where the state's existing commercial wind turbine arrays are located (Table 1). (Only Clinton Township, Wayne County, exhibited no natural heritage conflict and was thus not captured in the study.)

Many of the townships mapped possessed relatively small amounts of Class 4 area—as little as 3 acres—and thus may not arouse the interest of developers. Seventy-one townships contained less than 100 Class 4 acres, with or without natural heritage conflict, and not necessarily contiguous. The state's existing wind developments typically cover areas ranging from hundreds to thousands of acres, although only a small portion of the land is used for the turbines themselves. For example, the Somerset Wind Power Project (six turbines) occupies 400 acres, while the Meyersdale facility (20 turbines) encompasses nearly 3,000 acres. The feasibility of commercial wind developments in townships with small or fragmented apportionments of Class 4 land will be heavily influenced by other mitigating factors like land ownership and accessibility.

This research serves as a first attempt that may certainly be revised as NHIs are updated, commercial wind technology evolves, and the nature of risks to specific species is better understood. Efforts to add missing information to GIS files derived from NHIs would allow the inclusion of more criteria and refinements to the model. Better understanding of flyways used by transitory migrants, as opposed to resident wildlife populations more fully captured in the NHAs, could also help to improve the model and its application in land use regulation.

Policy Considerations

Policy considerations from this study center on the municipal level, where natural heritage data would be applied to zoning ordinances or other local planning mechanisms. At the state level, such efforts could be encouraged by agencies such as DEP. The DEP model ordinance represents a first step in guiding local officials, however, it could be expanded to address concerns related to habitats and vulnerable species.

For townships with existing zoning ordinances, overlay zoning could be used in the development of wind energy special purpose zones. Overlay zoning places special districts atop underlying base zones to add provisions to those zones (Gravin, 2001). These may include regulations or incentives to protect specific resources or otherwise guide development. The overlay districts may

Table 4: Top 20 townships ranked by Class 4 area with no natural heritage conflict (index = 0)

Rank	County	Township	Acres
1	Somerset	Shade	2241
2	Somerset	Brothers Valley	2191
3	Bedford	Cumberland Valley	1599
4	Blair	Logan	1359
5	Somerset	Northampton	1137
6	Somerset	Elk Lick	1033
7	Somerset	Southampton	1028
8	Blair	Greenfield	999
9	Blair	Juniata	927
10	Somerset	Stoney Creek	908
11	Cambria	Adams	788
12	Somerset	Allegheny	755
13	Somerset	Addison	672
14	Cambria	Washington	608
15	Bedford	Napier	518
16	Somerset	Ogle	507
17	Bedford	Londonderry	439
18	Cambria	Cresson	387
19	Somerset	Larimer	378
20	Cambria	Portage	376

Table 5: Top 20 townships ranked by area of Core BDA-Class 4 overlap (index = 100 to 103)

Rank	County	Township	Acres
1	Somerset	Ogle	1471
2	Westmoreland	Donegal	1198
3	Westmoreland	Ligonier	1097
4	Westmoreland	Fairfield	912
5	Perry	Toboyne	907
6	Somerset	Elk Lick	900
7	Westmoreland	Cook	684
8	Somerset	Shade	608
9	Dauphin	Middle Paxton	597
10	Fulton	Todd	505
11	Lackawanna	Jefferson	477
12	Mifflin	Armagh	465
13	Huntingdon	Dublin	457
14	Franklin	Letterkenny	447
15	Westmoreland	St. Clair	440
16	Franklin	Lurgan	386
17	Clinton	Lamar	369
18	Bedford	Londonderry	361
19	Westmoreland	Derry	316
20	Fayette	Georges	295

share base zone boundaries or they may cut across them. In 2008, among Pennsylvania jurisdictions, only Logan Township in Blair County has used the overlay zone approach specifically for commercial wind energy facilities; this followed an amendment passed by the supervisors in 2006 that was based, in part, on the DEP model ordinance.

An overlay zone derived from the conflict index could supplement DEP's model ordinance and provide a more comprehensive method for siting wind energy facilities. For example, township planners could designate commercial wind development as a permitted land use in areas possessing an index score of 0. Wind energy might be declared a conditional land use among areas with scores ranging from 1 through 13, subject to case-by-case review. Commercial wind development would be prohibited in Core BDAs featuring scores of 100 through 103. Such a strategy would allow for development yet remove areas of greatest ecological concern from consideration. It would also require administrative commitment. Staff, technical abilities, and financial resources are necessary to create a wind energy zone and maintain a GIS database of current natural heritage data. Conditional use areas require a review process, perhaps based on the U.S. Fish and Wildlife Service (2003) guidelines. Post-construction wildlife impact studies also need to be considered.

Townships lacking a zoning ordinance might still use the conflict maps as a basis for establishing setbacks in wind energy ordinances. In this application, setback distances would increase with the conflict index score. Wind developments might be required to locate at least 1,000 feet away from areas with values ranging from 100 to 103, whereas development might be permitted beyond 500 feet from areas of moderate conflict. No setbacks would be required for areas scoring 0 on the index. Consultation with NHI staff and other scientists would aid in ensuring that distances used reflected local ecological concerns. Currently, a wind energy ordinance in Tyrone Borough, Blair County, employs a 2,000-foot setback from natural heritage and other resource areas.

The above measures, though focused locally, have potential for cumulative benefits at the regional and state levels if consistently applied. Ecologically significant areas frequently transcend political divisions. Continuing discussions among state resource management agencies, such as DEP, DCNR, the Game and Fish and Boat commissions and townships, would help establish common standards throughout adjoining jurisdictions. Ultimately, more comprehensive land use planning that protects ecological assets in Pennsylvania's rural uplands can help wind energy live up to its green potential.

References

Arnett, E.B. (2005). *Relationships Between Bats and Wind Turbines in Pennsylvania and West Virginia: An Assessment of Bat Fatality Search Protocols, Patterns of Fatality, and Behavioral Interactions with Wind Turbines. A Final Report Submitted to the Bats and Wind Energy Cooperative*. Austin, TX: Bat Conservation International.

Associated Press (AP) (2008, August 2). "Wind Power Project Gets OK from State." *The Indiana Gazette*, p. 3.

American Wind Energy Association (AWEA) (2008). *U.S. Wind Energy Projects.* http://www.awea.org/projects/Default.aspx (last accessed 15 September 2008).

Baerwald, E.F., G.H. D'Amours, B.J. Klug, and R.M.R. Barclay. (2008). "Barotrauma Is a Significant Cause of Bat Fatalities at Wind Turbines." *Current Biology* 18:R695-R696.

Barclay, R. and L. Harder. (2003). "Life Histories in Bats: Life in the Slow Lane." In *Bat Ecology*. pp. 209-253. Chicago: The University of Chicago Press.

Barrios, L. and A. Rodriquez. (2004). "Behavioral and Environmental Correlates of Soaring-Bird Mortality at On-Shore Wind Turbines." *Journal of Applied Ecology* 41:77-81.

Bourg, A. (2007, May 27). "Shaffer Mountain Turbine Fight Taken to Web." *Altoona Mirror*, pp. A1, A11.

Chambers, D.L. (2008). "Logging Road Effects on Breeding-Site Selection in *Notophthalmus Viridescens* (Red-spotted Newt) and Three Mmbystomatid Salamanders in South-Central Pennsylvania." *Northeastern Naturalist* 15:123-130.

Crawford, R.L. and W.W. Baker. (1981). "Bats Killed at a North Florida Television Tower: A 25-Year Record." *Journal of Mammology* 62:651-652.

Erikson, W.P., G.D. Johnson, M.D. Strickland, D.P. Young, J.A. Sernka, and R.E. Good. (2001). *Avian Collisions with Wind Turbines: A Summary of Existing Studies and Comparisons to Other Sources of Avian Collision Mortality in the United States.* National Wind Coordinating Committee: Washington, DC.

Forman, R.T.T. (1995). *Land Mosaics: The Ecology of Landscapes and Regions*. Cambridge, U.K.: Cambridge University Press.

Forman, R.T.T. and R.D. Deblinger. (2000). "The Ecological Road-Effect Zone of a Massachusetts (USA) Suburban Highway." *Conservation Biology* 14: 36-46.

Gravin, E. (2001). "Making Use of Overlay Zones." *Planning Commissioners Journal* 43:16-17.

Hoover, S.L. and M.L. Morrison. (2005). "Behavior of Red-tailed Hawks in a Wind Turbine Development." *Journal of Wildlife Management* 69:150-159.

Horn, J.W., E.B. Arnett, and T.H. Kunz. (2008). "Behavioral Responses of Bats to Operating Wind Turbines." *Journal of Wildlife Management* 72:123-132.

Hunt, G. (1997). *A Population Study of Golden Eagles in the Altamont Pass Wind Resource Area: Second-Year Progress Report.* Prepared by Predatory Bird Research Group, Santa Cruz, CA for the National Renewable Energy Laboratory, Golden, CO. Publication NREL SR-440-230-87.

Johnson, G.D., W.P. Erickson, M.D. Strickland, M.F. Shepherd, and S.A. Sarappo. (2002). "Collision Mortality of Local and Migrant Birds at a Large-Scale Wind-Power Development on Buffalo Ridge, Minnesota." *Wildlife Society Bulletin* 30: 879-888.

Kunz, T.H., E.B.Arnett, P.E. Wallace, A.R. Hoar, G.D. Johnson, R.P. Larkin, M.D. Strickland, R.W. Thresher, and M.D. Tuttle. (2007). "Ecological Impacts of Wind Energy Development on Bats: Questions, Research Needs, and Hypotheses." *Frontiers in Ecology and the Environment* 5:315-324.

Kuvlesky, W.P., L.A. Brennan, M.L. Morrison, K.K. Boydston, B.M. Ballard, and F.C. Bryant. (2007). "Wind Energy Development and Wildlife Conservation: Challenges and Opportunities." *Journal of Wildlife Management* 71:2487-2498.

Mueller, H.C. and D.D. Berger. (1967). "Wind Drift, Leading Lines, and Diurnal Migration." *Wilson Bulletin* 79:50-63.

Nelson, H.K. and R.C. Curry. (1995). "Assessing Avian Interaction with Wind Power Development and Operation." *Transactions of the North American Wildlife and Natural Resource Conference* 60:266-277.

Orloff, S. and A. Flannery. (1992). *Wind Turbine Effects on Avian Activity, Habitat Use, and Mortality in Altamont Pass and Solano County Wind Resources Areas.* Prepared by BioSystems Analysis, Inc., Tiburon, CA for the California Energy Commission, Sacramento.

Orloff, S. and A. Flannery. (1996). *A Continued Examination of Avian Mortality in the Altamont Pass Wind Resource Area*. Prepared by BioSystems Analysis, Inc., Tiburon, CA for the California Energy Commission, Sacramento.

Osborn, R.G., C.D. Dieter, K.F. Higgins, and R.E. Usgaard. (1998). "Bird Flight Characteristics Near Wind Turbines in Minnesota." *American Midland Naturalist* 139:29-38.

Osborn, R.G., K.F. Higgins, C.D. Dieter, and R.E. Usgaard. (1996). "Bat Collisions with Wind Turbines in Southwestern Minnesota." *Bat Research News* 37:105-107.

Osborn, R.G., K.F.Higgins, R.E. Usgaard, C.D. Dieter, and R.D. Neiger. (2000). "Bird Mortality Associated with Wind Turbines at the Buffalo Ridge Wind Resource Area, Minnesota." *American Midland Naturalist* 143:41-52.

Pennsylvania Department of Conservation and Natural Resources (DCNR) (2006). *Local Land Use Controls in Pennsylvania as They Relate to Wind Farm Development.* Harrisburg, PA: DCNR.

Pennsylvania Department of Environmental Protection (DEP) (2006). *Model Ordinance for Wind Energy Facilities.* www.depweb.state.pa.us/energy/lib/energy/docs/wind_model_ordinance_draft_(12-8-06).doc (last accessed 13 September 2008).

Pennsylvania Game Commission (2008). *Game Commission Wind Energy Voluntary Cooperative Agreement*. http://www.pgc.state.pa.us/pgc/cwp/view.asp?a=483&q=171755 (last accessed 15 September 2008).

Rodman, L.C., and R.K. Meentemeyer. (2006). "A Geographic Analysis of Wind Turbine Placement in Northern California." *Energy Policy,* 34(15):2137-2149.

Save Our Allegheny Ridges (SOAR) 2008. *Save Our Allegheny Ridges.* http://www.saveouralleghenyridges.com/ (last accessed 15 September 2008).

Smallwood, K.S. and C.G. Thelander. (2004). *Developing Methods to Reduce Bird Mortality in the Altamont Pass Wind Resource Area.* Public Interest Energy Research Program, Final Project Report 500-04-052, prepared for the California Energy Commission.

Smith, P.G.R. and J.B. Theberge. (1987). "Evaluating Natural Areas Using Multiple Criteria: Theory and Practice." *Environmental Management* 11:447-460.

Trombulak, S.C. and C.A. Frissell. (2000). "Review of Ecological Effects of Roads on Terrestrial and Aquatic Communities." *Conservation Biology* 14:18-30.

Tuttle, M. (2004). "Wind Energy and the Threat to Bats." *Bats* 22:4-5.

U.S. Fish and Wildlife Service (USFWS) (2003). *Interim Guidelines to Avoid and Minimize Wildlife Impacts from Wind Turbines.* Washington, D.C.: USFWS.

U.S. Government Accountability Office (USGAO) (2005). *Wind Power: Impacts on Wildlife and Government Responsibilities for Regulating Development and Protecting Wildlife.* Publication GAO-05-906. Washington, D.C.: GAO.

Western Pennsylvania Conservancy (WPC) (2005). *Somerset County Natural Heritage Inventory.* Pittsburgh, PA: Western Pennsylvania Conservancy.

Wisconsin Department of Natural Resources. (2004). *Considering Natural Resource Issues in Windfarm Siting in Wisconsin: A Guidance.* Wisconsin Department of Natural Resources: Madison, WI.

Yahner, R.H. (2003). "Terrestrial Vertebrates in Pennsylvania: Status and Conservation in a Changing Landscape." *Northeastern Naturalist* 10:343-360.

Appendix: List of Townships Possessing Conflicts Between Class 4 or Greater Winds and PNHP Conservation Areas

ADAMS: Franklin, Hamiltonban

BEDFORD: Colerain, Cumberland Valley, East Providence, Hopewell, Juniata, Kimmel, Liberty, Lincoln, Londonderry, Monroe, Napier, Pavia, Snake Spring, Southampton, South Woodbury, West St. Clair, Woodbury

BERKS: Albany, Upper Bern

BLAIR: Antis, Blair, Catharine, Frankstown, Freedom, Greenfield, Huston, Juniata, Logan, North Woodbury, Snyder, Taylor, Tyrone, Woodbury

BRADFORD: Armenia, Monroe

CAMBRIA: Adams, Cresson, Gallitzin, Jackson, Lower Yoder, Portage, Reade, Summerhill, Upper Yoder, Washington, West Taylor

CAMERON: Grove

CARBON: Banks, East Penn, Kidder, Packer

CENTRE: Gregg, Haines, Harris, Miles, Potter, Rush, Spring, Union, Walker, Worth

CLINTON: Beech Creek, Chapman, Lamar, Noyes, Porter

COLUMBIA: Conyngham, Jackson, Locust, Roaring Creek, Sugarloaf

CUMBERLAND: Dickinson, Hopewell, Lower Frankford, Lower Mifflin, South Middleton, Southampton, Upper Frankford, Upper Mifflin

DAUPHIN: Halifax, Jackson, Jefferson, Lower Paxton, Lyken, Middle Paxton, Reed, Rush, Wayne, Williams, Wisconisco

FAYETTE: Georges, Henry Clay, North Union, Saltlick, South Union, Springfield, Springhill, Stewart, Wharton

FRANKLIN: Fannett, Greene, Hamilton, Letterkenny, Lurgan, Metal, Montgomery, Peters, Quincy, Southampton, St. Thomas, Warren

FULTON: Ayr, Belfast, Brush Creek, Dublin, Licking Creek, Thompson, Todd, Union, Wells

HUNTINGDON: Brady, Cass, Clay, Cromwell, Dublin, Franklin, Jackson, Logan, Miller, Shirley, Spruce Creek, Tell, Union, West

JUNIATA: Beale, Delaware, Fayette, Lack, Milford, Spruce Hill, Turbett, Tuscarora, Walker

LACKAWANNA: Carbondale, Jefferson

LEBANON: Cold Spring

LEHIGH: Washington

LUZERNE: Bear Creek, Butler, Dorrance, Hanover

LYCOMING: Armstrong, Limestone, Washington

MIFFLIN: Armagh, Bratton, Brown, Decatur, Derry, Granville, Menno, Union, Wayne

MONROE: Eldred, Jackson, Pocono, Ross

NORTHUMBERLAND: Coal, West Cameron, Zerbe

PERRY: Jackson, Northeast Madison, Southwest Madison, Spring, Toboyne, Tyrone

PIKE: Blooming Grove

POTTER: Hector

SCHUYLKILL: Barry, Delano, East Union, Hegins, Mahanoy, North Union, Porter, Tremont, Union

SNYDER: Beaver, Spring, West Beaver, West Perry

SOMERSET: Addison, Allegheny, Black, Brothers Valley, Conemaugh, Elk Lick, Fairhope, Greenville, Jefferson, Jenner, Larimer, Lincoln, Lower Turkeyfoot, Middlecreek, Northampton, Ogle, Shade, Somerset, Stoney Creek, Southampton, Summit

SULLIVAN: Cherry, Colley, Davidson

SUSQUEHANNA: Clifford

TIOGA: Elk, Sullivan

UNION: Hartley, West Buffalo, White Deer

WAYNE: Canaan, Preston

WESTMORELAND: Cook, Derry, Donegal, Fairfield, Ligonier, St. Clair

WYOMING: Forkston, Monroe, North Branch, Noxen

For a copy of the manual, *Using Pennsylvania Natural Heritage Program Data for Wind Energy Planning: A Manual for Townships*, and the overlay maps for the townships listed above, visit the Center for Rural Pennsylvania's website at www.ruralpa.org or call (717) 787-9555.

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