New York State Energy Research and Development Authority

Wind Power and Biodiversity in New York: A Tool for Siting Assessment and Scenario Planning at the Landscape Scale

Final Report

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Wind Power and Biodiversity in New York: An Online Tool for Siting Assessment and Scenario Planning at the Landscape Scale

Final Report

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Summary

Use of renewable energy sources is vital to providing for New York State's future energy needs and mitigating climate change and its effects on biodiversity. The nationwide growth of wind energy projects offers great potential to enable transition away from fossil fuel dependence. Renewable energy resources, including wind power, are an important part of meeting New York's goal to reduce greenhouse gas emissions by 80% by 2050.Wind power is increasingly competitive economically and produces zero air pollutant emissions.

The Nature Conservancy (the Conservancy) supports the development of renewable energy as a means of reducing carbon emissions. At the same time, the Conservancy is committed to understanding, avoiding, and mitigating the impacts of energy development on important natural resources that provide economic and environmental benefits to communities. Virtually all forms of energy production have impacts from this perspective, including renewables, which can have an even larger footprint than traditional forms of energy production. Energy and infrastructure development can result in significant alteration to habitats that include a broad array of resources and values, including wildlife, cultural resources, unique natural communities, scenic views, air quality, recreational opportunities, and water supplies for human use. This report focuses on avoiding and reducing impacts on natural habitats and wildlife.

The Conservancy is a national leader in advocating for policies and practices related to infrastructure development that avoid or reduce fragmentation of intact terrestrial habitats, such as forests and grasslands, and critical freshwater and marine ecosystems. Reducing these impacts can be accomplished by planning at a landscape scale in order to avoid, minimize, and mitigate impact on important natural resources. In addition to meeting conservation needs, landscape scale planning approaches can increase efficiency by reducing the time, costs, and complexities associated with project reviews, environmental analysis, and permitting, saving both the applicant and the regulatory agency time and money.

S.1 The Project

The Nature Conservancy, the New York Natural Heritage Program (Heritage) and the New York State Energy and Research Authority (NYSERDA) developed the Biodiversity and Wind Siting Online Mapping Tool to protect New York's biodiversity and to help New York meet its renewable energy goals.

Each partner on this project each played an important role. The New York Natural Heritage Program's mission is to facilitate conservation of New York's biodiversity by providing comprehensive information and scientific expertise on rare species and natural ecosystems to resource managers and other conservation partners. For this project, Heritage staff collated and modelled spatial habitat data and worked with the Conservancy to design the interactive mapping tool. NYSERDA provided funding for the project.

Throughout the project, the project team worked closely with a Project Advisory Committee (PAC) consisting of representatives from industry, government, and nonprofit groups. The PAC was instrumental in helping the design team consider which information was important for development, analysis, and ultimate display online. Nevertheless, all final decisions were made by the project team and NYSERDA and the final products do not necessarily represent endorsement by the PAC.

A NYSERDA study[1] conducted in 2014 found that New York has significant potential to develop wind power, both on and offshore, and that if both are developed fully, wind power could provide eight times New York's projected electrical consumption projected for 2030. As of 2013, 1,634 megawatts (MW) of onshore wind power had been developed, providing 2% of New York's electricity. A 2010 study by the New York Independent System Operator (NYISO) found that New York's grid could accept an additional 6,600 MW of wind power without compromising reliability.[2] Wind generation capacity on land has continued to grow with approximately 2,000 MW of additional capacity in the NYISO interconnection queue for 2014-2016.

However, the growth of wind energy projects in New York State has led to increased concern about the impacts of wind projects on biodiversity, including impacts resulting from collisions of birds and bats with turbine blades, and fragmentation impacts resulting from placement of turbines, access roads, and transmission lines. Minimizing these various impacts depends on appropriate siting of projects in areas less sensitive to habitat loss and fragmentation, and in areas less frequented by migrating, breeding, and wintering birds and bats.

Some relevant data for making siting decisions are readily available through other resources. However, the online tool presented here represents the first online tool and largest suite of fine-scale information related to biodiversity and energy development in New York State.

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1 NYSERDA. 2014. "Energy Efficiency and Renewable Energy Potential Study of New York State."– NYSERDA Report 14-19. https://www.nyserda.ny.gov/Energy-Data-and-Prices-Planning-and-Policy/Energy-Prices-Data-and-Reports/EA-Reports-and-Studies/EERE-Potential-Studies.aspx

2 Growing Wind – Final Report of the NYSIO 2010 Wind Generation Study - http://www.uwig.org/growing_wind_-_final_report_of_the_nyiso_2010_wind_generation_study.pdf

The primary goals of this project are to develop a new mapping tool consisting of data layers that best represent areas important for biodiversity and wind development in New York State and to improve siting and regulatory review of on-land wind power projects so that New York can meet its renewables goals and protect the state's biodiversity. Table S-1 shows the biodiversity and energy development mapping information included in the mapping tool. The complete mapping tool is available at www.ebd.mapny.info

Table S-1. Biodiversity and Energy Development Mapping Information

Data Type	Data Layers and Mapping Information
Biodiversity	• Habitat-for at-risk species. • Bat distribution and migration. • Large forested areas. • Connectivity zones among the forested blocks. • Connectivity via migrating bird stopover sites. • Stream information (resilient stream networks, floodplain complexes, higher quality streams. • Terrestrial landscape resilience.
Energy Development	• Wind power. • Existing and proposed wind turbine locations. • Elevation. • Distance to major power lines. • Marcellus Shale and Utica Shale thickness and depth.

In addition to developing and providing access to these data layers, the project team also built a method for synthesizing these layers to prioritize development and biodiversity needs and then balance these needs to identify locations with the least conflict between energy development and biodiversity conservation. The return on investment (ROI) method is an approach for synthesizing and balancing biodiversity protection and wind siting. This synthesis depends on weighting a variety of components that might be weighted or prioritized differently depending on the user. The project team used this approach to address the question of how much more on-land wind development is feasible in New York while avoiding sensitive habitats and wildlife. The data and the methods presented in this report allow users with GIS expertise to recreate these synthesis analyses for their own needs.

Using the ROI method, the project team found:

- 5,430 square kilometers (1.3 million acres) of land in New York that are both suitable for wind power development and avoid areas that are likely to have high biodiversity values. Using an estimate of 3.0 MW/km^2, this area translates to a megawatt capacity estimate of 16,300 MW (±9,000 MW) for New York's terrestrial landscape.
- New York State has the on-land capacity to develop at least three times the existing wind power in the state while avoiding areas that are likely to be sensitive habitat areas.

It should be noted, however, that these estimates do not consider other wind energy development constraints such as proximity to homes and roads.

Although the wind mapping tools make it possible to evaluate where turbines could be sited to avoid adverse impacts to habitat and wildlife, they do not eliminate the need for site-by-site analysis to examine the impacts of a particular wind development project.

S.2 Conclusion

As one of many factors in the complex process of siting energy infrastructure, biodiversity protection must be a consideration in the suitability of an area for wind development. The Biodiversity and Wind Siting Online Mapping Tool is intended to help New York meet its renewable energy goals while avoiding and minimizing impacts on sensitive biodiversity resources and to enable decision-makers to balance environmental concerns with siting wind power. Using the tool to evaluate sites can save time and money on permit reviews and can result in a more expedited review process. While initially intended to address wind power siting, the tools presented in this report are relevant to many types of energy and infrastructure development decisions.

1 Background and Introduction

Renewable energy is key to mitigating climate change and its effects on biodiversity, and wind energy is one of the most sustainable sources. However, the growth of wind energy projects in New York State has led to increased concern about its effects on biodiversity. Wind energy projects have two primary short-term impacts on biodiversity: 1) direct impacts resulting from collisions of flying organisms, particularly birds and bats, with turbine blades, and 2) indirect impacts resulting from the footprint of the turbines and associated infrastructure like roads and transmission lines.

Efforts to avoid these known and suspected impacts have been hampered by the paucity of biodiversity information assembled in an easy and digestible manner, the lack of a synthesis of this information to guide siting of wind energy projects, and the absence of a comprehensive statewide strategy for siting wind projects with input from regulatory agencies, conservation groups, and the wind industry.

Appropriate siting of projects with respect to these impacts depends largely on identifying areas less sensitive to habitat loss and fragmentation, and less frequented by migrating, breeding, and wintering birds and bats. Some relevant data for making siting decisions are readily available through tools such as the Great Lakes Wind Collaborative (GLWC) Great Lakes Wind Atlas, New York Nature Explorer, and the American Wind and Wildlife Institute (AWWI) Landscape Assessment Tool. However, no publicly available synthesis of this information exists to identify areas most sensitive to loss of biodiversity in New York. In addition, much of the available data on bird migration routes in New York, which have great potential to inform the proper siting of wind energy projects, have remained unanalyzed at appropriate spatial scales.

Planning for energy infrastructure is best done at a landscape scale to minimize impacts on important habitats and natural systems. Evaluating impacts at the scale of individual turbines is insufficient to account for the impacts to resource values of a given landscape or region. Implementing landscape-scale planning and mitigation approaches can reduce impacts, meet conservation needs, and increase agency efficiency and development costs by reducing the time and complexity of project reviews, environmental analysis, and permitting.

To address these needs, The Nature Conservancy (TNC) and the New York Natural Heritage Program (NYNHP), with funding support from NYSERDA, developed a spatial mapping tool to identify statewide biodiversity priorities using the most comprehensive biodiversity data available. The tool brings these priorities together with multiple data layers representing wind project suitability, and creates a set of example scenarios for using a custom mapping tool. This comprehensive tool represents the first of its kind specific to New York. This report describes the project structure, an overview of what was produced, guidance for using the online mapping tool, and approaches for additional analyses for supporting energy development and biodiversity conservation.

1.1 Project Advisory Committee

The project benefited greatly from the involvement of a Project Advisory Committee (PAC). PAC members were recruited individually and consisted of 23 representatives of 19 industry, government, and nonprofit groups (see Table 1).

The project team conducted a series of webinars for the PAC; each consisted of a presentation updating the committee on our progress (seven webinars) or describing the technical details of our approach (four webinars), followed by discussion.

PAC members had varying levels of involvement throughout the project; some PAC members participated in every webinar, while others rarely participated. *Note*: PAC membership and participation do not necessarily indicate endorsement of our products.

Table 1. Project Advisory Committee Members

- Adirondack North Country Association
- Adirondack Park Agency
- Alliance for Clean Energy New York
- American Wind and Wildlife Institute
- Audubon New York
- Bat Conservation International
- Cardno-Entrix
- Ecology & Environment
- EDPR
- EverPower
- Hawk Migration Association of North America
- Iberdrola Renewables
- Invenergy
- NYS Department of Environmental Conservation
- NYS Department of Public Service
- Old Bird, Inc.
- Tug Hill Commission
- US Fish and Wildlife Service
- Wildlife Conservation Society

2 Data Layers in the Online Tool

The online tool includes 31 layers that represent pre-existing and newly developed biodiversity data and models, and energy data (Table 2). The newly available biodiversity data and models are described in greater detail later in this section. The online tool is available at www.ebd.mapny.info; the data layers are also available for download from http://nynhp.org/data. Detailed step-by-step instructions on how to use many of the features of the mapping tool are provided in Appendix A.

Table 2. Biodiversity and Energy data layers in the Online Mapping Tool

Data and Models	Includes
Pre-existing biodiversity data and models	• Resilient stream networks, floodplain complexes, predicted mussel richness, and predicted aquatic macroinvertebrate richness from TNC's and NYNHP's 2011 "Freshwater Blueprint" project • Terrestrial landscape resilience from TNC's 2011 "Resilient Sites for Species Conservation in the Northeast and Mid-Atlantic Region" • Percent forest in the landscape from the National Land Cover Database • Conservation lands from the NY Protected Areas Database
New biodiversity data and models *(See below for details*.)	• Suitable habitat for at-risk species • Bat distribution and migration • Large unbroken expanses of natural land critical for the persistence of intact ecosystems • Connectivity through corridors, travel routes, and stopover sites.
Energy data	• Existing and proposed wind turbine locations from the Federal Aviation Administration • Wind power class at 50 m, as modeled by AWS Truepower • Elevation • Distance to major power transmission lines • Marcellus Shale thickness and depth to base • Utica Shale thickness and depth to base

2.1 New biodiversity data and models

Several new biodiversity layers were assembled or created for this effort. Additional details about each of the layers in the online mapping tool are available in Appendix B.

2.1.1 Suitable habitat for at-risk species

Like other kinds of development, energy development may cause habitat loss and fragmentation. Such effects on habitat may compound other threats to at-risk species, which are often already patchily distributed, in small populations, and facing significant barriers to dispersal and gene flow. Knowledge of the distributions of at-risk species is incomplete and reliance on known locations for these species may greatly underestimate their true distributions. Thus, to best assess where the most important habitat for the highest priority species occurs, a series of statewide distribution models were built for 371 rare and at-risk plants and animals tracked in the NYNHP database. Species were selected to represent a range of habitat preferences, niche breadth, and spatial distribution.

The distribution models identified areas of the state with habitat conditions similar to those where the species are known to exist. We attributed 30-m grid cells covering NY with 44 environmental variables representing land cover, development, geology, soils, and climate. Next, the environmental characteristics of cells were compared with known presence and 10,000 randomly distributed background points using Random Forest analysis. The results of this model were used to predict the probability of suitable habitat for each species, converting the continuous probability values to predicted presence or absence. Assessment and validation metrics were calculated on every model, and models failing such assessment were not included in any final products. Finally, because inclusion of hundreds of distribution models in the online tool would have been cumbersome, and conservation planning for single species is not advocated, these models were stacked to yield the predicted richness of at-risk plants and animals.

2.1.2 Bat distribution and migration

Bats are the group of species of greatest concern regarding impacts from wind development. The primary concern is collision with turbines, but the footprint of development may also cause loss of suitable habitat. Little information is available on bat migration, particularly the longer distance migrations of tree bats, and even bat distributions during the breeding season have been poorly known in New York until recently.

Models were built to help understand bat migrations and summer bat habitat in New York. First, identity and location data were extracted for six bat species from acoustical survey data obtained from NYS Department of Environmental Conservation plus other mist-net data, and built distribution models using similar methods as previously described. Second, existing data on Indiana bat and little brown bat movements from hibernacula were used to display the patterns of short-distance migration for these species.

2.1.3 Large, unbroken expanses of natural land critical for the persistence of intact ecosystems

Prioritizing large chunks of unfragmented habitat (usually larger than 10,000 acres) has been a focus of conservation efforts for years. As forests are the dominant ecosystems of Eastern North America, assessments from this region identified areas of large, unfragmented forest (matrix forest blocks) as critical for conservation. The tool displays all of New York's matrix forest blocks, including in the Great Lakes Ecoregion, which were developed as part of this project. Matrix forest blocks from the other regions were developed by The Nature Conservancy through the Ecoregional Planning process (see Anderson 2008 and http://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/edc/reportsdata/terrestrial/ecoregional/Pages/default.aspx).

2.1.4 Connectivity through corridors, travel routes, and stopover sites

Populations in isolation have a much lower probability of persisting over time. Sustaining adequate gene flow among populations as well as among habitats large enough to support dynamic responses to outside stimuli (such as weather and climate) also requires functional biological connections. In addition to the bat movement data described above, connections and corridors were evaluated in three ways. First, forest connectivity was evaluated using a graph theory approach to assess connections among matrix forest blocks and their relative contributions to larger scale conservation planning. Second, a collaboration with the Cornell Lab of Ornithology identified important stopover habitat in spring and fall for 28 migratory birds, using data available from the Avian Knowledge Network (and the eBird database within) in a rigorous modeling framework. Individual species were stacked to yield predicted richness of migratory birds statewide.

3 Examples of Data Syntheses and Finding a Balance

The number of data layers assembled for this project may seem overwhelming, and users of the online tool and those who download the data may be uncertain how best to proceed. Here an approach is offered for generating single layers that represent best locations for wind development and most important areas for biodiversity. These synthesis layers may then be compared to one another to attempt to find a balance between wind development and local biodiversity conservation. This section describes three examples of data syntheses and a comparative approach, return on investment (ROI), which weighs the benefits of an action to its costs and likelihood of success. The synthesis examples include attempts to yield spatially explicit data on 1) the "benefits" of wind development—that is, locations best suited for wind development; 2) the biodiversity-related "costs" of wind development—the locations where permitting, siting, and other costs related to biodiversity would be lowest; and 3) the "benefits" of conservation based on the biodiversity in a location.

These synthesis layers are presented as examples only and are not included in the online tool as the data available for download.

3.1 Wind priorities: environmental conditions associated with turbine locations

This section discusses the approach for developing a wind priorities GIS layer. At the outset, it was clear that different wind power companies set priorities in different ways and that what is presented here is not an attempt to replicate any specific formula for choosing the priority development sites for any specific company. Even that would not be possible without all the data inputs that others might have used.

What was possible, however, was to use the known locations for existing and proposed wind facilities to help us understand where additional future facilities might be placed. Due to various constraints, turbines have not necessarily been placed at locations with the highest wind speeds. Such constraints are wide ranging, and include factors such as land ownership, distance to existing transmission lines, and amount of forested land in the immediate vicinity. The goal was to include as many of these other factors as possible to best understand turbine development choices for New York State.

Similar analytic approaches have been conducted in other locales, including northern California (Rodman and Meentemeyer 2006), Colorado (Janke 2010), Iowa (Petrov and Wessling 2014), and the United Kingdom (Baban and Parry 2001). To the authors' best knowledge, no one else has used the random forests classifier and the wide range of environmental variables that we used in this study, although Petrov and Wessling (2014) used other machine-learning algorithms.

This approach had three steps:

1. Collecting and cleaning up the turbine location information.
2. Assembling the environmental variables.
3. Modeling the relationship between turbine locations and environmental variables.

3.1.1 Turbine location information

All tall towers must go through a permitting and registration process with the Federal Aviation Administration (FAA) and this information is made public online from the Federal Aviation Administration (https://oeaaa.faa.gov/oeaaa/external/portal.jsp).

All available "cases" data from 1990 through 9 January 2013 were downloaded. All efforts were made to include all existing and proposed turbines but exclude all other towers, including meterological towers installed as part of a wind farm. The following were removed: all turbines below 50 meters in height, a small set of proposed vertical-bladed turbines that were never installed on Long Island, and a set of proposed turbines for offshore in Lake Erie (our focus was on terrestrial development). Duplicate entries were removed by checking for redundant case ID values (ASN), redundant location coordinates, and for reported locations within 90 meters of each other.

3.1.2 Environmental variables

Nineteen environmental layers were chosen that had potential to be directly or indirectly associated with wind turbine siting. These layers included wind production capacity, elevation, slope, aspect, distance to the nearest large transmission lines, and variety of land cover, surface relief, and roughness measures (Table 3).

Table 3. Environmental data layers used to model the locations of existing wind turbines

A total of 19 layers were input into the model to evaluate their relationship with the presence of existing turbines

Group	Layer
Wind	Wind production capacity at 50 m
Elevation	Elevation
Elevation	Slope
Elevation	Aspect
Elevation	Surface relief ratio at 90, 270, 810 m
Elevation	Roughness at 90, 270, 810 m
Elevation	Terrain wetness indicator
Power	Distance to transmission
Land Cover	% developed at 30, 300, 990 m
Land Cover	Prop. Open cover at 300, 990 m
Land Cover	Prop. Forest at 300, 990 m

3.1.3 Model

The random forests algorithm (Breiman 2001) was used to model the conditions of the 19 environmental data layers at each mapped wind turbine. The statistical software R (R Development Core Team 2011) was used with installed packages randomForest (Liaw and Wiener 2002), ROCR (Sing et al. 2005), vcd (Meyer et al. 2010), abind (Plate and Heiberger 2011), RODBC (Ripley and Lapsley 2010), foreign (R Development Core Team et al. 2011), and raster (Hijmans et al. 2014). The random forests algorithm has been shown to be quite robust and accurate for this type of spatial modeling (Iverson et al. 2004, Lawler et al. 2006, Bisrat et al. 2012).

The accuracy of the model (model validation) was evaluated by testing model subsets. Specifically, a model was built with some turbine locations excluded (all turbines within groups of 10 km by 10 km squares) and then tested how accurately this model could predict the locations for those turbines left out. This process was then repeated 100 times, with the full cycle testing every turbine location ("leave-one-out"; Fielding 2002).

Once the complex relationship among environmental variables and turbine locations was encapsulated in the random forests model, that model was used to evaluate the potential suitability throughout the state for turbine siting. A GIS surface (raster layer with 30-m pixel size) was created where each cell containing a value representing the probability that the location is suitable for wind turbine development. Input data was used to determine the probability value at which pixels were classed into a "suitable" versus "not suitable" group.

3.1.4 Results and discussion

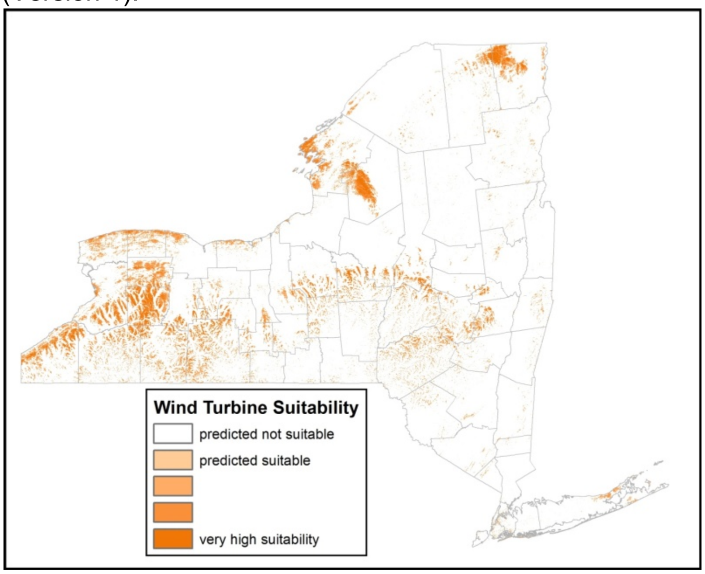
The three most important environmental layers for the model were wind production capacity, elevation, and distance to transmission lines (Appendix C). Turbines were positively associated with wind power and elevation, and negatively associated with distance to transmission (a higher probability for turbines at shorter distances to transmission lines). Turbines were positively associated with nearby development and negatively associated with the amount of forest nearby, the next two important variables.

Overall accuracy, as measured by the True Skill Statistic (Allouche et al. 2006), was 0.60, where zero is equivalent to the performance of the model being no better than random, and 1.0 equivalent to a perfect classifier. The area under the curve (AUC) was 0.88.

Using the relationships among environmental variables and turbine locations, a GIS surface was created for all of New York State that shows a prediction of the probability that the conditions are similar to those of other turbines (Figure 1). Throughout NYS, probability values (probability that a location is similar to other wind turbine sites, based on the model) ranged from 0 to 0.99. The cutoff value for determining similar versus dissimilar locations for turbines was set to 0.185, as based on the point along the ROC curve closest to the upper left corner. Statistically, this point offers the best statistical balance (between true-positives and false-positives). An alternate approach was applied to finding the cutoff by lowering the cutoff value until all turbines were captured within the similar habitat designation. This value, 0.1433, increased the amount of land predicted as similar for turbine development a little bit. Both of these approaches are discussed in the ROI section below, referring to them as Version 1 and 2, respectively.

Figure 1. Model of wind turbine distribution based on existing and proposed wind turbine locations and a suite of environmental variables

Orange locations on the map indicate locations similar to existing and proposed turbine locations (Version 1).



The model seemed to do a very good job at identifying locations similar to those where wind turbines are currently located. Output was clearly not solely a reflection of wind speed, as locations in the mountains of the Adirondacks and Catskills were not generally identified as similar. These summits are not near existing power lines or development land-use classes, for example, and thus come out as poor sites for turbine development despite the high wind speed and high elevations.

The moderate accuracy measure (TSS = 0.60) seems to be a reflection that turbines have been placed in enough variety of environmental conditions (e.g., shorelines in highly urbanized areas as well as agricultural areas far from water), some conditions could not easily be elucidated based on conditions of other sites. Thus, even though the random forests model creates multiple solutions, some localities will be missed as appropriate in the final model, particularly those that occur in locations with conditions that differ greatly from others. Also, new approaches in wind development, such as smaller turbines in a more distributed network or small turbines within cities, cannot be modeled with the input data available and thus siting for this type of development is not captured.

While not a part of the online tool, once developed, the output from this model (e.g., Figure 1) can be used as supporting information for the data layers provided by the online tool. It can help understand the current distribution of turbines across the New York landscape, and where other turbines might be placed given similar requirements for construction siting.

The focus of this project, however, is on the interface of wind development priorities (this wind turbine model) with biodiversity and conservation priorities. How these two components play together with Return on Investment scenarios are explored in the following section.

3.2 Biodiversity "costs"

A glance at the wind turbine distribution model (Figure 1) suggests that many opportunities may exist for expanding wind infrastructure. This model, however, is not a perfect representation of reality. For example, public and private lands offer varying development opportunity and local communities offer varying degrees of support for wind development.

Attempting to synthesize all the factors influencing wind development success would be extremely difficult. Indeed, approaches for siting turbines vary among developers and these methods are proprietary. Biodiversity and conservation, however, influence siting decision-making and understanding significant biodiversity issues ahead of time can help developers as they navigate the permitting and site development process. Thus, the goal with this project is to develop a method that integrates different priorities within a consistent, transparent framework so that the method can be applied by others based on their priorities and needs.

There are explicit costs with regard to biodiversity, such as those associated with extra permits, wildlife or wetland mitigation, or additional construction costs. Other external costs (such as potential biodiversity loss or degradation of ecosystem services) are more difficult to quantify and so this project focused deliberately on the biodiversity factors most related to those more direct, explicit costs. In that category are layers relating to state and federally listed species, water quality, and the amount of forest in the landscape.

In addition to choosing which GIS layers are related to wind development costs, this ROI analysis requires being explicit about how important each layer is relative to the other. Transparency in this application of layer weighting is crucial as it has the potential to greatly change the output depending on the weighting scheme. Here, each layer was weighted equally, with each continuous surface varying from zero to ten and the travel zone and bat location categories of the Indiana Bat layer to be seven and ten, respectively (Table 4).

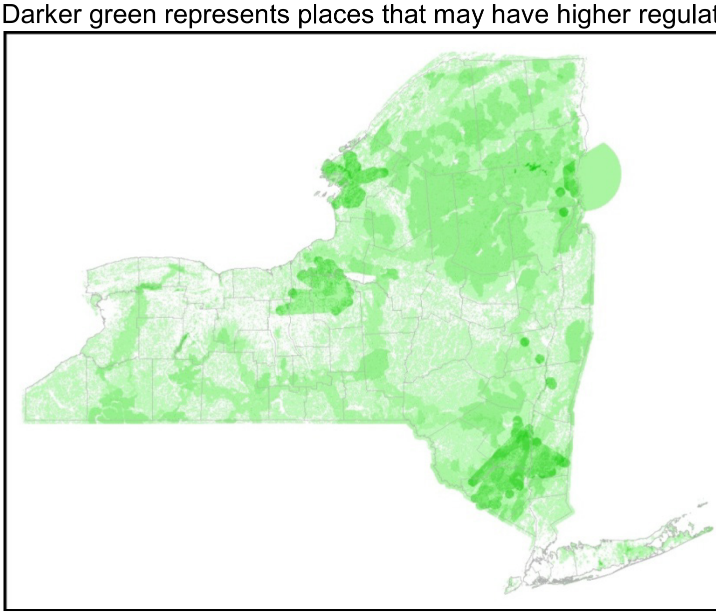
Table 4. Four layers used to develop the cost surface for the wind turbine development ROI analysis

The variable is listed first, with a short justification for the use of this layer as the second variable and then the chosen scaling as the final column.

Variable	Why	Scaling
Distribution model: State Listed Species	More state-listed species are likely to increase permit related costs	0-10
Indiana Bat hibernacula, summer roosting areas, travel zones	This federally listed species will trigger additional permitting. (0 = not in any categories, 7 = travels zones, 10 = hibernacula or roosting areas).	0,7,10
Stream quality estimate	Stream crossings require additional permits; higher quality streams like potential trout streams have special requirements; wetlands (more permits) are often associated with stream systems.	0-10
Amount of forest and forest conservation priorities	Building roads and timber harvesting increases development costs in forests; trees increase turbulence and require higher hubs.	0-10

Figure 2. Biodiversity costs for wind turbine development, based on adding together four biodiversity layers

Darker green represents places that may have higher regulatory burden for wind development activity.



3.3 Biodiversity conservation priorities

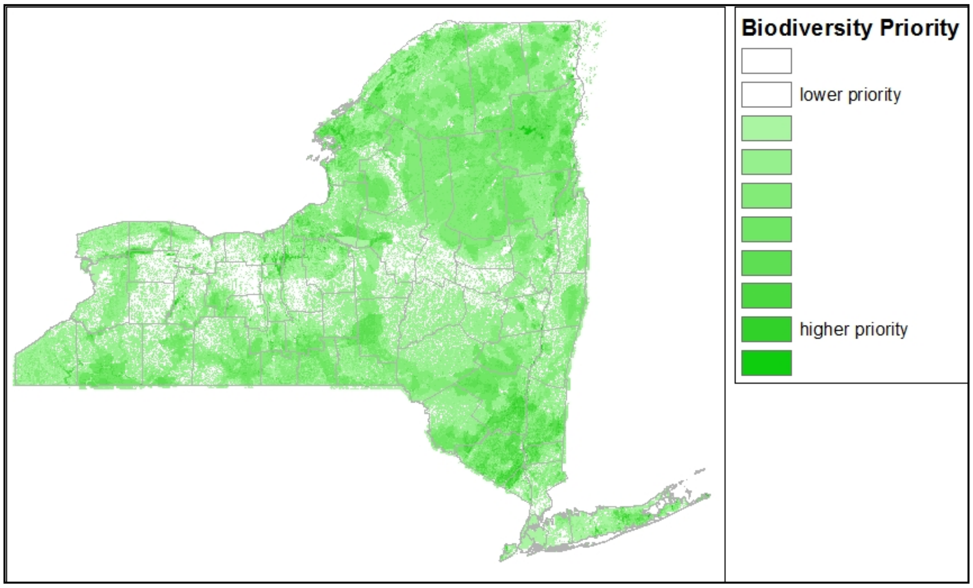
In addition to considering the biodiversity layers that may be directly attributable to wind development costs, the full suite of biodiversity information was synthesized in a way that could inform conservation priorities. To build this single conservation priorities layer, layers were rescaled based on the relative contribution (weight) each layer should provide toward a combined layer and then the 10 selected layers were simply added together (Table 5; Figure 3).

Table 5. A list of the layers used to create the biodiversity priorities layer used in the conservation priorities ROI

The first group (first three rows) scales to the maximum value of the original layer; the next group (next 5 rows) scales to a limit of five; the final group scales to 10.

Variable	Why	Scaling
Distribution model: Rare species	Higher intersections of rare species habitats increases site conservation priority	0-32
Distribution model: State-listed species	Among rarities, state-listed species receive extra points with the inclusion of this layer	0-24
Bat summer distributions	An independent estimate of summer bat distributions highlights these important species	0-3
Mussel richness	An estimate of stream quality	0-5
EPT richness	A second, independent, estimate of stream quality	0-5
Migratory birds (spring)	An estimate of important habitats for migratory birds	0-5
Migratory birds (fall)	An estimate of important habitats for migratory birds	0-5
Indiana Bat hibernacula, summer roosting areas, travel zones	A single species layer, but an important, Federally listed species	0,3,5
Floodplain complexes	The few remaining floodplains in the state offer quality ecosystem services and other conservation benefits	5-10
Forested areas	Large forested areas and connectivity zones offer myriad of conservation benefits (inside matrix forest blocks, vary by forest percent cover to create scores ranging from 8-10; inside connectivity zones between forest blocks, vary by forest cover to create scores ranging from 6-8; remaining areas in state vary by forest cover to create scores 0-6)	0-6, 6-8, 8-10

Figure 3. Biodiversity priorities for conservation with a focus on sensitivity toward wind development



3.4 Return-on-investment approach to find a balance

The approach used ROI to balance priorities. Often used in other fields, ROI has been gaining more attention in the conservation field (Murdoch et al. 2007, Underwood et al. 2008). The advantage of this approach is that it allows integration of potentially competing interests within a particular frame of reference. In the following two scenarios, ROI was applied from two frames of reference, wind development and conservation, with the goal to focus the priorities of each group within the context of the other.

3.4.1 Scenario 1: Focusing wind priorities with ROI

These scenarios follow Tear et al. (2014) with the idea that the magnitude of benefit should be tempered by known uncertainties as well as costs for achieving that benefit. Those two components are incorporated through Equation 1:

$$\mathrm{ROI} = \frac{\mathrm{Return} \times \mathrm{Probability\ of\ Success}}{\mathrm{Cost}} \qquad (1)$$

In this application of the formula, the return value is the measure of the value of a pixel in the landscape with respect to the specific priorities of the scenario. For this scenario, return would be taken from the wind turbine distribution model developed as part of this project and discussed in the previous section. The assumption is that the higher the similarity, then the better the location is for placing a turbine, in essence providing higher return.

Similarly, there are many factors that influence the probability of success at a site. Some of these factors are very hard to predict, such as the level of support or resistance among the local community or changes in real estate or residential development patterns. One factor was related to land ownership that we felt does influence development success: the level of protection for private and public lands. Thus, for the probability of success term in the formula, we used the protected lands layer, with those designated as having very high protection (such as state wilderness areas in the Adirondacks and Catskills) receiving a very low value for probability of success (i.e., GAP Status 1 = 1% probability). Properties with less protection, as defined by GAP status (http://gapanalysis.usgs.gov/blog/iucn-definitions/), received higher probability values (i.e., GAP Status 2, 3, 4 = 30, 50, and 70%, respectively) and all lands not covered with any protection status were considered to have 100% probability of success.

As the interest here is the consideration of turbine development with respect to biodiversity, the "Cost" term could range considerably based on perspective. Here, we included only the four layers that might be involved in regulatory or direct development costs, as discussed in the Biodiversity Costs section, above.

The formula for ROI in this scenario then becomes Equation 2:

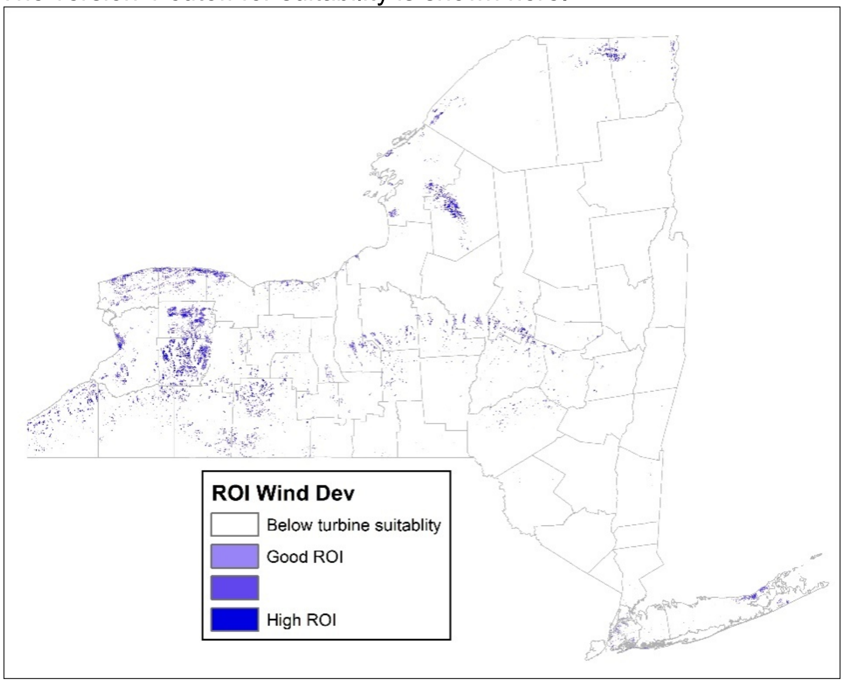
$$ROI = \frac{\text{turbine suitability} \times \text{success probability re: land protection}}{\text{potential costs related to biodiversity}} \qquad (2)$$

The final ROI output consists of a GIS surface that adjusts the turbine distribution map based on the added constraints of existing land conservation actions and biodiversity costs. It is accomplishes in a transparent way that can be modified based on individual or organizational priorities. The scenario presented here applied equal weight to amount of forest, the number of state listed species, the presence of Indiana Bat (federally listed), and stream quality.

In this scenario, the low end of acceptable return is set to be equal to the original version 1 cutoff value for the turbine distribution model. Thus, return on investment values range from 0.185 to 0.996 and locations with these return values are present in various parts of the State (Figure 4).

Figure 4. ROI results for wind development priorities while considering biodiversity constraints and land protection status

The version 1 cutoff for suitability is shown here.



Understanding how the different components of the ROI model interact to provide the final output can help demonstrate how this model works. Jefferson County, for example, showed a large decrease from the amount of suitable landscape for turbine development to the amount of landscape within a favorable ROI. The primary drivers in decreasing the suitability for this area are the rare species components of the biodiversity layers. Specifically, the high values for state-listed species and the presence of Indiana bat reduced the very high wind turbine similarity values to convert much of the landscape to less than suitable conditions. Other counties changed very little in their representation of wind turbine sites similar to existing and proposed turbines and suitable sites with ROI incorporated.

Many scenarios are possible, each with unique outcomes depending on how each component of the ROI is formulated. In this specific formulation (Version 1), the total amount of land suitable for wind turbine development, based solely on the turbine distribution model (cutoff 0.185), is 11,930 square kilometers. Using ROI as described here leaves 5,430 square kilometers (1,341,993 acres), the total area of blue in Figure 4. If the amount of suitable habitat is modified by lowering the cutoff (Version 2), the total amount of appropriate land based solely on the turbine distribution model becomes 15,252 square kilometers, with ROI reducing that number to 7,409 square kilometers.

What do these numbers mean in terms of MW of wind development potential? There are many different ways to convert available acreage to megawatts. In 2009, NREL produced a report that assessed the land-use requirements of wind development and provided estimates based on the footprints of single towers (direct impact area) all the way up to the "total area" of land used by entire wind farms (Denholm et al. 2009). For 161 projects, they found total-area capacity density to be 3.0 ± 1.7 MW/km^2. This translates to the ROI analysis providing about 16,300 MW (with a range from 7,060 to 25,525 MW considering the ± error) of total capacity in Version 1 and 22,000 MW of total capacity in Version 2.

A recent report to NYSERDA indicated that onshore nameplate capacity (registered power output for turbines) may be limited to 6,600 MW based on grid reliability (Mosenthal et al. 2014). The findings presented here suggest that New York's landscape may be able to accommodate more than double this amount while still taking into account biodiversity concerns.

3.4.2 Scenario 2: Focusing conservation priorities within the context of wind development using ROI

A benefit of applying the ROI model is the ability to apply it to different perspectives with clarity on what each component is and how these are applied. In this scenario, conservation priorities were considered based on the information gathered related to biodiversity and large forest priorities, recognizing, just as with assessing wind development priorities, that conservation priorities differ with every conservation organization and that there is no way to incorporate all components for setting priorities for all organizations. Thus, for the return portion of the ROI formula, biodiversity components were incorporated in a manner that highlighted habitats for rare species, potentially important areas for migratory species, higher quality streams, and important forest and floodplain habitats (Table 4).

The Probability of Success term in the ROI formula should reflect how successful any action would be for conserving the targets for a particular site. While many factors would contribute to true conservation success, one contributing factor is the ability of the site to withstand disturbance and other stressors. The Nature Conservancy developed a site resilience scoring that tries to address this issue (Anderson *et al.* 2012) with the assumption that sites with a higher diversity of landforms and geology types are likely to have higher resilience. This layer is used as the Probability of Success term, with it scaled from zero to one.

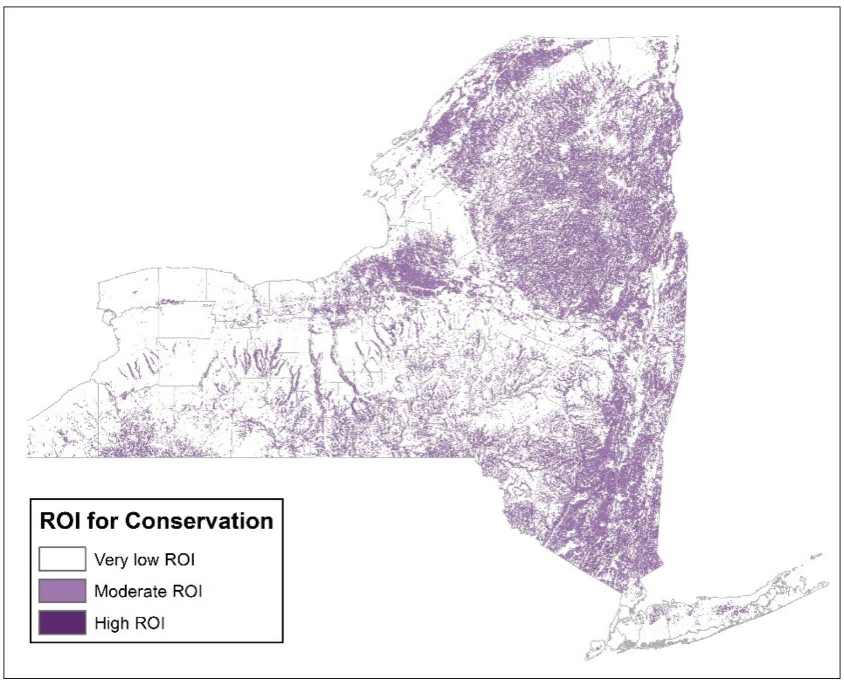
The cost term follows from the core goal of this project, that wind development in general supports conservation because of the high detrimental effects of traditional energy on ecosystems and biological diversity (e.g., Lovett et al. 2009). If the lack of alternative energy development is detrimental, then setting aside places with high potential for wind development would be a *cost* for conservation. Or, said another way, locations for conservation that do not conflict with wind development should be prioritized. Operationally, this idea translates to using the turbine distribution model (Figure 1) as the cost term in the ROI formula.

The formula for ROI in this scenario then becomes Equation 3:

$$ROI = \frac{\text{biodiversity priorities} \times \text{resilience}}{\text{turbine suitability}} \quad (3)$$

The final ROI output for this scenario focuses conservation priorities toward places with higher resilience and least conflict with wind energy development (Figure 5). Conservation priorities include elements of rare species, bird migration habitats, and higher quality stream and forest ecosystems. Understanding which conservation targets are setting the ROI priority requires delving into the details of the individual layers that formed the biodiversity priorities data set.

Figure 5. A return on investment scenario for setting conservation priorities while accommodating wind development priorities



4 Overall Conclusions and Findings

The primary goal for the online mapping tool to was to create a single portal available to the public where users could visualize, overlay, compare, and contrast mapped information related to biodiversity, conservation, and energy development. This goal was driven by the desire to ensure equal data access among all interested parties. Many of the data layers were newly developed and many have never been made available to the public in this manner. This approach is expected to reduce barriers for viewing and assessing these data.

Many of the available data layers that were newly developed for this project benefitted greatly from the input of the PAC, which was instrumental in ensuring that the layers were appropriate, adequate, and not overreaching. Data gaps were identified, however, and these are discussed in the following section. This project changed throughout its life, primarily because of interaction with the PAC. Perhaps the best example of a change in course concerns the final products initially envisioned for this project. Quite early into the project, it became clear that creating a final synthesis map showing priority wind development landscapes that minimized interference with biodiversity conservation was an impossibility. Instead, any synthesis depends on the needs and perspective of the person or organization conducting the analysis. It is more appropriate to build methods that would allow others to explore their own synthesis maps. Providing the methods and the data inputs for these methods became the primary focus.

The ROI analysis provides the method for synthesizing the input data sets. This analysis is quantitative but also relatively simple; for example, it does not require the very complex modeling approaches used in the species distribution modeling. While requiring the user to be very clear in the assumptions put into the model, it also gives the user flexibility in what goes into the model. The two scenarios previously show the flexibility of this approach. Although new analyses must be conducted by a person with GIS experience, the input data layers developed through this project are available for download to ease this process (http://nynhp.org/data).

5 Future Directions

Future iterations of the online mapping tool might be improved with the following thoughts about use of the online tool generally and additional data needs.

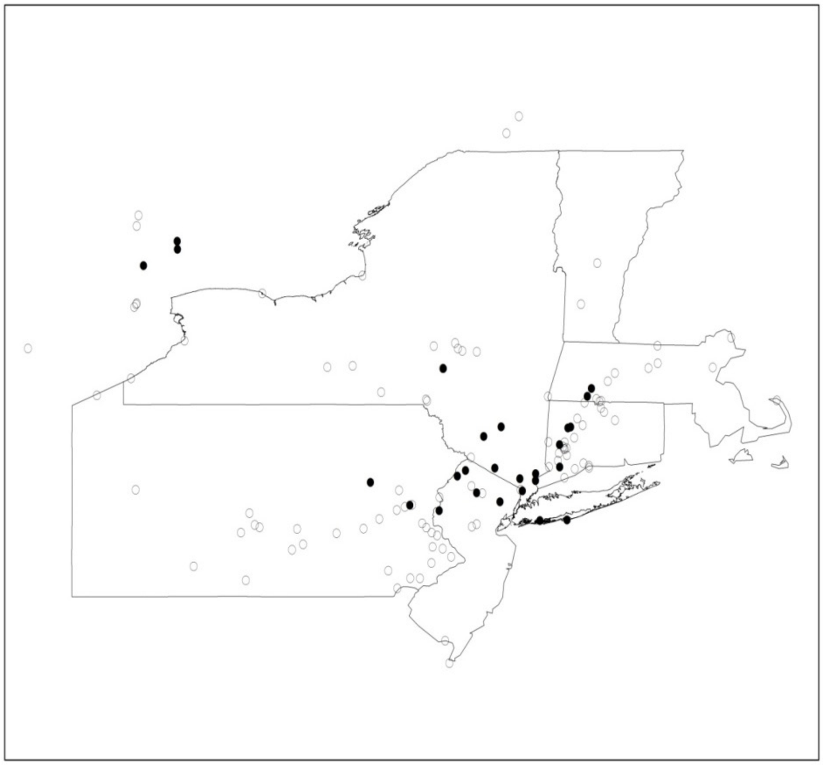
5.1 Online tool

- Allowing the synthesis of data using user-defined layer weights and tools such as ROI would allow those without GIS capacity to make maximal use of the tool.
- Other site assessment tools allow users to draw a polygon of their site. The tool then returns an analysis of what occurs within that polygon. This capability would expand the utility of this tool.

5.2 Additional data needs

An appropriate statewide data set on raptor migration (or even a data set that could be extrapolated to the whole state or otherwise modeled) could not be found. Information at HawkCount.org held promise for providing data that could be kriged or otherwise extrapolated to the whole state, especially by incorporating data from neighboring states. But as we weeded out count locations that did not have enough recent data (we retained sites with 5 years of fall count data within the last 10 years) and locations with low effort (min. of 50 observer-hours per year), we were left with a subset of 27 locations in and around NY that did not appear representative of the range of conditions in New York. In Figure 6, the circles represent all sites in the HawkCount database and the ones filled in with black represent the ones with adequate data to include in a potential modeling or extrapolation effort. All the best sites are clustered in the southern portion of New York State, with no representation in the New York portion of the Great Lakes, nor any in or near the Adirondacks. It would be hard to justify any sort of statewide extrapolation of these data. There exists an excellent dataset of migratory pathways of Golden Eagle, but access to those data could not be obtained for this tool. In addition, there is a big hole in knowledge in New York about the migration patterns and other movements of tree bats in particular. This area is prime for research.

Figure 6. HawkCount sites in NY and surrounding states



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Appendix A: Using the Online Mapping Tool

A.1 The Website

The online mapping tool is available at http://www.ebd.mapny.info . Modern versions of most browsers should be suitable for satisfactory display and use. When visiting the site, all users first encounter a disclaimer that emphasizes the intended and appropriate uses for the tool and the data contained within. These details are discussed throughout this report, but it is important to emphasize the two key points contained in the disclaimer:

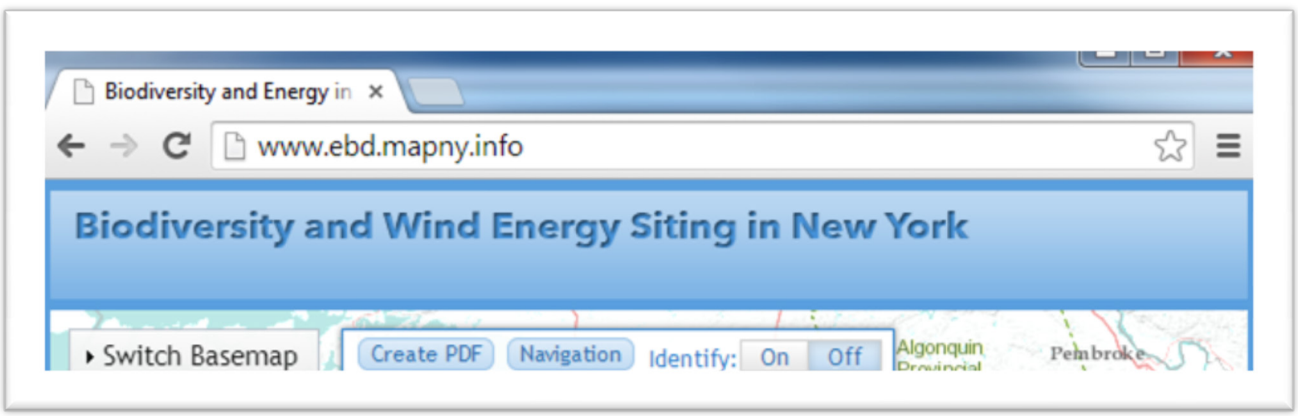
1. The tool is intended as one source of information for decision making and other information sources must be queried to ensure a full understanding of the questions being asked.
2. The data layers vary in quality, and although some may appear very fine scale in some contexts, they are intended to be used at broader, landscape scales, not necessarily for determining where individual turbines might be placed, for example.

It is critical to understand that GIS data and GIS models can be very useful, but users must exercise caution in applying them beyond the use for which they were intended. And always, data collected onsite is critical for informing any decision making.

A.2 Navigation

To orient users to the mapping interface, see the first row of buttons in Figure A-1.

Figure A-1. The top row of buttons on the mapping tool website: Switch Basemap, Create PDF Navigation and Toggle Identify



These buttons allow, from left to right, the user to:

- Switch Basemaps – click on this button and choose any of the images that appear.
- Create a PDF of the map as it is currently displayed to be saved as a file.
- Display navigation tips for moving and zooming around in the map.
- Turn on or off the ability to identify features by clicking on the map.

Below these buttons, the map initializes with two more boxes: a slider bar to facilitate zooming and a Table of Contents with map layers nesting within categories as shown in Figure A-2.

Figure A-2. The second row of frames that appears when the map first displays: Slider bar, Table of Contents

To see what layers are available for viewing on the map, click the + icon just left of the categories to expand them and show the contents.

A.3 Viewing and finding information about individual layers

Within the categories reside specific layers that can be displayed on the map as shown in Figure A-3.

Check the box to the left of the layer to turn it on or off.

Expand the layer to display a legend of how the information is displayed.

Figure A-3. When layers are turned on, another frame appears in the upper right: Visible Layer Properties

To read specifics about the layer, such as what is being displayed, the source of the layer, or how it was created, choose the layer from the dropdown box in the upper right (click on "Visible Layer Properties" and choose the layer). The bottom two buttons (Description, Metadata) provide information about the layer (Figure A-4).

Figure A-4. When a particular layer is chosen with the Visible Layer dropdown, additional information and controls for that layer appear

Clicking on "Description" pops up a window in the lower right corner containing a short explanation of what the layer is and why the layer was included in this mapping tool. Clicking on "Metadata" opens a PDF document in another tab in your browser with additional details about the layer. Equivalent details about each layer are provided in the Technical Details section of the main report.

A.4 Layer custom controls and identify functionality

A.4.1 Transparency

The transparency of each layer can be set individually with the slider in the Layer Properties dialog in the upper right corner of the map. This feature allows the viewer to see features on the base map or the outlines of other layers underneath the layer you have on.

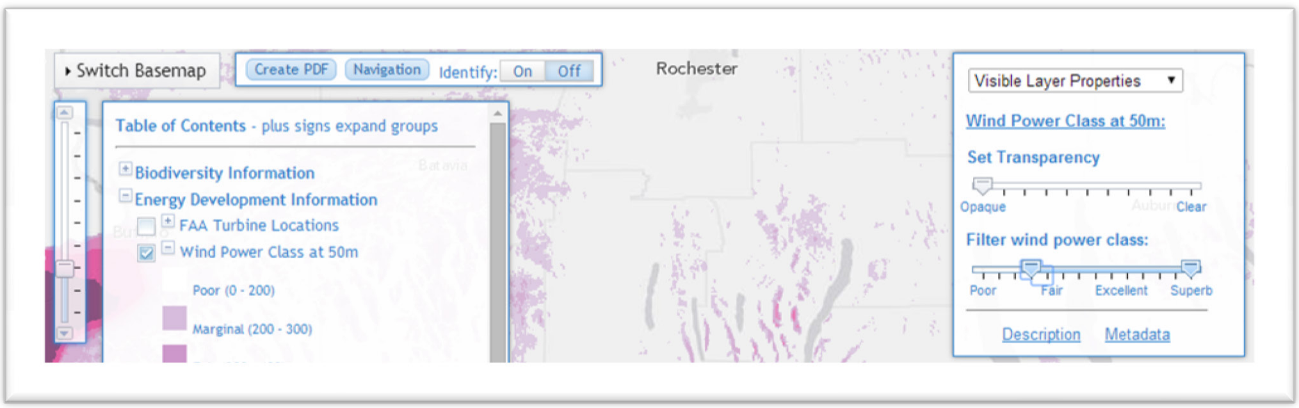
A.4.2 Filter by attribute

Two layers (Distance to Power Transmission and Wind Power Class) allow you to choose only a portion of the layer to display, based on the layer value. This functionality will appear in the Layer Properties dialog as well. For example, Wind Power Class will appear as shown in Figure A-5:

Figure A-5. Additional control of layer display is provided for some layers via the second slider in the upper right dialog box

The "Filter" slider allows you to display any contiguous subset of the wind layer. Figure A-6 shows the landscape with the lower power classes turned off.

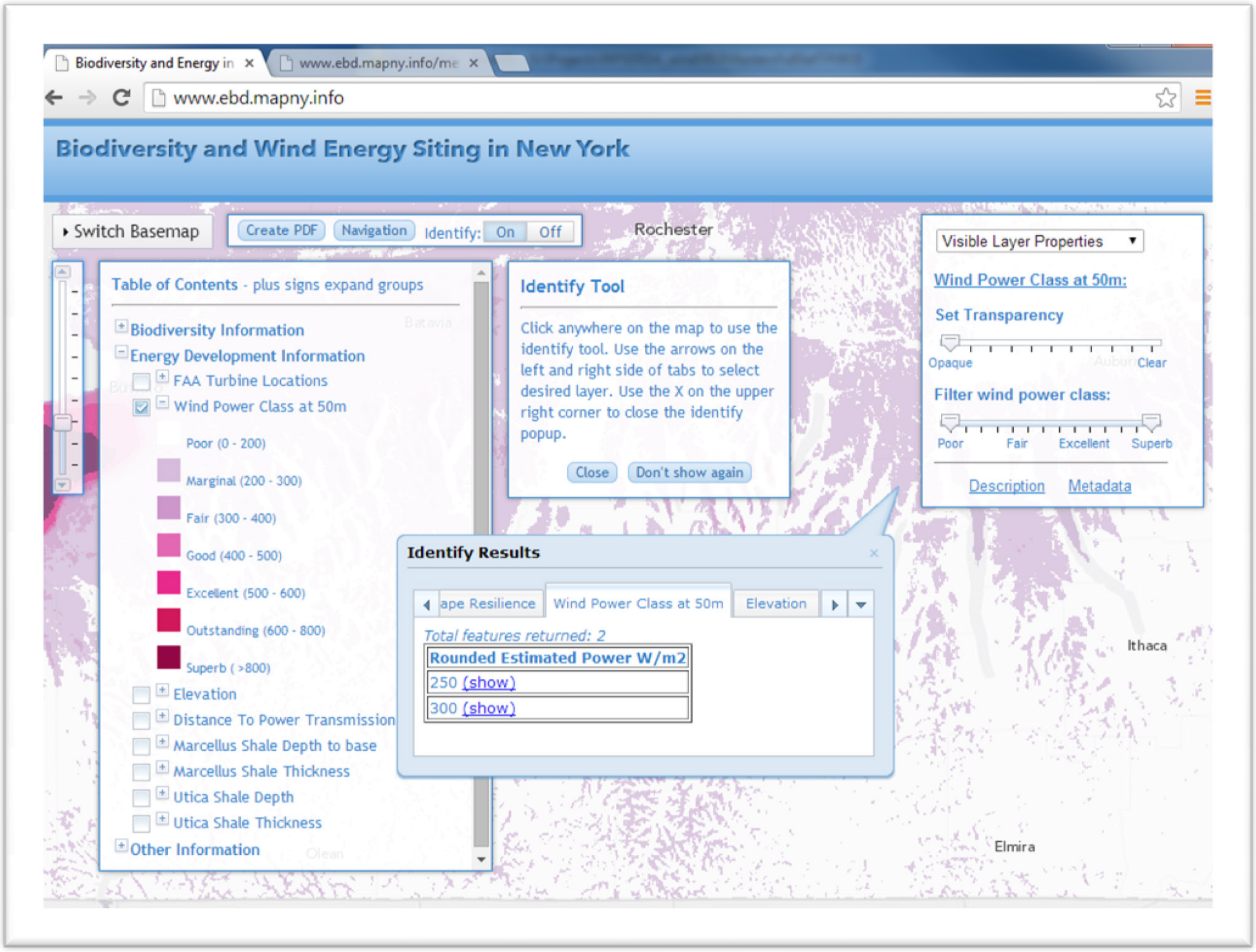
Figure A-6. An example of the additional control applied using the Filter Slider



A.4.3 Identify tool

When the Identify button is turned on, a small window with usage directions appears. This may be closed at any time. After clicking on any location in New York State, a results window appears with results for ALL layers that intersect with that location. This includes layers that are not turned on. To find the layer of interest, either scroll through the tabs with the left/right arrows or choose the layer from the dropdown button (down arrow shown in Figure A-7).

Figure A-7. How results of an 'Identify' click are displayed on the mapping tool

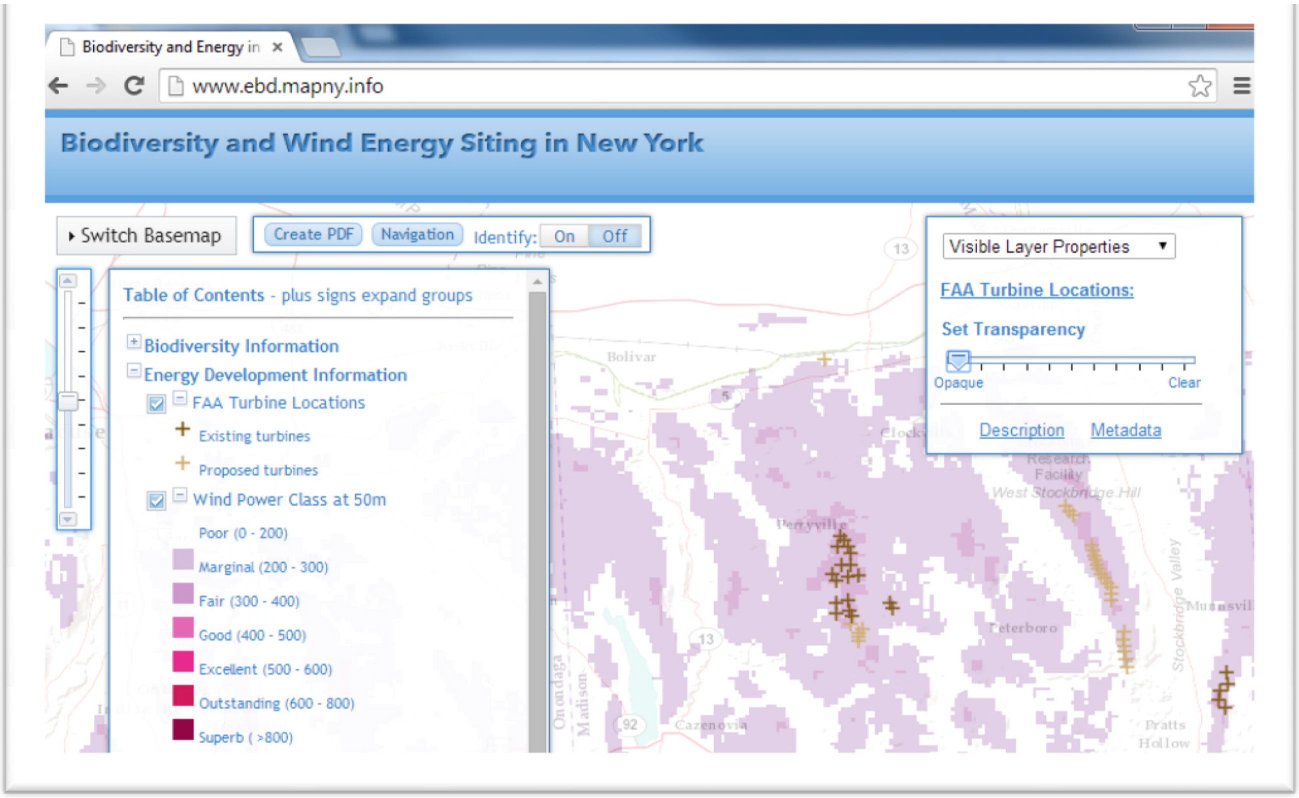


A.5 Viewing multiple layers at once

Viewing multiple layers is as easy as turning on more than one layer in the Table of Contents. The layers are stacked in the same order that they appear in the Table of Contents. Thus, for example. FAA Turbine Locations will be drawn on top of Wind Power Class, as shown in Figure A-8.

If the layer is obscured too much by an overlapping layer, use the transparency setting to increase transparency of the top layer.

Figure A-8. Two layers drawn together on the map. Note the two boxes 'checked' in the Table of Contents



A.6 How to Perform Common Tasks with the Online Tool

A.6.1 What are the best sites for wind development in New York State?

Although this tool does provide information that can support questions about the best remaining turbine sites in the state, there are many other components that play a role in such a decision. Because there is no single best answer, this tool is designed to provide information to support decision making but not to depict various scenarios balancing different siting priorities.

A.6.2 How do I find out how a layer was created or where it came from?

Additional information about each layer is available as metadata in a separate PDF. After turning on the layer in the Table of Contents, choose the layer name from the "Visible Layer Properties" window in the upper right corner. Then click on the "Metadata" hotlink at the bottom of that properties box. A new tab in the browser should open with the information about the chosen layer. A shorter layer description is also available.

A.6.3 How can I quickly navigate around the map?

Hold down the SHIFT key and drag a box with your mouse to zoom in. Hold down SHIFT+CTRL and drag a box to zoom out. Other quick navigation tips are available at the "Navigation" button at the top of the map.

A.6.4 How can I see a layer hidden underneath another layer?

Change the transparency of the top layer(s). In the "Visible Layer Properties" box at the upper right of the map window, select the layer that is obscuring other layers. Slide the Set Transparency slider to the right (toward "Clear") until you see the layers underneath.

A.6.5 Could this information be used for other purposes, such as road or other infrastructure planning purposes?

These data may have appropriate uses outside the expressed intent of the current tool. It is very important, however, that all users recognize the appropriate scales for use and inherent limitations in use. For scale, each layer is rendered at relatively fine scales (e.g., 30-meter pixels), but use and interpretation should not occur at the pixel-by pixel level. Rather, the overall pattern of pixels should be used to inform projects more broadly.

Users must also recognize that much of the information incorporated into the tool shows, for example, potential habitat and potential wind power. On-the-ground site survey and monitoring is crucial to inform final decision making.

A.6.6 How do I download data for use in modeling on my computer?

If the data layer came directly from another source, follow the links to that source on the metadata page. If the data were developed as part of this project, it is available for direct download nynhp.org/data.

A.6.7 What format are the GIS files in?

All raster data are provided as geoTIFF files. Polygon data are provided in ESRI Shapefile format.

A.6.8 Won't the data be out-of-date in a few years? Do you plan to update the data regularly?

All information goes out of date with time and these data are no exception. Each layer incorporated into this tool is unique and all layers will remain current for different lengths of time. It is up to users to note the date the information was developed and decide for themselves the current value and utility. Note, however, that models depicting predicted suitable habitat are less likely to go out of date than known species locations as habitats are likely to change a bit more slowly than species populations. There are no current plans to update the data.

A.6.9 Have the models that produced many of the data layers been ground truthed?

In the sense that each model was tested with data held out from the model (validation data), yes, each model was carefully validated and poor-performing models were excluded from this tool. On-site fieldwork after model development has not been completed, emphasizing the need for site-level data collection and monitoring prior to project initiation.

A.6.10 What is the scale of the data? Does the scale vary by data layer?

Although presented at a relatively fine resolution, scale does vary by data layer. Users should consider these layers as appropriate for use at landscape scales rather than at scales for siting individual turbines, for example.

A.6.11 How should I cite the tool if I am using it in support of a publication?

Please cite this full report and/or the tool as follows:

Tool:

New York Natural Heritage Program and The Nature Conservancy. 2014. Biodiversity and Energy Siting in New York online mapping tool. Available at http://www.ebd.mapny.info/

Full Report:

New York State Energy Research and Development Authority (NYSERDA). 2014. "Wind Power and Biodiversity in New York: A Tool For Siting Assessment and Scenario Planning at the Landscape Scale," NYSERDA Report 14-46. Prepared by The Nature Conservancy and New York Natural Heritage Program. nyserda.ny.gov/publications

Appendix B: Metadata for Each Layer Provided Online

B.1 Layer: Predicted Ephemeroptera, Plecoptera, and Trichoptera (EPT) Richness

Layer developed by: New York Natural Heritage Program

Short Description: This layer depicts the predicted number of species of mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) for streams in New York, based on the NYS DEC Stream Biomonitoring Unit's database of aquatic macroinvertebrate samples.

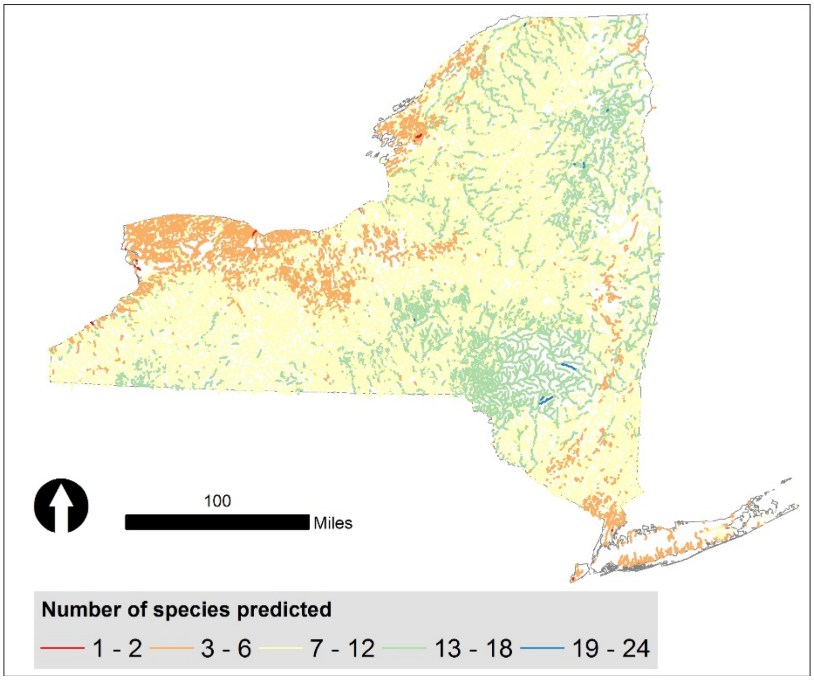
Why this layer matters: Macroinvertebrates respond rapidly to changes in stream condition and thus are known to be good indicators of water quality.

Source: New York Natural Heritage Program developed this layer in collaboration with The Nature Conservancy as part of their Freshwater Blueprint project for New York (White et al. 2011).

Processing Overview:

1. A database was obtained from NYSDEC Stream Biomonitoring Unit (SBU) with data up to and including the 2010 field season, a total of 7,132 samples. Data were used from 2000 on with locations marked as within the state, which left 1,728 kicknet sites. With data for multiple samples at a site, the maximum value of the response variable was taken in an effort to best represent the biological potential of the site.
2. All locations were attributed to the stream reaches in which they occur, using the National Hydrography Dataset medium-scale (1:100,000) stream data (nhd.usgs.gov). A version was used of this dataset already attributed with many environmental variables developed for The Northeast Association of Fish and Wildlife Agencies (http://rcngrants.org/spatialData).
3. Regression modeling was used in random forests to model the relationship between environmental variables and observed measures. 146 environmental variables were used. The resulting model explained 47% of the variance, with mean annual velocity, percent forest and shrub cover in the upstream catchments, and mean annual temperature as the most important variables in the model.
4. This model was then used to predict the value for EPT richness throughout the rest of the State, excluding large rivers and medium mainstem rivers as they were not a part of the original sample pool (Figure B-1).
5. For additional details, see (White et al. 2011).

Figure B-1. Map of predicted EPT richness



Literature Cited:

White, E. L., J. J. Schmid, T. G. Howard, M. D. Schlesinger, and A. L. Feldmann. 2011. New York State Freshwater Conservation Blueprint Project, Phases I and II: Freshwater Systems, Species, and Viability Metrics. New York Natural Heritage Program, Albany, NY. 85 pages. Available at http://nynhp.org/FBP

B.2 Layer: Floodplain Complexes

Layer developed by: New York Natural Heritage Program

Short Description: This layer depicts floodplain cores and corridors along the larger streams in the state. Floodplain cores are contiguous areas of natural cover greater than 150 acres within the Active River Area. Floodplain corridors are undeveloped and natural lands within the same stream reach or adjacent to these cores.

Why this layer matters: Intact floodplains help absorb floodwaters to minimize the effects of flooding downstream, help filter excess contaminants and sediment from streams, and, with trees lining the stream, help maintain cooler stream temperatures for the benefit of stream organisms.

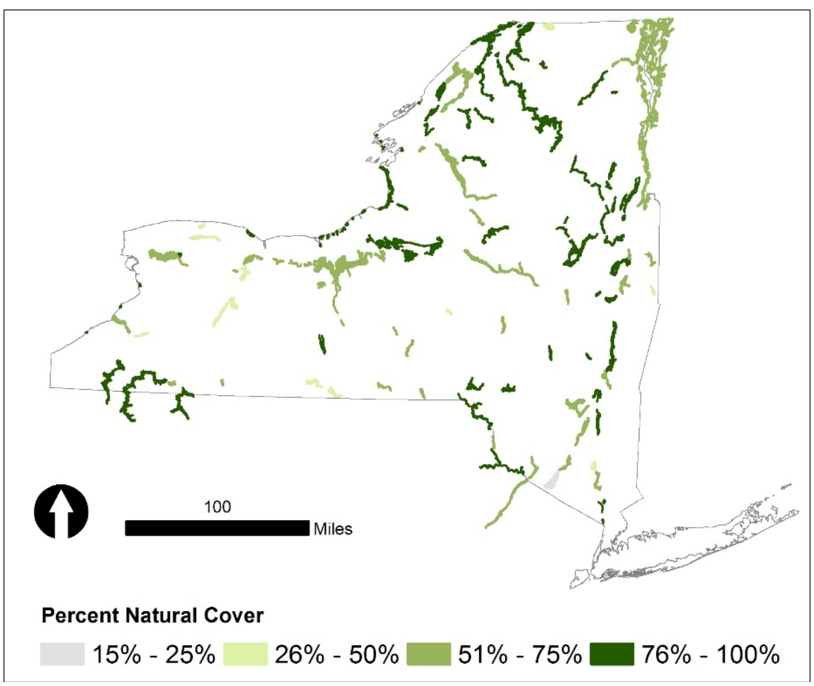
Source: New York Natural Heritage Program developed this layer in collaboration with The Nature Conservancy as part of their Freshwater Blueprint project for New York (White et al. 2011). This concept was developed by The Nature Conservancy for the Delaware Assessment (Fanok et al. 2010). The Delaware River Basin Integrated

Landscape Team (Delaware Team) worked with The Nature Conservancy's Southern Resource Office to link the Active River Areas (ARAs) to the Northeast Aquatic Habitat Classification (NEAHC) dataset, each developed by The Nature Conservancy's Eastern Conservation Science Office. This project followed the Delaware Team's methodology for floodplain analysis.

Processing Overview:

1. Identify contiguous patches of natural land greater than 150 acres within the Active River Area (ARA; http://www.floods.org/PDF/ASFPM_TNC_Active_River_%20Area.pdf) of medium and large rivers. These are the floodplain cores. Natural cover was determined from the following classification types from EPA's National Land Cover Data (NLCD) from 2001: Deciduous Forest, Emergent Herbaceous Wetlands, Evergreen Forest, Mixed Forest, Shrub/Scrub, and Woody Wetlands.
2. Floodplain corridors were created by identifying all natural and undeveloped land along a stream reach that contains a core and natural and undeveloped patches greater than 100 acres adjacent to a core. Undeveloped cover was determined from the following classification types from EPA's National Land Cover Data (NLCD) from 2001: Open Water in tributaries or the ARA riparian zone, Cultivated Crops, and Hay/Pasture.
3. Floodplain corridors and cores were then merged to create floodplain complexes. Each was attributed with the percent natural cover to better quantify differences in quality among the complexes (Figure B-2).
4. For additional details, see (White et al. 2011).

Figure B-2. Map of floodplain complexes



Literature Cited:

Fanok, S., M. DePhilip, E. Creveling, M.-B. DeLucia, and T. Moberg. 2010. A freshwater conservation assessment for the Upper Delaware River Basin: Floodplains, headwaters, wetlands, and freshwater conservation areas. The Nature Conservancy's Delaware River Basin Integrated Landscape Team. 27 pages.

White, E. L., J. J. Schmid, T. G. Howard, M. D. Schlesinger, and A. L. Feldmann. 2011. New York State Freshwater Conservation Blueprint Project, Phases I and II: Freshwater Systems, Species, and Viability Metrics. New York Natural Heritage Program, Albany, NY. 85 pages. http://nynhp.org/FBP

B.3 Layer: Predicted Mussel Richness

Layer developed by: New York Natural Heritage Program

Short Description: This layer depicts stream segments in which one or more species of mussel are predicted to occur, based on 2750 separate records for the 39 species known to currently occur in New York.

Why this layer matters: Mussels respond rapidly to changes in stream condition and thus may be good indicator species, both in terms of natural flows and water quality. Many species are imperiled, and a high diversity of mussels is recognized as an important conservation target.

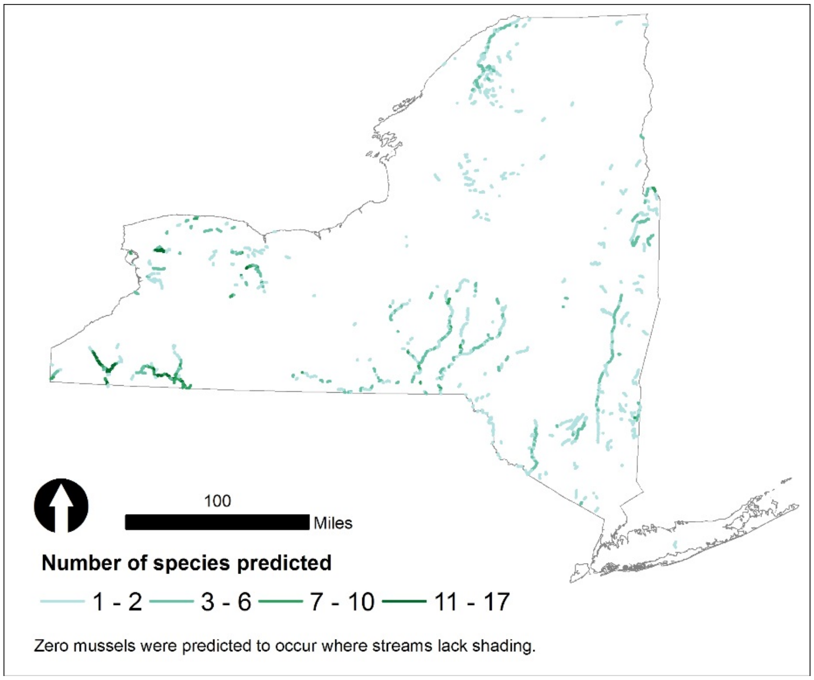
Source: New York Natural Heritage Program developed this layer in collaboration with The Nature Conservancy as part of their Freshwater Blueprint project for New York (White et al. 2011).

Processing Overview:

1. Mussel locations were acquired from the *Pearly Mussels of New York State* (Strayer and Jirka 1997) and six other data sets of mussel locations from various researchers and groups (see White et al. 2011).
2. All locations were attributed to the stream reaches in which they occur, using the National Hydrography Dataset medium-scale (1:100,000) stream data (nhd.usgs.gov). A version of this dataset already attributed with many environmental variables developed for The Northeast Associated of Fish and Wildlife Agencies (http://rcngrants.org/spatialData) was used.
3. For each of the 39 species, the association between species presence and 146 environmental variables was modeled using the random forests routine.
4. For those species passing cross-validation, their distribution was modeled statewide. For those not passing validation, their known locations were used as input for the next step (Figure B-3).
5. Separate maps of each species were generated, either based on the modeled presence or only the known locations. The number of species was then summed for each stream reach.

For additional details, see (White et al. 2011).

Figure B-3. Map of predicted mussel richness



Literature Cited:

Strayer, D. L., and K. J. Jirka. 1997. The pearly mussels of New York State. New York State Education Department, Albany, NY. 113 pages.

White, E. L., J. J. Schmid, T. G. Howard, M. D. Schlesinger, and A. L. Feldmann. 2011. New York State Freshwater Conservation Blueprint Project, Phases I and II: Freshwater Systems, Species, and Viability Metrics. New York Natural Heritage Program, Albany, NY. 85 pages. http://nynhp.org/FBP

B.4. Layer: Resilient Stream Networks

Layer developed by: The Nature Conservancy

Short Description: This layer depicts the New York portion of complex, connected stream networks in the Northeast and Mid-Atlantic coded by resilience based on four physical properties (network length, number of size classes, number of gradients classes and number of temperature classes) and three condition characteristics (risk of hydrologic alterations, natural cover in the floodplain, and amount of impervious surface in the watershed).
A complex network was defined as a continuous system of connected streams bounded by dams or upper headwaters that contained over four different size classes of streams or lakes (adapted from Anderson et al. 2013).

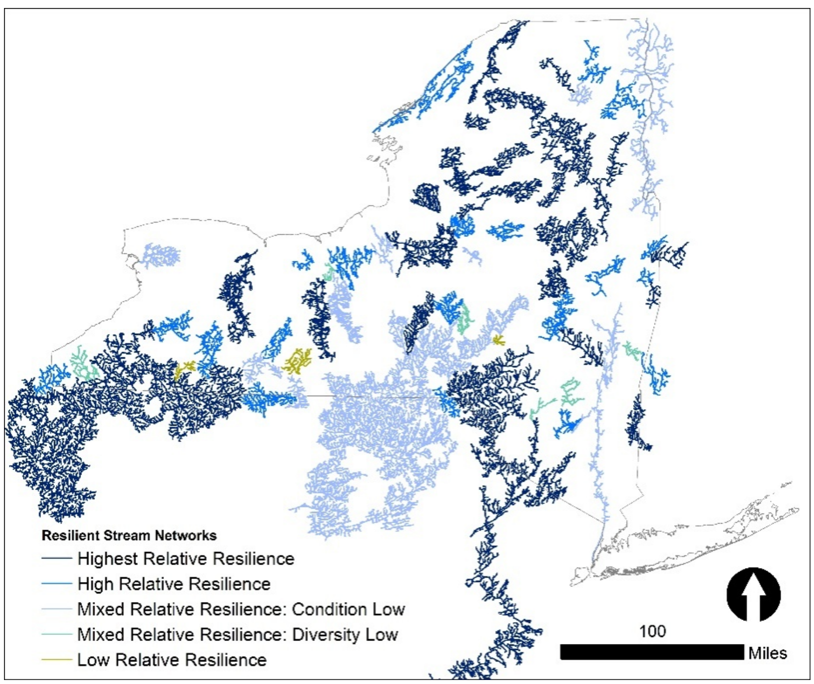
Why this layer matters: Resilient stream systems are those that will support a full spectrum of biodiversity and maintain their functional integrity even as species compositions and hydrologic properties change in response to shifts in ambient conditions due to climate change. Although the precise species composition in a given area will undoubtedly evolve in response to environmental changes, the ability to identify rivers and streams with the capacity to adapt to these changes, and maintain similar biodiversity characteristics and functional processes under novel conditions, is a critical step toward protecting healthy freshwater systems (from Anderson et al. 2013; Figure B-4).

Source: For background and information about the methods for identifying resilient stream networks, see http://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/edc/Documents/FW%20resilience_5_28_2013_distribute.docx

Processing Overview:

Download the data sets from http://easterndivision.s3.amazonaws.com/Freshwater/FW_resilience_package.zip

Figure B-4. Map of resilient stream networks



Literature Cited:

Anderson, M., A. Olivero Sheldon, C. D. Apse, A. Bowden, A. Barnett, B. Beaty, C. Burns, D. Crabtree, D. A. Bechtel, J. Higgins, J. Royte, J. K. Dunscomb, and P. Marangelo. 2013. Assessing the Resilience of Freshwater Ecosystems in the Northeast and Mid-Atlantic. The Nature Conservancy, Eastern North America Division, Boston, MA.

B.5. Layer: Modeled Rare Species Distributions

Layer developed by: New York Natural Heritage Program

Short Description: These nine layers depict the predicted richness (number) of up to 379 rare species in various categories. The probability of the existence of suitable habitat for each species was modeled and converted to a presence or absence of suitable habitat; then summed across all species in each category (i.e., created model "stacks") to yield the number of species for which suitable habitat was predicted to be present in each cell.

Source: Location data come primarily from NY Natural Heritage element occurrence databases. Other sources of known locations, and sources of environmental variables, are noted in Howard and Schlesinger (2012).

Processing Overview:

1. Species were selected to represent a range of habitat preferences, niche breadth, and spatial distribution within New York State. Species known to predominantly occupy habitats within streams or lakes were generally excluded from this study in recognition of the additional (catchment and basin-level) landscape metrics needed to adequately model distributions. 243 plant and 136 animal species were selected to be modeled. The number of known locations for each species varied from 2 to 200 (mean = 11) among species. Twenty-six of the animals were modeled for a separate project (Howard and Schlesinger 2012) and included here. The two rare bats were modeled using a modified approach (see Step 8).
2. Each 30-m cell was attributed with 44 environmental variables (see Howard and Schlesinger [2012]).
3. The environmental characteristics of cells were compared with known presence and 10,000 randomly distributed background points using Random Forest analysis.
4. The results of this model were used to predict the probability of suitable habitat for each species.
5. Validation statistics were computed for each model and retained models with TSS (Allouche et al. 2006) greater than or equal to 0.5.
6. To convert each model value to a predicted presence (1) or absence (0) of suitable habitat, the F-measure (Van Rijsbergen 1979, Sing et al. 2005) were used with alpha = 0.01 to find a balance of precision and recall weighted conservatively towards higher recall (more land area represented as suitable).
7. For each of the 10 categories, the 0/1 values for each species were summed to arrive at the number of species predicted to have suitable habitat in each cell.
8. Bat data came from statewide 2009 and 2010 acoustic surveys from 49 fifteen-mile road transects and mist-net surveys (318 points) from various targeted projects 2003-2010. For hibernacula models, locations from the NY Natural Heritage database were used. Summer distribution of two rare species were modeled for inclusion in model stacks Figures B-5 through B-13 and Tables B-1 and Table B-2).

Figure B-5. All distribution models for all rare species represented as a single stack

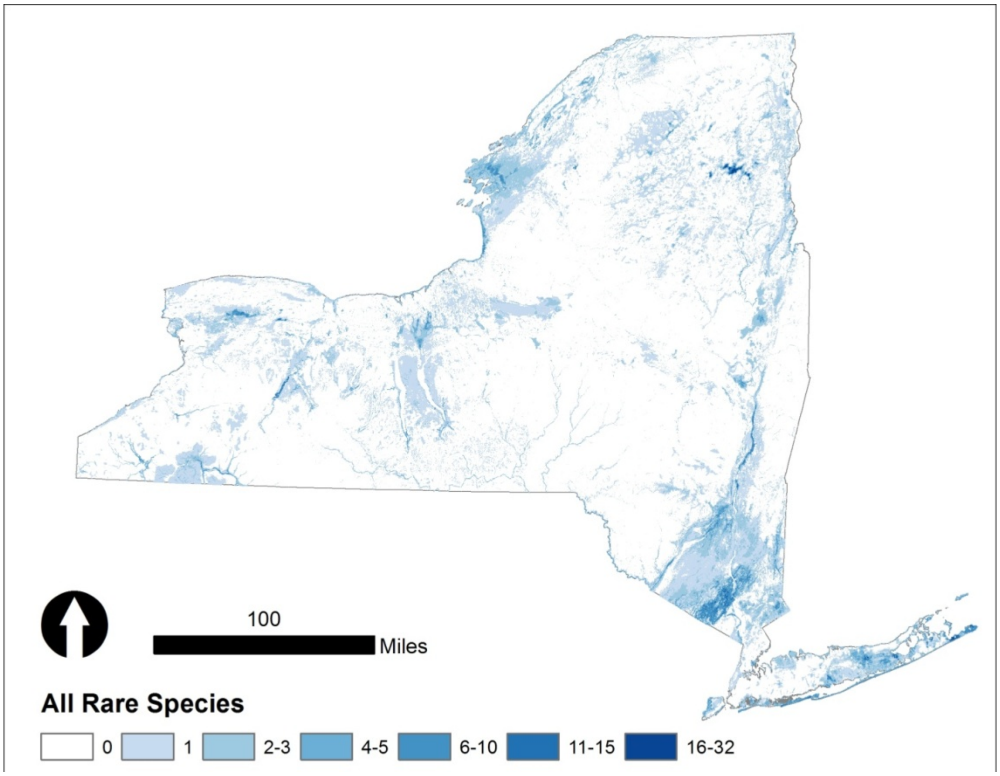


Figure B-6. All distribution models for rare animal distributions as a single stack

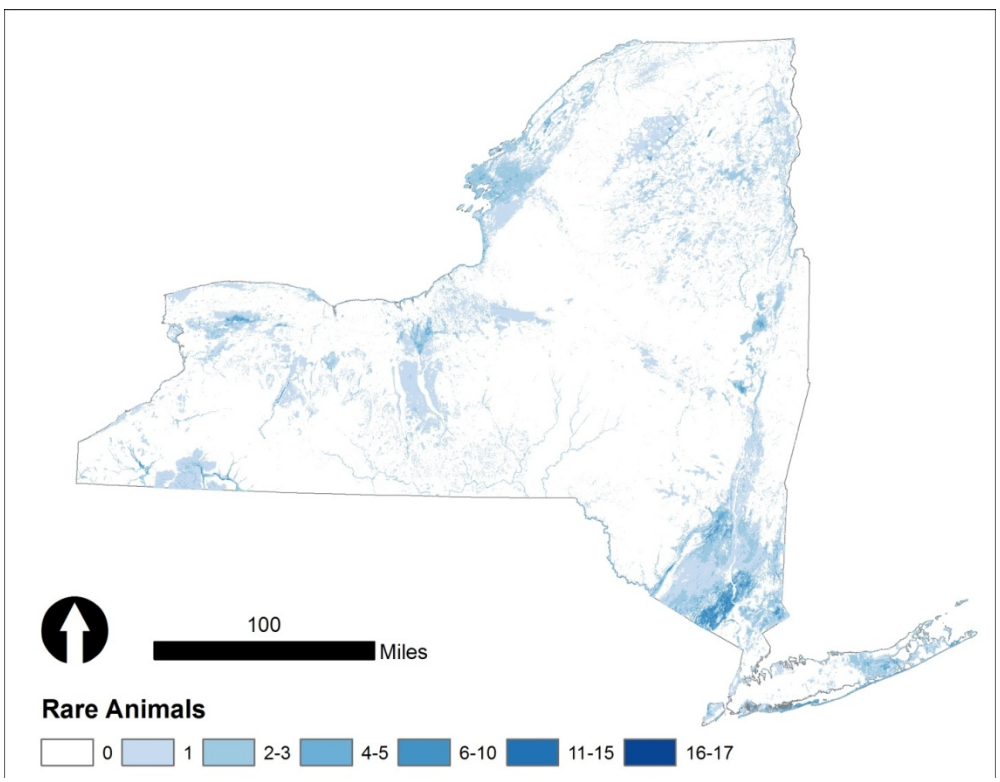


Figure B-7. All distribution models for rare vertebrates represented as a single stack

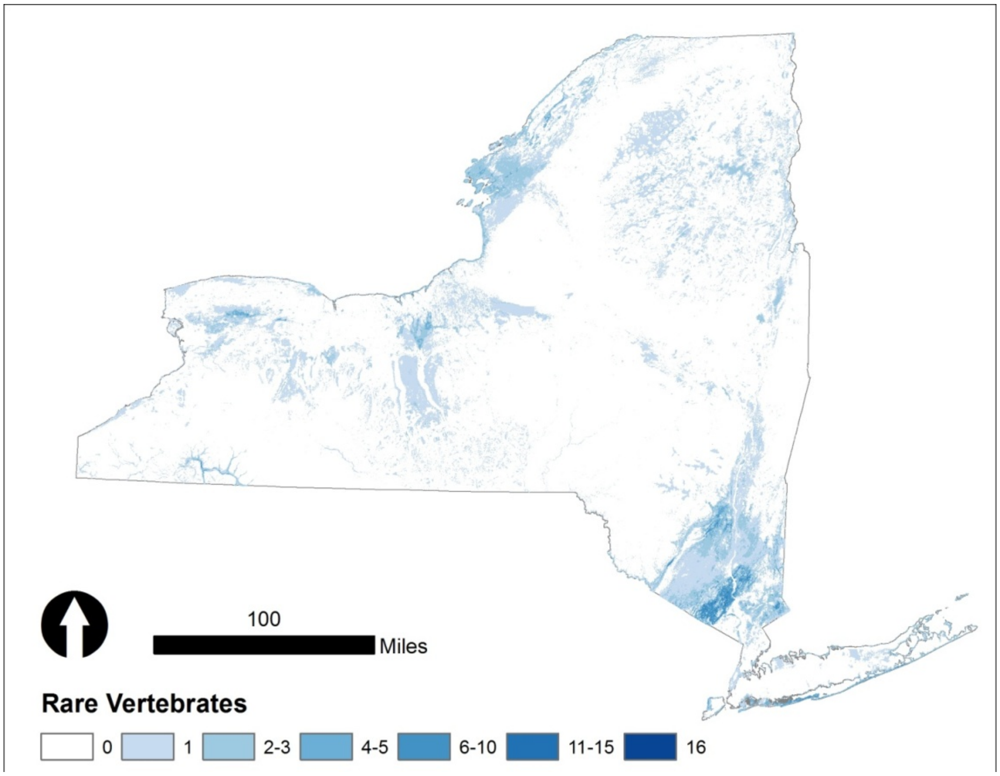


Figure B-8. All distribution models for rare birds represented as a single stack

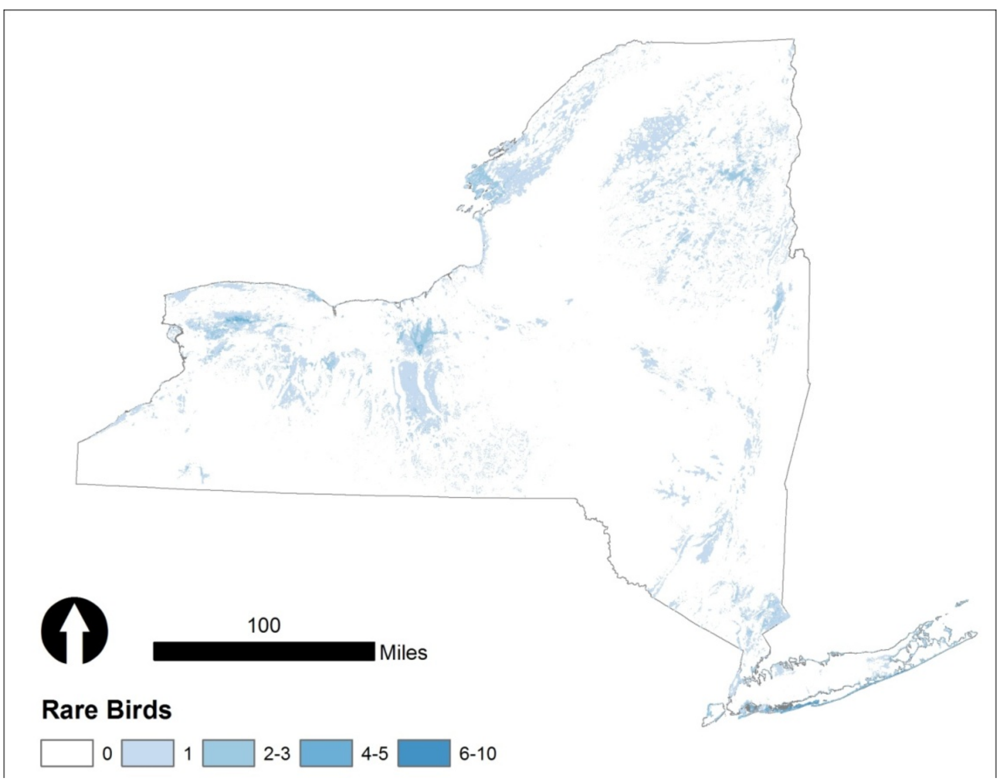


Figure B-9. All distribution models for bat hibernacula represented as a single stack

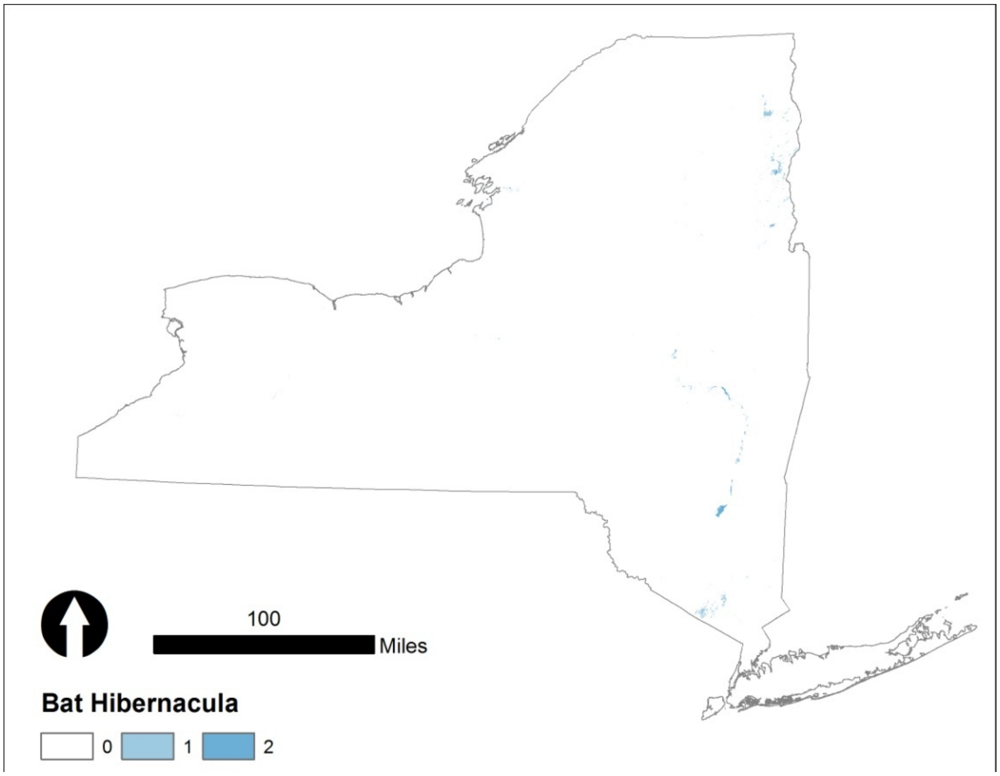


Figure B-10. All distribution models for rare invertebrates represented as a single stack

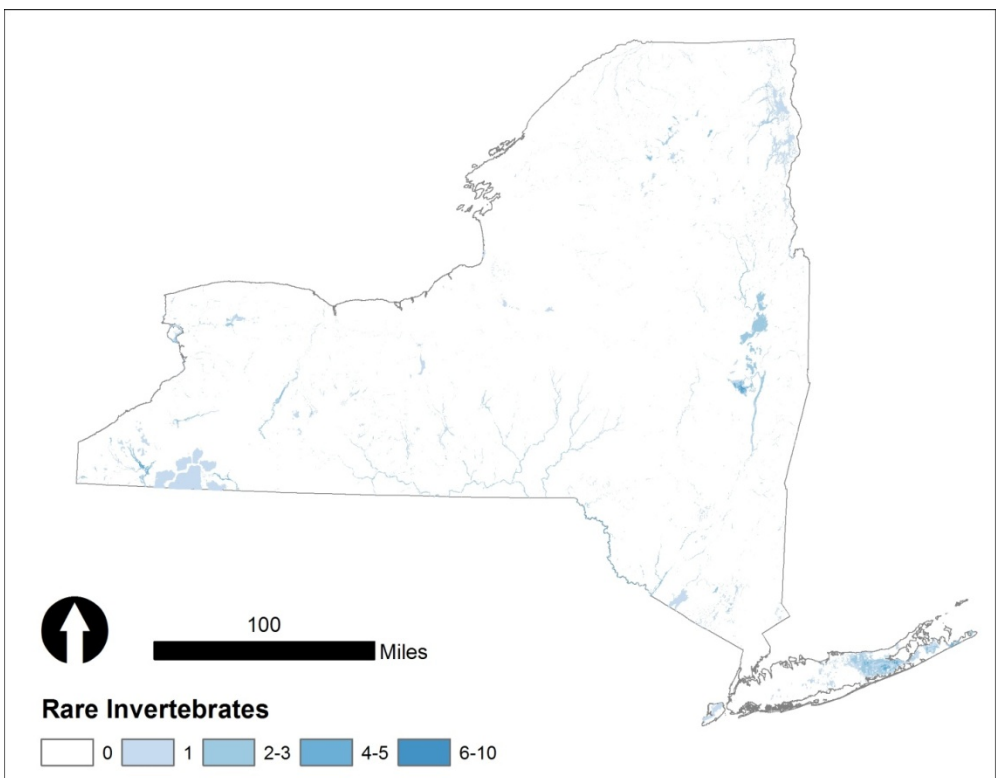


Figure B-11. All distribution models for rare aerial insects represented as a single stack

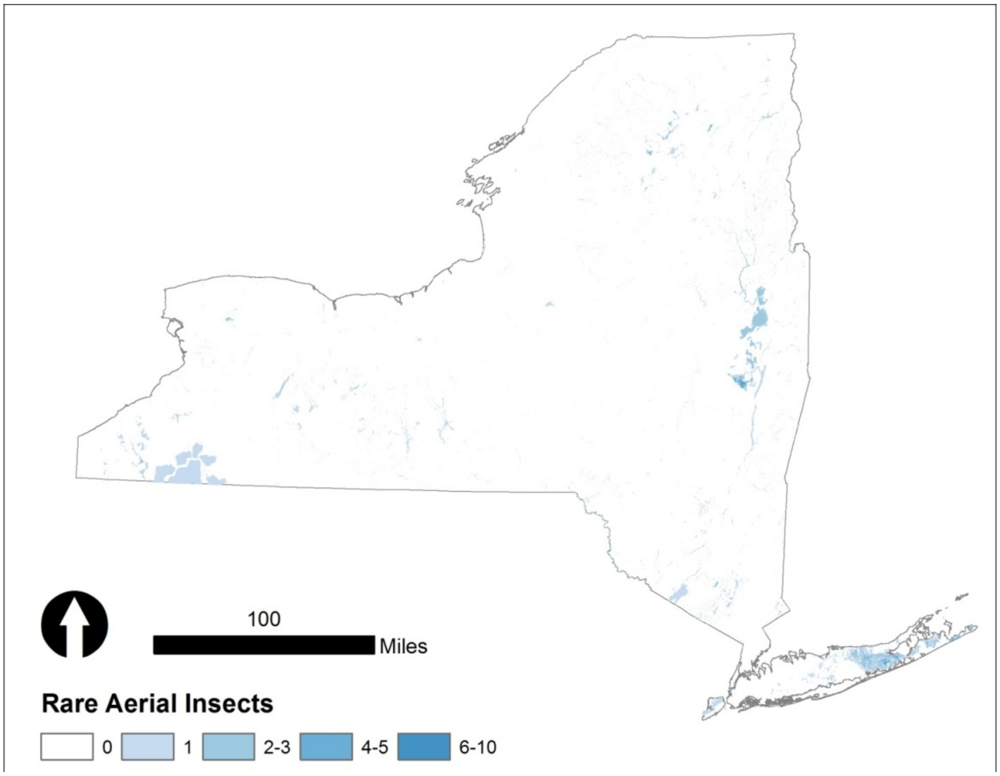


Figure B-12 All distribution models for rare planes represented as a single stack

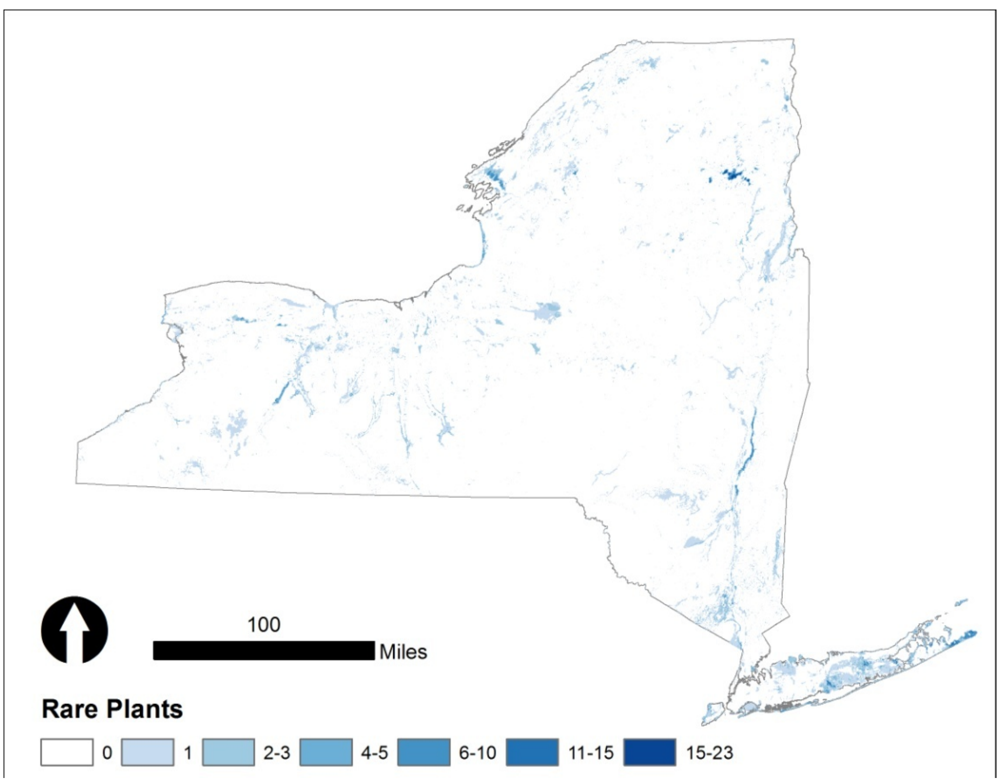


Figure B-13. All distribution models for state-listed species represented as a single stack

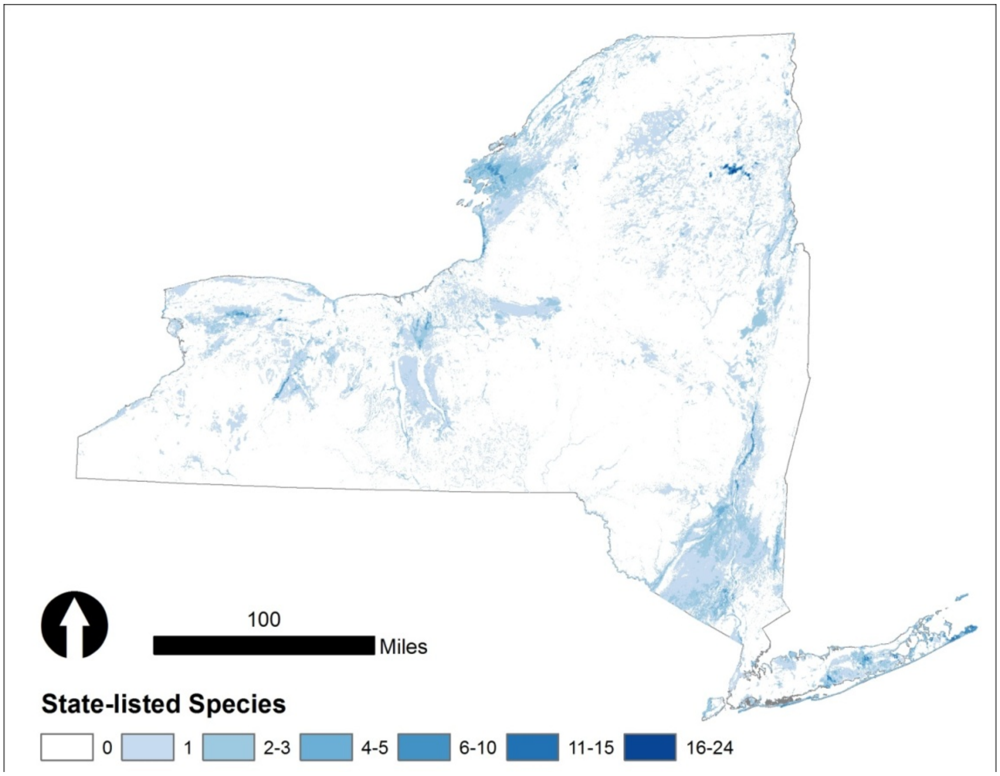


Table B-1. Model stacks including this species

Scientific name	Common name	TSS	Animals	Verts	Bat hib.	Birds	Inverts	Aerial insects	Plants	State listed
Amphibians										
Acris crepitans	Northern Cricket Frog	0.928	X	X						X
Ambystoma jeffersonianum x laterale	Jefferson Salamander Complex	0.537	X	X						
Ambystoma opacum	Marbled Salamander	0.509	X	X						
Cryptobranchus alleganiensis	Hellbender	0.966	X	X						
Eurycea longicauda	Longtail Salamander	0.813	X	X						
Hemidactylium scutatum	Four-toed Salamander	0.591	X	X						
Rana sphenocephala	Southern Leopard Frog	0.854	X	X						
Scaphiopus holbrookii	Eastern Spadefoot	0.890	X	X						
Beetles										
Cicindela ancocisconensis	Appalachian Tiger Beetle	0.772	X				X			
Cicindela marginipennis	Cobblestone Tiger Beetle	0.917	X				X			
Birds										
Ammodramus henslowii	Henslow's Sparrow	0.546	X	X		X				X
Ammodramus maritimus	Seaside Sparrow	0.992	X	X		X				
Asio flammeus	Short-eared Owl	0.608	X	X		X				X
Caprimulgus carolinensis	Chuck-will's-widow	0.665	X	X		X				
Catharus bicknelli	Bicknell's Thrush	0.963	X	X		X				
Charadrius melodus	Piping Plover	0.948	X	X		X				X
Chlidonias niger	Black Tern	0.841	X	X		X				X
Dendroica cerulea	Cerulean Warbler	0.515	X	X		X				
Euphagus carolinus	Rusty Blackbird	0.654	X	X		X				
Falcipennis canadensis	Spruce Grouse	0.936	X	X		X				X
Falco peregrinus	Peregrine Falcon	0.803	X	X		X				X
Helmitheros vermivorum	Worm-eating Warbler	0.574	X	X		X				
Leucophaeus atricilla	Laughing Gull	0.918	X	X		X				
Nyctanassa violacea	Yellow-crowned Night-heron	0.866	X	X		X				

Scientific name	Common name	TSS	Animals	Verts	Bat hib.	Birds	Inverts	Aerial insects	Plants	State listed
Oporornis formosus	Kentucky Warbler	0.620	X	X		X				
Picoides dorsalis	Three-toed Woodpecker	0.698	X	X		X				
Plegadis falcinellus	Glossy Ibis	0.938	X	X		X				
Protonotaria citrea	Prothonotary Warbler	0.851	X	X		X				
Rallus elegans	King Rail	0.883	X	X		X				X
Rynchops niger	Black Skimmer	0.986	X	X		X				
Sterna forsteri	Forster's Tern	0.562	X	X		X				
Sternula antillarum	Least Tern	0.934	X	X		X				X
Tyto alba	Barn Owl	0.664	X	X		X				
<u>Butterflies and moths</u>										
Abagrotis nefascia benjamini	Coastal Heathland Cutworm	0.625	X				X	X		
Callophrys hesseli	Hessel's Hairstreak	0.837	X				X	X		X
Callophrys irus	Frosted Elfin	0.910	X				X	X		X
Catocala herodias gerhardi	Herodias or Pine Barrens Underwing	0.950	X				X	X		
Catocala jair ssp. 2	Jersey Jair Underwing	0.715	X				X	X		
Chaetaglaea cerata	Waxed Sallow	0.819	X				X	X		
Chytonix sensilis	A Noctuid Moth	0.862	X				X	X		
Erastria coloraria	Broad-lined Catopyrrha	0.654	X				X	X		
Eucoptocnemis fimbriaris	A Noctuid Moth	0.625	X				X	X		
Fagitana littera	A Noctuid Moth	0.500	X				X	X		
Hemileuca maia maia	Inland Barrens Buckmoth	0.911	X				X	X		
Hemileuca maia ssp. 5	Coastal Barrens Buckmoth	0.958	X				X	X		
Hemileuca sp. 1	Bogbean Buckmoth	0.992	X				X	X		X
Itame sp. 1 nr. inextricata	Barrens Itame	0.823	X				X	X		
Oeneis jutta	Jutta Arctic	0.961	X				X	X		
Pieris virginiensis	West Virginia White	0.864	X				X	X		
Plebejus melissa samuelis	Karner Blue	0.904	X				X	X		X
Psectraglaea carnosa	Pink Sallow	0.803	X				X	X		

Scientific name	Common name	TSS	Animals	Verts	Bat hib.	Birds	Inverts	Aerial insects	Plants	State listed
Xylena thoracica	Acadian Swordgrass Moth	0.568	X				X	X		
Zanclognatha martha	Pine Barrens Zanclognatha	0.921	X				X	X		
Fish										
Acipenser fulvescens	Lake Sturgeon	0.906	X	X						X
Ammocrypta pellucida	Eastern Sand Darter	0.940	X	X						X
Enneacanthus obesus	Banded Sunfish	0.904	X	X						X
Erimystax x-punctatus	Gravel Chub	0.600	X	X						X
Exoglossum laurae	Tonguetied Minnow	0.660	X	X						
Hiodon tergisus	Mooneye	0.807	X	X						X
Ichthyomyzon bdellium	Ohio Lamprey	0.858	X	X						
Ichthyomyzon fossor	Northern Brook Lamprey	0.722	X	X						
Ichthyomyzon greeleyi	Mountain Brook Lamprey	0.531	X	X						
Menidia beryllina	Inland Silverside	0.765	X	X						
Menidia menidia	Atlantic Silverside	0.895	X	X						
Moxostoma valenciennesi	Greater Redhorse	0.789	X	X						
Notropis heterodon	Blackchin Shiner	0.808	X	X						
Percina copelandi	Channel Darter	0.816	X	X						
Percina macrocephala	Longhead Darter	0.878	X	X						X
Prosopium cylindraceum	Round Whitefish	0.920	X	X						X
Mammals										
Myotis leibii	Eastern Small-footed Myotis hibernacula	0.834			X					
Myotis sodalis	Indiana Bat hibernacula	0.556			X					X
Myotis sodalis	Indiana Bat summer	0.765	X	X						X
Sylvilagus transitionalis	New England Cottontail	0.912	X	X						
Crustaceans and mollusks										
Cambarus diogenes	Devil Crawfish	0.811	X				X			
Actinonaias ligamentina	Mucket	0.968	X				X			
Alasmidonta heterodon	Dwarf Wedgemussel	0.846	X				X			X

Scientific name	Common name	TSS	Animals	Verts	Bat hib.	Birds	Inverts	Aerial insects	Plants	State listed
Alasmidonta varicosa	Brook Floater	0.928	X				X			X
Amblema plicata	Threeridge	0.876	X				X			
Anodonta implicata	Alewife Floater	0.732	X				X			
Fusconaia flava	Wabash Pigtoe	0.660	X				X			
Lampsilis cariosa	Yellow Lampmussel	0.936	X				X			
Lampsilis fasciola	Wavyrayed Lampmussel	0.927	X				X			X
Lasmigona subviridis	Green Floater	0.862	X				X			X
Ligumia nasuta	Eastern Pondmussel	0.785	X				X			
Margaritifera margaritifera	Eastern Pearlshell	0.791	X				X			
Pleurobema sintoxia	Round Pigtoe	0.926	X				X			
Ptychobranchus fasciolaris	Kidneyshell	0.793	X				X			
Villosa fabalis	Rayed Bean	0.983	X				X			X
<u>Dragonflies and damselflies</u>										
Anax longipes	Comet Darner	0.624	X				X	X		
Argia tibialis	Blue-tipped Dancer	0.859	X				X	X		
Cordulegaster erronea	Tiger Spiketail	0.531	X				X	X		
Cordulegaster obliqua	Arrowhead Spiketail	0.739	X				X	X		
Enallagma laterale	New England Bluet	0.911	X				X	X		
Enallagma minusculum	Little Bluet	0.500	X				X	X		X
Enallagma pictum	Scarlet Bluet	0.894	X				X	X		X
Enallagma recurvatum	Pine Barrens Bluet	0.807	X				X	X		X
Epitheca semiaquea	Mantled Baskettail	0.797	X				X	X		
Gomphus fraternus	Midland Clubtail	0.697	X				X	X		
Gomphus quadricolor	Rapids Clubtail	0.801	X				X	X		
Ischnura ramburii	Rambur's Forktail	0.863	X				X	X		
Libellula auripennis	Golden-winged Skimmer	0.974	X				X	X		
Ophiogomphus anomalus	Extra-striped Snaketail	0.949	X				X	X		
Ophiogomphus aspersus	Brook Snaketail	0.692	X				X	X		
Ophiogomphus howei	Pygmy Snaketail	0.619	X				X	X		

Scientific name	Common name	TSS	Animals	Verts	Bat hib.	Birds	Inverts	Aerial insects	Plants	State listed
Rhionaeschna mutata	Spatterdock Darner	0.687	X				X	X		
Somatochlora cingulata	Lake Emerald	0.880	X				X	X		
Somatochlora forcipata	Forcipate Emerald	0.838	X				X	X		
Somatochlora incurvata	Incurvate Emerald	0.996	X				X	X		
Stylurus plagiatus	Russet-tipped Clubtail	0.948	X				X	X		
Tachopteryx thoreyi	Gray Petaltail	0.741	X				X	X		
Williamsonia fletcheri	Ebony Boghaunter	0.994	X				X	X		
Reptiles										
Agkistrodon contortrix	Copperhead	0.673	X	X						
Apalone spinifera	Spiny Softshell	0.931	X	X						
Carphophis amoenus	Worm Snake	0.790	X	X						
Clemmys guttata	Spotted Turtle	0.652	X	X						
Coluber c. constrictor	Racer	0.623	X	X						
Crotalus horridus	Timber Rattlesnake	0.898	X	X						X
Elaphe obsoleta	Eastern Ratsnake	0.575	X	X						
Emydoidea blandingii	Blanding's Turtle	0.811	X	X						X
Eumeces anthracinus	Coal Skink	0.526	X	X						
Eumeces fasciatus	Five-lined Skink	0.760	X	X						
Glyptemys insculpta	Wood Turtle	0.586	X	X						
Glyptemys muhlenbergii	Bog Turtle	0.815	X	X						X
Kinosternon subrubrum	Eastern Mud Turtle	0.807	X	X						X
Regina septemvittata	Queen Snake	0.613	X	X						X
Sceloporus undulatus	Fence Lizard	0.990	X	X						X
Terrapene c. carolina	Eastern Box Turtle	0.597	X	X						
Thamnophis sauritus	Eastern Ribbonsnake	0.514	X	X						
Nonvascular plants										
Conardia compacta	Coast Creeping Moss	0.667							X	
Didymodon fallax var. reflexus	Rusty Beard-moss	0.500							X	
Sphagnum angermanicum	Angerman's Peat Moss	0.583							X	

Scientific name	Common name	TSS	Animals	Verts	Bat hib.	Birds	Inverts	Aerial insects	Plants	State listed
Taxiphyllum taxirameum	Yew-leaf Moss	0.850							X	
<u>Vascular plants</u>										
Aconitum noveboracense	Northern Monkshood	0.856							X	X
Agalinis acuta	Sandplain Gerardia	0.857							X	X
Agalinis maritima var. maritima	Seaside Gerardia	0.980							X	
Agrimonia rostellata	Woodland Agrimony	0.870							X	X
Agrostis mertensii	Northern Bentgrass	0.777							X	X
Aletris farinosa	Stargrass	0.912							X	X
Allium cernuum var. cernuum	Nodding Wild Onion	0.995							X	X
Amaranthus pumilus	Seabeach Amaranth	0.915							X	X
Amelanchier nantucketensis	Nantucket Juneberry	0.884							X	X
Ammophila breviligulata ssp. champlainensis	Champlain Beachgrass	0.900							X	X
Angelica lucida	Seacoast Angelica	0.889							X	X
Anthoxanthum monticola ssp. monticola	Alpine Sweetgrass	0.796							X	X
Anticlea elegans ssp. glaucus	Mountain Death Camas	0.882							X	X
Arethusa bulbosa	Dragon's Mouth Orchid	0.793							X	X
Argentina egedii ssp. groenlandica	Coastal Silverweed	0.565							X	X
Asclepias viridiflora	Green Milkweed	0.962							X	X
Asimina triloba	Pawpaw	0.931							X	X
Asplenium scolopendrium var. americanum	Hart's-tongue Fern	0.858							X	X
Bartonia paniculata ssp. paniculata	Screw-stem	0.500							X	X
Betula minor	Dwarf White Birch	0.891							X	X
Betula pumila	Swamp Birch	0.846							X	X
Bidens bidentoides	Delmarva Beggar-ticks	0.802							X	
Bidens laevis	Smooth Bur-marigold	0.856							X	X
Boechera grahamii	Purple Rock-cress	0.867							X	

Scientific name	Common name	TSS	Animals	Verts	Bat hib.	Birds	Inverts	Aerial insects	Plants	State listed
Boechera missouriensis	Green Rock-cress	0.860							X	X
Boechera stricta	Drummond's Rock-cress	0.798							X	X
Bolboschoenus maritimus ssp. paludosus	Seaside Bulrush	0.824							X	X
Bolboschoenus novae-angliae	Saltmarsh Bulrush	0.731							X	X
Bouteloua curtipendula var. curtipendula	Side-oats Grama	0.657							X	X
Cardamine longii	Long's Bittercress	0.840							X	X
Cardamine rotundifolia	Mountain Watercress	0.887							X	X
Carex abscondita	Thicket Sedge	0.661							X	X
Carex backii	Back's Sedge	0.791							X	X
Carex bigelowii	Bigelow's Sedge	0.804							X	X
Carex bullata	Button Sedge	0.711							X	X
Carex chordorrhiza	Creeping Sedge	0.852							X	X
Carex collinsii	Collins' Sedge	0.609							X	X
Carex crawei	Crawe's Sedge	0.522							X	X
Carex davisii	Davis' Sedge	0.790							X	X
Carex debilis var. debilis	White-edge Sedge	0.688							X	
Carex formosa	Handsome Sedge	0.698							X	X
Carex haydenii	Cloud Sedge	0.846							X	X
Carex jamesii	James' Sedge	0.821							X	X
Carex livida	Livid Sedge	0.628							X	X
Carex mesochorea	Midland Sedge	0.545							X	X
Carex mitchelliana	Mitchell's Sedge	0.852							X	X
Carex nigromarginata	Black-edge Sedge	0.592							X	X
Carex sartwellii	Sartwell's Sedge	0.943							X	X
Carex scirpoidea ssp. scirpoidea	Canadian Single-spike Sedge	0.858							X	X
Carex straminea	Straw Sedge	0.636							X	X
Carex tenuiflora	Sparse-flowered Sedge	0.729							X	X
Carex typhina	Cat-tail Sedge	0.635							X	X

Scientific name	Common name	TSS	Animals	Verts	Bat hib.	Birds	Inverts	Aerial insects	Plants	State listed
Carya laciniosa	Big Shellbark Hickory	0.921							X	X
Castilleja coccinea	Scarlet Indian-paintbrush	0.769							X	X
Ceanothus herbaceus	Prairie Redroot	0.700							X	X
Cenchrus tribuloides	Dune Sandspur	0.722							X	X
Chamaecyparis thyoides	Atlantic White Cedar	0.911							X	
Chamaelirium luteum	Fairy Wand	0.826							X	X
Chenopodium berlandieri var. macrocalycium	Large Calyx Goosefoot	0.774							X	X
Chenopodium rubrum	Red Pigweed	0.992							X	X
Corydalis aurea	Golden Corydalis	0.864							X	X
Crocanthemum dumosum	Bushy Rockrose	0.757							X	X
Cuscuta obtusiflora var. glandulosa	Southern Dodder	0.600							X	X
Cyperus flavescens	Yellow Flatsedge	0.712							X	X
Cyperus polystachyos var. texensis	Coast Flatsedge	0.686							X	X
Cypripedium arietinum	Ram's-head Ladyslipper	0.780							X	X
Diapensia lapponica var. lapponica	Diapensia	0.923							X	X
Digitaria filiformis	Slender Crabgrass	0.801							X	X
Diospyros virginiana	Persimmon	0.792							X	X
Diphasiastrum complanatum	Northern Running-pine	0.559							X	X
Draba arabisans	Rock-cress	0.803							X	X
Draba reptans	Carolina Whitlow-grass	0.709							X	X
Dryopteris fragrans	Fragrant Cliff Fern	0.826							X	X
Eleocharis equisetoides	Knotted Spikerush	0.760							X	X
Eleocharis tenuis var. pseudoptera	Slender Spikerush	0.959							X	X
Eleocharis tricostata	Three-ribbed Spikerush	0.833							X	X
Eleocharis tuberculosa	Long-tubercled Spikerush	0.602							X	X
Eleocharis uniglumis var.	Salt-marsh Spikerush	0.792							X	X

Scientific name	Common name	TSS	Animals	Verts	Bat hib.	Birds	Inverts	Aerial insects	Plants	State listed
halophila										
Empetrum atropurpureum	Purple Crowberry	0.919							X	X
Empetrum nigrum	Black Crowberry	0.888							X	
Endodeca serpentaria	Virginia Snakeroot	0.913							X	X
Equisetum palustre	Marsh Horsetail	0.701							X	X
Equisetum pratense	Meadow Horsetail	0.809							X	X
Eupatorium torreyanum	Fringed Boneset	0.951							X	X
Eurybia spectabilis	Showy Aster	0.861							X	X
Fimbristylis castanea	Marsh Fimbry	0.856							X	X
Frasera caroliniensis	Green Gentian	0.968							X	X
Gaylussacia bigeloviana	Northern Dwarf Huckleberry	0.889							X	X
Gentianopsis virgata	Lesser Fringed Gentian	0.839							X	X
Geocaulon lividum	False Toadflax	0.990							X	X
Geum triflorum var. triflorum	Prairie-smoke	0.967							X	X
Halenia deflexa	Spurred Gentian	0.720							X	X
Hasteola suaveolens	Sweet-scented Indian-plantain	0.870							X	X
Helianthus angustifolius	Swamp Sunflower	0.889							X	X
Hottonia inflata	Featherfoil	0.833							X	X
Hydrangea arborescens	Wild Hydrangea	0.742							X	X
Hydrastis canadensis	Golden-seal	0.643							X	X
Hypericum adpressum	Creeping St. John's-wort	0.750							X	X
Hypericum hypericoides ssp. multicaule	St. Andrew's Cross	0.908							X	X
Hypericum prolificum	Shrubby St. John's-wort	0.796							X	X
Iris prismatica	Slender Blue Flag	0.863							X	X
Jeffersonia diphylla	Twin-leaf	0.802							X	X
Juncus debilis	Weak Rush	0.846							X	X
Juncus scirpoides	Scirpus-like Rush	0.625							X	X
Juncus trifidus	Arctic Rush	0.890							X	X

Scientific name	Common name	TSS	Animals	Verts	Bat hib.	Birds	Inverts	Aerial insects	Plants	State listed
Lechea tenuifolia	Slender Pinweed	0.706							X	X
Leptochloa fusca ssp. fascicularis	Salt-meadow Grass	0.994							X	X
Lespedeza angustifolia	Narrow-leaved Bush-clover	0.574							X	
Lespedeza stuevei	Velvety Bush-clover	0.930							X	X
Liatris scariosa var. novae-angliae	Northern Blazing-star	0.841							X	X
Ligusticum scothicum ssp. scothicum	Scotch Lovage	0.606							X	X
Lilaeopsis chinensis	Eastern Grasswort	0.778							X	X
Lilium michiganense	Michigan Lily	0.500							X	X
Linum intercursum	Sandplain Wild Flax	0.750							X	X
Linum sulcatum	Yellow Wild Flax	0.889							X	X
Liparis liliifolia	Large Twayblade	0.575							X	X
Lipocarpha micrantha	Dwarf Bulrush	0.633							X	X
Listera australis	Southern Twayblade	0.718							X	X
Ludwigia sphaerocarpa	Globe-fruited Ludwigia	0.853							X	X
Lycopus rubellus	Gypsy-wort	0.875							X	X
Lysimachia hybrida	Lance-leaved Loosestrife	0.942							X	X
Magnolia virginiana	Sweetbay Magnolia	0.649							X	X
Myriophyllum alterniflorum	Water Milfoil	0.846							X	X
Myriophyllum farwellii	Farwell's Water-milfoil	0.748							X	X
Myriophyllum pinnatum	Green Parrot's-feather	0.500							X	X
Oldenlandia uniflora	Clustered Bluets	0.667							X	X
Oligoneuron ohioense	Ohio Goldenrod	0.711							X	X
Oligoneuron rigidum var. rigidum	Stiff-leaf Goldenrod	0.735							X	X
Orontium aquaticum	Golden Club	0.758							X	X
Paspalum laeve	Field Beadgrass	0.791							X	X
Pedicularis lanceolata	Swamp Lousewort	0.824							X	X
Pellaea glabella ssp. glabella	Smooth Cliff Brake	0.922							X	X

Scientific name	Common name	TSS	Animals	Verts	Bat hib.	Birds	Inverts	Aerial insects	Plants	State listed
Persicaria careyi	Carey's Smartweed	0.533							X	X
Persicaria setacea	Swamp Smartweed	0.610							X	X
Pinguicula vulgaris	Butterwort	0.886							X	X
Pinus virginiana	Virginia Pine	0.519							X	X
Piptatherum canadense	Canada Ricegrass	0.914							X	X
Plantago maritima var. juncoides	Seaside Plantain	0.843							X	X
Platanthera cristata	Crested Fringed Orchis	0.722							X	X
Poa paludigena	Slender Marsh Bluegrass	0.793							X	X
Podostemum ceratophyllum	Riverweed	0.732							X	X
Polygonum aviculare ssp. buxiforme	Small's Knotweed	0.615							X	X
Polygonum douglasii	Douglas' Knotweed	0.692							X	X
Polygonum glaucum	Seabeach Knotweed	0.973							X	
Populus heterophylla	Swamp Cottonwood	0.872							X	X
Potamogeton alpinus	Northern Pondweed	0.987							X	X
Potamogeton hillii	Hill's Pondweed	0.689							X	X
Potamogeton pulcher	Spotted Pondweed	0.631							X	X
Potamogeton strictifolius	Straight-leaf Pondweed	0.909							X	X
Prenanthes boottii	Boott's Rattlesnake-root	0.811							X	X
Primula mistassinica	Bird's-eye Primrose	0.916							X	X
Proserpinaca pectinata	Comb-leaved Mermaid-weed	0.806							X	X
Prunus pumila var. depressa	Dwarf Sand-cherry	0.919							X	X
Prunus pumila var. pumila	Low Sand-cherry	0.758							X	X
Ptelea trifoliata ssp. trifoliata	Wafer-ash	0.711							X	X
Pterospora andromedea	Giant Pine-drops	0.868							X	X
Pycnanthemum verticillatum var. verticillatum	Whorled Mountain-mint	0.556							X	X
Pyrola asarifolia ssp. asarifolia	Pink Wintergreen	0.812							X	X
Quercus phellos	Willow Oak	0.667							X	X

Scientific name	Common name	TSS	Animals	Verts	Bat hib.	Birds	Inverts	Aerial insects	Plants	State listed
Rhododendron canadense	Rhodora	0.733							X	X
Rhododendron lapponicum	Lapland Rosebay	0.880							X	X
Rhynchospora inundata	Drowned Beakrush	0.625							X	X
Rhynchospora nitens	Short-beaked Beakrush	0.729							X	X
Rorippa aquatica	Lake-cress	0.740							X	X
Rotala ramosior	Tooth-cup	0.760							X	X
Rumex fueginus	Golden Dock	0.714							X	X
Sabatia angularis	Rose-pink	0.667							X	X
Sabatia stellaris	Sea-pink	0.900							X	X
Sagittaria montevidensis var. spongiosa	Spongy Arrowhead	0.968							X	X
Salicornia bigelovii	Dwarf Glasswort	0.969							X	X
Salix cordata	Sand Dune Willow	0.921							X	X
Salix uva-ursi	Bearberry Willow	0.810							X	X
Saxifraga aizoides	Yellow Mountain-saxifrage	0.810							X	X
Schoenoplectus heterochaetus	Slender Bulrush	0.931							X	X
Scirpus georgianus	Georgia Bulrush	0.556							X	X
Scleria triglomerata	Whip Nutrush	0.594							X	X
Scutellaria integrifolia	Hyssop-skullcap	0.897							X	X
Sericocarpus linifolius	Flax-leaf Whitetop	0.894							X	X
Sisyrinchium mucronatum	Michaux's Blue-eyed-grass	0.749							X	X
Solidago latissimifolia	Coastal Goldenrod	0.933							X	X
Solidago leiocarpa	Alpine Goldenrod	0.835							X	X
Solidago simplex var. monticola	Rand's Mountain Goldenrod	0.724							X	X
Sporobolus heterolepis	Northern Dropseed	0.862							X	X
Stellaria longipes	Longstalk Starwort	0.896							X	X
Suaeda linearis	Narrow-leaf Sea-blite	0.920							X	X
Suaeda rolandii	Roland's Sea-blite	0.733							X	X
Symphyotrichum boreale	Northern Bog Aster	0.848							X	X

Scientific name	Common name	TSS	Animals	Verts	Bat hib.	Birds	Inverts	Aerial insects	Plants	State listed
Symphyotrichum subulatum var. subulatum	Saltmarsh Aster	0.887							X	X
Thalictrum venulosum var. confine	Veiny Meadow-rue	0.800							X	X
Trichophorum cespitosum ssp. cespitosum	Deer's Hair Sedge	0.743							X	X
Triglochin palustre	Marsh Arrow-grass	0.780							X	X
Triphora trianthophora	Nodding Pogonia	0.521							X	X
Tripsacum dactyloides	Northern Gamma Grass	0.884							X	X
Utricularia juncea	Rush Bladderwort	0.801							X	X
Utricularia radiata	Small Floating Bladderwort	0.548							X	X
Utricularia striata	Fibrous Bladderwort	0.771							X	X
Vaccinium boreale	High-mountain Blueberry	0.872							X	X
Valeriana uliginosa	Marsh Valerian	0.950							X	X
Viburnum dentatum var. venosum	Southern Arrowwood	0.846							X	X
Viburnum edule	Squashberry	0.688							X	X
Viburnum nudum var. nudum	Possum-haw	0.750							X	X
Viola nephrophylla	Northern Bog Violet	0.500							X	X
Viola primulifolia	Primrose-leaf Violet	0.737							X	X
Woodsia alpina	Alpine Cliff Fern	0.500							X	X
Xyris smalliana	Large Yellow-eyed-grass	0.944							X	

Table B-2. Species not passing validation

Scientific name	Common name	TSS
Animals		
Myotis leibii	Eastern Small-footed Myotis summer	0.244
Dendroica caerulescens	Black-throated Blue Warbler	0.418
Hylocichla mustelina	Wood Thrush	0.279
Oxyura jamaicensis	Ruddy Duck	0.486
Piranga olivacea	Scarlet Tanager	0.493
Vermivora peregrina	Tennessee Warbler	0.021
Chytonix ruperti	A Noctuid Moth	0.333
Euchlaena madusaria	A Geometrid Moth	0.469
Notropis buccatus	Silverjaw Minnow	0.389
Progomphus obscurus	Common Sanddragon	0.377
Nonvascular plants		
Cyrto-hypnum pygmaeum	Pygmy Cedar Moss	0.222
Meesia triquetra	Three-leaved Thread Moss	0.267
Myurella julacea	Small Mousetail Moss	-0.167
Platydictya jungermannioides	False Willow Moss	0.333
Sematophyllum demissum	Hanging Long Beak Moss	0.056
Sphagnum andersonianum	Anderson's Peat Moss	0.333
Vascular plants		
Ageratina aromatica var. aromatica	Small White Snakeroot	0.446
Calamagrostis stricta ssp. inexpansa	Northern Reedgrass	0.294
Carex buxbaumii	Brown Bog Sedge	0.432
Carex frankii	Frank's Sedge	0.381
Carex houghtoniana	Houghton's Sedge	0.386
Carex lupuliformis	False Hop Sedge	0.475
Cuscuta cephalanthi	Button-bush Dodder	0.250
Desmodium obtusum	Stiff Tick-trefoil	0.068
Eleocharis ovata	Blunt Spikerush	0.375
Eleocharis quadrangulata	Angled Spikerush	0.300
Epilobium hornemannii ssp. hornemannii	Alpine Willow-herb	0.333
Eupatorium pubescens	Serrate Round-leaf Boneset	0.476
Geum virginianum	Rough Avens	0.072
Gymnocladus dioicus	Kentucky Coffee Tree	0.026
Juncus subcaudatus	Woodland Rush	0.487
Lactuca hirsuta	Downy Lettuce	0.000
Linum medium var. texanum	Southern Yellow Flax	0.256

Scientific name	Common name	TSS
Lygodium palmatum	Climbing Fern	0.070
Monarda clinopodia	Basil-balm	0.444
Oenothera oakesiana	Oakes' Evening-primrose	0.489
Phlox maculata ssp. maculata	Wild Sweet-william	0.464
Platanthera hookeri	Hooker's Orchid	0.456
Potamogeton diversifolius	Water-thread Pondweed	0.361
Potentilla paradoxa	Bushy Cinquefoil	0.400
Scleria pauciflora var. caroliniana	Few-flowered Nutrush	0.333
Silene caroliniana ssp. pensylvanica	Wild Pink	0.448
Sparganium natans	Small Bur-reed	0.333
Stachys hyssopifolia	Rough Hedge-nettle	0.478

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B.6 Layer: Modeled Migratory Bird Stopovers

Layer developed by: Cornell Laboratory of Ornithology and New York Natural Heritage Program

Short Description: This layer depicts the results models predicting stopover habitat for 28 species of migratory birds. For each species, known stopover locations were obtained from the eBird database and used to predict the probability of occurrence throughout the State using landcover data. The probability of occurrence for each species was rescaled from 0 to 1 and the values for each species were added together. The higher the number in a grid cell, the more species are predicted to stop over within that cell during their species-specific migration window.

Why this layer matters: Migratory birds are known to be killed by wind turbines and may be especially susceptible within heavily used flyways and stopover hotspots. Understanding where migratory birds are most likely to fly through and stop over may be important for avoiding impacts of development or for mitigation during certain times of year or in certain weather conditions.

Source: Location data derived from the eBird dataset.

Processing Overview:

9. Methods for generating continuous probability of occurrence surfaces for each of the 28 species in both spring and fall were developed.
10. Each species was normalized by dividing all values by the maximum to rescale each species from 0 to 1.
11. The values for each species in each cell was added to yield a composite value representing the probability of multiple species occurring in each cell during each species' migration window. This range was labeled from low to high (Figures B-14 and B-15).

Figure B-14. Summed probabilities for 28 models of migratory birds during the spring migration

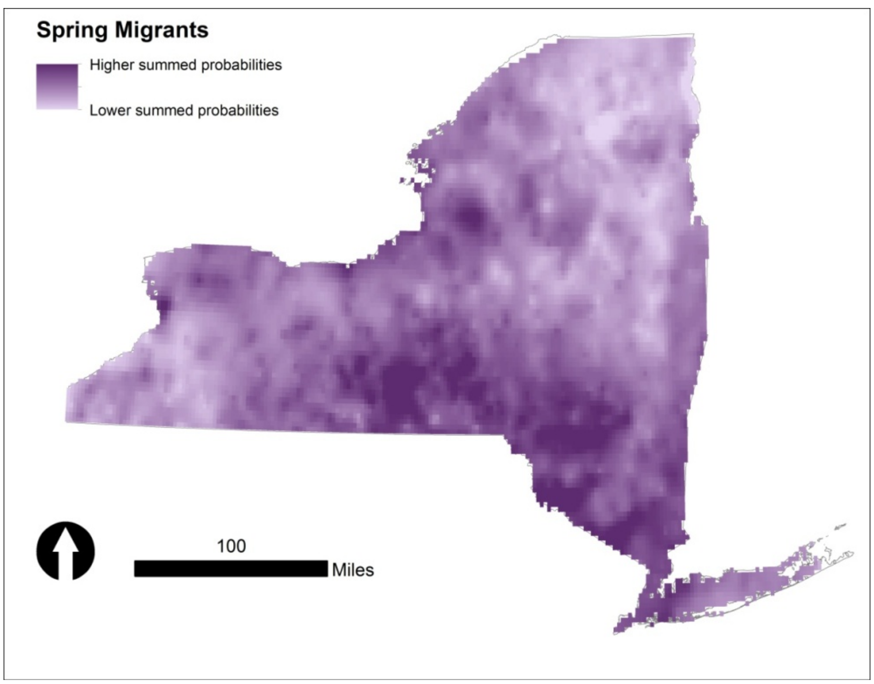
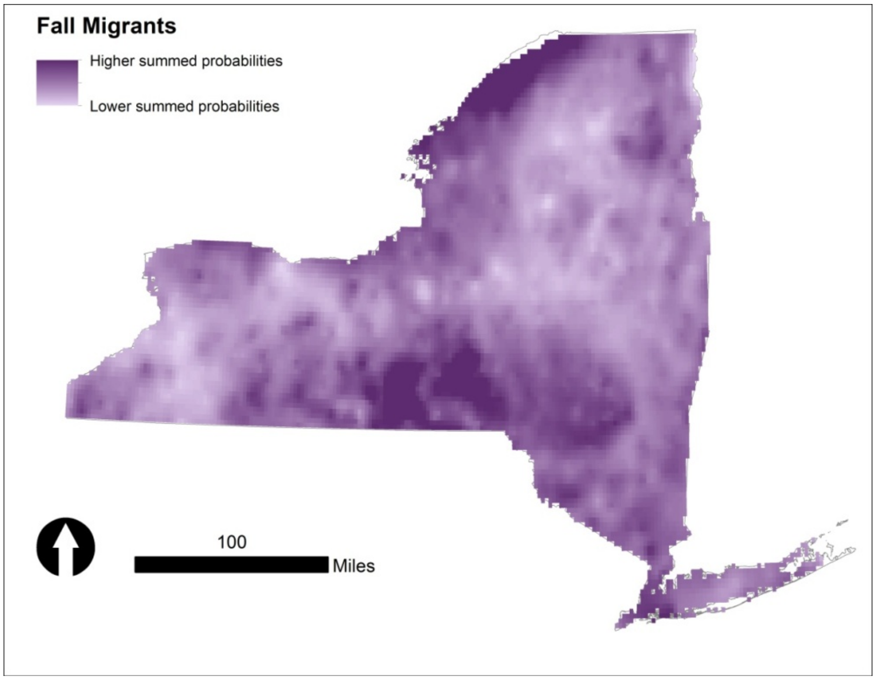


Figure B-15. Summed probabilities for 28 models of migratory birds during the fall migration



B.7 Layer: Modeled Bat Summer Distributions

Layer developed by: New York Natural Heritage Program

Short Description: This layer depicts the predicted richness (number) of up to three species of bat that occur in New York during the summer. The probability of suitable habitat for each species was modeled and converted to the predicted presence (1) or absence (0) of suitable habitat. These layers were then summed across all species to yield the number of species for which suitable habitat was predicted to be present in each cell.

Why this layer matters: Due to their high mobility, large home range sizes, and frequent movements between roosting and foraging locations within summer habitat, bats are best managed at a landscape scale (Lacki et al. 2007). Little brown bats are of conservation concern due to dramatic declines from white-nose disease (NYS DEC unpublished data) and the status of migratory tree bats, such as the hoary bat and eastern red bat, are not well known but they are thought to be uncommon in New York (Stegmann and Hicks 2008). Understanding where these species occur throughout the landscape is important for conservation-planning for bats and may be important for mitigation as well.

Source: Location data came from two sources a statewide acoustic dataset (2009-2010) from the NYS Department of Environmental Conservation and a mist-netting data set that was a compilation of many independent studies (2003-2010). Data sources did not include any sampling from Long Island, so caution should be exercised in using the models to predict species locations there.

Processing Overview:

1. Eight of the nine bat species occurring in New York during the summer were examined, and created models were created for three species that had over 500 presence locations and low error rates for predicting presence (0.08-0.32) and absence (<0.01 for all).
2. Each 30-m cell was attributed with 57 environmental variables (see Howard and Schlesinger [2012]).
3. The environmental characteristics of known presence cells were compared to nondetections, locations that were sampled but where no individual of a particular species was found, using Random Forest analysis.
4. Results of this model were used to predict the probability of suitable habitat for each species.
5. For each species, we attributed any location (raster cell) with greater than 50% probability of suitable habitat as "suitable" were attributed as (1) and all locations with lower probabilities as "unsuitable" (0).
6. For each of the 3 species, the 0/1 was summed to arrive at the number of species predicted to have suitable habitat in each cell (Figure B-16 and Tables B-3 and B-4).

Figure B-16. A stack of three modeled bat summer distributions

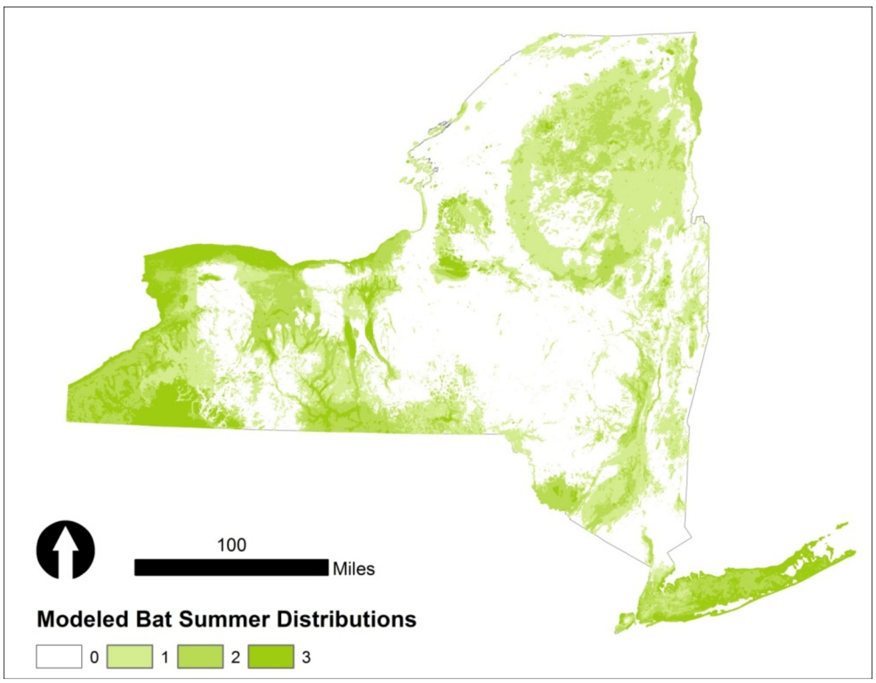


Table B-3. Models passing validation

Scientific Name	Common Name	Model error[1]	Presence error	Absence error
Eptesicus fuscus[2]	Big Brown Bat	0.041	0.195	0.008
Lasiurus borealis[3]	Eastern Red Bat	0.024	0.318	0.003
Lasiurus cinereus[3]	Hoary Bat	0.024	0.291	<0.001
Myotis lucifugus[3]	Little Brown Bat	0.025	0.266	0.004

1. The model error rate refers to the "out-of-bag" error rate in Random Forest analysis that uses a subset of the original dataset to validate the model (Breiman 2001).
2. This species was not included in the stacked spatial model because it is currently common, widespread, and not a conservation priority.
3. These species were included in the stacked spatial model.

Table B-4. Models that did not pass validation

Scientific Name[1]	Common Name	Model error[2]	Presence error	Absence error
Myotis leibii	Small-footed Bat	0.035	0.917	0
Myotis septentrionalis	Northern Bat	0.008	0.791	0.001
Myotis sodalis	Indiana Bat	0.004	0.750	0.007
Periomyotis subflavus	Tri-colored Bat	0.002	0.574	<0.001

1. The number of detections (6) of silver-haired bats (*Lasionycteris noctivagans*) prohibited modeling this species.
2. The model error rate refers to the "out-of-bag" error rate in Random Forest analysis that uses a subset of the original dataset to validate the model (Breiman 2001).

Literature Cited:

Breiman, L., 2001. Random forests. Machine Learning 45, 5–32.

Howard, T., and M. Schlesinger. 2012. PATHWAYS: Wildlife Habitat Connectivity in The Changing

Climate of the Hudson Valley. New York Natural Heritage Program, Albany, NY.

Lacki, M.J., Hayes, J.P., Kurta, A., 2007. Bats in forests: conservation and management. The Johns Hopkins University Press, Baltimore, MD.

Stegmann, E., Hicks, A., 2008. Bats of New York. New York State Conservationist 62(4): 19-22.

B.8 Layer: Indiana Bat Migration

Layer developed by: New York Natural Heritage Program

Short Description: This layer depicts generalized areas for Indiana bat (*Myotis sodalis*) hibernacula and summer roosting or foraging locations and the zones where travel between these seasonal locations may be expected to occur. Exact migration pathways are unknown and there are likely additional Indiana bat locations on the landscape that are unknown.

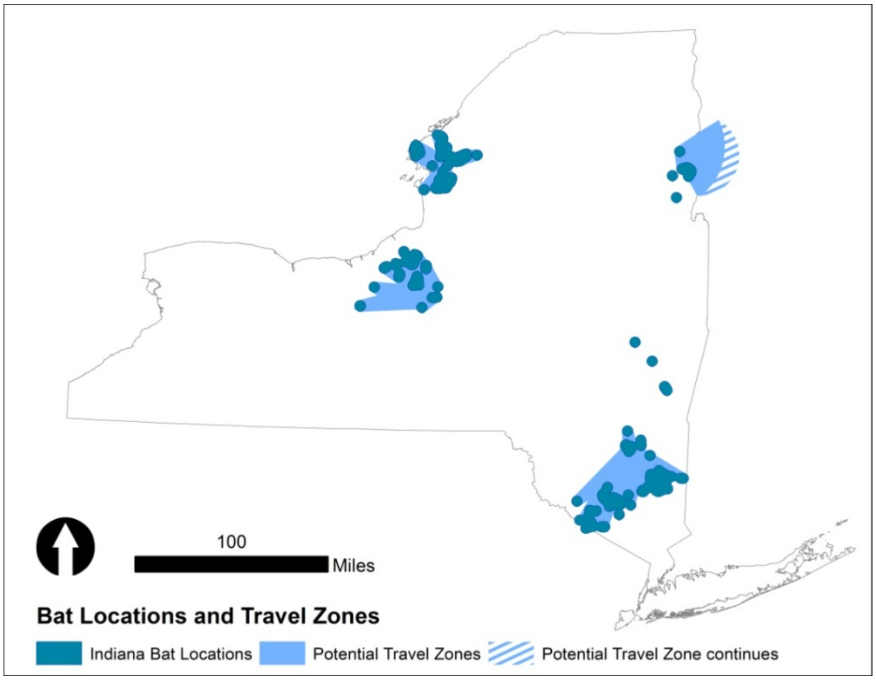
Why this layer matters: Bat fatalities are known to occur at wind turbine sites, especially during seasonal movements, so understanding where throughout the landscape bats may be more likely to occur (or fly through), may be important for mitigation.

Source: The hibernacula and summer roosts, foraging, and capture locations came from the New York Natural Heritage Program element occurrence database. Radio-tracking data from the New York Department of Environmental Conservation linked bat hibernacula to known summer locations.

Processing Overview:

1. Summer locations (captures, foraging areas, and roost trees) and hibernacula were buffered by 2.5 miles to encompass an estimated home range that would be used by Indiana bats in summer including individuals that may remain near the hibernacula.
2. The resulting polygons previously described were merged into a single layer.
3. Radio-tracking data was used to link bat summer locations to their hibernacula.
4. Potential travel zones were created using a dissolved 4 mile wide buffer.
5. The travel zones and summer location layers were merged.
6. Hibernacula without radio-tracking data or summer locations where hibernacula were not known remained as buffered polygons without travel zones in the final layer (Figure B-17).

Figure B-17. A map of Indiana bat locations and travel zones



B.9 Layer: Priority Large Forested Areas

Layer developed by: The Nature Conservancy

Short Description: This layer depicts the matrix forest blocks selected by The Nature Conservancy as the most viable examples of the dominant forest communities throughout New York State. Matrix sites are large contiguous areas whose size and natural condition allow for the maintenance of ecological processes, viable occurrences of matrix forest communities, embedded large and small patch communities, and embedded species populations. The goal of the matrix forest selection was to identify viable examples of the dominant forest types that, if protected and allowed to regain their natural condition, would serve as critical source areas for all species requiring interior forest conditions or associated with the dominant forest types.

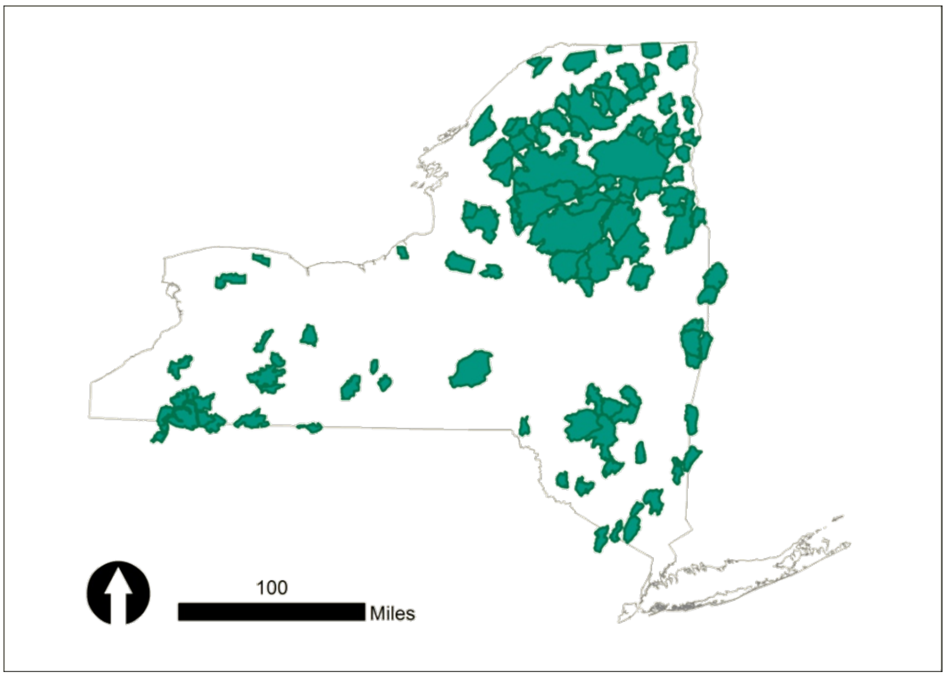
For most of the ecoregions in New York, these matrix-forming ecosystem targets were selected as part of their extensive Ecoregional Planning process. This work was never conducted for the Great Lakes Ecoregion and thus the Nature Conservancy in New York and the New York Natural Heritage Program identified a small set of blocks (nine additional) for this ecoregion. In total, there are 114 matrix forest blocks occurring at least in part in New York State.

Source and Methods: For general information about the methods for identifying matrix forest blocks see http://conserveonline.org/workspaces/ecs/lne/docs/matrix_methods/view.html

With the exception of the Great Lakes ecoregion, each ecoregion has specific information and data availability. All of these ecoregional plans are available at http://conserveonline.org/workspaces/ecs/plans

For the New York portion of the Great Lakes Ecoregion, a set of candidate blocks were developed based on the extent of forest and the patterns of fragmenting features such as roads, railroad corridors, and other development. Scientists from the Central/Western New York, Eastern New York, and New York State offices of The Nature Conservancy and the Natural Heritage Program reviewed these candidate blocks individually and then together at a meeting to come up with a final set of blocks that met both condition and representation standards (Figure B-18).

Figure B-18. Matrix Forest Blocks for New York State



B.10 Layer: Matrix Forest Block Linkages and Linkage Zones

Layer developed by: New York Natural Heritage Program

Short Description of Forest Block Linkages:

This layer depicts the Least Cost Paths (LCP) among forest blocks; one model of the best way to maintain connectivity for the populations of plants and animals of these forests. A least cost path balances travel distance and ease of travel; here it is designated as the amount of natural land within 1 kilometer. The goal is to describe the most permeable part of the landscape between a pair of forest blocks. LCPs may help identify habitat stepping stones, riparian zones, or even wide swaths of natural land and thus should be viewed within the context of the landscape, not simply as a line on the ground.

Short Description of Linkage Zones:

This layer depicts the Conditional Minimum Transit Cost linkage zones among forest blocks. A zone between two forest blocks depicts the area around all the paths represented by the cost of the single LCP plus 20%. The goal is to describe the most permeable part of the landscape between a pair of forest blocks. The LCP and the associated linkage zone may help identify habitat stepping stones, riparian zones, or even wide swaths of natural land and thus should be viewed within the context of the landscape.

Why these layers matter: To best maintain viable populations within matrix forest blocks there needs to be a minimal amount of movement and genetic exchange among blocks. Understanding where successful movement is most likely to occur helps us prioritize for landscape permeability and barrier mitigation.

Source: These layers are modeled by the New York Natural Heritage Program based on work developed through funding from NYSERDA and NYSDEC. The LCP is based on a surface depicting the amount of natural land in the landscape, which is derived from the NOAA C-CAP Land Cover data set MRLC Land Use/Land Cover dataset (30 meter raster data) (http://www.csc.noaa.gov/digitalcoast/).

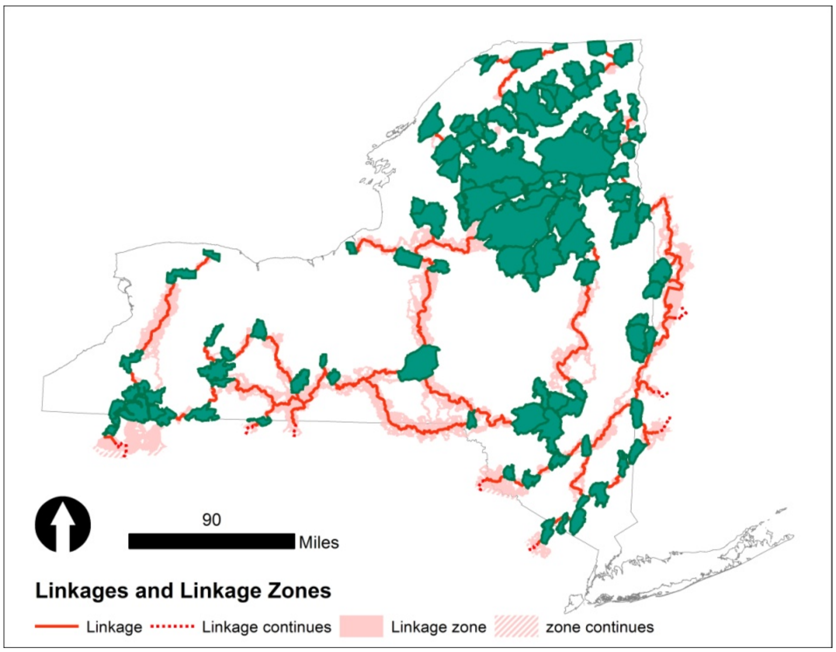
Processing Overview:

1. To create a generalized representation of natural land for the study area, all natural land categories were extracted: Grassland/Herbaceous (8), Deciduous Forest (9), Evergreen Forest (10), Mixed Forest (11), Scrub/Shrub (12), Palustrine Forested Wetland (13), Palustrine Scrub/Shrub Wetland (14), Palustrine Emergent Wetland (15), Estuarine Forested Wetland (16), Estuarine Scrub/Shrub Wetland (17), and Estuarine Emergent Wetland (18).
2. A roving-window (focal statistics) analysis on this extracted layer was conducted, using a circle of radius 1,000 meters, to create a surface depicting the proportion of natural land within 1,000 meters.
3. The resolution of the raster data set was then reduced from 30-m cells to 330-m cells using the Aggregate tool (cell factor of 11) in ArcGIS with the output cell representing the mean of the cells aggregated. This layer was used to represent the resistance surface.
4. Each matrix forest block occurring at least partially within New York State was evaluated as a patch. Least Cost Paths (LCP) were evaluated from and to every patch.
5. A single LCP is derived as a balance of straight distance and “cost” to travel, which comes from the surface of proportion natural land. A key assumption is that forest species see the natural landscape as easier to travel through than the developed landscape and thus areas with a higher proportion of natural land are more permeable to our species of interest. The formula describing the balance between distance and cost used in this assessment is:
6. Cost for traveling one step = distance * average cost between points$^{1.5}$
7. Points are represented by single nodes along the path, and vary in their distance depending on the homogeneity of the cost surface. The total cost of the LCP is the sum of all the step to step costs.
8. The linkage zone is then an aggregation of all the paths between two patches with a total cost less than the LCP plus 20% (Figure B-19).

For more details about the approach used here to develop these linkages, see Howard, T., and M. Schlesinger. 2012. PATHWAYS: Wildlife Habitat Connectivity in the Changing Climate of the Hudson Valley. New York Natural Heritage Program, Albany, NY. 143 pages. http://nynhp.org/pathways

The approach for developing linkage zones follows the theory developed in Pinto, N., and T. H. Keitt. 2009. Beyond the least-cost path: evaluating corridor redundancy using a graph-theoretic approach. Landscape Ecology 24:253–266.

Figure B-19. Linkages and Linkage zones among matrix forest blocks in New York State



B.11 Layer: Percent Forest in the Landscape

Layer developed by: The Nature Conservancy

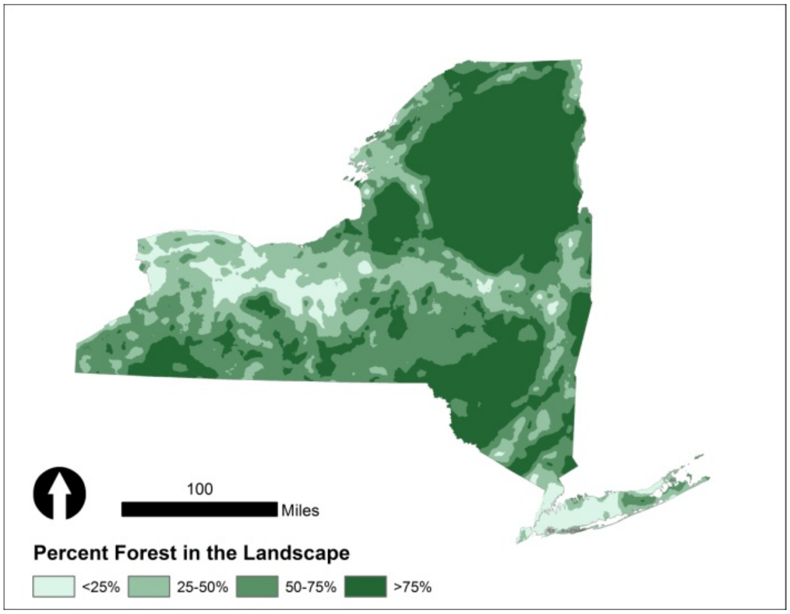
Short Description: The overall goal of this layer is to broadly depict the amount of forest in the landscape. The layer is based on the 2006 version of the National Land Cover Database and depicts the amount of forested land within 300 meters of any location.

Source: This data layer is derived from the 2006 version of the Multi-Resolution Land Characteristics Consortium (MRLC) National Land Cover Database (NLCD; http://www.mrlc.gov).

Processing Overview:

1. All the forest types were extracted from the NLCD layer (41: Deciduous Forest; 42 Evergreen forest; 43: Mixed Forest) and a new layer was created coded as forest/non-forest (1/0).
2. With the new layer, a neighborhood analysis was completed in ArcGIS (tool: Focal Statistics) using a 300-meter radius and statistics type = MEAN. The VALUE for each 30-m cell represents the proportion of forest in the neighborhood, based on the NLCD classification.
3. This layer was then clipped to New York State. The data are depicted in four simple groups: <25% forested in the neighborhood, 25-50% forested in the neighborhood, 50-75% forested in the neighborhood, and > 75% forested in the neighborhood (Figure B-20).

Figure B-20. A map of how densely the landscape is forested



B-12. Layer: Terrestrial Landscape Resilience

Layer developed by: The Nature Conservancy

Short Description: The Nature Conservancy's terrestrial resilience analysis evaluated all land across 13 states in the Northeast and Mid-Atlantic region, for characteristics that impart resilience. To perform the analysis, the region was partitioned into 156,581 hexagon-shaped units, each 1,000 acres in size (like hexagons on the surface of a soccer ball). For each 1,000-acre hexagon, extensive ecological information was compiled including its geology, elevation range, landform diversity, wetland density, degree of connectedness, terrestrial habitats, rare species, and more. The compiled information was used to score each hexagon for its estimated resilience to a changing climate, and was based on the number of microclimates and the degree of connectedness found within it. For ranking purposes, hexagons were compared only to other hexagons of the same geophysical setting (i.e., sites of the same geology type and elevation zone) and within the same ecological region. For example, limestone sites in the Central Appalachians were compared to other limestone sites within the Central Appalachians, not to limestone sites in Lower New England. The final results are therefore relative to a specific setting and ecoregion, and this ensured that the analysis identified the sites with the highest estimated resilience for all important natural settings in the region.

Why this layer matters: Landscape resilience is the ability of a site to maintain ecological functions and a diversity of native species, even as the species composition changes with the climate (Figure B-21).

Source: See more at https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/edc/reportsdata/terrestrial/resilience/ne/Pages/default.aspx#sthash.jQpN3JUj.dpuf

Includes a link to the full report, "Resilient Sites for Species Conservation in the Northeast and Mid-Atlantic Region" (Anderson et al. 2011).

Processing Overview:

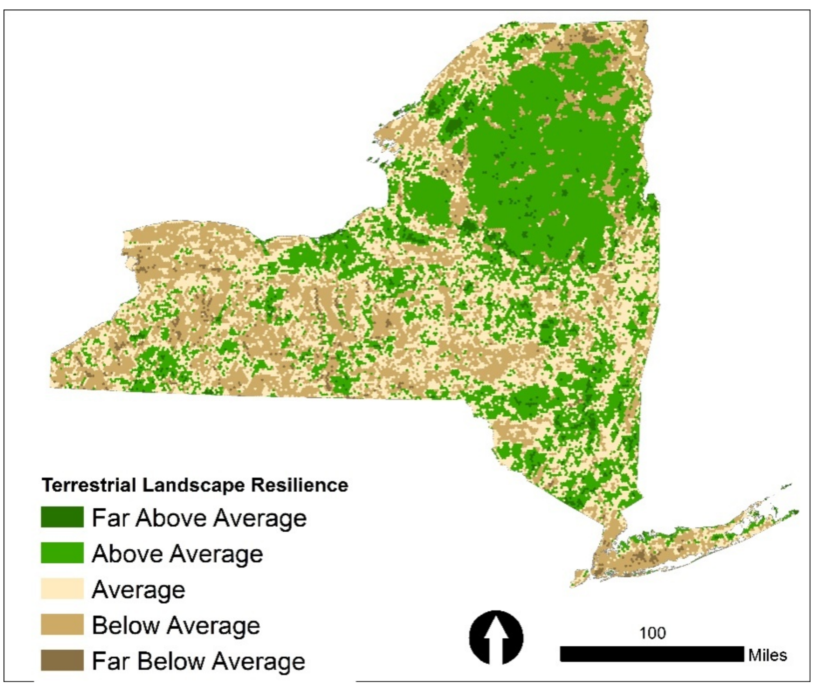
Download the datasets from

https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/edc/reportsdata/terrestrial/resilience/ne/Pages/default.aspx#sthash.jQpN3JUj.dpuf

Literature Cited:

Anderson, M., M. Clark, and A. Olivero Sheldon. 2011. Resilient Sites for Species Conservation in the Northeast and Mid-Atlantic Region. The Nature Conservancy, Eastern Conservation Science. 122 pages.

Figure B-21. Terrestrial landscape resilience



B.13 Layer: FAA Turbine Locations

Layer developed by: New York Natural Heritage Program

Short Description: This layer depicts existing and proposed wind turbines in New York State, as provided by the Federal Aviation Administration's obstruction evaluation process. All construction projects that have the potential to affect navigable airspace must file a "Notice of Proposed Construction or Alteration" to the FAA. Wind turbine cases from 1990 through January 2013 are included in this layer, with duplicate cases removed.

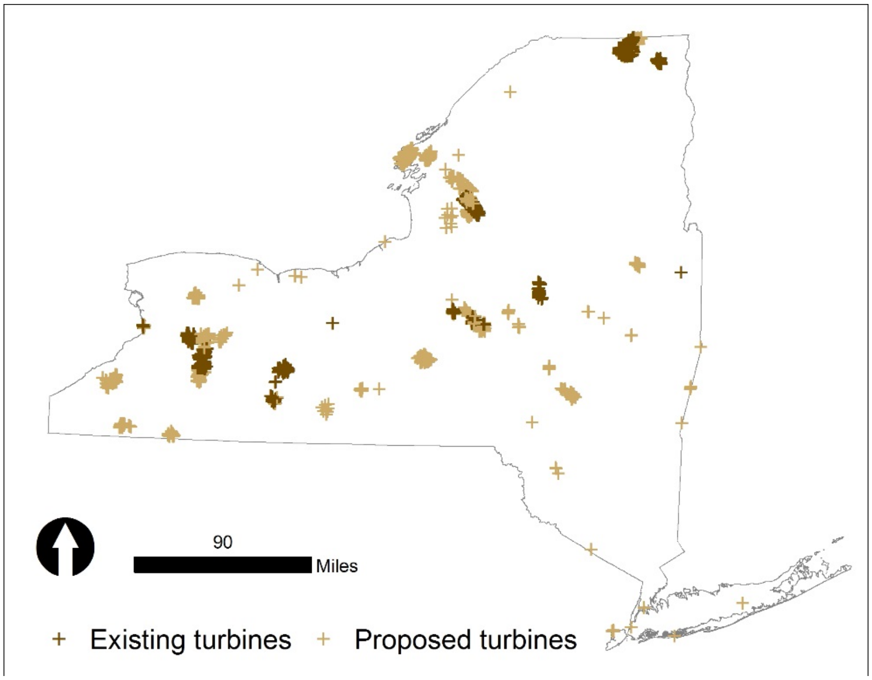
Why this layer matters: A spatial representation of existing and proposed turbine sites gives users an important perspective on the distribution of and pattern of wind power generation in New York. To better understand how turbines are situated, these locations were also used to model the relationship between turbine locations and other environmental variables, such as wind production capacity, elevation, distance to transmission, and developed and forested lands.

Source: The original locations were downloaded from the FAA (https://oeaaa.faa.gov/oeaaa/external/public/publicAction.jsp?action=showCaseDownloadForm). These points were subsequently cleaned up by the New York Natural Heritage Program.

Processing Overview:

1. All "Off Airport Cases" for WTE (Wind Turbines East) and AEA (Eastern Region: VA to NY) were downloaded for the years 1990 to 2013. Downloads were completed in January and thus include information available up to that time.
2. A script was built in the R statistics package that processed the data as follows:
    - Merge all the download files
    - Extract only structures in New York (structure state = NY)
    - Extract only wind turbines (structure type = Wind Turbine or "wind turbine" appearing in the "proposal description" field). Remove those tagged as meteorological towers (Met Towers).
    - Remove duplicates both as recorded by Autonomous System Number (ASN) numbers and records with locations reported as within 90 meters of another location. Also remove temporary towers and older cases that had been assigned new ASN numbers
    - A few special case farms were also removed: A large offshore project in Lake Erie that has not been completed and a series of vertical axis turbines on Long Island ("Windstor Power Co." applications) that also have not been built.
    - Remove all turbines labeled as under 50 m (164 feet) in height.
    - Label all entries tagged as "Existing" in the "Notice_of" field or having a date entry in the "Built_date" field were labeled as "Exists." Tag all others as "Proposed."
3. The final result was a layer with 1,886 records. Without manually checking each point in a GIS, it is very difficult to determine the accuracy of the existing and proposed determinations, but spot checking indicates most attributions are correct (Figure B-22).

Figure B-22. Existing and proposed commercial wind turbines in New York State



B.14 Layer: Wind Power Class at 50m

Layer developed by: AWS Truepower and National Renewable Energy Laboratory (NREL)

Short Description: This layer depicts annual average wind resource potential at 50 meters above the ground surface, as modeled by AWS Truepower and validated with surface data by NREL and wind energy consultants.

Why this layer matters: How much the wind blows (the wind resource potential) at a site is important for determining the cost effectiveness in developing wind power facilities. The siting of wind energy projects requires consideration of many factors. Although wind speed is one such factor, other aspects of a site are balanced with wind speed when determining the suitability of the site for wind energy development (Figure B-23).

Source: NREL and AWS Truepower (http://www.awstruepower.com/). A polygon version of this data set is available at http://www.nrel.gov/gis/data_wind.html

Additional metadata are available at

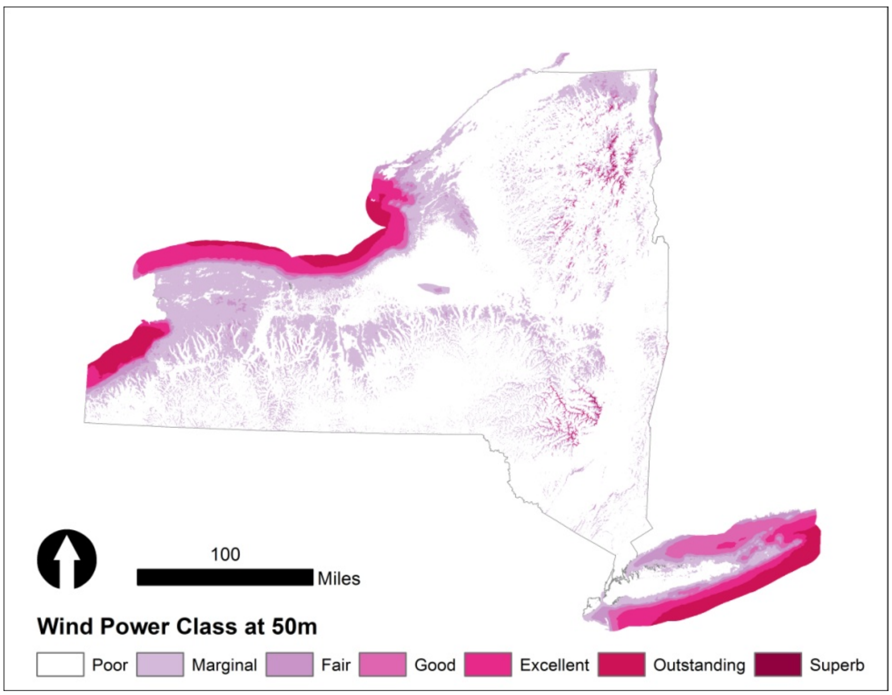
http://www.nrel.gov/gis/cfm/data/GIS_Data_Technology_Specific/United_States/Wind/metadata/ny_50m_metadata.htm

For hub heights 120 feet or less, NYSERDA worked with AWS Truewind to develop a free wind mapping tool called "Smallwind Explorer," which is available at http://nyswe.awstruepower.com/

Processing Overview:

1. Wind resource potential is modeled in the units Watts/meters^2 (W/m^2) and depicted with these levels: Poor = 0-200; Marginal = 200-300; Fair = 300-400; Good = 400-500; Excellent = 500-600; Outstanding = 600-800; Superb = > 800 W/m^2.
2. For display purposes, we converted the original ArcGIS grid to vector (polygon), with cells grouped by values spanning 50 W/m^2. Each cell value was rounded up to the next value divisible by 50, using PYTHON syntax in Field Calculator in ArcGIS on the converted polygon layer [(!grid_code! - math.fmod(!grid_code!, 50)) + 50)]].

Figure B-23. Wind Power Class in New York State



B.15 Layer: Distance to Power Transmission

Layer developed by: The Nature Conservancy

Short Description: This layer depicts, in broad bands, how far any part of the landscape is from major power transmission lines.

Why this layer matters: How close a potential site is from transmission lines may influence the feasibility for developing wind power at the site. The siting of wind energy projects requires consideration of many factors.

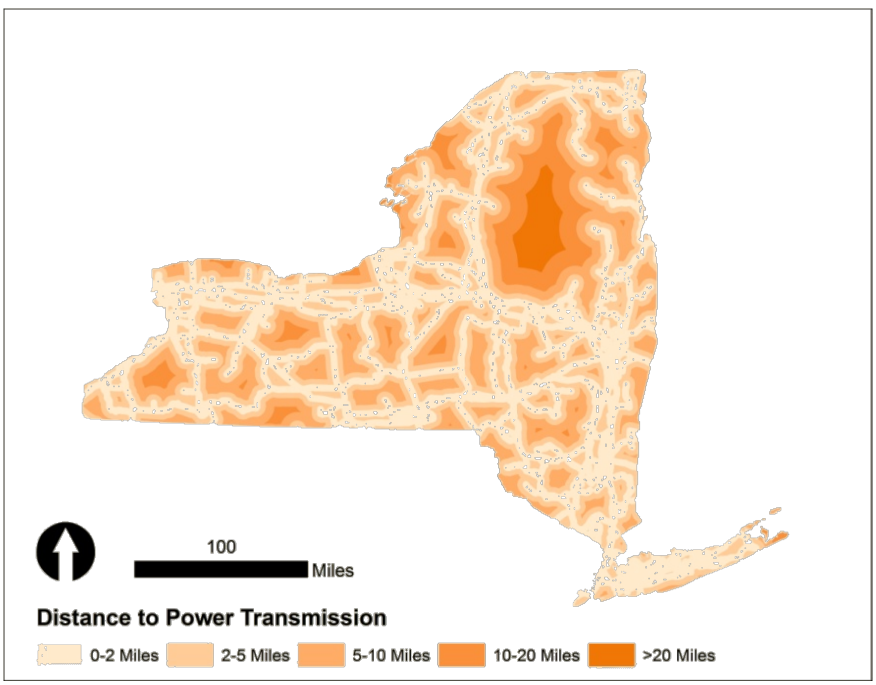
Although distance to power transmission is one such factor, other aspects of a site are balanced with distance to transmission lines when determining the suitability of the site for wind energy development. Other transmission factors that play a role include transmission capacity of the lines and availability of the lines to take new energy inputs.

Source: This layer is derived from data obtained through a License Use Agreement with Ventyx Energy, LLC which includes permission to share this derived output as a "Customer Work Product." This summary data layer is necessarily coarse to restrict the ability to recreate the original line shapefile, which the License Agreement disallows.

Processing Overview:

1. All in service lines linking substations within and around New York State were buffered 2 miles initially, and then 1 mile repetitively afterwards to create the continuous surface of bands.
2. These bands are depicted in five simple groupings for the best visual effect, but the 1-km bands are retained for manual visualization by the end user.

Figure B-24. Distance to power transmission lines in New York State



B.16 Layer: Elevation

Layer developed by: New York Natural Heritage Program

Short Description: This layer depicts topography throughout New York in terms of elevation above sea level, in meters.

Why this layer matters: In a model of existing and permitted wind turbine locations, elevation came out as the second most important environmental variable, after wind production capacity. With the exception of shoreline locations, inland turbine sites are strongly associated with higher elevations (Figure B-25).

Source:

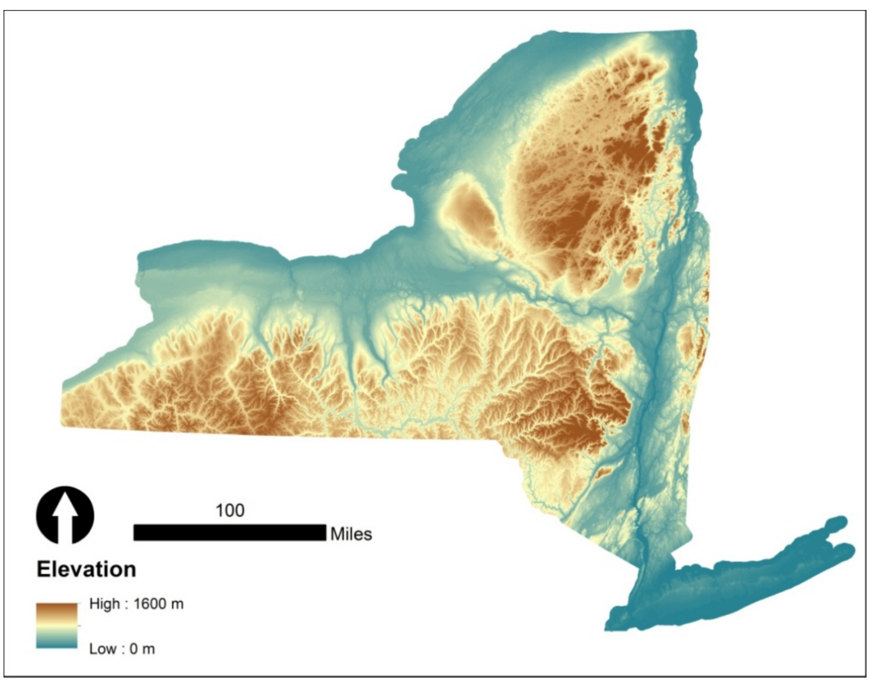
This layer was derived from the USGS Digital Elevation Model, now termed the National Elevation Dataset (NED; http://ned.usgs.gov/).

Processing Overview:

Download DEM data from USGS at 30m resolution.

1. Clip to New York State, with a buffer beyond the state of 5 km.

Figure B-25. A map of elevation in New York State



B.17 Layer: Marcellus Shale Depth to Base

Layer developed by: New York Natural Heritage Program, adapted from the Penn State Marcellus Center for Outreach and Research

Short Description: This layer depicts the distance from ground surface to the bottom of the Marcellus Shale layer, in groups of 1000 foot intervals.

Why this layer matters: Both shale depth and shale thickness influence the amount and quality of extractable natural gas in the Marcellus formation.

Source: These data were extracted from the publicly available maps provided by the Penn State Marcellus Center for Outreach and Research (http://www.marcellus.psu.edu/resources/maps.php). The northern boundary, where the shale bed is exposed at ground level, was modified based on the New York State Bedrock Geology map (Figure B-26; http://www.nysm.nysed.gov/gis/).

This layer is only a very rough representation of the depth of the shale layer and should only be interpreted at very coarse scales.

Processing Overview:

1. The map provided by the Marcellus Center (see Figure B-27) was georeferenced in ArcGIS using many reference points scattered throughout the state.
2. Each boundary was hand-digitized at about 1:400,000 scale.
3. Boundaries at the north end were modified so that they fall within the Marcellus Formation as defined by the NYS Geology Map (Material = Dhm, Dhmr).

Figure B-26. The depth of Marcellus Shale in New York

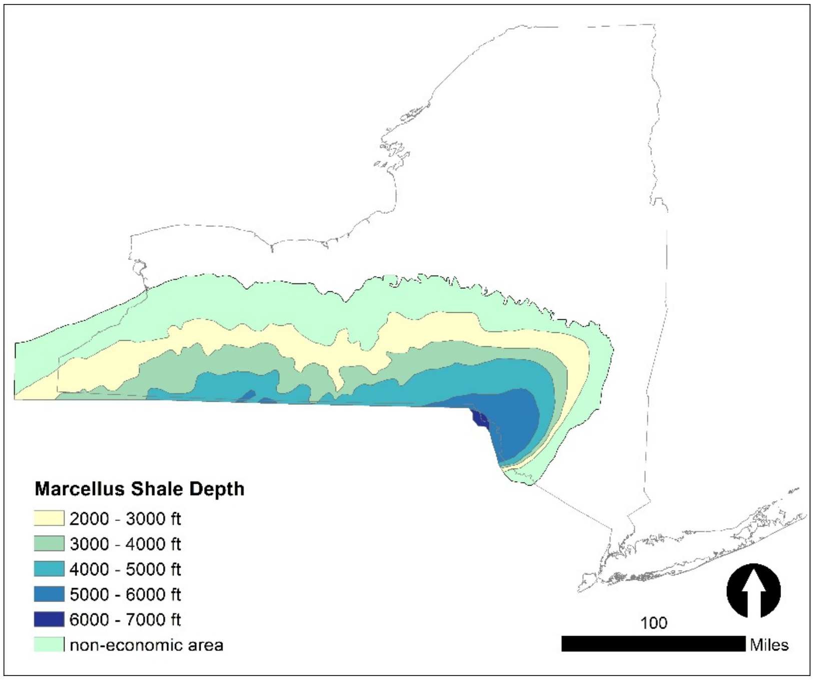
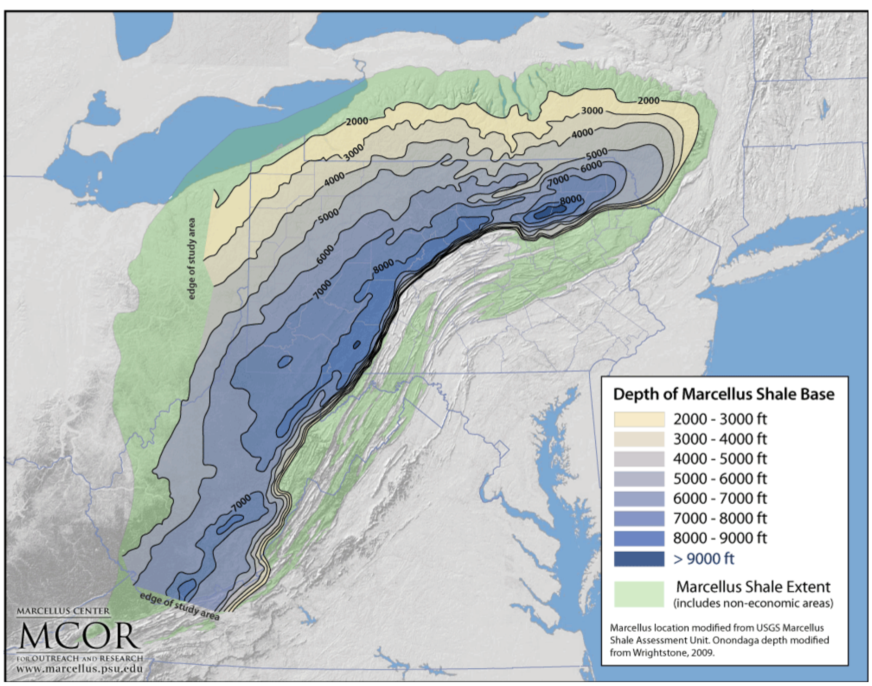


Figure B-27. Depth of Marcellus Shale as produced by the Marcellus Center



B.18 Layer: Marcellus Shale Thickness

Layer developed by: New York Natural Heritage Program, adapted from the Penn State Marcellus Center for Outreach and Research

Short Description: This layer depicts the thickness of the Marcellus Shale Formation in New York, in groups of 50 foot intervals.

Why this layer matters:

Both shale depth and shale thickness influence the amount and quality of extractable natural gas in the Marcellus formation (Figure B-28).

Source: These data were extracted from the publicly available maps provided by the Penn State Marcellus Center for Outreach and Research (http://www.marcellus.psu.edu/resources/maps.php). The northern boundary, where the shale bed is exposed at ground level, was modified based on the New York State Bedrock Geology map (http://www.nysm.nysed.gov/gis/).

This layer is only a very rough representation of the depth of the shale layer and should only be interpreted at very coarse scales.

Processing Overview:

1. The map provided by the Marcellus Center (see Figure B-29) was georeferenced in ArcGIS using many reference points scattered throughout the state.
2. Each boundary was hand-digitized at about 1:400,000 scale.
3. Boundaries at the north end were modified so that they fall within the Marcellus Formation as defined by the NYS Geology Map (Material = Dhm, Dhmr).

Figure B-28. Map of Marcellus Shale thickness in New York State

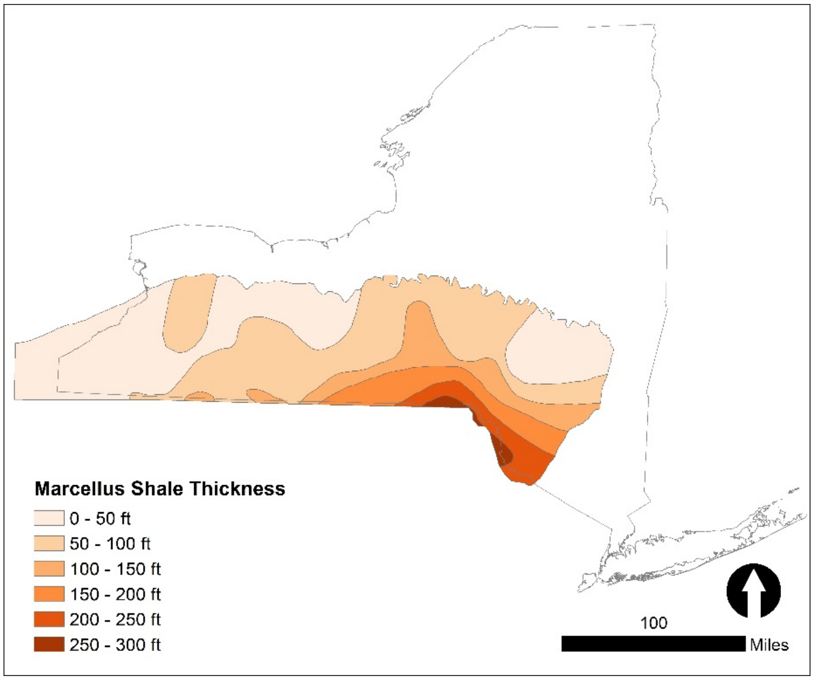
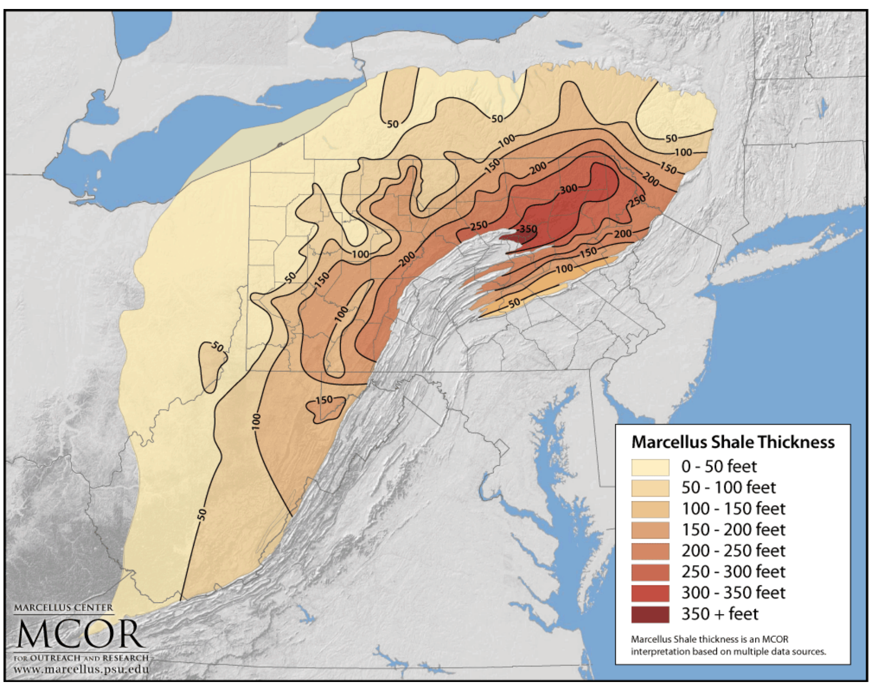


Figure B-29. Map of Marcellus Shale thickness as produced by the Marcellus Center



B.19 Layer: Utica Shale Depth

Layer developed by: New York Natural Heritage Program, adapted from the Penn State Marcellus Center for Outreach and Research

Short Description: This layer depicts the depth of the Utica Shale Formation in New York, in groups of 2000 foot intervals.

Why this layer matters: Both shale depth and shale thickness influence the amount and quality of extractable natural gas in the Utica formation (Figure B-30).

Source: These data were extracted from the publicly available maps provided by the Penn State Marcellus Center for Outreach and Research (http://www.marcellus.psu.edu/resources/maps.php). The northern boundary, where the shale bed is exposed at ground level, was modified based on the New York State Bedrock Geology map, available here (http://www.nysm.nysed.gov/gis/).

This layer is only a very rough representation of the depth of the shale layer and should only be interpreted at very coarse scales.

Processing Overview:

1. The map provided by the Marcellus Center (see Figure B-31) was georeferenced in ArcGIS using many reference points scattered throughout the state.
2. Each boundary was hand-digitized at about 1:400,000 scale.
3. Boundaries at the north end were modified so that they fall within the Utica Shale bedrock type (Formation Member) as defined by the NYS Geology Map.

Figure B-30. Map of the depth of Utica Shale in New York

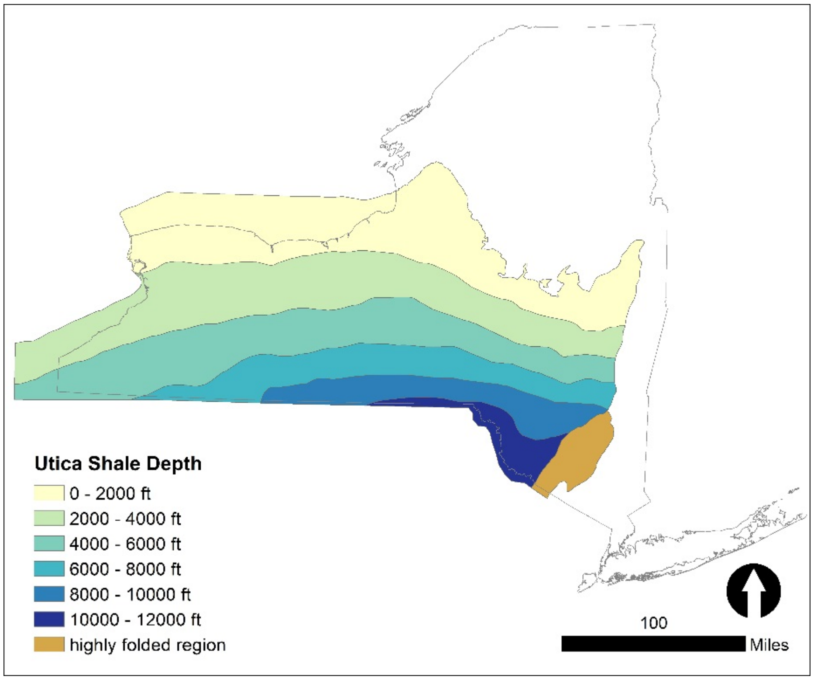
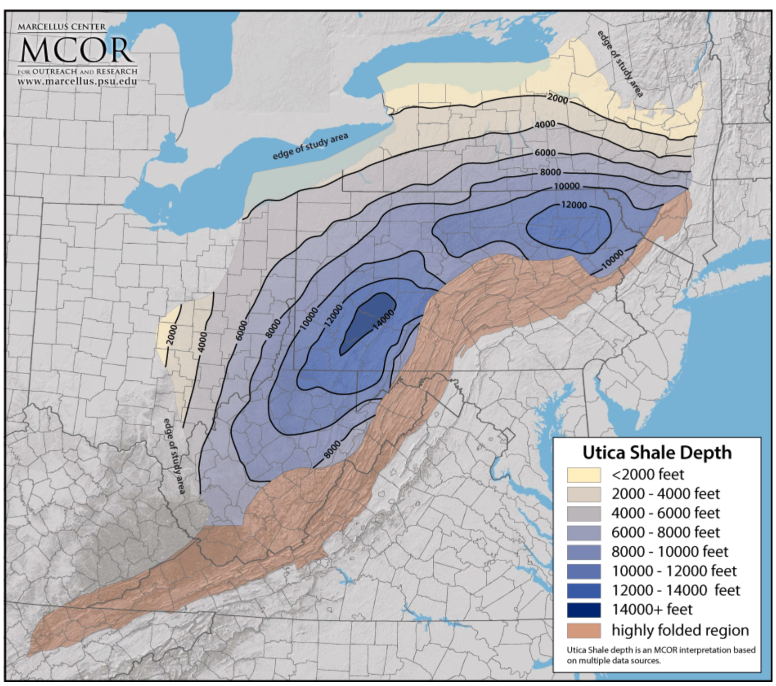


Figure B-31. Map of depth to Utica Shale as provided by the Marcellus Center



B.20 Layer: Utica Shale Thickness

Layer developed by: New York Natural Heritage Program, adapted from the Penn State Marcellus Center for Outreach and Research

Short Description: This layer depicts the thickness of the Utica Shale Formation in New York, in groups of 50 foot intervals.

Why this layer matters: Both shale depth and shale thickness influence the amount and quality of extractable natural gas in the Utica formation (Figure B-32).

Source: These data were extracted from the publicly available maps provided by the Penn State Marcellus Center for Outreach and Research (http://www.marcellus.psu.edu/resources/maps.php). The northern boundary, where the shale bed is exposed at ground level, was modified based on the New York State Bedrock Geology map (http://www.nysm.nysed.gov/gis/).

This layer is only a very rough representation of the depth of the shale layer and should only be interpreted at very coarse scales.

Processing Overview:

1. The map provided by the Marcellus Center (see Figure B-33) was georeferenced in ArcGIS using many reference points scattered throughout the state.
2. Each boundary was hand-digitized at about 1:400,000 scale.
3. Boundaries at the north end were modified so that they fall within the Utica Shale bedrock type (Formation Member) as defined by the NYS Geology Map.

Figure B-32. Map of Utica Shale Thickness in New York

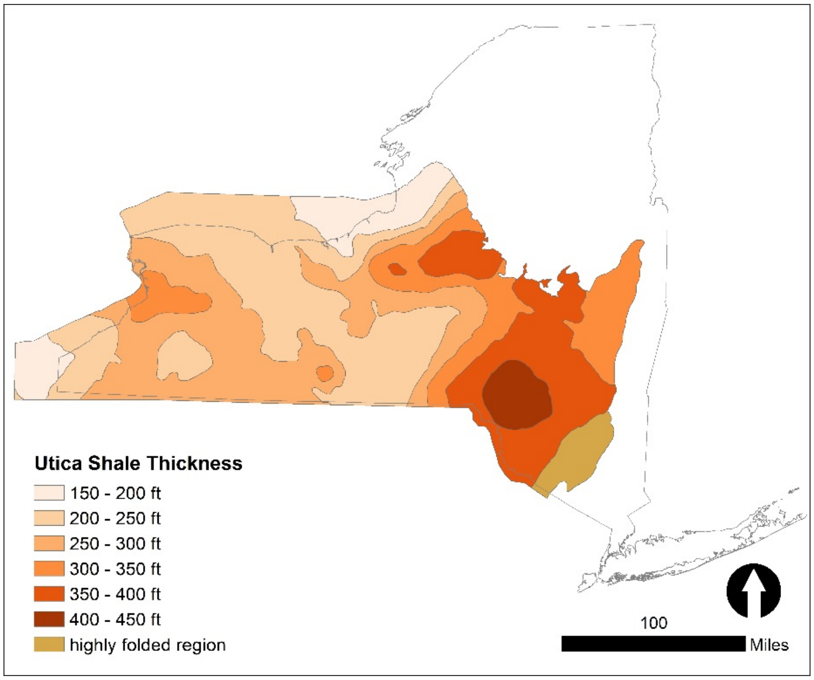
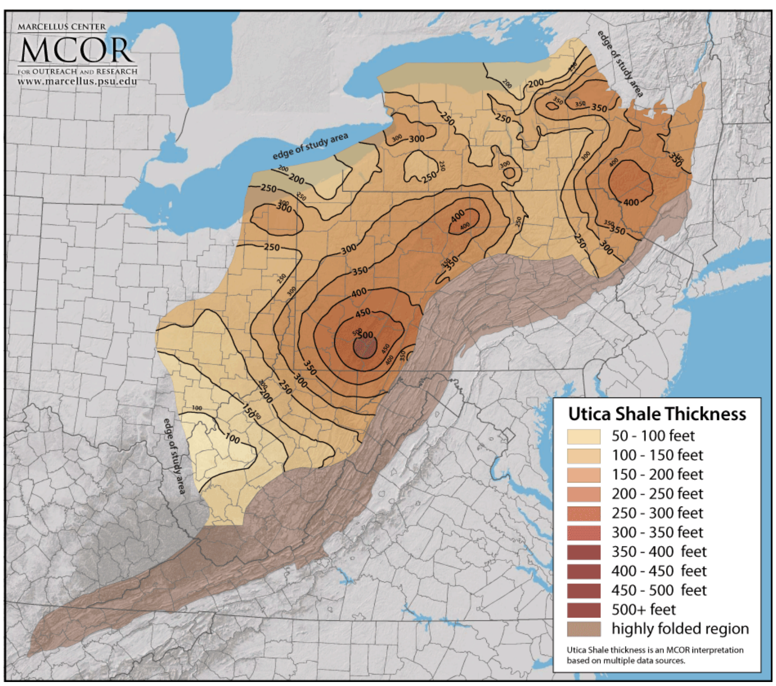


Figure B-33. Map of Utica Shale thickness as provided by the Marcellus Chenter



B.21 Layer: Protected Areas

Layer developed by: New York Natural Heritage Program

Short Description: This map shows the current extent of protected areas in New York.

Source: The New York Protected Areas Database (NYPAD), available at http://nypad.org . Displayed here is version 1.1 (October 2013).

From the NYPAD metadata:

Summary

NYPAD is a spatial database of lands protected, designated, or functioning as open space, natural areas, conservation lands, or recreational areas. These lands cover over six million acres, approximately 20% of New York State. Although the database has "Protected" in its name, term broadly is used broadly. Lands in NYPAD may be public or private, open or closed to public use, permanently protected from development or subject to future changes in management.

Description

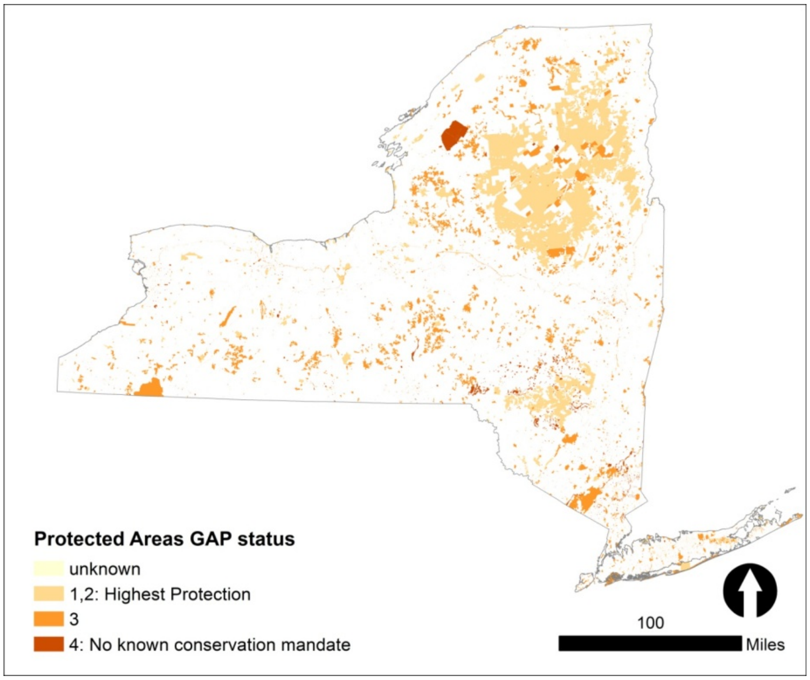
The New York Protected Areas Database (NYPAD) is intended to be the most comprehensive geospatial dataset of protected lands in New York State. Protected lands are defined as those lands which are protected, designated, or functioning as conservation lands, open space, natural areas, or recreational areas through fee ownership, easement, management agreement, current land use, or other mechanism Figure B-34). The geospatial and associated attribute data were assembled from the best available data sources of protected areas, including county cadastral (tax parcel) data; federal, state and local agencies; and organizations whose missions include land conservation and management.

Credits

New York Protected Areas Database (NYPAD) New York Natural Heritage Program 625 Broadway Albany, NY 12233-4757

For more information, see http://nypad.org/sites/default/files/metadata/NYPAD%20v1.1%20metadata.pdf

Figure B-34. Protected Areas in New York

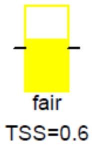


For more information on GAP status, see http://www.gap.uidaho.edu/padus/gap_iucn.html

Appendix C: Metadata for Wind Turbine Model

Wind turbines statewide

Element Distribution Model (EDM) assessment metrics and metadata
Common name: Wind turbines from FAA database
Date: 19 Mar 2013
Code: windturb



ability to find new sites

This EDM incorporates the number of known and background locations indicated in Table 1, modeled with the random forests routine [1, 2] in the R statistical environment [3, 4]. We validated the model by jackknifing (also called leave-one-out, see [5, 6, 7]) by 10 km grid, grouped to 100 levels, for a total of 100 groups. The statistics in Table 2 report the mean and variance for these jackknifing runs.

Table 1. Input statistics. Groups = number of input grid cells or cell groupings with PR points; BG points = background points; PR points = presence points placed throughout all polygons.

Name	Number
Groups	100
BG points	10192
PR points	1881

Table 2. Validation statistics for jackknife trials. Overall Accuracy = Correct Classification Rate, TSS = True Skill Statistic, AUC = area under the ROC curve; see [7, 8, 6].

Name	Mean	SD	SEM
Overall Accuracy	0.80	0.22	0.02
Specificity	0.91	0.15	0.01
Sensitivity	0.69	0.43	0.04
TSS	0.60	0.44	0.04
Kappa	0.60	0.44	0.04
AUC	0.88	0.26	0.03

Validation runs used 19 environmental variables, with 5 variables tried at each split (mtry) and 1000 trees built. The final model was built using 10000 trees, all presence and background points, with an mtry of 5, and the same number of environmental variables.

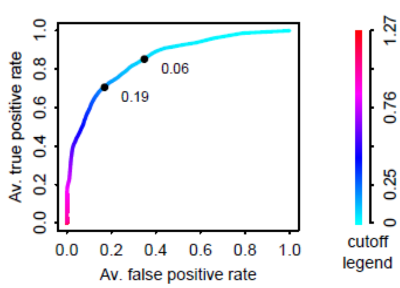


Figure 1. ROC plot for all 100 validation runs, averaged along cutoffs. The first cutoff indicated (0.185) is generated by finding the point along this curve closest to the upperleft-most corner. Validation statistics requiring a cutoff use this value. The second (0.064) uses the full model and maximizes the precision-recall F-measure using alpha=0.01 [9].

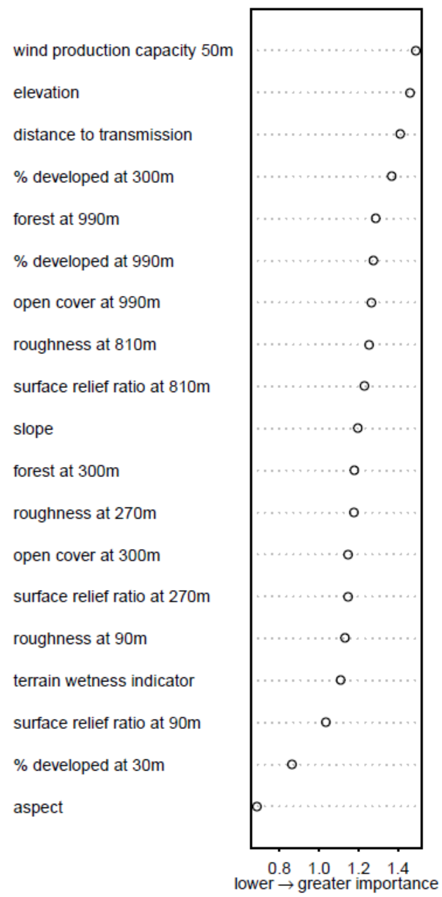


Figure 2. Relative importance of each environmental variable based on the full model using all sites as input.

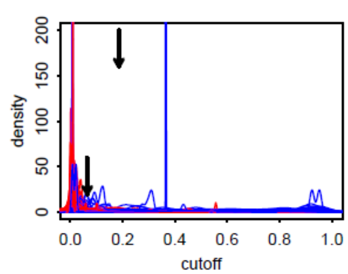


Figure 3. Separation between presence and background points. Red and blue lines show densities of absence and presence points, respectively. One of each is drawn for each validation run. Arrows indicate cutoff locations as in Fig. 1.

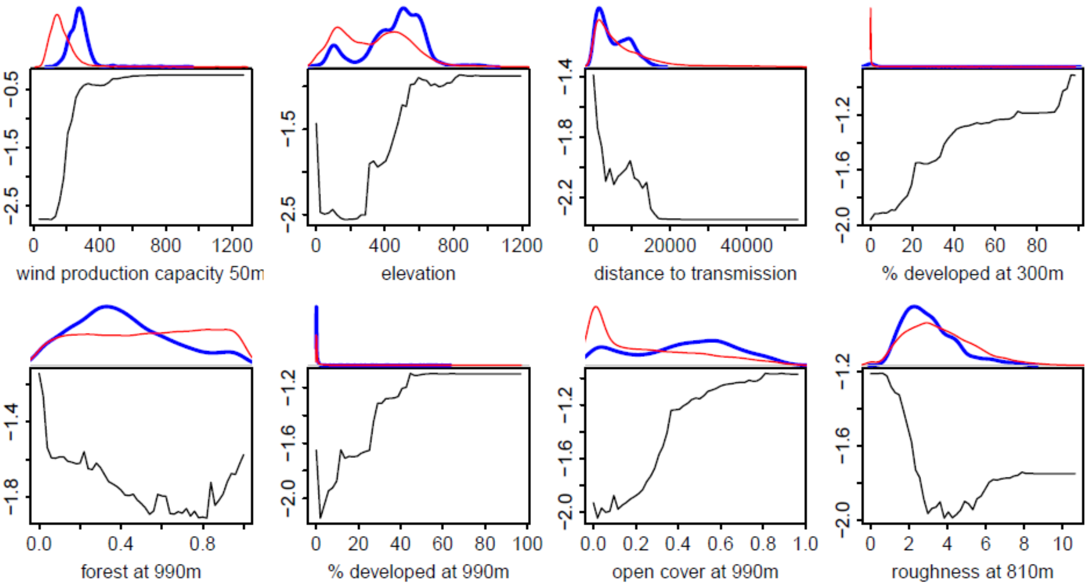


Figure 4. Partial dependence plots for the eight environmental variables with the most influence on the model. Each plot shows the effect of the variable on the probability of appropriate habitat with the effects of the other variables removed [3]. Peaks in the line indicate where this variable had the strongest influence on predicting appropriate habitat. The distribution of each category (thin red = BG points, thick blue = PR points) is depicted at the top margin. Categorical variables are depicted with barplots.

Important! Element distribution models map places of similar environmental conditions to the submitted locations (PR points). No model will ever depict sites where a targeted element will occur with certainty, it can *only* depict locations it interprets as appropriate habitat for the targeted element. EDMs can be used in many ways and the depiction of appropriate habitat should be varied depending on intended use. For targeting field surveys, an EDM may be used to refine the search area; users should always employ additional GIS tools to further direct search efforts. A lower cutoff depicting more land area such as that derived from the validation ROC plots (0.185) may be appropriate to use in this case. For a more conservative depiction of suitable habitat that shows less land area, a higher cutoff such as that derived from the final model (0.064) may be more appropriate.

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Wind Power and Biodiversity in New York: A Tool for Siting Assessment and Scenario Planning at the Landscape Scale

Final Report
November 2014

Report Number 14-46

State of New York
Andrew M. Cuomo, Governor

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