A Statewide Geographic Analysis

of the Intersection of High-value
Wildlife Resources and Wind Resources

Introduction

Maine's wind energy landscape is changing: where there was one operating terrestrial wind project when the Wind Energy Act passed in 2008[32] there are 18 today, and new technologies have produced taller wind turbines that are able to access steadier, stronger winds found at higher altitudes. Taller turbines create more opportunities to access commercially viable wind resources across more of Maine's landscape, making wind an important potential source of energy to help fulfill the state's commitments to a clean energy future.[33] However, taller turbines with larger rotors could pose a greater threat to wildlife and may have greater scenic impacts compared to turbines currently operating in Maine. With these changes comes the need for additional information and planning tools to ensure that Maine continues its transition to a clean energy future, while protecting the important ecological, recreational, and scenic values of undeveloped landscapes.

In 2013, Maine Audubon published a report detailing the results of a spatial analysis of the potential intersection between commercially viable wind resources and high-value wildlife resources in Maine ("Wind Power and Wildlife in Maine: A State-wide Geographic Analysis of High-value Wildlife Resources and Wind Power Classes"). The report determined that enough commercially viable wind resources that did not overlap with high-value wildlife resources were available to meet the state's wind power energy goal of 3,000 MW capacity, including both onshore and offshore wind.[34] In other words, wind energy could be developed in Maine with minimal impact to the state's wildlife. The report served as an important tool for developers and decision-makers as they navigated wind energy development.

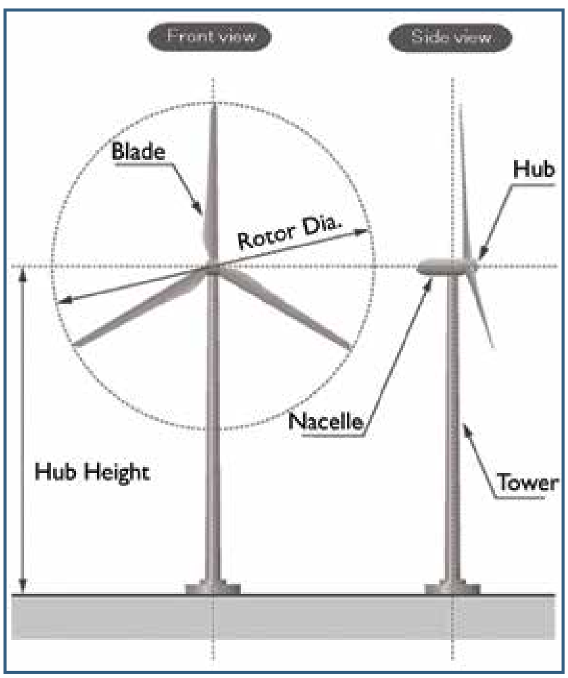

Diagram 1

This report details the results of a new Geographic Information System (GIS) analysis using updated natural resource and wind data, for the purposes of understanding where commercially viable wind resources and natural resources overlap today. New natural resource data include previously

[32] 35-A M.R.S.A, Chapter 34: THE MAINE WIND ENERGY ACT

[33] For highlights of recent policies supporting Maine's investment in renewable energy, see page 10 under the heading "New Policies Will Trigger More Renewables in Maine."

[34] 35-A M.R.S.A, Chapter 34: THE MAINE WIND ENERGY ACT §3404

unknown locations of rare species and natural communities, as well as new conservation lands. New wind resource data include wind resources at 100 meters and 140 meters above the ground, rather than the 80 meters analyzed in 2013. These heights represent current and expected proposed wind turbine hub heights (*see Diagram 1, from Venti Japan, Inc.*). These hub heights are currently used in other countries and are beginning to be proposed in the United States.[35] As in 2013, in this analysis we examined where these wind resources overlap with a variety of wildlife resources in order to determine where onshore wind energy resources can be developed in Maine while avoiding high-value wildlife resources.

For this analysis, Maine Audubon partnered with the Appalachian Mountain Club, who ran a similar GIS analysis to identify where wind projects may have visual impacts to recreationally-significant peaks and lakes in Maine, and the potential intersection of viable wind resource areas and areas identified as having high climate resiliency.[36]

This report is not meant to replace Maine Audubon's 2013 report, but instead is meant to supplement it. We encourage you to review "Wind Power and Wildlife in Maine: A State-wide Geographic Analysis of High-Value Wildlife Resources and Wind Power Classes," which can be accessed at Maine Audubon's website:maineaudubon.org/projects/wind. The 2013 report includes more background information and an assessment of the potential to meet the state's goal of 3,000 MW capacity of wind energy by 2030 with minimal impact to Maine's wildlife resources. Knowing that the goal is obtainable, this report focuses specifically on changes resulting from the new wind and wildlife data and is a part of a larger project evaluating how Maine's renewable energy future—focusing specifically on solar, onshore and offshore wind, and transmission—can have the smallest negative impact on wildlife. Like the 2013 report, the purpose of this analysis is to improve planning, siting, and permitting for future terrestrial wind power projects across the state by demonstrating that there is significant potential to increase renewable wind energy while avoiding high-value wildlife at the same time.

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[35] For example, the Weaver Wind project permitted for the towns of Eastbrook and Osborn, Maine, in 2019 includes turbine heights of 117m.

[36] Sites that are resilient are ones that are most likely to retain high quality habitat and continue to support a diverse array of plants and animals as our climate changes. For more information on the topic, please see The Nature Conservancy's Resilience Fact Sheet at *https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/edc/Documents/ED_Resiliency%20Fact%20Sheet_full%20region_07112014%20(1).pdf*

Methods

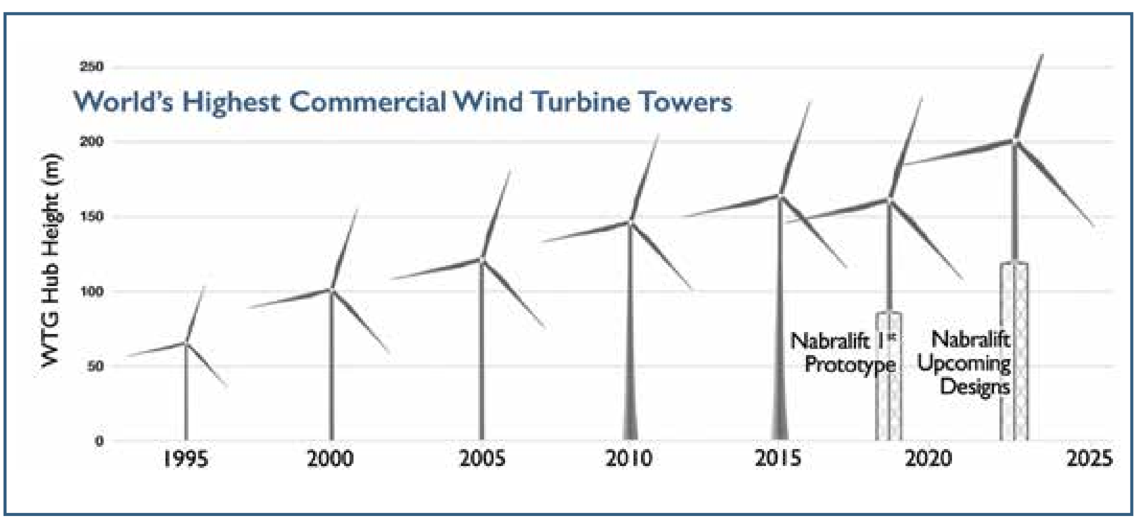
This analysis uses GIS layers of mapped wind energy resources at two different hub heights, 100m and 140m, and multiple wildlife resource values to identify their areas of overlap and to analyze the potential for wind energy development in Maine that avoids high-value wildlife resource areas.

Wildlife resource values are classified into two different groups: Tier 1 resources, which are site-specific and relatively discrete, including specific wildlife habitats and natural communities, and Tier 2 resources, which are landscape-level habitat areas that cover larger expanses, are in part based on spatial models, and that identify locations that are important at the landscape scale for multiple wildlife species.

This analysis is modeled on the analysis conducted for the 2013 report, with several critical differences:

- In 2013, wind resources were categorized according to Wind Power Class, which is a way of quantifying the strength of the wind at a particular height using wind speed and wind power density (how much energy, in watts, is available) on a scale of 1 to 7. The U.S. Department of Energy defined Wind Power Class in 1986, but the industry is moving away from the use of Wind Power Classes. In this analysis, we define wind resources simply based on wind speed in meters per second (m/s). That said, the viable wind speeds in this analysis roughly correspond to the wind speeds associated with the viable wind power classes used in the 2013 analysis.
- In our 2013 analysis, the wind resources examined were those considered potentially viable at 80m hub heights. Because stronger and more consistent winds are found at greater altitudes, raising the height of the wind turbines will allow for the capture of more wind power at any given site. Recent advancements in wind turbine technology have led to the development of wind turbines able to capture available wind energy at 100m, 140m,

Diagram 2



and higher. Taller turbines also have longer blades that can cover a larger area and therefore capture a larger amount of wind energy. This factor also allows more energy to be captured at relatively lower wind speed. This analysis uses wind resources at 100m and 140m hub heights to appropriately capture the geographic expansion of wind resources made available by these technological advances. For a graphic of the change in wind turbine heights over time, see Diagram 2 from Nabra Wind.

- Since 2013, there have been changes in the boundaries of the Expedited and Non-expedited Areas, according to revisions made under *An Act To Improve Regulatory Consistency within the Jurisdiction of the Maine Land Use Planning Commission*, enacted in 2015.[37] As a result of this law, over 731,000 acres of land previously delineated as Expedited Areas under the Wind Energy Act were removed and are now classified as Non-expedited Areas.

As in the 2013 report, we also placed special emphasis on analyzing the wind resources and high priority wildlife resources available within the coastal zone, delineated as the land extending two miles inland from estuaries and the coastline of Maine. Like ridgelines, the land along the coast experiences high wind speeds and this area is home to a high proportion of valuable wildlife resources. We therefore include additional analyses on the viable wind resources and high priority wildlife resources within this coastal zone at 100m and 140m hub heights.

GIS Layers Used in Analysis

Natural Resource Layers

We divided the natural resources for which we have GIS layers into two tiers. Tier 1 resources are based primarily on field surveys of known, mapped, and relatively discrete natural resources. These are generally places on the landscape where turbines and their associated roads and structures should be avoided. Tier 2 resources, in contrast, cover larger areas, and are primarily models of important habitat that stretch across the landscape. Avoiding Tier 2 resources to maximize quality wildlife habitat is preferred, but best management practices that minimize impacts may be practicable for siting in or at the edges of Tier 2 resource blocks. The specific Tier 1 and 2 layers are listed below. We removed open water from the wind layer as it cannot be developed for terrestrial wind. In order to draw a direct comparison, we also removed open water from the natural resource layer. This is not to suggest that terrestrial wind projects do not impact open water habitats, but rather, that direct impacts to open water habitats will be assessed using impacts to riparian and wetland buffers where construction activities for wind projects might occur.

[37] "An Act To Improve Regulatory Consistency within the Jurisdiction of the Maine Land Use Planning Commission," P.L. 2015, ch. 265.

Tier I Natural Resources: Discrete habitat areas based on site-specific data

- **Riparian and Wetland Buffers (Wetland Buffers):** We created buffers around riparian and wetland areas similar to those in place for municipal Shoreland Zoning. They include an upland buffer of 250 feet from the edge of lakes, ponds, rivers, coastline and wetlands greater than 10 acres, as well as 75 feet around ponds less than 10 acres and perennial streams. *(Source: Maine Department of Inland Fisheries and Wildlife (MDIFW), 2018)*

- **Deer Wintering Areas (DWA):** Polygons for these Significant Wildlife Habitats are included for organized towns as well as the Fish and Wildlife Protection Subdistrict (P-FW zones) within the Land Use Planning Commission's jurisdiction (LUPC). *(Source: MDIFW, 2018)*

- **Inland Waterfowl and Wading Bird Habitat (IWWH):** Polygons for these Significant Wildlife Habitats include moderate and high-value wetlands and a 250-foot upland habitat area around the wetland. *(Source: MDIFW, 2018)*

- **Endangered, Threatened, and Special Concern Species (ETSC):** This layer includes known locations for 101 rare and special concern species (*See List of Endangered, Threatened, and Special Concern species in the DIFW GIS layer, page 74*). Lands around observed locations or polygons are species-specific, based on habitat use. *(Source: MDIFW, 2018)*

- **Shorebird Habitat (Shorebird):** Polygons for these Significant Wildlife Habitats include a 250-foot area around all designated roosting areas and a 100-foot area around all designated feeding areas. *(Source: MDIFW, 2018)*

- **Tidal Waterfowl and Wading Bird Habitat (TWWH):** Polygons for these Significant Wildlife Habitats include the identified tidal wetland habitat. *(Source: MDIFW, 2018)*

- **Exemplary Natural Communities (MNAP):** Polygons provided by the Maine Natural Areas Program for rare plants and rare or exemplary natural communities include both specific points (or for some species, habitat) where populations of rare, threatened, and endangered plants have been documented, as well as rare natural communities and those that are common but in exemplary condition. *(Source: Maine Natural Areas Program, 2018)*

- **Wading Bird Colony Buffers (GBH):** This layer includes Great Blue Heron rookery locations plus land within one-quarter mile of the rookery. Herons travel well beyond this distance to feed, but any areas beyond a quarter-mile would need to be directional and based on observed behavior, so are not included in our analysis. *(Source: MDIFW, 2018)*

Tier 2 Natural Resources: Landscape-level habitat areas

- **Beginning with Habitat Focus Areas**: These are natural areas of statewide ecological significance that contain unusually rich concentrations of high-value and at-risk species and habitats. These areas support rare plants, animals, and natural communities; high quality common natural communities; Significant Wildlife Habitats; and their intersections with large blocks of undeveloped habitat. Beginning with Habitat (BwH) Focus Area boundaries are drawn based on the species and natural communities that occur within them and the supporting landscape conditions that contribute to the long-term viability of the species, habitats, and community types. *(Source: Beginning with Habitat, MDIFW, 2018)*
- **Modeled Bicknell's Thrush Habitat**: Bicknell's Thrush is the rarest migratory songbird in the east and is endemic to subalpine spruce-fir forest in the northeastern United States and maritime Canada. The layer includes potential Bicknell's Thrush habitat as identified in a model developed by the Vermont Institute of Natural Sciences in 2005. *(Source: Vermont Center for Ecostudies, 2016)*

Base Wind Layers

The base wind layers we used were developed from datasets accessed from Windnavigator, AWS Truepower, LLC, in August 2017. The data were in the form of floating point raster datasets projected in the World Geographic System (WGS) for winds at 100m and 140m above ground. To facilitate the spatial analyses, we reclassified these data to integer rasters with 0.5 m/s intervals above 4.49 m/s. We converted the rasters to feature classes, which were re-projected to UTM19N to work with the resource data.

We know that wind speed is only one of many factors that interact in a complex fashion to make a site suitable for wind development. While we cannot account for many of those factors, we eliminated areas with wind speeds too low to be considered commercially viable, as well as very small and isolated areas as their likelihood of development is quite low. Commercially viable wind speeds were determined by examining the average annual wind speeds found in the final configurations at all operating and potential turbines in Maine that are included in the November 2017 FAA data available from USFWS. Based on this information, we removed all areas with wind speed under 6.5 m/s at both heights of 100m and 140m. We kept the next lowest wind speed areas (6.50-6.99 m/s) only if they abutted areas with 7.0 m/sec wind or more.

In other words, areas of wind speeds 6.50-6.99 m/s had to abut areas of greater wind speeds to remain in the Base Wind Layers. We also clipped all polygons that were less than 4 ha in size, regardless of wind speed or proximity to other polygons, as well as any isolated 4 ha (single pixel) polygons that were more than 400m away from any other polygons. Additionally, we removed from the wind layer any wind resource overlapping open water (lakes, ponds, and ocean) as these areas are not developable for terrestrial wind projects.

We created two base wind layers using the methods described above for wind resources at 100m hub heights and 140m hub heights. These layers will be identified as the "100m Wind Base" and the "140m Wind Base" respectively throughout this report.

Expedited and Non-Expedited Permitting Areas

These areas were designated in the 2008 Wind Power Siting Law, *An Act To Implement Recommendations of the Governor's Task Force on Wind Power Development*, and have been modified by the Land Use Planning Commission (LUPC, 2018). Under this law, Expedited Permitting Areas are those areas defined by the legislature as being more appropriate for grid-scale wind energy developments. While standards for natural resource protection are the same in Expedited and Non-expedited Permitting Areas, standards for scenic impacts are higher in Non-expedited areas and they require an additional step of rezoning before the Maine Land Use Planning Commission. See Figure 1, Expedited and Non-expedited Wind Permitting Areas, for current delineations.

Expedited and Non-expedited Wind Permitting Areas

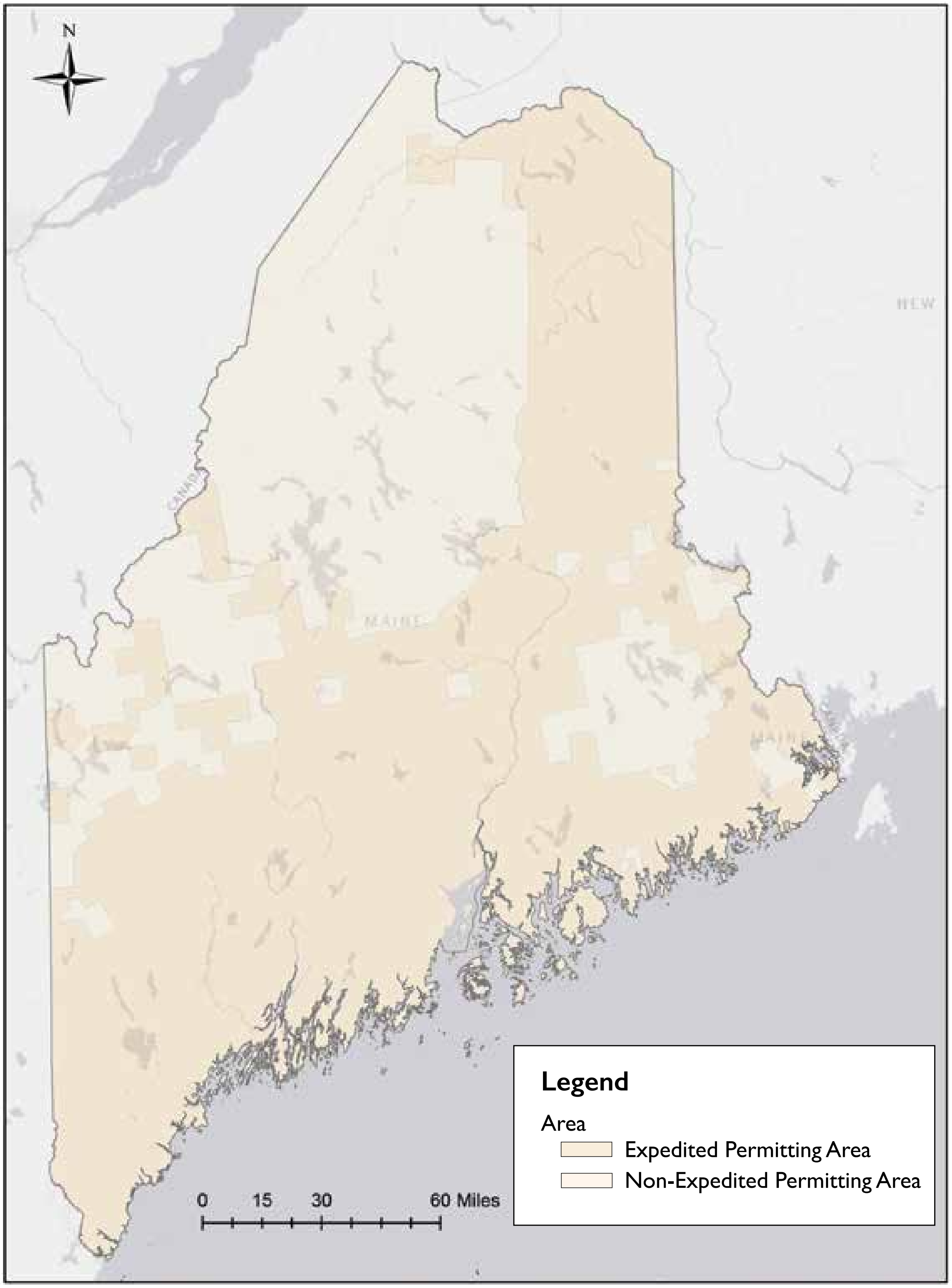


Figure 1: Expedited and Non-expedited Wind Permitting Areas pursuant to the Maine Wind Energy Act

Coastal Areas

For this analysis, we delineated the land base within 2 miles of the coast and estuaries. This is because terrestrial areas in close proximity to coastlines often contain important wind resources and important wildlife resources where the overlap between energy development projects and wildlife habitats may be higher.

Conservation Lands

The Conserved Lands layer contains conservation lands ownership boundaries at 1:24,000 scale for Maine land in federal, state, municipal, and nonprofit ownership and includes conservation lands held in fee and those with conservation easements. The ownership lines do not represent legal boundaries nor are the ownership lines a survey. *(Source: State Planning Office, 1993)*

Limitations

It is important, before a discussion of the results of this analysis, to highlight several limitations that should restrict the interpretation of our results.

1) **The wind data used for these analyses, although mapped on a fine scale, are only a model of actual wind power potential.** We recognize that the base layer of potential wind power is a model of expected wind, based on a suite of geographic variables and modeled on a fairly coarse grid across the state. We recognize that some areas with high wind speeds on the map will not be acceptable sites for wind development due to other factors such as sheer, turbulence, soils, slopes, etc. We also recognize that some of the areas identified as having low wind resources may in reality have much higher wind speeds, and that developers must collect several years of site-specific meteorological data in order to fully evaluate and assess the potential suitability of a site for development. Any maps created as a result of this project should not be interpreted as pinpointing specific, project-level locations on the ground. The wind speed data used in this analysis provide a starting point for the creation of possible scenarios for where viable wind resources might be more or less likely, but we realize that it vastly oversimplifies the process used to identify suitable sites for wind development.

2) **The siting of wind development projects is a complex process.** There are many factors that affect the profitability, and therefore the economic viability, of a wind development project. It is beyond the scope of this analysis to evaluate the economic viability of different locations within the state, especially in relation to transmission lines, either existing or proposed.

3) **Not all wildlife resources have been adequately mapped, many wildlife resources lack statewide geographical information, and not every available mapped wildlife resource was included in this analysis, though many deserve consideration during the wind permitting process.** Because of these data limitations, the results of this analysis should not be used to absolutely identify areas for wind development with an expectation that there will be no impacts to wildlife. Rather, the lack of complete wildlife resource data illustrates the continued need to evaluate wind project proposals on a site-specific basis. Areas that show up in this analysis with little or no potential impacts to natural resources may in fact, once evaluated more closely with site-specific data, be unsuitable for wind development from the perspective of adverse impacts to wildlife resources.

4) **There are many values on the landscape beyond wildlife resources that may affect the level of impact of any particular wind development project.** Maine Audubon's mission is conserving wildlife and wildlife habitat, and that is our focus when evaluating the impact of potential wind developments. This analysis is limited to wildlife-related resources and potential overlap with wind resources. The Appalachian Mountain Club used the same wind speed data to analyze potential visual and scenic impacts, as well as potential overlap with the landscape resiliency data developed by The Nature Conservancy[38]; these should be taken into consideration when evaluating a potential site as well. Additional values such as noise, impacts to recreation opportunities, tourism, etc., are not included as part of this analysis.

5) **Impacts from wind development projects extend far beyond just the turbines and pads.** Access roads, clearing for maintenance, and transmission lines are all necessary components of an industrial scale wind project and can have significant and cumulative impacts on rare and endangered species, high-value habitats, wetlands and other water resources, soils, steep slopes, habitat fragmentation, and connectivity. We are unable to fully account for these impacts in our analysis of the overlap of known wind and wildlife resources.

[38] See "The impact of existing and potential wind power development on high-value scenic resources in Maine" to be published late 2019 by the Appalachian Mountain Club.

Results and Discussion

Wind Resources

As expected, increased turbine height significantly expanded the area available for potential wind projects, with commercially viable wind resources found on 3.3 million acres in Maine (16% of the state's total land cover) using the 100m Wind Base, and nearly four times that amount—12.2 million acres—using the 140m Wind Base. With taller wind turbines, more than half of the total land cover of Maine—59%—has the potential for commercially viable wind resources. The wind speed distribution of available wind resources is fairly similar at both heights, with most of the available wind power concentrated at the lowest viable wind speeds (87% at each height, at wind speeds between 6.5 and 7.5 m/s). However, because of the dramatic expansion of commercially viable Wind Base available with taller turbines, there are 1.6 million acres with wind speeds above 7.5 m/s at a hub height of 140m *(See Figure 2, Wind Resources Available)*.

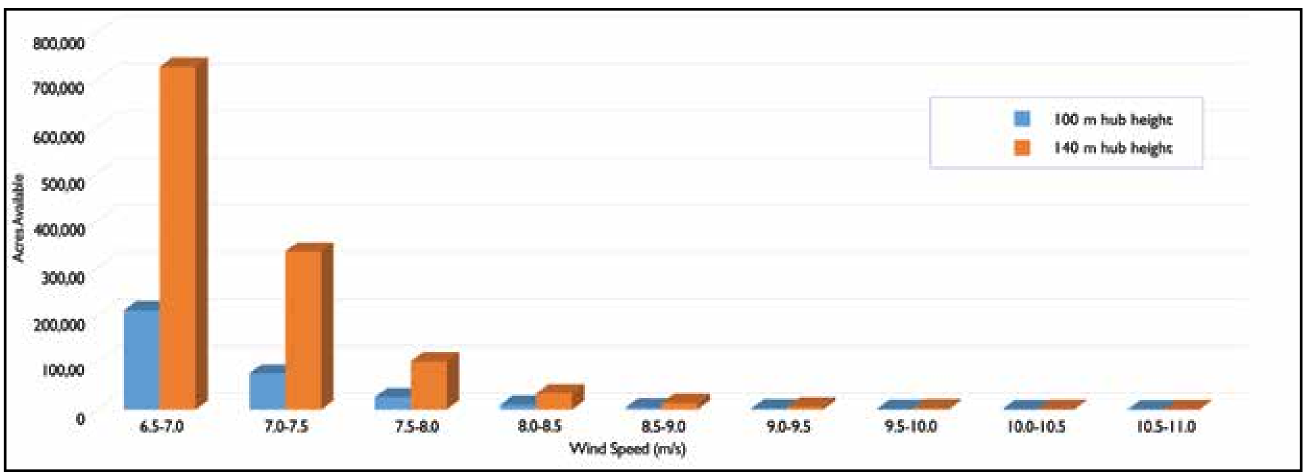


Figure 2. Wind Resources Available at wind speeds above 6.5m/s, at 100m hub height and 140m hub height.

The areas with potentially viable wind speeds at each of these heights are also split fairly evenly between the Expedited Areas and the Non-expedited Areas. See Figures 3a-3c for comparisons of proportional acres of land within the Expedited and Non-expedited Areas, and the proportional acres of land with commercially viable wind resources within these permitting areas at 100m and 140m hub heights. Figures 4 and 5 are maps showing where commercially viable wind resources at 100m and 140m hub heights can be found in Maine.

Proportion of Land within each Permitting Area

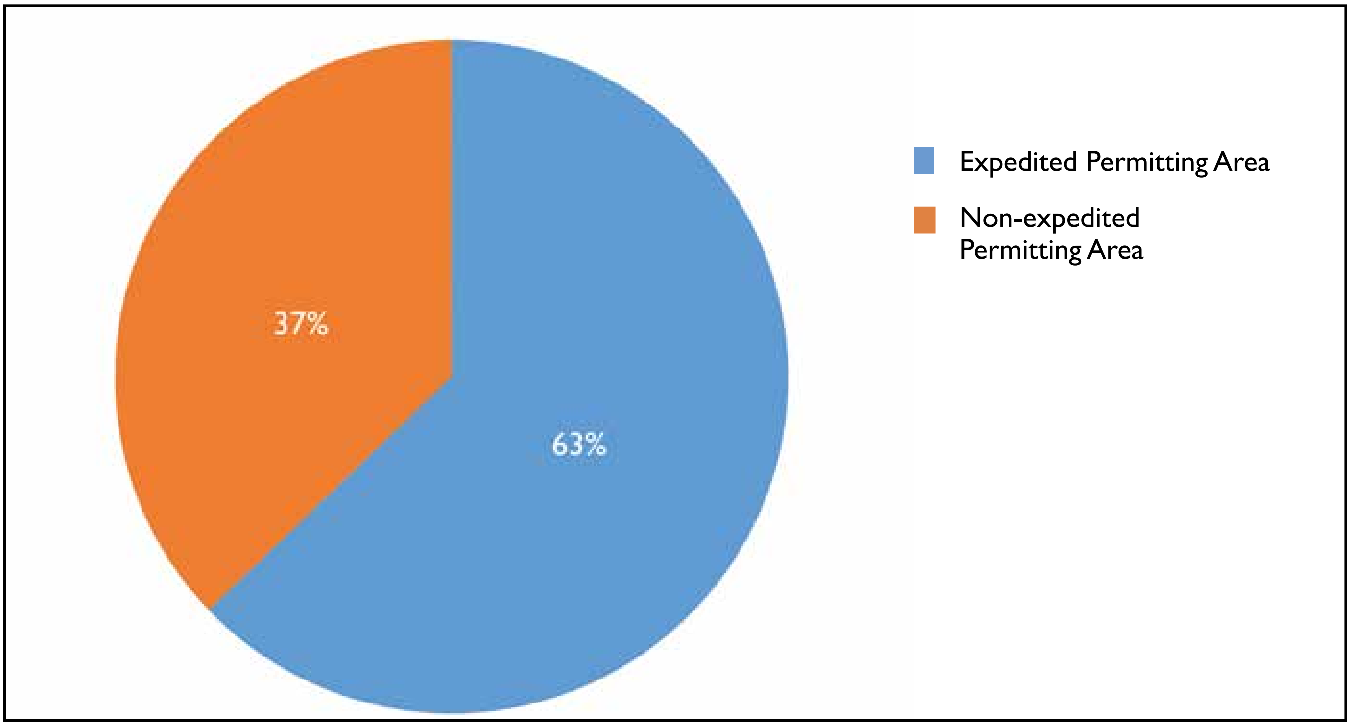


Figure 3a. Proportion of land within the Expedited and Non-expedited Permitting Areas within the state of Maine.

Proportional Viable Wind Resources at 100m Hub Heights

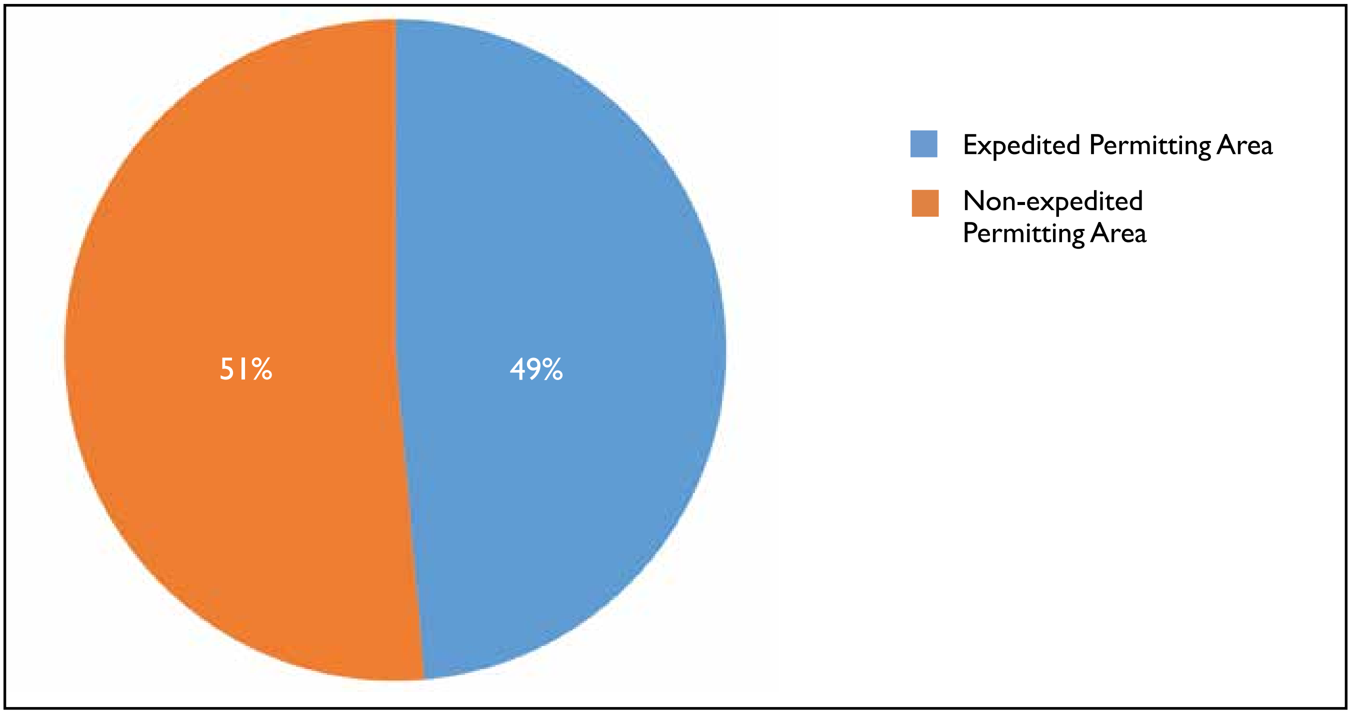


Figure 3b. Proportion of land with commercially viable wind resources, at a hub height of 100m, found within the Expedited and Non-expedited Permitting Areas within the state of Maine.

Proportional Viable Wind Resources at 140m Hub Heights

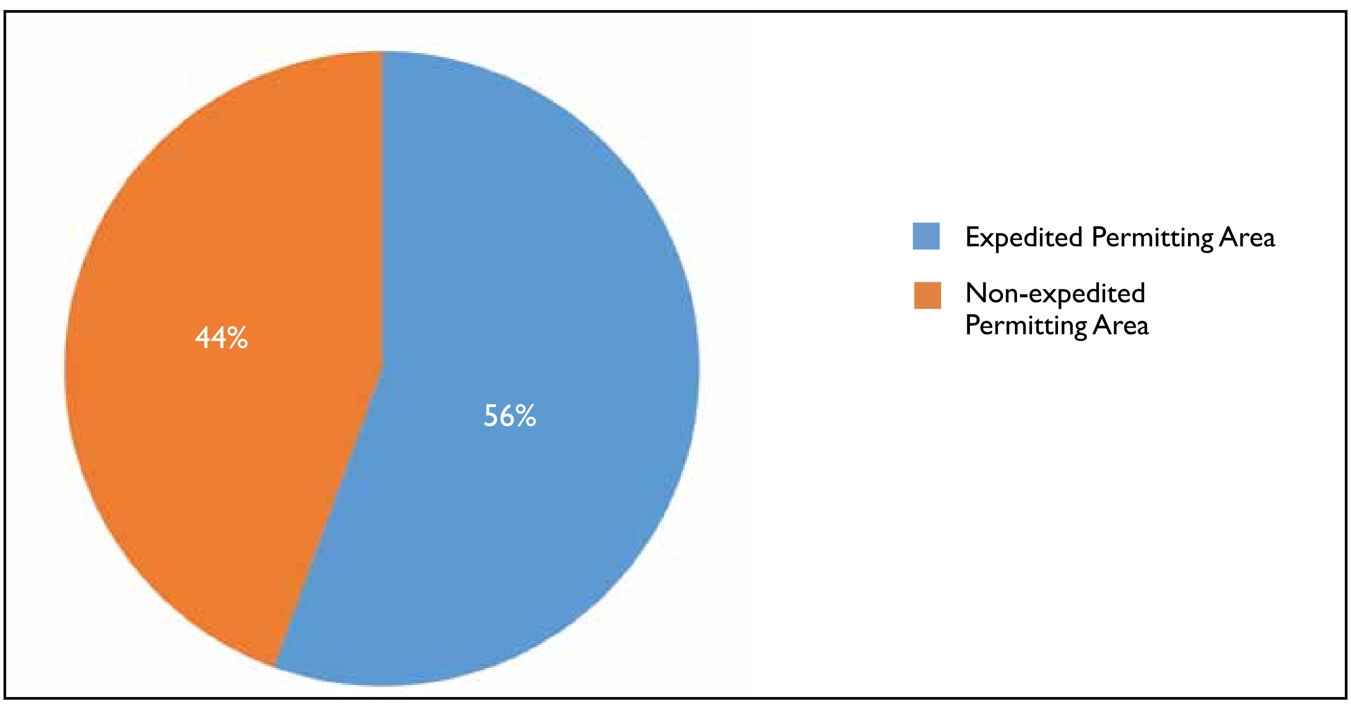


Figure 3c. Proportion of land with commercially viable wind resources, at a hub height of 140m, found within the Expedited and Non-expedited Permitting Areas within the state of Maine.

Commercially Viable Wind Resources at 100m Hub Height

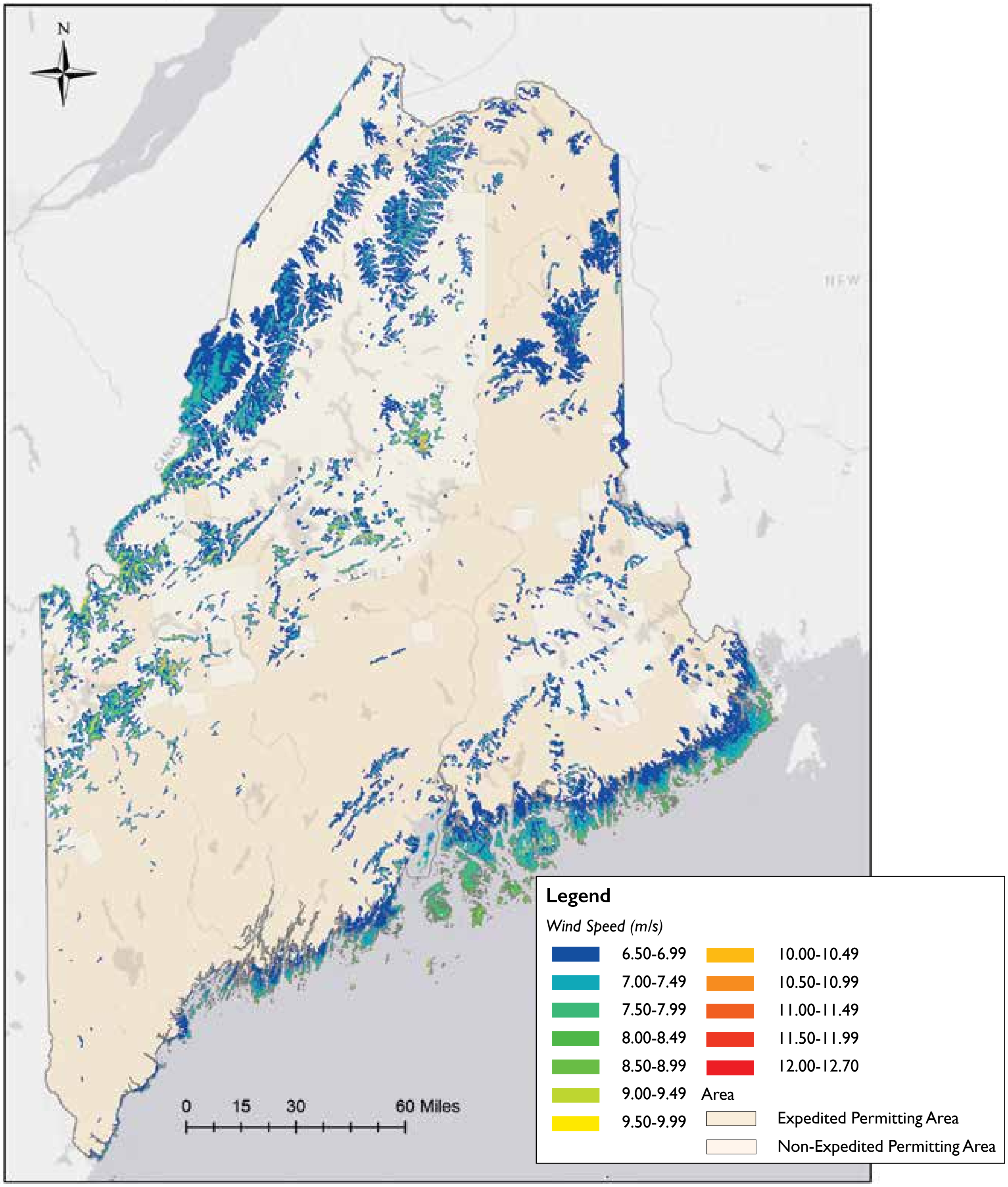


Figure 4. Map of where commercially viable wind resources at 100m hub height can be found in Maine.

Commercially Viable Wind Resources at 140m Hub Height

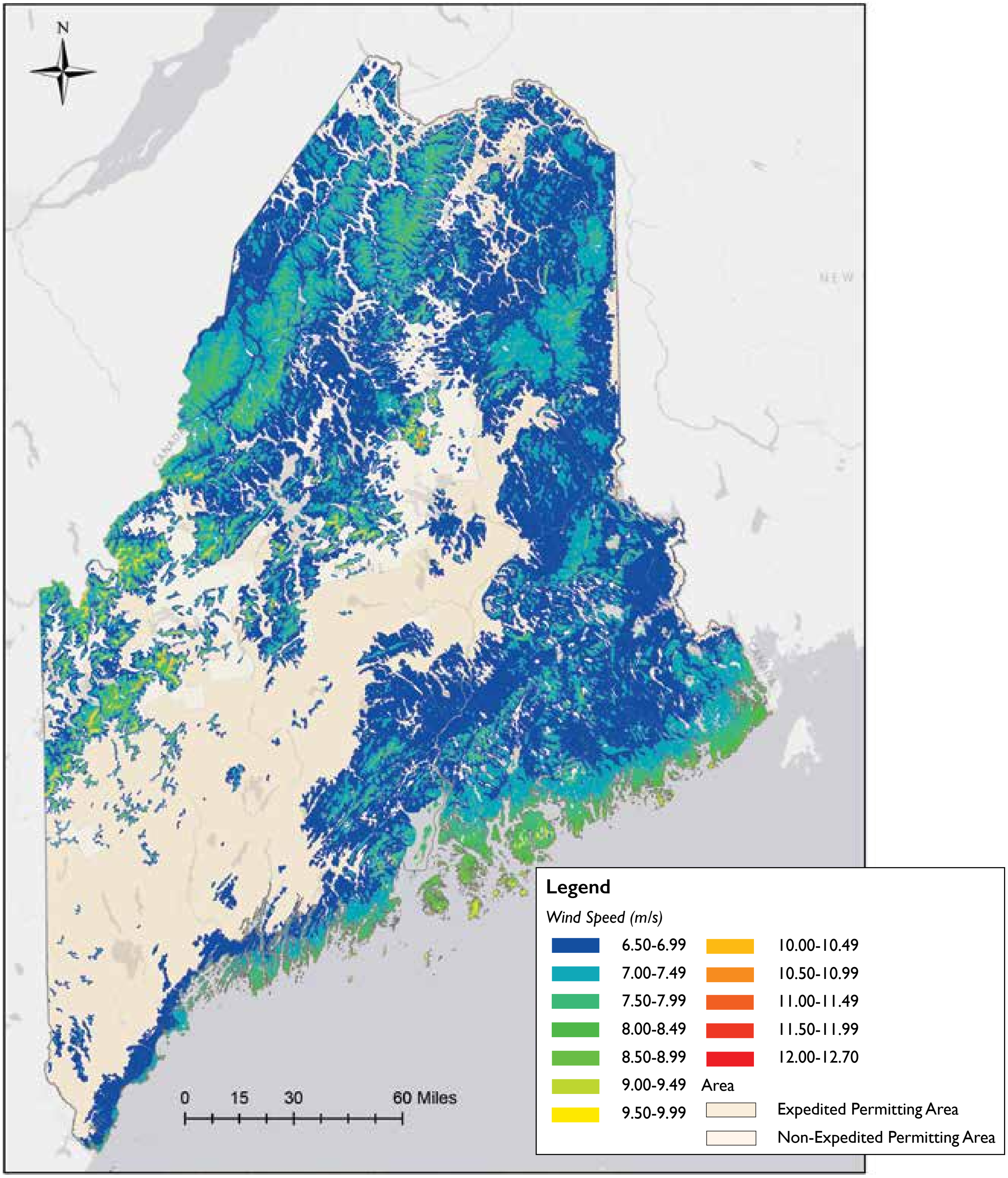


Figure 5. Map of where commercially viable wind resources at 140m hub height can be found in Maine.

Wildlife Resources

The potentially viable wind resources available at the different hub heights overlap the wildlife resources differently, e.g., shorter turbines are likely to be sited at higher elevations where vulnerable alpine natural communities and Bicknell's Thrush habitat can be found, whereas taller turbines can be located at lower elevations where there may be more wetlands and wetland buffers. More specifically, a larger proportion of the 100m Wind Base overlaps with rare species habitats (ETSC Resources) and Exemplary Natural Communities (MNAP Resources) compared to the 140m Wind Base. Similarly, a larger proportion of the 140m Wind Base overlaps with Wetland Buffers, Inland Waterfowl and Wading Bird Habitat, and Deer Wintering Areas compared to the 100m Wind Base. Please note many of these wildlife resources overlap with each other, so totals add up to more than 100%. See Figure 6.

As noted in Figure 6, many of these wildlife resources overlap each other, with some areas housing multiple Tier 1 Wildlife Resources as well as Tier 2 Wildlife Resources. Areas with multiple Tier 1 and/or Tier 1 and Tier 2 Wildlife Resources should be prioritized above others to avoid when developing wind energy projects or other development, as impacts to such unique places can have long-term and far-reaching effects on wildlife and habitat. See Figures 7 and 8a-8d showing multiple Tier 1 and Tier 2 Wildlife Resources overlap and where they overlap with the 100m Wind Base.

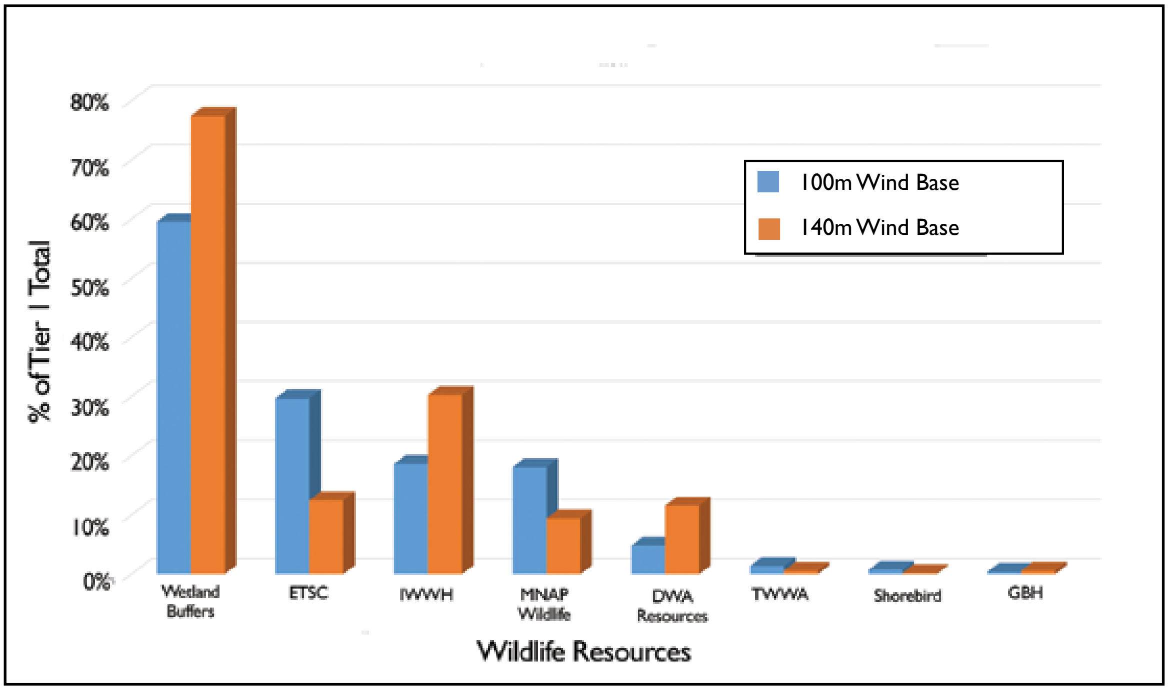


Figure 6. Distribution of Tier 1 Wildlife Resources overlapping with areas of commercially viable wind at 100m and 140m hub height.

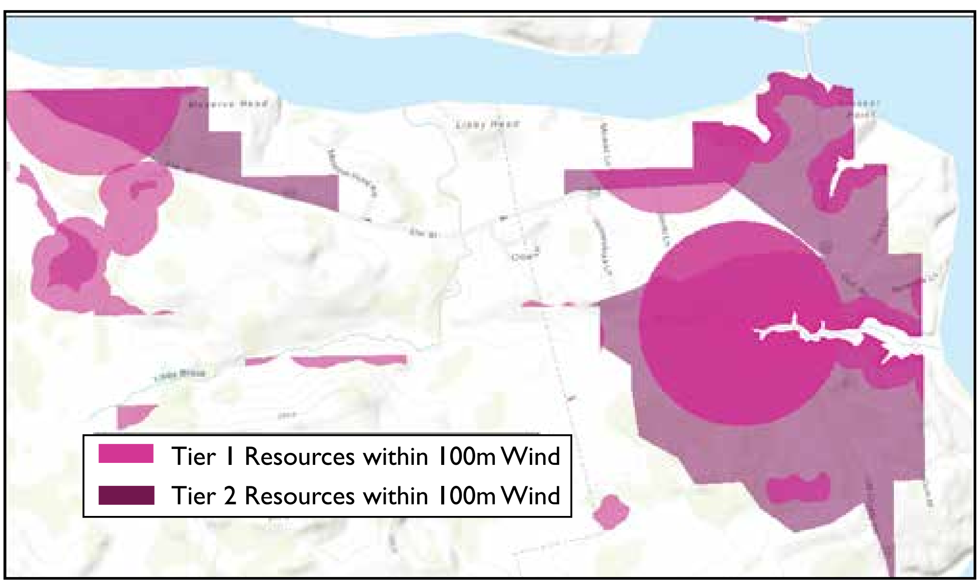


Figure 7. Multiple Tier 1 and Tier 2 Wildlife Resources overlap within the 100m Wind Base. Note here and in detailed example below how wildlife resources are "clipped" to the boundary of the Wind Base layer.

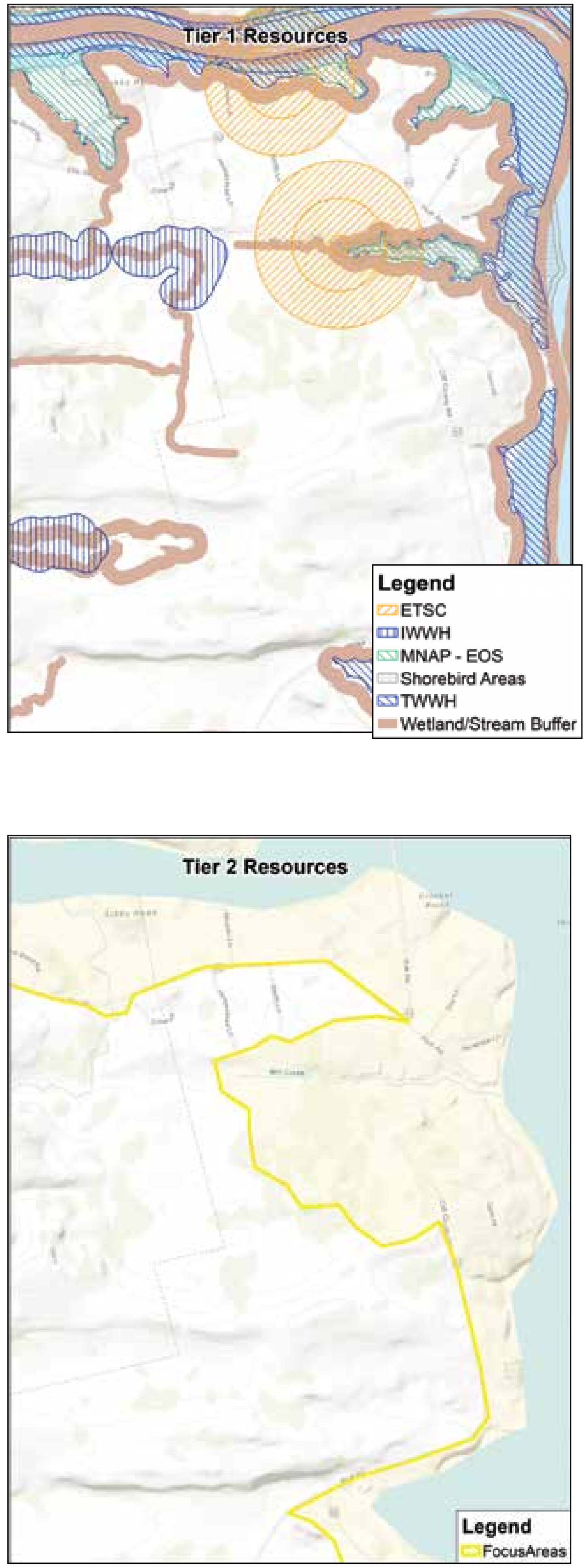
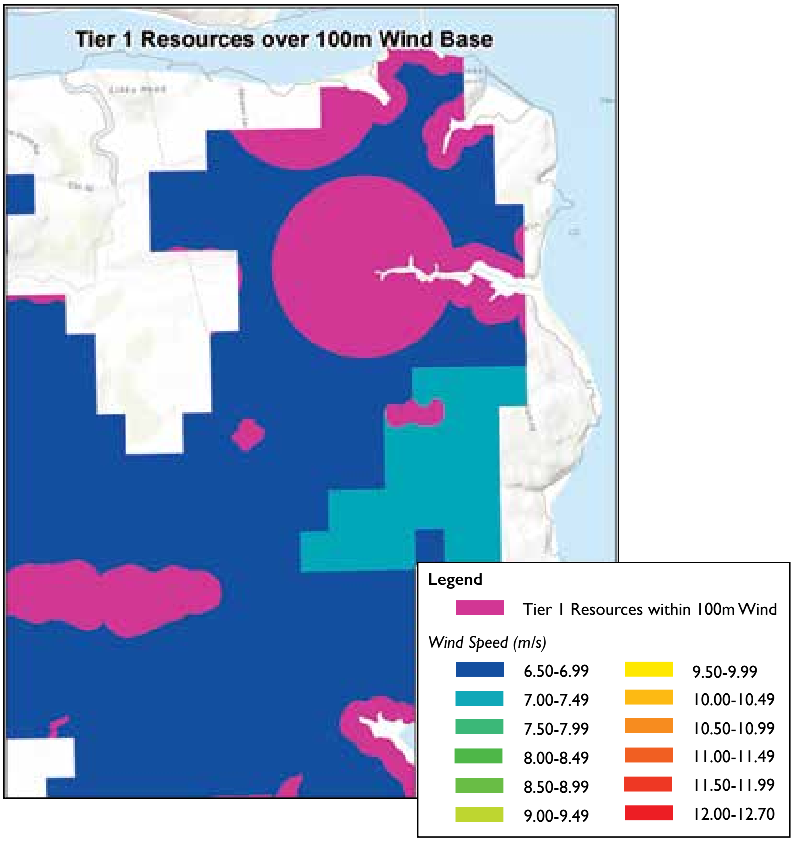
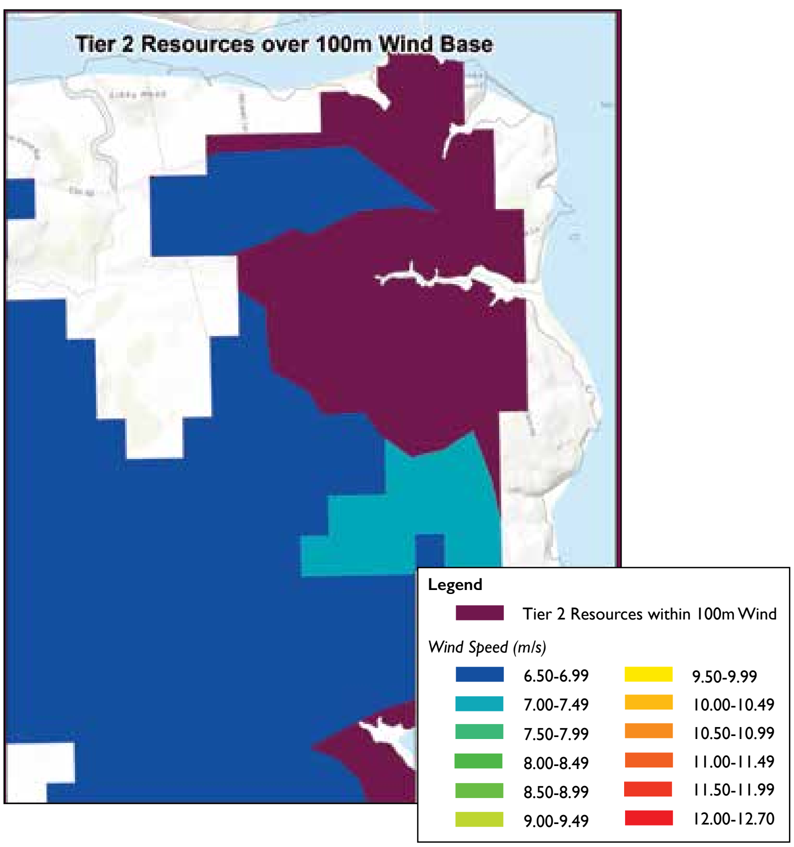


Figure 8: a) Multiple Tier 1 Wildlife Resources overlap; b) Tier 2 Wildlife Resources in the same area.





Because increased hub heights expand the available acreage of commercially viable wind resources, it may be possible for new wind projects to avoid mapped wildlife resources altogether. Even using the 100m Wind Base, if all mapped Tier 1 resources were avoided, 2.8 million acres would still be available for commercial wind power generation. If Tier 1 resources *and* Tier 2 resources were avoided, 2.4 million acres of 100m Wind Base are still available; that is more than double the 1.1 million *total* acres of Wind Base available at 80m, as detailed in the 2013 report *(See Figure 9, Map of 100m Wind Base, minus Tier 1 and Tier 2 Wildlife Resources).*

Looking at the 140m Wind Base, if mapped Tier 1 resources are avoided, 9.4 million acres are still available, and avoiding both Tier 1 and Tier 2 resources leaves 8.7 million acres, or 71% of the total commercially viable wind resource at 140m *(See Figure 10, Map of 140m Wind Base, minus Tier 1 and Tier 2 Wildlife Resources).* Of that, 3.7 million acres have wind speeds at or above 7.0 m/s.

Please note, a desktop evaluation of these resources should not take the place of detailed site-specific investigations of any proposed site to identify any unmapped habitats, species, or resources such as Significant Vernal Pools and talus slopes/rocky outcrop areas present at the site. Likewise, it should be recognized that GIS mapping may not be accurate and site specific investigations may supercede GIS mapping.

Figure 8: c) where Tier 1 Wildlife Resources overlap with an area of commercially viable wind resources at 100m hub height; and d) where Tier 2 Wildlife Resources overlap with areas of commercially viable wind resources at 100m hub height.

Commercially Viable Wind Resources at 100m that Avoid Tier 1 and Tier 2 Natural Resources

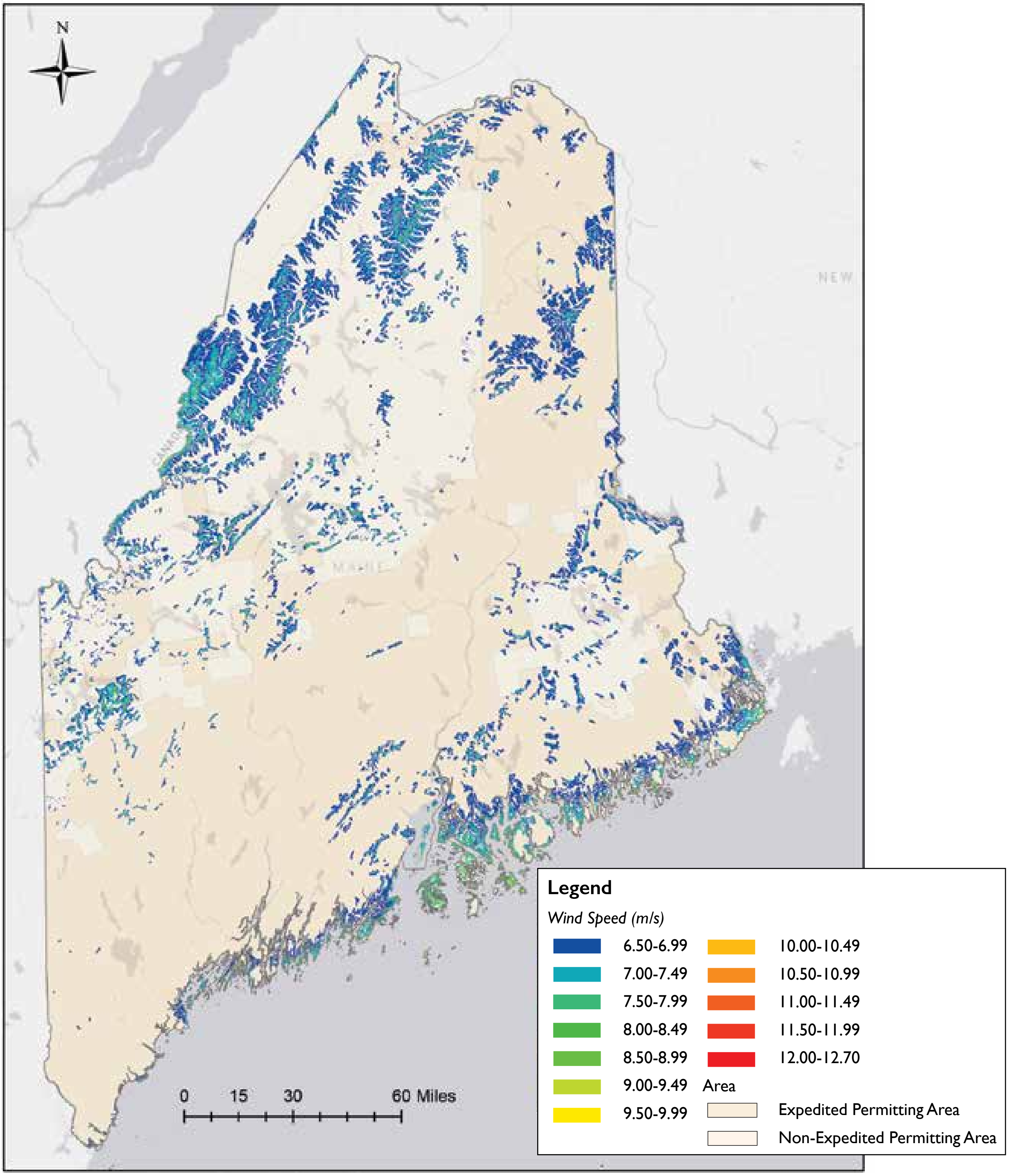


Figure 9. Map showing commercially viable wind resources at 100m hub height if Tier 1 and Tier 2 Wildlife Resources are avoided. 2.4 million acres of area with commercially viable wind resources are available.

Commercially Viable Wind Resources at 140m that Avoid Tier 1 and Tier 2 Natural Resources

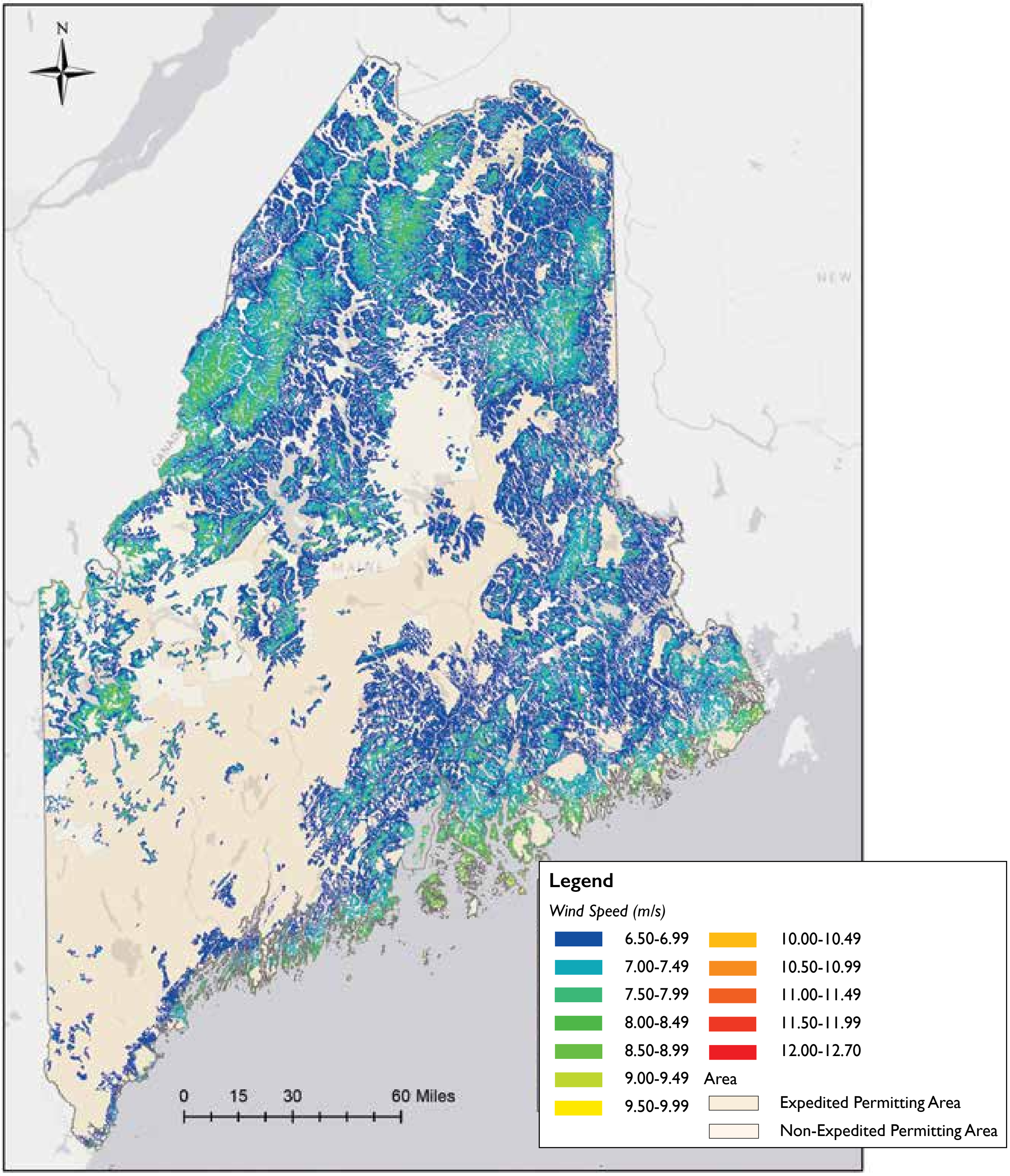


Figure 10. Map showing commercially viable wind resources at 140m hub height if Tier 1 and Tier 2 Wildlife Resources are avoided. 8.7 million acres of area with commercially viable wind resources are available.

Coastal Habitats and Wind Resources

As noted in the 2013 report, wind resources at 80m hub heights are often concentrated along ridgelines and in coastal areas; this is also true for wind resources at 100m hub heights. As in 2013, we looked specifically at the wind resources available on the land base within 2 miles of the coast and estuaries of Maine. For the 100m Wind Base, 20.4% was found within the Coastal Area *(see Figure 4, 100m Wind Base map)*, even though the Coastal Area only accounts for 7.2% of the land base of Maine. In addition, the wind speeds in the Coastal Area included a larger proportion of higher wind speeds *(see Figure 11).*

The 140m Wind Base, however, told a slightly different story. While wind speeds were higher along the coast, the 140m Wind Base was not as concentrated in the Coastal Area as it was for the 100m and 80m Wind Bases *(see Figure 5, 140m Wind Base map)*. The proportion of Coastal Area compared to the entire 140m Wind Base, at 9.7%, was much more aligned with the proportion of Coastal Area compared to the land base of Maine, at 7.2%. In addition, proportionally more of the 140m Wind Base in higher wind speed categories is found along the coast, compared to the distribution of wind speeds across the state *(see Figure 12)*.

Distribution of Wind Resources at 100m Wind Base

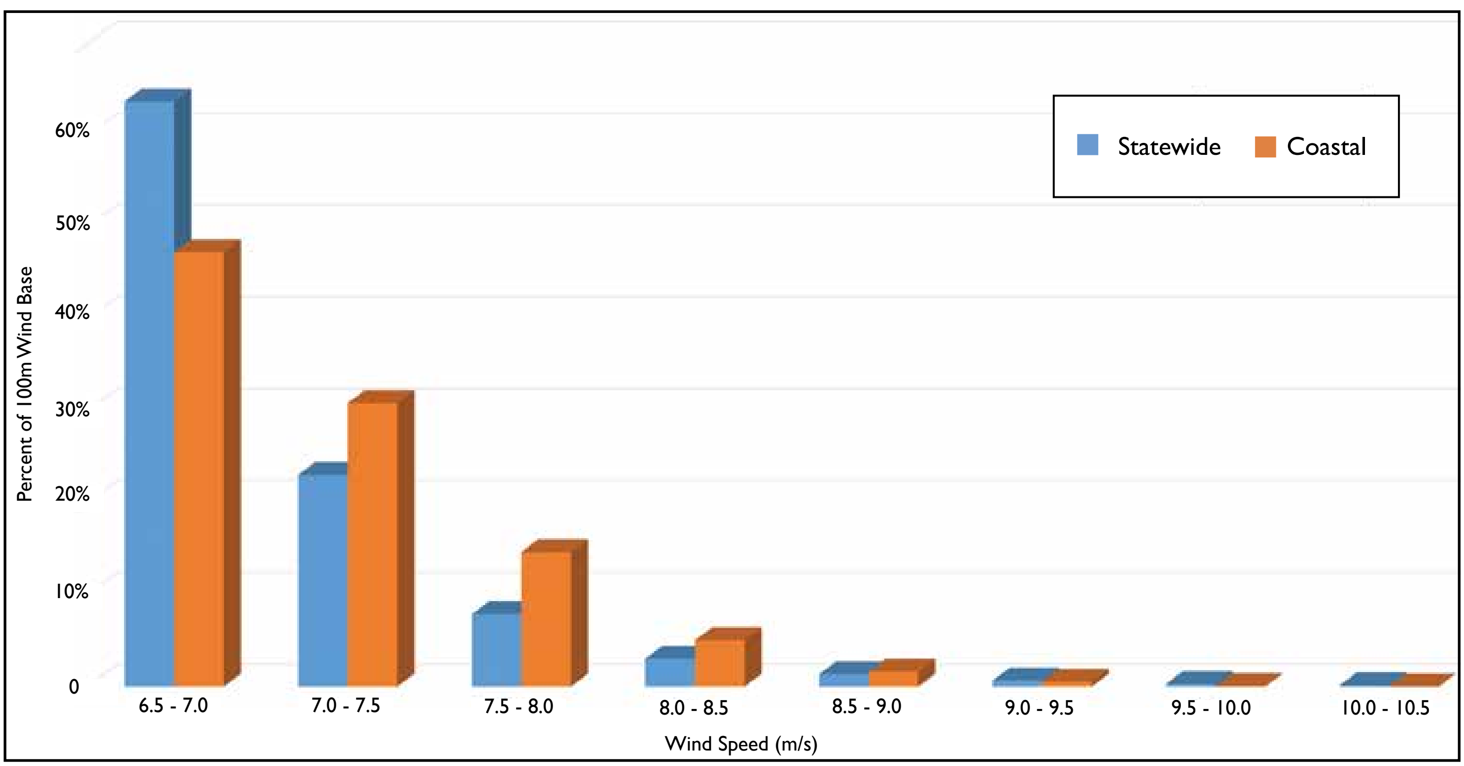


Figure 11. Comparison of the distribution of commercially viable wind resources at 100m hub height within the coastal area vs. statewide. Higher wind speeds are found within the coastal area compared to the rest of the state, proportionally.

Distribution of Wind Resources at 140m Wind Base

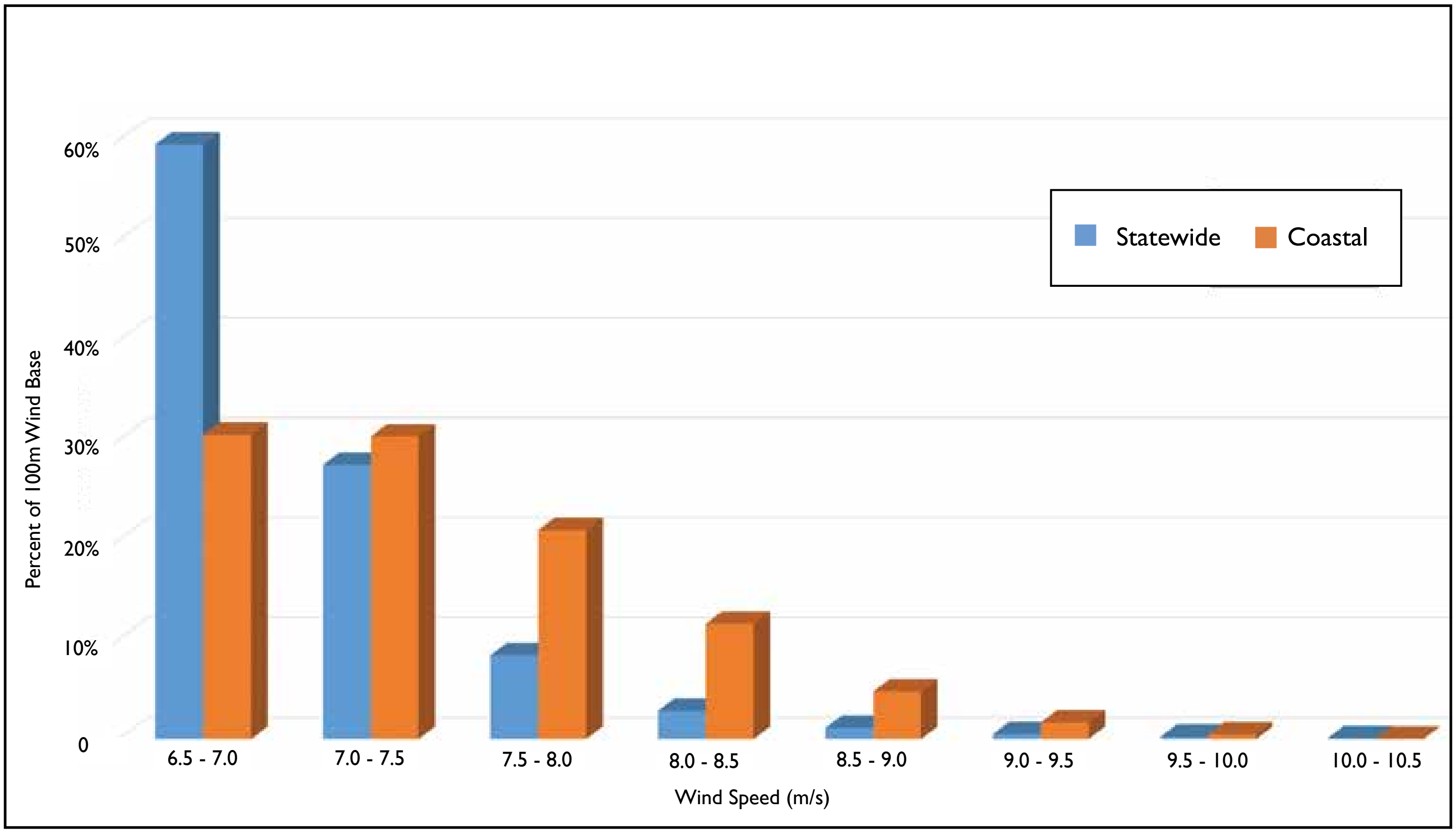


Figure 12. Comparison of the distribution of commercially viable wind resources at 140m hub height within the coastal area vs. statewide. Higher wind speeds are found within the coastal area compared to the rest of the state, proportionally.

Conservation Land

Conservation Land is land protected in fee and/or through conservation easements to provide land-based recreational, ecological, economic, and scenic values for this and future generations *(see Figure 13).* They are another valuable natural resource on Maine's landscape that could be impacted by wind energy development. Making up approximately one-quarter of both the 100m Wind Base and the 140m Wind Base, conservation land significantly but not overwhelmingly overlaps the commercially viable Wind Base *(see Figures 14 and 15)*. These lands and waters typically contain important ecological values, restrict development in order to maintain agricultural and forest resources, and provide habitat for rare, sensitive, and high-value fish and wildlife. In addition, they often provide public access and opportunities for hunting, fishing, and nature-based recreation and tourism. In unusual circumstances, some of these lands may allow wind energy development, but in general conservation land should be avoided, and every effort should be made to seek alternative sites for wind turbines and alternative routes for transmission lines.

Conservation Land

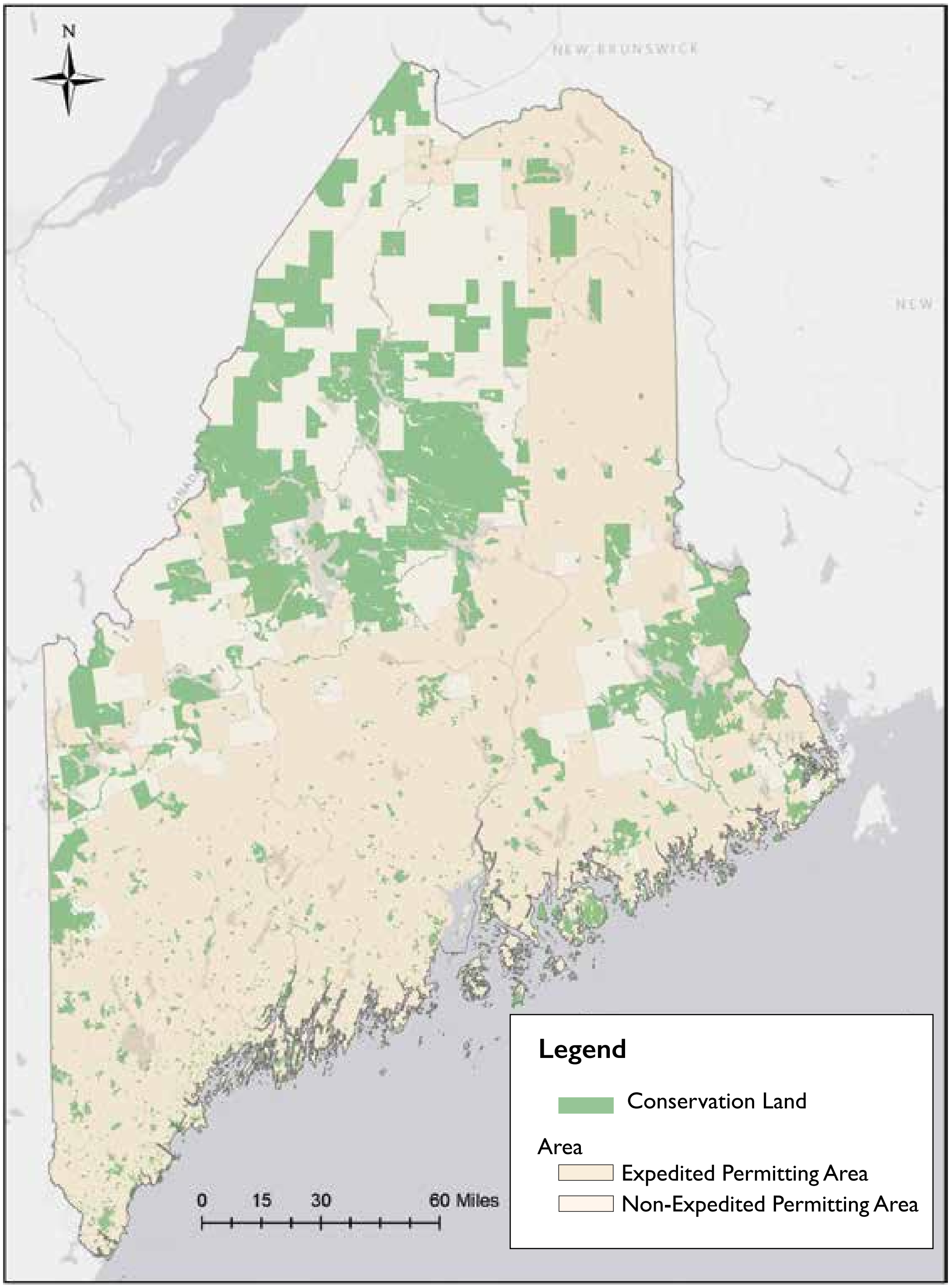


Figure 13. Conservation land across the state of Maine.

Conservation Land and Wind Resources at 100m

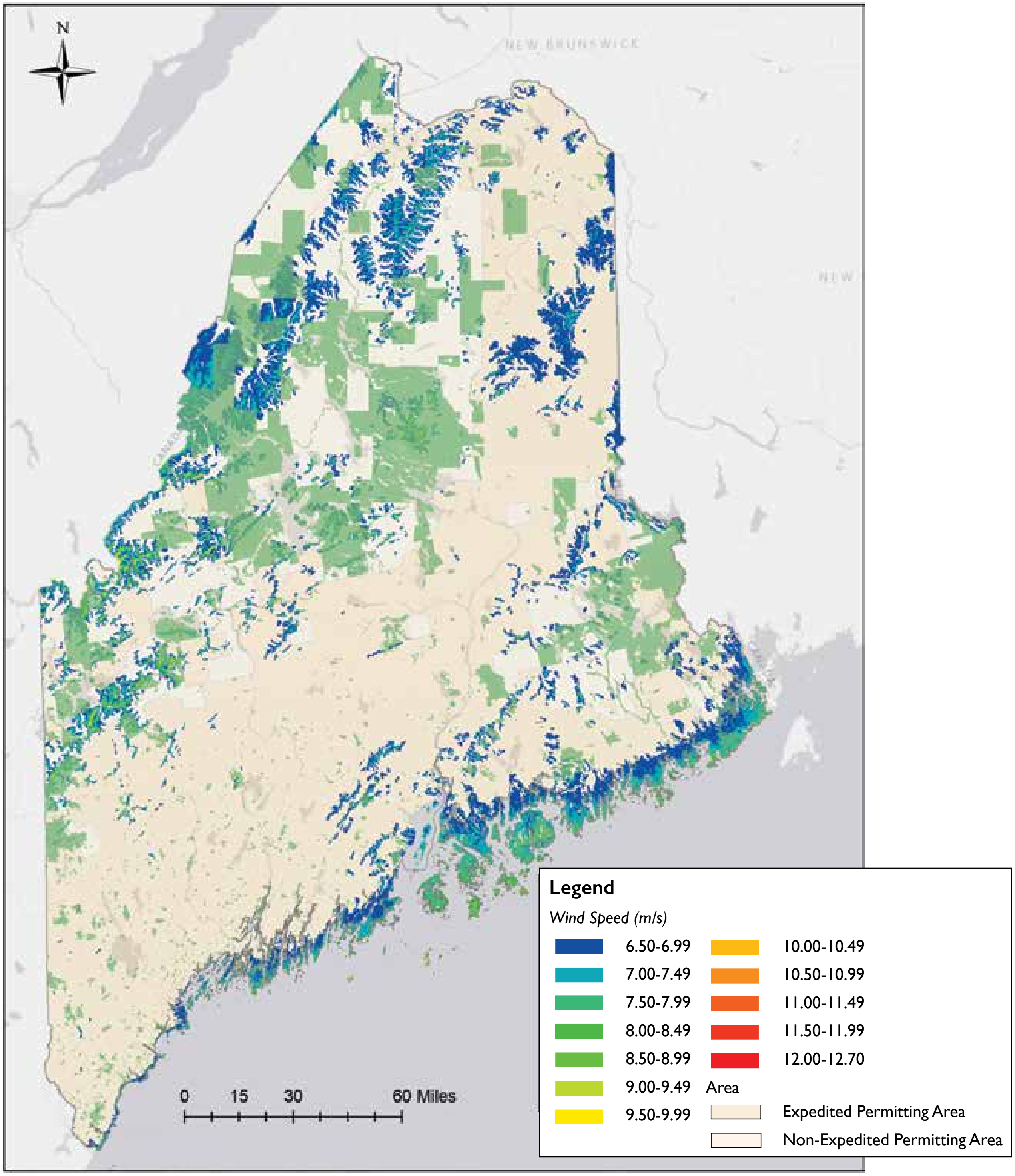


Figure 14. Conservation land where it overlaps 100m Wind Base.

Conservation Land and Wind Resources at 140m

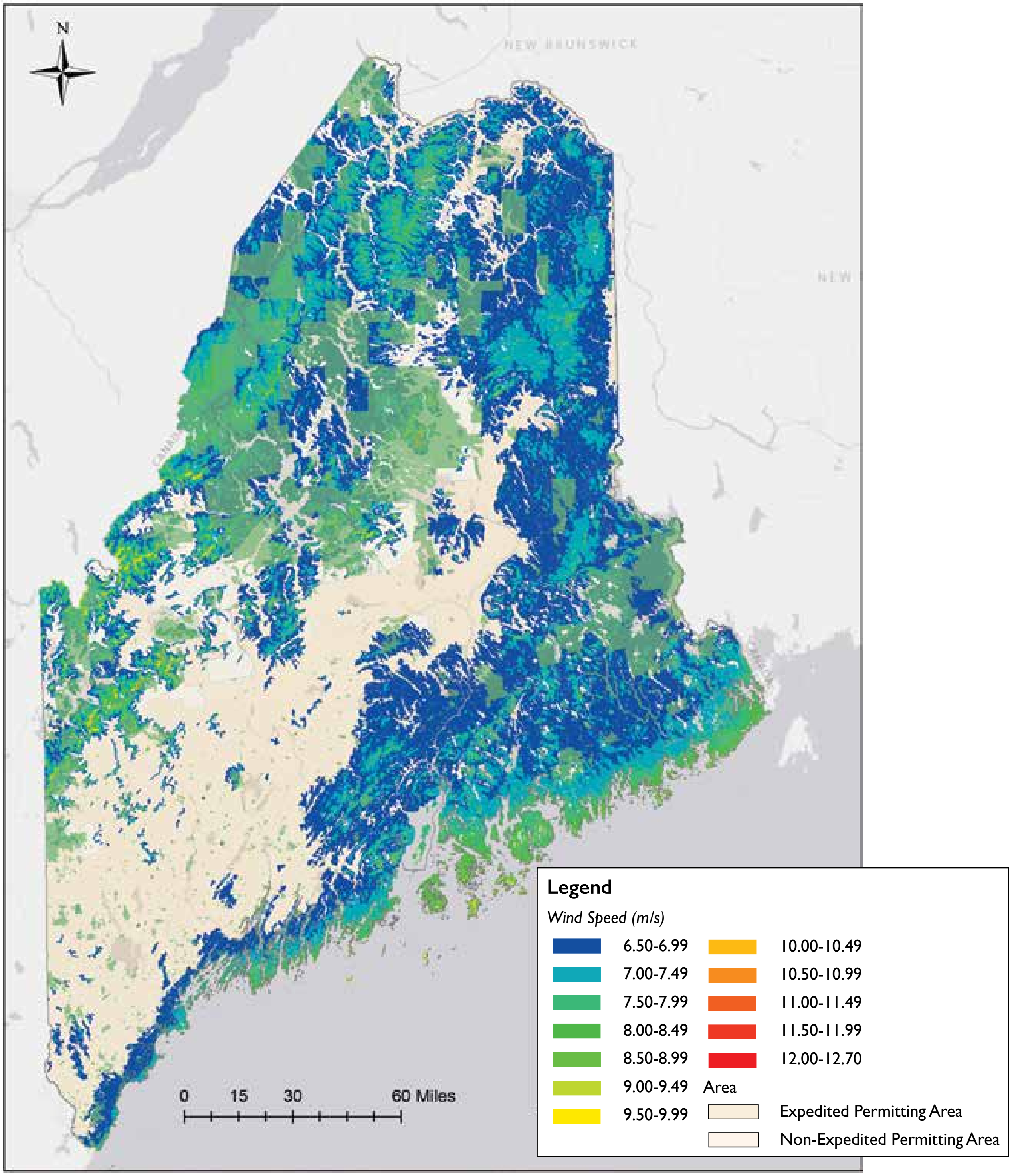


Figure 15. Conservation land where it overlaps 140m Wind Base.

Impacts of Wind Turbines for Birds and Bats

As described in this analysis, increasing wind turbine hub heights greatly expands the potential area for commercial wind energy generation, allowing developers to site wind projects away from the most sensitive wildlife areas. But wind turbines generally, and taller turbines specifically, come with risks to wildlife that may not be captured in this analysis such as collision risk for birds and bats. Increased turbine height may increase collision risk for birds; the higher the turbines and their rotors go, the more they enter the normal flight height for migrating birds. Additionally, when weather conditions deteriorate, migrating birds tend to reduce their flying height, thereby increasing their potential for collision with taller wind turbines. On the other hand, bat activity, for most species, tends to decrease with increasing height, so taller turbines may reduce bat collisions, although research is only just beginning on this topic.

And while location is a large factor in collision risk for birds and bats, it is not the only factor. The potential for bird and bat collisions with wind turbines, guy wires, or other structures also increases at night and in bad weather, when visibility is poor and structures are more difficult to avoid. Additionally, some birds and bats can be attracted to wind turbines due to type of construction, lighting, colors, and patterns, which developers can address through careful facility design.

Furthermore, many species avoid wind turbines rather than fly through a wind facility. For birds that are flying around arrays on daily foraging trips, or migrating birds on extreme energy rations avoiding one or more wind turbine arrays, there may be cumulative effects that lower fitness and survival.

This potential for increased risk of bird and bat collisions is not addressed in this analysis, because the wildlife variables analyzed in this study do not include bird or bat migration pathways. This is because such pathways are not well-known or mapped, and they may vary between species and with weather, time of year, and other factors. Because of this, and because even the datasets we did use are incomplete, site-specific wildlife and habitat information must be gathered early in the siting phase of any potential wind energy project. Areas with high concentrations of wildlife and wildlife habitats, migration corridors or pathways, and areas with rare or exemplary species or natural communities should be avoided.

By expanding the area that is potentially available for wind energy development, the potential for increased habitat fragmentation and cumulative effects of widespread development across the landscape also increases. Careful siting is still necessary for wind turbines and their associated infrastructure (transmission corridors, roads, etc.), and the cumulative effects of such development on wildlife and habitats should be investigated prior to wind energy project approval. As noted in this report[39], curtailment may be necessary to avoid harm to bats during low winds late in the year.

Conclusion

Taller turbines mean that more wind resources are commercially viable and accessible across Maine, creating ample opportunity to avoid high-value wildlife habitat while helping Maine meet its renewable energy goals. In fact, complete avoidance of Tier 1 and Tier 2 resources still leaves more than 2 million acres of viable wind at 100m hub height and more than 7 million acres of viable wind at 140m hub height. Maine Audubon recommends avoiding all areas with threatened and endangered species, and that every effort possible be taken to avoid other high-value wildlife habitat mapped in this analysis, especially where there are multiple wildlife resources and high concentrations of wildlife resources in the same place. If, despite all efforts, such resources cannot be avoided, impacts to wildlife and wildlife habitat should be minimized and/or mitigated, consistent with the recommendations in this report, found in the Mitigation section beginning on page 37. Additionally, while we used buffers to aquatic resources that are consistent with shoreland zoning laws, wider buffers—such as 100 ft. or more on perennial and intermittent streams—would provide better protection for these systems. Finally, other wildlife resources that are not already mapped—such as unknown locations of rare species or migratory pathways—need to be taken into consideration before finalizing any new wind power project.

[39] See page 30, Construction, Operation, Maintenance, and Decommissioning: Wind Considerations.

List of Endangered, Threatened, and Special Concern species in the DIFW GIS layer

Aeshna juncea
Sedge Darner

Alasmidonta varicosa
Brook Floater

Alca torda
Razorbill

Ammodramus caudacutus
Saltmarsh Sparrow

Ammodramus savannarum
Grasshopper Sparrow

Anax longipes
Comet Darner

Anthus rubescens
American Pipit

Aquila chrysaetos
Golden Eagle

Ardea herodias
Great Blue Heron

Arigomphus furcifer
Lilypad Clubtail

Asio flammeus
Short-eared Owl

Atrytonopsis hianna
Dusted Skipper

Bartramia longicauda
Upland Sandpiper

Boloria chariclea grandis
Purple Lesser Fritillary

Boloria frigga saga
Frigga Fritillary

Bucephala islandica
Barrow's Goldeneye

Callophrys gryneus
Juniper Hairstreak

Callophrys hesseli
Hessel's Hairstreak

Catharus bicknelli
Bicknell's Thrush

Catocala similis
Similar Underwing

Chaetaglaea tremula
Barrens Chaetaglaea

Charadrius melodus
Piping Plover

Chlidonias niger
Black Tern

Cicindela ancocisconensis
White Mountain Tiger Beetle

Cicindela marginata
Salt Marsh Tiger Beetle

Cicindela marginipennis
Cobblestone Tiger Beetle

Cistothorus platensis
Sedge Wren

Clemmys guttata
Spotted Turtle

Coluber constrictor
Northern Black Racer

Cordulegaster obliqua
Arrowhead Spiketail

Coturnicops noveboracensis
Yellow Rail

Emydoidea blandingii
Blanding's Turtle

Enallagma carunculatum
Tule Bluet

Enallagma durum
Big Bluet

Enallagma pictum
Scarlet Bluet

Epeorus frisoni
Roaring Brook Mayfly

Erynnis brizo
Sleepy Duskywing

Euphagus carolinus
Rusty Blackbird

Falco peregrinus
Peregrine Falcon

Fratercula arctica
Atlantic Puffin

Fulica americana
American Coot

Gallinula galeata
Common Gallinule

Glyptemys insculpta
Wood Turtle

Gomphus quadricolor
Rapids Clubtail

Gomphus vastus
Cobra Clubtail

Gyrinophilus porphyriticus
Northern Spring Salamander

Haliaeetus leucocephalus
Bald Eagle

Hemileuca maia maia
Eastern Buckmoth

Hesperia metea
Cobweb Skipper

Histrionicus histrionicus
Harlequin Duck

Ischnura hastata
Citrine Forktail

Ischnura ramburii
Rambur's Forktail

Ixobrychus exilis
Least Bittern

Lampsilis cariosa
Yellow Lampmussel

Lanthus vernalis
Southern Pygmy Clubtail

Lapara coniferarum
Southern Pine Sphinx

Leptodea ochracea
Tidewater Mucket

Leucorrhinia patricia
Canada Whiteface

Libellula needhami
Needham's Skimmer

Lycaena dorcas claytoni
Clayton's Copper

Lycia rachelae
Twilight Moth

Myotis leibii
Eastern Small-footed Myotis

Nycticorax nycticorax
Black-crowned Night-heron

Oeneis polixenes katahdin
Katahdin Arctic

Ophiogomphus colubrinus
Boreal Snaketail

Ophiogomphus howei
Pygmy Snaketail

Pantala hymenaea
Spot-winged Glider

Paonias astylus
Huckleberry Sphinx

Papilio troilus
Spicebush Swallowtail

Phalacrocorax carbo
Great Cormorant

Plebejus idas empetri
Crowberry Blue

Polygonia satyrus
Satyr Comma

Progomphus obscurus
Common Sanddragon

Rhionaeschna mutata
Spatterdock Darner

Satyrium edwardsii
Edwards' Hairstreak

Siphlonisca aerodromia
Tomah Mayfly

Somatochlora albicincta
Ringed Emerald

Somatochlora brevicincta
Quebec Emerald

Speranza exonerata
Barrens Itame

Stagnicola mighelsi
Bigmouth Pondsnail

Sterna dougallii
Roseate Tern

Sterna paradisaea
Arctic Tern

Sternula antillarum
Least Tern

Storeria dekayi
Northern Brownsnake

Strophitus undulatus
Creeper

Stylurus spiniceps
Arrow Clubtail

Sylvilagus transitionalis
New England Cottontail

Synaptomys borealis sphagnicola
Northern Bog Lemming

Terrapene carolina carolina
Eastern Box Turtle

Thamnophis sauritus
Eastern Ribbon Snake

Thorybes bathyllus
Southern Cloudywing

Tramea carolina
Carolina Saddlebags

Tramea lacerata
Black Saddlebags

Vertigo malleata
Malleated Vertigo

Vertigo morsei
Six-whorl Vertigo

Vertigo paradoxa
Mystery Vertigo

Williamsonia lintneri
Ringed Boghaunter

Xylena thoracica
Acadian Swordgrass Moth

Xylotype capax
Broad Sallow

Xystopeplus rufago
Red-winged Sallow

Zale lunifera
Bold-based Zale Moth

Zale obliqua
Oblique Zale

Zanclognatha martha
Pine Barrens Zanclognatha