STATE OF MAINE
LAND USE REGULATION COMMISSION

CHAMPLAIN WIND, LLC
BOWERS WIND PROJECT
DEVELOPMENT PERMIT DP 4889

PREFILED DIRECT TESTIMONY OF

Cameron Wake

ON BEHALF OF

CONSERVATION LAW FOUNDATION

Name and Qualifications

My name is Cameron Wake. I am a research associate professor at the Earth System Research Center, Institute for the Study of Earth, Oceans and Space and the Department of Earth Sciences at the University of New Hampshire. I research global climate and environmental change, reconstructing climate change in the past through analysis of ice cores from around the world and instrumental records from the Northeast U.S. I received my Ph.D. in Geochemical Systems (1993) from the University of New Hampshire. My CV is attached Exhibit A.

As part of the Northeast Climate Impacts Assessment (NECIA), I was a co-lead of the climate team, an author on three research papers (published in the peer-reviewed literature), lead editor of a special issue of "Mitigation and Adaptation Strategies for Global Change" that contained 14 peer-reviewed scientific papers, and a contributor to a series of reports detailing past and future climate change in the Northeast U.S.[1] Over the past year, I have presented these findings to fellow scientists, hundreds of policymakers, business and civic leaders, members of

[1] The full "synthesis report" of NECIA, entitled *Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions*, is available at: http://www.northeastclimateimpacts.org/pdf/confronting-climate-change-in-the-u-s-northeast.pdf. The summary specific to Maine is attached as Exhibit B.

the media, our congressional delegation (both Maine and New Hampshire), and members of the public.

More recently, I have authored the "Climate Assessment for the Casco Bay Watershed," a report on changes in extreme precipitation across the Northeast U.S., and a paper on our changing wintertime climate (published in the peer-reviewed scientific literature).[2]

I have also previously testified before this Commission in other permitting proceedings for wind power projects, including the Stetson I project on behalf of the Conservation Law Foundation and the Natural Resources Council of Maine.

Purpose of this Testimony

The purpose of this testimony is to provide the context in which renewable energy projects, such as this wind power project, must be considered. Specifically, my testimony will describe changes in climate across the Northeast U.S. over the past 100 years and the next 100 years. My focus is on the NECIA and Casco Bay Climate Assessment findings concerning potential impacts of climate change on the natural resources, economy, and character of the state of Maine – particularly impacts on Forests, Winter Recreation, and Coastal Communities – under two different scenarios of future heat-trapping emissions. The first (the higher-emissions scenario) is a future where people—individuals, communities, businesses, states, and nations—allow emissions to continue growing rapidly, and the second (the lower-emissions scenario) is one in which societies choose to rely less on fossil fuels and adopt more resource-efficient technologies, such as wind power.

[2] The Casco Bay report is available at: http://www.cascobay.usm.maine.edu/pdfs/Climate_Change_in_Casco_Bay.pdf. The winter climate paper is attached as Exhibit C.

Recent Developments in Global Climate Change

The Earth has continued to warm at a rate that is in line with scientific projections based on increases in the content of greenhouse gas in the atmosphere. Global temperatures are rising, with 2005 and 2009 being the two warmest years in the past 130 years, continuing a warming trend of 0.30°F per decade over the past four decades.[3] Human factors are by far the most significant cause of the warming. Solar variability has accounted for only 10 percent of the surface warming over the past century and an even smaller amount over the past quarter century.[4] In addition, several key components of the Earth's climate system are changing more rapidly than had been projected in the 2007 Intergovernmental Panel on Climate Change Report.[5] These include:

- accelerated melting of the Greenland and Antarctic ice sheets, and glaciers around the world;
- rapid Arctic sea-ice decline during the summer melting period;
- increasing rates of sea-level rise, consistent with an approximate doubling of the contribution from melting glaciers and ice-sheets;
- carbon dioxide uptake by the oceans which has resulted in increasing ocean acidity; and
- accelerated thawing of permafrost (permanently frozen ground) in the Northern Hemisphere, a potentially significant source of both CO_2 and CH_4.[6]

Additionally, scientists recently discovered that the permafrost under the East Siberian Arctic Shelf is perforated and is starting to leak large amounts of methane into the atmosphere, another example of a key threshold or "tipping point" in the climate system that we may be close to

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[3] Temperature data analysis by NASA Goddard Institute for Space Studies. http://data.giss.nasa.gov/gistemp/

[4] Lean, JL & DH Rind, (2008) How natural and anthropogenic influences alter global and regional surface temperatures: 1889 to 2006. Geophysical Research Letters 35, L18701. http://www.agu.org/pubs/crossref/2008/2008GL034864.shtml

[5] Solomon, S, D Qin, M Manning, Z Chen, M Marquis, KB Averyt, M Tignor, HL Miller (eds.)(2007) Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007. Cambridge University Press. http://www.ipcc.ch/publications_and_data/ar4/wg1/en/contents.html

[6] The Copenhagen Diagnosis, 2009: Updating the World on the Latest Climate Science.. The University of New South Wales Climate Change Research Centre (CCRC), Sydney, Australia. http://www.copenhagendiagnosis.com/

crossing. Release of even a fraction of the methane stored in the shelf could trigger abrupt climate warming.[7]

On the national front, a 2009 report published by the U.S. Global Change Research Program summarized the science of climate change and the impacts of climate change on the U.S., now and in the future.[8] The report provides a synthesis of information from a wide variety of scientific assessments and published research to summarize what is known about the observed and projected consequences of climate change on various sectors such as energy, water, and transportation. The report concludes: “Observations show that warming of the climate is unequivocal. The global warming observed over the past 50 years is due primarily to human-induced emissions of heat-trapping gases. . . . Warming over this century is projected to be considerably greater than over the last century. The global average temperature since 1900 has risen by about 1.5°F. By 2100, it is projected to rise another 2 to 11.5°F.”

More recently, the National Research Council of the National Academies published its final report in the “America’s Climate Choices” series. The report reinforces the notion that climate change is occurring and response efforts are needed at both the local and national level. The authors of the report suggest that mobilizing action to reduce greenhouse gas emissions today will reduce society’s vulnerability to climate change impacts in the future. Major investments in equipment and infrastructure are being made today that will effectively commit us to greenhouse gas emissions for decades to come. Policies to reduce emissions must therefore be instituted now so as to guide investment in energy efficiency and low-carbon energy infrastructure. The report notes that the risks of continuing in a high-emissions direction are far

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[7] Shakhova N, I Semiletov, A Salyuk, V Yusupov, D Kosmach, Ö Gustafsson (2010) Extensive Methane Venting to the Atmosphere from Sediments of the East Siberian Arctic Shelf. Science 327 (5970), 1246. http://www.sciencemag.org/cgi/content/short/327/5970/1246

[8] Karl TR, JM Melillo & TC Peterson (eds.)(2009) Global Climate Change Impacts in the United States. Cambridge University Press. http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts

greater than the risks of continuing in a low-emissions manner. The report highlights that the scientific uncertainty associated with projecting future greenhouse gas emissions and in estimating climate change impacts is not sufficient justification for inaction. Climate change mitigation policies and emissions reductions efforts can be scaled back in the future if needed, whereas adverse changes to the climate system would be difficult or impossible to reverse. [9]

Climate Change Over the Last 100 Years in the Northeast United States

Over the past 100 years, and especially the last 30 years, all of the climate change indicators for the Northeast U.S.—including factors such as annual temperature, length of growing season, lake ice-in and ice-out dates, precipitation, sea level rise, and snowfall—reveal a warming trend. For example, the Northeast's average annual temperature has increased by about 1.8ºF, the growing season has increased by 8 days, lake ice-out dates are 9 to 16 days earlier, and there has been a decrease in total snowfall amounts.

Winter temperatures in New England have warmed much faster than in any other season over the past four decades. Since 1965, monthly and seasonal temperature records from 138 meteorological stations across the northeastern U.S. exhibited region-wide winter warming on the order of approximately 3°F. The number of snow-covered days has decreased by more than a week, while total winter snowfall decreased by about 3.8 inches. Winter temperatures can be expected to rise by an additional 5.8°F by 2100 under a lower emissions scenario and an additional 8°F to 12°F under a high emissions scenario. In other words, the decision we make today and over the next decade concerning how we produce and how we use energy will determine how much warmer the winter season in the northeastern U.S. will be in the future.

[9] http://dels.nas.edu/Report/Americas-Climate-Choices/12781

Overview of NECIA Climate Projections

NECIA climate projections found that over the next several decades, due to heat-trapping emissions released in the recent past, temperatures across the Northeast will rise 2.5°F to 4°F in winter and 1.5°F to 3.5°F in summer regardless of the emissions choices we make now. By mid-century and beyond, however, today's emissions choices generate starkly different climate futures. While these scenarios represent strikingly different emissions choices that societies may make, they do not represent the full range of possible emissions futures.

A number of factors, including unrestrained fossil-fuel use, could drive global emissions above the "high-emissions" scenario, while rapid, concerted efforts to adopt clean, efficient technologies could reduce emissions below the "lower-emissions" scenario used in the study. The lower-emissions scenario describes a world in which atmospheric concentrations of CO_2 rise from ~380 parts per million (ppm) today to ~550 ppm by the end of the century, in contrast to 940 ppm under the higher-emissions scenario. However, many lines of evidence indicate that even greater emissions reductions, and thus less severe impacts, are well within our reach. The latest assessment of the Intergovernmental Panel on Climate Change (IPCC) describes the technical and economic potential for stabilizing atmospheric concentrations of heat-trapping gases at or below the equivalent of 450 ppm of CO_2. Achieving such a target would require the U.S. and other industrialized nations to make deep emissions reductions by mid-century – on the order of 80 percent below 2000 levels – along with substantial reductions by developing countries. In the Northeast, as well as elsewhere in the U.S. and the world, there is growing momentum to pursue deep emissions reductions consistent with staying below the lower-emissions pathway.

Climate change will impact a wide range of sectors in our society, including marine resources, coastal infrastructure, winter recreation, agriculture, forests, and human health. For example, warmer winter temperatures have been associated with earlier river and lake ice-out, which shortens the ice-fishing season; a shift to earlier and decreased spring runoff has been shown to impact the survival of salmon juveniles; and an observed decrease in the number of extreme cold temperature days can lead to increases in tick populations, making vector-borne diseases like Lyme disease more widespread. Cold-temperature days are important to cool-temperature crops such as apples, blueberries, cranberries and grapes, which require 200 to 2000 cumulative winter cooling hours (between 32°F and 50°F). If the cooling period requirement is not met, flower buds may die or blossoms may drop before they open, and those flowers that do develop may not set fruit or the fruit may be undersized. Snow cover also plays an important role in soil temperature and moisture properties and, if reduced, can have negative impacts on crops such as wild blueberries. In Maine, for example, where ninety percent of the nation's wild blueberries are grown, blueberry crops in 2004 were down 43 percent from the previous year, partly due to frost damage brought on by inadequate snow cover and extreme cold temperatures.

Impacts on Forests

The character of the Northeast's forests may change dramatically over the coming century as the center of suitable habitat for most of the region's tree species shifts northward—as much as 500 miles by late-century under the higher-emissions scenario and as much as 350 miles under the lower-emissions scenario. Many tree species, including the hardwoods that generate the region's brilliant fall foliage, may be able to persist this century even as their optimal climate zones shift northward. Other species, however, may succumb to climate stress, increased competition, and other pressures. If the higher-emissions scenario prevails, productivity of spruce/fir forests is expected to decline and suitable habitat will all but disappear from the Northeast by the end of the century. Major losses are projected even under the lower-emissions scenario. This would greatly exacerbate stresses on the pulp and paper industry in the Northeast, particularly in Maine, where the forest-based manufacturing industry is key to the state's economy.

Diminished spruce/fir habitat, especially at higher elevations, would increase pressure on associated animal species such as the snowshoe hare, Canada lynx, and Bicknell's thrush, one of the region's prized songbirds. With the late-century summer warming projected under the higher-emissions scenario, suitable habitat for the Bicknell's thrush could be eliminated from the region. Substantial changes in bird life are expected across the Northeast due to rising temperatures, shifting distribution of suitable habitat, or declining habitat quality. The greatest changes are projected under the higher-emissions scenario, including declines in the abundance of many migratory songbirds such as the American goldfinch, song sparrow, and Baltimore oriole. Winter warming will threaten hemlock stands, not only by reducing suitable habitat for these trees but also by allowing northward expansion of a fatal pest known as the hemlock woolly adelgid—as far north as Canada by late-century under the higher-emissions scenario.

Pronounced Impact on Maine's Spruce/Fir Forests

The most vulnerable of the Northeast's forests are the vast cool-climate communities dominated by conifers such as red spruce and balsam fir. These include forests such as the North Woods of Maine that are vital to the pulp and paper industry in the Northeast and equally treasured for their scenic and recreational value. In Maine, where the forest-based manufacturing industry is central to the state's economy, spruce and fir species provide 50 percent of all sawlogs and 20 percent of all pulpwood harvested. Suitable habitat for the group of species that make up spruce/fir forests is projected to diminish substantially with global warming under either emissions scenario. All areas of the Northeast now dominated by spruce/fir forests are projected to become less suitable for this group of tree species and better suited to others. As this happens, habitat for different species of spruce and fir trees is projected to change at different rates, but these rates are consistently greater under the higher-emissions scenario. Under the higher-emissions scenario, balsam fir is projected to lose 70 to 85 percent of its suitable habitat across Maine, New Hampshire, New York, and Vermont, and red spruce is projected to lose 55 to 70 percent of its suitable habitat. For both species, losses will be greatest in Maine, where this forest type currently dominates the landscape.

Growth rates for spruce/fir forests are also projected to decline significantly throughout the latter half of this century under the higher-emissions scenario. The decline will begin earlier and be more pronounced if CO_2 fertilization does not occur. Even under the lower-emissions scenario, suitable habitat for balsam fir is projected to decline 55 to 70 percent across Maine, New Hampshire, New York, and Vermont, and habitat for red spruce is projected to drop 45 to 65 percent. Again, the greatest losses are projected for Maine. If lower emissions prevail, spruce/fir forests could experience some increase in growth rates as a result of more modest warming, a longer growing season, CO_2 fertilization, and more efficient water use caused by rising CO_2. Without CO_2 fertilization, however, forest productivity will likely decline even under lower emissions.

The direct impact of rising atmospheric CO_2 on forest growth represents a major uncertainty in current projections of how future forests will function. Although experiments have shown that trees exposed to increased CO_2 exhibit accelerated rates of photosynthesis and growth over the short term, whether this will translate into sustained growth increases over longer timescales is unknown. There is also relatively little evidence for historical enhancements in growth in response to the 35 percent rise in CO_2 that has taken place since the onset of the Industrial Revolution. Dramatic declines in spruce/fir forests projected under the higher-emissions scenario would greatly exacerbate stresses on the Northeast's economically important pulp and paper industry, particularly in Maine. Winter warming, in addition to its direct role in redefining tree habitat, interferes with traditional timber harvesting practices in the region, which typically take advantage of the cold winter months when soils are frozen, minimizing the soil damage that could be caused by the heavy equipment used for cutting trees. As winters continue to warm over the coming century, forest soils will remain frozen for shorter periods, freeze less deeply, or potentially not freeze at all in more southerly areas.

Impacts on Winter Recreation

Global warming is projected to profoundly affect winter recreation and tourism in the Northeast as winter temperatures continue to rise and snow cover declines, especially under the higher emissions scenario. Maine is part of a six-state network of snowmobile trails totaling 40,500 miles and contributing $3 billion a year to the regional economy. Snowmobiling, like cross country skiing and snowshoeing, relies almost entirely on natural snowfall because of the impracticality of snowmaking on such a vast system of trails. This fact, combined with projected losses in natural snow cover, means that Maine's snowmobiling season could be cut substantially by mid-century. Under the higher-emissions scenario, the average season length across Maine is projected to shrink to roughly 30 days by late-century—a nearly 70 percent decline below recent levels—and to roughly 50 days under the lower-emissions scenario—a 40 percent decline.

Maine's 17 ski areas contribute $300 million a year to the state's economy, providing recreation for Mainers and visitors. Milder winters are expected to shorten the average ski season, increase snowmaking requirements, and drive up operating costs in an industry that has already contracted in recent years. Under the higher-emissions scenario, western Maine is projected to be the only area in the entire Northeast able to support viable ski operations by late-century. However, in order to stay open, resorts in this area would require substantial increases in snowmaking capacity and, therefore, operating costs. Ice fishing and pond hockey are winter favorites in Maine. Global warming will render lake ice cover increasingly thin and shorten its duration. In fact, ice cover duration on Sebago Lake has already declined by two weeks over the past several decades. Combined with fewer opportunities for sledding, snowshoeing, and other outdoor activities, winter recreation as it is now known in Maine is at great risk. These projections may be conservative, as the climate models used in this analysis have consistently underestimated the rapid winter warming and snowpack decline observed in recent decades.

Impacts on Casco Bay Watershed and the Gulf of Maine

As greenhouse gases continue to accumulate in the atmosphere, seasonal and annual temperatures will rise in the Casco Bay watershed. Depending on the emissions scenario, mid-century temperatures may increase as much as 2°F to 6°F in the region, and end-of-century temperatures may increase as much as 3°F to 8°F. Very cold days (below 0°F) are projected to drop from their current average of 40 days per year to 24 days per year under a lower emissions scenario and 12 days under a higher emissions scenario at inland sites by 2100. Extreme heat days in the summer are projected to occur more often and to be hotter. By end-of-century, days with temperatures above 90°F may increase from a current average of 4 days per year to 14 days per year. Under a higher-emissions scenario, the increase could be as much as 60 days. This raises concerns regarding the impact of extreme and sustained heat on human health, infrastructure, and the electricity grid.

Rising sea levels caused by global warming are projected to increase the frequency and severity of storm surges and coastal flooding along Maine's coast. Changes in sea level contribute to increased erosion, saltwater contamination of freshwater ecosystems and loss of salt marshes and cordgrass. Low-lying shorelines such as Old Orchard Beach are likely to be the most vulnerable to rising seas. Preliminary estimates of coastal flooding elevations in 2100 suggest that large areas of coastal Portland could be flooded, including areas along the southern coast of Back Cove as well as areas of both Portland and South Portland adjacent to the Fore River. An increase of 2 feet over current flood elevations is estimated under a low-emissions scenario and 5 feet under a high-emissions plan. Sea surface temperatures have likewise been linked to winter storm tracks and storm intensity in the northeastern U.S. The average annual sea surface temperature in the Gulf of Maine has been increasing at a rate of about 0.06°F per decade. Warmer sea surface temperatures threaten the Gulf of Maine's $450 million dollar shellfish industry. As the Gulf of Maine warms, the waters become more hospitable to diseases such as lobster shell disease and red tide organisms.

The implications of warmer temperatures, shifting precipitation patterns, and increased coastal flooding for the Casco Bay area are pervasive. For example, warmer temperatures affect the types of trees, plants, and even crops—such as blueberries—likely to grow in the area. Long periods of very hot conditions in the summer are likely to increase demands on electricity and water resources. Hot summer weather can have damaging effects on agriculture, human and ecosystem health, and outdoor recreational opportunities. Less extreme cold in the winter will be beneficial to heating bills and cold-related injury and death; however, rising minimum temperatures in winter could open the door to invasion of cold-intolerant pests that prey on the region's forests and crops. Although little change in snowy days is expected until later in the century, rising winter and spring precipitation could increase the risk of spring riverine flooding. Under the higher emissions future, frequency of drought is projected to increase from a current average of 1 in every 10 years to one month of drought every 3 years. Coastal flood elevations will continue to increase due to sea level rise, leading to increasingly larger areas of flooding during coastal storms. All combined, these changes will have serious repercussions on the region's environment, economy, and society.

Conclusion

Of course, actions in Maine and the Northeast alone will not be sufficient to reduce global warming. But with its reputation as a state of sensible and resourceful people and a history of national leadership in environmental policy, Maine (along with the rest of the Northeast) is well positioned to drive national and international progress in reducing emissions. Decision makers have myriad options available today to move toward this goal, including accelerating the region's transition from fossil fuels to clean, renewable energy resources.

Wind energy represents one of the most attractive near-term prospects among renewable resources for making substantial, relatively low-cost contributions to electricity generation in the Northeast. Onshore wind resources have the technical potential to meet almost half of the region's annual energy needs; Maine has the largest wind resource among all New England states. Emissions choices we make today—in Maine, the Northeast, and worldwide—will help determine the climate our children and grandchildren inherit, and shape the consequences for their economy, environment, and quality of life.

Dated:___________________ _______________________________
Cameron P. Wake

STATE OF _______________________
COUNTY OF ______________________

Personally appeared before me the above-named __________________and made oath that the foregoing is true and accurate to the best of his/her knowledge and belief.

Dated: ___________________ _______________________________
Notary Public
My Commission Expires: