Vermont Agency of Natural Resources
Fish and Wildlife Department
Bat-Wind Guidelines
September 2016

Purpose

The purpose of this guidance document is to inform prospective wind energy developers of the current expectations of the Vermont Agency of Natural Resources (VANR) for addressing bat-wind turbine collisions during project siting, surveys, operations, and monitoring of wind energy projects requiring Act 248 Certificates of Public Good from Vermont's Public Service Board.

The guidance will also provide for a consistent approach to all operating wind energy facilities in Vermont, establish a fair and equitable standard, and will enable the industry to more efficiently and effectively coordinate a Vermont industry-wide approach to addressing impacts to Vermont's bat populations.

It is also recommended that prospective wind energy developers review the U.S. Fish and Wildlife Service's *Land-Based Wind Energy Guidelines* for information and its tiered approach to wind energy project planning.

Background

Since the discovery of high levels of bat fatalities at a West Virginia wind energy facility in 2003, significant attention has been warranted for mitigating bat-wind energy fatalities across the eastern United States. In particular, utility-size (i.e., greater than 65-meter tower height) wind turbines located along forested ridgelines observe higher fatality rates (Barclay 2007). By 2012, it was estimated that approximately 400,000 to 600,000 bats are killed each year by operating wind turbines across the United States (Hein and Schirmacher 2016, Hayes 2013). While Vermont's endangered bat species likely make up a small percentage of bats killed by wind turbines, the far majority (i.e., >75%) is comprised of the three species of migratory tree bats.

The Appalachian Mountain Range has been identified as the region with the greatest estimated bat fatality rates, often exceeding 30 bats/turbine. Fatality rates in the Northeast are lower, most likely due to lower bat populations at these northern latitudes, and fewer numbers of migratory bats migrating through the area. Even so, annual estimated fatality rates in Vermont have ranged from 1.95 to 14.65 bats/turbine (Table 1).

Table 1. Bat fatalities observed and estimated at Vermont wind energy facilities.

Facility	First Wind Sheffield		GMP Lowell		Georgia Mtn	
Study Year	*2012*	*2013*	*2013*	*2014*	*2013*	*2014*
Silver-haired Bat	14	9	10	13	8	2
Red Bat	26	1	1	0	2	0
Hoary Bat	47	9	5	8	2	1
Big Brown Bat	0	0	0	0	1	0
Total Observed	87	19	16	21	13	3
Estimated Mortality (bats/turbine/year)	14.65	2.83	1.95	4.96	11.7	2.83

The status of Vermont's bat populations has changed dramatically since the impacts of wind energy facilities on bats were realized in the eastern United States. Since 2007, White-nose Syndrome (WNS) has devastated populations of cave bat species across the eastern half of the United States. In Vermont, a 2010 statewide assessment estimated declines in certain cave bat species, ranging from 75% to 95% in just three years (Darling and Smith 2011). As a result, the state of Vermont listed the little brown bat, northern long-eared bat, and tri-colored bat as state endangered (Table 2). These three species joined the Indiana bat and the small-footed bat as state threatened or endangered. All nine of Vermont's bat species are designated as Species of Greatest Conservation Need (SGCN) in the state's Wildlife Action Plan.

In 2015, the U.S. Fish and Wildlife Service (USFWS) listed the northern long-eared bat as federally threatened. In doing so, the USFWS simultaneously established a final 4D Rule exempting wind energy facilities from the take provisions of the Endangered Species Act. The federally endangered Indiana bat; however, has no such exemption.

Table 2. The status of Vermont's bat species.

Species	Common Name	SGCN Priority	Status
Eptesicus fuscus	Big brown bat	Medium	S4 Apparently Secure
Lasionycteris noctivagans	Silver-haired bat	High	S2 Rare
Lasiurus borealis	Eastern red bat	High	S4 Apparently Secure
Lasiurus cinereus	Hoary bat	High	S3 Uncommon
Myotis leibii	Small-footed bat	High	S1 State Threatened
Myotis lucifugus	Little brown bat	Medium	S1 State Endangered
Myotis septentrionalis	Northern long-eared bat	Medium	S1 State Endangered/Federally Threatened
Myotis sodalis	Indiana bat	High	S1 State/Federally Endangered
Perimyotis subflavus	Tri-colored bat	High	S1 State Endangered

In Vermont, all utility-scale wind energy facilities are required to obtain a Certificate of Public Good from the Vermont Public Service Board (PSB). During its proceedings, the VANR

provides testimony regarding the project's impacts to natural resources, including bats. In addition, if it is deemed that the project is likely to take any state threatened or endangered bats, the facility will need to obtain a Vermont Threatened and Endangered Species Takings Permit from the Secretary of VANR.

Definitions

For the purposes of consistency in meaning, the VANR adopts the following definitions described by Arnett et al (2013):

Curtailment: The act of limiting the supply of electricity to the grid during conditions when it would normally be supplied. This is usually accomplished by cutting out the generator from the grid and/or feathering the turbine blades.

Cut-in Speed: The wind speed at which the generator is connected to the grid and producing electricity. The manufacturer's set cut-in speed for most contemporary turbines is between 3.0 and 4.0 m/s. For some turbines, their blades will spin at full or partial RPM below cut-in speed when no electricity is being produced.

Feathering: Adjusting the angle of the rotor blade parallel to the wind, or turning the whole unit out of the wind, to slow or stop blade rotation. Normally operating turbine blades are angled perpendicular to the wind at all times.

Free-wheeling: Blades that are allowed to slowly rotate even when fully feathered and parallel to the wind. In contrast, blades can be "locked" and cannot rotate, which is a mandatory situation when turbines are being accessed by operations personnel.

Increasing Cut-in Speed: The turbine's computer system (referred to as the Supervisory Control and Data Acquisitions or SCADA system) is programmed to a cut-in speed higher than the manufacturer's set speed, and turbines are programmed to stay feathered at 90 degrees until the cut-in speed is reached over some average of minutes (usually 5-10 minutes), thus triggering the turbine blades to pitch back "into the wind" and begin to spin normally.

Goals for Reducing Bat Fatalities

The goals of VANR's review of wind energy projects, participation in PSB proceedings, position before the PSB, and in its deliberations of a state Threatened and Endangered Species Takings Permit are to:

- Ensure the long-term sustainability of Vermont's native bat populations.
- Reduce total bat fatality levels as much as practicable, and in all instances below levels that are unduly adverse.
- Reduce the likelihood of take of any state or federal threatened or endangered bat species.

While few state/provincial agencies have adopted bat fatality thresholds, VANR has testified before the PSB that bat fatality rates of 8 or fewer non-listed bats/turbine/year would be adverse, but not unduly adverse, and at a level at which the VANR would not seek further measures to reduce fatalities if opposed by the applicant. The threshold serves as guidance for wind energy facilities seeking some level of certainty in VANR's response to realized estimated fatality rates that result from post-construction monitoring.

Mitigation Approaches

VANR approaches its review of prospective wind energy facilities in a step-wise progression:

- Avoidance: Can impacts be avoided by site selection or other practicable measures? Selecting alternative sites is likely the most effective means of avoiding impacts when they are considered significant.
- Minimization: Can impacts be reduced to acceptable levels through various practicable measures? Reducing the number of turbines, curtailment, or the potential development of commercial acoustic deterrents are examples of mitigation measures that would reduce fatalities.
- Compensation: Can impacts be adequately compensated through other actions that benefit the species impacted? In Vermont, the Maternity Colony Technical Assistance Program is a collaborative endeavor funded by operating wind energy facilities to allow VANR to protect bats through assistance to homeowners with bats in their buildings or gating hibernacula to eliminate human disturbance to hibernating bats.

In all instances to date, wind energy facilities in Vermont implement more than one of the above efforts to reduce bat fatalities.

The most effective and efficient means of adequately addressing VANR interests in bat conservation is for applicants to meaningfully engage with VANR as early in the planning stages as possible. This is particularly true for large projects or if the developer is not willing to consider the mitigation approaches described above.

Site Selection

Site selection provides an opportunity to evaluate a potential development site for the prospects that bat fatalities may exceed thresholds described above. In particular, the project's potential site should consider the following features during the planning stages:

Bat Hibernacula: VANR has documented nearly 30 bat hibernacula where cave bats hibernate during the winter months throughout the state. Nearly all of these hibernacula contain state threatened or endangered species and 24 contain federally threatened or endangered species. Prospective wind energy projects proximate to hibernacula or directly in line with likely migration corridors increase the likelihood of unduly adverse levels of take of state and federally listed species. Such take is most likely to occur in the spring during emergence and in the autumn during the fall swarming period.

Summer Concentrations of Bats: Since WNS's impacts to many bat species, there are specific areas within the state where concentrations of state listed bats are known to exist. These include:

- Champlain Valley: The Champlain Valley contains concentrations of Indiana bats and little brown bats. Developers of prospective sites within the valley or directly adjacent to it should consider the potential for increased take of these listed species.
- Talus slopes, cliffs, and ledges: Such sites are summer roosting habitat for the state threatened small-footed bat. These conditions also exist along artificial dam sites where extensive rip-rap receives solar radiation.

Project Planning

Project planning to assess potential impacts to bats includes decisions regarding the make and model of turbine, the number of turbines, the orientation and number of turbine strings, and the suitability of the wind resource to accommodate curtailment requirements. Data from wind energy facilities in New England and New York suggest there is a poor relationship between a facility's number of turbines and the total estimated bat fatalities for the site. Even a single wind turbine in Delaware was estimated to kill 111 bats in a single year (Buler 2012). Admittedly; however, of two sites with identical bat fatality rates (i.e., number of bats killed/turbine/year), the site with the fewer number of turbines will kill fewer total bats. As a result, VANR does take facility size into consideration when reviewing pre-construction acoustic surveys, minimization measures, or compensation requirements when fewer than 5 turbines are proposed.

Turbine strings running perpendicular to bat migration patterns are more likely to kill more bats (Baerwald et al. 2011). In Vermont, bat migration patterns are typically north-south, unless the project is proximate to critical hibernacula where large numbers of bats emerge in the spring or converge for the fall swarm. In general, site planning on forested ridges should limit the extent of turbine strings running east-west.

Lastly, turbines vary in their cut-in speed, their programs to implement bat curtailments, and their ability to force turbines to rotate at low RPM's when below cut-in wind speeds. Turbine make, model, and specifications should be considered with the expectation that curtailment to reduce bat fatalities will be an outcome of the PSB and/or Threatened and Endangered Species permitting processes.

Site Inventory

Once a site is nearing selection, an inventory of both bat habitats and bat activity by species is necessary to inform an assessment of the level of risk from the project. It is highly recommended that the developer work with their consultant and VANR to prepare an approved site inventory plan prior to implementing the inventory work. Failure to adequately conduct acoustic surveys may delay the project for more than a year.

Bat Habitats: An inventory and mapping of the following habitat types are appropriate for each project.

- Concentrations of water sources, including beaver ponds, vernal pools, open-water wetlands, streams, and riverine systems. Bats require access to sources of drinking water and aquatic systems also provide an important source of forage (i.e., aquatic insects).
- Small-footed bat habitat of ledges, cliff-faces, and talus slopes that receive adequate solar radiation. Cliffs generally require an aspect between 90 and 270 degrees.

Bat Activity: Acoustic monitoring surveys should be conducted for a minimum of one full season (April 15 – September 30) in a manner to sufficiently sample bat use of an area. Projects of fewer than 5 turbines in size are generally only required to conduct one season of acoustic monitoring from the period June 1 – September 30. The survey design should be able to target both migrating bats and resident threatened and endangered bats. The purpose of the surveys is to determine bat activity levels of all species, including selected state or federally endangered species, throughout the turbine string. A bat survey plan should be prepared by the applicant for review by VANR and include, at a minimum:

- Number of acoustic detectors: The number of acoustic detectors needed should be guided by the number of turbines, the spatial extent of the turbine strings, the existence of concentrations of bat habitats, and the need to capture activity of both migratory tree bats and residential cave bats, most of which are state listed. This typically requires that detectors be placed at both high and low locations on trees, poles, temporary towers, or meteorological towers.
- Detector efficiency: Detectors must be actively recording at least 75% of the possible detector nights for the survey period (April 15-September 30). Failure to do so will likely require an additional year of acoustic surveys.
- Call analysis: Call analysis must be conducted using no fewer than two USFWS approved call analysis software programs. High frequency calls must be individually-vetted for species identification/confirmation. Other calls may be combined into guilds, if desired. Bat activity rates for the survey period must be calculated.
- Reporting: It is strongly recommended that the results of the acoustic monitoring surveys be made available to VANR prior to the developer submitting its petition to the PSB. By doing so, VANR and the developer may be able to identify improvements in project design or operation that will minimize adverse impacts on a range of bat species, prior to submitting formal testimony. The report should include:
    - The consultant's expertise and experience in conducting acoustic surveys at wind energy facilities
    - The number, height, orientation, and location of acoustic detectors and microphones

- The make and model of detectors and their deployment settings
- The methods for call and bat activity analysis, including the software programs employed and vetting procedures
- The qualifications of the personnel conducting the vetting of calls

Developers should be aware that sites having bat activity levels for all species that are above average for Vermont or bat activity levels of state threatened or endangered bats will likely require further consideration of site selection, the number of turbines, and additional minimization measures to reduce bat fatalities to acceptable levels.

Project Construction

If the results of the acoustic monitoring indicate the probable presence of threatened or endangered tree-roosting bats, then any cutting of trees or land-clearing activities will need to be conducted when bats are migrating (September-October) or hibernating (November 1-April 15).

Project Operations

The elimination of bat fatalities altogether would require complete shut-down of turbine blades during the entire time when bats are active in Vermont – typically April 15 through October 31. Developers of several existing Vermont facilities have demonstrated that such a restriction is not practicable. Instead, the curtailment of rotors during low-wind periods has been proven to reduce bat fatalities between 50% and 90% (Arnett et al 2013). Research conducted at the First Wind's Sheffield, Vermont facility during 2013 and 2014 demonstrated that the appointed curtailment regime (i.e., 6.0 m/sec cut-in speed) reduced bat fatalities by an estimated 60%.

Until such time that other strategies or technologies (e.g., acoustic deterrents) have demonstrated comparable efficacy in reducing or eliminating bat fatalities, VANR will continue to seek curtailment requirements during the proceedings for both the PSB's Certificate of Public Good and the Secretary's Vermont Threatened and Endangered Species Takings Permit.

While the cost of bat curtailment has been difficult to determine due to proprietary interests and varying energy contracts, data from select Vermont wind energy facilities supports claims at the national level that the loss of energy production approximates 1% of the annual production at a given facility. Consequently, VANR believes that the cost of bat curtailment is a practicable constraint for in-state wind facilities.

Research focusing on the effects of ambient air temperature on bat activity and bat fatalities is mixed. While several acoustic studies show a steep decline in bat activity when temperatures fall below 50 degrees Fahrenheit, research conducted at First Wind's Sheffield, Vermont facility showed no relationship between bat fatalities and air temperatures (Martin et al 2015). More recently, analyses conducted in the mid-Atlantic region over several years suggest a relationship between wind speed and air temperature that influences bat activity levels (Peterson, unpublished). Despite the uncertainty, ambient air temperature thresholds may allow Vermont wind energy facilities to avoid curtailment on the cooler autumn evenings. VANR will continue

to allow a 50 degrees Fahrenheit threshold below which operating wind energy facilities need not curtail turbines.

Over the past four operating years at Vermont's three, utility-scale operating wind energy facilities, 14% of all bat fatalities observed were found during the month of June, none of which were state endangered species. In these 4 years of operations, 95% of all observed bat fatalities have been found during the period June 1 through September 30 (Table 3). As a result, VANR will seek a curtailment period of June 1 through September 30 for all wind energy facilities of 5 turbines or more in size.

Table 3. The number and percentage of bat fatalities observed by month at Vermont's wind facilities during 2012, 2013, and 2014. The data represent number observed and not estimated mortality by month, which would be higher.

Facility (Year)	April	May	June	July	August	September	October
VT Wind (2012)	0	0	2	22	41	18	4
VT Wind (2013)	0	1	5	2	2	7	2
Georgia Mtn (2013)	0	1	4	2	5	3	0
Georgia Mtn (2014)	0	0	2	0	1	0	0
KCW (2013)	0	0	4	4	3	5	0
KCW (2014)	0	0	6	3	4	7	1
TOTAL	**0**	**2**	**23**	**33**	**56**	**40**	**7**
% of All Fatalities	**0%**	**1%**	**14%**	**20%**	**35%**	**25%**	**4%**

It should be noted that wind energy projects proximate to bat hibernacula may require more significant curtailment conditions that may include curtailment during the spring months and October.

Should new information or technology demonstrate that changes to the operational adjustments can be made that maintain the reduced level of take, both parties may agree to revisit the issue.

Following post-construction monitoring, VANR may consider changes to the mitigation measures of project operations (e.g., curtailment cut-in speed, curtailment period). Implementation of reduced mitigation measures will only be considered if two years of project monitoring (see below) demonstrate fatality estimates well below bat fatality thresholds and two additional years of project monitoring is then conducted to assess the impacts of the changes. To the contrary, VANR may seek increases in mitigation measures should bat fatality rates greatly exceed bat fatality thresholds.

Projects of 5 or More Turbines: For projects with 5 or more turbines, curtailment will be recommended for the life of the project for the period June 1 – September 30 under the following environmental conditions:

- Rotor cut-in wind speeds of 6.0 m/sec based on no less than 10 minute averages; and
- Temperatures $\geq$ 50 degrees F

When wind speeds are below 6.0 m/sec, the turbine blades are to be feathered so that their RPMs are at or below 1 RPM prior to entering the cut-in speed.

Projects Fewer Than 5 Turbines: VANR recommends initial lesser curtailment requirements for cut-in speeds for projects having fewer than five (5) turbines. In order to reduce the number of collisions with migratory bats and the take of state-endangered little brown bats, projects with fewer than 5 turbines will require curtailment for the period June 1 – September 30 under the following environmental conditions:

- Rotor cut-in wind speeds of 5.0 m/sec based on no less than 10 minute averages; and
- Temperatures $\geq$ 50 degrees F

When wind speeds are below 5.0 m/sec, the turbine blades are to be feathered so that their RPMs are at or below 1 RPM prior to entering the cut-in speed of 5.0 m/sec.

Project Monitoring

Bat fatality monitoring studies are often the most expensive and labor intensive monitoring work required of wind energy facilities. For this reason, it is important that the studies have specific objectives and be meaningful to our understanding of the facility's impacts on bats and any adaptive measures that may be warranted. VANR seeks bat fatality monitoring for the following objectives:

- To estimate bat fatality rates for the facility.
- To determine if bat fatality rates exceed bat fatality thresholds.
- To determine if state or federally threatened or endangered species are killed at the facility.

Bat fatality monitoring must be conducted in a scientifically rigorous manner to yield sufficient estimates of mortality that can be compared with other facilities across the state and region and with established bat fatality thresholds. This is particularly challenging when attempting to detect and estimate fatality rates of rare/endangered species (Huso 2010).

A bat fatality monitoring plan should be prepared by the applicant for review and approval by VANR and should include, at a minimum, a detailed description of the following:

Number of Years of Monitoring: The number of years for which fatality monitoring is required is an issue that continues to be examined and may vary by site. In Vermont, permitted, operating

facilities have been required to conduct fatality studies over the first two years following the onset of operations. In each case, bat fatality rates differed greatly between the two years with the second year experiencing a lower estimate of bat fatalities. The number of wind energy facilities that have conducted more than two years of monitoring is extremely limited, leaving much uncertainty in predicting long-term impacts. Until such time that there is a scientific consensus on the number of years of monitoring needed to establish sound, long-term estimates of fatality, VANR recommends that wind energy facilities with fewer than five turbines conduct two years of bat fatality monitoring. Facilities with five or more turbines may be required to conduct a third year of fatality monitoring if any of the first two years exceed bat fatality thresholds or survey methodology differs significantly between years. Consideration may be given to a third year of monitoring, applying a less intensive, yet still systematic, survey to estimate bat fatalities.

Monitoring Period: VANR requires a minimum of bat fatality monitoring during the period June 1 through September 30. This may be amended based on bat activity patterns from the pre-construction acoustic survey results or if the site is proximate to bat hibernacula. If the latter, monitoring may be required during the spring emergence and fall swarming periods as well.

Number of Turbines Searched: All of the turbines should be searched within the search interval period.

Fatality Monitoring Methodology: Bat fatality monitoring should occur from June 1 through September 30 to estimate overall bat fatality rates and gather *insights* into the take levels for state-endangered species. Unless the project developer wishes to evaluate other environmental conditions for operational adjustments (e.g., precipitation, barometric pressure) or establish valid estimates of the take of threatened or endangered bats, bat fatality estimates can be adequately achieved through 3-day search intervals (versus daily) unless scavenger removal rates are determined to be higher than expected. The common elements of a standard fatality monitoring methodology are:

- Search interval of three days unless the developer can adequately demonstrate that the search interval will not meet or exceed the carcass persistence period for the site.
- Maximum search area of 120-m by 120-m plot centered on turbine with transects 6m apart.
- Searcher speed of 10-20 meters per minute.
- Vegetation mapping into 4 classes:
    - Class 1 (easy): Bare ground 90% or greater; all ground cover sparse and 6 inches or less in height (i.e., gravel pad or dirt road).
    - Class 2 (moderate): Bare ground 25% or greater; all ground cover 6 inches or less in height and mostly sparse.
    - Class 3 (difficult): Bare ground 25% or less; 25% or less of ground cover over 12 inches in height.
    - Class 4 (very difficult): Little or no bare ground; more than 25% of ground cover over 12 inches in height.
- Searcher efficiency trials conducted at least once per month using a target of 50 carcasses (preferably all bats).

- Carcass persistence trials conducted at least once per month, independent of searcher efficiency trials, using a target of 50 carcasses (preferably bats).
- A response plan for injured bats.
- Documentation of observed fatalities.
- Data analysis and fatality estimation, including the specific estimators to be applied.

Incidental Fatality Monitoring: During years without bat fatality monitoring studies, wind energy facilities must conduct incidental (i.e., in the course of normal facility operations) monitoring for bat fatalities. Facility staff are expected to note bat fatalities found on the premises, photograph the animal, record data on the incident, collect the animal, and report the finding within 72 hours to VANR for species identification.

Vermont Threatened and Endangered Species Takings Permit

WNS and its impacts on populations of several species of bats has greatly reduced the take of cave bats in the Northeast, many of which are now state or federally threatened and endangered. Yet, residual populations of little brown bats in Vermont and New York may be large enough to remain very vulnerable to collisions with wind turbines. Following appropriate site selection and design, operational adjustments are the most appropriate means of reducing that take. Operational adjustments; however, will not preclude all take of this species, or others for that matter.

As a result, the Secretary of VANR requires all operating wind energy facilities to apply for and receive a Vermont Threatened and Endangered Species Takings Permit prior to operation during the period when bats are active. Initial permits are typically for the duration of the bat fatality monitoring period, followed by a five-year permit renewal based on the monitoring results.

Conditions under such permits generally reiterate mitigation requirements spelled out in the CPG or other conditions necessary to reduce the likelihood of take of state listed bats. In addition, wind energy facilities are required to conduct incidental monitoring (see above) for the take of threatened and endangered bats. Finally, facilities are encouraged to consider collectively funding a little brown bat maternity colony technical assistance project to compensate for this take. Funds collected through this collaborative program are applied to activities and technical assistance to maintain colonies of state endangered bats. Fund contributions are evenly distributed among the operating facilities on a per turbine basis.

Reporting

VANR seeks annual reporting of the results of bat fatality monitoring studies and incidental fatality occurrences. These reports are typically due the following January. In addition, VANR requests sufficient evidence from the facility's Supervisory Control and Data Acquisitions (SCADA) data to demonstrate that the turbines were programmed as specified by the PSB or the Vermont Threatened and Endangered Species Takings Permit. SCADA data on time, wind speed, temperature, and RPM on each turbine from one select week of each month of curtailment (June-September) is to be provided by the facility. The specific week of each month to be reported shall be provided by VANR by November 30 of each year.

Literature Cited

Arnett, E.B., G. Johnson, W. Erickson, and C. Hein.2013. A synthesis of operational mitigation studies to reduce bat fatalities at wind energy facilities in North America. A report submitted to the national Renewable Energy laboratory. Bat Conservation International. Austin, TX, USA.

Baerwald, E. and R. Barclay. 2011. Patterns of activity and fatality of migratory bats at a wind energy facility in Alberta, Canada. J. Wildlife Management: 75(5):1103-1114.

Barclay, R.M., E. Baerwald, and J. Gruver. 2007. Variation in bat and bird fatalities at wind energy facilities: assessing the effects of rotor size and turbine height. Can J. Zool. 85:381-387.

Buler, Jeffrey, K. Horton, and G. Shriver. 2012. Post-construction avian and bat impact assessment of the University of Delaware wind turbine in Lewes, DE. 16pp.

Darling, S. and R. Smith. 2011. Assessment of Vermont cave bat populations and proposal to list bat species. Vermont Fish and Wildlife Department. 15pp.

Hayes, Mark A. 2013. Bats killed in large numbers at United States wind energy facilities. Bioscience. 93:975-979.

Hein, C. and M. Schirmacher. 2016. Impact of wind energy on bats: a summary of our current knowledge. Human-Wildlife Interactions 10(1):19-27.

Huso, M. 2010. An estimator of wildlife fatality from observed carcasses. Environmetrics 22:318-329.

Martin, C., E. Arnett, and M. Wallace. 2015. Evaluating Bat and Bird Post-Construction Impacts at the Sheffield Wind Facility, Vermont. Final report. Texas Tech Univ. 116pp.

Approved.

Louis Porter, Commissioner
Vermont Fish and Wildlife Department

Oct 5 '16
Date