Reanalysis of Galloo Island 2008 Avian Radar Data

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Executive Summary

Galloo Island Wind, LLC is developing a wind energy facility on Galloo Island in Hounsfield, New York. Through the course of regulatory review, the New York State Department of Environmental Conservation (NYSDEC) has requested that avian radar data, collected on Galloo Island, be analyzed using a methodology developed by the US Fish and Wildlife Service (USFWS). This methodology is described in a 2016 report entitled *Great Lakes Avian Radar Technical Report Niagara, Genesee, Wayne and Jefferson Counties, New York* (Rathbun et al. 2016). The USFWS approach utilizes vertical radar data to measure avian passage rates while a more typical approach, historically, has been to utilize horizontal radar data for the calculation of avian passage rate. Horizontal radar is limited in the flight height that it can observe. Vertical radar can observe to greater height but lacks the ability to establish target flight speed, an important metric in distinguishing insects from birds or bats. This report describes the USFWS methodology, presents the results of the Galloo data analyzed using this approach and discusses the challenges and relevance of radar data in the context of the current body of evidence correlating pre-construction avian analysis work with post-construction avian risk.

The original Galloo Island avian radar horizontal data set, screened for insects, indicated a mean passage rate of 624 targets/km/hr observing targets up to 245 m above ground level (Stantec 2008). The Galloo Island vertical data set (no ability to screen for insects), when reanalyzed using the USFWS methodology (up to 1,400 m above the ground) indicated a mean passage rate of 1,660 targets/km/hr. Passage rate from both data sets were in relative agreement up to the limiting altitude of the horizontal radar data (i.e., when only the vertical data up to a height of 245 m are used).

The USFWS report recognizes the potential of mistaking insects for avian targets. That report analyzed data obtained with S-band radar which has a wavelength long enough to avoid insect detection but also may underreport smaller passerines, particularly at greater distances. The Galloo Island data set was obtained with X band radar. X-band has a shorter wavelength and finer resolution that detects insects. With X-band horizontal data, flight speed can be measured and this provides an effective means of differentiating insects from birds and bats. With X-band vertical data flight speed cannot be determined and so there is no effective means of screening insects from avian data collected with X-band vertical radar. There are other important differences between how USFWS data was obtained and how the Galloo Island data was obtained which make direct comparisons of results scientifically invalid.

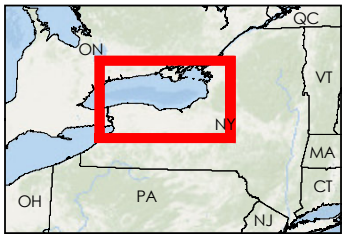
Pre-construction avian radar study has been common practice at wind farm sites for many years. Over time an abundance of pre-construction radar study has been collected. Similarly, numerous post-construction avian mortality studies have been conducted over time. Two observations emerge from this body of data: 1) pre-construction passage rates are uncorrelated with post-construction mortality rates suggesting that pre-construction radar is not a useful predictor of risk, and 2) overall post-construction mortality rates have been low regardless of pre-construction passage rates.

1.0 INTRODUCTION

Radar surveys targeting nocturnal migration were conducted on Galloo Island in Hounsfield, New York in 2008 by Stantec Consulting Services Inc. (Stantec). During permitting stages of the Galloo Island Wind Project in 2017, the New York State Department of Environmental Conservation (NYSDEC) requested that the radar survey data collected on Galloo Island in 2008 be reanalyzed using the same analysis methods used in a USFWS 2013 radar survey. The reanalysis was completed and is reported herein, however, important differences in radar technology and the sampling methods between the two studies make comparisons of the results between the Stantec and USFWS efforts inappropriate.

Stantec used an X-band radar unit at 1 site centrally located on Galloo Island during the spring 2008 nocturnal radar migration surveys. This radar unit operated in horizontal and vertical mode with a range of up to 1,400 meters (m). The wavelength of the radar was 3 centimeters (cm), enabling detection of small birds and bats, as well as insects. Radar images were converted to video samples and manually analyzed using a digital analysis software tool developed by Stantec. Stantec used horizontal data to calculate passage rate because it enables the determination of target flight speed, allowing bird or bat targets to be differentiated from slower flying insects. Stantec used vertical radar data to calculate the average flight height of targets only. The vertical limit for the horizontal data set (i.e., the altitude when the upper edge of the radar beam passes the range limit of 1.4 km on the radar screen) was 245 m. Consequently, the passage rate from the horizontal data collected in 2008 represents nighttime activity within 245 m of the ground. For full 2008 survey and analysis methods, refer to the *Spring 2008 Radar Survey Report for the Hounsfield Wind Project on Galloo Island, New York* (Stantec 2008).

In 2013, the USFWS collected radar data of bird migration using MERLIN S-band radar systems at 3 sites along the shoreline of Lake Ontario and 1 site approximately 35 kilometers (km) inland from the shore (Figure 1). These radar units operated in horizontal mode with a range of up to 3,700 m and in vertical mode with a range of up to 2,800 m. The wavelength of the radar was 10 cm enabling detection of birds but not insects. The USFWS used vertical data to calculate passage rate. Targets that were captured within the "standard front", defined as the volume of space that extended horizontally 500 m to either side of the radar and vertically up to the maximum height of data collected in vertical mode (2,800 m; Rathbun et al. 2016), were used to calculate target passage rates. USFWS used horizontal data primarily to provide information on target direction. For full 2013 survey and analysis methods, refer to the USFWS *Great Lakes Avian Radar Technical Report, Niagara, Genesee, Wayne and Jefferson Counties, New York* (Rathbun et al. 2016).



Legend

- Stantec 2008 Radar Location
- U.S. Fish and Wildlife Service 2013 Radar Location

0 20 Miles

1 inch = 20 miles (At original document size of 8.5x11)

Notes

1. Coordinate System: NAD 1983 UTM Zone 18N
2. Base map: ESRI World Topographic Map
3. U.S. Fish and Wildlife Radar Location coordinates taken from the Great Lakes Avian Radar Technical Report, Niagara, Genesee, Wayne and Jefferson Counties, New York, Spring 2013 Season. https://www.fws.gov/radar/documents/Avian%20Radar%20Sp2013%20Ontario%20Full.pdf

Stantec

Project Location
Lake Ontario, New York

195601224
Prepared by GC on 2017-05-05
Reviewed by BR on 2017-05-05

Client/Project
Galloo Island Wind Project

Figure No.
1

Title
2008 and 2013 Radar Survey Locations

2.0 METHODS

2.1 PASSAGE RATE

Stantec recalculated passage rates derived from the 2008 data in a manner as similar to the 2013 USFWS analysis as possible, using vertical data only to calculate passage rate. Using data files created during the original analysis of vertical radar video images, Stantec removed all targets that were detected and identified as greater than 500 m horizontally from the radar unit such that only those targets that were detected within the standard 1-km front used by Rathbun et al. (2016) were included. Nightly mean passage rates were calculated as targets per km per hour (targets/km/hr). The seasonal mean passage rate was calculated by averaging each hourly passage rate within survey nights.

2.2 TARGET DENSITY

Target density (number of targets per 50-m altitude band) was estimated using the same methods as the 2013 USFWS study. Two density estimates were made:

- Unadjusted density – representing target density per altitude band per hour, assuming that all 50-m altitude bands are of the same volume, and
- Adjusted density – representing target density per altitude band per hour but corrected for the change in air volume sampled within each 50-m altitude band (higher bands sampled more volume of the air).

For the unadjusted density estimate the number of targets per hour within each 50-m altitude band was divided by the number of 1-minute samples per hour and multiplied by 60 (i.e., [number of targets/number of 1-minute samples]*60) to calculate the hourly number of targets per 50-m altitude band. This passage rate was then converted to a density estimate (targets/1,000,000 m^3) by multiplying it by that standard volume of 1,000,000 m^3 and then dividing by an average volume if all altitude bands were the same size (total radar sampling volume divided by the number of 50-m altitude bands).

For the adjusted density estimate the hourly number of targets per altitude band were multiplied by that same standard volume of 1,000,000 m^3 but then divided by the true volume of each 50-m altitude band. The volume of each 50-m altitude band was calculated using the same method as the 2013 USFWS work but accounting for physical differences between the two radar systems (range setting and beam width differences).

The 2008 Galloo Island seasonal mean and median flight height and percent below turbine height were also calculated using the vertical data and the 1-km standard front. These were calculated using the same methodology as used in the 2013 USFWS analyses of mean flight altitude.

3.0 RESULTS

3.1 PASSAGE RATE

The seasonal mean passage rate at Galloo Island for 2008 following the USFWS methodology was 1,660 ± 1,248 t/km/hr (Table 1 and Appendix A Table 1). Among the 4 USFWS sites, the seasonal mean passage rates in spring 2013 as reported by Rathbun et al. (2016) ranged from 555 ± 492 t/km/hr to 818 ± 850. These latter estimates do not include insects. Interestingly, the original 2008 analysis of horizontal radar data from Galloo Island derived a seasonal mean passage rate (624 ± 355) within the range of the 4 sites surveyed by Rathbun et al. (2016).

Table 1. Summary of seasonal mean passage rates (targets/km/hr) with standard deviation in spring 2008 based on analysis of radar data.

Study Year and Location	Radar Unit Used	Data Analyzed to Derive Passage Rate	Seasonal Mean Passage Rate (targets/km/hr)	Citation
2008 Galloo Island	X-band	Horizontal	624 ± 355	Stantec 2008
2008 Galloo Island	X-band	Vertical	1,660 ± 1,248	This report
2013 Jefferson County	S-band	Vertical	555 ± 492	Rathbun et al. 2016
2013 USFWS Niagara County	S-band	Vertical	582 ± 663	Rathbun et al. 2016
2013 Wayne County	S-band	Vertical	732 ± 690	Rathbun et al. 2016
2013 Genesee County	S-band	Vertical	818 ± 850	Rathbun et al. 2016

3.2 TARGET DENSITY

The greatest level of migrant activity in the Galloo reanalysis occurred within the 200-m to 250-m altitude band, which had an unadjusted density estimate of 15 targets/1,000,000 m^3/hr and an adjusted density estimate of 31 targets/1,000,000 m^3/hr (Figure 2). For the USFWS study in 2013, the greatest level of nightly activity occurred in the 50-200 m altitude bands for most of the sites surveyed (Rathbun et al. 2016).

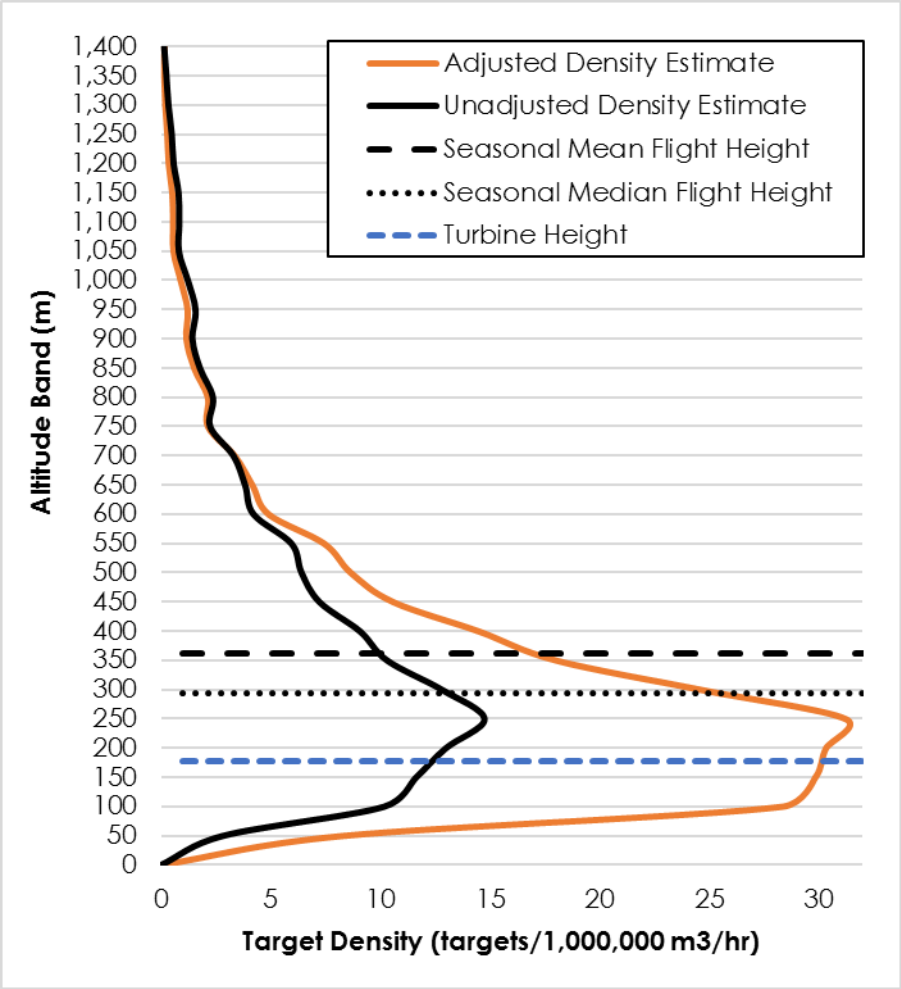


Figure 2. Target density per altitude band on Galloo Island in spring 2008 based on analysis of vertical radar data.

The seasonal mean flight height was 363 m and the percent of targets below the proposed turbine height of 178.5 m was 25%. The band with the highest density estimates and the seasonal mean and median flight heights are above the proposed turbine height of 178.5 m.

4.0 DISCUSSION

4.1 DATA COMPARISON LIMITATIONS

Results herein must be interpreted with caution due to multiple factors, including differences in location, sampling equipment and methods, and sampling timing and frequency. The alternative analysis of the X-band data set from Galloo Island presented in this report should not be expected to improve accuracy of that data set or provide reasonable comparability to the

USFWS data. The 2008 and 2013 radar surveys were conducted at different locations—on Galloo Island and at several shoreline locations around Lake Ontario—at different survey frequency, during different years, and dates. The two survey efforts did not sample nocturnal migrants in the same airspace at or for the same period of time.

The two radar systems used for these surveys are notably different. The X-band radar used in 2008 had a wavelength of 3 cm, which provided a greater sensitivity and finer resolution to detect small targets such as insects. In fact, X-band radar cannot be used reliably for birds and bats during periods of rain because even rain drops are detected and contaminate the radar data. The S-band radar had a wavelength of 10 cm, which allowed the system to see through rain and eliminated insect contamination of the data set, but as a result could underestimate or not detect some smaller avian and bat targets. These represent the primary reasons why passage rates in 2008 were calculated with horizontal radar data (because the slower flying insects can be identified and eliminated from the data set).

Any insects that were detected in vertical mode in the 2008 radar data were included in the recalculation of passage rate at Galloo Island presented here. Insects were not included in analyses of 2013 USFWS radar data due to the S-band wavelength. As a result, the newly calculated passage rate should not be considered evidence of greater levels of migrant activity over Galloo Island than along other locations on the shoreline of Lake Ontario. The only way to reliably define how the differences in technology affects any comparisons of identical data analyses of data from these two radar systems would be to run both systems simultaneously and perform identical analyses.

Interestingly, when truncating the X-band vertical data to just those targets occurring between ground level and 245 m (the limiting elevation of the X-band horizontal radar), the passage rate was 661 ± 434 targets/km/hr, similar to the original Galloo Island passage rate calculated using horizontal data (624 ± 355 targets/km/hr). This suggests that the vertical and horizontal Galloo Island radar data are providing similar information about passage rate; vertical radar is just sampling at a much higher height (well above rotor swept height) and, therefore, providing a greater passage rate. Differences between the results from the new analysis of the 2008 data and the USFWS study, therefore, are likely due more to physical differences between the radar energy used than any other factors (differences in survey locations or years).

4.2 RADAR AND MORTALITY

Figure 3 shows the pre-construction radar seasonal mean passage rates and the post-construction bird mortality rates of 50 operating wind projects in the northeastern US[1]. Comparisons of radar passage rates with bird mortality estimates at the project level show no apparent visual pattern. See Appendix B Table 1 for references of projects displayed in Figure 3.

[1] For those projects with multiple seasons and/or multiple years of radar surveys, seasonal mean passage rates were averaged. For those projects with multiple bird mortality rates within a survey year due to multiple search interval types, bird mortality rates were averaged.

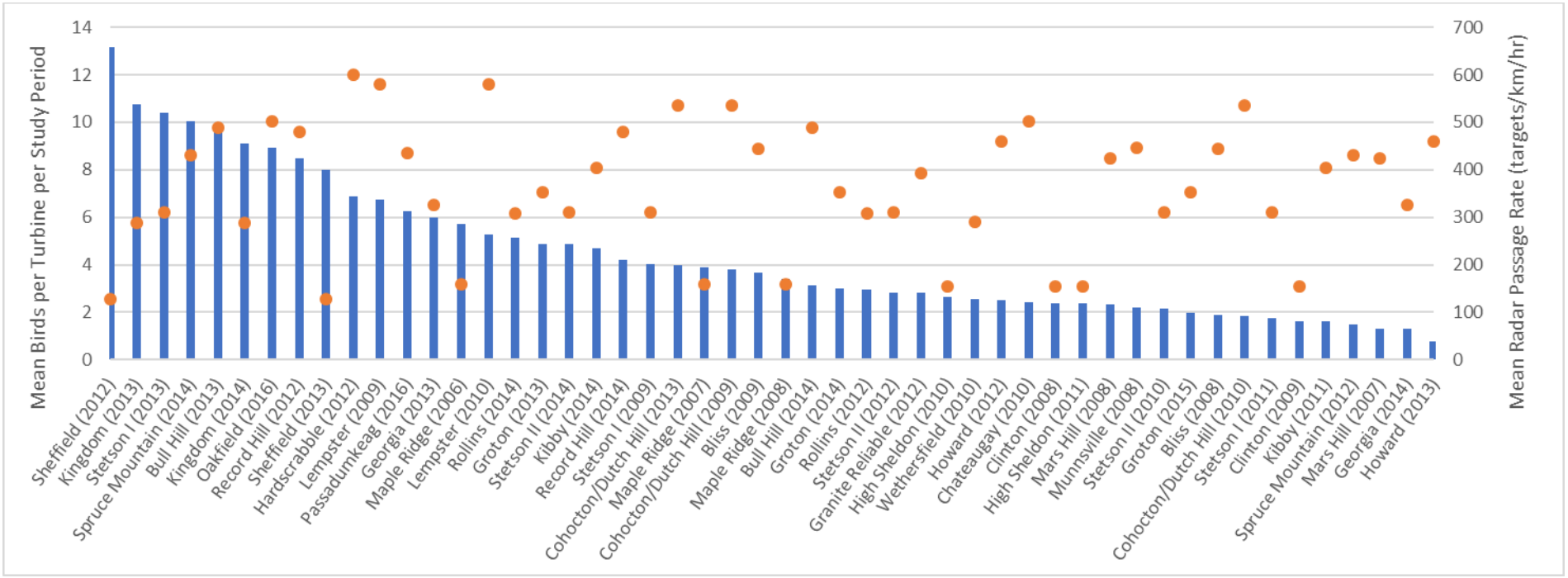


Figure 3. Mean bird mortality rates (blue columns) plotted with radar passage rate (orange dots) for commercial wind projects in the northeastern US.

5.0 CONCLUSION

Reanalysis of the Galloo Island 2008 radar data using the method of Rathbun et al. (2016) yielded a passage rate notably greater than both the original passage rate and the passage rates for nearby sites reported by Rathbun et al. (2016). However, as explained herein, the radar systems used for the two studies were notably different, which likely contributes more significantly to the differences between the results than biological factors (such as the location of the survey sites or differences in true number of night migrants that passed over each of the survey locations).

An interesting result from this reanalysis was the similarity in the passage rates of the original 2008 effort (using horizontal data that only reaches an altitude of 245 m) and the passage rate of the reanalyzed 2008 vertical data when that data is truncated to 245 m, to match the maximum altitude of the horizontal data set. This similarity between two forms of data analysis applied to the same type of radar data (X-band), combined with the notable difference between one form of data analysis applied to two types of radar (X-band vs. S-band), indicates that the physical difference between the two types of radar technology is likely contributing most to differences between the results of Rathbun et al. (2016) and the Galloo Island 2008 reanalysis presented here.

Also of note was the vertical passage rate data from this reanalysis relative to the original passage rate that was limited to 245 m. While both analyses were similar when the vertical data was truncated to 245 m the data set showed migration traffic (i.e., target density) well above that altitude. Approximately 60% of targets were identified above 245 m and well above rotor swept height. Combined, these analyses suggest that Galloo Island does not experience significantly higher passage rates than is typically found at commercial wind projects in the northeastern US but does indicate that there were an abundance of targets flying over Galloo at flight altitudes well above the rotor swept height.

Regardless of the technology used, the use of passage rates derived from nocturnal radar surveys at proposed wind energy projects have not proven to be useful in predicting the level of risk to nocturnal migrants at operational wind energy projects, due to the lack of documented relationship between pre-construction radar data and bird fatality rates. The reanalysis presented in this report provides additional flight height characteristics of night migrants over Galloo Island in the spring of 2008. The magnitude of migration activity documented above 245 m may provide some insight into this lack of a relationship. Notably, available radar data sets may be "characterizing" such a small percentage of the overall population of night migrants over a site that the ability to establish such a relationship may be statistically impossible. Conversely, there may be biological or climatological factors determining fatality of night migrants at wind turbines that are simply not measured by radar.

6.0 REFERENCES

Rathbun, N.A., T.S. Bowden, R.L. Horton, D.C. Nolfi, E.C. Olson, D.J. Larson, and J.C. Gosse. 2016. Great Lakes Avian Radar Technical Report; Niagara, Genesee, Wayne, and Jefferson Counties, New York; Spring 2013. U.S. Department of Interior, Fish and Wildlife Service, Biological Technical Publication FWS/BTP-3012-2016

Stantec (Stantec Consulting Services Inc.). 2008. Spring 2008 Radar Survey Report for the Hounsfield Wind Project on Galloo Island, New York. Prepared for American Consulting Professionals of New York, PLLC.

Appendix A SPRING 2008 PASSAGE RATE REANALYSIS RESULTS

Appendix A Table 1. Summary of passage rates by hour, night and for season based on data collected in vertical mode, spring 2008, Galloo Island, New York.

Night of	Passage Rate (targets/km/hr) by hour after sunset											Entire Night			
	1	2	3	4	5	6	7	8	9	10	11	Mean	Median	Stdev	SE
4/15	270	280	780	1,600	1,950	2,250	2,190	2,715	2,550	1,830	1,770	1,653	1,830	853	257
4/16	996	1,463	3,564	5,060	5,610	4,680	4,423	2,560	3,220	--	--	3,508	3,564	1,601	534
4/17	1,030	588	1,260	1,300	1,080	--	1,320	1,080	1,470	1,080	--	1,134	1,080	252	84
4/18	780	405	560	900	930	1,220	1,200	1,425	1,311	1,223	--	995	1,065	338	107
4/19	1,020	1,838	2,424	3,240	3,972	3,930	2,970	2,860	2,460	1,860	1,680	2,569	2,460	937	282
4/20	60	1,176	1,500	1,733	1,980	1,980	1,760	747	630	560	--	1,213	1,338	678	215
4/21	900	1,230	2,400	2,280	2,970	3,210	2,472	1,620	1,140	1,320	--	1,954	1,950	816	258
4/22	1,680	1,128	2,100	2,865	2,592	2,640	3,405	3,225	2,860	2,410	2,040	2,450	2,592	674	203
4/23	740	1,820	2,400	4,890	4,425	2,988	1,860	1,668	1,180	590	--	2,256	1,840	1,458	461
4/25	--	2,100	2,660	2,860	2,570	3,045	3,503	3,705	2,990	--	--	2,929	2,925	513	181
4/26	--	--	1,260	1,596	2,100	1,826	1,630	1,300	626	360	--	1,337	1,448	591	209
4/27	1,920	1,260	1,397	2,250	2,220	2,175	1,240	880	720	540	N/A	1,460	1,329	645	204
4/28	210	120	90	180	90	135	90	108	204	315	N/A	154	128	73	23
4/29	210	300	189	255	285	90	140	180	170	180	N/A	200	184	65	21
4/30	220	320	180	360	533	420	264	360	660	540	N/A	386	360	153	49
5/2	810	1,200	2,580	3,384	3,128	3,390	--	2,560	2,532	2,235	N/A	2,424	2,560	904	301
5/4	670	1,330	1,170	2,110	1,125	960	1,050	930	1,080	900	N/A	1,133	1,065	386	122
5/5	1,848	1,392	2,256	3,804	2,655	2,500	2,445	2,016	1,560	1,695	N/A	2,217	2,136	700	221
5/6	887	920	1,005	1,733	1,560	1,120	--	--	--	--	N/A	1,204	1,063	356	145
5/7	--	--	--	--	--	5,580	5,127	4,364	3,720	1,395	N/A	4,037	4,364	1,640	733
5/8	1,860	1,327	860	756	883	609	660	--	--	--	N/A	993	860	449	170
5/9	240	1,187	1,404	1,480	1,526	1,248	975	1,368	1,180	--	N/A	1,179	1,248	391	130
5/10	1,800	1,470	1,584	3,444	3,980	3,330	3,069	1,716	1,320	1,980	N/A	2,369	1,890	977	309
5/11	1,240	4,290	8,000	7,068	5,980	4,665	3,560	2,496	1,240	760	N/A	3,930	3,925	2,539	803
5/12	1,183	2,268	3,500	4,236	4,500	3,430	3,540	3,168	1,635	960	N/A	2,842	3,299	1,254	396
5/13	1,800	1,440	1,548	1,470	2,100	2,340	2,655	1,890	2,535	2,040	N/A	1,982	1,965	433	137
5/15	4,360	1,920	2,186	1,560	1,320	1,280	1,305	1,245	1,170	240	N/A	1,659	1,313	1,078	341
5/16	1,275	1,320	1,185	1,760	3,120	4,478	3,525	2,477	--	--	N/A	2,392	2,119	1,220	431
5/17	2,172	1,365	2,240	2,250	2,220	2,040	1,950	2,540	2,460	2,280	N/A	2,152	2,230	326	103
5/18	760	420	564	480	137	1,290	150	--	--	--	N/A	543	480	397	150
5/19	80	120	100	377	740	930	788	1,140	1,044	--	N/A	591	740	426	142
5/20	264	1,234	1,380	1,380	1,940	2,112	2,160	975	1,164	--	N/A	1,401	1,380	605	202
5/22	1,000	1,310	1,090	1,200	1,335	917	1,050	1,080	1,030	--	N/A	1,112	1,080	141	47
5/23	670	1,380	1,689	2,265	1,335	855	940	672	800	N/A	N/A	1,178	940	539	180
5/24	1,728	3,420	3,740	4,269	3,996	3,220	3,450	--	1,908	N/A	N/A	3,216	3,435	927	328
5/26	3,624	1,845	3,270	--	2,670	2,400	1,830	1,110	1,152	N/A	N/A	2,238	2,123	924	327
5/27	590	705	280	195	150	120	240	120	60	N/A	N/A	273	195	224	75
5/28	255	150	540	564	800	768	400	300	264	N/A	N/A	449	400	232	77
5/29	948	1,440	1,687	1,491	1,340	1,392	1,650	1,140	672	N/A	N/A	1,307	1,392	332	111
5/31	2,405	2,160	2,520	2,213	1,800	--	--	--	--	N/A	N/A	2,220	2,213	276	123
6/1	560	480	780	760	960	516	480	588	375	N/A	N/A	611	560	185	62
6/2	609	458	975	820	780	730	580	420	300	N/A	N/A	630	609	216	72
Mean Entire Season	**1,120**	**1,264**	**1,729**	**2,061**	**2,083**	**2,070**	**1,847**	**1,588**	**1,389**	**1,187**	**1,830**	**1,660**	**1,335**	**1,248**	**64**
Median Entire Season	**900**	**1,285**	**1,404**	**1,666**	**1,940**	**2,010**	**1,650**	**1,300**	**1,170**	**1,080**	**1,770**				

-- indicates no data for that hour N/A indicates that sunrise did not extend to those hours on those dates

Appendix B WIND ENERGY PROJECT REFERENCES – RADAR PASSAGE RATE AND BIRD MORTALITY

Appendix B Table 1. References for bird mortality estimates and radar passage rates at wind energy projects in the northeastern US.

State	Project	Bird Mortality Reference	Radar Passage Rate Reference
ME	Bull Hill	Stantec Consulting Services Inc. 2014. Bull Hill Year 1 Post-Construction Wildlife Monitoring Report, 2013. Prepared for First Wind, LLC.	Stantec Consulting Services Inc. 2010. Spring 2010 Avian and Bat Survey Report for the Bull Hill Wind Project. Prepared for Blue Sky East Wind LLC.
			Stantec Consulting Services Inc. 2011. Spring 2011 Radar Survey Results and Comparison to Spring 2010 Results: Memo for the Bull Hill Wind Project. Prepared for First Wind.
		Stantec Consulting Services Inc. 2015. Bull Hill Wind Project Year 2 Post-Construction Wildlife Monitoring Report, 2014. Prepared for First Wind, LLC.	Stantec Consulting Services Inc. 2010. Summer and Fall 2009 Avian and Bat Survey Report for the Bull Hill Project. Prepared for Blue Sky East Wind, LLC.
			Stantec Consulting Services Inc. 2011. Fall 2011 Radar Survey Results and Comparison to Fall 2009 Radar Results: Memo for the Bull Hill Wind Project. Prepared for Blue Sky East Wind, LLC.
	Kibby	Stantec Consulting Services Inc. 2011. 2011 Post-Construction Monitoring Report Kibby Wind Power Project, Franklin County, Maine. Prepared for TransCanada Hydro Northeast, Inc.	Woodlot Alternatives, Inc. 2006. A Spring 2006 Survey of Bird and Bat Migration at the Proposed Kibby Wind Power Project in Kibby and Skinner Townships, Maine. Prepared for TransCanada Maine.
		TRC. 2015. Post-Construction Avian and Bat Mortality Survey Report for the Kibby Wind Power Project. Prepared for TransCanada Energy Ltd.	Woodlot Alternatives, Inc. 2006. A Fall 2005 Survey of Bird and Bat Migration at the Proposed Kibby Wind Power Project in Kibby and Skinner Townships, Maine. Prepared for TransCanada Maine.
	Mars Hill	Stantec Consulting Services Inc. 2008. Spring, Summer, and Fall Post-construction Bird and Bat Mortality Study at the Mars Hill Wind Farm, Maine. Unpublished report prepared for UPC Wind Management, LLC.	Woodlot Alternatives, Inc. 2006. A Spring 2006 Radar, Visual, and Acoustic Survey of Bird Migration at the Mars Hill Wind Farm in Mars Hill, Maine. Prepared for Evergreen Windpower, LLC.
		Stantec Consulting Services Inc. 2009. Post-construction Monitoring at the Mars Hill Wind Farm, Maine – Year 2. Unpublished report prepared for First Wind Management, LLC.	Woodlot Alternatives, Inc. 2006. A Fall 2005 Radar, Visual, and Acoustic Survey of Bird Migration at the Mars Hill Wind Farm in Mars Hill, Maine. Prepared for Evergreen Windpower, LLC.
	Oakfield	Stantec Consulting Services Inc. 2016. Year 1 Post Construction Bird and Bat Fatality Monitoring Report.	Woodlot Alternatives, Inc. 2008. A Fall 2008 Survey of Bird and Bat Migration at the Oakfield Wind Project, Washington County, Maine. Prepared for Evergreen Wind, LLC.
	Passadumkeag	West. 2017. Post-Construction Monitoring Study for the Passadumkeag Wind Project Penobscot County, Maine April – October 2016 Final Report Draft. Prepared for Southern Power Company.	Stantec Consulting Services Inc. 2011. Spring and Summer 2011 Avian and Bat Survey Report for the Passadumkeag Wind Project in Grand Falls Township, Maine. Prepared for Passadumkeag Windpark LLC.
			Stantec Consulting Services. 2011. Summer and Fall 2011 Avian and Bat Survey Report for the Passadumkeag Wind Project in Grand Falls Township, Maine. Prepared for Passadumkeag Windpark LLC.
	Record Hill	Stantec Consulting Services Inc. 2012. Record Hill Wind Project Post-Construction Monitoring Report, 2012. Prepared for Record Hill Wind, LLC.	Woodlot Alternatives, Inc. 2007. A Fall 2007 Survey of Bird and Bat Migration at the Record Hill Wind Project, Roxbury, Maine. Prepared for Roxbury Hill Wind LLC.
		Stantec Consulting Services Inc. 2015. Record Hill Wind Project Year 2 Post-Construction Wildlife Monitoring Report. Prepared for Record Hill Wind, LLC.	Woodlot Alternatives, Inc. 2007. A Spring 2007 Survey of Bird and Bat Migration at the Record Hill Wind Project, Roxbury, Maine. Prepared for Roxbury Hill Wind LLC.
	Rollins	Stantec Consulting Services Inc. 2012. Rollins Wind Project Post-Construction Monitoring Report, 2012. Prepared for First Wind, LLC.	Stantec Consulting Services Inc. 2008. Spring 2008 Bird and Bat Migration Survey Report: Visual, Radar and Acoustic Bat Surveys for the Rollins Wind Project. Prepared for First Wind, LLC.

State	Project	Bird Mortality Reference	Radar Passage Rate Reference
		Stantec Consulting Services Inc. 2015. Rollins Wind Project Year 2 Post-Construction Wildlife Monitoring Report, 2014. Prepared for First Wind, LLC.	Woodlot Alternatives, Inc. 2008. A Fall 2007 Survey of Bird and Bat Migration at the Rollins Wind Project, Washington County, Maine. Prepared for Evergreen Wind, LLC.
	Spruce Mountain	TetraTech. 2013. Spruce Mountain Wind Project Post-construction Bird and Bat Fatality and Raptor Monitoring Year 1 Annual Report. Prepared for Patriot Renewables.	TetraTech. 2009. Spring 2009 – Bird and Bat Biological Survey Report. Prepared for Patriot Renewables.
		TetraTech. 2015. Spruce Mountain Wind Project Post-construction Bird and Bat Fatality and Raptor Monitoring 2014. Prepared for Patriot Renewables.	
	Stetson I	Stantec Consulting Services Inc. 2010. Stetson I Mountain Wind Project, Year 1 Post-Construction Monitoring Report, 2009. Prepared for First Wind Management, LLC.	Woodlot Alternatives, Inc. 2007. A Spring 2007 Survey of Bird and Bat Migration at the Stetson Wind Project, Washington County, Maine. Prepared for Evergreen Wind V, LLC.
		Normandeau Associates. 2010. Year 3 Post-construction avian and bat casualty monitoring at the Stetson I Wind Farm. Prepared for First Wind, LLC.	Woodlot Alternatives, Inc. 2007. A Fall 2006 Survey of Bird and Bat Migration at the Stetson Wind Project, Washington County, Maine. Prepared for Evergreen Wind V, LLC.
		Stantec Consulting Services Inc. 2014. Stetson I Wind Project 2013 Post-Construction Wildlife Monitoring Report, Year 5. Prepared for First Wind, LLC.	
	Stetson II	Normandeau Associates. 2010. Stetson Mountain II Wind Project Year 1 Post-Construction Avian and Bat Mortality Monitoring. Prepared for First Wind, LLC.	Woodlot Alternatives, Inc. 2007. A Spring 2007 Survey of Bird and Bat Migration at the Stetson Wind Project, Washington County, Maine. Prepared for Evergreen Wind V, LLC.
		Stantec Consulting Services Inc. 2012. Stetson II Wind Project Post-Construction Monitoring Report, 2012. Prepared for First Wind, LLC.	Woodlot Alternatives, Inc. 2007. A Fall 2006 Survey of Bird and Bat Migration at the Stetson Wind Project, Washington County, Maine. Prepared for Evergreen Wind V, LLC.
		Stantec Consulting Services Inc. 2015. Stetson II Wind Project Year 3 Post-Construction Monitoring Report, 2014. Prepared for First Wind, LLC.	
NH	Granite Reliable	Curry and Kerlinger. 2013. Post-construction mortality study Granite Reliable Power Wind Park, Coos County, New Hampshire, Annual Report January 2013. Prepared for Granite Reliable Power, LLC.	Stantec Consulting Services Inc. 2007. Spring 2007 Radar, Visual, and Acoustic Survey of Bird and Bat Migration at the Proposed Windpark in Coos County, New Hampshire by Granite Reliable Power, LLC. Prepared for Granite Reliable Power, LLC.
			Stantec Consulting Services Inc. 2007. Fall 2006 Radar Surveys of Nighttime Migration Activity at the Proposed Windpark in Coos County, New Hampshire by Granite Reliable Power, LLC. Prepared for Granite Reliable Power, LLC.
			Stantec Consulting Services Inc. 2007. Fall 2007 Radar, Visual, and Acoustic Survey of Bird and Bat Migration at the Proposed Windpark in Coos County, New Hampshire by Granite Reliable Power, LLC. Prepared for Granite Reliable Power, LLC.
	Groton	Stantec Consulting Services Inc. 2014. 2013 Post Construction Avian and Bat Survey Report. Prepared for Groton Wind, LLC.	Stantec Consulting Services Inc. 2008. Spring 2008 Radar Survey Report for the Groton Wind Project. Prepared for Groton Wind, LLC.
		Stantec Consulting Services Inc. 2015. 2014 Post Construction Avian and Bat Survey Report. Prepared for Groton Wind, LLC.	Stantec Consulting Services Inc. 2008. Fall 2008 Radar Survey Report for the Groton Wind Project. Prepared for Groton Wind, LLC.
		Stantec Consulting Services Inc. 2016. 2015 Post Construction Avian and Bat Survey Report. Prepared for Groton Wind, LLC.	

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	Lempster	Tidhar, D., W. Tidhar, and M. Sonnenberg. 2010. 2009 Post-Construction Fatality Surveys for Lempster Wind Project. Prepared for Lempster Wind, LLC.	Woodlot Alternatives, Inc. 2007.A Spring 2007 Survey of Nocturnal Bird Migration, Breeding Birds, and Bicknell's Thrush at the Proposed Lempster Mountain Wind Power Project Lempster, New Hampshire. Prepared for Lempster Wind, LLC.
		Tidhar, D., W. Tidhar, L. McManus, and Z. Courage. 2011. 2010 Post-Construction Fatality Surveys for Lempster Wind Project. Prepared for Lempster Wind, LLC.	Woodlot Alternatives, Inc. 2007. A Fall 2006 Survey of Nocturnal Bird Migration, Breeding Birds, and Bicknell's Thrush at the Proposed Lempster Mountain Wind Power Project Lempster, New Hampshire. Prepared for Lempster Wind, LLC.
NY	Bliss	Jain, A., P. Kerlinger, R. Curry, L. Slobodnik, J. Quant, D. Pursell. 2009. Annual Report for the Noble Bliss Windpark, LLC. Postconstruction Bird and Bat Fatality Study – 2008. Prepared by Curry and Kerlinger, LLC.	Ecology and Environment, Inc. 2006. Avian and Bat Risk Assessment Bliss Windpark Town of Eagle, Wyoming County, New York. Prepared for Noble Environmental Power, LLC.
		Jain, A., Kerlinger, P., Slobodnik, L., Curry, R., Russel, K. 2010. Annual Report for the Noble Bliss Windpark, LLC Post-Construction Bird and Bat Fatality Study - 2009. Prepared for Noble Environmental Power, LLC.	
	Chateaugay	Jain, A., Kerlinger, P., Slobodnik, L., Curry, R., Russel, K. 2011. Annual Report for the Noble Chateaugay Windpark, LLC Post-Construction Bird and Bat Fatality Study - 2010. Prepared for Noble Environmental Power, LLC.	Woodlot Alternatives, Inc. 2006. Spring 2006 Radar Surveys at the Proposed Chateaugay Windpark in Chateaugay, New York. Prepared for Ecology and Environment, Inc. and Noble Power, LLC.
			Woodlot Alternatives, Inc. 2006. Fall 2006 Radar Surveys at the Proposed Chateaugay Windpark in Chateaugay, New York. Prepared for Ecology and Environment, Inc. and Noble Power, LLC.
	Clinton	Jain, A., P. Kerlinger, R. Curry, L. Slobodnik, J. Histed, and J. Meacham. 2009. Annual Report for the Noble Clinton Windpark, LLC. Postconstruction Bird and Bat Fatality Study – 2008. Prepared by Curry and Kerlinger, LLC.	Mabee, T. J., J. H. Plissner, B. A. Cooper, J. B. Barna. 2006. A Radar and Visual Study of Nocturnal Bird and Bat Migration at the Proposed Clinton County Windparks, New York, Spring and Fall 2005. Final Report prepared by ABR, Inc. for Ecology and Environment, Inc. and Noble Environmental Power, LLC.
		Jain, A., Kerlinger, P., Slobodnik, L., Curry, R., Russel, K. 2010. Annual Report for the Noble Clinton Windpark, LLC Post-Construction Bird and Bat Fatality Study - 2009. Prepared for Noble Environmental Power, LLC.	Mabee, T. J., J. H. Plissner, B. A. Cooper, J. B. Barna. 2006. A Radar and Visual Study of Nocturnal Bird and Bat Migration at the Proposed Clinton County Windparks, New York, Spring and Fall 2005. Final Report prepared by ABR, Inc. for Ecology and Environment, Inc. and Noble Environmental Power, LLC.
	Cohocton/Dutch Hill	Stantec Consulting Services Inc. 2010. Cohocton and Dutch Hill Wind FarmsYear 1 Post-Construction Monitoring Report, 2009 for the Cohocton and Dutch Hill Wind Farms In Cohocton, New York. Prepared for Canandaigua Power Partners, LLC and Canandaigua Power Partners II, LLC.	Woodlot Alternatives, Inc. 2006. A Fall 2006 Survey of Bird and Bat Migration at the Proposed Dutch Hill Wind Project Cohocton, New York. Prepared for UPC Wind Management, LLC.
		Stantec Consulting Services Inc. 2011. Cohocton and Dutch Hill Wind Farms Year 2 Post-Construction Monitoring Report, 2010 for the Cohocton and Dutch Hill Wind Farms In Cohocton, New York. Prepared for Canandaigua Power Partners, LLC and Canandaigua Power Partners II, LLC.	

State	Project	Bird Mortality Reference	Radar Passage Rate Reference
		Stantec Consulting Services Inc. 2014. Cohocton and Dutch Hill Wind Farms 2013 Post-ConstructionWildlife Monitoring Report. Prepared for Canandaigua Power Partners, LLC and Canandaigua Power Partners II, LLC.	
	Hardscrabble	Jain, A., Kerlinger, P., Slobodnik, L., Curry, R., Russel, K. 2010. Annual Report for the Noble Ellenburg Windpark, LLC Post-Construction Bird and Bat Fatality Study - 2009. Prepared for Noble Environmental Power, LLC.	Woodlot Alternatives, Inc. 2005. A Spring 2005 Radar Survey of Bird and Bat Migration at the Proposed Top Notch Wind Project in Fairfield, New York. Prepared for PPM Atlantic Renewable.
			Woodlot Alternatives, Inc. 2005. A Fall 2005 Radar Survey of Bird and Bat Migration at the Proposed Top Notch Wind Project in Fairfield, New York. Prepared for PPM Atlantic Renewable.
	High Sheldon	West. 2011. 2010 Post-construction Fatality Monitoring Study and Bat Acoustic Study for the High Sheldon Wind Farm Wyoming County, New York Final Report April 15 – November 15, 2010. Prepared for High Sheldon Wind Farm Sheldon Energy, LLC.	Woodlot Alternatives, Inc. 2006. A Spring 2005 Radar Survey of Bird Migration at the Proposed High Sheldon Wind Project in Sheldon, New York. Prepared for Invenergy.
		West. 2011. 2011 Post-construction Fatality Monitoring Study and Bat Acoustic Study for the High Sheldon Wind Farm Wyoming County, New York Final Report April 15 – November 15, 2011. Prepared for High Sheldon Wind Farm Sheldon Energy, LLC.	Woodlot Alternatives, Inc. 2006. A Fall 2005 Radar Survey of Bird Migration at the Proposed High Sheldon Wind Project in Sheldon, New York. Prepared for Invenergy.
	Howard	West. 2013. 2012 Post-Construction Monitoring Studies for the Howard Wind Projgect Steuben County, New York. Prepared for Howard Wind, LLC.	Woodlot Alternatives, Inc. 2006. A Spring 2006 Survey of Bird and Bat Migration at the Proposed Howard Wind Power Project in Howard, New York. Prepared for Everpower Global.
		West. 2014. 2013 Post-Construction Monitoring Studies for the Howard Wind Projgect Steuben County, New York. Prepared for Howard Wind, LLC.	Woodlot Alternatives, Inc. 20065 A Fall 2005 Survey of Bird and Bat Migration at the Proposed Howard Wind Power Project in Howard, New York. Prepared for Everpower Global.
	Maple Ridge	Jain, A., P. Kerlinger, R. Curry, and L. Slobodnik. 2007. Annual report for the Maple Ridge wind power project post-construction bird and bat fatality study—2006. Annual report prepared for PPM Energy and Horizon Energy. Curry and Kerlinger, Cape May Point, New Jersey, USA.	Mabee, T. J., J. H. Plissner, B. A. Cooper. 2005. A Radar and Visual Study of Nocturnal Bird and Bat Migration at the Proposed Flat Rock Wind Power Project, New York, Fall 2004. Prepared by ABR, Inc. for Atlantic Renewable Energy Corporation
		Jain, A. P. Kerlinger, R. Curry, and L. Slobodnik. 2008. Annual report for the Maple Ridge wind power project post-construction bird and bat fatality study—2007. Annual report prepared for PPM Energy and Horizon Energy. Curry and Kerlinger, Cape May Point, New Jersey, USA.	
		Jain, A. P. Kerlinger, R. Curry, and L. Slobodnik. 2009. Annual report for the Maple Ridge wind power project post-construction bird and bat fatality study—2008. Annual report prepared for PPM Energy and Horizon Energy. Curry and Kerlinger, Cape May Point, New Jersey, USA.	
	Munnsville	Stantec Consulting Services Inc. 2009. Post-construction monitoring at the Munnsville Wind Farm, New York, 2008. Prepared for E.ON Climate and Renewables.	Woodlot Alternatives, Inc. 2005. A Spring 2005 Radar, Visual, and Acoustic Survey of Bird and Bat Migration at the Proposed Munnsville Wind Project in Munnsville, New York. Prepared for AES-EHN NY Wind, LLC.

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			Woodlot Alternatives, Inc. 2005. A Fall 2005 Radar, Visual, and Acoustic Survey of Bird and Bat Migration at the Proposed Munnsville Wind Project in Munnsville, New York. Prepared for AES-EHN NY Wind, LLC.
	Wethersfield	Jain, A., Kerlinger, P., Slobodnik, L., Curry, R., Russel, K., Harte, A. 2011. Annual Report for the Noble Wethersfield Windpark, LLC Post-Construction Bird and Bat Fatality Study - 2010. Prepared for Noble Environmental Power, LLC.	Mabee, T.J., J.H. Plissner, and B.A. Cooper. 2006a. A Radar and Visual Study of Nocturnal Bird and Bat Migration at the Proposed Centerville and Wethersfield Windparks, New York, Spring 2006. Report prepared for Ecology and Environment, LLC and Noble Environmental Power, LLC. July 2006.
			Mabee, T. J., J. H. Plissner, J. B. Barna, B. A. Cooper. 2006. A Radar and Visual Study of Nocturnal Bird and Bat Migration at the Proposed Centerville and Wethersfield windparks, New York, Fall 2006. Final Report prepared by ABR, Inc. for Ecology and Environment and Noble Environmental Power, LLC
VT	Georgia	Stantec. 2014. Georgia Mountain Community Wind 2013 Post-Construction Monitoring Report - Year 1. Prepared for Georgia Mountain Community Wind, LLC.	Stantec Consulting Services Inc. 2008. A Fall 2008 Survey of Bird Migration at the Georgia Mountain Wind Project, Vermont. Prepared for Georgia Mountain Community Wind.
		Stantec. 2015. Georgia Mountain Community Wind 2014 Post-Construction Monitoring Report – Year 2. Prepared for Georgia Mountain Community.	
	Kingdom	Stantec. 2014. Kingdom Community Wind 2013 Post-Construction Monitoring Report - Year 1. Prepared for Green Mountain Power.	Stantec Consulting. 2009. Spring 2009 Nocturnal Migration and Breeding Bird Surveys for the Kingdom Community Wind Project in Lowell, Vermont. Prepared for Vermont Environmental Research Associates.
		Stantec. 2015. Kingdom Community Wind 2014 Post-Construction Monitoring Report – Year 2. Prepared for Green Mountain Power.	Stantec Consulting. 2008. Fall 2008 Bird and Bat Migration Survey Report: Radar Surveys for the Kingdom Community Wind Project in Lowell, Vermont. Prepared for Vermont Environmental Research Associates.
	Sheffield	Martin, C., E. Arnett, M. Wallace. 2013. Evaluating Bird and Bat Post-Construction Impacts at the Sheffield Wind Facility, Vermont 2012 Annual Report. Prepared for Bat Conservation International and First Wind.	Woodlot Alternatives, Inc. 2006. A Spring 2005 Radar, and Visual Survey of Bird Migration at the Proposed Sheffield Wind Farm in Sheffield and Sutton, Vermont. Prepared for UPC Wind Management, LLC.
		Martin, C., E. Arnett, M. Wallace. 2014. Evaluating Bird and Bat Post-Construction Impacts at the Sheffield Wind Facility, Vermont 2013 Annual Report. Prepared for Bat Conservation International and First Wind.	Woodlot Alternatives, Inc. 2005. A Fall 2004 Radar, Visual, and Acoustic Survey of Bird and Bat Migration at the Proposed Hardscrabble Mountain Wind Project in Sheffield, Vermont. Prepared for UPC Wind Management, LLC.