7.6 INTEGRATION OF NEXRAD, MARINE RADAR, SODAR AND CONVENTIONAL ANEMOMETRY FOR AVIAN RISK ASSESSMENT

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1. ABSTRACT

A community wind project in rural Albany County, NYS, conducted studies of bird and bat activity. Multiple sources of data were integrated, including an on-site X-band marine radar for tracking avian passage rates, Doppler SoDAR profiling, a 50-m meteorological tower, acoustic monitoring for bats, and NexRad data. The SoDAR allowed the determination of wind speed and direction as well as turbulence intensity to a height of 200 m.

Community members and students played an active role in the assessment of migratory bird and bat activity; more than 25 individuals were trained in the use of the marine radar for making avian counts.

2. INTRODUCTION

Wind energy permitting often requires intensive monitoring of bird and bat activity in conjunction with meteorological conditions. Such monitoring is critical to ecological sustainability and economic profitability. Community wind projects may find the up-front costs associated with monitoring and permitting prohibitive. The use of community members as trained citizen scientists serves to gather the large data sets required for reliability, educate the community about wind energy potential and concerns and simultaneously ameliorate costs.

3. METHODS

The site selected for this study was in the Town of Knox and will be called the Octagon Barn Site for the purposes of this assessment. The Octagon Barn Site (OBS) is located at approximately N 42.6848 latitude, W 74.1525 longitude on Middle Road in the Town of Knox. The area consists largely of farm fields (hay production and grazing) with hedgerows (fencerows) separating the fields. There are delineated wetlands to the northwest approximately 1300 m from the site and to the southeast approximately 1550 m. Interspersed throughout the agricultural landscape are varying sized patches of forested areas.

Migratory bird activity was tracked with X-band marine radar at site as well as (regional) NexRad. Three migration seasons of NEXRAD data were collected, 2 of them concurrent with onsite X-band marine radar. The X-band marine radar screens were captured so that a digital record of each night's "voyage" was kept. The marine radar was operated in a "vertical" mode so that bird migration could be tied to particular heights above the ground. The movement of individual birds was tracked, allowing correlation between the meteorological conditions and rate of movement of the birds. At least 20 community members and students participated in the bird and bat study, making it an important tool for outreach and education.

Bat activity was monitored using a Binary Acoustic Technologies, Inc AR-125 bat detector. Over 50 hours of active recording were conducted near the tower at the ground level and during driving tours.

As part of the wind resource assessment for this project, there was a 50-m tilt-up meteorological tower on the site instrumented with cup anemometers (3 levels), wind direction (2 levels) and temperature (top and bottom). In addition, sodar wind profilers were used for periods of 2 weeks to 3 months at various points during the project. The sodar provided wind speed and direction profiles from 30 m to 200 m every 10 minutes.

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4. RESULTS AND DISCUSSION

Night-migrating birds took flight within a short period of time after sunset, and returned to ground shortly before sunrise. The bulk of night-migrating birds were found to be at least 300 m above the ground, well above the top of the rotor sweep of utility-scale wind turbines. Total bird counts obtained using the onsite marine radar ranged widely, with typical counts of 150 to 800 birds per session. Each session included 40 to 60 minutes of active counting time. No more than one bat per night was recorded. At least 2 species of bats were represented.

Night-migrating birds were detected in the KENX radar whenever it was operating in clear-air mode. The overall reflectivity increased sharply after sunset and decreased gradually prior to sunrise (Figures 2 and 3), in the manner described by Diehl and Larkin (2005). The evening reflectivities were also higher than those in the morning. The spring 2007 reflectivities were lower overall than those in the fall of 2007.

Tables 1 and 2 illustrate the association of the maximum nightly Nexrad reflectivity with wind direction. Although the wind roses (Figure 5) in both and spring and fall are dominated by WNW winds both in frequency and energy, south winds were more frequent overall during the fall. The fall also had higher reflectivity overall. Nonetheless, for both fall and spring the greatest contribution to radar reflectivity (considering only clear-air mode) were conditions where the wind was from the WSW through the NW.

Seasonal summaries of the maximum nightly Nexrad reflectivity and meteorological conditions are shown in Figures 7 and 8 for the spring and fall of 2007, respectively. Migration on a given night at the Octagon Barn site proceeds almost independently of the wind direction or even the wind speed. For instance, the general northward migration of birds in the spring occurred on nights when the wind had a southerly component, as expected, but also when the wind was from the WNW or even the E. Likewise the southward migration of birds captured in the KENX radar in the fall occurred even on nights with southerly winds.

Migrating raptors were observed during the mid-day hours on September 14, 2007 during a period when a sodar was operating. Despite the gusty S winds, birds were flying in a southerly direction, generally at an altitude of 300 m or more above the ground. Passage rates of 7 to 10 birds per minute were observed. The sodar wind profile for this period (Figure 6) suggests there is a an increase in shear with height, possibly because of inhomogeneous upwind roughness in the southerly direction.

The use of citizen scientists required a commitment to training, a reliable system of quality assurance and a method to retain raw data. The results of using local volunteers were effective cost containment and development of a group of educated constituents who often became local advocates.

5. CONCLUSIONS

Night-migrating birds took flight within a short period of time after sunset, and returned to ground shortly before sunrise. The bulk of night-migrating birds were found to be at least 300 m above the ground, well above the top of the rotor sweep of utility-scale wind turbines.

The KENX NEXRAD radar was useful for the detection of general trends in migratory bird activity in the region. The reflectivity at the 13 km range gate, corresponding to the community wind site, was best correlated with bird counts at 300 m height above the ground.

Within minutes of the start of nightly migratory activity, the counts and the passage rates of birds are 3 to 4 times greater at heights greater than 140 m than they are below 140 m.

In spring, migratory bird activity was greatest on nights with southerly winds, while in the fall migration appeared to be independent of the wind direction. Bird movement at the Octagon Barn site, as viewed with the onsite radar, corresponded to the direction of the wind on that night. (e.g. easterly winds on 9/17/07, and birds moving easterly).

The study represents an unusual integration of multiple sources and scales of meteorological and biological data of importance for environmental permitting of wind energy. Also unusual was the active participation of community "citizen scientists", which facilitated community education about wind energy and avian behavior.

6. REFERENCES

Diehl, R. H., and R. P. Larkin, 2005. Introduction to the WSR-88D (NEXRAD) for ornithological research. USDA Forest Service Gen. Tech. Rep. PSW GTR-191.

7. ACKNOWLEDGEMENT

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8. FIGURES AND TABLES

Figure 1 - Marine x-band radar in operation (vertical mode) at the community wind site. A sodar is shown in the background.

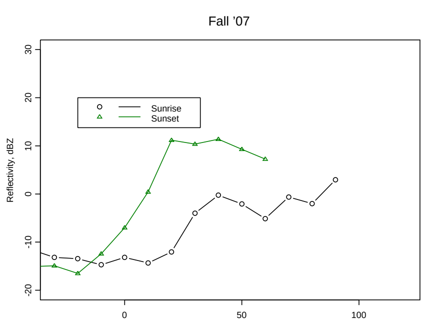

Figure 2. NEXRAD reflectivities at the Knox Octagon Barn site (13 km from KENX) during the fall migration season, relative to times of sunset or sunrise.

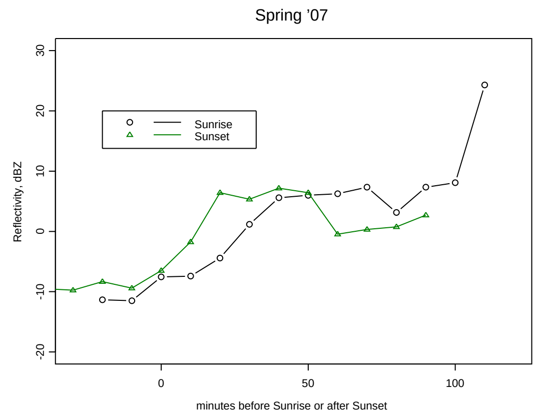

Figure 3. As in Figure 2, but for Spring '07.

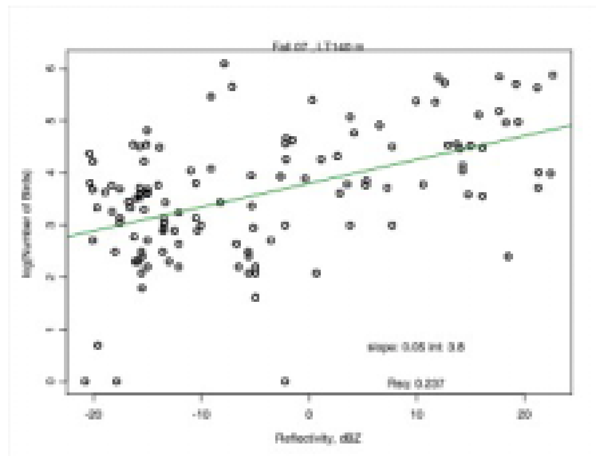

Figure 4 – NEXRAD reflectivities and bird passage rates

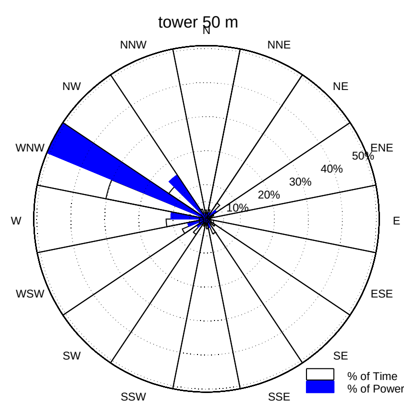

Figure 5. Wind rose for the 50 m met. tower at the Octagon Barn site.

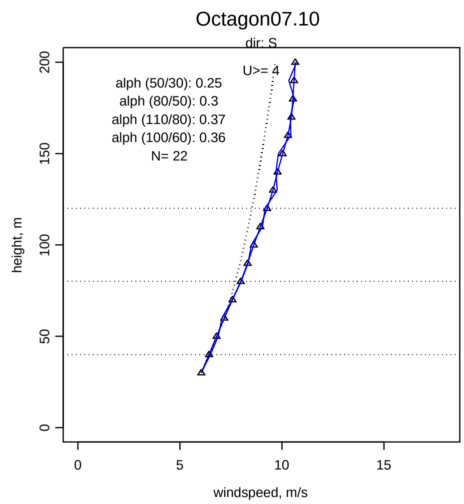

Figure 6. Sodar wind profile (triangles, blue line) for the late morning of September 14, 2007. Dashed line is the extrapolated power law profile based on the shear parameter from 30 m to 50 m.

Maximum Reflectivity, dBZ	NNE	NE	ENE	E	SE	S	WSW	W	WNW	NW	NNW
-10 to 0	1	0	0	0	0	0	1	0	1	3	0
0 to 9	0	1	0	0	0	0	0	0	0	6	0
10 to 19	0	0	3	0	0	0	1	2	4	2	1
20 to 29	0	0	0	1	1	2	3	1	2	0	0

Table 1. Maximum reflectivity per night (radar in clear-air mode) by wind direction sector for Spring, 2007.

Maximum Reflectivity, dBZ	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
-20 to -19	0	0	0	1	0	0	0	0	0	0	0	0	0
-10 to 0	0	0	0	0	1	3	0	0	1	0	0	0	0
0 to 9	0	1	0	0	0	3	2	0	1	2	3	1	0
10 to 19	2	0	2	1	3	3	0	1	1	1	2	1	0
20 to 29	0	0	1	0	0	0	1	0	0	1	6	3	1

Table 2. Maximum reflectivity per night (radar in clear-air mode) by wind direction sector, during Fall, 2007.

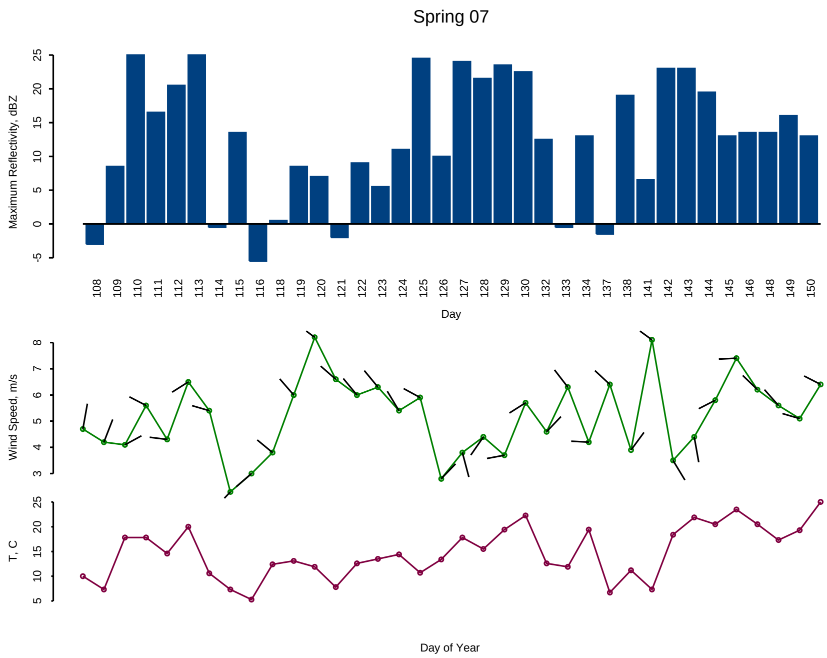

Figure 7. Nightly maximum NEXRAD reflectivities during the Spring 2007 migration season, with concurrent meteorological conditions (wind speed, wind direction, and temperature).

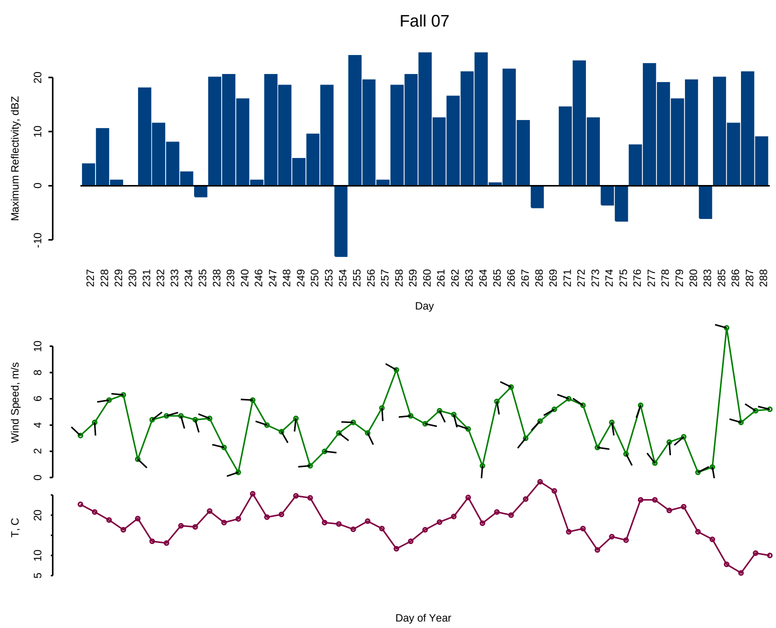

Figure 8. Nightly maximum NEXRAD reflectivities during the Fall 2007 migration season, with concurrent meteorological conditions (wind speed, wind direction, and temperature).