AVIAN MIGRATION AND IMPLICATIONS FOR WIND POWER DEVELOPMENT IN THE EASTERN UNITED STATES

This session was arranged to convey what is known about avian migration, particularly in the eastern US. The first presentation frames the issue of migratory bird interactions with wind energy facilities from an ecological perspective: when, where, and why are migrant bird species vulnerable to wind turbine collision? The second presentation reported on radar studies conducted at wind sites in the eastern US, including Mount Storm, Clipper Wind, and others.

**Migration Ecology: Issues of Scale and Behavior**

by Sarah E. S. Mabey, *North Carolina State University*²¹

This presentation aims to provide a picture of bird migration as ecologists see it, taking into account:

- the scale on which migration takes place – and its import for ecology and policy;
- constraints – how weather, geomorphology, landscape, resources, and habitat factors influence the choices that lead to migration patterns;
- what it means to be a migratory bird in a changing world; and,
- consequences of changing world to migratory bird populations.

Migratory birds lead extremely challenging lives when they are in transit, facing new foraging circumstances, predators, and competition on a daily basis. The process of migration is spatially and temporally dynamic, thus the pattern and timing of migration can be highly unpredictable. In effect, predictability is scale-dependent. The broader the spatial and temporal scale (i.e., greater area and longer time-frame), the more predictable migration movements appear. As we scale down to a particular local on a given day or hour, it becomes much more difficult to predict whether migrants will or will not be present. The dynamic nature of bird migration makes it difficult to describe migratory patterns of songbirds in detail, particularly of specific species. Another problem is that much of what is known about certain species is geographically biased because data are only available for the places where researchers work. In fact, the Wilson’s Warbler is arguably the only neo-tropical migratory songbird for which scientists actually know something about the actual migration routes of sub-populations.

There is a hierarchy of factors that determine the migratory patterns of birds, influencing where and when birds stop, where and when species concentrations occur, species

²¹ Department of Zoology, Raleigh, NC 27695-7617
composition, and the distribution of age and sex classes. The hierarchy is arranged according to the degree of control birds have over the factors that influence their migration choices. At the top of the hierarchy is the factor over which birds have the least influence, weather. Birds cannot control the weather, but they can and do respond to it. They also cannot control the second factor in the hierarchy, geomorphology (landmasses). As birds respond to weather (fronts), moving north in the spring and south in the fall, their choices of where to stop are constrained by geomorphology. Once they make an initial decision about where and when to stop, migrants enter the “landscape level” where their choices are constrained only by the availability (or lack of availability) of habitat and resources within the local landscape.

The stopover site chosen by a migrant is directly related to the hierarchy of constraints that determine the individual bird’s range of choices. Based on this understanding of stopover ecology, a number of colleagues and I developed a series of functional definitions for different kinds of stopover sites used by migratory birds (Duncan et al. 2002). A “fire escape” is a stopover site near an ecological barrier such as the Great Lakes or Gulf of Mexico where birds are highly concentrated. The use of such sites is related to bad weather and occurs infrequently under “emergency” conditions. A “convenience store” is a site within a patchy, ecologically unsuitable habitat matrix that is used if nothing better is available within a particular landscape. The “full-service hotel” designation refers to extensive, suitable habitat with diverse resources such as the Great Smoky Mountains. Unfortunately, full-service hotels are becoming increasingly more difficult for birds to locate as habitat is continually being lost to or fragmented by development, reducing birds’ choices. Migrants must stop to rest and regain the fat stores that fuel their migratory flights. Habitat suitability impacts birds’ migratory behavior as it directly affects the amount of energy and time required to refuel during stopovers. Thus, all of these types of migratory stopover habitats should be considered when making policy and conservation planning decisions.

At present, we do not have a clear understanding of how plastic or static many bird migration behaviors might be. There exist empirical data to support both possibilities. For example, a number of important questions remain open. Are diet shifts opportunistic (plastic) or are they essential for fat deposition (static)? Does orientation of bird flight depend on their physical condition (plastic) or is it genetically determined (static)? Are migrants socially tolerant, sticking together in flocks, or are they territorial and defensive of their resources? It also is not known whether there is rapid evolution of migratory routes or if species can consistently track the changing climate. Recent work has shown that some birds fatten only under certain magnetic field conditions (i.e., at particular latitudes) that exist where the birds prepare to cross an ecological barrier. This means that these birds may not adjust to deteriorating resources at that location by fattening opportunistically when they encounter better resources elsewhere.

We have looked at migration from the perspective of the individual songbird migrant, but what does this all mean for populations? Population models help us understand how resilient species are to a changing world. As we have seen earlier, models for migratory species must begin to include migration events. There are both direct and indirect consequences of avian migration events. Direct consequences include injuries/fatalities
caused by accidents as well as predation (including hunting). Indirect consequences of migration include intra- and inter-species-specific competition and seasonal resource declines. Weather, inexperience and orientation errors can lead to both types of consequences. Some factors that lead to mortality during migration affect populations at a general level. Stochastic (random) events such as hurricanes affect birds of all ages and sexes, but other events may affect young birds more than old birds. For example, young of the year tend to congregate in coastal areas during their first migration and are, therefore, more likely to be seriously affected by coastal development as it presents obstacles during migration. Given that, overall, young birds are more valuable to a population because of their reproductive potential, coastal mortality events could potentially have a significant impact on a bird population.

The key challenge to protecting migrating birds from fatality at wind turbines is that they are a moving target – as individuals and as populations. The intercontinental scale of birds’ movement requires scale-appropriate conservation planning. Moreover, because migration is spatially and temporally dynamic, it presents a challenge to traditional conservation paradigms. The demographic consequences of the changing world and its impacts on migratory songbirds will be knowable over time. Until then, protecting migratory birds requires a conservative approach applied at an intercontinental scale.

References
Duncan et al. 2002. “Protecting stopover sites for forest-dwelling migratory landbirds.”

_Radar Studies of Nocturnal Migration at Wind Sites in the Eastern US_

by

Brian Cooper, _ABR, Inc._

Nocturnal radar studies of bird migration are important because most birds (including warblers, tanagers, vireos, orioles, kinglets, thrushes, gnatcatchers, many sparrows, cuckoos, flycatchers, thrashers, and owls) migrate at night and approximately half of all bird mortality at wind turbines involves nocturnal migrants.

There are several types of radar tools available to researchers. NEXRAD (Next Generation Radar) is used by the National Weather Service to measure both precipitation and wind. A Doppler radar system currently deployed at about 150 locations around the US, NEXRAD can also be used to detect birds. This technology provides excellent data for many aspects of migration, but has some limitations for studies of individual wind energy sites: resolution is low (1 km x 1 km); eliminating insect noise data is difficult; there is a lack of low-altitude coverage for many areas (below 500 m); and there is a lack of precise altitude data – making it impossible to calculate passage rates in the zone of exposure to turbines.

22 P.O. Box 249, Forest Grove, OR 97116
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Researchers also use marine radar technology, which gives higher resolution and is mobile. These radars can be operated in horizontal surveillance mode to determine traffic rates and general movements/behavior, or operated in vertical mode to obtain flight altitude information. Marine radar studies on avian migration have been carried out at several locations across the US. Work carried out during Fall 2003 at the proposed (as yet undeveloped) Mt. Storm, West Virginia wind energy site (just east of the Mountaineer wind site along the Allegheny Front) offers a good example of the potential findings of avian migration radar studies in the Eastern US.

Mobile (vehicle-mounted) radar labs were set up at five locations within the proposed Mt. Storm wind development. The surveillance radar beam provided coverage over a 1.5-km radius and the vertical radar provided coverage up to ~1.5 km high. Flight altitudes are of interest, because birds flying well over turbine height are not at risk from wind farms. The radar “target” represents one bird. It is possible to distinguish between some species groups such as songbirds and waterfowl, or to distinguish small birds from insects, by their flight speed.

Passage rates varied widely from night to night, as well among sites within a night, but were found to be fairly stable over the course of any given night. Fall observations from the five sampling sites at the Mt. Storm site yielded mean fall nocturnal passage rates of 54-241 targets/km/hour. This is comparable to mean fall nocturnal passage rates (130-242 targets/km/hour) found at three sites in New York State (Cooper and Ritchie 1995); and higher than the fall rates (83-108 targets/km/hour) observed in Minnesota (Day and Byrne 1989 and 1990); or at two western wind sites (27-40 targets/km/hour at a site in South Dakota, and 19-26 targets/km/hour at sites in Oregon [Cooper and Mabee 2004]).

During fall 2003, 16% of targets (birds) were flying at or below turbine height (125 m above ground level) at the central Mt. Storm site. Most targets (birds) passed at an altitude between about 250 m to 750 m agl, with a mean of about 410 m above ground level. Based on temporary checks at the 3-km-range, it was estimated that about 6% of passing birds flew between 1500-3000 m agl. There was substantial among-night variation in flight altitudes but little among-site variation in flight altitudes at the Mt. Storm sites. Altitudes tended to peak in the middle of the night and taper off toward morning. Flight directions recorded at Mt. Storm indicate that birds do not concentrate along the Allegheny Front, but rather that they tend to fly across the ridge.

Using radar data to assess mortality risk for birds at wind developments involves determining passage rates at or below turbine height (i.e. combining passage rate and altitude data). In other words, researchers calculate the number of targets per hour at or below turbine height. This is multiplied by the following factors: the number of migrants per radar “target” (here assumed to be one); the length of the migration season (number of nights); the total number of hours per night; and the width (km of migratory front) of the wind resource area or total rotor swept area of the turbines. For example, applying this formula (using WRA width instead of total rotor swept area) to the Mt. Storm observations yields the following equation:
36 targets/km/h at or below turbine height * 1 migrant/target * 45 nights *
10 hours/night * 10 km migratory front\textsuperscript{23} 

= 162,000 migrants\textsuperscript{24} passing over the Mt. Storm WRA at or below turbine height during the Fall 2003 migration study period.

There are some conclusions that may be drawn and recommendations to make regarding radar studies of avian migration and the potential risk posed to birds by wind developments. It is important point to keep in mind that migrants determined to be at risk will not all be killed. In fact, it will most likely be a small proportion that is impacted because many birds will detect and avoid the turbines. To improve wind-bird radar studies, researchers could collect concurrent radar and mortality data to elucidate the relationship between numbers of migrants in the zone of exposure and mortality. Behavioral studies would help to determine the proportion of migrants that detect and avoid wind turbines. Finally, it would help to develop common or comparable metrics to facilitate comparisons among radar studies.

References


\textsuperscript{23} Note that while each radar has a 1.5 km band of detection, this formula extrapolates from radar data to calculate an estimated number of migrants passing over the entire (10 km wide) wind resource area (WRA).

\textsuperscript{24} Note that radar data does not distinguish between birds and bats. The only way to distinguish them would be to conduct concurrent surveys using night vision or spotlighting.
**Discussion, Questions and Answers**

*How do migrating birds use winds? Do they use them to their advantage or simply react to them?*

**Response (S. Mabey):** Most birds will leave a site on a strong tailwind, and tend not to leave in a headwind, but they also will leave at times when there is no wind at all. However, crossing a water body like the Gulf of Mexico may take ten hours, and the winds may change during the crossing. Birds do shift altitudes to take advantage of more favorable winds.

In response to a general question about how the wind industry can make use of the expertise of migration ecologists to help site wind energy developments, participants were referred to the Society for Conservation Biology and The Ornithological Council are good organizations to contact: [http://conbio.net/](http://conbio.net/); [http://www.nmnh.si.edu/BIRDNET/index.html](http://www.nmnh.si.edu/BIRDNET/index.html)

*Do researchers correct for wind direction and speed when looking at the concentration of migrants near the Allegheny Front?*

**Response (B. Cooper):** Wind direction and speed were corrected for in the study, in order to calculate actual air speed of radar targets and thus distinguish birds from insects.

Has there been research conducted on birds’ nocturnal flight orientation relative to ridgelines at any other sites?

**Response:** There are actually a few such studies under way around the US: near Chatauqua, New York; on a ridge in Idaho; and in western Oregon. Data from the New York and Idaho sites should be available soon. There also is a published paper by Williams et al. (2001, Auk 118:389-403) that describes nocturnal bird movements through a major pass in the northern Appalachians.

**Comment:** Developers have the option of putting stipulations into their contracts to release study results to (or via) NREL.

**Comment/Question:** In the West, results of night radar studies seem generally to be in line with information derived from conventional diurnal observations, at least in terms of predicting avian mortality by major birds groups. What analysis has been done to correlate these two types of data, given the high cost of night radar?

**Response:** At the Mt. Storm site, WEST Inc. compared there daytime visual data with our radar data and found that there was no significant correlation between the two data types. In Europe, some early studies actually found an inverse relationship between the numbers of birds on the ground and radar migration rates from the previous nights. On the other

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25 The Chautauqua data are available on the website [http://www.chautauquawind.ene.com/avian.htm](http://www.chautauquawind.ene.com/avian.htm) The other studies are still confidential and have not yet been released.
hand, there is study by Williams et al. (2001, Auk 118:389-403) in the northern Appalachians that found some positive correlations between daytime and nighttime bird movements. There also probably is positive correlation on the Gulf Coast, where big migration nights often are followed by large numbers of migrants on the ground during the day.

*Has post-construction fatality monitoring has been conducted at Mt. Storm to identify a kill ratio against the 162,000 migrants observed passing through the WRA?*

*Response:* Post-construction fatality monitoring has not yet been done at the Mt. Storm site, which does not yet have any turbines in place. Based on Mt. Storm radar radar data from the Fall 2003 and Fall 2003 mortality data from the nearby Mountaineer wind site (i.e., 2.4 birds per turbine per fall season), however, WEST, Inc. calculated that approximately 0.16% of the fall migrants flying at or below turbine height over the WRA at Mountaineer were killed.

*How do birds detect and avoid wind turbines, under what conditions do they not detect and avoid them, and is it possible for manufacturers to incorporate audio cues to make turbines more detectable?*

*Response:* Birds detect and avoid turbines primarily visually, thus poor visibility is probably one factor that makes detection more difficult for them. It has been noted that on moonless nights in Europe resident wintering seaducks made wider swings (than on nights with moonlight) around one wind farm surveyed, although clearly this strategy does not benefit migrating birds that are unfamiliar with the terrain and turbine locations. The presenter did not know anything about the potential for using audio cues.

*What do multi-year pre-construction studies tell state regulators about whether a wind facility will have unacceptable impacts on avian species in order for them to make a permitting decision?*

*Response:* Multi-year studies have shown variation in migration rates from year to year (Mabee and Cooper 2004), but clearly more information is needed to assess the degree of annual variation in rates and flight altitudes that one might expect in general. Regulators have to make decisions based on the best available information to assess nocturnal risk to birds and obviously more years of data would give them more information to make those decisions, but sometimes multi-year studies are cost-prohibitive or time-prohibitive.

*Can bird and bat species be distinguished via analysis of wing beat frequencies when using night radar?*

*Response:* Although there are tracking radars that could do this for some species, the surveillance radar equipment [Brian Cooper] has worked with cannot. However, a combination of radar and visual techniques can be used to help determine the proportion of bats vs. birds in surveillance radar data.

*What are the sample sizes for night radar studies?*
Response: The fall studies I summarized today generally were conducted over 45 nights per season, with 6-9 hours of each night monitored. During spring, we typically sample 30-45 nights per season.

Could the variability observed from night to night possibly be attributed to the fact that radar “targets” included both birds and bats? If so, then what level of confidence can be assigned to this data, given uncertain identity of the targets?

Response: Both birds and bats are included in “targets,” with birds being the majority later in the fall season (after early September). Some of the variation in the data could be due to this fact, but it could also be due to a number of other variables. To sort out these variables, it will be necessary to do more visual monitoring to assess the proportion of birds and bats, while concurrently examining the effects of factors such as weather and time of year.

When will the Clipper study be available?26

Response: Results of the radar study of the Clipper Criterion wind site, located along Backbone Ridge north of the Mountaineer site, was originally scheduled to be released to both Clipper Windpower and the public after the facility was operational.

Response [Kevin Rackstraw, Clipper Wind]: These reports are done but have not been released. Clipper followed the lead of the other developer working in Maryland [NedWind] in agreeing to additional studies (although theirs were far less extensive), but stipulating that they would not be made available until after the project was operating. The reason [for this stipulation was] that we didn't believe the [studies] would be appropriate for use in micro-siting turbines. We have long since agreed to release the information (dating back to at least the beginning of this year) but the individual interveners in our permit process, with whom we must have an agreement on the issue for legal reasons related to our settlement agreement with them, have not agreed to allow the data to be released. Their reason appears to be a concern that the data from the NedWind site contradicts their assertions about the site and about bird behavior around the site.

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26 This question refers to a two-season study (Fall 2003 and Spring 2004) using on-site marine radar and acoustic sampling. The Clipper Criterion wind site is located in Maryland, along Backbone Ridge north of the Mountaineer site in West Virginia.