

Bird and Bat Migration over Appalachian Ridges Progress Report, August 2006

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Background and Justification: Interest in developing wind power as an alternative renewable energy source has increased in recent years. Efforts are underway, both nationally and within states, to increase the proportion of electric power generated from wind and other renewable sources, and federal tax incentives are offered to energy companies that develop wind power projects. In the eastern United States, exposed summits or ridge crests in the Appalachian Mountains have high wind power potential, and numerous wind power projects are being developed or proposed. While generally supportive of energy development from renewable sources, the U.S. Fish & Wildlife Service (FWS), state wildlife agencies, non-governmental organizations, and the public are concerned about potential impacts of wind power development on wildlife. Large numbers of birds and bats are believed to follow or cross these landforms during their seasonal migrations, and wind power development potentially could impact populations of several species of concern.

Migratory bats and most migratory songbirds (Order Passeriformes) migrate at night, stopping during daylight hours to rest and forage. Radar studies have shown that nocturnal migrants generally fly at altitudes well above the maximum sweep height of wind turbine rotors (i.e., at $\gg 150$ m above ground level [AGL]), but it is still largely unknown if they maintain those altitudes when crossing or flying along ridgetops, where wind turbines typically are placed, or when weather conditions are poor. Although nocturnal migration is thought to generally occur across a broad front, a study in the northern Appalachians (Williams, T.C., J.M. Williams, P.G. Williams, and P. Stokstad. 2001. Bird migration through a mountain pass studied with high resolution radar, ceilometers, and census. *The Auk* 118: 389-403) found that migrants flying at lower altitudes are sometimes guided by local topography.

Baseline information on nocturnally migrating birds and bats has been collected at some wind power development sites in the Appalachians, generally within a single season. However, a stronger scientific basis is critically needed to assess and mitigate risks at a regional scale. This project, funded in part by the U.S. Geological Survey's FWS Science Support Program, implements a longer-term collaborative regional study of the spatiotemporal distribution patterns and flight characteristics of birds and bats that migrate nocturnally through the Appalachian Mountains of the Mid-Atlantic states (Maryland, Pennsylvania, Virginia, West Virginia).

Objectives: The overall objective of the project is to increase our understanding of the characteristics and dynamics of nocturnal bird and bat migration through the Appalachians, so that informed and scientifically sound recommendations can be made to reduce the risk to migrants of proposed and operational wind power projects.

Specific objectives include:

- 1) Document broad-scale spatiotemporal patterns of nocturnal migration through the Central Appalachians.
- 2) Document site-specific passage rates/densities, flight direction, and flight altitudes of migrating birds and bats during fall and spring at multiple locations in the Appalachian Mountain region of the Mid-Atlantic states.
- 3) Obtain information on the identity and relative abundance at each location of bird species that call while migrating.
- 4) Model the effects of weather, topography, land cover, or other variables on migrant densities and flight characteristics.
- 5) Map observed and predicted migrant densities for the region to identify locations and weather conditions where/when migrants might be at risk from wind power development.

Progress: Work to date has focused on collection and processing of data to assess both broad-scale and site-specific patterns of nocturnal migration through the region.

1. Assessing broad-scale patterns—In FY2005, a Research Work Order was established with Dr. Sarah Mabey, North Carolina State University (now at Sweet Briar College, Sweet Briar, VA), to assess broad-scale patterns of nocturnal migration through the Central Appalachians through analysis of weather surveillance radar (NEXRAD) data from the radar stations that are closest to the study region (Pittsburgh, PA, Charleston, WV, Roanoke, VA, and Knoxville, TN). NEXRAD images for nights during the Fall 2004 and Spring 2005 migrations were screened to identify those with targets that likely are migrating birds. Data have been downloaded and converted to GIS format so they can be overlaid on digital topographic data; topographic blockages to each station's radar beam are being mapped to delineate the geographic areas not covered by radar. Nightly densities and flight directions of migrating birds are being assessed, and used to describe the distribution and movements of migrants as they approach and move through the Appalachians. Although NEXRAD generally does not detect bird or bat targets within the airspace potentially occupied by wind turbines, the data provide information on large-scale spatiotemporal patterns of migration through the region and, possibly, on the response of migrants to mountain ridges or other prominent landforms. If analysis of radar data from these two seasons increases our understanding of regional migration patterns, we will analyze data from additional seasons to assess seasonal variation in migrant movements through the region.

2. Assessing site-specific migration patterns—We are using two methods, acoustic monitoring and portable marine radar sampling, to obtain site-specific information on the abundance and movements of nocturnal migrants at multiple sites in the region.

Acoustic monitoring—During the Fall 2005 and Spring 2006 migration periods, we used acoustical detectors to monitor the passage of migrating birds over 29 sites (Figure 1), recording the calls made by migrating birds in flight to index their abundance. Sites are openings on ridges, knobs, slopes, or valleys, on lands owned by the USDA Forest Service (George Washington and Jefferson National Forests [GWJNF], Monongahela National Forest [MNF]), FWS (Canaan Valley National Wildlife Refuge), the states, or The Nature Conservancy. At each site, an autonomous recording unit (ARU, Figure 2) is placed, and serviced at regular intervals through the season. The microphones can detect and record calls up to about 300 m AGL, the altitudinal zone that potentially could be occupied by wind turbines.

The sound files are being processed and analyzed. First, the night-time segments of the recordings are identified, and then flight calls are detected and extracted, using the XBAT software developed by programmers in the Bioacoustics Research Program, Cornell Laboratory of Ornithology. For each hour of sampling at each site, recorded calls are counted, to document migrant relative abundance within and among nights. When possible, calls are identified to species or species group, by examining call spectrograms and matching them to a reference set (Evans, W.R., and M. O'Brien. 2002. Flight Calls of Migratory Birds: Eastern North American Landbirds. Old Bird, Inc.).

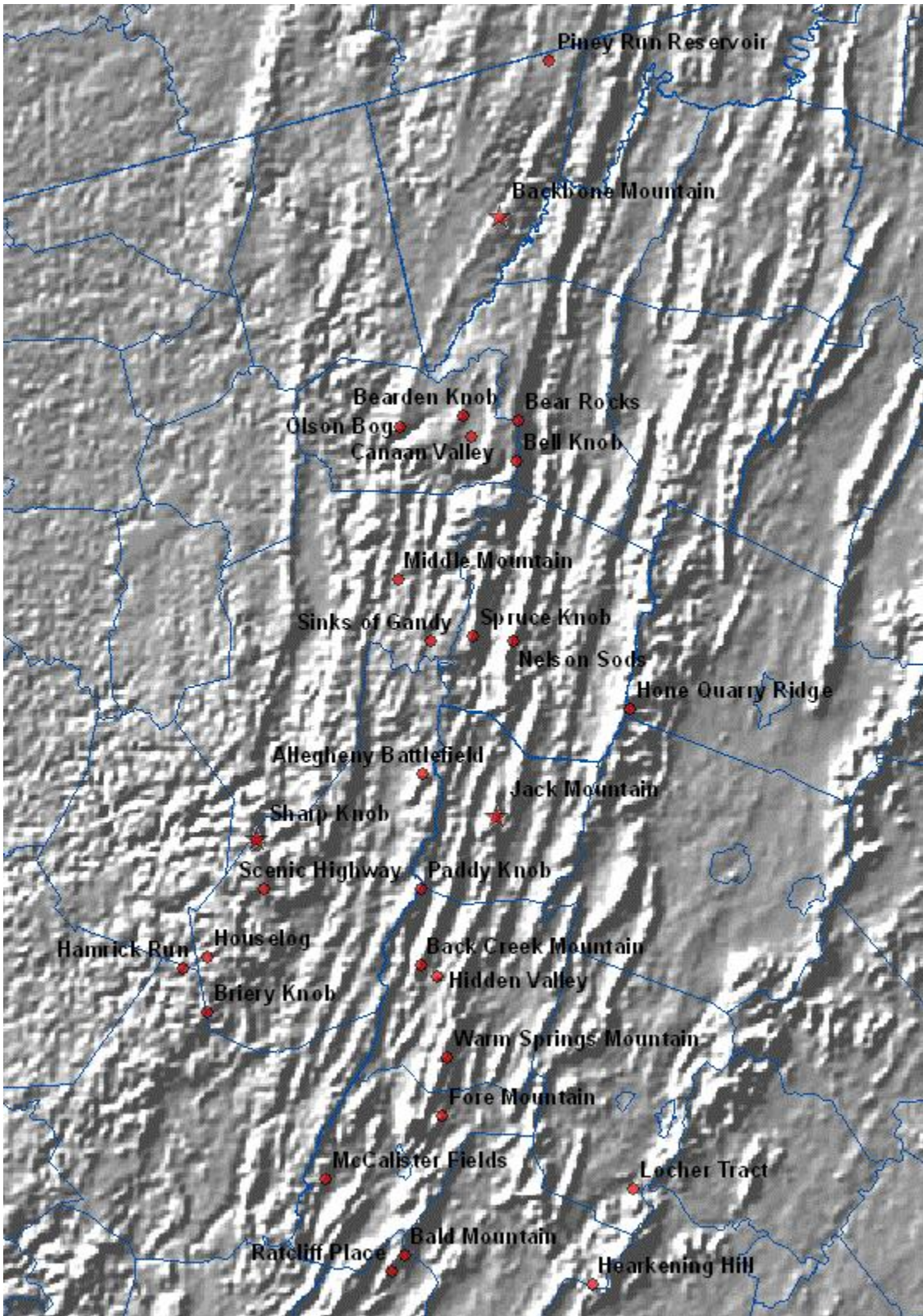


Figure 1. Acoustic monitoring sites in the Central Appalachians. Sites where portable radar sampling is also being conducted are indicated with stars.



Figure 2. Autonomous recording unit (ARU), Allegheny Battlefield, Monongahela National Forest, Pocahontas County, WV. Microphones, two per unit, are nestled in PVC housings covered by shag wind screens. Sounds are recorded onto an mp3 recorder with 100 GB hard drive, housed in a weather-tight access box mounted on a bucket that holds the batteries. Each unit can record continuously for up to 65 days.

Portable radar sampling—In Spring 2006, a Cooperative Agreement was established with New Jersey Audubon Society (NJAS) to sample migrant abundance and flight characteristics with portable marine radar. Radar sampling was conducted at three sites (Backbone Mountain, Potomac State Forest, Garrett County, MD; Jack Mountain, Highland Wildlife Management Area, Highland County, VA; Sharp Knob, MNF, Pocahontas County, WV; Figure 1) where abundance of migrating birds is also being monitored acoustically. The sites selected offered the best radar coverage from among a list of candidate sites developed by USGS/USFWS project co-investigators and biologists from the MNF, MD Department of Natural Resources (MD DNR), and VA Department of Game and Inland Fisheries (VA DGIF). There are no plans to develop wind power at these sites, but wind power projects are proposed on private lands in the vicinity. At each site, radar data were collected on a total of 12 nights, grouped in four 3-night sessions spaced at roughly 1-week intervals between 15 April and 24 May. On each sampling night, data collection started at sunset and continued until approximately sunrise the following morning.

Two X-band marine radars were used (Figure 3), one with antenna mounted in the horizontal plane (surveillance mode) and set to detect targets (birds and/or bats) out to 2.75 km, the other with antenna mounted in the vertical plane to sample the altitudinal distribution of targets up to 1.4 km AGL, encompassing the flight altitudes of most migrating songbirds. Three to five data images are automatically captured and archived every 10 min for every hour the radar is operating.

Data on target position and altitude are extracted for each radar image, using software developed by NJAS staff. The software removes stationary radar reflectors, smoothes the data, locates the centroid of each discrete target that remains, and exports information on each target's position to a text file. Mean target numbers, altitude, speed, and direction are calculated for each hour of sampling. These data are currently being processed and analyzed.



Figure 3. NJAS radar trailer, Highland Wildlife Management Area, Highland Co., VA. The tent houses a generator, which powers the radar and computers.

We view these two sampling methods as complimentary. Acoustic monitoring is easier and less costly to employ in forested or remote locations, but detects only the subset of migrants in the lower airspace that call while in flight. Pairing it with radar, which can detect all migrants passing through the sampled area, allows estimation of the proportion of migrants passing over a site that are detected acoustically, and how that varies with weather conditions and with time of night or season. The acoustic monitoring likewise can inform the radar sampling, providing information on the species

composition of migrants, thus allowing assessment of differences among species or species groups in flight dynamics and behavior, and factors that affect them.

Future Plans:

Fall 2006--ARUs were placed in the field in early to mid August for the fall field season, and will collect data through October. Portable radar sampling started on 16 August, and will continue through about 17 October. Each of the three sites will be sampled on a total of 18 nights, grouped in 3 or 4 days sessions through the season. Plans are also being made to implement visual surveys at one or more sites, concurrent with the radar sampling, to estimate the proportion of targets in the lower airspace that likely are bats, in order to better understand their temporal and spatial distribution patterns, and when and where they might be at risk.

2007 and beyond—Acoustic monitoring will continue during both the spring and fall migrations of 2007, as will portable radar sampling, if additional funding can be obtained. Additional NEXRAD data may be analyzed, pending results of the initial study. Processing of acoustic and radar data will continue, and work also will begin on statistical analysis of the data. Multivariate regression techniques and, possibly, hierarchical analysis will be used to model the effects of weather, site and landscape characteristics, time of night or season, or other variables on migrant density, mean or minimum flight altitude, or mean flight direction. The altitudinal distribution of migrants will be characterized under different migration density scenarios (e.g., low versus high) and weather conditions. Circular statistics will be used to determine mean flight direction relative to each study site and how this is affected by prevailing wind conditions. Together these analyses will allow us to understand flight behavior and dynamics and conditions that modify them.

GIS coverages of migrant density and flight characteristics at the sampling locations will be generated from the field data, and the regression or hierarchical models will be used in ArcGis to map them regionwide as a function of topographic or land cover characteristics. Sampled or modeled density will be summed across dates within seasons to identify locations over which large numbers of migrants pass, or pass at altitudes near or below the maximum sweep height of wind turbine rotors, either consistently or occasionally. This information will be used to develop a summary coverage of areas where the risk of migrant interactions with potential wind power projects is expected to be low, moderate, or high.

Funding and logistical support: USGS is contributing funds for the project over three fiscal years, FY2005 through FY2007. In Fall 2006, the USGS funds will be supplemented by State Wildlife Grant funds from Maryland, Virginia, and West Virginia, directed to NJAS to support portable radar sampling. The MNF and GWJNF have contributed considerable logistical support, through signed memoranda of understanding.

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