

Wind Wildlife Research Meeting VIII

October 19-21, 2010
Lakewood, Colorado

Presentation and Poster Abstracts

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Fatality Impacts to Birds & Bats

Kimberly Bay, WEST, Inc.

Updated Summary of Bird and Bat Fatalities from Wind-Energy Facilities

Kimberly Bay, Wally Erickson, Matt Kesterke (WEST, Inc.)

Research objectives, including hypotheses being tested: The presentation purpose is to provide an updated summary of the number of fatalities of birds and bats at wind-energy facilities from publicly available reports. The summary will provide a cumulative review of the available data. The compilation of this data has allowed for regional and temporal comparisons for both birds and bats. These summaries and comparisons will hopefully shed more light on peak fatality periods and regional differences. A comparison of this size hasn't been available to date.

Abstract: Upon the completion of the construction of most wind-energy facilities, formal bird and bat monitoring (fatality surveys) is conducted by trained consultants and will occur at most sites starting the first year of commercial operations. Typically at least 1 year of post-construction mortality monitoring will occur—more where specified by permit or voluntary agreement, where the first years' monitoring suggests an extraordinary fatality rate and/or where weather conditions are highly variable, substantially affecting migration timing and intensity.

WEST has compiled data from 40+ publicly available post-construction reports from wind-energy facilities across the county and spanning the timeframe of 1996 through early 2009. The data compiled includes general study information, including; county, state, dominant habitat, survey frequency, dates, number of turbines at site and number of turbines searched, and other similar attributes. When possible, we have also compiled actual fatality specific information, including; species, date the fatality was found, turbine/location of the fatality, and as much conditional information that was provided. Specific data was collected on approximately 8,000 fatalities, not all necessarily related to the wind-energy facility.

We will present seasonal and temporal patterns of the mortalities, along with regional comparisons and patterns. We will also summarize species composition, distance from turbine patterns and general habitat patterns. All of the above summaries will be completed for birds, bats, and bird types (i.e. raptors, passerines, etc.)

Regina Bispo, ISPA - Instituto Universitário and CEAUL

A new statistical method and a web-based application for the evaluation of the scavenging removal correction factor

Regina Bispo (Departamento de Estatística, ISPA - Instituto Universitário and CEAUL - Centro de Estatística e Aplicações da Universidade), Gustavo Palminha (Bio3), Joana Bernardino (Bio3), Tiago A. Marques (Centre for Research into Ecological and Environmental Modeling, The Observatory, Buchanan Gardens, St Andrews, Scotland and CEAUL), Dinis Pestana (Departamento de Estatística e Investigação Operacional, Faculdade de Ciências, Universidade and CEAUL)

Research objectives, including hypotheses being tested: The research aims to solve the problem of estimating scavenging rates. We present a new statistical method and a web-based application for modeling data from removal trials and, ultimately, compute the scavenging removal correction factor.

Abstract: In monitoring studies at wind farms, the estimation of bird and bat mortality caused by collision must take into account carcass removal by scavengers. Currently used methods to accommodate mortality estimates for scavenger removal vary greatly. The lack of a reliable scavenging correction factor is mentioned in recent literature (*e.g.*, Kunz *et al* 2007, Arnett *et al* 2008) as an important source of unreliability in the bird and bat mortality estimation. To solve this problem we present a new methodology for the statistical analysis of the time of carcass removal using parametric survival models, assuming four main competing lifetime distributions (exponential, Weibull, log-logistic and log-normal). This methodology avoids reporting findings exclusively on the grounds of empirical estimates using instead statistical models as a consequence of proper comparative goodness of fit analysis regarding diverse plausible models. The method naturally accounts for the presence of censored observations and diminishes bias in scavenging rate estimation.

To help final users in applying the new methodology we present a web-based application that provides an easy-to-use interface for the implementation of the statistical procedure in *R Environment for Statistical Computing*. The application accommodates experimental designs up to four factors, with a maximum of four levels each. It informs about the best model and presents both empirical (Kaplan-Meier) and best fitted model using tabular and graphical displays. Based on the best fitted model, the scavenging removal correction factor is calculated, within the factors levels, for any time interval (time between searches) requested by the user.

We present some application examples using data from trials conducted at Portuguese wind farms. In particular, we show the results from three wind farms regarding both homogeneous models and models accounting for season and carcass size effects.

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Kristen Chodachek, WEST, Inc.

Direct Impacts to Birds and Bats at Four Wind Energy Facilities in Iowa, Minnesota, and South Dakota

Kristen Chodachek, Clayton Derby (WEST, Inc.)

Research objectives, including hypotheses being tested: The efforts that will be reported on were conducted as part of implementing Iberdrola's Avian and Bat Protection Plan (ABPP). The primary objective of the monitoring study was to estimate avian and bat mortality at the sites and determine whether the estimated mortality is lower, similar or higher than the average mortality observed at other

local, regional, and national projects. A secondary objective was to collect information useful in informing siting decisions for future developments.

Abstract: Concern regarding direct impacts to birds and bats from wind energy facilities is a major area of concern for all parties involved in developing, operating, and regulating wind energy facilities. Western EcoSystems Technology, Inc. developed and implemented a standardized survey protocol for implementation at Iberdrola Renewable locations in the central United States. The objectives of the surveys are to estimate avian and bat mortality at the sites and determine whether the estimated mortality is lower, similar or higher than the average mortality observed at other local, regional, and national projects, and to provide information for siting decisions at future developments. Surveys were completed from March 2009 to March 2010 at the Winnebago, Iowa; Elm Creek, Minnesota; Moraine II, Minnesota projects and from May 2009 to May 2010 at the Buffalo Ridge I, South Dakota project. A systematic sample of turbines was taken at each site for two different survey panels. One sample of turbines was searched weekly during spring and fall migration and one sample of turbines was searched monthly for one year. Plot sizes were 200 m by 200 m and centered on the turbine. Croplands around turbines were cleared in a full plot configuration or strips were mowed into the crops to facilitate a higher searcher efficiency. The full 200 m by 200 m plot was searched in grasslands. Searcher efficiency trials and carcasses removal trials were conducted at each site. A minimum of 74 and a maximum of 231 bird carcasses were used for searcher efficiency trials at each project location during the study period. In addition, a minimum of 84 and a maximum of 133 bird carcasses were used for carcass removal trials at each site during the study period. Approximately 8 fresh bat carcasses were used for searcher efficiency trials at the Winnebago, Iowa site. Estimates of facility-related fatalities will be based on the observed number of carcasses found, removal rates as estimated from carcasses removal trials, and searcher efficiency rates. Total estimated bird and bat mortalities will be presented on a per turbine and per megawatt basis for each facilities. These estimates from 2009 and 2010 will be compared to historic studies from Minnesota (Buffalo Ridge), Iowa (Top of Iowa), and other regional facilities.

Caitlin Coberly, Merlin Environmental

A simple a priori risk estimator for wind projects using daytime abundance observations.

Caitlin Coberly (Merlin Environmental), Kelly M. Hogan (USFWS), Kim A. Chapman (Applied Ecological Services)

Abstract: We derive a simple risk index for avian mortality at wind turbine facilities within the central US. This risk index uses the observed bird abundance and impacts at other wind energy facilities to provide a rough *a priori* (initial) estimate of species-specific mortality in proposed wind development areas. By using the observed mortality rates at other wind development areas, this index avoids assumptions regarding birds' observed flight height, activity level, turbine avoidance behavior, or observer detection bias. This index may be useful in selecting between alternate sites or estimating potential impacts to sensitive and protected species before a project is built. The index can be easily updated using Bayesian methods to improve accuracy and species specific or group mortality rates.

The model has been applied to projects in Wyandotte, Michigan. Preliminary model results suggest that this methodology can be used to differentiate between potential wind development sites. Management implications include the ability to differentiate between potential wind development sites, and the potential to predict approximate mortality for trust species. The accuracy of this index should be verified by comparing these mortality estimates against observed post-construction mortality rates.

Steve Grodsky, University of Wisconsin – Madison

Bat Mortality at a Wind Farm in Southeastern Wisconsin (with a special focus on investigating the cause of death for bats killed by wind turbines)

Steve Grodsky (Department of Forest and Wildlife Ecology, University of Wisconsin – Madison), David Drake (Department of Forest and Wildlife Ecology, University of Wisconsin – Madison), Melissa Behr (Wisconsin Veterinary Diagnostic Lab), Andrew Gendler (Wisconsin Veterinary Diagnostic Lab), Nicole Walrath (Wisconsin Veterinary Diagnostic Lab)

Research objectives, including hypotheses being tested: Our research objective was to evaluate potential impacts of a 129 MW windfarm in southeast Wisconsin on bird and bat mortality during a two year study period from the summer and fall of 2008 to the spring of 2010. We aim to further uncover the proximate causes of bat mortality at wind farms by veterinary analysis of dead bats using radiography, histology, and necropsies. We hypothesize that bat fatalities will outnumber bird fatalities and furthermore, that bat mortality at wind farms is more abstract than the distinct differentiation between barotrauma and direct collision alone.

Abstract: This project's objectives centered around furthering the understanding of bat mortality at wind farms by estimating bat mortality numbers at a wind farm in central Wisconsin and determining the cause of death in bats killed by wind turbines. Twenty-nine randomly selected turbines were searched for bat mortality during fall and spring field seasons in the years of 2008 and 2009. Bats found as mortality during the Fall 2009 field season were radiographed, tissue-sampled, and necropsied at the Wisconsin Veterinary Diagnostic Lab to provide empirical data pertaining to cause of death. Bat species found during mortality searches included Little Brown bat (*Myotis lucifugus*), Big Brown bat (*Eptesius fuscus*), Silver-Haired bat (*Lasionycteris noctivigans*), Eastern Red bat (*Lasiurus borealis*), Hoary bat (*Lasiurus cinereus*). Of these species, the "tree bats" (genera *Lasiurus* and *Lasionycteris*) comprised over half of the mortality for the fall and all of the mortality during the spring. Many of the bats showed signs of death by direct collision with turbines, rather than or in addition to barotrauma, based on the extent of skeletal damage shown on radiographs and the necropsy results. Given the relatively high mortality rate of migratory tree bats, mitigation methods including temporarily shutting down night-time operation of wind farms during peak bat migration may be a viable management option. Additionally, proper placement of wind farms using pre-construction bat monitoring data and investigation into acoustic deterrents may help minimize bat mortality at wind farms.

Jeffery Gruver, WEST, Inc.

Using Discriminant Function Analysis and Other Quantitative Techniques to Classify Bat Echolocation Calls

Jeffery Gruver, Shay Howlin, Chris Nations, and Trent McDonald (WEST, Inc.)

Research objectives, including hypotheses being tested: Inability to reliably and consistently identify bat echolocation calls to species may hamper efforts to understand the risks to various species associated with operation of wind energy facilities. We set out to develop quantitative tools to achieve species discrimination for application and assessment of bat risks at proposed and existing wind projects.

Abstract: Modern commercial-scale wind turbines are known to kill bats, and surveys to assess risk prior to construction are generally conducted. Pre-construction surveys at proposed wind energy facilities

generally include the use of passive echolocation monitoring surveys to estimate relative levels of bat activity, a proxy for potential risk. However, risk has not been shown to be equal among species, and the predictive value of this approach has not been conclusively demonstrated, and may be difficult to demonstrate given the typical broad-level classification (high- versus low-frequency) generally produced. In addition, concern over risks to endangered species has spurred renewed interest in a method of reliably and quantitatively determining presence based on echolocation call data. Therefore, a multivariate canonical discriminant function was developed based on 640 echolocation sequences from 11 species of bats, for the purpose of classifying unknown bat call sequences from passively collected Anabat data. Cross-validation for all 11 species, indicated that the model had a correct classification rate of 90%, and ranged from 67% to 99%, depending on species. Results of a bootstrap simulation indicated that for most species, correct classification rates do not improve as the number of pulses per call increases over 5, therefore high-quality sequences with at least 5 good calls are needed. Application of the Discriminant model to real-world data, including assessment of presence/absence of endangered Indiana bat, and relative abundance of species thought to be at risk from wind turbine operation will be presented. Further refinements to the current model may improve overall model and species-specific accuracy. In addition to discriminant function analysis, a neural network approach to species determination will be presented and compared to discriminant classification. Neural networks may provide a better method for discriminating bat echolocation calls, and may be more robust to variability in call quality. The application of both methods will be discussed in the context of analysis of potential and realized risk to bats from wind turbine operations.

Amanda Hale, Texas Christian University

Estimating bird and bat mortality at a wind energy facility in north-central Texas

Amanda M. Hale, Kristopher B. Karsten (Texas Christian University)

Research objectives, including hypotheses being tested: The purpose of our study was to 1) estimate bird and bat mortality at a wind energy facility in Texas - a region that has been under-studied with respect to wind-wildlife interactions; and 2) test how precision (or lack thereof) of searcher and scavenger bias estimates can ultimately impact estimated mortality.

Abstract: Wind power has become the fastest growing source of renewable energy worldwide, and despite its recognized environmental benefits, concerns persist over the potential threats to bird and bat populations. Here, we used results from our first season of mortality monitoring at the Wolf Ridge Wind Energy Center in north-central Texas to estimate bird and bat mortality. At the same time, we also tested how precision in searcher efficiency and scavenger removal rates can ultimately influence estimated mortality. The Wolf Ridge Wind Energy Facility, owned and operated by NextEra Energy Resources, began operations in October 2008 and consists of 75 1.5-MW GE turbines extended over 48 km² within the cross timbers and prairies ecoregion of Texas. The landscape is diverse; consisting of shrub-woodlands and agricultural lands used primarily for cattle grazing, hay fields, and winter wheat. From 26 March to 30 October 2009, we conducted systematic mortality searches at a subset of the wind turbines. During this time period we found 100 bird carcasses representing more than 30 species. We also found 458 bat carcasses representing 5 species, the majority of which were eastern red bats (*Lasiurus borealis*) and hoary bats (*L. cinereus*). Bird fatalities were equally likely to occur across the months of our study; however in contrast, the vast majority of bat fatalities occurred between mid-July and mid-September which coincides with the fall migration season for North American tree bats. Searcher efficiency varied by carcass type with a greater proportion of larger carcasses detected compared to smaller carcasses. Scavenger removal rates varied by season and by carcass type; carcass

substitutes (i.e., mice and commercially available game birds) were removed at significantly higher rates than were bats and birds killed on site. We applied three different mortality estimators to our dataset, and not surprisingly, we obtained three different estimates. Regardless of method, however, our estimates of bird and bat mortality were toward the high end of values reported in other studies. Our data indicate that investing in robust sample sizes for searcher and scavenger efficiency trials can significantly improve precision of mortality estimates. We also caution that using carcass substitutes may lead to upward biased estimates of mortality. Obtaining accurate and reliable estimates of mortality is necessary to compare mortality across sites, understand impacts on populations, explore relationships between pre-construction activity and post-construction mortality, and test the effectiveness of curtailment experiments, deterrents, or other mitigation practices.

Benjamin Hale, Missouri State University

A new method for reliable and repeatable searcher efficiency for post-construction mortality surveys at wind energy locations

Benjamin T. Hale, David S. Joswick, Lynn W. Robbins (Missouri State University)

Research objectives, including hypotheses being tested: The Objective: To develop a method of carcass searching that is repeatable and unbiased

Hypothesis: Mechanical searcher efficiency is more reliable, repeatable and cost efficient than human searcher efficiency

Abstract: Wind turbines are a fast growing source of sustainable energy. Unfortunately, large numbers of bats have been killed at wind turbine locations due to blade impact and extreme pressure changes (barotrauma). The National Fish and Wildlife Service recommends that wind energy companies develop a Habitat Conservation Plan to minimize the effects of turbine construction and operation on bats, specifically the endangered Indiana bat, *Myotis sodalis*. To do this, a wind company conducts pre-construction surveys of existing bat populations. Following construction, post-construction surveys are necessary to assess the effectiveness of the Habitat Conservation Plan. As part of this, mortality searches must be conducted to estimate fatalities in project areas. Currently, the most widely used method for mortality estimates is based on human searches, which has a searcher efficiency as low as 25% and is highly variable. This project tests a modified agricultural machine for its ability to pick up, or “search” for bat carcasses in the vegetation. Formalin-prepared bat carcasses were randomly placed in transects across varying vegetation heights (2 trials at each grass height = 4.5, 6, and 8 inches). Searcher efficiency was the greatest (80%) in the lowest vegetation (4.5 inches). Twenty repeated transect-trials in a vegetation height of 4.5 inches resulted in a searcher efficiency of 81% with a low variance between trials (0.011). Without reliable searcher efficiency, effects of turbine construction cannot be accurately and efficiently assessed and therefore types and level of turbine mitigation cannot be accurately determined. These data indicate that carcass searching using machines reduces variability due to human bias and allows for a repeatable and more scientific approach to mortality surveys.

Kevin Heist, University of Minnesota

Predicting Bird and Bat Fatality Risk at Prospective Wind Farm Sites Using Acoustic-Ultrasonic Recorders

Kevin Heist (University of Minnesota), Douglas H. Johnson, PhD (USGS Northern Prairie Wildlife Research Center)

Research objectives, including hypotheses being tested:

- 1) Evaluate the ability of a dual acoustic-ultrasonic recorder to capture nocturnal calls of birds and bats at current and potential wind power sites.
- 2) Relate nocturnal call activity for birds and bats to results of fatality searches at operational wind farms. Our hypothesis is that the number of fatalities found per search interval will be correlated with the number of calls recorded during that search interval.
- 3) Evaluate whether call activity varies in relation to prominent landscape features. We will test the hypothesis that nightly call counts vary in predictable relations to specified physiographic and landscape features.

Abstract: We are using Wildlife Acoustics' acoustic-ultrasonic recorders to simultaneously detect bird and bat calls. Recording takes place nightly between sunset and sunrise, and Wildlife Acoustics analysis software is being used to extract call files from the recording data. Calls are catalogued by date and location for use in the other analyses. The success of this process will allow us to address objective 1.

Recorders have been set out in two scenarios, 1) at operating wind farms where fatality searches are being conducted independently of this study, and 2) across varied landscapes in southwestern Minnesota.

Wind Farms: We are collecting data at one facility in Iowa and one in Texas. Three recorders are set up at each facility, and recordings are taken nightly during the season(s) that fatality searches are being conducted. Nocturnal calls are counted and will be compared to fatality counts for the corresponding search interval. A regression of fatalities on call count will likely be used to address objective 2. If we are able to observe a consistent relationship between calls and fatalities across sites, we may be able to specify a predictive model for estimating fatality levels at prospective sites based on pre-construction observations with these recorders.

Landscape: Among the cropland of southwestern Minnesota, we have identified 4 migratory resource corridors: a forested river valley, a wetland chain, and two tallgrass prairie preserves. Recorders have been deployed to measure nocturnal call activity at the edge of each resource, and at 500m, 1,500m, and 5,000m east or west of each resource during spring and fall migration. We will examine differences in call rates between and within distance categories using ANOVA, and use regression to look at trends in grouped call rates at varying distances, assuming the effect of distance to be the same at all resource areas. If we find landscape-dependent patterns, and objective 2 is also met, we may be able to examine how fatality potential varies relative to certain landscape features in this region.

If successful, this study could provide managers with a standard, affordable, modular method for measuring nocturnal activity and predicting bird and bat fatalities at prospective wind farm sites.

Data collection at most sites began in March 2010 and we plan to collect 3 years of data. Preliminary findings from the first season will be available at the time of the meeting.

Manuela Huso, Oregon State University

Modeling the relationship of wildlife fatality to daily weather or activity patterns: Statistical design and implementation issues

Manuela Huso (Oregon State University)

Research objectives, including hypotheses being tested: Informed statistical analysis

Abstract: Models relating bird and bat fatality to easily measured weather and/or activity variables may reveal ways to efficiently apply curtailment or deterrent measures at minimum cost. The models themselves are often fairly simple general or generalized linear models, however the variables used to estimate model parameters must be very carefully measured and not all collected data will be applicable to these models. The fact that fatalities are incompletely observed leads to conditions that do not fit classic statistics text book examples. I describe several issues that arise when developing these models: establishing the appropriate observational unit of the study, determining the appropriate set of carcasses to include in the model, determining the 'weight' associated with each carcass, etc. I present the final results of models that address the issues listed above, and relate fatality to bat activity at Casselman, PA. As more data are collected at wind farms throughout the world, we will have expanded opportunity to fine tune our understanding of the impacts of wind energy developments on wildlife, if we apply statistical models appropriate to the unique conditions involved.

Greg Johnson, WEST, Inc.

Relationships between bat fatality and weather, marine radar, Anabat, and night vision data at a wind energy facility in the Midwest

Greg Johnson, Wallace Erickson, Donald Solick, Chris Nations, Jason Ritzert, Michelle Sonnenberg, and Kimberly Bay (WEST, Inc.)

Research objectives, including hypotheses being tested: Objectives of the study were to quantify bat fatality, determine if there are any relationships between bat fatality and weather data, and to determine relationships between bat fatality and bat activity metrics determined through use of marine radar and bat acoustical studies for possible use in predicting or mitigating bat fatality. The hypotheses tested was that there is no relationship between bat fatality and weather, or between bat fatality and concurrent data on bat activity as determined through use of marine radar and bat acoustical studies.

Abstract: From August 1 – October 15, 2009, we conducted a study to quantify bat fatality, determine relationships between bat fatality and weather, and determine relationships between bat fatality and bat activity metrics determined from marine radar and Anabat studies for possible use in predicting or mitigating bat fatality. Night vision surveys were also conducted to determine proportions of radar targets comprised of birds and bats. The facility had 240 1.65-MW wind turbines sited in a corn and soybean agroecosystem in McLean County, Illinois. Thirty-nine turbines were selected for sampling, and an 80 X 80 m square plot around each turbine was cleared of vegetation prior to the study. Half the turbines were searched daily and half were searched weekly for bat fatalities. Scavenger removal and searcher efficiency studies were conducted to measure biases. Marine radar stations were established at two turbine locations, and each had coverage of 4-5 other turbines searched daily. Anabat units were placed on the turbine nacelle and at the base of these same turbines, and night vision studies were conducted in conjunction with the radar and Anabat studies. Six additional Anabat units were placed at other turbines. The estimated bat fatality rate was moderate compared to other facilities in the

Midwest, with migratory tree bats comprising 98.7% of casualties. Bat fatality rates were relatively well-correlated ($R^2 = 0.63$) with bat activity levels at raised Anabats but not ground stations ($R^2 = 0.24$). There was a weak positive relationship between bat fatality and horizontal mode passage rates from marine radar data, and a weak negative relationship for target airspeed. The majority (51.3%) of targets identified during night vision surveys were bats, 27.8% were birds, and 20.9% were unidentified. Most targets (88.0%) did not show any obvious reaction to wind turbines, 6.0% altered course, and 2.1% inspected a turbine; two targets (0.8%) were observed to collide with a turbine. Our results suggest that bat activity levels from raised Anabat units were more correlated with bat fatality than marine radar data, and that Anabats raised on turbines were more closely related to bat fatality rates than bat activity levels determined on the ground. Bat fatality rates increased as mean nightly temperatures increased and during low wind speeds. These final study results provide data useful for designing pre-construction bat risk assessment studies and developing measures to mitigate bat fatality at wind projects.

Dave Johnston, H. T. Harvey & Associates

Migratory flight patterns and movement of birds and bats in relation to observed mortality at wind energy facilities in the Montezuma Hills, California

D.S. Johnston, J.A. Howell, J.H. Castle, N. Thorngate, D.P. Newman, S.B. Terrill (H. T. Harvey & Associates), T.J. Mabee (ABR Inc.)

Research objectives, including hypotheses being tested: Our first objective is to evaluate simultaneous use of radar, night vision and acoustic detection of bats and nocturnal birds at two wind facilities. We then correlate these measurements with direct mortality and other environmental factors. Our secondary objective is to explore relationships between bird and bat mortality, and their movement, and the meteorological, landscape, and vegetation features of the study area.

Abstract: Many studies have documented bird and bat mortality around wind turbines using carcass surveys, while others have examined migratory movements using radar and/or night vision devices. We present year one of a unique two-year study examining the relationship between migratory movements and mortalities of birds and bats near turbines, using concurrent radar, night vision, acoustic monitoring, and mortality surveys. To quantify this relationship we selected $n = 48$ 1.5 and 1.8 megawatt turbines at two sites near Fairfield, CA. We sampled using a marine radar and night-vision optics ($n = 40$ nights), and acoustic monitoring stations equipped with Avisoft software ($n = 8$ stations for birds and bats). We conducted mortality surveys ($n = 38$) the morning after each radar survey. During year one, the number of migrating birds detected by radar and acoustic monitoring was orders of magnitude greater than the small number of migratory bird ($n = 7$) and bat ($n = 12$) carcasses found. Carcass detection bias, which was measured using a conservative estimator ($n = 5$), was 36.7%. This study provides a framework for determining the number of birds and bats killed as a function of overall migration passage rate through wind energy facilities.

Patrick Kolar, Boise State University

Mortality of Fledgling Hawks at Wind Projects

Patrick Kolar, Marc Bechard (Boise State University)

Abstract: Hawks nesting in close proximity to wind farms may experience high rates of fledgling mortality as young hawks are learning to fly and to forage in habitats in the vicinity of nest sites. In

2010, we began a two-year study aimed at better documenting the severity of this type of mortality. When nestling hawks had reached 80% of fledging age, we equipped 30 nestling hawks with standard FM radio transmitters fitted with mortality switches and tracked their movements from the time of fledging until the young hawks dispersed from their natal areas. Preliminary results from the first year of this study will be presented and the potential threat of fledgling mortality when hawks nest in close proximity to wind turbines will be discussed.

Ellen Lance, Anchorage Fish and Wildlife Field Office

Who Ran Off With My Data? Estimating carcass persistence and scavenging bias in a human-influenced landscape in western Alaska

Paul L. Flint (U. S. Geological Survey, Alaska Science Center), Ellen W. Lance (Endangered Species Branch, Anchorage Fish and Wildlife Field Office), Kristine M. Sowl (U. S. Fish and Wildlife Service, Yukon Delta National Wildlife Refuge), and Tyrone F. Donnelly (U. S. Geological Survey, Alaska Science Center)

Research objectives, including hypotheses being tested: Our objectives were to assess carcass removal rates by scavengers and to test hypotheses regarding variation in carcass persistence in relation to season, carcass age, carcass size, and distance from existing structures.

Abstract: We examined variation in persistence rates of waterfowl carcasses placed along a series of transects in tundra habitats in western Alaska. This study was designed to assess the effects of existing tower structures and was replicated with separate trials in winter, summer and fall as both the resident avian population and the suite of potential scavengers varied seasonally. Carcass persistence rates were uniformly low, with <50% of carcasses persisting for more than a day on average. Persistence rate varied by carcass age, carcass size, among transects and was lowest in the fall and highest in the summer. We found little support for models where persistence varied in relation to the presence of tower structures. We interpret this as evidence that scavengers were not habituated to searching for carcasses near these structures. Our data demonstrate that only a small fraction of bird carcasses are likely to persist between searches, and if not appropriately accounted for, scavenging bias could significantly influence bird mortality estimates. The variation that we documented suggests that persistence rates should not be extrapolated among tower locations or across time periods as the variation in carcass persistence will result in biased estimates of total bird strike mortality.

Ronald Larkin, Illinois Natural History Survey

Are flying wildlife attracted to (or do they avoid) wind turbines?

Ronald P. Larkin (Illinois Natural History Survey, University of Illinois)

Research objectives, including hypotheses being tested: Provide information essential to a risk assessment framework for flying wildlife, namely determining if night-flying wildlife actively fly toward wind turbines (or away from them) from a distance, using natural post-construction observations with instrumentation tracking radar.

Abstract: Quantifying risk posed by commercial-scale wind turbines to flying wildlife has heretofore been impossible because the region of airspace and therefore the number of exposed animals has been unknown. If bats and birds are drawn in to turbines from a distance, horizontally or vertically, the exposed statistical population is much more numerous, and the converse is true for wildlife that may

avoid turbines. To address this critical question, the present study documents the paths of wildlife flying toward wind turbines (and “control” ones not flying toward turbines) in three dimensions. An X-band tracking radar, the only such instrument known to be available for civilian research in North America, followed individual flying bats and birds up to about 3 km maximum range, with accuracy of a few meters at shorter range. Statistical analysis of deviations from straightness of track and constancy of flight speed is broken down by type of target (bird, probable bat, unknown). Reactions are analyzed similar to previous published research by the author on natural sounds, artificial lights, and ELF emissions. Data are presented from 949 radar tracks recorded in August 2009 at a site in rolling land in the Alleghenies at Casselman, Pennsylvania. Similar (preliminary) data will be presented from planned summer 2010 field work from exceedingly flat locations in west-central Illinois. Each site featured a single turbine north of any other turbines so that it could be singled out for study. Avoidance of turbines was quite clear in many cases and attraction was also evident. But interpreting data on vertical reactions to turbines over the topographically-non-ideal Pennsylvania site was complicated because often the influence of orographic air motion could not be ruled out when seasonally-favorable winds for migration occurred. The Illinois site is quite flat and free of such orographic confounding. During this study the radar also documented extraordinary long, nonlinear tracks of high-flying animals that do not appear to be related to wind turbines but appear to represent an unknown biological phenomenon. The work is supported by the US Department of Energy and the 2009 field work coordinated with Bat Conservation International.

Miguel Mascarenhas, Bio3, Lda.

Improvement of bird and bat carcasses detection on wind farms using wildlife research dogs

João Paula, Miguel Costa Leal, Maria João Silva, Hugo Costa, Miguel Mascarenhas (Bio3 – Estudos e Projectos em Biologia e Valorização de Recursos Naturais, Lda.), Ramiro Mascarenhas (INRB/INIA-URGRMA)

Research objectives, including hypotheses being tested: The main objective of the research to present was to assess the use of dogs for bird and bat carcass searches in real field surveys. In this view, the following hypotheses were addressed: (1) dogs are more accurate than humans to detect bird and bat carcasses under different vegetation conditions, and (2) carcass decomposition, weather conditions (temperature and wind speed) and distance to the target affects the search accuracy and efficiency of the working dog.

Abstract: Management of avian populations near anthropogenic infrastructures, specifically wind farms, has been hampered due to biased bird fatalities estimates. Currently, these estimations are based on field surveys performed by humans, which is a method with low efficiency and accuracy. Detection dogs have been used for decades to assist humans and its use for wildlife surveys is of increasing interest to scientists and wildlife managers. To address the question of whether dogs could be used instead of humans for bird carcass searches the following hypothesis were tested: (1) dogs are more accurate than humans to detect bird and bat carcasses under different vegetation conditions, and (2) carcass decomposition, weather conditions (temperature and wind speed) and distance to the target affects the search accuracy and efficiency of the working dog. A human team and a trained dog were used to perform the field trials at Serra de Candeeiros wind farm (Portugal). Accuracy results were statistically tested using Kruskal-Wallis variance test and contingency table analysis while generalized linear models (GLM) were used to analyze dog’s efficiency. Results indicated that dogs are more accurate than humans, independently of vegetation density. Furthermore, carcass decomposition condition, distances to the carcass and weather conditions have shown to affect dog’s efficiency. Despite significant, the

observed effects were reflected in a reduced time scale. Results demonstrate the usefulness of using dogs during field surveys to improve bird-strike mortality estimates at wind farms and other anthropogenic structures that cause bird fatalities worldwide.

Roel May, Norwegian Institute for Nature Research

Spatio-temporal assessment of white-tailed eagle collision risk at the Smøla onshore wind-power plant in central Norway

Roel May, Torgeir Nygård, Ole Reitan, Espen Lie Dahl, Kjetil Bevanger, Frank Hanssen (Norwegian Institute for Nature Research), Steinar Engen (Norwegian University of Science and Technology, Department of Mathematical Sciences)

Research objectives, including hypotheses being tested: The objective of this study was to construct methodology to assess collision risk and avoidance in white-tailed eagles with respect to wind turbines based on their movement patterns.

Abstract: Energy from renewable sources has become increasingly important as part of energy policies worldwide. Energy and environmental management authorities, and the energy industry, have stressed the need for additional knowledge about environmental impacts of wind turbines. Impacts may be due to direct collision mortality caused by wind turbines, which in turn may be mediated by avoidance behavior. Since 2005, 36 white-tailed eagles (*Haliaeetus albicilla*) have collided with wind turbines at the Smøla on-shore wind-power plant in central Norway. In this study we constructed a statistical simulation model using Brownian bridge methodology for estimating collision risk rates. The model was based on three-dimensional GPS telemetry data from 27 sub-adult eagles equipped with backpack transmitters (September 2005 – May 2010). As this model does not yet include effects of avoidance, we further assessed avoidance behavior in white-tailed eagles. Probability of avoidance as a function of distance from wind turbines was assessed using discrete choice models based on eagle movements from avian radar employed within the wind-power plant. Eagles showed clear seasonal patterns in collision risk rates. Although the proximity to wind turbines mediated eagle movements, the avoidance rates of single wind turbines were limited compared to earlier published rates. Our results may provide industry and management authorities with new tools for assessing the extent of collision risks of wind energy structures.

Sílvia Mesquita, Bio3, Lda.

Bird and Bat Mortality Data in Portuguese Wind Farms – A Cumulative Analysis of 5 Years of Monitoring Surveys

Joana Bernardino, Sílvia Mesquita, Teresa Marques, Ana Cordeiro, Margarida Silva, Miguel Mascarenhas, Hugo Costa (Bio3 – Estudos e Projectos em Biologia e Valorização de Recursos Naturais, Lda.)

Research objectives, including hypotheses being tested: Evaluate mortality data from 17 wind farms post-construction monitoring programs in order to determine patterns of bird and bat fatalities in Portugal mainland.

Abstract: Since 2005 Bio3 has been monitoring fauna and flora communities in Portuguese wind farms by implementing BACI studies design. In this presentation we intend to focus on the mortality data obtained during the post-construction monitoring programs in 17 wind farms distributed along

Portuguese mainland. The mortality data was analyzed to establish which species are the most affected, which are the threatened species affected, how do the mortality events of such species are related to the habitat present in wind farms and what time of the year is particularly important for these events. 161 bird mortality records were registered and Northern House-martin (*Delichon urbica*) is the most common species found dead on a circle of 50 meter radius centered on the turbine (39 carcasses found, 24%). Mortality records of Eurasian Skylark (*Alauda arvensis*) and Common Kestrel (*Falco tinnunculus*) were also common (15 carcasses of each species, 9,3%). Common Kestrel is, in fact, the most common raptor found dead in our monitoring programs; however the mortality records were mainly gathered in 2 wind farms in a mountain region in the Centre of Portugal. The only threatened bird species found dead was Montagu's Harrier (*Circus pygargus*), however it represents 4,4% of the mortality records (7 carcasses found). This species is in a continuous decline in Portugal which led to its endangered status in the Portuguese Vertebrate Red List. The mortality records of this species appear to be specially associated to its reproduction habitat.

The bat mortality is less representative (29 records) as the post-construction monitoring programs occurred only in the last 2 years (2008 and 2009) and only in 5 wind farms. None of the species found dead are threatened but 2 of them are data deficient according to the Portuguese Vertebrate Red List, Lesser Noctule (*Nyctalus leisleri*) and Giant Noctule (*Nyctalus lasiopterus*). The most common species found dead around a circle of 50 meter radius around the turbine were Lesser Noctule and Common Pipistrelle (*Pipistrellus pipistrellus*), both with 6 records (20,7%).

This analysis will allow a better understanding of bird and bat patterns of mortality in Portugal and therefore contribute to more comprehensive environmental impact assessments. It will also be an important contribution to the design of more adequate monitoring programs in wind farms.

Trevor Peterson, Stantec Consulting

Combining Technologies to Assess Potential Impacts to Mexican Free-tailed Bats in Central Texas

Trevor Peterson, Kristen Watrous, Steve Pelletier (Stantec Consulting)

Research objectives, including hypotheses being tested: This study aimed to document movement patterns of Mexican free-tailed bats near a proposed wind project using multiple technologies (acoustic, X-band marine radar, and regional NEXRAD imagery) simultaneously. Research objectives included an evaluation of which technology was most suitable for monitoring the bats, whether simultaneous operation of survey techniques was required, and what types of data could be obtained that would be useful for predicting and potentially avoiding impacts.

Abstract: Mexican free-tailed bats (*Tadarida brasiliensis*), identified as a species prone to collision with wind turbines, occur by the millions in numerous caves in certain regions of Texas poised for wind development. These bats are known to fly large distances on a nightly basis, although their flight patterns have proven difficult to study. Stantec designed and conducted an innovative series of field surveys at a proposed wind project in Texas during 2009 in which data from regional weather radar, on-site X-band marine radar, and acoustic bat detectors were combined to characterize flight patterns of free-tailed bats. Whereas each type of technology has been used extensively in pre-construction ecological assessments, each operates on a very different scale and, therefore, has limited applicability considered on its own. However, when conducted simultaneously, surveys using these technologies helped to both characterize activity patterns of bats on a small scale within the proposed development site as well as on a regional level. The survey represents one of the first studies of its kind and the results

further our understanding of the factors that may lead to collision with wind turbines. Ultimately, this type of data could enable wind developers and natural resource agencies to predict, mitigate, or avoid collision mortality efficiently, providing a more refined method for overcoming the hurdles continuing to stumble wind development from making greater forward-moving strides.

Shannon Romeling, Missouri State University

*Analysis of the Effects of Take on the Indiana Bat (*Myotis sodalis*) Population at a Proposed Wind Energy Facility*

Shannon E. Romeling, Lynn W. Robbins (MSU), C. Ryan Allen (UMKC)

Research objectives, including hypotheses being tested: The Objective: To thoroughly analyze the potential effects of incidental Take on the Indiana bat population that is utilizing the habitat within a proposed wind farm.

Hypothesis: The potential impact of wind turbine mortality on a population of Indiana bats can be assessed using Lefkovitch Matrix Models to produce a variety of potential outcomes.

Abstract: In 2009, a mist netting and radio telemetry study at a proposed wind farm determined the presence of a minimum number of female Indiana bats (*Myotis sodalis*) during maternity roost exit counts within the project area. Methods for determining the amount of Indiana bat Take allowable to develop an Incidental Take Permit (ITP) are still in their beginning phases. Take is defined by the U.S. Fish and Wildlife Service as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect any threatened or endangered species. We examined a method of estimating the long term effects of Take on a population of Indiana bats using the little brown bat (*Myotis lucifugus*) as a surrogate for estimating Take possibilities and Lefkovitch Matrix Models for estimating population growth rates. Jain 2005 demonstrated a 54.5% decrease in mortality of little brown bats versus activity. Using this number and estimated yearly average Take numbers from three geographically similar wind farms and the average of the Take at the three sites, estimated Indiana bat potential mortality numbers at the proposed site were calculated. Three sets of demographic information were used to produce a range of potential growth rates of the Indiana bat population. These three growth rates (1.004, 1.07, 1.14) along with four potential Take numbers and zero Take were used in effect analyses to estimate 540 scenarios. The effect analysis equation estimated the population size over 30 years (the projected lifespan of a wind farm) using the different growth rates and took into account percent dependent young, additive mortality and recruitment (the number of female juveniles that return the following year). Of the 432 scenarios involving Take, 75% resulted in reduction in size or extinction of the colony over a 30 year period. Assuming this is a viable population, the results of zero Take showed that this population has growth rate and recruitment values above the line $Y = -330.97X + 431.24$, $R^2 = 0.999$. The methods used to conduct effect analyses and the resulting information gained is a repeatable method that can be used in the ITP process to make the best possible decision for the future of an endangered population.

Jerry Roppe, Iberdrola Renewables

Evaluation of Operations Personnel for Long-term Monitoring of Bird and Bat Fatalities

Jerry A. Roppe (Iberdrola Renewables), Wally Erickson, Clayton Derby (WEST Inc.)

Research objectives, including hypotheses being tested: To determine detection levels of bird and bat fatalities by operations personnel and assess application to long-term monitoring

Abstract: Iberdrola Renewables, Inc. (IBR) is implementing a Wildlife Monitoring and Reporting System (WMRS), as part of the corporate Avian and Bat Protection Plan (ABPP) to systematically survey post-construction bird and bat fatalities by using a designated onsite Environmental Coordinator (EC). A goal of the program is to use operations personnel to implement an acceptable method for measuring long-term operational impacts to birds and bats from wind energy facilities. A key factor on validity of method is determining the ability of operations personnel to detect bird or bat carcasses. Detection testing (searcher efficiency trials) was conducted to evaluate the efficacy of EC (operations personnel) to detect fatalities at the 4 test sites in Iowa, Oregon, Pennsylvania, and Texas. All the ECs received specific desktop and field training on conducting systematic searches along transects (access roads and turbine pads) at turbines selected for survey. Three to seven days of “blind” testing were done at the test sites between March and September with a consulting biologist dropping carcasses for the EC. A total of 18 to 47 carcasses were placed at search turbines. Detection levels were calculated for each EC based on the total number of carcasses and reported with descriptive statistics. The ECs found 105 of 139 carcasses for an overall detection level for all carcasses of 76% with variation from 65% to 89% at the four test sites. In addition to detection levels, reviews of field processing of carcasses and data entries indicated conformance to procedures.

Long-term monitoring of bird and bat fatalities by operations personnel provides a potential cost-effective approach to monitoring project impacts. Based on the high detection levels and conformance to survey protocols, the use of trained onsite personnel presents a valid option for long-term monitoring of post- construction bird and bat fatalities. Implications from the testing included the following:

- Visually unobstructed search areas (graveled access roads) aided detection and safety.
- Use of access roads may introduce biases such as road kills and vehicle collisions versus turbine strikes.
- Proper training, tools, and equipment are essential for operation personnel understanding and acceptance to operational monitoring.
- Ongoing training and audits need to be conducted to ensure conformance to WMRS protocol and confirm validity of approach.
- The Environmental Coordinator trained in bird and bat fatality monitoring also provides a potential onsite resource for other wildlife and environmental aspects for a project.

Michelle Sonnenberg, WEST, Inc.

Evaluation of Precision, Accuracy, and Cost of Fatality Estimation at Wind Facilities Following State and Federal Guidelines versus Other Monitoring Protocol

Michelle Sonnenberg, Wallace Erickson (WEST, Inc.)

Research objectives, including hypotheses being tested: The objective of this simulation study was to determine what precision and accuracy for fatality estimates can be obtained using various fatality monitoring protocols. We hypothesized that the precision and accuracy necessary for answering basic questions is attainable using less effort and cost than protocols required by agency guidelines.

Abstract: Due to concerns about fatality rates at wind energy facilities, fatality monitoring guidelines have been put in place by both state and federal agencies. These guidelines recommend specific carcass

search effort and trial effort for study components such as carcass persistence and searcher efficiency trials. However, depending on the conditions and objectives of the study, agency guidelines may require more effort and expense than is necessary to achieve the desired level of accuracy and precision for answering the most basic questions. To investigate this claim, simulations were conducted using various carcass persistence times, searcher efficiency rates, levels of fatality, search pattern designs, and sample sizes for carcass removal and searcher efficiency trials. Based on parameter combinations, simulated fatality studies were conducted and the resulting fatality estimates calculated. The coefficient of variation and expected confidence interval width was then used to compare levels of precision between estimates with different search patterns and parameter sets. For each scenario, cost of implementation was also examined. In general, while the design with daily searches on all turbines always gives the most precise estimate, depending on conditions, similar precision can be achieved with greatly reduced effort. For studies with basic objectives, acceptable levels of precision may be obtained with significantly reduced cost and effort compared to what is required to meet agency guidelines. Results of this analysis can be used to determine the most suitable study design at a particular site with estimable parameters.

David Tidhar, WEST, Inc.

Pre-construction nocturnal marine radar studies – what have they taught us about impact assessments?

David Tidhar, Chris Nations, David P. Young (WEST Inc.)

Research objectives, including hypotheses being tested: The primary objective of the research is to compare pre-construction nocturnal marine radar survey data collected as part of pre-construction risk assessment studies with post-construction fatality monitoring studies that provide actual measures of impact. Do pre- and post-construction data show that impacts to nocturnal migrant birds from wind turbines is as great as commonly believed and do these studies add value to pre-construction risk assessments? Objectives from this talk are support of a wind-wildlife study strategy that benefits from the wealth of information available from preceding studies. The work reported here provides a resource to industry and agencies supporting an approach to wind-wildlife studies that focuses on issues of concern rather than repeating studies when the outcome is nearly certain.

Abstract: Many studies of wind resource areas in the U.S. have included marine radar surveys for nocturnally migrating wildlife. Results of most radar studies have provided consistent values for metrics that are believed to be related to risk, such as flight altitudes, passage rates and flight directions. Between 2006 -2009 several wind projects have been constructed and monitored where pre-construction radar studies were conducted. The authors present fatality results from post-construction monitoring studies and examine the association between seasonal estimates bird use and fatality patterns. Analysis is presented from linear and non-linear linear models applied to seasonal radar studies and fatality estimates. Preliminary results of this study corroborate the pre-construction assessments of low impact to nocturnal migrant birds from wind turbines. Results suggest that impacts may be correlated with radar metrics such as passage rate and ratio of targets in the zone of risk, but that overall impacts to nocturnal migrant birds from wind turbines is relatively small. The analysis suggests that impact to nocturnal migrant birds from wind turbines, a portion of the total impact, is to individuals and are not biologically significant.

Rafael Villegas-Patracá, Instituto de Ecología AC

Poisson regression for count data: application to bird and bat mortality at the wind farm La Venta II, Oaxaca, Mexico

Rafael Villegas-Patracá, Marissa Mora Acosta, Clara Elena Pérez Sánchez (Instituto de Ecología AC)

Abstract: Wind power production is a fast growing source of renewable energy worldwide. Wind energy development can have ecological impacts, such as the increase of bird and bat fatalities through collision with the structures built at wind energy installations (e.g. turbines, rotors, towers). The wind farm La Venta II is located on one of the most important bird migration routes; therefore, the effects of the wind energy facility on bird populations and diversity are expected during the migration season. Birds fly at lower altitudes due to unfavorable weather conditions, especially at night, which is likely to increase the risk of collision. The number of bat fatalities has increased in the wind farm, but the causes of collisions are unknown. Identifying the factors associated with bird and bat turbine-related mortality is crucial to understand the effects of wind farms on their populations. In this study, counts of bird and bat collisions were obtained from field carcass searches and analyzed using a generalized linear model (GLM). Poisson regression belongs to the GLM family and was therefore used to model non-normally distributed count data and to identify the factors most related with the counts of bird and bat collisions. The results indicated the vegetation and the wind are the factors most related with bird and bat mortality in the wind farm La Venta II. The results also allowed identifying the turbines and the section of the wind farm with high number of collisions. This information will assist decision support in terms of management and mitigation practices at this wind energy facility located in a semi-humid, tropical environment.

Impacts to Wildlife Habitat and Behavior

Jesse Barber, Colorado State University

The costs of chronic noise exposure for wildlife

Jesse R. Barber (Colorado State University), Kurt M. Fristrup (National Park Service, Natural Sounds Program)

Research objectives, including hypotheses being tested: This talk will address (1) The geographical extent of anthropogenic noise, (2) data that indicates the importance of sound to intact ecological function and (3) recent evidence showing anthropogenic noise changes foraging and anti-predator behavior, reduces reproductive success, alters animal density and shifts community structure and (4) the role of wind farms in altering natural soundscapes.

Abstract: Sites that are selected for wind energy development will have higher natural ambient sound levels than randomly selected sites due simply to the natural resource being exploited—wind. This fact does not dismiss the possibility of anthropogenic noise impacts to wildlife that reside within or near wind farms. Decades of research has shown that anthropogenic infrastructure associated with high levels of noise, such as roads, alter animal behaviors and distributions. Recent work strengthens the evidence presented by road ecology studies and indicates that chronic noise exposure changes foraging and anti-predator behavior, reduces reproductive success, alters animal density and shifts community structure.

Wind farms raise the background sound level. Wind turbine type, blade design and tower height alter the noise footprint of an operating turbine. Acoustically-specialized species that depend heavily on current natural ambient conditions, such as northern harriers, owls, frogs, gleaning bats and several songbird species, among others, should be considered sensitive species; although it is difficult to predict the cascade of ecological consequences from increased sound levels.

A recent study found that by increasing turbine cut-in thresholds, bat fatalities can be reduced substantially. These same measures will assure that when background sound levels are naturally low, due to low wind, turbines do not add to the background sound level. Furthermore, the most important times for acoustically-mediated behaviors (both communication and hunting/anti-predator behaviors) occur during dusk and dawn. Reducing wind turbine activity during these crepuscular periods will simultaneously reduce bat/bird strike fatalities and keep background sound levels low during biological critical periods.

Site selection must also consider the impact of wind farms on habitat connectivity. Noise may amplify the fragmentation impacts of wind energy developments. For example a radio-tag study showed that a gleaning bat was much less likely to cross a roadway than a sympatric open-space foraging bat, implicating noise as a fragmenting agent for some acoustically-specialized species. The latter species hunts flying insects using echolocation (an auditory behavior that uses ultrasonic signals above the spectrum of anthropogenic noise) whereas gleaning bats rely on low-frequency sounds for hunting.

Explicit experimental manipulations should become an integral part of future adaptive management plans to decisively identify the most effective and efficient methods that reconcile human activities with resource management objectives. The costs of noise must be understood in relation to other anthropogenic forces, to ensure effective mitigation and efficient realization of environmental goals.

Rob Bouta, Westwood Professional Services

Mitigating effects of wind energy on Loggerhead Shrikes: a spatial habitat model

Rob Bouta (Westwood Professional Services), Brie Anderson (Westwood Professional Services), Bonnie Erpelding (Independent Ecologist)

Research objectives, including hypotheses being tested: This study was conducted to:

1. identify and rank the suitability of Loggerhead Shrike habitats in a wind project development area;
2. adjust the wind turbine layout to minimize potential effects on Loggerhead Shrikes; and
3. use a spatial habitat model to demonstrate the compatibility of wind energy and Loggerhead Shrike habitat.

Abstract:

Methods and Timeframe

We interpreted aerial photography and conducted an October 2009 field review to rank the habitat suitability of quarter-section (160-acre) blocks for Loggerhead Shrikes. Habitat blocks were ranked on a scale of 0 (unsuitable) to 5 (very highly suitable). Habitats ranked 3-5 were field verified and rankings were adjusted where appropriate. Proposed turbine locations were adjusted to minimize potential effects on Loggerhead Shrikes. Information from the literature on Loggerhead Shrike population densities and territory size was combined with project information on habitat composition and turbine layout to assess the compatibility of the project with Loggerhead Shrike habitat occupancy.

Location and Ecological Setting

The study was conducted at National Wind's Goodhue Wind Project, within Goodhue County of southeastern Minnesota. The project area is approximately 60% cultivated cropland (corn and soybeans), 32% grassland, 4% woodland, and 4% developed. Wetlands are mostly limited to intermittent streams.

Preliminary Results

Over half (119) of all quarter sections (N = 207) were at least minimally suitable for Loggerhead Shrikes. Nearly a third (64) of the quarter sections had at least moderately suitable breeding habitat. Approximately 16% of the quarter-section ranks were modified based on the field review. Two Loggerhead Shrikes were observed in habitats ranked moderately and highly suitable during October 2009. Most preliminary turbine locations were in low-ranked habitat.

Loggerhead Shrike behavior and habitat use patterns suggest that wind energy development is compatible with occupied Shrike habitat in Minnesota. Predominant Shrike flight patterns are below the typical rotor swept zone of commercial wind turbine blades. The small territory size of Loggerhead Shrikes suggests that occupied Shrike territories could fit between the typical 1,300 to 1,500-foot spacing of commercial wind towers.

Management Implications

Heightened wildlife agency concerns regarding ecological impacts of wind energy focus intently on rare species and migratory birds. The Loggerhead Shrike falls in both of these categories. The Loggerhead Shrike is a state-threatened species in Minnesota, a USFWS Region 3 Species of Concern, and is considered vulnerable in 16 states. Effective avian impact mitigation measures aid in addressing wildlife agency concerns and soliciting positive agency feedback on avian issues. Pre-construction habitat modeling aids in identification of mitigation strategies to reduce potential effects on this rare bird. The habitat model will be advanced during the summer of 2010 to map potential Shrike territories, estimate occupied habitats, and show the spatial habitat compatibility with wind turbine locations.

Jim Cummings, Acoustic Ecology Institute

Management implications of individual variability in sensitivity to noise within wildlife populations

Jim Cummings (Acoustic Ecology Institute)

Research objectives, including hypotheses being tested: This is not original research; rather, this will be an overview that highlights studies showing individual and species variability in behavioral responses, and the potential biologically significant implications of this variability.

Abstract: This presentation will take a closer look at two practices common in assessing the behavioral impact of anthropogenic noise on animals: results that focus on the percent of animals affected, and an assumption that moderate increases in ambient noise have generally negligible effects. Despite the practical merits and general applicability of these practices, species and individual variability in sensitivity to noise impacts may often warrant more nuanced assessment of research results. The presentation will draw on a range of previous studies showing individual variability in response, and discuss the management implications that may occur in some locations.

Many studies focus on determining the percentage of animals that show some measurable behavioral response (e.g., displacement, nesting patterns, or communication changes) in the presence of a noise source of interest; these percentages are treated as the concrete result of the study. In some management regimes, a fifty percent response rate is considered to be a prudent threshold for caution, with regulatory responses (e.g., permitted noise levels) tied to this metric. These concrete data points we commonly assess contain a subtler message, however: in addition to variability between species in response to a given noise source, there is also a significant amount of individual variability in response or sensitivity to noise within any species or population of animals. This has several implications, including the possibility that a subset of a local population will be repeatedly disrupted by a given noise source. In some situations, such repeated disruption, and associated stress responses, may have population-level impacts even when a relatively small proportion of animals is so affected. Likewise, some species (and perhaps individuals) are likely to be more sensitive to moderate increases in ambient background sound levels that may occur near operating wind farms. The episodic nature of these increases could create recurring stress responses or impact the energy budgets among those most affected, especially animals involved in predator-prey relationships that rely on acoustic cues near the limits of audibility. New research from the National Park Service provides a useful metric for considering such effects. In all these situations, population-level impacts of species or individual variability will be most pronounced where displacement to nearby suitable habitat is not a viable option. This may include breeding grounds or habitats that are relatively localized or constrained by geography, such as forested ridges in landscapes where bottomlands are extensively farmed or otherwise occupied by humans.

David Drake, University of Wisconsin – Madison

Response of Raptors to a Wisconsin Windfarm

Julia C. Garvin, Christopher S. Jennelle, David Drake, Steven M. Grodsky (Department of Forest and Wildlife Ecology, University of Wisconsin – Madison)

Research objectives, including hypotheses being tested: Our research objective was to evaluate potential impacts of a 129 MW windfarm in southeast Wisconsin on the abundance, richness, and behavior of raptors within the project area. The specific aims of our study were to determine (1) whether raptors are being displaced from within the windfarm, and if so, which species are most vulnerable; (2) the proportion of raptors displaying avoidance behaviours (i.e. changes in flight path to avoid a turbine or its blades); (3) the relative risk of collision of each raptor species, and all raptors as a group; (4) potential correlations with observed mortality and estimated avoidance rates.

Hypotheses: (1) expect no evidence of displacement from windfarm project areas; (2) expect to see species-specific differences in both avoidance behaviour and collision risk; (3) expect to observe few raptor mortalities since avoidance rates are likely to be high.

Abstract: A pre- and post-construction study was used to determine the impact of a Wisconsin windfarm on the abundance and behaviour of raptors, a group susceptible to windfarm impacts. The windfarm was constructed within an area dominated by agriculture with small patches of deciduous woodland (land cover = 97% and 2%, respectively). Hour-long raptor surveys from 12 locations were conducted pre-construction from April 15-August 31, 2005, and post-construction from June 16-August 31, 2008, and April 15-August 31, 2009. An additional eight locations outside the windfarm were added in 2009 for comparison to results from within the windfarm. Each location was surveyed five times between April-May and four times between June-August. Variation in raptor abundance and behavior

were examined both within and among years and in relation to important spatial, temporal and weather covariates. Generalized linear mixed models were used in addition to matched-pairs tests between years. Species-specific avoidance rates were estimated from both mortality data (separate study) and behavioral observations. Final results indicate that raptor abundance was 46% lower post-construction, and was 32% greater outside the windfarm. *Accipiter* spp., American kestrels *Falco sparverius*, and northern harriers *Circus cyaneus* showed the greatest declines (all > 50%). Flight behaviour varied by species, but most individuals remained farther than 100 m from turbines and above the height of the rotor zone. Turkey vultures *Cathartes aura*, and red-tailed hawks displayed high-risk flight behaviours more often than all other species, and were among those with the highest risk of collision. There were a total of five red-tailed hawks found beneath turbines (including incidentals), and no other raptor species. Carcasses displayed head, neck, or wing injuries typical of collisions with turbine blades. Red-tailed hawks had avoidance rates of 98% based on corrected mortality estimates, with all other species showing 100% avoidance. The observed behavior of red-tailed hawks corresponded with mortality rates, but that of turkey vultures did not. Our results provide some evidence of displacement from the windfarm project area. While certain species may be at risk of collision, flight behaviour data and mortality estimates indicate that the majority of raptors may not be directly affected by the presence of turbines. Thus, the impacts of the windfarm appear to be relatively minimal. However, additional years of study on possible displacement effects, and investigation of cumulative effects on raptor populations using data from all windfarms in the region are recommended.

Joelle Gehring, Michigan Natural Features Inventory

Night migration concentration areas in Michigan and the Great Lakes: knowledge important to the siting of wind farms and other tall structures.

J. L. Gehring, E. H. Schools, H. D. Enander (Michigan State University - Michigan Natural Features Inventory)

Research objectives, including hypotheses being tested: Specifically our objectives were to:

1. use radar (i.e., NEXRAD) to identify areas in Michigan and the Great Lakes with concentrations of migrating fauna higher than surrounding areas over time.
2. test whether areas of high concentration were randomly distributed in the landscape or clustered in specific areas.

Abstract: The Great Lakes and their associated shorelines have a propensity for high, steady winds often making them ideal locations for wind farm development. Portions of these shorelines are also of high value to migratory songbirds and bats and several studies have documented localized migrant songbird concentration areas. The USFWS is generally suggesting that turbines be placed >3 miles from Great Lakes' shorelines. In an effort to provide data and ensure these wind resources are developed sustainably, we used NEXt generation RADar (NEXRAD; WSR-88D) to quantify migration concentration areas in relation to the Michigan shorelines (Great Lakes of Superior, Michigan, Huron, and western portions of Erie). This type of radar can be useful for determining bird/bat migration at large-scales and estimates a density of targets (e.g., mean number of birds/ km⁻³) in an area. ArcGIS was then used to spatially delineate migration concentration areas based on existing state level radar data. To analyze the spatial distribution of reflectivity values, we utilized a grid of points evenly spaced 500 meters apart. The points were intersected with the radar polygons and each point was assigned the reflectivity value of the corresponding radar polygon. Upon analyzing the distribution of radar reflectivity values we found that most areas had low bird densities over time; thereby, highlighting those areas with high

densities. After identifying those areas with high concentrations of migrants we tested their spatial relationship to the Great Lakes' shoreline. Analysis of these data determined that some portions of the Great Lakes' shorelines supported high concentrations of migrants while others did not. In addition, not all high concentration areas were directly associated with shorelines. We also found differences between the spring and fall migration seasons. As wind developers and resource managers work toward more informed wind farm siting decisions, it is important to determine, at a site specific scale, if migrant concentration areas coincide with areas proposed for development. These data are useful for identifying those areas of potential high risk for the development of wind energy resources. This product can be utilized by wind developers, local planning and zoning commissions, and natural resource agencies during the wind farm planning and review assessment stages. Our research and mapping efforts provide information and recommendations that are based on sound science; thereby leading to more sustainable development of renewable energy.

Caleb Gordon, Pandion Systems, Inc.

Reproductive success of Black-capped Vireos and other shrub-nesting passerines in relation to distance from wind turbines.

Caleb Gordon (Pandion Systems, Inc.), Kristopher Karsten (Biology Department, Texas Christian University), Amanda Hale (Biology Department, Texas Christian University), Greg Forcey (Pandion Systems, Inc.), Scott Turner (Turner Biological Consulting), Joseph Grzybowski (College of Mathematics and Science, University of Central Oklahoma), Sam Noble (Oklahoma Museum of Natural History, University of Oklahoma), Bryan Suson (Pandion Systems, Inc.), John Kuba (Turner Biological Consulting), Harold F. Greeney (Yanayacu Biological Research Station, Cosanga, Napo, Ecuador)

Research objectives, including hypotheses being tested: Objective: to characterize the relationship between distance to nearest wind turbine and reproductive success in shrub-nesting songbirds of the central Texas-Oklahoma region.

(Null) Hypothesis being tested: There is no relationship between distance to nearest wind turbine and reproductive success in shrub-nesting songbirds of the central Texas-Oklahoma region. This hypothesis is being tested separately for six species: Black-capped Vireo, White-eyed Vireo, Painted Bunting, Blue-gray Gnatcatcher, Lark Sparrow, and Northern Cardinal

Abstract: This presentation reports the results of the first two field seasons of research conducted by the Shrub Nesting Passerine (SNP) Collaborative Research Project, directed at characterizing the relationship between the reproductive success of shrub-nesting passerine birds and the distance to the nearest wind turbine. This study provides the first rigorous scientific analysis of the potential indirect effects of wind turbine proximity on the reproductive success of birds. The focal species group, shrub-nesting passerines in the central Texas-Oklahoma region, is of particular interest because the breeding distributions of two federally-listed bird species, the Black-capped Vireo and the Golden-cheeked Warbler, are globally restricted to this ecoregion, and because of the high desirability of this region for wind energy development.

Fieldwork during both seasons consisted of intensive nest searching and monitoring efforts using the Mayfield Method. The first season was conducted from April to August, 2009 at NextEra Energy's Wolf Ridge Wind Energy Center in Cooke and Montague Counties, Texas. Herein we present the final results of a gradient impact analysis for White-eyed Vireo, Northern Cardinal, Painted Bunting, Blue-gray

Gnatcatcher, and Lark Sparrow. We employed three parallel and complementary analytical techniques: 1) conventional analysis of Mayfield's Daily Survival Rate (DSR) and related statistics, 2) univariate analysis of wind turbine impact using Mayfield logistic regression, and 3) information theoretic analysis of competing univariate and multivariate Mayfield logistic regression models that included distance to nearest turbine as well as additional potential explanatory variables. No statistical relationship between wind turbine proximity and reproductive success was found for any of the five study species, using any of the three analytical techniques. However, strong statistical evidence for a lack of such effect was only produced for one species, the Northern Cardinal.

We also present a preliminary summary of the findings from our second field season, conducted from April to August, 2010 at NextEra Energy's Horse Hollow Wind Energy Center in Taylor and Nolan Counties, Texas. During this season, we focused exclusively on Black-capped Vireo. This data set was gathered using the same field protocol, and will be analyzed with the same statistical tools as was the 2009 data.

Our results suggest that wind energy development may not negatively impact the reproductive success of Northern Cardinal, and potentially the four other species studied in 2009. Further research is needed to verify the robustness of this pattern, and to determine how generalizable it is to additional species, years, and sites.

Greg Johnson, WEST, Inc.

Greater Sage-Grouse Habitat Use and Population Demographics at the Simpson Ridge Wind Resource Area, Carbon County, Wyoming

Greg Johnson (WEST, Inc.), Chad LeBeau (WEST, Inc.), Matt Holloran (Wyoming Wildlife Consultants, LLC)

Research objectives, including hypotheses being tested: Objective of the study is to measure seasonal habitat use and demographic parameters (survival, nest success, brood success) of a sage-grouse population within an area containing 2 proposed and one existing wind energy facilities. The hypothesis being tested is that wind energy development does not affect sage-grouse habitat use or demographic parameters.

Abstract: Much debate has occurred regarding the potential impacts of wind-energy facilities on sage-grouse. Due to lack of research, however, it is unknown how sage-grouse would respond to numerous wind turbines hundreds of feet taller than the surrounding landscape. We are currently conducting the first large-scale study to assess response of greater sage-grouse to wind energy development. Objectives include determining how wind energy development may affect sage-grouse seasonal habitat use and demographics (nest and brood success, survival) using a BACI design. Data are being collected by tracking 75 radio-marked female sage-grouse and monitoring males on leks in the project vicinity. The study was initiated in April 2009 and is designed to collect at least 2 years of pre- and 4 years of post-construction data. This study is being conducted in Carbon County, Wyoming, in an area with two proposed and one existing wind-energy facilities. The study area is within a semiarid cold desert comprised of big sagebrush communities. Due to high densities of breeding greater sage-grouse, most of the study area is within an area mapped by the State of Wyoming as a greater sage-grouse "Core Population Area". The presence of an existing wind energy facility in the project area has allowed us to obtain some information on sage-grouse response to wind turbines the first study year. A total of 462

males were counted on all study area leks combined. The three leks closest (0.38–0.85 miles) to existing turbines were all active in 2009, the first breeding season after the turbines were erected. Over 1,600 locations of marked birds have been obtained to document seasonal habitat use (breeding, nesting, brood-rearing, winter). Nine nests were initiated within one mile of existing wind turbines; the four nests closest to turbines were located 130–486 m from the nearest turbine. Seventy-one percent of females initiated nests. Nest success was 37% and fledging success was 63%. Annual survival of adult females was 53%. The data collected to date should be considered preliminary and are not meant to provide a basis for forming any conclusions regarding potential impacts of wind energy development on greater sage-grouse. Final results will be invaluable to the wind industry for making informed siting decisions and for state wildlife agencies as they review proposals for wind energy developments in occupied sage-grouse habitats and provide input on methods to avoid and minimize impacts as well as measures to mitigate impacts.

Jason Jones, Tetra Tech EC, Inc.

Modeling habitat distributions of bats using GIS: wind energy and Indiana bats.

Jason Jones (Tetra Tech), Erik Jansen (Texas Tech University), Robert Friedel (Tetra Tech)

Research objectives, including hypotheses being tested: 1. To highlight the utility of habitat models in reducing the potential impact to bats (particularly threatened or endangered species), which will, in turn, minimize schedule delays and unexpected costs; 2. To underscore the importance of understanding animal behavior in estimating risk; and, 3. To provide specific recommendations (e.g., micro-siting, additional studies, project scheduling) for addressing potential risk to Indiana bats.

Abstract: Post-construction monitoring indicates that commercial wind energy facilities are a source of bat mortality resulting from collisions or other negative interactions with operational turbines. An understanding of the potential distribution and movement of bats on the landscape is essential to minimizing these impacts. Using remote sensing and Geographic Information Systems software, we present a modeling approach that evaluates the distribution of bat roosting and foraging habitat and potential flight paths at a landscape scale which may be used to assess the risk to bats from the development of a wind energy facility. Accurate assessment of these risks can minimize schedule delays and unexpected costs. Applied to the behavior and ecology of the federally endangered Indiana bat (*Myotis sodalis*) at two hypothetical wind farms, this method predicts the areas where the species is likely to travel while foraging, thereby highlighting the riskiest areas within a project area. The results of our modeling indicate that risk to bats is not directly proportional to habitat availability or suitability, in part because risk is associated with areas where bats are traveling. This modeling approach will assist wind energy developers in making both large-scale (e.g., choosing between different development locations) and small-scale decisions (e.g., choosing where to locate turbines) aimed at minimizing impacts to bats. Using habitat models can provide a cost-effective method for evaluating bat risk, satisfying requirements of United States Fish and Wildlife Service, and limiting the more intensive survey methods to projects that absolutely require them.

Will the data/study be independently peer reviewed prior to Wind Wildlife Research Meeting VIII? If so, by whom? A manuscript based on this modeling approach is currently in preparation for submission to Ecological Application within the month. As a result, this model will have received external review prior to the meeting, should the abstract be accepted. This method has been favorably reviewed by multiple USFWS field offices within the range of the Indiana bat.

Jason Jones, Tetra Tech EC, Inc.

Do operational turbines create a barrier to waterfowl movement in the Prairie Pothole Region of North America?

Jason Jones, Karl Kosciuch, Todd Gys (Tetra Tech), Jim Lindsay (NextEra Energy Resources Inc.)

Research objectives, including hypotheses being tested: Objective: To assess whether construction and operation of a wind farm will act as a barrier to waterfowl movement between two wetland complexes. Hypothesis: Based on observations from European wind farms, waterfowl will continue to move between the wetland complexes, altering their flight behavior to avoid the operational turbines.

Abstract: We conducted waterfowl flight behavior surveys at the Crystal Lake II Wind Energy Center to assess whether the construction and operation of the wind farm affects waterfowl movement between two relatively large wetland complexes in Hancock and Winnebago Counties, Iowa. We conducted flight behavior surveys at seven locations selected based on their proximity to the focal wetland areas and the wind farm turbines between these two wetland areas. We conducted the surveys during three periods: before wind farm construction (April 1 – May 7, 2008), during wind farm construction (September 27 – November 4, 2008), and following wind farm construction (April 26 – May 27, 2009). During each survey, the surveyor recorded all avian flights within a 400-m radius centered on the survey location. For each observation, the surveyor recorded species, number of individuals, average flight height and flight direction, and recorded the flight path onto data sheets for subsequent digitizing prior to analysis. Preliminary analysis suggests that the presence of operational turbines did not appear to affect the ability or tendency of waterfowl to move between the wetland complexes. The proportion of birds observed that flew through the wind farm did not change once the turbines became operational, nor did the direction in which the birds were observed flying. The major difference between flight behavior prior to and following the turbines becoming operational is that birds flying in the vicinity of the wind farm when the turbines were operating did so below the heights equivalent to the rotor swept area. This suggests that risk of turbine collisions will be low for those birds flying through the wind farm. The results (i.e., the shift in flight height profiles) suggest that waterfowl are behaviorally flexible with regard to their flight behavior, at least over short commuting distances. This behavioral flexibility may contribute to the general observation that waterfowl are rarely reported as fatalities at newer generation wind farms. The presence of operational turbines within 1 mile, and as close as 0.2 miles, of a wildlife area does not appear to have an effect on the movement patterns or spring use of these areas by breeding or migrating waterfowl. These findings may be important in determining the appropriate spatial scale for construction setbacks from wildlife areas.

Todd Katzner, WVU and Cellular Tracking Technologies

Interactions between migratory birds of prey and wind turbines: insights from novel high frequency GPS-GSM telemetry

Todd E. Katzner (West Virginia University, Cellular Tracking Technologies), David Brandes (Lafayette College), Robert P. Brooks (The Pennsylvania State University), Jeff Cooper (Virginia Department of Game and Inland Fisheries), Michael Lanzone (Carnegie Museum of Natural History, Cellular Tracking Technologies), Charles Maisonneuve (Ministère des Ressources naturelles et de la Faune), Trish Miller (Carnegie Museum of Natural History), Kieran O'Malley (West Virginia Department of Natural Resources), Junior Tremblay (Ministère des Ressources naturelles et de la Faune)

Research objectives, including hypotheses being tested: The objective of this research is to evaluate potential impacts of development of wind energy facilities on migratory birds of prey and to identify

potential mechanisms for mitigation of those impacts. Our research tests hypotheses about flight behavior of raptors, specifically related to altitude, ridge fidelity and age-related patterns.

Abstract: Wind power is among the fastest growing alternative energy sources and the mid-Atlantic region of North America is a primary focus for wind power development. Although considered a “green” energy source, wind energy can have negative impacts on wildlife, especially birds of prey. Threats to breeding and wintering raptors from wind turbines have been extensively studied in several areas but there has been little work on impacts of turbines on migratory individuals.

We evaluated interactions between migratory raptors and wind energy development in the central Appalachian region of eastern North America. Our study takes place at two spatial scales and focuses on rare golden eagles as an umbrella species for soaring raptors. At a continental level, we track and model eagle movements in relation to broad scale topographic and weather conditions to understand the determinants of flight behavior. At a local level, we are using high-frequency GSM telemetry to measure how eagles respond to micro-site slope, elevation, habitat and meteorological features. We are analyzing these data and models to understand the broad- and local-scale conditions when eagles and turbines are most likely to interact and how eagles may respond behaviorally to the presence of turbines.

Energy minimization models show that eagles should track “leading lines” when migrating through the Appalachian region, particularly when thermals are weak. Migration routes of telemetered birds show high fidelity to modeled tracks. Birds move in a broad front through the Appalachian Plateau in New York and Pennsylvania and show age specific patterns of behavior in this region. However, both tracks and models show large numbers of eagles of all ages passing through a bottleneck in the ridges of south-central Pennsylvania. Birds in this bottleneck spent less time in thermals, used more orographic lift and flew more quickly and more directly than when they were outside of this region. At these times, in-flight altitude above ground level was consistently low to the ground, frequently within the rotor swept zone of turbines.

Wind energy development risks impacting birds of prey throughout the annual cycle. Although migration is the shortest period of that cycle, because landscape features can concentrate birds into restricted areas, small populations of raptors may be at significant risk during these periods if key concentration areas are developed without attention to bird behavior.

Laura Nagy, Tetra Tech

Whooping and sandhill crane behavior at an operating wind farm

Laura Nagy, Jason Jones, Karl Kosciuch, Jina Sagar (Tetra Tech), Brandy Gibson (BP Wind Energy)

Research objectives, including hypotheses being tested:

Question 1: Does the Titan I Wind Farm act as a barrier to movement for high flying (>200 meters above ground level), migrating cranes?

Hypothesis: As they are flying at heights greater than the maximum blade tip height and are presumably not actively searching for a stopover location, cranes flying at high elevations should not perceive an operational wind farm as a barrier to movement.

Question 2: Does the Titan I Wind Farm act as a barrier to movement for low flying (<200 meters above ground level), migrating cranes?

Hypothesis: Based on observed crane flight behavior relative to roads and transmission lines (Morekill and Anderson 1991, Yee 2007), cranes flying at low elevations may perceive an operational wind farm as a barrier to movement.

Abstract: The objective of this research study is to determine if the operation of the Titan I Wind Farm in South Dakota acts as a barrier to migratory movements of cranes. Although the motivation for this study is to understand the behavior of whooping cranes with respect to wind farms, collecting meaningful data on whooping crane behavior during migration is difficult due to the small size of the population. Therefore, sandhill cranes are being used as surrogates because of similarities in the behavior of the two crane species and their tendency to migrate together. In addition, we evaluated the successfulness of a whooping crane management strategy that included turbine curtailment when whooping cranes were within 1 mile of the turbines. A biologist collected behavioral information from March 26 to May 15, 2010 on all cranes seen on and within 2 miles of the Titan I Wind Farm including flight heights, flight paths, foraging behaviors, and avoidance behaviors. Whooping cranes were observed within 2 miles of the Project for 3 days. Curtailment procedures were implemented during the time when the whooping cranes were in the area. Whooping cranes roosted in a wetland approximately 2 miles south of the Project and foraged in surrounding grain fields. When the whooping cranes re-initiated their migration, they flew within ½ mile of the wind farm at approximately 1000 meters above the ground. Sandhill cranes regularly flew over the wind farm at heights ranging from 200-1500 meters. Sandhill cranes were also observed flying between operating turbines at heights comparable to the rotor swept area. Based on the data collected to date, it does not appear that the Titan I Wind Farm is acting as a barrier to movement for either high or low flying sandhill cranes. This study is the first to systematically document crane stopover and migration behavior in the vicinity of a working wind farm, which can be used to assess project-related impacts and develop mitigation strategies. Implications also include the lessons learned from managing whooping crane presence at an operating wind.

Hall Sawyer, WEST, Inc.

Big Game Impact Assessment: lessons learned from natural gas development in Wyoming
Hall Sawyer (WEST, Inc.)

Research objectives, including hypotheses being tested: 1) Evaluate how big game respond to different types of energy development (i.e., indirect habitat loss); 2) Determine how to identify and prioritize big game migration routes to minimize potential impacts of energy development

Abstract: Increased levels of energy development across the Intermountain West have created a variety of big game and habitat management concerns. Two of the more pressing concerns include: 1) how big game respond when critical habitats (e.g., winter range) are affected by development and 2) how their migration routes can be identified and prioritized to minimize potential impacts. Here, we illustrate how these concerns have been addressed with the use of global positioning system (GPS) collars, state-of-the-art statistical methods, and before-after impact studies associated with gas development in Wyoming. First, we show how GPS data can be used to determine the response of big game to development by using resource selection functions (RSFs) that identify habitat selection and distribution patterns prior to, and after, energy development. Additionally, we demonstrate how this approach can be used to evaluate big game response to different types of infrastructure. To address migration concerns associated with large-scale energy development, we developed a quantitative framework that uses GPS data and the Brownian bridge movement model (BBMM) to: 1) provide a probabilistic estimate of the migration routes of a sampled population, 2) distinguish between route segments that

function as stopover sites versus those used primarily as movement corridors, and 3) prioritize routes based upon the proportion of the sampled population that uses them. For the first time, this method allows agencies and industry to quantify the migration routes of an entire population, rather than individuals. Importantly, we show that migration routes are characterized by a series of stopover sites where animals spend most of their time, connected by movement corridors through which they moved quickly. These results suggest management strategies and development plans that differentiate between stopover sites and movement corridors may be warranted, and that potential impacts may be minimized by avoiding construction in stopover sites. Because some migration routes are used by more animals than others, proportional level of use may provide a reasonable metric by which routes can be prioritized in order to reduce potential impacts. We discuss these statistical tools and results in the context of wind power development.

Lynn Sharp, Tetra Tech EC, Inc.

Comparison of pre-and post-construction bald eagle use at the Pillar Mountain wind project, Kodiak, Alaska, Spring 2007 and 2010

Lynn Sharp, Christina Herrmann, Robert Friedel (Tetra Tech EC, Inc.), Richard MacIntosh (Wildlife Consultant)

Research objectives, including hypotheses being tested: The objective was to document pre- and post-construction use by bald eagles at Kodiak Electric Association's wind project during a season when use was high. The hypothesis tested was that turbine construction and operation would not affect bald eagle use of the area and flight behavior (i.e., no avoidance).

Abstract: Standardized avian point count surveys were conducted for 30 minutes during the spring (March 15 through the end of May) in 2007 (pre-construction) and 2010 (post-construction) by the same observer. Thirty-five surveys were conducted each during 2007 and 2010. For each bald eagle observation, which could be an individual or a group, we recorded the number of birds observed, activity, flight direction, whether birds flew across the ridge, the range of flight heights in relation to the ridgetop where turbines were located, and we mapped each flight path. For the 2007 and 2010 surveys, for all birds and then only those birds observed flying across the ridge, we calculated the number of birds observed per 30 minutes, number of observations per 30 minutes, mean group size, proportion of all birds observed flying across the ridge, and proportion of birds flying within the elevation zone swept by the turbine rotors. We will compare use in relation to wind direction and the distribution of flight paths when the study is completed.

Pillar Mountain is a 360-m tall ridge that overlooks Kodiak, Alaska. The vegetation on the top of Pillar Mountain is tundra, with patches of Sitka spruce, willow, and alder shrub at lower elevations. The ridge is oriented northeast to southwest, and is very steep on the southeast side. Bald eagles are common throughout the year at Kodiak, and are reported to roost on the steep southern face of Pillar Mountain during the winter.

At the time this abstract was submitted, 17 of the 35 post-construction surveys had been completed. The results presented below are preliminary and will be finalized when the surveys are completed in early June. Bald eagle pre-construction (2007) mean use was 2.57 birds/30 min and post-construction (2010) mean use was 2.71 birds/30 min. Pre-construction and post-construction mean group size was 1.6. For birds that flew across the ridge, pre-construction mean use was 1 bird/30 min; post-

construction mean use was 0.24 birds/30 min. In 2007, 39 percent of eagles observed flew across the ridge, in 2010, 9 percent of eagles observed flew across the ridge. Based on these preliminary results, the approximate 75 percent reduction in the proportion of birds flying across the ridge in 2010 indicates that bald eagles are avoiding the turbines as mean use patterns are similar between years.

Kenton Taylor, WEST, Inc.

*Assessing Golden Eagle (*Aquila chrysaetos*) Use of Wind Resource Areas Using Observational Data*

Kenton Taylor, David Young, Wallace P. Erickson (WEST, Inc.)

Research objectives, including hypotheses being tested: Document golden eagle use (e.g. nest sites, roost and perch locations, and foraging areas) of proposed Wind Resource Areas to better inform wind energy development planning and minimize impacts to golden eagles.

Abstract: Golden eagles (*Aquila chrysaetos*) occur at the majority of Wind Resource Areas throughout the western US and golden eagles have been documented as collision fatalities at existing wind energy facilities. Increasing wind energy development in the western US has led to increasing concern over golden eagle fatalities. We provide methods to better assess the potential impacts of wind projects on golden eagles. Transect surveys to census golden eagle use of entire Wind Resource Areas, (in addition to initial site characterization studies, standardized avian use point counts, and raptor nest searches) allow for identification of important golden eagle use areas such as prevalent perch sites, roost locations, foraging areas, and occupied nest sites. Intensive observations of golden eagle use including detailed mapping of golden eagle behavior (e.g. flight paths, perch locations, foraging areas) allow for a spatial analysis and assessment of golden eagle use within Wind Resource Areas. We describe the sampling protocol for the spatial analysis and examples of results useful for impact assessment and project planning. The methodologies presented better inform wind energy development planning by providing data useful to better inform impact assessments and in designing wind energy facilities to minimize collision risk to golden eagles.

Junior Tremblay, MRNF

*A case study of the interaction between landscape configuration and wind farm visitation by Golden Eagles (*Aquila chrysaetos*)*

Junior A. Tremblay, Charles Maisonneuve (Ministère des Ressources naturelles et de la Faune), Todd Katzner (West Virginia University & Cellular Tracking Technologies), Tricia Miller (Carnegie Museum of Natural History), Micheal Lanzone (Carnegie Museum of Natural History), David Brandes (Lafayette College)

Research objectives, including hypotheses being tested: Determine how landscape level habitat structure affects space use by Golden Eagles near wind farms. Hypothesis: A higher proportion of open habitats near wind farms close to Golden Eagle nests will increase use by Golden Eagles of such areas surrounding the wind farms.

Abstract: Wind power is expanding all around the world and Quebec plans to increase its production from about 500 MW today to 2000 MW in 2012 and to 4000 MW in 2015. Some wildlife species are more vulnerable to blade-strike mortality and Golden Eagles (*Aquila chrysaetos*) are known to be one of

those. Not all wind farms present the same risk of mortality; windmill configuration and site particularities are two major parameters to take into account when evaluating such risks. The present study aims to determine how habitat configuration affects space use of breeding Golden Eagles, with a particular focus on areas adjacent to wind farms. We hypothesized that a higher amount of open habitats in the vicinity of wind farms will increase the use by Golden Eagle of the wind farm area. Our study area is located in the Gaspé peninsula (Quebec). Golden Eagles were tracked with Argos/GPS solar transmitters. Preliminary results show that nests established in areas with high availability of open habitats had smaller home ranges and individuals were less susceptible to using open habitats surrounding wind farms. Where open habitats near Golden Eagle nests were less available, openings created near wind farms offer new hunting areas, increasing the use by Golden eagles of the wind farm and thus increasing potential risk of blade-strike mortality. Hence, developers aiming to establish wind farm projects in forested mountainous areas, as is the case for many projects in Eastern North America, should consider that creating openings within a forested habitat may increase collision risk for Golden Eagles

Cumulative and Landscape-Scale Impacts to Specific Species or Groups

Greg Forcey, Pandion Systems, Inc.

Predicting wind turbine collision mortality using spatial models of avian abundance and exposure

Greg Forcey, Christian Newman, Crissy Sutter (Pandion Systems, Inc.)

Research objectives, including hypotheses being tested:

To model collision probability of Horned Larks across the central United States using both indexes of abundance, habitat, and exposure.

Abstract:

Avian collision mortality with wind turbines has been a widely studied topic through both pre and post construction monitoring studies in the United States. Most of these studies have occurred at the scale of the individual wind power facility and have not examined large-scale mortality effects and siting options at the state level or beyond. We modeled collision mortality of Horned Larks as a function of bird abundance, habitat, and estimated exposure conditions to wind turbines in the central United States. Separate models were constructed for each season given the temporal variation in abundance and exposure. We estimated bird abundance by modeling bird abundance from the North American Breeding Bird Survey and Christmas Bird Count as a function of land use. Mathematical land use models were mapped back into the landscape in a GIS environment to create a grid of predicted abundance across the study region. Because we did not have bird abundance data to model during migratory seasons, we estimated occurrence during migration by mapping migratory habitat based on known habitat preferences from the literature. Exposure was modeled using data on topography, weather, and behavior; exposure models were specific to each season given the large differences in behavior and weather across seasons. Abundance (winter and summer), habitat (migration), and exposure (winter, summer, and migration) models were combined to form a cumulative measure of collision probability across all seasons. Our research has application to regional scale siting of wind power facilities, making comparisons of collision probabilities among sites, and developing site-specific priorities for additional research. This modeling approach can also be expanded to other species and geographic regions in the United States to aid in siting wind power facilities.

Gino Giumarro, Stantec Consulting, Inc.

Correlation of bat acoustic activity to bat mortality in the eastern United States: a broader understanding of seasonal and geographic trends in acoustic detection of tree-roosting bats

Gino J.M. Giumarro, Kristen S. Watrous, Joseph S. Johnson, Trevor S. Peterson, Sarah A. Boyden, (Stantec Consulting), Michael J. Lacki (University of Kentucky)

Research objectives, including hypotheses being tested: Migratory routes, timing, and behavior are some of the least studied facets of bat biology; however, these little studied biological patterns possibly play significant roles in the mortality rates observed at commercial wind energy facilities in North America. A better understanding of the timing of bat migration may be helpful in mitigating direct impacts of wind energy facilities. We used acoustic detectors to record activity at 14 commercial wind facilities in 7 eastern U.S. states. We compared bat activity patterns at survey locations within and among regions. We also compared bat activity at 1 survey location to bat mortality at an operational wind facility within 50 km. These data indicate that seasonal activity of eastern red bats, hoary bats, and silver-haired bats reflected migratory patterns of these 3 species. Results support the use of acoustic surveys to predict the timing of activity events at commercial wind energy developments.

Abstract: Migratory routes, timing, and behavior are some of the least studied facets of bat biology; however, these little studied biological patterns possibly play significant roles in the mortality rates observed at commercial wind energy facilities in North America. A better understanding of the timing of bat migration may be helpful in mitigating direct impacts of wind energy facilities. Between April and November 2007 and 2008, we used acoustic detectors to record activity above the forest canopy at 14 commercial wind facilities (13 proposed and 1 existing) in 7 eastern U.S. states. We first grouped survey locations into 3 geographic regions, then compared bat activity patterns at survey locations within and among regions. We also compared bat activity at 1 survey location to bat mortality at an operational wind facility within 50 km. During 2 years of survey, we identified 6,802 eastern red bat (*Lasiurus borealis*), 1,908 hoary bat (*L. cinereus*), and 2,603 silver-haired bat (*Lasionycteris noctivagans*) calls during 6,153 detector-nights. Each species exhibited seasonal activity patterns that varied among geographic regions, although activity patterns were highly correlated across surveys within the same geographic region. These data indicate that seasonal activity of eastern red bats, hoary bats, and silver-haired bats - as recorded by Anabat detectors - reflected migratory patterns of these 3 species. Results support the use of acoustic surveys to predict the timing of activity events at commercial wind energy developments and that acoustic activity is correlated to mortality at windfarms.

Joseph Grzybowski, University of Central Oklahoma

Modeling Wind-industry Effects on Wildlife: Framing Concepts for Assessing Population Impacts

Joseph Grzybowski (University of Central Oklahoma and Sam Noble Museum of Natural History, Craig Pease (Vermont Law School), Gary Schnell (University of Oklahoma, and Sam Noble Oklahoma Museum of Natural History)

Research objectives, including hypotheses being tested: To develop perceptions for the value of modeling population-level effects to wildlife from wind-energy facilities, and assess the needs and opportunities.

Abstract: Impacts from wind farms on wildlife generally come in two forms: landscape-level effects of decreased habitat occupancy, and direct mortality from turbines. The latter has involved a variety of taxa from raptors and migratory birds to bats. Perhaps most significantly affected have been a few tree-roosting, migratory bat species of the *Lasiurus* and *Lasionycteris* genera. Because the available data relating to population parameters are almost restricted to turbine-related deaths, the primary responses of the wind-industry have been to measure mortality as accurately as possible and to suggest methods to reduce the per/turbine or per/kilowatt mortality. However, this still leaves open the actual effects on populations. This becomes a more and more important consideration as the number of turbines increases, even with reduction in per/turbine mortality. The importance of modeling population-level effects with the paucity of basic data raises issues of data needs including the scale for delimiting the population under consideration, and may call for developing a centralized repository for bat specimens, and cooperative analysis tactics. Also needed are demographic data on birth and mortality rates. Issues such as seasonality of kills, and competing risks also arise. Population-level modeling (even initial, basic models) provides a platform from which to structure the system, direct research, and move towards understanding the actual impacts on populations; it also emphasizes the huge and valuable opportunity to organize and centralize some dimensions of specimen and data collection.

David Maddox, Sound Science

Toward landscape-scale monitoring guidelines for wind power projects

Lara Rozzell, Robert Unnasch, David Maddox (Sound Science), Jason Karl (USDA Agricultural Research Service)

Research objectives, including hypotheses being tested: This is a talk that summaries needs for and details of monitoring guidelines. No new research is being reported.

Abstract: Environmental assessments for land-based wind power projects (both siting studies and pre- and post-construction monitoring) have typically emphasized species-level monitoring (e.g., focusing on birds and bats). While these are important targets for monitoring, there are a variety of landscape-level issues that require attention. Such landscape-scale studies attempt to understand the larger “ecological footprint” of a project, including off-site effects of staging and construction efforts, direct and indirect effects on ecosystems of linear disturbances such as roads and transmission lines, impacts of habitat fragmentation on species populations and migration corridors, and additive and cumulative impacts of infrastructure development. Guidelines for assessing important landscape scale variables such as these are needed for wind projects. Landscape variables have proven to be useful tools in many land management contexts, and often reveal critical observations that could not be seen in single species studies. Important existing landscape syntheses include studies of monitoring erosion and soil loss on military bases and natural areas, habitat fragmentation that affects bird and wildlife, and land use planning. Based on existing landscape protocols for assessing and monitoring grassland and shrubland ecosystems, we outline a “straw man” proposal for landscape-scale measures that should be included in pre-siting studies to evaluate potential effects, and also in post-construction monitoring. Specifically we make recommendations for (1) the appropriate scale of measurement to detect the “ecological” footprint of the project (i.e., how far beyond a project’s construction or “literal” footprint are measurements needed?); (2) how to examine additive impacts compared to pre-construction landscape condition; and (3) a minimum set of remotely sensed and ground-based landscape data. Understanding and standardizing the collection and interpretation of appropriate landscape data will clarify important

and difficult decisions on site selection and provide useful data for understanding and moderating the long-term ecological effects of wind projects.

Kely Mertz, BHE Environmental, Inc.

Habitat Conservation Planning 201: The Winds of Change

Kely Mertz, Karen Tyrell, PhD, (BHE Environmental, Inc.)

Research objectives, including hypotheses being tested: Abstract describes trends in Section 10(a)(1)(B) consultation within the wind industry

Abstract: Recently, there has been growing recognition by the wind industry and the US Fish and Wildlife Service (USFWS) that an inherent conflict can exist between listed species conservation and the need to develop renewable energy. Environmental stewardship and policy requirements compel development of clean, sustainable energy; wind energy is compatible with these goals. As increasing numbers of facilities are built in a wider geographic range, the likelihood of take of listed species grows.

The process for resolving potential conflicts between private wind energy development and listed species conservation is under Section 10(a)(1)(b) of the Endangered Species Act (ESA), which allows USFWS issuance of Incidental Take Permits (ITP). A central component of the ITP application is a Habitat Conservation Plan (HCP).

Initially, HCPs for development projects were completed by a single applicant seeking a discreet ITP covering a defined activity within a relatively small (e.g., 50 acres or a single county) area. Over time, as applicants and USFWS regions have gained experience with Section 10 consultation, more HCPs have been developed, including a number of multiapplicant, multi-species, and/or large-scale ("regional") HCPs.

Even with this expanded approach, the wind industry faces unprecedented goals and regulatory challenges, listed species conservation, and energy development. The USFWS appreciates these challenges, and the magnitude of personnel and budget resources that would be required for the agency to actively participate in and evaluate multiple HCPs on an individual basis. Many developers face similar questions relative to the same listed species and often within the same region(s). As a result of these and other factors, we are experiencing a growing trend towards agency encouragement of multi-applicant, multispecies, "regional", "umbrella", or "programmatic" HCPs. These HCPs are time-consuming, complex, and often cover topics never before addressed by any entity.

In our paper, we will describe the climate which led to this trend, and discuss the present challenges, opportunities, and constraints related to various HCP structures. We will explain and answer questions including:

- What differs among various HCP structures?
- How do various HCPs and ITPs operate legally?
- What are benefits to industry and listed species as a result of various HCP structures?

By exploring these issues, we will introduce and provide a basic understanding of HCP process complexities and how they are applied in meeting the growing challenges faced by wind power developers now and in the near future.

Robert Pastorok, Integral Consulting, Inc.

Estimating Population-level Risks for Wildlife from a Landscape Perspective

Rob Pastorok, Matthew Behum, Damian Preziosi (Integral Consulting, Inc.)

Research objectives, including hypotheses being tested: The objective of this paper is to present a risk assessment modeling framework integrating habitat analysis from a landscape perspective, modeling to predict wildlife mortality from turbine encounters, and population-level risk assessment/management. This paper does not involve hypothesis testing. It's purpose is to improve the risk assessment process for predicting risks to wildlife associated with wind energy facilities.

Abstract: Estimating risks to wildlife populations from encounters of birds and bats with wind turbines is important in several phases of wind power development, including evaluating the potential location and design of a facility, operational monitoring, and impact mitigation. Yet methods for predicting encounters and evaluating relative risks of alternative plans for wind farm planning/management are in early stages of development. The objective of this paper is to present a risk assessment framework integrating wildlife habitat analysis from a landscape perspective, turbine encounter modeling to predict bird and bat mortality, and population-level risk analysis/mitigation. Using this wildlife risk modeling framework to integrate empirical data and modeling results within an adaptive management framework will improve risk assessments and management decisions for wind power development.

Key steps associated with wildlife risk estimation include: 1) identifying wildlife species at risk, characteristics of wind energy facilities and other stressors, and value-relevant endpoints (e.g., reduced wildlife abundance, increased extinction risk); 2) characterizing wildlife use of habitat at landscape scales in three dimensions, 3) predicting wildlife movements with desired precision in a seasonal and spatial context, 4) weighing various factors that affect wildlife encounter rates with turbines, 5) developing reliable models to predict encounters and associated mortality rates, and 6) extrapolating rates of wildlife mortality to express risks in terms of value-relevant endpoints at the population level. We propose a landscape-level GIS-based model to analyze the distribution and quality of habitats, wildlife corridors, meteorological data, and other factors to provide a basis for wildlife risk assessments at wind energy facilities. Combining the output of a landscape-based analysis of encounters with population projection models allows extrapolation of estimated mortality rates to population endpoints. Endpoints resulting from the analysis include increased extinction risk, which cannot be inferred directly from simple measurement of mortality rates, but is important for compliance with existing regulations, such as the Endangered Species Act.

Trevor Peterson, Stantec Consulting, Inc.

Suitable framework and scale for modeling and managing risk to migratory bats at wind projects

Trevor Peterson (Stantec Consulting)

Research objectives, including hypotheses being tested: The purpose of this presentation will be to explore whether or not traditional site-specific screening for rare species is suitable as a long-term method for minimizing potential impacts to at-risk bird and bat species at wind projects. The regional cumulative impacts to migratory species should be considered in the evaluation of wind projects, as these species tend to be more prone to collisions. Whereas the current permitting process in place for

wind projects in most states focuses on site-specific information regarding migratory species, a regional perspective is essential for understanding, managing, and mitigating impacts to long-distance migratory species, which may be more at risk of long-term cumulative impacts from wind projects than rare species less prone to collision. Methodology for assessing impacts to bird and bat species as a result of wind projects should be broadened to better assess impacts to migratory species on a large-scale, regional perspective.

Abstract: Permitting a wind project in most states requires a number of site-specific ecological surveys whose ultimate purpose is often to document and avoid “high risk” sites for various rare species. With respect to birds and bats, these surveys often focus on assessing migratory activity and patterns, documentation of resident breeding bird populations, and establishing presence or probable absence of rare species such as the Indiana bat (*Myotis sodalis*). However, such surveys rarely produce results that can be used to quantify risk at any one site, let alone compare risk between sites considered for development due to the long-distance migratory nature of many of the species most prone to collision mortality, the lack of information connecting the results of pre-construction surveys to post-construction mortality rates, and the fact that surveys typically focus on only one site at a time, rarely providing the opportunity to compare patterns across regions. Thus, data available to regulators and natural resource managers provides no opportunity to accurately predict or manage cumulative, long-term impacts to migratory species. Whereas site-specific information and risk analysis may be helpful in avoiding known concentration points or critical habitats for rare species such as Indiana bats, a regional framework will be necessary to reduce impacts to other species such as long-distance migratory bat species, which are currently more common but appear particularly prone to collision with wind turbines. Unfortunately, no existing regulatory framework allows for effective management of cumulative impacts to long-distance migratory bat species. The Endangered Species Act’s Habitat Conservation Plan and Incidental Take Permit processes are highly site-specific and not necessarily intended or suitable for managing cumulative impacts across large regions. To effectively understand and manage cumulative impacts to long-distance migratory bird and bat species, the wind industry will need to continue to be proactive in monitoring mortality rates, and if necessary, implementing regional adaptive management and/or mitigation frameworks for species most vulnerable to collision mortality. Such frameworks are unlikely to emerge from state and federal resource agencies in the near future.

Jesse Schwartz, ICF International

Wildlife Information for Decisions, Planning, and Operations of Wind Energy Resources

Jesse Schwartz, PhD (ICF International)

Research objectives, including hypotheses being tested: To develop a scalable analytical framework for standardized assessment of long-term impacts of wind turbine operations on birds and bats.

Abstract: Wind energy, despite its environmental advantages over fossil-fueled methods of generating electricity, still poses a variety of potential negative environmental impacts. This reality creates a need for a more thoughtful and systematic approach to siting, permitting, and managing wind energy infrastructure. Wildlife impacts present a potential obstacle to realizing the US Department of Energy’s 20% by 2030 goal for wind power. Agencies and industry lack a coherent analytical framework for standardized assessment of long-term impacts of wind turbine operations on birds and bats. ICF International is working with industry and agency stakeholders to develop a framework that will allow users to estimate the impacts of turbine strikes and habitat changes on long-term population

performance in the context of a species demography, genetic potential, and life history. Our goal is to develop a framework that can accommodate and analyze any species of bird or bat that might be of concern for either terrestrial or off-shore wind energy developments throughout the United States. We expect this to yield more refined and comprehensive outputs for population viability analysis (PVA) and environmental impact analysis than are currently available and to effectively reduce the permitting barriers, risks to developers, and burden on regulatory agencies. As part of this effort we have provided concept experts with internet-based tools for developing, defining, and managing key technical concepts surrounding cumulative impact assessments. This peer-based process will be used to design a conceptual model for impact assessment, and ultimately to craft an analytical framework for assessing population outcomes. The framework includes a growing set of key concepts such as species abundance, collision rates, other relevant cause-specific mortality rates, habitat capacity, fecundity, and life history information. These concepts are represented using previously published models, and integrated using a relational database and a loosely coupled code base. Each element makes a direct or indirect connection to the estimation of long-term steady state abundance using the Beverton-Holt a stock-recruitment parameters derived from a Lefkovitch stage based modeling approach. Through refinement and adaptation the system should provide a useful tool set for industry and agency analysts to further address cumulative impact issues associated with wind energy development.

Donald Solick, WEST, Inc.

Use of marine radar to study bat movements

Donald Solick (WEST, Inc.)

Research objectives, including hypotheses being tested: Objectives of the study were to evaluate the use of marine radar as a tool for tracking bat movements, particularly in the context of wind development.

Abstract: Marine radar is a valuable tool for studying the flight patterns of birds and insects, but few studies have used marine radar to characterize bat movements. In 2008, marine radar was used to monitor the emergence and re-entry of a large colony of Brazilian free-tailed bats (*Tadarida brasiliensis*). Large groups of bats were detected from 5 to 12 km from the radar, and flying at altitudes between ground and 800 m. Flight speed and flight direction of bat groups was also determined. Bats were more frequently detected during emergence, likely because they were more concentrated in space and time than during re-entry. As well, bats were more frequently detected during the summer than during the fall, likely because the colony tended to emerge in tighter formations during the summer. Examples from this work are presented to highlight the advantages and limitations of marine radar, and demonstrate its potential for addressing ecological and applied (e.g., wind energy) bat research questions.

Kristen Watrous, Stantec Consulting, Inc.

Evaluating Changes in Bat Activity and Species Composition from White Nose Syndrome at Fixed Acoustic Monitoring Locations in Vermont

Kristen Watrous (Stantec Consulting), Sarah Boyden (Stantec Consulting), Eric Britzke (U.S. Army Corps of Engineers), Ryan Smith (Vermont Fish and Wildlife Department), Scott Darling (Vermont Fish and Wildlife Department), Susi von Oettingen (U.S. Fish and Wildlife Service)

Research objectives, including hypotheses being tested: This study evaluates the relationship between results of a 3-year acoustic bat monitoring study with the simultaneous loss due to White Nose Syndrome (WNS) of 80-90 percent of overwintering bat populations within selected hibernacula in the state thought to contain large portions of the state's population of certain bat species. This study is currently the longest conducted acoustic study in Vermont to date. A primary hypothesis is that we would expect to see a decline in bat activity between pre- and post-WNS acoustic survey results. The study began in 2007, prior to the emergence of WNS, and continued through 2008 and 2009, at which point WNS had devastated the populations of certain bat species in selected hibernacula in the state.

Abstract: White Nose Syndrome (WNS) was first documented in southeastern Vermont during the winter of 2007/2008. This syndrome has spread throughout the region and has caused unprecedented mortality in certain bat species over the past two winters. Mortality associated with WNS has been documented at 80-90 percent in selected hibernacula in the state. It is vital to verify and model expected declines in northeastern bat populations due to the possible future extirpation of local or regional populations. With that in mind, Stantec augmented a two-year acoustic survey of bat activity on Grandpa's Knob in Vermont conducted in summers 2007 and 2008 with a third summer of acoustic surveys in 2009 to document changes in acoustic activity potentially related to the onset of WNS. These intensive studies, conducted specifically to document potential declines in acoustic activity due to WNS using consistent methods between years, include one season pre-WNS (2007), one season during the first year of WNS (2008), and one season during the second full year of WNS (2009). Together, these studies represent the most intensive acoustic survey conducted in Vermont to date and provide an opportunity to test whether documented population declines are reflected in acoustic bat activity levels. Because data collection began before WNS spread into Vermont, these studies provide an opportunity to compare pre- and post-WNS acoustic activity.

David Young, WEST, Inc.

*Determining Potential Take of Indiana Bat (*Myotis sodalis*) from Wind Energy Facilities*

David Young (WEST, Inc.)

Research objectives, including hypotheses being tested: Determine a defensible means by which reliable and realistic estimates of potential take of Indiana bat can be made to inform Endangered Species Act compliance actions.

Abstract: In the fall of 2009, two events occurred that elevated the endangered Indiana bat (*Myotis sodalis*) to one of the most prominent issues facing wind energy development throughout the Midwest and eastern U.S. A federal court determined that operation of a proposed wind facility in West Virginia would lead to take of Indiana bat, and an Indiana bat fatality was recorded at an existing wind facility in Indiana. The Endangered Species Act (ESA) has provisions by which an Incidental Take Permit (ITP) may be acquired to cover unintended take of a listed species by otherwise lawful actions, thus allowing wind development to proceed in light of potential ESA violations. At the crux of developing an application for an ITP under Section 10 of ESA is determining potential take of the listed species at risk. With only one example by which to evaluate the conditions and circumstances when Indiana bats are at risk, the ability to estimate impacts and potential take from wind turbines is limited. We have developed a model for determining potential incidental take of Indiana bat at wind energy facilities. We present three acceptable means by which take can be estimated in the absence of data: (1) a habitat equivalency approach, which utilizes habitat losses as the index to take; (2) a surrogate species approach, which utilizes data from similar species to estimate take of the focal species; and (3) a collision risk model

approach, which uses data on spatial occurrence and flight characteristics to estimate take. All three approaches have merit and may be variably applicable for different projects and may be combined to corroborate the level of estimated take. The combination of two or more of the proposed methods provides defensible and repeatable documentation necessary for the Fish and Wildlife Service to issue an ITP.

Mitigation Techniques and Technology

Ed Arnett, Bat Conservation International

Reducing Bat Fatalities At Wind Energy Facilities

Edward B. Arnett (Bat Conservation International)

Abstract: Unexpectedly high numbers of bat fatalities have been reported at utility-scale wind energy facilities, especially along forested ridge tops in the eastern United States. These fatalities raise important concerns about cumulative impacts of proposed wind energy development on bat populations. I will present findings from ongoing studies on the effectiveness of operational curtailment and acoustic deterrents to reduce bat fatalities. Operational curtailment studies indicate that bat fatalities can be reduced from 44 to 93% during selected high risk periods of the year and with marginal power losses (0.3 to 1% of total annual output). Research and development of acoustic deterrent devices is continuing and I will present first- and second-year results from a field test comparing fatalities at turbines with and without deterrents and discuss future research needs and efforts. Given the magnitude and extent of bat fatalities worldwide, the conservation implications of these findings are critically important.

Jenny Davenport, DeTect, Inc.

Using Radar-based Mitigation to Minimize Bird and Bat Strike Risk at Wind Energy Developments

Jenny K. Davenport, T. Adam Kelly (DeTect, Inc.)

Research objectives, including hypotheses being tested: Objectives include describing the process of using radar-based mitigation at windfarms, and exploring its adaptability by presenting a variety of examples illustrating how the system would be applied to windfarms experiencing different types of bird and bat collisions.

Abstract: Although wind energy is generally perceived to have low environmental impacts, a number of wildlife impacts from windfarms have been documented. In particular, a variety of bird and bat collision fatalities have been found at windfarms worldwide. Concerns with these impacts have heightened with the increased demand for clean, renewable energy and subsequent growth of the wind industry, and mitigation techniques are needed to reduce these impacts. However, challenges in developing these mitigation measures include minimizing wind turbine downtime to allow sufficient time for energy production and finding solutions that will be applicable to the myriad of collision risks documented throughout the world for both birds and bats.

With an objective of mitigating strike risk of birds and bats at operational windfarms, DeTect, Inc has developed a radar-based mitigation system that integrates avian radar technology with the windfarm

Supervisory Control and Data Acquisition (SCADA) system, called MERLIN SCADA. This radar-based mitigation system provides continuous monitoring and advance detection of mortality risk conditions at operating windfarms, automatically activating mitigation measures ranging from issuing alerts to windfarm operators to idling turbines whenever pre-defined conditions associated with high bird or bat mortality risk occur.

This mitigation solution has been implemented at two windfarms in the U.S. during 2009 with the objective of reducing collision risk of migratory birds. MERLIN SCADA, however, can be programmed with a variety of mitigation rule sets that would be tailored to high strike risk conditions specific to each windfarm, including those associated with raptors, migratory bats, as well as colonies of bats or birds. A variety of example rule sets based on current knowledge of bird and bat collision mortality at windfarms will be presented. It is important to understand the data requirements and technology limitations when developing these rule sets, and study designs need to adequately describe circumstances under which strikes occur so rule sets can be refined to optimize mitigation.

This mitigation technique is flexible enough to encompass different types of bird and bat collision risks at windfarms and also minimizes turbine downtime by targeting exact periods of high mortality risk specific to each windfarm. It may also provide an important tool in a comprehensive mitigation process for wind energy companies to reduce bird and bat strike risk at windfarms while maintaining profitable production of green energy.

Marc d'Entremont, Stantec Consulting, Inc. and UNBC

How does the accuracy of data on avian movement vary with radar methodology?

Marc d'Entremont (Stantec/University of Northern British Columbia), Dr. Andrea Pomeroy (Stantec), Naira Johnson (UNBC), Dr. Ken Otter (UNBC)

Research objectives, including hypotheses being tested: The objectives of this work is to test digitization hardware and tracking software that is being developed for avian tracking and then use these to measure movement patterns of nocturnal migrants around wind installations.

Abstract: Real-time analysis of radar migration data has a number of potential limitations: 1) the inability to record all targets on the radar screen during busy periods of migration; and 2) observer bias in recording accurate distance and bearing information from the radar. These limitations can lead to the perceived risk of collision with wind turbines being over- or understated. We have recorded the movement patterns of nocturnal migrants around wind installations during spring and fall migration in northeastern British Columbia using digitization hardware and tracking software designed for a marine surveillance radar. Using recorded data from one hour sample blocks based on relative densities (i.e., high, moderate and low passage rates), the real-time analysis of data is compared to manual analysis of recorded data and auto-tracking features of the tracking software to determine the amount of variation (error and unreliabilities) in data analysis. We conduct a cost/benefit analysis between data accuracy and analysis time, and will offer options for standardized protocols that can be applied to accurately monitor bird movements around wind farms.

Wally Erickson, WEST, Inc.

Texas Gulf Coast Avian and Bat Fatality and Curtailment Approaches

Wally Erickson (WEST, Inc.), Gary Andrews (DeTect, Inc.), Manuela Huso (EcoStats), Jerry Roppe (Iberdrola Renewables), Jim Sinclair (TX-ESA Environmental Consultants)

Research objectives, including hypotheses being tested: to evaluate the effectiveness of MERLIN radar system and episodic turbine curtailment to reduce avian mortality, especially during spring and fall migration.

Abstract: A Merlin avian radar system has been installed and been running for testing and implementation of risk reduction strategies at the Penscal Wind Project in Kennedy County Texas. The system has been developed to actively interface with the turbine operations software. Turbine curtailment is implemented when risk factors such as low visibility and high biological target rates meet certain criteria. Studies have been on-going to evaluate the effectiveness of this approach, and in implementing adaptive management to modify and improve on these approaches. Methods and approaches used to help evaluate the curtailment strategy as well as understand collision risk include daily fatality searches using dogs, evaluation of continuous radar data collected on site, and evaluation of other risk factors (e.g. weather, location).

Ana Teresa Marques, Bio3, Lda.

Is it necessary to adjust a wind farm layout? A proposal to identify and minimize potential impacts on raptors and soaring birds

Ana Teresa Marques, Rita Ferreira, Hugo Costa, Miguel Mascarenhas (Bio3 – Estudos e Projectos em Biologia e Valorização de Recursos Naturais, Lda.)

Research objectives, including hypotheses being tested: The main objective of the presentation is to demonstrate a methodological protocol developed to predict and evaluate the effects of wind farms on raptor and soaring bird populations, through the presentation of different case studies.

Abstract: A methodological protocol was established to study raptor and soaring birds populations in wind farms, with the objective to investigate the need for wind farms' layout adjustment, in order to minimize bird mortality, during pre-construction monitoring. This methodology was developed and improved during the last six years on several ecological wind farm studies.

The analysis was based on data collected through field point observations, which allow a good cover of the wind farm area and its surroundings. Data analysis was conducted in a GIS, where horizontal and vertical use maps were built, and a "Collision Hazard Index" was estimated. This index was determined for all the species occurring in the area and for the species selected by a risk assessment matrix, which classifies each species according to their use of the study area, their sensitivity to collision and their conservation status.

This analysis was performed in two case studies in Portugal, a wind farm which is being projected and where was possible to make adjustments on the wind farm layout, and a different one, already built which was not submitted to this analysis prior to its construction.

The methodological protocol presented can be useful to identify high risk collision areas and, therefore, give important guidelines to the locations of the turbines.

Cara Meinke, Stantec Consulting, Inc.

Using a Predictive Indiana Bat Habitat Suitability Model to Inform a Tiered Curtailment Strategy for an Ohio Wind Power Project

Cara W. Meinke, Kristen S. Watrous (Stantec Consulting, Inc.)

Research objectives, including hypotheses being tested: The objective of this project was to create a curtailment strategy based on empirically-based data that maximized protection of the Indiana bat while allowing for an economically viable renewable energy project. The efficacy of the curtailment strategy will be tested with a long-term monitoring program that will allow for adaptive management to adjust specific operational curtailment levels and periods to which they are applied.

Abstract: The rapid expansion of wind power development within the range of the federally endangered Indiana bat has highlighted the need for increased scientific understanding of potential impacts and solutions to avoid and minimize those impacts. We created a predictive habitat suitability model to inform a tiered curtailment strategy for a wind power project in Champaign County, Ohio. We used a partitioned Mahalanobis D2 model based on 1,124 nighttime radio-locations and 43 roost locations from 19 Indiana bats radio-tagged in the vicinity of the project area during summer mist-netting in 2008 and 2009. We used a Geographic Information System (GIS) to measure spatial characteristics of forest patches, habitat heterogeneity, slope, elevation, and distance to stream, wetland, and forested stream within 2-km buffers of each pixel in the project area. The distances (D2) between the vector of environmental conditions measured at each pixel and the mean vector of environmental conditions at known Indiana bat roosting and telemetry locations were rescaled using a Chi-square distribution, converted to p-values, and divided into 4 quantiles, representing most to least suitable. Indiana bat foraging habitat suitability was strongly associated with the configuration and spatial relationships of forested patches; the 3 most important variables were the degree of fragmentation, the connectedness of forest patches, and the total core area of forested habitat. This differed from roosting habitat suitability, which was driven largely by distance to forested streams, distance to streams, and distance to the nearest forest edge. A tiered approach to operational curtailment was developed based on the predicted Indiana bat habitat suitability at each proposed turbine location. Curtailment regimes differed in terms of cut-in speeds, duration, and seasonality, with turbines located in the most suitable Indiana bat habitat having the highest cut-in speeds applied over the longest duration.

Chris O'Meilia, U.S. Fish & Wildlife Service

*A System to Avoid or Minimize and Offset Negative Impacts of Development on the Lesser Prairie-Chicken (*Tympanuchus pallidicinctus*) through a Spatially-Based Planning Tool, Promoting Voluntary Offsets and Targeted Conservation Work: A Multi-Entity Collaboration in Oklahoma.*

Chris O'Meilia (U.S. Fish and Wildlife Service, Oklahoma Ecological Services Field Office), Russ Horton (Oklahoma Department of Wildlife Conservation), Luke Bell (U.S. Fish and Wildlife Service, Oklahoma Ecological Services Field Office), Megan McLachlan (Playa Lakes Joint Venture), Chris Hise (The Nature Conservancy, Four Canyon Preserve), Don Wolfe (The G. M. Sutton Avian Research Center, University of

Oklahoma), Dwayne Elmore (Oklahoma State University), J.D. Strong (Office of the Secretary of Environment, State of Oklahoma)

Abstract: The Oklahoma Lesser Prairie-Chicken Spatial Planning Tool (OKLEPCSPT; <http://www.wildlifedepartment.com/lepcdevelopmentplanning.htm>) is a multiscale spatially-based planning tool designed to allow for proactive evaluation of anthropogenic impacts, promote voluntary offsets and targeted conservation work for an area sensitive species and candidate for federal listing under the Endangered Species Act. The core product of the OKLEPCSPT is a spatial model that combines eight factors, including biological and ecologically relevant spatial data (e.g., lek locations, suitable and potentially suitable land use/land cover) and fragmenting features (e.g., oil and gas well locations, roads, transmission lines, etc.) that exist within the Oklahoma portion of the current and historical range of the LEPC. The OKLEPCSPT is a relative valuation of the lands within the range of the LEPC in Oklahoma. The OKLEPCSPT was developed through a coordinated effort between the Oklahoma Department of Wildlife Conservation, the Oklahoma Ecological Services Field Office of the U.S. Fish and Wildlife Service, the Oklahoma Chapter of The Nature Conservancy, the Playa Lakes Joint Venture, the George Miksch Sutton Avian Research Center and the Office of the Oklahoma Secretary of Environment. The first part of this talk will offer an overview of the need for such an effort and description of the OKLEPCSPT that was developed to help in our endeavor. While the impetus for the group's work is the potential for significant and rapid expansion of wind energy facilities and associated infrastructure in proximity to the LEPC in Oklahoma, the OKLEPCSPT can be used to evaluate any type of potentially detrimental development (e.g. transmission lines, road construction or oil/gas development). The second part of the presentation will describe the three current applications of the OKLEPCSPT:

1. Identification of areas important to the conservation of the LEPC and those more suited for development of wind energy facilities and associated infrastructure (i.e., where wind could go and have reduced or no impact on the LEPC),
2. Ranking of sites for targeted conservation work (e.g., ranking applications for cost-share assistance in the USFWS Partners for Fish and Wildlife program), and
3. Estimation of voluntary offset costs for proposed development projects.

Alicia Oller, Tetra Tech EC, Inc.

Lessons Learned From Habitat Conservation Plans: Applications For Wind And Endangered Species.

Alicia Oller, Laura Nagy, Brita Woeck (Tetra Tech EC, Inc.)

Research objectives, including hypotheses being tested:

1. to describe habitat conservation plans (HCP) and how they can be applied to wind developers with endangered species issues;
2. to identify simple steps that can be the difference between success and failure in the HCP application process; and
3. to provide a realistic understanding of schedule and financial realities associated with the HCP process.

Abstract: The rapid development of the wind industry in the US has resulted in situations in which wind sites without environmental constraints are becoming increasingly rare. Therefore, more sites with potential conflicts with endangered species and their habitats are under consideration for development. To minimize risk on non-federal lands, such as wind farms on privately owned land, an Incidental Take

Permit can be obtained in conjunction with a Habitat Conservation Plan (HCP) under Section 10 of the Endangered Species Act. Obtaining an HCP in a timely and cost-effective manner can be challenging. Through interviews with agencies, consultants, applicants, and personal experience, we summarize lessons learned from successful habitat conservation plans. The group developing the HCP needs to 1) have the appropriate technical experience, 2) skillfully coordinate and communicate with multiple stakeholders, 3) develop strong relationships with the United States Fish and Wildlife Service (USFWS) at the state, regional, and national level, and 4) generate a realistic understanding of timing and funding requirements. The applicant and the USFWS together need to 1) accurately assess the project impacts, and 2) develop realistic and appropriate mitigation strategies that are both biologically based and economically feasible. By applying these lessons learned, applicants may facilitate resolution of threatened and endangered species issues of a wind development project. The three most important learning objectives of this presentation are: 1) to describe habitat conservation plans (HCP) and how they can be applied to wind developers with endangered species issues; 2) to identify simple steps that can be the difference between success and failure in the HCP application process; and 3) to provide a realistic understanding of schedule and financial realities associated with the HCP process. This presentation will benefit attendees by explaining a potential option to manage risk when developing a wind farm in areas with threatened or endangered species. Locations with threatened or endangered species issues are becoming more common as the industry becomes more competitive. Although the species may differ, consistent problems with special status species exist nationwide. We will use case studies to actively engage participants. Our lessons learned are from real examples and personal experience, but have been distilled to provide generalizations that are applicable for all projects.

Understanding the Current Knowledge of Offshore Wind and Wildlife Issues

Andrea Copping, Pacific Northwest National Laboratory

Addressing Environmental Effects of Offshore Wind Development

Andrea E. Copping, Richard M. Anderson, F. Brie Van Cleve (Pacific Northwest National Laboratory)

Research objectives, including hypotheses being tested:

1. Understand the potential environmental effects of offshore wind development on marine organisms and the marine environment;
2. Determine which potential effects are likely to cause harm through the application of risk assessment techniques; and
3. Develop a risk framework that will provide regulators and offshore wind developers with clear priorities for environmental assessment and monitoring priorities for permitting requirements.

Abstract: Successful deployments of wind farms off European coastlines, and continued pressure to develop new renewable energy sources, has encouraged wind developers in the US to propose offshore wind deployments in coastal and offshore waters. While technology challenges, economic incentives, and grid integration questions are significant, the greatest barriers identified are likely to be the uncertainty and regulatory hurdles associated with environmental effects of offshore wind platforms, pilings, and turbines on the marine environment, particularly on vulnerable animals such as seabirds and marine mammals.

Scientists at Pacific Northwest National Laboratory in Washington State are beginning to examine the range of potential environmental effects of offshore wind platforms and installations on marine life and

ecosystems using a risk-informed framework. The framework draws on datasets from laboratory, pilot and commercial offshore wind deployments. A knowledge management system, or “smart” database will be developed to organize and archive data for the risk framework; the knowledge management system can also be used to help set the research, development, and deployment agenda for DOE’s national laboratories and their university and industry partners. This paper will describe the strategy for integrating information on environmental effects including model results and laboratory exposure studies of attraction and avoidance of organisms, effects of electromagnetic fields and acoustic signals, as well as integrating the results of international offshore wind permitting processes.

Results will be presented of the early stages of the offshore wind risk framework. A similar framework for marine and hydrokinetic (MHK) energy devices (tidal, wind, ocean current) is more fully developed. There are many analogues and similarities between the effects of MHK and offshore wind installations, and permitting concerns are similar. Early results from the MHK risk framework will be presented. Initial presentations of the MHK framework to industry and regulators has yielded a high degree of interest and the desire to engage in the development process.

Jenny Davenport, DeTect, Inc.

Challenges and Solutions for Using Radar at Offshore Wind Energy Developments

Jenny K. Davenport, T. Adam Kelly, Tim E. West, Andreas Smith (DeTect, Inc.)

Research objectives, including hypotheses being tested: Objectives include listing current challenges of using radar for bird and bat studies at offshore wind energy developments, exploring possible solutions while considering the pros and cons of each, and outlining important considerations when developing offshore radar studies.

Abstract: Offshore wind energy development presents new challenges in assessing potential impacts to birds and bats from wind turbines. Radar has become an important tool for assessing bird and bat impacts at land-based wind energy sites, and promises to play an even greater role at offshore sites given both the lack of knowledge about bird and bat activity offshore and the increased difficulty in obtaining data from offshore sites that are often remote, difficult to access, and unable to support traditional land-based assessment methods. Most radar studies to date have used off-the-shelf or modified marine radars, however, there are several issues that continue to hinder the potential usefulness of these radars at wind energy sites, with offshore sites providing a particular suite of challenges. These challenges include sea clutter from wave action, detecting and tracking targets on or immediately above the water’s surface, interference from other radars used by boats for navigation, site remoteness, and weather conditions that affect radar performance. We provide an overview of and discuss these challenges as well as present current or developing solutions that address these challenges. We also outline important considerations when developing an offshore radar study (e.g. study time periods, pros and cons of different radar systems, and availability of power sources and support structures).

Greg Forcey, Pandion Systems, Inc.

Evaluating Piping Plover and Red Knot use of the AOCS during migration using the Avian Knowledge Network

Greg Forcey, Caleb Gordon, Joanna Burger, Larry Niles (Pandion Systems, Inc.)

Research objectives, including hypotheses being tested: To examine the hypothesis that migrant Red Knots and Piping Plovers migrate across offshore waters where future wind development could occur.

Abstract: The Atlantic Outer Continental Shelf (AOCS) is an area of high potential wind development which may impact birds that migrate over the open ocean. Two species that may “shortcut” across large bays and other sections of offshore waters during the course of their generally coast-hugging migrations are Piping Plovers (federally threatened) and Red Knots (species of special concern). These offshore migrations may potentially expose them to risk from offshore wind development in the AOCS. The Avian Knowledge Network (AKN) contains thousands of coastal observations of these species which can provide information on bird movements in and around coastal waters. We evaluated the shortcut hypothesis by 1) evaluating AKN data for observations that occur in offshore and coastal waters and 2) comparing relative counts in and around offshore and coastal waters to estimate whether birds are shortcutting across open water or migrating strictly along the coast. We performed separate analyses for Piping Plovers and Red Knots for each migratory season. Sampling units were delineated along coastal areas that allowed us to quantify relative bird abundance in these areas. Our results suggest that both Piping Plovers and Red Knots use offshore shortcuts during their spring and fall migrations. Offshore wind siting decisions should therefore consider that these shortcut areas represent regions where Piping Plovers and Red Knots could be exposed to offshore wind turbines during migration. Further research on flight height and behavioral avoidance is necessary in order to determine the degree to which this increased exposure translates into increased collision risk in the AOCS.

Jesper Kyed Larsen, Vattenfall Wind Power

Danish experiences with offshore wind farm and wildlife – results of a strategic environmental monitoring programme

Jesper Kyed Larsen (Vattenfall Wind Power, Chair of Steering Group for strategic environmental monitoring programme on Danish offshore wind farms)

Research objectives, including hypotheses being tested: Wildlife impacts of offshore wind farms

Abstract: Wildlife impacts of offshore wind farms have been studied in Denmark since 1991, when the first small-scale offshore wind farm was built. Since then the number of wind farms have increased to 11, including 3 large-scale wind farms, currently totalling 660 MW of installed capacity. A large number of studies on wildlife impacts have been carried out by now, and the present talk intends to provide an up-dated overview of studies and their main results, as well as convey some major lessons learnt with regard to the management, setup and design of offshore wind and wildlife interaction studies, as an inspiration for setting-up and conducting similar types of studies on US offshore wind farms.

A comprehensive environmental monitoring programme was connected to the demonstration wind farms Horns Rev and Nysted, the first large-scale Danish offshore wind farms consisting of 80 2MW and 72 2.3MW turbines, respectively. The programme, which was initiated in 2000, included studies on benthic fauna, fish, marine mammals and birds, as well as socioeconomics. In general, studies used the

BACI approach, but also required that several novel techniques were developed. The original programme was finalized in 2006, and the results presented in the form of reports and a book. In continuation from this a follow-up programme was decided, with an aim to clarify outstanding issues of specific relevance to the planned future offshore wind farm development in Danish waters. This programme includes studies on fish, marine mammals and seabirds, most of which are ongoing, but some new results can be presented as well.

The original and the follow-up programme was (and are) both coordinated by a steering group (The Environmental Group), consisting of representatives from The Danish Energy Authority, The Danish Forest and Nature Agency, and the operators of the two wind farms, Vattenfall and DONG Energy. The total budget is 84 million DKK (equivalent to about 15 million USD). The steering group is assisted by an advisory panel of recognized international experts within a range of fields within marine ecology. In addition, during the original programme, the steering group was in continuous dialogue with a “green group” of key ngo’s.

Chris Nations, WEST, Inc.

A Simulation Model for Assessing Bird – Wind Turbine Collision Risk

Christopher S. Nations, Wallace P. Erickson (WEST Inc.)

Research objectives, including hypotheses being tested: The primary objective of this work was to develop a simulation model to estimate collision risk for birds flying through wind farms. In contrast to alternative models, this new model offers both a high degree of detail and comprehensive inclusion of biotic and physical factors. Furthermore, rather than exemplifying a black box, all aspects of model structure and assumptions are available for critical evaluation. Appropriate assessment of collision risk can assist in project siting, and it may also inform selection of turbine design, turbine layout within a proposed site, and mitigation strategies for both proposed and existing projects.

Abstract: An individual-based mathematical model has been developed for estimating probabilities of bird collisions with wind turbines. Tucker’s (1996) approach to calculating collision probability for an active rotor is a sub-component, though collisions with stationary structures are also possible. The model is designed to explicitly account for bird characteristics, wind conditions, turbine design, and wind park layout. Bird size, flight patterns (altitude, direction, and speed), and avoidance behaviors can be included based on literature reviews and/or results of data collected for a project. A key aspect of modeled bird behavior is avoidance probability, which is implemented hierarchically with separate input parameters for the entire wind park and individual rotors, towers, and nacelles. Wind characteristics are based on data collected from onsite meteorological towers or nearby weather stations. Modeled wind turbine features include dimensions of towers, nacelles, and blades, as well as operational properties such as rotational velocity and blade pitch. Furthermore, the model incorporates the spatial arrangement of the individual turbines within a wind park. Other input conditions may include season, time of day, and options such as temporary curtailment of power generation implemented as a mitigation strategy. Collision probabilities are assessed by simulating flight paths of individual birds through the wind park and calculating the proportion of all such paths that result in collision. Predicted numbers of fatalities are then calculated by multiplying collision probabilities by avian passage rates estimated from onsite surveys. Model assumptions, design, and performance will be illustrated with an example from an existing wind project. Estimates of both pre-construction avian passage rates and post-construction fatalities have been used to calculate “empirical” estimates of collision probability for

several species. Model predictions based on reasonable assumptions are consistent with these estimates. Models such as the one presented here can be useful in assessing risk to birds prior to construction, and may assist in tailoring mitigation strategies to site-specific conditions. This model has potential for application to bats as well as birds, though current knowledge of bat flight behavior suggests that such extension of the model should be considered carefully.

Steve Pelletier, Stantec Consulting, Inc.

Maine Offshore Bird and Bat Pilot Project

Steve Pelletier, George Kendrick, Trevor Peterson, Adam Gravel (Stantec Consulting)

Research objectives, including hypotheses being tested:

1. Initiate 1st offshore avian (x-band) radar study in Gulf of Maine;
2. Compare radar survey results with 4 concurrent onshore (interior Maine) studies;
3. Initiate 1st quantitative offshore regional bat survey;
4. Compare methodologies and results of prior terrestrially-based seasonal surveys (138 acoustic bat; 109 radar) with off- & near shore surveys;
5. Obtain baseline data on day/night avian migration characteristics;
6. Assess viability of regional fall migration data trends;
7. Assess effectiveness of equipment & methods in marine environment; and
8. Refine protocols & sites for expanded comprehensive study

Hypotheses – Previously identified seasonal trends and patterns of (fall) avian and bat migration in terrestrial onshore regions are influenced by seasonal offshore conditions.

Abstract: Challenges associated with developing offshore ocean energy sources are diverse and complicated by a lack of fundamental resource data. In addition, opportunities for collecting offshore data are generally difficult, prohibitively expensive and frequently hazardous due to restricted access options. Recent offshore investigations (e.g., Cape Wind) have specifically revealed critical information gaps in regard to day and night bird migration, and more particularly for bats. In 2009 Stantec designed and conducted a region-wide pilot study, in cooperation with federal, state, and NGO partners, to evaluate the presence and movements of birds and bats during fall migration within the Gulf of Maine. The study also assessed the viability and effectiveness of current survey tools and techniques in the marine environment. For the study Stantec deployed two x-band radar systems and 12 digital acoustic bat echolocation detectors at two coastal and ten remote island locations. Sites were distributed along an approximate 150-mile coastal transect and up to 20 miles offshore. Radar survey results were also compared with concurrent ongoing radar surveys at four onshore locations in Maine. Surveys indicated flight heights of nocturnal migrants in the offshore were slightly lower than those occurring at interior, land-based sites within Maine. Most flight characteristics were otherwise generally similar to other terrestrial studies. A variety of bat species were detected at each sampling location with activity documented as late as November 10. Migratory tree bats were documented at each site. *Myotis* species, silver-haired, hoary, and eastern red were among the most commonly detected species, with big brown and eastern red bats locally abundant at some sites. Included in the study were limited post-nesting-season, daytime radar observations of local seabird movements on and off islands. The pilot study provides a preliminary glimpse into the presence/absence, timing, flight heights, and passage rates of offshore avian and bat targets moving southward during late summer and fall migration seasons, and begins to identify a seasonal and geographic distribution of bat species as they occur in the Gulf of Maine. It also provides important technical and logistical information on the effectiveness of equipment and survey methods in the marine environment and offers key guidance towards

implementing future bat and avian research efforts, including passerines, shorebirds and seabirds, in the offshore.

Angela Sjollema, UMCES and Frostburg State University

Bat activity in the vicinity of proposed wind facilities along the Mid-Atlantic Coast

Angela Sjollema (University of Maryland Center for Environmental Sciences and Frostburg State University), Dr. J. Edward Gates (UMCES), Dr. John Sherwell (Maryland Department of Natural Resources, Power Plant Research Program)

Research objectives, including hypotheses being tested: Study Objectives: 1.) Determine if migration pathways exist near and offshore on the Mid-Atlantic Coast; 2.) Assess coastal and offshore bat migration in the following ways: a.) identify which species are active in these areas b.) whether or not there is seasonality to the activity, and c.) if there is a gradient to activity depending on distance from shore; 3.) Determine how weather affects bat activity and migration, including wind speed, barometric pressure, and air temperature.

Hypotheses: H1: There is no substantial bat activity offshore or near shore; H2: Species diversity and richness will be similar onshore and offshore; H3: There is no difference between spring and fall migratory activity, nor is there a difference based on offshore or onshore locations; H4: Bat migration and activity is not affected by weather variables.

Abstract: Although wind power plants are considered a renewable source of energy, they have tremendous effects on wildlife in the eastern United States. Bat fatalities at some wind facilities in the Appalachian Mountains during fall have been estimated to be in the thousands. Other possible migration routes for bats include areas near and off the Atlantic Coast. A comprehensive study of offshore bat activity has not been conducted despite bat occurrences on boats at sea for decades. Recently, wind power plants have been proposed off the Atlantic Coast, rendering a comprehensive assessment of offshore bat migration dynamics necessary to prevent potential detrimental effects to their populations. Determining if there are predictors for high activity, such as favorable weather patterns, is also vital. Bat species richness and density will be studied using acoustic monitoring equipment near and offshore in the Mid-Atlantic region. Four sites have been set up onshore to record year-round nightly bat calls in New Jersey, Delaware, and Maryland beginning in spring of 2009 and ending fall 2010. Offshore acoustic monitoring is conducted from boats traveling close to shore during the migration seasons of 2009 and 2010. Early findings include a substantial number of *Lasiurus borealis*, *Eptesicus fuscus* and *Lasionycteris noctivagans* near the coast. One bat, a *L. noctivagans*/*E. fuscus*, was recorded 8.53 km from the New Jersey coast in the spring of 2009. Preliminary fall detections total 69 offshore calls from two boats traveling the New Jersey and Maryland coast. Bats were recorded up to 19.31 km from shore with an estimated average of 9.64 km. The most frequently recorded species was *L. borealis* suggesting that these bats use offshore pathways in fall. Other species detected included *L. cinereus*, *E. fuscus*/*L. noctivagans*, and *Myotis* species. Therefore, their occurrences at these distances suggest that planned offshore wind energy developments could affect migratory bats.