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Status of the U.S. Department of Energy/National Renewable Energy Laboratory Avian Research Program

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ABSTRACT

As wind energy development expands, concern over possible negative impacts of wind farms on birds remains an issue to be addressed. The concerns are twofold: 1) possible litigation over the killing of even one bird if it is protected by the Migratory Bird Treaty Act and/or the Endangered Species Act, and 2) the effect of avian mortality on bird populations. To properly address these concerns, the National Renewable Energy Laboratory (NREL), working collaboratively with stakeholders including utilities, environmental groups, consumer advocates, regulators, government officials, and the wind industry, supports an avian-wind interaction research program. The objectives of the program are to conduct and sponsor scientifically based research that will ultimately lead to the reduction of avian fatality due to wind energy development throughout the United States. The approach for this program involves cooperating with the various stakeholders to study the impacts of current wind plants on avian populations, developing approaches to siting wind plants that avoid avian problems in the future, and investigating methods for reducing or eliminating impacts on birds due to the development of wind energy. This paper summarizes the research projects currently supported by NREL.

INTRODUCTION

An earlier paper (Sinclair and Morrison 1997) contains a summary of the history and approach of the federal government's avian research program. That basic approach continues today. NREL continues to seek input from various stakeholders including utilities, environmental groups, consumer advocates, regulators, government officials, and the wind industry to determine a focus for resources to address the bird response to wind developments. The concern for the potential effects of wind turbines on birds is driven by two primary issues: possible litigation over the killing of even one bird if it is protected by the Migratory Bird Treaty Act and/or the Endangered Species Act, and the effect of bird fatalities caused by wind developments on bird populations. The primary focuses of this paper are to summarize the activities of the research program over the last 2 years and describe the future program direction.

PROGRAM DEVELOPMENT

Bird fatalities were first noted during the early years of commercial wind development. In particular, dead golden eagles (*Aquila chrysaetos)* were found in the Altamont Pass wind farm in California. Because of the number of fatalities and the fact that the golden eagle is protected by both state and federal laws, the counties of Alameda, Contra Costa, and Solano and the California Energy Commission initiated a study to try to understand the magnitude of the problem, identify the causes, and recommend mitigation measures. The researchers observed 15 species of raptors in the Altamont wind resource area (WRA). From the carcasses they found during their fatality searches over a 2-year period, they conservatively estimated that 39 golden

eagles along with 100-300 other raptors were killed each year in the WRA but cautioned that the "estimates have a large potential for error because of the number of variables involved and the small number of fresh carcasses found" (Orloff 1992). Nevertheless, this early study clearly suggested that wind turbines cause bird fatalities.

Serious debates ensued over the research or study objective questions, the study methodologies and the conclusions drawn from limited data. As a result of this controversial atmosphere, the U.S. Department of Energy (DOE) decided to develop a scientifically based avian research program funded out of the DOE's wind program and managed by NREL. A summary of the collaborative activities that occurred prior to and just after the inception of the DOE/NREL program can be found in a recent paper (Sinclair and Morrison 1997). In addition to collaborating with stakeholders, NREL calls on experts in the fields of biostatistics, population modeling, epidemiology/mortality, ornithology, and statistics to provide advice when designing new research projects, provide critical review of reports, and consult on a variety of issues related to the avian research program.

As a result of the collaborative effort, numerous research projects have been funded since the program's inception that focus on those issues believed to be the most important. To reduce or eliminate contentious debates over how studies were done, one of the most pressing projects has been the development of a guidance document that describes options for sample design, methods and metrics. Although the document is still undergoing peer review, the sample designs, methods and metrics discussed in the document have been implemented in most of the projects funded through NREL over the last several years. Using a scientifically based, consistent set of methodologies and metrics normalizes the results of a large number of studies. Thus, our understanding of what factors are contributing to adverse avian-wind turbine interactions will be easier to identify, and recommendations on how to resolve the problem will be advanced.

The knowledge of bird fatalities at some wind developments, especially those at the Altamont Pass WRA, continues to cause greater scrutiny for potential developments at other wind resource areas. Poor or inadequate attention to the avian issue at one site can have ramifications for other sites. The lack of proven solutions in the Altamont Pass WRA to reduce the continued death of birds by wind turbines is a case in point. Wind developments may be required to conduct more research than is actually necessary due to concerns raised by the Altamont Pass situation.

Development of new wind projects is almost always constrained by cost. Conducting rigorous avian research, using methods and designs that adhere to accepted scientific protocol, can be time consuming and costly. Thus, much of the avian research being conducted today is either funded or co-funded by the DOE/NREL. In addition, some members of the wind industry are involved in their own avian research projects on their sites that involve varying levels of intensity.

All projects sponsored by NREL must be based on an initial study plan that fully justifies all sampling methods. This justification includes a review of the pertinent scientific literature and quantitative analyses of potential sample sizes, including power analysis. As a standard, the research must produce results that are suitable for publication in peer-reviewed scientific journals. By holding to this standard, NREL's goal is that the research results will lead to findings and conclusions that are based on rigorous research protocols and eliminate impugning debates over the study design.

SPECIFIC AVIAN RESEARCH PROJECTS

DOE/NREL's avian research program has resulted in a multifaceted approach to addressing the impacts of

wind power development on birds. Early research program guidance was the result of discussions from two national meetings. Many of the projects that were suggested in those meetings are either complete or almost complete. A few other projects were funded as a result of a risk reduction solicitation or as unique situations where NREL involvement helped leverage resources from other organizations. Table 1 summarizes those research projects and their status.

KENETECH (now Green Ridge Services) initiated research on the ecology of golden eagles in the Altamont Pass WRA. NREL assumed responsibility for the eagle research in 1994 and expanded the work to include development of models for predicting the viability of the population. This research is the first to attempt to develop population models of a bird population inhabiting a wind resource area. The results of this 4-year study will be published this year (Hunt 1999).

In another industry-initiated study, KENETECH funded laboratory research at Boise State University's Raptor Research Center. Data were gathered on eight studies of raptor visual physiology, raptor flight behavior, and conspicuity ratings of potential blade patterns. The objective was to develop recommendations for making turbine blades more visible to raptors. Although all the research studies had been completed prior to KENETECH'S bankruptcy, none of the data had been analyzed or reported. DOE/NREL subsequently funded Boise researchers to complete data analyses and report on their findings. The results indicated that raptors can distinguish between several patterns painted on blades, but extrapolation to field tests is premature. At this time, the final reports are still pending.

NREL has begun a rigorous study in the Altamont Pass to investigate the behavior of birds flying near, and perching on, turbines and to determine the relationship between flight behavior, perching, and bird mortality. The research focuses mostly on turbines with tubular towers, turbines on lattice towers with diagonal crossbars, and vertical axis turbines, where operators were interested in participating in the study. The first year data suggest some interesting findings, including the impact of tubular towers on birds in the Altamont, the role of non-end turbines in bird fatalities, and the diversity of birds killed during the study period. A first year progress report will be published by early fall 1999.

A companion study will help understand prey abundance and distribution in the Altamont WRA. The principle objectives of the research are to 1) determine the relationship between raptor flight behavior and specific characteristics of the topography and weather conditions on a seasonal basis, 2) determine the relationship between prey abundance and raptor activity, and 3) determine the relative contribution of both topographic characteristics and prey abundance in explaining raptor distribution. The researchers will develop recommendations for reducing raptor mortality in wind farms.

Two major studies are being conducted in the Tehachapi Pass WRA and San Gorgonio Pass WRA in California. Preliminary data indicate that this research will provide a significant contrast to the concerns raised in the Altamont WRA. The objectives of these studies, which are co-funded by the California Energy Commission, are to investigate the influence of tower type (tubular versus lattice) and size (small and larger turbines) on bird use, behavior, and mortality. Early results indicate that some birds collide with wind turbines, and raptors appear to be at a higher risk for collision. However, the impacts are not biologically significant. A final report on this multiple-year study should be completed in spring 2000.

Several pre-construction studies were conducted to determine the potential impact to birds. In these studies, the reconnaissance research indicated that the site was likely to have a low potential for impact. After the completion of one year of preconstruction surveys, the bird abundance and utilization continued to appear low. Few bird fatalities were found. In the Ponnequin WRA in Colorado, turbines have been installed and are operational. This site will continue to be monitored; risk appears low. The Conservation and Renewable

Energy System site near Goldendale, Washington, has not been developed. The avian research project was cancelled pending site development.

A third pre-construction avian research project was conducted at the Norris Hill WRA, Montana, site. Because of the volume of nighttime bird activity, marine surveillance radars were used to collect the data. The study refined the use of radar for application to small areas and showed that approximately 75% of the birds present at the site went undetected through visual observation. Bird activity included migratory birds, breeding and local raptors, and breeding and local nonraptorial birds. Development of the site has been indefinitely postponed.

NREL is also working with the National Wind Coordinating Committee's Avian Subcommittee. The Subcommittee meets periodically to discuss avian/wind issues and to provide input regarding research needs. Currently, the Subcommittee is working on a guidance document that describes options for developing an avian research protocol. The document describes methods and metrics that should be used in conducting scientifically rigorous avian research. It is anticipated that the NWCC will adopt this document in the near future (Anderson, et al).

The NREL National Wind Technology Center also maintains an avian literature database on its web site. The database, which can be found at http://www.nrel.gov/wind/avianlit.html, contains information originally compiled by the California Energy Commission. Each document reference contains an annotated bibliography. In addition, in most cases NREL has hard copies of the full document in its library. The database is continually being expanded and updated as more studies are completed and documents are published.

PLANNED PROJECTS

Two significant new projects have or will be started. At the Foote Creek Rim WRA in Arlington, Wyoming, researchers will collect data from installed, operating turbines to determine if applying ultraviolet-based paint to turbine blades can reduce bird deaths in a wind farm. Approximately two-thirds of the turbines will have ultraviolet paint on the blades; the others will not. This research will piggyback on avian monitoring work being conducted by the developer.

A second study was recently initiated to learn whether motion smear is contributing to the problem of bird collisions with wind turbines. There has been much discussion on whether painting blades with a certain type of pattern would aid birds in seeing the blades and therefore provide a mitigation strategy and reduction in bird fatalities. To date, however, the issue of motion smear has not been studied. This project will use the pattern electroretinogram to determine which blade patterns provide the highest contrast. In addition, some preliminary work will be conducted exploring birds' auditory capabilities in the field. It is expected that these two pilot studies will help refine the focus of the research and, assuming funding availability, that this laboratory work will be taken to the field for testing.

SUCCESS OF PROGRAM

The avian research program has only been in existence at DOE/NREL since 1994. A major success of the program, however, is the collaborative approach to defining the projects. Stakeholder groups are now able to work together more effectively in developing a program identifying the problems and develop solutions regarding avian-wind turbine interactions.

From our initial work, we know that there are numerous covariants that affect avian-wind interactions.

Topography, weather, habitat, fragmentation, urban encroachment, habitat loss, species abundance, distribution and behavior, turbine type, and turbine location are some of the more important factors that influence bird interactions with wind turbines. The nighttime activity of owls, migratory birds, and bats can also be risky. All these parameters play a role in this issue. One solution will not fit all situations.

We have found that birds fly into non-operating turbines as well as operating ones, that turbines mounted on tubular towers as well as lattice towers cause fatalities, that dead birds are found near non end-row turbines as well as end-row turbines, and that non-perching behavior as well as perching can result in fatalities. Some behavior is riskier than other behaviors; some locations are riskier than others are, and some species are more at risk than others are.

Progress in finding solutions to this issue will be made more quickly in a collaborative environment. We can all learn from mistakes and share information. Over the next 4 months, DOE/NREL will develop a strategic plan for the program. We are currently working with wind industry representatives to provide input to this process. We will be soliciting input from other stakeholder groups as well. In the spring of next year, we plan to hold another National Wind Power Planning meeting, bringing together researchers and interested parties to share details of recent avian research, improvements in technology and methodologies, and to participate in discussions to focus the research program's direction for the near future.

TABLE 1
RECENTLY COMPLETED AND CURRENT AVIAN RESEARCH PROJECTS

Project Title	P. I.*/ Organization	Project Objective	Location	Start	End
Population Study of Golden Eagles in the Altamont Wind Resource Area [1], [2], [3]	G. Hunt/ University of California - Santa Cruz	Determine survival and reproductive rate of golden eagle population; collect data necessary to develop population model to predict trend in survival of population	Altamont WRA, California	1994	1997
Conducting Nest Surveys of Golden Eagles in the Altamont Wind Resource Area California [4]	G. Hunt/ University of California - Santa Cruz	Estimate the reproductive rate of golden eagles during 1998	Altamont WRA, California	1998	1998
Avian Use of Norris Hill Wind Resource Area (pre-construction survey) [5]	A. Harmata/ Montana State University	Establish WRA baseline avian utilization and mortality; determine # of swans, water fowl, neotropical migrants, and resident raptors using the area; evaluate usefulness of radar in identifying bird migrations	Norris Hill WRA, Montana	1995	1997
Potential Impacts of an Operating Wind Turbine on the Flight Behavior of Migrating and Breeding Birds at the Green Mountain Power Searsburg Wind Turbine Project [6]	P. Kerlinger/ Vermont Department of Public Service	Investigate the impacts of wind turbines on migrating birds during both pre- and post-construction periods in eastern North America	Green Mountain, Vermont	1996	1998
Wind/Avian Mortality Research and Model Development	R. Anderson/ California Energy Commission	Determine if the development and operation of a WRA would result in an increased risk of bird mortality	Tehachapi and San Gorgonio WRA, California	1997	1999
Raptor Visual Capacities and Blade-Pattern Conspicuity - Report of Studies Completed [7]	H. McIsaac/ Boise State University	Analyze data collected over 2-1/2 years and write up results of those analyses	Boise, Idaho	1997	1998
Biostatistical and Population Modeling Analysis for Avian Wind Power Research [8]	K. Pollock/ North Carolina State University	Development of a modeling framework for evaluating bird-wind power interactions	Raleigh, North Carolina	1996	1997
Comparing Differential Bird Risk Between Types: Tehachapi and San Gorgonio	M. D. Strickland/ Western EcoSystems Tech (WEST) & R. Anderson/ California Energy Commission	Compare bird use, behavior, and mortality at small and large turbines; compare tubular and lattice towers; develop recommendations for reducing bird mortality in wind farms.	Tehachapi and San Gorgonio WRA, California	1997	1998

* Principal Investigator

TABLE 1
RECENTLY COMPLETED AND CURRENT AVIAN RESEARCH PROJECTS (cont.)

Project Title	P. I.*/ Organization	Project Objective	Location	Start	End
Effects of Bird Flight Diverters Installed on Guy Wires of Turbines [9]	B. Wolff/ Conservation and Renewable Energy System (CARES) & M. D. Strickland/ Western EcoSystems Tech (WEST)	Evaluate the effects of bird flight diverters installed on guy wires of turbines on avian behavior, use, and mortality	Klickitat County, Washington	1997	1999
The Influence of Prey Distribution and Abundance on Raptor Behavior and Mortality, Altamont Pass Wind Resource Area, California	G. Trapp/ California State University Sacramento	Qualify the seasonal abundance and distribution of primary raptor prey; relate raptor behavior and distribution to prey abundance and distribution; and develop recommendations for reducing bird mortality in wind farms	Altamont WRA, California	1999	2000
Ponnequin Wind Energy Project – Reference Site Avian Study [10]	R. Curry/ Richard Curry Associates	Document avian use of and relative abundance on reference sites prior to and during construction; document the use of existing power line poles and fence posts on and adjacent to the reference areas; record burrowing activities of ground squirrels on the reference sites in tandem with the studies done on the project site before and during all phases of the project development; record and report avian fatalities on the reference sites during construction and operation of the project; include reference sites in raptor nesting surveys; document raptor nesting populations in reference sites	Ponnequin WRA, Colorado	1997	1998
Reducing Bird Perching and Mortality at the Altamont Wind Resource Area, California [11]	C. Thelander/ BioResource Consultants	Determine the behavior of birds flying near, and perching on, turbines; determine the relationship between flight behavior and perching and bird mortality; explore factors responsible for bird-turbine interactions and bird deaths; develop recommendations for reducing bird-turbine interactions	Altamont WRA, California	1998	2000

* Principal Investigator

TABLE 2
PLANNED PROJECTS

Project Title	P. I./ Organization	Project Objective	Location	Start	End
The Effects of UV Light Reflective Paint Applied to Wind Turbines in the Foote Creek Rim WRA, Wyoming	D. Young/ Western EcoSystems Technology, Inc. (WEST)	Estimate spatial and temporal use and behavior of birds near turbines treated with and without UV reflective paint; compare number of carcasses between turbines with and without UV reflective paint; develop recommendations for reducing bird mortality in wind farms	Arlington, Wyoming	1999	2000
Minimization of Motion Smear and Evaluating Possible Acoustic Deterrents: An Approach to Reducing Avian Collisions with Wind Turbines	W. Hodos & R. Dooling/ University of Maryland	In a laboratory setting, a pilot study will seek to understand the effects of motion smear – the reduced visibility of blades, especially the tips, on raptors; understand raptors angle of approach to the blades at the moment of collision; assemble and review data on hearing in birds; measure ambient noise levels in the field; estimate how well turbine noise can be heard by raptors and passerines	University of Maryland	1999	1999

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