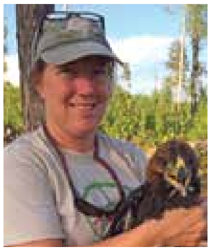
Quest for Safer Skies

MODELING GOLDEN EAGLES AND WIND ENERGY TO REDUCE TURBINE RISK

By Todd Katzner, Tricia Miller, and Scott Stoleson

Credit: Bill Parsons

Todd Katzner, Ph.D., is a Research Assistant Professor at West Virginia University in a position largely funded by the U.S. Forest Service.



Credit: Åke Nordström

Tricia Miller, Ph.D., is a Wildlife Biologist at West Virginia University.

In a patch of sky above Pennsylvania, a golden eagle moves languidly, never flapping but passing quickly as it cruises southward on a cushion of air. It is migrating to its wintering grounds after a season of breeding in Quebec. As part of a team studying eagles on a daily basis—a project supported by the U.S. Forest Service (USFS), West Virginia University, and other partners—we never tire of watching these iconic birds soar. The fall migration is especially notable here in the central Appalachians, where golden eagles often migrate at low altitudes, close to those of us who watch them from atop the region's long linear ridges.

The central Appalachians of Pennsylvania and West Virginia hold many U.S. Forest Service lands in the East and are also a focus area for wind energy development, as they provide wind suitable for power generation and locations close enough to urban centers to allow efficient transmission of electricity. The region's long north-south ridges are well suited to the placement of wind turbines, yet these same ridges also channel thousands of migratory raptors every spring and autumn—a potentially dangerous combination.

Credit: John Terry

Credit: Michael Lanzone

Turbines on a ridge in West Virginia generate renewable energy but also pose a potential risk for migrating raptors like golden eagles (inset). New research on eagle flight behavior may help guide turbine placement to reduce risk to wildlife.

Large soaring birds, especially eagles and vultures, are known to be at risk from the rotating blades of wind turbines. In some parts of the world, scores of eagles and vultures are killed every year by turbines (Smallwood and Thelander 2008, DeLucas et al. 2012). To assess risk in the central Appalachians, in 2005 our team began a large project to track golden eagles in the region, hoping to understand how their flight behavior might expose them to risk from turbines. We used telemetry to track eagle flight behavior, and modeled the birds' movements with respect to topography and updraft potential. We then compared modeled output to potential siting of wind energy turbines. Our work has led to the creation of detailed risk maps that can help planners optimize turbine placement while minimizing risk to golden eagles (Miller et al. 2014). As production of wind energy continues to grow, this research could have potential applications for other species and energy projects both in the U.S. and abroad.

Eagles and Wind Turbines

Distributed throughout the U.S. and Canada, golden eagles are enigmatic apex predators of high public and ecological value. Though protected by the Bald and Golden Eagle Protection Act, the Migratory Bird Treaty Act, and many state and provincial laws, the species is poorly understood and of conservation concern nationwide (Millsap et al. 2013). Factors contributing to death of eagles include lead poisoning, capture in leg-hold traps, habitat loss, and wind energy.

Wind energy is a special case that in recent years has defined the problem of golden eagle conservation in North America. One reason for this relates to golden eagle ecology. The species' distribution is primarily defined by the availability of three essentials: food, nesting habitat, and lift. Reaching up to 13 pounds, golden eagles are too heavy to use flapping flight for long periods of time, so they require updrafts from thermals or deflected winds to keep them aloft for extended flight.

Credit: Randy Flament

Credit: Doug Bell

The remains of a golden eagle hit by a turbine lie in California's Altamont Pass (below). Tracking-technology expert Mike Lanzone (left) holds a female golden eagle fitted with a transmitter to provide flight-behavior data that may help protect eagles from turbines in the eastern U.S.

The potential risk of mixing wind power and golden eagles in flight has been well-studied at Altamont Pass in California, a region with an abundance of eagle food (primarily California ground squirrels in that area), nesting and perching habitat, and conditions that generate significant updrafts. Because it is so windy, Altamont also has thousands of wind turbines, which have killed significant numbers of golden eagles and a host of other raptors. Peer-reviewed science suggests that on an annual basis from 1998 to 2002, about 65 golden eagles and about 1,100 other raptors were killed in the pass (Smallwood and Thelander 2008). In spite of recent efforts at "repowering"—replacing large numbers of small turbines with fewer, bigger turbines in the hopes of killing fewer birds—the numbers of deaths are still high and, for a low-density apex predator such as the golden eagle, it is unlikely that this mortality is simply compensatory.

To help address problems associated with wind-energy mortality, the U.S. Fish and Wildlife Service (FWS) in 2013 developed its "Eagle Conservation Plan Guidance" to provide "specific in-depth guidance for conserving bald and golden eagles in the course of siting, constructing, and operating wind energy facilities" (FWS 2013). The Service developed a risk model, founded in Bayesian statistics, to predict an annual fatality rate for eagles at a given wind facility. The model is built using generalized collision and fatality probabilities and site-specific observational data on eagle exposure. It also accounts for uncertainties in estimating all these input parameters.

The FWS model is the standard given the agencies' statutory obligation to manage eagles across the nation at facilities with hugely varying degrees of eagle density, environmental characteristics, and risk. However, at a more local scale, there are opportunities to predict risk to birds using detailed knowledge of flight behavior and eagle biology. So far this has been done in two different ways. At Altamont,

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University Partnerships with the Forest Service

The U.S. Forest Service's (USFS) Research and Development branch oversees a partnership program with cooperating universities that involves "shared faculty positions"—faculty posts that split time between teaching (funded by the university) and Forest Service research (funded by USFS). Offered through USFS's Northern Research Station (NRS), the program currently has 12 such shared faculty positions at nine different universities in the Northeast and Midwest, ranging from the University of Maine to Purdue University in Indiana.

The faculty in these posts may or may not be in tenure positions and typically spend anywhere from 25 percent to 75 percent of their time doing USFS research on a wide variety of natural resource issues ranging from wildlife and biometrics to ecology and forestry. Todd Katzner's research on golden eagles, for example, occurred while he served in a shared faculty position at West Virginia University that was jointly supported by the university and NRS. His other recent work for the partnership includes investigating how prescribed fire—used on the Monongahela National Forest in West Virginia to restore mixed-oak forests—alters avian habitat and use.

"These USFS shared faculty partnerships are a win-win for the host universities and the Forest Service," says Thomas Schmidt, assistant research director of the NRS in St. Paul, Minnesota. "The Forest Service gets the research, and students can use it in their coursework, gaining exposure to the Forest Service." Ultimately, the program offers students a way to see research in action—both in the classroom and on the ground—an inspiration to future natural resource professionals.

Recycling the Dead

How Deer Carcasses Aid Golden Eagle Research

By Scott Stoleson

Credit: Barbara McGuinness/USFS

Scott Stoleson is a Research Wildlife Biologist at the USDA Forest Service Northern Research Station in Irvine, Pennsylvania.

"Someone is dumping deer carcasses in the parking lot! Does anyone know anything about that?" This newest staff member at the Forest Service Research Lab in Irvine, Pennsylvania, was learning that anything can happen in the name of research. In this case, the deer carcasses—often obtained from roadkill—were destined to serve as bait at carefully selected sites where researchers had placed trail cams in hopes of capturing images of golden eagles feeding on the carrion. Such images help researchers understand the eagles' abundance, habitat use, and other behaviors.

There are now more than 150 deer-carcass bait sites across the Northeast and Midwest, some in experimental forests and others in a variety of public-land settings. Each site is equipped with a trail cam triggered by the motion of animals visiting the sites. Though golden eagles are the primary species of interest, many other species have been captured on film, including bobcat at a site in Ohio, where the species is state endangered; wild elk at a Pennsylvania site; fishers at another Pennsylvania site; and a wide variety of bird species.

Several of the 150 sites are maintained by U.S. Forest Service (USFS) staff, a vital part of this collaborative effort. A host of dedicated USFS scientists, professionals, technicians, and other volunteers serve as boots on the ground to collect and freshen bait, change camera memory cards, and supply images to research teams. Once images are collected in the field, they are passed to regional coordinators and ultimately to a USFS ecologist who sorts through millions of images each year and shares them with the research team for further analysis. Much of this research is captured at the Appalachian Eagles website.

While analysis of photos is ongoing, this work has generated new ideas about the relative abundance of golden eagles and the boundaries of their winter range. "The vast geographic scope of this project and the volume of data generated are unprecedented," says eagle researcher Todd Katzner, "and this would never be possible without the network of volunteers willing to haul deer carcasses to advance science."

Credit: Scott Stoleson

An immature golden eagle visits a deer-carcass bait pile in the Allegheny National Forest, Pennsylvania. Motion-sensitive cameras placed at these bait piles help document the number of eagles and other species that visit the region.

Shawn Smallwood, Doug Bell, and their collaborators have placed observers in the turbine fields and recorded flight behavior of eagles and other raptors as they passed through the observers' field of view and within range of turbines. With thousands of records, the team can now estimate the topographic and meteorological conditions under which specific species of birds are most at risk, and they can thus guide turbine locations using that knowledge.

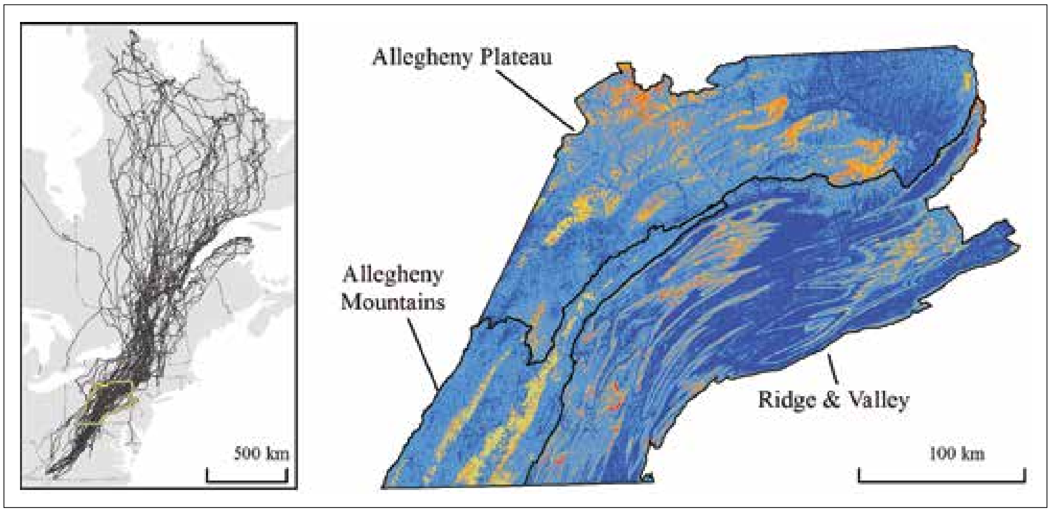
The Altamont risk maps are extremely useful, but they are built for a specific site and have also required investment of time to observe bird flight. It is nearly impossible to collect such observational data when eagle densities are lower, as they are in the central Appalachians. As an alternative approach, our team developed a plan based on GPS-GSM telemetry systems, giving us a similar product to what the researchers at Altamont have produced, but designed at a much broader spatial scale and based on GPS-derived flight altitude information.

Relating Flight Height to Risk

The conceptual approach we took was broad based (Miller et al. 2014). First, we outfitted about 35 golden eagles with advanced GPS-GSM telemetry systems. These tracking devices collect GPS data with remarkably short time-between fixes, usually at 30-to-60-second intervals. Each of those GPS fixes is similar to what you would get on your personal GPS: it provides not only x and y coordinates, but also a position in 3D (flight altitude above sea level) and information on heading, instantaneous flight speed, fix accuracy, and a host of other important details.

We can also derive additional information by using the GPS data to calculate characteristics of flight described by multiple GPS fixes and external datasets, such as topography and land cover. These types of derived data include speed between points, flight altitude, and distance to predicted wind resources for energy development. For additional detail, we can obtain weather characteristics—such as temperature, wind speed, and humidity—that the bird experienced at the specific altitude it was flying.

Using a subset of these external predictors, our team then built models of resource selection functions (RSFs; Manly 2002) for eagles, to characterize and predict the situations when eagles fly below 150 meters above ground throughout three physiographic regions of the central Appalachians: the Allegheny Mountains, the Allegheny Plateau, and the Ridge and Valley region. Since flight altitude is directly correlated to risk from 150-meter-tall turbines, characterizing such behavior can aid management. The RSFs were then used to predict distribution of sites across regions where eagles would engage in low-altitude, high-risk flight. Understanding the circumstances of this low-altitude flight is the key to understanding when eagles could interact with, and be at risk from, turbines.



Credit: Tricia Miller

Data lines trace the long migration routes of golden eagles in the eastern U.S., ranging from North Carolina to Canada (inset at left). The map at right color-codes relative risk in three key regions of the Pennsylvania Appalachians based on an area's wind potential and use by eagles during spring migration. For example, dark blue denotes low risk because of poor wind potential and low use by eagles, while orange indicates high risk because of good eagle habitat and turbine potential.

Location Matters

Predicting this low-altitude flight, though, is not enough for effective management of risk to eagles. We also want to understand the characteristics of the areas that wind developers select for turbine placement in various regions of the country. Since every company has its own wind development policies, the second conceptual step we took in our research was to characterize the turbine locations in a similar manner to that done for eagle telemetry locations. Once again, we mapped the location of every turbine within those same three topographically distinct physiographic provinces, and we then used those locations to develop resource selection probability functions (RSPFs) and predictive maps for wind turbines, using the same external predictors as in our eagle model.

We overlaid maps of resource selection for low-altitude eagle flight and for wind turbine placement to produce a risk map for golden eagles (see map above).We classified areas that eagles rarely selected as low risk, regardless of the area's utility to turbines. We classified as moderate risk the areas eagles selected with intermediate frequency but that were chosen infrequently or frequently for turbines. We categorized as highest risk the areas that were selected most frequently for both turbines and eagles. As it turned out, the physiographic province with the greatest number of long, linear ridges (the Ridge and Valley region) was the province with the highest risk habitat. Those areas with more diverse and less linearly organized topography were comparatively lower risk to eagles. Such a classification system allows us to provide feedback to wind-energy developers and conservation planners. It identifies not only areas of high risk to eagles, but alternative sites of relatively lower risk to eagles but of still potentially high value to wind developers.

In addition to producing large-scale guidance on what physiographic provinces are relatively high and low risk to eagles, our model lets us zoom down to specific sites and advise on siting of individual turbines anywhere within the modeled region. Thus, when agency staff or developers request details on a proposed facility, we are able to provide risk categories for every turbine within the facility and, for high-risk turbines, suggest potentially safer siting alternatives. The next step of course—for our model and for every other risk model—is to use real fatality data from existing turbines to validate and improve the model's predictions.

The partnership formed by the USFS and the academic community provides a framework for problem solving that can help address key management issues in the U.S. The potential for conflict between wind energy and eagles is one that requires careful attention from developers, regulators, managers and researchers of all types. This is increasingly important as our country faces a suite of challenges associated with environmentally-friendly energy development. The recent prosecution of Duke Energy by the U.S. Department of Justice for taking of eagles demonstrates the serious stance on this issue taken by federal wildlife and regulatory agencies (U.S. Department of Justice 2013).

It is unlikely that anyone—agencies, developers, operators, or the general public—wishes for eagles and other protected species to be killed at wind facilities. Thus, development of risk models presents an opportunity for improved siting within the low-altitude flight corridors of the Appalachians and also provides a template for developing partnership-based risk models in other areas, nationwide and internationally. ■

This article has been reviewed by subject-matter experts.