Draft
Eagle Conservation Plan Guidance

U.S. Fish & Wildlife Service
January 2011

TABLE OF CONTENTS

APPENDICES

EXECUTIVE SUMMARY

The mission of the U.S. Fish and Wildlife Service is to work with others to conserve, protect and enhance fish, wildlife, plants and their habitats for the continuing benefit of the American people. As part of this, we are charged with implementing statutes including the Bald and Golden Eagle Protection Act (BGEPA), the Migratory Bird Treaty Act, and the Endangered Species Act. The draft Eagle Conservation Plan Guidance (draft Guidance) is intended to assist parties to avoid, minimize, and mitigate adverse effects on bald and golden eagles. The draft Guidance calls for scientifically rigorous surveys, monitoring, assessment, and research designs proportionate to the risk to eagles. The draft Guidance describes a process by which wind energy developers can collect and analyze information that could lead to a programmatic permit to authorize unintentional take of eagles at wind energy facilities.

The *Draft Eagle Conservation Plan Guidance Module 1: Wind Energy Development* (Draft Eagle Conservation Plan Guidance) provides recommendations for the development of *Eagle Conservation Plans* (ECPs) to support issuance of eagle programmatic take permits for wind facilities. Programmatic take permits will authorize limited, incidental mortality and disturbance of eagles at wind facilities, provided effective offsetting conservation measures that meet regulatory requirements are carried out. To comply with the permit regulations, conservation measures must avoid and minimize take of eagles to the maximum degree, and, for programmatic permits necessary to authorize ongoing take of eagles, advanced conservation practices (ACPs) must be implemented such that any remaining take is unavoidable. Further, for eagle management populations that cannot sustain additional mortality, any remaining take must be offset through compensatory mitigation such that the net effect on the eagle population is, at a minimum, no change. The Draft Eagle Conservation Plan Guidance interpret and clarify the permit requirements in the regulations at 50 Code of Federal Regulations (CFR) 22.26 and 22.27, and do not impose any binding requirements beyond those specified in the regulations.

The Service recommends that ECPs be developed in five stages. Each stage builds on the prior stage, such that together the process is a progressive, increasingly intensive look at likely effects of the development and operation of a particular site and configuration on eagles. The objectives, recommended actions, and recommended data sources for each of the five stages in the ECP are described in the following table. The Draft Eagle Conservation Plan Guidance recommends that project proponents employ fairly specific procedures in their site assessments so the data can be combined with that from other facilities in a formal adaptive management process. This adaptive management process is designed to reduce uncertainty about the effects of wind facilities on eagles. Project proponents are not required to use the recommended procedures, however, if different approaches are used, the proponent should coordinate with the Service in advance to ensure that proposed approaches will provide comparable data.

The Draft Eagle Conservation Plan Guidance recommend that at the end of each of the first four stages, project proponents determine which of the following categories the project, as planned, falls into: (1) high risk to eagles, little opportunity to minimize effects; (2) high to moderate risk to eagles, but with an opportunity to minimize effects; (3) minimal risk to eagles; or (4) uncertain.

Projects in category 1 should be moved, significantly redesigned, or abandoned because the project would likely not meet the regulatory requirements for permit issuance. Projects in categories 2, 3, and possibly 4 are candidates for ECPs. Service biologists are available to work with project proponents in the development of their ECP. Frequent close coordination from the outset is beneficial to the Service and the project proponents and it will help ensure the ECP meets the needs and requirements of all parties involved.

	Objective	**Actions**	**Data Sources**
STAGE 1	Identify potential wind facility locations with manageable risk to eagles at the landscape level	Broad, landscape-scale evaluation	Literature, agency files, on-line databases, experts
STAGE 2	Obtain site-specific data to predict eagle fatality rates and disturbance take at wind-facility sites that pass Stage 1 assessment.	Site-specific surveys (on and within 10 miles of project footprint) to determine eagle exposure rate in project footprint, the location and pre-construction occupancy and productivity of potentially-affected eagle nests, and to locate eagle migration corridors and stopover sites, foraging concentration areas, or communal roosts in the project area	800-m radius point count surveys in project footprint, nesting surveys in the project area, migration counts on likely migratory routes in the project area, roost searches and counts in the project area. Ideally conducted for 3 years pre-construction
STAGE 3	Conduct turbine-based risk assessment and estimate the fatality rate of eagles for the facility evaluated in Stage 2, excluding possible advanced conservation practices (ACPs)	Assess risk factors for each turbine, such as nearby cliff rim, migration pass, or prey concentration. Use results of this risk factor assessment along with an estimate of eagle exposure rate derived from Stage 2 data in Service-provided models to predict the annual eagle fatality rate for the project	Point count data from Stage 2 and turbine-based, risk-factor assessment
STAGE 4	Identify and evaluate ACPs that might avoid or minimize fatalities identified in Stage 3. When required to do so, identify compensatory mitigation necessary to reduce any remaining fatality effect to a no-net-loss standard	Re-run fatality prediction models with risk adjusted to reflect application of ACPs. Calculate required compensatory mitigation amount and identify the method to accomplish it	Turbine-based risk-factor assessment modified on a turbine-by-turbine basis after application of ACPs, and point count data from Stage 2
STAGE 5	Document annual eagle fatality rate and disturbance effects. Identify additional ACPs to reduce observed level of mortality, and determine if initial ACPs are working and should be continued. When appropriate, monitor effectiveness of compensatory mitigation	Conduct fatality monitoring in project footprint. Monitor occupancy and productivity of nests of eagle pairs that are likely using the project footprint. Monitor eagle use of communal roosts in the project area	Use line-transect surveys in project footprint to estimate the eagle fatality rate. Monitor nests adjacent to the project footprint to determine productivity for comparison with pre-construction levels. Count eagles at roosts for comparison with pre-construction levels, for 3 years post-construction, and targeted thereafter to assess effectiveness of any additional ACPs.

A. INTRODUCTION AND PURPOSE

The mission of the U.S. Fish and Wildlife Service (Service) is to work with others to conserve, protect and enhance fish, wildlife, plants and their habitats for the continuing benefit of the American people. As part of this, we are charged with implementing statues including the Bald and Golden Eagle Protection Act (BGEPA), the Migratory Bird Treaty Act, and the Endangered Species Act. BGEPA prohibits all take of eagles unless otherwise authorized by the Service. A goal of BGEPA is to achieve and maintain stable or increasing populations of bald and golden eagles. The draft Eagle Conservation Plan Guidance (draft Guidance) is intended to provide a means of compliance with BGEPA by:

(1) conducting early pre-construction assessments to identify important eagle use areas;
(2) avoiding, minimizing, and/or compensating for potential adverse effects to eagles; and,
(3) monitoring for impacts to eagles during construction and operation.

The draft Guidance calls for scientifically rigorous surveys, monitoring, risk assessment, and research designs proportionate to the risk to eagles. The draft Guidance was developed as a tool to assist wind energy developers and facility operators during the decision-making process, and describes a means by which to collect and analyze information that could lead to a programmatic permit to authorize unintentional take of eagles at wind energy facilities. The process described here is not required, but project proponents should coordinate closely with the Service concerning alternatives.

1. Purpose

The U.S. Fish and Wildlife Service (Service) published a final rule (Eagle Permit Rule) on September 11, 2009 under the Bald and Golden Eagle Protection Act (BGEPA) (50 Code of Federal Regulations [CFR] 22.26) authorizing limited issuance of permits to take bald eagles (*Haliaeetus leucocephalus*) and Golden Eagles (*Aquila chrysaetos*) ‘‘for the protection of . . . other interests in any particular locality’’ where the take is compatible with the preservation of the bald eagle and the golden eagle, is associated with and not the purpose of an otherwise lawful activity, and cannot practicably be avoided (USFWS 2009a). The Draft Eagle Conservation Plan Guidance explains the Service’s approach to issuing programmatic eagle take permits under this authority, and provides guidance to permit applicants (project proponents), Service biologists, and biologists with other jurisdictional agencies on the development of draft *Eagle Conservation Plans* (ECPs) to support permit issuance.

Since finalization of the Eagle Permit Rule, the development and planned development of wind facilities (developments for the generation of electricity from wind turbines) has increased dramatically in the range of the Golden Eagle in the western United States. Golden Eagles are vulnerable to collisions with wind turbines (Hunt 2002, Chamberlain *et al.* 2006), and in some areas such collisions are a major source of mortality (Hunt *et al.* 1999, 2002). Although significant numbers of bald eagle mortalities have not yet been reported at North American wind facilities, the closely related white-tailed sea eagle (*Haliaeetus albicilla*) has been killed regularly at wind facilities in Europe (Krone 2003, Cole 2009). Because of this risk to eagles, many of the current and planned wind facilities require permits under this provision in the regulations in order to be in compliance with the law. In addition to being legally necessary to comply with BGEPA and 50 CFR 22.26, the conservation practices and adaptive management necessary to meet standards required for issuance of these permits can offset the short- and long-term effect of wind facilities on eagle populations.

Because of the urgent need for guidance on permitting eagle take at wind facilities, this initial module focuses on this issue. Many of the concepts and approaches outlined in this module can be readily exported to other situations, and we expect to release other modules in the near future specifically addressing other forms of eagle take. In all cases, the Draft Eagle Conservation Plan Guidance are intended to provide interpretive guidance to Service biologists and others in applying the regulatory permit standards as specified in the rule. They do not in-and-of themselves impose additional regulatory requirements.

The Draft Eagle Conservation Plan Guidance is written to guide wind-facility projects starting from the earliest conceptual planning phase. For projects already in the development or operational phase, implementation of all stages of the recommended approach in these Draft Eagle Conservation Plan Guidance may not be applicable or possible. Project proponents with operating or soon-to-be operating facilities at the time this Draft Eagle Conservation Plan Guidance were first released that are interested in obtaining a programmatic eagle take permit should coordinate with the Service. The Service will work with project proponents to determine if the facility might be able to meet the permit requirements in 50 CFR 22.26 by conducting eagle fatality and disturbance monitoring and by agreeing to adopt reasonable operational avoidance and minimization measures that might reduce the eagle fatalities detected through monitoring. Sections of the Draft Eagle Conservation Plan Guidance that address these topics are relevant to both planned and operating wind facilities.

The Draft Eagle Conservation Plan Guidance is compatible with the more general guidelines provided in the *U.S. Fish and Wildlife Service Draft Land-based Wind Energy Guidelines* (guidelines which project proponents should consult on addressing other migratory bird issues associated with wind facilities). However, because the Draft Eagle Conservation Plan Guidance describes actions which help to comply with the regulatory requirements in the BGEPA for an eagle take permit as described in 50 CFR 22.26, they are more specific.

2. Legal Authorities and Relationship to Other Statutes and Guidelines

BGEPA is the primary law protecting eagles. It defines “take” as “to pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, destroy, molest, disturb individuals, their nests and eggs” (16 USC 668c). “Disturb” is defined by regulation at 50 CFR 22.3 in 2007 as “to agitate or bother a bald or golden eagle to a degree that causes…injury to an eagle, a decrease in productivity, or nest abandonment…” (USFWS 2007). A goal of BGEPA is to achieve and maintain stable or increasing populations of bald and golden eagles.

In 2009, two new permit rules were created for eagles. Under 50 CFR 22.26, the Service can issue permits that authorize limited take of bald and golden eagles when the take is associated with, but not the purpose of an otherwise lawful activity, and cannot practicably be avoided. Further, as explained above, the regulation also authorizes ongoing or programmatic take, but requires that any authorized programmatic take is unavoidable after implementing advanced conservation practices. Under 50 CFR 22.27, the Service can issue permits that allow the intentional take of eagle nests where necessary to alleviate a safety emergency to people or eagles, to ensure public health and safety, where a nest prevents use of a human-engineered structure, and to protect an interest in a particular locality where the activity or mitigation for the activity will provide a net benefit to eagles. Only inactive nests are allowed to be taken except in cases of safety emergencies.

The new Eagle Permit Rule provides a mechanism where the Service may legally authorize the non-purposeful take of eagles. However, BGEPA provides the Secretary of the Interior with the authority to issue eagle take permits only when that the take is compatible with the preservation of each species, defined in USFWS (2009a) as "…consistent with the goal of increasing or stable breeding populations." The Service ensures that any take it authorizes under 50 CFR 22.26 does not exceed this preservation standard by setting regional take thresholds for each species determined using the methodology contained in the National Environmental Policy Act (NEPA) Final Environmental Assessment (FEA) developed for the new permit rules (USFWS 2009b). The details and background of the process used to calculate these take thresholds are presented in the FEA (USFWS 2009b).

The programmatic permits under the BGEPA were originally envisioned to be broad, industry-wide take permits. However, the greatest demand in practice has been from individual companies, and as a result, we are seeing a demand for many smaller-scale permits covering individual installations that may take few eagles individually, but cumulatively could take many.

The Draft Eagle Conservation Plan Guidance is not intended to relieve any individual, company, or agency of its obligations to comply with any applicable Federal, state, tribal, or local laws, statutes, or regulations. Wind facility projects that are expected to cause take of endangered or threatened wildlife species must still receive incidental take authorizations under sections 7 or 10 of the Endangered Species Act (ESA) of 1973 as amended (ESA; 16 United States Code [USC] § 1531 *et seq*.). A project proponent seeking an Incidental Take Permit (ITP) through the ESA section 10 Habitat Conservation Plan process may be issued an ITP only if the permitted activity is otherwise lawful (section 10(a)(1)(B)). If the project and covered activities in the HCP are likely to take bald or golden eagles, the project proponent must obtain a BGEPA permit or include the bald or golden eagle as a covered species in the HCP. If bald and golden eagles are included as covered species in an HCP, the avoidance, minimization, and other mitigation measures in the HCP must meet the BGEPA permit issuance criteria of 50 CFR 22.26, and include flexibility for adaptive management. If a BGEPA permit is denied, an ITP may not be issued in association with the proposed HCP because the activities covered by the proposed HCP are not otherwise lawful if they cause unauthorized take of eagles. If the project proponent proposes to include the bald or golden eagle as a covered non-listed species in the ITP but the minimization and mitigation measures are found not to meet the BGEPA permit issuance criteria an ITP may not be issued in association with the proposed HCP because the permit revocation criterion at 50 CFR 22.11(a) applies when the permitted activity is incompatible with the preservation of the bald eagle or golden eagle.

In addition to the ESA, wind facility project proponents must comply with the Migratory Bird Treaty Act (MBTA). The Migratory Bird Treaty Act (MBTA; 16 USC § 703 *et seq*.) prohibits the taking, hunting, killing, collecting, capture, possession, sale, purchase, transport import, and export of migratory birds, their eggs, parts, and nests, except when authorized by the Department of Interior. Because neither the MBTA nor its permit regulations at 50 CFR Part 21 currently provide a specific mechanism to permit "incidental" take, it is important for project proponents to work proactively with the Service to avoid and minimize take of migratory birds. The Service is actively working to develop guidance for the development of plans specific to migratory birds other than bald and golden eagles, as well as other species listed under the ESA.

The National Environmental Policy Act of 1969 as amended (NEPA) (42 U.S.C. 4321 *et seq.*) applies to issuance of eagle take permits because issuing a permit is a federal action. While providing technical assistance to agencies conducting NEPA analyses, the Service will participate in the other agencies' NEPA to the extent feasible, in order to streamline subsequent NEPA related to a project. For actions that may result in applications for or development of programmatic permits, the Service may participate as a cooperating agency to streamline the permitting process.

If no other federal nexus exists, the Service must complete a NEPA analysis before it can issue a permit. The Service will work with the project proponent to conduct a complete NEPA analysis, including assisting with data needs and determining the scope of analysis. Developers should coordinate closely with the Service for projects with no federal nexus other than the eagle permit, and to facilitate timely preparation of NEPA documents, project proponents may provide assistance in accordance with 40 CFR §1506.5. Close coordination between project proponents and the Service regarding the data needs and scope of the analysis required for a permit will reduce delays.

Through 50 CFR 22.26 and the associated FEA, the Service defined "mitigation" as per the Service Mitigation Policy (46 FR 7644, Jan. 23, 1981), and the President's Council on Environmental Quality (40 CFR 1508.20 (a–e)), to sequentially include the following: (1) Avoiding the impact on eagles altogether by not taking a certain action or parts of an action; (2) Minimizing impacts by limiting the degree or magnitude of the action and its implementation; (3) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment; (4) Reducing or eliminating the impact over time by implementing preservation and maintenance operation during the lifetime of the action; and (5) Compensating for the impact by replacing or providing substitute resources or environments. The NEPA on our permits and the discussion of mitigation in this document follow this system, and in this Draft Eagle Conservation Plan Guidance we refer to (1) – (4) as avoidance and minimization measures, and to (5) as compensatory mitigation. To the extent that the Service acknowledges a developer's commitments to mitigate adverse environmental impacts, the Service will work with the developer to achieve those commitments, monitor how they are implemented, and report on the effectiveness of the mitigation. Additionally, the Service will make generic information on take and mitigation monitoring available to the public.

Eagles are highly significant species in Native American culture and religion (Palmer 1988) and may be viewed as contributing elements to a "traditional cultural property" under Section 106 of the National Historic Preservation Act (NHPA). Some locations where eagles would be taken have traditional religious and cultural importance to Native American tribes and thus have the potential of being regarded as traditional cultural properties under NHPA. Permitted take of one or more eagles from these areas, for any purpose, could be considered an adverse effect to the traditional cultural property.

Indian tribes have a special status in American law as sovereign nations. Tribes also possess certain rights that are different from the rights of other Americans. Some of the special rights of tribes are based on treaties, some are based on acts of Congress, some are based on actions taken by the Executive Branch of the federal government, and others are clarified by federal court rulings. The Service will consult with tribes on a government-to-government basis as described under Executive Order 13175 and Secretarial Order 3206 during the public comment period on the draft Eagle Conservation Plan Guidance. During the process for bald eagle and golden eagle permitting, the Service will, where appropriate, and to the extent practicable and permissible by law, engage with tribes in open and meaningful communication. Consultation regarding eagle permits under 50 CFR 22 and management of eagle populations will be consistent with overall Service guidance for tribal consultation, but may include additional provisions specific to bald and golden eagles. This draft Guidance changes nothing from the September 2009 regulations concerning eagle take permits in 50 CFR 22.26 and 50 CFR 22.27.

3. Background and Overview of Process

Increased energy demands and the nationwide goal to increase energy production from renewable sources have intensified the development of energy facilities, including wind energy. The Service supports renewable energy development that is compatible with fish and wildlife conservation. The Service closely coordinates with state, tribal, and other federal agencies in the review and permitting of wind energy projects to address potential resource effects, including effects to bald and golden eagles. However, our knowledge of these effects and how to address them at this time is limited. Given this and the Service's statutory and regulatory mandate to only authorize actions that are "compatible with the goal of stable or increasing breeding populations" of eagles has led us to adopt an adaptive management framework for consideration and issuance of programmatic eagle take permits. This framework consists of case specific considerations applied within a national framework, and with the outcomes carefully monitored so that we maximize learning from each case. The knowledge gained through monitoring can then be used to update and refine the process for making future permitting decisions, as well as to consider operational adjustments at individual projects at regular intervals. The Draft Eagle Conservation Plan Guidance provides the background and information necessary for wind facility project proponents to prepare an ECP that assesses the risk of a prospective or operating project to eagles, and how siting, design, and operational modifications can mitigate that risk. The final ECP must reduce predicted eagle take, and the population level effect of that take, to a degree compatible with regulatory standards to justify issuance of a programmatic take permit by the Service.

a. Risks to Eagles

Energy development can affect bald and golden eagles in a variety of ways. First, structures such as wind turbines can cause direct mortality through collision (Hunt 2002, Krone 2003, Chamberlain *et al.* 2006). This is the primary threat to eagles from wind facilities, and the monitoring and avoidance and minimization measures advocated in the Draft Eagle Conservation Plan Guidance primarily are aimed at this threat. Second, activities associated with pre-construction, construction, or maintenance of a facility can cause disturbance and result in loss of productivity at nearby nests or disturbance to nearby concentrations of eagles. Third, if disturbance or mortality effects are permanent, they can result in the permanent or long term loss of a nesting territory. All of these impacts, unless properly permitted, are violations of BGEPA (USFWS 2009a). Additionally, disturbances near areas that are important for roosting or foraging might stress eagles to a degree that leads to reproductive failure or mortality elsewhere; these impacts are of concern as well as they would likely amount to prohibited take. Thus, the Draft Eagle Conservation Plan Guidance addresses both direct mortality and disturbance.

b. General Approach to Address Risk

Applicants for permits under 50 CFR 22.26, non-purposeful eagle take, are required to avoid and minimize the potential for take of eagles to the maximum degree practicable. Permits for wind-energy development are programmatic in nature as they will authorize recurring take, rather than isolated incidences of take. For programmatic take permits, the regulations at 50 CFR 22.26 require that any authorized take is unavoidable even though ACPs are being implemented. 50 CFR 22.3 defines “advanced conservation practices” as “scientifically supportable measures that are approved by the Service and represent the best available techniques to reduce eagle disturbance and ongoing mortalities to a level where remaining take is unavoidable.”

Where take is unavoidable and when eagle populations at the scale of the eagle management unit (as defined in USFWS 2009b) are not healthy enough to sustain additional mortality over existing levels, applicants must reduce the effect of permitted mortality to a no-net-loss standard, best accomplished through compensatory mitigation. No-net-loss means that additional mortality caused by the permitted activities is offset by compensatory mitigation that reduces another, ongoing form of mortality by an equal or greater amount. Compensatory mitigation may also be necessary to offset substantial effects in other situations as well (USFWS 2009a). The approach described in the Draft Eagle Conservation Plan Guidance is applicable for all land-based wind facility projects within the range of the bald and golden eagle where interactions with wind facility infrastructure are reasonably expected to occur. The Draft Eagle Conservation Plan Guidance is intended to provide a national framework for assessing and mitigating risk through development of ECPs.

As part of the application process for a programmatic eagle take permit, the Service recommends that project proponents should prepare an ECP that outlines the project development process and includes conservation and monitoring plans as described in this Draft Eagle Conservation Plan Guidance. The Draft Eagle Conservation Plan Guidance provides examples of ways that applicants can meet the regulatory standards in the rule, and while other approaches may be acceptable, they will be determined on a case-by-case basis.

B. ASSESSING RISK AND EFFECTS

1. Areas of Importance to Eagles for Consideration When Assessing Risk

Bald eagles and golden eagles associate with distinct geographic areas and landscape features throughout their respective ranges. The Service defines these "important eagle-use areas" as "an eagle nest, foraging area, or communal roost site that eagles rely on for breeding, sheltering, or feeding, and the landscape features surrounding such nest, foraging area, or roost site that are essential for the continued viability of the site for breeding, feeding, or sheltering eagles" (USFWS 2009b). Because migration corridors and migration stopover sites provide important foraging areas for eagles during migration (e.g., Restani *et al.* 2001, Mojica 2008), we believe these areas fall within the regulatory definition of important eagle-use areas, and we include them as such in this Draft Eagle Conservation Plan Guidance.

Wind energy projects that overlap important eagle use areas may pose risks to the eagles for reasons described earlier. Project proponents should identify the location and type of all important eagle use areas on and within a 10-mile perimeter of a project footprint (the project footprint is the minimum convex polygon that encompasses the wind facility area inclusive of a 100 meter-radius of all turbines and any associated infrastructure, including utility lines, out-buildings, roads, etc.). The 10-mile perimeter is derived from the definition of project area nesting population in the regulations at 50 CFR 22.26 (see below). Evaluating the spatial area described above for each wind facility is a key part of the programmatic take permitting process. As described later, surveys should be conducted initially to obtain data to predict effects of wind facility projects on eagles, and then after the facility begins operating, studies will again be conducted to determine the actual effects. The following sections include descriptions and criteria for identifying important eagle-use areas in these assessments.

a. Nests and Breeding: Implications of the Nesting Territory, Nest Spacing, and Non-Breeding Individuals for Risk Assessment

An eagle territory is defined in 50 CFR 22.3 as an area that contains, or historically contained, one or more nests within the home range of a mated pair of eagles. Newton (1979) considered the nesting territory of a raptor as the defended area around a pair's nest site and defined the home range as "...the area traveled by the individual in its normal activities of food gathering, mating, and caring for the young." For golden eagles at least, the extent of the home range and territory during nesting season generally are similar; the eagle defends its territory by undulating flight displays near the home range boundaries and adjoining territories barely overlap (Harmata 1982, Collopy and Edwards 1989, Marzluff *et al.* 1997). The nesting season home range is, at a most basic level, described as a minimum-convex polygon formed by connecting the outermost occurrences of an eagle or pair of eagles during the nesting season (Mohr 1947).

Size and shape, and distribution of use of bald and golden eagle nesting territories vary with topography, prey availability, region, and between sexes and both species. To adequately describe the nesting territory of an individual eagle or pair of eagles, systematic, direct observation (Walker *et al.* 2005), telemetry (Kenward 2001, Fuller et al. 2005), or a combination of the two (McGrady *et al.* 2002) for at least three years is recommended, and in areas where prey availability is known to vary among years, many years of data may be required to fully account for annual variations in territory size and shape. An eagle's distribution of use within its territory can then be estimated by using standard kernel analyses (Worton 1989, 1995, Seaman and Powell 1996, Kenward 2001) or other probabilistic approaches, comparable to Moorcroft *et al.* (1999), McGrady *et al.* (2002), and McLeod *et al.* (2002). The size and shape of use areas can vary seasonally (Newton 1979), so documentation of spatial use by resident eagles should encompass all seasons.

Spatial disturbance avoidance zones have been prescribed to protect nests and other types of eagle use areas. Recommendations for the size of avoidance zones for nests of bald and golden eagles have been based on documented distances between nests and territory boundaries. For example, McGrady *et al.* (2002) and Watson and Davies (2009) indicated nesting territories of golden eagles extend to at least four miles from their nests. Garrett et al. (1993) found that bald eagle territories extend at least 2 miles from nests, though studies in areas of dense bald eagle breeding territories in superior habitat suggest home ranges may be much smaller (Sherrod *et al.* 1976, Hodges and Robards 1982, Anthony 2001). Spatial avoidance recommendations for eagle nests are not accurate throughout the entire range of both species due to marked variation in the size and configuration of nesting territories of both species; spatial avoidance prescriptions have been conservative because site-specific data on territory location and spatial extent are rare in the published and unpublished literature.

Directly determining home-range size and utilization contours of individual eagles requires that birds be captured or marked, usually using radio- or satellite-telemetry. Benefits of this approach are that it can provide information on behavioral responses and spatial use of eagles that is relevant to more than assessing the risk of mortality within the project footprint. This additional information can also be useful in identifying and assessing important prey sources, displacement of eagles, behavioral responses to turbines, and cumulative effects from habitat impacts. However, the down side to this approach is that specific target eagles must be captured, and not all eagles using a wind-facility footprint are equally likely to be captured or provide useful data (e.g., migrants or floaters [adult eagles that have not yet settled on a breeding territory] are not as likely to be captured or monitored). Furthermore, the process of capturing and radio-marking eagles can have behavioral and use-area effects (e.g., Marzluff *et al.* 1997, Gregory *et al.* 2002), and these need to be better understood before widespread use of these techniques can be recommended for wind-facility effect assessments. Despite these caveats, the Service recognizes that telemetry studies can yield considerably more detailed area-use information than observational studies, and as such in specific situations it can inform important pre-construction turbine siting decisions and aid in assessing site risk.

The approach that we recommend as a standard practice in this Draft Eagle Conservation Plan Guidance for evaluating siting options and for assessing disturbance effects of wind facilities on eagles breeding on proximate territories is to determine locations of occupied nests of bald and golden eagles within the project footprint and within 10 miles of the perimeter of the footprint, then for each species calculate the mean nearest neighbor distance between the occupied nests (the project-area inter-nest distance). We use a 10-mile distance because the Service has defined the area nesting population for Golden Eagles to be the "number of pairs of Golden Eagles known to have a nesting attempt during the preceding 12 months within a 10-mile radius of a golden eagle nest" (50 CFR 22.3). To avoid confusion with the regulatory term and definition, we use the term project-area nesting population to describe the eagle population targeted in these surveys.

We also recommend application of this survey approach and scale for bald eagles for the purposes of this Draft Eagle Conservation Plan Guidance. However, where the project area nesting density is high-enough to make the 10-mile perimeter infeasible, we recommend an alternative approach (see Appendix C). The effectiveness of this approach for targeting nest searches will be evaluated through post-construction monitoring and the adaptive management framework described later in this Draft Eagle Conservation Plan Guidance. One-half the inter-nest distance has been widely used as a coarse approximation for the territory boundary in a number of raptor studies (e.g., Thorstrom 2001, Wichmann *et al.* 2003, Soutullo *et al.* 2006).

For the purposes of this Draft Eagle Conservation Plan Guidance, we use the mean value of the project-area inter-nest distance (project-area inter-nest distance) to delineate which territories and associated breeding and juvenile eagles are likely to be affected by the wind facility, either through injury, mortality, or disturbance. This information is useful in decisions on whether the wind facility might be able to meet permit requirements at 50 CFR 22.26, for evaluating various siting alternatives, and in monitoring for disturbance effects. The advantages of this approach are that it does not require capture and marking of individual eagles, and it weights all territories equally, not just those on which eagles can be captured and marked.

This approach has the disadvantage of not providing the fine scale behavioral and spatial use information that can be helpful in analyses of behavior. Overall, we believe the advantages of this approach outweigh the disadvantages for most wind facility studies. The data used to calculate the project area inter-nest distance should be secured during the initial site specific surveys, as described later in this Draft Eagle Conservation Plan Guidance. If site specific data are lacking, or if nesting habitat is patchily distributed or nests are widely spaced, calculating the project area inter-nest distance can be problematic. We provide alternative suggestions for these circumstances in Appendix H. If information from the literature is adopted, conservative values should be used because nearest neighbor distances vary widely across populations of both species. For example, mean distances to nearest nests were 2.7 to 3.3 miles for golden eagles in Wyoming and in two areas in Idaho (Craig and Craig 1984, Kochert 1972, Phillips et al. 1984), but 13.4 miles for golden eagles in western Arizona (Millsap 1981).

The presence of nesting territories can also be a predictor for the occurrence of eagles that are not nesting. The non-breeding component of eagle populations includes juveniles (fledged that year), subadults, and, in healthy populations, adult "floaters" that have not settled on a breeding territory (Hunt et al. 1995, Hunt 1998). Many non-breeding eagles exist on margins of territories occupied by breeding adults (Watson 1997, Hunt 1998, Caro et al. 2010). Floaters have been shown to be more vulnerable to collision with turbine blades at wind energy projects than locally breeding adults and juveniles (Hunt et al. 1999, 2002). Wind turbines sited proximally to eagle nesting territories may pose significant risks to eagle populations, because population stability hinges on a robust non-breeding cohort, especially surplus adults in the form of floaters, to replace breeding individuals that die. A systematic, observational approach for documenting frequency of eagle use of the project footprint has the substantial advantage of accounting for any eagle regardless of its breeding or residency status. The Draft Eagle Conservation Plan

Guidance recommends such an approach (point count surveys) for the collection of data that will be used to predict eagle fatality rates at wind facilities.

b. Concentration Areas: Communal Roosts and Foraging Concentrations

During the breeding season, some non-breeding individuals, especially bald eagles, roost communally. Outside the breeding season, communal roosts include individuals of all ages and residency status. Bald eagles may roost singly or in small groups but larger communal roosts are common throughout the year (Platt 1976, Mojica *et al.* 2008). Large roosts tend to be associated with nearby foraging areas. Direct, systematic observation in early morning and evening is the most practical means of locating roosts and documenting numbers of eagles and movements of eagles to and from roosts on a local scale (Steenhof *et al.* 1980, Crenshaw and McClelland 1989). Aerial surveys may be needed for repeated surveys of eagles at extensive roosts (Chandler *et al.* 1995). Direct observation has been used to compare occurrence and activity of eagles before and after construction and operation of a project (Becker 2002), and may be a valid means to identify disturbance effects on roosting concentrations.

c. Migration Corridors and Stopovers

Bald and golden eagles tend to migrate during midday along north-south oriented cliff lines, ridges, and escarpments, where they are buoyed by uplift from deflected winds (Kerlinger 1989, Mojica *et al.* 2008). Bald eagles typically migrate during midday by soaring on thermal uplift or on winds aloft, the onset of migration being influenced by rising temperatures and favorable winds (Harmata 1984). Bald and golden eagles often hunt during this type of migration flight. Both species of eagle will forage during migration flights, though for bald eagles foraging is often restricted to wetland systems (Mojica *et al.* 2008). Both species use lift from heated air from open landscapes to move efficiently during migration and seasonal movements, gliding from one thermal to the next and sometimes moving in groups with other raptor species.

Passage rates of migrant eagles can be influenced by temperature, barometric pressure, winds aloft, storm systems, weather patterns at the site of origin, and wind speed (Yates et al. 2001). Both species avoid large water bodies during migration and funnel along the shoreline, often becoming concentrated in situations where movement requires water crossings (Newton 1979). Eagles annually use stopover sites with predictably ample food supplies (e.g., Restani *et al.* 2000, Mojica *et al.* 2008), although some stopovers may be brief and infrequent, such as when optimal migration conditions suddenly become unfavorable and eagles are forced to land and seek roosts. Presence of a migration corridor or stopover site in the project area is best documented and delineated by using a standard hawk migration counting protocol as recommended in this Draft Eagle Conservation Plan Guidance as a component of the site-specific surveys.

2. Eagle Risk Factors

Factors known or thought to be associated with increased probability of collisions between eagles and other raptors and wind turbine blades and structures are given in Table 1 (page 18). While some of these factors are not known to affect eagles, because of the similarity of flight behavior between eagles and the other soaring raptors we include them here because they may have applicability for eagles. Evidence across multiple studies suggests three main factors contribute to increased risk of collision by eagles: (1) the interaction of topographic features, season, and wind currents to create favorable conditions for slope soaring or kiting (stationary or near-stationary hovering) in the vicinity of turbines; (2) behavior that distracts eagles and presumably makes them less vigilant (e.g., active foraging or inter- and intra-specific interactions); and (3) residence status, with resident adults and young less vulnerable and dispersers and migrants (especially sub-adults and floating adults) more vulnerable. This latter point should not be taken to undercut the potential severity of the risk to breeding adult eagles and their young, as loses from these segments of the population, especially breeding adults, can have serious consequences to populations.

Table 1. Factors potentially associated with wind turbine collision risk in raptors

Risk Factor	Status of Knowledge from Literature	Citations
Bird Density	Mixed findings; likely some relationship but other factors have overriding influence across a range of species	Barrios and Rodriguez (2004), De Lucas *et al.* (2008), Hunt (2002), Smallwood *et al.* (2009)
Bird Age	Higher risk to subadult and adult Golden Eagles	Hunt (2002)
Bird Residency Status	Mixed findings, higher risk to resident adults in Egyptian vultures (*Neophron percnopterus*), but higher risk to subadults and floating adults and lower risk to resident adults and juveniles in Golden Eagles	Barrios and Rodriguez (2004), Hunt (2002)
Season	Mixed findings, with general consensus that risk is higher in seasons with greater propensity to use slope soaring (fewer thermals) or kiting flight (windy weather) while hunting across a range of species	Barrios and Rodriguez (2004), De Lucas et al. (2008), Hoover and Morrision (2005), Smallwood *et al.* (2009)
Flight Style	High risk associated with slope soaring and kiting flights across a range of species	Barrios and Rodriguez (2004), De Lucas *et al.* (2008), Hoover and Morrision (2005)
Interaction with Other Birds	Higher risk when interactive behavior is occurring, across a range of species	Smallwood et al. (2009)
Active Hunting / Prey Availability	High risk when hunting close to turbines, across a range of species	Barrios and Rodriguez (2004), De Lucas *et al.* (2008), Hoover and Morrision (2005), Hunt (2002), Smallwood et al. (2009)
Turbine Height	Mixed, contradictory findings across a range of species	Barclay *et al.* (2007), De Lucas *et al.* (2008)
Turbine Type	Higher risk associated with lattice turbines for Golden Eagles, higher risk with tubular towers for Burrowing Owls (*Athene cunicularia*)	Hunt (2002), Smallwood *et al.* (2007)
Rotor Speed	Higher risk associated with higher blade-tip speed for Golden Eagles	Chamberlain *et al.* (2006)

Perch Availability	Possible higher risk with higher perch availability in the general project area for golden eagles	Chamberlain *et al.* (2006)
Rotor-swept Area	Mixed findings; higher mortality associated with larger rotor-swept area in one study for non-raptors, meta-analysis found no effect	Barclay *et al*. (2007), Chamberlain et al. (2006)
Topography	Several studies show higher risk of collisions with turbines on ridge lines and on slopes where declivity currents facilitate slope soaring and kiting flight of soaring raptors. Also a higher risk in saddles that present low-energy ridge crossing points. Higher risk for Burrowing Owls in canyons.	Barrios and Rodriguez (2004), De Lucas *et al.* (2008), Hoover and Morrission (2005), Smallwood and Thelander (2004), Smallwood *et al.* (2007)
Wind Speed	Mixed findings; general pattern of higher risk in situations that favor slope soaring or kiting (high winds in some locales, low winds in other, likely depending on degree of slope and aspect)	Barrios and Rodriguez (2004), Hoover and Morrision (2005), Smallwood *et al.* (2009)

3. Overview of Process to Assess Risk

The Draft Eagle Conservation Plan Guidance outlines a decision-making process that gathers information at each stage of project development, with an increasing level of detail. This approach provides a framework for making decisions sequentially at three critical phases in project development: (1) siting, (2) construction, and (3) operations. The greatest potential to avoid and minimize impacts to eagles occurs when eagle risk factors are taken into account at each stage. If siting and construction have proceeded without consideration of risks to eagles, significant opportunities to avoid and minimize risk may have been lost. This can potentially result in greater compensatory mitigation requirements or, in the worst case, an unacceptable level of mortality for eagles.

The related, but more general, *U.S. Fish and Wildlife Service Draft Land-based Wind Energy Guidelines* advocates using a five-tiered approach for iterative decision making relative to assessing and addressing wildlife effects from wind facilities. Elements of all of those tiers are applicable here, but the process for eagles is more defined and falls more into six broadly overlapping, iterative stages: Stage 1 site assessment; Stage 2 site-specific surveys and assessments; Stage 3 predicting eagle fatalities; Stage 4 avoidance and minimization of risk; and Stage 5 post-construction monitoring.

Stage 1 for eagles combines tiers 1 and 2 from the *U.S. Fish and Wildlife Service Draft Land-based Wind Energy Guidelines*, and consists of an **initial site assessment**. In this stage project proponents evaluate broad geographic areas to assess the relative importance of various areas to resident breeding and non-breeding eagles, and to migrant and wintering eagles. The Service is available to assist project proponents in identifying potential important eagle use areas and habitat at this stage. To increase the probability of meeting the regulatory requirements for a programmatic permit, Service biological advice should be requested as early as possible in the company's planning process, ideally prior to any financial commitment or finalization of any lease agreements. During Stage 1 the project proponent should gather existing information from publicly available databases and other available information, and use those data to refine potential project sites balancing suitability for development with potential risk to eagles.

Once a site has been selected, the next stage, **Stage 2**, is **site-specific surveys and assessment** (this is the first component of tier 2 in the *U.S. Fish and Wildlife Service Draft Wind Energy Guidelines*). During Stage 2 the project proponent should collect quantitative data through scientifically rigorous surveys designed to assess the potential risk of the proposed project to eagles at and surrounding the specific site(s) selected in Stage 1.

In **Stage 3**, **the initial fatality prediction stage**, the Service and project proponents use data from Stage 2 in standardized models linked to the Service's adaptive management process to generate predictions of eagle risk in the form of a predicted number of fatalities per year. These models can be used to comparatively evaluate alternative siting, construction, and operational scenarios, a useful feature in quantifying the predicted effects of ACPs. We encourage project proponents to use the recommended pre-construction survey protocol in this Draft Eagle Conservation Plan Guidance in Stage 2 to help inform our models in Stage 3. If Service-recommended survey protocols are used, this risk assessment can be greatly facilitated using Excel-based models provided by the Service. If project proponents use other forms of information for the Stage 2 assessment, they will need to employ and fully describe those methods and the analysis approach taken for the eagle risk assessment, and more time will be required for Service biologists to evaluate and review the data. For example, the Service will compare the results of the project proponent's eagle risk assessment with predictions from our generic, risk-averse models, and if the results differ, we will work with the project proponents to determine if the site specific data collected warrants modification of the Service's predictions. The risk assessments at Stage 2 and Stage 3 are consistent with developing the information necessary to assess the efficacy of ACPs, and to develop the monitoring required by the permit regulations at 50 CFR 22.26(c).

Stage 4 is the **application of ACPs and compensatory mitigation**. Regardless which approach is employed in the Stage 2 assessment, in Stage 4 the information gathered is used by the project proponent and the Service to determine potential ACPs that can be employed to avoid and/or minimize the predicted risks at a given site. The Service will compare the initial predictions of eagle mortality for the project with predictions that take into account proposed and potential ACPs to determine if the project proponent has avoided and minimized risks to the maximum extent achievable, thereby meeting the requirements for programmatic permits in 50 CFR 22.26 that remaining take is unavoidable. This final eagle risk assessment completed at the end of Stage 4 after application of ACPs along with a plan for compensatory mitigation if required (e.g., if unavoidable take exceeds that allowable under calculated take thresholds), will be used by the Service to determine if the applicant has met the regulatory standards for issuance of a programmatic take permit.

If a permit is issued and the project goes forward, **Stage 5** of the process is **risk validation**, equivalent to tiers four and, in part, five in the *U.S. Fish and Wildlife Service Draft Wind Energy Guidelines***.** During this stage, post-construction surveys are conducted to generate empirical data for comparison with the pre-construction risk-assessment predictions. Again, we recommend project proponents use the post-construction survey protocols included in this Eagle Conservation Guidelines for this monitoring, but we will consider other monitoring protocols provided by permit applicants, so long as they meet the permit-condition requirements at 50 CFR 22.26(c)(2). We will use the information from post-construction monitoring will be used in a meta-analysis framework to weight and improve pre-construction predictive models. Additionally, the Service and project proponents will use this data to explore operational changes that might be warranted at a project to reduce observed mortality and ensure that the permit condition requirements at 50 CFR 22.26(c)(7) are met. After implementation of any additional necessary ACPs, project proponents will be eligible for renewal of their eagle take permit. The effectiveness of the additional ACPs will be determined through continued post-construction monitoring.

4. Site Categorization Based on Mortality Risk to Eagles

We recommend project proponents use a standardized approach to categorize the likelihood that a site or operational alternative will meet standards in 50 CFR 22.26 for issuance of a programmatic eagle take permit (Figure 1). A proposed project can be categorized as either: (1) high risk to eagles, little opportunity to minimize effects; (2) high to moderate risk to eagles, but with an opportunity to minimize effects; or (3) minimal risk to eagles. The risk category of a project has the potential to change from one of higher risk to one of lower risk through additional site-specific analyses and application of measures to reduce the risk, as outlined in this document. Distance criteria for evaluating risk should not be considered as protective buffers, but instead as the bounds of zones of proximity to important eagle use areas where more specific data and measures may be necessary to evaluate and reduce risk. If a project cannot practically be placed in one of these categories, the project proponent and the Service should work together to determine if the project can meet programmatic eagle take permitting requirements in 50 CFR 22.26 and 22.27.

a. Category 1 – High risk to eagles/potential to avoid or mitigate impacts is low

A project is in this category, as sited and planned, if it is (1) likely to take eagles at a rate greater than is consistent with maintaining stable or increasing populations (taking into account opportunity for reasonable compensatory mitigation), and (2) the effects cannot be minimized to the degree that any take that occurs is unavoidable. In general, prospective project footprints that include important eagle use areas as described previously will fall into category 1. Examples include:

1. For breeding eagles
    a) The project footprint includes or is within half the project area inter-nest distance of an eagle nest or cluster of nests in an occupied territory.

b) Information (e.g., from radio or satellite telemetry) is available to demonstrate that the project footprint is visited regularly by eagles occupying a proximate nesting territory.

2. For non-breeding eagles
   a) The project footprint includes the roost location(s) or a primary foraging area associated with an eagle concentration, or a migration corridor, or stopover area.
3. For all eagles
   a) Based on site-specific survey data collected as part of the Stage 2 site assessment process (described later in this Draft Eagle Conservation Plan Guidance), the estimated eagle fatality rate for the wind facility cannot reasonably be mitigated.

Projects or alternatives in category 1 should be substantially redesigned so that they at least meet the category 2 criteria. If they cannot be redesigned, they should be moved or abandoned; construction of projects at sites in category 1 is not recommended because the project would likely not meet the regulatory requirements for permit issuance. However, when a project has been determined by the Service to be in category 1, Service biologists and Special Agents of the Service's Office of Law Enforcement may consider a detailed re-assessment of risks to eagles posed by the project if it is warranted by additional biological data made available by the project proponent.

b. Category 2 – High to moderate risk to eagles/opportunity to mitigate impacts

A project is in this category if, as currently sited and planned, it is (1) reasonably likely to take eagles at a rate greater than is consistent with maintaining stable or increasing populations, but (2) the risk might be minimized to the maximum degree achievable through a combination of conservation measures and reasonable compensatory mitigation, per an effective and verifiable ECP. These projects have a risk of ongoing take of eagles, but this risk can be minimized. For projects in this category an ECP should be prepared following this Draft Eagle Conservation Plan Guidance to assist the applicant in meeting the regulatory requirements for a programmatic permit. For Golden Eagles nationwide, and for bald eagles in the southwest management unit, the conservation measures in the ECP must result in no-net-loss to the breeding population to be compatible with the permit regulations. Examples of likely category 2 situations include:

1. the project as proposed has potential to cause take of eagles in the form of disturbance (e.g., it is within the project area inter-nest distance of a nest), either from the individual project or due to cumulative impacts of the project and other anthropogenic changes in the vicinity; or
2. the project is located where important eagle use areas are present within 10 miles of, but not within, the project footprint; or
3. is based on site-specific survey data collected as part of the Stage 2 site assessment process (described later in this Draft Eagle Conservation Plan Guidance), the estimated eagle fatality rate for the wind facility, after application of all indicated avoidance and minimization measures, can likely be mitigated; or
4. the project is located where important use areas of bald or golden eagles are at least 10 miles from the project footprint but the area within 10 miles contains potential breeding or foraging habitat and the population of eagles in the eagle management

unit (as defined in USFWS 2009b) is increasing or is expected to increase over the lifetime of the project; or

5. in rare circumstances where eagle nests are within or proximate to the project footprint but the project, with strong compensatory mitigation can meet the requirements in 50 CFR 22.27(a)(iv) for take of inactive eagle nests (these situations are not addressed in this Draft Eagle Conservation Plan Guidance, but will be addressed case-by-case basis between the project proponent and the Service).

c. Category 3 – Minimal risk to eagles

A project in this category poses little risk to eagles. A project proponent may wish to create an ECP that documents the project's low risk to eagles, and outlines mortality monitoring for eagles and a plan of action if eagles are taken during project construction or operation. If take should occur, the proponent must contact the Service to discuss ways to avoid take in the future. In general, projects that are unlikely to have or do not currently have important eagle-use areas within 10 miles of the project footprint will fall into category 3.

d. Category 4 – Uncertain risk to eagles

Sites lacking sufficient data to assign them to categories 1 through 3 should be placed in this category. In general, these are sites for which little or no pre-existing data is available to assign them to a category in the Stage 1 assessment. In these cases, assignment to a category (category 1, 2, or 3) should occur no later than Stage 2. It is recommended that project proponents delay making any commitments to sites in this category. After Stage 2 and Stage 3 analyses for the ECP are complete, the project can be put into one of the above risk categories for consideration.

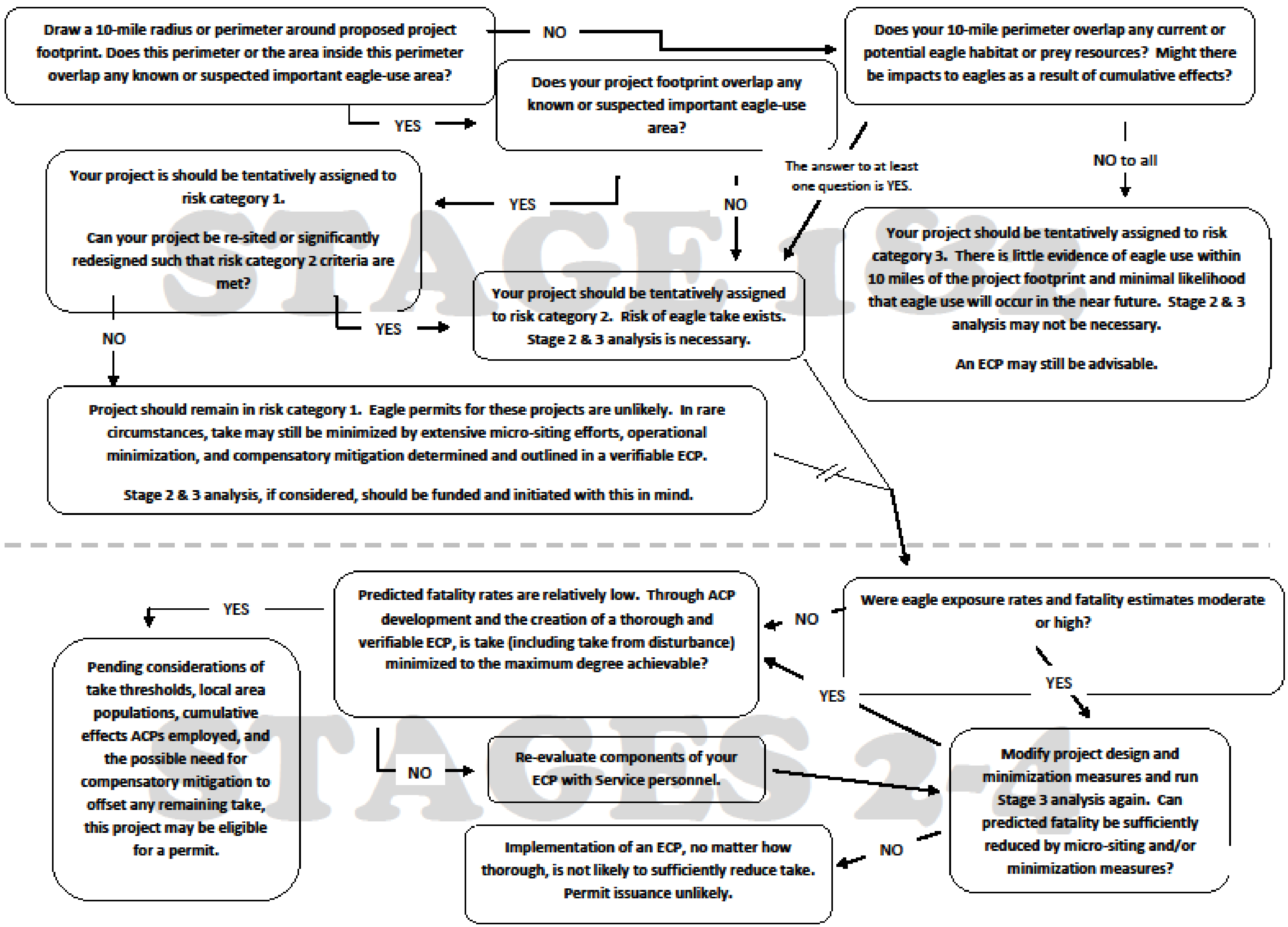


Figure 1. Flow chart for wind-facility site categorization in Stages 1 - 4

5. Cumulative Effects Considerations

a. Early Planning

Regulations at 50 CFR 22.26 require the Service to consider the cumulative effects of programmatic eagle take permits. Cumulative effects are defined as: “the incremental environmental impact or effect of the proposed action, together with impacts of past, present, and reasonably foreseeable future actions” (50 CFR 22.3). Thorough cumulative effects analysis will depend on effective analysis during the NEPA process associated with an eagle permit. Scoping and other types of preliminary analyses can help identify important cumulative-effects factors; set suitable boundaries for analysis; and identify applicable past, present, and future actions. Comprehensive evaluation during early planning may identify measures that would avoid and minimize the effects to the degree that take of eagles is not likely to occur. In that case, there may be no permit, and thus no need for NEPA associated with an eagle take permit. Where a permit is sought, a comprehensive cumulative effects analysis at the early planning stage will serve to streamline subsequent steps, including the NEPA process. In addition, considering cumulative effects is essential to developing appropriate ACPs.

The Service recommends that cumulative effects analyses be consistent with the principles of cumulative effects outlined in the Council on Environmental Quality (CEQ) handbook, "Considering Cumulative Effects under the National Environmental Policy Act (1997) (CEQ handbook). The Service recommends consideration of the following examples from the CEQ handbook that may apply to cumulative effects to eagles and the ecosystems they depend upon:

1. Time crowding - frequent and repetitive effects on an environmental system.
2. Time lags - delayed effects.
3. Space crowding - High spatial density of effects on an environmental system.
4. Cross- boundary - Effects occur away from the source.
5. Fragmentation - change in landscape pattern.
6. Compounding effects - Effects arising from multiple sources or pathways.
7. Indirect effects - secondary effects.
8. Triggers and thresholds - fundamental changes in system behavior or structure.

b. Analysis Associated with Permits

The cumulative effects analysis for a wind facility and a permit authorization should include whether the anticipated take of eagles is compatible with eagle preservation as required at 50 CFR 22.26, including indirect impacts associated with the take that may affect eagle populations. It should also include consideration of the cumulative effects of other permitted take and additional factors affecting eagle populations.

Whether or not a permit authorization is compatible with eagle preservation was analyzed in the FEA that established the thresholds for take (USFWS 2009b). The scale of that analysis was based upon eagle management units as defined in USFWS (2009b). However, the scale for cumulative effects analysis of wind facility projects and associated permits may include greater- and/or lesser- scales than in the FEA, and will be determined by the Service and project proponent on a case-by-case basis.

The cumulative effects analyses for programmatic permits should cover the time period over which the take will occur, not just the period the permit will cover, including the effect of the proposed action, other actions affecting eagles, predicted climate change impacts, and predicted changes in number and distribution of affected eagle populations. Effects analyses should note whether the project is located in areas where eagle populations are increasing or predicted to increase based on available data, over the lifetime of the project, even if take is not anticipated in the immediate future. In addition, conditions where populations are saturated should be considered in cumulative effects analyses. Numerous relatively minor disruptions to eagle behavior from multiple activities, even if spatially or temporally distributed, may lead to disturbance that would not have resulted from fewer or more carefully sited activities (e.g., Whitfield *et al.* 2007).

Additional detailed guidance for cumulative impacts analyses can be found on the Council on Environmental Quality website at http://ceq.hss.doe.gov/nepa/ccenepa/ccenepa.htm. The Service is developing additional specific guidance and recommendations on the scope and scale of cumulative effects analyses associated with programmatic eagle take permits.

C. ADAPTIVE MANAGEMENT

The role of adaptive management with respect to this Draft Eagle Conservation Plan Guidance is to improve our predictive capability relative to likely effects of wind facilities on eagles, and to improve our predictive capabilities relative to effective mitigation measures. There are many sources of uncertainty that can be reduced with better data. Generally, eagle monitoring at the level of the wind-facility site is needed to reduce uncertainty in four categories: (1) exposure risk, (2) rate of mortality, (3) direct and indirect effects on territory occupancy and productivity, and (4) measuring the success of compensatory mitigation. Much of the pre-siting and post-construction monitoring sections of this Draft Eagle Conservation Plan Guidance are devoted to describing advised, standardized monitoring methods that will provide data in a standardized format that will, for example, help us integrate eagle-use data with information on topography, weather, habitat, and prey density to predict, with increasing accuracy, rates of eagle mortality. The ultimate measure of success is a reduction in the number of dead eagles at a site, thus good mortality monitoring is essential to evaluating site risk and the efficacy of the avoidance and minimization measures undertaken by companies to reduce those risks.

Methods for estimating the number of annual eagle fatalities at a site are described in detail, and by comparing fatality rates before and after ACPs are undertaken by companies, we will be able to evaluate the effectiveness of those practices. These evaluations may show that additional ACPs are warranted to address documented problems, but they may also show that ACPs in place are not effective and need not be continued. We will also employ adaptive management to evaluate the effectiveness of compensatory mitigation actions to verify that predicted levels of mortality reduction are achieved. Adaptive management is, therefore, critical to determine the efficacy of applied ACPs and compensatory mitigation measures. This aids the Service in complying with both regulatory permit condition 50 CFR 22.26(c)(7), which determines when the Service may amend, suspend, or revoke a programmatic permit if new information indicates that revised permit conditions are necessary, and permit condition 50 CFR 22.26(c)(2), which requires monitoring after completion of an activity for purposes of adaptive management.

In an adaptive management framework, monitoring that evaluates factors that affect mortality risk, and evaluates the efficacy of measures taken to avoid, minimize, or compensate for mortality, should feed back into planning and operation of wind facilities at the site level with the ultimate goal of a gradual reduction in eagle mortality. Additionally, the data will roll up into population-wide models that incorporate survival, productivity, and population status information from many sources to assess the effects of our permits at the scale of continental eagle populations. By collecting these data in a systematic, unified, stepwise manner, ultimately a clearer picture will ultimately emerge about the nation's eagle populations and the effects that increasing energy developments and other factors have on them. By using adaptive management principles to guide eagle management, the Service in cooperation with our partners and industry can focus its attention on those actions that will most effectively meet our goal of stable or increasing breeding populations of both species of eagle, as established in USFWS (2009b). More information on adaptive management can be found in APPENDIX A.

D. DEVELOPMENT OF AN EAGLE CONSERVATION PLAN

The following sections of this Draft Eagle Conservation Plan Guidance, including attached appendices, provide a descriptive instructional template for developing an ECP. The ECP is an integral part of the permit process, and the following chronological step-by-step outline shows how the pieces fit together:

1. This Draft Eagle Conservation Plan Guidance offer recommends guidance for project proponents, the Service, and other jurisdictional agency biologists to reference when developing and evaluating ECPs.
2. Using these Draft Eagle Conservation Plan Guidance as a non-binding reference, the Service will work with programmatic take-permit applicants to develop an ECP, which documents how the applicant will comply with the regulatory requirements for programmatic permits and the associated NEPA process by avoiding and minimizing the risk of taking eagles up-front, and formally evaluating possible alternatives in (ideally) siting, configuration, and operation of wind projects. The Service's ability to influence siting and configuration factors depends on the stage of development of the project at the time the applicant comes to us.
3. ECPs should be developed following the five staged approach: (1) initial site assessment; (2) site specific surveys and assessment; (3) initial fatality prediction; (4) application of ACPs that avoid and minimize risk, and a re-assessment of fatality predictions; and (5) post-construction monitoring. During Stages 1 and 2, projects or alternatives should be categorized as either: (1) category 1 – high risk; (2) category 2 – moderate risk; and (3) category 3 – low risk. For projects that fall into category 1 or 2, the Service will either (a) accept an ECP that offers siting, configuration, and an operational alternative that avoids and minimizes take to the point any remaining take is unavoidable and, if required, mitigates that remaining take to meet the statutory preservation standard; or (b) determine that the project cannot be permitted because risk to eagles is too high such that the applicant would be unlikely to meet the regulatory permit requirements. If the Service determines the project can be permitted, the duration of the permit will be no longer than five years, with the expectation that the permit will be renewed if, at that time, all conditions have been satisfactorily met.

4. For permitted projects, the Service and the applicant will use the standardized models developed as part of the adaptive management process to predict unavoidable eagle mortality after implementing the acceptable alternative. These models will rely heavily on pre-construction monitoring by the applicant, ideally following the standardized protocol described in this Draft Eagle Conservation Plan Guidance. If the applicant cannot or chooses not to conduct pre-construction monitoring, the Service will generate a risk-averse estimate of annual mortality using a set of conservative, predictive models.
5. For predicted recurring eagle take that is in excess of calculated take thresholds (i.e., take in excess of the regional thresholds designed to meet the statutory preservation standard as described in USFWS 2009b), the Service will either (a) collect a compensatory mitigation payment from the applicant that will be deposited into a Service-established eagle conservation fund for pooled compensatory mitigation; or (b) approve a compensatory mitigation proposal from the applicant. Under either (a) or (b), the compensatory mitigation cost and actions will be calibrated so as to offset the predicted unavoidable take, such that we bring the individual permit's (and cumulatively over all such permits') predicted mortality effect to a net of zero. Compensatory mitigation may also be required in other situations where predicted effects to eagle populations are substantial.
6. Systematic, standardized, post-construction monitoring, ideally following protocols established in the Draft Eagle Conservation Plan Guidance, are recommended to derive an estimate of the number of eagle fatalities each year at each permitted wind facility and to document disturbance effects at nearby nests. This monitoring information will be used in a formal adaptive management framework to evaluate and improve the predictive accuracy of our models. In addition, the information will be used by the Service and the applicant to identify any project specific additional ACPs that can be implemented to potentially reduce eagle mortalities based on the observed, specific situation at each site. Continued monitoring will determine the effectiveness of any additional ACPs implemented in each situation.

Holders of programmatic eagle take permits will be required to allow Service personnel, or other qualified persons designated by the Service, access to the areas where take is possible, within reasonable hours and with reasonable notice from the Service, for purposes of monitoring eagles at the site(s). The regulations provide, and a condition of any permit issued will require, that the Service may conduct such monitoring while the permit is valid, and for up to three years after it expires (50 CFR 22.26(c)(4)). Typically, these follow-up site visits would be performed by Service employees.

In general, verifying compliance with permit conditions is a secondary purpose of site visits; the primary purpose is to monitor the effects and effectiveness of the permitted action and mitigation measures. This may be done if a project proponent is unable to observe or report to the Service the information required by the annual report—or it may serve as a "quality control" measure the Service can use to verify the accuracy of reported information and/or adjust monitoring and reporting requirements to provide better information for purposes of adaptive management.

1. Contents of the Eagle Conservation Plan

a. Stage 1 - Site assessment

The objective of the Stage 1 site assessment is to cast a broad look at the landscape of interest and identify, based on existing information and studies, known or likely important eagle-use areas. Based on that information, project proponents should work with the Service to place potential wind –facility sites in one of the three site categories described in Section B 4 of these Draft Eagle Conservation Plan Guidance. For detailed recommendations on the Stage 1 process, go to APPENDIX B.

b. Stage 2 - Site-specific surveys and assessments

In Stage 2, project proponents collect detailed, site-specific information on eagle use of the specific sites that passed review in Stage 1. The information collected in Stage 2 is used to generate predictions of the annual number of fatalities for a prospective wind facility site and to identify important eagle-use areas likely to be affected by the project. For detailed recommendations on the Stage 2 methods and metrics, go to APPENDIX C.

c. Stage 3 - Predicting eagle fatalities

In this section of the ECP, project proponents should work in coordination with the Service to determine risk factors associated with each turbine in the facility. Then, an annual predicted mortality rate for the project can be calculated by using the estimated annual eagle exposure rate generated from the Stage 2 assessment and Excel-based models. The initial estimate of mortality rate should not take into account possible ACPs; these will be factored in as part of Stage 4. Additionally, any loss of production that may stem from disturbance is not considered in these calculations, but is instead derived from post-construction monitoring as described in Stage 5. Specific elements of the adaptive management process will be further developed as they emerge in actual cases, through coordination with project proponents. Therefore, this stage and Stage 5 of the ECP will require close coordination between the project proponent and the Service. For detailed recommendations on Stage 3 methods and metrics, go to APPENDIX D.

d. Stage 4 - Avoidance and Minimization of Risk using ACPs, and Compensatory Mitigation

Siting of a wind facility is the most important factor when considering potential effects to eagles. Based on information gathered in Stage 2 and analyzed in Stage 3, the project proponent should revisit the site categorization from the Stage 1 assessment to determine if the site(s) still falls into an acceptable category of risk (at this stage, acceptable categories are 2 and 3, and very rarely 1). When information suggests that a proposed wind facility has a high eagle exposure rate and presents multiple risk factors, it should be considered a category 1 site; we recommend relocating the project to another area because a location at that site would be unlikely to meet the regulatory requirements for a programmatic permit. If the site falls into categories 2 or 3, or for some rare category 1 sites where there is potential to adequately abate risk, the ECP should next address ACPs that might be employed to minimize or, ideally, avoid eagle mortality and disturbance.

In this section of the ECP, we recommend project proponents re-run models predicting eagle fatality rates *after* implementing the scientifically supportable ACPs for all the plausible alternatives. This re-analysis serves two purposes: (1) it demonstrates the degree to which minimization and avoidance measures might reduce effects to eagle populations compared to the baseline project configuration, and (2) it provides a prediction of unavoidable eagle mortality. For detailed recommendations on considerations for the development of ACPs go to APPENDIX E.

Compensatory Mitigation

Compensatory mitigation occurs in the eagle permitting process if ACPs do not remove the potential for take, and projected take exceeds calculated take thresholds for the species or management population affected. Compensatory mitigation may also be required in other situations as described in the preamble to 50 CFR 22.26 (USFWS 2009a) and the following guidance applies to those situations as well. To be consistent with this compensatory mitigation guidance, project proponents must ensure their projects are "compatible with the preservation of the eagle" and "…consistent with the goal of increasing or stable breeding populations" (USFWS 2009a).

For new projects, compensatory mitigation will be required upfront before project operations commence because projects must meet the statutory and regulatory eagle preservation standard before FWS may issue a permit. For operating projects that may meet permitting requirements, compensatory mitigation should be applied from the start of the permit period, not retroactively from the initiation of project operations. Compensatory mitigation will also be applied in the future, at each permit reissuance or renewal point, so long as it is still necessary to meet the preservation standard at that time. As stated previously in the adaptive management section of this Draft Eagle Conservation Plan Guidance "monitoring that evaluates factors that affect mortality risk; and that evaluate the efficacy of measures taken to avoid, minimize, or compensate for mortality; all should feed back into planning and operation of energy facilities at the site level with the ultimate goal of a gradual reduction in eagle mortality at wind facilities." With this in mind, as new data are made available, the Service will modify the compensatory mitigation process to adapt to any improvements in our knowledge base.

To determine the level of compensatory mitigation required for a proposed or current project, the Service will estimate the quantitative potential for take of all age classes of eagles using informed modeling, as described in Stage 3 of the ECP (APPENDIX D). This fatality prediction will be one of several fundamental variables that will be used to populate a Resource Equivalency Analysis (REA). Economists extended the economic theory from valuation studies and information from scientific models to develop the REA model (based on Unsworth and Bishop 1994; Jones and Pease 1997).

An REA responds to the question, "What, but for the 'take,' would have happened to the eagles?" With REA, the services of the eagles killed are quantified in physical units of *bird-*

years.[1] The selected compensation is "scaled" so that the quantity of replacement bird years equals the quantity of lost bird-years in present value terms to fully compensate the public, accomplishing the stated objective of no-net-loss of birds. For the purposes of this document we refer to an REA as a stepwise replacement model (Sperduto *et al*. 1999, 2003) for eagles that will be taken. The Service will use REA to calculate mitigation offset for a wind facilities' estimated unavoidable take. Application of this model follows other comparable analyses used for white-tailed sea eagles (Cole 2009) and other species (Sperduto *et al*. 1999, 2003, Industrial Economics Inc. 2004).

The use of REA, while relatively new for Service raptor management, is consistent with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Oil Pollution Act (OPA), and Natural Resource Damage Assessment and Restoration (NRDAR) federal regulations, and has been explicitly identified in revised CERCLA regulations (2008). REA calculations using the stepwise replacement model involve wildlife population modeling, including elements of the Leslie matrix and life tables, and include discounting to provide compensatory mitigation costs per unit of take (See APPENDIX F; Cole 2009). The required life history parameters (e.g., survival, fecundity, and longevity) are based on the best available published data to document how individual eagles per age class may be removed from the population during the life of a project and offset through mitigation.

The REA will generate a project level eagle take calculation (debit), expressed in bird-years, as well as an estimate of the quantity of compensatory mitigation (credit) (e.g., power pole retrofits) necessary to offset this take. Compensatory mitigation will then be initiated, subsequently funded per an established rate, and implemented by one of the following mechanisms:

1. Project proponent will directly contract and fund Service-approved compensatory mitigation project; or
2. Project proponent will pay into a Service-established BGEPA account; or
3. Project proponent will pay into a third-party mitigation account identified by the project proponent and approved by the Service.

Effectiveness monitoring of the resulting mitigation projects should be included within the above options using the best scientific and practicable method available. All mitigation projects will be subjected to random inspections by the Service or appointed subcontractors to examine efficacy, accuracy, and reporting rigor.

The Service considered the following compensatory mitigation options to reduce or eliminate factors known or suspected to be negatively affecting eagles of one or both species: (1) improving range management prescriptions to eliminate loss of extant eagle territories; (2) environmental lead abatement; (3) addressing mortality due to collision or drowning; and (4) addressing potential electrocution due to non-APLIC standard powerlines. However, to be

[1] A *bird- year* refers to all services provided by one bird for one year. This measure of services is specific to the type of bird since different birds provide different services. So, e.g., the replacement services for 20 bird-years could be 20 birds for only one year, one bird over 20 years, or anything in between.

effective, any potential compensatory mitigation must have quantifiable adverse impacts and verifiable benefits that can be assessed on a per eagle basis, and have measurable metrics for monitoring.

The Service will focus initial compensatory mitigation efforts towards proactive power pole retrofitting, which is in addition to the reasonable corrective actions required of companies (after implementing ACPs) to avoid the unlawful take of eagles and other migratory birds. We focus mitigation efforts toward eliminating electrocutions because:

1. Utility power poles cause quantifiable adverse impacts to eagles,
2. the 'per eagle' and population effects of utility power pole retrofitting to create safe conditions for eagles are quantifiable and verifiable through accepted practices,
3. success of and subsequent maintenance to retrofitting can be monitored, and
4. electrocution causes a significant amount of eagle mortality and, in most cases, is correctable.

These efforts will be structured to reduce the electrocution hazard from high-risk transmission infrastructure to adult, subadult, and juvenile eagles throughout their range in North America (APLIC 2006, Lehman et al. 2007, Lehman et al. 2010, Millsap et al. 2004). If the benefits can be clearly demonstrated, other forms of compensatory mitigation may also be an option. The Service, in coordination with State and Tribal wildlife agencies, will evaluate and approve the final compensatory mitigation plans for non-power pole efforts. For details on the approach used to calculate appropriate compensatory mitigation values go to APPENDIX F.

e. Stage 5. Post-construction monitoring

In this section of the ECP, the project proponent should describe the proposed post-construction survey methodology for the project. The objective of post-construction monitoring is to estimate (1) the annual number and circumstances of eagle fatalities at operating wind facilities, and (2) disturbance effects in the form of reduced productivity at eagle territories proximate to operating wind facilities. 50 CFR 22.26 requires monitoring as a condition of eagle take permits for ongoing activities like wind facilities for as long as the data are needed to assess effects on eagles. Given the adaptive management framework the Service has adopted and the regulatory conditions at 50 CFR 22.26(c)(2)&(4), this will require wind-facility operators to monitor during construction and for at least three years post construction, to include a minimum of three years of operation, then assess monitoring data to consider whether additional ACPs are appropriate and warranted. If additional or different ACPs are warranted, an additional three years of monitoring data will be required to assess the effectiveness of the new or revised ACPs for at least three years post construction. Detailed recommendations for post-construction monitoring are in APPENDIX H. The Stage 5 post-construction monitoring plan is the final section of the ECP.

Post construction monitoring is essential to identify possible factors associated with eagle fatalities at wind facilities that might warrant additional ACPs or improvement or elimination of ACPs found to be ineffective. Implementation of these additional ACPs and further monitoring following identical (though perhaps more targeted) protocols will help the Service and project proponents rigorously evaluate the effectiveness of conservation measures under different conditions

E. INTERACTION WITH THE SERVICE

As noted throughout this Draft Eagle Conservation Plan Guidance, frequent and through coordination between project proponent and Service and other jurisdictional-agency biologists is crucial to the development of an effective and successful ECP. This is particularly true for the first several wind-facility projects that attempt to obtain programmatic eagle take permits, where many of the operational details of the ECP will be tested through application in the field. Close coordination will also be necessary in the refinement of the modeling process used to predict fatalities, as well as in post-construction monitoring to evaluate those models. We anticipate this Draft Eagle Conservation Plan Guidance and the recommended methods and metrics will evolve rapidly as the Service and project proponents learn together. The Service will continue to refine this Draft Eagle Conservation Plan Guidance with input from all stakeholders with the objective of maintaining stable or increasing breeding populations of both bald and golden eagles while simultaneously developing science-based eagle-take regulations and procedures that are neither excessive nor unduly burdensome.

F. GLOSSARY

Adaptive management – iterative process of decision making considering uncertainty, with the goal of reducing that uncertainty over time.

Advanced conservation practices — scientifically-supportable measures approved by the Service, representing the best-available techniques to reduce eagle disturbance and ongoing mortalities to a level where remaining take is unavoidable.

Adult – an eagle five or more years of age.

Alternate nests – additional sites within a nesting territory that are available to be used within a nesting season.

Area-nesting population – number of pairs of eagles known to have a nesting attempt during the preceding 12 months within a 10-mile radius of an eagle nest.

Avoidance and minimization measures – conservation actions targeted to remove or reduce specific risk factors (e.g., avoiding important eagle-use areas, placing turbines away from ridgelines).

Breeder (resident breeder) – an eagle that is a member of a breeding pair on a territory.

Calculated take thresholds – annual allowable eagle take limits established in USFWS (2009b).

Collision probability (risk) – the probability that an eagle will collide with a turbine during a minute of exposure.

Compensatory mitigation – an action in the eagle permitting process if ACPs do not completely remove the potential for take, and projected take exceeds calculated take thresholds for the species or the eagle management unit management population affected (or in some cases, under other circumstances as described in USFWS 2009a).

Conservation measures – actions that avoid (this is best achieve at the siting stage), minimize, rectify, and reduce or eliminate an effect over time. Determination of which conservation measure or suite of measures, will provide the most benefits to eagles will rely upon a thorough cumulative effects analysis, as well as close coordination with the Service and state and tribal wildlife agencies, and implementation of an adaptive management approach compatible with the process described in the Department of Interior (DoI) Adaptive Management Handbook (Williams *et al.* 2009).

Decorated nest – a nest with fresh whitewash, feathers, or with fresh greenery, all of which are evidence of occupancy.

Disturb - means to agitate or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available, (1) injury to an eagle, (2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or (3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior.

Eagle Conservation Plans (ECP) – a document produced by the project proponent in coordination with the Service that supports issuance of an eagle take permit under 50 CFR 22.26 (or demonstrates that such a permit is unnecessary).

Eagle Management Unit – regional eagle population defined in the FEA (USFWS 2009b). For Golden Eagle's regional management populations follow Bird Conservation Regions (see http://www.nabci-us.org/map.html), whereas for bald eagles they follow U. S. Fish and Wildlife Service regional boundaries.

Eagle exposure rate – a value expressed as eagle exposure minutes (flight minutes) per daylight hour within the footprint of the project, averaged over daylight hours and over the annual cycle.

Eagle territory - an area that contains, or historically contained, one or more nests within the home range of a mated pair of eagles.

Fatality monitoring – searching for eagle carcasses beneath turbines and other facilities to estimate the number of fatalities.

Floater (floating adult) – as adult eagle that has not settled on a breeding territory.

Home range - the area traveled by and eagle in its normal activities of food gathering, mating, and caring for young. Breeding home range is the home range during the breeding season, and the non-breeding home range is the home range outside the breeding season.

Important eagle-use area - an eagle nest, foraging area (to include as interpreted here migration corridors and migration stopover sites), or communal roost site that eagles rely on for breeding, sheltering, or feeding, and the landscape features surrounding such nest, foraging area, or roost site that are essential for the continued viability of the site for breeding, feeding, or sheltering eagles.

Inactive nest (from the regulations**) —** a nest that is not currently being used by eagles as determined by the continuing absence of any adult, egg, or dependent young at the nest for at least 10 consecutive days immediately prior to, and including, at present. An inactive nest may become active again and remains protected under BGEPA.

Initial site assessment (Stage 1) – where project proponents evaluate broad geographic areas to assess the relative importance of various areas to resident breeding and non-breeding eagles, and to migrant and wintering eagles

Inventory –systematic observations of the numbers, locations, and distribution of eagles and eagle resources such as suitable habitat and prey in an area.

Jurisdictional agency – a government agency with jurisdictional authority to regulate an activity.

Juvenile – an eagle less than one year old.

Kiting – stationary or near-stationary hovering by an eagle, usually while searching for prey.

Meteorological towers (met towers) – towers erected to measure meteorological events such as wind speed, direction, air temperature, etc.

Migration corridors - the routes or areas where eagles may concentrate during migration as a result of the interplay between weather variables and topography.

Migration counts – standardized counts that can be used to determine relative numbers of diurnal raptors passing over an established point during fall or spring migration.

Monitoring - inventories over intervals of time (repeated observations), using comparable methods to enable comparisons in time or space.

No-net-loss – no net change in the overall eagle population mortality rate after issuance of a permit that authorizes take, because required compensatory mitigation reduces another form of mortality, or increases natality, by a comparable amount.

Occupied nest – a nest used for breeding in the current year by a pair. Presence of an adult, eggs, or young, freshly molted feathers or plucked down, or current years' mutes (whitewash) suggest site occupancy. In years when food resources are scarce, it is not uncommon for a pair of eagles to occupy a nest yet never lay eggs; such nests are considered occupied.

Occupied territory – an area that encompasses a nest or nests or potential nest sites and is defended by a mated pair of eagles.

Operational adjustments – modifications made to an existing wind facility that changes how that facility operates (e.g., increasing turbine cut in speeds, implementing curtailment of turbines during periods of migration).

Overall collision probability – the cumulative probability across all turbines in a wind facility (i.e., the chance that an eagle will collide with one of the turbines in the facility) of a collision.

Patagial tags – wing markers that are used to individually identify an eagle.

Power analysis – a statistical procedure used to determine the sample size necessary to determine the minimum sample size required to accept the outcome of a statistical test with a particular level of confidence.

Project-area inter-nest distance – the mean distance between simultaneously occupied eagle nests of a species (including occupied nests in years where no eggs are laid). We recommend calculating this metric from the nesting territory survey in Stage 2, using all nesting territories within 10 miles of the project footprint over multiple years.

Project-area nesting population – number of pairs of eagles nesting within the project footprint or within a 10-mile perimeter of the project footprint. In cases where nesting density is very high the perimeter distance can be scaled to equal the project-area inter-nest distance.

Project footprint - the minimum-convex polygon that encompasses the wind-facility area inclusive of a 100 meter-radius of all turbines and any associated utility infrastructure, roads, etc.

Project proponent – any developer that proposes to construct a project.

Productivity ─ the number of juveniles fledged from an occupied nest, often reported as a mean over a sample of nests.

Pylons – tower base of a wind turbine.

Renewable energy – energy produced by solar, wind, geothermal or any other methods that do not require fossil fuels.

Risk-averse – a conservative estimate in the face of considerable uncertainty.

Risk validation – as part of Stage 5 assessment, where post-construction surveys are conducted to generate empirical data for comparison with the pre-construction risk assessment predictions to validate if the initial assumptions were correct.

Roosting – activity where eagles seek cover, usually during night or periods of severe weather (e.g., cold, wind, snow). Roosts are usually found in protected areas, typically tree rows or trees along a river corridor.

Seasonal concentration areas – areas used by concentrations of eagles seasonally, usually proximate to a rich prey source.

Site categorization – a standardized approach to categorize the likelihood that a site or operational alternative will meet standards in 50 CFR 22.26 for issuance of a programmatic eagle take permit.

Standard kernel analysis - a non-parametric way to smooth estimates of the density of a random variable, where inferences about the population are made based on a limited data. . Used in describing the probabilistic spatial distribution of an animal within its home range.

Stopover sites – areas temporarily used by eagles to rest, seek forage, or cover on their migration routes.

Subadult – an eagle between 1 and 4 years old, typically not of reproductive age.

Survey –is used when referring to inventory and monitoring combined.

Unoccupied nest - those nests not selected by raptors for use in the current nesting season.

U.S. Fish and Wildlife Service Draft Land-based Wind Energy Guidelines – A document produced, with substantial input and cooperation from wind industry, by the U.S. Fish and Wildlife Service that describes how to site, construct, and operate wind facilities with minimal impacts to wildlife exclusive of eagles.

Wind facilities – developments for the generation of electricity from wind turbines

Wind turbine – a machine capable of converting wind energy into electricity by means of a wind-driven generator; usually mounted on a tower structure.

G. LITERATURE CITED

Anthony, R. G. 2001. Low productivity of bald eagles on Prince of Wales Island, Southeast Alaska. Raptor Research 35:1-8.

Arnett, E. B. 2006. A preliminary evaluation on the use of dogs to recover bat fatalities at wind energy facilities. Wildlife Society Bulletin 34(5):1440–1445.

Arnett, E. B., D. B. Inkley, D. H. Johnson, R. P. Larkin, S. Manes, A. M. Manville, R. Mason, M. Morrison, M. D. Strickland, and R. Thresher. 2007. Impacts of wind energy facilities on wildlife and wildlife habitat. Technical Review 07-2, The Wildlife Society, Bethesda, Maryland, USA.

Avian Power Line Interaction Committee (APLIC). 2006. Suggested practices for avian protection on power lines: the state of the art in 2006. Edison Electric Institute, APLIC, and the California Energy Commission. Washington D.C. and Sacramento, CA, USA. http://www.aplic.org/SuggestedPractices2006(LR-2watermark).pdf.

Barclay, R. M. R., E. F. Baerwald, and J. C. Gruver. 2007. Variation in bat and bird fatalities at wind energy facilities: assessing the effects of rotor size and tower height. Canadian Journal of Zoology 85: 381–387.

Barrios, L. and A. Rodriguez. 2004. Behavioural and environmental correlates of soaring-bird mortality at on-shore wind turbines. Journal of Applied Ecology 41:72–81.

Becker, J. M. 2002. Response of wintering bald eagles to industrial construction in southeastern Washington. Wildlife Society Bulletin 30:875-878.

BHE Environmental. 2010. Post-construction bird and bat mortality study Cedar Ridge wind farm Fond du Lac County, Wisconsin. Interim Report prepared for Wisconsin Power and Light and submitted to Wisconsin Public Service Commission.

Breidt, F. J. and W. A. Fuller. 1999. Design of supplemented panel surveys with application to the natural resources inventory. Journal of Agricultural, Biological, and Environmental Statistics 4:391-403.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to distance sampling. Oxford University Press, New York, New York, USA.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas (eds.). 2004. Advanced distance sampling. Oxford University Press, New York, New York, USA.

Buehler, D. A. 2000. Bald eagle (*Haliaeetus leucocephalus*). The Birds of North America no. 506 (A. Poole, ed.).. The Birds of North America Online, Cornell Lab of Ornithology, Ithaca, New York, USA. http://bna.birds.cornell.edu/bna/species/506

Caro, J., D. Ontiveros, M. Pizarro,and J. M. Pleguezuelos. 2010. Habitat features of settlement areas used by floaters of Bonelli's and Golden Eagles. Bird Conservation International, Available on CJO 23 Apr 2010 doi:10.1017/S0959270910000213.

Chamberlain, D. E., M. R. Rehfisch, A. D. Fox, M. Desholm, and S. J. Anthony. 2006. The effect of avoidance rates on bird mortality predictions made by wind turbine collision risk models. Ibis 148:198-202.

Chandler, S. K., J. D. Fraser, D. A. Buehler, and J. K. D. Seegar. 1995. Perch trees and shoreline development as predictors of bald eagle distribution on Chesapeake Bay. Journal of Wildlife Management 59:325-332.

Cole, S. 2009. How much is enough? Determining adequate levels of environmental compensation for wind power impacts using equivalency analysis. In: European Offshore Wind Conference 2009, 14-16 Sep 2009, Stockholm, Sweden.

Cole, S., and B. Kriström. 2008. Annex 5: Discounting in REMEDE toolkit for performing resource equivalency analysis to assess and scale environmental damage in the European Union. REMEDE Team for the European Commission. http://www.envliability.eu/docs/D13MainToolkit_and_Annexes/D13MainToolkit.html

Collopy, M. W., and T. C. Edwards, Jr. 1989. Territory size, activity budget, and role of undulating flight in nesting golden eagles. Journal of Field Ornithology 60:43-51.

Craig, T. H., E. H. Craig, and L. R. Powers. 1984. Recent changes in eagle and buteo densities in southeastern Idaho. Murrelet 65:91-93.

Crenshaw, J. G., and B. R. McClelland. 1989. Bald eagle use of a communal roost. Wilson Bulletin 101:626-633

De Lucas, M., G. F. E. Janss, D. P. Whitfield and M. Ferrer. 2008. Collision fatality of raptors in wind farms does not depend on raptor abundance. Journal of Applied Ecology 45:1695–1703.

Drake, D., J. Garvin, S. Grodsky, and M. Watt. 2010. Post-construction bird and bat monitoring at the Forward Energy Center. Interim Report prepared for Forward Energy LLC and submitted to the Wisconsin Public Service Commission.

Dunn, E. H., D. J. T. Hussell, and E. R. Inzunza. 2008. Recommended methods for population monitoring at raptor-migration watch sites. Pages 447-459 in K. L. Bildstein, J. P. Smith, E. R. Inzunza and R. R. Veit (eds.). State of North America's birds of prey. Series in

Ornithology No. 3. Nuttall Ornithological Club. Cambridge, Massachusetts, USA, and American Ornithologists' Union, Washington, D.C., USA.

Farmer, C. J., L. J. Goodrich, E. Ruelas Inzunza, and J. P. Smith. 2008. Conservation status of North America's birds of prey. Pages 303–419 in K. L. Bildstein, J. P. Smith, E. Ruelas Inzunza, and R. R. Veit (eds.). State of North America's birds of prey. Series in Ornithology No. 3. Nuttall Ornithological Club. Cambridge, Massachusetts, USA, and American Ornithologists' Union, Washington, D.C., USA.

Franson, J. C., L. Siloe, and J. J. Thomas. 1995. Causes of eagle deaths. Page 68 in E. T. LaRoe, G. S. Farris, C. E. Puckett, and P. D. Dora (eds). Our living resources: a report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. National Biological Service, Washington, D.C., USA.

Freeman, A.M., III. 1993. The measurement of environmental and resource values: theory and methods. Resources for the Future, Washington, D.C., USA.

Fuller, W. A. 1999. Environmental surveys over time. Journal of Agricultural, Biological, and Environmental Statistics 4:331-45.

Fuller, M. R., J. J. Millspaugh, K. Church, and R. Kenward. 2005, Wildlife radiotelemetry Pages 377-417 in C. E. Braun (ed.), Techniques for wildlife investigations and management, 6th ed. The Wildlife Society, Bethesda, Maryland, USA.

Garrett, M. G., J. W. Watson, and R. G. Anthony. 1993. Bald eagle home range and habitat use in the Columbia River estuary. Journal of Wildlife Management 57:19-27.

Gregory, M. J. P, A. G. Gordon, and R. Moss. 2002. Impact of nest-trapping and radio-tagging on breeding golden eagles *Aquila chrysaetos* in Argyll, Scotland. Ibis 145:113-119.

Gruver, J., M. Sonnenburg, K. Bay, and W. Erickson. 2009. Post-construction bat and bird fatality study at the Blue Sky Green Field Wind Energy Center, Fond du Lac County, Wisconsin. Final Report submitted to the Wisconsin Public Service Commission by WEST, Inc., Laramie, Wyoming, USA.

Harmata, A. R. 1982. What is the function of undulating flight display in golden eagles? Raptor Research 16:103-109.

Harmata, A. R. 1984. Bald eagles of the San Luis Valley, Colorado: their winter ecology and spring migration. Ph.D. dissertation, Montana State University, Bozeman, Montana, USA.

Hodges, J. I. and F. C. Robards. 1982. Observations of 3,850 bald eagle nests in southeast Alaska. Pages 37-46 *in* A symposium and workshop on raptor management and biology in Alaska and western Canada. (W. N. Ladd and P. F. Schempf, eds.) U.S. Fish and Wildlife Service, Anchorage, Alaska, USA.

Hoechlin, D. R. 1976. Development of golden eagles in southern California. Western Birds 7:137-152.

Homan, H. J., G. Linz, and B. D. Peer. 2001. Dogs increase recovery of passerine carcasses in dense vegetation. Wildlife Society Bulletin 29:292-296.

Hoover, S. L., and M. L. Morrison. 2005. Behavior of red-tailed hawks in a wind turbine development. Journal of Wildlife Management 69:150-159.

Hunt, W. G. 1998. Raptor floaters at Moffat's equilibrium. Oikos 82:191-197.

Hunt, W. G., R. E. Jackman, T. L. Brown, J. G. Gilardi, D. E. Driscoll, and L. Culp. 1995. A pilot golden eagle population study in the Altamont Pass Wind Resource Area, California. Report to National Renewable Energy Laboratory, Subcontract No. XCG-4-14200, Predatory Bird Research Group, University of California, Santa Cruz, California, USA.

Hunt, W. G., R. E. Jackman, T. L. Brown, and L. Culp. 1999. A population study of golden eagles in the Altamont Pass Wind Resource Area: population trend analysis 1994-1997. Report to National Renewable Energy Laboratory, Subcontracts XAT-5-15174-01, XAT-6-16459-01. Predatory Bird Research Group, University of California, Santa Cruz, California, USA.

Hunt, G. 2002. Golden eagles in a perilous landscape: predicting the effects of mitigation for wind turbine bladestrike mortality. California Energy Commission Report P500-02-043F. Sacramento, California, USA.

Huso, M. M. P. 2010. An estimator of mortality from observed carcasses. Environmetrics 21: in press.

Hutto, R. L., S. M. Pletschet, and P. Hendricks. 1986. A fixed-radius point count method for nonbreeding and breeding season use. Auk 103:593-602.

Industrial Economics, Inc. 2004. Final Lake Apopka natural resource damage assessment and restoration plan. www.sjrwmd.com/lakeapopka/pdfs/DARP.pdf

Johnson, F. A. 2001. Adaptive regulation of waterfowl hunting in the U.S. Pages 113-131 in R. G. Stahl, Jr., C. A. PittingerA, . L. Barton,J . R. Clark, P. L. deFur, S. J. Ells, M. W. Slimak, R. S. Wentsel, R. B. Beizer, and R. A. Bachman (eds.). Risk management: ecological risk-based decisionmaking. Society of Environmental Toxicology and Chemistry, Pensacola, Florida, USA.

Johnson, G. D., W. P. Erickson, M. D. Strickland, M. F. Shepherd, and D. A. Shepherd. 2000. Avian monitoring studies at the Buffalo Ridge Wind Resource Area, Minnesota: Results of a 4-year study. Technical report by WEST Inc. prepared for Northern States Power Co., Minneapolis, Minnesota, USA.

Jones, C., and K. Pease. 1997. Restoration-based compensation measures in natural resource liability statutes. Contemporary Economic Policy 4: 111-123.

Kenward, R. E. 2001. A manual for wildlife tagging. Academic Press, London, UK.

Kerlinger, P. 1989. Flight strategies of migrating hawks. University of Chicago Press, Chicago, Illinois, USA.

Kochert, M. N. 1972. Population status and chemical contamination in golden eagles in southwestern Idaho. M.S. Thesis. University of Idaho, Moscow, Idaho, USA.

Kochert, M. N., K. Steenhof, C. L. Mcintyre, and E. H. Craig. 2002. Golden eagle (*Aquila chrysaetos*). The Birds of North America No. 684 (A. Poole, Ed.). The Birds of North America Online. Cornell Lab of Ornithology, Ithaca, New York, USA. http://bna.birds.cornell.edu/bna/species/684.

Krone, O. 2003. Two white-tailed sea eagles (*Haliaeetus albicilla*) collide with wind generators in northern Germany. Journal of Raptor Research 37:174-176.

Kunz, T. H., E. B. Arnett, B. M. Cooper, W. P. Erickson, R. P. Larkin, T. Mabee, M. L. Morrison, M. D. Strickland, and J. M. Szewczak. 2007. Assessing impacts of wind-energy development on nocturnally active birds and bats: a guidance document. Journal of Wildlife Management 71: 2449-2486.

Kuvlesky, W. P. Jr., L. A. Brennan, M. L. Morrison, K. K. Boydston, B. M. Ballard, and F. C. Bryant. 2007. Wind energy development and wildlife conservation: challenges and opportunities. Journal of Wildlife Management 71:2487-2498.

Laing, S. E., S. T. Buckland, R. W. Burn, D. Lambie, and A. Amphlett. 2003. Dung and nest surveys: estimating decay rates. Journal of Applied Ecology 40:1102–1111.

Lehman, R. N., P. L. Kennedy, and J. A. Savidge. 2007. The state of the art in raptor electrocution research: a global review. Biological Conservation136:159-174.

Lehman, R. N., J. A. Savidge, P. L. Kennedy, and R. E. Harness. 2010. Raptor electrocution rates for a utility in the Intermountain Western United States. Journal of Wildlife Management 74:459-470.

Lind, R. 1982. A primer on the major issues relating to the discount rate for evaluating national energy options. Pages 21-94 in R. C. Lind and K. L. Corey (eds.), Discounting for time and risk in energy policy. John Hopkins University Press, Baltimore, Maryland, USA.

Marzluff, J. M., M. S. Vekasy, M. N. Kochert, and K. Steenhof. 1997. Productivity of golden eagles wearing backpack radiotransmitters. Journal of Raptor Research 31:223-227.

McDonald, T. L. 2003. Review of environmental monitoring methods: survey designs. Environmental Monitoring and Assessment 85:277-92.

McGrady, M. J., J. R. Grant, I. P. Bainbridge, and D. R. A. McLeod. 2002. A model of golden eagle (*Aquila chrysaetos*) ranging behavior. Journal of Raptor Research 36(1) supplement:62-69.

McLeod, D. R. A, D. P. Whitfield, and M. J. McGrady. 2002. Improving prediction of golden eagle (*Aquila chrysaetos*) ranging in western Scotland using GIS and terrain modeling. Journal of Raptor Research 36(1) Supplement:70-77.

Millsap, B. A. 1981. Distributional status and ecology of Falconiformes in west central Arizona, with notes on ecology, reproductive success, and management. U. S. Bureau of Land Management Technical Note 355.

Millsap, B., T. Breen, E. McConnell, T. Steffer, L. Phillips, N. Douglass, and S. Taylor. 2004. Comparative fecundity and survival of bald eagles fledged from suburban and rural natal areas in Florida. Journal of Wildlife Management 68:1018-1031.

Mohr, C. O. 1947. Table of equivalent populations of North American small mammals. American Midland Naturalist 37:223–249.

Mojica, E. K., J. M. Meyers, B. A. Millsap, and K. T. Haley. 2008. Migration of sub-adult Florida bald eagles. Wilson Journal of Ornithology 120:304-310.

Moorcroft, P. R., M. A. Lewis, and R. L. Crabtree. 1999. Home range analysis using a mechanistic home range model. Ecology 80:1656-1665.

National Oceanic and Atmospheric Administration (NOAA). 1999. Discounting and the treatment of uncertainty in natural resource damage assessment. NOAA Damage Assessment and Restoration Program Technical Paper 99-1. Washington, D.C., USA.

National Research Council (NRC). 2007. Environmental impacts of wind-energy projects. National Academies Press. Washington, D.C., USA. www.nap.edu

Natural Resource Trustees. 2006. *SS Jacob Luckenbach* and associated mystery oil spills. Final Damage Assessment and Restoration Plan/Environmental Assessment. Prepared by the California Department of Fish and Game, National Oceanic and Atmospheric Administration, U.S. Fish and Wildlife Service, and National Park Service, Sacramento, California, USA.

Newton, I. 1979. Population ecology of raptors. Buteo Books, Vermillion, South Dakota, USA.

Nichols, J. D., and B. K. Williams. 2006. Monitoring for conservation. Trends in Ecology and Evolution 21:668–673.

Orloff, S., and A. Flannery. 1992. Wind turbine effects on avian activity, habitat use, and mortality in Altamont Pass and Solano County Wind Resource Areas, 1989-1991. Final Report P700-92-001 to Alameda, Costra Costa, and Solano Counties, and the California Energy Commission by Biosystems Analysis, Inc., Tiburon, California, USA.

Palmer, R. S. 1988. Golden eagle *Aquila chrysaetos*. Pages 180-231 in R. S. Palmer (ed.), Handbook of North American birds, volume 5, diurnal raptors (part 2). Yale University Press, New Haven, Connecticut, USA.

Platt, J. B. 1976. Bald eagles wintering in a Utah desert. American Birds 30:783-788.

Phillips, R. L. and A. E. Beske. 1984. Resolving conflicts between energy development and nesting golden eagles. Pages 214-219 in R. D. Comer, J. M. Merino, J. W. Monarch, C. Pustmueller, M. Stalmaster, R. Stoecker, J. Todd, and W. Wright (eds.). Proceedings of asymposium: Issues and technology in the management of impacted western wildlife. Steamboat Springs, Colorado, November 15-17, 1982. Thorne Ecological Institute, Boulder, Colorado, USA.

Restani, M., A. R. Harmata, and E. M. Madden. 2000. Numerical and functional responses of migrant bald eagles exploiting a seasonally concentrated food source. Condor 102:561-568.

Rivera-Milán, F. F., M. E. Zaccagnini, S. B. Canavelli. 2004. Field trials of line-transect surveys of bird carcasses in agro-ecosystems of Argentina’s Pampas region. Wildlife Society Bulletin 32:1219–1228.

Seaman, D. E., and R. A. Powell. 1996. An evaluation of the accuracy of kernel density estimators for home range analysis. Ecology 77:2075–2085.

Sherrod, S. K., C. M. White, and F. S. L. Williamson. 1976. Biology of the bald eagle on Amchitka Island, Alaska. Living Bird 15:145-182.

Skrabis, K. 2004. Evaluation of a take under the Endangered Species Act: Rte 460 bridge mitigation, Tazewell County, Virginia. A resource equivalency analysis on an incidental take of endangered tan riffleshell and endangered purple bean mussels, prepared for the Virginia Field Office, U.S. Fish & Wildlife Service, Arlington, Virginia, USA.

Skrabis, K. E. 2005. Compendium of resource equivalency analyses: New Carissa oil spill. Report for the Bureau of Land Management and U.S. Fish and Wildlife Service by Office of Policy Analysis, U.S. Department of the Interior, Washington D.C., USA.

Skrabis, K. 2007. Revised draft evaluation of a take under the Endangered Species Act: resource equivalency analysis for effects to grizzly bears incidental to Burlington

Northern and Santa Fe Railway Company (BNSF) Operations. Prepared for the Montana Field Office, U.S. Fish and Wildlife Service, Helena, Montana, USA.

Smallwood, K. S. and C. G. Thelander. 2004. Developing methods to reduce bird fatalities in the Altamont Wind Resource Area. Final report prepared by BioResource Consultants to the California Energy Commission, Public Interest Energy Research-Environmental Area, Contract No. 500-01-019.

Smallwood, K. S., C. G. Thelander, M. L. Morrison, and L. M. Rugge. 2007. Burrowing owl mortality in the Altamont Pass Wind Resource Area. Journal of Wildlife Management 71:1513–1524.

Smallwood, K. S., L. Rugge, M. L. Morrison. 2009. Influence of behavior on bird mortality in wind energy developments. Journal of Wildlife Management 73:1082–1098.

Sperduto, M., Hebert, M. Donlan, and S. Thompson. 1999. Injury quantification and restoration scaling for marine birds killed as a result of the North Cape Oil Spill. U.S. Fish and Wildlife Service.

Sperduto, M. B., S. P. Powers, and M. Donlan. 2003. Scaling restoration to achieve quantitative enhancement of loon, seaduck, and other seabird populations. Marine Ecology Progress Series 264:221-232.

Soutullo, A., V. Urios, M. Ferrer, and S. G. Penarrubia. 2006. Post-fledging behaviour in golden eagles *Aquila chrysaetos*: onset of juvenile dispersal and progressive distancing from the nest. Ibis 148:307-312.

Steenhof, K., and I. Newton. 2007. Assessing nesting success and productivity. Pages 181-191 *in* D. M. Bird and K. Bildstein (eds.), Raptor Research and Management Techniques. Hancock House, Blaine, Washington, USA.

Steenhof, K., S. S. Berlinger, and L. H. Fredrickson. 1980. Habitat use by wintering bald eagles in South Dakota. Journal of Wildlife Management 44:798-805.

Thorstrom, R. 2001. Nest-site characteristics and breeding density of two sympatric forest-falcons in Guatemala. Ornitologia Neotropical 12:337–343, 2001.

Unsworth, R., and R. Bishop. 1994. Assessing natural resource damages using environmental annuities. Ecological Economics 11:35-41.

Urquhart, N. S., S. G. Paulsen, and D. P. Larsen. 1998. Monitoring for policy-relevant regional trends over time. Ecological Applications 8:246-57.

USFWS. 1983. Northern states bald eagle recovery plan. U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Washington D.C., USA.

USFWS. 2007. Protection of eagles; definition of "Disturb." Federal Register 72(107): 31132-31140.

USFWS. 2009a. Final environmental assessment. Proposal to permit take provided under the Bald and Golden Eagle Protection Act. U.S. Fish and Wildlife Service, Division of Migratory Bird Management, Washington D.C., USA.

USFWS. 2009b. Eagle permits; take necessary to protect interests in particular localities. Federal Register 74(175):46836-46879.

Walker, D., M. McGrady, A. McCluskie, M. Madders, and D. R. A. McLeod. 2005. Resident golden eagle ranging behaviour before and after construction of a windfarm in Argyll Scottish Birds 25:24-40.

Watson, J. 1997. The golden eagle. 1st ed. T and A. D. Poyser, London, U.K.

Watson, J. W., and R. W. Davies. 2009. Range use and contaminants of golden eagles in Washington. Progress Report. Washington Department of Fish and Wildlife, Olympia, Washington.

Wichmann, M. C., F. Jeltsch, W. R. J. Dean, K. A. Moloney and C. Wissel. 2003. Implication of climate change for the persistence of raptors in arid savanna. Oikos 102:186–202.

Williams, B. K., F. A. Johnson, and K. Wilkins. 1996. Uncertainty and the adaptive management of waterfowl harvests. Journal of Wildlife Management 60:223-232.

Williams, B. K., R. C. Szaro, and C. D. Shapiro. 2009. Adaptive management: the U.S. Department of the Interior Technical Guide. Adaptive Management Working Group, U.S. Department of the Interior, Washington, D.C., USA.

Whitfield, D. P., A. H. Fielding, M. J. P. Gregory, A. G. Gordon, D. R. A.McLeod, and P. F. Haworth. 2007. Complex effects of habitat loss on golden eagles *Aquila chrysaetos*. Ibis 149:26–36.

Whitfield, D. P. 2009. Collision avoidance of golden eagles at wind farms under the 'Band' collision risk model. Report from Natural Research to Scottish Natural Heritage, Banchory, UK.

Worton, B. J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology 70:164–168.

Worton, B. J. 1995. Using Monte Carlo simulation to evaluate kernel-based home range estimators. Journal of Wildlife Management 59:794–800.

Yates, R. E., B. R. McClelland, P. T. McClelland, C. H. Key, and R. E. Bennetts. 2001. The influence of weather on golden eagle migration in northwestern Montana. Journal of Raptor Research 35:81-90.

Zafonte, M., and S. Hampton. 2005. Lost bird-years: quantifying bird injuries in natural resource damage assessments for oil spills. Proceedings of the 2005 International Oil Spill Conference, May 15-19, 2005, Miami, Florida, USA. http://www.dfg.ca.gov/ospr/spill/nrda/iosc_lost_bird-years_paper_final.pdf

Zafonte, M., and S. Hampton. 2007. Exploring welfare implications of resource equivalency analysis in natural resource damage assessments. Ecological Economics 61: 134-145

APPENDIX A

ADAPTIVE MANAGEMENT

Learn by doing. This simple statement is the essence of adaptive management. What is implied is that we take action to achieve a goal, pay attention to the outcome, and apply that learning to our next action. Adaptive management is an iterative process, often conceived of as a continuous loop consisting of four to six sequential steps. They are: Planning - defining and describing goals and objectives and available data; Design - more formally describing management with models; Action - applying management actions; Monitoring - collecting data resulting from the action; Evaluation - analyzing the results and improving the models; and back to planning again to adjust the project design to meet the management goal, but incorporating new information from analyses of monitoring data collected during or after the previous management action (Figure 1). A definition used to describe adaptive waterfowl harvest

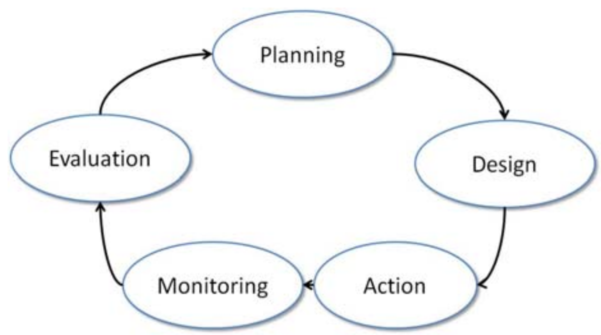


Figure A-1: Essential steps in an adaptive management framework, showing the iterative nature of the process designed to reduce uncertainty around decision making.

management is useful to describe our current task to manage eagle populations, and that is, "…managing in the face of uncertainty, with a focus on its reduction" (Williams and Johnson 1995).

In the case of managing eagle populations in the face of energy development there is considerable uncertainty to be reduced. For example, we believe that in some areas or specific situations, large soaring birds, specifically raptors, might be especially vulnerable to colliding with wind turbines (Barrios and Rodriguez 2004, Kuvlesky *et a*l. 2007), but we are uncertain about the relative importance of factors that influence that risk. We are also uncertain about the best way to mitigate the effects of wind turbine developments on raptors; we suspect some strategies might be effective, others are worth trying. We also suspect that a few species, including golden eagles (USFWS 2009b), may be declining in numbers already (Farmer *et al.* 2008), and while we can point to likely causes of those declines we are uncertain about their relative importance or magnitudes. Thus, there are uncertainties at several levels that challenge our attempts to manage eagle populations: (1) at the level of understanding factors that affect collision risk, (2) at the level that influences population trends, and (3) about the efficacy of various mitigation options. The Service, our conservation partners, and industry will never have the luxury of perfect information before needing to act to manage eagles. We are therefore left to make management decisions clouded with uncertainty about the outcomes of those decisions. Our goal is to reduce that uncertainty through use of formal adaptive management, thereby improving our predictive capability over time. Applying a systematic, cohesive, nationally-consistent strategy of management and monitoring is necessary to accomplish this goal.

1. Adaptive Management as a Tool

Using adaptive management as a tool to manage wildlife populations is not new to the Service. We and other agencies are increasingly using the principles of adaptive management across a range of programs, including waterfowl harvest management, endangered species, and habitat management at local and landscape scales; and, in the future, landscape management against the threat of climate change (e.g., USFWS 2005). Applying adaptive management to complex resource management issues is promoted throughout the DoI (Williams *et al.* 2009).

Waterfowl harvest management is the classic example of adaptive resource management. Harvest rates are reset each year in the United States and Canada through the application of adaptive management principles (Johnson 2001). The central question in waterfowl management is to what extent is harvest mortality compensated for by reductions in non-harvest mortality or by increases in productivity (Williams et al 1996)? Various population models have been built based on competing hypothetical answers to this question (hypotheses). Every year the Service and its Canadian counterpart monitor waterfowl and environmental conditions to estimate mortality and productivity. Thousands of waterfowl are banded and some are recovered resulting in estimates of hunting mortality rates.

Wings collected from a sample of hunters each year are identified to age and sex, yielding estimates of relative rates of harvest of different age and sex classes within a species. Surveys by air and ground count breeding populations and assess habitat conditions, which yield estimates of productivity. These data feed into the various competing models, and the models are evaluated annually based on how well they predict inter-year changes in waterfowl populations. Models that perform best year-after-year accrue increasing weight (i.e., evidence in support of the underlying hypothesis). Weighted model outputs directly lead to recommended sets of hunting regulations (e.g., bag limits and season lengths) for the subsequent year. Over time, by monitoring the population effects of various harvest rates on survivorship, and environmental conditions on productivity, our uncertainty about the degree to which harvest is compensated by other factors has been reduced, allowing for the setting of harvest rates with greater confidence every year. The application of adaptive management principles to waterfowl harvest regulation has helped the Service and its partners achieve or exceed population goals for most species of waterfowl (USFWS 2005).

2. Applying Adaptive Management to Eagle Management

At the scale of continental populations, the central question for eagles is not altogether different than it is for waterfowl: to what extent is mortality from energy development, or any other anthropogenic source, compensated by reductions in mortality from other sources, or by increases in productivity? These questions are best answered by building population models founded on competing hypotheses that incorporate estimates of mortality, productivity, and the variation around those vital rates. What is required is a systematic effort to collect information on mortality, breeding, and population status to feed those models. As for waterfowl, reducing uncertainty in population-level models for eagle management will require rolling up the results of local monitoring and research across the distribution of eagles. The results will allow the Service to make more informed management recommendations to reach the Service's population goal of stable or increasing breeding populations for both eagle species.

APPENDIX B

STAGE 1 - LANDSCAPE-SCALE SITE ASSESSMENT RECOMMENDATIONS

Eagle use of the landscape varies across large geographic scales. Thus, the first step for project development is to identify sites within a broad geographic area that are both suitable for wind energy and have low potential for effects to eagles through a rigorous, landscape-scale site-assessment process. The initial coarse site assessment should begin before any significant resources have been committed to a particular site. The site assessment should evaluate the suitability of a potential wind energy site within the ecological context of eagles, including considerations for the entire eagle life-cycle (i.e., breeding, migration, dispersal, and wintering.) At this point, the objective is to assess the potential effects to eagles and their habitats from modification at the landscape scale. The primary objective at this stage should be to determine if prospective wind development sites fall within areas used by eagles, and the relative extent and type of eagle use they receive. Areas that receive considerable use by eagles are likely to fall into category 1, and should be avoided if at all possible because the Service likely could not issue a permit that complies with all regulatory requirements for a project in those areas.

To evaluate a site for potential wind-energy development and its ecological relationship to eagle biology, multiple data sources should be consulted. Information gathered should focus on geographic and biological factors that could affect eagle risk from wind energy development. Preliminary site evaluation could begin with a review of publically available data. Good data sources include resource databases such as NatureServe [http://www.natureserve.org/], information from relevant federal, tribal and state agencies, peer-reviewed literature, technical reports, state ornithological societies, and conservation organizations with eagle expertise.

Where data gaps occur, or when beginning to look at sites in more detail, site-level reconnaissance may be necessary. The site assessment should be coordinated with Service staff early in the process to ensure all appropriate information has been included in the evaluation. The specific questions project proponents should be answering at this stage include (but are not necessarily limited to):

1. What information is available in the literature or wildlife occurrence databases on recent or historic nesting and occurrence data for eagles from the project area?
2. What information is available in the literature or raptor migration databases on eagle migration or movement through the project area?
3. What eagle concentration area information (winter [e.g., the midwinter eagle survey at http://ocid.nacse.org/nbii/eagles/] or other) is available for the project area?
4. What vegetation data are available to develop maps of potential eagle habitat?
5. What topographic features are present in the project area that might attract or concentrate eagles?

Using these and other data sources, a series of questions should be answered to help place the project or project alternative into the appropriate risk category. Relevant questions include:

1. Have you contacted the relevant agencies to discuss project development?

2. Does existing or historic data/information indicate that eagles or eagle habitat (including breeding, migration, dispersal, and wintering habitats) may be present within the geographic region under development consideration?
3. Does existing or historic data/information indicate that eagle prey habitat may be present within the geographic region under development consideration?
4. Are there areas of intact eagle habitat in the area of development that would be lost, degraded, or fragmented due to the project?
5. Are their indications the area of interest may be of special importance to eagles, and if so, can those areas of importance be delineated?

The goal of the site assessment is to ultimately select one or more sites that will be the focus of the more detailed site-specific surveys and assessments. We recommend development of a map that, based on the answers to the above questions should allow development of a map that shows broad areas that fall under site category levels 1 through 4, in areas where wind development would pose: (1) a high risk to eagle populations, (2) a moderate risk to eagle populations, (3) a low risk to eagle populations, and (4) areas where the potential effects to eagles are uncertain due to lack of information about the site. In general, sites or alternatives that fall into category 1 should be dropped from consideration, whereas sites that fall into categories 2, 3, and 4 would potentially move on to Stage 2. However, site classification at this stage should be regarded as tentative pending the outcome of the site-specific assessment. Sites in any of the categories could change as more detailed information regarding the sites and eagle populations within or adjacent to them is obtained. For example, a site classified as a category 2 site during the broad geographic assessment could ultimately be dropped from consideration once more site-specific data are collected in the next stage. Conversely, a site deemed high risk due to historical data could become selected if current site-specific data indicate that, based on local factors, it is actually low risk.

APPENDIX C

STAGE 2 – SITE-SPECIFIC ASSESSMENT RECOMMENDED METHODS AND METRICS

Data collected in this stage will be used to generate model-based predictions of annual eagle fatalities for specific potential project sites. The predictions will be generated with models ideally using survey data collected from the project locale following the standardized approach outlined below. Project proponents are free to propose other forms of pre-construction surveys and monitoring, but they should yield data that will satisfy the adaptive management requirements and the regulatory monitoring requirements. Recommended site-specific sampling consists of three components: (1) fixed-radius point counts within the project footprint, (2) characterization of the local-area nesting population, and (3) determination of presence of seasonal eagle concentration areas. Components (1) and (3) provide information useful in predicting potential annual eagle fatality rates from wind facilities, whereas component (2) identifies nesting territories that may be negatively affected by disturbance.

1. Point Counts

The metric that feeds into models used to predict the number of expected eagle fatalities per year is the *eagle exposure rate*, expressed as eagle exposure minutes (flight minutes) per daylight hour within the footprint of the project, averaged over daylight hours and over the annual cycle. The recommended approach for estimating eagle exposure rate for a project is based on 30-minute point count surveys of eagles at 800-m radius plots within and adjacent to the project footprint. Point count surveys of birds on fixed-radius plots were described by Hutto *et al*. (1986). Use of large-plot, long-duration point counts, most typically 20- or 30-minute counts at 800-m radius plots, appears to be standard in pre- and post-construction assessment of use of wind energy projects by large (crow size or greater) species of birds (Hoover and Morrison 1996, Johnson *et al.* 2000, Smallwood *et al.* 2009).

Relative abundance data from point counts (i.e., the mean number of individuals or breeding pairs observed per count) often are used to coarsely predict fatality rates by referencing a regression between like data and associated post-construction fatality results from multiple studies, although this approach is called into question by data from some studies (Orloff and Flannery 1992, DeLucas *et al.* 2008). A common approach to using point count data for assessing risk is to generate a relative index of exposure based on the product of mean abundance from the counts, the proportion of individual birds that were flying when observed, and the proportion of individuals flying at heights within a specified risk zone, usually the rotor-swept zone (Johnson *et al.* 2000). Like comparison with a regression based on many pre- and post-construction data, this coarse index provides a notion of risk relative to other facilities and allows rough comparisons among species within a facility. However, it does not take into account significant factors including species-specific avoidance behavior and site-specific design features other than blade length and hub height of turbines. Point count data can support more detailed risk assessment models (reviewed by Madders and Whitfield 2006), such as recommended in the Draft Eagle Conservation Plan Guidance.

To support our recommended modeling approach, a random or random-systematic approach should be used to distribute points across the project footprint such that all parts of the footprint are represented in proportion to their areal cover. A range of 20-30 point count plots probably represents the maximum number of plots that can be surveyed twice monthly at wind energy projects of moderate (50-100 MW) to large (> 100 MW) capacity. We recommend a sampling frequency targeting a coefficient of variation (ratio of the standard deviation to the mean; CV) for eagle exposure rate of 0.2. Lower sample size and sampling frequency will result in less precise estimates and potentially necessitate use of a more risk-averse approach to predict fatality rates. The two-dimensional area sampled at each 800-m radius plot is $\pi 800^2$ = 201 ha and the total area sampled within the project footprint is the sum of the area sampled across all points. Exposure rate can be estimated based on data from sampling points that are not independent of one another, although points must be separated by at least 1600 m to avoid overlap among the 800-m radius plots that are centered on the points. Observers should use the most efficient, logical route to move among sampling points, changing the starting point with the beginning of each survey cycle such that each point is surveyed during a range of daylight hours.

Likelihood of detecting eagles during point count surveys is low during the first and last 2-3 hours of the day, but increases during midday when the eagles are most active. We recommend use of a temporally stratified sampling approach, allocating most survey effort to the midday period to reduce sampling variance and improve the precision of estimates while maximizing the opportunity for detections. This recommendation is particularly germane to surveys of golden eagles; over the course of a year there may be almost no detections of golden eagles early and late in the day. A pilot study can help validate this and support a power analysis to better ascertain minimum sample sizes. Surveying should be done under all weather conditions except if visibility approaches 0 (blinding snow or fog), or where visibility is less than 800 m horizontally and 200 m vertically. We recommend use of the National Oceanic and Atmospheric Administration's Earth System Research Lab's sunrise-sunset calculator to determine appropriate survey intervals and available daylight hours (http://www.srrb.noaa.gov/highlights/sunrise/sunrise.html).

Every point should be surveyed twice monthly in each of four seasons annually for at least 2 years, and preferably for 3 years. At each survey visit, the observer remains at the point for a set time (20 or 30 minutes is typical, and should be determined based on sampling considerations, ideally after analysis of pilot data from the site) and records the total number of minutes of eagle flight activity within 800 m, except that eagle flight activity more than 175 m above ground is not recorded. Thus, the "plot" actually is three-dimensional, forming a cylinder. As a practical way of documenting eagle exposure, we recommend dividing the total sample interval into 1-minute intervals and then recording the number of birds in flight within the plot in each interval (such that one eagle in flight in the cylinder in a given minute = 1 exposure minute; two eagles in flight in the cylinder in a given minute [or the same eagle in flight continuing into a second minute interval] = 2 exposure minutes, and so on). One exposure minute should be ascribed to an eagle perched within a plot during the entire 30-minute survey, but perched birds should be noted as such so that can be taken into account in the analyses. Because counts will be repeated, each point should be permanently marked. The perimeter of a plot can be temporarily marked in several places to help the observer approximate its location; this also can be done with a rangefinder. Because of the large size of an eagle, we assume a detection probability of about1.0; therefore, no detectability corrections are required. Topography, forest cover, or anthropogenic structures may obstruct views of portions of some plots. In such cases, an observer could estimate the percentage of the plot area that is visible and factor this into the calculation of area surveyed; if an assumption of randomness can be relaxed, the point location could be shifted to the nearest location that provides an unobscured view. Point count surveys for eagles may be conducted in conjunction with other wildlife sampling, provided the sampling frame outlined above (or a suitable alternative) is implemented and that observers are fully qualified to survey eagles. Objectives for using 800-m radius point counts for other large species of birds may require independence among sampling points. If so, the points should be separated by at least 2400 m.

Field data forms should include a large circle representing the point count plot on which the observer can record approximate flight paths and heights of eagles plus ancillary notes on general behavior and activity. Behavior prevalent during each 1-minute interval should be recorded as either soaring flight (circling broadly with wings outstretched), flapping-gliding, kiting-hovering, stooping or diving at prey, stooping or diving in an agonistic context with other eagles or other bird species, being mobbed, undulating/territorial flight, or perched. Observations of eagles outside the plot should also be recorded. Age of each eagle can be categorized as juvenile (recently fledged or fledged the previous year), subadult, adult, or unknown. An eagle's above-ground height should be estimated for each 1-min interval record, using broad categories relevant to the height of the rotor-swept zone and other risk-specific considerations (e.g., 1-20 m, 21-50 m, and so on; Walker *et al.* 2005). The rotor-swept zone (i.e., lowest to highest extent of turbine blades) of a generic 2- to 3-MW wind turbine is 35-135 m high. Weather data also should be recorded: wind direction and speed, extent of cloud cover, precipitation (if any), and temperature.

2. Characterization of the Project-area Nesting Population

The approach that we recommend in this Draft Eagle Conservation Plan Guidance for evaluating siting options and for assessing disturbance effects of wind facilities on eagles breeding on proximate territories is to determine locations of occupied nests of bald and golden eagles within the project footprint and within 10 miles of the perimeter of the footprint, then for each species calculate the mean nearest neighbor distance between the occupied nests (the project-area inter-nest distance). We use a 10-mile distance because the Service has defined the area nesting population for golden eagles to be the "number of pairs of golden eagles known to have a nesting attempt during the preceding 12 months within a 10-mile radius of a golden eagle nest" (50 CFR 22.3). To avoid confusion with the regulatory term and definition we use the term project-area nesting population to describe the eagle population targeted in these surveys. We also recommend application of this survey approach and scale to bald eagles for the purposes of these Draft Eagle Conservation Plan Guidance; however, where the project area nesting density is high-enough to make the 10-mile perimeter infeasible, we suggest considering use of one of the alternative approaches discussed below.

The objective of the project-area nesting population survey is to determine: (1) the number; (2) occupancy status; and (3) productivity of bald and golden eagle nesting pairs within the search area for three or more breeding seasons prior to construction. Where eagle nesting density is especially high and data are available (either from prior studies or a pilot study) to do so, the project-area inter-nest distance can be calculated and used as the width of the perimeter survey area, as the territories immediately adjacent to the footprint are the ones most likely to be affected by the project. This approach is especially appropriate in areas with high densities of nesting bald eagles. The Service strongly encourages that nesting surveys be conducted by experienced biologists with several year's prior experience conducting eagle nest surveys. Recommended approaches for conducting nesting surveys are provided below.

Eagles generally show strong fidelity to the nesting area annually, but not all pairs attempt to breed or successfully breed every year and it is easy to mischaracterize territories where pairs are present but do not breed as unoccupied. Occupancy determination via inventory of all available suitable habitat is the most important goal of nest searches. The project-area nesting population survey should include all potentially suitable eagle-nesting habitat within the project footprint and a 10-mile perimeter (unless a lesser distance is warranted based on factors described previously). A nesting territory or inventoried habitat should be designated as unoccupied by eagles only after ≥ two complete surveys at least 30 days apart in a breeding season. Where ground observations are used, at least two ground observation periods lasting ≥ four hours are necessary to designate an inventoried habitat or territory as unoccupied as long as all potential nest sites and alternate nests are visible and monitored. Dates of starting and continuing inventory and monitoring surveys should be sensitive to local nesting (i.e., laying, incubating, and brooding) chronologies. All surveys should be conducted during weather conditions favorable for survey and/or monitoring from medium to long range distances (> ½ mile).

A 'decorated' nest (a nest with fresh whitewash, feathers, or with fresh greenery) will be sufficient evidence to indicate the probable location of a nesting attempt. If a decorated nest or pair of birds is located, the search in that territory should be continued to locate and map alternate nest sites. Identification and enumeration of alternate nests will help determine the relative value of individual nests to a territory in cases of applications for permits to take 'inactive' nests, and when determining whether abandonment of a particular nest is likely to result in abandonment of a territory.

Helicopters are an accepted and efficient means to monitor large areas of habitat to inventory potential habitat and monitor known territories only if accomplished by competent and experienced observers, and if sufficient aerial time is budgeted for the survey. They can be the primary survey method, or can be combined with follow-up ground monitoring. Effective aerial surveys of woodland habitat for eagle nests may require two- to three-times as much time as aerial surveys for cliff nests. Cliffs should be approached from the front, rather than flying over from behind, or suddenly appearing quickly around corners or buttresses. Inventories should be flown at slow speeds, ca. 30 – 40 knots. All potentially suitable nesting habitats (as identified in coordination with the Service) should be surveyed; multiple passes at several elevation bands may be necessary to provide complete coverage when surveying potential nesting habitat on large cliff complexes, escarpments, or headwalls. Hovering for up to 30 seconds no closer than a horizontal distance of 20 meters from the cliff wall or observed nests may be necessary to discern nest type, document the site with a digital photograph of the nest, and if possible, allow for the observer to read patagial tags, count young, and age young in the nest (Hoechlin 1976). Nest occupancy may be confirmed during later flights at a greater horizontal distance. Aerial surveys may not be appropriate in some areas (e.g., bighorn sheep lambing areas).

Whether inventories are conducted on the ground or aerially, the metrics of interest to the Service for the project-area nesting population area as follows:

1. Number and location of nests within territories with an occupied nest (i.e., an occupied territory).
2. Number and location of likely eagle nests within apparently unoccupied territories (i.e., suspected or previously occupied eagle territories without an occupied nest in the current year).
3. Productivity (number of young surviving to $\geq$51 days of age) in each occupied nest.

Nest location information should be recorded in decimal-degree latitude longitude or UTM coordinates, and the substrate (tree species, cliff, ground, or structure) and nest elevation should be provided. Dates of each nest visit and nest status (occupied, eggs or young present, or failed and abandoned) should also be provided. These data should be provided to the Service in an Appendix to the project proponent's ECP.

3. Eagle Migration and Concentration Area Surveys

Non-breeding bald and golden eagles occasionally use communal roosts and forage communally, and both species can become concentrated on spring and fall migration under particular combinations of weather and topographic conditions. Therefore, pre-development site-specific surveys should be conducted if the Stage 1 site assessments suggest that migratory or transient eagles are likely to be seasonally concentrated in the project area, or if existing biological data are not available to make such a determination. These temporal pulses may be detected by the fixed-radius point counts, however the baseline point-count sampling intensity and sampling intervals may not be sufficient to detect or adequately characterize short-term migration or concentrated non-breeding eagle use. If either migration or non-breeding eagle concentrations are present in the project area, targeted spatio-temporal increases in the frequency of fixed-radius point counts may be advisable to provide more precise measures of the eagle exposure rate.

Migration counts can be used to determine relative numbers of diurnal raptors passing over an established point (Dunn *et al.* 2008), usually a migration concentration site. Migration surveys should be employed using established techniques with appropriate, qualified staffing during primary migration periods if the Stage 1 site assessment suggests the project area may be a migration concentration area. Migration counts may involve staffing observation posts up to 7 days per week during time periods (species and latitude dependent) and weather windows when eagles may be moving.

The Service recommends that project proponents conduct thorough exploratory fall and/or spring migration counts for eagles at possible concentration locations (e.g., north-south oriented ridgelines, peninsulas extending into large water bodies) in the project footprint in the initial site-specific survey year for the duration of the fall/spring passage period (see the Hawk Migration Association of North America's [HMANA] website for information of seasonal passage periods: http://www.hmana.org/index.php, last visited January 2, 2011). If migrating eagles are observed, migration counts should be continued for three years, and project proponents should consult with the Service to determine if increased sampling at fixed-radius points on likely migration flight routes during periods when migration is occurring is warranted. Migration counts should be conducted following standards established HMANA. Migration count data in the form requested by HAMANA should be provided to the Service as an Appendix to the ECP.

As with migration concentrations, the potential for non-breeding (either winter or summer) eagle concentration areas in or near the project footprint should be carefully considered in Stage 1. If seasonal concentration areas are possible, then exploratory aerial surveys (fixed-wing or helicopter) of potential habitat should be conducted in the initial year of site-specific surveys. General guidelines and recommendations for conducting eagle concentration area surveys are provided in Appendix F of the Northern States Bald Eagle Recovery Plan (USFWS 1983: http://www.fws.gov/midwest/eagle/recovery/be_n_recplan.pdf , last visited January 3, 2011). If eagle concentrations are present in the project area, then project proponents should consult with the Service to determine if increased sampling is warranted at fixed-radius points in likely seasonally important use areas.

APPENDIX D

STAGE 3 – RISK ANALYSIS RECOMMENDED METHODS AND METRICS

The objectives of the risk analysis are to predict the number of eagle fatalities to expect for a particular siting and operational configuration at a wind facility. Project proponents should work in coordination with the Service to determine risk-factors associated with each turbine in the facility. Then, an annual predicted mortality rate for the project can be calculated by using the estimated annual eagle exposure rate generated from the Stage 2 assessment and using explicit models with templates possibly supplied in a spreadsheet, such as Excel. The initial estimate of mortality rate should not take into account possible ACPs; these will be factored in as part of Stage 4. Additionally, any loss of production that may stem from disturbance is not considered in these calculations, but is instead derived from post-construction monitoring as described in Stage 5. Specific elements of the adaptive management process will be further developed as they emerge in actual cases, through coordination with project proponents. Therefore, this stage and Stage 5 of the ECP will require close coordination between the project proponent and the Service.

1. Risk-factor Analysis

Risk of collision varies from turbine to turbine in a wind facility based on the presence of one or more risk factors (see Figure 1, also Table 1 in the *Proposed Guidance for Eagle Conservation Plans Module 1. Wind Energy Development*) specific to each turbine. In the risk factor analysis, each turbine is evaluated to determine which of these site-based factors might be present:

1. Topographic features conducive to slope soaring
    - a. On or bordering the top of a slope oriented perpendicular to the prevailing wind direction
    - b. Near (within 50 meters) of a ridge-crest or cliff edge
2. Topographic features that create potential flight corridors
    - a. In a saddle or low point on a ridge line
    - b. Near a riparian corridor, at a forest or wetland edge, or near shorelines of large water bodies that eagles are reluctant to traverse
3. Proximate to potential foraging sites
    - a. Near perennial or ephemeral water sources that support a robust fishery or harbor concentrations of waterfowl
    - b. Near a prairie dog (*Cynomys* spp.) colony or area of high ground squirrel density
    - c. Near cover likely to support rabbits or hares
    - d. Near concentrations of livestock where carcasses and neonatal stock occur
    - e. Near sources of carrion
    - f. Near game dumps or landfills
4. Near likely perch structures or roost sites
5. In an area where eagles may frequently engage in territorial interactions
    - a. At about one-half of the mean project-area inter-nest distance (based or Stage 2 surveys) from an eagle nest site.
6. Other risk factors not identified above

Because of the importance of factor 3 above, the Service recommends project proponents conduct thorough surveys to document the distribution and availability of eagle food sources within the project footprint to inform the turbine-specific risk-factor analysis. Results of the risk factor analysis for each turbine should be compiled and provided as an appendix to the project proponent's ECP, along with the specific location (decimal-degree latitude longitude or UTM coordinates) of each turbine and its number or other identifier. The permit applicant and the Service will use the information collected to generate predictions of eagle fatality rates as described in the next section, and to facilitate consideration of specific, micro-siting alternatives (ACPs) in Stage 4 that could reduce risk.

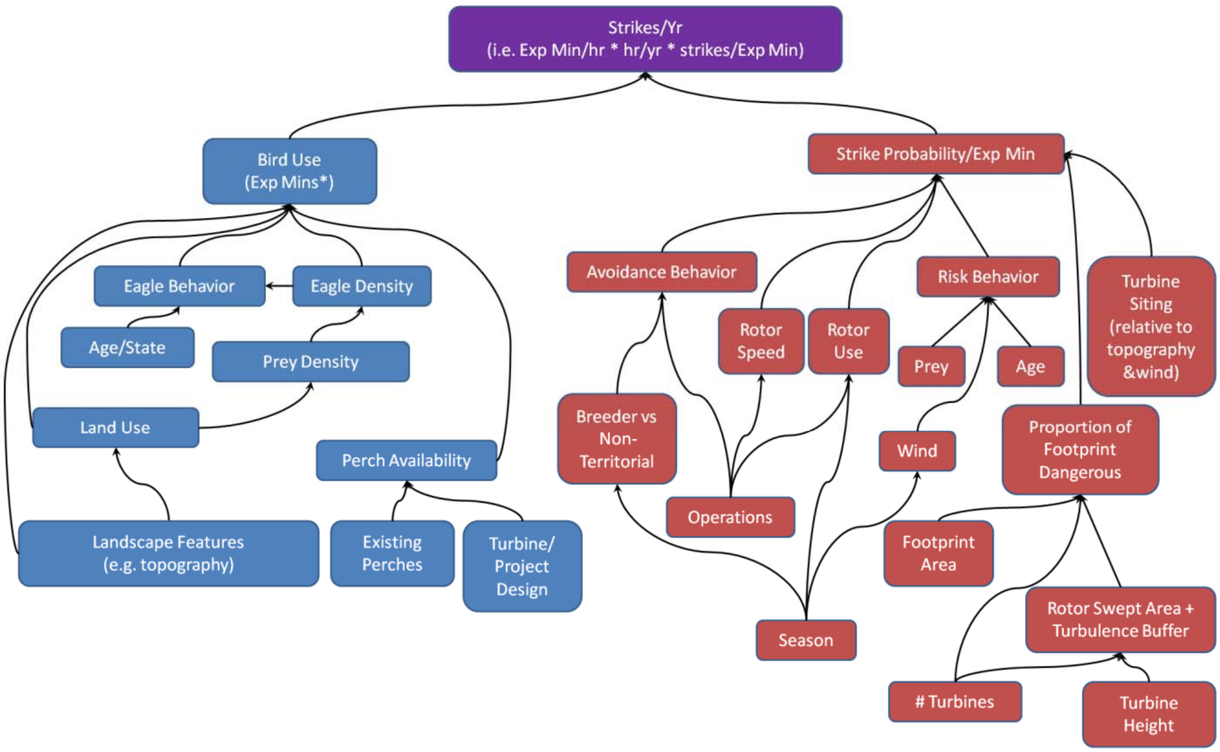
2. Generating an Estimate of Annual Fatality Rate

The predicted number of fatalities per year is estimated from the product of exposure rate and collision probability. Exposure rate is the number of eagle flight minutes in the footprint per minute calculated from point count surveys in Stage 2. Exposure rate is dimensionless (i.e., exposure minutes/observation minutes) and proportional (i.e., each observation is made within a fixed sampling area and the estimate of exposure is scaled up to the footprint of the facility).

Collision probability (risk) is the probability than an eagle will collide with a turbine during a minute of exposure. Collision probability is estimated for the project footprint as a whole based on the risk factor analysis described above, and taking into account the proportion of the project area that represents a collision risk to an eagle (the area within 100 m of the base of a turbine). The overall collision probability is the cumulative probability across all turbines (i.e., the chance that an eagle will collide with one of the turbines in the facility). An assumption is that all collisions result in fatality. A general description of the approach with an example is provided in Table D-1, and a flow chart showing elements of the model is provided in Figure D-1.

Ideally, all parameters on the left (blue) side of Figure D-1 will not have to be estimated because the metric of eagle use is determined empirically through the point count surveys. However, the Service is developing predictive models that will include risk-averse estimates for parameters associated with eagle exposure rate so that conservative estimates of the eagle exposure rate can be generated where appropriate survey data are not available. The last term of the model defines the probability of collision during a minute of exposure. Collision risk is predicted using the collision part of the model (Figure 2), and is a function of its compliment, a basic avoidance rate (e.g., ~1% [Whitfield 2009]), adjusted downward based on the presence of one or more risk factors.

The actual number of fatalities per year is estimated using standardized line-transect surveys of carcasses in the footprint of the facility, corrected to account for imperfect detection, carcass scavenging, and carcass decay as described in Stage 5 (Buckland et al. 2001, 2004; Laing et al. 2003; Rivera-Milán et al. 2004). Updating the collision model using these Stage 5 monitoring data will lead to improved decision-making through adaptation (Nichols and Williams 2006). In addition, data collected across wind-power facilities in a state or region will be used for meta-analysis to better understand cumulative impacts of wind facilities on eagle populations.



*Exp min = exposure minutes (time eagles are within the project footprint)

Figure D-1. Flow chart showing structure of the model used to predict annual eagle fatality rate at a wind facility. The proportion of the footprint that is dangerous is that within 100 meters of the base of a wind turbine.

Stage 2 and 3 Exposure Survey and Take Model Predictions Example

The predicted number of annual fatalities is estimated from three terms: (1) a measure of eagle use of the project area, (2) the proportion of the project area that is dangerous, and (3) the rate of collisions per minute in the danger zone based on the various site and turbine features. Eagle use (exposure) of the project area is determined from preconstruction surveys or estimated when survey data are insufficient or unavailable. The proportion of the project area that is dangerous (danger zone) is a direct calculation of hazardous areas relative to the total project area. The risk of a strike fatality is first determined from quantifying the risk of relevant turbine siting, model, and operating characteristics at first determined from expert elicitation and refined by applying a statistical model to results of Stage 5 carcass surveys. The product of these becomes the estimate of fatalities. To illustrate this, we use a simple, hypothetical example of what would be, by today's standards, an extensive wind energy facility, but which may also represent multiple adjoining facilities.

A wind facility has a planned foot print of A=1,000 km^2 (3183 turbines). A pre-construction survey was run for a year to estimate eagle exposure (minutes) relative to total daylight minutes (262,980). The facility conducted a systematic sample of n = 300 fixed radius (800m) points with $r = 5$ visits for each point i. (For this example, no observations were missing, but missing replicates are easily accommodated by allowing r to vary among points with the notation, r_i.) Areas ($a_i^{Sample} = \pi \times 0.8^2 = 2.01 \text{ km}^2$) around each point were observed for t_{Sample} = 20 minutes and the time eagles were observed in the sample area recorded (eagle flight minutes). Although in this example all sample areas are complete, in practice observable area may be limited by topography or other features, and area a_i^{Sample} may vary among points.

Eagle Exposure

The example exposure per km^2 (eagle flight min/min/km^2) is obtained in 2 steps:

Let y_{ij} be the observed rate of exposure (eagle flight min per 20 minute sample period) at sample point i (i = 1 to n) and replicate observation j (j = 1 to r_i). First, the means at each sample point (i) are taken from all the replicate observations and standardized by the area sampled,

$$\bar{y}_i = \frac{\sum_{j=1}^{r_i} y_{ij}}{r_i a_i^{Sample}} = \frac{\sum_{j=1}^{r} y_{ij}}{r a^{Sample}}$$

(The right part of the equation is a simplified version when no observations are missing and all points have a_i = 0.8 km^2 sample area.)

Second, the average of the sample point means is calculated

$$E_{\text{km}^2} = \frac{\sum_i^n \bar{y}_i}{n} \qquad SD\left(E_{\text{km}^2}\right) = \frac{\sum_i^n \left(\bar{y}_i - E_{\text{km}^2}\right)^2}{n-1}.$$

In the example, this results in: $E_{\mathrm{km}^2} = 5.53\times10^{-3}\ \frac{\text{eagle flight min}}{\text{daylight min}\times\text{km}^2}\ \left(\mathrm{SD} = 2.072\times10^{-3}\right).$

To get the exposure minutes for the project, multiply by project area, *A*, and the number of daylight minutes per year,

$$\mathrm{Exposure}_{\mathrm{Minutes}} = T_{\mathrm{Min}} \times A \times E_{\mathrm{km}^2} = 1{,}453 \text{ minutes}$$

$$\mathrm{SE}\left(\mathrm{Exposure}_{\mathrm{Minutes}}\right) = \mathrm{T}_{\mathrm{Min}} \times \mathrm{A} \times \frac{\mathrm{SD}\left(\mathrm{E}_{\mathrm{km}^2}\right)}{\sqrt{\mathrm{n}}} = 545$$

$\mathrm{Exposure}_{\mathrm{Minutes}}$ has a CV of 38 percent $\left(\mathrm{CV} = \mathrm{SE}\left(\mathrm{Exposure}_{\mathrm{Minutes}}\right)/\mathrm{Mean}\left(\mathrm{Exposure}_{\mathrm{Minutes}}\right).\right)$

Danger Zone

This is the portion of the project footprint that is in the danger zone, D, where eagles are in danger from the turbines, power lines, or other project hazards. For wind turbines, the zone includes 100 m buffers placed around each turbine, $D = n_{\mathrm{Turbine}} \times \pi \times 0.1^2 / A$. In our example, the danger zone is ten percent of total area (3183 turbines).

Collision Rate

The rate of strikes per minute of eagle flight in the danger zone is determined turbine by turbine, depending on associated risk factors, c_{ij}. The levels of the factors j are assigned a risk for each turbine i. A unspecified function, $\mathrm{f}_{\text{Collision Rate}}$, uses the factors to determine the turbine specific risk,

$$C_i^{\mathrm{Turbine}} = \mathrm{f}_{\text{Collision Rate}}\left(c_{i1},\cdots,c_{iJ}\right) = \exp\left(\sum_j \log\left(c_{ij}\right)\right)$$

An example function that keeps the rates positive might be a multiplicative function, exponentiating the sum of the logs.

The per turbine rates are averaged to get the overall collision rate.

$$C = \sum_i^{n_{\mathrm{Turbine}}} C_i^{\mathrm{Turbine}} \Big/ n_{\mathrm{Turbine}}.$$

In this example, let the overall collision rate be 0.0259.

The number of annual fatalities is the product of the three terms: exposure minutes, the proportion of the footprint in the danger zone, and the overall collision rate,

$$\text{Fatalities}_{\text{Project,Year}} = \text{Exposure}_{\text{Minutes}} \times D \times C$$

$$= \left(1453 \text{ minutes}\right) \times 0.10 \times \left(0.0259 \, \tfrac{\text{strikes}}{\text{minute}}\right).$$

Finally, the example eagle fatalities per year is 2.9. Because the only variation here is from the exposure survey the SE is 1.09.

To keep this example simple, exposure was not stratified into areas and times of the year thought to influence eagle use of habitat. With experience and data from projects, other parts of the model will be further refined, e.g., in Stage 3, the collision rate, C, will be updated in Stage 5 using data from the carcass surveys. Also, with data from multiple projects, the relationships among exposure, collision rate, and fatalities will be better understood and incorporated into the model.

APPENDIX E

STAGE 4 – DEVELOPMENT OF ADVANCED CONSERVATION PRACTICES

Siting of a wind facility is the most important factor when considering potential effects to eagles. Based on information gathered in Stage 2 and analyzed in Stage 3, the project proponent should revisit the site categorization from the Stage 1 assessment to determine if the site(s) still falls into an acceptable category of risk (at this stage, acceptable categories are 2 and 3, and very rarely 1. When information suggests that a proposed wind facility has a high eagle exposure rate and presents multiple risk factors (e.g., is proximate to an important eagle-use area and Stage 2 data suggest eagles frequently use the proposed wind-facility footprint), it should be considered a category 1 site; we recommend relocating the project to another area because a location at that site would be unlikely to meet the regulatory requirements for a programmatic permit. If the site falls into categories 2 or 3, or for some rare category 1 sites where there is potential to adequately abate risk, the ECP should next address Advanced Conservation Practices (ACPs) that might be employed to minimize or, ideally, avoid eagle mortality and disturbance.

In this section of the ECP, we recommend project proponents re-run models predicting eagle fatality rates *after* implementing the scientifically supportable ACPs for all the plausible alternatives. This re-analysis serves two purposes: (1) it demonstrates the degree to which minimization and avoidance measures might reduce effects to eagle populations compared to the baseline project configuration, and (2) it provides a prediction of the unavoidable eagle mortality. ACPs should be tailored to specifically address the risk factors identified in Stage 3 of the ECP. This section of the ECP should describe in detail the measures proposed to be implemented and their expected results.

1. Examples of ACPs Applicable Before and During Project Construction

Examples of avoidance and minimization measures that should be considered before and during project construction, depending on the specific risk factors involved, include:

1. Minimize the area and intensity of disturbances during pre-construction activities, such as monitoring and site reconnaissance, as well as during construction.
2. Consider undertaking real-time monitoring of proximate occupied nest sites, and curtailing activity if eagles exhibit signs of distress.
3. Prioritize locating development on disturbed lands that provide minimal eagle use potential.
4. Utilize existing transmission corridors and roads.
5. Avoid vegetation removal and construction during the breeding season.
6. Design project layout to reduce collision and electrocution:
    a. Site turbines in groups rather than spreading them widely but avoid areas where eagles concentrate which could result in high-risk rows of turbines (Smallwood and Thelander 2004).
    b. Consider using pylons at the ends of turbine rows, place pylons in ridge dips or leave dips undeveloped.

    c. Set turbines back from ridge edges at least 100 m where soaring is/will likely take place.
    d. Site structures away from high avian use areas and the flight zones between them.
    e. Dismantle nonoperational turbines and meteorological towers.
    f. Bury powerlines when feasible to reduce avian collision and electrocution.
    g. Follow the Avian Power Line Interaction Committee (APLIC) guidance on power line construction (APLIC 2006) and power line siting (APLIC 1994).
    h. Develop a transportation plan, including road design, locations and speed limits to minimize habitat fragmentation and wildlife collisions and minimize noise effects.
    i. Minimize the extent of the road network.
7. Select project features that minimize effects to eagles:
    a. Avoid use of lattice or structures that are attractive to birds for perching.
    b. Avoid construction designs (including structures such as meteorological towers) that increase the risk of collision, such as guy wires. If guy wires are used, mark them with bird flight diverters (according to the manufacturer's recommendation).
    c. Minimize lighting at facilities (see *U.S. Fish and Wildlife Service Draft Land-based Wind Energy Guidelines* for detailed recommendations). Require that all security lighting be motion- or heat-activated, not left "on" overnight, and down-shield all security and related infrastructure lights.
    d. During construction, implement spatial and seasonal buffers to protect individual nest sites/territories and/or roost sites, including:
        i. Maintaining a buffer between activities and nest/communal roost sites;
        ii. Keep natural areas between the project footprint and the nest site or communal roost by avoiding disturbance to natural landscapes.
    e. Avoid activities that may disturb eagles.
8. Avoid siting turbines in areas where eagle prey are abundant and conduct practices that do not enhance prey availability at the project site.
9. Consider use of pylons to divert eagle flight paths away from risk zones.
10. Avoid areas with high concentrations of ponds, streams, or wetlands.

With respect to item 6d, buffers can help ensure nesting or roosting eagles are not disturbed by construction or maintenance because they serve to minimize visual and auditory effects associated with human activities. Our understanding of how to design effective buffers is limited at the present time, but it seems likely that the size and shape of effective buffers vary depending on the topography and other ecological characteristics surrounding the important eagle-use area. In open areas where there are little or no forested or topographic features to serve as buffers, distance alone must serve as the buffer. Effective use of buffers is one of the key areas where we hope to reduce uncertainty through the adaptive management process.

2. Examples of ACPS Applicable During Project Operations

Examples of avoidance and minimization measures that should be considered during project operation, depending on the specific risk factors involved, include:

1. Maintain facilities to minimize eagle effects:
    a. If rodents and rabbits are attracted to project facilities, identify and eliminate activities that may be attracting them (do not control for native wildlife without contacting the appropriate regulatory agencies). Coordinate in advance with the Service if poisons or lead-based ammunitions are contemplated for control purposes.
    a. Avoid management that indirectly results in attracting raptors to turbines, such as seeding forbs or maintaining rock piles that attract rabbits and rodents.
    b. Move stored parts and equipment, which may be utilized by small mammals for cover, away from wind turbines.
    c. If fossorial mammals burrow near tower footprints, where feasible on a case-by-case basis fill holes and surround pad with gravel at least 2 inches deep and out to a perimeter of at least 5 feet.
    d. Immediately remove carcasses (other than those applicable to post-construction fatality monitoring; see below) that have the potential to attract raptors from roadways and from areas where eagles could collide with wind turbines.
2. Ensure responsible livestock husbandry (e.g. removing carcasses, fencing out livestock) is practiced if grazing occurs around turbines.
3. Reduce vehicle collision risk to wildlife:
    a. Instruct project personnel and visitors to drive at low speeds (< 25 mph), and be alert for wildlife, especially in low visibility conditions.
    b. Plow roads during winter so as not to impede ungulate movement. Snow banks can cause ungulates to run along roads resulting in them colliding with vehicles. Roadside carcasses attract eagles, subjecting them to collision as well.
4. Follow procedures that reduce risk to wildlife:
    a. Instruct employees, contractors, and visitors to avoid disturbing wildlife, especially during breeding seasons and periods of winter stress.
    b. Reduce fire hazards from vehicles and human activities (e.g., use spark arrestors on power equipment, avoid driving vehicles off road).
    c. Follow federal and state measures for handling toxic substances.
    d. Minimize effects to wetlands and water resources by following provisions of the Clean Water Act (33 USC 1251-1387).

3. Additional ACPs

The project proponent and the Service at this point should consider additional scientifically supportable ACPs that might reduce predicted mortality even further. However, to date, few additional practices have been implemented and monitored sufficiently to be demonstrably effective in reducing eagle mortality at wind facilities. Therefore, unless compelling evidence suggests additional practices are warranted up-front, the Service may authorize permits for category 2 and category 3 projects without additional ACPs initially, but with a permit condition that post-construction monitoring data be evaluated to identify potential operational modifications that might be implemented experimentally in the future to the reduce mortality rates (e.g., if observed mortalities are limited to a single turbine in a single season, shutting down that turbine in that season would be a potential additional ACP). Permit renewal may be contingent on implementing and monitoring these empirically derived ACPs, as a component of the adaptive management process.

Examples of additional ACPs that may be identified initially or after evaluation of post-construction fatality monitoring data, depending on the specific risk factors involved, include:

1. Seasonal or daily shut-downs (particularly relevant in situations where eagle strikes are seasonal in nature and limited to a few turbines or occur at a particular time of day) or turbine relocation or removal.
2. Retro-fit existing horizontal turbines with new designs (e.g., vertical axis wind turbines).
3. Placing visual and/or auditory bird flight diverters in critical locations.
4. Hazing big game off property, specifically under turbines (coordinate in advance with the Service and state or tribal wildlife authorities).
5. Prey-base enhancements and/or land acquisition and management to draw eagles out of a project footprint.
6. Retro-fitting tower pads to prevent fossorial mammals from burrowing;
7. Removal of artificial and/or natural habitats attracting prey.
8. Limiting domestic livestock grazing within the project area (e.g., under turbines).
9. Adjusting turbine cut in speeds.
10. Painting blades to reduce visual "smear" (also painting with UV paint or applying different patterns).
11. Installing sound devices to disorient eagles either by having intermittent but frequent emissions, or emissions triggered by remote sensors or radar (Orloff and Flannery 1992).

APPENDIX F

USING RESOURCE EQUIVALENCY ANALYSIS TO DEVELOP A FRAMEWORK OF COMPENSATORY MITIGATION FOR POTENTIAL TAKES OF GOLDEN EAGLES FROM WIND ENERGY DEVELOPMENT

Introduction

When birds are killed—whether from oil spills, hazardous substance releases, permitted or illegal takes—their value can be difficult to quantify in ecological and economic terms. Exactly how much are they worth to an ecosystem, as well as to the public? How much compensation is enough to offset that 'take' or loss of that bird's contribution to the population? The field of resource economics has experienced tremendous advances in the development of tools to measure ecosystem services[1] since the mid 1990's. In particular, economists have extended the economic theory from valuation studies and information from scientific models to develop an alternative approach to economic valuation called resource equivalency analysis (REA) (based on Unsworth and Bishop 1994; Jones and Pease 1997). An REA responds to the question, "What, but for the event, would have happened to the injured species?" With REA, the services of the birds killed are quantified in physical units of *bird-years*.[2] The selected compensation is *scaled* so that the quantity of replacement bird-years equals the quantity of lost bird-years in present value terms to fully compensate the public for depletion of that individual or groups of individuals from the public trust, i.e., no net loss of birds.

REA is referenced in Interior's natural resource damage assessment (NRDA) regulations (2008) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); National Oceanic and Atmospheric Association's Oil Pollution Act (OPA) guidance documents; and is commonly used in NRDA cases (see, e.g., Sperduto *et al*. 1999, 2003; Natural Resource Trustees 2006; Skrabis 2005). The model has also been applied to Federal Energy Regulatory Commission (FERC) licensing, Endangered Species Act (ESA) permitted takes (see, e.g., Skrabis 2004, 2007), and enforcement actions for illegal takes. Internationally, the European Union adopted the US' REA methods for addressing environmental liabilities (Cole & Kriström 2008), and REA was used to estimate the avoided losses of sea eagles from electric

---

[1] Although the fields of ecology and economics do not have a standard definition and measurement of ecosystem services, they are generally understood to be the benefits of nature to individuals, communities, and economies. Ecologists' general classification of provisioning, regulating, cultural, and supporting services aligns with the economic concepts of use and non-use values. In economics, direct use involves human physical involvement with natural resources (e.g., logging, fishing, cultural, and tourism); indirect use values resources that support humans or what humans directly use, e.g., climate regulation, flood control, animal/fish refugia, pollination, waste assimilation; and non-use does not involve physical interaction (i.e., bequest and option values).

[2] A *bird- year* refers to all services provided by one bird for one year. This measure of services is specific to the type of bird since different birds provide different services. So, e.g., the replacement services for 20 bird-years could be 20 birds for only one year, one bird over 20 years, or anything in between.

pole retrofitting as compensation for sea eagle mortalities from collisions with a wind farm in Norway (Cole 2009). With established methods and other comparable analyses, REA may be considered "informed modeling," as described in Stage 3 of the Eagle Conservation Plan, and thus an appropriate tool for estimating the required quantity of mitigation offset for estimated allowable or pre-permitted take of Golden Eagles from wind energy development.

For the purposes of the Draft Eagle Conservation Plan Guidance, the Service's Eagle Compensatory Mitigation Team (ECMT) has developed an REA example to calculate compensatory mitigation for the loss of golden eagles caused by wind power. The remainder of this paper provides a summary of the golden eagle REA results using the following scenario from the ECMT:

> **Example 1:** An annual take of five golden eagles over a five-year renewable permit, starting in 2011. Projected compensatory mitigation involves retrofitting electric power poles that pose a high likelihood of causing eagle mortality[3]. This power pole retrofit would occur in calendar year 2011, thus avoiding the potential loss of golden eagles from electrocution. Proper operation and maintenance (O&M) by the utility company of all retrofitted poles is an assumption; hereafter required for the 30-year life cycle of the wind power project. The results of the model are expressed in the total number of electric power poles to be retrofitted to equate to no net loss of 25 golden eagles (5 eagles annually over five years). The cost of the retrofit of the power poles may then be converted to an estimated minimum total cost of compensatory mitigation funded by the project proponent/ applicant.

An overview of REA methods, inputs, analysis, and references is also provided below.

Summary of Results

To expedite the REA for purposes of this draft guidance module on wind energy development, the best available peer-reviewed, published data and information from North American golden eagle experts were used.[4] It should be noted that additional modeling work within the REA may be needed, particularly on issues related to migration, super producers, adult female survivorship, natal dispersal, age at first breeding, and male-female productivity and population sex ratio, as identified and documented by experts.

---

[3] Companies responsible for power poles and infrastructure are also responsible for taking all reasonable and prudent measures to ensure their equipment does not kill eagles, which includes immediately retrofitting poles that have killed an eagle, and proactively retrofitting poles that are likely to kill eagles in the future. This mitigation is intended to speed up the process of proactively retrofitting power poles, and does not absolve any utility company of liability associated with eagle or other migratory bird mortalities.

[4] Dr. Jim Watson, Pete Bloom, and Karen Steenhof, personal communications to the National Golden Eagle Compensatory Mitigation Team, 12/22/10.

As a *framework* for compensatory mitigation, it needs to be clear that the following results are an illustration of how the REA works given the *current* understanding of the Golden Eagle life history inputs, effectiveness of retrofitting lethal electric poles, the expected annual take, and the timing of both the permitting and mitigation. As would be expected, smaller or larger annual takes lead to a smaller or larger number of poles to be retrofitted. The lengths of permits affect the number of retrofitted poles. Delays in retrofitting would lead to more retrofitted poles owed. As permits are being renewed, new information on changes in the level of take, understanding of the eagle life history, or effectiveness of retrofitting would be expected to change the number of retrofitted poles required for compensation. Finally, while only electric pole retrofitting is considered in this REA, the metric of bird-years lends itself to consideration of other compensatory mitigation options used to achieve the no-net loss standard in the future. With enough reliable information, any mitigation that directly leads to an increased number of Golden Eagles (e.g., habitat restoration) or the avoided loss of golden eagles (e.g., reducing vehicle/eagle collisions, retrofitting livestock water tanks, lead ammunition abatement, etc.) could be considered for compensation within the context of the REA.

The language of REA, which is described in greater detail later, includes:

- The **direct loss** of golden eagles from the take (first part of the *debit* in bird-years);
- The **lost reproduction** over two generations that is foregone because of the take (second part of the *debit* in bird-years);
- The **relative productivity** of retrofitting lethal power poles, which is the effectiveness in avoiding the loss of golden eagles by electrocution as a mitigation offset (measured in total bird-years per pole for 30 years); and
- The **mitigation owed**, with is the total debit divided by the relative productivity (*scaling*) to identify the number of lethal power poles that need retrofitting to completely offset the take of golden eagles.

Using the scenario described above, Table F-1 provides a summary of the results:

Table F-1
Mitigation Owed for a 5-Year Permitted Take of 25 Golden Eagles
(5 Eagles Annually)

Total Debit	485.74	PV bird-years for 5 years of Golden Eagle take
÷ Relative Productivity of Electric Pole Retrofitting	÷4.20	Avoided loss of PV bird-years per retrofitted pole
= Mitigation owed	=115.61	Poles to be retrofitted to achieve no net loss

PV=Present Value

If *all* of the REA inputs remain the same when the permit is renewed, then the estimated 116 poles may be multiplied by the expected number of renewals to provide an estimate of the total number of poles that would eventually be retrofitted. For example, for the 30-year life cycle of an average wind project, 115.6 poles would be multiplied by 6 permit renewals to equal approximately **694 lethal power poles** to be retrofitted as mitigation for the take of 150 Golden

Eagles over 30 years (5 eagles annually). Proper O&M of these poles would need to be conducted to ensure the expected effectiveness of the mitigation is achieved.

REA Methods

Deciding to Conduct a REA

There are two basic approaches to measuring the compensation for injuries to natural resources. The "consumer valuation approach" focuses on the demand side; the "replacement cost" approach focuses on the supply side. The former seeks to determine how much the public demands the services of natural resources (e.g., using a survey method like contingent valuation). The latter seeks to measure how much it costs to replace the natural resource services that the public loses as a result of the injury (i.e., how much it costs to supply natural resource services). The REA model focuses on the supply side of compensation for natural resource injuries, i.e., the "replacement cost" approach, as a variation of habitat equivalency analysis (HEA) (based on Unsworth & Bishop 1994, and Jones & Pease 1997).

At the US Department of the Interior, REA generally refers to a stepwise replacement model[5] for killed or injured species, which was first used in the North Cape NRDA case (Sperduto *et al*. 1999, 2003). As discussed above, this approach is consistent with both the CERCLA and OPA NRDA regulations, and is explicitly identified in the revised CERCLA regulations (2008). The model has also been applied in other US settings and internationally adopted by the European Union for addressing a full range of environmental liabilities (Cole & Kriström 2008). REA calculations using the stepwise replacement model involve basic population modeling, including elements of the Leslie matrix and associated life tables, with appropriate discounting to provide the final results in present value. This approach documents how individuals are lost by age class over time in a stepwise fashion based on survival rates and longevity, and seeks to measure how much it costs to replace the natural resource services that the public lost as a result of the injury.

Interior currently uses REA extensively in NRDA cases to measure the losses associated with individuals, not population-level effects.[6] NRDA case teams typically decide to use the REA model because of its: (1) appropriate focus on individuals killed and their replacement, (2) relatively reliable results that are transparent and reproducible, and (3) cost-effectiveness. More specifically, the current state-of-the-art REA has:

1. **Appropriate Focus.** As noted across the REA literature, the number of individuals killed in an incident can be counted or estimated. Although lost individual-years (e.g.,

---

[5] Term coined by Hampton & Zafonte in the *Luckenbach Final DARP*, Appendix C, 2003, which appropriately describes how lost bird-years are calculated by the age classes over time in a stepwise fashion (i.e., # in age class (0-1) (Year 1) * survival rate = # in age class (1-2) (Year 2) * survival rate = # in age class (2-3) (Year 3), etc.). The stepwise concept reflects the Leslie Matrix used by biologists/ecologists. Similar terms are seen in the economics and political science literature to describe various trajectories over time.
[6] There have been some limited efforts to model population effects by NRDA consultants (e.g., Tank Barge Bouchard No. 120) and the State of California (e.g., M/V Kure oil spill, SS Jacob Luckenbach).

bird-years, fish-years) can be difficult to observe, simulations and arguments in the literature suggest that removing even a small number of individuals from a population can produce persistent impacts (e.g., Sperduto *et al.* 1999, Zafonte & Hampton 2005). Thus, it seems reasonable to focus on individuals killed using REA when quantifying appropriate compensation

2. **Relatively Reliable Results.** The reality is that the public's valuation of a resource is not necessarily equal to the total replacement cost identified in a REA, particularly in the case of unique and scarce resources. Zafonte & Hampton (2007) conducted experiments to explore the degree to which violations of REA assumptions can result in either under-compensation or over-compensation of the public. Specifically, they looked at whether the results of compensatory restoration diverged from monetized settlements. They found that a traditional REA is consistent with a monetized approach except in cases where the demand for resources is inelastic (i.e., no substitutes) and the impact to local resources is severe (public values are likely affected). Zafonte & Hampton (2007) believe their results suggest "the welfare biases intrinsic to a traditional REA methodology are probably minor for many NRDA cases" (p. 10). In sum, REA applies basic ecological concepts in a standard economic framework to provide relatively reliable estimates of compensation.

3. **Cost-Effective Assessment.** REA can be run and reviewed by all stakeholders, often using existing literature. Certain species require more local study, so even REAs can become more expensive in those situations. "However, because it is easier and less costly to measure the total replacement cost than the total public value, REA has an advantage over other methods, especially for small to medium-sized incidents with minimal impact on rare species" (Kure Final DARP 2008: C-2).

While the same basic REA model is being used in a variety of settings, there is some variation on the number of generations to include in the assessment. According to Zafonte and Hampton (2005), "[i]t is difficult, however, to construct a rationale that links population recovery to a specific number of entirely lost future generations (i.e., if one full generation of offspring is lost, why not the next?)" (pp. 9-10). Instead, recovery can be quantified by focusing on the production of juveniles from the remaining live birds rather than what was foregone from the dead birds (e.g., SS Jacob Luckenbach, Tank Barge Bouchard No. 120). Population models provide flexibility to specify recovery mechanisms that are based upon individuals remaining in the population. Specifying these types of mechanisms may be helpful for guiding calculations when full juvenile replacement is not expected. "The same flexibility that makes population modeling attractive can also work against it. Even simple population models may require (or imply) the specification of parameters and relationships that may not be needed when doing direct calculations of lost individuals. On one hand, specifying these relationships may help place the analysis in a broader context (e.g., by helping calibrate appropriate modeling inputs). However, it may also introduce additional uncertainty. Addition of model complexity should be done with care" (pp. 10-11).

Given the current state of the art in the REA modeling, the extensive bird expertise in the US Fish and Wildlife Service and many state agencies, and the analysis of uncertainty in more advanced population modeling by Zafonte & Hampton (2005), DOI NRDA cases typically have decided to apply zero to two generations. Most often two generations of reproductive losses are estimated based on the site-specific bird injuries. All of these factors seem relevant to any context that REA would be applied, including Golden Eagle mitigation.

Background on Conducting a Stepwise Replacement Approach REA

The stepwise replacement model is commonly used for bird kills. The basic conceptual approach to measuring losses in bird-years for one year of a take is provided in Figure F-1.

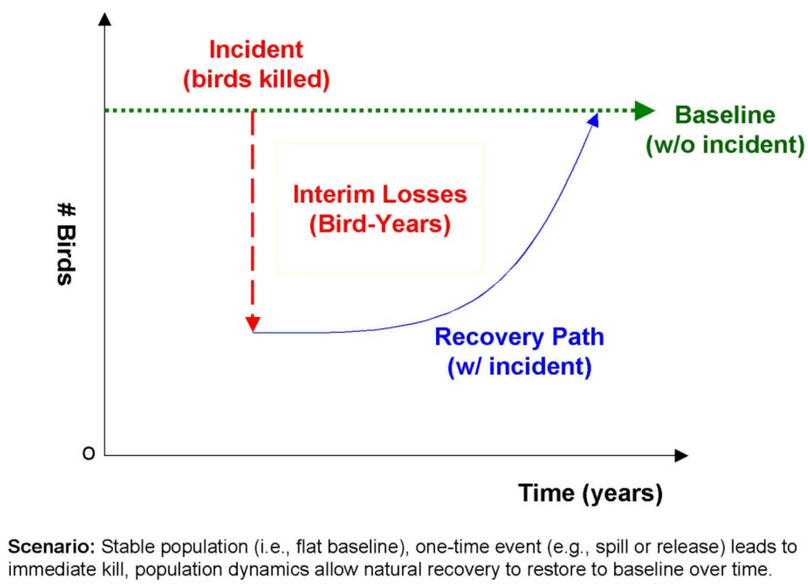


Figure F-2. Conceptually Measuring Lost Bird-Years in an REA

Mathematically, the stepwise replacement model approach is calculated as:

$$I = \sum_{t=o} [(NB_t - N_t) \div (1+r)^t] \quad (1)$$

where *I* is the injury in lost bird-years, *NBt* and *Nt* represent the number of individuals in the population (at time *t*) under existing baseline and take scenarios, respectively, *t* indexes time (usually years, but could be adjusted for months or days for short-lived and/or quick recovering species), and *r* is the annual discount rate (which can be adjusted for months or days depending on the units of *t*) (see, e.g., Sperduto *et al.* 1999, Zafonte and Hampton 2005).

REA using the stepwise replacement model is based upon the assumptions provided in Table F-2. These assumptions are necessary to obtain a static perspective of take and mitigation for compensation, which allows a reasonable simplification of the analysis by focusing on the dead birds and associated lost bird years (measuring injury (*I*) directly).

Table F-2 REA Assumptions

Assumption 1	Incident-related mortality is distributed across the various age classes of the injured population (unless an average age is assumed).
Assumption 2	The juvenile and adult survival rates are constant before and after the incident.
Assumption 3	The baseline and mitigated/restored populations are roughly constant in size and stable in age-distribution, as determined by demographic characteristics of the species (specifically survival rates and fecundity).
Assumption 4	There is a maximum age beyond which no individuals live that is constant before and after the incident.
Assumption 5	Reproductive rates by surviving individuals are unchanged by the incident (e.g., the number of post-spill nests equals the number of baseline nests).
Assumption 6	The real discount rate is 3%. Figures presented in *current value* have no discounting; the number presented is the actual number expected to occur in the year it appears. In contrast, figures reported in *present value* have been discounted, such that the number reported reflects its value today.

Sources: See, e.g., Sperduto *et al*. 2003; Natural Resource Trustees, SS Jacob Luckenbach 2006.

There are 16 steps in conducting any REA. There are 13 total steps involved in calculating the injury side (debit) of an REA, and three additional steps involved in estimating compensatory mitigation owed (credit).

On the injury side, the first five steps measure direct losses of birds, i.e., bird-years lost from the take of Golden Eagles by wind energy development.

Step 1: Identify how many eagles by age class should have been alive "but for" the take (REAs may use the % age distribution from a Leslie model, average age, or calculated age). The Eagle Compensatory Mitigation Team and supporting national eagle experts provided an age distribution of eagles killed. A Leslie model came up with similar results. A review of Cole (2009) showed an average age for the sea eagle used in the Norwegian wind power electrocution case study. Through personal communications, the author noted that the use of an average age was a "simplification based on a lack of data" (which has also been necessitated in some NRDA cases) and is making current efforts to "improve our estimates -- both the age of a collided bird and the age of an electrocuted bird" (1/12/11).

Step 2: Multiply the relevant survival rates by the lost birds per age class at the time of the incident (from Step 1), and identify the midpoint. The midpoint provides average bird-services for the year instead of overvaluing at the beginning of the year or undervaluing at the end of the year.

Step 3: For each subsequent year, multiply the number of birds progressing through each age class by the relevant annual survival rates for the remaining lifespan of the species.

Step 4: Total the lost bird-years across age classes and for each year of remaining lifespan to estimate the total direct loss in bird-years. Multiply by the discount factor to calculate the total lost bird-years in present value.

Step 5: Identify the subset of birds that are of reproducing age (i.e., Reproducing Subset).

The next three steps involve calculating the expected losses associated with the foregone production of one (dead) bird.

Step 6: Calculate the expected value in bird-years associated with one first-generation bird in the first year as the product of the annual survival rates over the expected lifespan.

Step 7: Multiply by the relevant discount factor to convert to present value.

Step 8: Extrapolate the results from Step 7 into future years using the 3% discount rate. Although some minor rounding error is introduced, the quickest and easiest way to adjust the future values is to continuously reduce the values by 3% by multiplying the previous year by 0.97.

The next five steps measure lost reproduction in bird-years.

Step 9: Using the Reproducing Subset identified in Step 5, calculate how many of the reproducing adults are females that would actually reproduce [# reproducing age (from Step 5) x proportion female x reproductive rate of females].

Step 10: Multiply the number of reproducing females (from Step 9) by the average number of young to estimate the total number of lost first-generation birds.

Step 11: Multiply the total number of lost first-generation birds (from Step 10) by the present value bird-years associated with their lifespan (from Steps 6-8).

Step 12: To calculate the number of lost second-generation birds, identify the total number of lost first-generation birds and follow Steps 2 through 5 to calculate the reproducing subset.

Step 13: Finally, to calculate the total second-generation reproductive losses, take the reproducing subset from Step 5 and repeat Steps 9 through 11.

Finally, there are three additional steps involved for scaling mitigation options to estimate the amount of compensatory mitigation required to offset the take of Golden Eagles.

Step 14: Identify the mitigation option(s). See the Eagle Compensatory Mitigation Team's mitigation option described above, which is based on the retrofitting of lethal electric poles.

Step 15: Identify the relative productivity of the mitigation. In this case, it is the number of bird-years per retrofitted electric pole over 30 years with proper O&M to ensure the relative productivity.

Step 16: Scale the mitigation project(s) by dividing the total lost bird-years (direct and reproductive losses) by the relative productivity of the mitigation option(s) to identify the size of the mitigation project (quantity of mitigation owed). Alternatively, a project of known size could be evaluated in terms of potential bird-years as an offset to the debit. This helps decision-makers understand whether they need to identify additional projects (not enough offset) or reduce the proposed mitigation project (too much offset).

Golden Eagle REA Inputs

Table F-3 provides a summary of the Golden Eagle life history inputs and assumptions used in this REA. As discussed above, to expedite the REA for purposes of this draft guidance module on wind energy development, the best available peer-reviewed, published data and information from North American Golden Eagle experts were used.

Table F-3
REA Inputs to Develop a Framework of Compensatory Mitigation for Potential Takes of Golden Eagles from Wind Energy Development

Parameter	REA Input		Reference
Start year of permit	2011		Test run of model
Length of permit	5 years		Can test with other permit lengths
Estimated take	5 birds annually		Test run of model
Maximum lifespan	30 years		28 years, 3 months, Bird Banding Lab. Consistent with Cole (2009) approach.
Age distribution of birds killed	(0-1) (1-2) (2-3) (3-4) (4-5) (5-6) (6-7) (7-8) (8-9) (9-10) (10-11) (11-12) (13-14) (14-15) (15-16) (16-17) (17-18) (18-19) (19-20) (20-21) (21-22) (22-23) (23-24) (24-25) (25-26) (26-27) (27-28) (28-29) (29-30)	20% 11.67% 11.67% 11.67% 1.73%	• 20% juveniles; age class (0-1) • 35% sub-adults; age classes (1-2) through 3-4) —Dr. Jim Watson, Pete Bloom, Karen Steenhof, 12/22/10 • 45% adults; age classes (4-5) through (29-30) Assume distributed evenly over time. The Leslie model produces a very similar population distribution for the maximum lifespan: • 19.6% juveniles; age class (0-1) • 33.5% sub-adults; age classes (1-2) through 3-4) • 46.9% adults; age classes (4-5) through (29-30)
Age start reproducing	Age 5 [age class (5-6)]		Jim Watson, Pete Bloom, Karen Steenhof, 12/22/10
Expected years of reproduction	25 years		Maximum lifespan – Age start reproducing
% of adult females that reproduce	80%		Jim Watson (82%), Karen Steenhof (79%) 12/22/10
# eggs/nest	2		Jim Watson (2), Pete Bloom (1.5-1.8), Karen Steenhof (2; 1.6 brood size), 12/22/10
Nesting success—the proportion of nesting or laying pairs that	50%		Jim Watson, Pete Bloom, 12/22/10

Parameter	REA Input	Reference
raise young to the age of **fledging** (i.e., the age when a fully-feathered offspring voluntarily leaves the nest for the first time)(Steenhof & Newton (2007): 184)		
year 0-1 survival	61%	Division of Migratory Bird Management, US Fish and Wildlife Service, *Final Environmental Assessment: Proposal to Permit Take as Provided Under the Bald and Golden Eagle Protection Act*, April 2009.
year 1-2 survival	79%	
year 2-3 survival	79%	
year 3-4 survival	79%	
year 4+ survival	90.9%	
Relative productivity of mitigation option	0.0102 eagle electrocutions per pole per year over 30 years	R. Harness, R. Lehman, EDM International, Fort Collins, CO, unpublished. Mitigation involves retrofitting of electric power poles, thus avoiding the loss of Golden Eagles from electrocution. Proper operation and maintenance (O&M) of the retrofitted poles is required for the 30-year life of the wind power project to achieve this relative productivity.
Discount rate	3%	A 3% discount rate is commonly used for valuing lost natural resource services (Freeman, 1993; Lind, 1982; NOAA, 1999; and court decisions on damage assessment cases)
Additional factors		Migration in model, superproducer, natal dispersion, age at first breeding. Jim Watson, Pete Bloom, Karen Steenhof, 12/22/10

Golden Eagle REA

Tables F-4 through F-11 provide the results of the 16 steps of the Golden Eagle REA. The discount factor for a 3% discount rate is calculated as $(1+r)^{P-t}$, where r is the discount rate, P is the present time period, and t is the time period of lost services. In 2011, for example, the discount factor is 1.0, because any number raised to the zero power equals 1.0 ($1.03^{(2011-2011=0)} = 1.0$). Readers should be aware that more than the usual one or two significant digits are shown for the computed values. This choice is not intended to convey an excessive level of confidence in the calculations. Rather, the decision was made to provide sufficient information to maximize the transparency and reproducibility of the results.

Table F-4
Golden Eagle REA Debit: Direct Loss from a Take in 2011*
(REA Steps 1-5)

Year	Discount Factor	Age Class (0-1)	(1-2)	(2-3)	(3-4)	(4-5)	(5-6)	(6-7)	(7-8)	(8-9)	(9-10)
2011	1.00	1.000	0.583	0.583	0.583	0.087	0.087	0.087	0.087	0.087	0.087
2012	0.97		0.895	0.522	0.522	0.557	0.083	0.083	0.083	0.083	0.083
2013	0.94			0.707	0.412	0.475	0.506	0.075	0.075	0.075	0.075
2014	0.92				0.559	0.375	0.431	0.460	0.068	0.068	0.068
2015	0.89					0.508	0.341	0.392	0.418	0.062	0.062
2016	0.86						0.462	0.310	0.356	0.380	0.056
2017	0.84							0.420	0.282	0.324	0.346
2018	0.81								0.381	0.256	0.295
2019	0.79									0.347	0.233
2020	0.77										0.315

Year	Discount Factor	(10-11)	(11-12)	(12-13)	(13-14)	(14-15)	(15-16)	(16-17)	(17-18)	(18-19)	(19-20)
2011	1.00	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087
2012	0.97	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083
2013	0.94	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075
2014	0.92	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068
2015	0.89	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062
2016	0.86	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056
2017	0.84	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051
2018	0.81	0.314	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047
2019	0.79	0.268	0.286	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
2020	0.77	0.212	0.243	0.260	0.039	0.039	0.039	0.039	0.039	0.039	0.039
2021	0.74	0.286	0.192	0.221	0.236	0.035	0.035	0.035	0.035	0.035	0.035
2022	0.72		0.260	0.175	0.201	0.214	0.032	0.032	0.032	0.032	0.032
2023	0.70			0.237	0.159	0.183	0.195	0.029	0.029	0.029	0.029
2024	0.68				0.215	0.144	0.166	0.177	0.026	0.026	0.026
2025	0.66					0.196	0.131	0.151	0.161	0.024	0.024
2026	0.64						0.178	0.119	0.137	0.146	0.022
2027	0.62							0.162	0.108	0.125	0.133
2028	0.61								0.147	0.099	0.113
2029	0.59									0.134	0.090
2030	0.57										0.121

Table F-4 (continued)
Golden Eagle REA Debit: Direct Loss from a Take in 2011
(REA Steps 1-5)

Year	Discount Factor	(20-21)	(21-22)	(22-23)	(23-24)	(24-25)	(25-26)	(26-27)	(27-28)	(28-29)	(29-30)	Total Direct Bird-Years	Total Lost Bird-Years in PV	Reproducing Subset
2011	1.00	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087	5.000	--	2.163
2012	0.97	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	4.561	4.428	2.065
2013	0.94	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	3.902	3.678	2.308
2014	0.92	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	3.395	3.107	2.461
2015	0.89	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	3.024	2.687	2.516
2016	0.86	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	2.692	2.322	2.692
2017	0.84	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	2.396	2.007	2.396
2018	0.81	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	2.131	1.733	2.131
2019	0.79	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	1.895	1.496	1.895
2020	0.77	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	1.684	1.291	1.684
2021	0.74	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.035	1.496	1.113	1.496
2022	0.72	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	1.328	0.959	1.328
2023	0.70	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	1.178	0.826	1.178
2024	0.68	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	1.045	0.711	1.045
2025	0.66	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.926	0.612	0.926
2026	0.64	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.820	0.526	0.820
2027	0.62	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.725	0.452	0.725
2028	0.61	0.121	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.641	0.388	0.641
2029	0.59	0.103	0.110	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.567	0.333	0.567
2030	0.57	0.081	0.094	0.100	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.500	0.285	0.500
2031	0.55	0.110	0.074	0.085	0.091	0.013	0.013	0.013	0.013	0.013	0.013	0.441	0.244	0.441
2032	0.54		0.100	0.067	0.077	0.083	0.012	0.012	0.012	0.012	0.012	0.389	0.209	0.389
2033	0.52			0.091	0.061	0.070	0.075	0.011	0.011	0.011	0.011	0.342	0.179	0.342
2034	0.51				0.083	0.056	0.064	0.068	0.010	0.010	0.010	0.301	0.153	0.301
2035	0.49					0.075	0.051	0.058	0.062	0.009	0.009	0.264	0.130	0.264
2036	0.48						0.068	0.046	0.053	0.056	0.008	0.232	0.111	0.232
2037	0.46							0.062	0.042	0.048	0.051	0.203	0.094	0.203
2038	0.45								0.057	0.038	0.044	0.138	0.062	0.138
2039	0.44									0.051	0.035	0.086	0.038	0.086
2040	0.42										0.047	0.047	0.020	0.047
Total													**30.194**	33.983

PV=Present Value

Table F-5
Golden Eagle REA Debit: Statistical Lifespan of One Eagle Fledgling Produced in 2011 (Services Start in 2012)
(REA Steps 6-7)

Year	Discount Factor		Bird-Years/ Fledgling		Bird-Years/ Fledgling in PV
2012	0.97		0.610		0.592
2013	0.94		0.482		0.454
2014	0.92		0.381		0.348
2015	0.89		0.301		0.267
2016	0.86		0.273		0.236
2017	0.84		0.249		0.208
2018	0.81		0.226		0.184
2019	0.79		0.205		0.162
2020	0.77		0.187		0.143
2021	0.74		0.170		0.126
2022	0.72		0.154		0.111
2023	0.70		0.140		0.098
2024	0.68		0.127		0.087
2025	0.66	x	0.116	=	0.077
2026	0.64		0.105		0.068
2027	0.62		0.096		0.060
2028	0.61		0.087		0.053
2029	0.59		0.079		0.046
2030	0.57		0.072		0.041
2031	0.55		0.065		0.036
2032	0.54		0.059		0.032
2033	0.52		0.054		0.028
2034	0.51		0.049		0.025
2035	0.49		0.045		0.022
2036	0.48		0.041		0.019
2037	0.46		0.037		0.017
2038	0.45		0.034		0.015
2039	0.44		0.030		0.013
2040	0.42		0.028		0.012
2041	0.41		0.025		0.010
					3.592

PV= Present Value

Table F-6
Golden Eagle REA Debit: 1st Generation Reproductive Losses from a Take in 2011
(REA Steps 8-11)

Year	Discount Factor	Total # Birds-- Reproducing Age	# Reproducing Females	Total # 1st Gen Fledglings	Bird-Years/ Fledgling in PV	1st Gen Lost Bird-Years Total in PV
2011	1.00	2.163	0.865	0.865	3.592	3.108
2012	0.97	2.065	0.826	0.826	3.484	2.878
2013	0.94	2.308	0.923	0.923	3.379	3.120
2014	0.92	2.461	0.984	0.984	3.278	3.227
2015	0.89	2.516	1.006	1.006	3.180	3.200
2016	0.86	2.692	1.077	1.077	3.084	3.321
2017	0.84	2.396	0.958	0.958	2.992	2.867
2018	0.81	2.131	0.853	0.853	2.902	2.474
2019	0.79	1.895	0.758	0.758	2.815	2.134
2020	0.77	1.684	0.674	0.674	2.730	1.839
2021	0.74	1.496	0.598	0.598	2.649	1.585
2022	0.72	1.328	0.531	0.531	2.569	1.365
2023	0.70	1.178	0.471	0.471	2.492	1.174
2024	0.68	1.045	0.418	0.418	2.417	1.010
2025	0.66	0.926	0.370	0.370	2.345	0.868
2026	0.64	0.820	0.328	0.328	2.274	0.746
2027	0.62	0.725	0.290	0.290	2.206	0.640
2028	0.61	0.641	0.257	0.257	2.140	0.549
2029	0.59	0.567	0.227	0.227	2.076	0.471
2030	0.57	0.500	0.200	0.200	2.014	0.403
2031	0.55	0.441	0.177	0.177	1.953	0.345
2032	0.54	0.389	0.156	0.156	1.895	0.295
2033	0.52	0.342	0.137	0.137	1.838	0.252
2034	0.51	0.301	0.120	0.120	1.783	0.215
2035	0.49	0.264	0.106	0.106	1.729	0.183
2036	0.48	0.232	0.093	0.093	1.677	0.156
2037	0.46	0.203	0.081	0.081	1.627	0.132
2038	0.45	0.138	0.055	0.055	1.578	0.087
2039	0.44	0.086	0.034	0.034	1.531	0.053
2040	0.42	0.047	0.019	0.019	1.485	0.028
Total		33.983	13.593	13.593		**38.723**

PV= Present Value

Table F-7
Golden Eagle REA Debit: 2nd Generation Reproductive Losses from a Take in 2011
(REA Steps 12-13)

		Age Classes									
Year	0	(0-1)	(1-2)	(2-3)	(3-4)	(4-5)	(5-6)	(6-7)	(7-8)	(8-9)	(9-10)
2011	0.865										
2012	0.826	0.697									
2013	0.923	0.665	0.550								
2014	0.984	0.743	0.525	0.435							
2015	1.006	0.793	0.587	0.415	0.343						
2016	1.077	0.810	0.626	0.464	0.328	0.312					
2017	0.958	0.867	0.640	0.495	0.366	0.298	0.284				
2018	0.853	0.771	0.685	0.506	0.391	0.333	0.271	0.258			
2019	0.758	0.686	0.609	0.541	0.399	0.355	0.303	0.246	0.234		
2020	0.674	0.610	0.542	0.481	0.427	0.363	0.323	0.275	0.224	0.213	
2021	0.598	0.542	0.482	0.428	0.380	0.389	0.330	0.293	0.250	0.203	0.194
2022	0.531	0.482	0.428	0.381	0.338	0.346	0.353	0.300	0.267	0.227	0.185
2023	0.471	0.428	0.381	0.338	0.301	0.308	0.314	0.321	0.273	0.242	0.207
2024	0.418	0.379	0.338	0.301	0.267	0.273	0.280	0.286	0.292	0.248	0.220
2025	0.370	0.336	0.300	0.267	0.237	0.243	0.249	0.254	0.260	0.265	0.225
2026	0.328	0.298	0.266	0.237	0.211	0.216	0.221	0.226	0.231	0.236	0.241
2027	0.290	0.264	0.235	0.210	0.187	0.192	0.196	0.201	0.205	0.210	0.215
2028	0.257	0.234	0.209	0.186	0.166	0.170	0.174	0.178	0.183	0.187	0.191
2029	0.227	0.207	0.185	0.165	0.147	0.151	0.155	0.158	0.162	0.166	0.170
2030	0.200	0.182	0.163	0.146	0.130	0.134	0.137	0.140	0.144	0.147	0.151
2031	0.177	0.161	0.144	0.129	0.115	0.118	0.121	0.125	0.128	0.131	0.134
2032	0.156	0.142	0.127	0.114	0.102	0.105	0.108	0.110	0.113	0.116	0.119
2033	0.137	0.125	0.112	0.101	0.090	0.093	0.095	0.098	0.100	0.103	0.106
2034	0.120	0.110	0.099	0.089	0.079	0.082	0.084	0.086	0.089	0.091	0.094
2035	0.106	0.097	0.087	0.078	0.070	0.072	0.074	0.076	0.079	0.081	0.083
2036	0.093	0.085	0.077	0.069	0.062	0.064	0.066	0.068	0.070	0.071	0.073
2037	0.081	0.075	0.067	0.061	0.054	0.056	0.058	0.060	0.061	0.063	0.065
2038	0.055	0.065	0.059	0.053	0.048	0.049	0.051	0.053	0.054	0.056	0.057
2039	0.034	0.045	0.052	0.047	0.042	0.043	0.045	0.046	0.048	0.049	0.051
2040	0.019	0.028	0.035	0.041	0.037	0.038	0.039	0.041	0.042	0.043	0.045
2041	0.000	0.015	0.022	0.028	0.032	0.033	0.035	0.036	0.037	0.038	0.040
2042	0.000	0.000	0.012	0.017	0.022	0.029	0.030	0.032	0.033	0.034	0.035
2043	0.000	0.000	0.000	0.009	0.014	0.020	0.027	0.028	0.029	0.030	0.031
2044	0.000	0.000	0.000	0.000	0.007	0.012	0.018	0.024	0.025	0.026	0.027
2045	0.000	0.000	0.000	0.000	0.000	0.007	0.011	0.016	0.022	0.023	0.024
2046	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.010	0.015	0.020	0.021
2047	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.009	0.014	0.018
2048	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.008	0.012
2049	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.008
2050	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004

Table F-7 (continued)
Golden Eagle REA Debit: 2nd Generation Reproductive Losses from a Take in 2011
(REA Steps 12-13)

Year	(10-11)	(11-12)	(12-13)	(13-14)	(14-15)	(15-16)	(16-17)	(17-18)	(18-19)	(19-20)
2022	0.176									
2023	0.168	0.160								
2024	0.188	0.153	0.146							
2025	0.200	0.171	0.139	0.132						
2026	0.205	0.182	0.155	0.126	0.120					
2027	0.219	0.186	0.166	0.141	0.115	0.109				
2028	0.195	0.199	0.169	0.150	0.128	0.104	0.099			
2029	0.174	0.177	0.181	0.154	0.137	0.117	0.095	0.090		
2030	0.154	0.158	0.161	0.165	0.140	0.124	0.106	0.086	0.082	
2031	0.137	0.140	0.143	0.147	0.150	0.127	0.113	0.096	0.078	0.075
2032	0.122	0.125	0.127	0.130	0.133	0.136	0.116	0.103	0.088	0.071
2033	0.108	0.111	0.113	0.116	0.118	0.121	0.124	0.105	0.093	0.080
2034	0.096	0.098	0.101	0.103	0.105	0.108	0.110	0.112	0.095	0.085
2035	0.085	0.087	0.089	0.091	0.094	0.096	0.098	0.100	0.102	0.087
2036	0.075	0.077	0.079	0.081	0.083	0.085	0.087	0.089	0.091	0.093
2037	0.067	0.069	0.070	0.072	0.074	0.076	0.077	0.079	0.081	0.083
2038	0.059	0.061	0.062	0.064	0.065	0.067	0.069	0.070	0.072	0.074
2039	0.052	0.054	0.055	0.057	0.058	0.060	0.061	0.062	0.064	0.065
2040	0.046	0.047	0.049	0.050	0.051	0.053	0.054	0.055	0.057	0.058
2041	0.041	0.042	0.043	0.044	0.046	0.047	0.048	0.049	0.050	0.052
2042	0.036	0.037	0.038	0.039	0.040	0.041	0.043	0.044	0.045	0.046
2043	0.032	0.033	0.034	0.035	0.036	0.037	0.038	0.039	0.040	0.041
2044	0.028	0.029	0.030	0.031	0.032	0.032	0.033	0.034	0.035	0.036
2045	0.025	0.025	0.026	0.027	0.028	0.029	0.029	0.030	0.031	0.032
2046	0.022	0.022	0.023	0.024	0.025	0.025	0.026	0.027	0.028	0.028
2047	0.019	0.020	0.020	0.021	0.022	0.022	0.023	0.024	0.024	0.025
2048	0.017	0.017	0.018	0.018	0.019	0.020	0.020	0.021	0.022	0.022
2049	0.011	0.015	0.016	0.016	0.017	0.017	0.018	0.018	0.019	0.020
2050	0.007	0.010	0.014	0.014	0.015	0.015	0.016	0.016	0.017	0.017
2051	0.004	0.006	0.009	0.012	0.013	0.013	0.014	0.014	0.015	0.015
2052	0.000	0.003	0.006	0.008	0.011	0.012	0.012	0.013	0.013	0.013
2053	0.000	0.000	0.003	0.005	0.008	0.010	0.011	0.011	0.011	0.012
2054	0.000	0.000	0.000	0.003	0.005	0.007	0.009	0.010	0.010	0.010
2055	0.000	0.000	0.000	0.000	0.003	0.004	0.006	0.008	0.009	0.009
2056	0.000	0.000	0.000	0.000	0.000	0.002	0.004	0.006	0.008	0.008
2057	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.004	0.005	0.007
2058	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.003	0.005
2059	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.003
2060	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002

Table F-7 (continued)
Golden Eagle REA Debit: 2nd Generation Reproductive Losses from a Take in 2011
(REA Steps 12-13)

Year	(20-21)	(21-22)	(22-23)	(23-24)	(24-25)	(25-26)	(26-27)	(27-28)	(28-29)	(29-30)	Subset Total
2032	0.068										1.785
2033	0.065	0.062									1.717
2034	0.072	0.059	0.056								1.645
2035	0.077	0.066	0.054	0.051							1.570
2036	0.079	0.070	0.060	0.049	0.046						1.493
2037	0.084	0.072	0.064	0.054	0.044	0.042					1.415
2038	0.075	0.077	0.065	0.058	0.049	0.040	0.038				1.337
2039	0.067	0.068	0.070	0.059	0.053	0.045	0.037	0.035			1.260
2040	0.059	0.061	0.062	0.063	0.054	0.048	0.041	0.033	0.032		1.185
2041	0.053	0.054	0.055	0.056	0.058	0.049	0.044	0.037	0.030	0.029	1.112
2042	0.047	0.048	0.049	0.050	0.051	0.052	0.045	0.040	0.034	0.027	1.015
2043	0.042	0.043	0.044	0.045	0.046	0.047	0.048	0.040	0.036	0.031	0.924
2044	0.037	0.038	0.039	0.040	0.041	0.041	0.042	0.043	0.037	0.033	0.830
2045	0.033	0.034	0.034	0.035	0.036	0.037	0.038	0.039	0.039	0.033	0.736
2046	0.029	0.030	0.031	0.031	0.032	0.033	0.034	0.034	0.035	0.036	0.645
2047	0.026	0.026	0.027	0.028	0.028	0.029	0.030	0.030	0.031	0.032	0.554
2048	0.023	0.023	0.024	0.025	0.025	0.026	0.026	0.027	0.028	0.028	0.475
2049	0.020	0.021	0.021	0.022	0.022	0.023	0.023	0.024	0.025	0.025	0.406
2050	0.018	0.018	0.019	0.019	0.020	0.020	0.021	0.021	0.022	0.022	0.346
2051	0.016	0.016	0.017	0.017	0.018	0.018	0.018	0.019	0.019	0.020	0.294
2052	0.014	0.014	0.015	0.015	0.016	0.016	0.016	0.017	0.017	0.018	0.249
2053	0.012	0.013	0.013	0.013	0.014	0.014	0.015	0.015	0.015	0.016	0.211
2054	0.011	0.011	0.011	0.012	0.012	0.012	0.013	0.013	0.014	0.014	0.177
2055	0.009	0.010	0.010	0.010	0.011	0.011	0.011	0.012	0.012	0.012	0.148
2056	0.008	0.009	0.009	0.009	0.009	0.010	0.010	0.010	0.011	0.011	0.124
2057	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.010	0.103
2058	0.006	0.007	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.084
2059	0.004	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.007	0.008	0.069
2060	0.003	0.004	0.005	0.005	0.006	0.006	0.006	0.006	0.006	0.007	0.056
2061	0.001	0.002	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.045
2062	0.000	0.001	0.002	0.003	0.004	0.005	0.005	0.005	0.005	0.005	0.035
2063	0.000	0.000	0.001	0.002	0.003	0.004	0.004	0.004	0.004	0.005	0.027
2064	0.000	0.000	0.000	0.001	0.002	0.003	0.004	0.004	0.004	0.004	0.021
2065	0.000	0.000	0.000	0.000	0.001	0.002	0.002	0.003	0.003	0.004	0.015
2066	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.002	0.003	0.003	0.011
2067	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.003	0.007
2068	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002	0.004
2069	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.002
2070	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001
Total:											**44.477**

Table F-7 (continued)
Golden Eagle REA Debit: 2nd Generation Reproductive Losses from a Take in 2011
(REA Steps 12-13)

Year	Discount Factor	Total # Birds-- 1st Gen-- Reproducing Age**	# Reproducing Females	Total # 2nd Gen Fledglings	Bird-Years/ Fledgling in PV	2nd Gen Lost Bird-Years Total in PV
2017	0.84	0.284	0.114	0.114	2.992	0.340
2018	0.81	0.529	0.212	0.212	2.902	0.614
2019	0.79	0.784	0.313	0.313	2.815	0.882
2020	0.77	1.035	0.414	0.414	2.730	1.130
2021	0.74	1.271	0.508	0.508	2.649	1.346
2022	0.72	1.508	0.603	0.603	2.569	1.550
2023	0.70	1.685	0.674	0.674	2.492	1.680
2024	0.68	1.812	0.725	0.725	2.417	1.752
2025	0.66	1.895	0.758	0.758	2.345	1.778
2026	0.64	1.944	0.778	0.778	2.274	1.768
2027	0.62	1.963	0.785	0.785	2.206	1.732
2028	0.61	1.959	0.783	0.783	2.140	1.677
2029	0.59	1.935	0.774	0.774	2.076	1.607
2030	0.57	1.896	0.758	0.758	2.014	1.527
2031	0.55	1.845	0.738	0.738	1.953	1.441
2032	0.54	1.785	0.714	0.714	1.895	1.352
2033	0.52	1.717	0.687	0.687	1.838	1.262
2034	0.51	1.645	0.658	0.658	1.783	1.173
2035	0.49	1.570	0.628	0.628	1.729	1.086
2036	0.48	1.493	0.597	0.597	1.677	1.001
2037	0.46	1.415	0.566	0.566	1.627	0.921
2038	0.45	1.337	0.535	0.535	1.578	0.844
2039	0.44	1.260	0.504	0.504	1.531	0.772
2040	0.42	1.185	0.474	0.474	1.485	0.704
2041	0.41	1.112	0.445	0.445	1.440	0.641
2042	0.40	1.015	0.406	0.406	1.397	0.567
2043	0.39	0.924	0.370	0.370	1.355	0.501
2044	0.38	0.830	0.332	0.332	1.314	0.437
2045	0.37	0.736	0.295	0.295	1.275	0.376
2046	0.36	0.645	0.258	0.258	1.237	0.319
2047	0.35	0.554	0.222	0.222	1.200	0.266
2048	0.33	0.475	0.190	0.190	1.164	0.221
2049	0.33	0.406	0.162	0.162	1.129	0.183
2050	0.32	0.346	0.138	0.138	1.095	0.151
2051	0.31	0.294	0.118	0.118	1.062	0.125
2052	0.30	0.249	0.100	0.100	1.030	0.103
2053	0.29	0.211	0.084	0.084	0.999	0.084
2054	0.28	0.177	0.071	0.071	0.969	0.069
2055	0.27	0.148	0.059	0.059	0.940	0.056
2056	0.26	0.124	0.049	0.049	0.912	0.045
2057	0.26	0.103	0.041	0.041	0.885	0.036
2058	0.25	0.084	0.034	0.034	0.858	0.029
2059	0.24	0.069	0.028	0.028	0.832	0.023
2060	0.23	0.056	0.022	0.022	0.807	0.018
2061	0.23	0.045	0.018	0.018	0.783	0.014
2062	0.22	0.035	0.014	0.014	0.760	0.011
2063	0.22	0.027	0.011	0.011	0.737	0.008
2064	0.21	0.021	0.008	0.008	0.715	0.006

Table F-7 (continued)
Golden Eagle REA Debit: 2nd Generation Reproductive Losses from a Take in 2011
(REA Steps 12-13)

2065	0.20	0.015	0.006	0.006	0.693	0.004
2066	0.20	0.011	0.004	0.004	0.673	0.003
2067	0.19	0.007	0.003	0.003	0.652	0.002
2068	0.19	0.004	0.002	0.002	0.633	0.001
2069	0.18	0.002	0.001	0.001	0.614	0.000
2070	0.17	0.001	0.000	0.000	0.595	0.000
Total		44.477	17.791	17.791		**34.238**

Table F-8
Golden Eagle REA Debit: Extrapolation of the Debit from a Take in 2011 to the Total Debit for a Five-Year Renewable Permit

Year	PV Bird-Years
2011	103.155
2012	100.061
2013	97.059
2014	94.147
2015	91.323
Total PV Bird-Years	485.745

Table F-9
Golden Eagle REA Mitigation: Lethal Electric Power Pole Retrofitting; The Avoided Loss of Direct and Reproductive Bird-Years Associated with The Relative Productivity of 0.0102 Bird-Years per Pole in 2011
(REA Steps 14-15)

Source of Bird-Years	PV Bird-Years
Avoided Direct Loss of Eagles:	0.06
Avoided Loss--1st Gen	0.08
Avoided Loss--2nd Gen	0.07
Avoided Loss of Eagle Reproduction:	0.15
Relative Productivity (Direct+ Reproductive):	**0.21**

PV= Present Value

Table F-10
Golden Eagle REA Mitigation: Extrapolation of the Relative Productivity of Electric Pole Retrofitting in 2011 Over the 30 Years Associated with the Average Life Cycle of Wind Energy Projects

Year	PV Bird-Years/pole
2011	0.210
2012	0.204
2013	0.198
2014	0.192
2015	0.186
2016	0.181
2017	0.175
2018	0.170
2019	0.165
2020	0.160
2021	0.155
2022	0.151
2023	0.146
2024	0.142
2025	0.137
2026	0.133
2027	0.129
2028	0.125
2029	0.122
2030	0.118
2031	0.114
2032	0.111
2033	0.108
2034	0.104
2035	0.101
2036	0.098
2037	0.095
2038	0.092
2039	0.090
2040	0.087
Total PV Bird-Years	4.202

Table F-11
Golden Eagle REA Scaling: Mitigation Owed for a 5-Year Permitted Take of 25 Golden Eagles (5 Eagles Annually)
(REA Step 16)

Total Debit	485.74	PV bird-years for 5 years of Golden Eagle take
÷ Relative Productivity of Electric Pole Retrofitting	÷4.20	Avoided loss of PV bird-years per retrofitted pole
= Mitigation owed	=115.61	Poles to be retrofitted to achieve no net loss

PV=Present Value

APPENDIX G

COMPENSATORY MITIGATION CASE STUDY[7]: POWER POLE RETROFITTING TO COMPENSATE FOR TAKE OF GOLDEN EAGLES

To offset projected and permitted take, retrofitting of non- Avian Power Line Interaction Committee (APLIC) compliant power poles has been selected by the Service as the initial focus of compensatory mitigation projects. Raptor electrocution is a known source of eagle mortality in the United States (Franson *et al.* 1995, Millsap *et al.* 2004, APLIC 2006, Lehman *et al.* 2007, Lehman *et al.* 2010). In particular, Golden Eagles are electrocuted more than any other raptor in North America; Lehman *et al.* (2007) noted Golden Eagles accounted for 50 – 93% of all reported mortalities of raptor electrocutions. Eagles often come into contact with non-APLIC compliant electric transmission poles. These poles are often responsible for the high incidence of eagle mortality, especially in open habitat devoid of natural perches.

Specific utility poles and line spans in need of retrofit due to known mortalities of eagles and other large raptors will be reviewed by the Service and selected for retrofit based on criteria specified below. Those ‘problem’ power poles and line spans will be referred to the utility companies to be replaced or retrofitted to make them safer for eagles.

The Service will concentrate compensatory mitigation on utility lines meeting the following categories:

1. Known eagle and raptor mortalities from specific power poles and/or span of line.
2. Located where topographic features suggest power poles and/or span of line is the sole perch, elevated above surrounding terrain, and/or provides a broad field of view.
3. Power pole and/or span of line is located 1) near and eagle territory or migration route, or 2) has a high incidence of eagles in the area documented through Breeding Bird Surveys, Christmas Bird Counts, or other annual standardized surveys.
4. Power pole and/or span of line has not received retrofit action since its initial construction.
5. Can be retrofitted within 1 year of permit issuance.
6. Power poles occur in same Bird Conservation Region as take is occurring.
7. Has already been identified as a priority replacement in an existing Avian Protection Plan.

Lehman *et al.* (2007:159) reviewed raptor electrocution literature and found that few research projects could “*demonstrate the reliability of standardized retrofitting procedures.*” Because of the lack of effective monitoring of attempts to reduce power-line mortalities through retrofitting procedures, the Service will emphasize that standardized, unbiased effectiveness monitoring techniques will be used by project proponents and utility companies involved in the compensatory mitigation process as a standard practice. Specific monitoring methods and study

[7] This REA for this case study used parameter estimates specific to golden eagles in the western United States and applies only to take associated with wind facilities and compensatory mitigation in the form of non-APLIC compliant power pole retrofits.

design will be pre-approved by the Service prior to final contracting for any and all monitoring activities. In all phases of this process, the Service's Office of Law Enforcement will be directly involved.

As stated in the Compensatory Mitigation section, a project proponent will have three options for providing compensatory mitigation:

> *Directly contract and fund a Service-approved compensatory mitigation project* - If a project proponent elects to directly contract for the mitigation project, the number of power poles retrofitted must be equivalent to or exceed the REA-generated estimate. The project proponent will have the burden of contracting either with the utility company owning the power poles or a third party to have the power poles retrofitted to protect eagles. Within one year of permit issuance, the project proponent will be responsible for providing the Service with evidence that the mitigation project was completed in the form of 1) documentation showing that the project proponent was financially responsible for the purchase of retrofitting equipment, 2) digital photographs of each power pole retrofitted, and 3) a Geographic Information System (GIS) shapefile containing the locations of all power poles retrofitted. The utility company will be responsible for effectiveness monitoring and maintenance of the retrofits.
>
> *Contribute funds to the National Fish and Wildlife Foundation's Bald and Golden Eagle Protection Act account (NFWF BGEPA)* - If a project proponent elects to contribute to the Service's NFWF NBGEPA account, the monetary contribution will be equivalent to the cost associated with retrofitting the number of power poles generated as compensation from the REA. The Service will use an estimate of $1,000 per pole for determining the monetary contribution based on current estimates ranging from $400 to >$2,000 per pole. These funds will be used to contract directly with a utility company or third party to have power poles retrofitted or otherwise removed to protect eagles. The utility company will be responsible for effectiveness monitoring and maintenance of the retrofits.
>
> *Identify and contribute funds to a third-party mitigation account approved by the Service* - If a project proponent elects to contribute to a third party account, the monetary contribution will be equivalent to the cost associated with retrofitting the number of power poles generated as compensation from the REA. The Service will use an estimate of $1,000 per pole for determining the monetary contribution based on current estimates ranging from $400 to >$2,000 per pole. These funds will be used to contract directly with a utility company or third party to have power poles retrofitted or otherwise removed to protect eagles. Within one year of permit issuance, the contractor will be responsible for providing the Service with evidence that the mitigation project was completed in the form of (1) documentation showing that the contractor was financially responsible for the purchase of retrofitting equipment, (2) digital photographs of each power pole retrofitted, and (3) a Geographic Information System (GIS) shapefile containing the locations of all power poles retrofitted. The utility company will be responsible for effectiveness monitoring and maintenance of the retrofits.

Any fiduciary delivery method should consider the costs of compensating for permitted take via the power pole retrofitting requirement, as well as contributing additional funds to cover the account's overhead charges. For example, the NFWF has minimal overhead charges; other mitigation accounts charges vary. If the NFWF BGEPA account is charged 5% overhead, then the project proponent must cover that overhead charge in addition to the compensatory mitigation charge.

In all three options above, the utility company receiving funds from either the project proponent or a mitigation account will be responsible for monitoring the effectiveness of power pole retrofits and the post-construction maintenance. The costs associated with these activities are not included as compensatory mitigation for permitted take, and therefore, are the responsibility of the utility company. Immediately following the completion of retrofits, monitoring will begin and include: 1) an initial survey to remove all carcasses from within a 10-meter radius centered on the base of each power pole; 2) monthly surveys for no less than 24 months to identify any post retrofit mortalities; 3) all mortalities and associated information should be reported to the Service using the Bird Injury and Mortality Reporting System (BIMRS) within 48 hours; and 4) submittal of monitoring reports to the local Service Ecological Services Field Office annually.

This initial effectiveness monitoring would insure that the method selected to retrofit power poles was immediately effective in stopping raptor mortality caused by the individual pole, or string of utility structures. In addition to this effectiveness monitoring, the utility company would also be responsible for monitoring and maintaining the retrofitted poles over their lifespan; for example, insuring that the retrofit maintains its effectiveness over a period of at least 25 years. This may include replacing any damaged or degraded plastic sleeves used to eliminate or reduce electrocution risk on one or multiple power poles. For a utility company that receives mitigation funds, we encourage development of an APP if they currently do not have one in place.

Monitoring reports should include the following minimal information for any detected mortalities:

1. Date.
2. Species (eagle carcasses must be submitted to the National Eagle Repository).
3. Age and sex.
4. Band number and notation if wearing a radio transmitter or auxiliary marker.
5. Observer name.
6. Decimal-degree latitude longitude or UTM coordinates of the pole and carcass.
7. Condition of the carcass (entire, partial, scavenged).
8. Power pole identification number.
9. High resolution photo of carcass.
10. Distance of the carcass from the pole.
11. Azimuth of the carcass from the pole.
12. Type of power pole.
13. High resolution photo of pole (to include the electrical structure).

As an example of how this process will work regarding contributions to the NFWF BGEPA account (or similar account), we provide the following example derived from the REA for the annual take of five Golden Eagles:

> For this example, we assume an annual take of five Golden Eagles over a five year renewable permit, starting in 2011. This power pole retrofit would occur in calendar year 2011, thus avoiding the potential loss of Golden Eagles from electrocution. Proper operation and maintenance by the utility company of all retrofitted poles is an assumption; hereafter required for the 30-year life cycle of the wind power project. The results of the model are expressed in the total number of electric power poles to be retrofitted to equate to no net loss of 25 Golden Eagles. The REA has estimated 116 power poles will need to be retrofitted to compensate for the estimated take of 25 eagles. The cost of the retrofit of the power poles may then be converted to an estimated minimum total cost of compensatory mitigation funded by the project proponent. If the project proponent chooses to contribute to an account, the cost will be $116,000 ($1,000 per pole X 116 poles) plus any administrative account overhead charges. At the 5 year renewal period for the life of the project, the Service will generate a new REA estimate for compensatory mitigation based on revised take estimates and any new cost estimates.

APPENDIX H

STAGE 5 – POST-CONSTRUCTION MONITORING RECOMMENDED METHODS AND METRICS

1. Fatality Monitoring

Fatality monitoring must be conducted at all wind facilities to meet regulatory permit requirements and should include a rigorous monitoring design that is able to accurately detect mortality events that result from all aspects of the facility operation (e.g., turbine collision, electrocution, collision with utility lines, etc). Fatality monitoring for eagles can be combined with monitoring mortality of other wildlife (and herein we borrow heavily from the *U.S. Fish and Wildlife Service Draft Wind Energy Guidelines*) so long as sampling intensity takes into account the relative infrequency of eagle mortality events. Fatality-monitoring efforts involve searching for eagle carcasses beneath turbines and other facilities to estimate the number of fatalities. The primary objectives of these efforts are to: (1) estimate eagle fatality rates for comparison with the model-based predictions prior to construction, and (2) to determine whether individual turbines or strings of turbines are responsible for the majority of eagle fatalities, and if so, the factors associated with those turbines that might account for the fatalities and which might be addressed via Advanced Conservation Practices (ACPs). This information is also relevant for evaluating micro-siting options when planning a future facility or expansion of the existing facility.

Fatality monitoring results should be of sufficient statistical validity to provide a reasonably precise estimate of the eagle mortality rate at a facility to allow meaningful comparisons with pre-construction predictions, and to provide a sound basis for determining if, and if so which, ACPs might be appropriate. The basic method of measuring fatality rates is the carcass search. All fatality monitoring should include estimates of carcass removal and carcass detection bias (scavenger removal and searcher efficiency) likely to influence those rates, using the currently accepted methods. Fatality and bias correction efforts should occur across all seasons to assess potential temporal variation. Where seasonal eagle concentrations were identified in the Stage 2 assessment, sampling protocols should take these periodic pluses in abundance into account in the sample design.

Some general guidance is given below with regard to the following design issues relative to protocols for fatality monitoring:

1. Duration and frequency of carcass searches.
2. Number of turbines to monitor.
3. Delineation of carcass search plots, transects, and habitat mapping.
4. General search protocol guidance.
5. Field bias and error assessment.
6. Estimators of fatality.

More-detailed descriptions and methods of fatality-search protocols for wildlife in general can be found on the Service Wind website at (http://www.fws.gov/habitatconservation/windpower/wind_turbine_advisory_committee.html).

a. Duration and Frequency of Carcass Searches

As noted previously, fatality monitoring will be required for a minimum of three years at all permitted facilities, likely followed by at least two additional years (or potentiallymore if permits are renewed), perhaps at lower intensity, to assess effectiveness of ACPs. This requirement is consistent with the permit condition stating that periodic monitoring may be required for as long as the data is needed to assess eagle impacts for ongoing activities that continue to cause take (50 CFR 22.26(c)(2)). The carcass-searching protocol should be adequate to estimate the density of eagle carcasses at an appropriate level of precision to make general conclusions about the project.

Carcass searches should occur in all seasons when eagle use of the project area is expected. The sampling protocol should take into possible temporal stratification to account for seasonal pulses in eagle occurrence. The search interval is the interval between carcass searches at individual turbines, and this interval may be lengthened or shortened depending on the carcass removal and decomposition rates and results of field bias and error trials. For large birds like eagles where carcass removal rates are typically low, a longer interval between searches may be sufficient. We recommend using a pilot study to determine an appropriate sampling frequency needed to estimate the density of eagle carcasses with a coefficient of variation (CV) of about 0.2.

b. Number of Turbines to Monitor

We recommend that a sufficient number of turbines be selected via a systematic sample with a random start point. A power analysis could be a useful tool to help decide the appropriate number of turbines to sample to achieve the desired CV in the fatality estimate. Sampling plans can be varied (e.g., rotating panels [McDonald 2003, Fuller 1999, Breidt and Fuller 1999, and Urquhart et al. 1998]) to increase efficiency as long as a probability sampling approach is used. If the project contains fewer than 10 turbines, it is recommended that all turbines in the area of interest be searched unless otherwise agreed to by the permitting or wildlife resource agencies. When selecting turbines, it is recommended that a systematic sample with a random start be used when selecting search transects to ensure interspersion among turbines. Stratification among different habitat types also is recommended to account for differences in fatality rates among different habitats (e.g., grass versus cropland or forest); a sufficient number of turbines should be sampled in each strata.

c. Delineation of Carcass Search Transects and Habitat Mapping

We recommend using a transect-based distance sampling framework for estimating fatalities (Buckland *et al.* 2001, 2004; Laing *et al.* 2003; Rivera-Milán *et al.* 2004). Three studies in Wisconsinshowed that bird carcasses could be found at least100 meters from the turbines (BHE Environmental, Inc. 2010; Drake *et al.* 2010; Gruver *et al.* 2009). We recommend using this distance as a general guide for placing transects relative to turbines, but final decisions regarding search transect placement should be made in discussions with the Service, state wildlife agency, local permitting agency, and/or tribes. Transect placement also needs to take into account distance-sampling assumptions that will need to be met in order to draw proper inferences from the data, including the assumption that transect distribution is independent of eagle carcass distribution (e.g., the perpendicular distance between any carcass and the transect centerline is independent of where the observer is along the centerline). Transects may need to be stratified according to vegetation or ground-cover class where delectability differs markedly between classes. If transects are so stratified, detection and removal biases need to be estimated for each class.

Fatality estimates in the form of carcass density estimates should be made for each class and summed for the total area sampled. Global positioning systems (GPS) are useful for accurately mapping the actual total area searched and area searched in each habitat visibility class, which can be used to adjust fatality estimates.

d. General Search Protocol Guidance

Personnel trained in proper search techniques should look for wildlife carcasses along transects or subplots within each plot and record and collect appropriate data (e.g., exact perpendicular distance from the transect center-line, GPS coordinates, and ancillary data outlined below).

Some locations and circumstances may best be searched using alternative methods such as human and dog teams (Arnett 2006). The olfactory capabilities of dogs could greatly improve the efficiency of carcass searches, particularly in dense vegetation (Homan *et al*. 2001) but using dogs also presents unique challenges that should be considered on a case by case basis. Other experimental mortality detection approaches (e.g., the use of bird-strike indicator sensors, such as microphones, accelerometers or fiber optic sensors, video cameras, or radar to identify circumstances of bird fatalities) are encouraged, but should be considered supplemental to transect surveys until their accuracy and utility has been confirmed by the project proponent and the Service. Where special techniques are employed to increase fatality detections, metadata associated with searches needs to clearly indicate when these tools were employed and when they were not so analyses can be appropriately partitioned.

Data that should be recorded for each search include:

1. Date.
2. Start time.
3. End time.
4. Interval since last search.
5. Observer.
6. Which turbine area was searched (including decimal-degree latitude longitude or UTM coordinates).
7. Weather data for each search, including the weather for the interval since the last search.

When a dead eagle is found, we recommend that the searcher place a flag near the carcass and continue the search. After searching the entire plot, the searcher should return to each carcass and record the following information on a fatality data sheet:

1. Date.
2. Species.
3. Age and sex (following criteria in Pyle 2008) when possible.
4. Band number and notation if wearing a radio-transmitter or auxiliary marker.
5. Observer name.
6. Turbine or pole number or other identifying character.
7. Distance of the carcass from the turbine or pole.
8. Azimuth of the carcass from the turbine or pole.
9. Decimal-degree latitude longitude or UTM coordinates of the turbine or pole and carcass.
10. Habitat surrounding the carcass.
11. Condition of the carcass (entire, partial, scavenged).
12. Description of the mortality (e.g., effect, wing shear, etc.).
13. Estimated time of death (e.g., $\leq$1 day, 2 days, etc.), and how estimated.
14. A digital photograph of the carcass should be taken.
15. Information on carcass disposition.

In some cases, eagle take permits may specify other biological materials or data that should be collected from eagle carcasses (e.g., feathers, tissue samples). Rubber gloves should be used to handle all carcasses to eliminate possible disease transmission and to reduce possible human-scent bias for carcasses later used in scavenger removal trials. All eagle fatalities (not just those found on post-construction surveys) and associated information should also be immediately reported to the OLE if the project proponent does not have a permit and to the Service's migratory bird permit issuing office if they have an eagle take permit. Mortality should also be reported to the Bird Injury and Mortality Reporting System (BIMRS) within 48 hours of discovery of a carcass. Examples of survey and fatality data sheets proposed for use should be included as attachments to the project proponent's ECP.

e. Field Bias and Error Assessment

Carcass searches underestimate actual mortalities at wind turbines. With appropriate sampling, however, carcass counts can be adjusted to account for biases in detection. Important sources of bias and error include: (1) low or highly variable fatality rates; (2) carcass removal by scavengers; (3) differences in searcher efficiency; (4) failure to account for the influence of site (e.g., vegetative) conditions in relation to carcass removal and searcher efficiency; and (5) fatalities or injured birds that may land or move outside search plots.

In situations like (1) above, when fatalities occur sporadically or in pulses, sampling error may be high. To account for this, we recommend that a sample of turbines be searched much more often than the overall sampling frame. To address bias categories 2-4 above, we recommend that all fatality monitoring efforts conduct carcass removal and searcher-efficiency trials using accepted methods (Kunz *et al.* 2007, Arnett *et al.* 2007, NRC 2007, Huso 2010; also see the

Service Wind website at:
http://www.fws.gov/habitatconservation/windpower/wind_turbine_advisory_committee.html).
Bias trials should be conducted throughout the entire monitoring period and searchers should be unaware of which turbines are to be used or the number of carcasses placed beneath those turbines during trials. There is no suitable method for addressing bias category 5 at present, although we anticipate that with increased post-construction monitoring, this factor will become better understood.

We recommend the following basic approach in designing bias and removal trials. Prior to a trial's inception, a list of random turbine numbers and random azimuths and distances (in meters) from turbines should be generated to guide placement of each carcass used in bias trials. Date of placement, species, turbine number, distance and direction from turbine, and visibility class surrounding the carcass should be recorded for each carcass. Before placement, each carcass should be uniquely marked in a manner that does not cause additional attraction, and its location should be recorded. There is no agreed upon sample size for bias trials, though some state guidelines recommend from 50 to 200 carcasses.

f. Disturbance Monitoring

Project proponents will also be required to monitor many of the eagle nesting territories and communal roost sites identified in the Stage 2 assessments for at least three years after project construction as stated in the permit regulations at 50 CFR 22.26(c)(2). The objective of such monitoring will be to determine if changes in (1) territory or roost occupancy rates, (2) nest success rates, or (3) productivity occur after project construction. Changes will be determined based on comparisons with mean values for each parameter from the Stage 2 assessment.

Eagle nesting territories most likely to be affected by disturbance from a wind facility are those that have use areas within or adjacent to the project boundary. In the absence of radio- or satellite-telemetry data to delineate the precise use areas of proximate nesting eagle pairs, the Service will accept an assumption that all pairs within the mean project-area inter-nest distance (as determined from the Stage 2 assessment) of the project boundary are territories that may be at risk of disturbance (e.g., if the mean distance between simultaneously occupied eagle territories in the Stage 2 assessment is five miles, we would expect disturbance to most likely affect eagles within 5 miles of the project boundary; Figures H-1 though H-4).

Where nesting habitat is patchy or eagle nesting density is low such that nearest neighbors are outside the survey area, we recommend either: (1) using a nearest-neighbor distance at the upper end of what has been recorded for the species in the literature as the project-area inter-nest distance (6.2 miles for Golden Eagles in western North America [Millsap 1981, Kochert *et al.* 2002], and 1.2 miles for bald eagles, from a study in Alaska [Sherrod et al.1976, Buehler 2000]); (2) extending the survey area outward to include nearest-neighbors (which, in this case, lie outside the project-area nesting-population boundary) for the purposes of estimating this value; or (3) undertaking detailed observational or radio- or satellite-telemetry studies of the adult eagles using the isolated nest site(s) to determine the home-range size. Regardless which approach is used, territories that meet this distance criterion should be re-sampled annually for at least three years post-construction following identical survey and reporting procedures as were used in the Stage 2 assessment.

If differences in territory occupancy, nest success, or productivity (taking into account statistical power limitations on detecting significant differences based on sample sizes) are observed, project proponents and the Service will consider possible ACPs that might reduce or eliminate disturbance, and if none are available, project proponents may be required to provide compensatory mitigation to offset the observed effective increase in mortality to the extent necessary to meet the statutory requirement to preserve eagles. For example, if the three-year average for productivity of proximate eagle territories in the Step 2 assessment was 0.8 young per territory over five territories, and during the post-construction monitoring the average was 0.2 young over the same five territories, the effective annual mortality rate from disturbance is 3 eagles per year.)

The Service and the project proponent should agree on a site-specific, post-construction survey protocol for eagle concentration areas identified in Stage 2 and make an *a priori* decision on how to interpret and act on potential outcomes. Mortalities of eagles using proximate communal roosts will be accounted for through the protocol for monitoring post-construction fatalities. However, if communal roosts are no longer used by eagles because of disturbance, that effect should be determined, quantified, and mitigated.

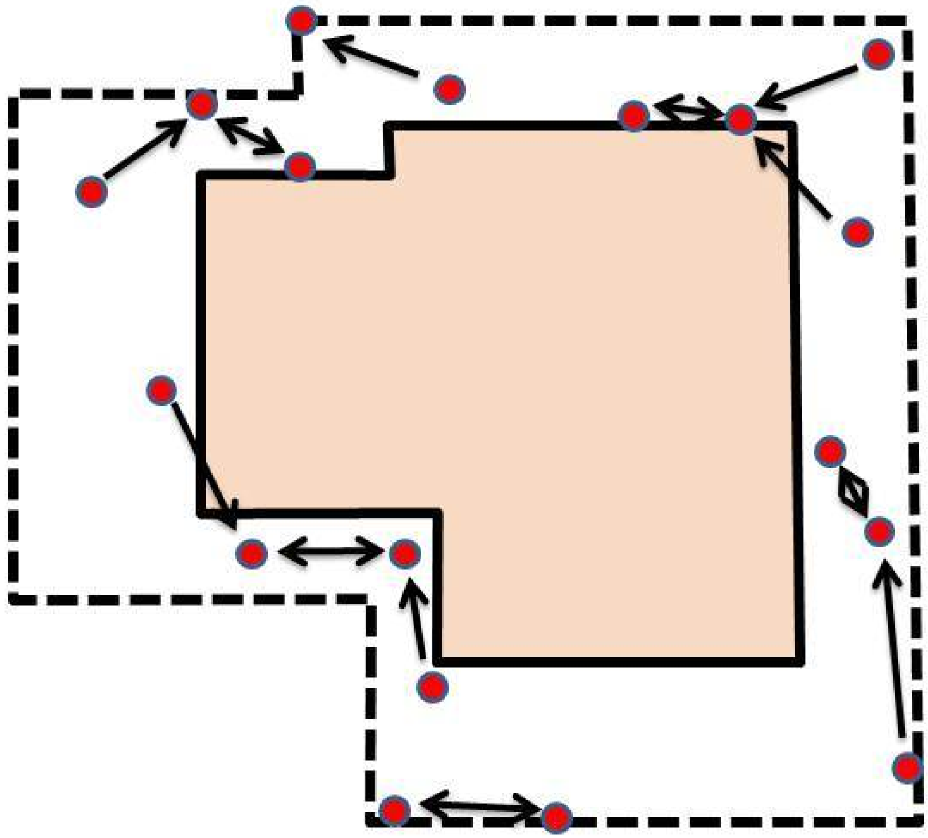


Figure H-1. Map showing hypothetical wind-facility project footprint (area inside the solid-black line, shaded peach), and the recommended project-area for eagle-use area surveys in Stage 2 (inside the dotted line). Red dots denote occupied eagle nests. Arrows represent distance measurements that would be collected and used in the calculation of the mean project-area inter-nest distance. In some cases, nests are reciprocal nearest neighbors (double arrows); in these cases the inter-nest distance is the same for both nests. In other cases, the relationship is not reciprocal (e.g., a nest's nearest neighbor may have closer to another nest; one-way arrows), in which case the two have different inter-nest distance values.

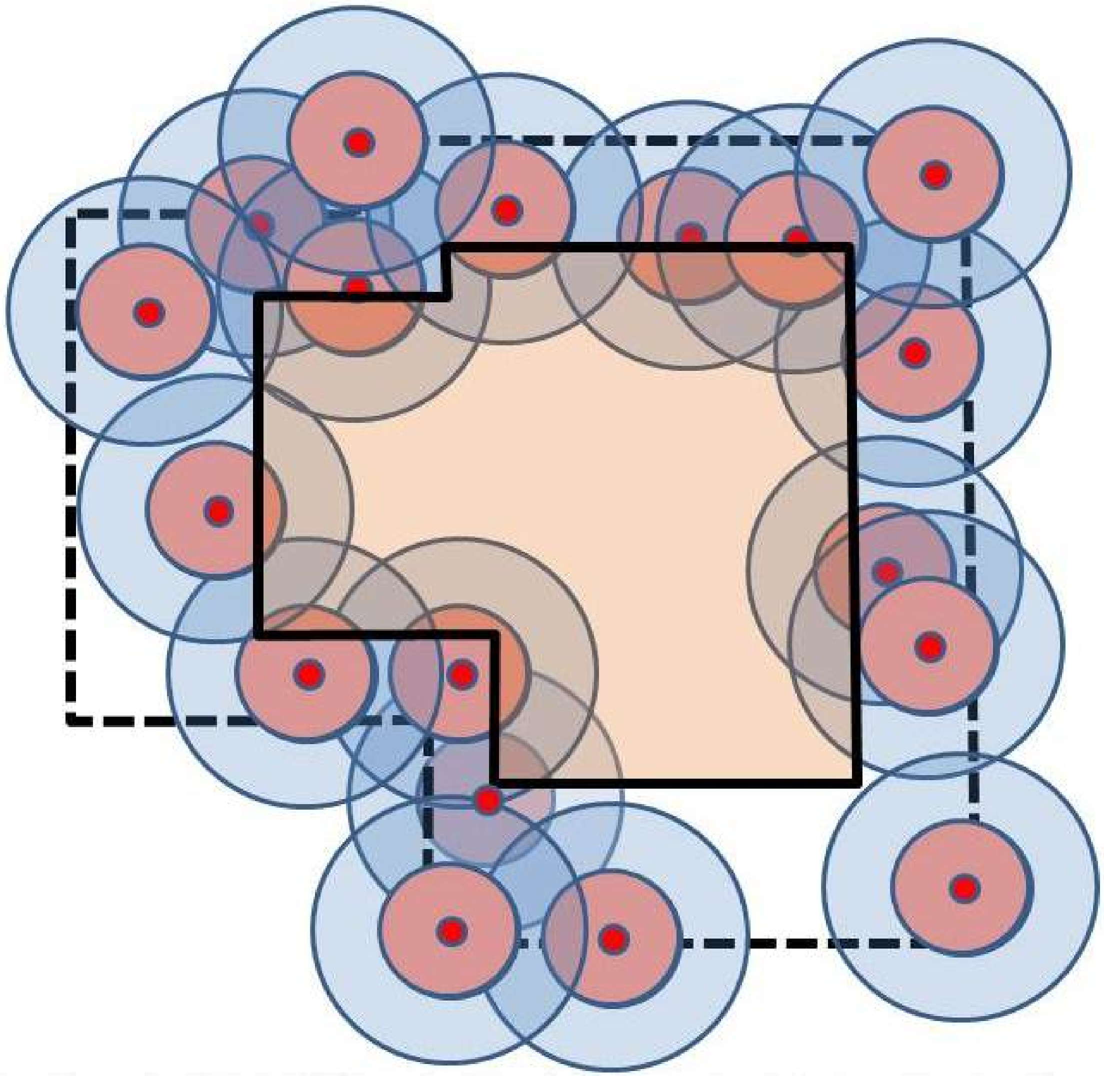


Figure H-2. Map of the same hypothetical wind-facility project as in Fig. H-1. Circles around occupied nests are at the radius of the mean project-area inter-nest distance (blue rings), and ½ the mean project-area inter-nest distance (pink rings), both calculated from the distance measurements collected as described in Fig. H-1.

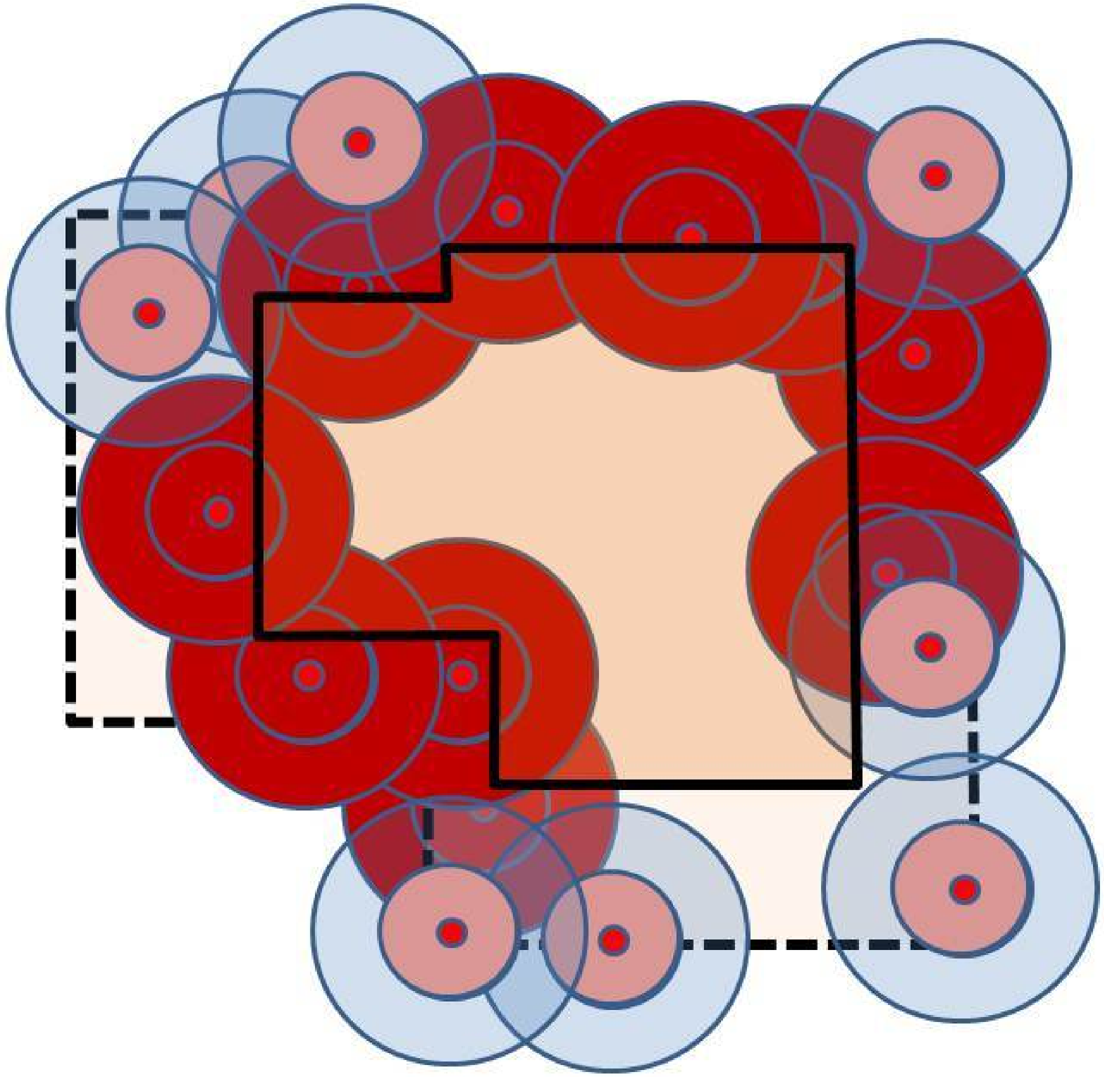


Figure H-3. Map of the same hypothetical wind-facility project area as in Figures H-1 and H-2, after applying site categorization criteria from the Guidelines. The site currently is in category 1 because the footprint includes important eagle-use areas, specifically the area within ½ the project-area inter-nest distance of those nests now highlighted in red.

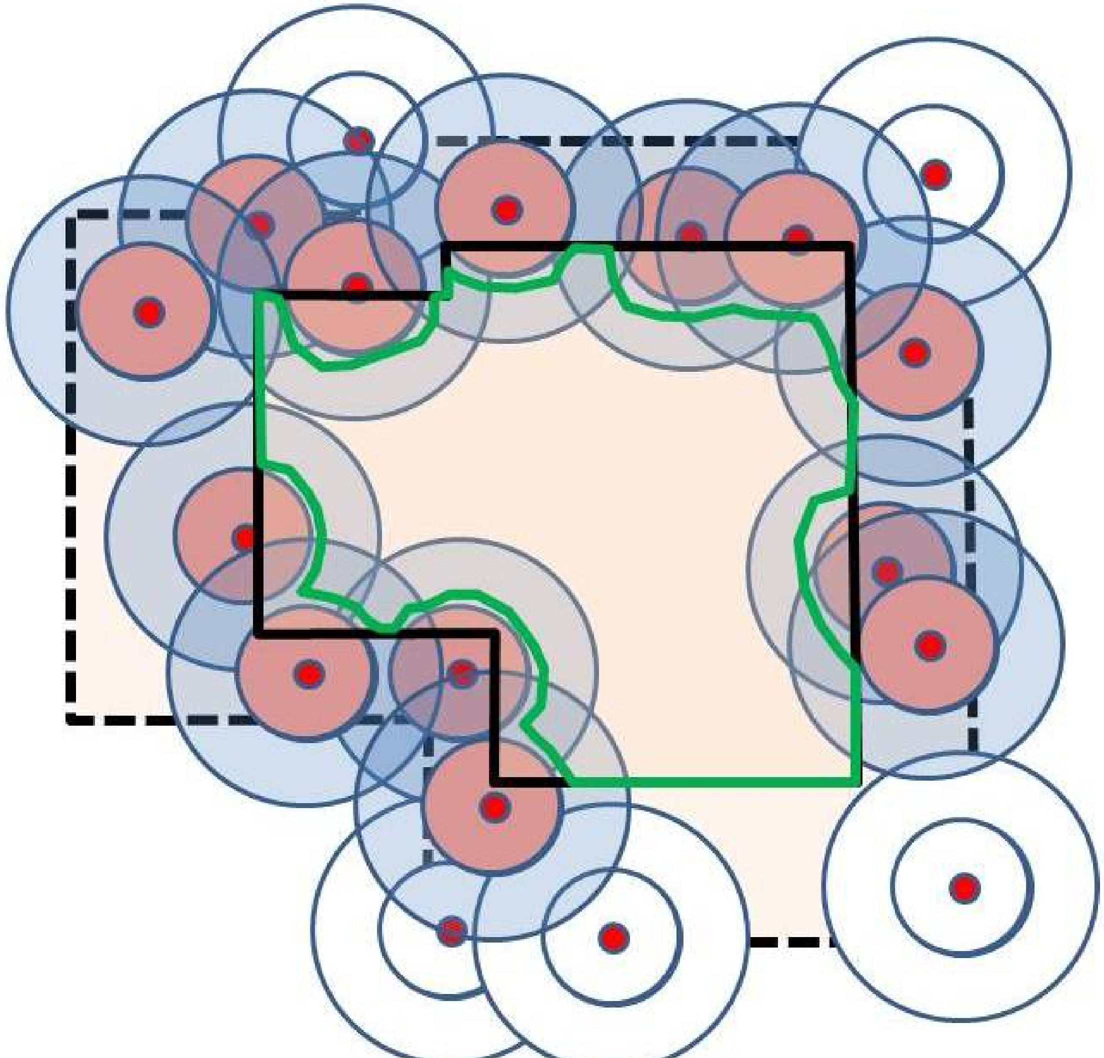


Figure H-4. The same hypothetical wind-facility project as in Figures H-1 – H-3, but re-designed such that the green line now includes the project footprint. The re-design results in the site now being placed in category 2. If the project moves forward and the project proponent receives a programmatic eagle take permit, those territories that are shaded should be monitored for disturbance effects following Stage 5 recommendations because they are at or within one project-area inter-nest distance of the project footprint.

Rowan Gould, Director U.S. Fish and Wildlife Service

Paul R. Schmidt, Assistant Director Migratory Bird Program, U.S. Fish and Wildlife Service