Appendix B

Bayesian Eagle Collision Risk Model

Goodnoe Hills Wind Project

1. Overview

This Appendix describes the details and assumptions of our modelling efforts that resulted in our predictions for both eagle species for the Goodnoe Hills Wind project (hereafter collectively referred to as 'Project').

Since all of the 47 wind turbines at the Project were constructed prior to September 11th, 2009, take at the original Project is part of "baseline" (USFWS 2016). However, repowering activities and a corresponding increase in hazardous area at the project occurred after Sept 11, 2009. The increase in eagle take resulting from this increase in hazardous area is not a part of "baseline" and, for golden eagles, must be offset by compensatory mitigation. Thus, this Appendix also describes details and assumptions of our modelling efforts for the increased hazardous area only.

Model details in this Appendix are specific to Alternative 2 in the associated EA. The Service also performed modelling to arrive at a unique fatality prediction for Alternative 3, but those details are not provided here. We decided it would be redundant to do so, since the only change in model inputs and assumptions between Alternative 2 and Alternative 3 was the use of fewer daylight hours.

1.1. Background

The Service uses explicit models in a Bayesian statistical framework to predict eagle fatalities at wind facilities while accounting for uncertainty. This model is hereafter referred to as the Collision Risk Model (CRM). The analysis presented below follows the Service's Eagle Conservation Plan Guidance version 2 (ECPG, USFWS 2013); a more detailed background on the Service's model and modelling framework are presented in Appendix D of the Technical Appendices of the ECPG.

The Service CRM is based on the assumption that there is a predictable relationship between pre-construction eagle exposure events (λ; eagle-minutes below 200m / hr·km^2) and subsequent annual fatalities resulting from collisions with wind turbines (F), such that:

$$F = \varepsilon \cdot \lambda \cdot C$$

where C is the probability of a collision given one minute of eagle flight within the hazardous area (see definition in the ECPG technical appendices), and ε is the expansion factor, a constant that describes the total area (or volume) and time within a project footprint that is potentially hazardous to eagles; this is used to expand λC, the number of birds killed per minute of exposure, into the annual number of predicted fatalities.

One advantage of using a Bayesian modelling framework is the ability to incorporate existing knowledge directly into the model by defining an appropriate prior probability distribution (hereafter "prior"). The Service has defined a prior distribution for eagle exposure (Gamma (0.97, 2.76)) based on the exposure rates across a range of projects under Service review and others described with sufficient detail in Whitfield (2009), and has defined a prior for collision probability (Beta (2.31, 396.69)) based on information from projects presented in Whitfield (2009). These prior distributions are updated with data collected from the wind facility under consideration to obtain posterior distributions (hereafter "posterior") that provide the project specific estimates of λ and C. Specifically, the exposure prior can be updated with pre-construction eagle use data collected at a site (note: when adequate pre-construction survey efforts are performed, the relative influence of the λ prior distribution on the resulting posterior λ becomes negligible). The collision probability prior can also be updated with post-construction fatality estimates if/when a project becomes operational. Details on these priors and how to update them can be found in the ECPG (USFWS 2013).

2. Calculating Model Variables

2.1. Exposure Rate Calculation (λ)

The exposure rate (λ) is defined in Appendix D of the Technical Appendices of the ECPG as the number of exposure events (eagle-minutes) per daylight hour per square kilometer. The exposure prior is defined in the ECPG as:

$$\textbf{Prior } \lambda \sim \textbf{\textit{Gamma}} \ \textbf{(0.97, 2.76)}$$

This prior assumes that the eagle use surveys collected data on the eagles flying between 0-200m above ground level. However, because many projects were constructed, or their pre-construction data collection completed, prior to the publication of the ECPG, pre-construction eagle survey methods are not always consistent with this assumption, which is laid out in the Service's recommendations in the ECPG. Exposure values calculated from data born from these surveys, especially where the 200m survey height was not achieved, may not be appropriate for use with the exposure prior as defined in the ECPG. However, deviations from the recommended survey height (i.e. survey ceilings less than or greater than 200m, or data only collected within a rotor swept zone) can be accounted for by re-defining the exposure rate as the number of exposure events per daylight hour per unit **volume (km^3)**, instead of unit area. When running the model with this three-dimensional exposure value, the exposure prior must also be adjusted as below:

$$\textbf{Volumetric Prior } \lambda \sim \textbf{\textit{Gamma}} \ \textbf{(0.968, 0.552)}$$

For projects that performed surveys at the recommended 200m survey height, or that did not perform surveys at all (i.e. only exposure priors were used in modelling), it matters not which of the above priors are used in modelling, the model outputs are the same. However, where the range of heights surveyed was not 0-200m as recommended, the Volumetric Prior should be used to account for this deviation.

Site specific exposure rates can be used to update either of the above exposure priors and determine a posterior distribution specific to a project area. The resulting posterior distribution (after updating the prior) is defined in the ECPG as:

$$\textbf{Posterior } \lambda \sim \textbf{\textit{Gamma}}\ (0.97 + \textstyle\sum_{i=1}^{n} ki,\ \ 2.76 + n)$$

or

$$\textbf{Volumetric Posterior } \lambda \sim \textbf{\textit{Gamma}}\ (0.968 + \textstyle\sum_{i=1}^{n} ki,\ \ 0.552 + n)$$

where *ki* is the summed number of eagle-minutes within the surveyed cylinder and where *n* represents the survey effort put forth – equal to either hr*km^2 (for the standard prior) or hr*km^3 (for the volumetric prior).

2.2. Pre-construction surveys

Pre-construction collection of eagle-use information did not occur within the project footprint. There may have been some avian survey points at adjacent proposed projects that overlapped the Goodnoe Hills project footprint, but it is not clear how applicable those survey points might be. Additionally, those surveys did not encompass an entire year and many were not performed prior to the construction of Goodnoe Hills.

For these reasons, we decided to run the CRM for both species with the un-updated exposure prior described above. The volumetric prior was used, although either prior would have been appropriate so long as it matched the values used in the Expansion Factor Calculation (Section 2.3).

2.3. Collision probability calculation (C)

The probability of collision (*C*) is the probability of an eagle colliding with a turbine for each minute of exposure (eagle-minutes in the hazardous area). The collision probability prior distribution is defined in Appendix D of the Technical Appendices of the ECPG as:

$$\textbf{Prior } C \sim \textbf{\textit{Beta}}\ (2.31, 396.69)$$

After construction, site-specific estimates of fatalities, based on post-construction fatality monitoring, can be used to update the collision probability prior. The posterior distribution (after updating of the prior) can be simply expressed[1] as:

$$\textbf{Posterior } C \sim \textbf{\textit{Beta}}\ (2.31 + f, 396.69 + g)$$

[1] Values in the equations are simplified to promote understanding. Actual parameters used in updated collision probability distributions were calculated using the R code attached below with functions provided with New *et al.* (2015) – see supporting information (Hyperlink: https://doi.org/10.1371/journal.pone.0130978.s001).

where *f* is the number of fatalities estimated to have occurred at the project and *g* is the estimated number of exposure events (represented by the exposure distribution) that did not result in a fatality. Once determined, this posterior distribution replaces the national collision probability prior in the model and can serve as a new prior for subsequent updates as new post-construction fatality monitoring data is collected and fatality estimates derived.

Two years of post-construction fatality surveys were conducted at the Project – one during 2009, and the other from April 2018 through March 2019. Because raw data from the 2009 monitoring effort was not available, we were not able to derive reliable fatality estimates for that effort. However, we were able to calculate a reliable fatality estimate from the 2018-2019 effort in Evidence of Absence (EoA). Inputs and bias trial data files used in the creation of these estimates are provided in Attachment 1 of this Appendix. The EoA software and details on this estimator can be obtained online at https://pubs.er.usgs.gov/publication/ds1055.

General assumptions made during EoA fatality estimation:

1) That each 100m radius search plot encompassed 95% of the area where an eagle carcass could be found around each turbine. This value was based on conclusions in Hull and Muir (2010) and was used when running EoA.
2) That *k* (the factor by which SE changes with each search of an area) is equal to 0.6. This value is the midpoint of the range recommended by Huso and Dalthorp (range: 0.5 to 0.7; pers. comm). This recommendation is based on information from Warren-Hicks (2013).
3) That actual eagle carcass removal rates at the Project are closely simulated by carcass persistence bias trials conducted in 2018-2019 (trials done with raptor carcasses). Data from 2018-2019 persistence trials were used when running EoA.

Table 2: Summary of post-construction fatality monitoring efforts and resulting eagle fatality estimates (yellow cells) used to update the collision probability prior.

Survey	Turbines Searched	Search Plot Radius (meters)	Search Frequency [$]	BAEA Carcasses Found	GOEA Carcasses Found	BAEA Annual Fatality Estimate*	GOEA Annual Fatality Estimate*
Apr 2018 – Mar 2019	47	100m	monthly	0	0	0.11	0.11

[$] Lists target search frequencies. Actual search frequencies varied slightly by turbine and with weather and other logistics at the site that occasionally made searches difficult/impossible/dangerous.
* Estimates account for biases from imperfect searcher efficiency, unsearched areas, and carcass removal rates – site-specific data on these biases were collected during monitoring efforts. Estimates are the Expected Value output from EoA.

One update to the collision probability prior was performed using the site-specific fatality estimate in Table 2, and the operational daylight hours and hazardous area from the project prior to repowering. Parameters of the resulting posterior distribution are listed below. These parameters describe the collision probability posteriors after the update, which become the new collision probability distribution to be used in the next update. The same prior parameters were derived for both species since the values were the same for each species.

Posterior C ~ *Beta* (2.417947, 716.9439)

2.4. Expansion Factor Calculation (ε)

2.4.1. Background Information

The expansion factor (ε) scales the resulting per unit fatality rate (fatalities per hr per km^2) to the daylight hours in one year (or other time period if desired) and total hazardous area within the project footprint. Since the Volumetric Exposure Prior is being used, the expansion factor must use a fatality rate that accounts for survey height (fatalities per hr per km^3) and account for volume of the hazardous area (km^3). Thus, the expansion factor is defined as the product of the total hazardous volume ($\delta = \pi \cdot r^2 \cdot h$, where r is the turbine rotor radius, h is 200 meters) and δ is summed across all turbines (nt = number of turbines) and daylight hours (τ).

$$\boldsymbol{\varepsilon = \tau \cdot \sum_{i=1}^{nt} \delta i}$$

For this Project we calculate four distinct expansion factors. The first two **(A and B)** are used to calculate fatality predictions under Alternative 2: **(A)** to be used when running the CRM for the entire project (to determine the authorized take to go on the permit), and **(B)** to be used when running the CRM for just the increased hazardous area resulting from the repowering of the project (to determine the amount of golden eagle take that must be mitigated for).

Another two **(C and D)** are used to calculate fatality predictions under Alternative 3: **(C)** to be used when running the CRM for the entire project (to determine the authorized take to go on the permit), and **(D)** to be used when running the CRM for just the increased hazardous area resulting from the repowering of the project (to determine the amount of golden eagle take that must be mitigated for).

2.4.2. Calculating Expansion Factor A

Expansion Factor A is to be used to predict fatalities at the entire project after repowering under Alternative 2. The total number of daylight hours over any 1-year period at the Project is estimated to be 4465.5 hours. If each turbine (n = 47) operates for all daylight hours, the total amount of hazardous daylight hours at the Project would be 209,879 turbine·hours. However, PacifiCorp has provided data that shows that not every turbine produces energy during every daylight hour. Put another way, each turbine is “feathered out” (i.e. blades turned parallel to the wind) for a percentage of each year.

By evaluating energy production data from November 2016 to January 2019, PacifiCorp estimated that all turbines at the Project combined to produce energy for an average of 136,286 daylight turbine·hours annually. PacifiCorp then extrapolated those turbine·hours to apply to the repowered Project. They estimated that the repowered project will operate for 175,441 daylight turbine·hours. Comparing this to the total number of available turbine·hours at the Project, eagles are thought to currently be at risk during 84 percent of the total daylight hours at the site.

We used PacifiCorp's data (above) to update the daylight hours when calculating the expansion factor for use in the Project CRM. By doing this, we assume that eagles were at risk only during daylight hours when turbines were producing energy; thereby assuming that risk to eagles was negligible during daylight hours when turbines were not producing energy.

The following expansion factor was used to run the CRM for both bald and golden eagles at the entire repowered Project under Alternative 2.

$$\boldsymbol{\varepsilon = 175{,}441 \text{ turbine·hours} \cdot (\pi \cdot (0.055\text{km}^2) \cdot 0.200\text{km}) = 333.45 \text{ hr·km}^3}$$

2.4.3. Calculating Expansion Factor B

Expansion Factor B is to be used to predict fatalities resulting from the increased hazardous area after repowering was completed under Alternative 2. This expansion factor will be used to run the CRM to predict fatalities that result from the repowering of the project. The prediction from this CRM will be used to calculate required compensatory mitigation for golden eagles under Alternative 2.

To calculate this expansion factor we use the same turbine·hours derived when calculating Expansion Factor A, but altered the hazardous volume to equal the increased hazardous area that resulted from the repowering of the Project.

The original hazardous radius at the Project was 46.25 meters, or 0.04625km. The total hazardous volume at each turbine was calculated to be 0.00134km^3. The new hazardous radius after repowering is 55 meters, or 0.055km. The total hazardous volume at each repowered turbine was calculated to be 0.00190km^3. The difference between these two volumes, which is the increase in hazardous volume between the original project and the repowered project, at each turbine is 0.000557km^3.

$$\boldsymbol{\varepsilon = 175{,}441 \text{ turbine·hours} \cdot 0.000557\text{km}^3 = 97.72 \text{ hr·km}^3}$$

2.4.4. Calculating Expansion Factor C

Expansion Factor C is to be used to predict fatalities at the entire project after repowering under Alternative 3. To calculate this expansion factor we start with the turbine·hours calculated when calculating Expansion Factor A (175,441) and further reduce them by 10%, which is the amount required to achieve a 10% reduction in the annual bald and golden eagle fatality predictions at the project. This equates to a reduction of 17,544.1 turbine·hours.

The following expansion factor was used to run the CRM for both bald and golden eagles at the entire repowered Project under Alternative 3.

$$\boldsymbol{\varepsilon = (175{,}441 - 17{,}544.1)\ \text{turbine·hours} \cdot (\pi \cdot (0.055\text{km}^2) \cdot 0.200\text{km}) = 300.11\ \text{hr·km}^3}$$

2.4.5. Calculating Expansion Factor D

Expansion Factor D is to be used to predict fatalities resulting from the increased hazardous area after repowering was completed under Alternative 3. This expansion factor will be used to run the CRM to predict fatalities that result from the repowering of the project. The prediction from this CRM will be used to calculate required compensatory mitigation for golden eagles under Alternative 3.

To calculate this expansion factor we use the same turbine·hours derived for Expansion Factor C, but altered the hazardous volume to equal the increased hazardous area that resulted from the repowering of the Project.

The original hazardous radius at the Project was 46.25 meters, or 0.04625km. The total hazardous volume at each turbine was calculated to be 0.00134km^3. The new hazardous radius after repowering is 55 meters, or 0.055km. The total hazardous volume at each turbine was calculated to be 0.00190km^3. The difference between these two volumes, which is the increase in hazardous volume between the original project and the repowered project, at each turbine is 0.000557km^3.

$$\boldsymbol{\varepsilon = (175{,}441 - 17{,}544.1)\ \text{turbine·hours} \cdot 0.000557\text{km}^3 = 87.95\ \text{hr·km}^3}$$

3. RUNNING THE BAYESIAN MODEL

3.1. Background

As described in Appendix D of the Technical Appendices of the ECPG, the Service's CRM calculates predicted fatalities using Gibbs sampling. As a result, the mathematical form of the posterior distribution is known because the distributions specified for the data and the prior are in the same family (known as conjugacy). To make inference on the parameters of interest (exposure and collision in this case), values are drawn from the mathematical representation of the exposure posteriors and collision probability posteriors described above (n = 1,000,000 for this Project) in order to obtain the posterior distribution of predicted fatalities. Distributions of predicted fatalities for both species at the Project under both action Alternatives (2 and 3) are depicted in the Figures below. Model results for both species, including the mean, standard deviation (SD), median (Q50), and 80th, 90th, and 95th quantiles (Q80, Q90, and Q95, respectively) are depicted in Table 5 through 8. Tables 5 and 6 depict fatality predictions under Alternative 2, both for the entire repowered projects (Table 5) and for the increased hazardous volume created from the repowering of the project (Table 6) for which compensatory mitigation will be required for golden eagles. Tables 7 and 8 depict fatality predictions under Alternative 3, both for the entire repowered projects (Table 7) and for the increased hazardous volume created from the repowering of the project (Table 8) for which compensatory mitigation will be required for golden eagles. R-code for the CRM runs described in this document are provided in this Appendix's Attachment A, using functions provided with New *et al.* (2015) – see supporting information (Hyperlink: https://doi.org/10.1371/journal.pone.0130978.s001

3.2. Alternative 2

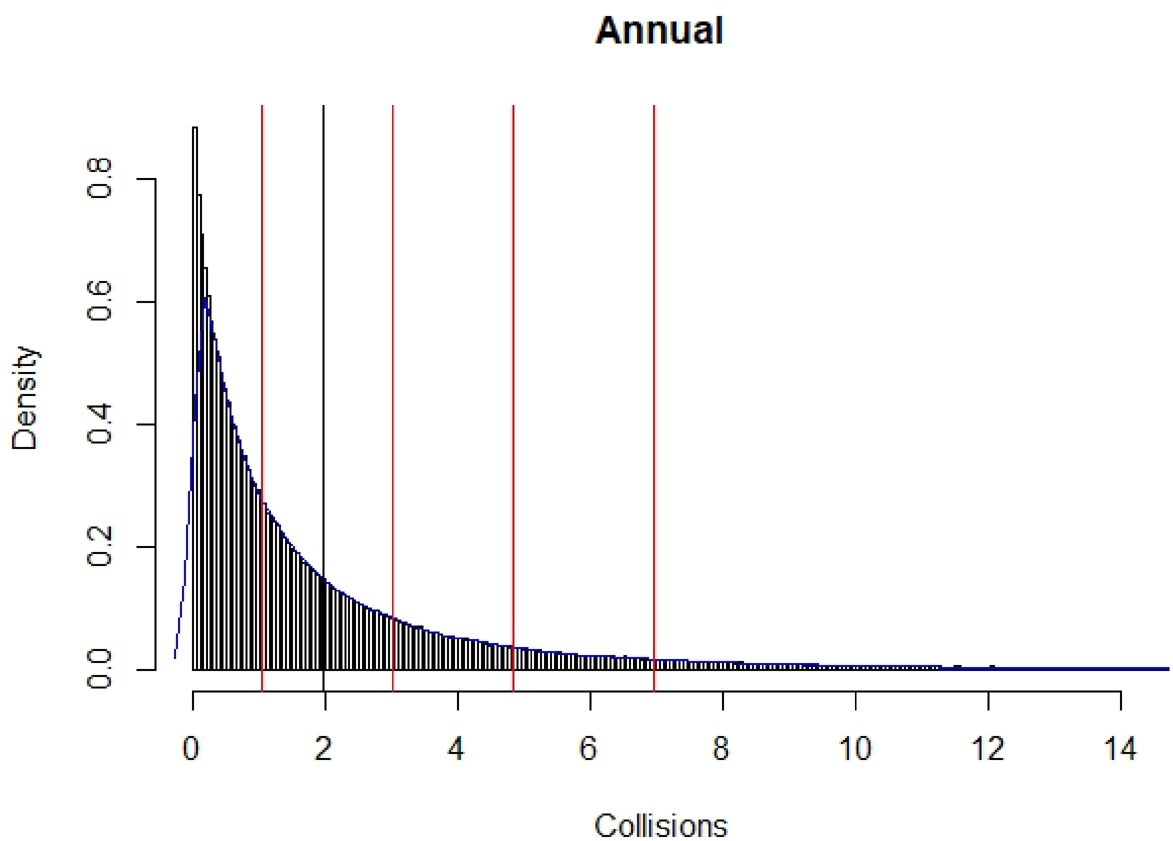

Figure 1 (above): Predicted eagle fatalities (for both eagle species) at the entire repowered project. The red vertical lines represent the 50th, 80th, 90th, and 95th quantiles (from left to right) of the distribution. The black line in each graph depicts the mean annual fatality prediction. The 80th quantile is the value the Service uses as a prediction of eagle fatalities.

Table 5: Summary of model outputs (take predictions in units 'eagles per year') for both species at the entire repowered project under Alternative 2 (using Expansion Factor A). Outputs include the mean, standard deviation (SD), median (Q50), 80th quantile (Q80), 90th quantile (Q90), and 95th quantile (Q95) for each species. The yellow output is the predicted annual take for all 47 repowered turbines. This value will be used to calculate the total predicted take across the permit tenure under Alternative 2.

	Mean	SD	Q50	Q80	Q90	Q95
Annual Prediction	1.97	2.68	1.05	3.01	4.85	6.95

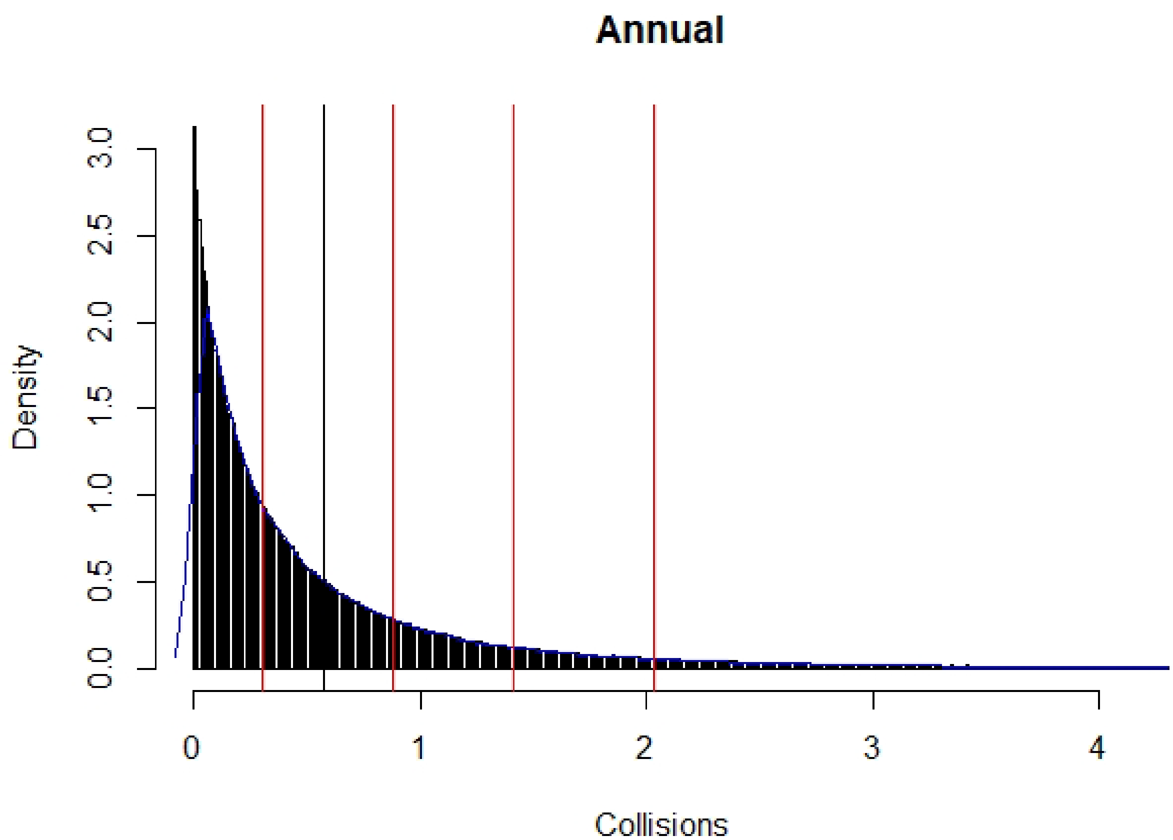

Figure 2 (above): Predicted eagle fatalities (for golden eagles) resulting from only the increased hazardous area. The red vertical lines represent the 50th, 80th, 90th, and 95th quantiles (from left to right) of the distribution. The black line in each graph depicts the mean annual fatality prediction. The 80th quantile is the value the Service uses as a prediction of eagle fatalities.

Table 6: Summary of model outputs (take predictions in units 'eagles per year') for golden eagles only from the increased hazardous area under Alternative 2 (using Expansion Factor B). Outputs include the mean, standard deviation (SD), median (Q50), 80th quantile (Q80), 90th quantile (Q90), and 95th quantile (Q95). The yellow output is the predicted annual take resulting from the increased hazardous are at the project after repowering. This value will be used to calculate the compensatory mitigation requirement for golden eagles under Alternative 2.

	Mean	**SD**	**Q50**	**Q80**	**Q90**	**Q95**
Annual Prediction	0.57	0.79	0.31	0.88	1.42	2.03

3.3. Alternative 3

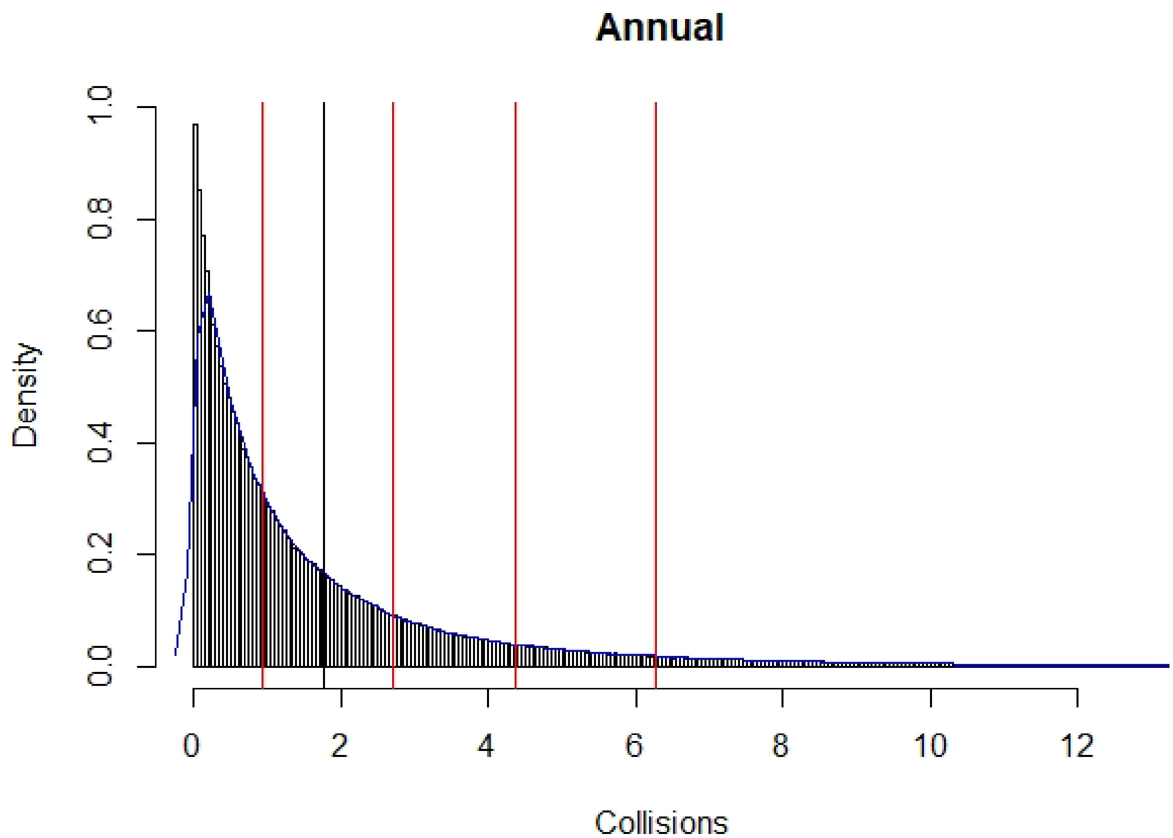

Figure 3 (above): Predicted eagle fatalities (for both eagle species) at the entire repowered project. The red vertical lines represent the 50th, 80th, 90th, and 95th quantiles (from left to right) of the distribution. The black line in each graph depicts the mean annual fatality prediction. The 80th quantile is the value the Service uses as a prediction of eagle fatalities.

Table 7: Summary of model outputs (take predictions in units 'eagles per year') for both species at the entire repowered project under Alternative 3 (using Expansion Factor C). Outputs include the mean, standard deviation (SD), median (Q50), 80th quantile (Q80), 90th quantile (Q90), and 95th quantile (Q95) for each species. The yellow output is the predicted annual take for all 47 repowered turbines. This value will be used to calculate the total predicted take across the permit tenure under Alternative 3.

	Mean	SD	Q50	Q80	Q90	Q95
Annual Prediction	1.77	2.42	0.94	2.70	4.37	6.28

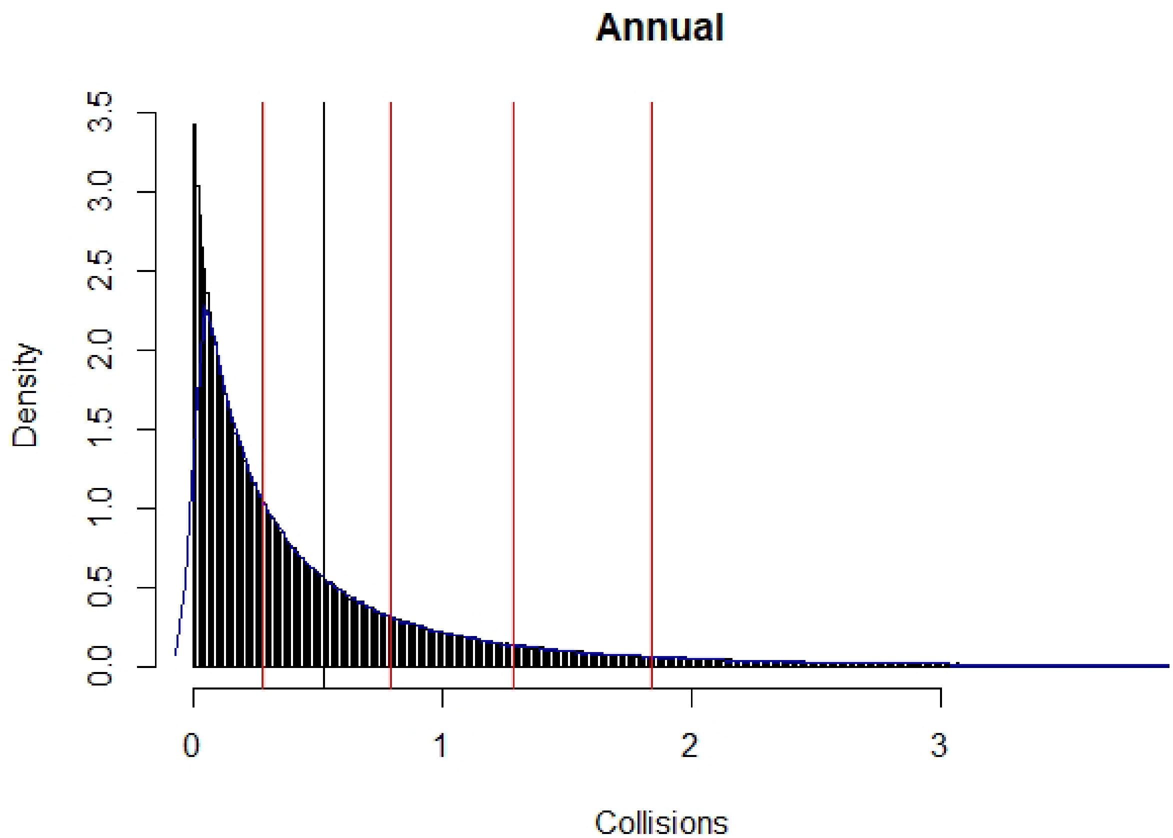

Figure 4 (above): Predicted eagle fatalities (for golden eagles) resulting from only the increased hazardous area. The red vertical lines represent the 50th, 80th, 90th, and 95th quantiles (from left to right) of the distribution. The black line in each graph depicts the mean annual fatality prediction. The 80th quantile is the value the Service uses as a prediction of eagle fatalities.

Table 8: Summary of model outputs (take predictions in units 'eagles per year') for golden eagles only from the increased hazardous area under Alternative 3 (using Expansion Factor D). Outputs include the mean, standard deviation (SD), median (Q50), 80th quantile (Q80), 90th quantile (Q90), and 95th quantile (Q95). The yellow output is the predicted annual take resulting from the increased hazardous are at the project after repowering. This value will be used to calculate the compensatory mitigation requirement for golden eagles under Alternative 3.

	Mean	**SD**	**Q50**	**Q80**	**Q90**	**Q95**
Annual Prediction	0.52	0.71	0.28	0.79	1.28	1.84

4. CONCLUSIONS

4.1. Authorized Take at the Project

Annual fatality predictions calculated and depicted in Tables 5 and 7 were used to calculate the amount of eagle take to be authorized over the tenure of a 30-year Eagle Incidental Take Permit. Our modelling conservatively predicts, at the 80th quantile, that 3.01 bald eagles and 3.01 golden eagles will be killed annually under Alternative 2, and 2.70 bald eagles and 2.70 golden eagles will be killed annually under Alternative 3 at the Project. Over 30 years, these annual predictions equate to 90.3 and 81.0 eagles of each species, respectively. If a 30-year eagle take authorization is given for this project, the Service would round these numbers up to the nearest whole number and authorize the incidental take of 91 bald eagles and 91 golden eagles over the 30-year permit term under Alternative 2, and 81 bald eagles and 81 golden eagles over the 30-year permit term under Alternative 3.

4.2. Golden Eagle Compensatory Mitigation Requirement

Annual fatality predictions calculated and depicted in Tables 6 and 8 were used to calculate the amount of golden eagle take that would need to be offset by compensatory mitigation over the tenure of a 30-year Eagle Incidental Take Permit. These same predictions were also used to calculate the amount of compensatory mitigation that would be required if the applicant chooses to provide such mitigation at 5-year intervals for the life of the permit. The modelling predicts, at the 80th quantile, that 0.88 golden eagles will be killed annually as a result of the increased hazardous area under Alternative 2, and 0.79 golden eagles will be killed annually as a result of the increased hazardous area under Alternative 3 at the Project. Over 30 years that equates to 26.4 and 23.7 golden eagles, respectively. If an eagle take authorization is given for this project, the Service would round this number up to the nearest whole numbers and require compensatory mitigation be provided for the take of 27 golden eagles over the a 30-year permit term under Alternative 2, or 24 golden eagles over the 30-year permit term under Alternative 3.

4.3. Administrative Check-ins

As outlined in the EA, the Service may amend the fatality prediction calculated here as project-specific eagle fatality data becomes available or as more is learned about species-specific eagle collision risk at wind projects. Such amendments would occur at scheduled administrative check-ins – not to occur less frequently than once every five years.

LITERATURE CITED

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ATTACHMENT A: R-Code

This attachment presents the R-code used to run the Service's CRM for both species. Sourced files can be found in New *et al.* (2015) – see supporting information (Hyperlink: https://doi.org/10.1371/journal.pone.0130978.s001). Code is presented for Alternative 2 only. The same code was used for Alternative 3, except that code included 17,544.1 fewer daylight hours (turbine·hours) to account for additional eagle conservation measures that would be required under that Alternative.

<u>Fatality Prediction for the entire repowered project:</u>

```
require(rv)
UCI<-c(0.5,0.8,0.9,0.95)
nSim<-1000000
nTurbine<-c(47)
HazRadKm<-c(46.25/1000)
HazKM3<-(0.2*pi*HazRadKm^2)
CntHr<-c(0/60)
ExpSvy<-data.frame(row.names=c("Annual"),
EMin=c(0),
nCnt=c(0),
CntKM3=c(0.2*pi*0.8^2),
DayLtHr<-c(136286))
Dead<-c(0.11)
AddTot<-TRUE

setnsims(nSim)
getnsims()
PlotFile<-NULL
nSvy<-nrow(ExpSvy)
cSvy<-(rownames(ExpSvy))
SmpHrKM3<-c(ExpSvy$nCnt*CntHr*ExpSvy$CntKM3)
ExpFac<-c(ExpSvy$DayLtHr*HazKM3)
postBH1<-simFatal(BMin=ExpSvy$EMin,
Fatal = Dead,
SmpHrKm=SmpHrKM3,ExpFac=ExpFac,aPriExp=0.9684375,bPriExp=0.5519703,
aPriCPr=2.31,bPriCPr=396.69)
postCPr<-attr(postBH1,"CPr")
postCPr
```

```
estBetaParams <- function(mu, var) {
  alpha <- ((1 - mu) / var - 1 / mu) * mu ^ 2
  beta <- alpha * (1 / mu - 1)
  return(params = list(alpha = alpha, beta = beta))
}
estBetaParams(0.003361239,0.002156469^2)
```

```
require(rv)
UCI<-c(0.5,0.8,0.9,0.95)
nSim<-1000000
nTurbine<-c(47)
HazRadKm<-c(55/1000)
HazKM3<-(0.2*pi*HazRadKm^2)
CntHr<-c(0/60)
ExpSvy<-data.frame(row.names=c("Annual"),
EMin=c(0),
nCnt=c(0),
CntKM3=c(0.2*pi*0.8^2),
DayLtHr<-c(175441))
# Dead<-c(x)
AddTot<-FALSE

setnsims(nSim)
getnsims()
PlotFile<-NULL
nSvy<-nrow(ExpSvy)
cSvy<-(rownames(ExpSvy))
SmpHrKM3<-with(ExpSvy,nCnt*CntHr*CntKM3)
ExpFac<-c(DayLtHr*HazKM3)
tmp<-with(ExpSvy,mapply(simFatal,BMin=EMin,
Fatal = -1,
SmpHrKm=SmpHrKM3,ExpFac=ExpFac,aPriExp=0.9684375,bPriExp=0.5519703,
aPriCPr=2.417947,bPriCPr=716.9439,SIMPLIFY=FALSE))
Fatalities<-rvnorm(nSvy)
Exp<-data.frame(Mean=rep(NA,nSvy),SD=NA,row.names=cSvy)
for(i in 1:nSvy){# i<-1 Fatalities[i]<-tmp[[i]] Exp[i,]<-attr(tmp[[i]],"Exp")}
rm(tmp)
names(Fatalities)<-cSvy
nSvy<-length(Fatalities)
if(is.null(nSvy))nSvy<-1
FatalStats<-RVSmry(cSvy,Fatalities,probs=UCI)
if(AddTot){  FatalStats<-rbind(FatalStats,RVSmry("Total",sum(Fatalities),probs=UCI))}
print(ModelDescription)
print(nTurbine)
print(HazRadKm)
print(CntHr)
print(ExpSvy)
print(ExpFac)
print(Exp,digits=3)
print(FatalStats,digits=3)
nPlot<-nSvy+as.integer(AddTot)
nCol<-floor(sqrt(nPlot))
nRow<-ceiling(nPlot/nCol)
xlim<-range(rvrange(Fatalities))
if(!is.null(PlotFile))jpeg(PlotFile)
par(mfrow=c(nRow,nCol))
```

```
for(iPlot in 1:nSvy){# iPlot<-1
plotFatal(Fatalities[iPlot],probs=UCI, main=cSvy[iPlot])}
if(AddTot)plotFatal(sum(Fatalities),main="Total")
if(!is.null(PlotFile))dev.off()
```

<u>Fatality Prediction for the increase in hazardous area only (using the same collision probability posterior):</u>

```
require(rv)
UCI<-c(0.5,0.8,0.9,0.95)
nSim<-1000000
nTurbine<-c(47)
NewHazRadKm<-(55/1000)
OldHazRadKm<-(46.25/1000)
HazKM3<-(sum(0.2*pi*NewHazRadKm^2)-(sum(0.2*pi*OldHazRadKm^2)))
CntHr<-c(0/60)
ExpSvy<-data.frame(row.names=c("Annual"),
EMin=c(0),
nCnt=c(0),
CntKM3=c(0.2*pi*0.8^2),
DayLtHr<-c(175441))
# Dead<-c(x)
AddTot<-FALSE

setnsims(nSim)
getnsims()
PlotFile<-NULL
nSvy<-nrow(ExpSvy)
cSvy<-(rownames(ExpSvy))
SmpHrKM3<-with(ExpSvy,nCnt*CntHr*CntKM3)
ExpFac<-c(DayLtHr*HazKM3)
tmp<-with(ExpSvy,mapply(simFatal,BMin=EMin,
Fatal = -1,
SmpHrKm=SmpHrKM3,ExpFac=ExpFac,aPriExp=0.9684375,bPriExp=0.5519703,
aPriCPr=2.417947,bPriCPr=716.9439,SIMPLIFY=FALSE))
Fatalities<-rvnorm(nSvy)
Exp<-data.frame(Mean=rep(NA,nSvy),SD=NA,row.names=cSvy)
for(i in 1:nSvy){# i<-1 Fatalities[i]<-tmp[[i]] Exp[i,]<-attr(tmp[[i]],"Exp")}
rm(tmp)
names(Fatalities)<-cSvy
nSvy<-length(Fatalities)
if(is.null(nSvy))nSvy<-1
FatalStats<-RVSmry(cSvy,Fatalities,probs=UCI)
if(AddTot){ FatalStats<-rbind(FatalStats,RVSmry("Total",sum(Fatalities),probs=UCI))}
print(ModelDescription)
print(nTurbine)
print(HazRadKm)
print(CntHr)
print(ExpSvy)
print(ExpFac)
print(Exp,digits=3)
```

```
print(FatalStats,digits=3)
nPlot<-nSvy+as.integer(AddTot)
nCol<-floor(sqrt(nPlot))
nRow<-ceiling(nPlot/nCol)
xlim<-range(rvrange(Fatalities))
if(!is.null(PlotFile))jpeg(PlotFile)
par(mfrow=c(nRow,nCol))
for(iPlot in 1:nSvy){# iPlot<-1
plotFatal(Fatalities[iPlot],probs=UCI, main=cSvy[iPlot])}
if(AddTot)plotFatal(sum(Fatalities),main="Total")
if(!is.null(PlotFile))dev.off()
```

ATTACHMENT B: EoA Carcass Persistence File

This attachment presents raw carcass persistence data that was used to arrive at the fatality estimates using EoA. Also included are screen shots of the inputs into EoA. Since no eagle remains were found during fatality monitoring, the fatality estimate derived from these inputs were the same for both species and for both Alternatives (2 and 3).

Persistence Trial Data:

CPmin	CPmax
20	32
3	7
3	Inf
7	10
3	Inf
3	Inf
112	Inf
112	Inf
56	Inf
14	21
32	41
59	Inf
0	3
56	Inf
56	Inf
3	7
21	29
58	Inf
58	Inf
49	58
58	Inf
58	Inf
58	Inf
14	21
58	Inf
3	7
57	85
41	57
95	Inf
95	Inf
57	85
20	38

<u>EoA Inputs</u>