Corr Chnoc Wind Farm

White-tailed Eagle Population Modelling

Technical Appendix 8.3

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1.0 Introduction

Population Viability Analysis (PVA) has been used to investigate the impact of additional mortality associated with wind turbine collisions on the future growth rates of the Natural Heritage Zone (NHZ) 14: Argyll West & Islands, and national (Scottish) white-tailed eagle populations.

The modelling approach used is similar to the that developed by RSPB Scotland on behalf of NatureScot using Vortex software (Lacy *et al.* 2005[1]) to predict the population trajectory of the re-introduced white-tailed eagle population in response to varying rates of additional mortality on adults and/or sub-adults due to identified threats such as illegal killing or wind farm collision mortality (Sansom *et al.* 2016[2]).

2.0 Model Methods and Assumptions

2.1 Model Parameters

There are four key demographic parameters in the model:

- number of occupied ranges;
- mean number of young fledged per pair per year;
- annual survival rate of young birds; and
- annual survival rate of adult, range-holding birds.

Estimates for the first two are available with a reasonable degree of confidence, due to the annual monitoring carried out as part of the Scottish Raptor Monitoring Scheme (SRMS)[3]. Although not all breeding attempts will be monitored in NHZ 14, or nationally, a reasonable estimate of minimum population size can be extrapolated from available monitoring data. It is also considered that there are enough nests monitored each year to provide a sufficiently accurate mean productivity rate for NHZ 14, and nationally.

The latter two (survival) parameters are more difficult to estimate, particularly at an NHZ level, and therefore the values in Sansom *et al.* (2016) have been used.

The parameters considered for assessing the potential impacts of additional collision mortality, and for comparison, those used in the Sansom *et al.* (2016) model, are outlined in **Table 1** below.

During population projections, to simulate environmental stochasticity, demographic rates at each time step were drawn at random from appropriate probability distributions (beta for survival, bounded at 0-1 and a stretched beta bounded at 0 and 3 for productivity[4]) and used to estimate the population at the following time step. Since small populations are at an

[1] Lacy, R. C., Borbat, M. & Pollak, J. P. (2005) Vortex: A stochastic simulation of the extinction process. Chicago Zoological Society, 9.50, Brookfield, IL.

[2] Sansom, A., Evans, R. & Roos, S. (2016) Population and future range modelling of reintroduced Scottish white-tailed eagles (Haliaeetus albicilla). Scottish Natural Heritage Commissioned Report No. 898.

[3] https://raptormonitoring.org/annual-report

[4] Morris, W.F. & Doak, D.F. (2002) Quantitative Conservation Biology: Theory and Practice of Population Viability Analysis. Sinauer Associates Inc., Sunderland, USA

elevated risk due to chance events, demographic stochasticity was also incorporated using a binomial method. The simulations were run as density independent with no feedback between population size and demographic rates.

Sansom *et al.* (2016) looked into the possibility of density-dependence acting on the national population, either at the time of writing or in future years. They found only limited indications of, at most, a weak density-dependent regulation of white-tailed eagles only in one or two areas, and no evidence of density-dependent population growth nationally in Scotland. For example, within the area with highest density of breeding white-tailed eagle pairs, the islands of Mull and Skye, there was no evidence that productivity had decreased with time or when the density of white-tailed eagles increased to current levels.

Here, the model was run for the baseline situation (i.e., without additional collision mortality), and for a range of additional annual mortalities, which could be attributable to wind turbine collisions. Comparison of the outputs from the paired baseline and impact simulations allows calculation of the relative change in population growth rate (counterfactual of population growth, C-PGR) and population size (counterfactual of population size, C-PS) predicted over a 25-year timeframe when additional losses occur, for the NHZ 14 and national populations.

Although the two counterfactual measures may appear to be equally informative with respect to understanding the population consequences of an impact scenario, the form of model used (density dependent or density independent) has an important bearing on which one is more appropriate. Consideration of the properties of density dependent and density independent population projections illustrates why this is:

- A population regulated by density dependent feedback will (all else being equal) maintain itself around an equilibrium level. Since there is no long-term growth or decline for such a population, when an impact is applied the population growth rate will only change in the short term, following which the population will once again settle at a new, lower, equilibrium size. Hence the change in growth rate (i.e. C-PGR) when using a density dependent model is of limited value for understanding the effect of an impact. In contrast, the change in population size (C-PS) provides useful information on how much smaller the population will be in the presence of the impact.
- Conversely, when a population is simulated without regulation (i.e. density independent), the population will grow or decline exponentially. The baseline and impacted predictions will both change in this manner but the difference in population size between the two will increase with duration as the baseline population grows more rapidly. Hence, the time point when the differences are considered is critical to the C-PS value obtained and how this is interpreted. However, the average growth rate (C-PGR) of a density independent population is constant and therefore, a comparison of the baseline and impacted growth rates is insensitive to the duration over which the comparison is made and therefore provides a more reliable and consistent assessment of the impact's effect on the population.

Thus, for density independent PVA, as presented here for white-tailed eagle (and in Sansom *et al*. 2016), the C-PGR is considered the more robust and reliable metric to use.

Table 1. Parameters used in the NatureScot and Corr Chnoc Wind Farm white-tailed eagle population models

Parameter	NatureScot Model	Values used in current PVA	Rationale
Number of breeding pairs: NHZ 14	n/a	25 to 45 pairs (in increments of 5 pairs)	In their EIA consultation response for Corr Chnoc Wind Farm (letter, 16 May 2025), NatureScot stated that "*it is agreed among raptor ornithologists that the NHZ14 population is unlikely to be more than c25pairs currently.*" 25 pairs is therefore presented as the worst-case scenario for NHZ 14. However, recent information indicates that the NHZ 14 population is significantly higher than this. In Argyll the population is now said to be circa 64 home ranges (as reported in the minutes of a 2025 meeting of the Raptor and Forestry Working Group, Alan Fielding *pers comm*). According to Scott Smith (Argyll RSG, *pers comm* with Alan Fielding), the number of pairs was uncertain during the years with Covid restrictions but there were 37/39 pairs in 2023 and 57/60 pairs in 2024. As there are circa 22 pairs on Mull, it is not unreasonable to conclude that there are in the region of (if not in excess of) 40 pairs on mainland Argyll plus Arran. This is due to the discovery of more home ranges in forestry, with some pairs taking over old osprey nests.
Number of breeding pairs: National (Scottish) population	90 pairs (in 2014)	200 pairs	A national population of around 200 pairs was recently estimated by NatureScot[5]. The national population is now likely to be closer to 220-240 pairs, based on unpublished information from raptor experts.
Carrying capacity	National population: None, 2,000, 3,000 and 4,000 individuals.	None	Most of the models presented in Sansom *et al.* (2016) did not specify any density-dependence in either breeding success or survival, and they assumed an infinite amount of available habitat and nest sites (i.e. no carrying capacity was set).
Survival rate from fledging to age 5	**Released:** 0-3: 0.785 ± 0.032 3-4: 0.809 ± 0.062 4-5: 0.757 ± 0.060 5+: 0.928 ± 0.016 **Wild:** 0-3: 0.874 ± 0.016 3-4: 0.890 ± 0.037 4-5: 0.855 ± 0.036 5+: 0.961 ± 0.008	0-3: 0.874 ± 0.016 3-4: 0.890 ± 0.037 4-5: 0.855 ± 0.036 5+: 0.961 ± 0.008	From Sansom *et al.* (2016), survival estimates by age class for released and wild-bred white-tailed eagles in Scotland based on the model with the best fit to the data. Wild bird rates have been used for the NHZ 14 and National populations in this model on basis that natural recruitment is now the primary means of population growth rather than further captive releases.

[5] https://www.nature.scot/scotlands-sea-eagles-balancing-conservation-and-farming

Parameter	NatureScot Model	Values used in current PVA	Rationale
Initial population in each age class (NHZ 14)	n/a	0-1: 15 1-2: 12 2-3: 10 3-4: 8 4-5: 7 5+: 50	Total estimated numbers in each age class (102 total individuals) based on original population size (25 pairs) and survival rates.
Initial population in each age class (National)	0	0-1: 123 1-2: 100 2-3: 81 3-4:65 4-5: 54 5+ 400	Total numbers in each age class (823 total individuals) based on original population size (200 pairs) and survival rates.
% females and males of breeding age which breed each year	82 ± 12.26	82 ± 12.26	Assumed in Sansom *et al.* (2016) to be the percentage of females hatching at least one egg and thereafter producing at least one fledgling.
Age of first breeding	5	5	Sansom *et al.* (2016) estimated age at first breeding of wild-bred birds showed that on average wild birds bred at five years of age, with males and females showing very similar average ages of first breeding (4.9 and 5.0).
Productivity: Number of fledglings produced per *successful* breeding attempt (time period and mean ± SD of chicks fledged per successful breeding attempt)	National population: 1975-1984: 0.000 ± 0.000 1985-1994: 1.506 ± 0.359 1995-2004: 1.524 ± 0.191 2005-2014: 1.382 ± 0.080	Not modelled	The number of fledglings produced per successful breeding attempt was used in Sansom *et al.* (2016). For those analyses, data from the years 1983 to 2014 were used. This is reported to be a slight difference compared with Evans *et al*. (2009[6]), who presented the number of fledglings produced per territorial pair (i.e. including pairs where the final outcome was not known, so the minimum number of young produced was spread across all pairs). Therefore, Sansom *et al.* (2016) reports a slightly higher productivity than some figures in Evans *et al*. (2009).
Productivity: Number of chicks fledged per territorial pair	National: 0.673	NHZ 14: 0.70 National: 0.858	Sansom *et al.* (2016) stated that from 2006 to 2014, the number of chicks fledged per breeding attempt appeared to have remained relatively constant at an average of 0.673 chicks fledged per territorial pair. NHZ 14 and national productivity estimates were provided by NatureScot in their Corr Chnoc Wind Farm EIA consultation response letter (08 October 2025).

[6] Evans, R. J., Wilson, J. D., Amar, A., Douse, A., MacLennan, A., Ratcliffe, N. & Whitfield, D. P. (2009) Growth and demography of a re-introduced population of White-tailed Eagles Haliaeetus albicilla. *Ibis*, **151**, pp. 244-254.

3.0 Model Results

3.1 Baseline Scenario

The baseline scenario represents the predicted population growth of the NHZ 14 and national white-tailed eagle populations, without any additional mortality associated with wind turbine collisions.

3.1.1 NHZ 14 Population

Under the baseline scenario, an average annual growth rate of 1.055 (5.5%) was predicted for the NHZ 14 population (starting at 25, 30, 35, 40 and 45 pairs[7]). By year 25, assuming there is no limit in carrying capacity, the number of individuals is predicted to increase from:

- 102 to c.400 (starting population of 25 pairs) (**Figure 1**);
- 123 to c. 450 (starting population of 30 pairs) (**Figure 2**);
- 144 to c. 580 (starting population of 35 pairs) (**Figure 3**);
- 165 to c. 630 (starting population of 40 pairs) (**Figure 4**); and
- 185 to c. 750 (starting population of 45 pairs) (**Figure 5)**.

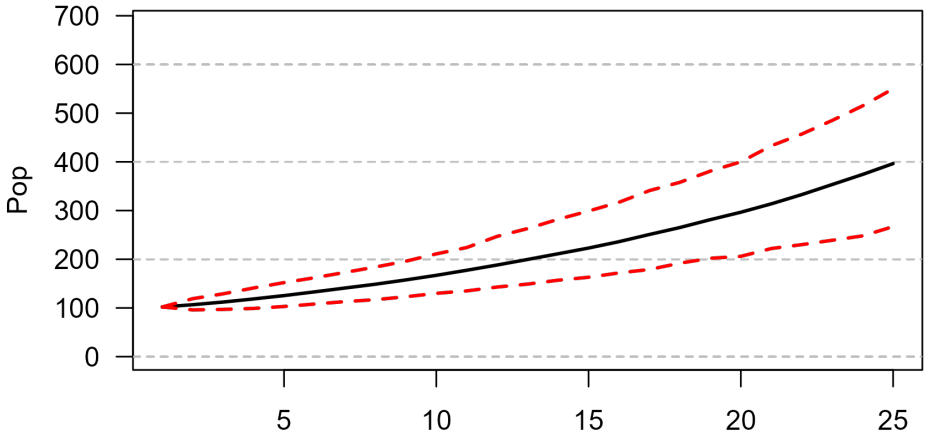


Figure 1: Projected white-tailed eagle population within NHZ 14 for a period of 25 years with no additional mortality, starting at 25 pairs. The average population prediction is shown in black, 95% confidence intervals in red (dashed).

[7] Modelling done in increments of 5 pairs up to 50 pairs. The most realistic current NHZ 14 population is likely to be between 25 and 45 pairs.

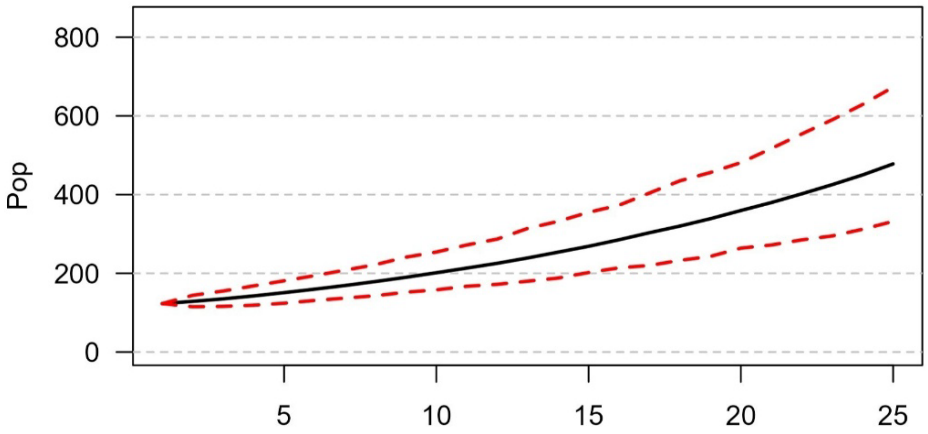


Figure 2: Projected white-tailed eagle population within NHZ 14 for a period of 25 years with no additional mortality, starting at 30 pairs. The average population prediction is shown in black, 95% confidence intervals in red (dashed).

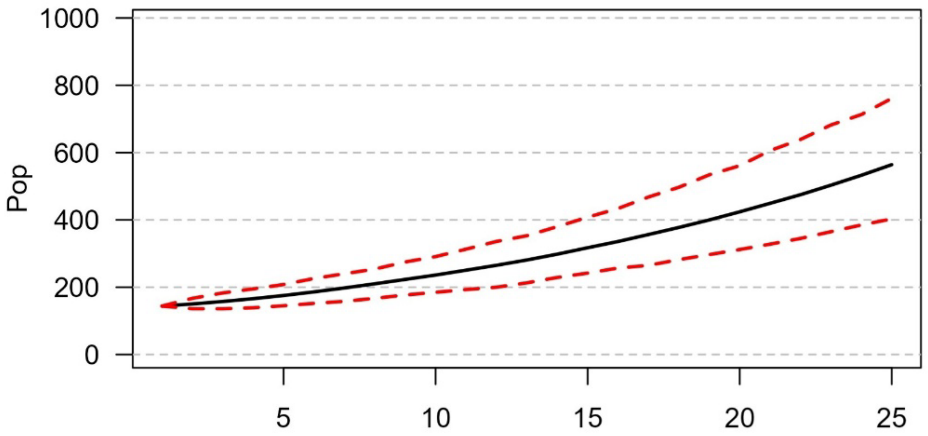


Figure 3: Projected white-tailed eagle population within NHZ 14 for a period of 25 years with no additional mortality, starting at 35 pairs. The average population prediction is shown in black, 95% confidence intervals in red (dashed).

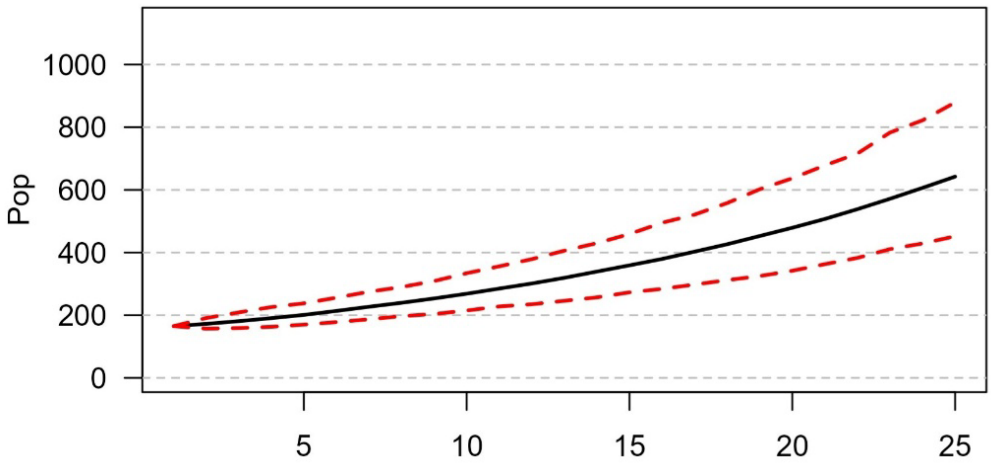


Figure 4: Projected white-tailed eagle population within NHZ 14 for a period of 25 years with no additional mortality, starting at 40 pairs. The average population prediction is shown in black, 95% confidence intervals in red (dashed).

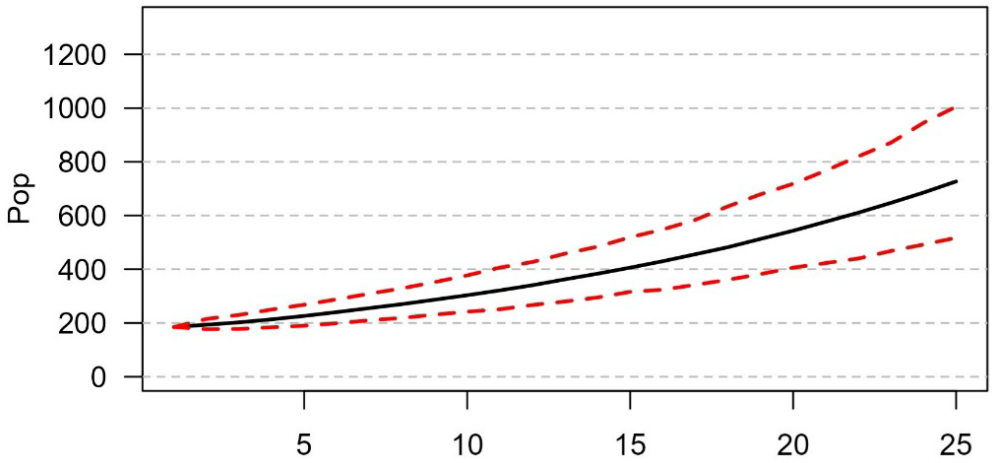


Figure 5: Projected white-tailed eagle population within NHZ 14 for a period of 25 years with no additional mortality, starting at 45 pairs. The average population prediction is shown in black, 95% confidence intervals in red (dashed).

3.1.2 National Population

Under the baseline scenario, an average annual growth rate of 1.090 (9.0%) was predicted for the national population. By year 25, assuming there is no limit in carrying capacity, the number of individuals is predicted to increase from 823 to c.7,000 (**Figure 6**).

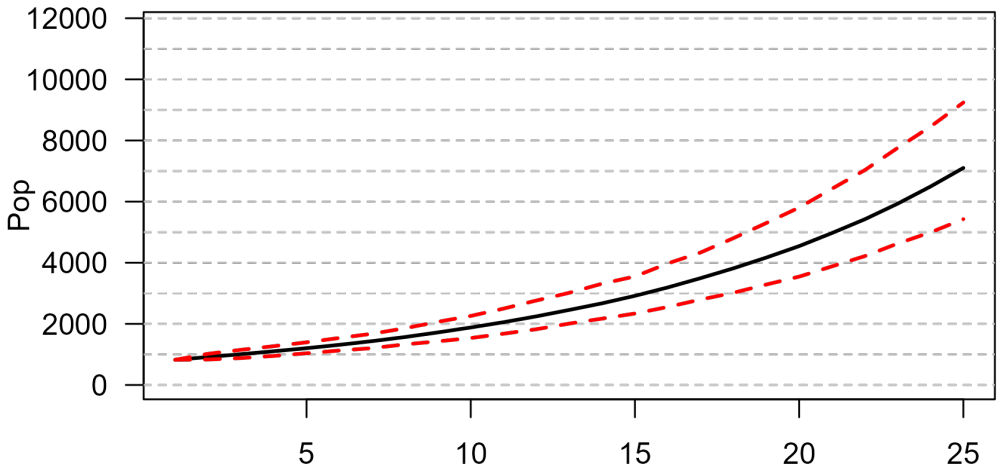


Figure 6: Projected national white-tailed eagle population for a period of 25 years with no additional mortality. The average population prediction is shown in black, 95% confidence intervals in red (dashed).

3.2 Additional Mortality

3.2.1 NHZ 14 Population

Additional annual mortality of 0.3 to 5 individuals per year was added to each model, split across each age class in proportion to their presence. Where values required applying mortalities of less than one individual to the individual age classes, the effect was instead applied by reducing the relevant survival rates by the equivalent amount.

Figure 7 to **Figure 11** present examples of the effect on the predicted population when including additional annual mortality of 1.0 individual[8], with starting populations of 25, 30, 35, 40 and 45 pairs, relative to the zero collision 5.5% growth baseline.

The result for these examples shows that growth remains strongly positive in these scenarios, albeit for the starting population of 25 pairs there is a predicted reduction in growth rate of 1.0 % (C-PGR = 0.989512), and an increase to c.300 individuals after 25 years (down from c.400 individuals under the baseline scenario).

For the starting population of 30 pairs there is a predicted reduction in growth rate of 0.9 % (C-PGR = 0.991398), and an increase to c.400 individuals after 25 years (down from c.450 individuals).

For the starting population of 35 pairs there is a predicted reduction in growth rate of 0.7 % (C-PGR = 0.992897), and an increase to c.450 individuals after 25 years (down from c.580 individuals).

For the starting population of 40 pairs there is a predicted reduction in growth rate of 0.6 % (C-PGR = 0.993822), and an increase to c.550 individuals after 25 years (down from c.630 individuals).

[8] The additional annual mortality of 1.0 is based on the CRM value of 0.643 used in the 2024 EIA submission

For the starting population of 45 pairs there is a predicted reduction in growth rate of 0.6 % (C-PGR = 0.994385), and an increase to c.620 individuals after 25 years (down from c.750 individuals).

Outputs for the NHZ 14 population are presented in **Table 2, Table 3, Table 4**, **Table 5** & **Table 6** as counterfactuals of population growth (C-PGR) and population size (C-PS), with C-PGR also shown on **Figure 12** to **Figure 16**.

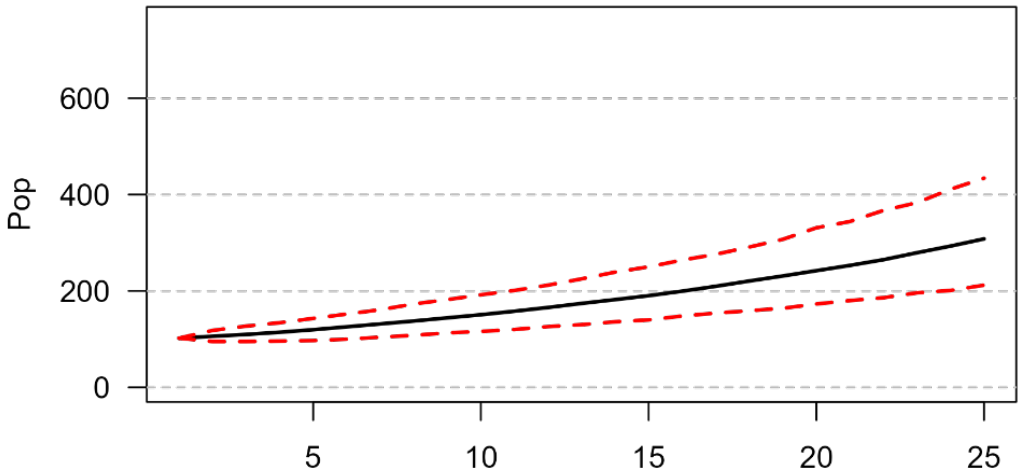


Figure 7: Projected NHZ 14 white-tailed eagle population (starting at 25 pairs) for a period of 25 years, when including an example additional mortality of 1.0 individual per year. The average population prediction is shown in black, 95% confidence intervals in red (dashed).

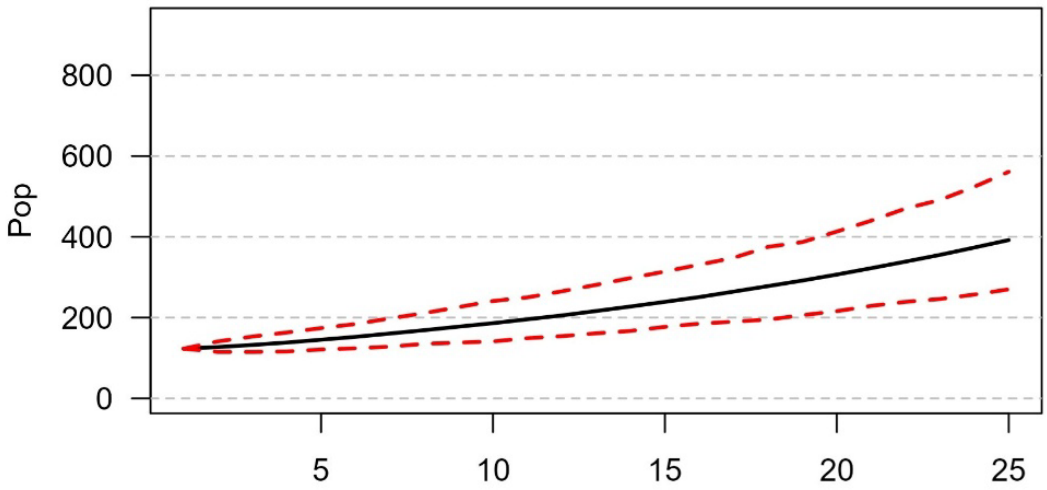


Figure 8: Projected NHZ 14 white-tailed eagle population (starting at 30 pairs) for a period of 25 years, when including an example additional mortality of 1.0 individual per year. The average population prediction is shown in black, 95% confidence intervals in red (dashed).

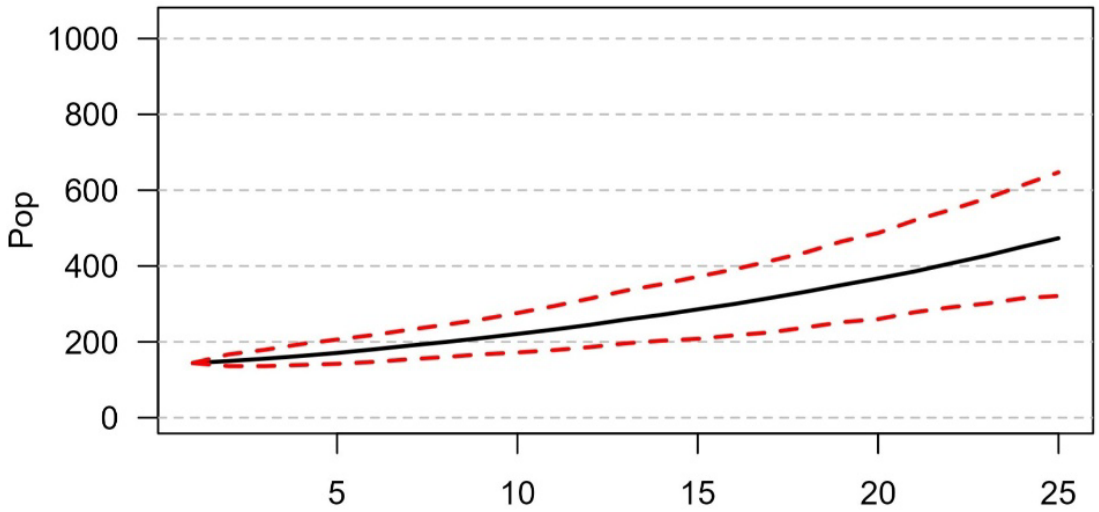


Figure 9: Projected NHZ 14 white-tailed eagle population (starting at 35 pairs) for a period of 25 years, when including an example additional mortality of 1.0 individual per year. The average population prediction is shown in black, 95% confidence intervals in red (dashed).

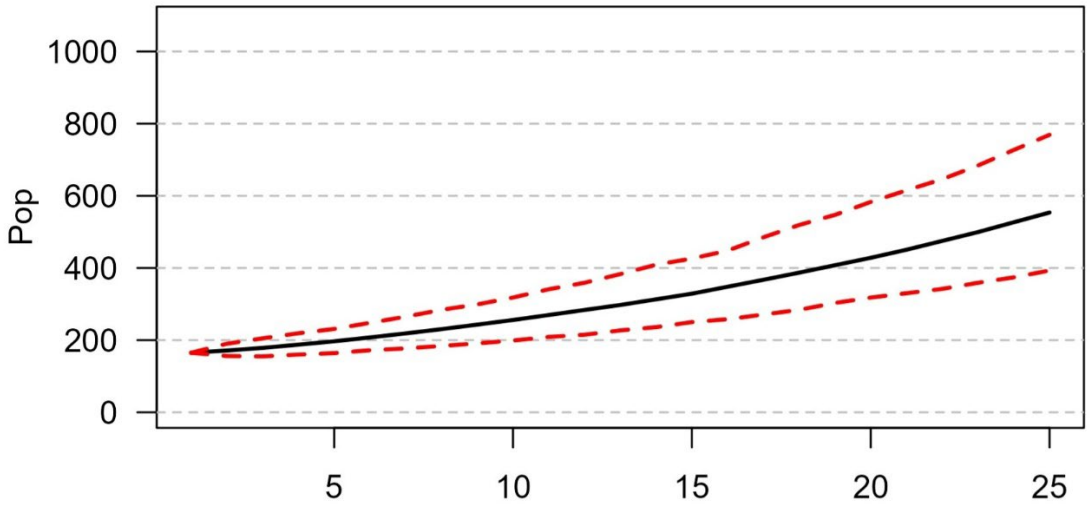


Figure 10: Projected NHZ 14 white-tailed eagle population (starting at 40 pairs) for a period of 25 years, when including an example additional mortality of 1.0 individual per year. The average population prediction is shown in black, 95% confidence intervals in red (dashed).

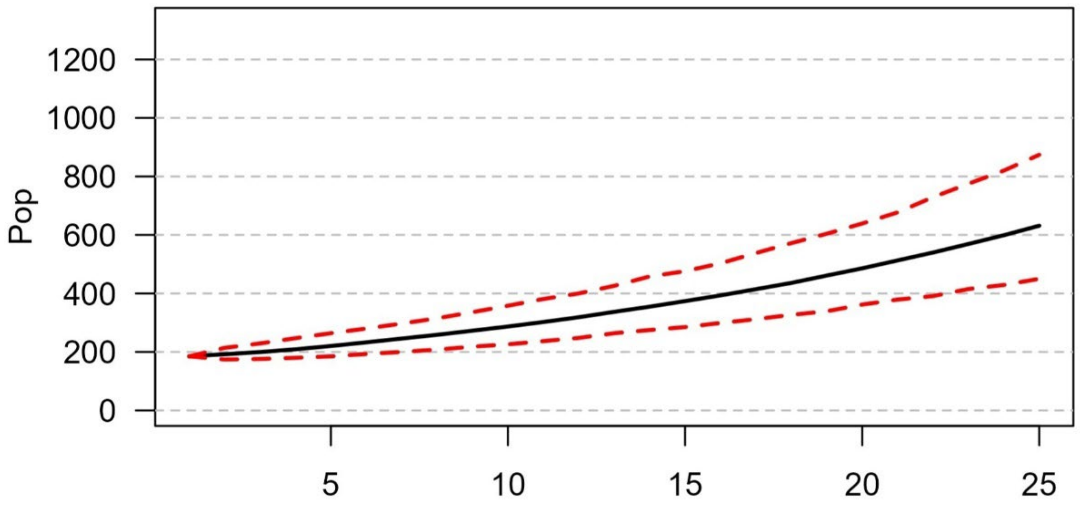


Figure 11: Projected NHZ 14 white-tailed eagle population (starting at 45 pairs) for a period of 25 years, when including an example additional mortality of 1.0 individual per year. The average population prediction is shown in black, 95% confidence intervals in red (dashed).

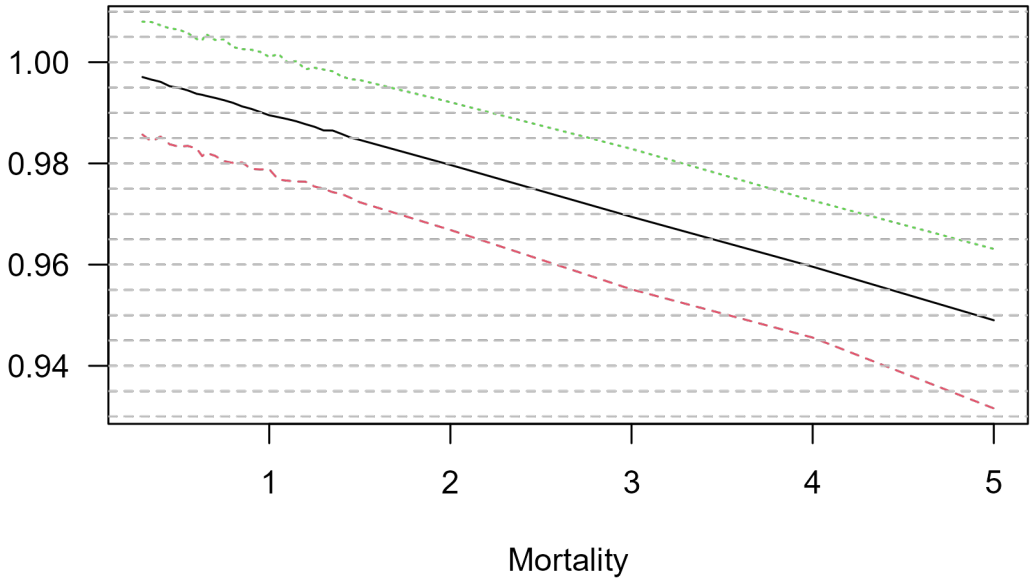


Figure 12: Predicted counterfactuals of population growth rate (C-PGR) for the NHZ 14 white-tailed eagle population (starting at 25 pairs) for a range of potential mortality values from 1 to 5 individuals per annum. The average population prediction is shown in black, upper and lower 95% confidence intervals in green and red (dashed) lines respectively.

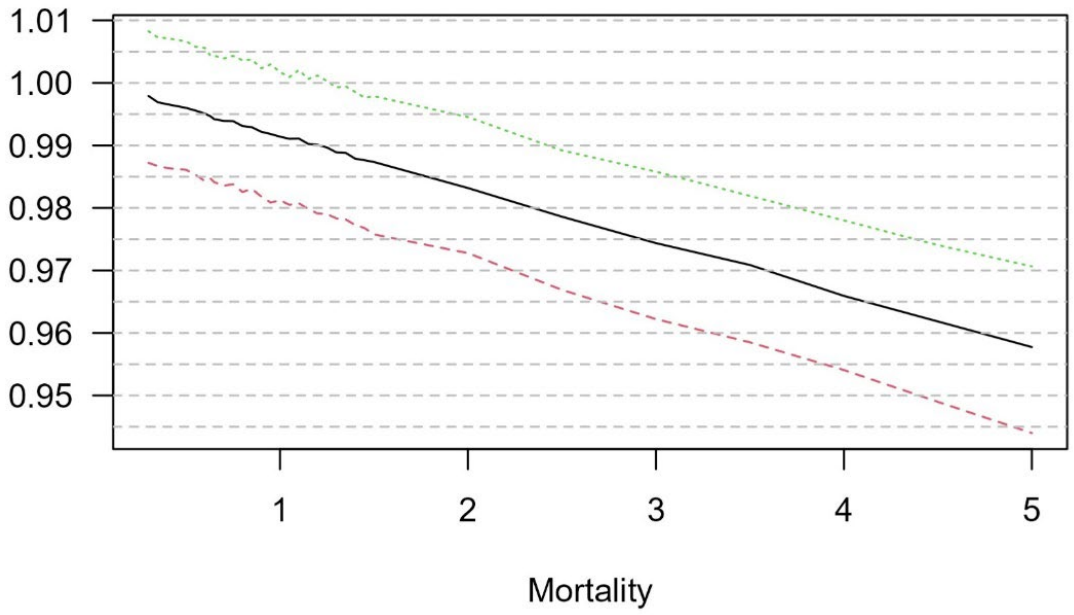


Figure 13: Predicted counterfactuals of population growth rate (C-PGR) for the NHZ 14 white-tailed eagle population (starting at 30 pairs) for a range of potential mortality values from 1 to 5 individuals per annum. The average population prediction is shown in black, upper and lower 95% confidence intervals in green and red (dashed) lines respectively.

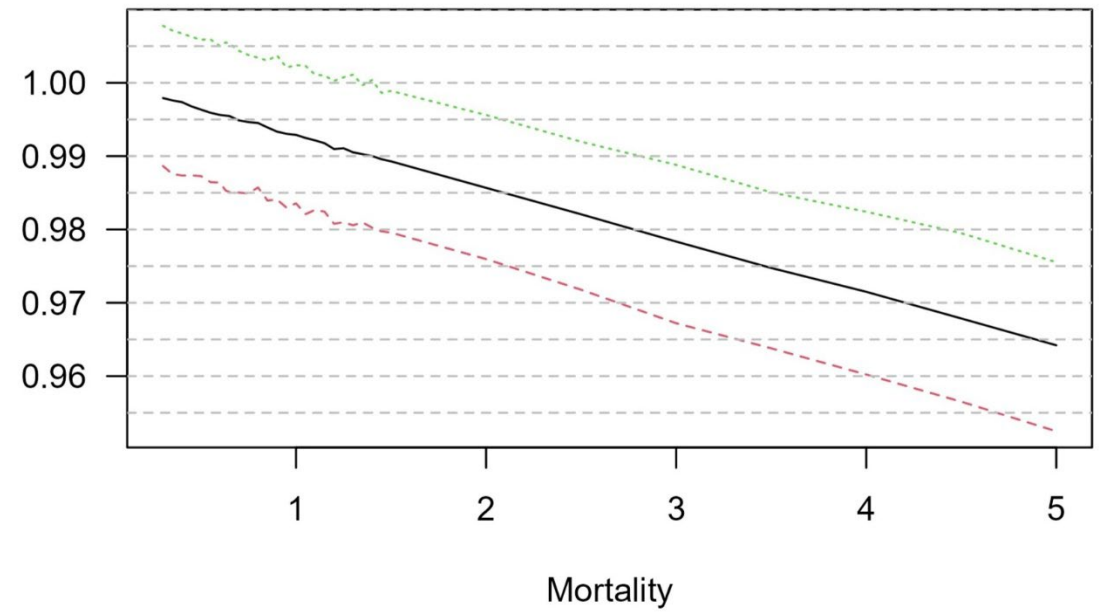


Figure 14: Predicted counterfactuals of population growth rate (C-PGR) for the NHZ 14 white-tailed eagle population (starting at 35 pairs) for a range of potential mortality values from 1 to 5 individuals per annum. The average population prediction is shown in black, upper and lower 95% confidence intervals in green and red (dashed) lines respectively.

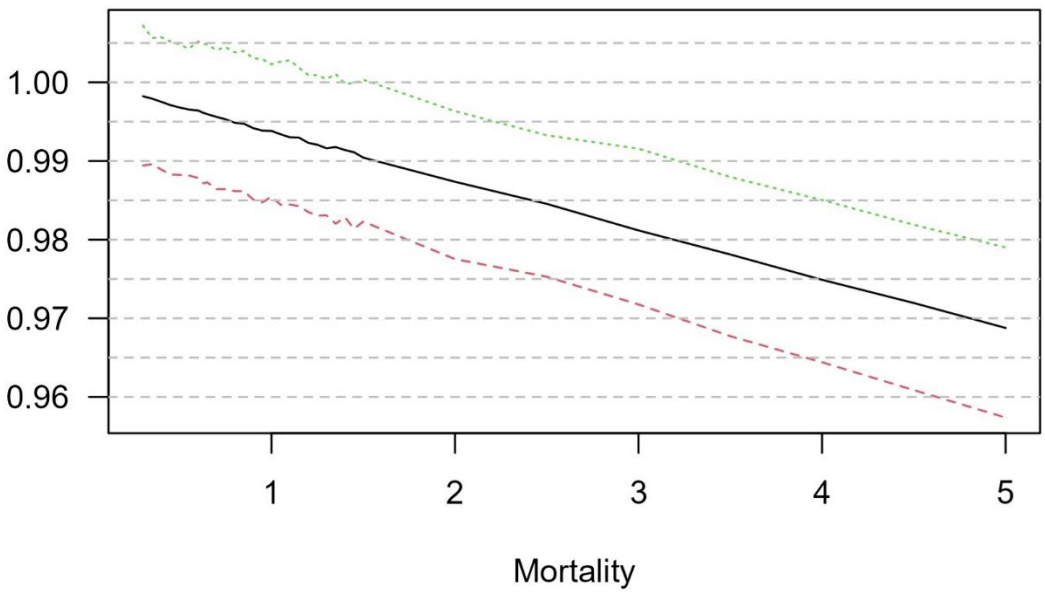


Figure 15: Predicted counterfactuals of population growth rate (C-PGR) for the NHZ 14 white-tailed eagle population (starting at 40 pairs) for a range of potential mortality values from 1 to 5 individuals per annum. The average population prediction is shown in black, upper and lower 95% confidence intervals in green and red (dashed) lines respectively.

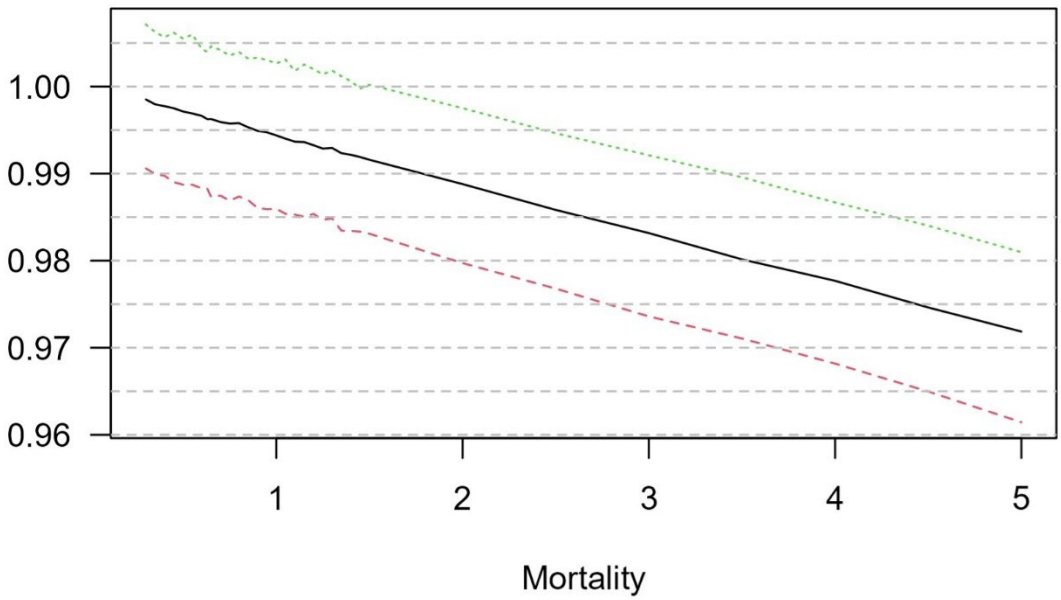


Figure 16: Predicted counterfactuals of population growth rate (C-PGR) for the NHZ 14 white-tailed eagle population (starting at 45 pairs) for a range of potential mortality values from 1 to 5 individuals per annum. The average population prediction is shown in black, upper and lower 95% confidence intervals in green and red (dashed) lines respectively.

Table 2: Predicted counterfactuals of population growth rate (C-PGR) and population size (C-PS) for the NHZ 14 population (starting at 25 pairs) for a range of potential mortality values between 0.3 to 5.0 individuals per annum. Mean C-PS and C-PGR as well as lower (2.5%) and upper 97.5% confidence intervals are presented.

Additional Mortality	C-PGR	2.5%	97.5%	C-PS	2.5%	97.5%
0.30	0.9970647	0.9856956	1.0080029	0.9383719	0.6975415	1.2205203
0.35	0.9965551	0.9843238	1.0079395	0.9278949	0.6736738	1.2186010
0.40	0.9961215	0.9852988	1.0072894	0.9166723	0.6905558	1.1991018
0.45	0.9952613	0.9837805	1.0066963	0.8970712	0.6644392	1.1815756
0.50	0.9949421	0.9833201	1.0064344	0.8899368	0.6567082	1.1739162
0.55	0.9944343	0.9834635	1.0057652	0.8785136	0.6591078	1.1545558
0.60	0.9937460	0.9829265	1.0045833	0.8632906	0.6501686	1.1211113
0.63	0.9935587	0.9814383	1.0043228	0.8596904	0.6260009	1.1138666
0.65	0.9933580	0.9820960	1.0055972	0.8551111	0.6365742	1.1497443
0.70	0.9929524	0.9815173	1.0044014	0.8467133	0.6272618	1.1160469
0.75	0.9924942	0.9804480	1.0045189	0.8374719	0.6103987	1.1193166
0.80	0.9919700	0.9801067	1.0030023	0.8261226	0.6051099	1.0778252
0.85	0.9912659	0.9802026	1.0025809	0.8114204	0.6065922	1.0665599
0.90	0.9907892	0.9789109	1.0024733	0.8022302	0.5869199	1.0637026
0.95	0.9901567	0.9788107	1.0020457	0.7895155	0.5854204	1.0524192
1.00	0.9895123	0.9788553	1.0010442	0.7765351	0.5860876	1.0264337
1.05	0.9891444	0.9768114	1.0016169	0.7698189	0.5562477	1.0412164
1.10	0.9887607	0.9765875	1.0000074	0.7618434	0.5530693	1.0001852
1.15	0.9883204	0.9764182	1.0001991	0.7538625	0.5506760	1.0049893
1.20	0.9877538	0.9763933	0.9985944	0.7424407	0.5503256	0.9654458
1.25	0.9872346	0.9754306	0.9989092	0.7334324	0.5369196	0.9730842
1.30	0.9865199	0.9749901	0.9985560	0.7203508	0.5308903	0.9645192
1.35	0.9865014	0.9743206	0.9982045	0.7200665	0.5218524	0.9560670
1.40	0.9858157	0.9739451	0.9971845	0.7073483	0.5168473	0.9319411
1.45	0.9850900	0.9731806	0.9966197	0.6945553	0.5068000	0.9188326
1.50	0.9846435	0.9723222	0.9964807	0.6872736	0.4957409	0.9156341
2.00	0.9797023	0.9668477	0.9920939	0.6072473	0.4304787	0.8200119
3.00	0.9694453	0.9551055	0.9828696	0.4674168	0.3171639	0.6492278
4.00	0.9595835	0.9455824	0.9726597	0.3622486	0.2468792	0.5000613
5.00	0.9490065	0.9315853	0.9630981	0.2756564	0.1700459	0.3906280

Table 3: Predicted counterfactuals of population growth rate (C-PGR) and population size (C-PS) for the NHZ 14 population (starting at 30 pairs) for a range of potential mortality values between 0.3 to 5.0 individuals per annum. Mean C-PS and C-PGR as well as lower (2.5%) and upper 97.5% confidence intervals are presented.

Additional Mortality	C-PGR	2.5%	97.5%	C-PS	2.5%	97.5%
0.30	0.997916	0.987216	1.008270	0.957126	0.7249456	1.228638
0.35	0.996901	0.986690	1.007267	0.932944	0.7153571	1.198448
0.40	0.996580	0.986381	1.007148	0.925491	0.7097707	1.194923
0.45	0.996293	0.986222	1.006887	0.919329	0.7069178	1.187209
0.50	0.996000	0.986105	1.006664	0.912024	0.7048209	1.180653
0.55	0.995576	0.985317	1.005775	0.902596	0.6908829	1.154850
0.60	0.995095	0.984283	1.005595	0.891482	0.6729861	1.149704
0.63	0.994658	0.984706	1.004355	0.882176	0.6802441	1.114780
0.65	0.994200	0.984122	1.004355	0.871694	0.6702382	1.114775
0.70	0.993931	0.983542	1.003884	0.866130	0.6604363	1.101776
0.75	0.993893	0.983797	1.004321	0.864973	0.6647270	1.113840
0.80	0.993108	0.982554	1.003621	0.848376	0.6440382	1.094576
0.85	0.992912	0.983037	1.003729	0.844416	0.6520057	1.097530
0.90	0.992185	0.981834	1.002332	0.828820	0.6323420	1.059965
0.95	0.991827	0.980859	1.002965	0.821760	0.6168408	1.076841
1.00	0.991398	0.981217	1.001736	0.812453	0.6224815	1.044318
1.05	0.991056	0.980495	1.000928	0.806043	0.6111430	1.023478
1.10	0.991096	0.980751	1.002067	0.807242	0.6151363	1.052988
1.15	0.990246	0.979838	1.000633	0.789542	0.6009883	1.015946
1.20	0.990089	0.979115	1.001169	0.787368	0.5899891	1.029662
1.25	0.989668	0.979014	1.000269	0.778786	0.5884688	1.006763
1.30	0.988883	0.978330	0.999272	0.763005	0.5782758	0.981960
1.35	0.988805	0.978151	0.999450	0.761575	0.5756439	0.986354
1.40	0.987878	0.977270	0.998552	0.743950	0.5628180	0.964432
1.45	0.987637	0.976776	0.997625	0.739531	0.5557499	0.942308
1.50	0.987348	0.975762	0.997864	0.734521	0.5415022	0.947957
2.00	0.983185	0.972778	0.994543	0.661036	0.5015862	0.872145
2.50	0.978599	0.966896	0.989193	0.588272	0.4310175	0.762136
3.00	0.974372	0.962219	0.985808	0.528478	0.3818176	0.699539
3.50	0.970879	0.958507	0.981930	0.483192	0.3466452	0.633899
4.00	0.965933	0.954073	0.978004	0.425580	0.3087089	0.573487
4.50	0.961843	0.948985	0.974051	0.383458	0.2700817	0.518265
5.00	0.957749	0.943999	0.970655	0.345181	0.2367499	0.474924

Table 4: Predicted counterfactuals of population growth rate (C-PGR) and population size (C-PS) for the NHZ 14 population (starting at 35 pairs) for a range of potential mortality values between 0.3 to 5.0 individuals per annum. Mean C-PS and C-PGR as well as lower (2.5%) and upper 97.5% confidence intervals are presented.

Additional Mortality	C-PGR	2.5%	97.5%	C-PS	2.5%	97.5%
0.30	0.997921	0.988657	1.007779	0.956113	0.7518702	1.213775
0.35	0.997599	0.987555	1.007123	0.948913	0.7311987	1.194169
0.40	0.997365	0.987359	1.006726	0.942999	0.7275898	1.182460
0.45	0.996786	0.987371	1.006271	0.929446	0.7278067	1.169177
0.50	0.996344	0.987278	1.005871	0.919008	0.7260867	1.157610
0.55	0.995916	0.986456	1.005923	0.909178	0.7111296	1.159111
0.60	0.995613	0.986386	1.005011	0.902245	0.7098626	1.133118
0.63	0.995525	0.985301	1.005505	0.900583	0.6906063	1.147123
0.65	0.995466	0.985107	1.005355	0.899543	0.6872149	1.142864
0.70	0.994870	0.985025	1.004360	0.885848	0.6857737	1.114917
0.75	0.994643	0.984920	1.003782	0.880741	0.6839623	1.098989
0.80	0.994518	0.985723	1.003421	0.877630	0.6980359	1.089143
0.85	0.993911	0.983944	1.003026	0.864633	0.6672049	1.078468
0.90	0.993342	0.984085	1.003733	0.852711	0.6696059	1.097633
0.95	0.993044	0.982975	1.002085	0.845861	0.6509724	1.053456
1.00	0.992897	0.983556	1.002410	0.842575	0.6606608	1.062050
1.05	0.992483	0.982090	1.002300	0.834177	0.6364824	1.059119
1.10	0.992147	0.982663	1.001124	0.826603	0.6458377	1.028494
1.15	0.991762	0.982426	1.000984	0.819097	0.6419574	1.024904
1.20	0.990967	0.980776	1.000262	0.803062	0.6155267	1.006576
1.25	0.991076	0.980977	1.000750	0.805221	0.6186898	1.018937
1.30	0.990521	0.980567	1.001116	0.794298	0.6122664	1.028283
1.35	0.990266	0.980958	0.999663	0.788848	0.6183901	0.991627
1.40	0.990012	0.980249	1.000376	0.784327	0.6073148	1.009465
1.45	0.989578	0.979744	0.998618	0.775430	0.5995473	0.966019
1.50	0.989287	0.979568	0.998893	0.769813	0.5968560	0.972707
2.00	0.985677	0.975960	0.995606	0.703001	0.5442592	0.895763
2.50	0.982067	0.971780	0.991963	0.641655	0.4888878	0.817329
3.00	0.978348	0.967212	0.988809	0.584049	0.4345553	0.754770
3.50	0.974748	0.963790	0.985066	0.532603	0.3977124	0.686500
4.00	0.971498	0.960216	0.982415	0.490338	0.3624336	0.641770
4.50	0.967861	0.956515	0.979494	0.446564	0.3290764	0.595725
5.00	0.964205	0.952479	0.975532	0.406593	0.2960642	0.538325

Table 5: Predicted counterfactuals of population growth rate (C-PGR) and population size (C-PS) for the NHZ 14 population (starting at 40 pairs) for a range of potential mortality values between 0.3 to 5.0 individuals per annum. Mean C-PS and C-PGR as well as lower (2.5%) and upper 97.5% confidence intervals are presented.

Additional Mortality	C-PGR	2.5%	97.5%	C-PS	2.5%	97.5%
0.30	0.998234	0.989423	1.007208	0.962694	0.7665845	1.196694
0.35	0.997920	0.989590	1.005640	0.954600	0.7698204	1.150983
0.40	0.997521	0.988903	1.005738	0.945251	0.7565752	1.153776
0.45	0.997101	0.988285	1.005189	0.935259	0.7448344	1.138144
0.50	0.996793	0.988242	1.004817	0.928087	0.7440205	1.127669
0.55	0.996545	0.988159	1.004269	0.922073	0.7424732	1.112386
0.60	0.996418	0.987848	1.005206	0.919830	0.7366499	1.138616
0.63	0.996108	0.987155	1.004894	0.912655	0.7238393	1.129827
0.65	0.995958	0.987294	1.004810	0.909065	0.7263783	1.127462
0.70	0.995614	0.986421	1.004101	0.901710	0.7104936	1.107745
0.75	0.995298	0.986412	1.004477	0.894565	0.7103334	1.118172
0.80	0.994866	0.986169	1.003806	0.884773	0.7059745	1.099628
0.85	0.994736	0.986173	1.003974	0.881983	0.7060520	1.104242
0.90	0.994180	0.985112	1.003070	0.869414	0.6872964	1.079668
0.95	0.993864	0.984723	1.002936	0.862845	0.6805523	1.076066
1.00	0.993822	0.985468	1.002293	0.861595	0.6935316	1.058945
1.05	0.993395	0.984430	1.002639	0.853144	0.6754950	1.068114
1.10	0.993010	0.984457	1.002803	0.844467	0.6759560	1.072504
1.15	0.992973	0.984274	1.001846	0.843637	0.6728290	1.047203
1.20	0.992313	0.983515	1.000953	0.829868	0.6599794	1.024102
1.25	0.992063	0.983054	1.000898	0.824426	0.6522918	1.022708
1.30	0.991614	0.983090	1.000412	0.815089	0.6528922	1.010363
1.35	0.991766	0.982026	1.001049	0.818919	0.6354498	1.026559
1.40	0.991396	0.982860	0.999844	0.810671	0.6490758	0.996126
1.45	0.991108	0.981379	0.999871	0.805458	0.6250676	0.996789
1.50	0.990429	0.982295	1.000332	0.791285	0.6398058	1.008351
2.00	0.987358	0.977530	0.996340	0.732545	0.5665726	0.912415
2.50	0.984550	0.975285	0.993269	0.682538	0.5349236	0.844647
3.00	0.981171	0.971760	0.991568	0.626639	0.4886305	0.809216
3.50	0.978113	0.967725	0.987959	0.579605	0.4403612	0.738717
4.00	0.974892	0.964411	0.985034	0.534093	0.4041601	0.685942
4.50	0.971945	0.960870	0.981888	0.495240	0.3686562	0.633224
5.00	0.968773	0.957382	0.979015	0.456782	0.3366143	0.588496

Table 6: Predicted counterfactuals of population growth rate (C-PGR) and population size (C-PS) for the NHZ 14 population (starting at 45 pairs) for a range of potential mortality values between 0.3 to 5.0 individuals per annum. Mean C-PS and C-PGR as well as lower (2.5%) and upper 97.5% confidence intervals are presented.

Additional Mortality	C-PGR	2.5%	97.5%	C-PS	2.5%	97.5%
0.30	0.998514	0.990595	1.007122	0.968633	0.7895971	1.194141
0.35	0.997951	0.989938	1.006258	0.954940	0.7766136	1.168797
0.40	0.997745	0.989755	1.005659	0.950203	0.7730371	1.151515
0.45	0.997502	0.989014	1.006178	0.944661	0.7586895	1.166477
0.50	0.997128	0.988725	1.005498	0.936026	0.7531779	1.146914
0.55	0.996901	0.988719	1.005976	0.930464	0.7530532	1.160637
0.60	0.996629	0.988294	1.004322	0.923828	0.7449953	1.113843
0.63	0.996247	0.988245	1.003976	0.914925	0.7440884	1.104302
0.65	0.996268	0.987342	1.004620	0.915780	0.7272619	1.122160
0.70	0.995927	0.987472	1.004194	0.907961	0.7296651	1.110307
0.75	0.995744	0.986894	1.003555	0.903916	0.7190592	1.092791
0.80	0.995791	0.987362	1.003964	0.904837	0.7276369	1.103971
0.85	0.995307	0.986932	1.003186	0.893954	0.7197647	1.082772
0.90	0.994913	0.986045	1.003315	0.885370	0.7037595	1.086281
0.95	0.994738	0.985908	1.003046	0.881542	0.7013224	1.079008
1.00	0.994385	0.985947	1.002650	0.873553	0.7020185	1.068403
1.05	0.994008	0.985378	1.003079	0.865719	0.6919602	1.079912
1.10	0.993667	0.985289	1.001794	0.857715	0.6903889	1.045851
1.15	0.993619	0.985051	1.002539	0.857350	0.6862280	1.065447
1.20	0.993256	0.985371	1.002004	0.849405	0.6918311	1.051346
1.25	0.992868	0.984706	1.001403	0.840821	0.6802567	1.035672
1.30	0.992940	0.984850	1.001826	0.842507	0.6827388	1.046676
1.35	0.992338	0.983437	1.001177	0.830122	0.6586682	1.029844
1.40	0.992160	0.983424	1.000628	0.826147	0.6584494	1.015842
1.45	0.991903	0.983336	0.999758	0.820724	0.6569838	0.993981
1.50	0.991588	0.983095	1.000198	0.814381	0.6529612	1.004968
2.00	0.988795	0.979722	0.997517	0.759353	0.5992078	0.939742
2.50	0.985829	0.976793	0.994638	0.704352	0.5559879	0.874242
3.00	0.983169	0.973595	0.992101	0.658511	0.5122322	0.820161
3.50	0.980148	0.971059	0.989579	0.609940	0.4798987	0.769605
4.00	0.977686	0.968176	0.986687	0.572919	0.4455121	0.715306
4.50	0.974623	0.964974	0.984021	0.529740	0.4101021	0.668518
5.00	0.971857	0.961443	0.980972	0.493768	0.3741883	0.618621



3.2.2 National Population

Additional annual mortality of 1 to 45 individuals per year was added to the model of the national population. C-PGR and C-PS results are presented in **Table 7** and C-PGR results are also shown on **Figure 19**. The results show that growth remains positive, albeit as an example, at an additional annual mortality of five individuals, the reduction in growth rate is 0.6 % (C-PGR = 0.9936646) and at 20 individuals this would be 2.5 % (C-PGR = 0.9747043). **Figure 17** presents the predicted population when including additional annual mortality of 5 individuals, and **Figure 18** shows this with 20 individuals.

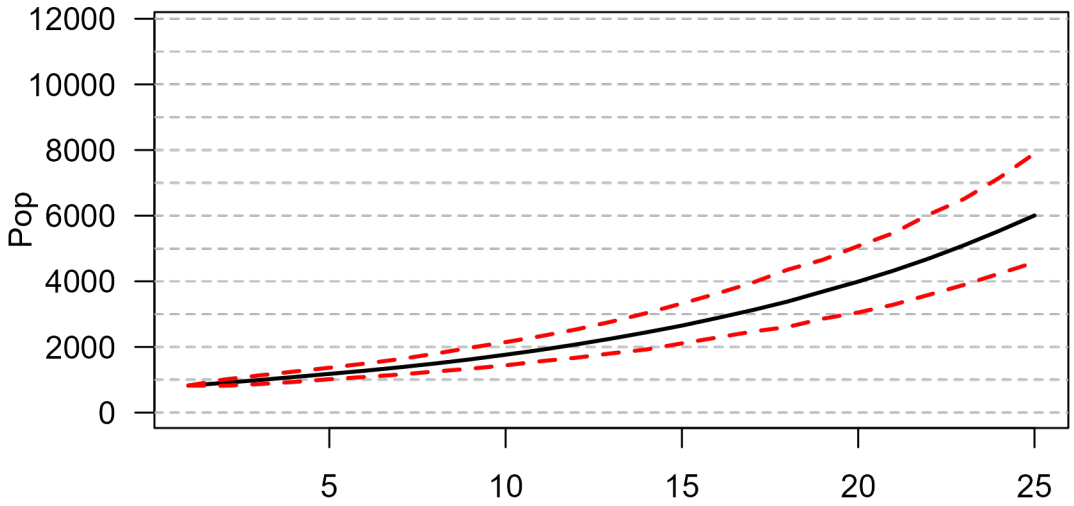


Figure 17: Projected national white-tailed eagle population for a period of 25 years, when including additional mortality of 5 individuals per year. The average population prediction is shown in black, 95% confidence intervals in red (dashed).

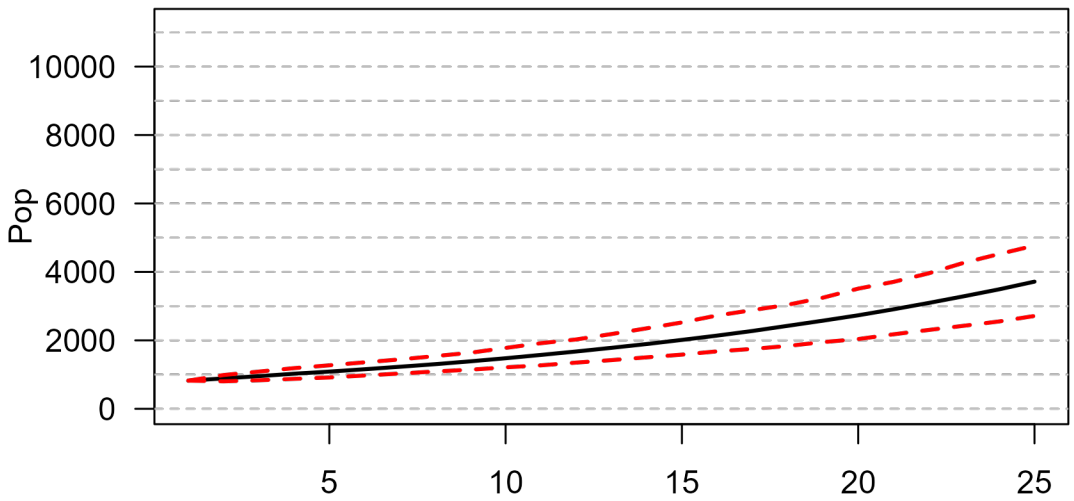


Figure 18: Projected national white-tailed eagle population for a period of 25 years, when including additional mortality of 20 individuals per year. The average population prediction is shown in black, 95% confidence intervals in red (dashed).

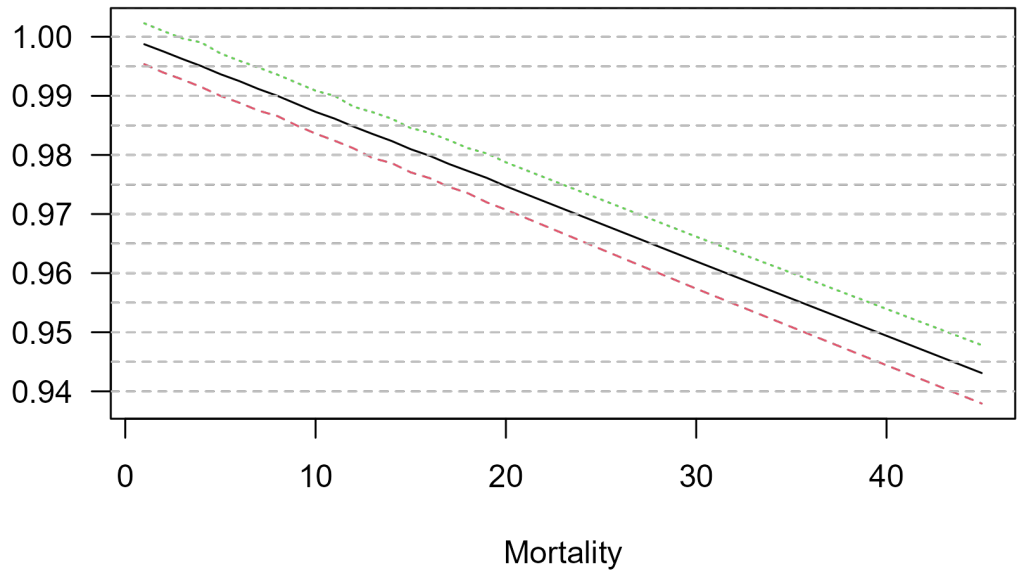


Figure 19: Predicted counterfactuals of population growth rate (C-PGR) for the National white-tailed eagle population for a range of potential mortality values from 1 to 45 individuals per annum. The average population prediction is shown in black, upper and lower 95% confidence intervals in green and red (dashed) lines respectively.

Table 7: Predicted counterfactuals of population growth rate (C-PGR) and population size (C-PS) for the National population for a range of potential mortality values between 1 and 45 individuals per annum. Mean C-PS and C-PGR as well as lower (2.5%) and upper 97.5% confidence intervals are presented.

Additional Mortality	C-PGR	2.5%	97.5%	C-PS	2.5%	97.5%
1	0.9987305	0.9953568	1.0022722	0.9696877	0.8901633	1.0583814
2	0.9975145	0.9939390	1.0009660	0.9406151	0.8590001	1.0244324
3	0.9962377	0.9927713	0.9997239	0.9109155	0.8341243	0.9931195
4	0.9950294	0.9914762	0.9990173	0.8838787	0.8073414	0.9757212
5	0.9936646	0.9900013	0.9971832	0.8540038	0.7778478	0.9319095
6	0.9924877	0.9888275	0.9959337	0.8290381	0.7551161	0.9031519
7	0.9911572	0.9874992	0.9947893	0.8016621	0.7301616	0.8775621
8	0.9899955	0.9865715	0.9935782	0.7785127	0.7132042	0.8512384
9	0.9886376	0.9849960	0.9922316	0.7523004	0.6852706	0.8228604
10	0.9872856	0.9836091	0.9908687	0.7270060	0.6615520	0.7950651
11	0.9861443	0.9824109	0.9899972	0.7063336	0.6416966	0.7777670
12	0.9847888	0.9811083	0.9881608	0.6823723	0.6207603	0.7424908
13	0.9835407	0.9794725	0.9872342	0.6611911	0.5953971	0.7252790
14	0.9823559	0.9786212	0.9861239	0.6415574	0.5825929	0.7051584
15	0.9809706	0.9770542	0.9845475	0.6193625	0.5597143	0.6775126
16	0.9798524	0.9760690	0.9837276	0.6019322	0.5457737	0.6635468
17	0.9784804	0.9746080	0.9825160	0.5812404	0.5257142	0.6434140
18	0.9772848	0.9735315	0.9811464	0.5637131	0.5113875	0.6213623
19	0.9761102	0.9719727	0.9802430	0.5471217	0.4913053	0.6072165
20	0.9747043	0.9707329	0.9787500	0.5277326	0.4758755	0.5845128
30	0.9619916	0.9573688	0.9661659	0.3801693	0.3364976	0.4229535
45	0.9430999	0.9379400	0.9478217	0.2316671	0.2015471	0.2619186



4.0 Summary

PVA has been used to investigate the impact of additional mortality associated with wind turbine collisions on the future growth rates of the NHZ 14: Argyll West & Islands, and national (Scottish) white-tailed eagle populations.

The modelling approach used is similar to the that developed by RSPB Scotland on behalf of NatureScot to predict the population trajectory of the re-introduced white-tailed eagle population in Scotland, including with annual mortality attributable to collisions (Sansom *et al.* 2016).

The scenario of an NHZ 14 starting population of 25 pairs (102 birds) has been modelled, based on NatureScot's population estimate. In the scenarios of additional cumulative mortality of one to five birds[9], population growth would remain on an upward trajectory. Although at five birds, the annual growth rate would reduce by up to 5.1%, the population in 25 years would be over 50% larger than the starting population (c.156 birds). Without additional mortality and without density dependence the population would be c.369 birds; however, this is not considered to be an ecologically realistic scenario.

Based on the more recent Argyll population information made available (see **Table 1**), a still precautionary scenario of a starting population of 35 pairs (144 birds) for NHZ 14 and collision rates of five birds per annum would reduce the annual growth rate by 3.6%. The population in 25 years would be over 60% larger than the starting population (c.240 birds). Without additional mortality and without density dependence the population would be c.527 birds; although again, this is not an ecologically realistic scenario.

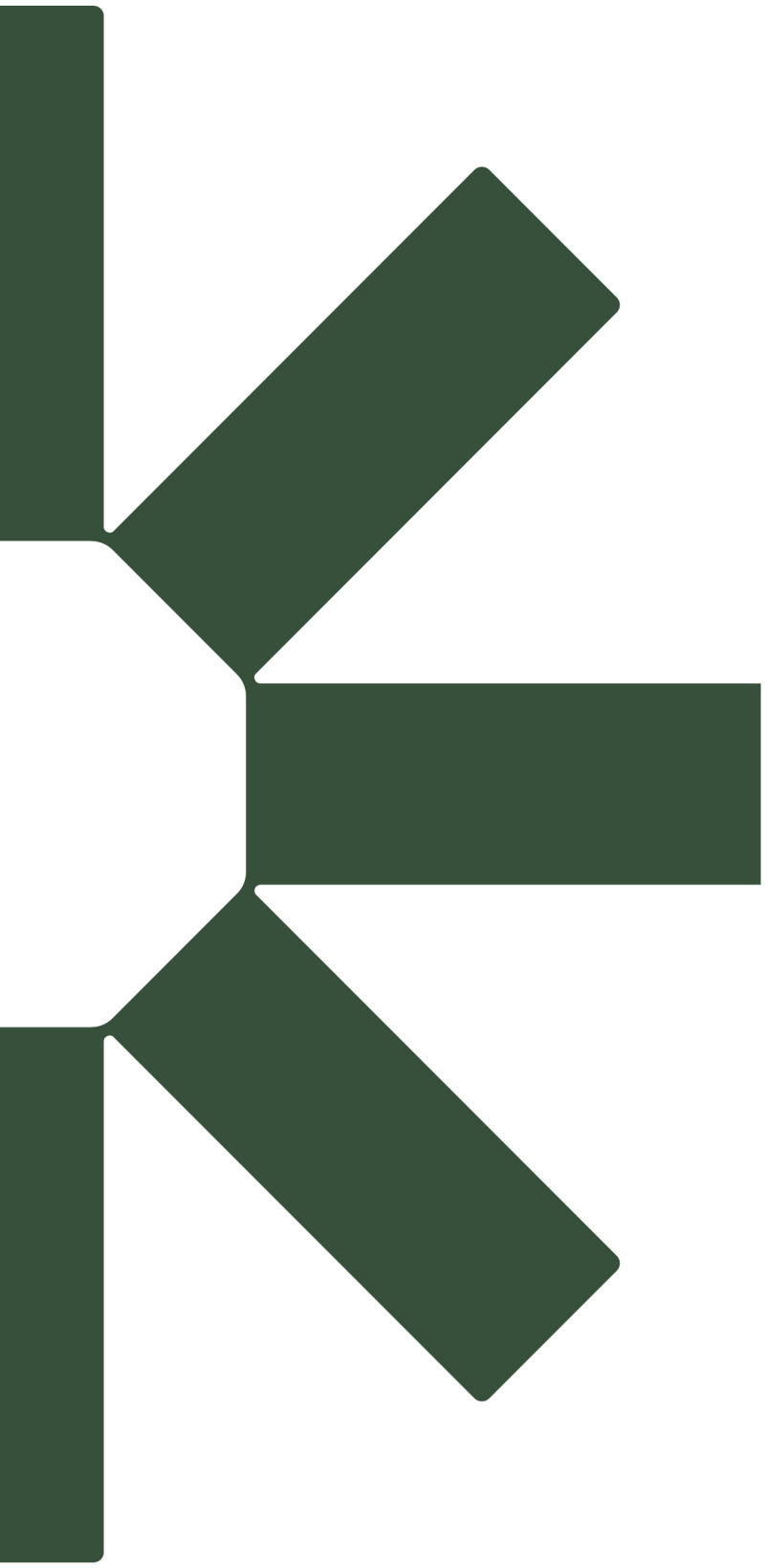
Using the most accurate scenario of a starting population of 45 pairs (185 birds) for NHZ 14, and collision rates of 3.5 birds[10] per annum, the annual growth rate would reduce by 2.0%. The population in 25 years would be over 120% larger than the starting population (c.418 birds). Without additional mortality and without density dependence the population would be c.678 birds; although again, this is not an ecologically realistic scenario.

Whilst the last scenario is the most accurate of those assessed in this report it should be noted that, NatureScot, in their response to a Freedom of Information Request[11] stated that they have received reports of 12 white-tailed eagle collisions across the whole of Scotland since 2016. Therefore, without a more systematic approach for monitoring and reporting collisions, there is a lack of evidence to support the levels of annual mortality currently predicted in NHZ 14 and nationally.

[9] 0.64 birds rounded up to 1.0 bird for the project alone, and 3.3 birds, rounded up to 5.0 birds cumulative total for NHZ 14 (from consolidated NatureScot CRM spreadsheet, March 2026).

[10] 3.3 birds, rounded up to 3.5 birds, cumulative total for NHZ 14. From consolidated NatureScot CRM spreadsheet, (March 2026).

[11] Ross Jamison, Galileo Empower, dated 26 May 2026. Ref. SIR183820/A5855004



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