Appendix 7-8 – Golden Eagle Population Model Report

INTERNAL

Table of Contents

Table of Figures

A7.8.1 INTRODUCTION

This appendix presents the methods and results of the application of the Golden Eagle Population Model to the Cloghercor Wind Farm project. The data analysis and reporting were carried out by Tom Gittings.

A7.8.2 THE GOLDEN EAGLE POPULATION MODEL

The Golden Eagle Population Model was first developed by O'Toole *et al.* (2002) and subsequently refined by Whitfield *et al.* (2006, 2008) and Haworth Conservation (2010). It uses productivity and survival rates to track the growth of a population until it achieves full occupancy of all available home ranges. It also includes random variation in the population parameters. The model is widely used in Scottish wind farm assessments (e.g., MacArthur Green, 2018, 2021).

A7.8.3 METHODS

The Golden Eagle Population Model was implemented in R (R Core Team, 2020). The code used for the basic model (excluding the random variation) was tested against the worked example in Haworth Conservation (2010; pp. 30-32).

Demographic parameters

The input parameters used for the model are shown in Table A7.8.1. The values used for the number of pairs, total number of home ranges, and fledging rates were based on Irish data. No Irish data was available for survival rates from fledging to age 4, and adult survival rates, so values used in Scottish wind farm assessments were used instead.

Table A7.8.1. Demographic parameters used for the application of the Golden Eagle Population Model to the Cloghercor Wind Farm project.

Parameter	Value	Source
Number of pairs	6	5 territorial pairs in 2018 (Burke *et al.*, 2020) plus the new Cloghercor territorial pair established in 2020-2022
Total number of home ranges	23	O'Toole *et al.* (2002)
Fledging rate	0.4042	Cumulative fledgling rate for home ranges occupied by territorial pairs in Ireland across the years 2008-2018 (Hillis, 2009-2012; Perry, 2013; Perry and Newton, 2014; Newton, 2015, 2016; and Burke *et al.*, 2020; see Table 7.3 in the main chapter)
Survival rate from fledging to age 4	0.25, 0.30, 0.35, 0.40, 0.45	Range of values used by MacArthur Green (2018, 2021)
Adult survival rate	0.9512	Value used by MacArthur Green (2018, 2021)

Stochastic variation in the fledging rates, survival rates from fledging to age 4, and adult survival rate was generated by sampling from a normal distribution with a mean representing the parameter value and a standard deviation of 10% (fledging rate and survival rate from fledging

to age 4), or 5% (adult survival rate), of the mean. This procedure follows that used by Whitfield *et al.* (2008). However, the standard deviation for the adult survival rate was reduced, because a 10% standard deviation would have resulted in survival rates > 1, which is a biological impossibility.

Assessment of collision risk

The model was run without any collisions, to provide a baseline, and with the worst-case scenario collision rate from the collision risk model of 0.068 collisions / year, and with a precautionary doubling of this collision rate to 0.136 collisions / year. The precautionary doubling was carried out to allow for the uncertainty that is inherent collision risk modelling. As the Golden Eagle Population Model only models the female half of the population, the above collision rates were halved following the protocol used in Scottish wind farm assessments (MacArthur Green, 2018, 2021). Note that this halving assumes a 1:1 sex ratio and equal levels of flight activity by males and females.

The collisions were incorporated in the model in a probabilistic manner: i.e., the collision risk was taken to be the probability of a collision occurring each year. The mean number of collisions across all runs of the model was equivalent to the actual value of the collision rate, but the number of collisions per run varied. This procedure was considered to be a more accurate reflection of the meaning of a collision risk value than applying a fixed collision rate.

The model was run for 100 years, and was run 1000 times for each scenario tested. The output parameters used to evaluate the scenarios were the mean annual growth rate for Years 4-35, the number of territory holding pairs at Year 35, and the years to reach favourable conservation status.

The growth rates were the mean ratios of population sizes between consecutive years during the lifespan of the wind farm but excluded the first three years as these reflect the starting conditions of the model. Positive growth rates represent population growth and negative rates represent population decline.

The number of territory holding pairs at Year 35 represent the Irish population size at the end of the lifespan of the wind farm.

Favourable conservation status was defined as 66% occupancy of the available home ranges (Whitfield *et al.*, 2008).

Irish population growth

The model was also run to simulate the growth of the Irish population between 2009 and 2017. For this analysis, the number of territory holding pairs at the start of the model was taken to be the thee year running mean for 2009. The results of the analyses were compared with the three year running means from the recorded data to assess which juvenile survival rate produced the best fit. The years 2008 and 2018 were excluded from this analysis, as, while there is population data available for these years, three year running means could not be generated due to the lack of data for 2007 and 2019.

Assessment of collision risks from different turbine models

The model was also run to assess the collision risks from the eight different turbine models that represent the range of turbine specifications being considered for this wind farm. This analysis used the precautionary doubling of the maximum collision rate calculated for each turbine model, and a juvenile survival rate of 0.40.

Assessment of nest site disturbance

The model was also run to assess the potential effects of nest site disturbance. Based on the recorded use of nest sites between 2020 and 2022, this analysis assumed that the Cloghercor pair would occupy a nest site close to the operational part of the wind farm site one in every three years. The disturbance impact was modelled as a worst-case scenario by assuming that every three years during the operational period of the wind farm, one territorial pair of Golden Eagle would fail to breed as a result.

A7.8.4 RESULTS

The results of the collision risk assessment simulations are shown in Figure A7.8.1 and Figure A7.8.2. The output parameters used to evaluate the collision risk scenarios are shown in Table 7.11 in the main chapter.

The simulated Irish population figures in 2017 under each juvenile survival rate are compared with the three year running mean of the recorded Irish population in 2017 in Table A7.8.2.

The results of the simulations of collision risks for the eight turbine models are shown in Table 7.12 in the main chapter.

The results of the nest site disturbance simulations are shown in Figure A7.6.3. The mean annual growth rates, number of territory holding pairs at Year 35, and years to reach favourable conservation status, for each juvenile survival rate are shown in Table A7.8.3. Note that, because of the stochastic elements in the models, there are slight differences in some of the output parameter values for the baseline scenarios between this analysis and the collision risk assessment analysis shown in Table 7.11 in the main chapter.

Discussion and interpretation of the results are included in the relevant sections of the main chapter.

Table A7.8.2. Simulated number of Irish territorial pairs in 2017 from running the Golden Eagle Population Model under different juvenile survival rates.

Juvenile survival rate	Number of territorial pairs in 2017	
	Recorded 3-year mean	Simulated
0.25	5.0	4.0
0.30	5.0	4.2
0.35	5.0	4.8
0.40	5.0	5.0
0.45	5.0	5.2

Table A7.8.3. Results of simulations of the growth of the Irish Golden Eagle population under a worst-case nest site disturbance scenario, compared to the do-nothing scenario.

Juvenile survival rate	Nest site disturbance	Growth rate	Number of territory holding pairs at Year 35	Years to reach favourable conservation status
0.25	no	1.001	6.3	> 100
	yes	1.000	5.9	> 100
0.30	no	1.009	8.3	100
	yes	1.007	7.8	> 100
0.35	no	1.017	10.9	56
	yes	1.015	9.2	60
0.40	no	1.024	14.1	39
	yes	1.022	13.2	42
0.45	0	1.031	18.1	30
	0.068	1.029	16.8	33

The growth rates are the mean ratios of population sizes between consecutive years during the lifespan of the wind farm but exclude the first three years as these reflect the starting conditions of the model. Positive growth rates represent population growth and negative rates represent population decline. Favourable condition was defined as 66% occupancy of the available home ranges.

A7.8.5 REFERENCES

Burke, B., Crowe, O., & Newton, S. F. (2020). Rare and scarce breeding birds in Ireland in 2017 and 2018. Irish Birds, 42, 63–70.

Haworth Conservation. (2010). Golden Eagles and Wind Farms. shorturl.at/qFI17.

Hillis, J. P. (2008). Rare Irish breeding birds 2007. The annual report of the Irish Rare Breeding Birds Panel (IRBBP). Irish Birds, 8(3), 365–372.

Hillis, J. P. (2009). Rare Irish breeding birds 2008. The annual report of the Irish Rare Breeding Birds Panel (IRBBP). Irish Birds, 8(4), 571–582.

Hillis, J. P. (2010). Rare Irish breeding birds 2009. The annual report of the Irish Rare Breeding Birds Panel (IRBBP). Irish Birds, 9(1), 67–76.

Hillis, J. P. (2011). Rare Irish breeding birds 2010. The annual report of the Irish Rare Breeding Birds Panel (IRBBP). Irish Birds, 9(2), 241–250.

Hillis, J. P. (2012). Rare Irish breeding birds 2011. The annual report of the Irish Rare Breeding Birds Panel (IRBBP). Irish Birds, 9(3), 411–420.

MacArthur Green. (2018). Glenshero Wind Farm: Golden Eagle Population Model Report. https://bit.ly/3ewZqKp.

MacArthur Green. (2021). Bhlaraidh Extension Wind Farm Golden Eagle Population Modelling. https://bit.ly/3CBw71q.

Newton, S. F. (2015). Rare breeding birds in Ireland in 2014 and 2015. Irish Birds, 10(2), 227–234.

Newton, S. F. (2016). Rare breeding birds in Ireland in 2016. Irish Birds, 10(3), 383–392.

O'Toole, L., Fielding, A. H., & Haworth, P. F. (2002). Re-introduction of the golden eagle into the Republic of Ireland. Biological Conservation, 103(3), 303–312.

Perry, K. W. (2013). Rare breeding birds in Ireland in 2012. The annual report of the Irish Rare Breeding Birds Panel (IRBBP), including a review of significant population changes over the past decade. Irish Birds, 9(4), 613–622.

Perry, K. W., & Newton, S. F. (2014). Rare breeding birds in Ireland in 2013. The annual report of the Irish Rare Breeding Birds Panel (IRBBP). Irish Birds, 10(1), 63–70.

R Core Team (2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Whitfield, D. P., Fielding, A. H., McLeod, D. R. A., & Haworth, P. F. (2008). A conservation framework for golden eagles: Implications for their conservation and management in Scotland. Scottish Natural Heritage Commissioned Report, 193(193).

Whitfield, D. P., Fielding, A. H., McLeod, D. R. A., Haworth, P. F., & Watson, J. (2006). A conservation framework for the golden eagle in Scotland: Refining condition targets and assessment of constraint influences. Biological Conservation, 130(4), 465–480. https://doi.org/10.1016/j.biocon.2006.01.008.

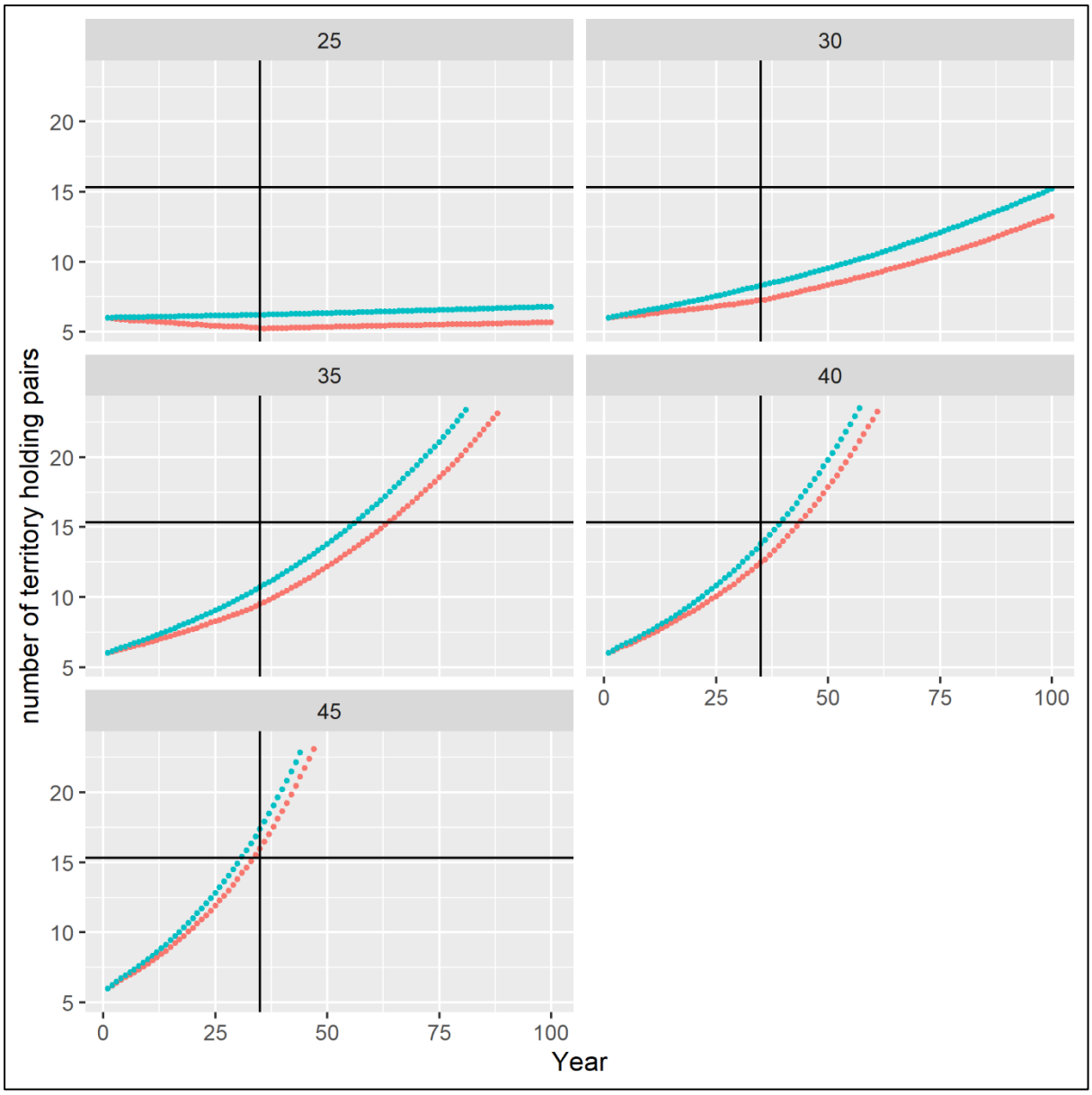

Figure A7.8.1 - Simulated growth of the Irish Golden Eagle population with a collision rate from the Cloghercor Wind Farm of 0.068 collisions/year (red), compared to the baseline scenario with no collisions (blue), shown separately for juvenile survival rates of 25-45%. The horizontal line represents 66% of the available home ranges. The vertical line indicates Year 35, which is the end of the wind farm lifespan.

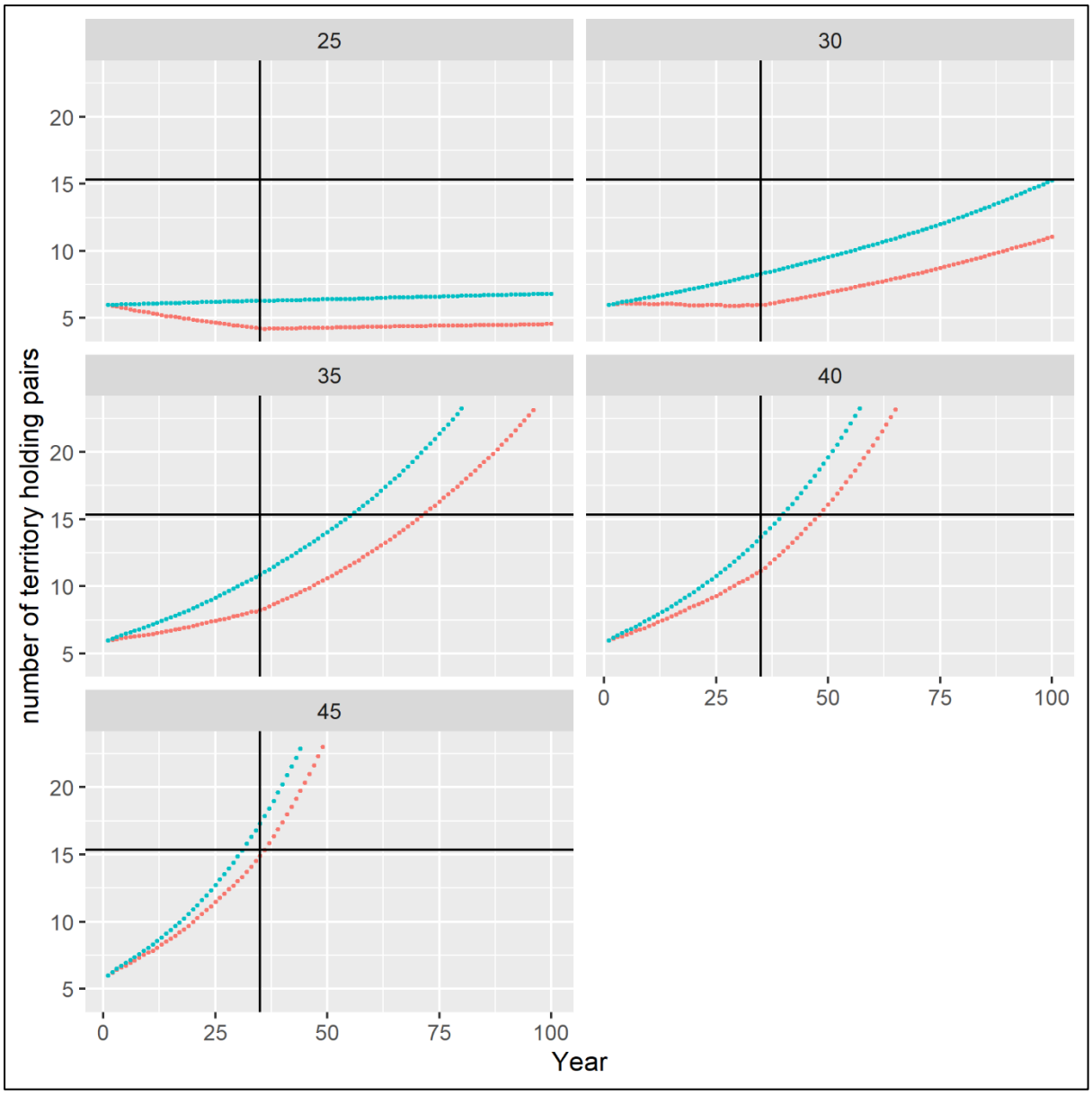

Figure A7.8.2 - Simulated growth of the Irish Golden Eagle population with a collision rate from the Cloghercor Wind Farm of 0.136 collisions/year (red), compared to the baseline scenario with no collisions (blue), shown separately for juvenile survival rates of 25-45%. The horizontal line represents 66% of the available home ranges. The vertical line indicates Year 35, which is the end of the wind farm lifespan.

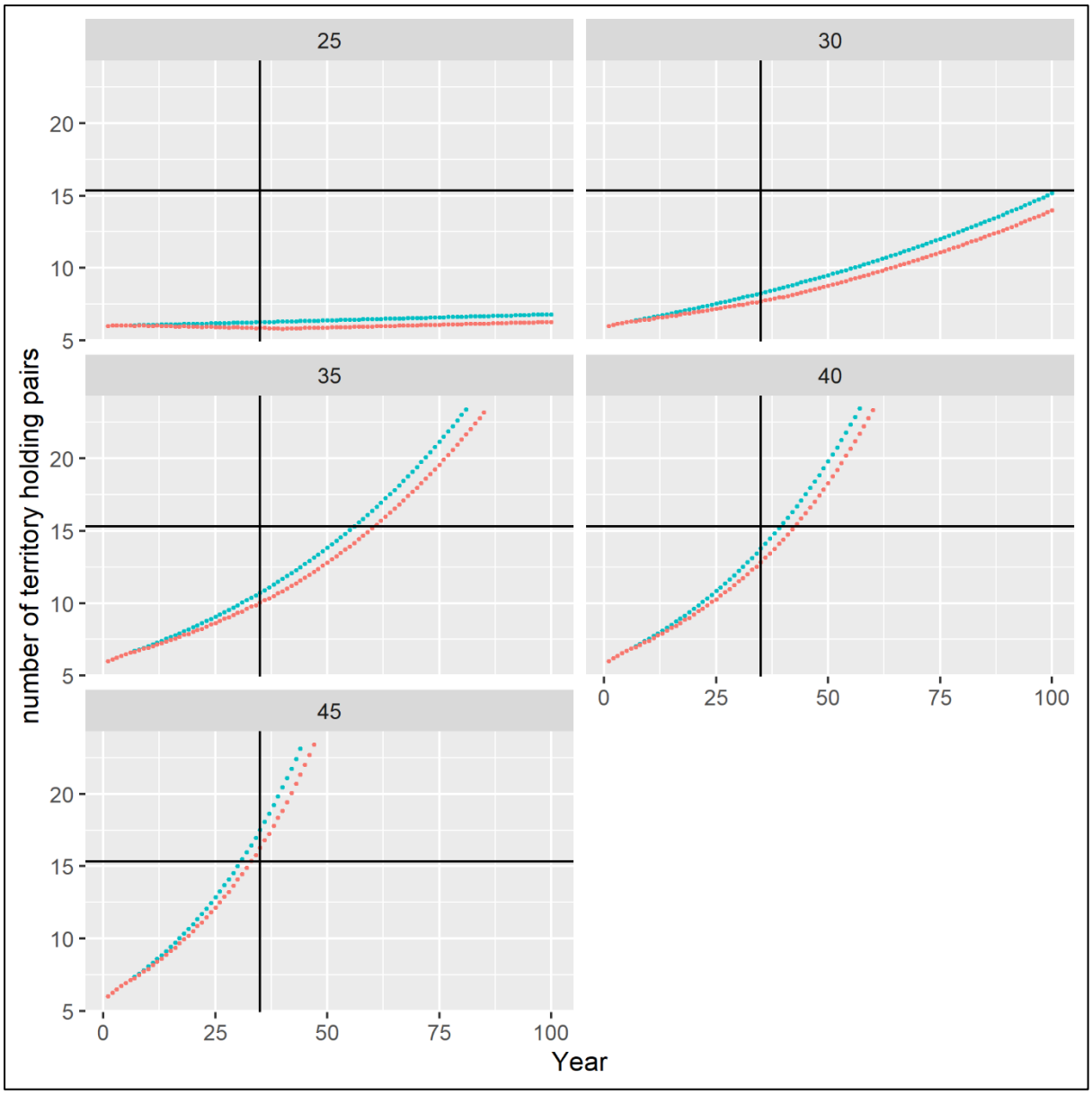

Figure A7.6.3 - Simulated growth of the Irish Golden Eagle population with a nest site disturbance impact causing one pair to fail to breed one out of every three years (red), compared to the baseline scenario with no disturbance impact (blue), shown separately for juvenile survival rates of 25-45%. The horizontal line represents 66% of the available home ranges. The vertical line indicates Year 35, which is the end of the wind farm lifespan.