Technical Appendix

Lairdmannoch Energy Park

Technical Appendix 7-3: Ornithology Modelling

Lairdmannoch Energy Park Limited

May 2025

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1 Introduction

In September 2022, Atmos Consulting Ltd. was commissioned by the Applicant to undertake ornithological surveys in relation to a Proposed Development at Lairdmannoch, Dumfries and Galloway.

Results of surveys indicated relatively high activity from Red kite *Milvus milvus* such that when collision risk modelling (CRM) was undertaken, estimates of collision risk were also relatively high. As a result, it was decided further assessment was required to determine the impact of additional mortality due to collision risk on the Red kite population.

This Technical Appendix describes the modelling undertaken and the outcomes of the modelling. It presents the methodology and results of the Population Viability Analysis (PVA) modelling carried out.

2 Methodology

PVA is a quantitative technique used to determine the probability that a population will persist for a given number of years under particular environmental conditions (Beissinger & McCulloch, 2002).

To investigate the effects of the additional collision risk on the populations of Red kite a dual approach was used. Two models were produced; a deterministic age-structured female-only matrix model, and a model using population modelling software (VORTEX (Lacy, Borbat, & Pollack, 2005)) which enabled the effects of stochasticity to be investigated.

PVA modelling was based on the results of the surveys carried out between September 2019 and August 2021. Table 7-3-1 shows the flight activity for this period. Full details on the methodology to collect this data and the collision risk modelling are provided in **Technical Appendix 7-1**.

Table 7-3-1: Flight activity for Red kite

Year	Min. No. of Birds	Max. No. of Birds	Mean No. of Birds	No. of flights	Total Bird Seconds	At Risk Bird Seconds
Year 1 (Sep 2019 – Aug 2020)	1	4	1.2	151	28,212	21,824
Year 2 (Sep 2020 – August 2021)	1	4	1.05	134	27,622	21,451

This flight activity was subject to collision risk modelling and the Table 7-3-2 shows the outcome of collision risk modelling for the species.

Table 7-3-2: Collision risk modelling results for Red kite

				Uncertainty				Range	
	Collisions at standard rate	Years per collision	Collisions over 40 year operational period	Variance in flight activity	Model Simplifications	Design options	Total	Lower range value	Upper range value
Year 1	**0.475**	2.11	18.985	50%	20%	15%	56%	0.209	0.740
Year 2	**0.859**	1.16	34.353	50%	20%	15%	56%	0.379	1.339
Mean	**0.667**	**1.5**	**26.669**	**50%**	**20%**	**15%**	**56%**	**0.294**	**1.039**

The parameters used for the two versions of the modelling, stochastic and deterministic, are shown in Table 7-3-3.

The model was run using three scenarios, with:

- No collision risk (to establish the future baseline scenario);
- Collision risk (to allow a review of the potential effects of collision risk); and
- Cumulative collision risk (to allow a review of the potential cumulative effects of collision risk).

The model was run for a period of 40 years, to enable life time effects of the Proposed Development to be considered.

For the deterministic model, a female only model was used, which means certain parameters - such as population size and breeding output - were halved to ensure that

only females were included in the model. Results are as such, presented for a population which accounts only for females. Collision risk was applied to adults only, this represents the most severe test of the model since deterministic models can be very optimistic, given they capture no variation in the population.

For the stochastic model, the model was run 500 times for each model version.

Table 7-3-3: Parameters for population modelling

Parameter	Value		Comments	Reference
Population basis (total)	356 birds (178 females)		Based on a breeding population of a mean of 128.4 pairs (Dumfries and Galloway population 2017 – 2022)	Scottish Raptor Monitoring Scheme (SRMS) reports (Challis, et al., 2023)
Survival	1yst yr survival	0.41 (sd =0)	Highland population	(Samson, Etheridge, Smart, & Roos, 2016)
	2nd yr survival	0.71 (sd=0.04)		
	adult	0.86 (sd=0.004)		
Productivity	1.11 (Sd=0.06)		Calculated from productivity for the Dumfries and Galloway population (2017 – 2022)	Scottish Raptor Monitoring Scheme (SRMS) reports (Challis, et al., 2023)
Collision risk (Proposed Development only)	0.667 birds per annum			Chapter 7
Collision risk (Cumulative, consented and Proposed Development)	1.761 birds per annum			Chapter 7

3 Results

3.1 Deterministic Model

An age-structured, relatively simplistic matrix model was developed with the parameters as outlined in Annex A. The population was based on the populations from the Dumfries and Galloway Raptor Study Group monitoring (Challis, et al., 2023) which approximates the area contained within Natural Heritage Zone (NHZ) 19 Western Southern Uplands and Inner Solway.

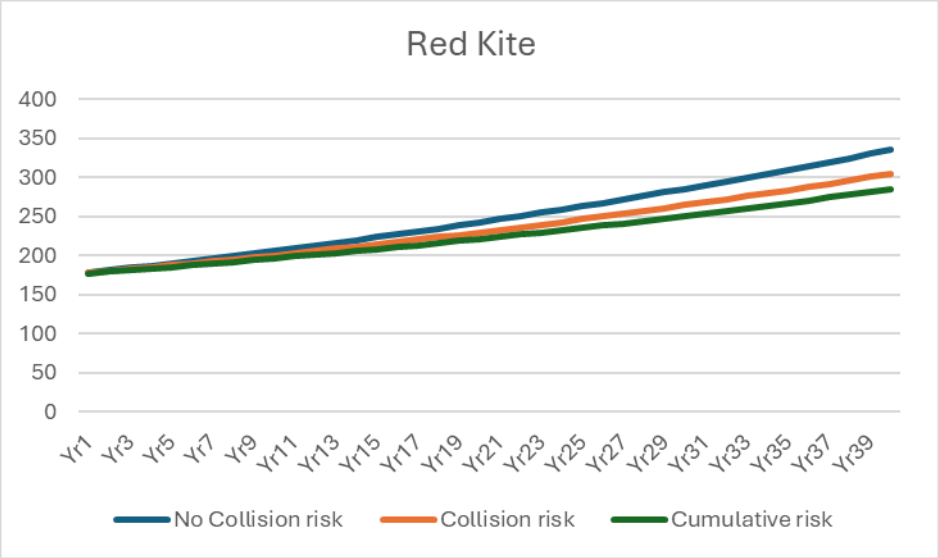
Table 7-3-4 summarises the outcomes of the deterministic modelling.

Table 7-3-4: Deterministic model outcomes

Model	Starling populations (female birds only)	Final population (at 40 years; female birds only)	Approximate annual growth rate
No collision risk	178	335	1.64%
Collision risk	178	305	1.48%
Cumulative risk	178	285	1.23%

Chart 1 shows the results graphically. This shows for all three scenarios, populations continue to expand despite higher levels of mortality as a result of collision risk.

Chart 1 Deterministic population outcomes for modelled Red kite populations



3.2 Stochastic Model

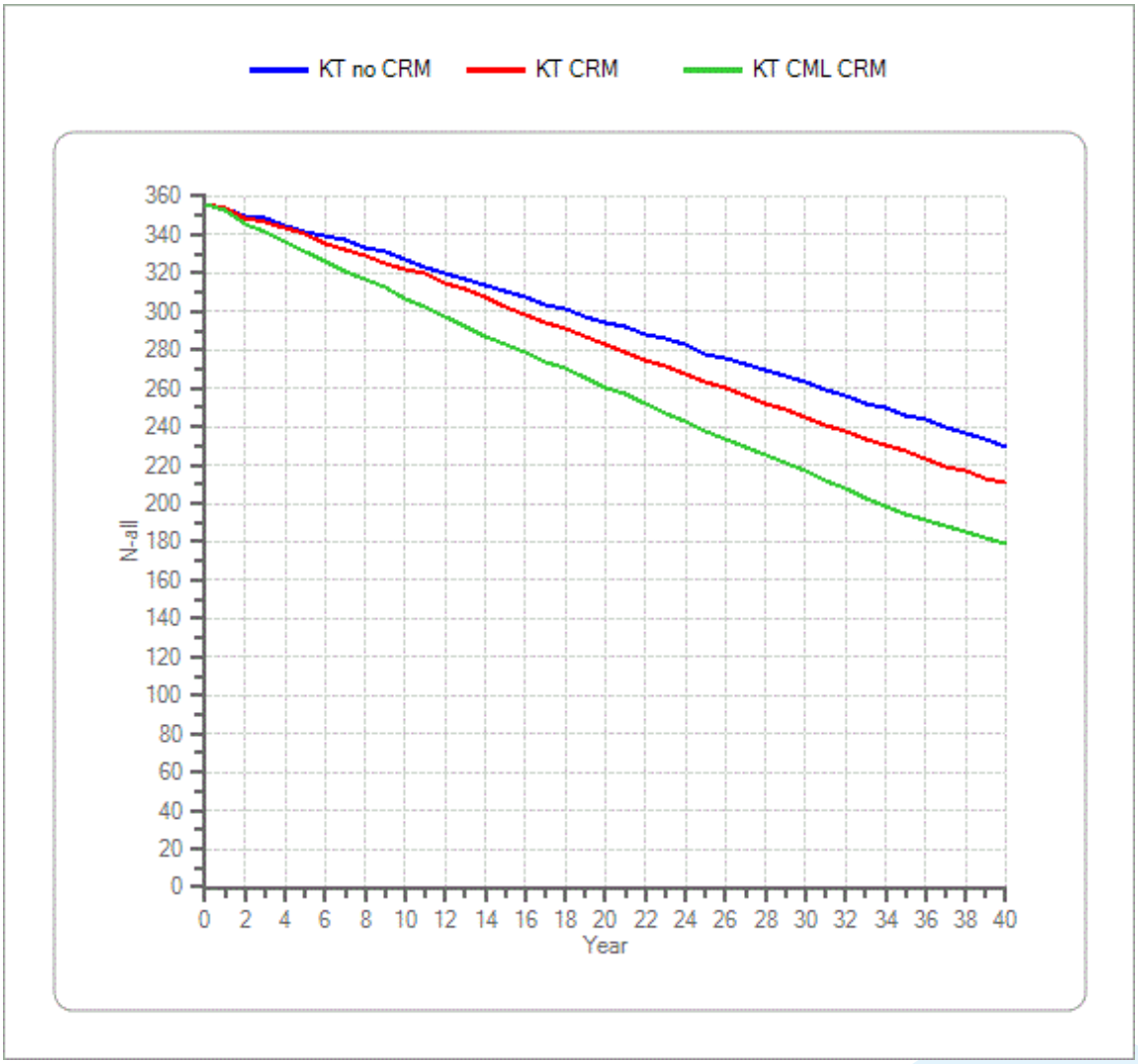
Table 7-3-5 shows the results of the stochastic models. This is shown graphically in Chart 2.

Table 7-3-5: Stochastic model outcomes

Model	Starling populations	Final population (at 40 years)	Approximate annual growth rate (%)	Probability of Extinction (%)
No collision risk	356	230	-1.21%	0.00
Collision risk	356	211	-1.45%	0.00
Cumulative risk	356	179	-1.87%	0.00

For the stochastic model, all three populations are declining and the additional collision mortality has increased the rate of decline but there has been no change in the overall direction.

Chart 2 Stochastic population outcomes for Red Kite populations



4 Discussion

The results of the stochastic and deterministic models showed very different results. The stochastic suggested positive growth across all three models, and the deterministic showed population decline across all three models.

Understanding the differences between the two models helps understand this. The deterministic model shows that in an ideal world, with no variation, the parameters of the kite population would cause positive growth. This shows that the population being assessed is fundamentally sound; population productivity is on average greater than mortality such that the population would be expected to continue growing. The deterministic model however suggests that there can be situations where the natural variability in the population fluctuates over the long term such that productivity is no longer greater than population mortality and so the population declines.

To determine which is the more accurate model for this population, it is standard to consider what is happening in the real world population. The Red kite population in Dumfries and Galloway has continued to rapidly increase between 2009-2018 (SRMS, 2023) although the number of fledglings reported has declined over this period. However these analyses are caveated with the fact that relative to the population size across this period, the monitoring of the population has decreased – as the population has grown, the ability it to monitor it has declined. At this stage, the population size is likely to be underestimated (because not all new breeding attempts are identified and monitored) and because most monitoring is occurring in the well-established part of the population, this also may be underestimating brood size or breeding success. These parameters, in a growing population, can be very large initially but then as the population matures, population effects such as density dependency can start to reduce them. In a PVA of the same population carried out in 2017 (Atmos Consulting , 2017) the productivity was 35% higher, at 1.5 fledged chicks per breeding pair. The current estimate is 1.11 fledged chicks per breeding pair.

If the monitoring of the population predominantly occurs in the well-established part of the population, then it will underestimate the productivity of the population, and this would feed into a model that was unduly conservative.

The other area where the model may be unduly conservative is in mortality. Mortality rates from Samson (Samson, Etheridge, Smart, & Roos, 2016) have been used, but these mortality rates are based on the Highland population, which has shown the poorest growth rates of the reintroduced populations. Using the mortality from the Highland population could be overly conservative for the Dumfries and Galloway population when it comes to levels of natural mortality. In particular, survival rates for first year birds were estimated at 41%; however Duffy (Duffy, 2014) suggests that 80% of their first year birds survived, in a study based on the Perthshire population, and that that was a similar survival to observations from England.

As a result, the combination of underestimated population size, productivity and survival of first year birds in particular are likely combining produce a deterministic model which does not reflect the real world situation of the expanding Dumfries and Galloway population. Given that, the deterministic model, while much more simplistic, is probably closer to the actual situation and this would suggest that there is sufficient capacity in the population to accept the level of additional mortality even the cumulative collision risk would add in. Additionally, it is worth noting that because the

deterministic model can be very positive, that all collision risk in that model occurs only to adult birds, where the mortality from collision risk has greatest impact. Despite this, the populations continued to grow in all three scenarios.

5 References

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