# Appendix 8-5- Derryadd Wind Farm: Collision Risk Modelling Report (Gittings, 2025)

# DERRYADD WIND FARM: COLLISION RISK MODELLING REPORT

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# CONTENTS

**LIST OF FIGURES**



**LIST OF MAPS**

## SUMMARY

This report presents the results of collision risk modelling for the proposed Derryadd Wind Farm, Co. Longford. The proposed wind farm will comprise 22 turbines. The turbines will have a hub height of 107.5 m and a rotor diameter of 165 m, which creates a potential collision height airspace of 25 -190 m.

The collision risk model was based on seven seasons of vantage point survey data from nine vantage points with a survey effort of around six hours / month / vantage point. The NatureScot model was used. As well calculating predicted collision risks, the uncertainty ranges around the estimates were quantified. Collision risks that would cause a 1% or greater increase in mortality to the affected population were considered potentially significant and assessed further.

The predicted collision risks generated increases in mortality rate that substantially exceeded the 1% threshold for the local Golden Plover wintering population, the local Lapwing breeding population and the County Longford breeding population. However, in each case there were a number of factors that suggested that the increase in mortality rate was over-estimated.

The predicted increases in annual mortality to the Lough Ree Whooper Swan wintering population, the Lough Ree Cormorant and Lesser Black-backed Gull breeding populations, and the County Longford Sparrowhawk breeding population only just exceeded the 1% threshold. Given the precautionary nature of the 1% threshold, and the precautionary assumptions made in the calculations of these increases, while allowing for the potential under-detection of Cormorant and Black-headed Gull commuting flights, the predicted collision risk is unlikely to have significant impacts on these populations.

# 1. INTRODUCTION

## 1.1. SCOPE

This report presents the collision risk modelling and collision risk assessment for the proposed Derryadd Wind Farm, Co. Longford. The proposed wind farm will comprise 22 turbines. The site location and proposed site layout is shown in Map 1.1. The turbines will have a hub height of 107.5 m and a rotor diameter of 165 m, which creates a potential collision height airspace of 25-190 m.

The collision risk modelling methodology was based on the NatureScot guidance on collision risk modelling (NatureScot, 2024), and current practice in collision risk modelling.

This work was commissioned by TOBIN. The collision risk modelling, assessment and reporting was carried out by Tom Gittings.

## 1.2. COLLISION RISK MODELLING

Collision risk modelling uses statistical modelling techniques to predict the likely collision risk. It uses flight activity data from before the construction of a wind farm to calculate the likely risk of birds colliding with turbines in the operational wind farm. The flight activity data is used to calculate flight activity densities at potential collision height within the risk area of the wind farm. These densities are then used to predict the number of transits of the rotor swept volume in the wind farm based on the proportion of the total air space that is occupied by the rotor swept volume. However, most transits of the rotor swept volume will not result in a collision, because, for the duration of a transit, most of the rotor swept volume is not occupied by the turbine blades. Therefore, the probability that a bird will collide with a turbine blade when it transits the rotor swept volume is calculated. Most birds try to avoid the turbine blades, either by avoiding the wind farm area altogether, or by taking evasive action if they are likely to collide with a blade while transiting the wind farm, so it is also necessary to factor in an avoidance rate. The final collision risk is calculated by multiplying the number of predicted transits by the probability of a collision on a single transit and correcting for the avoidance rate and other relevant factors.

## 1.3. COLLISION RISK ASSESSMENT

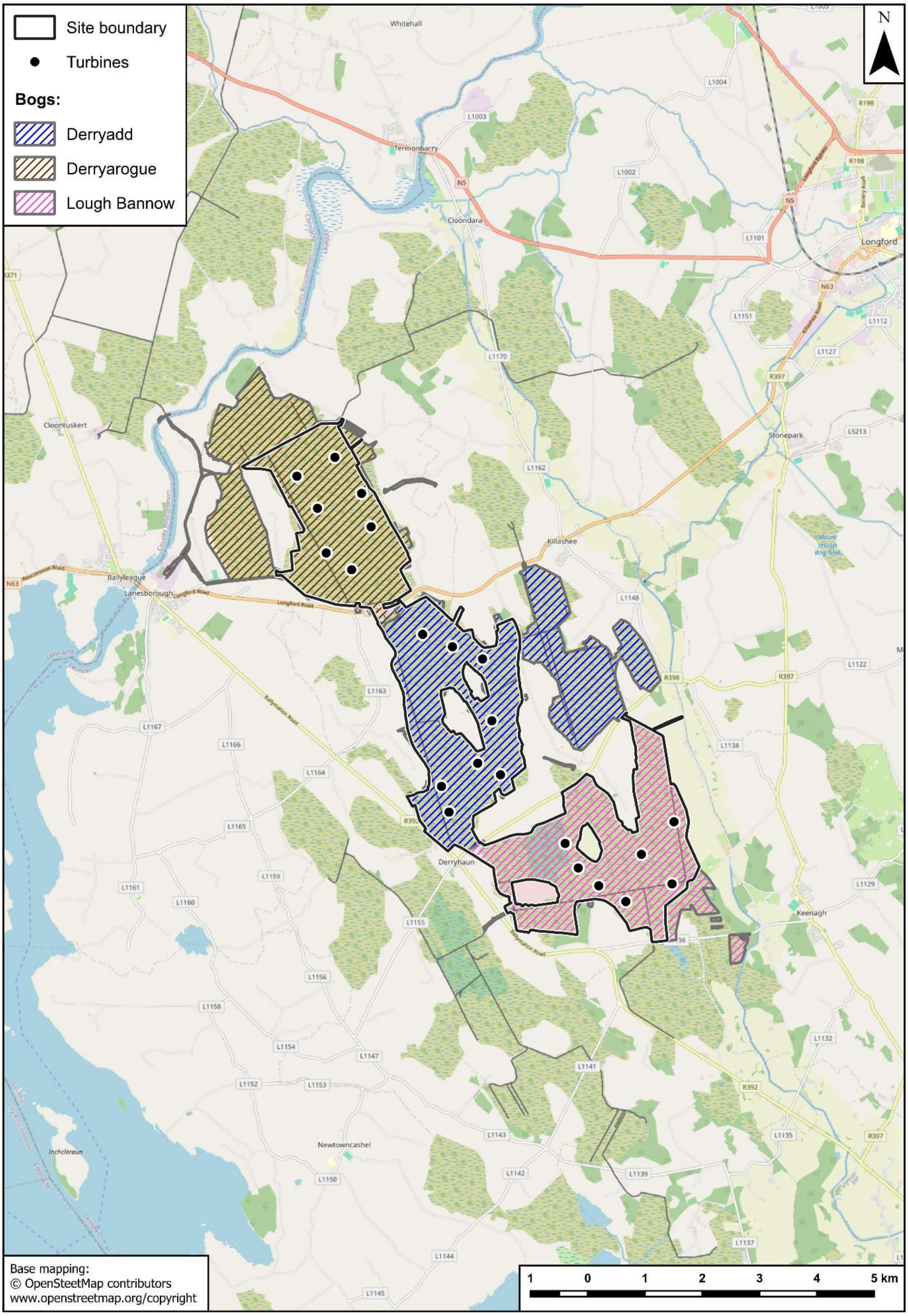
The potential impact of the predicted collision risk depends on the size of the affected population and their demographics. The collision risk assessment examines whether the level of the predicted collision risk could have a significant effect on the dynamics of the affected population.

## 1.4. NATURE SCOT GUIDANCE

NatureScot (2024) provides detailed guidance for carrying of collision risk modelling for onshore wind farm projects. This guidance was developed by Band (2024) from the original Scottish collision risk model (SNH, 2000) and the refinement of this model by Band (2012). The basic methods remain the same, but the NatureScot guidance introduces a number of new components. It deals with issues not covered by the previous guidance, such as how to combine data from multiple vantage points and how to account for nocturnal flight activity. It also includes a specific requirement to assess the uncertainty around the collision risk estimates, which is an issue that has been poorly dealt with in Irish collision risk modelling. There is a spreadsheet that accompanies the guidance that can be used to implement the collision risk model.

## 1.5. STATEMENT OF COMPETENCE

Tom Gittings has a BSc in Ecology, a PhD in Zoology and is a member of the Chartered Institute of Ecology and Environmental Management. He has 29 years' experience in professional ecological consultancy work and research. He has specific expertise in ornithological assessments for wind energy projects and has been involved in numerous wind energy projects. His input to these projects has variously included field surveys (including vantage point surveys, breeding wader and raptor surveys and wintering waterbird surveys), collision risk modelling, writing the ornithological sections of EIS/EIAR and NIS reports, expert witness services at oral hearings, and provision of scoping advice and peer review services.




Map 1.1. Site location and proposed site layout.

# 2. METHODOLOGY

## 2.1. INTRODUCTION

The collision risk modelling methodology was based on the NatureScot guidance on collision risk modelling (NatureScot, 2024), additional guidance provided by Band (2024), and current practice in collision risk modelling.

## 2.2. SPECIES

All the waterbird and raptor species recorded flying at potential collision height during the surveys, apart from Snipe, were included in the modelling of predicted transits. Snipe was not included because vantage point surveys are not an effective method of sampling their flight activity, so the results from collision risk modelling would not be very meaningful.

## 2.3. DATA SOURCES

### 2.3.1. Flight activity data

The flight activity data used for the collision risk model comprised a seven-season vantage point survey carried out between summer 2021 and summer 2024.

The survey was carried out by two separate survey teams: the Fehily Timoney survey team between April 2021 and March 2022 and the TOBIN survey team between April 2022 and September 2024. Both survey teams used eleven vantage points. However, the vantage point locations and viewsheds differed between the two survey teams. The vantage points and viewsheds used by the Fehily Timoney survey team are shown in Map 2.1. The vantage points and viewsheds used by the TOBIN survey team are shown in Map 2.2.

The viewsheds were mapped by TOBIN using QGIS© 3.28. The viewsheds were mapped to show visibility from the vantage points at a minimum elevation of 25 m above ground level.

The raw viewshed mapping that was supplied to me included a large number of very small outlying segments: the mapping for each set of viewsheds included over 10,000 discrete polygons with over 94% of the polygons having areas of < 0.01 ha. For the analyses in this report, I generated simplified viewshed maps. I first removed all viewshed segments with areas of less than 10 ha. I then used the *st_simplify* function with a dTolerance value of 10 from the R package *sf* (Pebesma and Bivand, 2023) to simplify the remaining polygons. I then used the *fill_holes* function from the R package *smoothr* (Strimas-Mackey, 2023) to remove gaps smaller than 10 ha within the polygons. Finally, I used the *smooth* function from the *smoothr* package, with the ksmooth method and a smoothness parameter of 1.5, to smooth the boundaries of the polygons. This process resulted in deletion of all the viewshed segments for the Fehily Timoney VP1 and VP2 viewsheds.

A minimum of 36 hours of vantage point watches were completed at each vantage point in each season, apart from VP1, VP7 and VP9 in the winter of 2021/22, VP8 on the summer of 2023, and VP6 in the winter of 2023/24 (Table 2.1). The survey effort was usually evenly distributed across months (six hours per vantage point per month). However, there were occasional months where no surveys were carried out at some vantage points, with the hours being made up in a subsequent month. The higher overall survey effort in the summer of 2021 was due to an extra set of six-hour migration watches that were carried out in September 2021.

Table 2.1. Total number of vantage point survey hours per vantage point per season.

| Season | VP1 | VP2 | VP3 | VP4 | VP5 | VP6 | VP7 | VP8 | VP9 | VP10 | VP11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2021 summer | 42 | 42 | 42 | 41.5 | 42 | 42 | 42 | 42 | 42 | 42 | 42 |
| 2021/22 winter | 30 | 36 | 36 | 36.5 | 36 | 36 | 35.5 | 36 | 34 | 36 | 36 |
| 2022 summer | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 |
| 2022/23 winter | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 |
| 2023 summer | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 30 | 36 | 36 | 36 |
| 2023/24 winter | 36 | 36 | 36 | 36 | 36 | 34 | 36 | 42 | 36 | 36 | 36 |
| 2024 summer | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 |

Seasons: summer = April – September; winter = October – March. Note that the vantage point locations used for first two seasons differed from those used for the last two seasons (see text).

The survey recorded timed flight activity of all raptor and waterbird species in various height bands. The Fehily Timoney survey team used the following height bands: 0-30 m, 30-50 m, 50-185 m and above 185 m. The TOBIN survey team used the following height bands: 0-25 m, 25-50 m, 50-150 m, 150-190 m and above 190 m.

The full vantage point survey data is included in the relevant appendices to the Environmental Impact Assessment Report Ornithology chapter.

### 2.3.2. Turbine specifications

The turbine specifications used for the collision risk model (apart from mean pitch angle; see Section 2.6.4) were supplied by TOBIN and are shown in Table 2.2.

Table 2.2. Turbine parameters used for the collision risk model.

| Parameter | Value |
|---|---|
| Hub height | 107.5 m |
| Rotor diameter | 165 m |
| Max chord | 4.0 m |
| Rotor speed (nominal) | 9.7 m/sec |
| Mean pitch angle | 0° |

Sources: data supplied by TOBIN, except for mean pitch for which see Section 2.6.4.

### 2.3.3. Bird biometrics

The bird biometric parameters used for the collision risk model are shown in Table 2.3.

### 2.3.4. Seasonal periods

The seasonal periods used in the collision risk model and assessment are shown in Table 2.4. For the species not included in this table the collision risk was calculated and assessed for the whole year.

Table 2.3. Bird biometric parameters used for the collision risk model.

| Species | Length (m) | Wingspan (m) | Flight speed (m/sec) |
|---|---|---|---|
| Mute Swan | 1.525 | 2.180 | 16.2 |
| Whooper Swan | 1.520 | 2.300 | 17.3 |
| Greylag Goose | 0.820 | 1.640 | 17.1 |
| Wigeon | 0.480 | 0.805 | 20.6 |
| Teal | 0.360 | 0.610 | 19.7 |
| Mallard | 0.580 | 0.900 | 18.5 |
| Cormorant | 0.900 | 1.450 | 15.2 |
| Little Egret | 0.600 | 0.915 | 10.2 |
| Grey Heron | 0.940 | 1.850 | 11.2 |
| Marsh Harrier | 0.520 | 1.225 | 11.2 |
| Hen Harrier | 0.480 | 1.100 | 9.1 |
| Sparrowhawk | 0.330 | 0.620 | 11.3 |
| Buzzard | 0.540 | 1.200 | 11.6 |
| Golden Plover | 0.280 | 0.720 | 17.9 |
| Lapwing | 0.295 | 0.845 | 12.8 |
| Whimbrel | 0.410 | 0.820 | 16.3 |
| Curlew | 0.550 | 0.900 | 16.3 |
| Black-headed Gull | 0.360 | 1.050 | 11.9 |
| Lesser Black-backed Gull | 0.580 | 1.420 | 13.1 |
| Kestrel | 0.340 | 0.760 | 10.1 |
| Merlin | 0.280 | 0.560 | 10.1 |
| Peregrine | 0.420 | 1.020 | 12.1 |

Length and wingspan from BirdFacts (www.bto.org/understanding-birds/birdfacts); flight speed from Alerstam *et al.* (2007). For Little Egret, Great White Egret speed used; for Golden Plover, Grey Plover speed used.

Table 2.4. Seasonal periods used in the collision risk modelling and assessment.

| Species | Season | Months |
|---|---|---|
| Whooper Swan | winter | October – March |
| Wigeon | winter | October – March |
| Cormorant | breeding | April – July |
| | non-breeding | August – March |
| Hen Harrier | non-breeding | September – March |
| Golden Plover | summer | May - September |
| | winter | October – April |
| Lapwing | breeding | April – July |
| | autumn | August – October |
| | winter | November – March |
| Whimbrel | migration | April – May and July – September |
| Curlew | breeding | April – July |
| | non-breeding | August – March |
| Black-headed Gull | breeding | April – July |
| | non-breeding | August – March |
| Lesser Black-backed Gull | breeding | April – July |
| | autumn | August – October |
| | winter | November – March |

### 2.4. DATA MANAGEMENT

Before beginning the analyses, I audited the flight activity data for data entry errors and missing data. I also removed non-flight records.

### 2.5. EXPLORATORY ANALYSES

#### 2.5.1. Scope

Before beginning the development of the collision risk model, I carried out a review of the vantage point survey coverage and results. This helped to assess the degree of spatial and temporal variability in the recorded flight activity, which needed to be taken into account in the development of the collision risk model. Note that spatial and temporal variability can only be assessed for the regularly occurring species. With species that were only recorded occasionally, it is not possible to distinguish between sampling effects and true spatial and temporal variability.

I also reviewed breeding bird survey data to generate estimates of the local Lapwing breeding population for the collision risk assessment.

Details of the specific methodologies used for some of these exploratory analyses are provided in the following sections.

#### 2.5.2. Distance effects

Declines in detection rates with distance from vantage points is a common issue in vantage point surveys, and the guidance on vantage point surveys (SNH, 2017) recommends considering corrections for detectability effects. Therefore, I carried out analyses to assess the relationships between distance from the vantage point locations and the flightline detections.

The analyses assumed that flight activity is randomly distributed in relation to distance from the vantage point locations. At individual vantage points, habitat associations and / or topography may affect the relationship between distance from the vantage point location and flight activity. Averaging across a number of vantage points is likely to minimise these biases, because the habitat / topographic effects will differ between vantage points. However, very strong habitat / topographic effects affecting a lot of the flight activity at a vantage point could still bias these analyses.

As detectability will be strongly affected by body size, I divided the species recorded in the vantage point surveys into three size groups, based on their cross-sectional indices (the body length multiplied by the wingspan). The small species included Wigeon, Teal, Sparrowhawk, Golden Plover, Lapwing, Whimbrel, Black-headed Gull, Kestrel and Merlin with body lengths of 0.17-0.48 m and wingspans of 0.25-1.05 m. The medium species included Mallard, Little Egret, Marsh Harrier, Hen Harrier, Buzzard, Lesser Black-backed Gull and Peregrine with body lengths of 0.41-0.71 m and wingspans of 0.80-1.42 m. The large group included Mute Swan, Whooper Swan, Greylag Goose and Grey Heron with body lengths of 0.72-1.53 m and wingspans of 1.45-2.30 m.

In addition to the exclusion of the Fehily Timoney VPs 1 and 2 and the TOBIN VPs 1 and 3 (see Section 3.1), I also excluded the Fehily Timoney VP7: the viewshed for this vantage point had almost no coverage of the distance bands greater than 1000 m from the vantage point.

I divided each viewshed into eight bands, representing increasing distance from the vantage point, from 0-250 m to 1750-200 m. However, some of the viewsheds in the Fehily Timoney dataset had limited coverage of distance bands greater than 1250 m from the vantage point. Therefore, for the analysis of the Fehily Timoney dataset, I grouped the 1250-1500, 1500-1750 and 1750-2000 m distance bands into a single 1250-2000 m distance band.

I then calculated the total length of flightlines for each species group in each band. Flightlines that only occurred in the 0-25 m height band were excluded, because the viewsheds had been derived using a minimum height of 25 m.

I then calculated the flightline density for each distance band in each viewshed using Equation EX1. This equation standardises the flightline density in each distance band by the total amount of flight activity recorded at that vantage point, to avoid the analyses being biased by vantage points where large amounts of flight activity were recorded.

Equation EX1: $FD_{i^*} = \sum(FD_i / FD_{VP}) \times FD_{mean}$

$FD_{i^*}$ = weighted flightline density in band i; $FD_i$ = raw flightline density in band i; $FD_{VP}$ = summed flightline densities across all bands in the viewshed containing grid square i; $FD_{mean}$ = mean of $FD_{VP}$ = across all the vantage points included in the analysis.

For the Tobin dataset, I used the ratio of the weighted flightline density in each band to the maximum weighted flightline density across all bands to calculate weightings for each distance band. These weightings indicate the degree of under-recording in each distance band, based on the assumption that all flightlines were detected in the band with the maximum density. The latter was 0-250 m, or the 250-500 m distance band.

The analyses of the Fehily Timoney data only showed distance effects beyond 1250 m. Therefore, I used the mean weighted flightline density across 0-250 m, 250-500 m, 500-750 m, 750-1000 m and 1000-1250 m distance bands to calculate a weighting for the 1250-2000 m distance band.

### 2.5.3. Species-specific spatial structure

The basic model assumes random distribution of flight activity across the wind farm site, or across portions of it. Therefore, in addition to considering the distance effects on detectability, it is also necessary to consider whether deviations from this assumption are likely to significantly bias the model. In large wind farm sites, such as the Derryadd Wind Farm site, species are likely to show significant deviations from this assumption.

I investigated spatial structure for species / populations of conservation importance that had strong associations with the wind farm site. These included breeding populations within the wind farm site, non-breeding populations regularly using the wind farm site, and populations regularly commuting over the wind farm site.

For Whooper Swan, Cormorant (breeding population), Golden Plover, Lapwing (breeding population), Lapwing (wintering population) and Black-headed Gull (breeding population), I investigated spatial structure by direct examination of the flightline mapping.

For the Lesser Black-backed Gull (breeding population), Lesser Black-backed Gull (autumn) and Kestrel, which had high levels of flight activity, I mapped flightline densities across the wind farm site to investigate whether there was species-specific spatial structure in flight activity. The method that I used included corrections for overlapping viewsheds and for reduced detection of distant flightlines.

For all the species assessed, I also examined the distributions of flight activity densities at potential collision height between vantage points, which were generated in Stage A of the collision risk model.

#### *Flightline density mapping methods*

I used a 250 x 250 m grid to map flightline densities and carried out separate analyses for the Fehily Timoney and TOBIN datasets.

I intersected the flightline mapping with the viewsheds to exclude flightlines, or portions of flightlines, that were outside the viewsheds. I then intersected the flightline mapping with the grid and calculated the number of unique flightlines, and the total flightline length in each grid square. I excluded flightlines where all the flight activity was in the lowest height band as these flights would have been below the minimum height covered by the viewsheds.

I generated 250 m distance bands for each viewshed and intersected these distance bands with the grid. I then calculated the weighted viewshed area in each distance band as the sum of the viewshed areas in each distance band multiplied by the weighting for the distance band.

I then calculated the densities of flightline numbers and flightline lengths in each grid square by dividing the flightline numbers and flightline lengths by the weighted viewshed areas. I excluded grid squares where the weighted viewshed area was less than 1 ha to avoid the analyses being biased by very high densities created by grid squares with very small weighted viewshed areas.

After carrying out separate analyses for the Fehily Timoney and TOBIN datasets, I generated densities for the combined dataset by calculating the mean densities for each grid square covered by the density maps for both datasets, weighted by the number of seasons included in each dataset.

### 2.5.4. Lapwing breeding population

I defined the local population as the population occupying Derryarogue Bog, Derryadd Bog (including the eastern section outside the wind farm site) and Lough Bannow Bog.

I used the records from breeding wader surveys, breeding season transect surveys, and breeding season vantage point surveys to map the distribution of Lapwing breeding season activity and calculate the number of territories for the local population in the 2022-2024 breeding season. The available data was not sufficient to carry out this exercise for the 2021 breeding season.

I classified the breeding evidence associated with each record using the standard BTO codes (see Table 2.2 in Balmer *et al.*, 2013). I also included an additional code (PB) to categorise flocks of Lapwing recorded in July that may have represented post-breeding aggregations, or early migrants.

In some cases, I reclassified records that had been allocated a different code in the dataset supplied. In particular, there were several records that were classified as recently fledged young (FL). However, for nidifugous species like Lapwing that leave their nest shortly after hatching, this code should only be applied to downy young and detecting young at this stage is difficult. The detail available for most of these records either did not make clear the status of the young or indicated that they were too advanced for such a classification.

I interpreted records with probable or confirmed breeding evidence (excluding pairs observed in suitable nesting habitat) as indicating occupied territories. I used a separation distance of 500 m to define separate territories (Brown and Sheppard, 1993). Lapwing often breed in loose neighbourhood groups (Cramp and Simmons, 2004). Therefore, I classified some territories as being occupied by multiple pairs if there were records indicating this (e.g., two pairs recorded displaying in a single record).

## 2.6. COLLISION RISK MODELLING METHODOLOGY

### 2.6.1. General

I followed the NatureScot guidance for the collision risk modelling methodology.

The NatureScot guidance includes a spreadsheet that can be used to implement the collision risk model. However, use of spreadsheets for complex modelling is not best practice due to the difficulty of auditing the code. Also, in this case, where there were multiple species to model, and where I was running multiple variants of the model, use of spreadsheets would be very cumbersome. Therefore, I implemented the NatureScot methodology using custom scripts in R version 4.4.1 (R Core Team, 2024). I audited the scripts against the spreadsheet to ensure that they produced identical results. The scripts used for the modelling can be provided on request.

### 2.6.2. Stage A: flight activity

***NatureScot methodology***

Stage A involves calculating the density of flight activity in the area where collision risk will be generated by the installation of wind turbines. It also includes ranking nocturnal activity and calculating the distribution of daytime and nighttime hours.

*Flight activity density*

For onshore wind farms, calculations of flight activity density are usually based on flight durations recorded by vantage point surveys. This involves adjusting the total amount of flight activity recorded in the vantage point surveys by the area surveyed and the survey duration. Where data from multiple vantage points is available, it is also necessary to consider how to combine the data.

The NatureScot methodology for Stage A first calculates the mean areal density of flight activity in the viewshed of each vantage point:

Equation A1: $D1 = b / (t \times A)$ birds $m^{-2}$

$b$ = total flight activity (bird-seconds); $t$ = total duration of vantage point watches (seconds); $A$ = viewshed area ($km^2$).

Note that flight activity is expressed as the sum of the duration of each flight multiplied by the number of birds: e.g., a record of 20 birds flying for 10 seconds = 200 bird-seconds.

The flight activity density is then averaged across all the vantage points. The NatureScot guidance presents two methods for doing this.

Where there were significant differences in survey effort between the vantage points, the flight activity density can be averaged by weighting for the viewshed area and the duration of the vantage point survey at each vantage point. This reflects the fact that, in principle, larger survey areas and/or survey durations will sample more flights and will, therefore, be less affected by sampling effects. However, note that there are some issues with this weighting method (see Section 4.7.3).

Equation A2: $D^* = \Sigma(D_i \sqrt{(t_i \times A_i)}) / \Sigma \sqrt{(t_i \times A_i)}$

$D_i$ = flight activity areal density at VP i ; $t$ = total duration of vantage point watches at VP i (seconds); $A$ = viewshed area at VP i ($km^2$).

Where the variation in flight activity density between vantage points is likely to reflect real differences in flight activity, the flight activity density can be averaged by weighting for the number of turbines within the viewshed of each vantage point. However, before applying the weighting it is important to consider whether apparent variation between vantage points could be due to sampling effects.

Equation A3: $D^* = \Sigma(N_i \times D_i) / \Sigma N_i$

$D_i$ = flight activity areal density at VP i ; $N_i$= the number of turbines in the viewshed of VP i.

Although not discussed in the NatureScot guidance, the weightings in Equations A2 and A3 can be combined to weight for both differences in survey effort and real differences in flight activity between vantage points.

*Daytime and nighttime hours*

The NatureScot methodology uses the formula in Forsythe *et al.* (1995) to calculate daytime and nighttime hours.

*Nocturnal flight activity*

Vantage point surveys only record flight activity during daylight hours (normally sunrise to sunset). Therefore, for species that also fly at night, it is necessary to adjust the flight activity densities to allow for nocturnal flight activity.

The NatureScot methodology adjusts for nocturnal flight activity by using a nocturnal activity ranking to categorise each species by its degree of nocturnal activity on a scale of 1-5, where 1 = hardly any nocturnal activity and 5 = as active at night as by day. It then uses this categorisation to include nocturnal flight activity in the calculation of predicted transits in Stage B.

To illustrate the effect of nocturnal flight activity on the collision risk predictions, I calculated nocturnal correction factors for species with non-zero nocturnal flight activity (nocturnal activity rankings of more than one), as shown in Equation A4.

Equation A4: $NCF = 1 + ((NAR - 1) \times 0.25) \times h_{night^*} / h_{day^*}$

NAR = nocturnal activity ranking (see text); $h_{night^*}$ = mean night-time hours across seasonal period of occurrence; $h_{day^*}$ = mean day-time hours across seasonal period of occurrence.

The nocturnal correction factor represents the increase in flight activity densities that is generated by the adjustment for nocturnal flight activity in the calculation of predicted transits in Stage B.

***Data sources and preparation***

*Parameters*

The parameters required for the Stage A modelling of flight activity densities using Equation A1 are the flight activity duration (b), the vantage point survey duration (t) and the viewshed area (A).

Stage A also requires classifications of nocturnal activity rankings for all species included in the model and calculations of monthly totals of daytime and nighttime hours.

The derivation of the data required for these parameters is described in the following sections.

*Vantage points*

I used flight activity data from the Fehily Timoney VPs 3-11 and the TOBIN Vantage Points 2 and 4-11. The excluded vantage points had very small viewsheds and were outside the wind farm site.

*Flight activity duration (b)*

The flight activity durations included in Equation A1 comprise the sum of the duration of each flightline multiplied by the number of birds recorded on the flightline: e.g., a flock of 100 Golden Plover recorded flying for 10 seconds would generate a flight activity duration (b) value of 1000 bird-secs.

The flight activity durations were obtained from the vantage point survey datasets. These contain timed durations of flight activity for each record in specified height bands.

In the Fehily Timoney dataset, I used the data from all the height bands. The inclusion of the data from the 0-30 m and > 185 m Fehily Timoney height bands will have caused some overestimation of the flight activity density at potential collision height. However, this was necessary as these height bands included part of the potential collision height zone (25-185 m).

In the TOBIN dataset, I used the data from the 25-185 m height bands.

Equation A1 uses the viewshed area to derive the density of flight activity recorded during the vantage point surveys. Therefore, flight activity that occurred outside the viewshed of the vantage point being surveyed should be excluded from the analyses.

I excluded flightlines that occurred entirely outside the relevant viewshed.

Where a flightline occurred partly outside the relevant viewshed, I adjusted its duration by the proportion of the flightline length that occurred in the viewshed. The flightline was clipped by the viewshed. The duration was then recalculated by multiplying the original value by (clipped flightline length) / (original flightline length). It should be noted that, this recalculation procedure assumes that the flight speed and flight height distribution were similar between the segments used for the recalculation.

*Vantage point survey duration (t)*

The vantage point survey duration parameter represents the total vantage point survey effort over the seasonal period used for the collision risk modelling. I calculated this duration separately for each vantage point and each month in each dataset.

*Viewshed area (A)*

The viewshed area represents the spatial extent of the area covered by the vantage point survey. I calculated raw viewshed areas from the mapped viewsheds for each vantage point. I also calculated corrected viewshed areas that were adjusted to allow for the effects of under-estimation of distant flightlines. For each viewshed, I multiplied the area in each 250 m distance band by the band weightings derived from the analyses of distance effects (see Section 2.5.2).

*Daytime and nighttime hours*

I used the formula in Forsythe *et al.* (1995) to calculate day-time and night-time hours. I used the latitude of the centroid of the turbine locations and a p-value of 0.8333. The p-value represents the position of the sun relative to the horizon at sunrise and sunset.

*Nocturnal activity ranking*

The nocturnal activity ranking is an estimation of the degree of nocturnal activity ranked on a scale from 1 (hardly any nocturnal activity) to 5 (as active at night as by day). I applied nocturnal activity rankings of more than one to Wigeon, Teal, Mallard, Little Egret, Grey Heron, Golden Plover, Lapwing and Whimbrel.

The Whimbrel overflying the wind farm are likely to be on direct migration, which is probably equally likely to occur by night as by day. So, the nocturnal flight activity rate for Whimbrel was set as 5.

For Mallard, visual inspection of Figure 2 in Korner *et al.* (2016) suggests that nocturnal activity is around half that of diurnal activity, so the nocturnal activity ranking was set as 3. The same rate was applied to the ecologically similar Wigeon and Teal.

For Golden Plover, a figure of 25% of the day-time activity levels across the night-time hours is often used in collision risk modelling (e.g., MKOS, 2019), so the nocturnal activity ranking was set as 2. The same rate was applied to the ecologically similar Lapwing.

Flight activity patterns for Grey Heron from Vessem and Draulans (1987) indicate low levels of nocturnal flight activity, so the nocturnal activity ranking was set at the same rate as Golden Plover. The same rate was applied to the ecologically similar Little Egret.

I used nocturnal activity rankings of 1 for all the other species. This resulted in no nocturnal flight activity being included in the model for these species.

***Implementation***

*Flight activity densities*

The NatureScot spreadsheet requires the user to enter mean flight activity densities for each month. I used custom scripts in R to calculate these densities.

I calculated flight activity densities separately for each vantage point in each month in each dataset. I calculated two sets of flight activity densities: one using the raw viewshed areas and the other using the viewshed areas that were corrected for distance effects.

I used the weighted averaging method in Equation A2 to calculate mean flight activity densities for each month across all the vantage points. This method down weighted the contribution of the Fehily Timoney vantage points reflecting the lower survey effort at these vantage points (two seasons) compared to the TOBIN vantage points (five seasons).

Based on the review of the flightline distributions and flightline densities and consideration of the likely habitat dynamics over the lifetime of the wind farm site (see Section 2.5.3), I did not consider that weighting for uneven distribution of flight activity between vantage points (Equation A3) was appropriate.

*Daytime and nighttime hours*

The NatureScot spreadsheet requires the user to enter the latitude of the wind farm site, and nocturnal activity rankings for each species. It then uses the formula from Forsythe *et al.* (1995) to calculate the day-time and night-time hours. The correction for nocturnal flight activity is applied in Stage B.

I used a custom script in R to implement the formula from Forsythe *et al.* (1995) and calculate the day-time and night-time hours.

*Nocturnal correction factors*

I used a custom script in R to implement Equation A4 to calculate the nocturnal correction factors.

### 2.6.3. Stage B: transits

***NatureScot methodology***

Stage B involves calculating the number of bird transits through the turbine rotors. It uses the flight activity densities, distribution of daylight and nighttime hours, and nocturnal activity rankings derived in Stage A.

The NatureScot guidance does not provide details of the calculation procedure for Stage B, but Band (2024) includes an equation (Equation B1).

Equation B1: $v \times (D \times Q_{2R} / 2R) \times (T \times \pi R^2) \text{ x } (t_{day} + f_{night} \times t_{night})$

$v$ = bird flight speed; $D$ = flight activity density; $Q_{2R}$ = proportion of flight activity at potential collision height; $R$ = rotor radius; $T$ = number of turbines; $t_{day}$ = total daylight hours; $f_{night}$ = nocturnal activity ranking - 1 × 0.25; $t_{night}$ = total night-time hours.

The equation converts the areal density to a volumetric density by dividing the flight activity density by the rotor diameter and adjusting for the proportion of flight activity at potential collision height ($D \times Q_{2R} / 2R$). It then converts the density to a flux rate by multiplying by the rotor area ($T \times \pi R^2$) and the bird flight speed ($v$). It converts the flux rate to an absolute number of transits by multiplying by the total number of hours available for flight activity, including a correction for nocturnal flight activity ($t_{day} + f_{night} \times t_{night}$).

***Data sources and preparation***

The parameters required for the Stage B modelling are the bird flight speed ($v$), the flight activity density ($D$), the vantage point survey duration ($t$), the proportion of flight activity at potential collision height ($Q_{2R}$), the rotor area ($R$), the number of turbines ($T$), the total daylight and nighttime hours ($t_{day}$ and $t_{night}$) and the nocturnal activity ranking.

The flight activity density, total daylight and nighttime hours and nocturnal activity ranking were derived in Stage B. The derivation of the data required for the remaining parameters is described in the following sections.

*Bird flight speed*

The NatureScot guidance states that for bird flight speed, "a typical mean flight speed as given in standard references will usually be adequate" but consideration should be given to exploring "the collision risk arising from different types of bird behaviour involving very different flight speeds".

Most collision risk modelling for onshore wind farms uses the mean bird flight speeds from Alerstam *et al.* (2007). This source covers most species relevant to collision risk modelling for Irish onshore wind farms. I have used the mean bird flight speeds from this source. The values used in this collision risk model are shown in Table 2.3.

*Proportion of flight activity at potential collision height ($Q_{2R}$)*

The NatureScot methodology involves calculating the total areal flight activity density across all height bands and then adjusting for the proportion of flight activity at potential collision height. However, this may introduce biases in the calculations due to variation between viewsheds in the proportion of viewshed that was visible below the height used to map the viewshed. In this collision risk model. I have only used the flight activity at potential collision height to calculate the flight activity density. Therefore, for Equation B1, the value of the $Q_{2R}$ parameter is 1.

*Turbine parameters*

The proposed number of turbines ($T$) is 22 and the proposed rotor radius ($R$) is 82.5 m.

***Implementation***

The NatureScot spreadsheet automatically calculates the projected number of transits per month from the bird density and hours per month values calculated in Stage A and data entered by the user for the other parameters.

I implemented Equation B1 through a custom script in R to calculate the predicted number of transits per month.

### 2.6.4. Stage C: single transit collision risk

***NatureScot methodology***

Stage C involves calculating the probability of a collision when a bird makes a transit of the rotor swept volume (the single transit collision risk).

The NatureScot methodology for Stage C is based on the Scottish Natural Heritage collision risk model (SNH, 2000; Band *et al.*, 2007; Band, 2012). This calculates the probability, p (r, φ), of collision for a bird at radius r from the hub and at a position along the radius that is at angle φ from the vertical. This probability is then integrated over the entire rotor disc, assuming that the bird transit may be anywhere at random within the area of the disc. Separate calculations are made for flapping and gliding birds and for upwind and downwind transits. This method assumes that: birds are of a simple cruciform shape; they fly through turbines in straight lines with a perpendicular approach to the plane of the rotor; their flight is not affected by the slipstream of the turbine blade; and that the turbine blades have width and pitch angle, but no thickness.

***Parameters***

The parameters required for Stage C are the bird body length, wingspan, flight speed and flight type, the percentage of flights upwind/downwind, and the turbine rotation speed, rotor radius, mean blade width, pitch angle and blade profile.

*Turbine parameters*

The turbine rotation speed, rotor radius, mean blade width and pitch angle values used for the modelling are shown in Table 2.2. The default blade profile values from the NatureScot spreadsheet were used for the modelling.

One of the turbine parameters used to calculate collision probability is the mean pitch angle of the turbine blade. This parameter specifies the angle of the blade from the horizontal, so the collision probability will increase as the mean pitch angle increases. Data on mean pitch angle can be difficult to obtain so generic values are often used in collision risk models. The NatureScot guidance states that a mean pitch angle of "15-30 degrees is reasonable for a typical large turbine". However, monitoring at an onshore wind farm (Meenwaun, Co. Offaly) indicated that much lower pitch angles are typical for onshore turbines (MKOS, 2019). This monitoring found that over a continuous 12-month period at this site the pitch angle was between -3° and 9° for approximately 90% of the time.

I modelled single transit collision risks using three values for mean pitch angle: 0°, 15 ° and 30°. The pitch value of 0° was the value within the -3° to 9° range that produced the highest collision probability values for most species in sensitivity analyses (see Section 2.6.7).

*Bird parameters*

The bird body length and wingspan values were obtained from Cramp and Simmons (2004). The bird flight speed values were obtained from Alerstam *et al.* (2007). The values used in the modelling are shown in Table 2.3.

The review of the vantage point survey flightlines did not show any consistent directional bias. Therefore, the percentages of flights upwind/downwind was set at 50%.

*Implementation*

I carried out all the calculations of single transit collision risks in R, using an adapted version of the R code provided by Masden (2015). This code implements the methodology of Band (2012) and provides identical values to the spreadsheet provided by that source and to the values generated by the NatureScot spreadsheet.

I carried out separate sets of calculations using pitch angle values of 0°, 15° and 30°.

I calculated separate values for upwind and downwind flapping and gliding flight.

The NatureScot spreadsheet only allows values for either flapping or gliding flight to be used. I used the values for flapping flight, as these were slightly higher.

The spreadsheet uses the mean of values for upwind and downwind flight weighted by the relative proportion of these flight direction. As there was no indication of consistent bias in flight directions for any species included in the collision risk model, I used a simple mean of the upwind and downwind single transit collision risks (i.e., a 50/50 weighting).

### 2.6.5. Stage D: non-avoidance collision risk

*NatureScot methodology*

Stage D multiplies the number of predicted transits from Stage B and the single transit collision risk from Stage C to provide an estimate of the overall predicted collision risk before avoidance. It also includes a correction for the proportion of time that the turbines are operational.

Equation D1: collision rate before avoidance = transits × stcr × $Q_{op}$

transits = predicted transits from Stage B; stcr = single transit collision risk from Stage C; $Q_{op}$ = proportion of time that the turbines are operational.

*Parameters*

The parameters required for Stage D are the predicted transits from Stage B, the single transit collision risk values from Stage C, and the proportion of time that the turbines are operational ($Q_{op}$).

Site-specific values for $Q_{op}$ were not available for this project. Therefore, I used a value of 0.85 for all the species in the model, which is a widely value for this parameter in collision risk modelling for onshore wind farms in Ireland.

*Implementation*

The NatureScot spreadsheet automatically calculates the projected number of transits per month from the bird density and hours per month values calculated in Stage A and data entered by the user for the other parameters.

I implemented Equation D1 through a custom script in R to calculate the collision rate before avoidance.

### 2.6.6. Stage E: collision risk after avoidance

*NatureScot methodology*

Stage E applies an avoidance rate to the non-avoidance collision risk to reflect the fact that most potential collisions are avoided due to birds taking evasive action (SNH, 2010).

Equation E1: collision rate after avoidance = collision rate before avoidance × (1 – A)

collision rate before avoidance = predicted rates from Stage D; A = avoidance rate.

The avoidance rate includes both behavioural avoidance (micro-avoidance) and behavioural displacement (macro-avoidance).

Behavioural avoidance is "action taken by a bird, when close to an operational wind farm, which prevents a collision". Behavioural displacement refers to the process by which a "bird may (possibly over time) change its home range, territory, or flight routes between roosting areas and feeding areas, so that its range use (or flight paths) no longer brings the bird into the vicinity of an operational wind farm".

The NatureScot guidance for Stage E also notes that "consideration should be given to whether any habitat changes associated with developing the wind farm may result in attracting bird species". This issue is considered in Section 4.7.2.

Stage E can also include a large turbine array correction factor. This reflects the fact that "where the overall probability of a bird colliding is appreciable, it may be appropriate to take account of the fact that a declining proportion of the birds will survive passage through early rows of turbines and will thus be exposed to collision risk in later rows". However, this correction factor is only likely to be significant for wind farms with much larger numbers of turbines than are proposed for the Derryadd Wind Farm. Therefore, I did not apply this correction factor.

The NatureScot spreadsheet sums the monthly collision risks to provide a total annual collision risk. However, for some species it is more appropriate to calculate seasonal collision risks (e.g., to differentiate between separate breeding and wintering populations).

***Parameters***

The parameters required for Stage E are the non-avoidance collision risks from Stage D and avoidance rates for each species included in the model. In addition, definitions of the months included in seasonal periods are required if seasonal collision risks are to be calculated.

*Avoidance rates*

The default set-up in the NatureScot spreadsheet calculates the predicted collision risk after avoidance using four avoidance rates: 95%, 98%, 99% and 99.5%. However, the guidance states "if possible, use avoidance rates which have been established from previous monitoring studies for this species, and an appropriate range to cover the uncertainties involved".

Scottish Natural Heritage provides guidance on avoidance rates to use in collision risk modelling for onshore wind farms (SNH, 2010, 2018). For some species, including Whooper Swan, Hen Harrier and Kestrel, there is some evidence available that has been used to specify species-specific avoidance rates (SNH, 2018). In addition, a recent review for Scottish Natural Heritage has recommended the use of an avoidance rate of 0.992 for small gulls (including Black-headed Gull and Common Gull) and 0.995 for large gulls (including Lesser Black-backed Gull) at onshore wind farms (Furness, 2019).

For Golden Plover, my review of collision monitoring data from four UK wind farms recommended that collision risk modelling for wintering Golden Plover populations should use two avoidance rate values: 99.6% and 99.8% (Gittings, 2022).

For the other species included in this collision risk model, the Scottish Natural Heritage guidance specifies a default avoidance rate of 98%.

*Seasonal periods*

The periods used to calculate seasonal collision risks are defined in Table 2.4. For the species not included in this table the final collision risk was calculated for the whole year.

***Implementation***

The NatureScot spreadsheet automatically calculates the collision rate after avoidance per month from the collision rate before avoidance values calculated in Stage D and the avoidance rate values entered by the user.

I implemented Equation E1 through a custom script in R to calculate the collision rate after avoidance. This produced monthly predicted collision risks for various avoidance rates and for pitch angles of 0°, 15 ° and 30°.

For the final predicted collision risks used in the collision risk assessments, I summed the monthly predicted collision risks for the recommended avoidance rate and a pitch angle of 0° to produce annual or seasonal collision risks, as appropriate.

### 2.6.7. Stage F: assessing uncertainty

Stage F involves assessing the level of uncertainty that applies to the collision risk predictions.

In this assessment, I carried out analyses to provide some degree of quantification of the potential uncertainty in the flight activity data due to sampling effects, variability in flight height estimates, and imprecision of the estimates of nocturnal flight activity. Another source of potential uncertainty in the flight activity data is incomplete detection of flightlines, which is already accounted for in this collision risk model (see Section 2.5.2).

I also carried out analyses to quantify potential uncertainty in the single transit collision risk predictions due to variation in pitch angle and rotation speed.

I carried out qualitative assessments of other sources of potential uncertainty.

***Sampling effects***

The standard vantage point survey effort of 36 hours per season only samples around 1.5-2% of the total daylight hours across the season. The temporal distribution of flight activity is often highly aggregated, while a small number of long duration flightlines can make a large contribution to the overall collision risk. Therefore, sampling effects are likely to strongly influence the collision risk predictions.

I assessed the potential influence of sampling effects on the collision risk predictions by using a simulation model. This model used the observed distribution of flight activity to simulate flight activity across the entire season. This simulated distribution was then sampled to generate samples of vantage point survey data. I then compared the flight activity densities in the samples to the flight activity densities across the entire season.

I first calculated the total duration of daylight hours across the season using the R package *suncalc* (Thiermel and Elmarhraoui, 2022) and divided this duration by three to set up a dataframe representing all 3-hour periods of daylight hours at each vantage point across the season.

I used the negative binomial distribution to simulate the distribution of records in each 3-hour period across the entire season at each vantage point and the distribution of flock sizes per record (excluding simulated zero values for flock sizes). I used the *fitdist* function with the maximum likelihood estimation method in the R package *fitdistplus* (Muller and Dutang, 2015) to fit these negative binomial distributions. I used the exponential distribution to simulate the distribution of flight durations at potential collision height per record. I used the *rexp* function in the R package *stats* (R Core Team, 2024), with a rate that was the reciprocal of the mean duration of observed flights potential collision height, to fit the exponential distributions.

For each species / season, I compared the distribution of the simulated values with the observed values to assess the validity of the simulated data.

I then took 1000 sets of random samples without replacement of twelve 3-hour periods to simulate vantage point survey samples.

I calculated the flight activity densities for the entire season, and for each set of vantage point survey samples, by summing the bird-secs per record, dividing by the total duration of daylight hours (for the entire season dataset) or 36 hours (for the vantage point survey datasets).

I used the distribution of the vantage point survey datasets to calculate 95% confidence intervals for the vantage point survey samples, where the lower limit was the 2.5% percentile of the distribution, and the upper limit was the 97.5% of the distribution.

I assessed the potential influence of sampling effects by comparing the upper and lower confidence interval limits of the flight activity densities in the simulated vantage point survey samples with the overall flight activity density in the complete dataset. This provides an indication of the potential maximum over- or underestimation of the true flight activity density if the sampling effects happen to result in the vantage point survey sample representing the upper or lower limits of the 95% confidence interval of the true flight activity density distribution. For example, if the lower limit was half the value of overall flight activity density, then the true collision risk would be twice the value of the predicted collision risk calculated from a vantage point survey sample representing this limit.

I carried out these analyses using a single year and using three or four years (the numbers of winter or summer seasons, respectively, covered by the vantage point surveys for this project).

***Height distribution***

The collision risk model used data from all height bands in the Fehily Timoney dataset. Therefore, uncertainty in flight height estimates is not an issue for the component of the collision risk predictions derived from this dataset.

I assessed the potential influence of uncertainty in flight height estimates in the TOBIN dataset on the collision risk predictions by comparing the recorded height distributions of the three surveyors involved in the TOBIN vantage point surveys. If three independent surveyors produced broadly similar distributions of flight height estimates, then it would be reasonable to assume that there was low uncertainty. Conversely if there were large differences in the distributions, that would indicate significant inaccuracies in flight height estimates by one or more of the surveyors.

I compared the numbers and durations of flights recorded in the 0-25 m height band, with the numbers and durations of flights recorded across the 25-185 m height bands. I restricted the comparisons to species with a total of at least 50 records included in the TOBIN dataset.

I found that one observer consistently recorded low flight height estimates across all the species analysed. I used the ratio of flight durations between the two height bands assessed recorded by the other two observers to correct the flight durations recorded by this observer for all records with non-zero durations in the 0-25 m height band. I then re-ran the calculations of flight activity densities in Stage A and transits in Stage B using the corrected flight durations. The ratio of the corrected transits to the uncorrected transits provides an indication of the potential effect on the predicted collision risks of this observer's under-estimation of flight heights.

***Nocturnal flight activity***

The collision risk model uses a crude ranking of the degree of nocturnal flight activity to calculate nocturnal correction factors and the information available about the degree of nocturnal flight activity for most species is very limited. I examined the effects of uncertainty about nocturnal flight activity for each species with a nocturnal activity ranking of more than one. I did this by calculating nocturnal correction factors using nocturnal activity rankings of ±1 of the values used in the model. The ratio of these nocturnal correction factors to the nocturnal correction factor value used in the collision risk model indicates the potential effect on the predicted collision risk: e.g., if the nocturnal correction factor calculated using the NAR+1 value is 1.25 times the nocturnal correction factor using the NAR value, the true collision risk could be 25% higher than the predicted collision risk.

***Single transit collision risk***

I carried out analyses to quantify potential uncertainty in the single transit collision risk predictions due to variation in pitch angle and rotation speed. These involved calculating single transit collision risk values for each 1° increment in pitch angle between -5° and 90° and each 0.1 rpm increment in rotor speed between values of 5.0 and 12.5 rpm. I used the nominal rotor speed value for the pitch calculations and a pitch angle value of 0° for the rotor speed calculations. The range used for the rotor speed analyses was based on typical rotor speed ranges for onshore wind turbines in Ireland.

## 2.7. COLLISION RISK ASSESSMENT

The significance of the predicted collision risk is a function of the size of the predicted collision risk, the size of the affected population, and the typical level of background mortality in the affected population. The same predicted collision risk will have larger impacts in small populations and/or populations with low levels of annual mortality, compared to large populations and/or populations with high levels of annual mortality. Therefore, the significance can be assessed by calculating the percentage increase in annual mortality that would be generated by the predicted collision risk.

A threshold level of a 1% increase in annual mortality has been suggested to determine whether the impact is nonnegligible (Percival, 2003). Note that this refers to the increase in absolute mortality not the increase in the percentage mortality rate. This 1% threshold is widely used in UK wind farms assessments as a threshold for assessing significance. However, this is likely to be a very conservative threshold, and in some cases, such as small populations with low mortality rates, biologically implausible.

I assessed the potential increase in annual mortality, as a percentage of the background annual mortality, for most species / populations, with a predicted risk that would result in at least one collision within the 30 year lifespan of the wind farm. The species / populations with this level of risk that I did not assess were Buzzard, the migrant Whimbrel population and the autumn Lesser Black-backed Gull population. I did not assess Buzzard because this species has been rapidly increasing in Ireland and there are no recent national or county population estimates available. I did not assess the migrant Whimbrel population and the autumn Lesser Black-backed Gull population because no relevant data on national or county population sizes is available.

For each of the species / populations, I assessed the impact at the national scale. I also assessed the impact at regional and/or local scales where relevant population data was available or could be estimated.

The sources of the population data are listed in Table 2.1.

For Whooper Swan, I used data from the 2020 International Swan Census (Burke *et al.*, 2021). I defined the regional population as the totals for Lough Ree and County Longford; all the non-Lough Ree sites in Longford were in the western part of the county close to Lough Ree. I defined the local population as the totals for the sites within 5 km of the wind farm site; 5 km is the core foraging range from roost sites for Whooper Swan defined by SNH (2016).

For Mallard, Little Egret and Grey Heron, there are national estimates available for both the breeding and non-breeding populations. These species were recorded throughout the year in the vantage point surveys. Their local breeding populations are likely to be resident, although the populations may be supplemented in the non-breeding season. Mallard and Grey Heron are poorly covered by the Irish-Wetland Bird Survey (the source for the non-breeding population estimate) as they are widespread outside the monitored sites. Therefore, while their national populations are likely to be larger in the non-breeding season, the estimates of their national breeding populations are larger than the estimates of their national non-breeding populations. Therefore, for Mallard and Grey Heron, I used the estimates of their breeding populations for the national population. For Little Egret, I used the estimates of its non-breeding population for the national population. This species is increasing in Ireland, and the estimate of its breeding population is probably out of date.

Sparrowhawk and Kestrel are widespread species that are not likely to show highly aggregated distribution patterns. I estimated the Longford population sizes of these species using the Bird Atlas dataset from the National Biodiversity Data Centre[1]. This included hectad presence-absence data covering the whole of the Republic of Ireland, and tetrad data of relative abundance for samples of tetrads from most of the hectads. I used the hectad data to estimate the proportion of the Republic of Ireland breeding range of each species that occurs in Longford. I then used the

[1] BirdWatch Ireland, Bird Atlas 2007 - 2011, National Biodiversity Data Centre, Ireland, accessed 07 September 2022, https://maps.biodiversityireland.ie/Dataset/220.

tetrad data to estimate the mean relative abundance of the species in Longford as a percentage of its mean relative abundance throughout its range in the Republic of Ireland. I then used the product of these two factors to multiply the Republic of Ireland population figure to give an estimate for the Longford population.

For the local Golden Plover population, I used the mean annual peak Irish Wetland Bird Survey counts for Lough Ree subsites from the winters of 2018/19, 2019/20, 2021/22 and 2022/23[2]. This data is likely to underestimate the size of the local population because it is likely that the birds at collision risk will include some from other local populations outside the Lough Ree wintering populations.

For the local Lapwing breeding population, I used the mean number of Lapwing territories recorded in Derryaroge Bog, Derryadd Bog and Lough Bannow Bog in 2022-2024 (see Section 2.5.4).

For Black-headed Gull, I only assessed the impact on the national population. There is, or at least was, a large breeding colony in Lough Ree but no recent data appears to be available for it. The breeding data for Longford in Burnell *et al.* (2003) refers to a breeding colony at Lough Gowna. This colony is 30 km from the wind farm site, while the Lough Ree colony sites are around 5-10 km from the wind farm site.

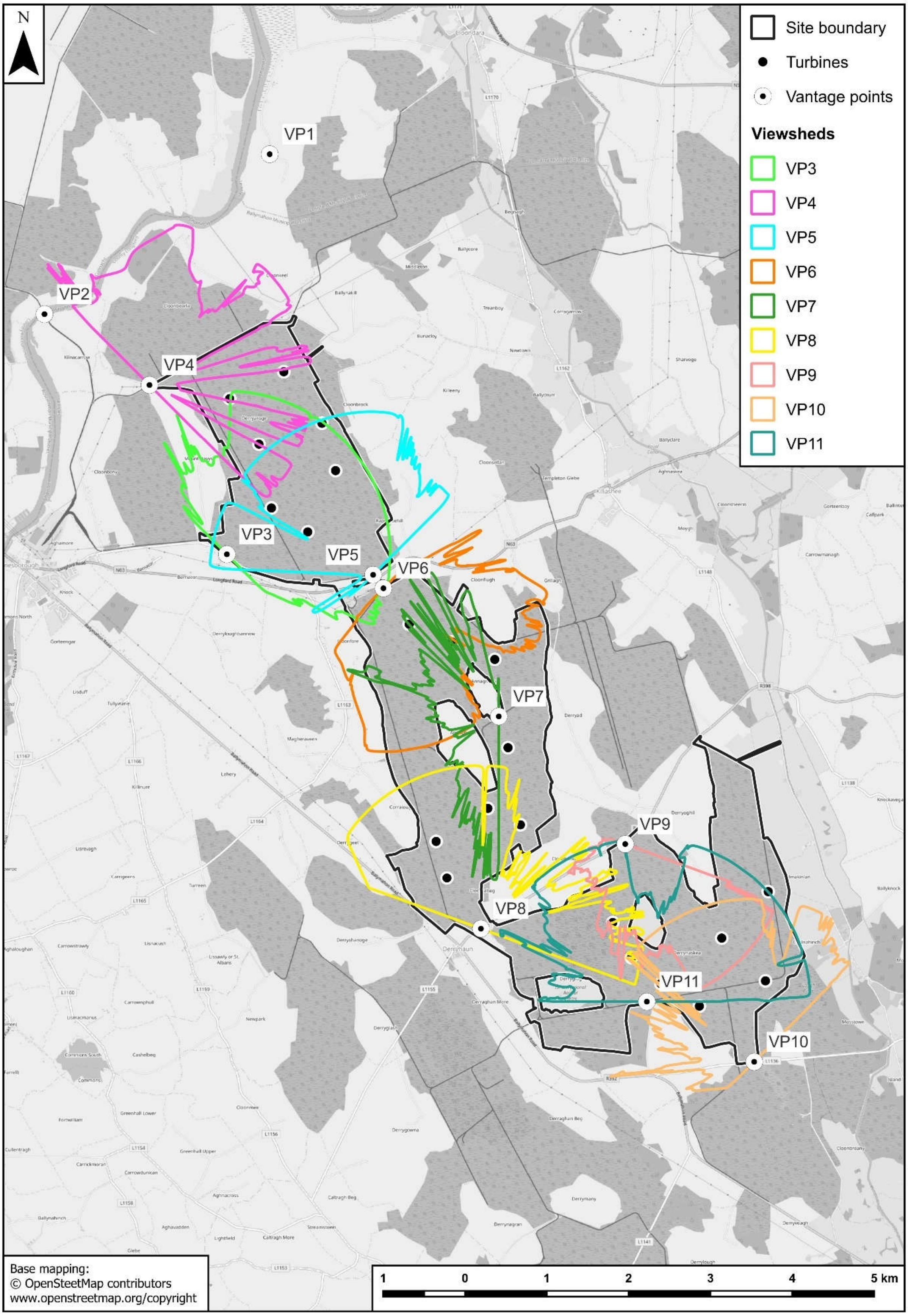
The background mortality rates that I used were derived from the adult survival rates on the BirdFacts website[3]. Where separate rates were given for males and females, I used the mean of the rates.

[2] Data were supplied by the Irish Wetland Bird Survey (I-WeBS), a scheme coordinated by BirdWatch Ireland under contract to the National Parks and Wildlife Service of the Department of Housing, Local Government and Heritage.
[3] www.bto.org/understanding-birds/birdfacts; accessed 19/02/2024.

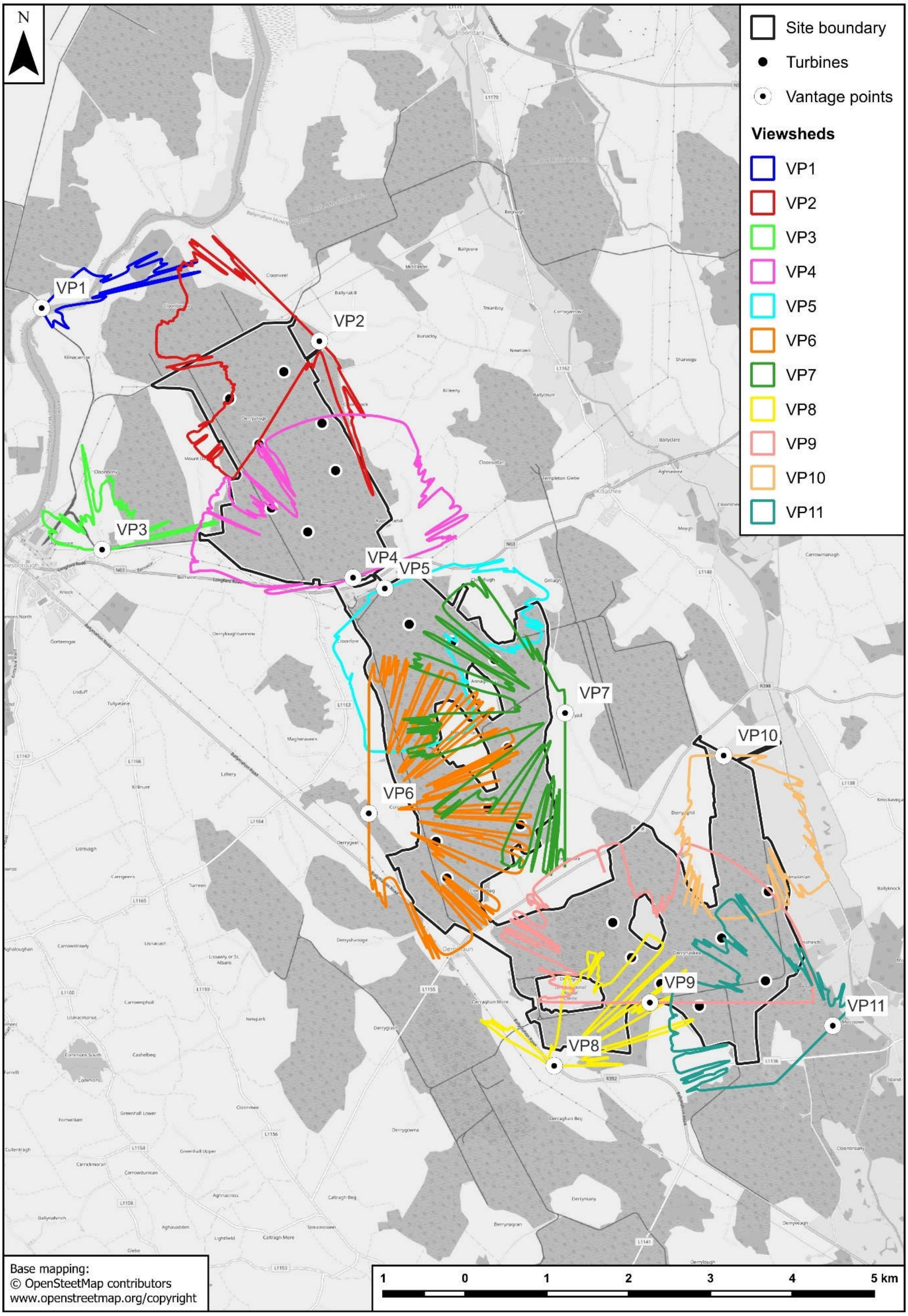
Table 2.5. Population data used for the collision risk assessment.

| Species | Population | Scale | Geographic extent | Value | Units | Period / Source |
|---|---|---|---|---|---|---|
| Whooper Swan | winter | national | all-Ireland | 19,111 | individuals | 1 |
| | winter | county | Longford / Lough Ree | 394 | individuals | 1 |
| | winter | local | 5 km buffer | 247 | individuals | 1 |
| Teal | winter | national | all-Ireland | 35,740 | individuals | 3 |
| Mallard | breeding | national | Republic of Ireland | 15,400 | pairs | 4 |
| | winter | national | all-Ireland | 28,230 | individuals | 3 |
| Cormorant | breeding | national | all-Ireland | 4,685 | AON | 5 |
| | breeding | local | Lough Ree | 144 | AON | 5 |
| Little Egret | breeding | national | Republic of Ireland | 375 | pairs | 4 |
| | non-breeding | national | all-Ireland | 1,390 | individuals | 3 |
| Grey Heron | breeding | national | Republic of Ireland | 3,087 | pairs | 4 |
| | non-breeding | national | all-Ireland | 2,610 | individuals | 3 |
| Sparrowhawk | breeding | national | all-Ireland | 17,580 | individuals | 6 |
| | breeding | county | Longford | 134 | individuals | 7 |
| Golden Plover | winter | national | all-Ireland | 92,060 | individuals | 3 |
| | winter | local | Lough Ree | 1,225 | individuals | 2 |
| Lapwing | breeding | national | Republic of Ireland | 2,000 | pairs | 8 |
| | breeding | national | Northern Ireland | 860 | pairs | 9 |
| | breeding | local | local area | 15.7 | pairs | 10 |
| | winter | national | all-Ireland | 84,690 | individuals | 3 |
| Black-headed Gull | breeding | national | all-Ireland | 19,611 | AON | 5 |
| Lesser Black-backed Gull | breeding | national | all-Ireland | 16,389 | AON | 5 |
| | breeding | local | Lough Ree | 1,009 | AON | 5 |
| Kestrel | breeding | national | all-Ireland | 19,970 | individuals | 6 |
| | breeding | county | Longford | 283 | individuals | 7 |

Sources: 1 = 2020, Burke *et al.* (2021); 2 = mean annual Irish Wetland Bird Survey peak counts, 2018/19, 2019/20, 2021/22 and 2022/23; 3 = 2011/12-2015/16, Burke *et al.* (2018); 4 = 2008-2011, NPWS (undated); 5 = 2015-2021, Burnell *et al.* (2023); 6 = 2006-2011, Crowe *et al.* (2014); 7 = 2006-2011, derived from Crowe *et al.* (2014) and Bird Atlas data (see text); 8 = 2008, Lauder and Donaghy (2008); 9 = 2013, Colhoun *et al.* (2015); 10 = 2022-2024, see text.




Map 2.1. Vantage points and viewsheds used by the Fehily Timoney survey team.




Map 2.2. Vantage points and viewsheds used by the TOBIN survey team.

# 3. REVIEW OF THE VANTAGE POINT SURVEY COVERAGE AND RESULTS

## 3.1. SPATIAL COVERAGE AND VIEWSHEDS

The processing of the viewshed mapping to generate simplified viewsheds (see Section 2.3.1) resulted in the deletion of all segments for the viewsheds for the Fehily Timoney VP1 and VP2. The viewsheds for the TOBIN VP1 and VP3 were also very small. These vantage point locations were all at the northern end of the wind farm site and their raw viewsheds did not include any turbine locations. Therefore, these vantage points were excluded from the collision risk model. The collision risk model was based on flight activity data from the Fehily Timoney VPs 3-11 and the TOBIN VPs 2 and 4-11.

The simplified Fehily Timoney viewsheds used for the collision risk model covered 15 of the 22 turbine locations and 80% of the 500 m buffer around the turbine locations (Map 2.1). The simplified TOBIN viewsheds used for the collision risk model covered 18 of the 22 turbine locations and 82% of the 500 m buffer around the turbine locations (Map 2.2). However, while there is incomplete coverage of the turbine locations and the 500 m buffer around the turbine locations, the gaps in coverage are small and there are not any significant areas lacking coverage. The gaps in coverage do not affect the reliability of the collision risk estimates.

## 3.2. SPATIAL PATTERNS OF FLIGHT ACTIVITY

### 3.2.1. Distance effects

The analyses of the Fehily Timoney dataset did not show strong distance effects on detection rates (Figure 3.1). The flightline densities in the 0-250 m to 1000-1250 m distance bands did not show any strong variation with wide overlaps of the confidence intervals for each of these bands. The flightline densities in the 1250-2000 m distance band were smaller than the other distance bands. This difference was stronger for the small and medium-sized species (Groups 1 and 2), with little overlap of the confidence intervals between the 1250-2000 m distance band and the other distance bands. For the large species (Group 3), the flightline density in the 1250-2000 m distance band was only marginally smaller than several of the other distance bands and there was almost complete overlap of confidence intervals.

The analyses of the TOBIN dataset showed much stronger distance effects on detection rates (Figure 3.2). There were strong declines in detection rates at distances of greater than 500 m for small (Group 1) species, and at distances greater than 750 m for medium-sized (Group 2) species. The large (Group 3) species showed more a gradual decline in detection rates, but all three groups had very low detection rates at distances of greater than 1250 m.

The correction factors calculated from the weighted viewshed areas are shown in Table 3.1. These indicate the increase in collision risk that results from correcting for under-detection of distant flightlines. The SNH correction factors were derived using the theoretical maximum possible viewshed that complies with Scottish Natural Heritage guidance (SNH, 2017). The Derryadd correction factors were derived using the actual viewsheds from the relevant datasets. The SNH correction factors allow comparison of the detectability effects across datasets. The Derryadd correction factors indicate the approximate values of the corrections for under-detection of distant flightlines that were applied in the collision risk modelling. Note, that for each species, the actual correction factor that was applied will vary depending on the species distribution between the vantage points included in the model.

Table 3.1. Correction factors.

| Correction factor | Dataset | Group 1 | Group 2 | Group 3 |
|---|---|---|---|---|
| SNH correction | Fehily Timoney | 1.28 | 1.25 | 1.19 |
| | TOBIN | | | |
| Derryadd correction | Fehily Timoney | 1.68 | 1.66 | 1.61 |
| | TOBIN | | | |

### 3.2.2. Species-specific spatial structure

***Assessment***

The Whooper Swan flightlines were widely distributed across the wind farms without any obvious spatial structure (Map 3.1). The flight activity densities at potential collision height did not show obvious concentrations at individual vantage points (Table 3.2).

There was a strong concentration of Cormorant breeding season flightlines along the River Shannon (Map 3.2). However, these flightlines were outside the wind farm site and were recorded from vantage points that are not included in the collision risk model. Within the wind farm site, there was some indication of a concentrations of flightlines along a corridor through the middle of Derryaroge Bog in 2021 (Map 3.2), which was reflected in the distribution of flight activity densities at potential collision height between the Fehily Timoney vantage points (Table 3.2). However, the number of flightlines was small, and this pattern was not repeated in 2022-2024, when very few flightlines were recorded across the wind farm site.

There was a concentration of Golden Plover flightlines in Lough Bannow Bog in all three winters (Map 3.3), which was reflected in the distribution of flight activity densities at potential collision height between the vantage points (Table 3.2).

The Lapwing breeding season map (Map 3.4) shows some indication of a concentration of flight activity in the central / eastern section of Derryaroge Bog in 2021. However, this was not repeated in subsequent years when the flightlines were widely scattered around the wind farm site.

There was a concentration of Lapwing winter flightlines along the River Shannon (Map 3.5), but, as discussed for Whooper Swan, this is not relevant to the collision risk model. Elsewhere, the small number of flightlines were widely distributed across the wind farm site without any obvious spatial structure (Map 3.5). There were large differences between vantage points in the flight activity densities at potential collision height (Table 3.2) but, given the small number of flightlines, this was most likely due to sampling effects.

The Black-headed Gull breeding season flightlines were widely distributed across the wind farm site, but there was a concentration in the northern section of Derryadd Bog (Map 3.6). This was reflected in the high flight activity at potential collision height in the relevant TOBIN vantage point (VP5), but not in the relevant Fehily Timoney vantage point (VP6) (Table 3.2).

The Lesser Black-backed Gull breeding season flight activity was widely distributed across the wind farm site with generally little evidence of significant spatial structure (Map 3.7). There was an area of high Lesser Black-backed Gull flightline density across the middle / southern section of Derryaroge Bog, which was apparent in both breeding season datasets. However, this was not reflected in the distribution between vantage points of flight activity densities at potential collision height (Table 3.2).

The Lesser Black-backed Gull autumn flightlines are shown in Map 3.8. The flight activity in the autumn of 2021 did not show strong spatial structure. There were low numbers of flightlines recorded in the autumn of 2022, so the flightline density map should not be interpreted as showing strong evidence of spatial structure. There were large differences in flight activity densities at potential collision height between the Fehily Timoney vantage points, but the vantage points with high flight activity densities were not spatially clustered (Table 3.2).

Table 3.2. Mean flight activity densities at potential collision height (birds/km²/month).

| Species | Season | Dataset | Derryaroge Bog | | | | Derryadd Bog | | | | Lough Bannow Bog | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | VP2 | VP3 | VP4 | VP5 | VP5 | VP6 | VP7 | VP8 | VP8 | VP9 | VP10 | VP11 |
| Whooper Swan | winter | FT | | 399 | 234 | 100 | | 129 | 236 | 573 | | 139 | 0 | 0 |
| | | TB | 14 | | 3 | | 21 | 57 | 274 | | 124 | 83 | 523 | 312 |
| Cormorant | breeding | FT | | 161 | 270 | 528 | | 64 | 0 | 330 | | 0 | 0 | 71 |
| | | TB | 93 | | 8 | | 4 | 0 | 0 | | 0 | 0 | 13 | 14 |
| Golden Plover | non-breeding | FT | | 221 | 4 | 415 | | 0 | 0 | 0 | | 2,848 | 126 | 242 |
| | | TB | 0 | | 0 | | 681 | 10,599 | 17 | | 6,512 | 22,220 | 4,373 | 38,478 |
| Lapwing | breeding | FT | | 569 | 55 | 1,678 | | 65 | 0 | 0 | | 0 | 84 | 0 |
| | | TB | 18 | | 99 | | 4 | 486 | 58 | | 170 | 64 | 291 | 0 |
| | winter | FT | | 34 | 497 | 11 | | 95 | 0 | 8 | | 0 | 0 | 14 |
| | | TB | 0 | | 1,933 | | 4 | 0 | 3,255 | | 0 | 208 | 13,556 | 0 |
| Black-headed Gull | breeding | FT | | 3,944 | 255 | 696 | | 791 | 1,792 | 1,779 | | 732 | 133 | 175 |
| | | TB | 79 | | 237 | | 3,391 | 334 | 456 | | 157 | 63 | 373 | 96 |
| Lesser Black-backed Gull | breeding | FT | | 2,926 | 2,114 | 1,680 | | 10,968 | 1,584 | 9,086 | | 4,856 | 1,986 | 4,264 |
| | | TB | 8,135 | | 1,239 | | 5,213 | 2,366 | 1,372 | | 1,200 | 898 | 687 | 2,381 |
| | autumn | FT | | 229 | 493 | 360 | | 888 | 3,004 | 1,848 | | 5,888 | 839 | 953 |
| | | TB | 32 | | 313 | | 425 | 112 | 298 | | 165 | 276 | 596 | 99 |
| Kestrel | all year | FT | | 191 | 82 | 223 | | 664 | 357 | 22 | | 434 | 324 | 176 |
| | | TB | 293 | | 304 | | 141 | 319 | 927 | | 467 | 553 | 257 | 1,203 |

The flight activity densities in this table are the values generated in Stage A of the collision risk model. The vantage point positions and viewsheds differed between the two datasets. The vantage points are grouped in this table by the bog that their viewsheds covered. The viewshed for the Fehily Timoney VP8 was divided between Derryadd Bog and Lough Bannow Bog. The Fehily Timoney VPs 1 and 2 and the TOBIN VPs 1 and 3 were not included in the collision risk model (see Section 3.1).

Kestrel flight activity was widely distributed across the wind farm site (Map 3.9). There were concentrations of flight activity in certain areas of the wind farm site in each dataset, but these were not consistent between datasets. The distribution of flight activity densities at potential collision height between vantage points did not show obvious spatial structure (Table 3.2).

***Conclusions (Whooper Swan, Golden Plover, Lapwing and Kestrel)***

The most obvious spatial structure was shown by the distribution of Golden Plover flightlines and flight activity densities at potential collision height, which were strongly concentrated in Lough Bannow Bog. However, in the winters of 2016/17-2018/19, Golden Plover flightlines were widely distributed across the wind farm site without a significantly higher concentration in Lough Bannow Bog (Gittings, 2019). These differences may reflect differences between winters in habitat conditions. The distribution of Golden Plover flight activity across the wind farm site is likely to reflect the distribution of suitable roosting habitat within the bogs, and the distribution of suitable feeding habitat in agricultural lands outside the bog. The former is likely to show large changes over the operational life of the wind farm due to management of drainage in the bogs and vegetation succession in areas of recently worked-out bog. The latter is likely to vary from winter to winter, probably to a lesser degree, due to year-to-year variation in conditions of individual fields.

The distribution of Whooper Swan, Lapwing and Kestrel flight activity did not show strong spatial structure. These are also species where the distribution of their flight activity operational life of the wind farm may show strong changes due to vegetation succession and, in the case of Whooper Swan and Lapwing, drainage management.

For Whooper Swan, Golden Plover, Lapwing and Kestrel, to build in spatial structure into collision risk model in a realistic way would require developing model of how the habitat suitability for these species is likely to change over the lifespan of the wind farm.

***Conclusions (Cormorant, Black-headed Gull and Lesser Black-backed Gull)***

The Cormorant, Black-headed Gull and Lesser Black-backed Gull flight activity largely involved birds commuting across the wind farm site probably to/from breeding colonies / roost sites in Lough Ree. Therefore, the distribution of the flight activity across the wind farm site is not likely to be affected by habitat changes and may not vary significantly over the operational life of the wind farm.

For Cormorant, there was some indication of a concentration of flight activity in Derryaroge Bog in 2021, which was associated with high levels of flight activity along the River Shannon outside the wind farm site. However, this was not reflected in subsequent years when the level of flight activity was much lower.

There was no evidence of consistent spatial structure in the distribution of Black-headed Gull breeding season flight activity, or Lesser Black-backed Gull breeding season and autumn flight activity.

## 3.3. TEMPORAL PATTERNS OF FLIGHT ACTIVITY

### 3.3.1. Seasonal patterns

The recording rates of regularly occurring species across the seven seasons of vantage point surveys are compared in Table 3.3. The recording rates are used, rather than actual number of records, to standardise comparisons across seasons with variable survey effort.

There were higher recording rates of several species in the summer of 2021, compared to subsequent summers. This may reflect differences in vantage point positions and recording protocols between the surveys carried out by the Fehiley Timoney and TOBIN survey teams, although there weren’t any consistent differences in the winter recording rates between the winter of 2021/22 and the subsequent winters.

Table 3.3. Seasonal recording rates (records / 330 hours) of flightline records during the vantage point survey.

| Species | 2021 summer | 2021/22 winter | 2022 summer | 2022/23 winter | 2023 summer | 2023/24 winter | 2024 summer |
|---|---|---|---|---|---|---|---|
| Mute Swan | 0 | 8 | 1 | 10 | 1 | 7 | 0 |
| Whooper Swan | 0 | 49 | 0 | 52 | 0 | 32 | 0 |
| Teal | 1 | 8 | 0 | 4 | 0 | 4 | 2 |
| Mallard | 23 | 24 | 13 | 23 | 8 | 18 | 19 |
| Cormorant | 24 | 1 | 2 | 1 | 6 | 5 | 4 |
| Little Egret | 48 | 27 | 11 | 14 | 3 | 10 | 7 |
| Grey Heron | 69 | 26 | 15 | 7 | 8 | 10 | 21 |
| Hen Harrier | 0 | 10 | 0 | 0 | 1 | 7 | 0 |
| Sparrowhawk | 27 | 10 | 14 | 20 | 11 | 8 | 10 |
| Buzzard | 215 | 41 | 61 | 41 | 52 | 42 | 59 |
| Golden Plover | 0 | 27 | 4 | 14 | 2 | 22 | 0 |
| Lapwing | 20 | 12 | 4 | 10 | 7 | 4 | 7 |
| Snipe | 22 | 7 | 5 | 5 | 0 | 6 | 4 |
| Black-headed Gull | 51 | 0 | 21 | 4 | 28 | 1 | 17 |
| Lesser Black-backed Gull | 263 | 1 | 104 | 11 | 90 | 12 | 82 |
| Kestrel | 94 | 38 | 66 | 39 | 76 | 41 | 41 |
| Peregrine | 4 | 7 | 2 | 5 | 6 | 1 | 2 |

The data in this table is derived from all the flightline records during timed watches at vantage points included in the collision risk model, including records outside viewsheds. The recording rate is shown as the number of records per 330 hours as this represents the mean vantage point survey effort per season. Additional species recorded with a total of less than 10 records: White-fronted Goose, Greylag Goose, Wigeon, Little Grebe, Marsh Harrier, Whimbrel, Curlew, Common Gull, Merlin.

### 3.3.2. Monthly variation

The monthly recording rates of regularly occurring species are compared in Table 3.3. The recording rates are used, rather than actual number of records, to standardise comparisons across months with variable survey effort.

For species with low numbers of records, any apparent seasonal variation in recording rates may not be reliable, as this variation may just reflect random sampling effects. Of the more frequently recorded species, several show clear seasonal patterns of variation.

Whooper Swan and Golden Plover are winter visitors and their main seasonal occurrence patterns were typical for these species in Ireland: October – March for Whooper Swan and October – April for Golden Plover. There was also a single Golden Plover record in September.

Lesser Black-backed Gull mainly occurred in summer and autumn (April – August). This probably reflects birds commuting to/from the Lesser Black-backed Gull breeding colony on Lough Ree, as well as autumn migration. The seasonal patterns of the Cormorant and Black-headed Gull recording rates may also reflect birds commuting to/from their Lough Ree breeding colonies.

Lapwing is likely to have two distinct populations using the wind farm site: a breeding population and a wintering population. This is reflected in the recording rates for the Lapwing breeding season (April – July) and main wintering period (November – March). While the recording rates for the breeding and wintering populations were similar, the total bird-secs at potential collision height were much higher in winter.

Table 3.4. Monthly recording rates (records / 60 hours) of flightline records during the vantage point survey.

| Species | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mute Swan | 1.1 | 4.0 | 1.9 | 0.4 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 1.4 | 0.4 | 0.4 |
| Whooper Swan | 15.5 | 5.8 | 3.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.8 | 12.3 | 10.5 |
| Teal | 0.4 | 0.4 | 1.5 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 | 0.5 | 0.7 | 2.3 | 0.7 |
| Mallard | 0.4 | 6.5 | 7.8 | 5.2 | 5.6 | 1.4 | 2.3 | 0.7 | 3.4 | 2.2 | 4.6 | 2.2 |
| Cormorant | 0.0 | 0.7 | 1.5 | 1.9 | 3.1 | 2.5 | 2.3 | 0.5 | 0.9 | 0.4 | 0.0 | 0.0 |
| Little Egret | 3.4 | 1.1 | 2.2 | 1.1 | 10.0 | 2.8 | 0.5 | 2.6 | 3.2 | 1.8 | 3.5 | 6.5 |
| Grey Heron | 0.8 | 0.7 | 3.0 | 3.7 | 5.6 | 3.9 | 5.4 | 4.8 | 8.6 | 6.5 | 3.1 | 1.5 |
| Hen Harrier | 1.1 | 1.1 | 2.2 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.8 | 1.1 |
| Sparrowhawk | 3.4 | 1.8 | 2.2 | 1.9 | 3.9 | 1.7 | 3.8 | 4.1 | 2.0 | 2.5 | 0.8 | 3.3 |
| Buzzard | 4.2 | 8.3 | 10.0 | 8.9 | 20.3 | 21.9 | 22.8 | 18.1 | 16.6 | 8.3 | 7.7 | 6.5 |
| Golden Plover | 1.1 | 1.1 | 4.4 | 1.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 8.3 | 4.6 | 3.3 |
| Lapwing | 1.1 | 2.5 | 2.6 | 0.4 | 4.2 | 4.7 | 1.8 | 0.2 | 0.0 | 0.4 | 2.3 | 0.7 |
| Snipe | 1.5 | 0.7 | 0.0 | 0.0 | 0.0 | 1.7 | 3.3 | 0.0 | 3.4 | 1.1 | 2.3 | 1.1 |
| Black-headed Gull | 0.0 | 0.4 | 1.1 | 4.4 | 8.3 | 14.7 | 6.2 | 1.0 | 0.0 | 0.0 | 0.0 | 0.4 |
| Lesser Black-backed Gull | 0.0 | 0.0 | 7.8 | 23.0 | 30.8 | 24.4 | 39.5 | 33.6 | 3.2 | 0.4 | 0.4 | 0.4 |
| Kestrel | 5.7 | 5.4 | 3.3 | 12.2 | 12.5 | 10.8 | 15.9 | 11.5 | 13.4 | 11.6 | 10.8 | 6.2 |
| Peregrine | 0.4 | 0.4 | 0.7 | 0.4 | 0.3 | 0.8 | 0.8 | 0.2 | 1.1 | 0.4 | 0.8 | 2.2 |

The data in this table is derived from all the flightline records during timed watches at vantage points included in the collision risk model, including records outside viewsheds. The recording rate is shown as the number of records per 60 hours as this represents the mean vantage point survey effort per month. Additional species recorded with a total of less than 10 records: White-fronted Goose, Greylag Goose, Wigeon, Little Grebe, Marsh Harrier, Whimbrel, Curlew, Common Gull, Merlin.

### 3.3.3. Diel patterns

The diel distribution of the survey effort is compared to the diel distribution of total daylight hours in Table 3.5 and Table 3.6. There was a fairly even spread of survey effort across most of the day. However, survey effort was lower in the early morning and evening, particularly in summer.

The variation in the diel recording rates of the species included in the collision risk assessment (Section 5) is summarised in Figure 3.3 and Figure 3.4.

The Whooper Swan recording rate and Golden Plover recording rates were higher in the early and mid-morning, which could reflect birds commuting from night roosts. However, there was no corresponding increase in recording rates during the evening commuting period.

The species that were commuting to/from breeding colonies in Lough Ree (Cormorant, Black-headed Gull and Lesser Black-backed Gull) and the raptors (Sparrowhawk and Kestrel) generally had higher recording rates in the middle of the day.

Table 3.5. Diel distribution of survey effort during the summer (April – September) vantage point surveys.

| Hour | Daylight hours | VP minutes | VP minutes / daylight hour |
|---|---|---|---|
| Sunrise - 1 | 183 | 77 | 0.4 |
| Sunrise | 183 | 495 | 2.7 |
| Sunrise + 1 | 183 | 647 | 3.5 |
| Sunrise + 2 | 183 | 976 | 5.3 |
| Sunrise + 3 | 183 | 968 | 5.3 |
| Sunrise + 4 | 183 | 1185 | 6.5 |
| Sunrise + 5 | 183 | 1234 | 6.8 |
| Sunrise + 6 | 160 | 1011 | 6.3 |
| Sunrise + 7 | 129 | 930 | 7.2 |
| **Solar Noon** | | | |
| Sunset - 7 | 129 | 1227 | 9.5 |
| Sunset - 6 | 160 | 1540 | 9.6 |
| Sunset - 5 | 183 | 2060 | 11.3 |
| Sunset - 4 | 183 | 1814 | 9.9 |
| Sunset - 3 | 183 | 1511 | 8.3 |
| Sunset - 2 | 183 | 1135 | 6.2 |
| Sunset - 1 | 183 | 1175 | 6.4 |
| Sunset | 183 | 812 | 4.4 |
| Sunset + 1 | 183 | 283 | 1.5 |

The Sunrise + 7 and Sunset – 7 hours included all the time between seven hours after sunrise, or seven hours before sunset, and solar noon. Sunrise and sunset times were calculated using the suncalc package (Thieurmel and Elmarhraoui, 2022) in R version 4.4.4 (R Core Team, 2024).

Table 3.6. Diel variation in survey effort during the winter (October – April) vantage point surveys.

| Hour | Daylight hours | VP minutes | VP minutes / daylight hour |
|---|---|---|---|
| Sunrise - 1 | 182 | 487 | 2.7 |
| Sunrise | 182 | 1347 | 7.4 |
| Sunrise + 1 | 182 | 2033 | 11.2 |
| Sunrise + 2 | 182 | 2292 | 12.6 |
| Sunrise + 3 | 173 | 2062 | 11.9 |
| Sunrise + 4 | 138 | 1704 | 12.4 |
| **Solar Noon** | | | |
| Sunset - 4 | 138 | 2276 | 16.5 |
| Sunset - 3 | 173 | 1911 | 11.0 |
| Sunset - 2 | 182 | 1692 | 9.3 |
| Sunset - 1 | 182 | 1804 | 9.9 |
| Sunset | 182 | 1538 | 8.5 |
| Sunset + 1 | 182 | 622 | 3.4 |

The Sunrise + 4 and Sunset - 4 hours included all the time between four hours after sunrise, or four hours before sunset, and solar noon. Sunrise and sunset times were calculated using the suncalc package (Thieurmel and Elmarhraoui, 2022) in R version 4.4.4 (R Core Team, 2024).

## 3.4. HEIGHT BAND DISTRIBUTION OF FLIGHT ACTIVITY

The height band distribution of the flight activity recorded in the vantage point surveys is summarised in Figure 3.5 and Figure 3.6.

Figure 3.5 shows the distribution of the number of unique records in each height band and includes data from all the vantage points. This indicates the overall height distribution of flight activity.

Figure 3.6 shows the distribution of the total bird-minutes in each height band and only includes data from the vantage points used for the collision risk modelling. This indicates the potential influence of the height band distribution on the collision risk modelling.

Whooper Swan, Little Egret, Grey Heron and Kestrel mainly occurred in the lower height bands (below 50 m), while Cormorant, Sparrowhawk, Golden Plover, Lapwing, Black-headed Gull, Lesser Black-backed Gull and Peregrine often occurred in Band 3 (50-185/190 m).

For Golden Plover, Lapwing and Lesser Black-backed Gull, the bird-minutes were much more concentrated in Band 3 compared to the number of records. This was mainly due to longer flight durations / recorded in Band 3 compared to the lower height bands, while, for Golden Plover, larger flock sizes tended to occur in Band 3.

Very little flight activity was recorded above potential collision height (Band 4).

## 3.5. LAPWING BREEDING SEASON RECORDS

The Lapwing breeding season records in 2022, 2023 and 2024 are shown in Map 3.10-Map 3.12. Table 3.7 shows the estimated number of breeding pairs, based on the distribution of these records and the numbers of birds observed.

The breeding wader surveys were designed to cover the 500 m buffer around the wind farm site. Therefore, there may have been incomplete and variable coverage of bog sections outside this buffer (the peripheral areas of Derryarouge Bog and most of the eastern section of Derryadd Bog).

Table 3.7. Estimated number of local Lapwing breeding pairs in 2022, 2023 and 2024.

| Year | Derryaroge | Derryadd (main) | Derryadd (eastern) | Lough Bannow | Total |
|---|---|---|---|---|---|
| 2022 | 5 | 3 | 2 | 3 | 13 |
| 2023 | 4 | 7 | 0 | 3 | 14 |
| 2024 | 10 | 5 | 3 | 2 | 20 |

Derryadd (main) is the section of Derryadd Bog included in the wind farm site. Derryadd (eastern) is the eastern section of Derryadd Bog outside the wind farm site.

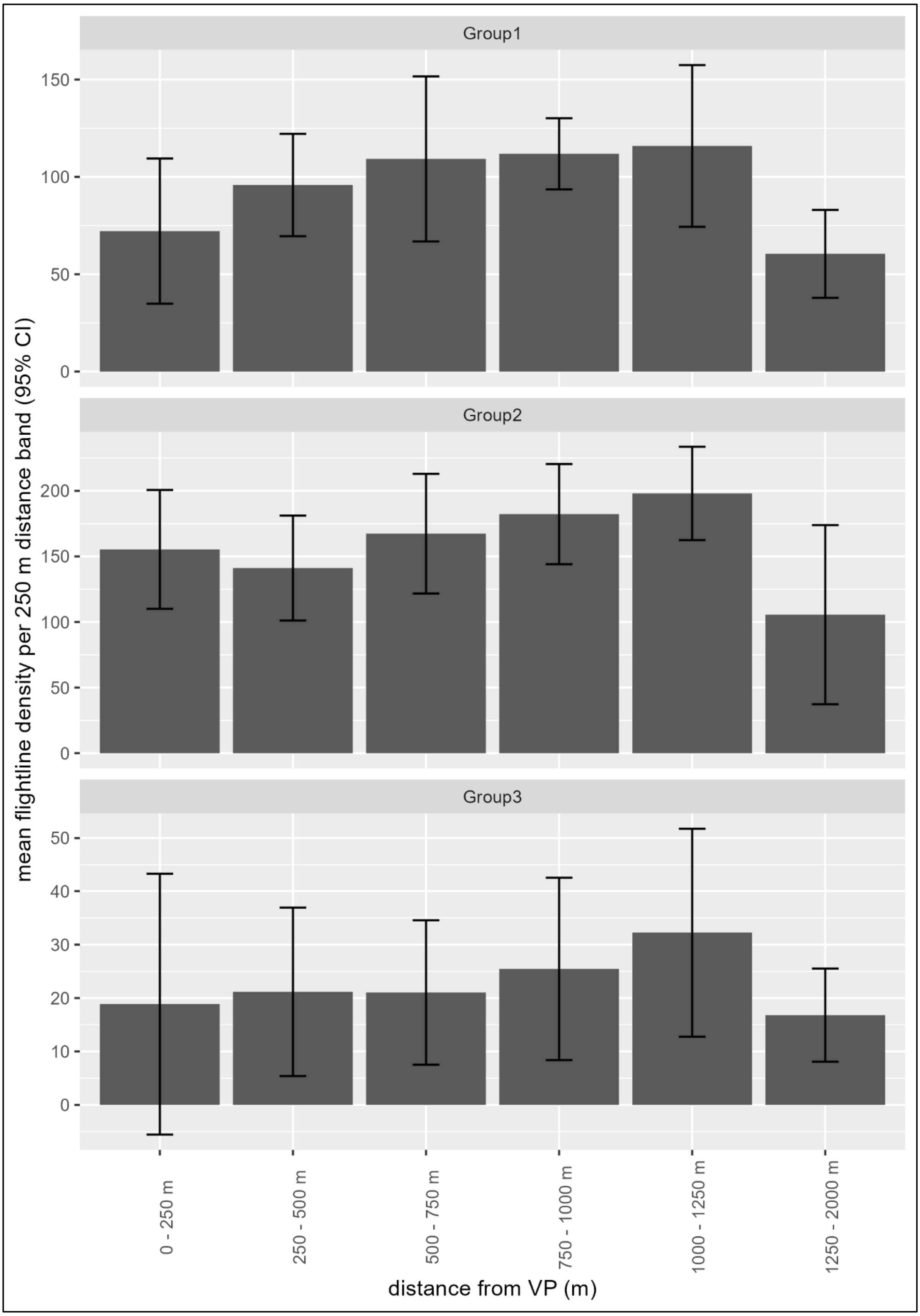



Figure 3.1. Relationship between flightline density and distance from vantage point location in the Fehily Timoney dataset for small (Group 1), medium (Group 2) and large (Group 3) species.

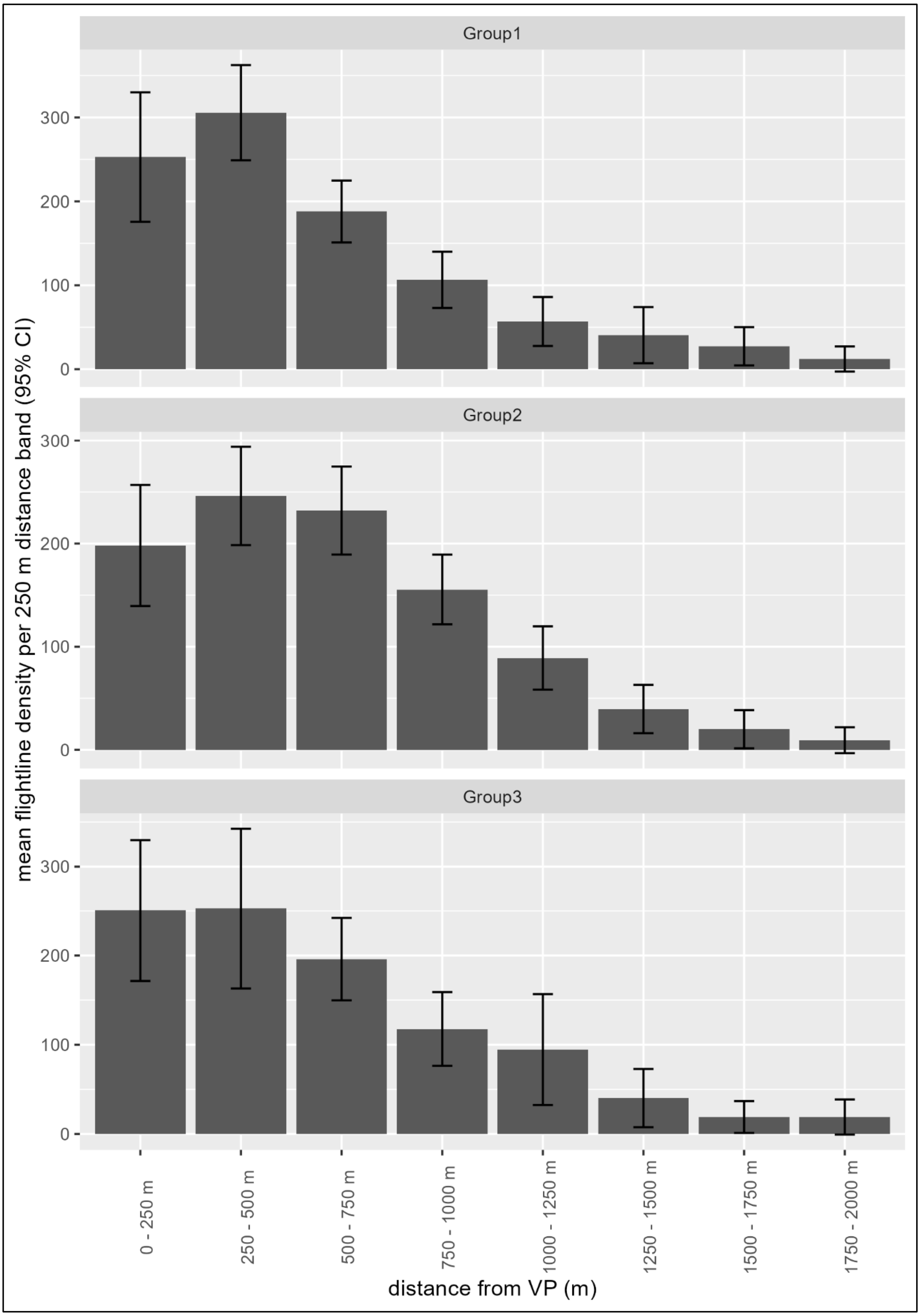
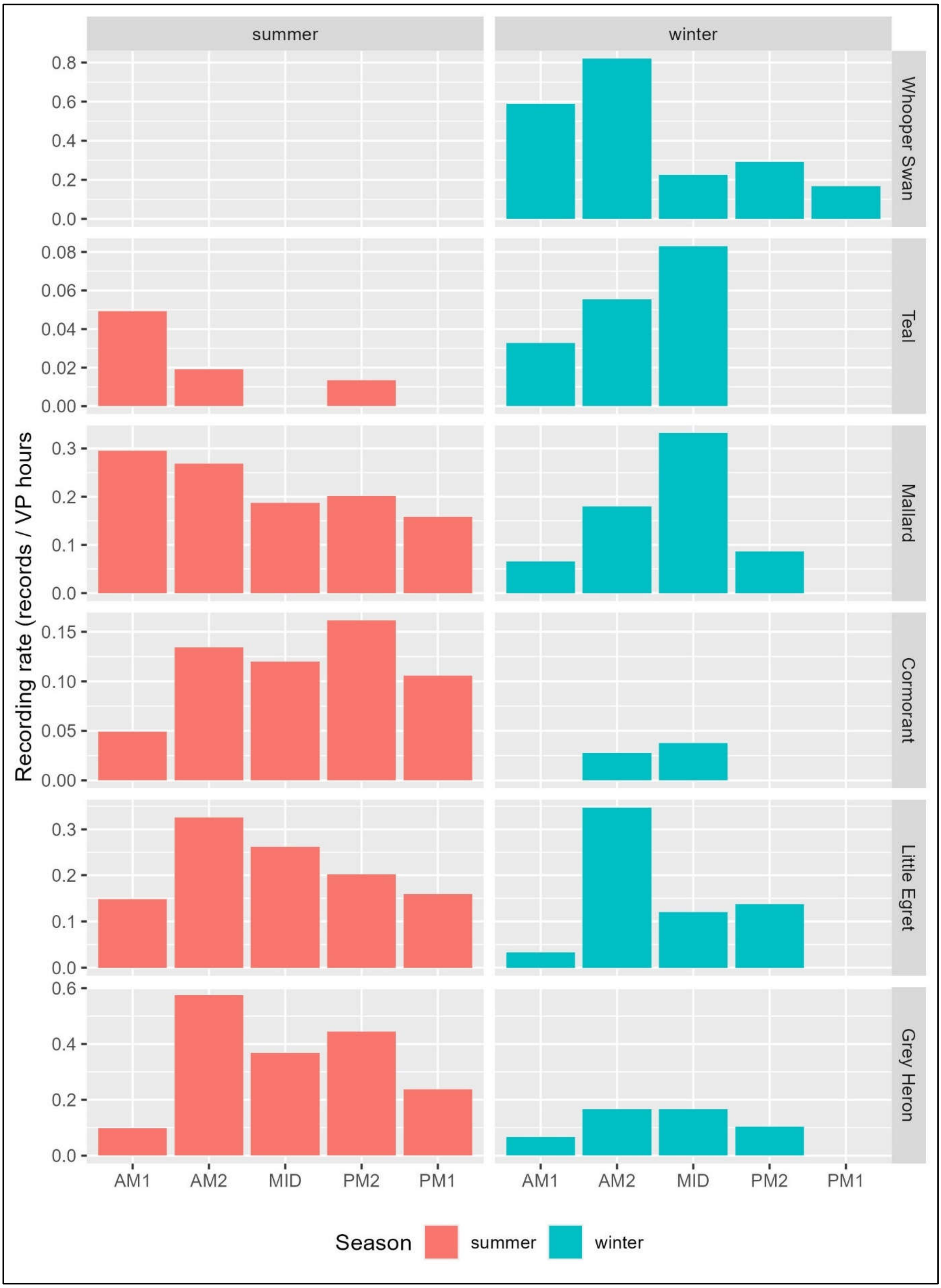



Figure 3.2. Relationship between flightline density and distance from vantage point location in the TOBIN dataset for small (Group 1), medium (Group 2) and large (Group 3) species.

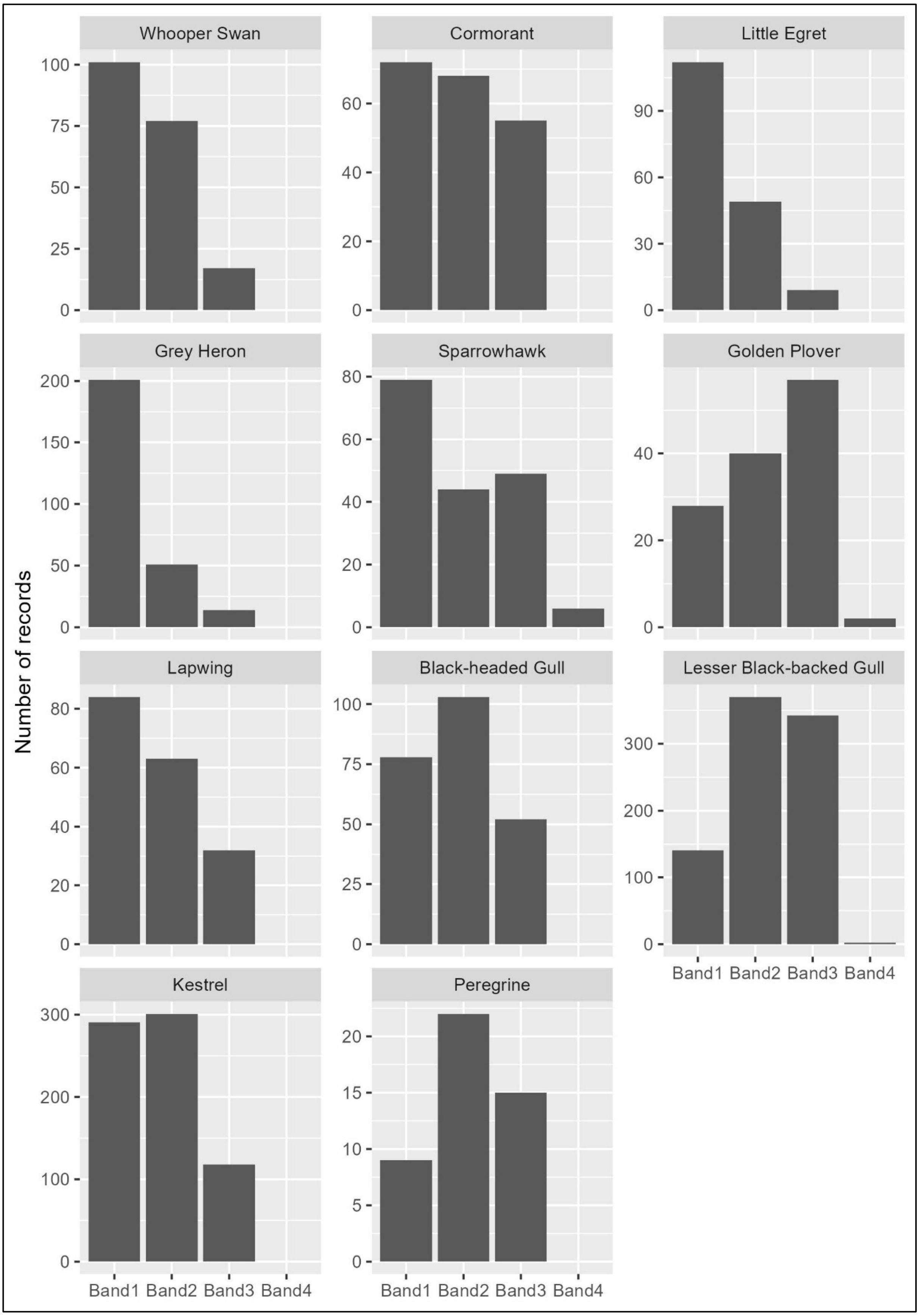



Summer: AM1 = 1 hour before sunrise to 2 hours after sunrise; AM2 = 2 hours after sunrise to 6 hours after sunrise; MID = 6 hours after sunrise to 6 hours before sunset; PM2 = 6 hours before sunset to 2 hours before sunset; PM1 = 2 hours before sunset to 1 hour after sunset. Winter: AM1 = 1 hour before sunrise to 1 hour after sunrise; AM2 = 1 hour after sunrise to 3 hours after sunrise; MID = 3 hours after sunrise to 3 hours before sunset; PM2 = 3 hours before sunset to 1 hour before sunset; PM1 = 1 hour before sunset to 1 hour after sunset.

Figure 3.3. Recording rates of Whooper Swan, Teal, Mallard, Cormorant Little Egret and Grey Heron during the early morning, mid-morning, midday, mid-afternoon and evening periods.

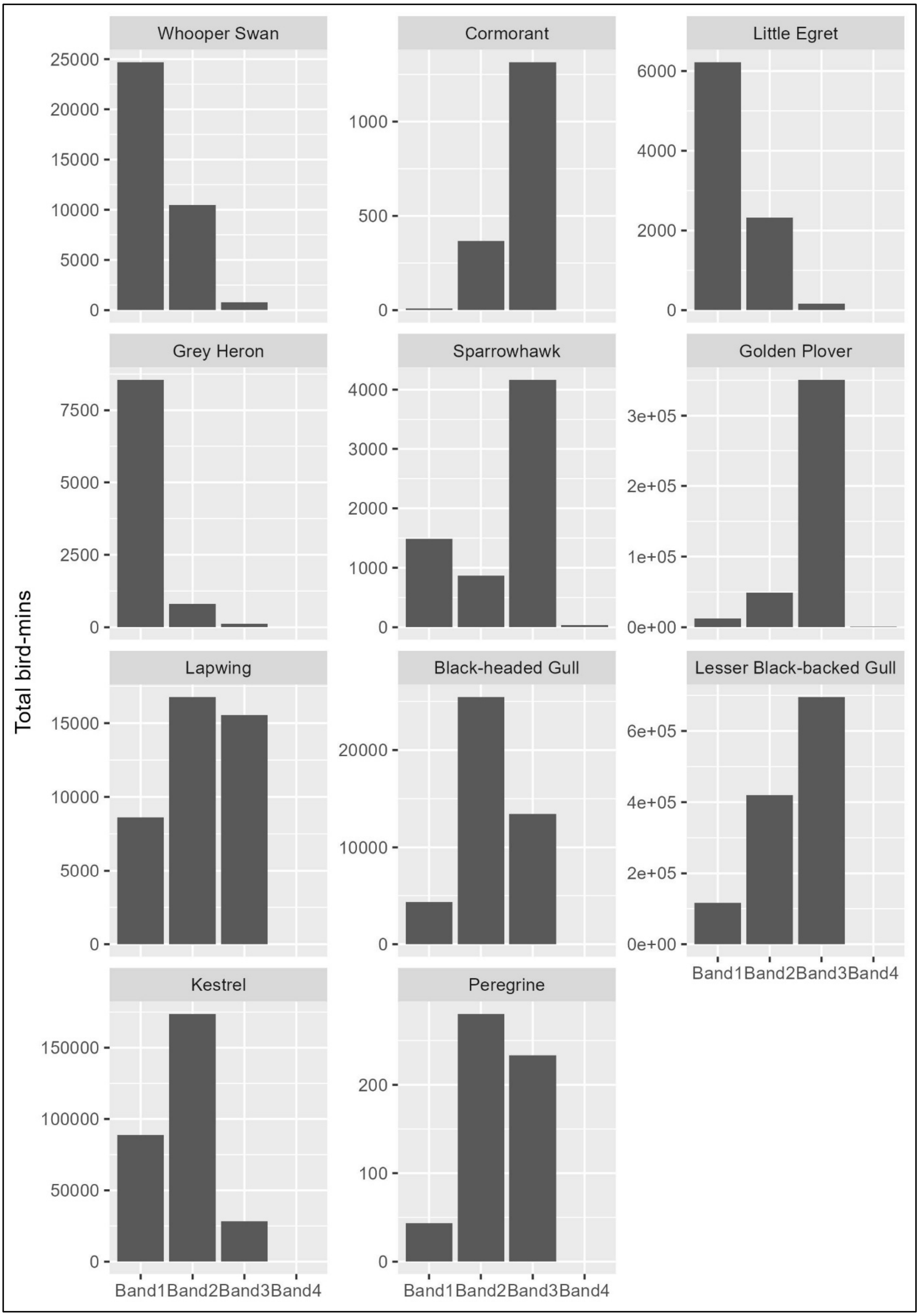

Summer: AM1 = 1 hour before sunrise to 2 hours after sunrise; AM2 = 2 hours after sunrise to 6 hours after sunrise; MID = 6 hours after sunrise to 6 hours before sunset; PM2 = 6 hours before sunset to 2 hours before sunset; PM1 = 2 hours before sunset to 1 hour after sunset. Winter: AM1 = 1 hour before sunrise to 1 hour after sunrise; AM2 = 1 hour after sunrise to 3 hours after sunrise; MID = 3 hours after sunrise to 3 hours before sunset; PM2 = 3 hours before sunset to 1 hour before sunset; PM1 = 1 hour before sunset to 1 hour after sunset.

Figure 3.4. Recording rates of Sparrowhawk, Golden Plover, Lapwing, Black-headed Gull Lesser Black-backed Gull and Kestrel during the early morning, day and evening periods.



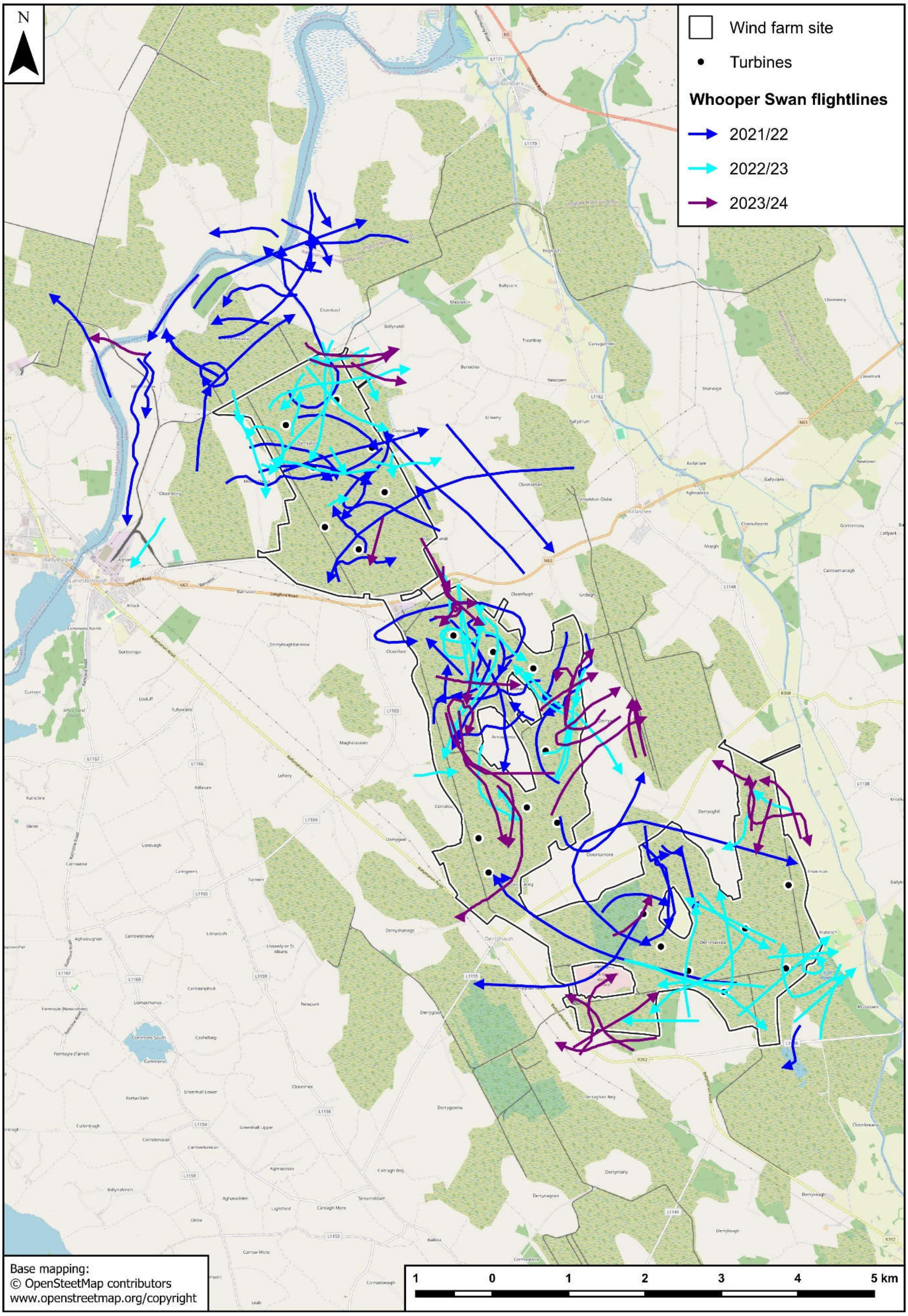

Analyses included all records. Bands: Band1 = 0-25/30 m; Band2 = 25/30-50 m; Band3 = 50-185/190 m; Band4 = > 185/190 m.

Figure 3.5. Height distribution of vantage point survey records.

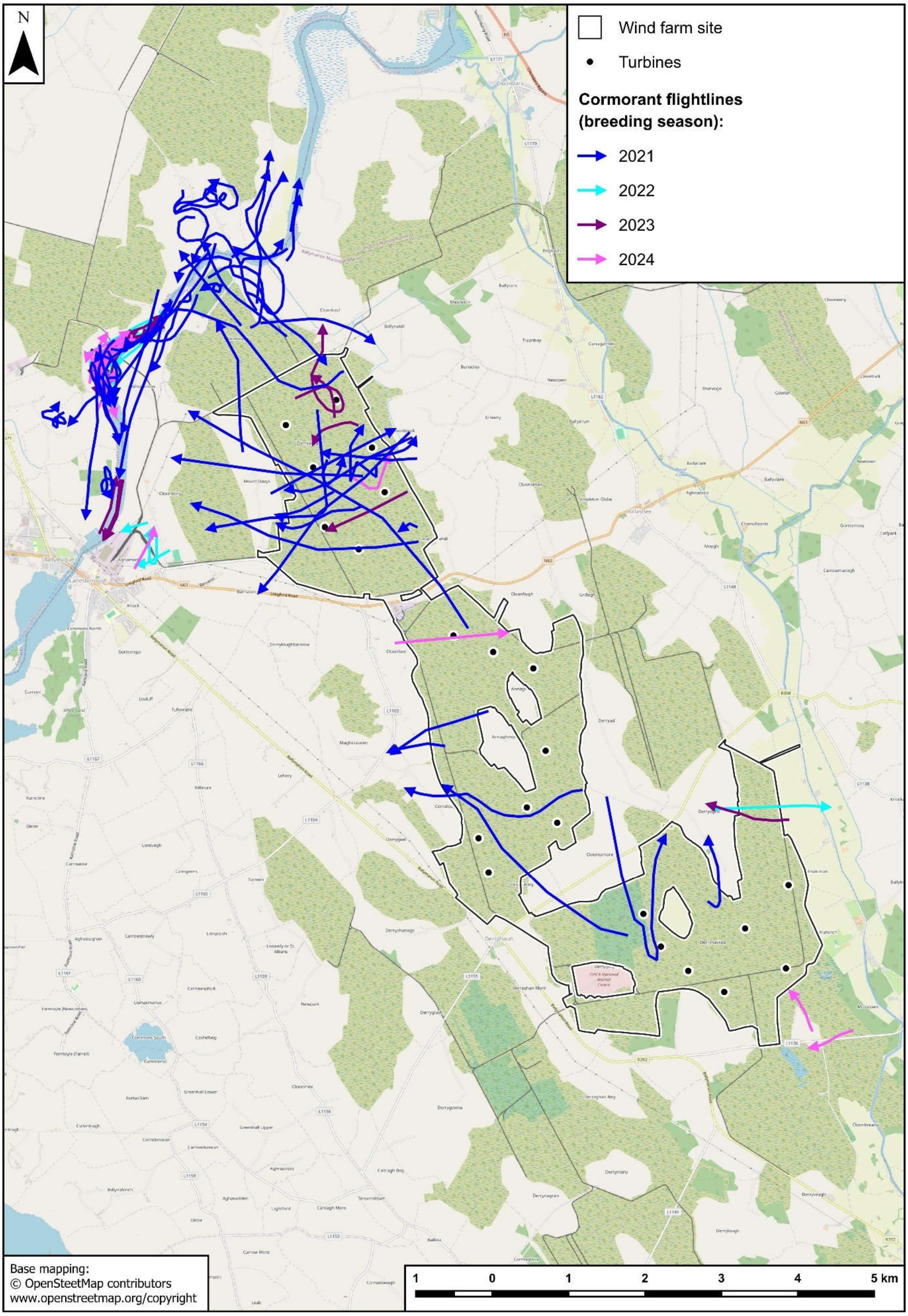



Analyses only included records from the vantage points included in the collision risk modelling. Bands: Band1 = 0-25/30 m; Band2 = 25/30-50 m; Band3 = 50-185/190 m; Band4 = > 185/190 m.

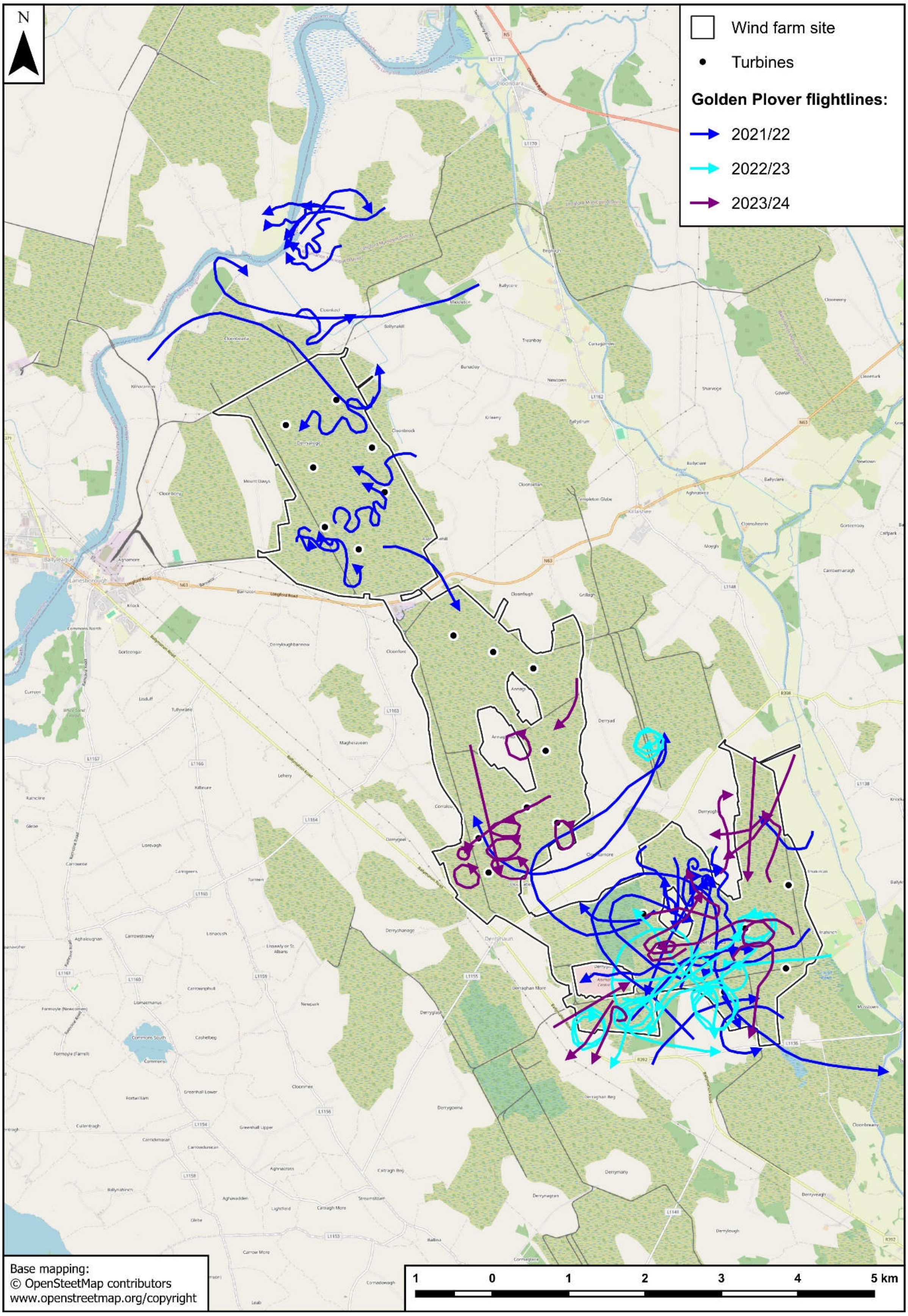
Figure 3.6. Height distribution of the total bird-minutes recorded in the vantage point surveys.



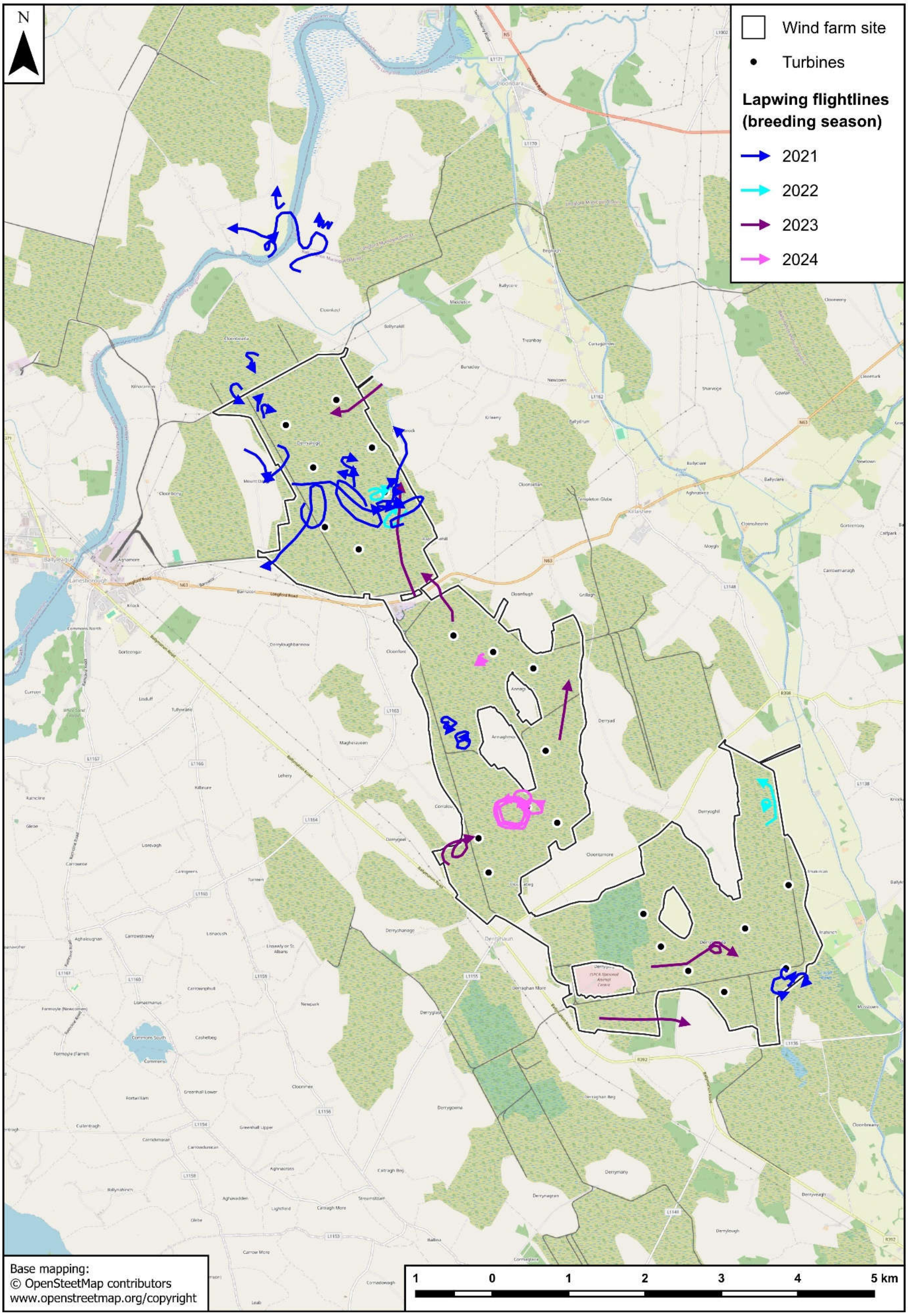

Map 3.1. Whooper Swan flightlines.



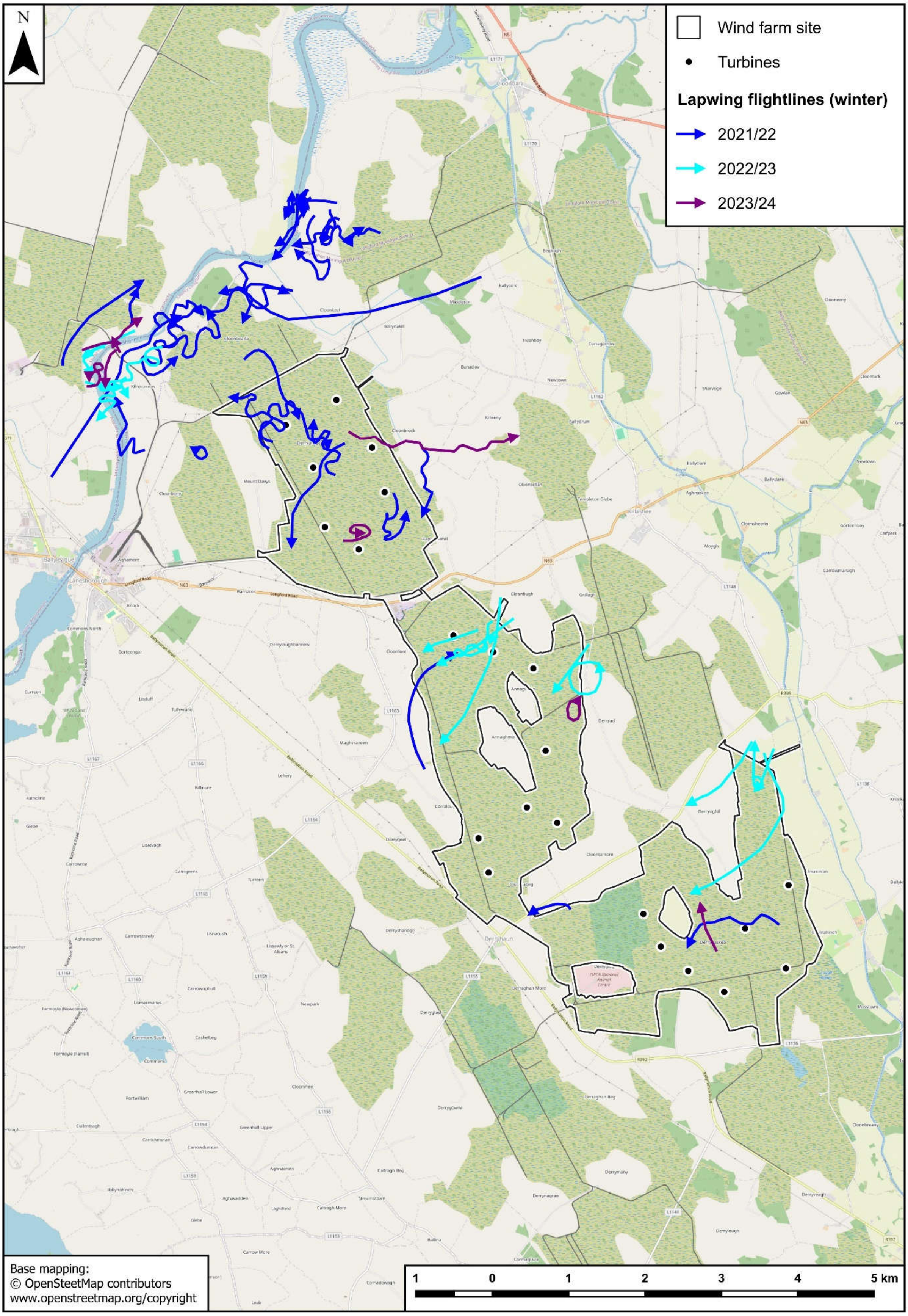

Map 3.2. Cormorant flightlines (breeding season).



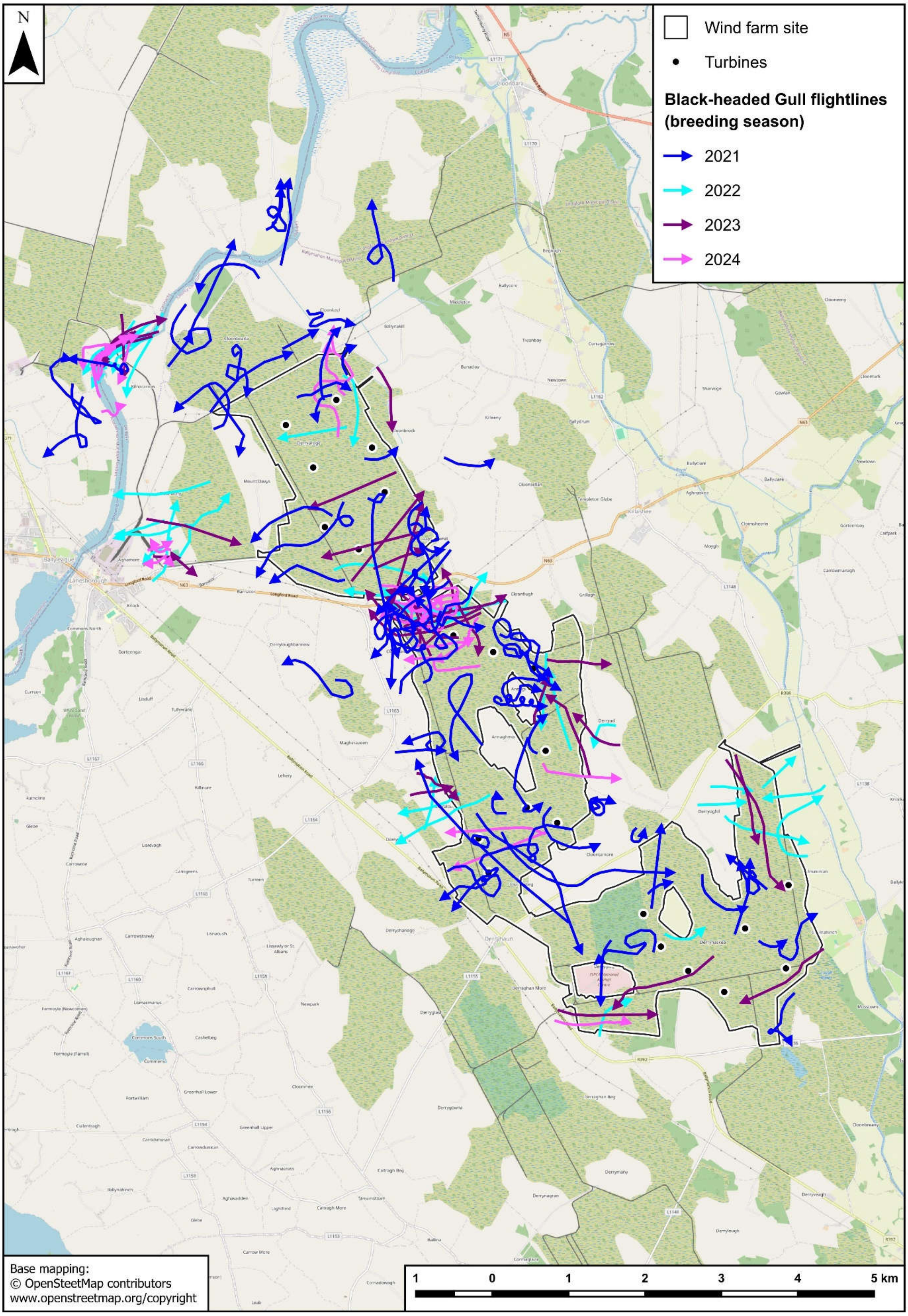

Map 3.3. Golden Plover flightlines.



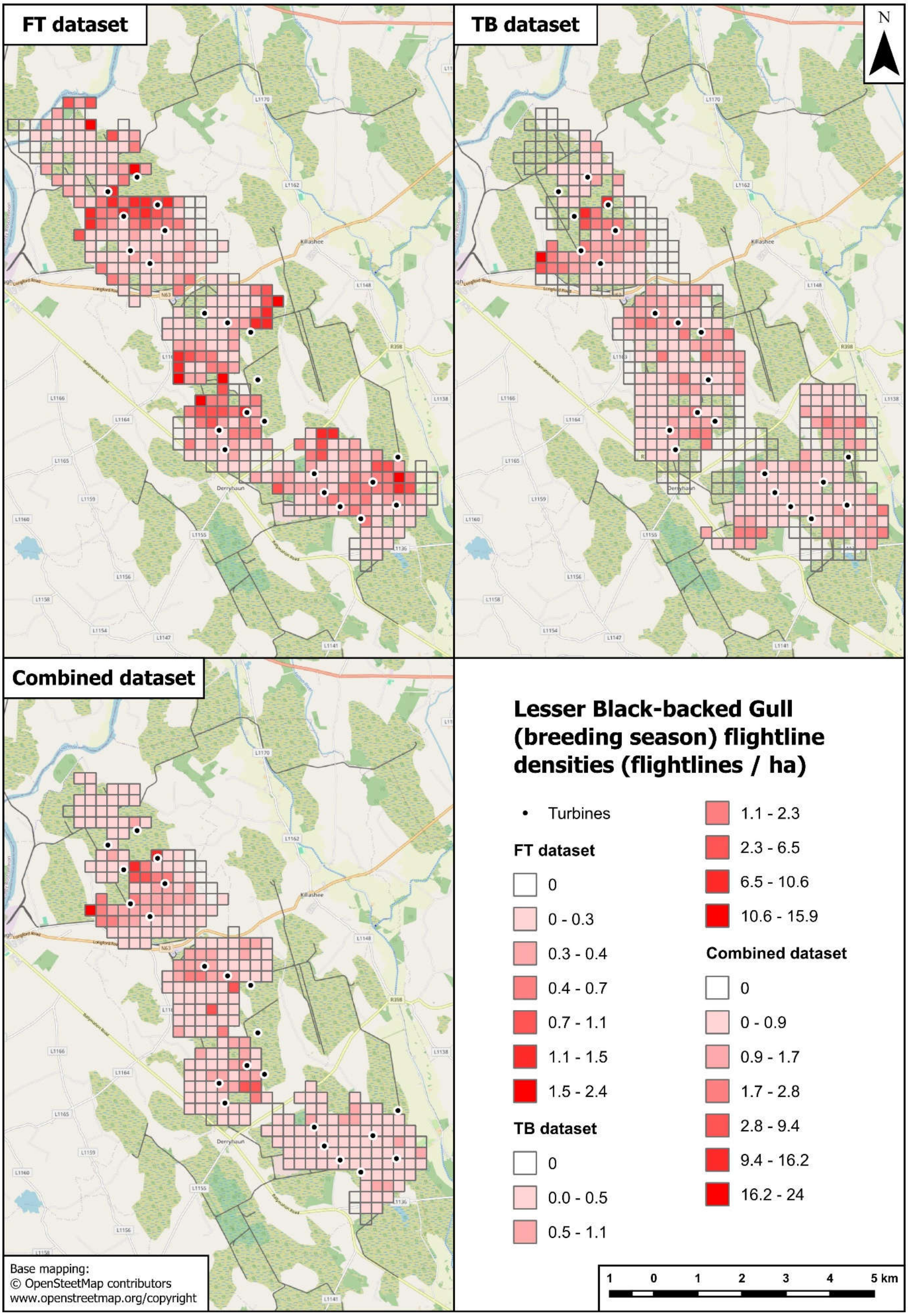

Map 3.4. Lapwing flightlines (breeding season).



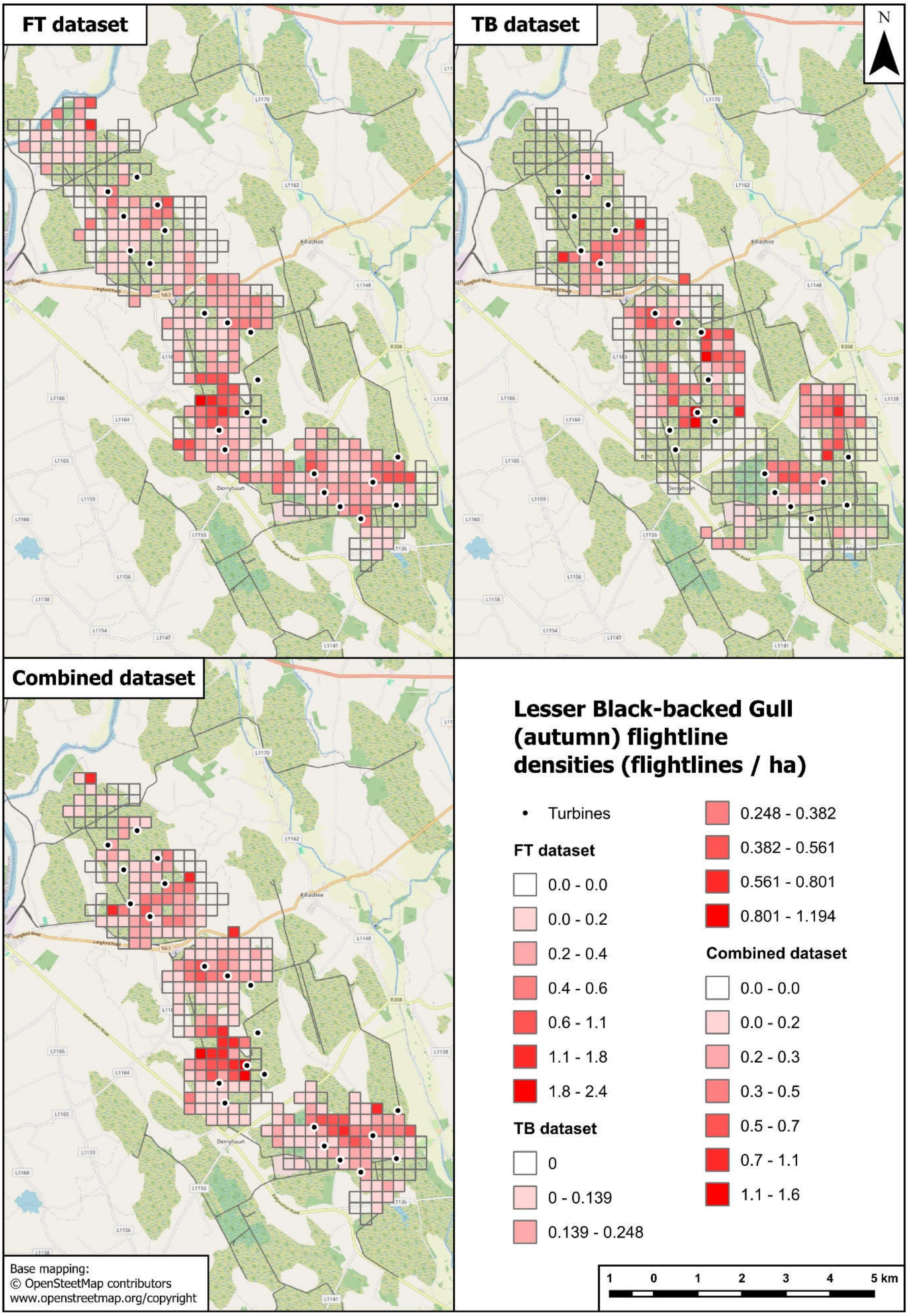

Map 3.5. Lapwing flightlines (winter).



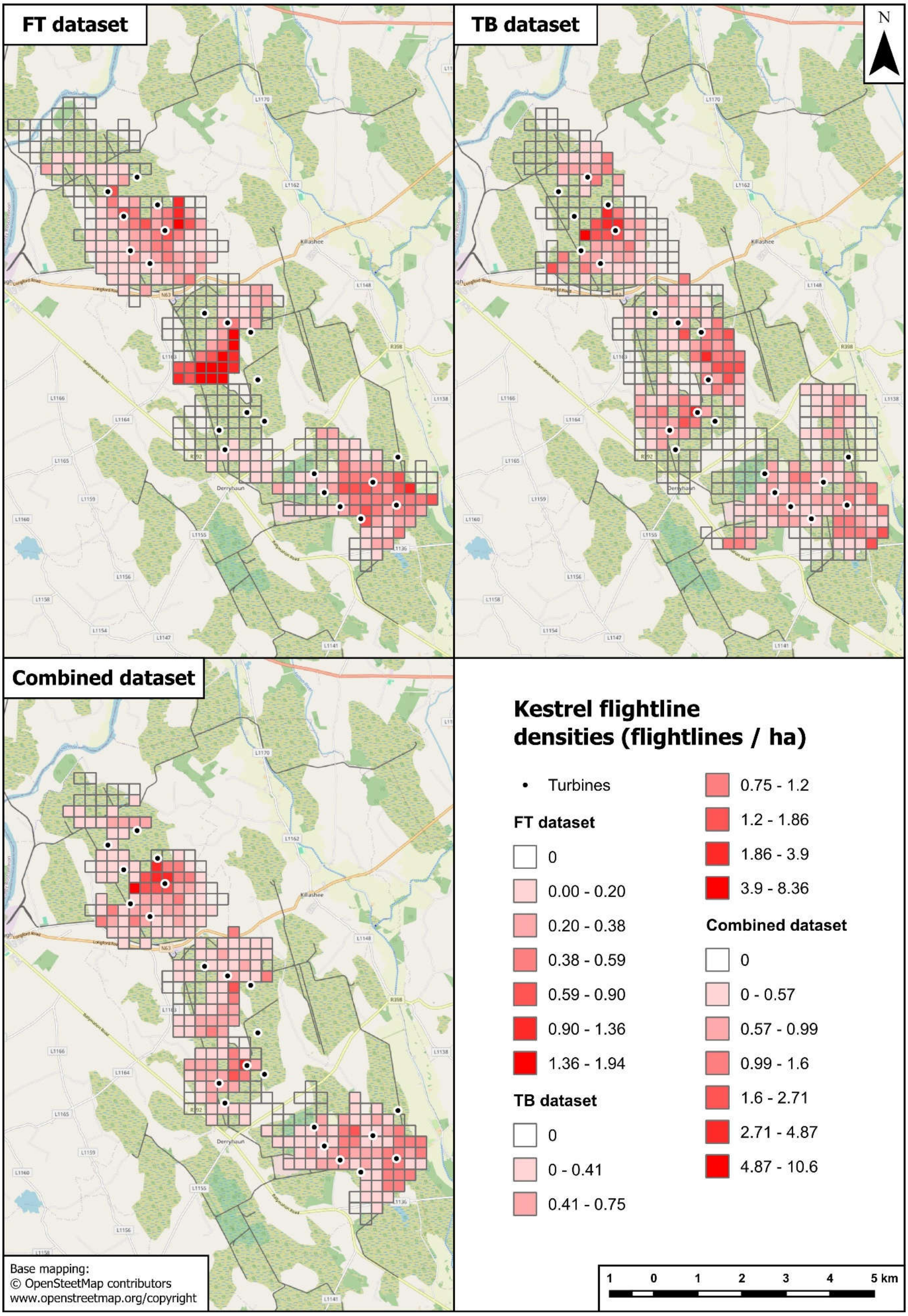

Map 3.6. Black-headed Gull flightlines (breeding season).



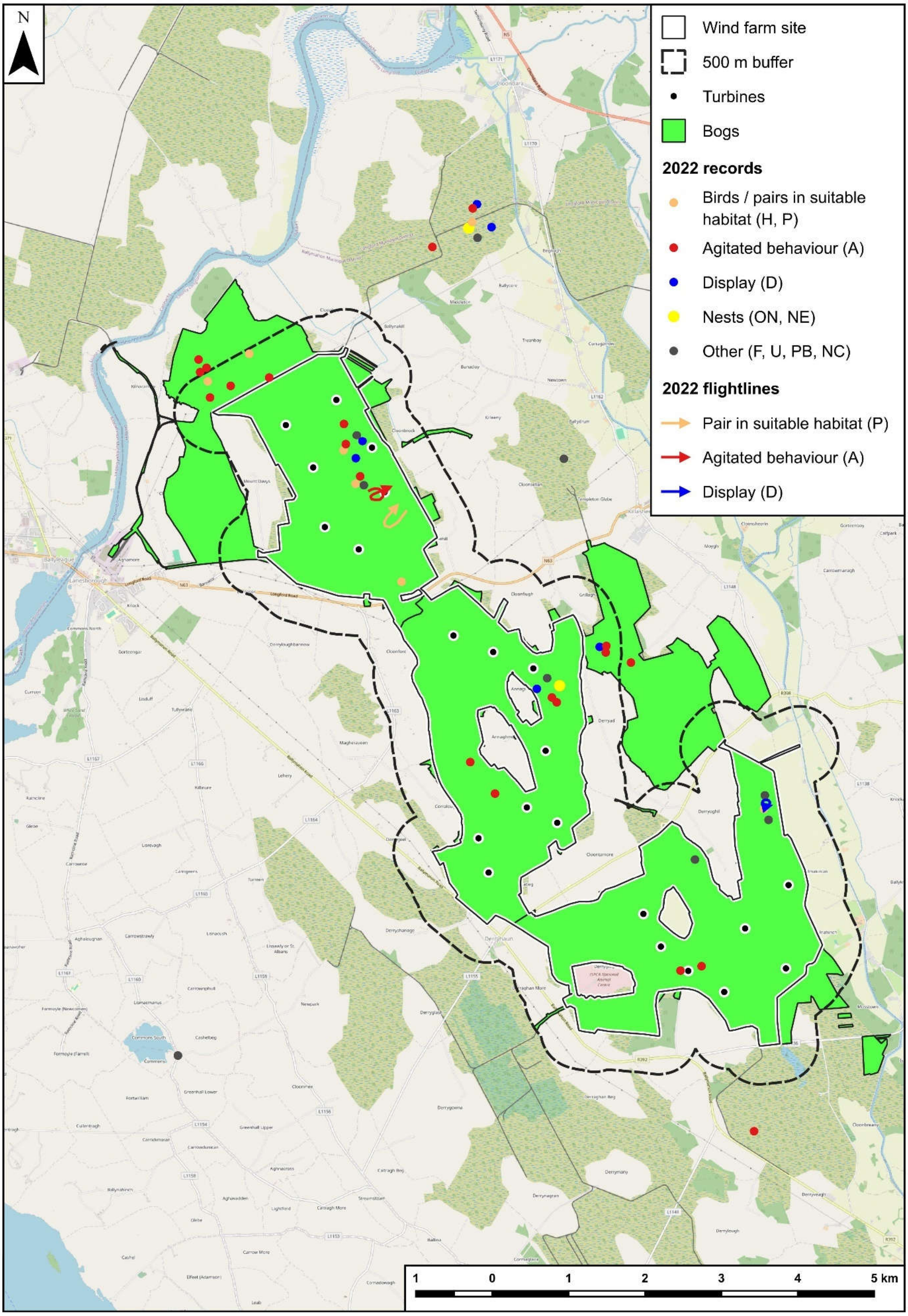

Map 3.7. Lesser Black-backed Gull flightline densities (breeding season).




Map 3.8. Lesser Black-backed Gull flightline densities (autumn).

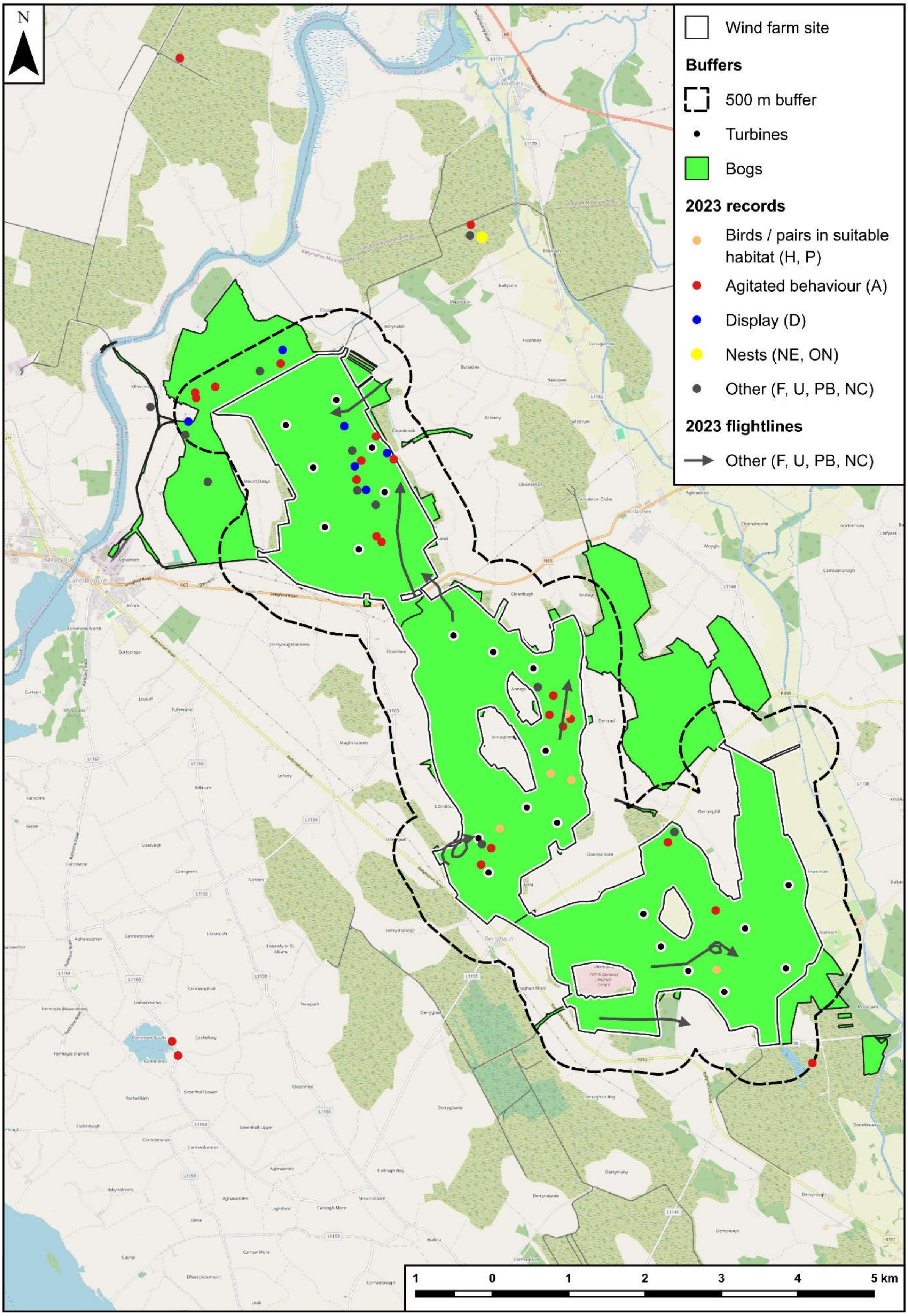



Map 3.9. Kestrel flightline densities.



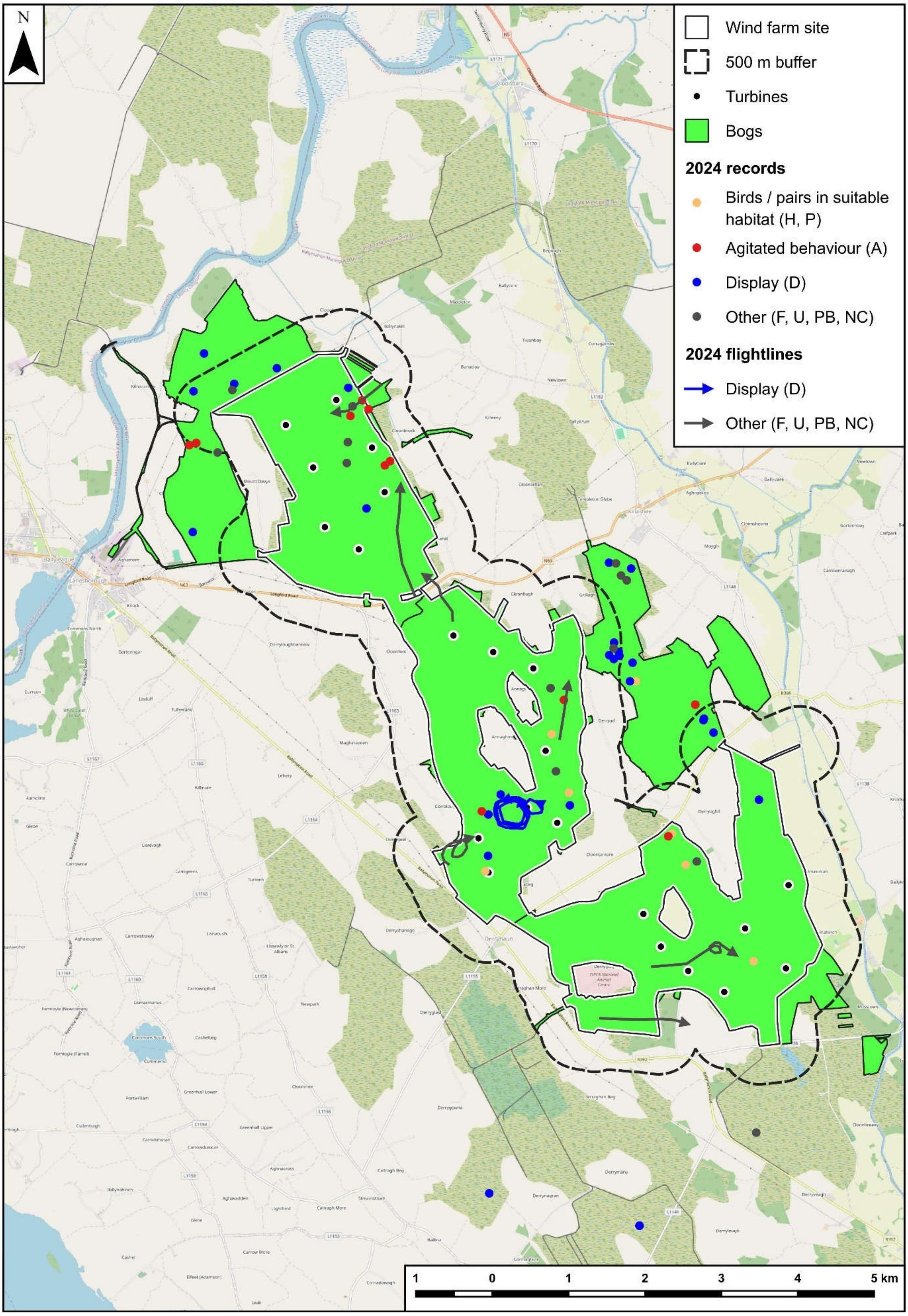

Some records were jittered by distances of up to 150 m to allow display of overlapping records.

Map 3.10. Lapwing breeding season records, 2022.




Some records were jittered by distances of up to 150 m to allow display of overlapping records.

Map 3.11. Lapwing breeding season records, 2023.




Some records were jittered by distances of up to 150 m to allow display of overlapping records.

Map 3.12. Lapwing breeding season records, 2024.

# 4. COLLISON RISK MODELLING RESULTS

## 4.1. INTRODUCTION

The results from the sequential stages of the NatureScot collision risk model are described below. The detailed results tables for the intermediate stages are included in Appendix 1, with the final collision risk estimates used for the collision risk assessment presented in this chapter.

## 4.2. STAGE A: FLIGHT ACTIVITY

### 4.2.1. Flight activity densities

The monthly daytime flight activity densities calculated in Stage A of the collision risk model are shown in Table A2.1 in Appendix 1. These are the values that would be entered in the *Daytime bird density* row in the Stage A section of the NatureScot spreadsheet if the spreadsheet was being used for the modelling.

There are two sets of values in Table A2.1: one set used the raw viewshed areas and did not correct for distance effects; the other set used viewshed areas that were corrected for distance effects (see Section 2.5.2).

The daytime flight activity densities in Table A2.1 are weighted averages of the flight activity densities for each vantage point. These were calculated using the formula provided in the NatureScot guidance (Equation A2). The weightings included in the averaging did not have large effects on the mean densities. Across all species, using the uncorrected viewshed areas, the weighted averages were a mean of 0.93 times lower than the raw averages (range 0.80 -1.18), while using the corrected viewshed areas, the weighted averages were a mean of 1.02 times higher than the raw averages (range 0.92 -1.22).

### 4.2.2. Daylight and nighttime hours

The daylight and nighttime hours per month calculated in Stage A of the collision risk model are shown in Table A2.2 in Appendix 1. These are the values that would be entered in the *Daylight hours per month* and *Nighttime hours per month* rows in the Stage A section of the NatureScot spreadsheet if the spreadsheet was being used for the modelling.

## 4.3. STAGE B: TRANSITS

### 4.3.1. Nocturnal correction factors

The nocturnal correction factors for species with nocturnal activity rankings greater than one are shown in Table A2.3 in Appendix 1. These represent the correction for nocturnal flight activity that is applied by $f_{night} \times t_{night}$ term in Equation B1. That is the formula that generates the *Projected number of rotor transits* values in the Stage B section of the NatureScot spreadsheet.

### 4.3.2. Transits

The monthly number of predicted transits calculated in Stage B of the collision risk model are shown in Table A2.4 in Appendix 1. These are the values that are produced in the *Projected number of rotor transits* row in Stage B section of the NatureScot spreadsheet.

## 4.4. STAGE C: SINGLE TRANSIT COLLISION RISK

### 4.4.1. Single transit collision risk values

The single transit collision risk values calculated in Stage C of the collision risk model are shown in Table A2.5 in Appendix 1. These are the values that are produced in the *Single transit risk* rows in the Stage C section of the NatureScot spreadsheet.

All the single transit collision risk values used in the collision risk model were calculated using flapping flight (see Section 2.6.4). The single transit collision risks generated by gliding flight were a mean of 97% lower (range 95-99%).

The upwind and downwind single transit collision risks were the same with a pitch angle of 0° but were around 2.1 times higher (range 1.5-2.7) with pitch angles of 15° and 30°.

The single transit collision risks calculated with a pitch angle of 15° were a mean of 1.02 times higher than those calculated with a pitch angle of 0° (range 0.98-1.12). The values calculated with a pitch angle of 30° were a mean of 1.26 times higher than those calculated with a pitch angle of 0° (range 1.05-1.56).

#### 4.4.2. Interpretation of single transit collision risk values

Single transit collision risk values are often misinterpreted. They represent the probability of a collision on a single transit of the rotor airspace. While they contribute to the calculation of the predicted collision risk, they should not be interpreted as providing any information about the likely magnitude of the predicted collision risk. The predicted transits have a much larger influence of the predicted collision risk and a species with a relatively high single transit collision risk may have a very low predicted collision risk if the number of predicted transits is low.

### 4.5. STAGE D: NON-AVOIDANCE COLLISION RISK

The non-avoidance collision risk values calculated in Stage D of the collision risk model are shown in Table A2.6 in Appendix 1. These are the values that are produced in the *Collision rates before avoidance* row in the Stage D section of the NatureScot spreadsheet.

### 4.6. STAGE E: COLLISION RISK AFTER AVOIDANCE

#### 4.6.1. Monthly collision risks

The monthly collision risk after avoidance values calculated in Stage E of the collision risk model are shown in Table A2.7 in Appendix 1. These are the values that are produced in the *Collision rates allowing for avoidance* rows in the Stage E section of the NatureScot spreadsheet.

The values in Table A2.7 are shown rounded to two decimal places (following the formatting of the NatureScot spreadsheet. Note that for some cells, non-zero collision risks < 0.005 are shown as 0.00 due to the rounding. All the monthly collision risks for Hen Harrier and Marsh Harrier were less than < 0.005, so these species are not included in Table A2.7.

The annual / seasonal collision risks used for the collision risk assessment were calculated from the unrounded monthly collision risks.

#### 4.6.2. Annual / seasonal collision risks

The annual or seasonal totals of the collision risks are shown in Table A2.8 in Appendix 1.

#### 4.6.3. Collision risks used for the collision risk assessment

The predicted collision risks used for the collision risk assessment are shown in Table 4.1. These are the collision risks that were generated by the most suitable avoidance rate for each species using the single transit collision risk values for a pitch angle of 0°.

### 4.7. STAGE F: ASSESSING UNCERTAINTY

#### 4.7.1. General

The NatureScot guidance lists three broad categories to consider:

- *uncertainty or variability in flight activity data, including imprecision on flight height estimates and lack of knowledge about night-time behaviour;*
- *uncertainty due to the limitations of the collision model, including the variability of bird dimensions and flight speed, the simplification in shape of a bird and turbine blades; and*

- *uncertainty arising from turbine options yet to be decided, in number, size and speed. These options should include a 'worst case' in terms of the option likely to present greatest bird collision risk.*

In addition, the discussion about Stage F in the NatureScot guidance also refers to the influence of sampling effects and natural variability in bird populations. Other factors that should also be considered are the effects of sampling biases, behavioural effects, and uncertainty about avoidance rates. There are also some issues with aspects of the NatureScot guidance and the design of the NatureScot spreadsheet.

### 4.7.2. Uncertainty or variability in flight activity data

***Sampling effects***

The results of the simulations that examined the influence of sampling effects are summarised in Table 4.2.

The under-estimation ratios in this table indicate the potential effect if the vantage point survey happened to sample low levels of flight activity relative to the overall distribution of flight activity across the season: e.g., an under-estimation ratio of 3 indicates that the true collision risk is three times higher than the collision risk estimated from the vantage point survey data.

The over-estimation ratios in this table indicate the potential effect if the vantage point survey happened to sample high levels of flight activity relative to the overall distribution of flight activity across the season: e.g., an over-estimation ratio of 0.5 indicates that the true collision risk is only half the value of the collision risk estimated from the vantage point survey data.

The range from the predicted collision risk multiplied by the over-estimation ratio to the predicted collision risk multiplied by the under-estimation ratio provides an indication of the confidence interval due to sampling effects around the predicted collision risk.

The species with higher under-estimation ratios and lower over-estimation ratios were species with relatively low numbers of records (Mallard, Little Egret and Sparrowhawk) and species that occurred in large flocks (Golden Plover and Lapwing).

For all species, the degree of under- and over-estimation decreased when the simulation was carried out across multiple years, compared to simulations over a single year. While the sampling rate remained the same, the absolute size of the samples increased, which increased the probability of generating more representative samples.

In reality, species populations and/or usage of the wind farm site are likely to vary from year-to-year. This type of variation was not included in the simulations. Therefore, the true potential uncertainty due to sampling effects is likely to fall somewhere between the ranges indicated by the one-year and multiple year simulations. For this assessment, I have used the median of the one-year and multiple year ranges to quantify the potential uncertainty due to sampling effects.

***Height distribution***

The distribution of flight height estimates is compared between the three surveyors that contributed to the TOBIN dataset in Figure 4.1 and Figure 4.2. Surveyor A consistently recorded lower flight heights than Surveyors B and C.

The potential effects on the predicted collision risks of the apparent under-recording of flight activity at potential collision height by Surveyor A are shown in Table 4.3. This compares the predicted transits from the baseline collision risk model with predicted transits generated by a model that included corrections for the under-recording. The collision risk is directly proportional to the predicted transits.

For Lesser Black-backed Gull, the corrections increased the predicted transits by around 30%. However, for the other species, the corrections had little effect on the number of predicted transits. This reflects the fact that, for many records, the flight durations below potential collision height recorded by Surveyor A were small, while for some species, the data from Surveyor A had a negligible contribution to the collision risk model.

***Nocturnal flight activity***

The effects on the nocturnal correction factors of increasing or decreasing the nocturnal activity rankings by one unit caused potential variation in the predicted collision risks of around 10-30% (Table 4.4). The largest effects occurred to the Golden Plover and Lapwing winter populations, while the smallest effects occurred to the Lapwing breeding population and Whimbrel migrating population. This reflected the larger proportion of nighttime hours in winter compared to summer, and, for Whimbrel, the fact that the nocturnal activity ranking value used in the collision risk model was the maximum value.

***Natural variability***

Species populations show natural variability from year to year due to stochastic effects and external factors (such as cold winters), while some populations may show longer term increasing or decreasing trends.

If the usage of the wind farm site tracks the population variation, the collision risk will change but the significance of the collision risk should remain the same as the population against which the risk is assessed will increase or decrease in line with the changes in the collision risk.

Even if the population remains the same, there may be variation in usage of the wind farm site due to habitat changes within the wind farm site. In the Derryadd Wind Farm site, vegetation succession and changes in drainage management are likely to cause large changes in habitat conditions over the lifetime of the wind farm project. In general, these are likely to favour species such as Sparrowhawk and Kestrel for which the later stages of vegetation succession are likely to provide better habitat conditions. Habitat conditions are likely to be become less suitable for species that exploit recently worked out bog, where vegetation is just beginning to colonise the bare peat, such as Whooper Swan, Golden Plover and Lapwing. However, drainage management may impede vegetation succession if areas are kept wet, while bat mitigation measures may keep areas open around the turbine locations.

***Sampling biases***

Sampling biases could arise if the survey effort has uneven spatial, seasonal or diel coverage in relation to factors that affect species occurrence.

Uneven spatial coverage is difficult to avoid in vantage point surveys of large wind farm sites due to overlapping viewsheds and the under-detection of distant flightlines. The weighting of viewshed areas and the averaging across vantage points used in Stage A of the collision risk model account to a large degree for these effects.

The survey effort was distributed more or less uniformly across the survey months.

The diel distribution of the survey effort was uneven with lower coverage in the early morning and evening, particularly in summer. This may have resulted in some under-detection of Whooper Swan, flight activity as this species seemed to show higher levels of flight activity in the early – mid-morning, compared to later in the day. Conversely, it may have resulted in over-detection of several other species that showed low levels of flight activity in the early morning and evening.

***Behavioural effects***

The equation for calculating predicted transits (Equation B1) includes the mean bird flight speed as part of the numerator. However, for Kestrel, a significant proportion of their flight activity will typically involve hovering birds. The flight speed of a hovering Kestrel is close to zero (a small amount of drift in position will often occur during long bouts of hovering). Therefore, using the mean flight speed for Kestrel (10.1 m/sec; Alerstam *et al.*, 2007) in Equation 1 to predict transits of hovering Kestrel is clearly inappropriate and will result in highly inflated estimates.

In the collision risk model for the Castlebanny Wind Farm (Gittings, 2021), I used data collected during the vantage point survey on the duration of hovering flight, and the mean number of hovering positions per second, to calculate separate predicted transits for hovering Kestrels, with the standard collision risk model only used for direct Kestrel flight activity. This resulted in a predicted collision risk that was less than half the value of the collision risk that would have been generated by using the standard model for all Kestrel flight activity.

### 4.7.3. Uncertainty due to collision risk model limitations

***Stage A***

The weighted averaging procedure used to calculate mean flight activity densities in Stage A (Equation A2) assumes that longer durations of vantage point surveys and large viewsheds will produce more reliable estimates. This will be true for longer durations of vantage point surveys. However, in general, there is likely to be an increased risk of under-detection of all flightlines in larger viewsheds. More specifically, larger viewsheds usually have higher proportions of their survey area occupied by the more distant parts of the viewshed (Figure 4.3), which is likely to result in increased under-detection of distant flightlines. The adjusted viewshed areas used to correct for distance effects addresses the latter issue.

***Stage B***

*Monthly calculations*

Stage B calculates transits separately for each month. By combining Equations A1 and B1, it can be seen that the predicted transits are proportional to the ratio of the total daylight hours to the vantage point survey effort ($t_{day}$/ t). As vantage point survey effort is usually more or less constant between months the ratio will vary between months with the highest values in mid-winter and the lowest values in mid-summer.

If variation in the distribution of flight activity densities between months reflects real differences in flight activity, the variation in the $t_{day}$/ t ratio will not affect the reliability of the predicted collision risk. However, in practice, the variation in flight activity densities between months is likely to include a large component that is due to sampling effects. This means that calculating transits separately for each month is likely to exacerbate the influence of sampling effects on the degree of uncertainty around the predicted collision risk. The effects will be reduced for species with non-zero nocturnal flight activity included in the model.

A better procedure would be to calculate flight activity densities for groups of months where there are unlikely to be real differences in flight activity: e.g., across the entire winter period for wintering species. This is the procedure that I have followed in previous collision risk modelling. In fact, the worked example that is provided in Annex 1 of the NatureScot guidance uses this procedure. However, it is not possible to implement this method using the NatureScot spreadsheet. Therefore, as I have tried to implement the calculation procedures in the NatureScot spreadsheet, I have used the monthly calculation of predicted transits, despite the above issues.

*Proportion of flight activity at potential collision height*

The height bands used for the Fehily Timoney surveys did not exactly match the range of potential collision heights. The lowest and highest height bands each included 5 m within the potential collision height range. To account for the mismatch between the Fehily Timoney height bands and the range of potential collision heights, I included all the flight activity recorded by the Fehily Timoney surveys in the lowest and highest height bands in the modelling of bird transits. This will have caused some over-estimation of the collision risk.

The over-estimation of the collision risk will be most significant for species with high proportions of flight activity in the lowest height band, particularly Whooper Swan, Little Egret and Grey Heron, and, to a lesser extent, Lapwing and Kestrel. However, the effects will have been reduced by the weighting procedure used to calculate mean bird densities cross vantage points. This down-weighted the contribution of the Fehily Timoney vantage points due to the lower survey effort at these vantage points.

The inclusion of all the flight activity recorded by the Fehily Timoney surveys in the highest height band will have had a negligible effect on the predicted collision risk as very little flight activity was recorded in this height band.

***Stage C***

*Pitch angle*

The relationships between single transit collision risks and pitch angles are shown in Figure 4.4 for a selection of the species included in the collision risk model. The single transit collision risk values showed little variation up to pitch values of around 10-20°, after which they increased sharply with increasing pitch. The inflection point was related to flight speed (Figure 4.4): the start of the increase in single transit collision risk with pitch angle occurred at around 8-10° in the species with the slowest flight speeds (Kestrel and Little Egret), and at around 15-20° in the species with the fastest flight speeds (Golden Plover and Teal).

As discussed above, monitoring data indicates that pitch angles at onshore wind farms in Ireland rarely exceed 9°. In the pitch angle range from -5° to 9°, the maximum collision probability for most species occurred at a pitch angle of 0° (Figure 4.6). The exceptions were Kestrel and Little Egret, where the inflection point occurred before 9° and the collision probability with a pitch angle of 9° was slightly higher than the collision probability at 0°. However, the difference was marginal.

*Rotation speed*

The relationships between single transit collision risks and rotation speeds are shown in Figure 4.4 for the species included in the collision risk model.

The effects of variation in rotation speed generally increased with body size, but species with slow flight speeds (Sparrowhawk, Kestrel and Little Egret) were exceptions to this pattern. For small species like Golden Plover, the variation in rotation speed, within the operational speed ranges, had negligible effects on the single transit collision risks. However, for large species like Whooper Swan and Cormorant, there was a 2-3% variation in single transit collision risks across the operational speed ranges. For these two species, this variation would result in an increase in the predicted collision risk of up to 1.5 times between the minimum and maximum rotation speeds.

*Overall effects*

There are a number of other sources of potential uncertainty in the calculations of single transit collision risks. Band (2024) notes that "having regard for the various simplifications in the model, and the potential sources of under- and over-estimation …, it is judged that [Stage C] of the model should be regarded as indicative of collision probability within around ± 20%".

***Stage E***

The avoidance rates that are applied in the Stage E of the collision risk model have large effects, causing 20-fold to 500-fold decreases in the predicted collision risk. However, the evidence for most avoidance rates used in collision risk modelling for onshore wind farms is very limited.

The default avoidance rate of 98% was applied when species-specific avoidance rates are not available. In most cases, the latter were higher: 99% for Hen Harrier, 99.2% for Black-headed Gull and Common Gull, 99.5% for Mute Swan, Whooper Swan and Lesser Black-backed Gull, 99.6-99.8% for Golden Plover, and 99.8% for Greylag Goose. Increasing the avoidance rate from 98% to 99% halves the predicted collision risk, while increasing the avoidance rate from 98% to 98.8% causes a 10-fold reduction in the predicted collision risk.

The exception was Kestrel, which has a recommended avoidance rate of 95% (SNH, 2018). This causes a 2.5-fold increase in the collision risk compared to the default avoidance rate of 98%. However, the evidence for the Kestrel avoidance rate is weak. The avoidance rate is described as being based on: "sufficient evidence from flight behaviour (including hovering) and collision monitoring studies for vulnerability to collisions". The cited source (Whitfield and Madders, 2006) is, in fact, a review of avoidance rates for Red Kite. The information on Kestrel is derived from an analysis which finds a significant correlation between the "numbers of individuals seen" against numbers of carcasses found for 16 raptor species at a single wind farm in Spain. Kestrel is a large outlier above the regression line, and this appears to be the only empirical evidence that has been used by Scottish Natural Heritage to support the 95% avoidance rate for Kestrel. However, even taken at face value, all this analysis does is indicate that Kestrel has a lower avoidance rate than other raptor species, but it does not provide any quantitative data that can be used to estimate the avoidance rate. More seriously, this analysis does not account for behavioural and ecological differences between species that may affect the relationship between bird activity and collisions. It is also subject to the perennial problem with analyses of collision rates: the small absolute numbers of collisions which means that random sampling error may have significant effects.

#### 4.7.4. Uncertainty due to turbine options

This collision risk model is based on a fixed turbine model so there is no uncertainty due to turbine options.

#### 4.7.5. Overall uncertainty

Table 4.5 summarises the quantitative uncertainty estimates discussed above and provides an overall quantitative uncertainty estimate. It also indicates where there are other significant factors, which couldn't be quantified, that are likely to affect the uncertainty around the predicted collision risk.

Table 4.1. Collision risks used for the collision risk assessment.

| Species | Season | Avoidance rate | Collision risks with distance effects | |
|---|---|---|---|---|
| | | | uncorrected | corrected |
| Mute Swan | all year | 0.995 | 0.00 | 0.01 |
| Whooper Swan | winter | 0.995 | 0.17 | 0.30 |
| Greylag Goose | all year | 0.998 | 0.00 | 0.00 |
| Wigeon | winter | 0.980 | 0.00 | 0.01 |
| Teal | all year | 0.980 | 0.23 | 0.32 |
| Mallard | all year | 0.980 | 0.38 | 0.64 |
| Cormorant | breeding | 0.980 | 0.14 | 0.22 |
| | non-breeding | 0.980 | 0.01 | 0.02 |
| Little Egret | all year | 0.980 | 0.20 | 0.34 |
| Grey Heron | all year | 0.980 | 0.13 | 0.21 |
| Little Grebe | all year | 0.980 | 0.00 | 0.01 |
| Marsh Harrier | all year | 0.980 | 0.00 | 0.00 |
| Hen Harrier | non-breeding | 0.990 | 0.00 | 0.00 |
| Sparrowhawk | all year | 0.980 | 0.13 | 0.24 |
| Buzzard | all year | 0.980 | 1.36 | 2.57 |
| Golden Plover | summer | 0.996 | 0.02 | 0.04 |
| | summer | 0.998 | 0.01 | 0.02 |
| | winter | 0.996 | 2.33 | 6.84 |
| | winter | 0.998 | 1.16 | 3.42 |
| Lapwing | breeding | 0.980 | 0.23 | 0.39 |
| | autumn | 0.980 | 0.05 | 0.07 |
| | winter | 0.980 | 0.66 | 1.68 |
| Whimbrel | migration | 0.980 | 2.21 | 3.08 |
| Curlew | breeding | 0.980 | 0.01 | 0.02 |
| | non-breeding | 0.980 | 0.01 | 0.01 |
| Black-headed Gull | breeding | 0.992 | 0.31 | 0.56 |
| | non-breeding | 0.992 | 0.00 | 0.01 |
| Common Gull | all year | 0.992 | 0.00 | 0.00 |
| Lesser Black-backed Gull | breeding | 0.995 | 0.98 | 1.82 |
| | autumn | 0.995 | 0.22 | 0.38 |
| | winter | 0.995 | 0.01 | 0.02 |
| Kestrel | all year | 0.950 | 1.69 | 3.44 |
| Merlin | all year | 0.980 | 0.00 | 0.00 |
| Peregrine | all year | 0.980 | 0.03 | 0.05 |

Table 4.2. Potential under- and over-estimation of the true collision risks due to sampling effects in the flight activity data.

| Species | Season | Years | Under-estimation ratio | Over-estimation ratio |
|---|---|---|---|---|
| Whooper Swan | winter | 1 | 1.92 | 0.61 |
| | | 3 | 1.42 | 0.76 |
| Mallard | all year | 1 | 2.26 | 0.56 |
| | | 3 | 1.46 | 0.71 |
| Cormorant | breeding | 1 | 2.08 | 0.62 |
| | | 4 | 1.42 | 0.79 |
| Little Egret | all year | 1 | 3.64 | 0.49 |
| | | 3 | 1.81 | 0.66 |
| Grey Heron | all year | 1 | 1.95 | 0.60 |
| | | 3 | 1.42 | 0.74 |
| Sparrowhawk | all year | 1 | 2.55 | 0.55 |
| | | 3 | 1.71 | 0.65 |
| Golden Plover | winter | 1 | 3.36 | 0.46 |
| | | 3 | 1.82 | 0.61 |
| Lapwing | breeding | 1 | 5.44 | 0.42 |
| | | 4 | 1.93 | 0.61 |
| | winter | 1 | 3.48 | 0.40 |
| | | 3 | 1.86 | 0.57 |
| Black-headed Gull | breeding | 1 | 1.73 | 0.69 |
| | | 4 | 1.31 | 0.79 |
| Lesser Black-backed Gull | breeding | 1 | 1.34 | 0.79 |
| | | 4 | 1.15 | 0.88 |
| Kestrel | all year | 1 | 1.58 | 0.68 |
| | | 3 | 1.29 | 0.78 |

The under-estimation ratio is the ratio of the lower limit of the 95% confidence interval of the mean flight activity density in the sampled flight activity distributions to the mean flight activity density in the overall dataset. The over-estimation ratio is the ratio of the upper limit of the 95% confidence interval of the mean flight activity density in the sampled flight activity distributions to the mean flight activity density in the overall dataset.

Table 4.3. Predicted transits calculated using flight activity data with the height band distribution recorded by Surveyor A in the TOBIN dataset corrected for potential under-estimation of flight activity at potential collision height, compared to the predicted transits calculated using uncorrected data.

| Species | Predicted transits | | Increase factor |
|---|---|---|---|
| | uncorrected | corrected | |
| Whooper Swan | 506 | 517 | 1.02 |
| Mallard | 476 | 492 | 1.03 |
| Cormorant | 112 | 112 | 1.00 |
| Little Egret | 200 | 201 | 1.00 |
| Grey Heron | 105 | 106 | 1.01 |
| Sparrowhawk | 115 | 115 | 1.00 |
| Buzzard | 1383 | 1390 | 1.01 |
| Lapwing | 1299 | 1299 | 1.00 |
| Black-headed Gull | 975 | 1037 | 1.06 |
| Lesser Black-backed Gull | 5101 | 6651 | 1.30 |
| Kestrel | 831 | 842 | 1.01 |

Table 4.4. Variation in nocturnal correction factors generated by decreasing or increasing the nocturnal activity rankings by one unit, and the range of effects on the predicted collision risks generated by this variation.

| Species | Season | NAR value | Nocturnal correction factors calculated using | | | Range of effects on collision risk |
|---|---|---|---|---|---|---|
| | | | NAR-1 | NAR | NAR+1 | |
| Wigeon | winter | 3 | 1.39 | 1.78 | 2.16 | 0.78-1.21 |
| Teal | all year | 3 | 1.24 | 1.48 | 1.71 | 0.84-1.16 |
| Mallard | all year | 3 | 1.24 | 1.48 | 1.71 | 0.84-1.16 |
| Little Egret | all year | 2 | 1.00 | 1.24 | 1.48 | 0.81-1.19 |
| Grey Heron | all year | 2 | 1.00 | 1.24 | 1.48 | 0.81-1.19 |
| Golden Plover | winter | 2 | 1.00 | 1.35 | 1.69 | 0.74-1.25 |
| Lapwing | breeding | 2 | 1.00 | 1.13 | 1.26 | 0.88-1.12 |
| Lapwing | winter | 2 | 1.00 | 1.40 | 1.81 | 0.71-1.29 |
| Whimbrel | migration | 5 | 1.43 | 1.57 | - | 0.91-1.00 |

For Whimbrel, the maximum potential value of the nocturnal activity ranking was used, so a NAR+1 nocturnal correction factor is not included in this table.

Table 4.5. Overall uncertainty factors that should be applied to the predicted collision risks.

| Species | Season | Sampling effects | Height bands | Nocturnal activity | Single transit risk | Overall | Other factors |
|---|---|---|---|---|---|---|---|
| Whooper Swan | winter | 0.69-1.67 | 1.02 | 1.00 | 0.8-1.2 | 0.55-2.04 | |
| Teal | winter | - | - | 0.84-1.16 | 0.8-1.2 | - | ↓ |
| Mallard | all year | 0.64-1.86 | 1.03 | 0.84-1.16 | 0.8-1.2 | 0.43-2.67 | ↓ |
| Cormorant | breeding | 0.71-1.75 | 1.00 | 1.00 | 0.8-1.2 | 0.57-2.10 | ↓ |
| Little Egret | all year | 0.58-2.73 | 1.00 | 0.81-1.19 | 0.8-1.2 | 0.38-3.90 | ↓ |
| Grey Heron | all year | 0.67-1.69 | 1.01 | 0.81-1.19 | 0.8-1.2 | 0.43-2.44 | ↓ |
| Sparrowhawk | all year | 0.60-2.13 | 1.00 | 1.00 | 0.8-1.2 | 0.48-2.56 | ↓ |
| Golden Plover | winter | 0.54-2.59 | 1.00 | 0.74-1.25 | 0.8-1.2 | 0.32-3.89 | |
| Lapwing | breeding | 0.52-3.69 | 1.00 | 0.88-1.12 | 0.8-1.2 | 0.37-4.96 | |
| | winter | 0.49-2.67 | 1.00 | 0.71-1.29 | 0.8-1.2 | 0.28-4.13 | |
| Black-headed Gull | breeding | 0.74-1.52 | 1.06 | 1.00 | 0.8-1.2 | 0.59-1.93 | |
| Lesser Black-backed Gull | breeding | 0.84-1.25 | 1.30 | 1.00 | 0.8-1.2 | 0.67-1.95 | |
| Kestrel | all year | 0.73-1.44 | 1.01 | 1.00 | 0.8-1.2 | 0.58-1.75 | ↓ |

The uncertainty factors indicate the degree by which the predicted collision risk should be increased or decreased to indicate the range of uncertainty around the estimate. A value of 1.00 means that the relevant issue did not cause measurable uncertainty.

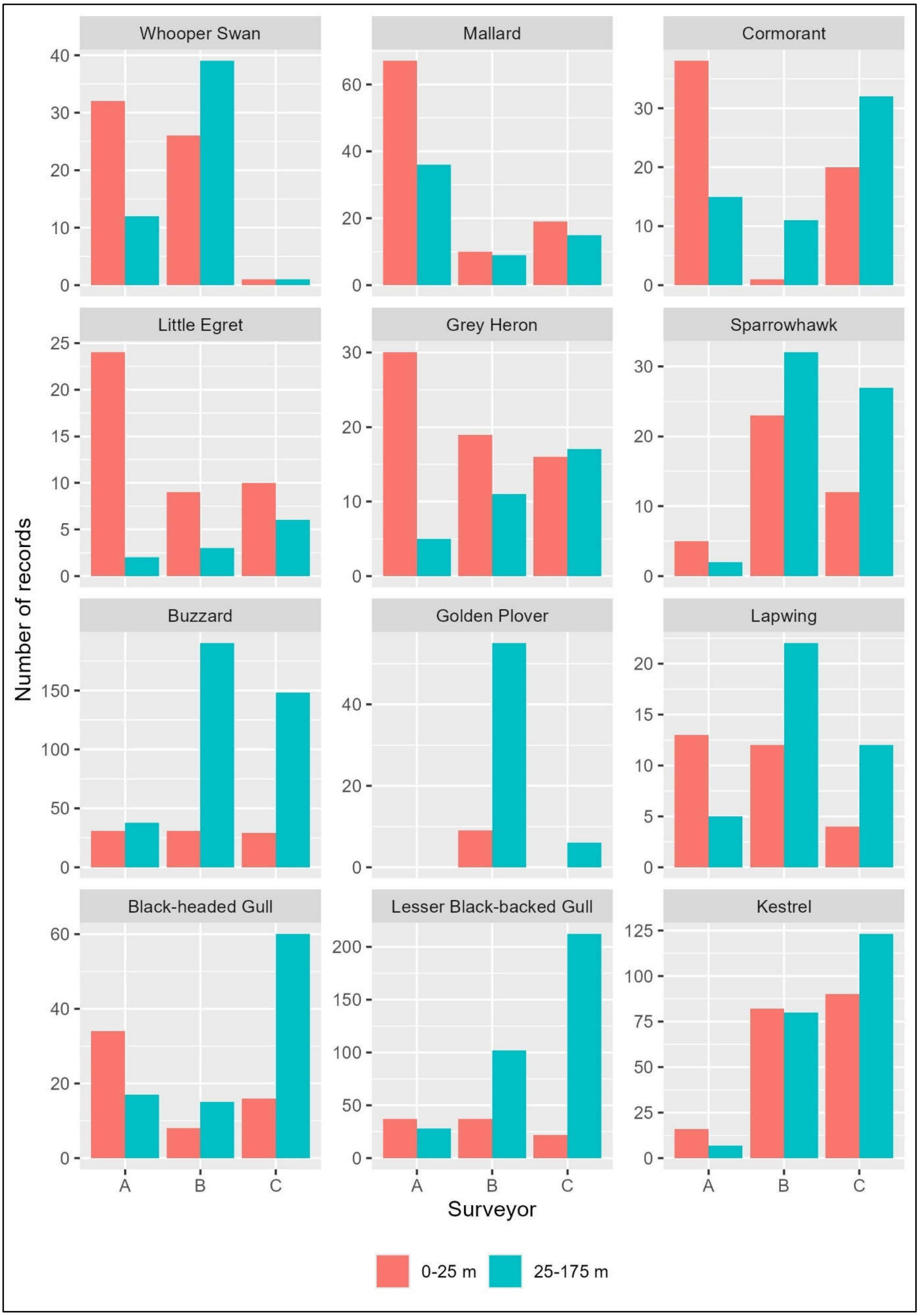



Figure 4.1. Comparison of height band distribution of flightline records between surveyors in the TOBIN dataset.

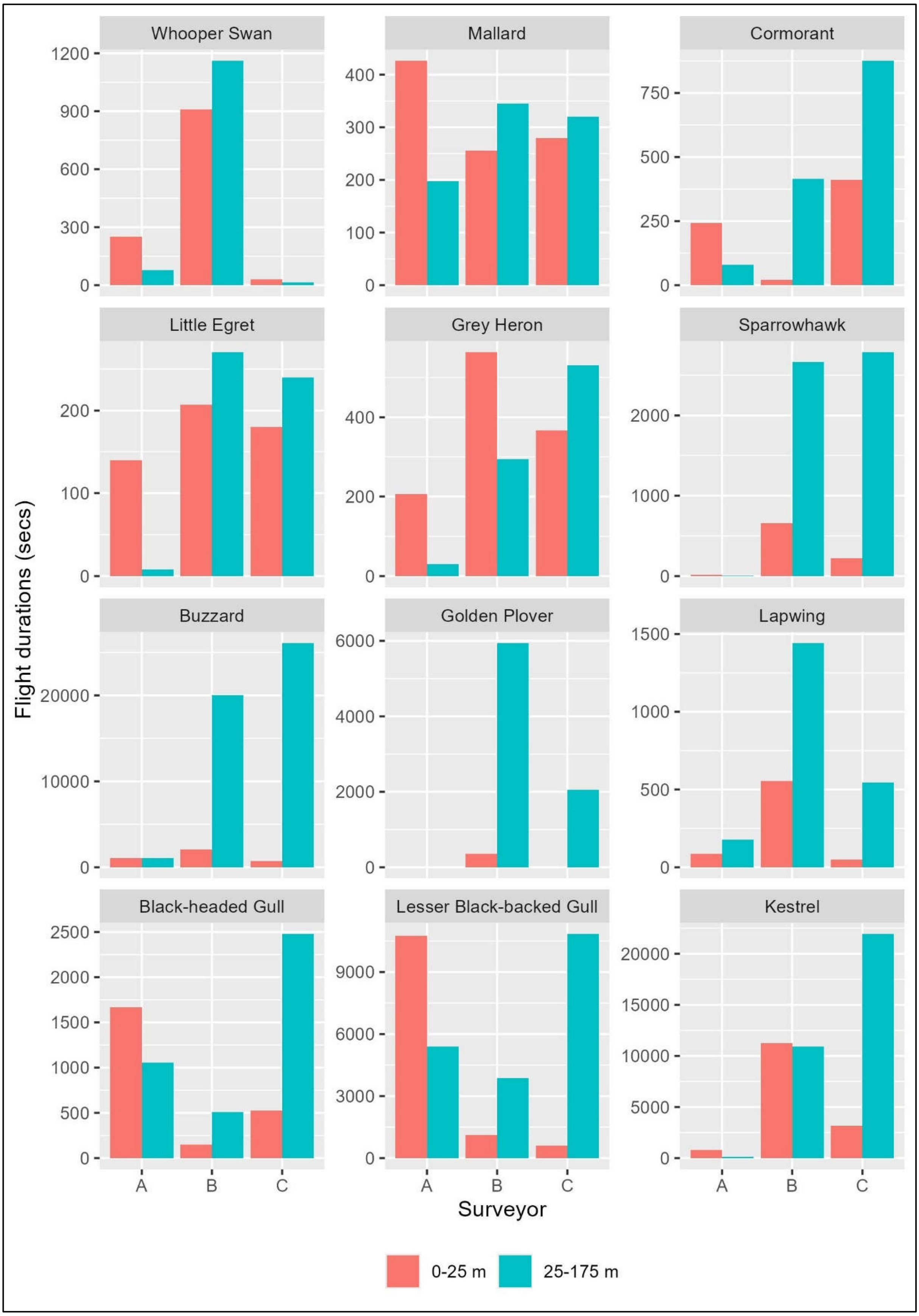



Figure 4.2. Comparison of height band distribution of flightline durations between surveyors in the TOBIN dataset.

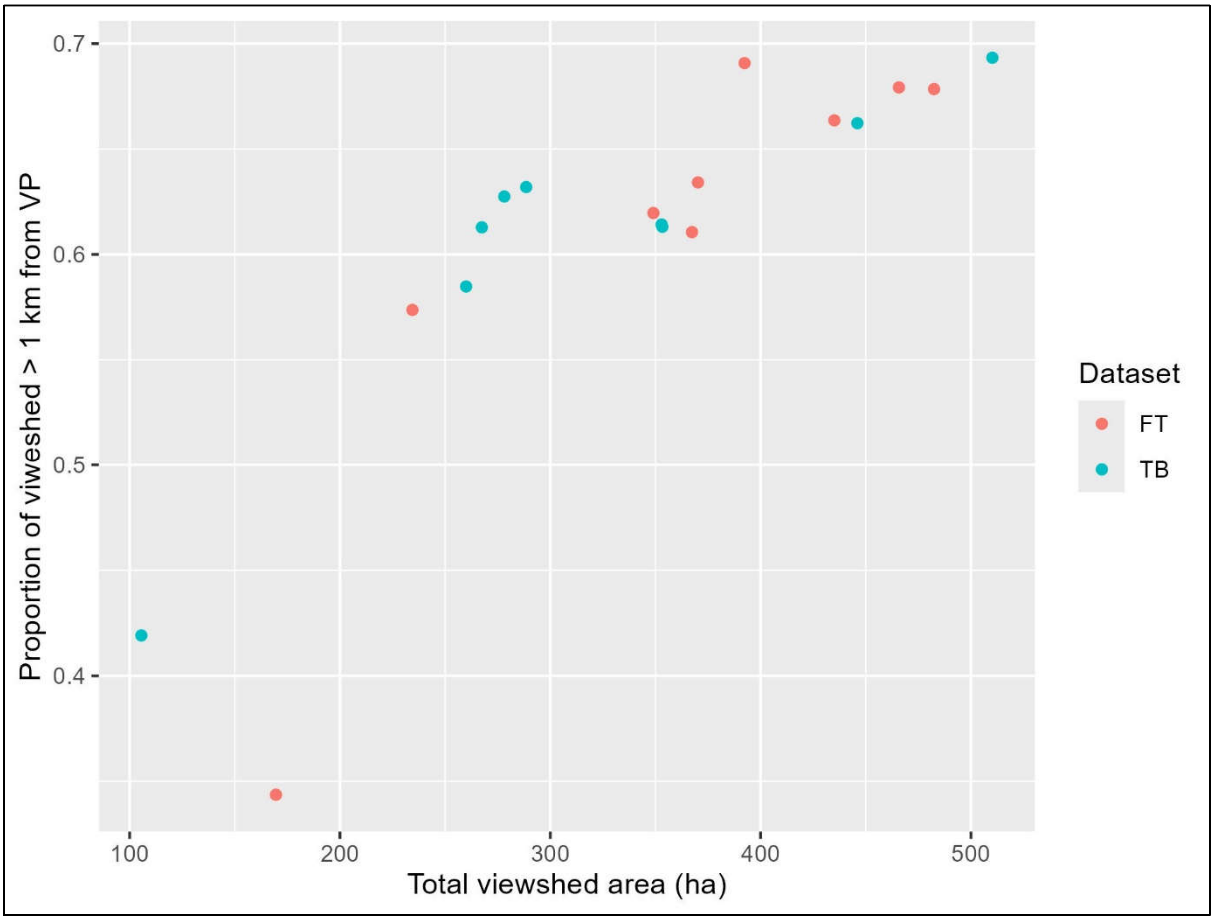



Figure 4.3. Relationship between the total viewshed area and the proportion of the viewshed more than 1km from the vantage point for the vantage points included in the collision risk model.

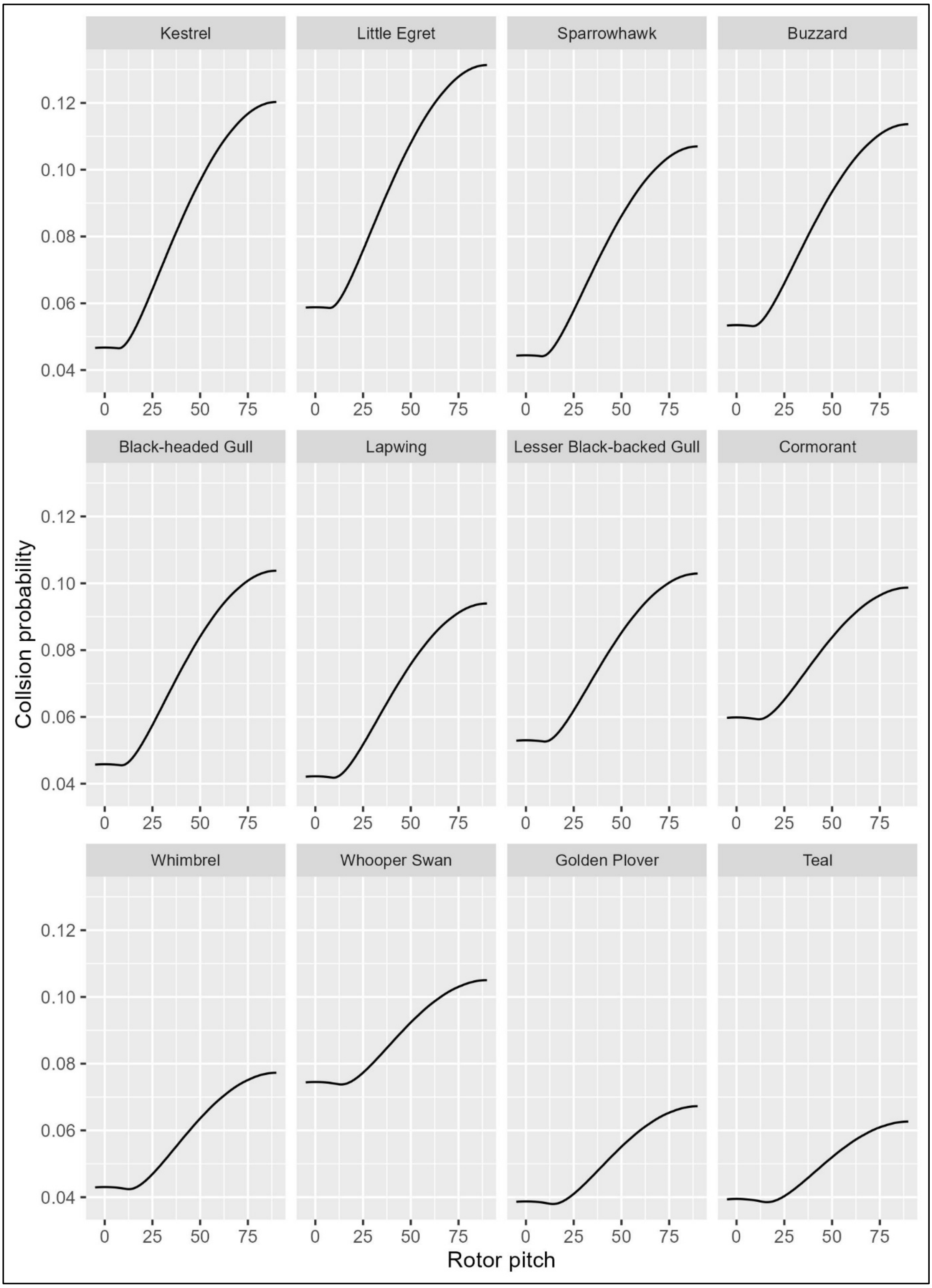



Figure 4.4. Relationship between pitch angle and single transit collision risk, with species arranged in order of increasing flight speed.

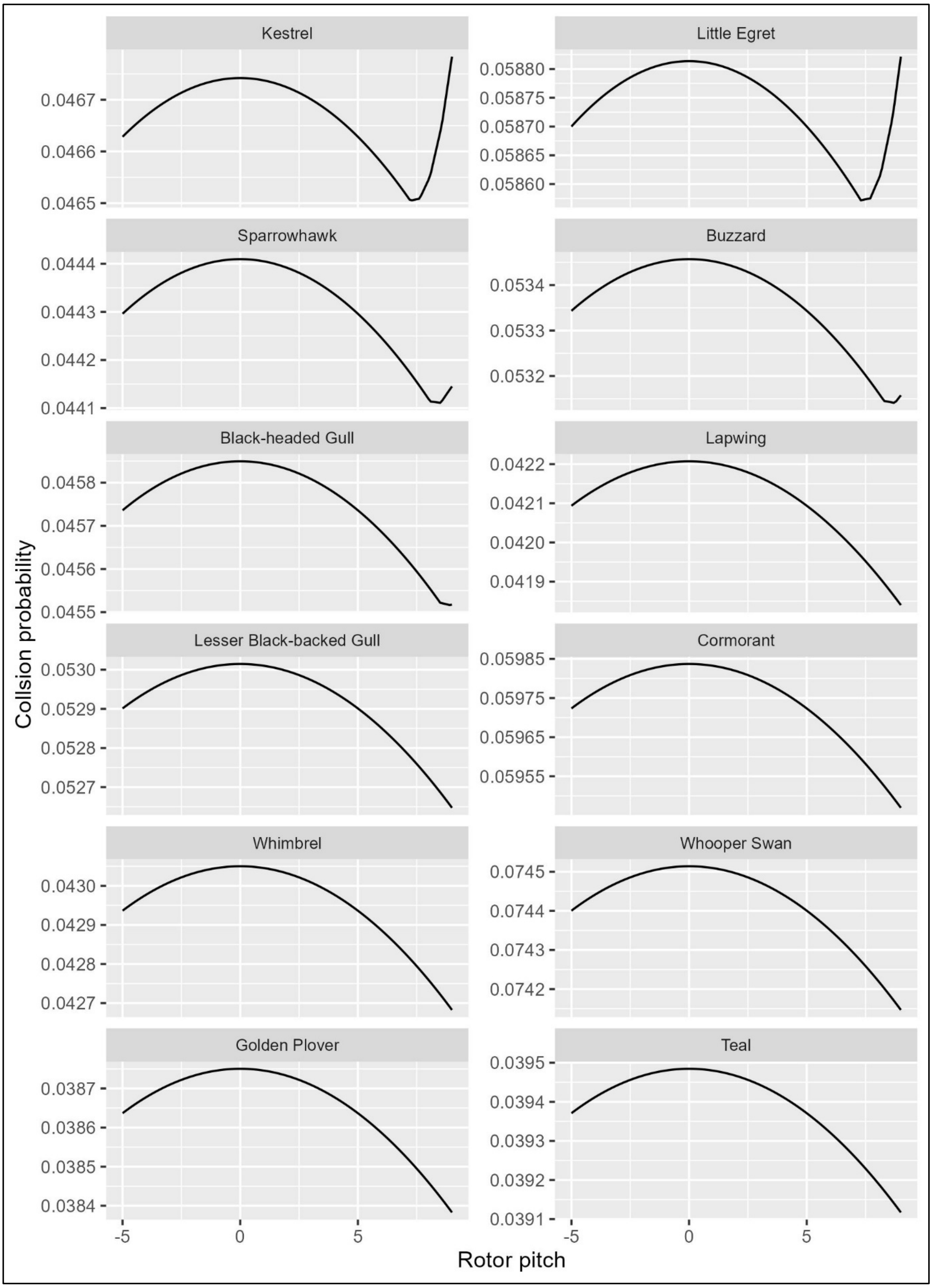



Figure 4.5. Maximum single transit collision risks with pitch angle of between -5 and 9°, with species arranged in order of increasing flight speed.

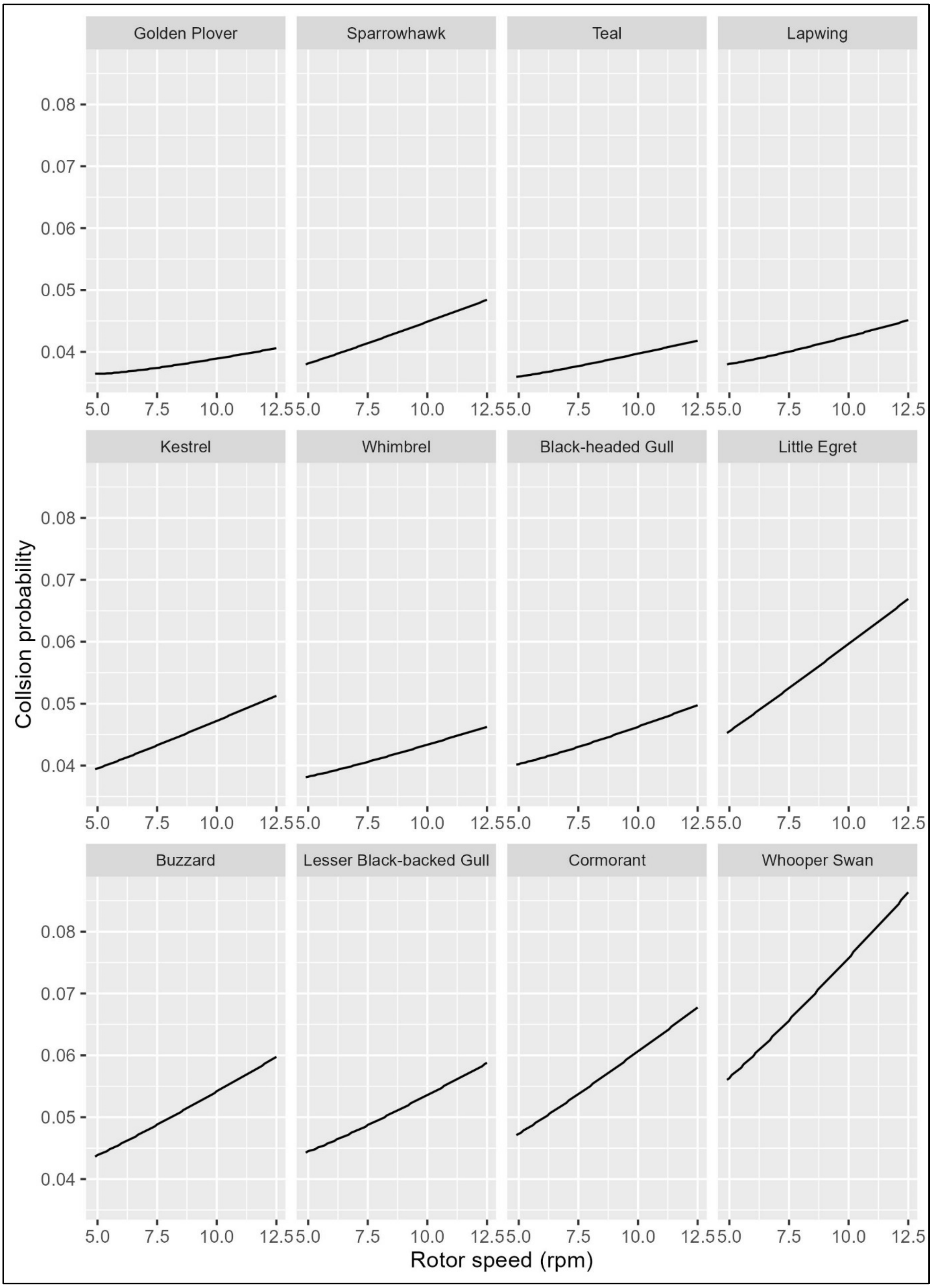



Figure 4.6. Relationship between rotor speed and single transit collision risk, with species arranged in order of increasing body size (body length × wingspan).

# 5. COLLISION RISK ASSESSMENT

## 5.1.1. Overall results

The results of the collision risk assessment are shown in Table 5.1. For each population, two sets of estimates of increases in annual mortality rates are included: one generated by the collision risk modelling that did not correct for distance effects (under-detection of distant flightlines) and one generated by the modelling that did correct for these effects. The range of uncertainty around the mortality increases due to the calculated uncertainty in the predicted collision risk is also shown.

Table 5.1. Potential increase in annual mortality rates due to the predicted collision risk from the Derryadd Wind Farm.

| Species | Season | Scale | Distance effects | |
|---|---|---|---|---|
| | | | uncorrected | corrected |
| Whooper Swan | winter | national | 0.0% (0.0% - 0.0%) | 0.0% (0.0% - 0.0%) |
| | | regional | 0.2% (0.1% - 0.4%) | 0.4% (0.2% - 0.8%) |
| | | local | 0.4% (0.2% - 0.7%) | 0.6% (0.3% - 1.2%) |
| Teal | winter | national | 0.0% | 0.0% |
| Mallard | winter | national | 0.0% (0.0% - 0.0%) | 0.0% (0.0% - 0.0%) |
| Cormorant | breeding | national | 0.0% (0.0% - 0.0%) | 0.0% (0.0% - 0.0%) |
| | | local | 0.4% (0.2% - 0.8%) | 0.6% (0.4% - 1.3%) |
| Little Egret | non-breeding | national | 0.1% (0.0% - 0.2%) | 0.1% (0.0% - 0.3%) |
| Grey Heron | breeding | national | 0.0% (0.0% - 0.0%) | 0.0% (0.0% - 0.0%) |
| Sparrowhawk | breeding | national | 0.0% (0.0% - 0.0%) | 0.0% (0.0% - 0.0%) |
| | | regional | 0.3% (0.1% - 0.8%) | 0.6% (0.3% - 1.5%) |
| Golden Plover (99.6%) | winter | national | 0.0% (0.0% - 0.0%) | 0.0% (0.0% - 0.1%) |
| | | local | 0.7% (0.2% - 2.7%) | 2.1% (0.7% - 8.0%) |
| Golden Plover (99.8%) | winter | national | 0.0% (0.0% - 0.0%) | 0.0% (0.0% - 0.1%) |
| | | local | 0.4% (0.1% - 1.4%) | 1.0% (0.3% - 4.0%) |
| Lapwing | breeding | national | 0.0% (0.0% - 0.1%) | 0.0% (0.0% - 0.1%) |
| | | local | 2.5% (0.9% - 12.6%) | 4.2% (1.6% - 21.0%) |
| | winter | national | 0.0% (0.0% - 0.0%) | 0.0% (0.0% - 0.0%) |
| Black-headed Gull | breeding | national | 0.0% (0.0% - 0.0%) | 0.0% (0.0% - 0.0%) |
| Lesser Black-backed Gull | breeding | national | 0.0% (0.0% - 0.1%) | 0.1% (0.0% - 0.1%) |
| | | local | 0.6% (0.4% - 1.1%) | 1.0% (0.7% - 2.0%) |
| Kestrel | breeding | national | 0.0% (0.0% - 0.0%) | 0.1% (0.0% - 0.1%) |
| | | regional | 1.9% (1.1% - 3.4%) | 3.9% (2.3% - 6.9%) |

Separate estimates of mortality increases are included for Golden Plover using avoidance rates of 99.6% and 99.8%. The values in parentheses indicate the range of uncertainty around the mortality increases due to uncertainty in the predicted collision risk. No range is shown for Teal as it was not possible to quantify the uncertainty due to sampling effects.

The central estimates of the potential increase in annual mortality due to the predicted collision risk calculated without correcting for distance effects exceeded the 1% threshold for the local Lapwing breeding population and the County Longford Kestrel breeding population, while the upper limit of the uncertainty range exceeded the threshold for the local Golden Plover wintering population and the Lough Ree Lesser Black-backed Gull breeding population. When corrections for distance effects were included, the central estimates also exceeded the 1% threshold for the local Golden Plover wintering population and the Lough Ree Lesser Black-backed Gull breeding population, while the upper limits of the uncertainty range exceeded the threshold for the local Whooper Swan wintering population, the Lough Ree Cormorant breeding population and the County Longford Sparrowhawk breeding population.

As discussed in Section 2.7, the 1% threshold is likely to be very precautionary. The calculations of the increase in annual mortality also made strong precautionary assumptions that all the collision fatalities were adult birds, and that the collision mortality was additive not compensatory. Therefore, substantial increases in annual mortality well above the 1% threshold are likely to be required to cause significant impacts on the affected populations.

## 5.2. LAPWING

The largest predicted increase in annual mortality was to the local breeding Lapwing population with central estimates of 2.5-4.2% and upper limits of 13-21%. The wide range of uncertainty around the estimates was due mainly to sampling effects, which reflected the low number of records that contributed to the collision risk model.

The inclusion of all the flight activity in the lowest height band from the Fehily Timoney vantage point surveys will have caused some over-estimation of the collision risk (see Section 4.7.2).

There may have been some under-recording of the local population due to limited survey effort in the sections of the bogs outside the 500 m buffer. Also, the scale used to define the local population was based on the survey area; it is arguable that a larger area, including adjacent bogs to the west and south should be used to define the local population.

Over 50% of the total flight activity included in the model was generated by a single record of a flock of 26 birds in late July. This could have referred to post-breeding dispersing / migrating birds that were not associated with the local population. There were also three other records included in the collision risk model of flocks of 8-24 birds in July.

Two of the records included in the collision risk model included fledged juveniles, while the age composition of many of the records (including the flock of 26 birds in late July) were not specified. Therefore, the precautionary assumption that all the collision fatalities generated by the predicted collision risk will be adult birds was violated. Juveniles have higher annual mortality rates, so the percentage increase in mortality generated by a collision risk will be smaller.

The collision risk was calculated using the default avoidance rate of 98%. Species-specific avoidance rates are usually higher than the default avoidance rate. However, this may not be the case for breeding Lapwing because they do not appear to be displaced by turbines.

## 5.3. KESTREL

The predicted increase in annual mortality to the County Longford breeding population was sizeable with central estimates of 1.9-3.9% and upper limits of 3.4-6.9%. The relatively narrow range of uncertainty around the estimates, reflected the high record rate, and the fact that variation in flock size and uncertainty around nocturnal flight activity are not issues.

Standard collision risk modelling techniques will tend to overestimate Kestrel collision risk due to the high incidence of hovering flight activity (see Section 4.7.3). If such flight activity was accounted for in the model, it is likely that there would be a large decrease in the potential impact on mortality rates. The inclusion of all the flight activity in the lowest height band from the Fehily Timoney vantage point surveys will also have caused some over-estimation of the collision risk (see Section 4.7.2).

A lot of the collision risk was generated in late summer (Table A2.7) when the local Kestrel population was likely to have included a large component of juvenile birds. The Kestrel juvenile survival rate is around double the adult survival rate. Accounting for juvenile flight activity in the collision risk assessment would be likely to cause a significant decrease in the potential impact on mortality rates.

As with all the populations assessed, the mortality increases were higher when the collision risks that accounted for distance effects were used. The data used to calculate the correction factors included large components of Kestrel flight activity, while their size and flight behaviour makes them particularly susceptible to under-detection at long distances.

The recommended avoidance rate of 95% for Kestrel results in a non-avoidance rate that is 2.5 times higher than for the default 98% avoidance rate. The evidence supporting the Kestrel avoidance rate is weak (Section 4.7.3). However, there are anecdotal reports of relatively high levels of Kestrel fatalities from post-construction monitoring of Irish wind farms, although this data has not been published.

## 5.4. GOLDEN PLOVER

The predicted increase in annual mortality to the local Golden Plover wintering population was sizeable with central estimates of 0.4-2.1% and upper limits of 1.4-8.0%. The wide range of uncertainty around the estimates was due mainly to sampling effects, which reflected the large variation in flock sizes and flight durations.

The correction for distance effects may have resulted in an over-estimation of the Golden Plover collision risk. Most of the collision risk was generated by records of large flocks. It is likely that the under-detection of distant flightlines is much less of an issue for large flocks compared to small groups and individual birds. Therefore, the smaller collision risk generated by the uncorrected model may be more reliable in this case.

The local population was estimated from Irish Wetland Bird Survey data. As many Golden Plover occur away from wetland sites, the size of the local population used for the collision risk assessment may have been a significant under-estimate.

Golden Plover is a quarry species with an open season from September and January. The Irish Government does not regulate the hunting of this species: there are no bag limits, and no published data on annual hunting mortality. This means that there is no restriction on the number of Golden Plover that can be shot between September and January each winter. Therefore, given this apparent lack of concern about harvest levels, presumably the Irish Government considers that low levels of mortality from anthropogenic sources are likely to be compensatory rather than additive and are, therefore, unlikely to affect the conservation status of the wintering Golden Plover population.

## 5.5. WHOOPER SWAN, CORMORANT, SPARROWHAWK AND LESSER BLACK-BACKED GULL

The predicted increases in annual mortality to the Lough Ree Whooper Swan wintering population, the Lough Ree Cormorant and Lesser Black-backed Gull breeding populations, and the County Longford Sparrowhawk breeding population only just exceeded the 1% threshold. Given the precautionary nature of the 1% threshold, and the precautionary assumptions made in the calculations of these increases, the predicted collision risk is unlikely to have significant impacts on these populations.

# 6. CONCLUSIONS

The predicted collision risks would result in multiple collision fatalities for a number of species over the 30-year lifespan of the wind farm. However, in most cases, these collision rates would not result in significant impacts to the relevant populations of conservation significance.

The predicted collision risk to Lapwing during the breeding season could potentially cause an increase in mortality rate to the local Lapwing breeding population of 2.5-4.2%, with an uncertainty range of 0.9-21%. However, the increase in mortality rate may have been over-estimated due to the inclusion of records of juveniles and presumed non-local post-breeding / migrating Lapwing flocks in the data used for the collision risk model, and incomplete coverage of the local area in the surveys used to generate estimates of the local population.

The predicted collision risk for Kestrel could potentially cause an increase in mortality rate to the County Longford breeding population of 1.9-3.9%, with an uncertainty range of 1.1-6.9%. However, the increase in mortality rate may have been over-estimated due to inclusion of hovering flight activity in the calculation of predicted transits, and the inclusion of records of juveniles in the data used for the collision risk model.

The predicted collision risk to Golden Plover could potentially cause an increase in mortality rate to the local Golden Plover wintering population of 0.4-2.1%, with an uncertainty range of 0.1-8.0%. However, the corrections for distance effects that generated the higher end of these ranges may not be appropriate for Golden Plover due to the high contribution of flight activity by large flocks to the predicted collision risk. Under-estimation of the local population, and the likely significant occurrence of juveniles are other factors that may have caused over-estimation of the increase in mortality rate.

The predicted increases in annual mortality to the Lough Ree Whooper Swan wintering population, the Lough Ree Cormorant and Lesser Black-backed Gull breeding populations, and the County Longford Sparrowhawk breeding population only just exceeded the 1% threshold. Given the precautionary nature of the 1% threshold, and the precautionary assumptions made in the calculations of these increases, the predicted collision risk is unlikely to have significant impacts on these populations.

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# Appendix 1 Results tables for intermediate stages of the collision risk model.

Table A2.1. Monthly daytime flight activity densities (bird/km$^2$).

| Species | Distance effects | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mute Swan | uncorrected | 0.0000 | 0.0002 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Mute Swan | corrected | 0.0001 | 0.0003 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Whooper Swan | uncorrected | 0.0012 | 0.0005 | 0.0014 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0003 | 0.0050 | 0.0028 |
| Whooper Swan | corrected | 0.0025 | 0.0008 | 0.0029 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0006 | 0.0078 | 0.0046 |
| Greylag Goose | uncorrected | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 |
| Greylag Goose | corrected | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 |
| Wigeon | uncorrected | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Wigeon | corrected | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Teal | uncorrected | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0032 | 0.0000 |
| Teal | corrected | 0.0000 | 0.0002 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0045 | 0.0000 |
| Mallard | uncorrected | 0.0000 | 0.0004 | 0.0003 | 0.0000 | 0.0011 | 0.0000 | 0.0001 | 0.0000 | 0.0003 | 0.0001 | 0.0021 | 0.0003 |
| Mallard | corrected | 0.0000 | 0.0006 | 0.0005 | 0.0001 | 0.0018 | 0.0000 | 0.0001 | 0.0001 | 0.0005 | 0.0001 | 0.0035 | 0.0005 |
| Cormorant | uncorrected | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0009 | 0.0005 | 0.0002 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Cormorant | corrected | 0.0000 | 0.0000 | 0.0002 | 0.0002 | 0.0014 | 0.0007 | 0.0004 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 |
| Little Egret | uncorrected | 0.0000 | 0.0000 | 0.0003 | 0.0001 | 0.0023 | 0.0002 | 0.0000 | 0.0002 | 0.0001 | 0.0001 | 0.0001 | 0.0001 |
| Little Egret | corrected | 0.0001 | 0.0000 | 0.0004 | 0.0002 | 0.0039 | 0.0003 | 0.0001 | 0.0004 | 0.0002 | 0.0001 | 0.0002 | 0.0002 |
| Grey Heron | uncorrected | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0004 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0004 | 0.0001 | 0.0000 |
| Grey Heron | corrected | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0006 | 0.0003 | 0.0003 | 0.0004 | 0.0004 | 0.0006 | 0.0001 | 0.0000 |
| Little Grebe | uncorrected | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Little Grebe | corrected | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Marsh Harrier | uncorrected | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Marsh Harrier | corrected | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Hen Harrier | uncorrected | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0000 |
| Hen Harrier | corrected | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 |
| Sparrowhawk | uncorrected | 0.0001 | 0.0001 | 0.0001 | 0.0002 | 0.0008 | 0.0003 | 0.0005 | 0.0006 | 0.0001 | 0.0004 | 0.0000 | 0.0001 |
| Sparrowhawk | corrected | 0.0003 | 0.0002 | 0.0003 | 0.0006 | 0.0012 | 0.0005 | 0.0008 | 0.0010 | 0.0003 | 0.0010 | 0.0000 | 0.0003 |
| Buzzard | uncorrected | 0.0004 | 0.0018 | 0.0032 | 0.0029 | 0.0046 | 0.0043 | 0.0043 | 0.0032 | 0.0018 | 0.0006 | 0.0012 | 0.0004 |
| Buzzard | corrected | 0.0008 | 0.0035 | 0.0066 | 0.0068 | 0.0081 | 0.0079 | 0.0078 | 0.0058 | 0.0031 | 0.0011 | 0.0023 | 0.0007 |

| Species | Distance effects | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Golden Plover | uncorrected | 0.0007 | 0.0000 | 0.0195 | 0.0662 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0014 | 0.0448 | 0.0704 | 0.0180 |
| Golden Plover | corrected | 0.0013 | 0.0001 | 0.0499 | 0.2402 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0039 | 0.1183 | 0.1772 | 0.0471 |
| Lapwing | uncorrected | 0.0086 | 0.0035 | 0.0006 | 0.0000 | 0.0004 | 0.0009 | 0.0030 | 0.0010 | 0.0000 | 0.0000 | 0.0024 | 0.0033 |
| Lapwing | corrected | 0.0223 | 0.0078 | 0.0014 | 0.0002 | 0.0008 | 0.0015 | 0.0048 | 0.0014 | 0.0000 | 0.0000 | 0.0068 | 0.0085 |
| Whimbrel | uncorrected | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0236 | 0.0000 | 0.0000 | 0.0002 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| Whimbrel | corrected | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0329 | 0.0000 | 0.0000 | 0.0003 | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| Curlew | uncorrected | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Curlew | corrected | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0003 | 0.0002 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Black-headed Gull | uncorrected | 0.0000 | 0.0000 | 0.0000 | 0.0016 | 0.0037 | 0.0084 | 0.0022 | 0.0002 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Black-headed Gull | corrected | 0.0000 | 0.0001 | 0.0001 | 0.0052 | 0.0058 | 0.0132 | 0.0051 | 0.0005 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Common Gull | uncorrected | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Common Gull | corrected | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Lesser Black-backed Gull | uncorrected | 0.0000 | 0.0000 | 0.0006 | 0.0099 | 0.0353 | 0.0086 | 0.0110 | 0.0156 | 0.0003 | 0.0000 | 0.0003 | 0.0000 |
| Lesser Black-backed Gull | corrected | 0.0000 | 0.0000 | 0.0011 | 0.0240 | 0.0633 | 0.0152 | 0.0192 | 0.0262 | 0.0005 | 0.0000 | 0.0005 | 0.0000 |
| Kestrel | uncorrected | 0.0006 | 0.0006 | 0.0005 | 0.0011 | 0.0035 | 0.0016 | 0.0024 | 0.0026 | 0.0029 | 0.0018 | 0.0013 | 0.0009 |
| Kestrel | corrected | 0.0015 | 0.0016 | 0.0011 | 0.0036 | 0.0064 | 0.0031 | 0.0045 | 0.0052 | 0.0050 | 0.0032 | 0.0034 | 0.0024 |
| Merlin | uncorrected | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Merlin | corrected | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Peregrine | uncorrected | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0001 |
| Peregrine | corrected | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0002 | 0.0001 | 0.0003 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0002 |

Table A2.2. Daylight and nighttime hours per month.

| Month | Daylight hours ($t_{day}$) | Nighttime hours ($t_{night}$) |
|---|---|---|
| Jan | 250.3 | 493.7 |
| Feb | 273.0 | 399.0 |
| Mar | 366.3 | 377.7 |
| Apr | 419.2 | 300.8 |
| May | 492.7 | 251.3 |
| Jun | 508.9 | 211.1 |
| Jul | 511.7 | 232.3 |
| Aug | 459.9 | 284.1 |
| Sept | 382.8 | 337.2 |
| Oct | 329.3 | 414.7 |
| Nov | 260.0 | 460.0 |
| Dec | 234.1 | 509.9 |

Table A2.3. Nocturnal correction factors.

| Species | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wigeon | 1.99 | 1.73 | 1.52 | 1.36 | 1.26 | 1.21 | 1.23 | 1.31 | 1.44 | 1.63 | 1.88 | 2.09 |
| Teal | 1.99 | 1.73 | 1.52 | 1.36 | 1.26 | 1.21 | 1.23 | 1.31 | 1.44 | 1.63 | 1.88 | 2.09 |
| Mallard | 1.99 | 1.73 | 1.52 | 1.36 | 1.26 | 1.21 | 1.23 | 1.31 | 1.44 | 1.63 | 1.88 | 2.09 |
| Little Egret | 1.49 | 1.37 | 1.26 | 1.18 | 1.13 | 1.10 | 1.11 | 1.15 | 1.22 | 1.31 | 1.44 | 1.54 |
| Grey Heron | 1.49 | 1.37 | 1.26 | 1.18 | 1.13 | 1.10 | 1.11 | 1.15 | 1.22 | 1.31 | 1.44 | 1.54 |
| Golden Plover | 1.49 | 1.37 | 1.26 | 1.18 | 1.13 | 1.10 | 1.11 | 1.15 | 1.22 | 1.31 | 1.44 | 1.54 |
| Lapwing | 1.49 | 1.37 | 1.26 | 1.18 | 1.13 | 1.10 | 1.11 | 1.15 | 1.22 | 1.31 | 1.44 | 1.54 |
| Whimbrel | 2.97 | 2.46 | 2.03 | 1.72 | 1.51 | 1.41 | 1.45 | 1.62 | 1.88 | 2.26 | 2.77 | 3.18 |

Table A2.4. Projected number of rotor transits.

| Species | Distance effects | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mute Swan | uncorrected | 2 | 9 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mute Swan | corrected | 4 | 15 | 1 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Whooper Swan | uncorrected | 54 | 23 | 93 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 229 | 118 |
| Whooper Swan | corrected | 113 | 40 | 191 | 0 | 0 | 0 | 0 | 0 | 0 | 35 | 359 | 189 |
| Greylag Goose | uncorrected | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 3 |
| Greylag Goose | corrected | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 4 |
| Wigeon | uncorrected | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Wigeon | corrected | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Teal | uncorrected | 1 | 13 | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 0 | 314 | 2 |
| Teal | corrected | 2 | 17 | 1 | 0 | 2 | 0 | 0 | 0 | 7 | 0 | 444 | 3 |
| Mallard | uncorrected | 0 | 33 | 31 | 4 | 128 | 2 | 9 | 5 | 30 | 9 | 199 | 28 |
| Mallard | corrected | 0 | 57 | 52 | 11 | 216 | 5 | 16 | 8 | 55 | 15 | 328 | 50 |
| Cormorant | uncorrected | 0 | 0 | 4 | 5 | 71 | 36 | 20 | 3 | 2 | 2 | 0 | 0 |
| Cormorant | corrected | 0 | 0 | 9 | 12 | 110 | 58 | 30 | 6 | 3 | 3 | 0 | 0 |
| Little Egret | uncorrected | 2 | 1 | 13 | 4 | 137 | 11 | 3 | 12 | 5 | 3 | 4 | 5 |
| Little Egret | corrected | 3 | 2 | 21 | 11 | 228 | 18 | 4 | 20 | 9 | 5 | 7 | 8 |
| Grey Heron | uncorrected | 0 | 1 | 3 | 2 | 22 | 12 | 14 | 15 | 13 | 19 | 3 | 1 |
| Grey Heron | corrected | 0 | 1 | 5 | 6 | 37 | 18 | 22 | 23 | 21 | 29 | 5 | 1 |
| Little Grebe | uncorrected | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Little Grebe | corrected | 0 | 0 | 0 | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Marsh Harrier | uncorrected | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Marsh Harrier | corrected | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hen Harrier | uncorrected | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Hen Harrier | corrected | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 |
| Sparrowhawk | uncorrected | 4 | 3 | 4 | 9 | 44 | 18 | 30 | 30 | 6 | 15 | 0 | 4 |
| Sparrowhawk | corrected | 9 | 7 | 12 | 31 | 66 | 31 | 50 | 54 | 15 | 38 | 0 | 8 |
| Buzzard | uncorrected | 13 | 58 | 138 | 144 | 272 | 259 | 261 | 177 | 82 | 24 | 37 | 12 |
| Buzzard | corrected | 25 | 112 | 287 | 341 | 478 | 478 | 475 | 317 | 142 | 42 | 72 | 20 |

| Species | Distance effects | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Golden Plover | uncorrected | 51 | 2 | 1651 | 6012 | 0 | 0 | 0 | 0 | 124 | 3561 | 4848 | 1196 |
| Golden Plover | corrected | 90 | 4 | 4226 | 21818 | 0 | 0 | 0 | 0 | 334 | 9410 | 12211 | 3132 |
| Lapwing | uncorrected | 424 | 173 | 35 | 3 | 28 | 66 | 225 | 69 | 0 | 2 | 116 | 158 |
| Lapwing | corrected | 1092 | 381 | 84 | 11 | 56 | 110 | 361 | 94 | 0 | 3 | 335 | 404 |
| Whimbrel | uncorrected | 0 | 0 | 0 | 0 | 2943 | 0 | 0 | 24 | 10 | 0 | 0 | 0 |
| Whimbrel | corrected | 0 | 0 | 0 | 0 | 4101 | 0 | 0 | 32 | 13 | 0 | 0 | 0 |
| Curlew | uncorrected | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 8 | 0 | 0 | 0 | 1 |
| Curlew | corrected | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 13 | 0 | 0 | 0 | 1 |
| Black-headed Gull | uncorrected | 0 | 1 | 1 | 81 | 224 | 520 | 138 | 10 | 0 | 0 | 0 | 0 |
| Black-headed Gull | corrected | 0 | 2 | 2 | 268 | 350 | 818 | 318 | 28 | 0 | 0 | 0 | 0 |
| Common Gull | uncorrected | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| Common Gull | corrected | 0 | 0 | 0 | 0 | 0 | 3 | 2 | 0 | 0 | 0 | 0 | 0 |
| Lesser Black-backed Gull | uncorrected | 0 | 0 | 28 | 559 | 2339 | 590 | 757 | 962 | 15 | 0 | 11 | 0 |
| Lesser Black-backed Gull | corrected | 0 | 0 | 54 | 1354 | 4195 | 1037 | 1323 | 1621 | 24 | 1 | 19 | 0 |
| Kestrel | uncorrected | 16 | 18 | 20 | 46 | 179 | 82 | 126 | 124 | 113 | 61 | 35 | 23 |
| Kestrel | corrected | 40 | 45 | 43 | 156 | 329 | 163 | 236 | 248 | 198 | 109 | 93 | 58 |
| Merlin | uncorrected | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Merlin | corrected | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Peregrine | uncorrected | 0 | 0 | 1 | 1 | 7 | 3 | 13 | 0 | 3 | 0 | 1 | 3 |
| Peregrine | corrected | 0 | 0 | 1 | 3 | 12 | 7 | 22 | 1 | 5 | 0 | 1 | 6 |

Table A2.5. Collision probabilities for flapping flight.

| Species | Pitch | Single transit collision risks | | |
|---|---|---|---|---|
| | | upwind | downwind | weighted mean |
| Mute Swan | 0 | 0.078 | 0.078 | 0.078 |
| | 15 | 0.094 | 0.062 | 0.078 |
| | 30 | 0.107 | 0.065 | 0.086 |
| Whooper Swan | 0 | 0.076 | 0.076 | 0.076 |
| | 15 | 0.091 | 0.060 | 0.075 |
| | 30 | 0.102 | 0.061 | 0.082 |
| Greylag Goose | 0 | 0.057 | 0.057 | 0.057 |
| | 15 | 0.071 | 0.040 | 0.056 |
| | 30 | 0.083 | 0.042 | 0.062 |
| Wigeon | 0 | 0.043 | 0.043 | 0.043 |
| | 15 | 0.055 | 0.029 | 0.042 |
| | 30 | 0.064 | 0.026 | 0.045 |
| Teal | 0 | 0.040 | 0.040 | 0.040 |
| | 15 | 0.053 | 0.025 | 0.039 |
| | 30 | 0.062 | 0.023 | 0.043 |
| Mallard | 0 | 0.047 | 0.047 | 0.047 |
| | 15 | 0.060 | 0.031 | 0.046 |
| | 30 | 0.071 | 0.031 | 0.051 |
| Cormorant | 0 | 0.061 | 0.061 | 0.061 |
| | 15 | 0.077 | 0.044 | 0.061 |
| | 30 | 0.091 | 0.048 | 0.070 |
| Little Egret | 0 | 0.059 | 0.059 | 0.059 |
| | 15 | 0.085 | 0.043 | 0.064 |
| | 30 | 0.106 | 0.060 | 0.083 |
| Grey Heron | 0 | 0.073 | 0.073 | 0.073 |
| | 15 | 0.096 | 0.056 | 0.076 |
| | 30 | 0.115 | 0.070 | 0.093 |
| Little Grebe | 0 | 0.039 | 0.039 | 0.039 |
| | 15 | 0.056 | 0.022 | 0.039 |
| | 30 | 0.069 | 0.026 | 0.048 |
| Marsh Harrier | 0 | 0.054 | 0.054 | 0.054 |
| | 15 | 0.077 | 0.037 | 0.057 |
| | 30 | 0.097 | 0.051 | 0.074 |
| Hen Harrier | 0 | 0.057 | 0.057 | 0.057 |
| | 15 | 0.085 | 0.041 | 0.063 |
| | 30 | 0.110 | 0.063 | 0.086 |
| Sparrowhawk | 0 | 0.045 | 0.045 | 0.045 |
| | 15 | 0.068 | 0.028 | 0.048 |
| | 30 | 0.087 | 0.041 | 0.064 |
| Buzzard | 0 | 0.054 | 0.054 | 0.054 |
| | 15 | 0.076 | 0.037 | 0.057 |
| | 30 | 0.095 | 0.050 | 0.072 |

| Species | Pitch | Single transit collision risks | | |
|---|---|---|---|---|
| | | upwind | downwind | weighted mean |
| Golden Plover | 0 | 0.040 | 0.040 | 0.040 |
| | 15 | 0.054 | 0.024 | 0.039 |
| | 30 | 0.065 | 0.024 | 0.044 |
| Lapwing | 0 | 0.043 | 0.043 | 0.043 |
| | 15 | 0.063 | 0.026 | 0.044 |
| | 30 | 0.080 | 0.035 | 0.057 |
| Whimbrel | 0 | 0.044 | 0.044 | 0.044 |
| | 15 | 0.059 | 0.027 | 0.043 |
| | 30 | 0.072 | 0.030 | 0.051 |
| Curlew | 0 | 0.048 | 0.048 | 0.048 |
| | 15 | 0.063 | 0.031 | 0.047 |
| | 30 | 0.076 | 0.034 | 0.055 |
| Black-headed Gull | 0 | 0.047 | 0.047 | 0.047 |
| | 15 | 0.068 | 0.029 | 0.049 |
| | 30 | 0.087 | 0.041 | 0.064 |
| Common Gull | 0 | 0.048 | 0.048 | 0.048 |
| | 15 | 0.067 | 0.030 | 0.048 |
| | 30 | 0.083 | 0.038 | 0.060 |
| Lesser Black-backed Gull | 0 | 0.054 | 0.054 | 0.054 |
| | 15 | 0.074 | 0.037 | 0.055 |
| | 30 | 0.090 | 0.046 | 0.068 |
| Kestrel | 0 | 0.047 | 0.047 | 0.047 |
| | 15 | 0.073 | 0.031 | 0.052 |
| | 30 | 0.095 | 0.048 | 0.072 |
| Merlin | 0 | 0.044 | 0.044 | 0.044 |
| | 15 | 0.070 | 0.027 | 0.049 |
| | 30 | 0.092 | 0.045 | 0.068 |
| Peregrine | 0 | 0.048 | 0.048 | 0.048 |
| | 15 | 0.070 | 0.031 | 0.050 |
| | 30 | 0.088 | 0.042 | 0.065 |

Table A2.6. Collision risk before avoidance.

| Species | Distance effects | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mute Swan | uncorrected | 0.13 | 0.6 | 0.07 | 0 | 0 | 0.07 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mute Swan | corrected | 0.27 | 1 | 0.07 | 0 | 0 | 0.2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Whooper Swan | uncorrected | 3.49 | 1.49 | 6.02 | 0 | 0 | 0 | 0 | 0 | 0 | 1.1 | 14.81 | 7.63 |
| Whooper Swan | corrected | 7.31 | 2.59 | 12.36 | 0 | 0 | 0 | 0 | 0 | 0 | 2.26 | 23.22 | 12.23 |
| Greylag Goose | uncorrected | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.14 |
| Greylag Goose | corrected | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.24 | 0.19 |
| Wigeon | uncorrected | 0.11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.04 |
| Wigeon | corrected | 0.18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.07 |
| Teal | uncorrected | 0.03 | 0.44 | 0 | 0 | 0.03 | 0 | 0 | 0 | 0.1 | 0 | 10.66 | 0.07 |
| Teal | corrected | 0.07 | 0.58 | 0.03 | 0 | 0.07 | 0 | 0 | 0 | 0.24 | 0 | 15.07 | 0.1 |
| Mallard | uncorrected | 0 | 1.31 | 1.23 | 0.16 | 5.07 | 0.08 | 0.36 | 0.2 | 1.19 | 0.36 | 7.88 | 1.11 |
| Mallard | corrected | 0 | 2.26 | 2.06 | 0.44 | 8.55 | 0.2 | 0.63 | 0.32 | 2.18 | 0.59 | 12.98 | 1.98 |
| Cormorant | uncorrected | 0 | 0 | 0.21 | 0.26 | 3.66 | 1.85 | 1.03 | 0.15 | 0.1 | 0.1 | 0 | 0 |
| Cormorant | corrected | 0 | 0 | 0.46 | 0.62 | 5.67 | 2.99 | 1.55 | 0.31 | 0.15 | 0.15 | 0 | 0 |
| Little Egret | uncorrected | 0.1 | 0.05 | 0.65 | 0.2 | 6.88 | 0.55 | 0.15 | 0.6 | 0.25 | 0.15 | 0.2 | 0.25 |
| Little Egret | corrected | 0.15 | 0.1 | 1.05 | 0.55 | 11.45 | 0.9 | 0.2 | 1 | 0.45 | 0.25 | 0.35 | 0.4 |
| Grey Heron | uncorrected | 0 | 0.06 | 0.19 | 0.12 | 1.36 | 0.74 | 0.87 | 0.93 | 0.8 | 1.18 | 0.19 | 0.06 |
| Grey Heron | corrected | 0 | 0.06 | 0.31 | 0.37 | 2.29 | 1.11 | 1.36 | 1.42 | 1.3 | 1.8 | 0.31 | 0.06 |
| Little Grebe | uncorrected | 0 | 0 | 0 | 0.17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Little Grebe | corrected | 0 | 0 | 0 | 0.53 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Marsh Harrier | uncorrected | 0 | 0 | 0.09 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Marsh Harrier | corrected | 0 | 0 | 0.14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hen Harrier | uncorrected | 0.05 | 0.05 | 0.05 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.05 | 0.05 |
| Hen Harrier | corrected | 0.1 | 0.05 | 0.05 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 | 0.05 |
| Sparrowhawk | uncorrected | 0.15 | 0.11 | 0.15 | 0.34 | 1.67 | 0.68 | 1.14 | 1.14 | 0.23 | 0.57 | 0 | 0.15 |
| Sparrowhawk | corrected | 0.34 | 0.27 | 0.46 | 1.18 | 2.51 | 1.18 | 1.9 | 2.05 | 0.57 | 1.44 | 0 | 0.3 |
| Buzzard | uncorrected | 0.6 | 2.67 | 6.36 | 6.64 | 12.53 | 11.94 | 12.03 | 8.16 | 3.78 | 1.11 | 1.71 | 0.55 |
| Buzzard | corrected | 1.15 | 5.16 | 13.23 | 15.71 | 22.03 | 22.03 | 21.89 | 14.61 | 6.54 | 1.94 | 3.32 | 0.92 |

| Species | Distance effects | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Golden Plover | uncorrected | 1.71 | 0.07 | 55.44 | 201.89 | 0 | 0 | 0 | 0 | 4.16 | 119.58 | 162.8 | 40.16 |
| Golden Plover | corrected | 3.02 | 0.13 | 141.91 | 732.68 | 0 | 0 | 0 | 0 | 11.22 | 316 | 410.06 | 105.18 |
| Lapwing | uncorrected | 15.47 | 6.31 | 1.28 | 0.11 | 1.02 | 2.41 | 8.21 | 2.52 | 0 | 0.07 | 4.23 | 5.76 |
| Lapwing | corrected | 39.84 | 13.9 | 3.06 | 0.4 | 2.04 | 4.01 | 13.17 | 3.43 | 0 | 0.11 | 12.22 | 14.74 |
| Whimbrel | uncorrected | 0 | 0 | 0 | 0 | 109.2 | 0 | 0 | 0.89 | 0.37 | 0 | 0 | 0 |
| Whimbrel | corrected | 0 | 0 | 0 | 0 | 152.17 | 0 | 0 | 1.19 | 0.48 | 0 | 0 | 0 |
| Curlew | uncorrected | 0 | 0 | 0 | 0 | 0 | 0 | 0.53 | 0.32 | 0 | 0 | 0 | 0.04 |
| Curlew | corrected | 0 | 0 | 0 | 0 | 0 | 0 | 1.01 | 0.53 | 0 | 0 | 0 | 0.04 |
| Black-headed Gull | uncorrected | 0 | 0.04 | 0.04 | 3.22 | 8.9 | 20.66 | 5.48 | 0.4 | 0 | 0 | 0 | 0 |
| Black-headed Gull | corrected | 0 | 0.08 | 0.08 | 10.65 | 13.9 | 32.49 | 12.63 | 1.11 | 0 | 0 | 0 | 0 |
| Common Gull | uncorrected | 0 | 0 | 0 | 0 | 0 | 0.08 | 0.04 | 0 | 0 | 0 | 0 | 0 |
| Common Gull | corrected | 0 | 0 | 0 | 0 | 0 | 0.12 | 0.08 | 0 | 0 | 0 | 0 | 0 |
| Lesser Black-backed Gull | uncorrected | 0 | 0 | 1.29 | 25.69 | 107.48 | 27.11 | 34.78 | 44.2 | 0.69 | 0 | 0.51 | 0 |
| Lesser Black-backed Gull | corrected | 0 | 0 | 2.48 | 62.22 | 192.76 | 47.65 | 60.79 | 74.49 | 1.1 | 0.05 | 0.87 | 0 |
| Kestrel | uncorrected | 0.64 | 0.72 | 0.8 | 1.84 | 7.17 | 3.29 | 5.05 | 4.97 | 4.53 | 2.44 | 1.4 | 0.92 |
| Kestrel | corrected | 1.6 | 1.8 | 1.72 | 6.25 | 13.18 | 6.53 | 9.46 | 9.94 | 7.93 | 4.37 | 3.73 | 2.32 |
| Merlin | uncorrected | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.04 |
| Merlin | corrected | 0.04 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.04 |
| Peregrine | uncorrected | 0 | 0 | 0.04 | 0.04 | 0.29 | 0.12 | 0.54 | 0 | 0.12 | 0 | 0.04 | 0.12 |
| Peregrine | corrected | 0 | 0 | 0.04 | 0.12 | 0.49 | 0.29 | 0.91 | 0.04 | 0.21 | 0 | 0.04 | 0.25 |

Table A2.7. Collision risk after avoidance.

| Species | Distance effects | Avoidance rate | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mute Swan | uncorrected | 0.950 | 0.01 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.950 | 0.01 | 0.05 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.980 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.980 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.990 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.990 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Whooper Swan | uncorrected | 0.950 | 0.17 | 0.07 | 0.30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.74 | 0.38 |
| | corrected | 0.950 | 0.37 | 0.13 | 0.62 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 | 1.16 | 0.61 |
| | uncorrected | 0.980 | 0.07 | 0.03 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.30 | 0.15 |
| | corrected | 0.980 | 0.15 | 0.05 | 0.25 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.46 | 0.24 |
| | uncorrected | 0.990 | 0.03 | 0.01 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.15 | 0.08 |
| | corrected | 0.990 | 0.07 | 0.03 | 0.12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.23 | 0.12 |
| | uncorrected | 0.995 | 0.02 | 0.01 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.07 | 0.04 |
| | corrected | 0.995 | 0.04 | 0.01 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.12 | 0.06 |
| Greylag Goose | uncorrected | 0.950 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| | corrected | 0.950 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 |
| | uncorrected | 0.980 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.980 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.990 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.990 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| Species | Distance effects | Avoidance rate | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wigeon | uncorrected | 0.950 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.950 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.980 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.980 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.990 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.990 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Teal | uncorrected | 0.950 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.53 | 0.00 |
| | corrected | 0.950 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.75 | 0.01 |
| | uncorrected | 0.980 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.21 | 0.00 |
| | corrected | 0.980 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.30 | 0.00 |
| | uncorrected | 0.990 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 | 0.00 |
| | corrected | 0.990 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.15 | 0.00 |
| | uncorrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.00 |
| | corrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 0.00 |
| Mallard | uncorrected | 0.950 | 0.00 | 0.07 | 0.06 | 0.01 | 0.25 | 0.00 | 0.02 | 0.01 | 0.06 | 0.02 | 0.39 | 0.06 |
| | corrected | 0.950 | 0.00 | 0.11 | 0.10 | 0.02 | 0.43 | 0.01 | 0.03 | 0.02 | 0.11 | 0.03 | 0.65 | 0.10 |
| | uncorrected | 0.980 | 0.00 | 0.03 | 0.02 | 0.00 | 0.10 | 0.00 | 0.01 | 0.00 | 0.02 | 0.01 | 0.16 | 0.02 |
| | corrected | 0.980 | 0.00 | 0.05 | 0.04 | 0.01 | 0.17 | 0.00 | 0.01 | 0.01 | 0.04 | 0.01 | 0.26 | 0.04 |
| | uncorrected | 0.990 | 0.00 | 0.01 | 0.01 | 0.00 | 0.05 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.08 | 0.01 |
| | corrected | 0.990 | 0.00 | 0.02 | 0.02 | 0.00 | 0.09 | 0.00 | 0.01 | 0.00 | 0.02 | 0.01 | 0.13 | 0.02 |
| | uncorrected | 0.995 | 0.00 | 0.01 | 0.01 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.04 | 0.01 |
| | corrected | 0.995 | 0.00 | 0.01 | 0.01 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.06 | 0.01 |

| Species | Distance effects | Avoidance rate | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cormorant | uncorrected | 0.950 | 0.00 | 0.00 | 0.01 | 0.01 | 0.18 | 0.09 | 0.05 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 |
| | corrected | 0.950 | 0.00 | 0.00 | 0.02 | 0.03 | 0.28 | 0.15 | 0.08 | 0.02 | 0.01 | 0.01 | 0.00 | 0.00 |
| | uncorrected | 0.980 | 0.00 | 0.00 | 0.00 | 0.01 | 0.07 | 0.04 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.980 | 0.00 | 0.00 | 0.01 | 0.01 | 0.11 | 0.06 | 0.03 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.990 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.02 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.990 | 0.00 | 0.00 | 0.00 | 0.01 | 0.06 | 0.03 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Little Egret | uncorrected | 0.950 | 0.01 | 0.00 | 0.03 | 0.01 | 0.34 | 0.03 | 0.01 | 0.03 | 0.01 | 0.01 | 0.01 | 0.01 |
| | corrected | 0.950 | 0.01 | 0.01 | 0.05 | 0.03 | 0.57 | 0.05 | 0.01 | 0.05 | 0.02 | 0.01 | 0.02 | 0.02 |
| | uncorrected | 0.980 | 0.00 | 0.00 | 0.01 | 0.00 | 0.14 | 0.01 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | 0.01 |
| | corrected | 0.980 | 0.00 | 0.00 | 0.02 | 0.01 | 0.23 | 0.02 | 0.00 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 |
| | uncorrected | 0.990 | 0.00 | 0.00 | 0.01 | 0.00 | 0.07 | 0.01 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.990 | 0.00 | 0.00 | 0.01 | 0.01 | 0.11 | 0.01 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.995 | 0.00 | 0.00 | 0.01 | 0.00 | 0.06 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| Grey Heron | uncorrected | 0.950 | 0.00 | 0.00 | 0.01 | 0.01 | 0.07 | 0.04 | 0.04 | 0.05 | 0.04 | 0.06 | 0.01 | 0.00 |
| | corrected | 0.950 | 0.00 | 0.00 | 0.02 | 0.02 | 0.11 | 0.06 | 0.07 | 0.07 | 0.07 | 0.09 | 0.02 | 0.00 |
| | uncorrected | 0.980 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.00 | 0.00 |
| | corrected | 0.980 | 0.00 | 0.00 | 0.01 | 0.01 | 0.05 | 0.02 | 0.03 | 0.03 | 0.03 | 0.04 | 0.01 | 0.00 |
| | uncorrected | 0.990 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 |
| | corrected | 0.990 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.00 | 0.00 |
| | uncorrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |
| | corrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 |

| Species | Distance effects | Avoidance rate | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Little Grebe | uncorrected | 0.950 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.950 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.980 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.980 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.990 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.990 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Sparrowhawk | uncorrected | 0.950 | 0.01 | 0.01 | 0.01 | 0.02 | 0.08 | 0.03 | 0.06 | 0.06 | 0.01 | 0.03 | 0.00 | 0.01 |
| | corrected | 0.950 | 0.02 | 0.01 | 0.02 | 0.06 | 0.13 | 0.06 | 0.10 | 0.10 | 0.03 | 0.07 | 0.00 | 0.02 |
| | uncorrected | 0.980 | 0.00 | 0.00 | 0.00 | 0.01 | 0.03 | 0.01 | 0.02 | 0.02 | 0.00 | 0.01 | 0.00 | 0.00 |
| | corrected | 0.980 | 0.01 | 0.01 | 0.01 | 0.02 | 0.05 | 0.02 | 0.04 | 0.04 | 0.01 | 0.03 | 0.00 | 0.01 |
| | uncorrected | 0.990 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 | 0.00 | 0.00 |
| | corrected | 0.990 | 0.00 | 0.00 | 0.00 | 0.01 | 0.03 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.00 | 0.00 |
| | uncorrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 | 0.00 | 0.00 |
| Buzzard | uncorrected | 0.950 | 0.03 | 0.13 | 0.32 | 0.33 | 0.63 | 0.60 | 0.60 | 0.41 | 0.19 | 0.06 | 0.09 | 0.03 |
| | corrected | 0.950 | 0.06 | 0.26 | 0.66 | 0.79 | 1.10 | 1.10 | 1.09 | 0.73 | 0.33 | 0.10 | 0.17 | 0.05 |
| | uncorrected | 0.980 | 0.01 | 0.05 | 0.13 | 0.13 | 0.25 | 0.24 | 0.24 | 0.16 | 0.08 | 0.02 | 0.03 | 0.01 |
| | corrected | 0.980 | 0.02 | 0.10 | 0.26 | 0.31 | 0.44 | 0.44 | 0.44 | 0.29 | 0.13 | 0.04 | 0.07 | 0.02 |
| | uncorrected | 0.990 | 0.01 | 0.03 | 0.06 | 0.07 | 0.13 | 0.12 | 0.12 | 0.08 | 0.04 | 0.01 | 0.02 | 0.01 |
| | corrected | 0.990 | 0.01 | 0.05 | 0.13 | 0.16 | 0.22 | 0.22 | 0.22 | 0.15 | 0.07 | 0.02 | 0.03 | 0.01 |
| | uncorrected | 0.995 | 0.00 | 0.01 | 0.03 | 0.03 | 0.06 | 0.06 | 0.06 | 0.04 | 0.02 | 0.01 | 0.01 | 0.00 |
| | corrected | 0.995 | 0.01 | 0.03 | 0.07 | 0.08 | 0.11 | 0.11 | 0.11 | 0.07 | 0.03 | 0.01 | 0.02 | 0.00 |

| Species | Distance effects | Avoidance rate | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Golden Plover | uncorrected | 0.950 | 0.09 | 0.00 | 2.77 | 10.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.21 | 5.98 | 8.14 | 2.01 |
| | corrected | 0.950 | 0.15 | 0.01 | 7.10 | 36.63 | 0.00 | 0.00 | 0.00 | 0.00 | 0.56 | 15.80 | 20.50 | 5.26 |
| | uncorrected | 0.980 | 0.03 | 0.00 | 1.11 | 4.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.08 | 2.39 | 3.26 | 0.80 |
| | corrected | 0.980 | 0.06 | 0.00 | 2.84 | 14.65 | 0.00 | 0.00 | 0.00 | 0.00 | 0.22 | 6.32 | 8.20 | 2.10 |
| | uncorrected | 0.990 | 0.02 | 0.00 | 0.55 | 2.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 1.20 | 1.63 | 0.40 |
| | corrected | 0.990 | 0.03 | 0.00 | 1.42 | 7.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 | 3.16 | 4.10 | 1.05 |
| | uncorrected | 0.995 | 0.01 | 0.00 | 0.28 | 1.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.60 | 0.81 | 0.20 |
| | corrected | 0.995 | 0.02 | 0.00 | 0.71 | 3.66 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 1.58 | 2.05 | 0.53 |
| Lapwing | uncorrected | 0.950 | 0.77 | 0.32 | 0.06 | 0.01 | 0.05 | 0.12 | 0.41 | 0.13 | 0.00 | 0.00 | 0.21 | 0.29 |
| | corrected | 0.950 | 1.99 | 0.69 | 0.15 | 0.02 | 0.10 | 0.20 | 0.66 | 0.17 | 0.00 | 0.01 | 0.61 | 0.74 |
| | uncorrected | 0.980 | 0.31 | 0.13 | 0.03 | 0.00 | 0.02 | 0.05 | 0.16 | 0.05 | 0.00 | 0.00 | 0.08 | 0.12 |
| | corrected | 0.980 | 0.80 | 0.28 | 0.06 | 0.01 | 0.04 | 0.08 | 0.26 | 0.07 | 0.00 | 0.00 | 0.24 | 0.29 |
| | uncorrected | 0.990 | 0.15 | 0.06 | 0.01 | 0.00 | 0.01 | 0.02 | 0.08 | 0.03 | 0.00 | 0.00 | 0.04 | 0.06 |
| | corrected | 0.990 | 0.40 | 0.14 | 0.03 | 0.00 | 0.02 | 0.04 | 0.13 | 0.03 | 0.00 | 0.00 | 0.12 | 0.15 |
| | uncorrected | 0.995 | 0.08 | 0.03 | 0.01 | 0.00 | 0.01 | 0.01 | 0.04 | 0.01 | 0.00 | 0.00 | 0.02 | 0.03 |
| | corrected | 0.995 | 0.20 | 0.07 | 0.02 | 0.00 | 0.01 | 0.02 | 0.07 | 0.02 | 0.00 | 0.00 | 0.06 | 0.07 |
| Whimbrel | uncorrected | 0.950 | 0.00 | 0.00 | 0.00 | 0.00 | 5.46 | 0.00 | 0.00 | 0.04 | 0.02 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.950 | 0.00 | 0.00 | 0.00 | 0.00 | 7.61 | 0.00 | 0.00 | 0.06 | 0.02 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.980 | 0.00 | 0.00 | 0.00 | 0.00 | 2.18 | 0.00 | 0.00 | 0.02 | 0.01 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.980 | 0.00 | 0.00 | 0.00 | 0.00 | 3.04 | 0.00 | 0.00 | 0.02 | 0.01 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.990 | 0.00 | 0.00 | 0.00 | 0.00 | 1.09 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.990 | 0.00 | 0.00 | 0.00 | 0.00 | 1.52 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.00 | 0.55 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.00 | 0.76 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |

| Species | Distance effects | Avoidance rate | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Curlew | uncorrected | 0.950 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.950 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.980 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.980 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.990 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.990 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Black-headed Gull | uncorrected | 0.950 | 0.00 | 0.00 | 0.00 | 0.16 | 0.44 | 1.03 | 0.27 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.950 | 0.00 | 0.00 | 0.00 | 0.53 | 0.70 | 1.62 | 0.63 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.980 | 0.00 | 0.00 | 0.00 | 0.06 | 0.18 | 0.41 | 0.11 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.980 | 0.00 | 0.00 | 0.00 | 0.21 | 0.28 | 0.65 | 0.25 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.990 | 0.00 | 0.00 | 0.00 | 0.03 | 0.09 | 0.21 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.990 | 0.00 | 0.00 | 0.00 | 0.11 | 0.14 | 0.32 | 0.13 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.02 | 0.04 | 0.10 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.05 | 0.07 | 0.16 | 0.06 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| Common Gull | uncorrected | 0.950 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.950 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.980 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.980 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.990 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.990 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| Species | Distance effects | Avoidance rate | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lesser Black-backed Gull | uncorrected | 0.950 | 0.00 | 0.00 | 0.06 | 1.28 | 5.37 | 1.36 | 1.74 | 2.21 | 0.03 | 0.00 | 0.03 | 0.00 |
| | corrected | 0.950 | 0.00 | 0.00 | 0.12 | 3.11 | 9.64 | 2.38 | 3.04 | 3.72 | 0.06 | 0.00 | 0.04 | 0.00 |
| | uncorrected | 0.980 | 0.00 | 0.00 | 0.03 | 0.51 | 2.15 | 0.54 | 0.70 | 0.88 | 0.01 | 0.00 | 0.01 | 0.00 |
| | corrected | 0.980 | 0.00 | 0.00 | 0.05 | 1.24 | 3.86 | 0.95 | 1.22 | 1.49 | 0.02 | 0.00 | 0.02 | 0.00 |
| | uncorrected | 0.990 | 0.00 | 0.00 | 0.01 | 0.26 | 1.07 | 0.27 | 0.35 | 0.44 | 0.01 | 0.00 | 0.01 | 0.00 |
| | corrected | 0.990 | 0.00 | 0.00 | 0.02 | 0.62 | 1.93 | 0.48 | 0.61 | 0.74 | 0.01 | 0.00 | 0.01 | 0.00 |
| | uncorrected | 0.995 | 0.00 | 0.00 | 0.01 | 0.13 | 0.54 | 0.14 | 0.17 | 0.22 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.995 | 0.00 | 0.00 | 0.01 | 0.31 | 0.96 | 0.24 | 0.30 | 0.37 | 0.01 | 0.00 | 0.00 | 0.00 |
| Kestrel | uncorrected | 0.950 | 0.03 | 0.04 | 0.04 | 0.09 | 0.36 | 0.16 | 0.25 | 0.25 | 0.23 | 0.12 | 0.07 | 0.05 |
| | corrected | 0.950 | 0.08 | 0.09 | 0.09 | 0.31 | 0.66 | 0.33 | 0.47 | 0.50 | 0.40 | 0.22 | 0.19 | 0.12 |
| | uncorrected | 0.980 | 0.01 | 0.01 | 0.02 | 0.04 | 0.14 | 0.07 | 0.10 | 0.10 | 0.09 | 0.05 | 0.03 | 0.02 |
| | corrected | 0.980 | 0.03 | 0.04 | 0.03 | 0.13 | 0.26 | 0.13 | 0.19 | 0.20 | 0.16 | 0.09 | 0.07 | 0.05 |
| | uncorrected | 0.990 | 0.01 | 0.01 | 0.01 | 0.02 | 0.07 | 0.03 | 0.05 | 0.05 | 0.05 | 0.02 | 0.01 | 0.01 |
| | corrected | 0.990 | 0.02 | 0.02 | 0.02 | 0.06 | 0.13 | 0.07 | 0.09 | 0.10 | 0.08 | 0.04 | 0.04 | 0.02 |
| | uncorrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.01 | 0.04 | 0.02 | 0.03 | 0.02 | 0.02 | 0.01 | 0.01 | 0.00 |
| | corrected | 0.995 | 0.01 | 0.01 | 0.01 | 0.03 | 0.07 | 0.03 | 0.05 | 0.05 | 0.04 | 0.02 | 0.02 | 0.01 |
| Merlin | uncorrected | 0.950 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.950 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.980 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.980 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.990 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.990 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| Species | Distance effects | Avoidance rate | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Peregrine | uncorrected | 0.950 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.03 | 0.00 | 0.01 | 0.00 | 0.00 | 0.01 |
| | corrected | 0.950 | 0.00 | 0.00 | 0.00 | 0.01 | 0.02 | 0.01 | 0.05 | 0.00 | 0.01 | 0.00 | 0.00 | 0.01 |
| | uncorrected | 0.980 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.980 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.990 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.990 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | uncorrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | corrected | 0.995 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Table A2.8. Annual / seasonal collision risks.

| Species | Season | Distance effects | Avoidance rate | | | |
|---|---|---|---|---|---|---|
| | | | **0.95** | **0.98** | **0.99** | **0.995** |
| Mute Swan | all year | uncorrected | 0.04 | 0.02 | 0.01 | 0.00 |
| | all year | corrected | 0.08 | 0.03 | 0.02 | 0.01 |
| Whooper Swan | winter | uncorrected | 1.73 | 0.69 | 0.35 | 0.17 |
| | winter | corrected | 3.00 | 1.20 | 0.60 | 0.30 |
| Greylag Goose | all year | uncorrected | 0.01 | 0.00 | 0.00 | 0.00 |
| | all year | corrected | 0.02 | 0.01 | 0.00 | 0.00 |
| Wigeon | winter | uncorrected | 0.01 | 0.00 | 0.00 | 0.00 |
| | winter | corrected | 0.01 | 0.01 | 0.00 | 0.00 |
| Teal | all year | uncorrected | 0.57 | 0.23 | 0.11 | 0.06 |
| | all year | corrected | 0.81 | 0.32 | 0.16 | 0.08 |
| Mallard | all year | uncorrected | 0.95 | 0.38 | 0.19 | 0.09 |
| | all year | corrected | 1.61 | 0.64 | 0.32 | 0.16 |
| Cormorant | breeding | uncorrected | 0.34 | 0.14 | 0.07 | 0.03 |
| | breeding | corrected | 0.54 | 0.22 | 0.11 | 0.05 |
| | non-breeding | uncorrected | 0.03 | 0.01 | 0.01 | 0.00 |
| | non-breeding | corrected | 0.05 | 0.02 | 0.01 | 0.01 |
| Little Egret | all year | uncorrected | 0.50 | 0.20 | 0.10 | 0.05 |
| | all year | corrected | 0.84 | 0.34 | 0.17 | 0.08 |
| Grey Heron | all year | uncorrected | 0.33 | 0.13 | 0.07 | 0.03 |
| | all year | corrected | 0.52 | 0.21 | 0.10 | 0.05 |
| Little Grebe | all year | uncorrected | 0.01 | 0.00 | 0.00 | 0.00 |
| | all year | corrected | 0.03 | 0.01 | 0.01 | 0.00 |
| Marsh Harrier | all year | uncorrected | 0.00 | 0.00 | 0.00 | 0.00 |
| | all year | corrected | 0.01 | 0.00 | 0.00 | 0.00 |
| Hen Harrier | non-breeding | uncorrected | 0.01 | 0.00 | 0.00 | 0.00 |
| | non-breeding | corrected | 0.02 | 0.01 | 0.00 | 0.00 |
| Sparrowhawk | all year | uncorrected | 0.32 | 0.13 | 0.06 | 0.03 |
| | all year | corrected | 0.61 | 0.24 | 0.12 | 0.06 |
| Buzzard | all year | uncorrected | 3.40 | 1.36 | 0.68 | 0.34 |
| | all year | corrected | 6.43 | 2.57 | 1.29 | 0.64 |
| Golden Plover | summer | uncorrected | 0.21 | 0.08 | 0.04 | 0.02 |
| | summer | corrected | 0.56 | 0.22 | 0.11 | 0.06 |
| | winter | uncorrected | 29.08 | 11.63 | 5.82 | 2.91 |
| | winter | corrected | 85.45 | 34.18 | 17.09 | 8.54 |
| Lapwing | breeding | uncorrected | 0.59 | 0.23 | 0.12 | 0.06 |
| | breeding | corrected | 0.98 | 0.39 | 0.20 | 0.10 |
| | autumn | uncorrected | 0.13 | 0.05 | 0.03 | 0.01 |
| | autumn | corrected | 0.18 | 0.07 | 0.04 | 0.02 |
| | winter | uncorrected | 1.65 | 0.66 | 0.33 | 0.17 |
| | winter | corrected | 4.19 | 1.68 | 0.84 | 0.42 |
| Whimbrel | migration | uncorrected | 5.52 | 2.21 | 1.10 | 0.55 |
| | migration | corrected | 7.69 | 3.08 | 1.54 | 0.77 |

| Species | Season | Distance effects | Avoidance rate | | | |
|---|---|---|---|---|---|---|
| | | | **0.95** | **0.98** | **0.99** | **0.995** |
| Curlew | breeding | uncorrected | 0.03 | 0.01 | 0.01 | 0.00 |
| | breeding | corrected | 0.05 | 0.02 | 0.01 | 0.01 |
| | non-breeding | uncorrected | 0.02 | 0.01 | 0.00 | 0.00 |
| | non-breeding | corrected | 0.03 | 0.01 | 0.01 | 0.00 |
| Black-headed Gull | breeding | uncorrected | 1.91 | 0.77 | 0.38 | 0.19 |
| | breeding | corrected | 3.48 | 1.39 | 0.70 | 0.35 |
| | non-breeding | uncorrected | 0.02 | 0.01 | 0.00 | 0.00 |
| | non-breeding | corrected | 0.06 | 0.03 | 0.01 | 0.01 |
| Common Gull | all year | uncorrected | 0.01 | 0.00 | 0.00 | 0.00 |
| | all year | corrected | 0.01 | 0.00 | 0.00 | 0.00 |
| Lesser Black-backed Gull | breeding | uncorrected | 9.75 | 3.90 | 1.95 | 0.98 |
| | breeding | corrected | 18.17 | 7.27 | 3.63 | 1.82 |
| | autumn | uncorrected | 2.24 | 0.90 | 0.45 | 0.22 |
| | autumn | corrected | 3.78 | 1.51 | 0.76 | 0.38 |
| | winter | uncorrected | 0.09 | 0.04 | 0.02 | 0.01 |
| | winter | corrected | 0.17 | 0.07 | 0.03 | 0.02 |
| Kestrel | all year | uncorrected | 1.69 | 0.68 | 0.34 | 0.17 |
| | all year | corrected | 3.44 | 1.38 | 0.69 | 0.34 |
| Merlin | all year | uncorrected | 0.00 | 0.00 | 0.00 | 0.00 |
| | all year | corrected | 0.00 | 0.00 | 0.00 | 0.00 |
| Peregrine | all year | uncorrected | 0.07 | 0.03 | 0.01 | 0.01 |
| | all year | corrected | 0.12 | 0.05 | 0.02 | 0.01 |