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# Collision Risk Model for Low Carbon and Rezolv Energy Vifor Wind Farm

Estimating annual mortality of priority bird species within the proposed wind farm array

08/09/2023

Project No.: 0634323

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| Document details | |
|---|---|
| Document title | Collision Risk Model for Low Carbon and Rezolv Energy Vifor Wind Farm |
| Document subtitle | Estimating annual mortality of priority bird species within the proposed wind farm array |
| Project No. | 0634323 |
| Date | 08/09/2023 |
| Version | 2.00 |
| Author | Sebastian Ellis |
| Client Name | Low Carbon and Rezolv Energy |

Document history

| | | | | ERM approval to issue | | |
|---|---|---|---|---|---|---|
| Version | Revision | Author | Reviewed by | Name | Date | Comments |
| 1 | 00 | Sebastian Ellis | Les Hatton | Dana Bratu | 00.00.0000 | For issue to client |
| 2 | 00 | Sebastian Ellis | Les Hatton | Dana Bratu | 00.00.0000 | Windfarm Layout Amendments – Turbines Re-sited from SE to NW locations |
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## Signature Page

08/09/2023

# Collision Risk Model for Low Carbon and Rezolv Energy Vifor Wind Farm

Estimating annual mortality of priority bird species within the proposed wind farm array

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## Acronyms and Abbreviations

| | |
|---|---|
| BTO | British Trust for Ornithology |
| CRH | Collision risk height |
| CRM | Collision risk model |
| IUCN | International Union for Conservation of Nature |
| NatureScot (SNH) | Scotland’s nature agency (Formerly known as Scottish Natural Heritage (SNH)) |
| RPM | Revolutions per minute |
| PBR | Potential biological removal |
| SPA | Special Protection Area |
| VP | Vantage point |
| WTG | Wind turbine generator |

# 1. INTRODUCTION

## 1.1 Purpose and scope

This report contains the methods and results of Collision Risk Modelling (CRM) for 15 bird species, and subsequently Potential Biological Removal (PBR) calculations for 8 bird species, within the proposed wind farm array of the Low Carbon and Rezolv Energy Vifor project.

Data for the CRM calculations is from Vantage Point (VP) surveys conducted by between March 2022 and February 2023 on the project site. Nine vantage points were used within the model with a total of 108 hours of observation for each VP. Target species recorded during VP surveys were categorised as:

- all raptors;
- all waterfowl (excluding cattle egrets);
- all waders; and
- all soaring birds (storks, pelicans, cranes etc).

As such data on a total 53 target species was collected and 15 of these species (shown in Table 1) were selected for input to a collision risk model. Focal species were taken forward for CRM analysis based on levels of flight activity, sensitivity to collision risk, inclusion as a qualifying feature of the Valea Călmățuiului Special Protection Area (SPA), being categorised as Near Threatened (NT) or above on the International Union for Conservation of Nature (IUCN) red list, and/or listed on Annex 1 of the EU Habitats Directive.

Many of the 53 species recorded were present for only a small period of time within the proposed wind farm, and consequently could be excluded from further analysis on the basis of low flight activity and low likelihood of a collision within the lifetime of the wind farm.

Red-footed falcon *Falco vespertinus* is the most notable species as it is globally Vulnerable (IUCN VU) and the population is decreasing, it was observed 153 times during VP surveys. Two other IUCN NT species were recorded, with sightings of 620 Northern Lapwing *Vanellus vanellus* and 105 Eurasian Curlew *Numenius arquata* during VP surveys. The focal species with the highest counts were mallard *Anas platyrhynchos* which was seen cumulatively 2824 times, great white-fronted goose *Anser albifrons* with 2448 observations, and White stork *Ciconia ciconia* 2158 observations.

**Table 1: Bird Species included within the Collision Risk calculations**

| Latin Name | English Common Name | IUCN Redlist[1] Status | EU Birds Directive | Valea Călmățuiului SPA | Cumulative observations during VP Surveys |
|---|---|---|---|---|---|
| *Anas crecca* | Eurasian teal | LC | | | 1342 |
| *Anas platyrhynchos* | Mallard | LC | | | 2824 |
| *Anser albifrons* | Greater white-fronted goose | LC | | | 2448 |
| *Buteo buteo* | Common buzzard | LC | | | 346 |
| *Ciconia ciconia* | White stork | LC | Annex 1 | Cited | 2158 |
| *Circus cyaneus* | Hen harrier | LC | Annex 1 | | 97 |
| *Egretta garzetta* | Little egret | LC | Annex 1 | | 113 |
| *Falco tinnunculus* | Common kestrel | LC | | | 665 |
| *Falco vespertinus* | Red-footed falcon | VU | Annex 1 | | 153 |
| *Glareola pratincola* | Collared pratincole | LC | Annex 1 | Cited | 174 |
| *Numenius arquata* | Eurasian curlew | NT | | Cited | 105 |
| *Pelecanus onocrotalus* | Great white pelican | LC | Annex 1 | | 97 |
| *Philomachus pugnax* | Ruff | LC | Annex 1 | Cited | 1184 |
| *Pluvialis apricaria* | Golden plover | LC | Annex 1 | | 1293 |
| *Vanellus vanellus* | Northern lapwing | NT | | | 618 |

[1] https://www.iucnredlist.org/

To assess the potential impact of the Vifor project on these species, collision risk modelling to estimate annual mortality as a result of the project was undertaken following the Band onshore model outlined in the Wind farm impacts on birds - Calculating a theoretical collision risk assuming no avoiding action guidance note (NatureScot, 2000). Species modelled for collision risk that were also IUCN European Redlist species above Least Concern, cited as qualifying interested in the Valea Călmățuiului SPA, and thought to be vulnerable to population effects as a result of collisions with Wind Turbine Generators (WTGs) were also input to a PBR calculation. This calculation, originally developed for marine mammals (Wade, 1998), and since adopted for estimating sustainable levels of bird mortality (Dillingham and Fletcher, 2008), was undertaken for White Stork *Ciconia ciconia,* Ruff *Philomachus pugnax*, Lapwing *Vanellus vanellus*, Kestrel *Falco tinnunculus,* Great White pelican *Pelecanus onocrotalus,* Collared pratincole *Glareola pratincola,* Red-footed falcon *Falco vespertinus,* and Curlew *Numenius arquata.*

# 2. METHODOLOGY AND DATA

## 2.1 Excel spreadsheet calculations

All calculations were made on a Microsoft Excel spreadsheet and values in this report have been rounded to two or three decimal places as appropriate. As such values in explained calculations, tables, and figures may not exactly equate to the detailed spreadsheet numbers, and calculations may look incorrect due to rounding variances.

## 2.2 Collision Risk Model

To estimate annual mortality, the collision risk model uses the Band two stage calculation. The calculation first assesses the probability of a bird species being hit whilst flying through the rotors, and then secondly applies this probability to the annual number of birds transiting the rotors within a windfarm array. Data used in the model includes bird morphological measurements and physical turbine parameters. Where this data is provided in a range, in order to provide a precautionary estimate, a reasonable assumption is made and explained. Where the data is unknown, proxy data from similar turbines or similar bird species is used.

### *2.2.1 Bird and Vantage Point Data*

Morphological data and flight speed information was gathered for each of the 15 species, and combined with data from the VP surveys as well as daylight availability at the project site.

Where possible morphological data (seen in Table 2: Bird Species morphological data, flight speed, expected presence at project site, and recommended avoidance rates) was gathered from BTO Birdfacts[2] for species length and wingspan, or where necessary other data sources including Birdsoftheworld.org, Collins Bird Guide, The Birds of the Western Paleartic, The Raptors of Europe and the Middle East, and Shorebirds of the Northern Hemisphere were used. Flight speed information was mainly gathered from the research paper Flight Speeds among Bird Species: Allometric and Phylogenetic Effects (Alerstam et al. 2007) or other relevant research papers.

[2] https://www.bto.org/understanding-birds/birdfacts

**Table 2: Bird Species morphological data, flight speed, expected presence at project site, and recommended avoidance rates**

| Latin Name | English Common Name | Length (meters) | Wingspan (meters) | Flight Speed (meters/second) | Days per year bird assumed present (days) | Average daylight hours per day bird present (hours) | SNH recommended avoidance rate (%) |
|---|---|---|---|---|---|---|---|
| *Anas crecca* | Eurasian teal | 0.36 | 0.61 | 19.7 | 212 | 10.64 | 98.0% |
| *Anas platyrhynchos* | Mallard | 0.58 | 0.9 | 18.5 | 365 | 12.22 | 98.0% |
| *Anser albifrons* | Greater white-fronted goose | 0.72 | 1.48 | 16.1 | 182 | 10.17 | 99.8% |
| *Buteo buteo* | Common buzzard | 0.54 | 1.2 | 11.6 | 365 | 12.22 | 98.0% |
| *Ciconia ciconia* | White stork | 1.025 | 1.99 | 16 | 242 | 13.5 | 98.0% |
| *Circus cyaneus* | Hen harrier | 0.48 | 1.1 | 9.1 | 212 | 10.64 | 99.0% |
| *Egretta garzetta* | Little egret | 0.6 | 0.92 | 8.7* | 245 | 13.57 | 98.0% |
| *Falco tinnunculus* | Common kestrel | 0.34 | 0.76 | 10.1 | 365 | 12.22 | 95.0% |
| *Falco vespertinus* | Red-footed falcon | 0.285 | 0.745 | 12.8 | 183 | 14.28 | 98.0% |
| *Glareola pratincola* | Collared pratincole | 0.25 | 0.58 | 12.5** | 91 | 14.64 | 98.0% |
| *Numenius arquata* | Eurasian curlew | 0.55 | 0.9 | 16.3 | 91 | 12.64 | 98.0% |
| *Pelecanus onocrotalus* | Great white pelican | 1.575 | 2.7 | 15.6 | 181 | 13.58 | 98.0% |
| *Philomachus pugnax* | Ruff | 0.25 | 0.53 | 17.4 | 92 | 13.42 | 98.0% |
| *Pluvialis apricaria* | European golden plover | 0.28 | 0.72 | 26 | 122 | 12.23 | 98.0% |
| *Vanellus vanellus* | Northern lapwing | 0.3 | 0.84 | 12.8 | 273 | 13.22 | 98.0% |

**Proxy flight speed from Snowy egret, ** Proxy flight speed from Oriental pratincole*

For the purposes of the model all species are assumed to have presence in the project site for the entire month that they are sighted within the project area, and to be only active during available daylight hours. Average daylight hours at the project site per survey month were taken from an online resource (Timeanddate.com, 2023) and are presented in Table 3: Daylight availability at the project site.

**Table 3: Daylight availability at the project site**

| Month | Average Daylight per day (hours) |
|---|---|
| January | 9.25 |
| February | 10.42 |
| March | 11.92 |
| April | 13.5 |
| May | 14.83 |
| June | 15.58 |
| July | 15.25 |
| August | 14 |
| September | 12.5 |
| October | 11 |
| November | 9.58 |
| December | 8.83 |

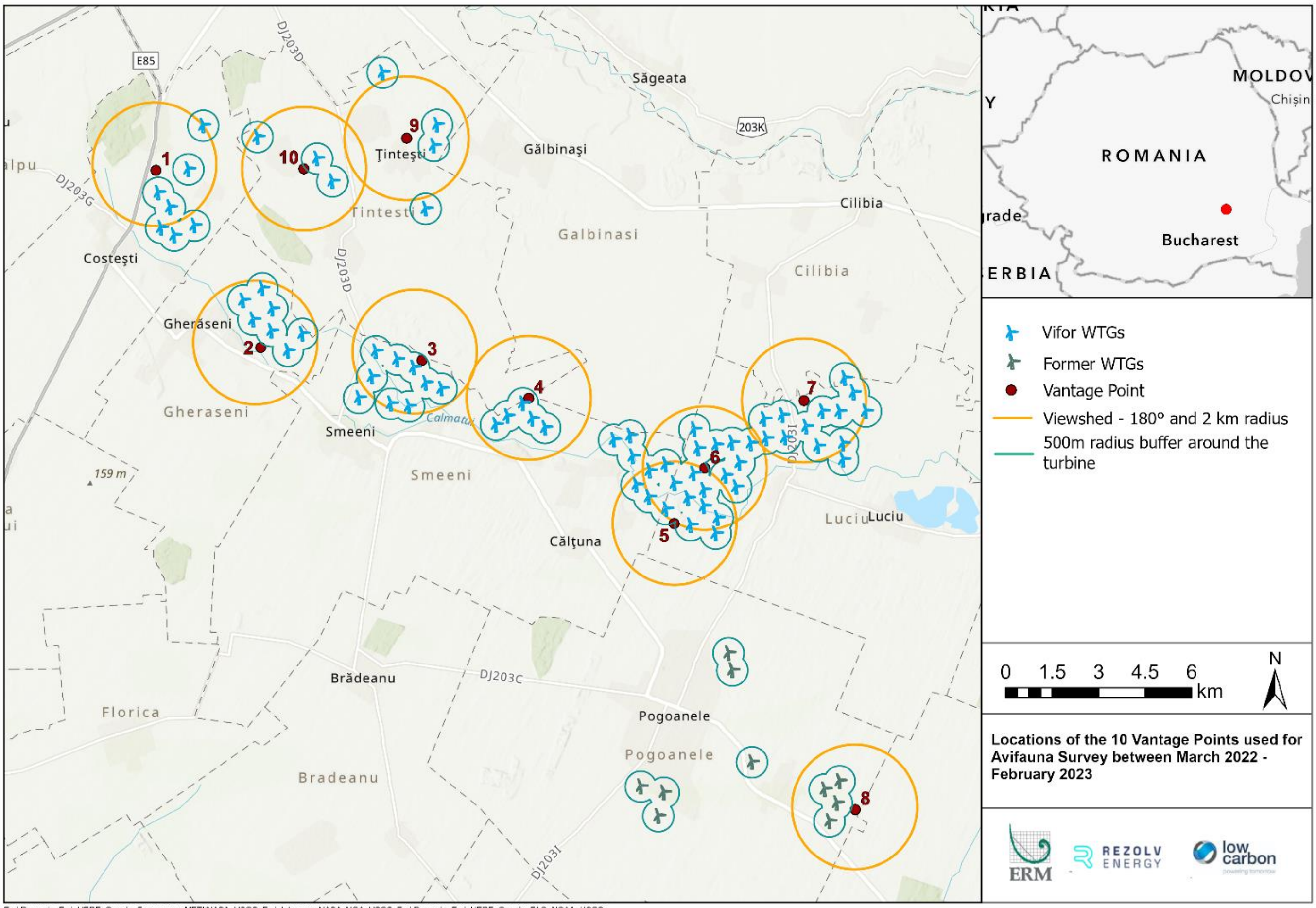
Vantage point surveys were conducted at 10 locations, but with project layout changes only data from nine has been used in the model. Each VP had a 2km sight line and a 180° field of view, and each survey therefore covered an area of 628.319ha. The surveys were conducted for 12 hours during migration months and 6 hours during non-migration months. In total therefore each vantage point was observed for 108 hours over 12 months. Combined this gives a total of 5654.867ha surveyed area, for 972 total hours. For each species time flying in 3 distinct height bands was recorded by surveyors. The flight bands are:

- H1 – Below rotor height – 0-80m
- H2 – Rotor Swept Zone - 80-240m
- H3 – Above rotor height – 240m and above

The actual dimensions of the proposed Vestas V162 6.4MW Wind Turbine Generator give a slightly larger rotor swept zone (2m increase) and as such a correction factor of 1.0125 has been applied, this is explained in section 2.2.2.

### *2.2.2 Turbine and Array Data*

The project will use Vestas V162 6.4MW Wind Turbine Generator in a 72 turbine array. The proposed turbine has 3 blades with a 162m rotor diameter giving a total swept area per turbine of 20612m². The hub height is 166m above ground level giving a maximum turbine height of 247m and a lowest swept height of 80m. A collision risk height correction factor was calculated for the turbine to adjust collected survey data from a survey assumed risk height of 80-240m to the design collision risk height of 85-247m. Data from height band H2 was used in the model as this bands overlaps the designs collision risk zone. Using a correction factor adjustment assumes uniform distribution of birds at all heights, however in reality it is expected that the largest number of bird flights would take place closer to the ground (this is further explained in section 4). The maximum blade width is 4.2m. A 10-degree blade pitch was assumed for the model, however the proposed turbines are variable pitch and will change during operation in accordance to wind speed and other factors. The maximum RPM for this turbine is 12.1 and this has been used as a precautionary worst case, in operation it is assumed the RPM will be lower and will vary in accordance to wind speed and other factors. Wind availability, otherwise describable as the proportion of time the turbines are spinning, is assumed to be 90%, this is a precautionary assumption for the model.




Esri Romania, Esri, HERE, Garmin, Foursquare, METI/NASA, USGS, Esri, Intermap, NASA, NGA, USGS, Esri Romania, Esri, HERE, Garmin, FAO, NOAA, USGS

**Figure 1: Locations of turbines and VPs within array with 500m buffer zone**

The locations of the 72 turbines are shown in Figure 1: Locations of turbines and VPs within array with 500m buffer zone with a 500m radius buffer area around the array used to calculate the arrays area for the purposes of the model. The array covers a 4404.86ha area. VP location 8 was surveyed for the full season based on preliminary array layout, a subsequent change to turbine locations means no turbines are within the viewing area for VP 8 and therefore data from these locations is discounted and not used within the model.

### 2.2.3 *Collision Calculations*

#### *2.2.3.1 First Stage – Risk of Collision*

The first stage of the CRM calculation uses NatureScot's 'Calculation of collision risk for bird passing through rotor area' spreadsheet (NatureScot, 2000). Inputting turbine and bird parameters yields an upwind, downwind and average collision risk.

Bird data was set as per Table 2: Bird Species morphological data, flight speed, expected presence at project site, and recommended avoidance rates, with flapping set as the flight type for all species except White stork *Ciconia ciconia* and Great white pelican *Pelecanus onocrotalus* which were set to gliding.

The parameters used for the turbine design are those outlined in section 2.2.2. Rotation period is defined as time taken for a single rotation and was calculated at 4.96 seconds using turbine maximum rated 12.1 RPM.

The resulting Collision Risk from the NatureScot spreadsheet was then multiplied by 90% to account for wind availability. The Collision Risk for each species adjusted for wind availability is shown in Table 4.

**Table 4: Collision Risk % for each species with proposed turbine design**

| Latin Name | English Common Name | Collision Risk with adjustment for wind availability |
|---|---|---|
| *Anas crecca* | Eurasian teal | 3.87% |
| *Anas platyrhynchos* | Mallard | 4.59% |
| *Anser albifrons* | Greater white-fronted goose | 5.40% |
| *Buteo buteo* | Common buzzard | 5.58% |
| *Ciconia ciconia* | White stork | 6.30% |
| *Circus cyaneus* | Hen harrier | 6.21% |
| *Egretta garzetta* | Little egret | 7.11% |
| *Falco tinnunculus* | Common kestrel | 4.95% |
| *Falco vespertinus* | Red-footed falcon | 4.14% |
| *Glareola pratincola* | Collared pratincole | 4.05% |
| *Numenius arquata* | Eurasian curlew | 4.68% |
| *Pelecanus onocrotalus* | Great white pelican | 8.37% |
| *Philomachus pugnax* | Ruff | 3.60% |
| *Pluvialis apricaria* | European golden plover | 3.60% |
| *Vanellus vanellus* | Northern lapwing | 4.23% |

### 2.2.3.2 Second Stage – Number of transits through rotors

To inform the second stage of the modelling the following calculations were made:

#### Flight risk volume

This is defined as the flight risk volume is equal to the maximum height of the rotor (m) multiplied by the area of the array (ha) multiplied by 10,000.

The maximum height of the rotor is taken from the technical specifications as in section 2.2.2 as 247m. The area of the array was 4404.86ha. 10,000 is used to convert hectares to metres so the result of the calculation is expressed as metres$^3$.

- Maximum height: 247m
- Area of the array: 4404.86ha
- Flight risk volume: 10,880,004,200m$^3$ = 247m × (4404.86ha × 10000)

### *Combined rotor swept volume*

The swept volume is equal to the number of wind turbines, multiplied by $\pi R^2$, multiplied by the maximum width of the rotor added to the length of the bird.

There are 72 wind turbines in the proposed array as seen in section 2.2.2. The radius of each turbine is 81m. The maximum width of the blade is 4.2m and the length of the bird is as seen in Table 2: Bird Species morphological data, flight speed, expected presence at project site, and recommended avoidance rates.

- For example, for Eurasian teal
  - Number of turbines in array: 72
  - Radius: 162m ÷ 2 = 81m
  - Maximum width of the blade added to length of the bird: 4.2m + 0.36m = 4.56m
  - Combined rotor swept volume: 6,767,328.36m$^3$ = 72 × $\pi 81^2$ × 4.56m

### *Bird occupancy*

Bird occupancy is equal to the number of birds within the array at risk height multiplied by time spent flying in flight risk volume within the 12 month survey period.

To calculate the number of birds within the array at risk height from the VP survey data, the total flight time at risk height in hours is divided by the total hectare hours and the result is then multiplied by the total array area in hectares. This gives activity at surveyed risk height across the site. Activity at risk height is then multiplied by collision risk height correction factor for the turbines being calculated (as explained in section 2.2.2) giving an adjusted activity at risk height. Adjusted activity at risk height is then multiplied by average daylight hours per day that the bird is present on site and days per year that the bird is present on site (see Table 2) to give bird occupancy.

- For example, for Eurasian teal
  - Surveyed activity at risk height: (11.946 hours ÷ 610725.612 hectare-hours) × 4404.86 hectares = 0.086159353 per hour
  - Adjusted activity at risk height: 0.086159353 × 1.0125 = 0.087236345Bird occupancy: 196.83hrs/yr = 0.087236345× 10.64 average daylight hours × 212 days

### *Bird occupancy of rotor swept volume*

The bird occupancy of rotor swept volume is bird occupancy multiplied by combined rotor swept volume divided by flight risk volume.

Bird occupancy, combined rotor swept volume and flight risk volume have all previously been calculated, there is a multiplication of 3600 to convert the result from hours to seconds.

- For example, for Eurasian teal
  - Bird occupancy of rotor swept volume: 440.74s = 196.83hrs/yr × (6767328.36m$^3$ ÷ 10,880,004,200m$^3$) × 3600

### *Bird transit time through rotor*

Bird transit time taken is the seconds it takes for a bird to pass through the length of the max rotor width plus bird length.

Using maximum blade width 4.2m, bird length and bird speed (see Table 2), it is calculated by adding bird length to blade width and dividing by bird speed.

- For example, for Eurasian teal

- Bird transit time through rotor: 0.23s = (4.2m + 0.36m) ÷ 19.7 m/sec

### *Number of transits through rotors*

The number of transits through the rotors is the number of bird expected to fly through the rotors in the year. It is calculated by taking the bird occupancy of the swept rotor volume and dividing it by the bird transit time.

- For example, for Eurasian teal
  - Number of transits through rotors: 1904.07 = 440.74s ÷ 0.23s [3]

### *2.2.3.3 Estimated annual number of collisions assuming no avoidance*

Once the above stage one and two calculations are concluded to calculate collision risk with no avoidance the number of transits through rotors in a year is multiplied by the risk of collision factoring in turbine availability. For the purposes of the model it is assumed all collisions are fatal.

- For example, for Eurasian teal
  - Annual estimated collision risk with no avoidance: 73.69= 1904.07 × 3.87%

Avoidance rates as deemed suitable can be applied to this number to get an estimated annual mortality, for this CRM SNH guidance has been followed and species-specific avoidance rates are shown in Table 2.

## 2.3 Potential Biological Removal

PBR is the maximum human caused mortality than be sustained to a population before To calculate PBR the Dillingham and Fletcher (2008) calculation was used.

$$PBR = N_{min} \times \frac{R_{max}}{2} \times F_R$$

$$N_{min} = \widehat{N}e^{(Z_p CV_{\widehat{N}})}$$

$$R_{max} = \lambda_{max} - 1$$

$$\lambda_{max} = \frac{(s\alpha - s + \alpha + 1) + \sqrt{(s - s\alpha - \alpha - 1)^2 - 4s\alpha^2}}{2\alpha}$$

This calculation requires input of:

- Estimated population size (individuals) – Ñ
- Recovery factor (0.1-1, where appropriate values may be: 1.0 for ‘least concern’ species population increasing or stable. 0.5 for ‘least concern’ species population decreasing. 0.3 for ‘near threatened' species, and 0.1 for all threatened species) - $F_r$
- Adult survival (0.1 – 1) – s
- Age at first reproduction (years) – α
- $Z_p$ was set at -0.842 and $CV_N$ was set at 10% following Dillingham and Fletcher (2008) guidance, these values are used to incorporate uncertainty around population estimates.

For this assessment White stork, Collared pratincole, Curlew, and Ruff were assessed both against the minimum population estimate from the Valea Călmățuiului SPA Table 5, as they are SPA qualifying species, and against the IUCN European minimum population estimate Table 6. The other

3 Excel rounding for ease of display in this report accounts for difference in result and displayed calculation

four species were assessed only once against the IUCN European minimum population estimate. The assessment against the SPA population was made as populations within are most directly at risk from the project. The assessments against European populations are to inform cumulative impacts of the project.

## Table 5: Valea Călmățuiului population estimates

| Latin Name | English Common Name | IUCN European Red List Category | Survival Rate (s) | Age at first reproduction (α) | Minimum Population estimate (Ñ) |
|---|---|---|---|---|---|
| *Ciconia ciconia* | White stork | LC | 0.85 | 4 | 1,500 |
| *Glareola pratincola* | Collared pratincole | LC | 0.74* | 1 | 80 |
| *Numenius arquata* | Curlew | NT | 0.899 | 2 | 80 |
| *Philomachus pugnax* | Ruff | NT | 0.524 | 2 | 800 |

## Table 6: European population estimates

| Latin Name | English Common Name | IUCN European Red List Category | Survival Rate (s) | Age at first reproduction (α) | Minimum Population estimate (Ñ) |
|---|---|---|---|---|---|
| *Ciconia ciconia* | White stork | LC | 0.85 | 4 | 502,000 |
| *Falco tinnunculus* | Common kestrel | LC | 0.69 | 1 | 823,000 |
| *Falco vespertinus* | Red-footed falcon | VU | 0.67 | 2 | 115,000 |
| *Glareola pratincola* | Collared pratincole | LC | 0.74* | 1 | 17,500 |
| *Numenius arquata* | Eurasian curlew | NT | 0.899 | 2 | 405,000 |
| *Pelecanus onocrotalus* | Great white pelican | LC | 0.78** | 3 | 18,700 |
| *Philomachus pugnax* | Ruff | NT | 0.524 | 2 | 513,000 |
| *Vanellus vanellus* | Northern lapwing | VU | 0.705 | 2 | 3,180,000 |

**Survival rate used is a proxy derived from Northern Lapwing and Golden Plover and research by Watson et al 2006*

***Survival rate used is a proxy derived from Brown Pelican and research by Walter et al 2013*

IUCN European Red List category and European population estimates were taken from IUCN redlist online, SPA minimum population estimates were taken from the Valea Călmățuiului Europa.eu Natura2000 data sheet, survival rate and age at first reproduction were taken from either BTO birdfacts and/or Birds of the Western paleartic. For Collared pratincole and Great white pelican proxy survival rates are used based on similar species with similar lifestyles.

# 3. RESULTS

## 3.1 Estimated Annual Mortality

Following all the calculations detailed in section 2.2.3 based on parameters and data contained in section 2 yields the results shown in Table 7.

The highest estimated mortality with avoidance is for Mallard at 8.53 collisions per year. The next highest is White stork with 1.7 collisions per year, and then Eurasian teal with 1.47 collisions per year. All other species modelled have <1 mortality per year and the next highest is Golden plover with an estimated 0.54 collisions per year.

The two IUCN globally Vulnerable species Red-footed falcon and Northern lapwing are estimated to have 0.045 and 0.291 collisions annually respectively. This can be expressed as 1 mortality every 22.2 years, and 1 mortality every 3.4 years respectively. Within the project assumed lifespan of 25 years this is a total of 1.13 estimated project mortalities and 7.29 estimated project mortalities respectively.

The two IUCN globally Near Threatened species Curlew and Ruff are estimated to have 0.026 and 0.510 collisions annually respectively. This can be expressed as 1 mortality every 38.5 years, and 1 mortality every 2 years respectively. Within the project assumed lifespan of 25 years this is a total of 0.65 estimated project mortalities and 12.76 estimated project mortalities respectively.

Four species, White stork, Ruff, Collard pratincole, and Eurasian curlew are qualifying species of the Valea Călmățuiului SPA. All four of these species are estimated to have less than 2 mortalities per year (range 0.026-1.702) as seen in Table 7. Some of the birds counted during VP survey are assumed to be from passage and some are assumed resident with the SPA, therefore mortality estimates for these species will involve a proportion of birds on passage rather than those solely associated with the SPA site. White stork with 1.702 estimated annual collisions is the most at risk of the four SPA cited species.

These are precautionary assessments, as in reality a proportion of the birds potentially affected by collision mortality will be on passage rather than drawn directly from the SPA population.

Results in Table 7 are presented with SNH recommended avoidance rates applied (bold text), and the 0% avoidance result of the model is also given. This allows different avoidance rates to be applied to these results in the future if appropriate.

## Table 7: Estimated Annual Mortality of Species in the Vifor Wind Farm Array

| Latin Name | English Common Name | SNH recommended avoidance rate | Estimated mortality (0% avoidance) | Estimated mortality (with avoidance) | Years per estimated bird mortality (with avoidance) |
|---|---|---|---|---|---|
| *Anas crecca* | Eurasian teal | 98.0% | 73.69 | **1.474** | 0.7 |
| *Anas platyrhynchos* | Mallard | 98.0% | 426.28 | **8.526** | 0.1 |
| *Anser albifrons* | Greater white-fronted goose | 99.8% | 33.03 | **0.066** | 15.1 |
| *Buteo buteo* | Common buzzard | 98.0% | 13.633 | **0.273** | 3.7 |
| *Ciconia ciconia* | White stork | 98.0% | 85.12 | **1.702** | 0.6 |
| *Circus cyaneus* | Hen harrier | 99.0% | 0.51 | **0.005** | 194.4 |
| *Egretta garzetta* | Little egret | 98.0% | 0.80 | **0.016** | 62.6 |
| *Falco tinnunculus* | Common kestrel | 95.0% | 5.83 | **0.292** | 3.4 |
| *Falco vespertinus* | Red-footed falcon | 98.0% | 2.25 | **0.045** | 22.2 |
| *Glareola pratincola* | Collared pratincole | 98.0% | 2.73 | **0.055** | 18.3 |
| *Numenius arquata* | Eurasian curlew | 98.0% | 1.30 | **0.026** | 38.5 |
| *Pelecanus onocrotalus* | Great white pelican | 98.0% | 9.50 | **0.190** | 5.3 |
| *Philomachus pugnax* | Ruff | 98.0% | 25.52 | **0.510** | 2.0 |
| *Pluvialis apricaria* | European golden plover | 98.0% | 27.13 | **0.543** | 1.8 |
| *Vanellus vanellus* | Northern lapwing | 98.0% | 14.57 | **0.291** | 3.4 |

## 3.2 Potential Biological Removal

### 3.2.1 *Valea Călmățuiului SPA populations*

The results of the calculation for PBR using Valea Călmățuiului SPA population estimates are shown in Table 8.

**Table 8: PBR results for Valea Călmățuiului SPA populations**

| Species | λmax | Rmax | Nmin | Recovery factor ($F_r$) | PBR (individuals) | CRM estimated mortality | Project proportion of assessed PBR |
|---|---|---|---|---|---|---|---|
| White stork | 1.145 | 0.145 | 1378.871 | 1 | 100.246 | 1.702 | 1.7% |
| Collared pratincole | 1.510 | 0.510 | 73.540 | 1 | 18.750 | 0.055 | 0.29% |
| Curlew | 1.201 | 0.201 | 73.540 | 0.3 | 2.216 | 0.026 | 1.17% |
| Ruff | 1.383 | 0.383 | 735.398 | 0.3 | 42.266 | 0.51 | 1.21% |

The results show that whilst these SPA populations are highly sensitive to non-natural mortality (especially Curlew with 2.216 individual non-natural mortalities) the project annually is not expected to have a deleterious impact on the viable population of these species within the SPA, and therefore during the operational project lifespan it will also not have a population effect.

### 3.2.2 *European populations*

The results of the calculation for PBR using European population estimates are shown in Table 9.

**Table 9: PBR results for European populations**

| Species | λmax | Rmax | Nmin | Recovery factor ($F_r$) | European PBR (individuals) | CRM estimated mortality | Project proportion of assessed PBR |
|---|---|---|---|---|---|---|---|
| White stork | 1.145 | 0.145 | 461462 | 1 | 33549.068 | 1.702 | 0.005% |
| Common kestrel | 1.557 | 0.557 | 756541 | 0.5 | 105305.99 | 0.292 | <0.0003% |
| Red-footed falcon | 1.332 | 0.332 | 105713 | 0.1 | 1754.8178 | 0.045 | 0.003% |
| Collared pratincole | 1.510 | 0.510 | 16086.8 | 1 | 4101.353 | 0.055 | 0.001% |
| Eurasian curlew | 1.201 | 0.201 | 372295 | 0.3 | 11218.343 | 0.026 | <0.0003% |
| Great white pelican | 1.207 | 0.207 | 17189.9 | 1 | 1781.063 | 0.190 | 0.011% |
| Ruff | 1.383 | 0.383 | 471574 | 0.3 | 27102.981 | 0.510 | 0.002% |
| Northern lapwing | 1.317 | 0.317 | 2923207 | 0.1 | 46380.217 | 0.291 | 0.001% |

The results show that the project will have an estimated impact of maximum 0.011% of the total European PBR for Pelican, 0.005% of the total PBR for White stork, and 0.003% of the total PBR for Red-footed falcon. These when considered on a project only basis are unlikely to cause any population level effects, but should be considered as part of a cumulative analysis on European populations.

## 4. CONFIDENCE IN THE MODELLING

The vantage point surveys were conducted over a 5656.867ha area covering the majority of the area of the windfarm. The windfarm occupies a 4404.86ha area, this means 128.42% of the area of the Windfarm has been covered by the surveys. There is some minor overlap of the vantage point survey view sheds which could have led to some double counting of activity. The overlapping areas are not large and this is unlikely to be significant, it is likely there is only a slight increase in estimated mortality and no underestimation of collision risk as a result.

Turbine layouts have changed since initial vantage point survey design. Figure 1 shows VP 8 which no longer contains proposed turbine locations along with 6 turbines adjacent to VP 8. Data from VP8 was discounted from the modelling as it is geographically separate from the rest of the proposed array. The layout change doesn't significantly change confidence in the model and results.

Some turbines are located outside of VP survey viewsheds, this means that some of the array will not have been covered by the VP survey effort. This is a limitation and slightly reduces confidence in the model as species an activity levels in these areas are unknown. However, the landscape is similar in features and use to other areas covered by VP survey and the total number of turbine sites not surveyed is relatively low. They are also very close to areas that were surveyed. It is therefore likely that any species flying in this area would have been present at one of the VP locations.

The model follows the most up to date NatureScot (a.k.a SNH) guidance. The project is located within Romania and there is a possibility of local variances to best practice, particularly with avoidance rates, however it is acknowledged that NatureScot is the authority on Collision Risk Modelling. Some parameters used the model are based on worst case design and precautionary operational parameters, and this this could lead to overestimation of collisions. The Band model is acknowledged as precautionary in its estimates and the selection of worst case parameters also increases estimated collision risk, this is a slight increase and doesn't affect confidence in the model and results.

It is expected that the majority of flights by the majority of bird species will tend to be closer to the ground with a near exponential decrease in proportion of flights at greater heights, numerous studies show this relationship. The model assumes uniform flight heights and this has likely led to an overestimation of collisions. The utilisation of a correction factor for the 2m increased swept zone over the surveyed risk zone and the 5m increase in starting height of the collision risk zone height over that surveyed also add to the possibility of over estimation within the model. Realistically with a 5m increase in total height we expect less flights in the collision risk zone.

The PBR calculation is adapted from one originally created for marine mammals, the results are indicative of population resilience to depletion and do not constitute a quota of acceptable loss.

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