Avifaunal Impact Assessment, and Collision-Risk Modelling for the Proposed Aberdeen Wind Facility 2, 2023

Produced for:

Aberdeen Wind Facility 2

(Pty) Ltd - logo

Produced by:

CONTENTS

SUMMARY

Aberdeen Wind Facility 2 (Pty) Ltd proposes the development of the Aberdeen Wind Facility 2 (AWF2) on farmland 20-km west of Aberdeen, in the Eastern Cape, comprising up to 41 turbines. This is the final avian assessment combining four seasonal surveys (over five visits) by Birds & Bats Unlimited (BBU), and high resolution tracking data for breeding Black Harriers.

The main surveys were conducted by BBU over a 12-month period in 2021/2022 and were split into the southern and northern sections due to the size of survey area, (approx. 22 800-ha) and the additional monitoring hours required for the northern section, which fell within the satellite-tracked Black Harrier foraging areas from (2011/2012).

The DFFE Screening Tool classified the area as of High Sensitivity (with four Red Data species) and Birdlife South Africa' national avian sensitivity map suggests low to medium-high sensitivity for birds and wind farms. However, inspection of the national bird atlas data set (SABAP 2) including our own species records added five additional RD species and numerous collision-prone species. Thus, in high rainfall years BBU suggest that it be classed as Very High sensitivity and the data and models that follow allow us to reduce risk by constructing a model of the risks to the birds present.

Over four seasons, 2447 flights of 15 Priority species were recorded in 1527.6 hours of observations across all three wind farms. Because the WEF boundaries were established subsequent to the start of data collection, some of the VPs bisect WEF boundaries. Thus, the Collision-Risk modelling considers data collected cumulatively across the cluster, and all risk areas (including fatality estimates) will be more accurate as they are based on a large accumulation of data. The CRM then allows us to inform each WEF area for the avian risks therein, despite birds crossing the boundaries super imposed.

Of the 15 Priority species, seven Red Data species and six Least Concern species were recorded. We show the study area experienced high rainfall following years of drought which brought in locust swarms, mosquitos, and a rich diversity of birds. This is expected in arid Nama-Karoo areas and promotes more birds and more individuals. As such it provides a "worst case" (high richness) scenario against which to judge the impacts of a proposed wind farm.

Among the Red Data (RD) species, 1012 flights were recorded in 1467 hours in the WEF giving a medium-high Passage Rate of 0.69 RD flights per hour; these were dominated by Blue Cranes *Anthropoides paradiseus* (47% of all flights) and Ludwig's Bustards *Neotis ludwigii* (29%). Among Least Concern (LC) species the small falcons combined (Lesser Kestrel *Falco naumanni,* Amur Falcon *F. amurensis* and the rare European Hobby *F. subbuteo*) were commonly recorded.

Collision Risk Modelling (CRM) was used to fine-tune and identify areas where priority species are most likely to be impacted by proposed wind turbines and associated infrastructure. It was also able to calculate estimated annual fatality per year. The CRM analysed all priority species (i.e. all Red Data species and all Least Concern species considered to be collision-prone). This work marks the first time that CRM has been undertaken for a suite of species across an entire wind farm in southern Africa and was expertly undertaken by Dr Robin Colyn.

Adequate data were collected from 13 of the 15 species to undertake the CRM analysis: Risk was based on the predicted number of fatalities for each of the seven RD species and six LC species, spatially and per turbine. The CRM assessment weighted *Endangered* RD species higher than other classes and all higher than LC species. It also accounted for their collision-propensity to to produce a spatially explicit risk map giving eight levels of risk for the entire area.

The highest risk areas (class 5.5 and above) were clumped in the northern sections. Because they encompassed more than 80% of risky flights for most species these areas were classified as too risky for development and allocated as No-Go areas. This covered 12.6% of the total area of the three wind farms. Other areas classified as medium risk to birds were identified, and turbines there require two-tiers of mitigations: coloured-blade and shut-down-on-demand [SDOD] (automated or human-led).

Activity centres of four species (Blue Crane, and three small falcon/kestrel species) were not associated with the core areas of risk in the central north of the entire cluster and these maps will be assessed in the reports for Aberdeen WEFs 2 and 3 to relocate turbines away from all high risk areas.

Using these results, the applicant re-modelled the optimal turbine layout on AWF2 to (i) avoid all high-risk areas; and (ii) to minimise turbines in medium-risk areas as presented here. Impact Significance Tables are presented before and after these mitigations for the whole study site. Cumulative mitigations for all wind farms that fall within 30-km of the Aberdeen WEF are presented.

According to available information presented here from 18 months monitoring and subsequent CRM assessment based on the optimised layout for each of the 41 turbines for Aberdeen Wind Facility 2, the wind farm has avoided all identified high-risk areas. Birds & Bats Unlimited are of the professional opinion, that there are no fatal flaws from an avifaunal sensitivity perspective. Thus, we see no avian reasons preventing the Aberdeen Wind Facility 2 from receiving Environmental Authorisation (EA).

SPECIALIST EXPERTISE / DECLARATION

Dr Rob Simmons, Director of Birds & Bats Unlimited is an ecologist, ornithologist, and environmental consultant, with over 30 years' research experience in North America, Africa, Europe, and Asia. Permanent Resident in South Africa. Currently a Research Associate of the FitzPatrick Institute's Centre of Excellence, University of Cape Town. Formerly employed in Namibia's Ministry of Environment & Tourism as the state ornithologist, specialising in wetland, avian and montane biodiversity. Schooled in London (Honours: Astrophysics), Canada (MSC: Biology) and South Africa (PhD: Zoology).

SURVEY EXPERIENCE:

- **Sandwich Harbour avifauna** – a 30-year project assessing fluctuations in wetland avifauna relative to Walvis Bay via random plot counts - published in *Conservation Biology* (Simmons et al. 2015)
- **Arid species diversity across a rainfall gradient -** a 3-year project at 5 sites across a 270 km gradient, assessing avian diversity in 3 Namibian habitats. Dry rivers critical refugia as biodiversity declined *Ecosystems,* Seymour et al (2015)
- **Population monitoring of Namibian endemics**–Determined densities and overall population numbers of all 16 Namibian endemic birds with Edinburgh University published *Biological Conservation* Robertson et al (1996);
- **Damara Tern status** – devised a stratified random survey of the 1470-km Namibian coast, to determine the global population of this tern. Published *Ibis* 1998. Angolan breeding colonies published *Af J Mar Sci,*
- **Black Harrier status** – from 2000-present, study of *Endangered* Black Harriers in South Africa, followed by satellite tags to determine ecology and migration with FitzPatrick students. *PlosOne* Garcia-Heras et al. (2019).

Research on new avian mitigation measures for the wind and power industry:

- **testing use of vulture restaurants** to draw vultures away from wind farms in Lesotho.
- proposing and **testing coloured-blade mitigation** to reduce raptor fatalities in SA.
- **Implementing staggered pylons on parallel lines** as the first effective mitigation for high bustard deaths.

Environmental Impact Assessments (renewable energy, power lines, mining, airports):

- birds impacted by a proposed Haib **copper mine** near the Orange River (1994);
- siting of proposed Lüderitz **wind farm** prior to formal assessments for NamPower (1997);
- impact of **water abstraction** from Karst System wetland birds Tsumeb (2003) (J Hughes);
- impact of **uranium mine** at Valencia, Khan River, Namibia (Aug 2007, Feb 2008)
- **Biodiversity surveys** in Namib Desert, Angola, (SANBI–Angola joint surveys- Dr B. Huntley)
- **Wind farm** assessments on the west coast at Kleinsee and Koingnaas (Savannah – 2011)
- EIA report on avian impacts at Namaqualand + Springbok **wind farms** (Mulilo –2015, 2017)
- Pre-construction avian impacts at the Witteberg (Karoo) **wind farm** site – (Anchor Environmental 2011-2012) and Verreaux's Eagles (G7/Building Energy 2014-2015, 2019) + Amendments (Building Energy 2019)
- Pre-construction avian monitoring Karoshoek CSP-trough **CSP-tower** Solar Park (Upington) (Savannah Environmental for Emvelo Eco Projects, 2015-2016)
- Pre-construction avian impacts at a Tankwa Karoo **wind farm** (Genesis Eco-Energy 2016-17)
- Pre-construction avian impacts at **Juno SOLAR PV,** Strandfontein (AMDA Pty Ltd, 2016-2017)
- Specialist studies of Red Data raptors at Jeffreys Bay **wind farm** (Globeleq, 2016-2019)
- Pre-construction avian impacts at Namas and Zonnequa **wind farms**, Kleinsee N. Cape (Atlantic Energy Partners and Genesis Eco-Energy 2016-17);
- Pre-construction vulture impacts and mitigations tests, Letseng **wind farm** Lesotho (eGEN+AGR 2017-18);
- Walvis Bay **waterfront development** impacts on Walvis Bay lagoon avifauna (ECC) 2017
- Avian-**power line** EIA study of 450 km-long, 400 kV line (Lithon-Nampower 2017-2018);
- Pre-construction avian impacts of Kappa 1 and 2 **wind farms** in Tankwa (Eco-Genesis 2018-2019);
- Pre-construction avian impacts of Nama Karoo **wind farms** Komas + Gromis (Enertrag) 2019;
- Avian impacts along Kruisvallei **Hydro-project power line** Free State and IFC compliance(Building Energy 2019)
- Amendments to avian impact assessment -hub height considerations - at the Springbok (Nama-Karoo) **wind farm** site (Mulilo 2019) and the Namas and Zonnequa **wind farms** (Enertrag) 2019
- Specialist studies of Black Harriers at **Elands Bay** wind farm and aquaculture site (Planet Capital 2020)

I, Robert E. Simmons, as the appointed independent specialist, in terms of the 2014 EIA Regulations, declare that:

- I act as the independent specialist in this application;
- I perform the work in an objective manner, even if this results in findings that are not favourable to the applicant;
- I regard the information contained in this report as it relates to my specialist input/study to be true and correct, and do not have, and will not have, any financial interest in the undertaking of the activity, other than remuneration for work performed in terms of the NEMA, the Environmental Impact Assessment Regulations, 2014 and any specific environmental management Act;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I have no vested interest in the proposed activity proceeding;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- I have ensured that information containing all relevant facts in respect of the specialist input/study was distributed or made available to interested and affected parties and the public and that participation by interested and affected parties was facilitated in such a manner that all interested and affected parties were provided with a reasonable opportunity to participate and to provide comments on the specialist input/study;
- I have ensured that the comments of all interested and affected parties on the specialist input/study were considered, recorded and submitted to the competent authority in respect of the application;
- all the particulars furnished by me in this specialist input/study are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Dr R E Simmons

10 December 2022,

Revised 20 January 2023. 3 march 2023

Consultancy work at: http://www.birds-and-bats-unlimited.com

Papers and academic background at: www.fitzpatrick.uct.ac.za/fitz/staff/research/simmons

SPECIALIST DECLARATION

DETAILS OF THE SPECIALIST, DECLARATION OF INTEREST AND UNDERTAKING UNDER OATH

	(For official use only)
File Reference Number:	
NEAS Reference Number:	DEA/EIA/
Date Received:	

Application for authorisation in terms of the National Environmental Management Act, Act No. 107 of 1998, as amended and the Environmental Impact Assessment (EIA) Regulations, 2014, as amended (the Regulations)

PROJECT TITLE

Aberdeen Wind Facility 2, Eastern Cape Province - AVIAN Basic Assessment Report - 2023

Kindly note the following:

1. This form must always be used for applications that must be subjected to Basic Assessment or Scoping & Environmental Impact Reporting where this Department is the Competent Authority.
2. This form is current as of 01 September 2018. It is the responsibility of the Applicant / Environmental Assessment Practitioner (EAP) to ascertain whether subsequent versions of the form have been published or produced by the Competent Authority. The latest available Departmental templates are available at https://www.environment.gov.za/documents/forms.
3. A copy of this form containing original signatures must be appended to all Draft and Final Reports submitted to the department for consideration.
4. All documentation delivered to the physical address contained in this form must be delivered during the official Departmental Officer Hours which is visible on the Departmental gate.
5. All EIA related documents (includes application forms, reports or any EIA related submissions) that are faxed; emailed; delivered to Security or placed in the Departmental Tender Box will not be accepted, only hardcopy submissions are accepted.

Departmental Details

Postal address:

Department of Environmental Affairs

Attention: Chief Director: Integrated Environmental Authorisations

Private Bag X447, Pretoria 0001

Physical address:

Department of Environmental Affairs

Attention: Chief Director: Integrated Environmental Authorisations

Environment House

473 Steve Biko Road, Arcadia

Queries must be directed to the Directorate: Coordination, Strategic Planning and Support at:

Email: EIAAdmin@environment.gov.za

Specialist Details

Specialist Company Name:	Birds & Bats Unlimited			
B-BBEE	Contribution level (indicate 1 to 8 or non-compliant)	4	Percentage Procurement recognition	100
Specialist name:	Dr Robert E Simmons			
Specialist Qualifications:	PhD (Wits), MSc (Acadian Univ, Canada), BSc Hons (London)			
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E-mail:	Rob.Simmons@uct.ac.za			

DECLARATION OF INDEPENDENCE BY THE SPECIALIST

I, DR ROB SIMMONS, declare that –

- I act as the independent specialist in this application;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the Act, Regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, Regulations and all other applicable legislation;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- all the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of regulation 48 and is punishable in terms of section 24F of the Act.

Signature of the Specialist

Birds & Bats Unlimited

Name of Company

7 March 2023

1. INTRODUCTION

1.1 BACKGROUND

Aberdeen Wind Facility 2 (Pty) Ltd (hereafter referred to as "the applicant") has proposed the development of the Aberdeen Wind Facility 2 (AWF1) on farmland 20-km west of Aberdeen, in the Eastern Cape.

The entire extent of the site falls within the Beaufort West Renewable Energy Development Zones (i.e. REDZ Focus Area 11). The undertaking of a basic assessment process for the project is in-line with the requirements stated in GNR 114 of 16 February 2018.

The project is planned as part of a larger cluster of renewable energy projects, which includes two adjacent farms up to 240MW Wind Energy Facilities (i.e. Aberdeen Wind Facility 1 and Aberdeen Wind Facility 3).

As part of the feasibility investigations towards the suitability of the site for wind farm development, Birds & Bats Unlimited (BBU) was appointed by the applicant to conduct an avifaunal screening assessment for the site, conduct the necessary 12 months pre-construction bird monitoring for the developable area and undertake the Avifaunal Impact Assessment in compliance with Government Gazette 43110, GN 320, 20 March 2020 ("Protocol For The Specialist Assessment and Minimum Report Content Requirements for Environmental Impacts on Avifaunal Species by Onshore Wind Energy Generation Facilities where the Electricity Output is 20 Megawatts or More"). That is to

(i) complete a "Reconnaisance Study" (typically known as a Scoping/Screening study, but only if it's outside a REDZ)
(ii) prepare a pre-application avifaunal monitoring plan (BBU follows exactly the avifaunal monitoring of Birdlife South Africa [Jenkins et al. 2015]
(iii) undertake the avifaunal assessment and provide a detailed avifaunal report as found here.

1.2 PROJECT DESCRIPTION

Aberdeen Wind Facility 2 (Pty) Ltd is proposing the development of a commercial Wind Energy Facility and associated infrastructure on a site located approximately 20km west of the town of Aberdeen in the Eastern Cape Province. The site is located within the Dr Beyers Naude Local Municipality in the Sarah Baartman District Municipality (See Study area below)

The Aberdeen Wind Facility 2 is planned as part of a larger cluster of renewable energy projects, including two adjacent wind farms up to 240MW Wind Energy Facilities and 41 turbines each (i.e., Aberdeen WEF 2 and Aberdeen WEF 3).

Aberdeen Wind Facility 2 will have a contracted capacity of up to 240MW and comprise up to 41 wind turbines with a capacity of up to 8MW each. The project will have a preferred project site of approximately 9180-ha, and an estimated disturbance area of up to 62-ha. The Aberdeen Wind Facility 2 project site is proposed to accommodate the following infrastructure:

- Up to 41 wind turbines with a maximum hub height of 200-m, rotor diameter of up to 200-m, blade length of up to 100-m and have a rotor tip height of up to 300-m. The turbine foundations will have a combined permanent footprint of 6-ha and a further 13-ha for all turbine crane hardstands.

- Medium-voltage (MV) power lines internal to the wind farm will be trenched and located adjacent to internal access roads, where feasible.
- Up to 132kV on-site substation up to 2-ha in extent.
- Battery Energy Storage System (BESS) with a footprint of up to 5-ha.
- A main access road of approximately 2.5-km in length and up to 10-m in width.
- An internal road network between project components inclusive of stormwater infrastructure. A 12-m wide road corridor may be temporarily impacted during construction and rehabilitated to 6-m wide after construction.
- Access to the facility will be via an existing gravel road off the R61. The gravel road is well established (~10-m wide excluding road reserve), however it is likely upgrades will be required at the access point off the R61 and potentially at water crossings.
- Gate house and security: up to 0.5-ha
- Operation and Maintenance buildings (includes control centre, offices, warehouses, workshop, canteen, visitors centre, staff lockers, etc.): Up to 2-ha.
- Site camp up to 1-ha.
- Construction laydown areas up to 9-ha.

Table 1 Summary of all infrastructure and dimensions for turbines and related infrastructure for the proposed Aberdeen Wind Farm 2

Infrastructure	Footprint and dimensions
Number of turbines	Up to 41 turbines
Hub Height	Up to 200m
Tower height	Up to 200m
Rotor Diameter	Up to 200m
Length of blade	~100m
Contracted Capacity	Up to 240MW (individual turbines up to 8MW in capacity each)
Tower Type	Full steel, full concrete, or hybrid
Area occupied by the on-site substation	Main Facility Substation of 2ha. The general height of the substation will be a maximum of 10m, however, will include switchgear portals up to 15m in height and lightning masts up to 25m in height.
	132kV
Temporary infrastructure	Up to 51ha. Temporary infrastructure, including laydown areas and hardstand, will be required during the construction phase. The construction period laydown area will be rehabilitated. The temporary hardstand area (boom erection, storage, and assembly area) will also be rehabilitated. The preference for crane hardstands would be to leave them intact for unplanned maintenance/replacement of the blades or nacelle.

The power generated from the project will be sold to Eskom and will feed into the national electricity grid. Ultimately, the project is intended to be a part of the renewable energy projects portfolio for South Africa, as contemplated in the Integrated Resource Plan.

1.3 TERMS OF REFERENCE

The terms of reference for the final Pre-construction Basic Avian Assessment Report, based on the NEMA EIA regulations,
https://screening.environment.gov.za/ScreeningDownloads/AssessmentProtocols/Gazetted_Avifauna_Assessment_Protocols.pdf

are as follows:

- To determine which priority species occur on site and the flights per hour (hereafter passage rates) of each species, particularly the Red Data and collision-prone Least Concern species at the proposed Aberdeen Wind Farm 2 site.
- To provide a summary of Pre-feasibility "Reconnaissance Study" more commonly known as a Scoping/Screening Study, completed at the start of the 12-month process.
- To estimate the density and flight traffic of all collision-prone species in the WEF over a 12-month period.
- To provide sufficient data on all priority species to inform a Collision-Risk Model to identify all medium- and high-risk avian areas within the WEF, based on the occurrence, Passage Rate, flight heights of Priority species found throughout the year.
- To provide a summary of the DFFE Screening Tool output for the Animal Theme and provide an opinion as to whether the Screening Tool Sensitivity assessment is accurate based on our detailed on-site data and analysis
- To provide a semi-quantitative assessment of impacts – before and after – the proposed mitigations.
- To provide recommendations for mitigating the possible impacts identified.
- To provide an assessment of the Cumulative Impacts for other authorised renewable energy facilities with a current Environmental Authorisation within 30-km to estimate possible wide-scale mortalities or displacement; and
- To provide an Environmental Management Programme to implement during the monitoring of the construction-phase and operational-phase of the wind farm, and to ensure that the recommended mitigations are implemented to reduce potential impacts to the Priority avifauna of the area.

Note that this report employs a Collision-Risk Model that is a sophisticated statistical treatment of the risk involved to the collision-prone bird species found on site. This is not only the first time a suite of species have been so modelled for risk in South Africa, but it provides a very accurate assessment of the risk areas and the individual turbines that may be risky. The model is explained in detail below.

2. STUDY AREA

The site is located within the Dr Beyers Naude Local Municipality in the Sarah Baartman District Municipality of the Eastern Cape. The project site comprises the following farm portions:

- Farm Koppieskraal 157
- Remainder of the Farm Doornpoort 93
- Portion 1 of Farm Doorn Poort 93
- Farm Kraanvogel Kuil 155
- Portion 4 of Farm Sambokdoorns 92

2.1 HABITATS AND MICROHABITATS

The study site lies in south-eastern the dry Nama-Karoo biome and straddles two vegetation types officially designated as (i) Gamka Karoo and (ii) Eastern Lower Karoo (NKl 1 and NKl 2, Mucina and Rutherford 2006, p 341-342). The area lies on mudstones and sandstones, and supports arid-tolerant *Stipagrostis* grasses and Karoo dwarf shrubs such as *Chrysocoma ciliate* and *Eriocephalus ericoides*. MAP rainfall very low at 100 mm to 240 mm in the drier west and 150 – 350 mm in the wetter east and higher escarpment areas. In some riverlines, low *Acacia karoo* trees.

Avian habitats here range from the open stony grassy plains where larks and bustards are found. These areas also support the small karoo population of Blue Cranes, that are concentrated around farm dams and flooded areas following good rains. Abundant rains, that are known to promote high avian species richness and abundance in Nama Karoo areas (Seymour et al. 2015), bring influxes of insect-eating kestrels and other falcons onto the plains, and a roost of Lesser Kestrels *Falco naummani* and Amur Falcons *F. amurensis* is known in the town of Aberdeen, 20 km east.

The Camdeboo mountains offer a slightly different (cooler and wetter) environment which in turns supports more grasses, bushes, agriculture and (dammed) water bodies and vleis. This also provides habitat for several red data species in the form of cliff sites for nesting eagles, and wet areas for breeding Black Harriers.

Photos 1 and 2: The contrast between the wetter habitats in the Camdeboo Mountains (left) and the arid plains where wind farms are located (right).

Aquatic habitats on site were limited to ephemeral main water course - alluvial systems with or without riparian vegetation. These ranged from narrow channels to broad flood plain areas. Of importance are the channel areas with riparian vegetation as these remain functional, i.e., contain flows on a more regular basis, while the sandy alluvial areas, are only active during peak flood events with no permanent aquatic habitat or riparian systems. The area has numerous farm dams and weirs / berms but with no wetland or aquatic features. No wetlands were found within the study area, only riverine features such as alluvial floodplains and riparian thickets. Despite its aridity the study area forms the upper catchment of the Gamtoos and Sundays River systems respectively.

2.2 RAINFALL

Rainfall in arid areas is a major determinant of avian species richness (Dean 2004, Seymour et al. 2015) and so it is critical to determine what the rainfall conditions were before and during the 2021/2022 wind farm study. The La Niña conditions favour higher than average Mean Annual Precipitation (MAP) and this was borne out by an analysis of seasonal rainfall over our two study years (2021-2022) relative to the MAP over 37 years (Figures 1 and 2).

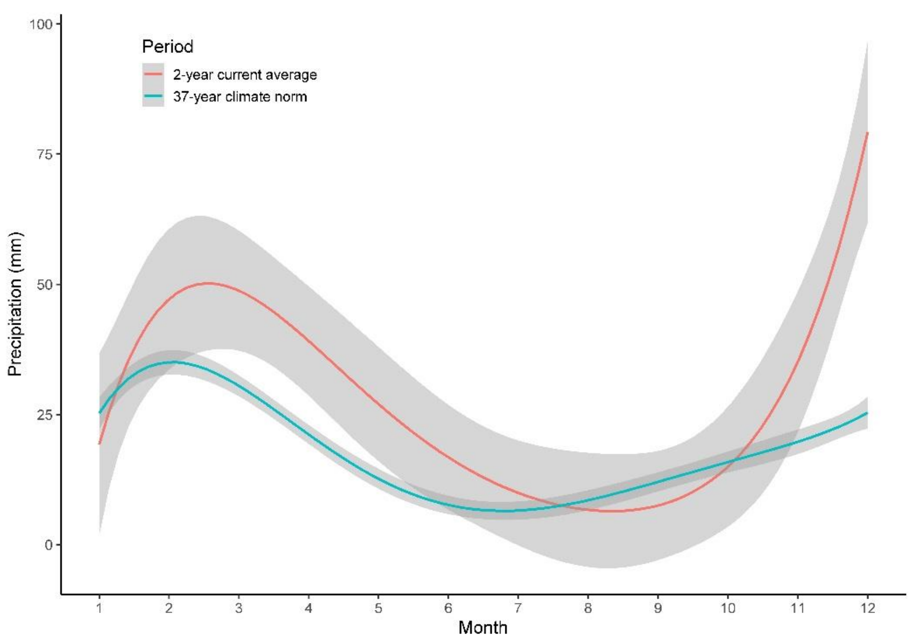


Figure 1: Seasonal difference in rainfall compared between the 2-year period of our surveys (red: 2021-2022) relative to the long term (blue: 37 year) mean.

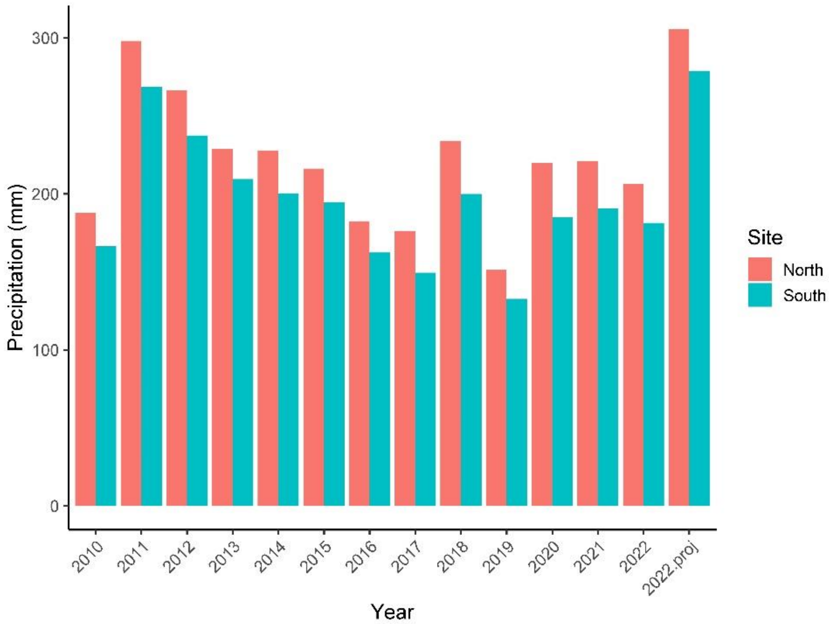


Figure 2: Mean annual precipitation (MAP) differences in rainfall over 12 years since 2010, between the northern and southern Aberdeen sites. Note the recent increase in rainfall in 2022 for both the north and south sites investigated.

Because the determination of rainfall in an arid Nama-Karoo site such as this is critical in understanding the avifauna, (because of the rapid avian response) we graphed the Mean Annual Precipitation (MAP) since 2021/2022 and the seasonal rainfall averaged over 37 years. Summer rainfall in the 2021/22 season was higher than the long term mean (Figures 1 and 2), and thus we can state with some confidence that the avian species richness and the abundance of birds will be higher than during drought years. This was borne out in an analysis of the presence of the Black Harrier and Blue Crane on site (Figure 3) Thus, the figures presented here represent high abundance and species-richness levels that are expected to decrease in future years. As such, from a wind farm perspective the data and modelling here represent the likely worst-case scenario. That is, the modelled high-risk areas and estimates of fatality would be higher than that expected in future drier years.

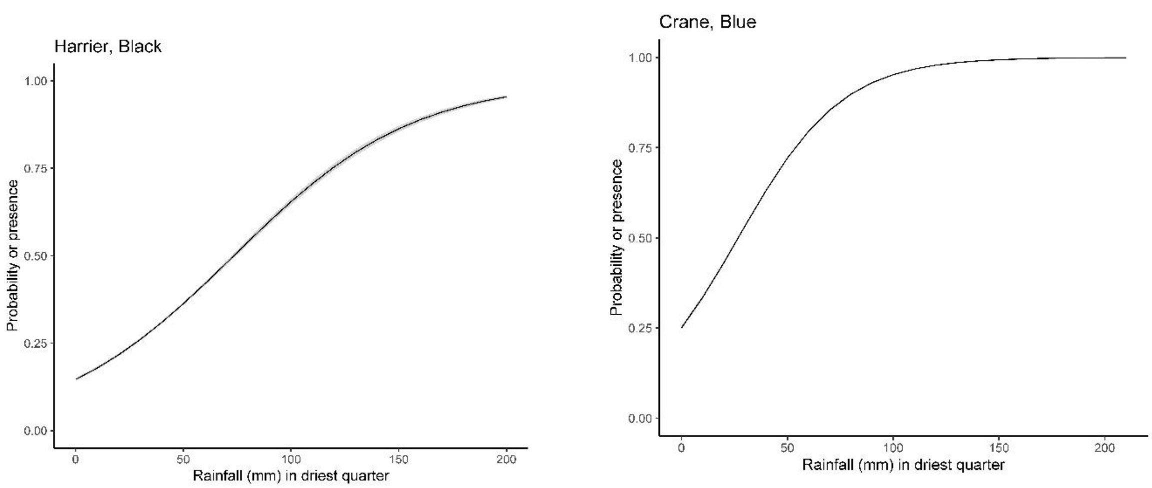


Figure 3: The response to increased rainfall in the study site for two RD species. The likelihood that they will be recorded increases to almost certain (1.0) as rainfall in the driest quarter exceeds 150 mm.

3. STUDY METHODS

3.1 SCREENING STUDY

A Screening Assessment of the proposed Aberdeen Wind Energy Facility (WEF) in the Eastern Cape was undertaken in October-November 2020 by BBU, to determine if the site had any fatal flaws, from an avian perspective. This was required because it lies outside any REDZ.

The 3-day site visit (30th, 31st October and 1st November 2020) allowed an initial snap-shot avian survey of the proposed Aberdeen WEF in the south-eastern Nama Karoo following light rains. We undertook 12 short Vantage Point observations of 1-2 hours each spanning the entire 250-km^2 site (including a North-eastern extension that is no longer considered).

We undertook 18.67-hours of observation from 11 of the 12 VPs (farm 94-0 was not surveyed due to a locked gate) and recorded 18 flights of six Priority species.

The majority of these flights were Red Data species

– the ***Near Threatened*** Blue Crane (*Anthropoides paradiseus);* and
– the ***Vulnerable*** Denham's Bustard (*Neotis denhami).*

We also recorded :

- More Priority birds present in the northern sections of the study site than elsewhere
- Higher densities of Blue Cranes in the eastern sections of the site. These birds were roosting and gave no indication of breeding. A wetland east of the study site held large numbers of birds.
- Large number of Ludwig's Bustards deaths in the western sections due to the presence of small 32-kV or 66-kV power lines that ran through the area. The unadjusted fatality rate of 4.62 bustards per km is well above the national average of 0.37 bustards killed per km on 66 kV lines (Shaw 2015), and should be mitigated.
- In the Camdeboo Mountains, we located the active nest of an *Endangered* Black Harrier with a nestling close to the nest site occupied by a pair in 2011. The female of that (2011) pair was tracked foraging south-east onto the plains just north of the proposed wind farm. (see Appendix 3 for the BBU report on this)

Black Harrier tracking: We recommended that the known harrier nest in the Camdeboo Mountains be checked during 2021 seasonal monitoring, and in further discussions with the developer and in consultation with Birdlife South Africa (and their Black Harrier guidelines: Simmons et al. 2020) that the male bird be tracked. The guidelines state that 24 months of monitoring be undertaken if harriers breed on or within 5-km of a wind farm site. In lieu of this however, it was agreed that tracking the harrier while breeding, for 6 months, will suffice. In 2021 the Black Harrier nest was not active, and thus no birds could be caught and tagged. However, in September 2022 a pair were found breeding and the male was trapped and fitted with a 10g Ornitela GPS-tracker and followed for 4 months throughout his full breeding season. Those tracks are reported here as agreed.

The DFFE Screening Report page for the Animal Theme is attached as Appendix 1.

3.2 PRE-CONSTRUCTION AVIFAUNAL MONITORING PROTOCOL

In accordance with the Best Practice guidelines for assessing and monitoring the impact of wind energy facilities on birds in southern Africa, 2015, four seasonally timed site visits across the entire 288-km^2 study area (Figure 4) were undertaken to record all flights of Priority species.

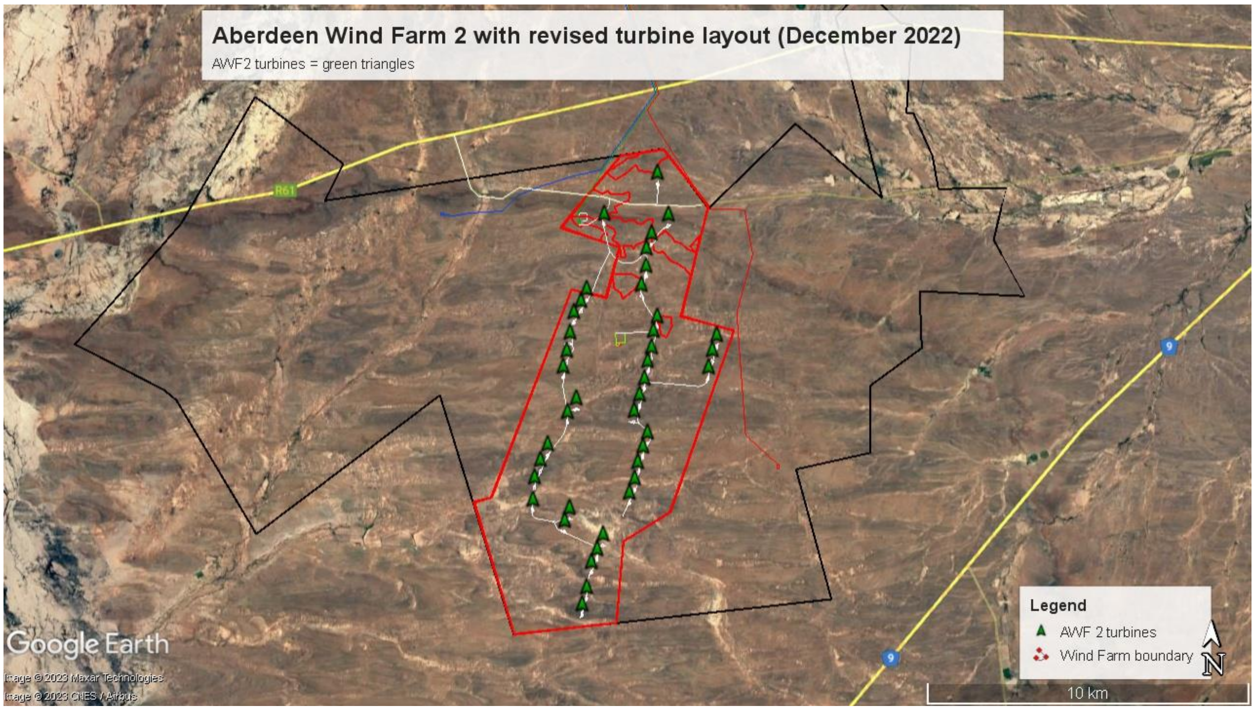


Figure 4: The study site (=red polygon) of the proposed Aberdeen Wind Farm 2, 20-km west of Aberdeen in the Eastern Cape. This map depicts only the wind farm 2 with the revised turbine layout (blue triangles) following the relocation of turbines based on the results of the CRM modelling undertaken here.

Given the large footprint of the whole site (Figure 4) the area was divided into northern and southern sites in which Vantage Point observations differed: In the north 18-hours of observation per VP were undertaken (due to the past presence of Black Harriers, see Figure 10), whereas 12-hours of observations were undertaken in the south. This not only made the large (288-km^2) study area more manageable for the survey teams, but different monitoring protocols (more VP hours) could be applied in the north where the harriers were more likely to occur.

It is not possible to determine the number of hours spent in each of the individual wind farms as the boundaries were revealed only after the majority of the field work was completed. Thus, we have given total hours across all wind farms.

All areas – except the far west – were covered, and species flights recorded. Methods for the Vantage Point (VP) monitoring are given in the seasonal Interim Reports which were undertaken according to the BARESG monitoring protocols (Jenkins et al. 2015).

The entire area was surveyed for Priority collision-prone species over four seasons and five visits.

Flights of all Priority species were recorded in the field, and were undertaken over four equally spaced seasons for the north and south sections as shown:

- October 2021 (spring); North and South

- January/February 2022 (summer); North and South
- April/May 2022 (autumn); North and South
- June/July 2022 (winter). North and South

An additional trip was undertaken to extend monitoring in the North site (where Black Harriers are expected)

- October (spring) North (and JP farm)

Where Black Harriers occur the Black Harrier- wind energy guidelines recommend:

- the observation hours per VP must increase from 12 h to 18 h in each season and
- the monitoring must span 24 months (or at least two full breeding seasons)

In addition to monitoring the northern sections for a 5th iteration we also monitored the breeding site of the Black Harriers in the Camdeboo Mts in November 2021 (and found no breeding) and again in September 2022 with a view to trapping and GPS-tagging the male Black Harriers. It was agreed in discussion with S Ralston-Paton of Birdlife South Africa that tracking results for the male harrier ("Gulliver" in the maps that follow) for six months would yield more spatially explicit data, with more precision, than would teams of observers on site for another 6 months. The capture and GPS-tracking of the male in September 2022 was successful (see Appendix 3) and satisfied these extra criteria. His tracks are presented below (see Figure 10). Note that the data were not subsequently used in the Collision Risk Model with the other species on site because the male never entered the site.

For all other species the BBU survey teams estimated flight height of every collision-prone species in 10-m bands, every 15 seconds; a critical factor in collision risk assessments as this gives an indication of the risk to birds flying within the blade-swept area. The proposed turbines have a hub height of 120-m and blade (rotor) length of 81.5-m. Thus, the blade swept area for the proposed turbines varies from 38-m to 202-m.

To delineate the risky flight heights of each track recorded we used the 80% quartile (rather than the average height) and the minimum, and maximum, heights.

3.3 COLLISION RISK MODELLING

3.3.1 BACKGROUND TO COLLISION RISK MODELLING

Collision Risk Modelling (CRM), developed by Band et al. (2007), has been used for many years to assess more precisely the risk to birds as they pass through a wind farm environment. More sophisticated models that take uncertainty into account have since appeared (New et al. 2015), fine-tuning the analysis. It is based on a combination of:

- the probability of collision,
- the birds' exposure to turbines (in time and space), and
- a measure of the spatial and temporal extent over which a bird is at risk of collision (the hazardous footprint).

By incorporating uncertainty into the equations, through a Bayesian modelling approach, more realistic estimates of the risk of fatalities are incorporated into the new model (New et al. 2015) used here.

Collision Risk Modelling was used in this study to fine-tune areas where priority collision-prone species are most likely to impact future wind turbines. This work is the first time that CRM has been undertaken for an entire wind farm in southern Africa across a suite inclusive of all collision-prone species identified on site. It was expertly undertaken by Dr Robin Colyn who co-authors this Basic Assessment Report.

3.3.2 GENERAL RISK ANALYSIS

The following inputs were used to inform the CRM:

- Flight density (Passage Rates of flights per hour for each species);
- Flight heights (proportion of time spent within the blade-swept area);
- Habitats;
- Proposed Turbine specifications;
- Topography (some raptors use slope and lift in their daily flights); and
- Seasonality (temporal use).

The result is a quantitative prediction of high-risk flights, presented as a proportion of time spent within the BSA. These are presented as classes from 1 (lowest risk) to 8 (highest risk).

As a test of how well these classes performed in protecting any birds that fall within them, we determined the number of "risky flight" minutes (those in the blade swept area) that were captured by each risk class. We took as a guide a figure that 80% of risky flights should be captured by the risk class. For most species the class that was chosen (5.5) performed well. However, for four species (one RD and three LC) this was not so, and we therefore visually inspected their individual spatial risk maps to determine where turbines might be re-located to reduce any risks to them. Thus, at each stage the modelling was fine-tuned to ensure the areas where risk occurred could be avoided by the turbine design. In this we worked closely with the applicant, Aberdeen Wind Farm 2 (Pty) Ltd.

3.3.3 SITE SPECIFIC RISK ANALYSIS

Time spent in the BSA does not alone predict collision risk. A number of other factors could influence collision-risk. For example, increased exposure to a turbine(s) could increase collision risk.

The CRM was taken one step further by including the following inputs:

- Turbine positions available at the time (possible indicator of turbine exposure);
- Conservation status (whereby Red Data species were given a higher weighting than Least Concern Species)[1]
- The turbine collision propensity from empirical data provided from South African Wind farm fatalities (Perold et al. 2020). More fatalities results in a higher ranking.

The result of this second phase of modelling is a "heat map" of the cluster showing the relationship between collision-risk of all priority species and the proposed turbine layout. By observing the change in colours across the map, one can gauge the change in collision-risk.

[1] In the CRM analyses that follow, the Red Data species are given a higher weight than Least Concern Species as follows:

- Endangered = 4
- Vulnerable = 3
- Near Threatened = 2
- Least Concern = 1

Once the collision-risks had been represented spatially, the next step is to determine which risk classes (/colours) were acceptable for development, which required mitigation, and which required avoidance altogether. Because there are few established thresholds for acceptable impacts on bird species in South Africa, this was mainly based on subjective opinion. However, for some species such as the Black Harrier, we know that the death of 3 to 5 more adults per year would send the population to extinction in about 75 years (Cervantes et al. 2022). Thus, for such precarious species we set the bar at zero fatalities for Black Harriers.

We hope that similar population viability modelling of other priority species will allow us to determine thresholds above and below which wind farm developers and specialists can set limits.

3.4 DATA SOURCES AND GUIDELINES

We accessed the DFFE Screening Tool as a first step to identifying if the proposed wind farm site is sensitive to development for birds. The online site was accessed and the results presented in Appendix 2 https://screening.environment.gov.za/screeningtool/#/pages/welcome

As a part of the DFFE defined protocol we must compare the results of the Screening Tool with the results presented here.

- For the Scoping study we accessed the Southern African Bird Atlas Project (SABAP2) national bird data base. This is high-resolution bird available online through the Animal Demography Unit at University of Cape Town and downloaded from http://sabap2.adu.org.za/map_interactive.php. This typically allows an up-to-date bird species list from 2011 to present. The pentads accessed allow an overall species list and a reporting rate (a measure of the likelihood of occurrence). Note that while the data collected on site and analysed via the CRM far exceeds the results presented in SABAP, we have presented it for completeness.
- The ranking of Priority collision-prone species (CPS) was drawn from the BARESG tabulation given in Ralston et al. (2017). We considered only the top 100 collision-prone species as priority species. The sensitivity of these Priority birds to wind farms was sourced from the Birdlife South Africa website site here http://www.birdlife.org.za/conservation/terrestrial-bird-conservation/birds-and-renewable-energy/wind-farm-map Among these priority species are Red Data species that require special attention;
- Red Data species conservation status, and the Red Data classification in South Africa, was sourced from Taylor et al. (2015);
- Important Bird Area (IBA) data were collated from Marnewick et al. (2015) and available at http://www.birdlife.org.za/conservation/important-bird-areas/documents-and-downloads
- We followed the Birdlife South Africa guidelines for monitoring birds at wind farms (Jenkins et al. 2015) and guidelines for red data species found breeding on or near the site (Black Harrier: Simmons et al. 2020, https://www.birdlife.org.za/wp-content/uploads/2020/09/Black-Harriers-Wind-Energy-Final-1.pdf)
- GPS-tracking of the Black Harriers was carried out under the research programme of RE Simmons at the FitzPatrick institute at the University of Cape Town https://www.youtube.com/watch?v=NAgRh-AiJ8I

3.5 LIMITATIONS AND ASSUMPTIONS

Inaccuracies in the above sources of information can limit this study. The SABAP2 national dataset is relatively sparse from this area with 47 full-protocol cards in the 29 pentads that cover the wind farm site and surrounds. These were only used in the modelling to give a historical perspective on overall species richness.

Any site visits to record birds, even over a 12-month period, may not provide a complete picture of all species likely to occur in an arid region. Rainfall is the chief limiting factor as it dictates if, and when, birds occur and whether they breed on site (Dean 2004, Seymour et al. 2015). While drought had dominated this area from 2014-2019, above average rainfall (approximately 3-fold higher) was recorded in the summer and provided a boom period for avian species that may otherwise may not have occurred. Thus, the data presented represent a “worst case scenario” at a particularly species-rich moment.

The CRM analysis is a data hungry model that requires large data sets for each species to determine probabilities and give accurate risk assessments. Some species did not reach these thresholds – because they were seldom recorded. These were : Verreaux’s Eagle, Black Stork and Secretarybird. While this means that no risk assessments can be determined, it also means that the risk for these species is likely to be very low simply because they are seldom on site.

4. BRIEF REVIEW OF WIND FARM IMPACTS

According to a position paper on the subject by Birdlife SA (http://www.birdlife.org.za/conservation/terrestrial-bird-conservation/birds-and-renewable-energy) the main avian wind farm impacts are:

- Collision with the turbine blades or associated infrastructure;
- displacement of nationally important species from their habitats,
- loss of habitat for such species, and
- disturbance during construction and operation of the facility.

Long-term analyses of the effect of wind energy facilities on birds originate from studies from the United Kingdom, the USA, and Spain (www.nrel.gov, Kingsley & Whittam 2005, Drewitt & Langston 2006, Kuvlevsky et al. 2007, Stewart et al. 2007, Drewitt & Langston 2008, Loss et al. 2013).

Studies from South Africa are now beginning to appear and add an African perspective to the data sets (Ralston-Paton et al. 2017, Simmons and Martins 2018, Perold et al. 2020).

With a few exceptions most studies suggest low numbers of bird fatalities at wind energy facilities numbering tens to hundreds of birds per year (Kingsley & Whittam 2005). The observed mortality caused by wind farms is also generally low compared to other existing sources of anthropogenic avian mortality (Crockford 1992, Colson & associates 1995, Gill et al. 1996, and Erickson et al. 2001, Sovacool 2009, 2013). As an example, population declines due to climate change and fossil fuels is estimated at 14.5 million birds annually, whereas wind energy facilities kill about 234 000 birds annually in the USA (Sovacool 2013). See *Benefits of wind farms* (5.2) below. In South Africa, with 32 operational wind farms by the end of 2022, and an average of 36.8 turbines per farm, at an average fatality rate of 4.6 birds/turbine/year (Perold et al. 2020), the projected mortality is about 5420 birds annually.

But which species are susceptible and why? And what mitigation measures have been tried to reduce the impacts?

4.1 COLLISION WITH THE TURBINE BLADES OR ASSOCIATED INFRASTRUCTURE

4.1.1 COLLISION RATES

Avian mortality rates at wind energy facilities are compared in terms of a common unit: mortalities/turbine/year, or mortalities/MW/year (Smallwood & Thelander 2008). Wherever possible, measured collision rates should allow for:

- the proportion of actual casualties detected (and missed) by observers (searcher efficiency); and
- the rate at which carcasses are removed by scavengers (scavenger removal rate, important in an African landscape).
- Cumulative effects over time, especially when applied to large, long-lived, slow-reproducing and/or threatened species (many of which are collision-prone) may be of conservation significance.

The most pertinent results include:

- Loss et al. (2013) estimated that 5.25 (95% Cl: 3.15-7.35) birds are killed per turbine per year across the contiguous United States from a meta-analysis of 53 studies (corrected for searcher efficiency and scavenger rates).

- A peak in California was due to high fatalities at Altamont pass – a migration corridor – where casualties of >1000 raptors, and nearly 3000 birds are killed in turbine collisions annually (Smallwood & Thelander 2008) or 2-4 mortalities per MW per year.
- 13% of the >5000 turbines at Altamont Pass, California, were responsible for all Golden Eagle *Aquila chrysaetos* and Red-tailed Hawk *Buteo jamaicensis* collisions (Curry & Kerlinger 2000).
- Similar figures are known from Jeffreys Bay Wind Farm (JBWF), South Africa, where 25% of the turbines caused 75% of all raptor fatalities (Simmons and Martins 2018).
- An average of about one raptor per month is killed at one South African wind farm over a 4-year period, of which 15% were Red Data species.
- In the Straits of Gibraltar, southern Spain, about 0.04-0.08 birds are killed/turbine/year (Janss 2000a, De Lucas et al. 2008), with relatively high collision rates for threatened Griffon Vultures *Gyps fulvus*.
- A review of South African fatalities over eight years at 20 of the first operational wind farms in South Africa found 4.6 $\pm$ 2.9 birds per turbine per year are killed (Perold et al. 2020). The equivalent for power production was 2.0 $\pm$ 1.3 birds per megawatt.

4.1.2 CAUSES OF COLLISION

Multiple factors influence the number of birds killed at wind energy facilities. These can be classified into three broad groupings:

- **avian variables** (some birds – especially raptors – are more prone to collision than others);
- **location variables** (wind farms placed on migration routes, in pristine vegetation, or near roosts or nests will attract more fatalities than others);
- **facility-related variables** (farms with more turbines, more lighting, or lattice towers may attract more fatalities).

Two studies have shown a direct correlation between the abundance of birds in an area and the number of collision victims (Everaert 2003, Smallwood et al 2009), but De Lucas et al. (2007) questioned this from studies in Spain. BBU however (Simmons and Martins 2018), also found a positive relationship in South Africa over three years between seasonal Passage Rates of Priority Species and the number of fatalities (Figure 5).

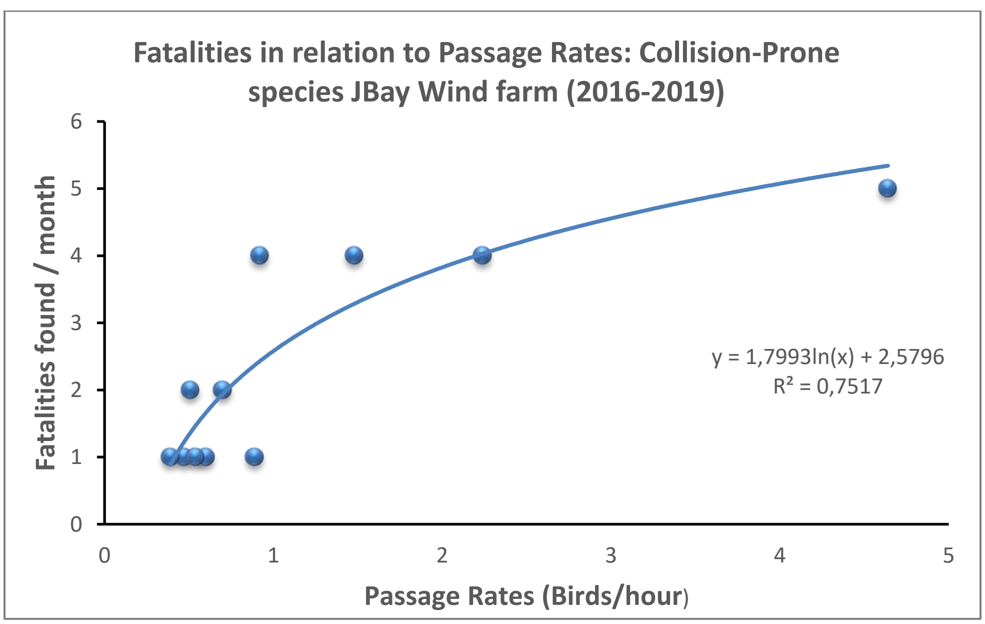


Figure 5: Raptor fatalities in relation to Passage Rates (bird flights/hour) of all raptors in 2-month sampling periods at a South African wind farm over three years (Simmons, Martins, Smallie and MacEwan unpubl data). The relationship is highly significant.

Species-specific variation in behaviour, such as foraging, commuting, or courting, also affect susceptibility to collision (Barrios & Rodríguez 2004, Smallwood et al. 2009). There may also be seasonal and temporal differences in behaviour, for example breeding males displaying, or food-carrying, may be particularly at risk (Simmons 2011, Simmons and Martins 2017).

In 2016, observations on a wind farm in the Eastern Cape indicated that breeding male raptors are particularly susceptible to impacts. This includes both Martial Eagles and Black Harriers flying frequently at rotor-swept height. Given that these birds are providing food for females and young at the time, there are clearly hidden costs to the fatalities beyond the loss of the individual birds – i.e., the loss of the next generation – because breeding females cannot rear a brood alone, as evidenced when all eagle and harrier chicks died after the death of both breeding males (Simmons and Martins 2017).

Landscape features often channel birds towards a certain area and, in the case of raptors, influence their flight and foraging behaviour. Ridges and steep slopes are important factors in determining the extent to which an area is used by gliding and soaring birds (Barrios & Rodríguez 2004). Golden Eagles *Aquila chrysaetos* fly higher (>250-m) over flat terrain and low hills where thermals occur, than over steep slopes (~150-m) where orographic winds give them lift (Katzner et al. 2012).

Migratory eagles tended to fly higher over all landforms (135-m to 341-m) than resident birds (63-m to 83-m). This suggests that wind farms placed on top of steep slopes are more likely to impact eagles than those on flat terrain, and resident birds are more likely to be impacted (flying within the rotor-swept area) than migrants.

High prey-densities will attract raptors, increasing the time spent hunting, and reducing vigilance. Poor weather affects visibility, with birds flying lower during strong headwinds (Hanowski & Hawrot 2000, Richardson 2000). So, when the turbines are functioning at maximum speed, birds are likely to be flying at their lowest – increasing collision risk (Drewitt & Langston 2006, 2008).

Larger wind energy facilities, with more than 100 turbines, are, by definition, more likely to incur increased bird casualties (Kingsley & Whittam 2005), and turbine size may be proportional to collision risk – with taller turbines associated with higher mortality rates in some instances (e.g., De Lucas et al. 2009, Loss et al. 2013).

With newer technology, fewer, larger turbines are needed to generate the same amount of power, which may result in fewer collisions per MW produced (Erickson et al. 1999). Certain tower structures, and particularly the old-fashioned lattice designs, present many potential perches for birds, increasing the likelihood of collisions as birds land at or leave these sites (Drewitt & Langston 2006, 2008).

However, Loss et al. (2013) undertook a meta-analysis of all wind farms and associated fatalities in the USA and found a strong correlation **between increasing hub height or blade length with increased impacts to birds**. Thus, taller turbines appear to be more risky for birds. We have taken that data set and added eight studies from South Africa and found that the relationship still holds (Figure 6).

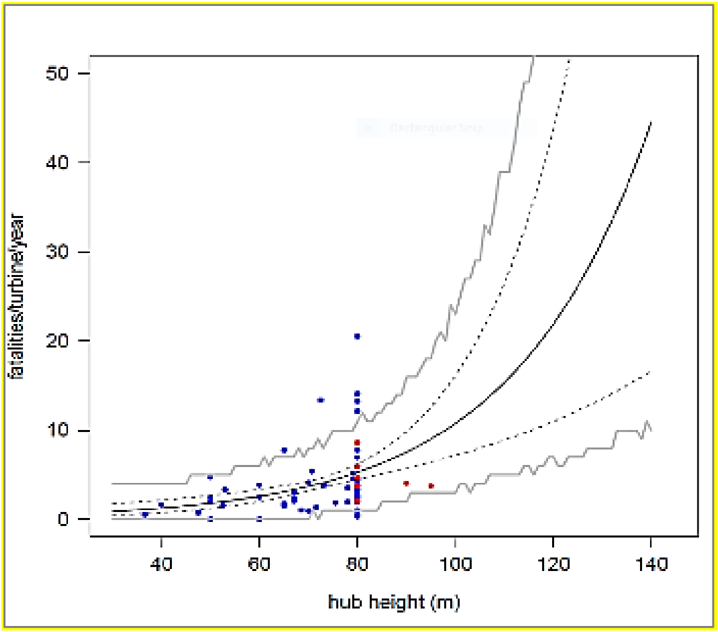


Figure 6: Modelled data combining avian fatalities from the USA (Loss et al. 2013) and from South Africa (= red dots, Ralston-Paton et al. 2017) and their relationship with hub height. The South African data (n=7 farms) include two farms with hub heights of 90-m and 95-m. The combined data and 95% confidence limits predict that 16 birds (95% CI = 9, 28) will be killed on average per year for 120-m-high turbines and 28 (95% CI = 12, 65) birds on average for 140-m-high turbines.

Given that the average number of birds killed for the typical 80-m turbines was 5.40 and it increased to 16 fatalities at 120-m, the increase in fatalities is forecast to be 2.9-fold if turbines are increased from 80-m to 120-m.

Illumination of turbines and other infrastructure often increases collision risk (Winkelman 1995, Erickson et al. 2001), either because birds flying at night mistake lights for stars (Kemper 1964), or because lights attract insects, which in turn attract foraging birds. Changing constant lighting to flashing lighting has been shown to reduce nocturnal collision rates (Richardson 2000, APLIC 1994, Jaroslow 1979, Weir 1976), and changing floodlighting from white to red (or green) can effect an 80% reduction in mortality rates (Weir 1976).

Spacing between turbines at a wind facility can also affect the number of collisions. Some authors have suggested that paths need to be left between turbines so that birds can move through unscathed. Alternatively, those turbines known to kill more birds can be temporarily taken out of service (e.g., during migration or breeding). For optimal wind generation, relatively large spaces are required between turbines to avoid wake and turbulence effects.

4.1.3 COLLISION-PRONE SPECIES

Collision-prone birds [CPB] generally include:

- Large species, or those with high wing-loading (i.e., the ratio of body weight to wing surface area), and with low manoeuvrability (cranes, bustards, vultures, gamebirds, waterfowl, falcons);
- species which fly at high speed (gamebirds, pigeons and sandgrouse, swifts, falcons);
- species which are distracted in flight – predators, or species with aerial displays (many raptors, aerial insectivores, some open country passerines);
- species that habitually fly in low light conditions (flamingos);

- species with narrow field, or no binocular vision (cranes and bustards) (Drewitt & Langston 2006, 2008, Jenkins et al. 2010, Martin & Shaw 2010).

To these we can add those species that more frequently fly at rotor-swept height (e.g., buzzards and eagles) and are more likely to impact turbines (Simmons & Martins unpubl data).

Studies by Martin & Shaw (2010) indicate that, particularly, collision-prone species such as bustards and cranes do not see ahead of them, due to skull morphology, and have a blind region that prevents them from seeing directly ahead. This is one reason why they hit overhead lines so regularly (Shaw et al. 2015).

These traits confer high levels of susceptibility, which may be compounded by high levels of exposure to man-made obstacles such as wind turbines (Jenkins et al. 2010). Exposure is greatest in:

(i) highly aerial species;
(ii) species that make regular and/or long-distance movements (migrants, or any species with widely-separated resources – food, water, roost and nest sites);
(iii) species that fly in flocks (increasing the chances of incurring multiple fatalities in single collision incidents); and
(iv) soaring species where this infrastructure is placed along ridges, because the turbines exploit the same updrafts favoured by such birds – vultures, storks, cranes, and most raptors (Erickson et al. 2001, Kerlinger & Dowdell 2003, Drewitt & Langston 2006, 2008, Jenkins et al. 2010, Katzner et al. 2012).

4.1.4 MITIGATING COLLISION RISK

One direct way to reduce the risk of birds colliding with turbine blades is to render the blades more conspicuous.

Blade conspicuousness is compromised by a phenomenon known as 'motion smear' or retinal blur, in which rapidly moving objects become less visible the closer they are to the eye (McIsaac 2001, Hodos 2002). The retinal image can only be processed up to a certain speed, after which the image cannot be perceived. This effect is magnified in low light conditions, so slow blade rotation may be difficult for birds to see.

Laboratory-based studies of visual acuity in raptors have determined that:

- visual acuity in kestrels is superior when objects are viewed at a distance, suggesting that the birds may view nearby objects with one visual field, and objects further away with another;
- moderate motion of the object ahead significantly influences acuity, and kestrels may be unable to resolve all portions of rotating turbine blades because of motion smear, especially in low light;
- this can be addressed by patterning the blade's surface to maximise the time between successive stimulations of the same retinal region; and
- the least-expensive, and most visible, blade patterns for this purpose, effective across several backgrounds, is a double striped single black blade (Figure 7 and Figure 8) in amongst white blades (McIsaac 2001, Hodos 2002).

Figure 7: A single, black-painted blade on turbines on the island of Smøla, Norway. This simple mitigation reduced eagle fatalities by 100% relative to unpainted controls over 7 years. Civil Aviation Authorities in Norway permitted this new mitigation technique, setting a precedent for other aviation authorities in the world (from May et al. 2020). South African CAA have recently allowed the first signal red blades in South Africa.

Black-painted blade technology was tested in Norway where, on the island of Smøla, high mortality rates of White-tailed Eagles *Haliaetus albicilla* occurred. Eagle fatalities were reduced 100% over a two-year experiment (May et al. 2020).

Indeed, in seven years since the black-blade mitigation was installed, Smøla has not experienced any further eagle fatalities at the black blades, despite continuing fatalities at the white-blade turbines (B. Iuell pers. comm).

Hence marking **one** of three blades, thereby making them more conspicuous, is an efficient means to reducing collision rates. In a landmark ruling, South African Civil Aviation Authorities (CAA) have recently (December 2022) allowed the Umoya wind farm the right to paint four turbines with signal red and the No. 4 patterning shown in Figure 8 below. This mitigation was strongly recommended by Birds & Bats Unlimited (BBU), and this constitutes the first test in Africa of this novel mitigation.

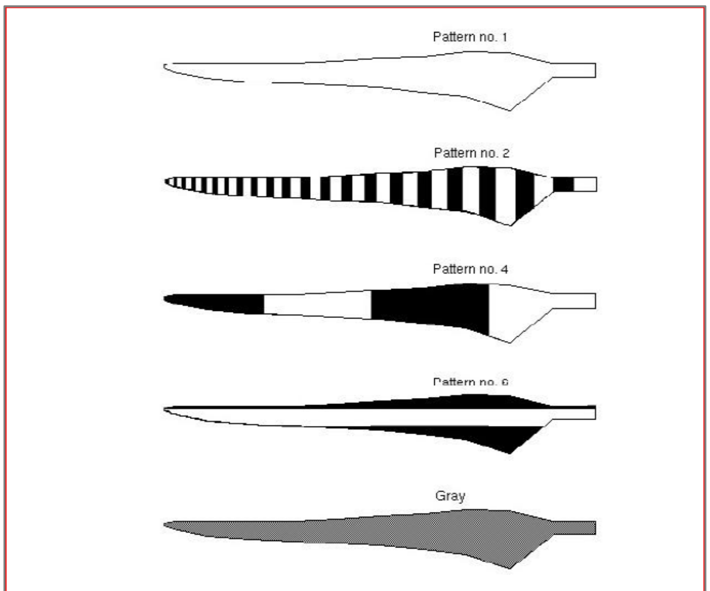


FIGURE 12. Kestrel-perceived blade-pattern conspicuity: stimulus blade patterns. *Depicted are the four black-and-white test patterns and the gray control pattern that were used to determine pattern conspicuity as perceived by a kestrel.*

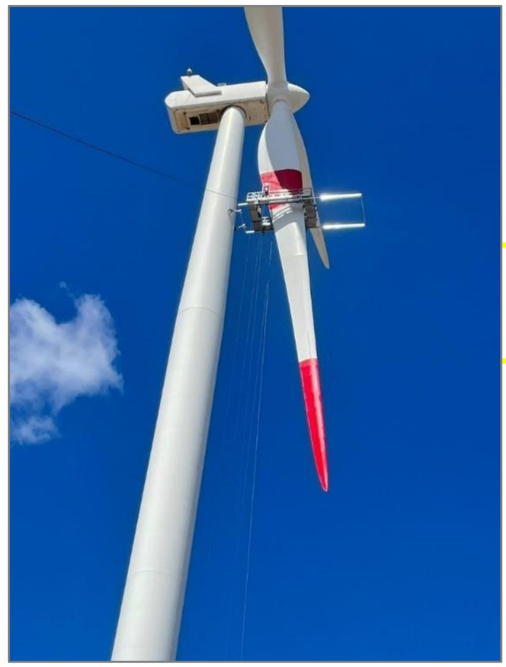


Figure 8: Striped patterns (left) tested for conspicuousness by McIsaac (2001) on raptors and human subjects (left). For both groups, pattern No. 4 was perceived best of all. The white blade (No. 1) was amongst the *least* conspicuous of the spinning blades tested. **Red stripes** (right) being painted for the first time on turbines in South Africa. Painting commenced at the Hopefield wind farm in the Western Cape in December 2022 as recommended by BBU.

Based on the patterns tested above by McIsaac, BBU recommended painting single blades at the Umoya Hopefield WEF with pattern No. 4. This was initiated in December 2022 by EIMS at Hopefield (Figure 8) starting with four high risk turbines.

In the only experimental test of the effectiveness of UV paint in deterring birds Young et al. (2003) found no difference in fatalities at UV-painted turbines. However, their results were compromised because they painted all *three* blades (rather than just one blade) and thus, probably did not reduce the problems associated with "motion-smear". It has also emerged the raptors do not see in the UV spectrum (Mitkus et al. 2018), and thus this test would not be expected to reduce raptor collisions.

Other mitigations to reduce fatalities are (Langston 2011, De Lucas et al. 2012; Jenkins et al. 2014, Perold et al. 2017):

- siting farms and individual turbines away from concentrations of birds or regular commuting/migrating or slope-soaring regions;
- buffering sensitive habitats (pans, breeding cliffs, roosting area) with appropriately sized buffers;
- buffering all threatened species nests with recommended nest buffers from Birdlife guidelines (e.g. 3.7 km - Ralston-Paton and Murgatroyd 2021) for Verreaux's Eagles and 3.0 km buffers for Black Harriers (Simmons et al. 2020)
- Applying the Verreaux's Eagle Risk Assessment model (Murgatroyd et al. 2020) to inform developers of areas where eagles are likely to be at risk and where they are not.
- using low-risk turbine designs and configurations;
- allowing sufficient space (corridors) for commuting birds to fly through the turbine strings; and
- systematically monitoring collision incidences and being prepared to shut down problem turbines at particular times or under particular conditions (e.g., breeding, or increased migration activity).

A recently tested suggestion at a banding station (Foss et al. 2017) is to use short bursts of intense short-wave lights. In experiments, the number of hawks approaching a lure with pulsed lights was 5-fold less than at a control area with no lights, indicating some success.

4.2 HABITAT LOSS – DESTRUCTION, DISTURBANCE AND DISPLACEMENT

While the final footprint of most wind farms is often relatively small, the construction phase of development may incur extensive temporary or permanent destruction of habitat. This may be of lasting significance where wind energy facility sites coincide with critical areas for restricted range, endemic, and/or threatened species.

Similarly, construction, and maintenance activities are likely to cause some disturbance to birds in the general surrounds, and especially of shy and/or ground-nesting species resident in the area. Mitigation of such effects requires that best-practice principles be rigorously applied – that sites are selected to avoid the destruction of key habitats, and construction and final footprints, as well as sources of disturbance of key species, must be minimised.

Some studies have shown significant decreases in the numbers of birds in areas where wind energy facilities occur – as a result of avoidance due to noise or movement of the turbines (e.g., Larsen & Guillemette 2007). Others have shown decreases attributed to a combination of collision casualties and avoidance, or exclusion from the impact zone of the facility in question (Stewart et al. 2007).

Such displacement effects are probably more relevant in situations where wind energy facilities are built in natural habitat (Pearce-Higgins et al. 2009, Madders & Whitfield 2006) than in modified environments such as farmland (Devereaux et al. 2008).

The different vectors that add up to species loss from a wind farm (collision, displacement and habitat loss) may or may not be related and there is little data on this from South African wind farms. However, in general, where a species is successful in reproduction they will return to (or remain) in an area, where they are unsuccessful they will drift away. Thus where collisions are frequent and fatalities decrease success, remaining birds are unlikely to return (and thus collisions are related to displacement).

4.3 IMPACTS OF ASSOCIATED INFRASTRUCTURE

Infrastructure commonly associated with wind farms can often be more detrimental to birds than the turbines themselves. For example, the power lines used to export the energy generated often kill more birds, especially bustards, vultures, and cranes than the operational farm does (Shaw et al. 2015). The construction and maintenance of substations, servitudes and roadways cause both temporary and permanent habitat destruction and disturbance.

Even wind farm or cattle fences can kill some species (e.g., Secretarybirds, owls, bustards, and flamingos) that either walk or fly into them more than any other structure (E. Retief pers comm. Birdlife South Africa). Thus, new roadways and fences should be carefully planned avoiding roosts or nests of susceptible species.

4.3.1 HABITAT DESTRUCTION: CONSTRUCTION AND MAINTENANCE OF ROADWAYS

Some habitat destruction and alteration inevitably take place during the construction of substations and associated roadways. These activities have an impact on birds breeding, foraging, and roosting in or close to the servitude, and retention of cleared servitudes can have the effect of altering bird community structure along the length of any roadway (e.g., King & Byers 2002).

4.4 BENEFITS OF WIND FARMS

Whilst most EIA studies focus on the negative impacts of wind farming, we must balance that with the positive aspects of such energy production. As a green, sustainable form of energy production, with no green-house gas emissions, wind farms have huge benefits over traditional fossil-fuel or nuclear energy production.

At present over 80% of South Africa's energy is derived from coal, oil or gas that increases South Africa's carbon-footprint. From an environmental point of view, wind farms use sustainable energy, do not emit green-house gases, and can be built on otherwise productive land without altering the land use practises. They are one of the most cost-effective sources of energy and provide energy at night when other renewable energy sources may be dormant (https://energy.gov/eere/wind/advantages-and-challenges-wind-energy).

The impacts to the environment, whilst highlighted by environmentalists, are relatively negligible when compared with other forms of energy that are taken for granted in our homes. Most of South Africa's energy is produced by coal-fired power stations (69%), crude oil (15%) or natural gas (~3%). Renewables accounted for ~0.2% of all energy production in 2012 (www.zapmeta.co.za/wiki/page/Energy_in_South_Africa). This will have increased since 2012 when these statistics where compiled.

Elsewhere, attempts have been made to determine the impact on birds of these various forms of energy production to contextualise the impacts reported from wind farms (Sovacool 2009). His paper summarised the impacts as follows:

"For wind turbines, the risk appears to be greatest to birds striking towers or turbine blades and for bats suffering barotrauma. For fossil-fuelled power stations, the most significant fatalities come from climate change, which is altering weather patterns and destroying habitats that birds depend on. For nuclear power plants, the risk is almost equally spread across hazardous pollution at uranium mine sites and collisions with draft cooling structures.

Yet, taken together, fossil-fuelled facilities are about 17 times more dangerous to birds on a per GWh basis than wind and nuclear power stations. In absolute terms, wind turbines may have killed about 20 000 birds [in the USA: Sovacool

2013] in 2006 but fossil-fuelled stations killed 14.5 million and nuclear power plants 327,000 birds." (Sovacool 2009, p2246).

Sovacools' (2013) revised data of 20 000 birds killed annually at wind farms in the USA were revised again by Loss et al. (2013), to 234 000 birds killed annually by American wind farms by non-lattice tower turbines. This revised estimate is still 62-fold lower than the estimated 14.5 million fatalities caused by fossil-fuel powered energy.

In a South African context, the 33 operational wind farms generating a maximum of 3357 MW of power (SAWEA 2020) kill on average 2.0 $\pm$ 1.3 birds per MW year. Thus, the annual toll is about 6700 birds of which 36% (2400) are estimated to be raptors. If 17% of these are Red Data species (Simmons and Martins 2018) then about 400 Red Data raptors are likely to be killed by South African wind turbines annually.

In a southern African or African context, this means that moving away from our heavy reliance on coal, to one based on renewable energies, could reduce the impact on birds at least 60-fold. If even a small proportion of these birds in southern Africa are threatened red-listed species (and climate change may be affecting these red-listed species more than other – more common – species: Simmons et al. 2004), then the threats to these species are likely to be reduced.

Thus, whilst this report details the potential negative impacts to birds at wind farm sites, the goal of turning away from fossil-fuel dependence through wind (and solar) energy is a hugely positive move for South Africa, which lies 19th in the world of CO^2 producers (Olivier et al. 2014) and should be encouraged.

5. AVIFAUNAL SENSITIVITY OF THE SITE

5.1 REGIONAL SENSITIVITY

The Aberdeen site, lying as it does in the arid summer rainfall portion of the eastern Nama-Karoo Karoo, is not expected to be of particularly high sensitivity for birds. It does not fall within any Important Bird Areas (IBAs : Marnewick et al. 2015) and the closest protected area is the Camdeboo National Park centred on Graaff Reinet, 80 km north-east. The area is generally overgrazed reducing its productivity and thus its capacity to support high species richness. The Camdeboo mountains in the north, however with higher rainfall may support higher species richness. The Birdlife South Africa sensitivity map (Figure 9) indicates a patchwork of low to medium-high sensitivities for collision-prone birds.

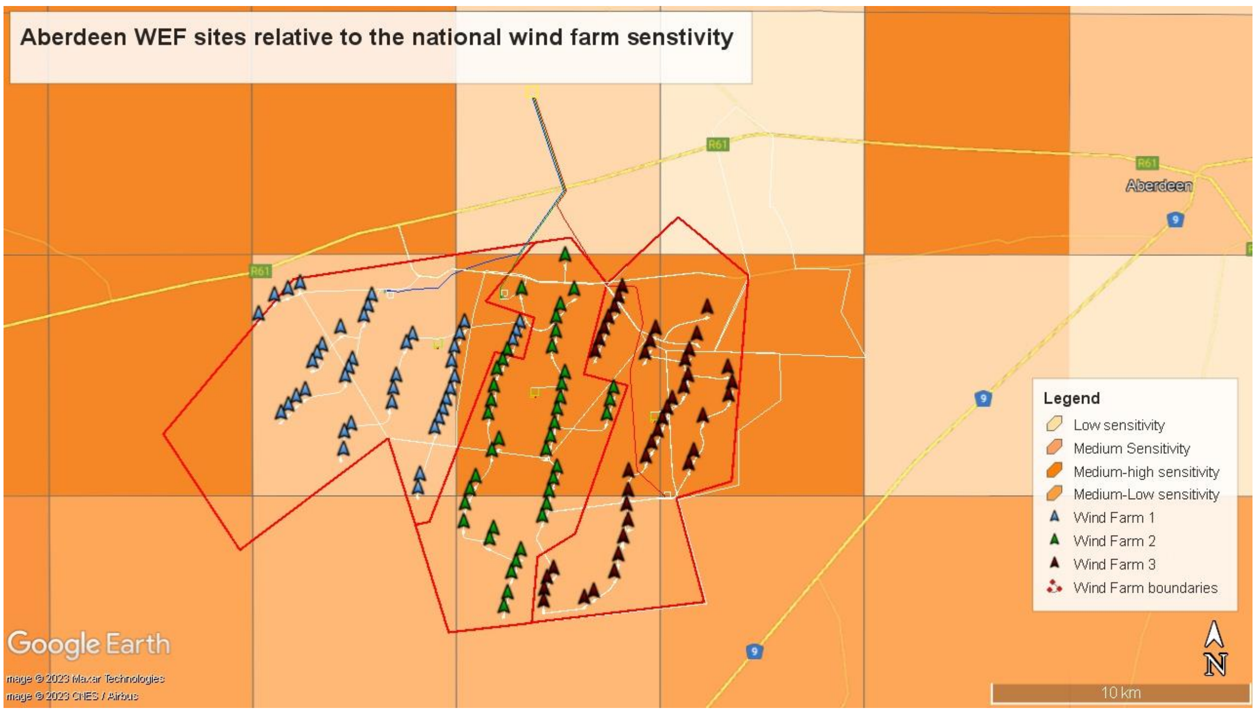


Figure 9: The avian sensitivity map of the Aberdeen area relative to all three proposed wind farms (= red boundary, coloured triangles). The coloured pentads represent the range in sensitivity ranging from low scores of 79 (top north-east) to medium-high of 631 (in the central and eastern sections of the WEFs). The Aberdeen Wind Farm 2 is represented by the green triangles.

5.1.1 BIRD SPECIES AND RICHNESS

According to SABAP2 records for the nine pentads surrounding the site, 180 species have been recorded on site. This includes records submitted by BBU during our surveys. Since the smaller passerine species are not expected to be affected by the proposed wind farms and no red data passerines were identified on site, we concentrate instead on the larger collision-prone species.

5.1.1 Collision-prone Species

5.1.1.1 Red-listed species

The bulk of the species at risk to development on the proposed Wind farm sites were raptors. We identified 19 species on site that fall within the 100 most collision-prone with respect to wind farms (Ralston-Paton et al. 2017). Nine were red data species and as shown in Table 2 and 12 were raptorial.

Table 2: The red data species identified across the three Aberdeen sites, with the number of flight and hours. Note that only seven with sufficient data could be included in the CRM. The Black Stork and Verreaux's Eagles did not reach the threshold for inclusion.

	North **WEF**	North Control	South **WEF**	South Control	Total	**Total WEF**	Passage Rate*	Total Control	**% of total**
Total hours	648.5	72	818.3	47	1585.8	**1466.8**		119	
# RD flights	829	33	183	14	1059	**1012**		47	100
Blue Crane	458	23	16	0	497	**474**	0.32	23	46.8
Black Harrier	2	0	2	0	4	**4**	0.003	0	0.4
Ludwig's Bustard	208	5	84	9	306	**292**	0.20	14	28.9
Karoo Korhaan	71	3	41	5	120	**112**	0.08	8	11.1
Kori Bustard	9	0	5	0	14	**14**	0.01	0	1.4
Lanner Falcon	68	0	10	0	78	**78**	0.05	0	7.7
S. Black Korhaan	10	0	25	0	35	**35**	0.02	0	3.5
Black Stork	1	0	0	0	1	**1**	0.001	0	0.1
Verreaux's Eagle	2	2	0	0	4	**2**	0.001	2	0.2

*flights per hour

Of the nine red data species the most frequently encountered species was the Blue Crane who performed 47% of all 1059 flights recorded over all wind farms over 12 months. Ludwig's Bustards were the next most common species recorded and the two species between them accounting for 76% of all flights (Table 2). Of the *Endangered* species the Black Harrier was the least often recorded.

Black Harrier

Black Harriers are known to breed in the Camdeboo Mountains (to the north of the site) and have very large foraging ranges (> 500-km²). These foraging ranges extended across the plains and close to the proposed wind farm. Thus, we have mapped these home ranges for two different birds over three years. The first satellite-tagged female 'Moraea' foraged to the northern sections of the proposed farm in 2011 and 2012. The (more recent) GPS-track of a male (Gulliver) tracked from October-November 2022 (green in Figure 10) is shown alongside his track for December-January 2023 (blue in Figure 10). The Aberdeen Wind Facility 2 does not overlap with this newly derived foraging track over the 4-months of tracking (October to January).

Photo 3: An example of an *Endangered* **Black Harrier,** found rarely on the study site, despite previously being tracked close to the proposed WEFs (see Figure 10). These species are highly susceptible to collisions and require special attention.

5.1.1.2 Least Concern species

On site we recorded 10 Collision-prone species which are classed as Least Concern from a conservation perspective. These and a measure of volume of their Passage Rates (flight per hour) indicates that small insectivorous falcons (Amur and Lesser) dominated the skies (Table 3).

Table 3: The 10 Least Concern Collision-prone species identified across the three Aberdeen sites, with the number of flight and hours. Note that only seven with sufficient data could be included in the CRM. The Black Stork and Verreaux's Eagles did not reach the threshold for inclusion.

Least Concern Species	WEF flights total	Control flights total	WEF + Control (flights)	Passage rate WEF	Passage Rate Control	Passage Rate WEF+Control
Amur Falcon	138	0	138	0.1017	0.0000	0.0938
Black-winged Kite	2	2	4	0.0015	0.0175	0.0027
Booted Eagle	20	1	21	0.0147	0.0088	0.0143
Common Buzzard	62	2	64	0.0457	0.0175	0.0435
Falcon Species*	208	1	209	0.1532	0.0088	0.1420
Greater Kestrel	22	1	23	0.0162	0.0088	0.0156
Jackal Buzzard	5	3	8	0.0037	0.0263	0.0054
Lesser Kestrel	158	2	160	0.1164	0.0175	0.1087
Northern Black Korhaan	2	0	2	0.0015	0.0000	0.0014
Pale Chanting Goshawk	106	4	110	0.0781	0.0351	0.0748
Spotted Eagle Owl	12	0	12	0.0088	0.0000	0.0082
Total hours	1466.8	119	1585.8	**0.50109081**	**0.134454**	**0.473578**
Total flights	735	16	751			

* Small hovering kestrels that were either Lesser Kestrels or Amur Falcons or Eurasian Hobbies

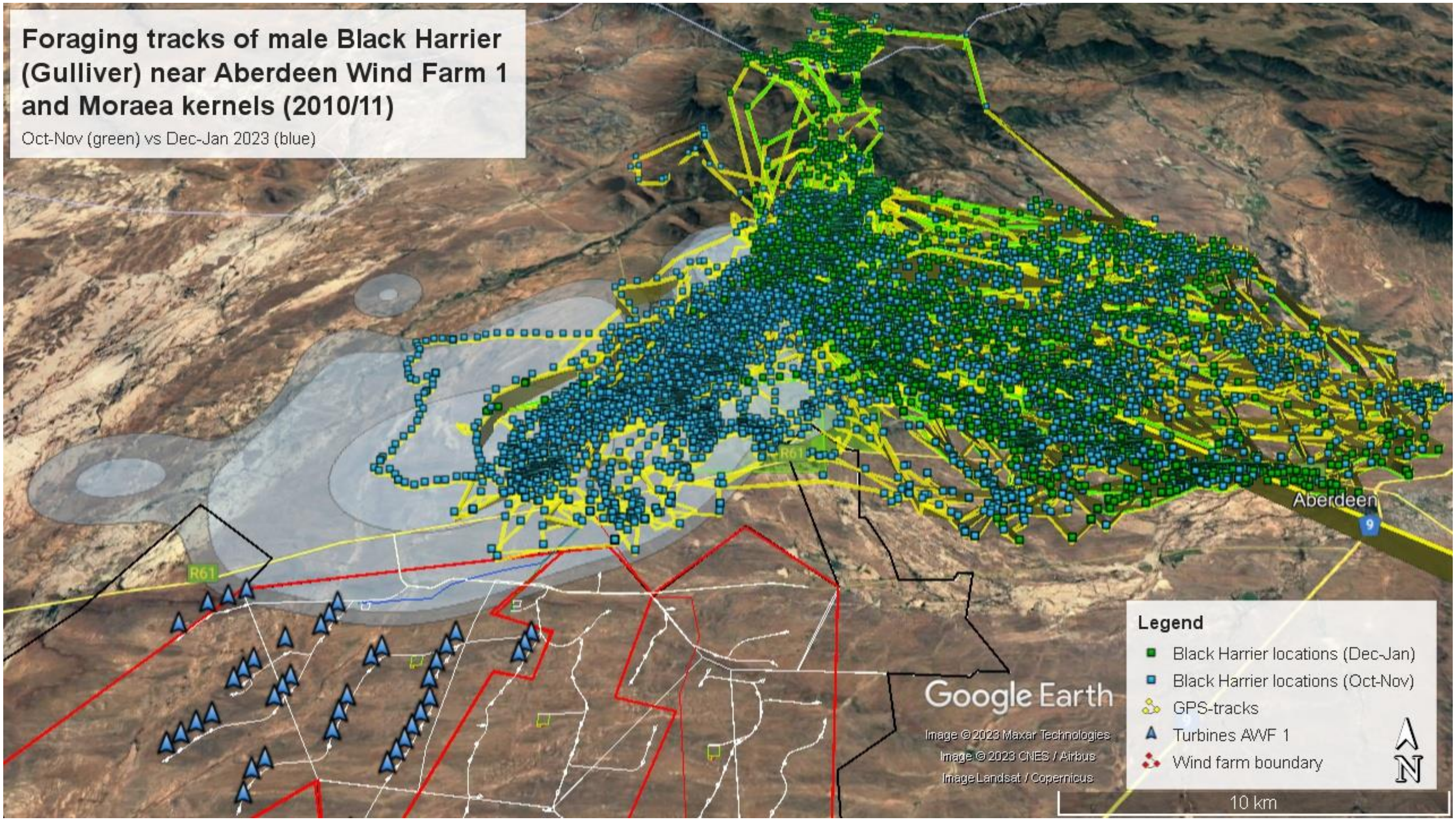


Figure 10: The GPS-track of a male Black Harrier (Gulliver) found breeding in the Camdeboo Mountains in Sept 2022. His foraging tracks show a switch from southeast of his nest (1 Oct – 30 Nov 2022 = green squares) relative to his foraging patterns to the SW (from Dec 2022 - Jan 2023 = blue squares). At no time did he enter the proposed Aberdeen Wind Farm 2 (= red polygon, green triangles). The wind farm also avoids the previous area of a female Black Harrier tracked here in 2010/2011 (Moraea) whose foraging kernels are shown (= pale grey contours). Three re-located turbines falling within the perimeter of the kernels represent the outer 5% of her previous foraging range.

For all 15 Priority species for which we had sufficient data we recorded 2447 flights in 1466.8 hours of systematic VP observations over four seasons in 2021-2022 across the combined WEF. This resulted in a relatively high Passage Rate of 1.60 flights per hour across the entire area. Of the 13 collision-prone Priority species, with sufficient data for future modelling, seven were Red Data (RD) species (Table 2) and six were Least Concern (LC) (Table 3).

Despite the known presence of two individual B lack Harriers in the greater area (see Section **Error! Reference source not found.**), this species had relatively low frequency of flights across the wind farm site (12 mins of flight across 12 months). Outside the site however, the GPS-tracked male had a high frequency of flights from October 2022 to January 2023, as shown in Figure 10.

The high number of flights of Lesser Kestrel, *Falco naumanni*, Amur Falcon *F. amurensis* and the rare European Hobby *F. Subbuteo* was likely due to good rainfall (Figures 2 and 3) and the locust swarms that were attracted to the area, on which they feed. A roost of the former two species occurs in Aberdeen, 20-km east of the study site.

The presence of 15 collision-prone species, of which seven were red data species, was initially surprising given the low numbers and arid, over-grazed nature of the environment chosen for the wind farm. However, the summer rains were exceptional in 2022 and abundant rains are known to precipitate influxes of nomadic bird species to exploit the flush of insects and small mammals that result shortly thereafter (Dean 2004, Seymour et al 2015).

The good rains also brought back the Black Harriers to breed in their traditional breeding grounds in the Camdeboo Mountains (on the farm The Ranges), 17 km north. This in turn allowed us to fulfill the obligations of the agreement with Birdlife South Africa that we track the closest breeding birds for 6 months, in lieu of a further 12 months of observer-based monitoring.

5.2 AVIFAUNAL RISK ASSESSMENT

5.2.1 TURBINE EXPOSURE

The proportion of flights occurring within the blade swept area (BSA) for all red data and Least Concern priority species is shown in Figure 11 for the proposed Aberdeen study site. Red bars represent the number of minutes spent flying in the high risk BSA; blue bars represent the total minutes recorded in flight over all five seasons from five site visits. Note that four seasons data went into the following CRM and the extra October 2022 season was undertaken too late to be included in the CRM as it was so advanced. This made little difference to the output given the large amount of data collected in the initial 12 months, but it did help confirm the low number of Black Harriers present in the northern sections of the proposed wind farms.

The graphic indicates:

- two species – the Blue Crane and the Ludwig's Bustard performed the highest number of flights (blue bars) and of those, the Blue Crane flew within the blade swept area approximately two thirds of the time. The Bustards flew there about 25% of the time (Figure 11).
- Those species most often recorded flying in the BSA included the Booted Eagles (94%), the three small falcon species (90%) of flights classed as risky in the BSA, followed by Common Buzzards at ~ 80% of the time.
- The two species found to spend the lowest proportion of time in the BSA were two korhaans/bustards – the Karoo Korhaan at 9% and Kori Bustard at 17%.

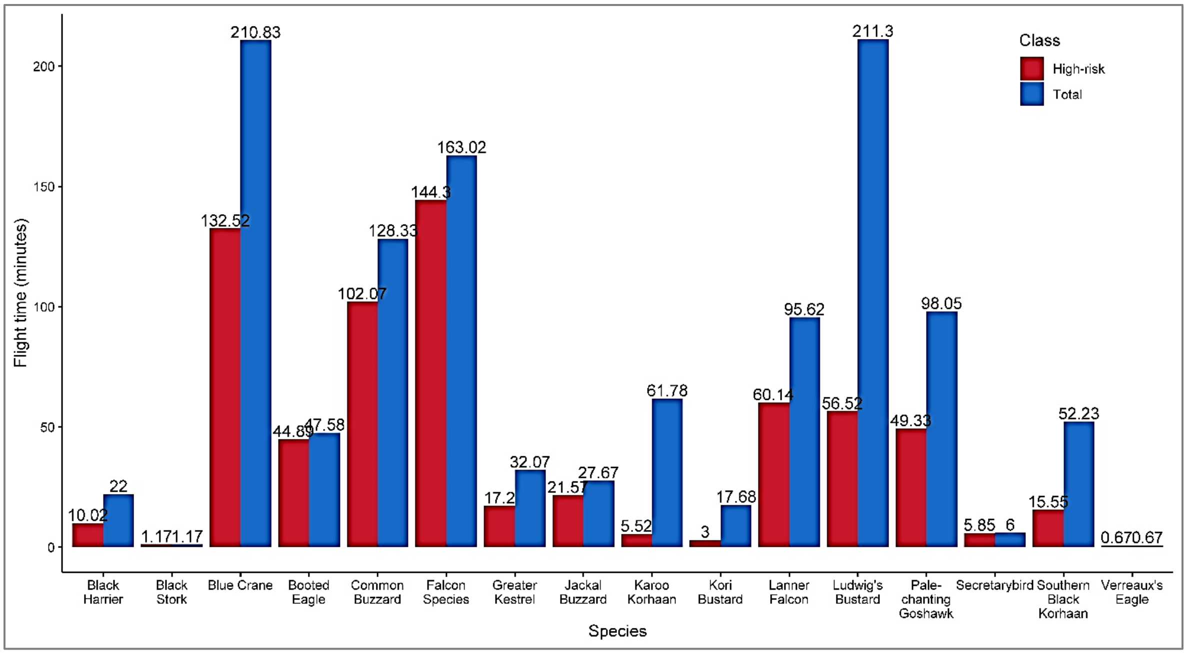


Figure 11: The proportion of flights occurring within the blade swept area (BSA) for all priority species recorded on the proposed Aberdeen study site. Red bars represent the number of minutes spent flying in the high risk BSA; blue bars represent the total minutes recorded in flight over all four seasons.

While Black Stork, Secretary Bird and Verreaux's Eagle were apparent, so few flights were recorded for these species that no conclusions could be reached on risk. This was not an issue because the low occurrence of these species would mean they are at low risk because they are rarely present. In total there were adequate data for 13 species (7 RD and 6 LC) to undertake the CRM analysis.

5.2.2 COLLISION RISK

We grouped together the small falcons (Lesser Kestrel, *Falco naumanni* Amur Falcon *F. amurensis* and the rare European Hobby *F. subbuteo*) as Falcon species (FS in the graphics that follow) that were brought in by good rainfall and locust swarms. We did so because these three species not only tend to forage together but look very similar to each other. As such they are difficult to distinguish in the field. Two if the species even roost together as evidenced by a known roost of Lesser and Amur Falcons in Aberdeen, 20-km east of the study site.

Collision Risk fatality rates per year were calculated for seven Red Data species (Table 2) and six Least Concern (LC) species. The latter includes the grouping of the three small falcon species too (Table 3).

In the CRM analyses that follow, the Red Data species are weighted more highly for risk given their threat status, and all were given a higher weight than Least Concern Species as follows:

- Endangered = 4
- Vulnerable = 3
- Near Threatened = 2
- Least Concern = 1

The CRM rankings were based on the number of flight minutes of Red data and Least Concern species through the areas which saw many flights of *Endangered* species were classed as higher risk compared to areas where similar numbers of flights of a *Near Threatened* species occurred. We have followed that line of reasoning in designating "No-Go" areas – using the Red Data spatial risk map first to delineate the high-risk areas, and then added the Least Concern mapping to check for additional high-risk areas.

As expected, the northern areas exhibited more high-risk areas than the south, as reflected in the CRM maps below (Figure 12a and 12b).

An important parameter to determine in the CRM analysis is the proportion of flights occurring in the BSA (Figure 8).

- More flights were recorded for Blue Cranes and Ludwig's Bustards than any other species, but Ludwig's Bustards spent little time in the BSA.
- Three species emerged as most frequently occurring in the BSA: Booted Eagle (94%), the three small Falcon species (88%), and Jackal Buzzard (78%).

Time spent in the BSA does not alone make these species susceptible to turbine collisions. The rate at which they pass through the site, and their exposure to the turbines, also play major roles.

An equation-based Collision-Risk Model (CRM) was used to determine annual fatality estimates for all 13 priority species based on the following inputs:

- Bird exposure (how much time was spent within the BSA – see **Error! Reference source not found.**);
- Survey effort (time spent monitoring in the WEF – 1 466 hrs); and
- Exposure factor (turbine specifications – see Section 1.2).

Estimated fatalities (per annum) are represented visually in the graphs below. It should noted that these calculations are based on the cluster as a whole and subsequently divided into the three individual WEFs.

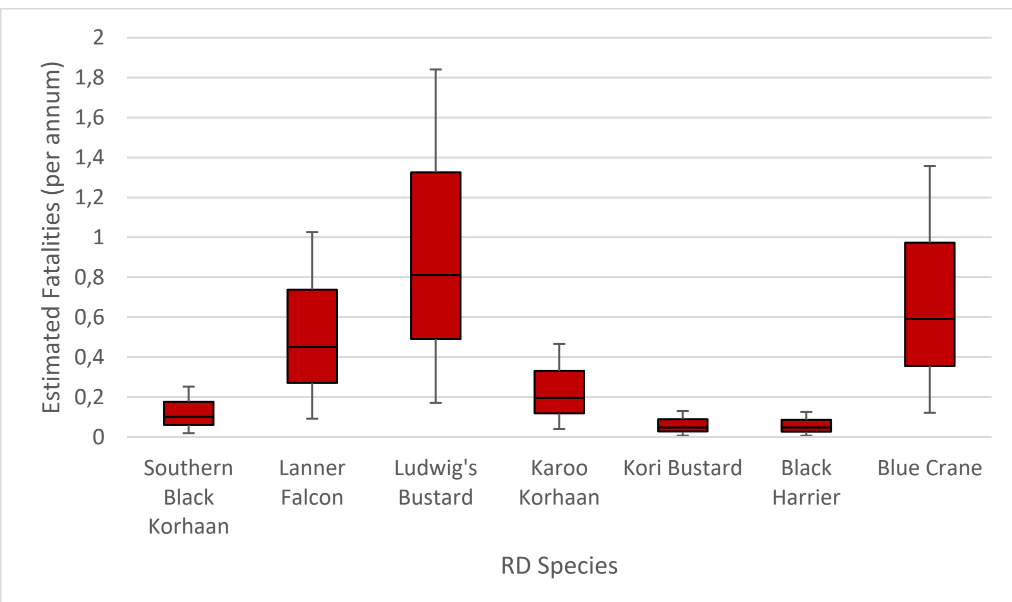


Figure 12a: Estimated fatalities (per annum) for the cluster for seven Red data species

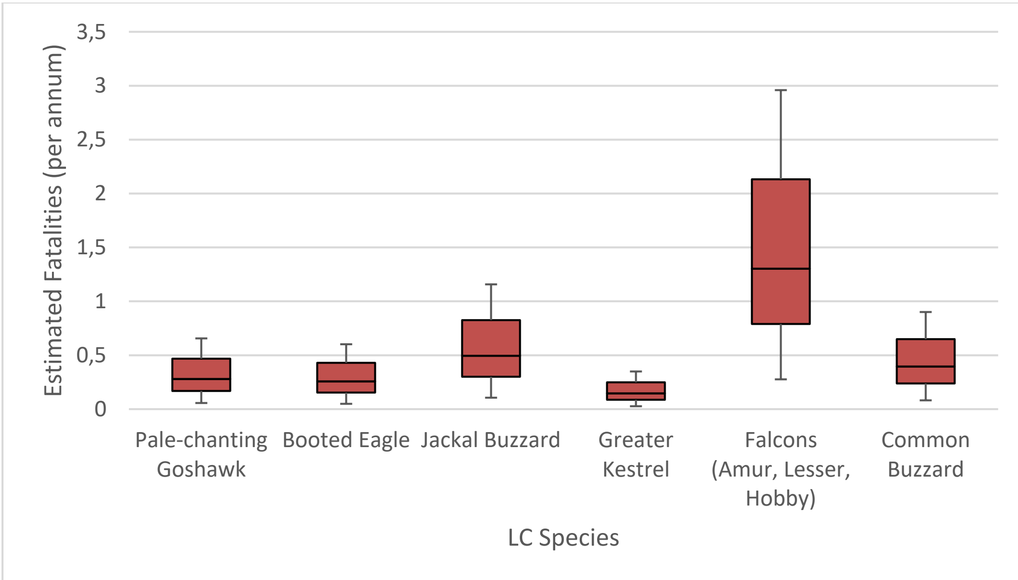


Figure 12b: Estimated fatalities (per annum) for the cluster for Least Concern species

5.2.3 VULNERABILITY RISK ASSESSMENT

The fatality estimates alone are not spatially explicit and therefore alone don't tell us which areas within the site are likely to result in high-risk flights. Because this an important factor to account for when siting turbines and has the potential to reduce the collision risk (and resultingly fatalities), it is an essential next step to refine the spatial extent of the CRM analysis.

This second step in the CRM, was undertaken to identify which factors (landscape and/or temporal) are likely to yield high-risk flights. Over 40 input variables were considered (e,g, topography, slope, land use, vegetation, soil) and the output is a species-specific "heat map" showing a risk profile for high-risk flights across the wind farm cluster.

The risk profile scores (per species) were then weighted to account for:

- Collision Risk: This was a subjective rating based on a combination of peer-reviewed (known) collision risks as well as site-specific collision risks (see Section 5.2.2). Species known to be more collision prone (e.g. Black Harrier and Verreaux's Eagle) where allocated the highest collision-prone factor, while those known to be less so the lowest (e.g. Kori bustard, Karoo korhaan);
- Conservation Status: This was based purely on Red Data status with *Endangered* CR species (e.g. Black Harrier) weighted the highest and LC the lowest

The above resulted in an adjusted risk profile score per species, and when overlaid with other species profiles produced an overall vulnerability risk map (see Figures 13a and 13b).

Spatially explicit high-risk and lower risk areas across the entire wind farm cluster is given for:

- all (7) Red Data (RD) species (Lanner Falcon, Black Harrier, Blue Crane, S Black Korhaan, Kori Bustard, Ludwig's Bustard, Karoo Korhaan) (Figure 13a)
- all (6) Least Concern (LC) species (Falcon species [Lesser Kestrel, Hobby, and Amur Falcon], Jackal Buzzard, Common Buzzard, Booted Eagle, Greater Kestrel, Pale Chanting Goshawk) (Figure 13b)

The resulting risk maps give nine classes of risk for the priority species. The risk classes are as follows:

- Class (8) represents the area most likely to yield risky flights for the group of seven RD species. As such it captures a small spatial area, given that highly risky flights were relatively uncommon.
- Areas classified as class 7 represents the next layer of risky flights, and when added to class 8 flights, covers a slightly larger area.
- The areas classed as 6 and lower add more and more risky flights and cover larger and larger areas.
- To refine the analysis we also investigated classes of 7.5, 6.5 and 5.5
- The spatially explicit outputs shown in Figures 13a and 13b indicate that areas in the northern sections of the study tend to yield more risky flights than in the south. This may arise because better wind resources are known from the north (Atlantic Energy Partners, pers comm), topographic highs (aiding lift) occur there and the rainfall tends to be higher.

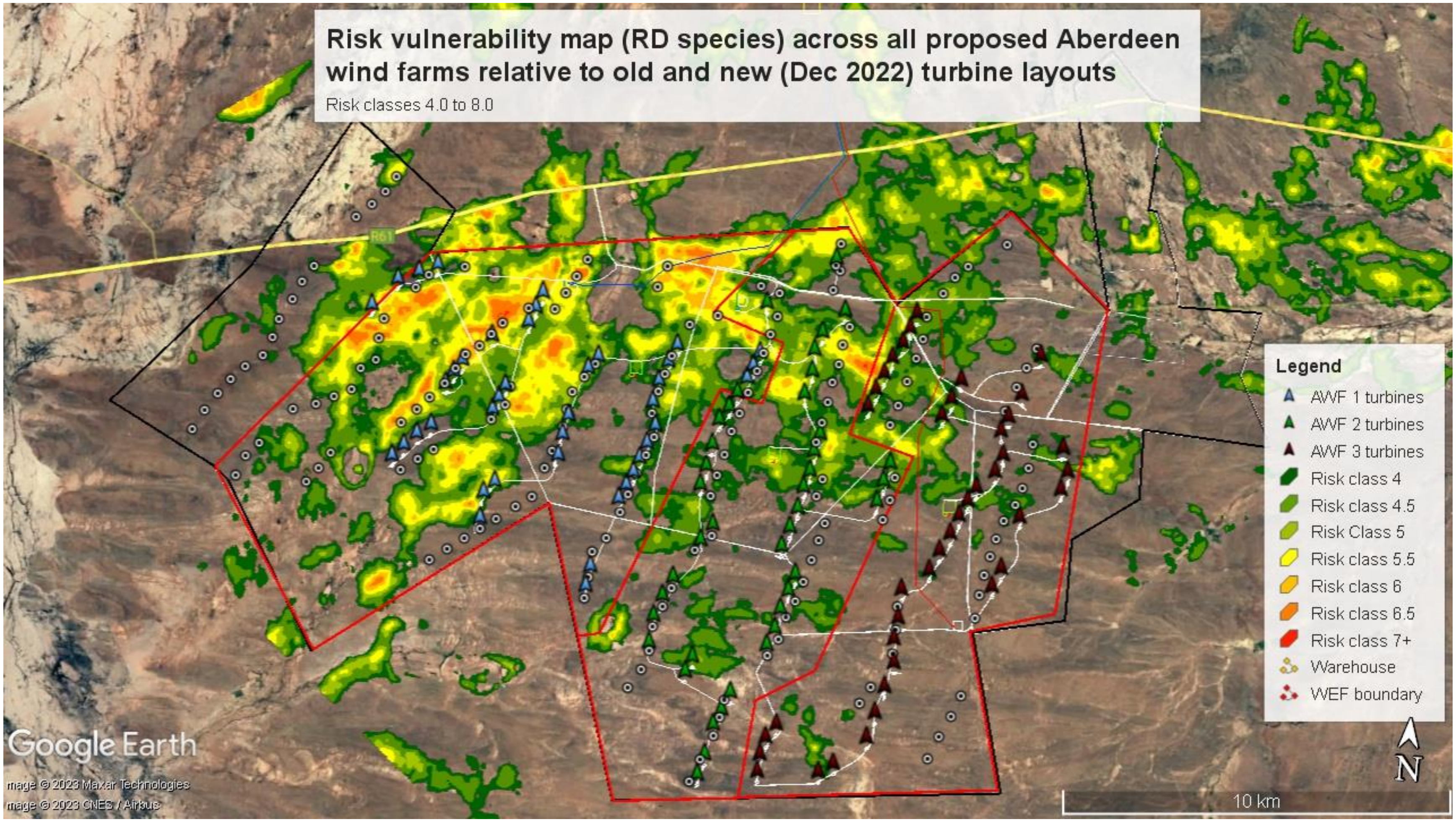


Figure 13a Risk vulnerability map for seven Red Data (RD) species based on 18 months' monitoring over all seasons for all three Aberdeen wind farms. The different classes represent different levels of flight risk for the RD species based on modelled passage rates, flight heights, flight seconds, and topography in relation to the old (Sept 2022 = circles) and new (Dec 2022 = triangles) turbine layout. Classes 5.5, 6, 7, and 8 combined are those areas designated as red and orange and represent the highest risk to Red Data birds. These are designated as No-Go areas and capture large proportions of risky flight minutes**.** AWF2 turbines are shown as green triangles.

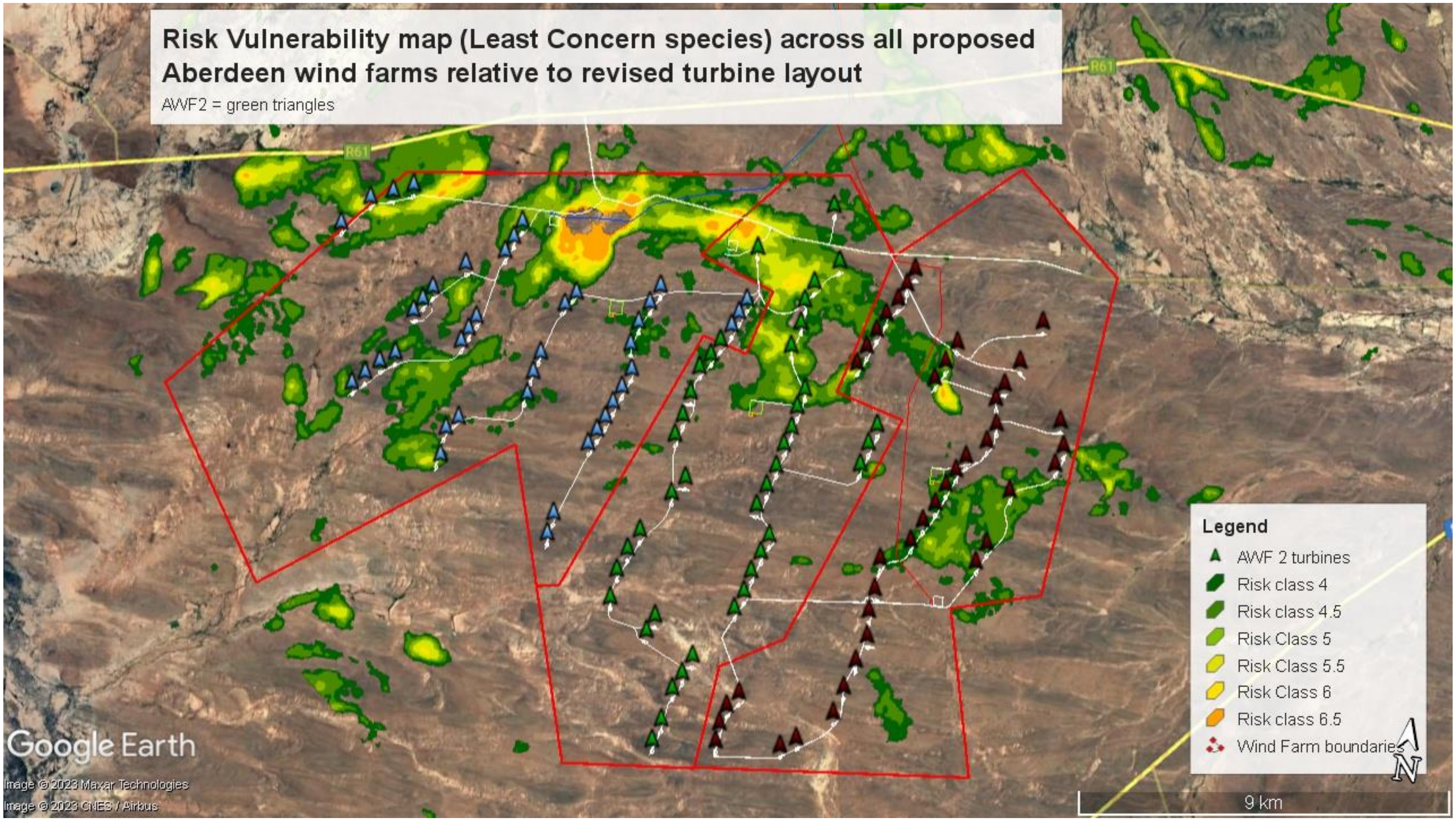


Figure 13b: Risk vulnerability map for six **Least Concern (LC)** species, based on 12 month's monitoring over all seasons for all three Aberdeen wind farms. The different classes represent different levels of flight risk for the Least Concern species occurring there based on modelled passage rates, flight heights, flight seconds, and topography in relation to the revised (Nov 2022 turbine layout = coloured triangles). Areas designated as red, orange, and yellow represent the highest risk to LC birds. These are Classes 5.5, 6, 7, and 8 combined. These are designated as No-Go areas and capture large proportions of risky flight minutes (those in the blade swept area: BSA). AWF2 turbines are shown as green triangles.

5.2.4 HIGH RISK AREAS

Based on the outcomes of the vulnerability risk assessment, it is evident when looking at the site holistically some areas have more high-risk flights than others. The next step in the analysis is to determine which of these areas are acceptable for development and which will require avoidance or mitigation.

To determine this, one needs to look at how (by removing certain areas for development) the estimated collision risk can be reduced.

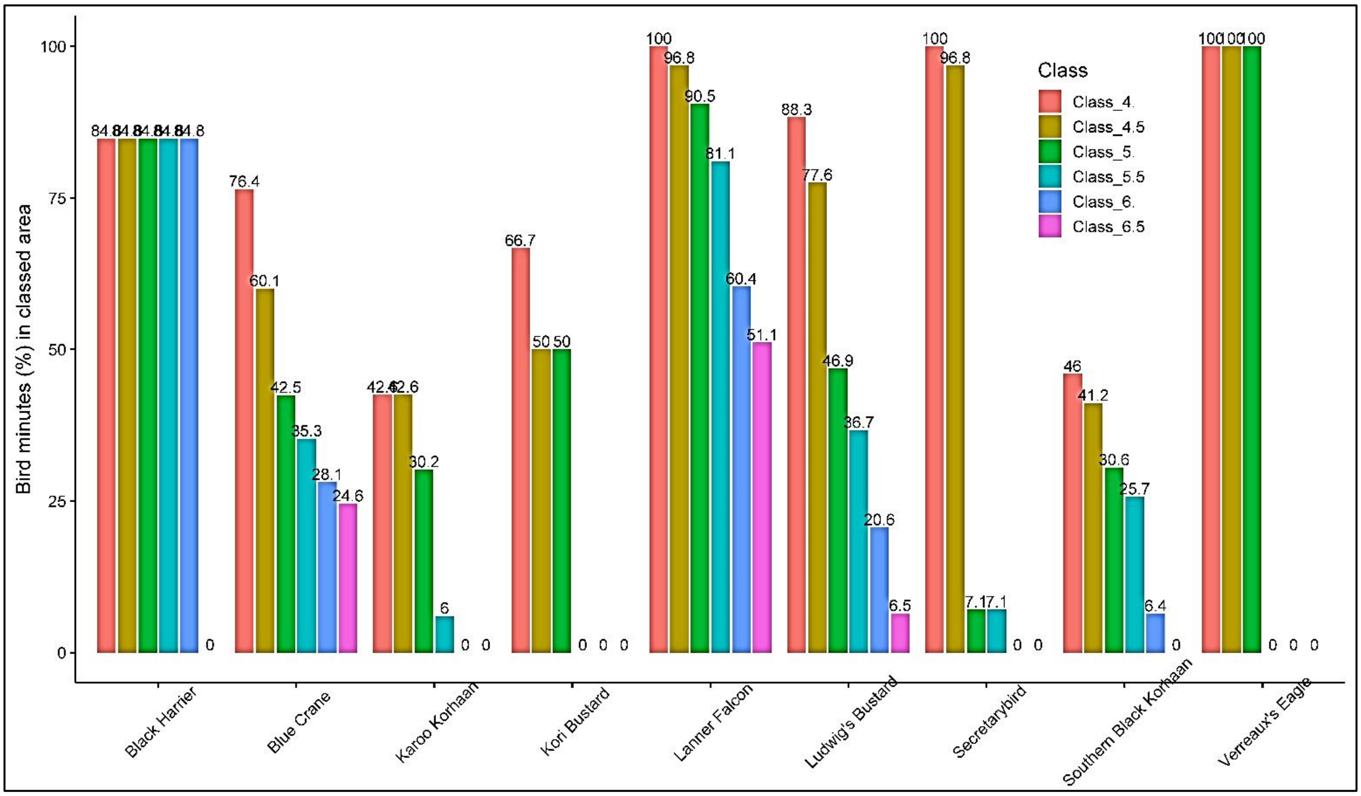


Figure 14a: The number of risky flight minutes captured by each Class of risk generated by the CRM for each Red Data species

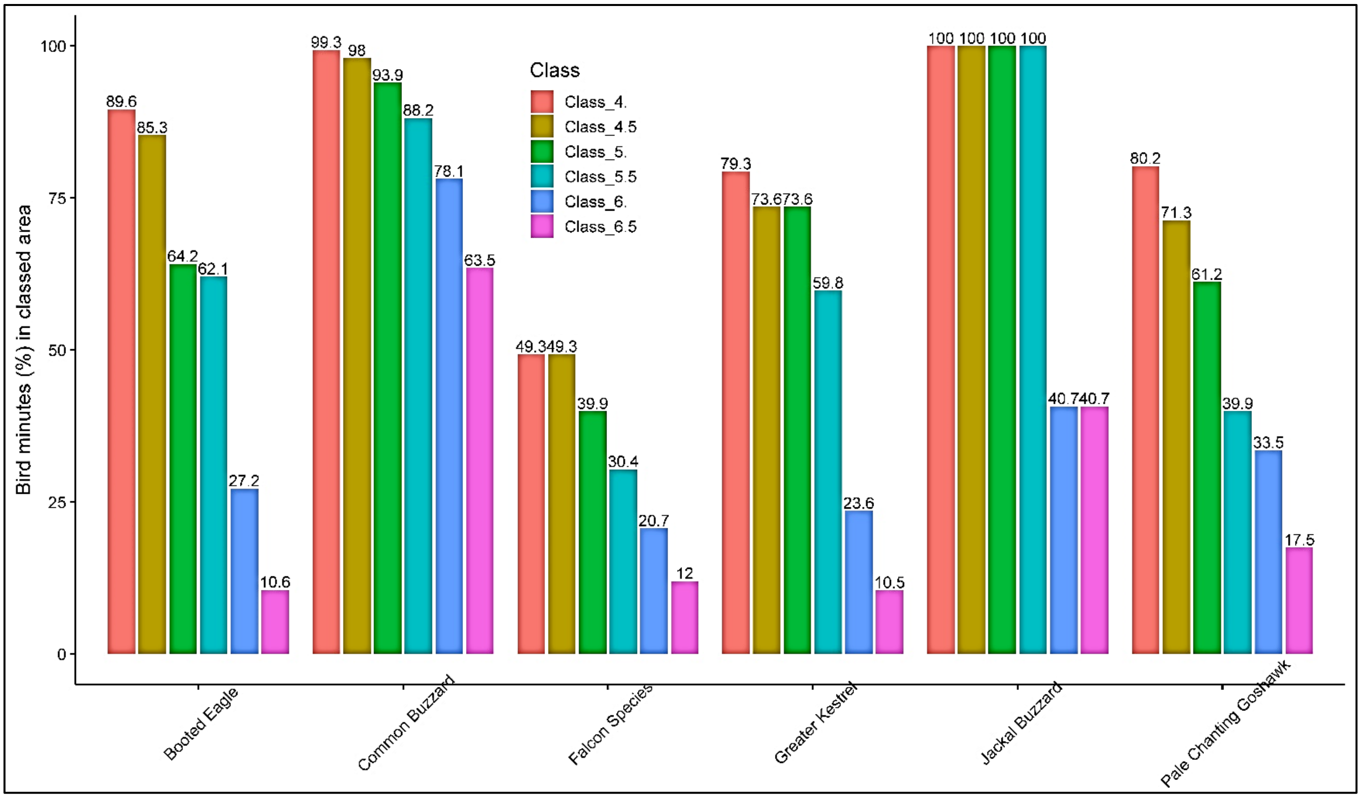


Figure 14b: The number of risky flight minutes captured by each Class of risk generated by the CRM for each Least Concern species.

For example, 100% of the Lanner Falcon's time spent within the BSA is likely to occur within areas classified as risk class 4 and above. Similarly, 81.1% of the Lanner Falcon's time spent within the BSA is likely to occur within areas classified as risk class 5.5 and above. By avoiding areas classified as risk class 5.5 and above from the developable area, we are likely to reduce the collision risk (of Lanner Falcons) by 81.1%.

The fact that 80% or more of some RD species' risky flights are almost completely captured by the risk Class 5.5 (e.g., Ludwig's Bustards, Secretarybird, Black Harrier, Lanner Falcon, and Figure 13a) is encouraging, and is expected to decrease their collision-risk to negligible levels. For some of those species less frequently found on site (e.g. Black Harrier, Kori Bustard, Verreaux's Eagle) the trends in flight minutes appears to plateau and the model may over-estimate the number of "risky" flight minutes captured . These species were relative rarely seen over the monitoring period and thus face lower risk. As such Class 5.5 was deemed appropriate for most of the frequently recorded and least recorded from a reduction of risk point of view.

To test to determine if all species risky flight minutes were captured by class 5.5 we checked Figure 14 to see if any species risky flights fell well below the 80%. We found three species: Blue Cranes often fly at risky heights (Figure 11) but Class 5.5 only captures 35% of their risky flights (Figure 13a). The same is true for the Falcon species (Amur, Lesser, and Hobby – "Falcon Species" in Figure 14b), whereby only 30% of the risky flight minutes occur in risk class 5.5. This probably arises because these groups often occurred outside the main centres of activity (in the central north regions).

To capture this risk, we inspected the individual risk vulnerability maps generated for the Blue Cranes (Figure 15) and the Falcon species (Figure 16) independently and searched for areas where high-risk flights were frequent. For Blue Cranes several areas in the north-east were apparent as high-risk areas and these were subsequently avoided for the revised turbine layout (this applies only to AWF 3). For the Falcon species the same exercise produced similar results indicating high risk in several northeast areas. Since this affects turbines in the northeast of the proposed wind farm (AWF 3) this will be presented and further analysed in the report for that wind farm.

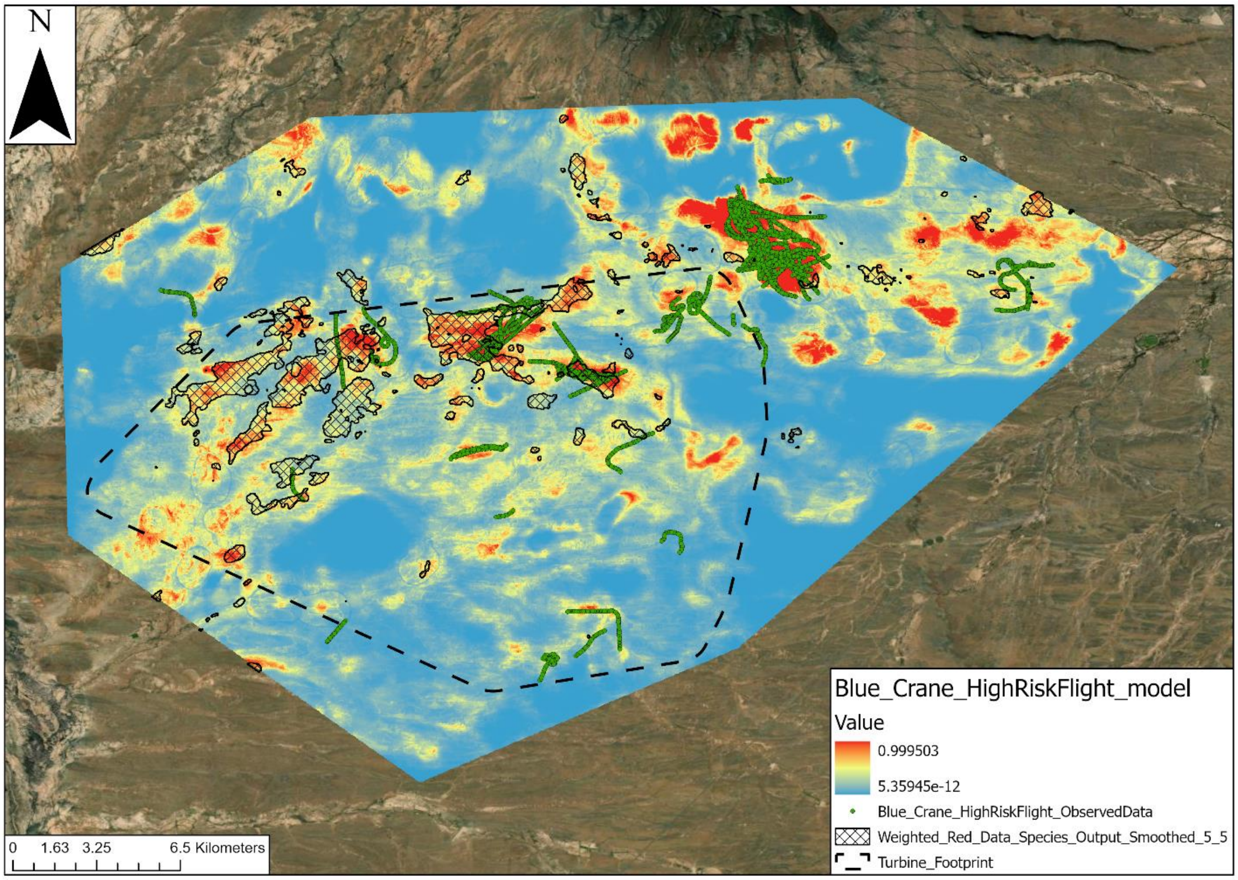


Figure 15: Individual risk vulnerability map for RD Blue Cranes across all three wind farms. Note the two higher risk areas in North-east (one outside the proposed farm boundary and one inside). Both lie outside the core high risk areas modelled for all other RD species in the north-central areas and turbines placements in the Northeast area (AWF 3) were subsequently re-located.

We have identified those turbines that, for these two groups of species, help reduce risk if they are relocated. None of these occur on the Aberdeen Wind Farm 2 and they will be presented in the relevant reports for Aberdeen Wind Farm 3.

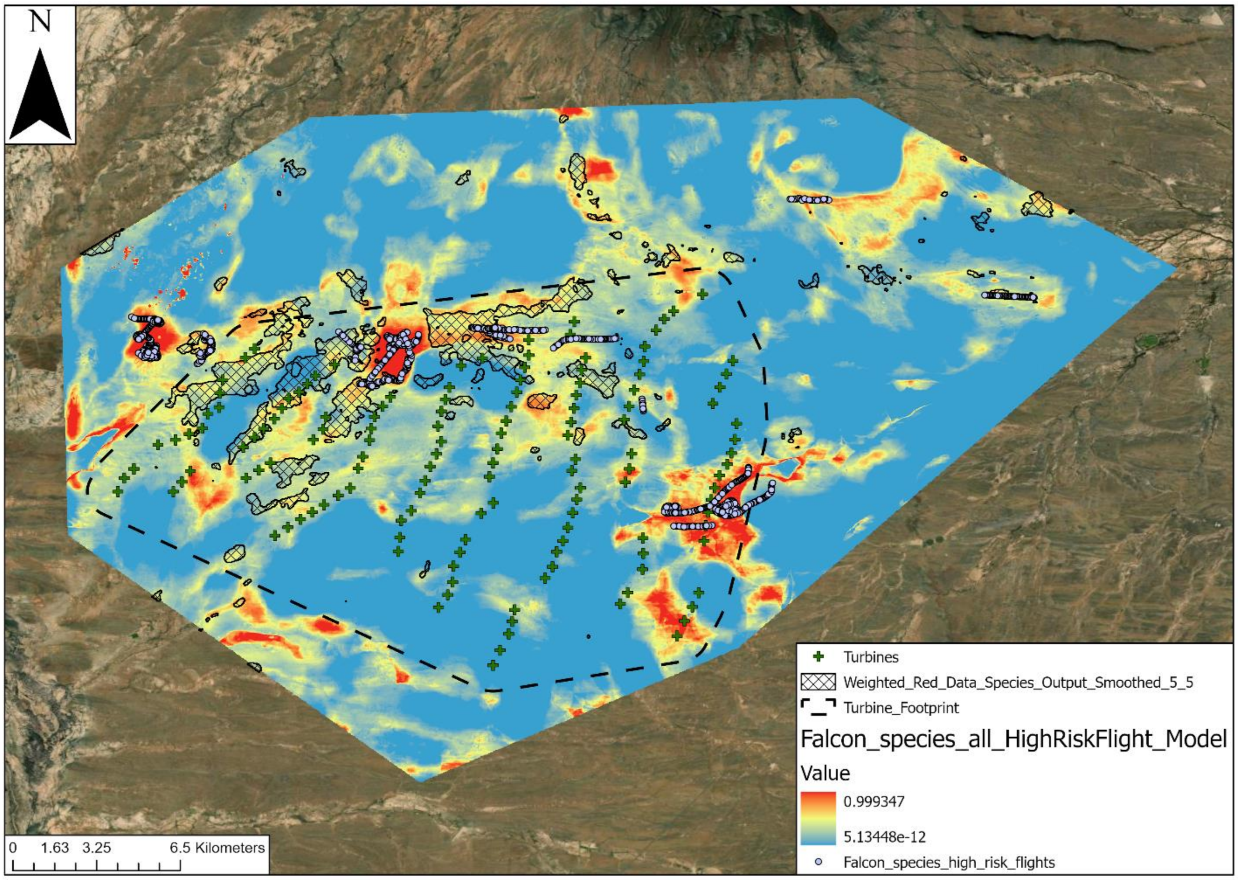


Figure 16: Individual risk vulnerability map for the three falcon/kestrel species (Lesser, Amur and Hobby). Note the higher risk areas (= red polygons) in the southeast that lie outside the core flight risk areas identified in the central-north. The relocation of turbines in those areas will be treated in the impact assessments for AWF3.

5.2.5 SUMMARY OF CRM

In summary the running of the CRM for all 13 RD and LC species with adequate data revealed that:

- Most species risky flight minutes could be captured by setting the no-go areas for wind turbines at the class level 5.5 and above.
- Most of these higher risk areas were clustered together in the northern areas of the proposed wind farm, allowing us to reduce risk (by about 80%) for most RD and LC species altogether (by designating them no-go for turbine development);
- On testing to determine if these identified northern areas captured the risky minutes for all species, Blue Cranes and the Falcon species were found to be poorly represented,
- Inspection of the individual risk vulnerability maps for Blue Crane and the Falcon species highlighted a few additional areas that were then avoided for turbine placement by the developer.
- The GPS-tracks of the Black Harrier breeding in the Camdeboo Mountains did not cross into the proposed wind farm site at any time over the pair's 4-month breeding period.

- Given that the present (Gulliver) and past (Moraea) tracks of the breeding Black Harriers did not cross any of the proposed wind boundaries breeding Black Harriers are very unlikely to be at risk from the wind farm development.

We can **summarise our CRM modelling results** as follows:

- For the first time in southern Africa all (13) Priority species in a proposed wind farm have been modelled for Collision Risks (CRM); the CRM based on New et al. (2015) was undertaken by Dr Robin Colyn.
- Thirteen species had sufficient data to perform Collision Risk Modelling (New et al. 2015): We did so for seven RD species and six LC concern.
- Northern sections of the study area were more likely to be designated high-risk areas probably due to higher rainfall (food related) and stronger wind resources (flight related); this comprised 12.6% of the entire 28,750-ha farm.
- Least risky areas were in the south, east, and far west of the study site.
- Three species were found to fly most often within the blade swept area: Booted Eagle (94%), the (3) Falcon species (88%) and Jackal Buzzard (78%).
- The most likely species to be impacted by the turbines according to the CRM were the Falcon species (Lesser Kestrel, Amur, and Hobby Falcon) with an average 1.3 birds estimated to be killed per year without mitigation.
- Among the RD species, Ludwig's Bustards (0.8 birds/year), Blue Cranes (0.6 birds/year) and Lanner Falcon (0.4 birds/year) were the most likely to suffer fatalities without mitigation.
- By avoiding areas classified as risk class 5.5, (and above) the collision risk for all species will be reduced to acceptable levels (subject to additional mitigation in medium risk areas below class 5.5).

5.3 OVERALL SITE SENSITIVITY

The DFFE Screening government tool defines the entire proposed Aberdeen wind farm area as of High Sensitivity for the Animal Theme (Appendix 1). This is based on the potential presence of the following RD species:

- Ludwig's bustard
- Southern black korhaan
- Martial eagle
- Black harrier

All of the above list of species (presumably extracted from the SABAP data set), were all recorded during the BBU monitoring except for the Martial Eagle. However, we also recorded an additional five red data species (**Error! Reference source not found.**) and seven other Collision-prone species (Table 3). Given their high volume of passage rates through the area, following rains, we would classify the site as of Very High sensitivity. Thus, the Screening Tool has not accounted for the influx of avian species likely after substantial rains.

As such, and in compliance with NEMA, a full avian impact assessment has been undertaken.

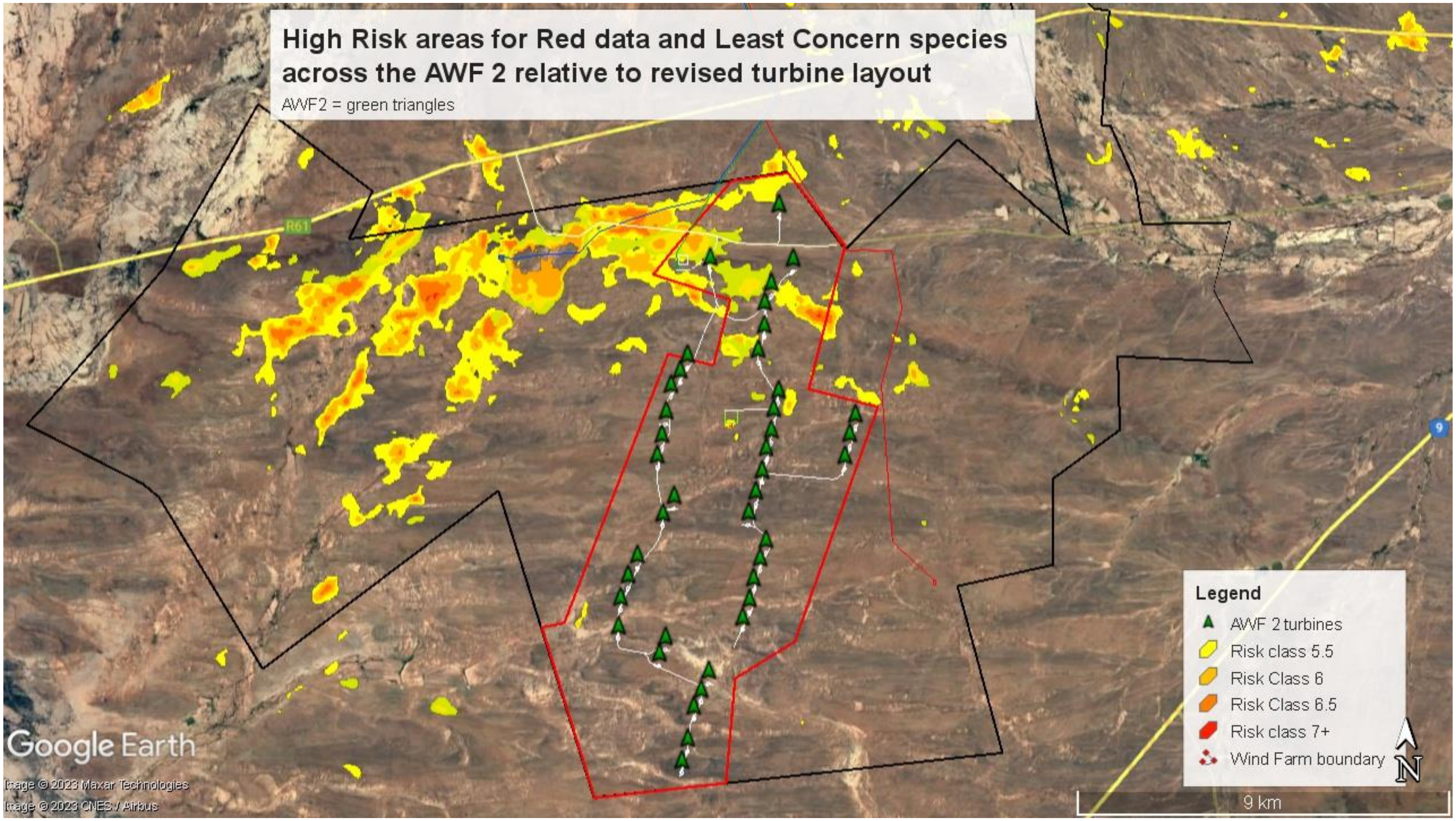


Figure 17: Final Collision Risk Modelling results for the No-Go zone (set at Class 5.5. and higher) for all seven RD and six LC species, combined based on 18 month's monitoring in the Aberdeen Wind Farm 2. All yellow, orange, and red areas are classed at 5.5. and above and were avoided for turbine development (green triangles are the revised [final] turbine positions). The area zoned as No-Go represents 7% (~472-ha) of the entire ~6458-ha AWF 2 area.

6. QUANTIFYING THE IMPACTS

Here we semi-quantify the overall wind farm for the construction and operational phase and evaluate the advantages of various forms of mitigation to reduce expected impacts.

Nature: The impact of the proposed WEF area will generally be negative for birds given the certainty that: (i) ~62 ha of habitat will be transformed and potentially fragmented; (ii) birds may be killed directly if they fly into the proposed 240 MW wind farm. Some displacement may also occur. The following assessment accounts for all of the possible impacts (habitat loss, fragmentation, disturbance, displacement and direct impact fatality) because we do not have enough detail to differentiate the different impacts.

The Extent (**E**, from 1-5) of the impact will be local within the 6458 -ha area = **(1)**.

The Duration (**D**, from 1-5) will be medium long-term **(3)** for the 1-2 years construction underway. This is so for all collision-prone species.

The Magnitude (**M**, from 0-10) of the WEF area is expected to cause a medium-high impact **(7)** for the raptors, blue cranes and bustards.

The Probability of occurrence (**P**, from 1-5) of the Priority species (Black Harriers, Blue Crane, two bustard species, two Korhaan species, Lanner Falcon and seven Least Concern species) having some sort of interaction with the WEF site is ranked as highly probable **(4)** given their high numbers, high passage rates (1.6 birds/h) and species richness (13 collision-prone species). The re-location of turbines out of high-risk areas has reduced this from certain.

The Significance S, [calculated as S = (E+D+M)P], is as follows (Tables 4 and 5) for the species identified as at risk.

The scale varies from:

- 0 (no significance), to≤30 Low (this impact would not have a direct influence on the decision to develop in the area), to
- 30-60 (the impact could influence the decision to develop in the area unless it is effectively mitigated),
- >60 (the impact must have an influence on the decision process to develop in the area).

6.1 CONSTRUCTION PHASE IMPACTS

Table 4. Assessment of all impacts to the priority species during the construction phase of AWF 2.

Impact Phase: Construction		
Nature of Impact: Generally negative due to displacement of priority species due to disturbance associated with the construction of the wind turbines and associated infrastructure. No direct fatalities of birds expected during this phase. Generally short term (approx. 24 months).		
	Without mitigation	**With mitigation**
Extent	**1 Small**	**1 Small**

Duration	**2 Short-term**	**2 Short-term**
Magnitude	**7 Medium high**	**6 Medium**
Probability	**4 Highly likely**	**3 Probable**
Significance (E+D+M)P	**40 Medium**	**27 Medium**
Status (+ve or –ve)	Negative	Negative
Reversibility	For habitat no: it will be permanently altered, For disturbance yes, birds temporarily displaced by disturbance are likely to return once construction complete	Yes: duration only for construction phase
Irreplaceable loss of species?	No	
Can impacts be mitigated?	Yes	

Mitigation for WEF site construction:

- Construction activity should be restricted to the immediate footprint of the infrastructure as far as possible. and should and avoid all sensitive areas (e.g., CRM-designated high-risk areas, wetlands).
- Measures to control noise and dust should be applied according to current best practice in the industry.
- Roads and tracks to avoid all identified sensitive areas wherever possible.
- An avifaunal walk down should be conducted to confirm final layout and identify any sensitivities that may arise between the conclusion of the EIA process and the construction phase.

Residual impacts:

The disturbance of birds is somewhat inevitable by activities on site, although the most sensitive receptors (e.g., CRM-designated high-risk areas) have already been protected through avoidance, through the application of no-go buffers. Post-construction monitoring recommended by Birdlife South Africa guidelines will help identify residual impacts should they occur and recommend any further mitigations required.

6.2 OPERATION PHASE IMPACTS

6.2.1 OPERATION PHASE IMPACT: FATALITIES OF PRIORITY SPECIES

Table 5. A quantification of impacts to the main, collision-prone species likely to be impacted by the **Operational Phase** of the Aberdeen WEF.

Impact Phase: Operational		
Nature of Impact: Generally negative due to potential for collision and displacement of six Red Data species or seven Least Concern species through the operation of the turbines and activity on site.		
	Without mitigation	**With mitigation**
Extent	1 (Small)	1 (Small)
Duration	4 (Short-term)	4 (Short-term)
Magnitude	8 (High)	7 (Moderate)
Probability	4 (Probable)	3 (Probable)
Significance (E+D+M)P	**52 (medium-high)**	**36 (medium)**
Status (+ve or –ve)	Negative	Negative
Reversibility	Yes, with appropriate contemporary mitigations	Yes with staggered pylons, bird diverters and appropriate pylon design
Irreplaceable loss of species?	Possibly	
Can impacts be mitigated?	Yes	Moving all turbines that fall within the high-risk areas as delineated by the CRM will reduce this significantly (and this has been carried out in consultation with clients)
Mitigation for WEF: Re-position all turbines that fall within the high-risk zones delineated by the CRM to lower risk areas (as delineated by the CRM). Additionally, re-locate any turbines that were risky to either (i) Blue Cranes or (ii) the three falcon species to lower risk areas. • The high-risk no-go zones delineated by the CRM should be adhered to (as depicted in this report). • A post-construction programme must be conducted by an avifaunal specialist (following the Birds and		

Renewable Energy Specialist Group guidelines) to (i) assess turbine-related fatalities and (ii) confirm that all aspects have been appropriately handled and in particular that road and hard stand verges do not provide additional substrate for raptor prey species. It is essential that the new wind farm does not create favourable conditions for such mammals in high-risk areas.

- A bird fatality threshold and adaptive management policy must be designed by an ornithologist for the site, prior to construction. This policy should form an annexure of the operational EMP for the facility. This policy should identify most importantly the number of bird fatalities of priority species which will trigger a management response, appropriate responses, and timelines for such responses. In general BBU recommends that should 1 RD species or 2 or more LC species be killed per turbine per year then those turbines will require further mitigation.
- Should the identified priority bird species fatality thresholds be exceeded in Year 1 and 2, either (i) an observer-led turbine Shutdown on Demand (SDOD) programme or (ii) and appropriate alternative mitigation (e.g. striped blade, automated SDOD) must be implemented on site The former programme must consist of a suitably qualified, trained and resourced team of observers present on site for all daylight hours 365 days of the year. This team must be stationed at vantage points with full visible coverage of all turbine locations (typically 1 VP covering four turbines). The observers must detect incoming priority bird species, track their flights, judge when they enter a turbine proximity threshold, and alert the control room to shut down the relevant turbine until the risk has passed. A full detailed method statement or protocol must be designed by an ornithologist.

NB note that that the applicant (Aberdeen Wind Farm 2 (Pty) Ltd , have complied with both recommendations in their revised layout of early December 2022 (Figures 13a and b and Figure 17).

Residual impacts: *(i.e. the risk that remains after all the recommended measures have been undertaken to mitigate the impact associated with the activity)*

Direct mortality through collision, or area avoidance, may occur if cranes, raptors and bustards remain here and the mitigations are insufficient. This possibility can be gauged from a systematic monitoring programme. There is some uncertainty around the effectiveness of bird-turbine collision mitigation at this stage in SA. As a result, the significance remains as “Moderate” post mitigation.

6.2.2 OPERATIONAL PHASE IMPACT: PRIORITY SPECIES POWER LINE COLLISIONS

Table 6. A quantification of impacts to the main, collision-prone species likely to be impacted by any **Overhead power lines associated with** the Aberdeen WEF.

<u>Impact Phase: Operational</u>
Nature of Impact: Generally negative from birds colliding with overhead power lines, particularly RD bustards and cranes

	Without mitigation	With mitigation
Extent	2	2
Duration	4	4
Magnitude	7	5
Probability	4	3
Significance (E+D+M)P	**52 (medium-high)**	**33 (Medium-Low)**
Status (+ve or –ve)	Negative	Negative
Reversibility	Yes, with appropriate contemporary mitigations	
Irreplaceable loss of species?	Possibly	
Can impacts be mitigated?	Yes	

Mitigation for WEF:

- Underground cabling should be used as much as practically possible.
- Because the majority of power line victims uncovered here were bustards, that do not see overhead lines, the newly proposed mitigation of staggered pylons must be implemented on site (Pallett et al. 2022): running new lines adjacent and parallel with existing lines is strongly recommended.
- Bird flight diverters must also be installed on all the overhead line sections for the full span length according to the applicable Eskom Engineering Instruction (Eskom Unique Identifier 240 – 93563150: The utilisation of Bird Flight Diverters on Eskom Overhead Lines). These devices must be installed as soon as the conductors are strung.
- If the use of overhead lines is unavoidable due to technical reasons, the Avifaunal Specialist must be consulted to ensure that a raptor friendly pole design to avoid electrocutions. The rule of thumb here is that all conductors be strung below the support structures. Where this is not possible, insulation of live components will be required to prevent electrocutions on terminal structures and transformers.

Residual impacts:

Mitigation for this impact should be relatively effective if the overhead lines are designed correctly, with staggered pylons and diverters. If not, then further input must be sought from an avifaunal specialist and Eskom's birds and power line group, to add additional mitigations.

6.3 CUMULATIVE IMPACTS

6.3.1 OTHER WIND AND SOLAR FACILITIES

Cumulative impacts are defined as “impacts that result from incremental changes caused by either past, present or reasonably foreseeable actions together with the project” (Hyder, 1999, in Masden et al. 2010).

In this context, cumulative impacts are:

- those that will impact the general avian communities in and around the Aberdeen Wind Facility 2 development, mainly by other renewable energy farms: and
- associated infrastructure in the form of power lines in Nama Karoo surrounds.

Here we focus on fatalities through collisions, associated with renewable energy developments, as they are easier to quantify than displacement effects and likely to be of higher magnitude. All renewable energy developments within a 30-km radius of the site need to be determined and, secondly, their impact on avifauna estimated.

Given the general assumption that footprint size and bird impacts are linearly related for wind and solar farms, a starting point in determining cumulative impacts is to calculate:

- the number of birds displaced per unit area, by habitat destruction, or disturbed or displaced by human activity;
- the number of birds killed by collision with the wind and solar facility nearby; and
- the number of birds killed by collision with infrastructure (e.g., power lines) within, or leading away from, the site.

Only one renewable energy developments are currently on record with the Department of Forestry, Fisheries and the Environment within 30-km of Aberdeen Wind Facility 2 (Table 7). Several others are proposed (one wind farm and one solar farm) but have yet to be registered. The combined energy output of the one “approved” projects is 200MW from another wind farm (Table 7).

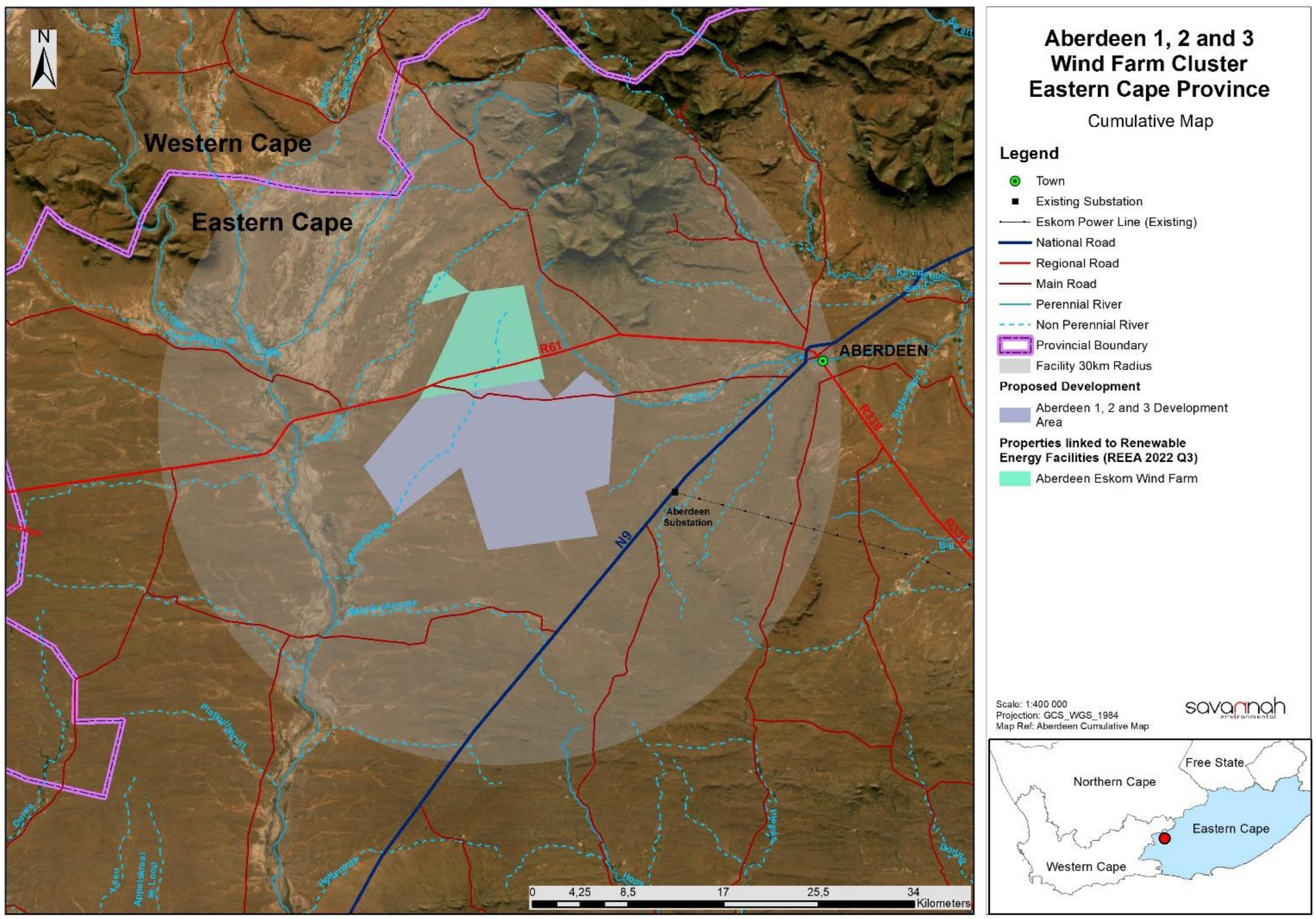
Table 7: All renewable energy projects within a 30-km radius of the Aberdeen WEFs, and their approval status with the DEA. Source: DFFE webpage https://egis.environment.gov.za/data_egis/data_download/current_2022_, second quarter.

	Project Title	Distance from Aberdeen WEF	Technology	Megawatts	Current Status
1	Aberdeen 200MW wind farm (Eskom Holdings)	2 km	Wind	200	Approved

Summary: 1 renewable energy facility (1 WEF)   Total power output: WIND **200 MW**

The national review of post-construction data (Perold et al. 2020), including data from Eastern Cape wind farms, indicates that:

- South African wind farms kill an average of 4.6 <u>+</u> 2.9 birds per turbine per year (corrected for scavenger and observer bias), similar to the international mean of bias-corrected estimates of 5.25 birds per turbine per



year (see Review [Point 5] above).

- The equivalent number of fatalities per Megawatt is **2.0 <u>+</u> 1.3 birds per MW** per year (Perold et al. 2020). Of concern is that 36% of the South African fatalities recorded are raptors (Table 7).
- Using these values, we can calculate the number of birds likely to be killed per megawatt.

Figure 18: All proposed renewable energy (RE) developments within a 30-km radius of the proposed Aberdeen wind farms. The two (green) sites are the Eskom Holdings 200MW wind farm.

We can estimate the potential cumulative number of fatalities using the known fatalities from Perold et al. (2020). The total power output of all proposed wind farms within 30-km is 200 MW. The potential fatalities attributable to this form of renewable energy is given in Table 7.

Table 8: Avian fatalities arising from the cumulative total of all authorised wind and solar projects within 30-km of the proposed Aberdeen Wind Farm 2.

Annual Avian fatalities due to WIND + SOLAR PV farms for CUMULATIVE IMPACTS		
WIND	**Number of wind MWs near the Aberdeen WEF**	**Total estimated fatalities**
2.0 ± 1.3 birds/MW/year	200 MW	400 birds killed
SOLAR	**Number of solar MWs near the Aberdeen WEF**	
4.5 ± 3.5 birds/MW/year	0 MW	0 birds killed
Total birds estimated killed per year		**400 birds**
Estimated total raptors forecast to be killed per year (~36%)		144 raptors
Estimated Red Data raptors (~17% of all raptors)		**24 Red Data raptors**

Thus, the estimated figure for all avian fatalities is 400 birds (all species) from interactions with wind farms within 30-km. If ~36% of these are raptors (Perold et al. 2017), then we expect about 144 raptor fatalities of which approximately 24 (17%) may be threatened Red Data raptors per year. This does not include species that may be displaced from these developments and excludes fatalities due to power line collisions. These are medium-high totals and suggest cumulative totals must be ranked a *medium* and significant.

We populated the Cumulative Impacts table with avian fatality rates from published studies. We sourced data from:

(i) post-construction wind farm data from avian assessments summarised by Birdlife South Africa from 1-2 years' post-construction monitoring (Perold et al. 2020).

Table 9. A quantification of Cumulative Impacts to the main, collision-prone species likely to be impacted by the Operational Phase of wind farms within 30 km of the Aberdeen Wind Farm 2**.**

Nature: Generally negative for birds due to direct fatalities due to collisions with spinning blades. Some species will also avoid the increased disturbance or move away as a result of habitat fragmentation or habitat destruction on site		
	Overall impact of the proposed project considered in isolation*	**Cumulative impact of the project and other projects in the area**

Extent	1 (small)	2 (regional)
Duration	4 (Short -term)	4 (Short-term)
Magnitude	7 (Moderate)	8 (Moderate)
Probability	3 (Probable)	3 (Probable)
Significance	**36 Medium**	**42 Medium-high**
Status (positive or negative)	Negative	Negative
Reversibility	High	Low
Irreplaceable loss of resources?	Possibly, yes	Possibly, yes
Can impacts be mitigated?	Yes	Yes

Confidence in findings: Medium (due to lack of on-site data from the other wind farm)

Mitigation for all WEFs

- The wind farm north of Aberdeen should ideally undertake the same CRM process undertaken so successfully here in AWF 2
- All high-risk zones as delineated by any CRM should be adhered to (as outlined in this report) at both farms
- Post-construction programmes must be conducted by an avifaunal specialist (following the Birds and Renewable Energy Specialist Group guidelines) to (i) assess turbine-related fatalities and (ii) confirm that all aspects have been appropriately handled and that road and hard stand verges do not provide additional substrate for raptor prey species. It is essential that the new wind farms do not create favourable conditions for such mammals in high-risk areas.
- A bird fatality threshold and adaptive management policy must be designed by an ornithologist for the site, prior to construction. This policy should form an annexure of the operational EMP for the facility. This policy should identify most importantly the number of bird fatalities of priority species which will trigger an appropriate management response, and timelines for such responses. In general, BBU recommends that should 1 RD species or 2 or more LC species be killed per turbine per year then those turbines will require further mitigation.
- Should the identified priority bird species fatality thresholds be exceeded in Year 1 and 2, either (i) an observer-led turbine Shutdown on Demand (SDOD) programme or (ii) and appropriate alternative mitigation (e.g. striped blade, automated SDOD) must be implemented on site. The former programme must consist of a suitably qualified, trained and resourced team of observers present on site for all daylight hours 365 days of the year. This team must be stationed at vantage points with full visible coverage of all turbine locations (typically 1 VP covering four turbines). The observers must detect incoming priority bird species timeously, track their flights, and when adjudged to have entered a turbine proximity threshold, alert the control room to shut down the relevant turbine. A full detailed method statement or protocol must be designed by an ornithologist.

- It is not known if a CRM is or has been undertaken at the other WEF north of AWF 2, but given the success of its application here by Aberdeen Wind Farm (Pty) Ltd in re-locating turbines BBU recommend it for all future wind farms in the area.

*With mitigation

7. MITIGATIONS

We recommend three ways to mitigate risk to birds:

- Move proposed turbines out of the highest risk areas predicted by the CRM (i.e., above class 5.5). This has undertaken by the applicant and therefore this mitigation has already been achieved (reflected in the figures in this report) and the current layout will have reduced the risk already.
- For turbines proposed in medium-risk areas (those lower than class 5.5), two-tiers of mitigation are recommended.

Aberdeen Wind Facility 2 re-modelled their proposed turbine layout (in November 2022) and accounted for the recommended No-Go areas in Figure 13. AWF 2 relocated all 41 proposed turbines into medium or low risk areas, and these are shown in Figure 17.

Note that three turbines fall within the outer perimeter (last 5% of the kernel drawn for her Home Range) of a satellite-tracked female Black Harrier (Moraea) that foraged here in 2010 and 2011. The BBU teams re-assessed all these areas (five site visits into the northern areas) in 2021/2022 and recorded only two harrier in 648,5 hours of systematic observations. This low encounter frequency coupled with the lack of GPS tracks by breeding male "Gulliver" (Figure 9) indicates that this area is very rarely used by harriers and does not require additional mitigations.

We recommend the following set of mitigations, contingent on the risk class that each turbine falls into:

- Turbines falling into Class 5 must be mitigated with 2-tiers of mitigation (striped-blade and SDOD).Note that we suggest that Striped blade mitigation may be preferable given that the simultaneous manufacture of the blade and additional paint patterns at source will add no extra costs, and once in place it will be a mitigation with no post-installation costs. [Should it be required once the blades are installed however, costs escalate to ~R600k per turbine]. Should human SDOD be implemented it should be in place for 24 months and should it prove unnecessary in a review of the number of risky flights recorded (e.g. < 1 per month) then it can be discontinued until such time that increasing Passage Rates or RD or LC fatalities are found
- Turbines in Class 4 to be mitigated with 1-tier of mitigation (preferably striped-blade).
- Turbines in Class 3 and below without mitigation.
    - Should any turbines kill 1 *Critically Endangered*/*Endangered* Red Data species per year they must be (retro-)fitted with some form of mitigation (striped blade, SDOD, hourly/daily/seasonal curtailment) to reduce fatalities to negligible level. This mitigation is recommended because it is essential that an immediate response is forthcoming. This covers in particular the Black Harrier, a species for which population viability modelling indicates that we cannot afford to lose even one more adult bird (Cervantes et al. 2022).
    - For other red data species (*Vulnerable* and *Near Threatened*) and other collision-prone species a specific response and bird fatality threshold must be discussed and implemented within a month by an avifauna specialist appropriate to the rarity (and population viability) of the species involved.
    - Ideally this should be a separate and adaptive management plan for the site prior to construction. This policy could be included as annexure to the operational EMP for the WEF This plan should identify most importantly the number of bird fatalities of priority species which will trigger a management response, the appropriate response, and time lines for such responses. Fatalities of

priority bird species are usually rare events (but with very high consequences) so such fatalities should be responded to timeously and as they occur. It is therefore important to have a threshold policy in place proactively to assist adaptive management.

- Note that given the extensive modelling of risk by the CRM, based on a data set collected in a high species-richness and abundance year, resulting in the re-location of all turbines outside all high risk areas by the client, the likelihood that fatalities will occur is very low, and these additional mitigations are unlikely to be required.

8. ENVIRONMENTAL MANAGEMENT PROGRAMME

Given the possible impact of the proposed Aberdeen Wind farm developments, the overall impact on avifaunal species requires systematic monitoring at both the construction-phase and operational-phase of the wind farm. This is a recommendation of the BARESG guidelines (Jenkins et al. 2015).

The guidelines suggest an adaptive and systematic monitoring of bird displacement (comparing avian densities before and after construction, particularly for Priority collision-prone and Red Data species) and particularly the monitoring of all turbine-related fatalities. The latter must take account of biases introduced by scavengers removing carcasses and observers failing to detect bird remains below the turbines.

The monitoring should include the following (as per BARESG guidelines):

- **Construction-phase** monitoring should begin as the wind farm construction is started – bearing in mind that the effects of construction on the environment can be higher than the operational phase. This phase should include monitoring nests and roosts and bustard leks on site to determine any disturbance or habitat loss where it may cause irreparable harm. These are more checks on the most important (threatened) components of the biodiversity on site than systematic surveys covering all species. This should cover a minimum 18-24 months.
- **Post-construction** monitoring can be divided into two categories:
  a) quantifying bird numbers and movements (replicating baseline data collection), and
  b) estimating bird mortalities.
- Carcass monitoring should be undertaken by trained observers, able to cover 4-5 turbines per day in all weather throughout the year at ~40% or more of all the turbines, overseen by an ornithologist competent to determine species identification, and a manager to collate and analyse each years' data.
- Estimating bird fatality rates includes:
  a) estimation of searcher efficiency and scavenger removal rates using carcasses;
  b) carcass searches; and
  c) data analysis incorporating systematically collected data from (a) and (b); these biases should then inform the fatality rates.

A minimum of 30-40% of the wind farm footprint should be methodically searched for fatalities, throughout the year, with a search interval informed by scavenger removal trials and objective monitoring. Any evidence of mortalities or injuries within the remaining area should be recorded and included in reports as incidental finds.

- The search area should be defined and consistently applied throughout monitoring.
- The duration and scope of post-construction monitoring should be informed by the outcomes of the previous year's monitoring and reviewed annually.
- Post-construction monitoring of bird abundance and movements, and fatality surveys, should span 2-3 years to take inter-annual variation into account, particularly in dry areas such as the Nama-Karoo, and
- If significant problems are found or suspected, the post-construction monitoring should continue in conjunction with adaptive management and mitigations – accounting for the risks related to that particular site and species involved.

An assessment guided by these principles is required not only to enact and test the effectiveness of different mitigation measures where significant mortality occurs but allow data to be collected that will benefit the welfare of avifauna at other renewable energy farms. This is also important for a study of cumulative avian impacts for the increasing number of wind farms planned for South Africa.

Management interventions: Where avian fatalities are found to occur:

(i) to *Critically Endangered/ Endangered* Red Data species (at a level of 1 RD fatality per turbine year); or

(ii) should 2 or more individuals of other Red data species (i.e. *Vulnerable* or *Near Threatened*) or a Least Concern Priority species be killed per turbine year, then a specific response and bird fatality threshold must be discussed and implemented within a month for those turbines causing the fatalities. This should be tailored to the rarity of the species involved such that the more range-restricted or rare the species is the lower the threshold (i.e. 2 vs 3 vs 4 fatalities) is at which mitigation action is triggered.

(ii) a full threshold-response plan, as detailed above should be initiated for Priority species avian fatalities. This requires workshopping a consensus on the "acceptable" levels of fatalities for each species. However, where fatalities occur for *Endangered* or *Critically Endangered* species the threshold remains at 1 bird fatality per turbine per year as a trigger for an immediate response (this is to avoid protracted negotiations that may well see other individuals of the same species unnecessarily killed by the same turbine).

Experiments, with bird deterrent techniques such as striped blades painted with black or signal red paint are encouraged (Martin and Banks 2023), or the initiation of human-led, or automated, shut-down-on-demand (SDOD) within two months to reduce fatality rates. Note that introducing striped blade mitigation at source is financially a significantly more affordable option (with no post-installation costs) than doing so once operations have begun. If mitigations are required during the operational phase then, SDOD or curtailment may be more financially viable and it is for the developer to choose one or the other. The results of these experiments should be publicised so that other wind farms, with similar issues, can be informed.

We encourage Developers to release the results of the annual monitoring to Birdlife South Africa, such that South Africa-wide fatality and displacement results can be collated and assessed. In this way cumulative impacts assessments, currently crudely estimated, can be refined, region by region.

9. CONCLUSIONS AND RECOMMENDATIONS

This 18-month, all season assessment of the risk to Priority avifauna, combined with a breeding season assessment of the movements of a locally breeding Black Harrier near the proposed Aberdeen Wind Farm 2 provides the first complete Collision Risk Modelling in South Africa for a suite of 13 species at potential risk from the proposed wind farm. Six Red Data species and seven Least Concern species with a high (combined) Passage Rate of 1.6 flights per hour made this site challenging, but data rich.

That the Red Data species alone had Passage Rates of 0.69 flights per hour across the WEFs (1.6 flights per hour for all priority species) indicates that risk from the proposed 41 turbines could be substantial. These rates may be high due to the exceptional rainfall, that occurred in the summer months following years of drought, which promotes increased diversity of birds in arid areas (Seymour et al. 2015) and RD species into the area. Given that the average rainfall is lower than this the species -richness and numbers of birds will, on average be lower and the analyses here represent the "worst" case scenario for possible risks to Priority birds.

The Collision Risk Modelling allowed a fine-tuned assessment of not only the Passage Rates, but flight heights, the placement of turbines, and a more precise spatially explicit assessment of risk to all 13 Priority species. It gave eight levels of risk (from 1, the lowest, to 8, the highest) and we examined the data (lumped together and for individual species) to determine where the number of risky-flight minutes could be minimised in relation to areas.

The resulting identification of risk across spatially explicit areas indicated the northern central areas tend to be the highest risk due to the high density of both RD and LC species. This resulted in 7% of the area designated for Aberdeen Wind Facility 2 as No-Go for turbines. The client used these outputs to relocate all turbines outside all designated high-risk areas. Those turbines lying outside the high-risk No-Go areas would require one of two tiers of mitigation (striped blade and SDOD) depending on the remaining risk.

Additional data were provided by the GPS-tagging of the male Black Harrier "Gulliver" in the Camdeboo Mountains. Analysis indicated that his vast foraging area (~530-km^2) across the plains of Camdeboo over his 4-month breeding period did not intersect the AWF2 anywhere. Previous satellite-tracking of (female) Black Harriers here indicated that only three of the 123 proposed turbines intersected the foraging kernels, and these were the least used (5%) section of the range of the female Black Harrier "Moraea". Only two Black Harriers were recorded in almost 650 hours monitoring in these same areas and thus the risk to these Endangered birds is negligible.

Birds & Bats Unlimited concluded differently to the DFFE Screening Tool Assessment that classified the Aberdeen area as of High Sensitivity. We classified it instead as of Very High Sensitivity based on the increased number of red data species [7] and other Collision-Prone species [6] present and the medium-high aerial traffic (Passage Rates) following substantial rains. However, given the in-depth CRM analysis and the subsequent re-location of all turbines from all high-risk areas, the sensitivity to collision or displacement for all 13 collision-prone species has been reduced to much lower and acceptable levels.

According to available information collected during this study and based on the CRM-optimised layout for each of the 41 turbines proposed for the Aberdeen Wind Facility 2, all high-risk areas for birds have been avoided by the finalised (Decembermber 2022) turbine layout. Because of the applicants' commitment to also implement the recommended mitigation measures in the medium risk areas, Birds & Bats Unlimited are of the professional opinion, that there are no fatal flaws from an avifaunal sensitivity perspective, that may prevent the Aberdeen Wind Facility 2 from receiving Environmental Authorisation (EA).

10. REFERENCES

Band W, Madders M, Whitfield DP 2007. Developing field and analytical methods to assess avian collision risk at wind farms. In: de Lucas M, Janss GFE, Ferrer M, editors. Birds and Wind Farms: Risk Assessment and Mitigation. Madrid: Quercus. pp. 259–275.

Cervantes F, Martins M, Simmons RE. 2022 Population viability assessment of an endangered raptor using detection/non-detection data reveals susceptibility to anthropogenic impacts. R. Soc. Open Sci. 9: https://doi.org/10.1098/rsos.220043

Dean WRJ. 2004. Nomadic Desert Birds. Springer, Switzerland.

Martin GR, Banks AN. 2023. Marine birds: Vision-based wind turbine collision mitigation**.** Global Ecology and Conservation 42 (2023) e02386

Mitkus et al. 2018. Raptor vision. http://neuroscience.oxfordre.com/

Murgatroyd M, Bouten W, Amar A. 2020. A predictive model for improving placement of wind turbines to minimise collision risk potential for a large soaring raptor. *J Appl Ecol*. 2020;00:1–12. https://doi.org/10.1111/1365-2664.13799

New L, Bjerre E, Millsap B, Otto MC, Runge MC (2015) A Collision Risk Model to Predict Avian Fatalities at Wind Facilities: An Example Using Golden Eagles, *Aquila chrysaetos*. PLoS ONE 10(7): e0130978. https://doi.org/10.1371/journal.pone.0130978

Perold , S Ralston-Paton, Ryan P 2020: On a collision course? The large diversity of birds killed by wind turbines in South Africa, Ostrich, DOI: 10.2989/00306525.2020.1770889 https://doi.org/10.2989/00306525.2020.1770889

Ralston Paton, S., Smallie J., Pearson A.,Ramalho R. 2017. Wind energy's impacts on birds in South Africa: A preliminary review of the results of operational monitoring at the first wind farms of the Renewable Energy Independent Power Producer Procurement Programme in South Africa. *BirdLife South Africa Occasional Report Series No. 2.* BirdLife South Africa, Johannesburg, South Africa

Seymour CL, Simmons, RE Joseph,GS, Slingsby JA. 2015. On Bird Functional Diversity: Species Richness and Functional Differentiation Show Contrasting Responses to Rainfall and Vegetation Structure in an Arid Landscape. Ecosystems (doi:10.1007/s10021-015-9875-8)

Simmons RE, Ralston-Paton, S, Colyn R, Garcia-Heras M-S. 2020. Black Harriers and wind energy: guidelines for impact assessment, monitoring and mitigation. https://www.birdlife.org.za/wp-content/uploads/2020/09/Black-Harriers-Wind-Energy-Final-1.pdf

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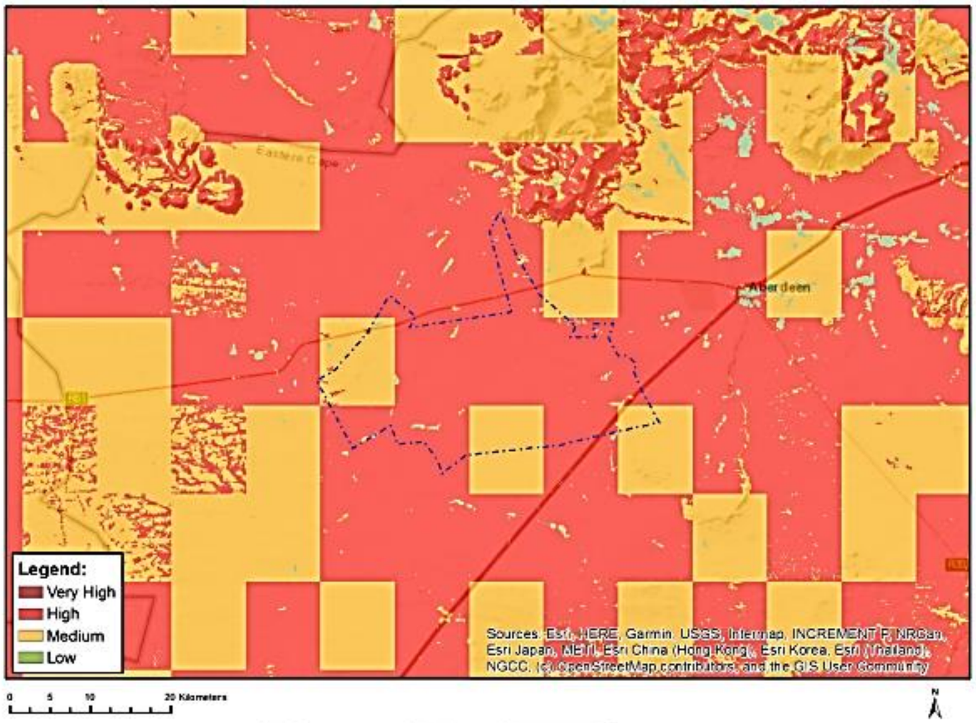
APPENDIX 1: SCREENING TOOL ASSESSMENT – ANIMAL THEME

MAP OF RELATIVE ANIMAL SPECIES THEME SENSITIVITY



Where only a sensitive plant unique number or sensitive animal unique number is provided in the screening report and an assessment is required, the environmental assessment practitioner (EAP) or specialist is required to email SANBI at eiadatarequests@sanbi.org.za listing all sensitive species with their unique identifiers for which information is required. The name has been withheld as the species may be prone to illegal harvesting and must be protected. SANBI will release the actual species name after the details of the EAP or specialist have been documented.

Very High sensitivity	High sensitivity	Medium sensitivity	Low sensitivity
	X		

Sensitivity Features:

Sensitivity	Feature(s)
High	Aves-Neotis ludwigii
High	Aves-Afrotis afra
High	Aves-Falco biarmicus
High	Aves-Polemaetus bellicosus
High	Reptilia-Chersobius boulengeri
Low	Subject to confirmation
Medium	Aves-Circus maurus
Medium	Aves-Neotis ludwigii
Medium	Aves-Afrotis afra
Medium	Mammalia-Bunolagus monticularis
Medium	Reptilia-Chersobius boulengeri

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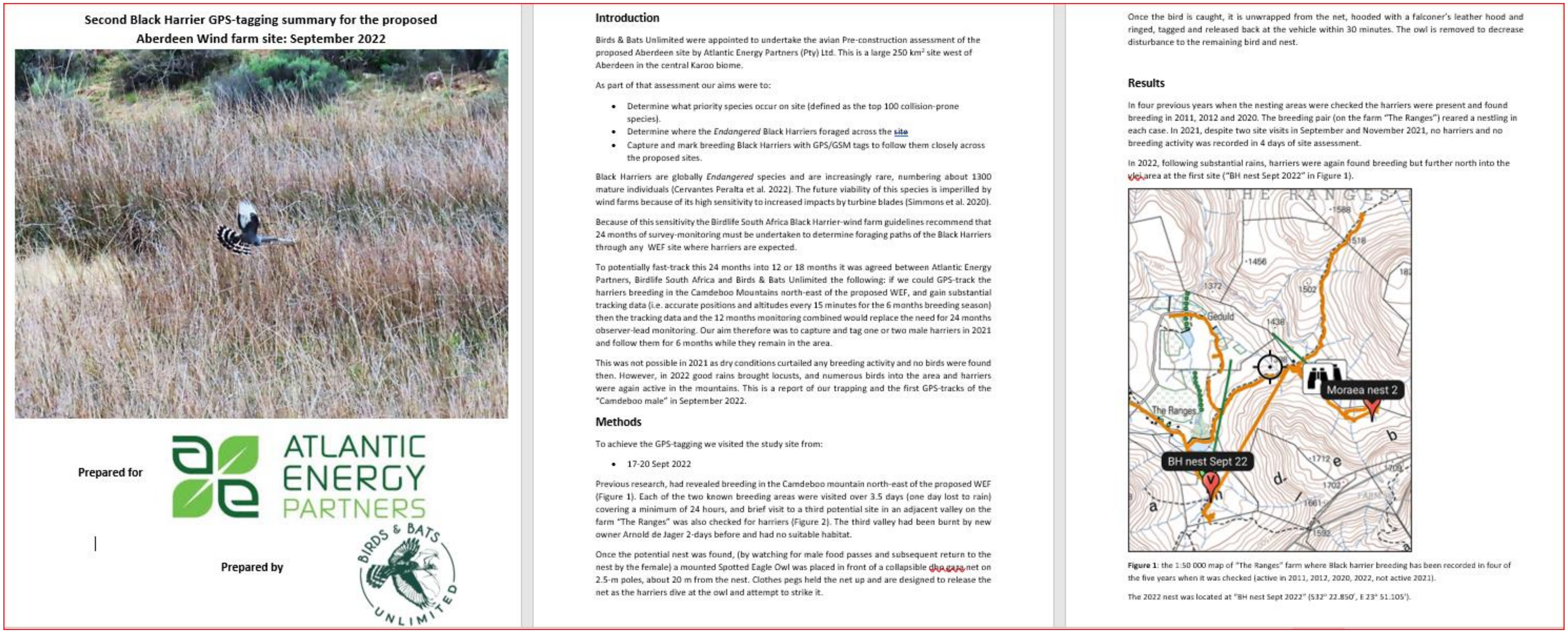
09/12/2022



Second Black Harrier GPS-tagging summary for the proposed Aberdeen Wind farm site: September 2022

Prepared for

ATLANTIC ENERGY PARTNERS

Prepared by

BIRDS & BATS UNLIMITED

Introduction

Birds & Bats Unlimited were appointed to undertake the avian Pre-construction assessment of the proposed Aberdeen site by Atlantic Energy Partners (Pty) Ltd. This is a large 250 km^2 site west of Aberdeen in the central Karoo biome.

As part of that assessment our aims were to:

- Determine what priority species occur on site (defined as the top 100 collision-prone species).
- Determine where the *Endangered* Black Harriers foraged across the site
- Capture and mark breeding Black Harriers with GPS/GSM tags to follow them closely across the proposed sites.

Black Harriers are globally *Endangered* species and are increasingly rare, numbering about 1300 mature individuals (Cervantes Peralta et al. 2022). The future viability of this species is imperilled by wind farms because of its high sensitivity to increased impacts by turbine blades (Simmons et al. 2020).

Because of this sensitivity the Birdlife South Africa Black Harrier-wind farm guidelines recommend that 24 months of survey-monitoring must be undertaken to determine foraging paths of the Black Harriers through any WEF site where harriers are expected.

To potentially fast-track this 24 months into 12 or 18 months it was agreed between Atlantic Energy Partners, Birdlife South Africa and Birds & Bats Unlimited the following: if we could GPS-track the harriers breeding in the Camdeboo Mountains north-east of the proposed WEF, and gain substantial tracking data (i.e. accurate positions and altitudes every 15 minutes for the 6 months breeding season) then the tracking data and the 12 months monitoring combined would replace the need for 24 months observer-lead monitoring. Our aim therefore was to capture and tag one or two male harriers in 2021 and follow them for 6 months while they remain in the area.

This was not possible in 2021 as dry conditions curtailed any breeding activity and no birds were found then. However, in 2022 good rains brought locusts, and numerous birds into the area and harriers were again active in the mountains. This is a report of our trapping and the first GPS-tracks of the "Camdeboo male" in September 2022.

Methods

To achieve the GPS-tagging we visited the study site from:

- 17-20 Sept 2022

Previous research, had revealed breeding in the Camdeboo mountain north-east of the proposed WEF (Figure 1). Each of the two known breeding areas were visited over 3.5 days (one day lost to rain) covering a minimum of 24 hours, and brief visit to a third potential site in an adjacent valley on the farm "The Ranges" was also checked for harriers (Figure 2). The third valley had been burnt by new owner Arnold de Jager 2-days before and had no suitable habitat.

Once the potential nest was found, (by watching for male food passes and subsequent return to the nest by the female) a mounted Spotted Eagle Owl was placed in front of a collapsible dho gaza net on 2.5-m poles, about 20 m from the nest. Clothes pegs held the net up and are designed to release the net as the harriers dive at the owl and attempt to strike it.

Once the bird is caught, it is unwrapped from the net, hooded with a falconer's leather hood and ringed, tagged and released back at the vehicle within 30 minutes. The owl is removed to decrease disturbance to the remaining bird and nest.

Results

In four previous years when the nesting areas were checked the harriers were present and found breeding in 2011, 2012 and 2020. The breeding pair (on the farm "The Ranges") reared a nestling in each case. In 2021, despite two site visits in September and November 2021, no harriers and no breeding activity was recorded in 4 days of site assessment.

In 2022, following substantial rains, harriers were again found breeding but further north into the vlei area at the first site ("BH nest Sept 2022" in Figure 1).

Figure 1: the 1:50 000 map of "The Ranges" farm where Black harrier breeding has been recorded in four of the five years when it was checked (active in 2011, 2012, 2020, 2022, not active 2021).

The 2022 nest was located at "BH nest Sept 2022" (S32° 22.850', E 23° 51.105').

APPENDIX 2: SECOND BLACK HARRIER GPS-TAGGING REPORT

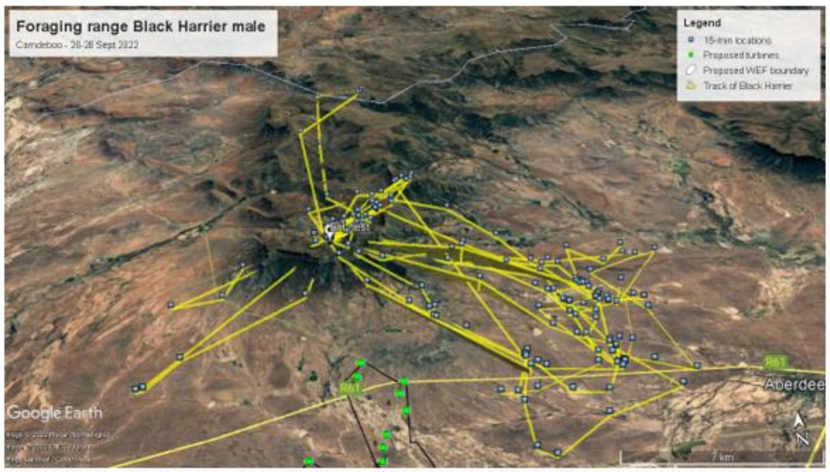


Figure 2: The GPS-foraging track of male Black Harrier (20-26 Sept 2022) breeding in the Camdeboo mountains (= BH nest). This gives the first indication of the foraging range from his nest on the top of the Camdeboo mountains. The (previous) boundary of the proposed WEF (= black polygon) is shown to the south. The first 4 days of tracking indicate that this male harrier did not forage into the proposed WEF.

Foraging tracks revealed by GPS tagging

Photo 1: The Camdeboo male Black Harrier in the hand , with GPS-tracker attached, just before release. The trackers are 9.5 g and allow highly accurate locations and height measurements.