Final Avifaunal Impact Assessment, and Collision-Risk Modelling for the Proposed KHOE Wind Energy Facility, 2023

Produced for:

energy TEAM

Produced by:

BIRDS & BATS UNLIMITED

CONTENTS

SUMMARY

Energy Team proposes the development of the KHOE Wind Energy Facility (WEF) on montane fynbos-dominated farmland south of de Doorns and north of Montagu, in the Western Cape. This is the final avian assessment combining four seasonal surveys by Birds & Bats Unlimited (BBU) and modelling the risk to all Priority bird species using sophisticated Collision Risk Modelling (CRM) undertaken by Dr Robin Colyn who co-authors this report.

The main surveys were conducted by BBU over a 12-month period in 2022-2023 and undertaken simultaneously with surveys of another proposed wind farm site at Hugo. The KHOE site is approx. 4113-ha in size and comprised mainly of agricultural areas with farm dams centrally placed and small ridges to the north and east.

The DFFE Screening Tool (Animal Theme) classified the area as of *High Sensitivity* (based on the presence of four Red Data species). Birdlife South Africa's national Avian Sensitivity Map suggests low to medium-high sensitivity for birds and wind farms. Inspection of the national bird atlas data set (SABAP 2) including our own species records added an additional Red Data species (Lanner Falcon *Falco biarmicus*) and other collision-prone species. We, thus, concur with the Screening Tool's assessment that the site is of High Sensitivity, and the data and models that follow allow us to reduce risk by constructing a detailed spatial picture of the risks to the Priority birds present.

Over four seasons, 1159 flights of 16 Priority species were recorded in 465 hours of observations across the proposed KHOE farm. The Collision Risk Modelling (CRM) based on a new (New et al. 2015) formulation of the previous Band model calculates risk classes across all areas of the farm based on the volume of flights, flight heights and their duration, and incorporates an assessment of topographic and environmental factors. The CRM then allows us to inform the WEF developers where turbines are best placed therein to reduce avian risks with fine-tuned precision. It also allows us to calculate expected fatalities as required by the DFFE protocols.

Of the 16 Priority species, eight Red Data species and eight Least Concern species were recorded and mapped.

Among the Red Data (RD) species, 1014 flights were recorded in 465 hours in the WEF giving a high Passage Rate of 2.18 RD flights per hour; these were dominated by Blue Cranes *Grus paradiseus* (93% of all flights) and Verreaux's Eagles (5%). Among Least Concern (LC) species the Booted Eagles *Aquila pennatus* were the most commonly recorded and the overall Passage Rate was 0.31 flights per hour.

Adequate flight data were collected from seven (5 RD and 2 LC) of the 16 species to undertake the CRM analysis. The CRM assessment weighted *Endangered* RD species higher than *Vulnerable* species and all RD species were ranked higher than LC species. It also accounted for the seven Priority species' collision-propensity, as well as habitat variables and topography, to produce a high resolution spatially explicit risk map giving eight levels of risk for the entire area.

The highest risk areas (Class 5.0 and above) were strongly clumped in the eastern and northern sections, due mainly to high flight rates of Blue Cranes and Verreaux's Eagles. The risky threshold chosen (Class 5.0+) encompassed more than 75% of risky flights for two species (Verreaux's Eagles and Black Harrier), and 50% of such flight for six of the seven species. The areas are classified as too risky for development and allocated as No-Go areas.

These high-risk class areas covered 67% of the area, leaving 33% of the area classified as medium- or low-risk to the Priority birds recorded, mainly in the south-west of the study site. Turbines in areas classified as risk Class 4.5 require one-tier of mitigations: either patterned-blades or shut-down-on-demand [SDOD] – automated, or human-led. Those

in Class 4.0 require no extra mitigation. Should one *Critically Endangered* or *Endangered* bird be killed per year at any turbine then an additional tier of mitigation must be applied. For Other Red data species, the threshold triggering mitigation is 1 to 2 fatalities depending on the species.

Note that two alternative approaches to mapping risks were also assessed.

A Revision 2 CRM that was explored to determine if more area was developable by mapping risk classes differently. However, the area available for development, was reduced more relative to the model presented here.

The second approach was a subjective mapping of high aerial traffic of RD and LC species, in combination with recommended buffers around known nests of RD species. This coarse, more subjective, approach also resulted in more areas lost to development. Thus, the quantitative CRM results allow repeatability and a statistically sound and high-precision assessment, with high-risk areas concentrated in the east of the site, and areas open to development in the southwest. The final turbine layout presented here avoids the risk areas and accompanies these CRM risk maps.

Since the applicant has optimised their turbine layout to (i) avoid all high-risk areas; and (ii) to minimise turbines in medium-risk areas as presented here then fatalities of all Priority species are expected to drop to ~0.1 birds/year for Black Harrier (BH), Blue Crane (BC), and Martial Eagle (ME) and ~0.4 birds/year for Verreaux's Eagle (VE), Jackal Buzzard (JB) and Booted Eagle (BE). That is one fatality every 10 years (BH, BC and ME) to one every 2.5 years (VE, JB and BE).

Thus, by avoiding the risk areas mapped in the spatially explicit model and micro-siting the turbines well away from high-risk areas, fatality estimates can be reduced between 10.6-fold (Blue Crane) and 9.4-fold (Black Harriers) to 6.6- and 6.8-fold for Martial and Verreaux's Eagles, respectively. Thus, following recommendations of the CRM will substantially reduce fatalities.

Impact Significance Tables are presented before and after these mitigations for the whole study site. They indicate a drop in significance from High to Medium with avoidance mitigation alone due to the 10- to 6-fold drop predicted by the CRM. Cumulative mitigations for all wind farms that fall within 30-km of the KHOE WEF are presented as required.

Birds & Bats Unlimited are of the professional opinion that should the client retain the optimised turbine layout for the KHOE Wind Farm according to the CRM assessment presented here then avian fatalities will be minimised, and no fatal flaws exist from an avifaunal sensitivity perspective. Thus, we see no avifaunal reasons preventing the KHOE Wind Energy Facility 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)
- **Green Hydrogen** desktop assessment project in Kleinsee **(**WSP 2021)
- **CRM analysis** and BAR for an avian assessment of three Aberdeen **wind farms** (Atlantic Energy 2022/23)
- **Cape Vulture fatal flaw assessment** for proposed Manzimahle wind farm (Manzimahle Pty Ltd, 2023)
- Avian impact assessment Khabasi North, East and West **wind farms** (Khabasi Developments, 2022/23)**.**

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

SACNASP: Pr Nat Sci. 008857

16 July 2023,

Revised 16 September 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

environmental affairs
Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

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

KHOE Wind Energy Facility, Western 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)			
Professional affiliation/registration:	Birdlife South Africa, Honourary Research Associate University of Cape Town SACNASP Pr Nat Sci (008857)			
Physical address:	8 Sunhill Estate, Trigg Road, Capri, Cape Town			
Postal address:	As above			
Postal code:	7975	Cell:	0827 800 133	
Telephone:	As above	Fax:		
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

19 July 2023

1 INTRODUCTION

1.1 BACKGROUND

KHOE WIND ENERGY FACILITY (PTY) LIMITED (hereafter referred to as "the applicant") has proposed the development of the KHOE Wind Energy Facility (KWF1) on farmland 22-km southeast of De Doorns, and 29-km north-west of Montagu in the Cape Fold mountains of the Western Cape.

The entire extent of the site falls outside the Komsberg Renewable Energy Development Zones (i.e., REDZ Focus Area 2). The undertaking of a full EIA 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 one adjacent farm (i.e., the proposed Hugo Wind Energy Facility to the north.

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, as well as 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:

(i) To complete a "Reconnaissance Study" (typically known as a Scoping/Screening study, but only if outside a REDZ).

(ii) To prepare a pre-application avifaunal monitoring plan for the surveys.
Note: BBU follow the avifaunal monitoring protocols published by Birdlife South Africa (Jenkins et al. 2015] and, thus, we do not repeat those publicly available protocols here.

(iii) To undertake the avifaunal assessment and provide a detailed avifaunal report as found here.

(iv) To compare the outcome of our avian assessments with the DFFE Screening Tool assessment, to verify if they concur.

(v) The Protocol also states that an estimate of fatalities likely to occur to Priority species, especially Species of Conservation Concern (SCC) is required.
Specialised knowledge is required for this and to this end we employed a Collision Risk Modelling (CRM) specialist to provide a spatial layer of high- and low-risk areas on site. Together with a preliminary turbine layout we can provide fatality estimates for each Priority species, before and after avoidance mitigations.

1.2 PROJECT DESCRIPTION

Energy Team (Pty) Ltd is proposing the development of a commercial Wind Energy Facility and associated infrastructure on a site located south-east of the town of de Doorns in the Western Cape Province. The site is located within the Cape Fold mountains (see Study Area below).

The KHOE Wind Energy Facility is planned as part of a larger cluster of renewable energy projects, including one adjacent wind farm – the proposed Hugo Wind Energy Facility about 13-km north, treated elsewhere.

KHOE Wind Energy Facility has an unknown predicted MW capacity but comprises up to 30 wind turbines. The project will have a preferred project site of approximately 4113-ha, and an unknown disturbance area. The KHOE Wind Energy Facility project specifics will be updated in the near future.

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, are as follows:
https://screening.environment.gov.za/ScreeningDownloads/AssessmentProtocols/Gazetted_Avifauna_Assessment_Protocols.pdf

- 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 KHOE Wind Farm 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, and flight duration of all Priority species found throughout the year.
- To provide an estimate of the avian fatalities likely from the turbine placements provided by the developer.
- 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 of the KHOE site to estimate possible wide-scale mortalities or displacement.
- 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 Priority avifauna of the area.

Note that this report employs a Collision Risk Model (CRM) that is a sophisticated statistical treatment of the risk involved to the collision-prone bird species found on site. It also allows us to calculate expected fatalities as required by the DFFE. This is the second time a suite of species have been so modelled for risk in South Africa, and it provides a very accurate assessment of the risk areas and the individual turbines that may be risky. Comparisons with subjective assessments using flight traffic data and nest buffers indicates that the CRM provides more developable area than the alternatives. The model is explained in detail below.

Priority species are defined as the top 100 most collision-prone species identified from a combination of flight characteristics, Red Data status, and known susceptibility to collisions (Ralston Paton et al. 2017).

2 STUDY AREA

The site is located within the Langeberg Local Municipality of the Western Cape. The project site comprises the following farm portions:

- Eendragt 1/38
- Eendragt 2/38
- Eendragt 11/38
- Plaas 193
- Eendragt RE/137

The study site is centred on S33°35'53" E 19°52'58”

2.1 HABITATS AND MICROHABITATS

The study area is predominantly *Matjiesfontein Shale Renosterveld* in the *Fynbos* biome (FRs6: Mucina and Rutherford 2006, p 179). It is designated as *Least Concern*. It is dominated by ploughed farmland and several large farm dams with *Renosterveld* fragments in between at mid-altitudes (~1200-m asl). Few ericas and proteas were present as most natural vegetation had been ploughed (Photo 2).

Rainfall averages 300-mm per annum, but varies with altitude from 150-470-mm. This area is denoted as a winter-rainfall area, with frost evident for 10 to 40 days per year.

Photo 1: The vast majority of the habitat on the proposed KHOE WEF site is agricultural and used for sheep grazing.

2.2 AVIAN MICROHABITATS

Bird habitat in the region consists of *Matjiesfontein Shale Renosterveld* but dominated agriculturally modified areas that fragment the natural vegetation. Low rocky ridges provide perch sites and topographic highs for soaring birds. The agricultural fields ares rarely punctuated by small trees that grow around water points. Few grasses are found, with the main land use being sheep farming. Some of the large farm dams provide ideal habitat for the Blue Cranes that are common throughout the area on the agricultural lands.

Power lines run north of the proposed site (though the Hugo site) while small stands of mature poplars occur in water courses outside the study areas. Both artificial habitats provide unexpected nesting habitat for large eagles while, surrounding cliffs, also off site, provide suitable breeding cliffs for Verreaux's Eagles.

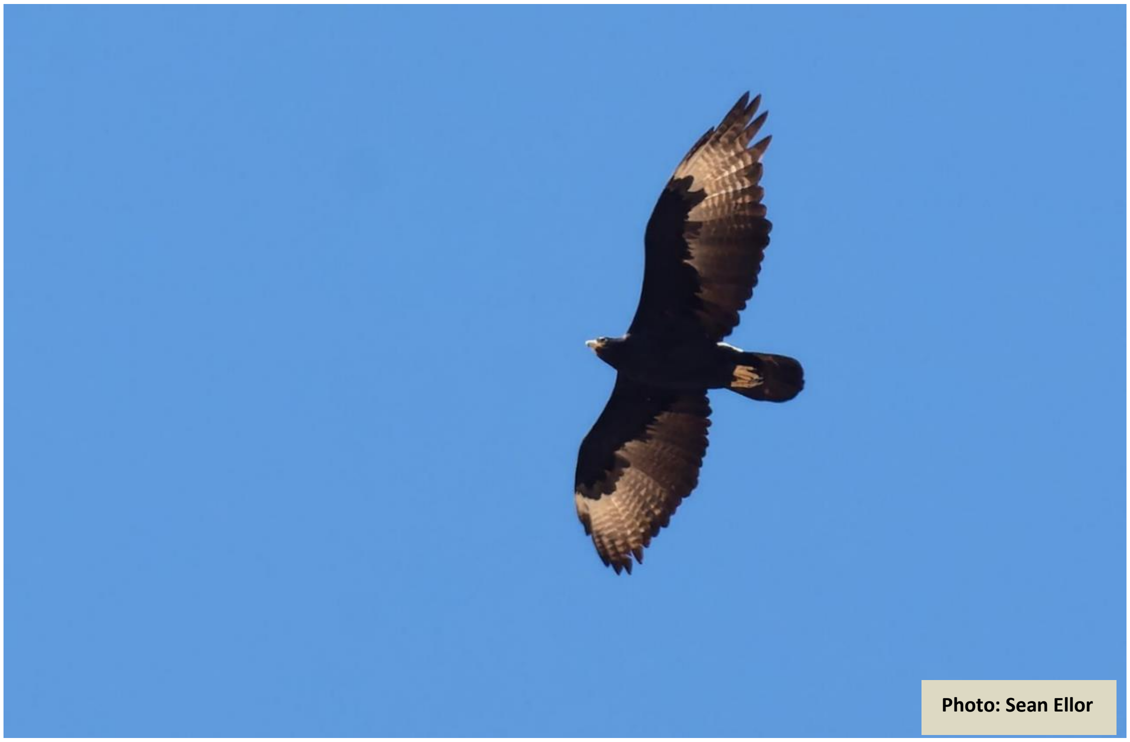

Photo: Sean Ellor

Photo 2: Verreaux's Eagles were commonly recorded over the KHOE Wind Farm site and were the most frequently recorded raptor with a Passage Rate of 0.11 flights/hour (about one flight per day).

3 STUDY METHODS

3.1 SCREENING STUDY

As part of the protocol a Screening Site Assessment of the proposed KHOE Wind Energy Facility (WEF) must be undertaken. This was carried out in summer (February) 2022 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 study took place over two days (10 and 11 February 2022) and was combined with the first pre-construction site visit in January 2022 (when the site was smaller, prior to additional farms being added). This allowed an initial snap-shot avian survey of the proposed KHOE WEF in the Cape Fold mountains south of De Doorns. We undertook short Vantage Point observations of 1-2 hours whilst driving and walking all areas of the proposed KHOE site. The results are summarised below in Section 5.1.

Further details of the Scoping Survey can be found in the report submitted to Genesis Eco-Energy Developments (Pty) Limited, the initial developers of this site (Birds & Bats Unlimited, 2022).

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 (Jenkins et 2015), four seasonally timed site visits across the entire 4113-ha study area (Figure 3) were undertaken to record all flights and heights of Priority species.

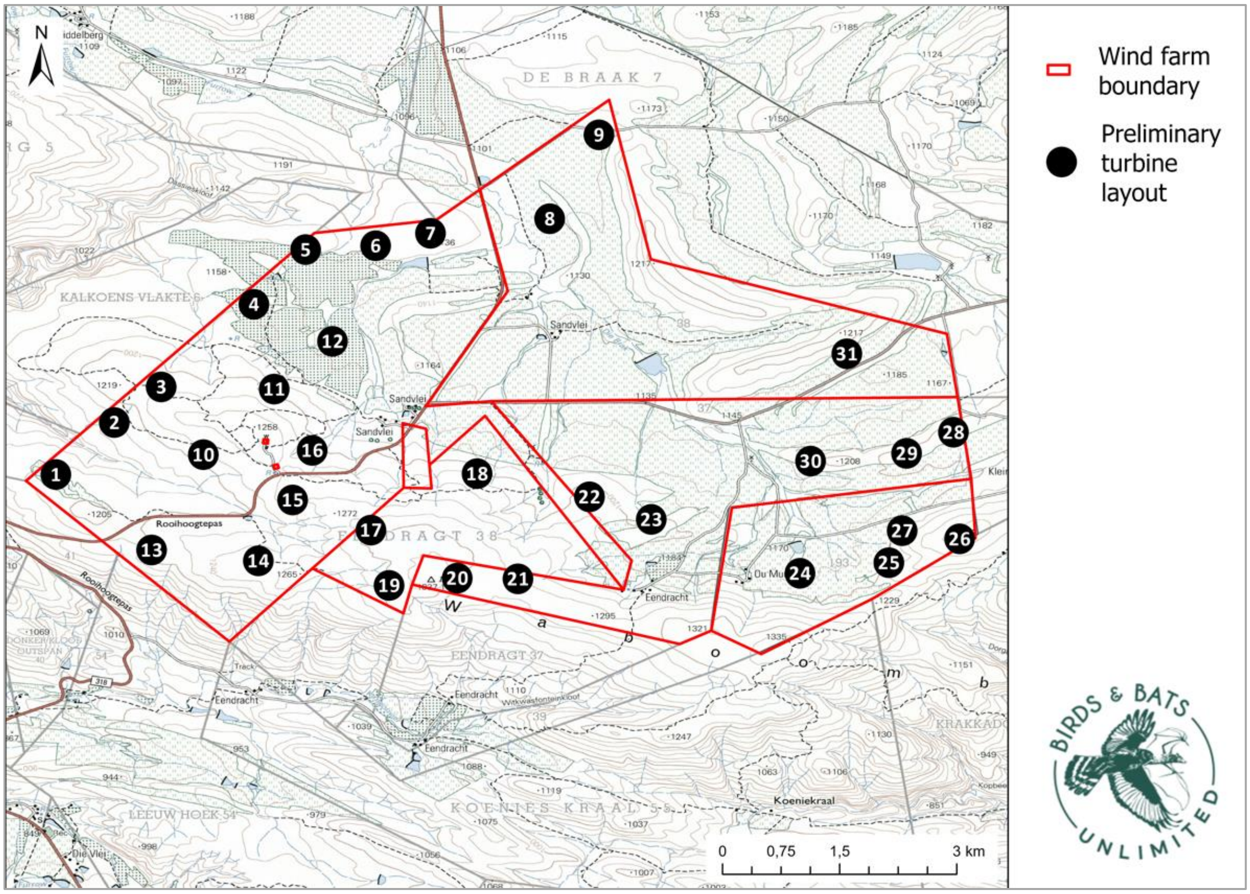

Figure 3: The study site (= red polygon) of the proposed KHOE Wind Farm, 20-km south of De Doorns in the Western Cape. This map depicts the preliminary May 2023 turbine layout (black circles).

All areas 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).

Flights of all Priority species were recorded in the field and are undertaken over four equally spaced seasons for the proposed KHOE Wind Farm site.

SITE VISITS to the KHOE WIND FARM

ITERATIONS	ORIGINAL FOOTPRINT	EXTENDED FOOTPRINT
EIA site visit: Summer1	28 to 31 Jan 2022	-
Scoping site visit	7 to 8 Feb 2022	
EIA site visit: Autumn	5 to 8 Mar 2022	23 to 26 Mar 2022
EIA site visit: Winter	1 to 4 Jun 2022	20 to 23 Jul 2022
EIA site visit: Spring	19 to 22 Sep 2022	5 to 8 Oct 2022
EIA site visit: Summer2	-	2 to 5 Nov 2022

Extra site visits during the year were to cover additional properties which the Developer added to the original areas of interest in early February 2022.

Where Black Harriers or Verreaux's Eagle occur the Birdlife South Africa wind energy guidelines for both species (Simmons et al. 2020, Ralston-Paton 2021) recommend:

- the observation hours per VP must increase from 12 hours to 18 hours in each season; and
- where no additional modelling or GPS-tracking occurs, the monitoring must span 24 months (preferably covering two full breeding seasons).

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 for the KHOE site 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 more precisely assess 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). The modelling used here has been taken a quantum leap forward by Dr Robin Colyn, as it also incorporates Habitat Suitability Models (HSM), terrain, topography and seasonality.

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 only the second time that CRM has been undertaken for an entire wind farm in southern Africa, across a suite of 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 variable 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 [BSA] or risk 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 within 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 RD species the class that was chosen (5.0) performed well. However, for two species (both 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 that areas where risk was predicted it could be avoided by the turbine layout. In this we worked closely with the developer, KHOE Wind Farm 1 (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 of individual species derived 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.

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.

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[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

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 three to five more adults per year would send the population to extinction in approximately 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 5 May 2023 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 database. This is high-resolution bird atlassing database 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 nearby.
  Black Harrier: Simmons et al. 2020, https://www.birdlife.org.za/wp-content/uploads/2020/09/Black-Harriers-Wind-Energy-Final-1.pdf)
  Verreaux's Eagle: Ralston-Paton and Murgatroyd 2021 https://www.birdlife.org.za/wp-content/uploads/2022/08/Verreauxs-Eagle-and-Wind-Energy-2021-2nd-edition.pdf

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 KHOE 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 dominated southern Africa from 2014-2019, above average rainfall occurred 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: Karoo Korhaan and Southern Black Korhaan, both Red Data species. 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 were seldom recorded on site.

One of the most difficult variables to record is the flying height of a bird, and sources of error are expected. We tried to minimise this by using known height objects on site to assist us gauge height. For example all wind farms have weather masts (Met masts) varying from 80m to 120m to measure wind speeds. These and pylon towers (typically 38m high for the 400 kV or 765 kV) transmission lines, also helps gauge the altitude at which birds are flying.

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 the 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 bird deaths 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 at the end of 2022, and an average of 36.8 turbines per wind 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 ± 2.9 birds per turbine per year are killed (Perold et al. 2020). The equivalent for power production was 2.0 ± 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 4).

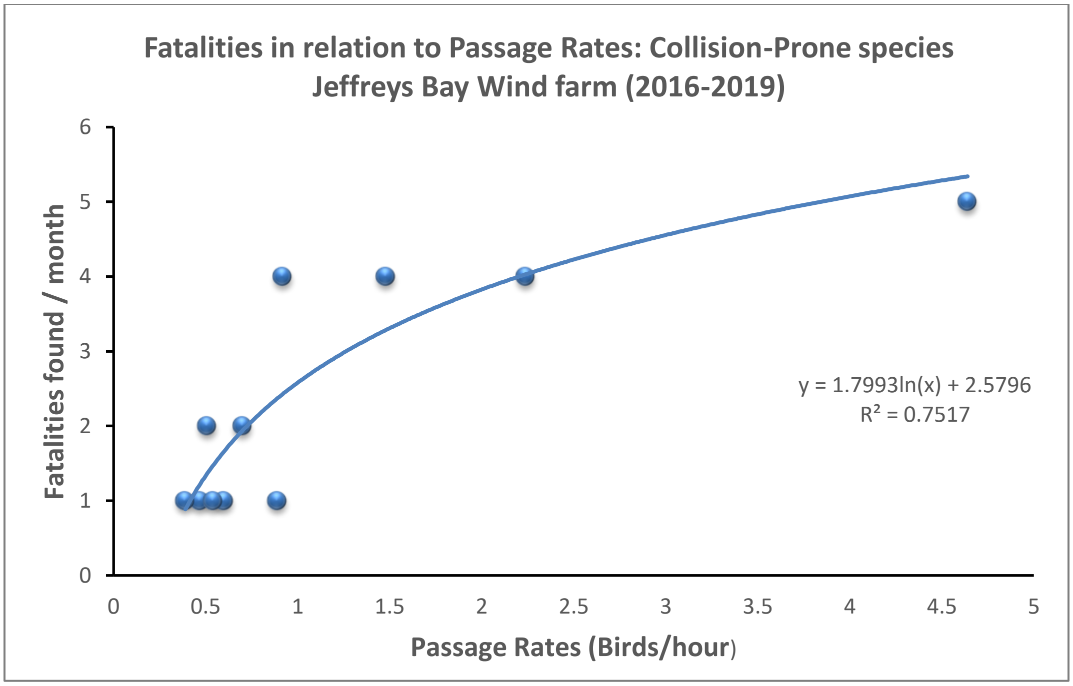


Figure 4: Raptor fatalities in relation to Passage Rates (bird flights/hour) of all raptors in 2-month sampling

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 Western 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 blade-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 the 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, larger and fewer 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 5).

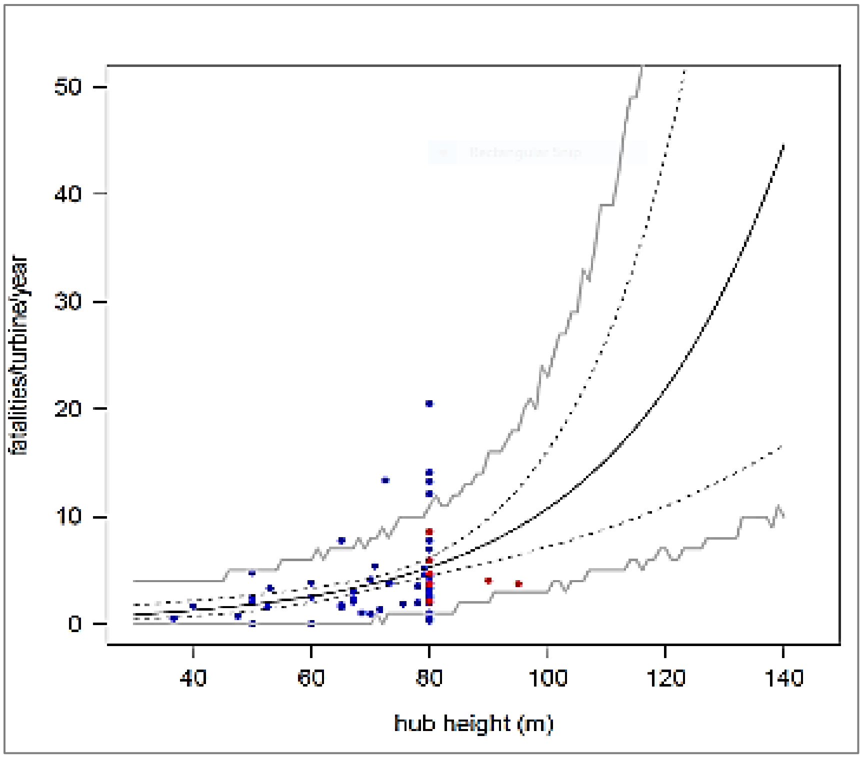


Figure 5: Modelled data combining avian fatalities from the USA (Loss et al. 2013) and from South Africa (= red dots, Ralston-Paton et al. 2017) and their relationship with hub height. The South African data (n=7 farms) include two farms with hub heights of 90-m and 95-m. The combined data and 95% confidence 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 by 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 that fly at high speed (gamebirds, pigeons and sandgrouse, swifts, falcons);
- species that are distracted in flight – predatory birds, or species with aerial displays (many raptors, aerial insectivores, some open country passerines);
- species that habitually fly in low light conditions (flamingos); and

- 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 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 (Figures 6 and Figure 7) in amongst white blades (McIsaac 2001, Hodos 2002).

Figure 6: 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 seven 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 a very efficient means to reducing collision rates. In a landmark ruling, South African Civil Aviation Authorities (CAA) have recently allowed the Umoya wind farm the right to paint four turbines with signal red and the No. 4 patterning shown in Figure 7 below. This mitigation was strongly recommended by Birds & Bats Unlimited (BBU) and this constitutes the first test in Africa of this novel mitigation.

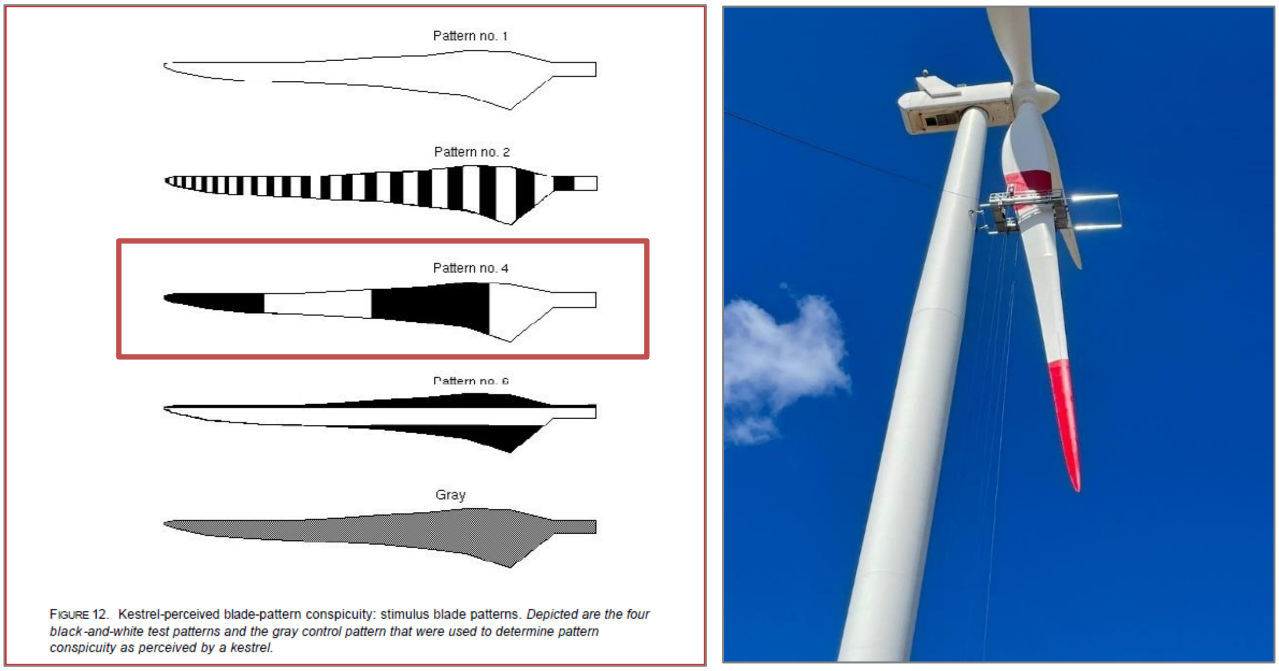


FIGURE 12. Kestrel-perceived blade-pattern conspicuity: stimulus blade patterns. *Depicted are the four black-and-white test patterns and the gray control pattern that were used to determine pattern conspicuity as perceived by a kestrel.*

Figure 7: Striped patterns (left) tested for conspicuousness by McIsaac (2001) on raptors and human subjects. 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 7, right) starting with four high-risk turbines. SAWEA have recently given guidance on Patterned blades as a mitigation (Morkel et al. 2023).

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, and away from 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 South Africa 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 South Africa, the 33 operational wind farms generating a maximum of 3357 MW of power (SAWEA 2020) kill on average 2.0 ± 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 SCOPING/SCREENING STUDY

Our initial assessment of the KHOE site combined the SABAP2 records (n = 80 cards from 14 pentads) and the results of first bird surveys in January 2022. This revealed:

- 206 species of bird have been recorded by SABAP2 data around the site;
- 21 of these species are Priority (top 100) collision-prone species;
- 10 of the 21 Priority Collision-prone species are Red Data species from SABAP data;
- One of the 10 Red Data species likely to occur (SABAP2) was recorded over the KHOE site: Blue Crane.

The position of a Verreaux's Eagle nest was supplied to us (E. Hermann), and this is plotted in the Figures below.

Table 2. All (21) Priority collision-prone species in the top 100 Priority species including the (10) Red Data birds (**in red**) recorded in bird atlas data (2008-2022) around the proposed KHOE WEF site. The (4) grey-shaded species occurred in the proposed WEF in our January 2022 site visit. Those with reporting rates over 10% are regarded as relatively regular visitors to the area.

				Susceptibility to:	
Common name	**Scientific name**	**Red-list status**	**Reporting Rate***	**Collision Rank****	**Disturbance**
Verreaux's Eagle	*Aquila verreauxii*	**Vulnerable**	**26%**	**2**	**Moderate**
Martial Eagle	*Polemaetus bellicosus*	**Endangered**	**9%**	**5**	**High**
Black Harrier	*Circus maurus*	**Endangered**	**19%**	**6**	**High**
Blue Crane	*Anthropoides paradiseus*	**Near Threatened**	**27%**	**11**	**Moderate**
Lanner Falcon	*Falco biarmicus*	Vulnerable	**14%**	**22**	**moderate**
African Fish Eagle	*Haliaetus vocifer*	Least Concern	**15%**	**27**	**moderate**
Southern Black Korhaan	*Afrotis afra*	Vulnerable	**21%**	**35**	**Low**
Cape Eagle Owl	*Bubo capensis*	Least Concern	**5%**	**41**	**Moderate**
Jackal Buzzard	*Buteo rufofuscus*	Least Concern	**49%**	**42**	**Low**
Peregrine Falcon	*Falco peregrinus*	Least Concern	**6%**	**45**	**moderate**
Booted Eagle	*Aquila pennatus*	Least Concern	**19%**	**55**	**Low**
Karoo Korhaan	*Eupodotis vigorsii*	Near Threatened	**50%**	**49**	**Low**
Steppe Buzzard	*Buteo vulpinus*	Least Concern	**11%**	**67**	**Low**
Pale Chanting Goshawk	*Melierax canorus*	Least Concern	**44%**	**73**	**Low**
African Harrier Hawk	*Polyboroides typus*	Least Concern	**14%**	**85**	**Low**
Spotted Eagle Owl	*Bubo africanus*	Least Concern	**12%**	**100**	**low**

[a] Reporting Rates is a measure of the likelihood of occurrence of each species, based on the number of times recorded on bird atlas cards on the 14 pentads around this area.

[b] Collision ranking is a measure of susceptibility to turbine collisions (Ralston-Paton et al. 2017).

5.1.1 PASSAGE RATES OF PRIORITY COLLISION-PRONE SPECIES

By observing from three Vantage Points (VPs) encompassing the smaller section of the KHOE site in our first site visit in January 2022, we calculated the frequency with which the four Priority species (Table 1) traversed the wind farm in 36-hours of field observations.

- We recorded 19 individual flights of four Priority species (including three Red Data species) in 36-hours in January 2022 giving a *medium* Passage Rate of 0.53 birds per hour (Table 3).
- These included only one Red Data species: Blue Crane.

These are preliminary Passage Rates and reflect the species present in January 2022 (summer). These are incorporated into our other three site visits in 2022 and are also used in the CRM presented below.

Table 3. Preliminary Passage Rates of all (4) collision-prone species recorded in the proposed KHOE WEF in January 2022.

Species	Flights	Hours	Passage Rate
Blue Crane	13	36	**0.36**
Booted Eagle	4	36	0.11
Jackal Buzzard	1	36	0.03
African Harrier Hawk	1	36	0.03
	19	**36**	**0.24**

The DFFE Screening Tool page for the Animal Theme is attached as Appendix 1. The KHOE site is designated as of *High Sensitivity.*

5.2 REGIONAL SENSITIVITY

5.2.1 NATIONAL BIRD SENSITIVITY MAP FOR THE PROPOSED KHOE WIND FARM

The Birds and Renewable Energy Specialist Group (BARESG) of Birdlife South Africa/EWT produced a South African bird sensitivity map: www.birdlife.org.za/images/stories/conservation/birds_and_wind_energy/sensitivitymap The area proposed for the KHOE Wind Facility falls into three pentads (Figure 1, blue and pink polygons).

These pentads have a low sensitivity score not exceeding 136. Thus, the KHOE study area (Figure 2) is ranked as *low sensitivity* from a national avian perspective.

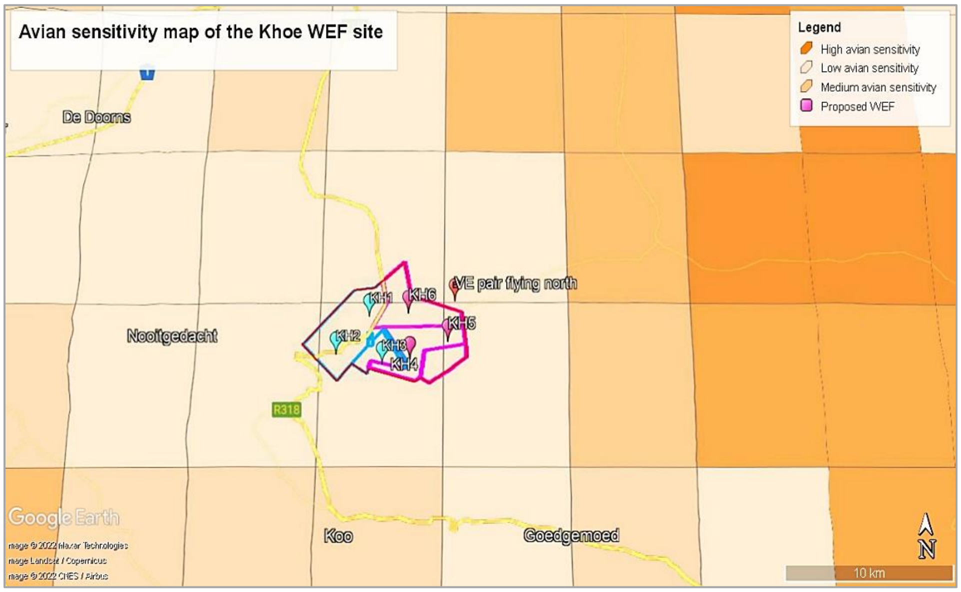


Figure 8: The proposed KHOE Wind farm (blue and purple polygons) in relation to the national avian sensitivity map. All four pentads covering the site fall within a very low avian sensitivity ranking (highest 75 out of ~1000). See http://www.birdlife.org.za/conservation/terrestrial-bird-conservation/birds-and-renewable-energy/wind-farm-map

The DFFE Screening tool (https://screening.environment.gov.za/screeningtool/#/app/screen_tool/Wind) did not support this classification, as it ranked the area as *High Sensitivity* for the Animal Species Theme (Appendix 2). The main reason for the triggered high sensitivity was the presence of *Vulnerable* Verreaux's Eagles *Aquila verreauxii.*

This was verified in our field work in which Verreaux's Eagles were recorded just outside the eastern boundary of the site in our Scoping study and a Verreaux's Eagle nest about 3.5-km west of the western boundary was reported to us (R Damonse, E Hermann pers comm) in February 2022.

While Black Harriers were not recorded on the KHOE site in the Scoping Report they were subsequently recorded in more appropriate seasons (winter) and this verifies:

(i) The SABAP2 data Reporting Rate suggesting birds will occur with 19% likelihood; and
(ii) the Black Harrier Habitat Suitability Model (HSM: In Simmons et al. 2020) predicts that the habitat in the western section has a 20-40% probability of holding breeding Black Harriers.

This *Endangered* species was incorporated into the risk assessment undertaken by the CRM.

The DFEE Sensitivity Theme for Wind Farms and Birds ranked the area as *Low Sensitivity* (Appendix 3). Thus, while the Birdlife Sensitivity Map (Figure 8) concurs with the DFFE Screening Tool for Wind farm and birds, both disagree with the Screening Tool output for the Animal Theme. We agree with the Animal Theme that the site is of *High Sensitivity* given the number of Red Data species (below).

We are not sure why the Bird-Wind Theme in the DFFE Screening Tool consistently gives low sensitivity results when numerous collision prone species occur in an area (and are recorded by the Animal Theme). We would suggest that this requires further refinement by the DFFE.

5.2.2 BIRD SPECIES AND RICHNESS

According to SABAP2 records for the nine pentads surrounding the KHOE 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 directly by the proposed wind farms and no Red Data passerines were identified on site, we concentrate instead on the larger collision-prone species.

5.2.3 COLLISION-PRONE SPECIES (INCLUDING RED DATA SPECIES)

Of the eight Red Data species the most frequently encountered species was the Blue Crane which performed 93% of all flights recorded over the wind farm over 12 months. Verreaux's Eagle was the next most common species recorded and both species combined accounted for 98% of all flights (Table 2). The Passage Rate for all Priority species was 2.55 flights per hour of which the RD species were the major component at 2.18 flights per hour.

Table 2: All Collision Prone species (ordered from most to least likely) including RD species and their individual Passage Rates (flights/hour) on the KHOE WEF and Control sites. Note that only seven with sufficient data could be included in the CRM. Those species with fewer than four flights did not reach the threshold for inclusion.

Species	WEF flights	Species Passage Rates	CONTROL flights	Species Passage Rates	Collision Rank
Number of hours	**465 h**		**62.5 h**		
Verreaux's Eagle VU	**52**	**0.11**			**2**
Martial Eagle EN	**5**	**0.01**			**5**
Black Harrier EN	**8**	**0.02**			**6**
Ludwig's Bustard EN	**2**	**0.00**			**10**
Blue Crane NT	**940**	**2.02**			**11**
Lanner Falcon VU	**4**	**0.01**			**22**
African Fish Eagle	0	-	1	0.02	**27**
S Black Korhaan VU	**1**	**0.00**			**35**
Jackal Buzzard	50	0.11	1	0.02	42
Peregrine Falcon	3	0.01			45
Karoo Korhaan NT	2	0.00			49
Booted Eagle	48	0.10	1	0.02	55
Yellow-billed Kite	2	0.00			60
Pale Chanting Goshawk	29	0.06	10	0.2	73
Grey-winged Francolin	2	0.00			82
African Harrier Hawk	5	0.01			85
Black-winged Kite	7	0.02			96
Greater Kestrel	1	0.00			97
Spotted Eagle Owl	1	0.00			100
Totals: **8 RD species**	**1014**	**2.18 flights/h**	13	-	
11 LC species	146	0.31 flights/h		0.21 flights/h	
All Priority species (n = 19)	1187	2.55 flights/h			

Blue Cranes and Verreaux's Eagles

Blue Cranes were the most common species encountered on site and were present on the agricultural field in pairs and threesomes (adults with a youngster). A centrally placed dam in the centre of the site was also a mecca for other cranes, that habitually came to roost there. Roosting cranes frequently travel some distance to water as a protection against terrestrial predators (Allan 2005). This dam will, thus, increase the presence of Blue Cranes here.

We also noted that the dam was one of the foci for the risky flight paths highlighted by the CRM output for the Verreaux's Eagles on KHOE (Figure 9).

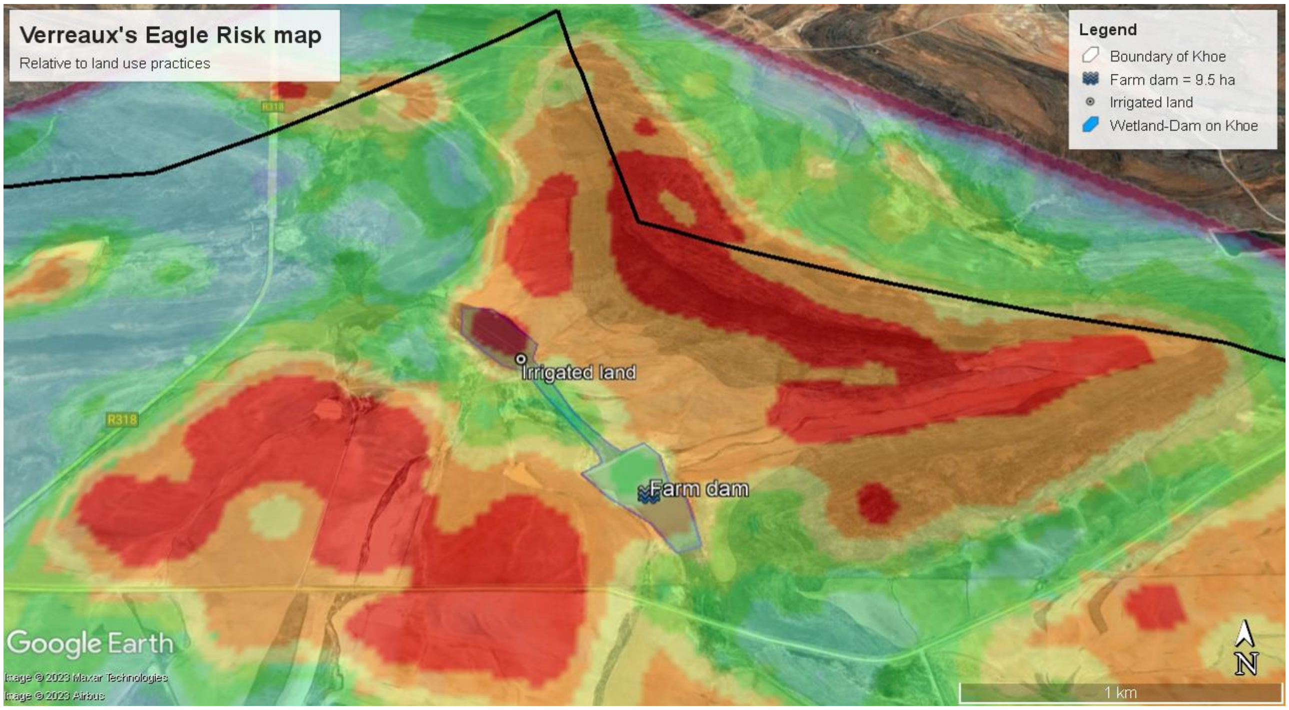


Figure 9: Individual CRM map output for Verreaux's Eagles in the northern section of the KHOE study site. Note the high use (= red polygons) of the highland ridge to the north, and the overflights of the 9.5-ha farm dam. and the irrigated land to the north. Thus, the eagles were using the ridges as expected but also foraging over the dam and lands to the west.

We recorded sufficient data for future modelling for seven Priority species in 465 hours of systematic VP observations over four seasons in 2022 in the WEF. Of these five were Red Data (RD) species and two were Least Concern (LC) (Table 2).

5.3 AVIFAUNAL RISK ASSESSMENT

5.3.1 TURBINE EXPOSURE

The proportion of flights occurring within the blade-swept area (BSA) for all Red Data (RD) and Least Concern (LC) Priority species is shown in Figure 10 for the proposed KHOE 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 from five site visits.

The graphic indicates:

- two species – Blue Crane and Verreaux's Eagle performed the highest number of flights (blue bars) and of those, the Blue Crane flew within the BSA approximately 60% of the time. The Verreaux's Eagle flew there almost 90% of the time (Figure 10).
- Other species most often recorded flying in the BSA included Booted Eagles (98%), and both Martial Eagle (100%) and Lanner Falcon (100%) always flew within the BSA zone, but based on few flights.
- Black Harriers flew within this risk zone 72% of the time, and Jackal Buzzards 87% of the time.

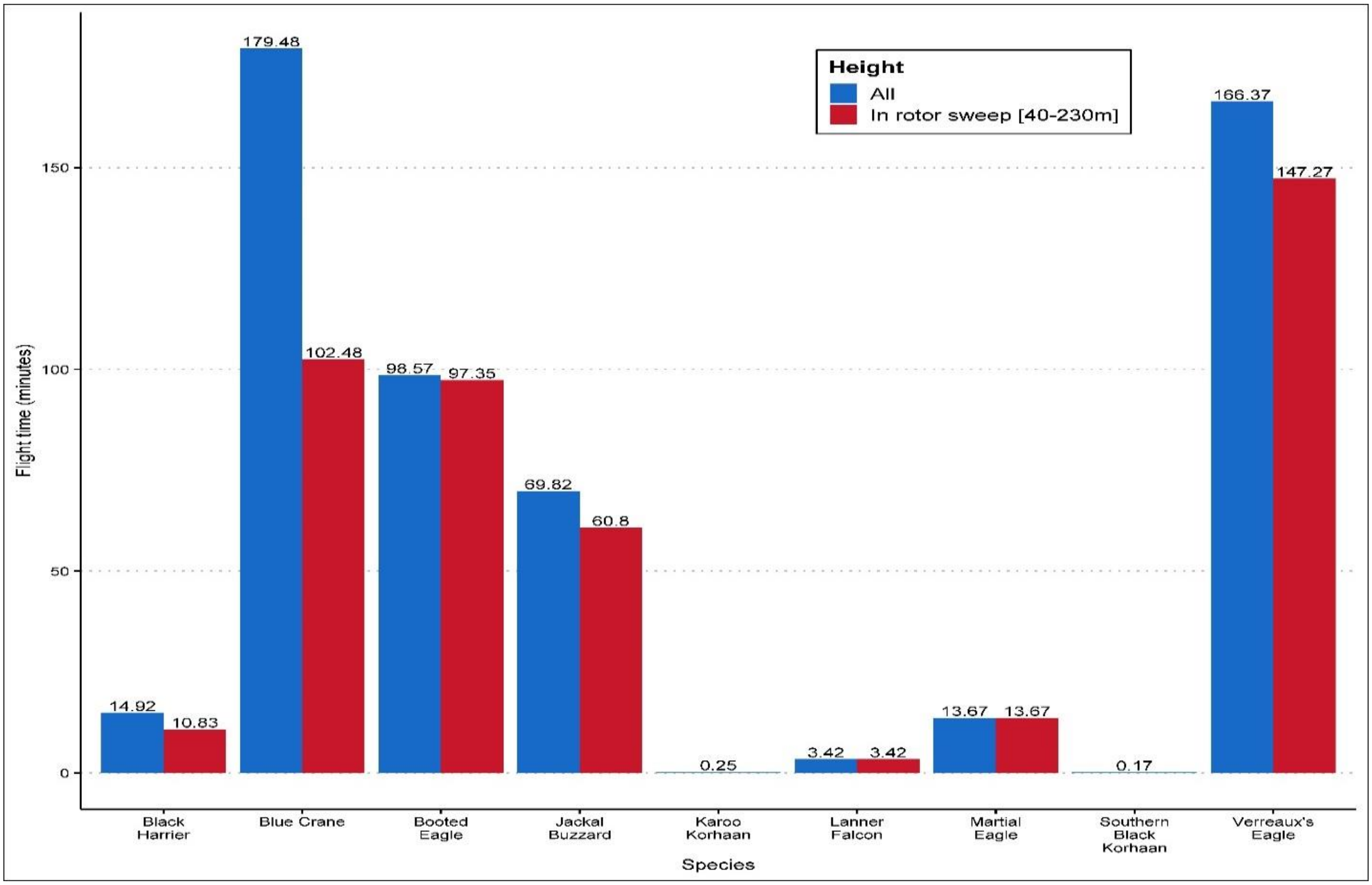


Figure 10: The proportion of flights occurring within the blade swept area (BSA) for all Priority species recorded on the proposed KHOE study site. Red bars represent the number of minutes spent flying in the high-risk BSA; blue bars represent the total minutes recorded in flight over all four seasons.

While two species of korhaan 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 seven species (5 RD and 2 LC) to undertake the CRM spatial risk analysis. For the Lanner Falcon, the low number of flights did not allow any fatality estimates.

5.3.2 COLLISION RISK AND PRIORITY SPECIES FATALITY ESTIMATES

Collision Risk fatality rates per year were calculated for four Red Data species (Table 2) and two Least Concern (LC) species.

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 weighting than Least Concern species as follows:

- *Endangered* = 4 - Black Harrier, Martial Eagle
- *Vulnerable* = 3 - Verreaux's Eagle, Lanner Falcon
- *Near Threatened* = 2 - Blue Crane
- *Least Concern* = 1 - Jackal Buzzard, Booted Eagle

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 (classed as higher risk compared to areas where similar numbers of flights of a *Near Threatened* species occurred). We have designated "No-Go" areas – using both Red Data species spatial risk map with a higher weighting than the Least Concern species.

As expected, areas along ridges were high-risk areas reflecting use by Verreaux's Eagles (Figure 13(a) and 13(b)).

An important parameter to determine in the CRM analysis is the proportion of flights occurring in the BSA (Figure 10).

- More flights were recorded for Blue Cranes (BC) and Verreaux's Eagles (VEs) than any other species, with VE spending 89% of the time in the BSA but BC spending about half their time in the BSA.
- Three species emerged as most frequently occurring in the BSA: Martial Eagles (100%), Booted Eagle (98%), Jackal Buzzard (87%), while Black Harriers spent 73% of their flights in the BSA (Fig 10).

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. Thus the following are essential:

- Bird exposure (how much time was spent within the BSA);
- Survey effort (time spent monitoring in the WEF – 1 466 hours); and
- Exposure factor (turbine specifications – see Section 1.2).

Estimated fatalities (per annum) are represented visually in the graphs below for all species. These are fatality rates based on the final turbine layout, which avoids all risk areas identified.

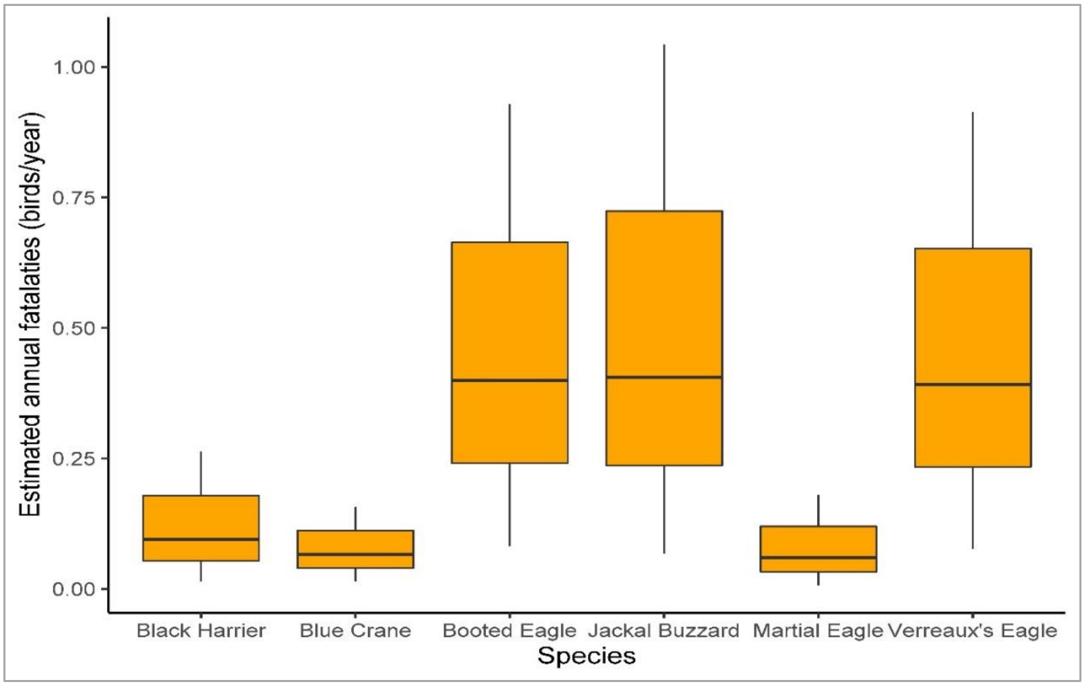


Figure 11: Estimated fatalities (per annum) for four Red Data species (BH, BC, ME, VE) and two Least Concern species (JB, BE).

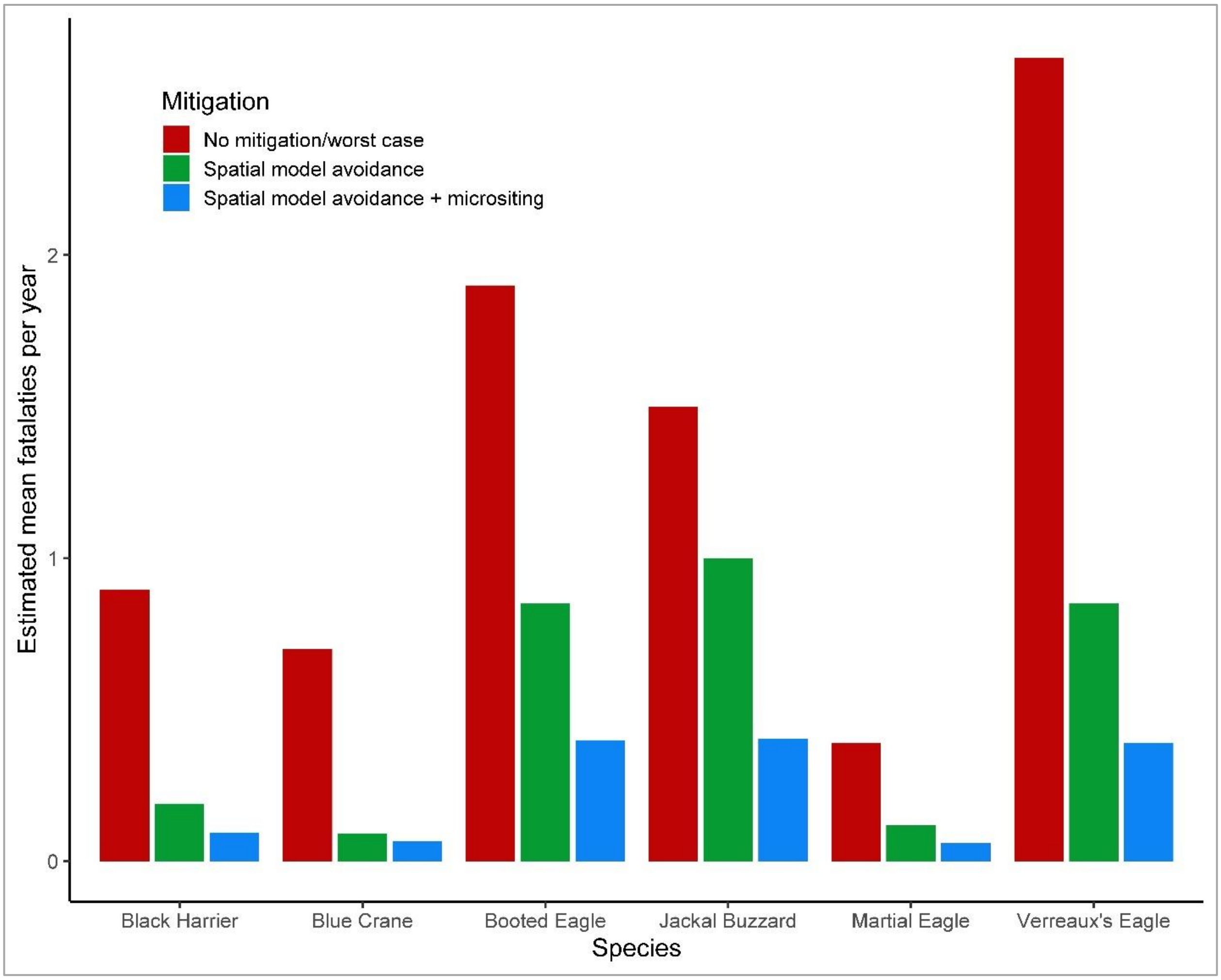


Figure 12: The decrease in CRM-predicted fatality rates (red = worst case, blue= best case) for four Red Data species (BH, BC, ME and VE) and two Least Concern species. The avoidance of all high-risk areas (below) and micro-siting turbines to avoid medium-risk areas decreases expected fatality rates between 10-fold (Blue Crane) and ~4-fold (Jackal Buzzard)

The annual fatality rates predicted by the CRM (Figure 11), and based on the latest turbine layout, show low fatality rates for Black Harrier, Blue Crane, and Martial Eagle (~0.1 birds/year: Figure 11), while Verreaux's Eagles, Booted Eagles and Jackal Buzzards are all predicted to have levels of about 0.4 fatalities per year. This translates to one fatality approximately every 2.5 years.

It is important to note that despite the very high passage rates for RD species like Blue Cranes and Verreaux's Eagles, the implementation of the No-Go zones (below) has reduced annual fatality substantially (Figure 12) as follows:

- Blue Crane 10.6-fold reduction
- Black Harrier 9.4-fold reduction
- Verreaux's Eagle 6.8-fold reduction
- Martial Eagle 6.6-fold reduction
- Booted Eagle 4.8-fold reduction.
- Jackal Buzzard 3.7-fold reduction.

5.3.3 SPATIAL RISK ASSESSMENT

The fatality estimates alone are not spatially explicit and, therefore, 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 to reduce the likelihood of 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 5.3.2). Species expected to be more collision prone (e.g., Black Harrier and Verreaux’s Eagle) were allocated the highest collision-prone factor, while those known to be less so, the lowest (e.g., Booted Eagle).
- **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.

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

- All (5) Red Data (RD) species (Black Harrier, Verreaux’s Eagle, Martial Eagle, Lanner, Blue Crane) (Figure 13(a)).
- Both (2) Least Concern (LC) species (Jackal Buzzard, Booted Eagle) (Figure 13(b)).

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.
- Areas classed as 6 and lower add the less risky flights, but covers 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 14(a) and 14(b) indicate that areas in the north-east and central sections of the study site yield more risky flights than in the south-west. This may arise because better wind resources are known from the north, a large farm dam brings in multiple Blue Cranes, and the topographic highs (aiding lift) occur there aiding lift for the big eagles such as Verreaux’s and Martials.

Based on the outcomes of the vulnerability risk assessment, it is evident when considering 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 assess how (by removing certain areas for development) the estimated collision risk can be reduced. We do this with the following steps:

- Inspection of the graphs depicting the proportion of risky flight minutes “captured” by each risk class (Figures 14(a) and 14(b)).
- Deciding on a threshold percentage that allows the vast majority of risky flights to be avoided.
- For example, if a threshold above 75% of all risky flights is chosen to safeguard one species, then the extent of the area that covers can be read from the Figure 13(a) for RD species and Figure 13(b) for LC species.

For example, 77% of Black Harrier and 82% of Verreaux's Eagle time spent within the BSA is likely to occur within the risk Class 5.0 (green bar in graph 13(a)) and shown in spatial map (Figure 14(a)).

Similarly, 62% of Blue Crane and 68% of Martial Eagle's risky flights spent within the BSA is likely to occur within areas classified as risk Class 5.0 and above (Figure 13(a)). By avoiding areas classified as risk Class 5 and above from the developable area, we are likely to also reduce the collision risk (of Lanner Falcons) by these percentages, even though the data for this RD falcon species were limited (Figure 13(a)).

The fact that 75% or more of some RD species' risky flights are almost completely captured by the risk Class 5 (e.g., Black Harriers and Verreaux's Eagles: Figure 13(a)) is encouraging and is shown above (Figure 12) to decrease their collision-risk to negligible levels.

As such Class 5.0 was deemed appropriate for all of the frequently recorded RD species on site.

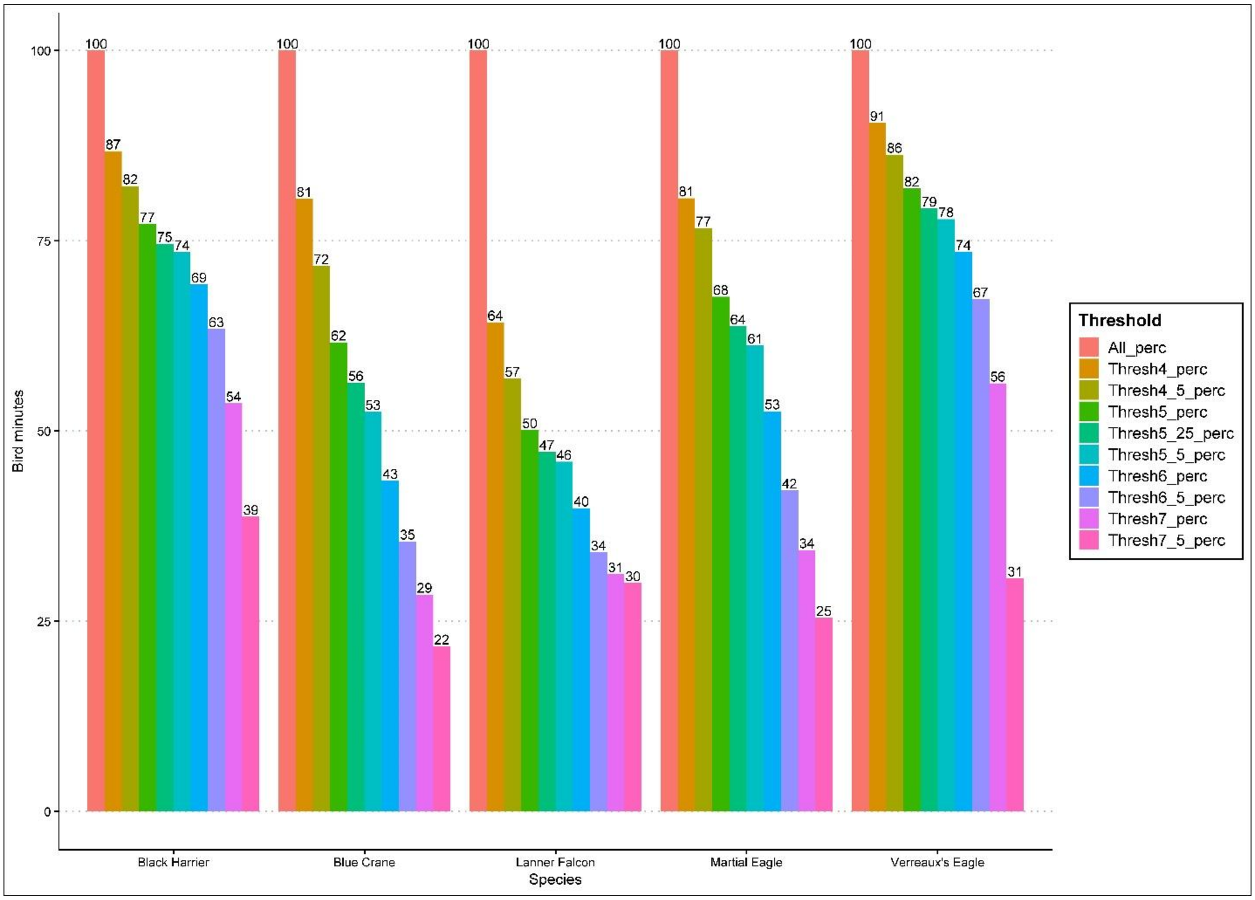


Figure 13(a): The number of risky flight minutes captured by each Class of risk generated by the CRM for each Red Data species. Based on the figures here we have chosen a threshold of 5.0 (green bars) to "capture" at least 70% of the risky flights made by Black Harriers (77%), Martial Eagles (68%) and Verreaux's Eagles (82%).

The developer can then use the risk classification 5.0 and above (5.5, 6.0, 6.5, 7.0, 7.5) shown in Figure 14(a) and Figure 14(b), to fine-tune the turbine layout to avoid fatalities for the majority of Priority species on site. This the Energy Team have done as shown in their final risk-limiting layout with the re-location of turbines 28 and 29 to less risky areas (Figure 15).

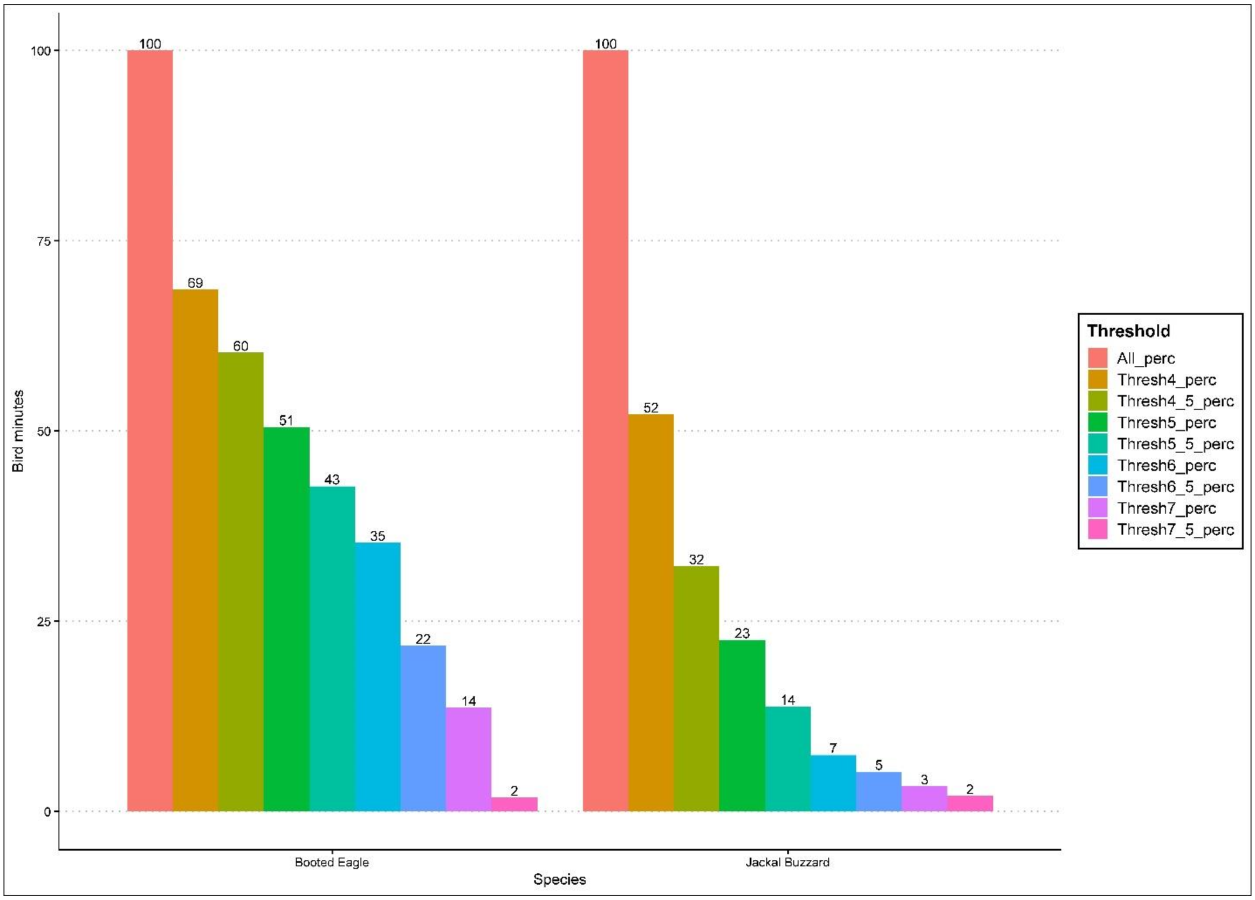


Figure 13(b): The proportion of risky flight minutes "captured" by each Class of risk generated by the CRM for the two Least Concern Priority species, Booted Eagle and Jackal Buzzard.

For some of those Least Concern species however (e.g., Booted Eagle and Jackal Buzzard: Figure 13b), the proportion of risky flight minutes captured within the same Class 5 was lower. For example, only 51% and 33% of risky flights respectively are captured by risk Class 5.0. This is partly an inevitable consequence of the lower weighting applied to LC species in the CRM process. However, it means that it is not a good idea to relax the risk classes to higher values (e.g., to 5.5 or 6.0) as that will further erode the proportion of risky minutes captured. Thus, the risk Class 5.0 was applied to LC species as well as the RD species.

Despite this lower ability to capture as many risky flights as those for RD species, avoidance of these areas for future turbines will decrease the predicted fatality estimates for the LC species by ~4- to 5-fold (Figure 12).

The final spatial risk maps for Red Data species and Least Concern species are respectively shown below in Figures 14(a) and 14(b). The two risk maps for RD and LC species are combined in Figure 15. This map was used by the developer to produce the final turbine layout. The final turbine layout is also shown in Figure 15.

The final layout provided by Energy Team (June 2023) is shown in Figure 15. Of the 31 proposed turbines, all avoid the riskiest areas predicted by the CRM. From the spatially explicit CRM for the RD and LC species combined (Figure 15), the area lost to development is approximately 2739-ha of the 4113-ha site (66.6%). Thus about 1374-ha remain for development or ~33% of the area.

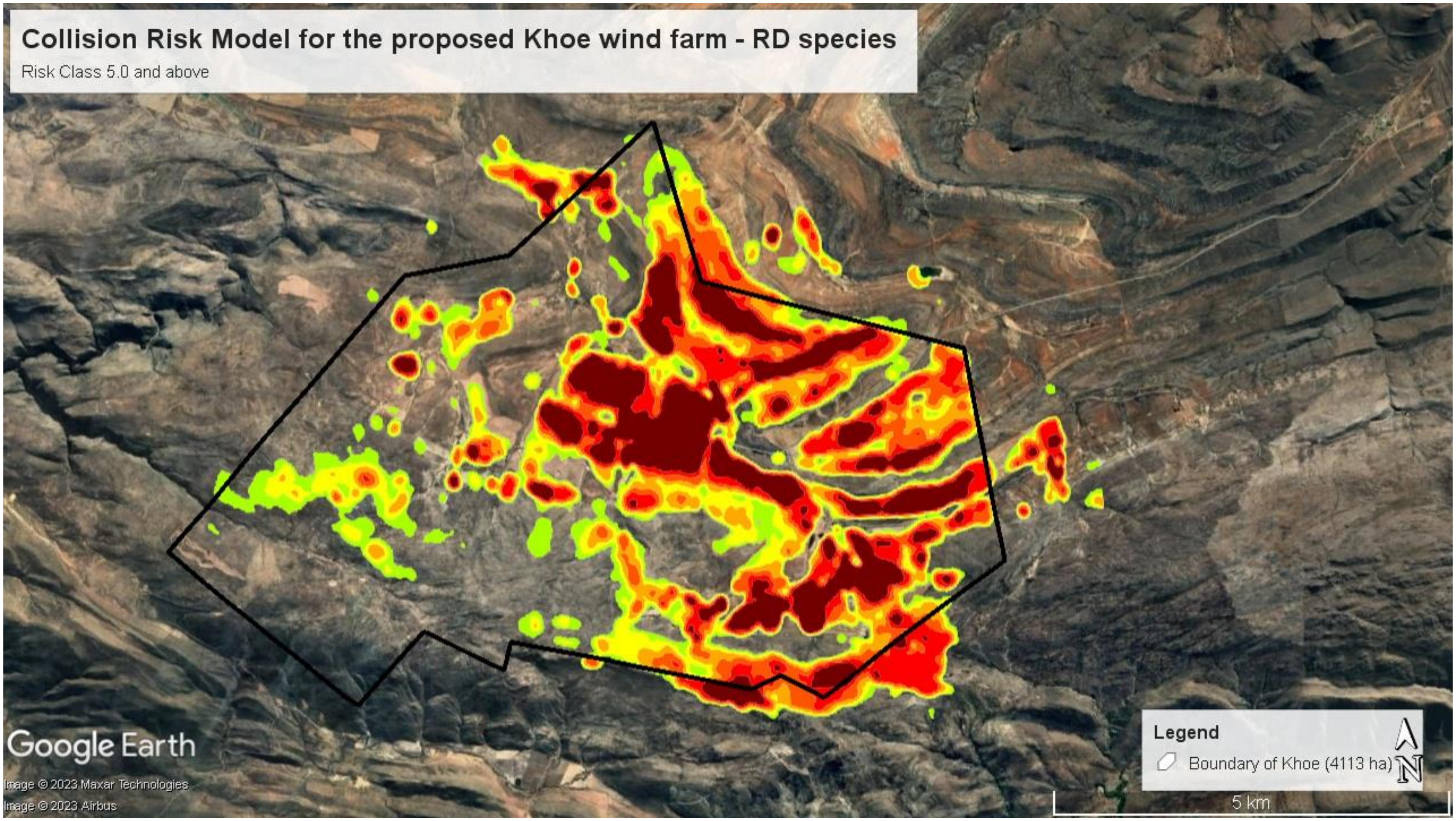


Figure 14(a): Collision Risk Model vulnerability map for five **Red Data (RD)** species based on 12 months' monitoring over all seasons for **the KHOE WEF**. The different classes represent different levels of flight risk for RD species based on modelled passage rates, flight heights, flight seconds, and topography**.** Classes 5.0 (= green) to Class 7.5 (= maroon) are combined and represent the increasing risk to Red Data species. These are designated as No-Go areas and capture large proportions of risky flight minutes. The hotspots of risk in the central and eastern regions are due mainly to numerous Blue Crane and Verreaux's Eagle flights.

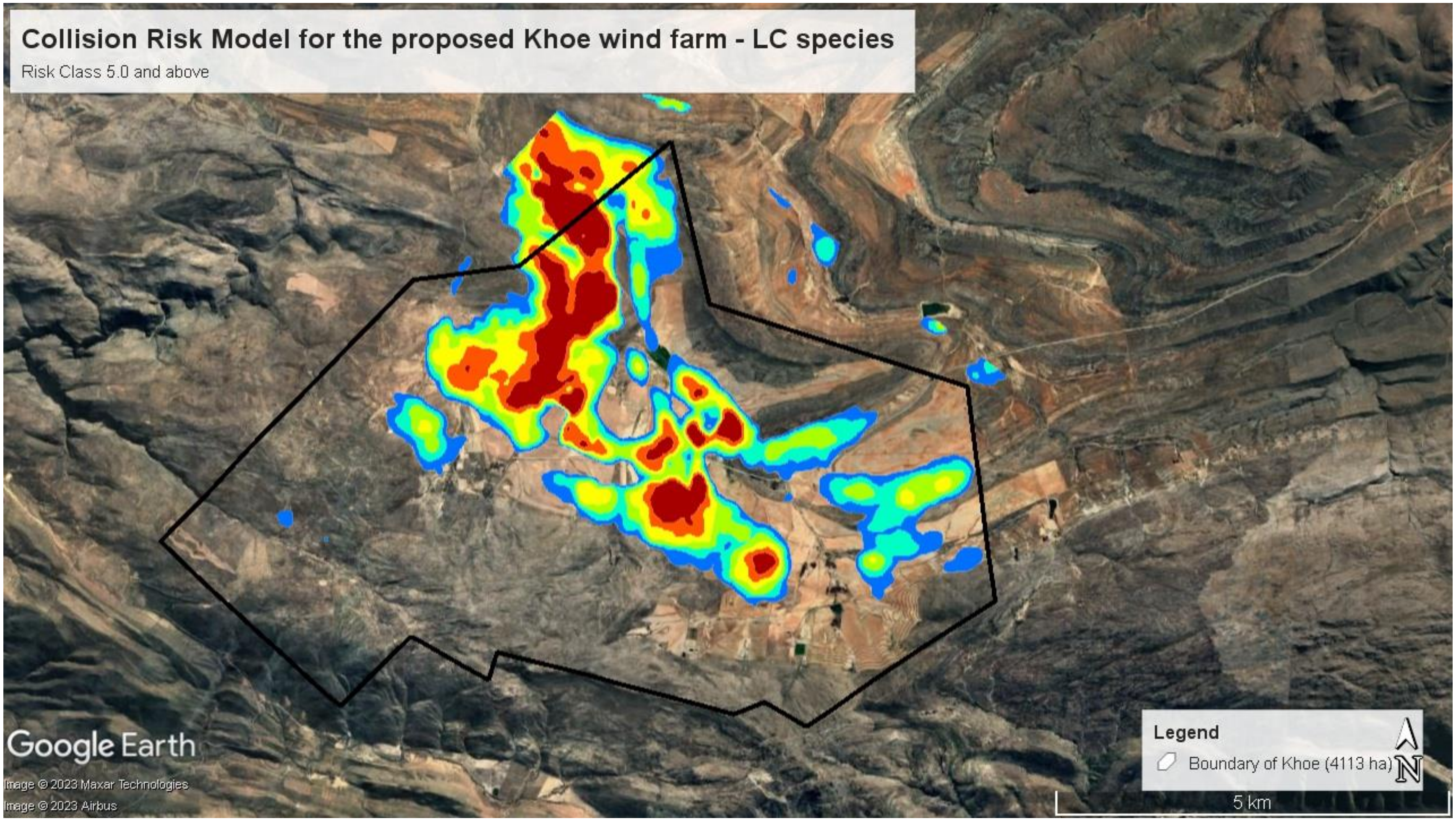


Figure 14(b): Collision Risk Model vulnerability map for the two **Least Concern (LC)** species, based on 12 month's monitoring over all seasons for the proposed **KHOE WEF**. The different classes represent different levels of flight risk for the Least Concern species occurring there based on modelled passage rates, flight heights, flight seconds, and topography. Areas designated as red, orange, and yellow represent the highest risk to LC birds. These are Classes 6.5, 7.0, and 7.5 combined. These are designated as No-Go areas and capture large proportions of risky flight minutes (those in the blade swept area: BSA).

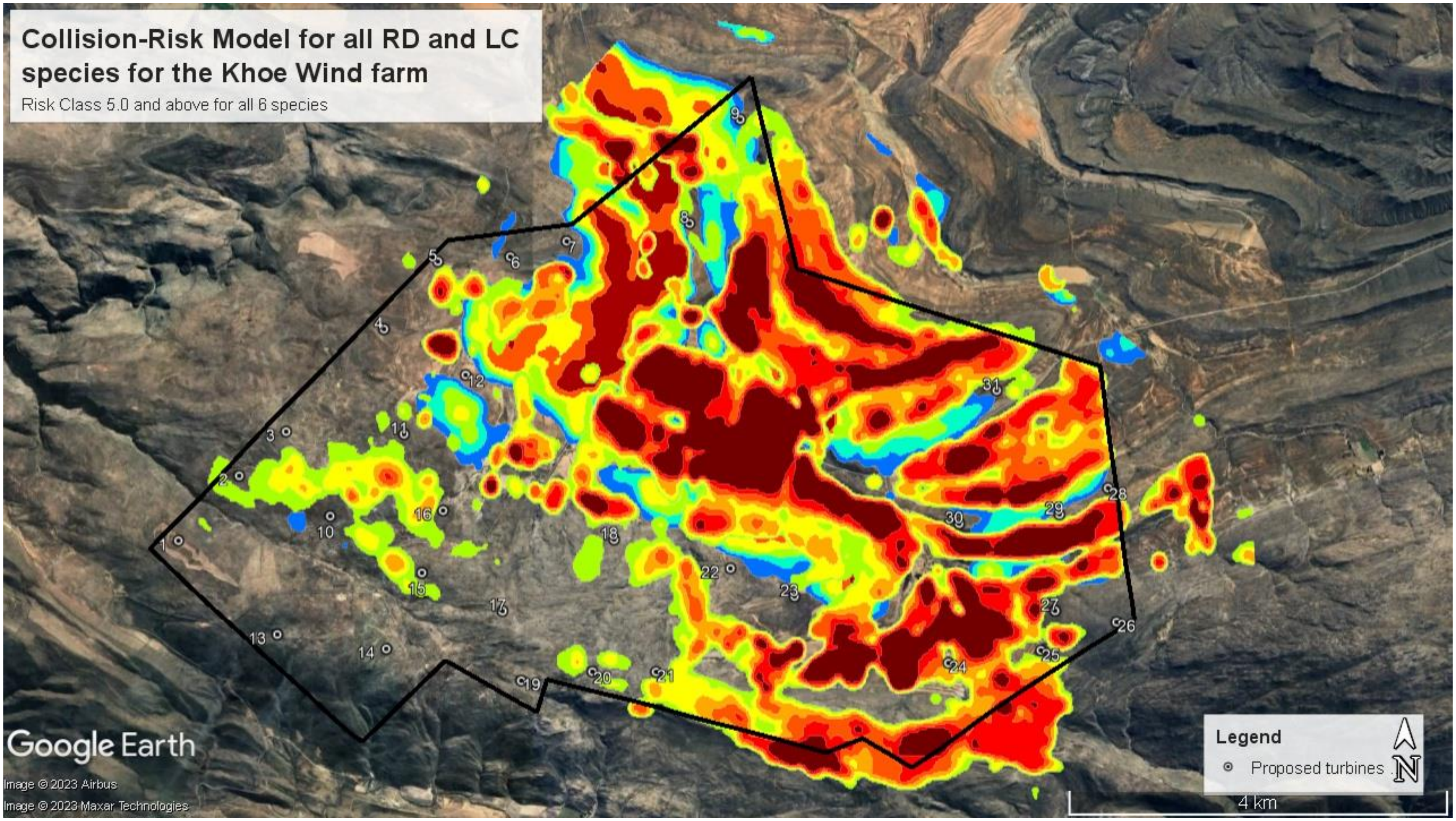


Figure 15: The combined CRM risk vulnerability map for the **four RD** and two **LC** species, based on 12 month's monitoring over all seasons for the proposed **KHOE WEF**. The turbine layout provided (10 May 2023) was revised by Energy Team for the 31 turbines (= white, numbered dots) completely avoiding all risk Classes 5.0 and above. Risk is concentrated in the central and north-east sections of the proposed site and, thus, the move for the majority of the turbines to the west and south-west of the site.

5.3.4 SUMMARY OF CRM

In summary the running of the CRM for all 5 RD and 2 LC species with adequate data revealed that:

- Of the nine Priority species recorded on the proposed KHOE wind farm, seven (5 RD and 2 LC) had sufficient data to allow collision risk assessments to be undertaken.
- Most RD species' risky flight minutes could be captured by setting the No-Go areas for wind turbines at the Class level 5.0 and above.
- Most of these higher risk areas for the RD species were clustered together in the east, north-eastern, and central areas of the proposed wind farm, allowing us to reduce risk (by about 70%) for these species (by designating them No-Go for turbine development).
- The majority of higher risk areas for the LC species were clustered together in the central and north areas of the proposed wind farm, allowing us to reduce risk (by about 50%) for these species (by designating them No-Go for turbine development).
- There was considerable overlap between the spatially explicit risk maps for RD and LC species making it easier to designate areas of high-risk for both groups of Priority birds.
- All turbines (100% of 31) in the final layout were placed outside the designated high-risk areas.

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

- For the second time in southern Africa multiple (7) Priority species recorded 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.

- Seven species had sufficient data to perform Collision Risk Modelling. We did so for five RD species (Black Harrier, Blue Crane, Lanner Falcon, Martial Eagle, Verreaux's Eagle) and two LC species (Booted Eagle and Jackal Buzzard).

- The northern, central, and eastern sections of the study area were more likely to be designated high-risk areas, probably due to a combination of suitable topography for "lift" for raptors, and a centrally placed wetland for Blue Cranes. This high-risk area comprised 66.6% of the 4113-ha farm.

- Least risky areas were in the south-west of the study site, and the majority of the turbines were placed there.

- The most likely species to be impacted by the turbines according to the CRM were Verreaux's Eagles with an average 2.65 birds estimated to be killed per year without mitigation.

- For the other RD species, the most likely to suffer fatalities without mitigation are Black Harriers (0.9 birds/year), Blue Cranes (0.7 birds/year) and Martial Eagles (0.4 birds/year).

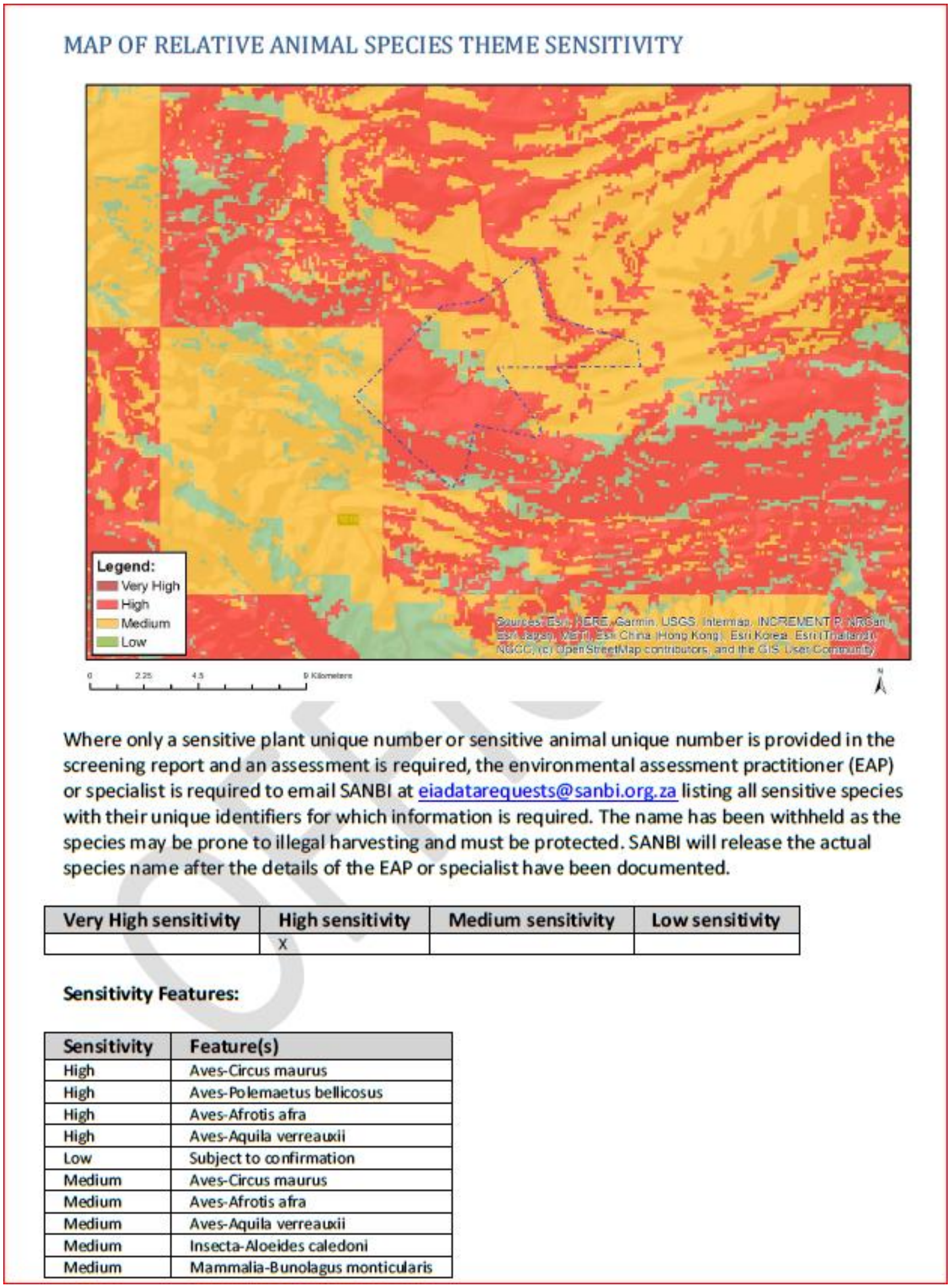
- By avoiding areas classified as risk Class 5.0 (and above) the predicted collision risk for all species was reduced between 10.6-fold (for Blue Cranes) to 6.8-fold for Verreaux's Eagles to levels of 0.1 birds to 0.4 birds per year for all species.

5.4 OVERALL SITE SENSITIVITY

The DFFE Screening Tool defines the entire proposed KHOE 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:

- Black Harrier
- Martial eagle
- Verreaux's Eagle
- Southern Black Korhaan.

All of the above species (presumably extracted from the SABAP data set) were recorded during the BBU monitoring with the addition of the RD Lanner Falcon. Given their presence and passage rates through the area, we would concur with the ranking of *High Sensitivity*. Thus, the Screening Tool has largely accounted for the presence of these threatened species.



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-Circus maurus
High	Aves-Polemaetus bellicosus
High	Aves-Afrotis afra
High	Aves-Aquila verreauxii
Low	Subject to confirmation
Medium	Aves-Circus maurus
Medium	Aves-Afrotis afra
Medium	Aves-Aquila verreauxii
Medium	Insecta-Aloeides caledoni
Medium	Mammalia-Bunolagus monticularis

Figure 16: The DFFE Screening Tool Animal Theme for the proposed KHOE wind farm site. The site is classified as of *High Sensitivity.* As such, and in compliance with NEMA, a full avian impact assessment has been undertaken.

6 QUANTIFYING THE IMPACTS

Here we semi-quantify the overall wind farm for the construction and operational phases 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) ~1375 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 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 1375 -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 korhaans.

The Probability of occurrence (**P**, from 1-5) of the Priority species (Black Harriers, Blue Crane, Verreaux's Eagle, Martial Eagle and two 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 (2.55 birds/hour) 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 Priority species during the **construction phase** of the KHOE WEF.

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,	Yes: duration only for construction phase

	For disturbance yes, birds temporarily displaced by disturbance are likely to return once construction complete	
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 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 further mitigations, if required.

6.2 OPERATIONAL PHASE IMPACTS

6.2.1 OPERATIONAL 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 KHOE WEF.

Impact Phase: Operational

Nature of Impact: Generally negative due to potential for collision, and displacement, of five Red Data species or two 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, the impacts can be reduced by appropriate placement of turbines guided by the CRM here and extra mitigations can be applied if placement is not enough.
Irreplaceable loss of species?	Possibly	unlikely
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 also identified by the CRM).

- 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 mitigations have been appropriately adhered to and, in particular, that road and hard stand verges do not provide additional substrate for raptor prey species.
- 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. Most importantly, this policy should identify 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 one Red Data species or two 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 must be immediately initiated; or (ii) 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 (VPs) 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 (KHOE Wind Farm 1 (Pty) Ltd, have complied with both recommendations in their revised layout of June 2023 (Figure 15).

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. Note that these can be reduced with additional mitigations.

6.2.2 OPERATIONAL PHASE IMPACT: POWER LINE COLLISIONS

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

Impact Phase: Operational

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 within the WEF.
- Because the only powerline victims uncovered on site were cranes that do not see overhead lines, the newly proposed mitigation of <u>staggered pylons</u> must be implemented on site (Pallett et al. 2022): that is, 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 a raptor-friendly pole design to avoid electrocutions. The rule of thumb here is that all conductors be strung <u>below</u> the support structures. Insulation of live components will be required to prevent electrocutions.

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 KHOE Wind Energy Facility 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 humans;
- 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, fences) within, or leading from, the site.

Only one renewable energy development is currently on record with the Department of Forestry, Fisheries and the Environment within 30-km of KHOE Wind Energy Facility (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 KHOE WEF, 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 KHOE WEF	Technology	Megawatts	Current Status
1	Hugo 200MW wind farm	2-km	Wind	240	Approved
2	Touwsrivier	~20-km	Solar	36	Approved
3	Montague Road (a)	~24-km	Solar	75	Approved
4	Montague Road (b)	~25-km	Solar	75	Approved
5	Sanval	~28-km	Solar	70	Approved
Summary: 1 WEF + 4 Solar PV - Total power output: WIND 496 **MW**					

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

- South African wind farms kill an average of 4.6 ± 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 ± 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.

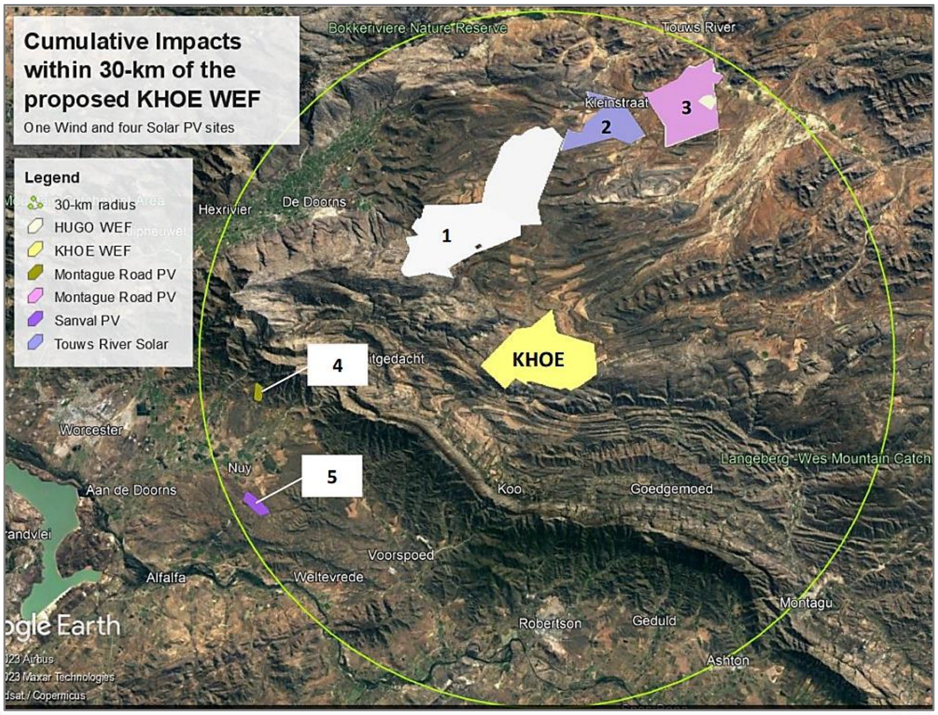


Figure 16: All proposed renewable energy (RE) developments within a 30-km radius of the proposed KHOE WEF (=yellow polygon).

The Hugo WEF site (=1) is the only wind farm within 30-km, while four Solar PV sites (Touwsrivier (2), Montague Road (3 and 4), and Sanval (5)) are approved.

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 (240 MW) and the four solar PV sites (256 MW) is shown in Table with their predicted fatalities also 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 KHOE WEF.

Annual Avian fatalities due to WIND + SOLAR PV farms for CUMULATIVE IMPACTS		
WIND	**Number of wind MWs near the KHOEWEF**	**Total estimated fatalities**
2.0 ± 1.3 birds/MW/year	(Hugo WEF) 240 MW	480 birds killed
SOLAR	**Number of solar MWs near the KHOEWEF**	
4.5 ± 3.5 birds/MW/year	(Touws Rivier Solar PV) 36 MW	162 birds killed
	(Montague Road Solar PV) 75 MW	338 birds killed
	(Montague Road Solar PV) 75MW	338 birds killed
	(Sanval Solar PV) 70MW	315 birds killed
Total birds estimated killed per year		**1663 birds**
Estimated total raptors forecast to be killed by WEFs per year (~36%)		173 raptors (of 480)
Estimated Red Data raptors (~17% of all raptors)		**29 Red Data raptors**

Thus, the estimated figure for all avian fatalities is 1663 birds (all species) from interactions with the one wind and four solar farms within 30-km. If ~36% of those killed by the wind farm are raptors (Perold et al. 2017), then we expect about 173 raptor fatalities of which approximately 29 (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-high* and significant. With CRM-based mitigations (at the Hugo WEF) it is likely that these totals will be lower.

We populated the Cumulative Impacts table with avian fatality rates from published studies. Data were sourced from post-construction wind farm 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 KHOE WEF**.**

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 fatality data from the other wind farm).		

Mitigation for all WEFs

- The Hugo wind farm north of KHOE will undertake the same CRM process of avoidance of high-risk areas undertaken here for KHOE.
- 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. Most importantly, this policy should identify 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) patterned blades to make rotors more visible; or (ii) an observer-led turbine Shutdown on Demand (SDOD) programme (or automated SDOD) must be implemented on site. The human lead 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 (VPs) 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.

*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 5.0). This has been undertaken by the applicant and, therefore, this mitigation has been enacted (reflected in the Figures in this report). The current layout will have reduced the risk by between 4- and 10-fold for the main Priority species.
- For turbines proposed in medium-risk areas (those lower than Class 5.0), we recommend that patterned blades are installed from the start on 50% of the remaining turbines.

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

- Turbines falling in the risk Class 5.0 and above should be moved into lower risk classes (uncoloured portions in Figure 14).
- Turbines falling into Class 4.5 must be mitigated with either patterned/striped-blades or SDOD.
- Turbines in Class 4 and below without mitigation.
    - Should any turbines kill one *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, 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 30 days 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 an annexure to the operational EMP for the WEF. Most importantly, this plan should identify the number of bird fatalities of Priority species which will trigger a management response, the appropriate response, and timelines 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 to proactively assist adaptive management.
    - 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 the high-risk areas by the client, the likelihood that fatalities will occur is low, and these additional mitigations are unlikely to be required.

8 ENVIRONMENTAL MANAGEMENT PROGRAMME

Given the possible impact of the proposed KHOE Wind Farm development, 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 at the same time as construction begins – 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 conditions throughout the year at ~40% or more of all 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 arid areas; 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 those 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 one RD fatality per turbine year); or

(ii) should two 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 30 days 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 one 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 patterned 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 60 days to reduce fatality rates. The results of these experiments should be publicised so that other wind farms, with similar issues, can be informed.

We would 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 12-month, all season assessment of the risk to Priority avifauna, of the proposed KHOE Wind Facility provides the second complete Collision Risk Modelling in South Africa for a suite of seven species at potential risk from the proposed wind farm. Four Red Data species and two Least Concern species with a high (combined) Passage Rate of 2.55 flights per hour made this site challenging, but data rich.

That the Red Data species alone had Passage Rates of 2.18 flights per hour across the WEF (dominated by Blue Cranes and Verreaux's Eagles) indicates that risk from the 31 proposed turbines could be substantial. These rates may be high due to the existence of a large dam in the centre of the site and cliffs suitable for soaring over the northern and eastern sections.

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 seven Priority species. It gave eight levels of risk (from 1, the lowest, to 7.5, 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 north-eastern and central areas were high risk for Red Data species and the central and northern areas were high risk for Least Concern species. This resulted in 66.6% of the area designated for KHOE Wind Energy Facility as No-Go for turbines.

Within the remaining 33% the developer was able to locate all (31) turbines outside the designated high-risk areas. The re-positioning of the turbines from the initial layout reduced the expected fatalities substantially for all species (e.g. from 2.8 birds/year to 0.4 birds/year for Verreaux's Eagles, and 0.9 birds/year to 0.094 birds/year for Black Harrier).

Birds & Bats Unlimited concur with the DFFE Screening Tool Assessment that classified the KHOE area as of *High Sensitivity*.

According to available information collected during this study and based on the CRM-optimised layout for each of the 31 turbines proposed for the KHOE Wind Energy Facility, all high-risk areas for birds have been avoided by the final (June 2023) 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 KHOE Wind Energy Facility from receiving Environmental Authorisation (EA).

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Dr R.E. Simmons, Dr R. Colyn, M. Martins

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www.birds-and-bats-unlimited.com

rob.simmons@uct.ac.za

082 780 0133