KAROO RENEWABLE ENERGY FACILITY

Avian impact assessment

- Scoping Phase -

AVISENSE
CONSULTING

EXECUTIVE SUMMARY

This study contains an extensive review of relevant literature on renewable energy facility impacts on avifauna, and identifies potential impacts of the proposed Karoo Renewable energy facility on the avifauna of the area. These expected impacts are: habitat destruction by construction of the facility itself and any associated power lines or substation/s, disturbance by both activities and possible displacement or disturbance of sensitive species by the operation of the facility, collision with blades of the wind turbines and other associated infrastructure.

The impact zone of the proposed renewable energy facility features mainly open, dry Karoo veld, bounded in the north and west by the rocky escarpment of the Horseshoe and its outlying range of koppies. The area supports over 220 bird species, including 15 Red-listed species, 70 endemics, and five red-listed endemics. Resident populations and/or seasonal influxes of large terrestrial birds (Ludwig's Bustard *Neotis ludwigii* Blue Crane *Anthropoides paradiseus*), a range of locally resident or visiting raptors, in particular Martial Eagle *Polemaetus bellicosus*, Verreaux's Eagle *Aquila verreauxii*, and possibly Lanner Falcon *Falco biarmicus* and/or Peregrine Falcon *Falco peregrinus*, and a suite of restricted range and/or endemic passerines, are the species of greatest conservation significance which may be impacted by the renewable energy facility, both in terms of the collision, displacement and disturbance impacts of the facility itself, and of the disturbance and mortality risks posed by its peripheral infrastructure.

These issues will be investigated in more detail during the EIA phase. In particular the significance of bird collisions with the wind turbines will be assessed in order to determine whether the risk warrants mitigation. The significance of this impact will depend mainly on the relative abundance of certain key species, and the distribution of their respective microhabitats. The result of the EIA phase will be a more detailed assessment of all impacts, recommended mitigation where necessary, and a comprehensive programme to fully monitor the actual impacts of the renewable energy facility throughout construction and well into its operational phase.

CONSULTANT'S DECLARATION OF INDEPENDENCE

Andrew Jenkins (*AVISENSE* Consulting cc) is an independent consultant to Savannah Environmental Pty (Ltd) and South African Renewable Green Energy (Pty) Ltd (SARGE). He has no business, financial, personal or other interest in the activity, application or appeal in respect of which they were appointed other than fair remuneration for work performed in connection with the activity, application or appeal. There are no circumstances that compromise the objectivity of this specialist performing such work.

1. INTRODUCTION

South African Renewable Green Energy (Pty) Ltd (SARGE) is proposing to establish a commercial renewable energy facility (REF) (project name 'Karoo Renewable energy facility'), consisting of both a wind energy facility component and a photovoltaic solar facility component, as well as associated infrastructure on a site located approximately 34 km south of Victoria West (Fig. 1). Based on a pre-feasibility analysis and site identification processes undertaken by SARGE, a favourable area has been identified for consideration and evaluation through an Environmental Impact Assessment (EIA). Savannah Environmental Pty (Ltd) was appointed to compile the EIA report, and subsequently appointed *AVISENSE* Consulting to conduct the specialist avifaunal assessment. The study was conducted by Dr Andrew Jenkins, an ornithologist with over 20 years of experience in avian research and impact assessment work. He has been involved in the design and/or execution of many of the completed EIA and EMP studies for wind energy facilities in South Africa to date, including the only two operational facilities at Darling and Klipheuwel, Western Cape Province.

2. TERMS OF REFERENCE

The terms of reference for the scoping phase, as supplied by Savannah Environmental (Pty) Ltd, were to provide:

- A description of the affected environment and the manner in which it may be affected.
- A description and evaluation of the avian issues and impacts identified, including detail on the nature and extent of any potential direct, indirect and cumulative impacts.
- A statement on the potential significance of identified issues based on the above evaluation.
- A comparative evaluation of any identified, feasible alternatives.
- Identification of any potentially significant impacts which will require particular attention in the EIA phase, with recommendations on the methodology to be adopted in assessing such, expressed as a Plan of Study for the EIA.

3 STUDY METHODOLOGY

3.1. Approach

This desktop study included the following steps:

- A review of available published and unpublished literature pertaining to bird interactions with wind energy facilities is provided summarising the issues involved and the current level of knowledge in this field. Various information sources (listed below), including data on the birdlife of the area and previous studies of bird interactions with renewable energy facility and electricity infrastructure, were examined.
- An inclusive, annotated list of the avifauna likely to occur within the impact zone of the proposed renewable energy facility was compiled using a combination of the existing distributional data and previous experience/knowledge of the avifauna of the general area.
- A short-list of priority bird species (defined in terms of conservation status and endemism) which could possibly be impacted by the proposed renewable energy facility was extracted from the total bird list. These species were subsequently considered as adequate surrogates for the local avifauna generally, and mitigation of impacts on these species was considered likely to accommodate any less important bird populations that may also potentially be affected.
- A summary of more likely and significant impacts of the renewable energy facility on the local avifauna was drawn up, and a brief methodology was devised for the EIA phase for confirming these impacts and developing an effective mitigation strategy.

3.2. Data sources used

The following data sources and reports were used in the compilation of this report:

- Bird distribution data of the Southern African Bird Atlas Project (SABAP – Harrison *et al.* 1997) were obtained from the Animal Demography Unit website (http://sabap2.adu.org.za/index.php) for the relevant quarter-degree squares (SABAP 1: 3123CA Verster, 3123CB Bulberg, 3123CC Three Sisters, 3123CD Tierhoek) or pentads (SABAP 2: 3140_2305, 3140_2310, 3140_2315, 3145_2305, 3145_2310, 3145_2315). A composite list of species likely to occur in the impact zone of the renewable energy facility was drawn up as a combination of these data, refined by a more specific assessment of the actual habitats affected, based on general knowledge of the avifauna of the region (APPENDIX 1).
- Conservation status and endemism of all species considered likely to occur in the area was determined as per the most recent iteration of the national Red-list for birds (Barnes 2000), and the most recent and comprehensive summary of southern African bird biology (Hockey *et al.* 2005).
- Data from the Animal Demography Unit's Coordinated Avifaunal Roadcount project (CAR: http://car.adu.org.za/, Young *et al.* 2003).

- EIA and EMP reports for other developments in the same area (Allan & Jenkins 1990, Jenkins 1998).
- EIA reports and any subsequent monitoring reports on the potential impacts on birds of other proposed and/or constructed and operational wind energy facilities in South Africa (van Rooyen 2001, Jenkins 2001, 2003, Küyler 2004, Jenkins 2008a, 2009).

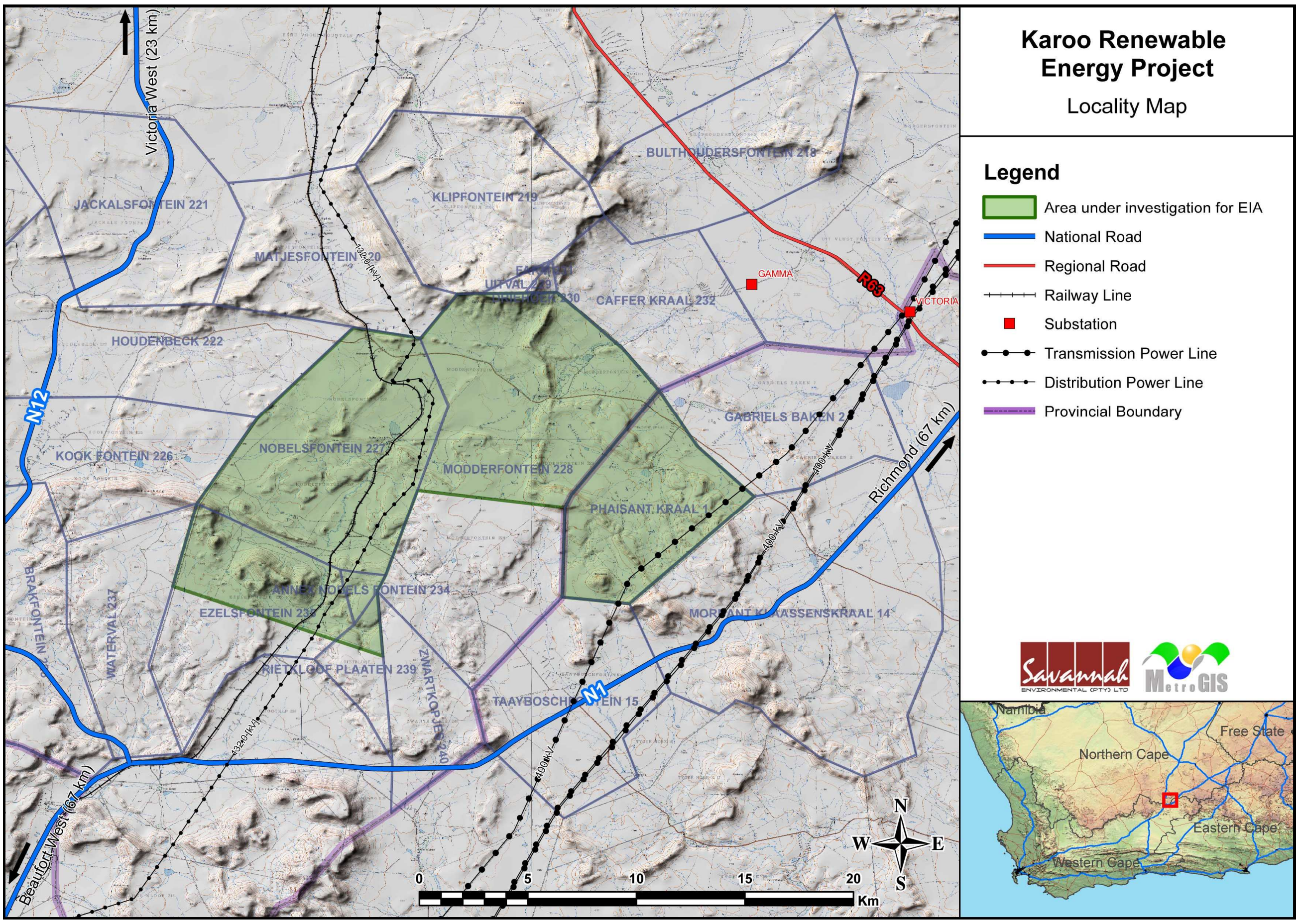

FIGURE 1. Location of the proposed Karoo Renewable Energy Facility.

3.3. Limitations & assumptions

Any inaccuracies in the above sources of information could limit this study. The SABAP 1 data for this area was sparse originally (only 79 cards submitted for the four relevant quarter-degree squares combined) and is now is now >15 years old (Harrison *et al.* 1997), and there is presently no SABAP 2 data available for the six relevant pentads. This deficiency will be rectified to some extent in a visit to the site as part of the EIA phase of this study.

Given that there are currently only three, very small wind energy facilities operative in South Africa (Coega, Klipheuwel and Darling, currently numbering only 1, 3 and 4 operational turbines respectively), practical experience of the environmental effects of wind energy facilities in this country is extremely limited, and it is necessary to base estimates of the possible impacts of new facilities farms largely on lessons learnt internationally. While many of the established, general principles can probably be usefully applied here, care should be taken in adapting international knowledge and experience to uniquely South African birds and conditions.

4. DESCRIPTION OF THE PROPOSED RENEWABLE ENERGY FACILITY

The project is proposed on portions of the following Farms: Nobelsfontein 227, Annex Nobelsfontein 234, Ezelsfontein 235, Rietkloofplaaten 239, Modderfontein 228 and PhaisantKraal 1. The site proposed for the facility falls within the Ubuntu- as well as the Beaufort West Local Municipality. A broader area of approximately 20 222 ha is being considered within which the facility is to be constructed. By undertaking a technical feasibility study which considered favourable climatic conditions (wind and solar renewable energy facilities are directly reliant on average wind speeds and solar radiation values for a particular area), access to the electricity grid, accessibility of the study site, and local site topography, an ideal site has been identified for the establishment of the proposed renewable energy facility.

The site under investigation for the proposed Karoo Renewable Energy Facility covers an approximate area of 200 km^2. The proposed facility is proposed to accommodate up to 350 MW which would comprise a combination of up to 150 wind turbines with a generating capacity of up to 300 MW, and an array of photovoltaic (PV) panels with a generating capacity of up to 50MW. Other infrastructure associated with the facility will include an on-site generator transformer and a small substation to facilitate the connection between the renewable energy facility and the Eskom electricity grid, foundations to support both the turbine towers as well as the PV panels, cabling between the project components, to be lain underground where practical, an overhead power line (132kV) of ~6km in length feeding into the Eskom electricity network at the existing Skietkuil/Biesiespoort Substation, a network of internal access roads, and workshop area for maintenance and storage.

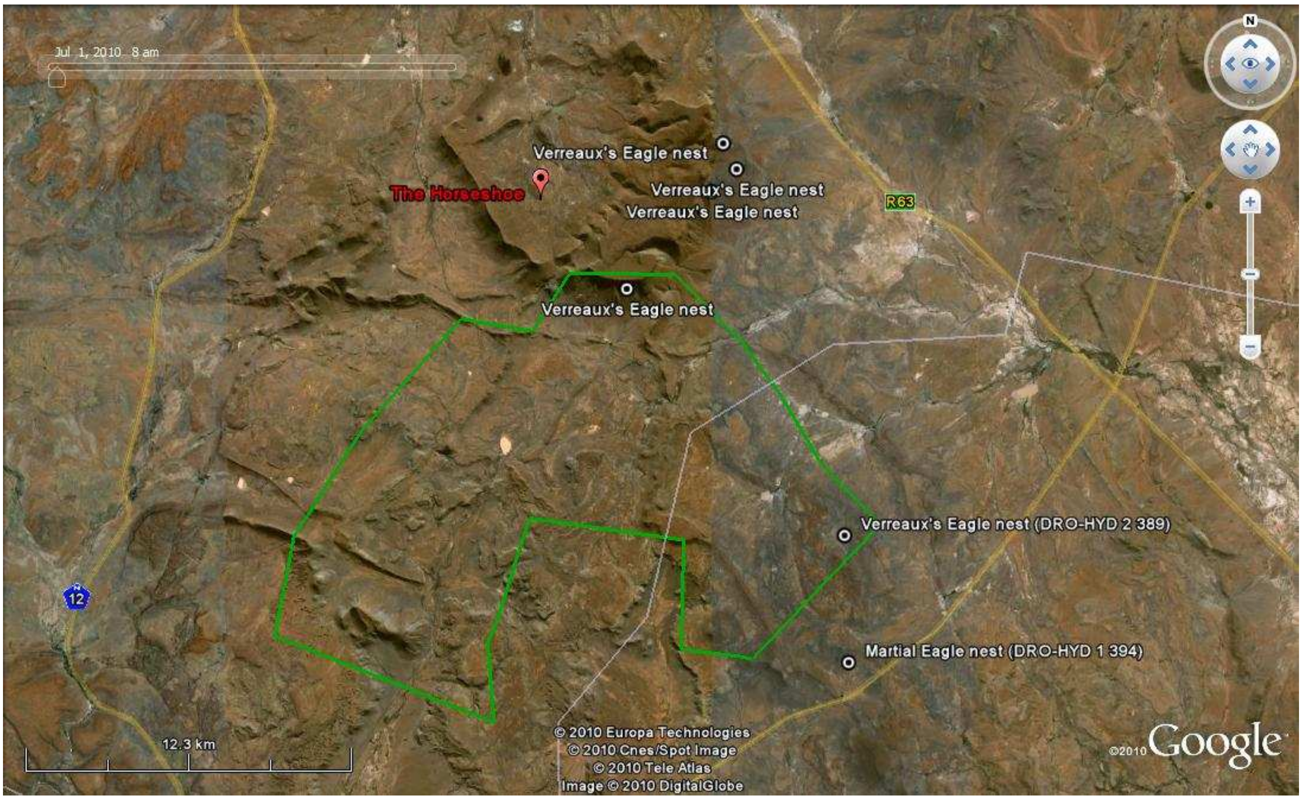

FIGURE 2. Location of the proposed Karoo Renewable energy facility in relation to known large eagle nest sites on cliffs and power lines in the general area.

5. DESCRIPTION OF THE AFFECTED ENVIRONMENT

5.1 Vegetation of the study area

The affected environment falls within the Upper Karoo Bioregion of the Nama Karoo Biome (Mucina & Rutherford 2006). The natural vegetation is dominated by Eastern Upper Karoo veld on the flats, with dwarf shrubs and drought resistant grasses, and by Upper Karoo Hardeveld on the slopes and koppies, featuring dwarf Karoo shrubs and grasses (Mucina & Rutherford 2005).

5.2 Avian microhabitats

These will be defined more accurately after a site visit during the EIA phase of the project, but will probably comprise mostly dry, open **Karoo veld**, degraded by grazing but otherwise intact. **Wetlands** may comprise a number of ephemeral waterbodies and scattered small farm dams. The major drainage lines probably feature denser, **woodland** vegetation, supplemented by stands of alien trees, and 'The Horseshoe' and its associated outlying koppies will provide the long, high, sheer **cliffs**, attended by areas of rocky scree.

5.3 Avifauna of the impact area

Over 220 bird species are considered likely to occur within the anticipated, broader impact zone of the REF (APPENDIX 1), including 70 endemic or near-endemic species, 15 red-listed species, and five species – Ludwig's Bustard *Neotis ludwigii*, Blue Korhaan *Eupodotis caerulescens*, Blue Crane *Anthropoides paradiseus*, Black Harrier *Circus maurus* and possibly Cape Vulture *Gyps coprotheres* – which are both endemic and red-listed (Barnes 1998, 2000, Young *et al.* 2003). The site falls just to the west of the Platberg-Karoo Conservancy Important Bird Area (Barnes 1998), which is known to support critical or regionally significant populations of Red-listed species such as Ludwig's and Kori Bustards *Ardeotis kori*, Blue Korhaan, Blue Crane, Secretarybird *Sagittarius serpentarius*, Martial Eagle *Polemaetus bellicosus*, Tawny Eagle *Aquila rapax* and Lesser Kestrel *Falco naumanni*, and Greater Flamingo *Phoenicopterus ruber.*

The birds of greatest potential relevance and importance in terms of the possible impacts of the REF are likely to be:

(i) Large terrestrial birds and raptors nesting or foraging on or commuting over the open Karoo flats – including Ludwig's and Kori Bustard, Blue Korhaan, Blue Crane, Secretarybird, Martial Eagle, Tawny Eagle, Black Harrier and Lesser Kestrel.

(ii) Raptors (and possibly storks) nesting either on the cliffs of the Horseshoe escarpment – including Verreaux's Eagle *Aquila verreauxii*, Booted Eagle *Aquila pennatus*, Jackal Buzzard *Buteo rufofuscus*, Rock Kestrel *Falco tinnunculus*, as well as red-listed species such as Peregrine Falcon *Falco peregrinus,* Lanner Falcon *Falco biarmicus*, Black Stork *Ciconia nigra*, and the scarce Cape Eagle Owl *Bubo capensis* (Jenkins 2008c). There are five known breeding territories of Verreaux's Eagle and one of Martial Eagle within the broader impact zone of the proposed development (A.R. Jenkins pers. obs, Jenkins *et al.* 2007).

(iii) Populations of endemic passerines (including Karoo Long-billed Lark *Certhilauda subcoronata*, Rufous-eared Warbler *Malcorus pectoralis*, Rock Pipit *Anthus crenatus*, and Black-headed Canary *Serinus alario*) (Barnes 1998).

(iv) Occasional influxes of Greater Flamingo to the larger waterbodies in the area, or passing through on their way to resource areas further afield.

The threatened species most likely to occur on the site (Table 1) are the focus of the remainder of this report, and all potential impacts of the REF on the local avifauna, as well as all required mitigation, are deemed to be adequately covered by catering only for these species, as effective surrogates for the entire avian assemblage.

Table 1. Red-listed bird species considered likely to occur within the impact zone of the proposed renewable energy facility, with estimates of their relative susceptibility to the environmental impacts of the construction and operational phases of the development. *Red-listed endemic species are highlighted in grey*.

Common name	Conservation status	Regional endemism	Relative importance of local population[1]	Susceptibility to collision	Susceptibility to electro-cution	Susceptibility to distur-bance
Ludwig's Bustard	Vulnerable	Near-endemic	High	High	-	Moderate
Kori Bustard	Vulnerable	-	High	High	-	Moderate
Blue Korhaan	Near-threatened	Endemic	High	Moderate	-	Moderate
Blue Crane	Vulnerable	Endemic	High	High	-	Moderate
Black Harrier	Near-threatened	Endemic	Low	High	-	Moderate
Tawny Eagle	Vulnerable	-	High	High	High	Moderate
Martial Eagle	Vulnerable	-	High	Moderate	High	Moderate
Secretarybird	Near-threatened	-	High	High	-	Moderate
Lesser Kestrel	Vulnerable	-	High	Moderate	-	Moderate
Lanner Falcon	Near-threatened	-	Moderate	High	Moderate	-
Peregrine Falcon	Near-threatened	-	Low	High	Moderate	-
Black Stork	Near-threatened	-	Low	High	Moderate	-
Greater Flamingo	Near-threatened	-	Low	High	-	-

[1]Relative to the national/global population

6. BACKGROUND TO THE STUDY

6.1 Interactions between wind energy facilities and birds

Recent literature reviews (www.nrel.gov), Kingsley & Whittam 2005, Drewitt & Langston 2006, Kuvlevsky *et al.* 2007, Stewart *et al.* 2007, Drewitt & Langston 2008, Krijgsveld *et al.* 2009, Sovacool 2009) are essential summaries and sources of information in this field. While the number of comprehensive, longer-term analyses of the effects of wind energy facilities on birds is increasing, and the body of empirical data describing these effects is rapidly growing, scientific research in this field is still in its infancy (Madders & Whitfield 2006, Stewart *et al.* 2007), and much of the available information originates from short-term, unpublished, descriptive studies, most of which have been carried out in the United States, and more recently across western Europe, where wind power generation is a more established and developed industry.

Concern about the impacts of wind facilities on birds first arose in the 1980s when numerous raptor mortalities were detected at facilities at Altamont Pass Wind Resource Area (California, USA) and Tarifa (southern Spain). More recently, there has been additional concern about the degree to which birds avoid or are excluded from the areas occupied by wind energy facilities – either because of the visible action of the turbine blades or because of the noise they generate - and hence suffer a loss of habitat (Larsen & Guillemette 2007, Stewart *et al.* 2007, Devereaux *et al.* 2008. Pearce-Higgins *et al.* 2009). With a few important exceptions, most studies completed to date suggest low absolute numbers of bird fatalities at wind energy facilities (Kingsley & Whittam 2005), and low casualty rates relative to other existing sources of anthropogenic avian mortality on a per structure basis (Crockford 1992, Colson & associates 1995, Gill *et al.* 1996, and Erickson *et al*. 2001).

6.1.1 Collisions with turbines

Collision rates

As more monitoring has been conducted at a growing number of sites, some generic standards and common units have been established, with bird collisions with turbine blades generally measured in mortalities/turbine/year, mortalities/Mega-Watt/year, or mortalities /Giga-Watt Hour (Smallwood & Thelander 2008, Sovacool 2009). Wherever possible, measured collision rates should allow for (i) casualty remains which are not detected by observers (searcher efficiency - Newton & Little 2009), and (ii) casualties which are removed by scavengers before detection, and the rate at which this occurs (scavenger removal rate). Also, although collision rates may appear relatively low in many instances, 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 considerable conservation significance.

The National Wind Co-ordinating Committee (2004) estimates that 2.3 birds are killed per turbine per year in the US outside of California – correcting for searcher efficiency and scavenger rates. However, this index ranges from as low as 0.63 mortalities/turbine/year in Oregon, to as high as 10 mortalities/turbine/year in Tennessee (NWCC 2004), illustrating the wide variance in mortality rates between sites. Curry & Kerlinger (2000) found that only 13% of the >5000 turbines at Altamont Pass, California were responsible for all Golden Eagle *Aquila chrysaetos* and Red-tailed Hawk *Buteo jamaicensis* collisions, but the most recent aggregate casualty estimates for Altamont run to >1000 raptor mortalities/turbine/year, and nearly 3000 mortalities/turbine/year overall (Smallwood & Thelander 2008), including >60 Golden Eagles, and at a mean rate of about 2-4 mortalities/MW/year.

At the Tarifa and Navarre wind energy facilities on the Straits of Gibraltar, southern Spain, about 0.04-0.08 birds are killed per turbine/year (Janss 2000a, de Lucas *et al.* 2008), with relatively high collision rates for threatened raptors such as Griffon Vulture *Gyps fulvus*, of particular concern (Table 1). At the same sites, collisions have also been found to be non-randomly distributed between turbines, with >50% of the vulture casualties recorded at Tarifa being killed by only 15% of the turbine array at the facility (Acha 1997). Collision rates from other European sites are equally variable, with certain locations sporadically problematic (Everaert 2003, Newton & Little 2009, Table 1).

To date, only eight wind turbines have been constructed in South Africa at two pilot wind energy facilities at Klipheuwel and Darling in the Western Cape (van Rooyen 2001, Jenkins 2001, 2003) and, more recently, one turbine in the first phase of a proposed bigger development at Coega in the Eastern Cape. An avian mortality monitoring program was established at the Klipheuwel facility once the turbines were operational, involving regular site visits to monitor both bird traffic through the area and detect bird mortalities (Küyler 2004). This study found that (i) 9-57% of birds observed within 500m of the turbines were flying at blade height, and (ii) 0-32% of birds sighted were flying either between the turbines or within the arc of the rotors of the outermost turbines. Five bird carcasses were found on the three-turbine site during the 8-month monitoring period, of which two, a Horus Swift *Apus horus* and a Large-billed Lark *Galerida magnirostris*, were thought to have been killed by collision with turbine blades, indicating a net collision rate for birds of about 1.00 mortality/turbine/year. It is important to note here that simple estimates of aggregate collision rates for birds are not an adequate expression of biodiversity impact. Rather, consideration must be given to the conservation status of the species affected or potentially affected, and the possibility that even relatively low collision rates for some threatened birds may not be sustainable in the long term.

Causes of collision

Multiple factors influence the number of birds killed at wind energy facilities. These can be classified into three broad groupings: (i) avian variables, (ii) location variables, and (iii) facility-related variables. Although only one study has so far shown a direct relationship between the abundance of birds in an area and the number of collisions (Everaert 2003), it would seem logical to assume that the more birds there are flying through an array of turbines, the higher the chances of a collision occurring. The nature of the birds present in the area is also very important as some species are more vulnerable to collision with turbines than others, and feature disproportionately frequently in collision surveys (Drewitt & Langston 2006, 2008, de Lucas *et al.* 2008). Species-specific variation in behaviour, from general levels of activity to particular foraging or commuting strategies, 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 may be particularly at risk.

Landscape features can potentially 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). High densities of prey will attract raptors, increasing the time spent hunting, and as a result reducing the time spent being observant. Poor weather affects visibility. Birds fly lower during strong headwinds (Hanowski & Hawrot 2000, Richardson 2000), so when the turbines are functioning at their maximum speed, birds are likely to be flying at their lowest, exponentially increasing collision risk (Drewitt & Langston 2006, 2008).

Table 1. Results of recent published studies of the effects of wind energy facilities on local avifauna.

Location	***n* wind farm/s assessed**	**Turbine hub height (m)**	***n* turbines**	**Habitat**	**Bird groups assessed**	**Evidence of displacement?**	**Collision rate (birds/turbine/year)**	**Reference**
Tarifa, Southern Spain	2	18-36	66-190	Hilly woodland	Raptors	N/A	Raptors = 0.27, Griffon Vultures = 0.12	Barrios & Rodríguez 2004
Tarifa, Southern Spain	2	28-36	66-190	Hilly woodland	Raptors	N/A	0.04-0.07, mostly Griffon Vultures	de Lucas *et al.* 2008
East Anglia, UK	2	60	8	Croplands	Gamebirds, corvids, larks and see-eaters	Minimal, only gamebirds significantly affected	N/A	Devereaux *et al.* 2008
Altamont Pass, California	1	14-43	5400	Hilly grassland	Various	N/A	4.67 , raptors = 1.94	Smallwood & Thelander 2008
Southern Spain	1	44	16	Hilly woodland	Various	Yes, >75% reduction in raptor sightings	0.03	Farfán *et al.* 2009
Netherlands	3	67-78	7-10	Farmland	Various	N/A	27.0-39.0	Krijgsveld *et al.* 2009
Northumberland, UK	1	30	9	Coastal	Seabirds	N/A	16.5-21.5, mostly large gulls	Newton & Little 2009
N England & Scotland	12	30-70	14-42	Moorland	Gamebirds, shorebirds, raptors, passerines	Yes, 53% reduction in Hen Harrier *Circus cyaneus* sightings, other species also decreased	N/A	Pearce-Higgins *et al.* 2009

Larger wind energy facilities, with more turbines, are almost by definition more likely to incur significant numbers of 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, but see Howell 1995, Erickson *et al.* 1999, Barclay *et al.* 2007), although with newer technology, fewer, larger turbines are needed to generate equivalent or even greater quantities of power, possibly resulting in fewer collisions per Megawatt of power produced (Erickson *et al.* 1999). Certain turbine tower structures, and particularly the old-fashioned lattice designs, present many potential perches for birds, increasing the likelihood of collisions occurring as birds land at or leave these perch or roost sites. This generally is not a problem associated with more modern, tubular tower designs (Drewitt & Langston 2006, 2008), such as those proposed to be used for this project.

Illumination of turbines and other infrastructure is often associated with increased collision risk (Winkelman 1995, Erickson *et al.* 2001), either because birds moving long distances at night do so by celestial navigation, and may confuse lights for stars (Kemper 1964), or because lights attract insects, which in turn attract birds. Changing constant lighting to intermittent lighting has been shown to reduce nocturnal collision rates (Richardson 2000, APLIC 1994, Jaroslow 1979, Weir 1976). Aviation warning lights for wind turbines as prescribed by the Civil Aviation Authority (CAA) are intermittent / flashing red lights. These are generally placed on the turbines around the edge of the facility, but not necessarily on every turbine within the facility. Changing flood-lighting from white to red can also reduce mortality rates by up to 80% (Weir 1976).

Spacing between turbines at a wind facility can have an effect on the number of collisions. Some authors have suggested that paths should be left between turbines to allow free passage through the turbine strings (Drewitt & Langston 2006, Kuvlevsky *et al.* 2007, Drewitt & Langston 2008). This approach tallies well with wind energy generation principles, which require relatively large spaces between turbines in order to avoid wake and turbulence effects. An alternative perspective suggests that all attempts by birds to fly through wind energy facilities, rather than over or around them, should be discouraged to minimise collision risk (Drewitt & Langston 2006, Kuvlevsky *et al.* 2007, Drewitt & Langston 2008). This approach effectively renders the entire footprint of the facility as lost habitat (see below).

Collision prone birds

Collision prone birds are generally either (i) large species and/or species with high ratios of body weight to wing surface area (wing loading), which confers low maneuverability (cranes, bustards, vultures, gamebirds, waterfowl, falcons), (ii) species which fly at high speeds (gamebirds, pigeons and sandgrouse, swifts, falcons), (iii) species which are distracted in flight - predators or species with aerial displays (many raptors, aerial insectivores, some open country passerines), (iv) species which habitually fly in low light conditions, and (v) species with narrow fields of forward binocular vision (Drewitt & Langston 2006, 2008, Jenkins *et al.* 2010, Noguera *et al.* 2010). These traits confer high levels of *susceptibility*, which may be compounded by high levels of *exposure* to man-made obstacles such as overhead power lines and wind turbine areas (Jenkins *et al.* 2010). Exposure is greatest in (i) very aerial species, (ii) species inclined to make regular and/or long distance movements (migrants, any species with widely separated resource areas - food, water, roost and nest sites), (iii) species that regularly fly in flocks (increasing the chances of incurring multiple fatalities in single collision incidents).

Soaring species may be particularly prone to colliding with wind turbines where the latter are placed along ridges to exploit the same updrafts favoured by such birds - vultures, storks, cranes, and most raptors - for cross-country flying (Erickson et al. 2001, Kerlinger & Dowdell 2003, Drewitt & Langston 2006, 2008, Jenkins *et al.* 2010, Noguera *et al.* 2010). Large soaring birds – for example, many raptors and storks - depend heavily on external sources of energy for sustainable flight (Pennycuick 1989). In terrestrial situations, this generally requires that they locate and exploit pockets or waves of rising air, either in the form of bubbles of vertically rising, differentially heated air – thermal soaring - or in the form of wind forced up over rises in the landscape, creating waves of rising turbulence – slope soaring.

Certain species are morphologically specialised for flying in open landscapes with high relief and strong prevailing winds, and are particularly dependent on slope soaring opportunities for efficient aerial foraging and travel. South African examples might include Bearded Vulture *Gypaetus barbatus* and Cape Vulture *Gyps coprotheres*, Verreaux's Eagle *Aquila verreauxii*, Jackal Buzzard *Buteo rufofuscus*, Rock Kestrel *Falco rupicolus*, Peregrine Falcon *Falco peregrinus*, Lanner Falcon *Falco biarmicus* and Black Stork *Ciconia nigra* and, to a lesser extent, most other open-country raptors. Such species are potentially threatened by wind energy developments where turbines are situated to exploit the wind shear created by hills and ridge-lines. In these situations, birds and industry are competing for the same wind resource, or a similar wind resource in the same general area (turbine arrays are generally positioned just off steep slopes to avoid turbulent, rising air and rather intercept accelerated, smooth, lateral flow; slope soaring raptors seek out and use both turbulent and smoothly flowing air to their advantage) and the risk that slope soaring birds will collide with the turbine blades, or else be prevented from using foraging habitat critical for their survival, is greatly increased. Evidence of these effects has been obtained from several operational wind energy facilities in other parts of the world – for example relatively high mortality rates of large eagles, buzzards and kestrels at Altamont Pass, California (>1100 raptors killed annually or 1.9 raptor casualties/MW/year, Smallwood & Thelander 2008), and of vultures and kestrels at Tarifa, Spain (0.15-0.19 casualties/turbine/year, Barrios & Rodríguez 2004, de Lucas *et al.* 2008, Table 1), and displacement of raptors generally in southern Spain (Farfán *et al.* 2009) and of large eagles in Scotland (Walker *et al.* 2005) – and one study has shown that the additive impact of wind farm mortality on an already threatened raptor could theoretically cause its localised extinction (Carrete *et al.* 2009).

Mitigating collision risk

The most direct way to reduce the risk of birds colliding with turbine blades is to make the blades more conspicuous and hence easier to avoid, however this type of marking is not supported by the CAA. Blade conspicuity 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 that even slow blade rotation can be difficult for birds to see.

Laboratory-based studies of visual acuity in raptors have determined that (i) visual acuity appears 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, (ii) moderate motion of the visual stimulus significantly influences acuity, and kestrels may be unable to resolve all portions of an object such as a rotating turbine blade because of motion smear, especially under low contrast or dim lighting conditions, (iii) this deficiency can be addressed by patterning the blade surface in a way which maximises the time between successive stimulations of the same retinal region, and (v) the easiest, cheapest and most visible blade pattern for this purpose, effective across the widest variety of backgrounds, is a single black blade in an array of white blades (McIsaac 2001, Hodos 2002). Hence blade marking may be an important means to reduce collision rates by making the rotating turbine blades as conspicuous as possible under the least favourable visual conditions, particularly at facilities where raptors are known or likely to be frequent collision casualties.

Even if the turbine rotor blades are marked, many species may still be susceptible to colliding with them, especially during strong winds (when the rotor speed is high and birds tend to fly low and with less control) and when visibility is poor (at night or in thick mist). All other collision mitigation options operate indirectly, by reducing the frequency with which collision prone species are exposed to collision risk. This is achieved mainly by (i) siting farms and individual turbines away from areas of high avifaunal density or aggregation, regular commute routes or hazardous flight behaviour, (ii) using low risk turbine designs and configurations, which discourage birds from perching on turbine towers or blades, and allow sufficient space for commuting birds to fly safely through the turbine strings, and (iii) carefully monitoring collision incidence, and being prepared to shut-down problem turbines at particular times or under particular conditions.

Effective mitigation can only be achieved with a commitment to rigorous pre- and post-construction monitoring (see below), ideally using a combination of occasional, direct observation of birds commuting or foraging through and around the renewable energy facility, coupled with constant, remote tracking of avian traffic using specialised radar equipment (e.g. see http://www.detect-inc.com/wind.html). Such systems can be programmed to set the relevant turbines to idle as birds enter a pre-determined danger zone around the turbine array, and to re-engage those turbines once the birds have safely passed.

6.1.2 Habitat loss – destruction, disturbance and displacement

Although the final, destructive footprint of most wind energy facilities is likely to be relatively small, the construction phase of development inevitably incurs quite extensive temporary damage or permanent destruction of habitat, which may be of lasting significance in cases where renewable energy facility sites coincide with critical areas for restricted range, endemic and/or threatened species. Similarly, construction, and to a lesser extent ongoing maintenance activities, are likely to cause some disturbance of birds in the general surrounds, and especially of shy and/or ground-nesting species resident in the area. Mitigation of such effects requires that generic best-practice principles be rigorously applied - 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 kept to an absolute minimum. Some studies have shown significant decreases in the numbers of certain birds in areas where wind energy facilities are operational as a direct result of avoidance of the noise or movement of the turbines (e.g. Larsen & Guillemette 2007, Farfán *et al.* 2009, Table 1), while others have shown decreases which may be 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 more modified environments such as farmland (Devereaux *et al.* 2008), and are highly species-specific in operation.

Note that the only post-construction monitoring that has been done at a wind energy facility in South Africa located a successful Blue Crane *Anthropoides paradiseus* nest only 400 m from the operating turbine array at Klipheuwel (Küyler 2004).

6.2 Interactions between solar energy facilities and birds

6.2.1 Habitat loss – destruction, disturbance and displacement

Perhaps the most significant potential impact on birds of any solar energy generation facility is the displacement or exclusion of threatened, rare, endemic or range-restricted species from critical areas of habitat. Given the considerable space requirements of commercially viable facilities (>50-100 ha), this effect could be significant in some instances, particularly given the possibility that the initial footprint of successful facilities may be expanded over time, and allowing for the possible cumulative effects of multiple facilities in one area.

To a lesser extent, construction and ongoing maintenance activities are likely to cause some disturbance of birds in the general surrounds of a solar facility, and especially of shy and/or ground-nesting species resident in the area. Mitigation of such effects requires that generic best-practice principles be rigorously applied - 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 kept to an absolute minimum.

6.2.2 Other effects

Concentrating solar power installations generate large amounts of heat, which may be sufficient to kill close overflying birds, depending on the particular design of the facility (Tsoutsos *et al.* 2005, Gunerhan *et al.* 2009). The proposed facility will however make use of PV panels, and is not a Concentrated Solar Power (CSP) system. Also, any vertical, reflective surfaces may confuse approaching birds with the result that numbers are killed in collisions with such surfaces. If either of these sources of unnatural mortality are a realistic expectation of a proposed solar installation, efforts should be made to restrict access by birds into the relevant, hazardous areas of the facility. Solar installations generally feature large areas of reflective paneling. It is possible that nearby or overflying birds may be disorientated by the reflected light, and consequently be displaced from an area more extensive than just the developed footprint of the facility.

Conversely, certain bird species may be attracted to the solar arrays. The possibility also exists that waterbirds will mistake the reflective surface for an expanse of water, and attempt to land on the panels, incurring injury and/or being disorientated in the process. Other species may seek to benefit from the installations, using the erected structures as prominent perches, sheltered roost sites or even nesting sites, and possibly foraging around the infrastructure in response to changes in the distribution of preferred foods (plants growing under the paneling, other animals attracted to the facility). Such scenarios might be associated with fouling of critical components in the solar array, bringing local bird populations into conflict with the facility operators. Under these circumstances, specialist advice should be sought in devising effective avian deterrents to minimize associated damage.

6.3 Impacts of associated infrastructure

Infrastructure commonly associated with wind energy facilities may also have detrimental effects on birds. The construction and maintenance of substations, power lines, servitudes and roadways causes both temporary and permanent habitat destruction and disturbance, and overhead power lines pose a collision and possibly an electrocution threat to certain species (Van Rooyen 2004a, Lehman *et al.* 2007, Jenkins *et al.* 2010).

Construction and maintenance of power line and substation

Some habitat destruction and alteration inevitably takes place during the construction of the power line, substation and associated access roads. Also, power line service roads or servitudes have to be cleared of excess vegetation at regular intervals in order to allow access to the line for maintenance, and to prevent vegetation from intruding into the legally prescribed clearance gaps between the ground and the conductors. These activities have an impact on birds breeding, foraging and roosting in or in close proximity to the servitude, and retention of cleared servitudes can have the effect of altering bird community structure along the length of any given power line (e.g. King & Byers 2002).

Collision with power lines

Power lines pose at least an equally significant collision risk to wind turbines, probably affecting the same suite of collision prone species (Bevanger 1994, 1995, 1998, Janss 2000b, Anderson 2001, van Rooyen 2004a, Drewitt & Langston 2008, Jenkins *et al.* 2010). Mitigation of this risk involves the informed selection of low impact alignments for new power lines relative to movements and concentrations of high risk species, and the use of either static or dynamic marking devices to make the lines, and in particular the earthwires, more conspicuous. While various marking devices have been used globally, many remain largely untested in terms of their efficacy in reducing collision incidence, and those that have been fully assessed have all been found to be only partially effective (Drewitt & Langston 2008, Jenkins *et al.* 2010).

Electrocution on power infrastructure

Avian electrocutions occur when a bird perches or attempts to perch on an electrical structure and causes an electrical short circuit by physically bridging the air gap between live components and/or live and earthed components (van Rooyen 2004b, Lehman *et al.* 2007). Electrocution risk is strongly influenced by the voltage and design of the power lines erected (generally occurring on lower voltage infrastructure where air gaps are relatively small), and mainly affects larger, perching species, such as vultures, eagles and storks, easily capable of spanning the spaces between energised components. Mitigation of electrocution risk involves the use of bird-safe structures (ideally with critical air gaps >2 m), the physical exclusion of birds from high risk areas of live infrastructure, and comprehensive insulation of such areas (van Rooyen 2004b, Lehman *et al.* 2007).

7. PROVISIONAL ASSESSMENT OF IMPACTS

Of the conservation priority, red-listed species, all are considered to be at some risk of colliding with the blades of the turbines or associated power lines, five species are considered to be at risk of electrocution on any bird-unfriendly power infrastructure associated with the renewable energy facility, and nine species are considered to be at risk of being disturbed and/or losing habitat during construction and possibly in the longer term (Table 1).

It is not possible at this stage to determine with confidence the relative significance of these various potential impacts, mainly because too little information is available on the relative abundance and movements of local populations of the implicated species (Table 1). The significance of impacts will be investigated in more detail during the EIA phase after spending some field time at the site.

The impact area of the REF may occasionally support significant populations of Ludwig's Bustard. This is a red-listed, near-endemic species, and is highly responsive to seasonal and inter-annual changes in environmental conditions in the Nama Karoo It is prone to relatively large-scale influxes into this region during or immediately after substantial rainfall events (Allan 1994, Hockey *et al.* 2005). The exact nature and pattern of these influxes is not well understood, and is therefore not easy to predict. Numbers and movements of other relevant and threatened species, e.g. Blue Crane, are also fundamentally but unpredictably affected by the timing and quantity of rainfall each year (Altwegg & Anderson 2009).

Collision with the turbine blades and power lines is potentially the most significant impact of the proposed development, and could negatively affect a variety of collision prone species, most notably individuals or loose flocks of Ludwig's Bustard and Blue Crane, and a suite of both diurnal and nocturnal predatory birds present in the area, especially Martial and Verreaux's Eagles, and possibly active pursuit hunters such as Peregrine Falcon and Lanner Falcon. Influxes or passages of wetland birds, especially Greater Flamingo, might be at risk of colliding with the turbine blades, or mistaking the banks of solar panels for expanses of water and injuring themselves in attempts to land on the panels. Locally resident large terrestrial birds and raptors may also be displaced from significant areas of foraging or breeding habitat by the action or noise of the turbines, or physically by the space occupied by the solar arrays.

At present, it is only possible to *speculate* on the biology and possible mitigation of the most likely risk factors (Table 2), an exercise which suggests that **collision mortality and displacement disturbance are possible, may well be significant, and will probably require considerable mitigation effort.**

8. CONCLUSIONS AND PLAN OF STUDY FOR EIA PHASE

The scoping phase has identified potential avifaunal issues associated with the proposed renewable energy facility and its associated infrastructure. These issues will be investigated in more detail during the full EIA phase. In particular, the significance of bird collisions with the turbines will be assessed in order to determine whether the risk warrants mitigation such as no-go areas for turbines or periodic shutting down of the wind turbines (as discussed above). This will be assessed mainly in terms of (i) the actual or estimated abundance of priority bird species in the area, and (ii) the distribution of relevant microhabitats and food resources, and the way in which the latter is likely to influence aggregation and movement of these birds through the impact zone of the proposed renewable energy facility.

Table 2. Provisional bird impacts matrix for the Karoo Renewable Energy Facility.

Impact	Cause	Affected taxa	Likeli-hood	Duration	Extent	Signifi-cance	Mitigation
Disturbance	Construction & maintenance	Bustards, cranes, raptors and smaller endemics	High	Short	Local	Low	Optimize timing and minimise duration of construction activity
	Operation - noise and movement	Foraging or nesting bustards and cranes, foraging or nesting raptors, endemic passerines	Moderate	Life of the facility	Local	*Cannot be specified at this stage*	Minimise noise output of facility?
Habitat loss: habitat destruction	Construction footprint (especially that of PV plant)	Ludwig's Bustard, Blue Korhaan, Blue Crane, Martial Eagle, endemic passerines	High	Life of the facility	Local	Low	Minimise construction footprint
Habitat loss: displacement	Operation - noise and movement	Foraging or nesting bustards and cranes, foraging or nesting raptors, endemic passerines	Moderate	Life of the facility?	Local	*Cannot be specified at this stage*	Minimise prominence in landscape and noise output
Mortality	Electrocution on associated infrastructure	Raptors	High	Life of the facility	Local	*Cannot be specified at this stage*	Use bird friendly hardware and power line designs
Mortality	Collision with turbine blades, power lines, and possibly with solar arrays	Commuting bustards and cranes, commuting or foraging raptors, commuting wetland species	Moderate	Life of the facility	Local	*Cannot be specified at this stage*	Turbine and power line siting, mark turbine blades/power lines, limit operational times or conditions, radar–sensitive management of turbine operation

The EIA phase will emphasise the outcome of the site visit, which in turn will include:

(i) Absolute or sample surveys of large terrestrial species, raptors and endemic passerines within the study area to determine the relative importance of local populations of these key taxa.

(ii) Estimates of the extent and direction of possible movements of these species within/through the anticipated impact zone of the renewable energy facility, in relation to the distribution of available resources – nesting or roosting sites (e.g. cliff-lines, wetlands, stands of trees, existing power lines) and foraging areas (e.g. wetlands, rocky screes and ridges).

(iii) Identification of the least sensitive/lowest risk areas to locate wind turbines within the broader study area, in terms of (i) and (ii) above.

The results will include a more detailed assessment of all impacts, recommended mitigation where necessary (particularly with reference to the siting of turbines) and, perhaps most importantly, a comprehensive, long-term programme for monitoring actual impacts from pre- to post-construction phases of the development, and improving our understanding of the long-term effects of wind energy developments on South African avifauna.

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APPENDIX 1. Annotated list of the bird species considered likely to occur within the impact zone of the proposed Karoo Renewable energy facility.

Common name	Scientific name	Conservation status	Regional endemism	Habitat				Risk of		
				Karoo veld	Drainage lines & alien trees	Cliffs, Screes and cuttings	Dams & ephemeral waterbodies	Collision	Electro-cution	Disturbance / habitat loss
Common Ostrich	*Struthio camelus*	-	-	X				-	-	High
Common Quail	*Coturnix coturnix*	-	-	X				-	-	High
Grey-winged Francolin	*Scleroptila africanus*	-	Endemic	X				Moderate	-	High
Helmeted Guineafowl	*Numida meleagris*	-	-		X			Moderate	-	High
White-faced Duck	*Dendrocygna viduata*	-	-				X	Moderate	-	-
Maccoa Duck	*Oxyura maccoa*	-	-				X	Moderate	-	-
Egyptian Goose	*Alopochen aegyptiaca*	-	-				X	High	High	-
South African Shelduck	*Tadorna cana*	-	Endemic				X	High	-	-
Spur-winged Goose	*Plectropterus gambensis*	-	-				X	High	Moderate	-
Cape Teal	*Anas capensis*	-	-				X	Moderate	-	-
African Black Duck	*Anas sparsa*	-	-				X	Moderate	-	-
Yellow-billed Duck	*Anas undulata*	-	-				X	Moderate	-	-
Cape Shoveler	*Anas smithii*	-	Endemic				X	Moderate	-	-
Red-billed Teal	*Anas erythrorhyncha*	-	-				X	Moderate	-	-
Southern Pochard	*Netta erythropthalma*	-	-				X	Moderate	-	-
Kurrichane Buttonquail	*Turnix sylvaticus*	-	-	X				-	-	High

Common name	Scientific name	Conservation status	Regional endemism	Habitat				Risk of		
				Karoo veld	Drainage lines & alien trees	Cliffs, Screes and cuttings	Dams & ephemeral waterbodies	Collision	Electro-cution	Disturbance / habitat loss
Greater Honeyguide	*Indicator indicator*	-	-		X			-	-	-
Lesser Honeyguide	*Indicator minor*	-	-		X			-	-	Moderate
Cardinal Woodpecker	*Dendropicos fuscescens*	-	-		X			-	-	Moderate
Acacia Pied Barbet	*Tricholaema leucomelas*	-	Near-endemic		X			-	-	Moderate
African Hoopoe	*Upupa africana*	-	-		X			-	-	Moderate
European Roller	*Coracias garrulus*	-	-	X	X			-	-	-
Malachite Kingfisher	*Alcedo cristata*	-	-				X	-	-	-
Pied Kingfisher	*Ceryle rudis*	-	-				X	-	-	-
Giant Kingfisher	*Megaceryle maximus*	-	-				X	-	-	-
Swallow-tailed Bee-eater	*Merops hirundineus*	-	-	X	X	X	X	-	-	Moderate
European Bee-eater	*Merops apiaster*	-	-					-	-	-
White-backed Mousebird	*Colius colius*	-	Endemic		X			-	-	Moderate
Red-faced Mousebird	*Urocolius indicus*	-	-		X			-	-	Moderate
Jacobin Cuckoo	*Clamator jacobinus*	-	-		X			-	-	Moderate
Diderick Cuckoo	*Chrysococcyx caprius*	-	-		X			-	-	Moderate
Alpine Swift	*Tachymarptis melba*	-	-					-	-	-

Common name	Scientific name	Conservation status	Regional endemism	Habitat				Risk of		
				Karoo veld	Drainage lines & alien trees	Cliffs, Screes and cuttings	Dams & ephemeral waterbodies	Collision	Electro-cution	Disturbance / habitat loss
Common Swift	*Apus apus*	-	-					-	-	-
African Black Swift	*Apus barbatus*	-	-			X		-	-	-
Little Swift	*Apus affinis*	-	-			X		-	-	-
White-rumped Swift	*Apus caffer*	-	-					-	-	-
Barn Owl	*Tyto alba*	-	-	X	X	X		-	Moderate	Moderate
Southern White-faced Scops-Owl	*Ptilopsis granti*	-	-		X			-	-	Moderate
Cape Eagle-Owl	*Bubo capensis*	-	-			X		-	High	Moderate
Spotted Eagle-Owl	*Bubo africanus*	-	-	X	X	X		-	High	Moderate
Fiery-necked Nightjar	*Caprimulgus pectoralis*	-	-	X	X			-	-	Moderate
Rufous-cheeked Nightjar	*Caprimulgus rufigena*	-	-	X				-	-	Moderate
Rock Dove	*Columba livia*	-	-			X		-	-	Moderate
Speckled Pigeon	*Columba guinea*	-	-			X		-	-	Moderate
Laughing Dove	*Streptopelia senegalensis*	-	-		X			-	-	Moderate
Cape Turtle-Dove	*Streptopelia capicola*	-	-		X			-	-	Moderate
Red-eyed Dove	*Streptopelia semitorquata*	-	-		X			-	-	Moderate
Namaqua Dove	*Oena capensis*	-	-	X	X			-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Habitat				Risk of		
				Karoo veld	Drainage lines & alien trees	Cliffs, Screes and cuttings	Dams & ephemeral waterbodies	Collision	Electro-cution	Disturbance / habitat loss
Ludwig's Bustard	*Neotis ludwigii*	Vulnerable	Near-endemic	X				High	-	Moderate
Kori Bustard	*Ardeotis kori*	Vulnerable	-	X				High	-	Moderate
Northern Black Korhaan	*Afrotis afraoides*	-	Endemic	X				Moderate	-	Moderate
Karoo Korhaan	*Eupodotis vigorsii*	-	Endemic	X				Moderate	-	Moderate
Blue Korhaan	*Eupodotis caerulescens*	Near-threatened	Endemic	X				Moderate	-	Moderate
Blue Crane	*Anthropoides paradiseus*	Vulnerable	Endemic	X			X	High	-	Moderate
Common Moorhen	*Gallinula chloropus*	-	-				X	-	-	-
Red-knobbed Coot	*Fulica cristata*	-	-				X	-	-	-
Namaqua Sandgrouse	*Pterocles namaqua*	-	Near-endemic	X			X	-	-	-
African Snipe	*Gallinago nigripennis*	-	-				X	-	-	-
Marsh Sandpiper	*Tringa stagnatilis*	-	-				X	-	-	-
Common Greenshank	*Tringa nebularia*	-	-				X	-	-	-
Wood Sandpiper	*Tringa glareola*	-	-				X	-	-	-
Common Sandpiper	*Actitis hypoleucos*	-	-				X	-	-	-
Little Stint	*Calidris minuta*	-	-				X	-	-	-
Curlew Sandpiper	*Calidris ferruginea*	-	-				X	-	-	-
Ruff	*Philomachus pugnax*	-	-				X	-	-	-

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				Karoo veld	Drainage lines & alien trees	Cliffs, Screes and cuttings	Dams & ephemeral waterbodies	Collision	Electro-cution	Disturbance / habitat loss
Spotted Thick-knee	*Burhinus capensis*	-	-	X	X			-	-	-
Black-winged Stilt	*Himantopus himantopus*	-	-				X	-	-	-
Pied Avocet	*Recurvirostra avosetta*	-	-				X	-	-	-
Kittlitz's Plover	*Charadrius pecuarius*	-	-				X	-	-	-
Three-banded Plover	*Charadrius tricollaris*	-	-				X	-	-	-
Blacksmith Lapwing	*Vanellus armatus*	-	-				X	-	-	-
Crowned Lapwing	*Vanellus coronatus*	-	-	X				-	-	-
Double-banded Courser	*Rhinoptilus africanus*	-	-	X				-	-	-
Burchell's Courser	*Cursorius rufus*	-	Near-endemic	X				-	-	-
Whiskered Tern	*Chlidonias hybrida*	-	-				X	-	-	-
White-winged Tern	*Chlidonias leucopterus*	-	-				X	-	-	-
Black-shouldered Kite	*Elanus caeruleus*	-	-	X	X			-	-	Moderate
Black Kite	*Milvus migrans*	-	-	X				-	-	-
African Fish-Eagle	*Haliaeetus vocifer*	-	-					-	High	-
Cape Vulture	*Gyps coprotheres*	Vulnerable	Endemic					High	High	-

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				Karoo veld	Drainage lines & alien trees	Cliffs, Screes and cuttings	Dams & ephemeral waterbodies	Collision	Electro-cution	Disturbance / habitat loss
Black-chested Snake-Eagle	*Circaetus pectoralis*	-	-					-	Moderate	Moderate
Black Harrier	*Circus maurus*	Near-threatened	Endemic	X			X	-	-	Moderate
African Harrier-Hawk	*Polyboroides typus*	-	-		X			-	-	Moderate
Southern Pale Chanting Goshawk	*Melierax canorus*	-	Near-endemic	X	X			-	Moderate	Moderate
Gabar Goshawk	*Melierax gabar*	-	-		X			-	-	Moderate
Rufous-chested Sparrowhawk	*Accipiter rufiventris*	-	-		X			-	-	Moderate
Steppe Buzzard	*Buteo vulpinus*	-	-	X				-	Moderate	Moderate
Jackal Buzzard	*Buteo rufofuscus*	-	Endemic	X				-	Moderate	Moderate
Tawny Eagle	*Aquila rapax*	Vulnerable	-		X			-	High	Moderate
Verreaux's Eagle	*Aquila verreauxii*	-	-					Moderate	High	Moderate
Booted Eagle	*Aquila pennatus*	-	-					-	-	Moderate
Martial Eagle	*Polemaetus bellicosus*	Vulnerable	-					Moderate	High	Moderate
Secretarybird	*Sagittarius serpentarius*	Near-threatened	-	X				High	-	Moderate
Lesser Kestrel	*Falco naumanni*	Vulnerable	-	X	X			Moderate	-	Moderate
Rock Kestrel	*Falco rupicolus*	-	-	X		X		-	-	Moderate
Greater Kestrel	*Falco rupicoloides*	-	-	X				-	-	Moderate

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Lanner Falcon	*Falco biarmicus*	Near-threatened	-	X				High	Moderate	-
Peregrine Falcon	*Falco peregrinus*	Near-threatened	-	X				High	Moderate	-
Little Grebe	*Tachybaptus ruficollis*	-	-				X	-	-	-
Black-necked Grebe	*Podiceps nigricollis*	-	-				X	-	-	-
African Darter	*Anhinga rufa*	-	-				X	-	-	-
Reed Cormorant	*Phalacrocorax africanus*	-	-				X	-	-	-
White-breasted Cormorant	*Phalacrocorax lucidus*	-	-				X	Moderate	-	-
Little Egret	*Egretta garzetta*	-	-				X	-	-	-
Grey Heron	*Ardea cinerea*	-	-				X	Moderate	Moderate	-
Black-headed Heron	*Ardea melanocephala*	-	-	X			X	Moderate	Moderate	-
Goliath Heron	*Ardea goliath*	-	-				X	High		
Cattle Egret	*Bubulcus ibis*	-	-				X	-	-	-
Hamerkop	*Scopus umbretta*	-	-				X	Moderate	-	-
Greater Flamingo	*Phoenicopterus ruber*	Near-threatened	-					High	-	-
Lesser Flamingo	*Phoenicopterus minor*	Near-threatened	-					High	-	-
Glossy Ibis	*Plegadis falcinella*	-	-				X	Moderate	-	-
Hadeda Ibis	*Bostrychia hagedash*	-	-		X			Moderate	-	-

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African Sacred Ibis	*Threskiornis aethiopicus*	-	-				X	Moderate	-	-
African Spoonbill	*Platalea alba*	-	-				X	Moderate	-	-
Black Stork	*Ciconia nigra*	Near-threatened	-				X	High	Moderate	-
Abdim's Stork	*Ciconia abdimii*	-	-				X	Moderate	Moderate	-
White Stork	*Ciconia ciconia*	-	-				X	High	High	-
Fork-tailed Drongo	*Dicrurus adsimilis*	-	-		X			-	-	Moderate
Bokmakierie	*Telophorus zeylonus*	-	Near-endemic		X			-	-	Moderate
Pririt Batis	*Batis pririt*	-	Near-endemic		X			-	-	Moderate
Cape Crow	*Corvus capensis*	-	-	X	X			-	-	Moderate
Pied Crow	*Corvus albus*	-	-	X	X	X		-	-	Moderate
White-necked Raven	*Corvus albicollis*	-	-	X		X		-	-	Moderate
Red-backed Shrike	*Lanius collurio*	-	-	X				-	-	Moderate
Lesser Grey Shrike	*Lanius minor*	-	-	X				-	-	Moderate
Common Fiscal	*Lanius collaris*	-	-	X	X			-	-	Moderate
Cape Penduline-Tit	*Anthoscopus minutus*	-	Near-endemic	X				-	-	Moderate
Ashy Tit	*Parus cinerascens*	-	Near-endemic	X				-	-	Moderate
Grey Tit	*Parus afer*	-	Endemic	X				-	-	Moderate

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Brown-throated Martin	*Riparia paludicola*	-	-				X	-	-	Moderate
Barn Swallow	*Hirundo rustica*	-	-				X	-	-	Moderate
White-throated Swallow	*Hirundo albigularis*	-	-				X	-	-	Moderate
Pearl-breasted Swallow	*Hirundo dimidiata*	-	-	X				-	-	Moderate
Greater Striped Swallow	*Hirundo cucullata*	-	-				X	-	-	Moderate
South African Cliff Swallow	*Hirundo spilodera*	-	Breeding endemic	X		X		-	-	Moderate
Rock Martin	*Hirundo fuligula*	-	-			X	X	-	-	Moderate
African Red-eyed Bulbul	*Pycnonotus nigricans*	-	Near-endemic		X			-	-	Moderate
Fairy Flycatcher	*Stenostira scita*	-	Endemic		X			-	-	Moderate
Long-billed Crombec	*Sylvietta rufescens*	-	-	X	X			-	-	Moderate
Yellow-bellied Eremomela	*Eremomela icteropygialis*	-	-	X	X			-	-	Moderate
Karoo Eremomela	*Eremomela gregalis*	-	Endemic	X				-	-	Moderate
African Reed-Warbler	*Acrocephalus baeticatus*	-	-				X	-	-	Moderate
Lesser Swamp-Warbler	*Acrocephalus gracilirostris*	-	-				X	-	-	Moderate

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Willow Warbler	*Phylloscopus trochilus*	-	-		X			-	-	Moderate
Layard's Tit-Babbler	*Parisoma layardi*	-	Endemic	X	X			-	-	Moderate
Chestnut-vented Tit-Babbler	*Parisoma subcaeruleum*	-	Near-endemic		X			-	-	Moderate
Orange River White-eye	*Zosterops pallidus*	-	Endemic		X			-	-	Moderate
Grey-backed Cisticola	*Cisticola subruficapilla*	-	Near-endemic	X	X			-	-	Moderate
Levaillant's Cisticola	*Cisticola tinniens*	-	-				X	-	-	Moderate
Neddicky	*Cisticola fulvicapilla*	-	-	X				-	-	Moderate
Zitting Cisticola	*Cisticola juncidis*	-	-				X	-	-	Moderate
Desert Cisticola	*Cisticola aridulus*	-	-				X	-	-	Moderate
Black-chested Prinia	*Prinia flavicans*	-	-		X			-	-	Moderate
Karoo Prinia	*Prinia maculosa*	-	Endemic	X	X			-	-	Moderate
Namaqua Warbler	*Phragmacia substriata*	-	Endemic		X			-	-	Moderate
Rufous-eared Warbler	*Malcorus pectoralis*	-	Endemic	X				-	-	Moderate
Cinnamon-breasted Warbler	*Euryptila subcinnamomea*	-	Endemic	X				-	-	Moderate
Eastern Clapper Lark	*Mirafra fasciolata*	-	Near-endemic	X				-	-	Moderate
Sabota Lark	*Calendulauda sabota*	-	-	X				-	-	Moderate

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Karoo Lark	*Calendulauda albescens*	-	Endemic	X				-	-	Moderate
Spike-heeled Lark	*Chersomanes albofasciata*	-	-	X				-	-	Moderate
Karoo Long-billed Lark	*Certhilauda subcoronata*	-	Endemic	X				-	-	Moderate
Black-eared Sparrowlark	*Eremopterix australis*	-	Endemic	X				-	-	Moderate
Grey-backed Sparrowlark	*Eremopterix verticalis*	-	Near-endemic	X				-	-	Moderate
Red-capped Lark	*Calandrella cinerea*	-	-	X				-	-	Moderate
Pink-billed Lark	*Spizocorys conirostris*	-	Near-endemic	X				-	-	Moderate
Large-billed Lark	*Galerida magnirostris*	-	Endemic	X				-	-	Moderate
Cape Rock Thrush	*Monticola rupestris*	-	Endemic	X				-	-	Moderate
Sentinel Rock Thrush	*Monticola explorator*	-	Endemic	X				-	-	Moderate
Short-toed Rock-Thrush	*Monticola brevipes*	-	Near-endemic			X		-	-	Moderate
Karoo Thrush	*Turdus smithi*	-	Endemic		X			-	-	Moderate
Chat Flycatcher	*Bradornis infuscatus*	-	Near-endemic	X				-	-	Moderate
Marico Flycatcher	*Bradornis mariquensis*	-	Near-endemic	X	X			-	-	Moderate
Fiscal Flycatcher	*Sigelus silens*	-	Endemic		X			-	-	Moderate
Spotted Flycatcher	*Muscicapa striata*	-	-		X			-	-	Moderate

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Cape Robin-Chat	*Cossypha caffra*	-	-		X			-	-	Moderate
Kalahari Scrub-Robin	*Cercotrichas paena*	-	Near-endemic	X	X			-	-	Moderate
Karoo Scrub-Robin	*Cercotrichas coryphoeus*	-	Endemic	X	X			-	-	Moderate
African Stonechat	*Saxicola torquatus*	-	-	X				-	-	Moderate
Mountain Wheatear	*Oenanthe monticola*	-	Near-endemic	X		X		-	-	Moderate
Capped Wheatear	*Oenanthe pileata*	-	-	X				-	-	Moderate
Sickle-winged Chat	*Cercomela sinuata*	-	Endemic	X				-	-	Moderate
Karoo Chat	*Cercomela schlegelii*	-	Near-endemic	X				-	-	Moderate
Tractrac Chat	*Cercomela tractrac*	-	Near-endemic	X				-	-	Moderate
Familiar Chat	*Cercomela familiaris*	-	-	X				-	-	Moderate
Ant-eating Chat	*Myrmecocichla formicivora*	-	Endemic	X				-	-	Moderate
Pale-winged Starling	*Onychognathus nabouroup*	-	Near-endemic			X		-	-	Moderate
Cape Glossy Starling	*Lamprotornis nitens*	-	-		X			-	-	Moderate
Pied Starling	*Spreo bicolor*	-	Endemic			X		-	-	Moderate
Wattled Starling	*Creatophora cinerea*	-	-	X	X			-	-	Moderate
Common Starling	*Sturnus vulgaris*	-	-		X	X		-	-	Moderate

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Malachite Sunbird	*Nectarinia famosa*	-	-		X			-	-	Moderate
Southern Double-collared Sunbird	*Cinnyris chalybeus*	-	Endemic		X			-	-	Moderate
Dusky Sunbird	*Cinnyris fuscus*	-	Near-endemic	X	X			-	-	Moderate
Scaly-feathered Finch	*Sporopipes squamifrons*	-	Near-endemic	X				-	-	Moderate
White-browed Sparrow-Weaver	*Plocepasser mahali*	-	-	X	X			-	-	Moderate
Cape Weaver	*Ploceus capensis*	-	Endemic		X		X	-	-	Moderate
Southern Masked-Weaver	*Ploceus velatus*	-	-		X		X	-	-	Moderate
Red-billed Quelea	*Quelea quelea*	-	-	X	X		X	-	-	Moderate
Southern Red Bishop	*Euplectes orix*	-	-				X	-	-	Moderate
African Quailfinch	*Ortygospiza atricollis*	-	-	X				-	-	Moderate
Red-headed Finch	*Amadina erythrocephala*	-	Near-endemic	X	X			-	-	Moderate
Common Waxbill	*Estrilda astrild*	-	-				X	-	-	Moderate
Red-billed Firefinch	*Lagonosticta senegala*	-	-		X			-	-	Moderate
Pin-tailed Whydah	*Vidua macroura*	-	-		X			-	-	Moderate

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House Sparrow	*Passer domesticus*	-	-		X			-	-	Moderate
Cape Sparrow	*Passer melanurus*	-	Near-endemic	X	X			-	-	Moderate
Southern Grey-headed Sparrow	*Passer diffusus*	-	-	X	X			-	-	Moderate
African Pied Wagtail	*Motacilla aguimp*	-	-				X	-	-	Moderate
Cape Wagtail	*Motacilla capensis*	-	-				X	-	-	Moderate
Cape Longclaw	*Macronyx capensis*	-	Endemic	X				-	-	Moderate
African Rock Pipit	*Anthus cinnamomeus*	-	Endemic	X				-	-	Moderate
Plain-backed Pipit	*Anthus leucophyrs*	-	-	X				-	-	Moderate
Buffy Pipit	*Anthus vaalensis*	-	-	X				-	-	Moderate
African Pipit	*Anthus cinnamomeus*	-	-			X		-	-	Moderate
Long-billed Pipit	*Anthus similis*	-	-	X				-	-	Moderate
Cape Canary	*Serinus canicollis*	-	Endemic	X				-	-	Moderate
Black-headed Canary	*Serinus alario*	-	Endemic	X				-	-	Moderate
Black-throated Canary	*Crithagra atrogularis*	-	-	X				-	-	Moderate
Yellow Canary	*Crithagra flaviventris*	-	Near-endemic	X				-	-	Moderate
White-throated Canary	*Crithagra albogularis*	-	Near-endemic	X				-	-	Moderate

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Lark-like Bunting	*Emberiza impetuani*	-	Near-endemic	X				-	-	Moderate
Cinnamon-breasted Bunting	*Emberiza tahapisi*	-	-	X				-	-	Moderate
Cape Bunting	*Emberiza capensis*	-	Near-endemic	X				-	-	Moderate