KAROO RENEWABLE ENERGY FACILITY

Avian impact assessment

AVISENSE CONSULTING

EXECUTIVE SUMMARY

This study contains an extensive review of relevant literature on wind energy impacts on birds, and identifies potential impacts of the proposed Karoo Renewable Energy Facility on the avifauna of the Victoria West area of the Western/Northern Cape, South Africa. These expected impacts are: habitat destruction by construction of the facility itself and any ancillary infrastructure, disturbance and possible displacement of sensitive species by the operation of the facility, and mortality in collision with the blades of the wind turbines, or in collision or electrocution incidents associated with ancillary infrastructure.

The impact zone of the proposed Renewable Energy Facility features ranched, grassy Karoo shrubland, with a major landscape features – 'Gys Roosberg' and 'The Horseshoe' – on the northern periphery, and a number of other areas of higher relief with stretches of quite high, vertical cliffs. Over 220 bird species, including 14 red-listed species, 70 endemics, and four red-listed endemics may occur in the broader area. The site falls on the eastern edge of the Platberg-Karoo Conservancy Important Bird Area, which supports critical or regionally significant populations of a number of potentially collision prone or otherwise sensitive species. The birds of greatest potential relevance and importance in terms of the possible impacts of the faclity are likely to be (i) raptors resident and nesting on the surrounding cliff-lines – particularly Verreaux's Eagle *Aquila verreauxii*, (ii) large terrestrial birds and raptors resident and breeding or foraging on, or commuting over, the Karoo flats – including Ludwig's Bustard *Neotis ludwigii* and Kori Bustard *Ardeotis kori*, Blue Korhaan *Eupodotis caerulescens*, Blue Crane *Anthropoides paradiseus*, Secretarybird *Sagittarius serpentarius*, Martial Eagle *Polemaetus bellicosus*, Tawny Eagle *Aquila rapax*, Black Harrier *Circus maurus*, Lesser Kestrel *Falco naumanni*, and populations of endemic passerines (including Cinnamon-breasted Warbler *Euryptila subcinnamomea* and African Rock Pipit *Anthus crenatus*).

The proposed Karoo Renewable Energy Facility is likely to have at least a moderate, long-term impact on the avifauna of the area, including negative effects on key rare, red-listed and/or endemic species. The main negative impact is likely to be on (i) the resident and breeding populations of at least six pairs of Verreaux's Eagle and two pairs of Martial Eagle, (ii) regular seasonal influxes of Ludwig's Bustard, and (iii) a resident population of Blue Crane. These birds are likely to be disturbed by construction of the REF, will lose foraging habitat (in terms of areas covered by the construction footprint of both the wind and the solar energy infrastructure, and by displacement from areas with operating turbines), and may suffer mortalities in collisions with the turbine blades and in collisions/electrocutions on the ancillary power infrastructure. These effects may be mitigated to some extent, but may have some detrimental impact even post-mitigation. An outline is provided for a comprehensive programme to fully monitor the actual impacts of the facility on the broader avifauna of the area, from pre-construction and into the operational phase. Strict adherence to this monitoring scheme, and strict compliance with mitigation stipulations arising from this monitoring, should be sufficient for the proposed development to proceed sustainably.

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 this environmental impact study, as supplied by Savannah Environmental (Pty) Ltd, were to provide:

- An indication of the methods used in determining the significance of potential impacts.
- A description of all the environmental issues (pertaining to birds) identified during the EIA process.
- An assessment of the significance of each of the identified direct, indirect and cumulative impacts, in terms of the expected nature, extent, duration, probability and severity of each, as well as in terms of the reversibility of impacts, and the degree to which each can be mitigated.
- A description and comparative assessment of alternatives in the development plan.
- Recommendations on practical mitigation of potentially significant negative impacts for inclusion in the Environmental Management Plan, with an indication of the expected efficacy of such mitigation measures.
- A description of any assumptions, uncertainties or knowledge gaps affecting this assessment.

- An environmental impact statement with a summary of key findings, an assessment of positive and negative implications of the proposed development, and a comparative assessment of identified alternatives.

3. STUDY METHODS

3.1. Approach

The initial scoping study, which forms the background to this report, 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.

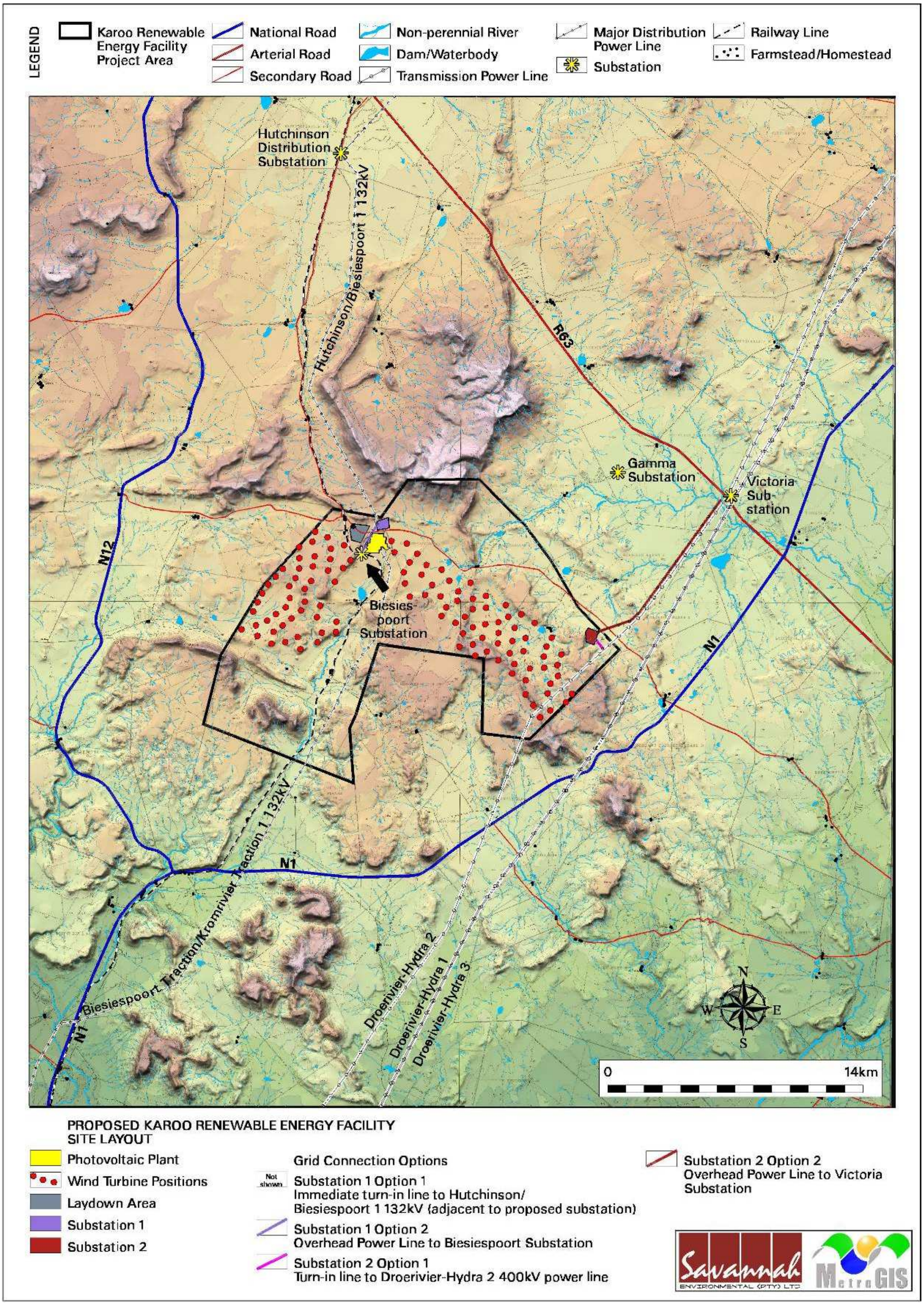


FIGURE 1. General location and layout of the proposed Karoo Renewable Energy Facility.

The present EIA report builds on the scoping study, with emphasis on the outcome of a site visit, made on 8-10 March 2011. While the scoping phase identified potential avifaunal issues associated with the proposed renewable energy facility and its possible associated infrastructure, the EIA investigates these issues in more detail and includes:

- Field 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.
- Refinement of the expected species and priority species lists based on (i), and compilation of SABAP 2 atlas lists for the pentads visited during the site visit.
- 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 (wetlands, stands of trees, existing power lines), foraging areas (croplands, wetlands), sources of list for slope soaring birds (ridge lines).
- Identification of any sensitive/high risk areas to locate wind turbines within the broader study area, in terms of (i) to (iii) above.
- Recommendations on mitigation where necessary (particularly with reference to the siting of turbines).
- 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.

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 – 15 cards submitted, 100 species recorded, 3123CB Bulberg – 10 cards, 80 species, 3123CC Three Sisters – 43 cards, 144 species, and 3123CD Tierhoek – 11 cards, 111 species) or pentads (SABAP 2: 3140_2305, 3140_2310, 3140_2315, 3145_2305, 3145_2310, 3145_2315 – no cards submitted yet for this area). 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), informed by a more recent revision for raptors (Jenkins 2008a), the most recent iteration of the global list of threatened species (http://www.iucnredlist.org), and the most recent and comprehensive summary of southern African bird biology (Hockey *et al.* 2005).

- Information on nesting raptors on the nearby Eskom 400 kV transmission lines from the Eskom Electric Eagle Project (Jenkins *et al.* 2007).
- Data from the Animal Demography Unit's Coordinated Avifaunal Roadcount project (CAR: http://car.adu.org.za/, Young *et al.* 2003), and Coordinated Waterbird Counts (CWAC: http://cwac.adu.org.za/, Taylor *et al.* 1999).
- Data from the Animal Demography Unit's Coordinated Avifaunal Roadcount project (CAR: http://car.adu.org.za/, Young *et al.* 2003).
- 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 (e.g. van Rooyen 2001a, Küyler 2004, Jenkins 2008b, 2009).

3.3. Limitations & assumptions

Any inaccuracies in the above sources of information could limit this study. The SABAP 1 data for this area are limited (only 79 atlas cards covering the whole area) and they are now >15 years old (Harrison *et al.* 1997), a problem that is compounded by the absence of any more recent, SABAP 2 data for the area. This deficiency was partially addressed by the short visit to the site.

Given that there are currently only three, very small wind energy facilities operational in South Africa (totaling only 8 turbines between them), practical experience of the environmental effects of wind energy facilities in this country is extremely limited, and we must base our estimates of the possible impacts of new facilities largely on lessons learned 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. BACKGROUND TO THE STUDY

4.1 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).

4.1.1 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/year, and nearly 3000 mortalities/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, in the first phase of a 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 the birds recorded per observation period 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 height, exponentially increasing collision risk (Drewitt & Langston 2006, 2008).

All other variables being equal, larger wind energy facilities, with more turbines, are more likely to incur significant numbers of bird casualties, simply because they present greater aggregate risk (Kingsley & Whittam 2005). Also, 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 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) and changing flood-lighting from white to red can reduce mortality rates by up to 80% (Weir 1976). A recent study found no significant difference in nocturnal collision rates by small passerines at unlit turbines *vs* turbines with regulation aviation safety lighting (small, flashing red lights) (Kerlinger *et al.* 2010).

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 a single collision incident).

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.

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

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 *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, 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 (Egyptian Vulture *Neophron percnopterus*) could theoretically cause its localised extinction (Carrete *et al.* 2009).

Mitigating collision risk

The only direct way to reduce the risk of birds colliding with turbine blades is to make the blades more conspicuous and hence easier to avoid. 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 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 rotors are marked in this way, 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 behavior, (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. Note that (i) each radar installation of this type has a maximum effective range of 10-15 km depending on topography, (ii) that maximum efficacy on any one site can only be achieved through trial and error, and a considerable amount of specialized analysis and software refinement, and (iii) that radar deployment is an expensive exercise, with each unit retailing at about ZAR 2.5-4.2 m.

4.1.2 Habitat loss – destruction, disturbance and displacement

Although the final, destructive footprint of most facilities of this nature 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), where the affected avifauna already have a degree of habituation to and tolerance of anthropogenic environmental change. Either way, displacement effects on birds by wind energy facilities are highly species-specific in operation.

4.2 Interactions between solar energy facilities and birds

4.2.1 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.

4.2.2 Other effects

Solar installations often feature large areas of reflective paneling. Any vertical, reflective surfaces may confuse approaching birds with the result that numbers are either disorientated and displaced from the area, or else killed in collisions with such surfaces, perhaps in some cases because they mistake them for expanses of open water. If such a scenario is 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 (Tsoutsos *et al.* 2005, Gunerhan *et al.* 2009).

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.

4.3 Impacts of associated infrastructure

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

4.3.1 Construction and maintenance of power lines and substations

Some habitat destruction and alteration inevitably takes place during the construction of power lines, substations and associated roadways. 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).

4.3.2 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 (both static and dynamic devices) have all been found to be only partially effective, and markedly less so for certain species (e.g. bustards) (Drewitt & Langston 2008, Jenkins *et al.* 2010).

4.3.3 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 hardware installed (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).

4.4. 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 (Fig. 1). The proposed facility will comprise 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 two small substations 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, a network of internal access roads, a workshop area for maintenance and storage, a lay-down area for large construction items, cabling between the project components, to be lain underground where practical, and two overhead power lines (132kV) connecting each of the two substations into the Eskom electricity network. There are two connection alternatives being considered at each substation, each comprising either very short lines connecting directly to the existing 132 or 400 kV transmission lines, or else longer lines running to the Biesiespoort and Victoria substations respectively (Fig. 1).

5. DESCRIPTION OF THE AFFECTED ENVIRONMENT

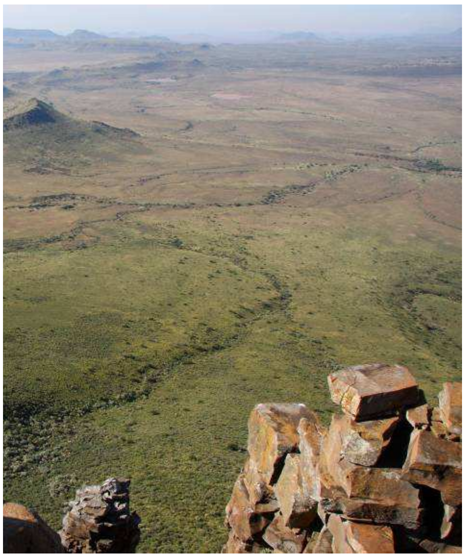
5.1 Vegetation of the study area

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

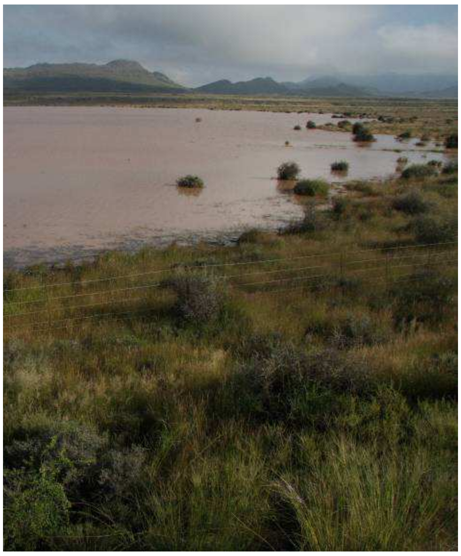
The area is presently used mainly for small stock (sheep) farming, with limited cultivation of crops, mostly confined to the immediate vicinity of occupied farmhouses. There are three farmsteads within the development area, and a liberal scattering of farm dams of varying sizes. The area is bounded by the R63 in the east, the N12 in the west, and the N1 to the south – all major arterial tarred roads (Fig. 1). In addition, each of the included properties has a network of gravel roads and smaller farm tracks. The western half of the proposed development area is traversed by the Eskom Biesiespoort-Kromrivier 132 kV power line, running more or less parallel with the railway line between Hutchinson and Three Sisters, and the three lines of the Eskom Droërivier-Hydra 400 kV transmission network cross the south-eastern boundary of the site.

The Victoria West area receives about 150 mm of rain annually, most of which falls in late summer (February-March). Temperatures range from a mean maximum in summer of about 30°C, to a mean minimum in winter of about 0.5°C. Altitude at the site averages about 1300-1400 m above sea level (a.s.l), rising to a maximum of >1800 m a.s.l. at the top of Gys Roosberg in the north. While the proposed development area is large, and the altitude range it encompasses considerable, the habitat on site from an avian perspective is relatively uniform, dominated by open, rocky, undulating or montane Karoo veld, with steep, rocky slopes, ridges and cliffs associated with the Horseshoe and its outlying koppies (Fig. 2a), denser, woody vegetation along the bigger drainage lines (and stands of alien trees) (Fig. 2b), and both natural and artificial wetlands - river courses, vleis and dams (Fig. 2c). The larger artificial impoundments in the area probably support good numbers of waterbirds in wet years, and the Eskom power pylons are used as roosting, hunting and/or nesting habitat by certain species (e.g. raptors and corvids).



IRE 2a. The
ern half of the
osed Karoo REF
lopment site from
op of Gys
berg, looking
n, showing the
of primary avian
tats present –
Karoo flats,
ded drainage lines,
rocky ridges.

IRE 2b. Karoo veld
ing into *Acacia*
dland along a
age line near
esfontein.



IRE 2c. The main
at Noblesfontein,
ually full after
nt heavy rain in
area.

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.*

Ninety-two species were seen during the March site visit (Appendix 1), including two sightings of pairs of Blue Crane, each with broods of two, well-developed young (both on Noblesfontein – Fig. 3), breeding pairs of both Martial Eagle and Verreaux's Eagle *Aquila verreauxii* on cliffs and/or power pylons within and on the near periphery of the proposed REF site (Fig. 3), and at least two sightings of small aggregations of Lesser Kestrel.

The cliffs of Gys Roosberg to the north and Skeurberg and its outliers in the south hold at least four, resident pairs of Verreaux's Eagles - Fig. 3; 31°41.576 S, 23°14.519 E; 31°48.620 S, 23°08.779 E; 31°46.572 S, 23°06.645 E; and 31°40.350 S, 23°11.360 E), with a further 3-4 pairs on the eastern half of the Horseshoe range. The same cliffs probably also support pairs of Rock Kestrel *Falco rupicolus* and Jackal Buzzard *Buteo rufofuscus*, and possibly hold 1-2 pairs each of Peregrine Falcon *Falco peregrinus* and/or Lanner Falcon *Falco biarmicus*, Booted Eagle *Aquila pennatus*, Black Stork *Ciconia nigra* and Cape Eagle Owl *Bubo capensis*.

In addition, two pairs of Martial Eagle (DRO-HYD 1 400 kV tower 394 - 31°49.200 S, 23°19.770 E, and on the Biesiespoort-Hutchinson 132 kV line at 31°36.761, 23°10.487), and two pairs of Verreaux's Eagle (DRO-HYD 2 400 kV tower 389 - 31°46.620 S, 23°19.667 E, and on the Biesiespoort-Kromrivier 132 kV line at 31°46.929 S, 23°11.280 E) nest on transmission pylons in the general area (Jenkins *et al.* 2007, Pers. obs). Also, there is a substantial Lesser Kestrel roost in Victoria West, about 30 km to the north of the site, which regularly holds up to 3000-4000 birds in summer (Barnes 1998, A.J. van Zyl pers. comm.), and which held in excess of 8000 of these globally threatened birds in March 2011 (Pers. obs), probably in response to exceptional rainfall in the area at this time.

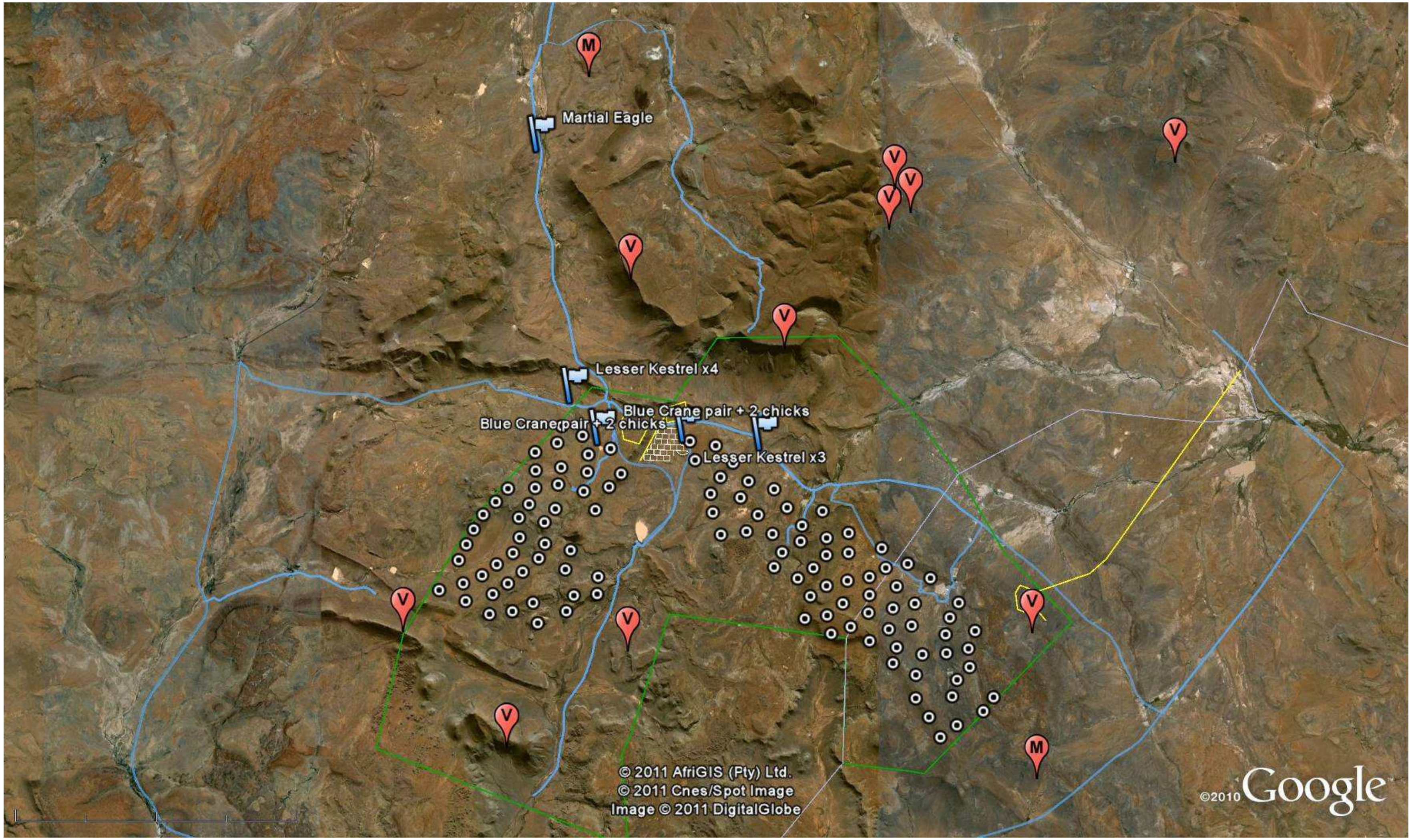


FIGURE 3. Survey route (blue line) and the distribution of significant sightings made at or in the near vicinity of the Karoo REF development site (green outline) during the March site visit. Large eagle nest sites found or known in the area are denoted by red balloons – "V" = Verreaux's Eagle, "M" = Martial Eagle.

Local endemics, such as Karoo Korhaan *Eupodotis vigorsii*, Eastern Clapper Lark *Mirafra fasciolata* and Rufous-eared Warbler *Malcorus pectoralis* were common on the plains, while African Rock Pipit *Anthus crenatus* was seen in the higher/more rocky areas. Ludwig's Bustard, Kori Bustard *Ardeotis kori*, Blue Korhaan, Black Harrier and Secretarybird *Sagittarius serpentarius* were not seen but must surely occur within the impact zone of the proposed development as the habitat is ideal. Likewise, Cinnamon-breasted Warbler *Euryptila subcinnamomea* was not seen in the boulder-strewn kloofs around the escarpment edges, but is highly likely to occur there.

On the basis of these observations, in combination with already documented information on the avifauna of the general area (e.g. Barnes 1998), seventeen priority species are recognized as key in the assessment of avian impacts of the proposed Karoo REF (Table 2). These are mostly nationally and/or globally threatened species which are known to occur, or could occur in relatively high numbers in the development area and which are likely to be, or could be, negatively affected by the REF project. Seven species – Cape Eagle Owl, Kori Bustard, Blue Korhaan, Tawny Eagle, Greater and Lesser Flamingo and Cinnamon-breasted Warbler were included despite the fact that they were not recorded in the SABAP 1 data for the area because the habitat on the site looks suitable and, in some cases, these birds have been recorded in the area by other formal surveys (e.g. Barnes 1998, Young *et al.* 2003). Cinnamon-breasted Warbler and African Rock Pipit are range-restricted endemics (Barnes 1998). Verreaux's Eagle and Cape Eagle Owl are not Red-listed (although see Jenkins 2008c) or endemic, but they are included because they are uncommon species and, with Martial Eagle, probably fulfill important ecological roles as apex predators in the area. Overall, the birds of greatest potential relevance and importance in terms of 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 Gys Roosberg, the Horseshoe and outliers to the south – particularly Verreaux's Eagle *Aquila verreauxii*, but including Peregrine Falcon *Falco peregrinus,* Lanner Falcon *Falco biarmicus*, Black Stork *Ciconia nigra*, and the scarce Cape Eagle Owl *Bubo capensis* (Jenkins 2008c), as well more abundant species such as Booted Eagle *Aquila pennatus*, Jackal Buzzard *Buteo rufofuscus*, and Rock Kestrel *Falco tinnunculus*.

(iii) Populations of endemic passerines (including Cinnamon-breasted Warbler *Euryptila subcinnamomea* and Rock Pipit *Anthus crenatus*).

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

Table 2. Priority bird species considered central to the avian impact assessment process for the Karoo Renewable Energy Facility, selected on the basis of South African (Barnes 2000) or global conservation status (www.iucnredlist.org or http://www.birdlife.org/datazone/species/), level of endemism, relative abundance on site (SABAP reporting rates, direct observation), and estimated conservation or ecological significance of the local population. Red-listed endemic species are shaded in grey.

Common name	Scientific name	SA conservation status/ (Global conservation status)	Regional endemism	Average reporting rate (*n* = 79 cards)	Estimated importance of local population	Preferred habitat	Risk posed by		
							Collision	Electro-cution	Disturbance / habitat loss
Cape Eagle Owl	*Bubo capensis*	-	-	0.0	Moderate	Cliffs and rocky ridges	Moderate	Moderate	Moderate
Ludwig's Bustard	*Neotis ludwigii*	Vulnerable (Endangered)	Near-endemic	41.8	High	Open Karoo	High	-	Moderate
Kori Bustard	*Ardeotis kori*	Vulnerable	-	0.0	Moderate	Open Karoo	High	-	Moderate
Blue Korhaan	*Eupodotis caerulescens*	Near-threatened	Endemic	0.0	High	Open Karoo	Moderate	-	Moderate
Blue Crane	*Anthropoides paradiseus*	Vulnerable (Vulnerable)	Endemic	34.2	High	Open Karoo, wetlands	High	-	Moderate
Black Harrier	*Circus maurus*	Near-threatened (Vulnerable)	Endemic	3.8	Moderate	Open Karoo	Moderate	-	Moderate
Verreaux's Eagle	*Aquila verreauxii*	-	-	36.7	High	Cliffs and rocky ridges	High	High	Moderate
Tawny Eagle	*Aquila rapax*	Vulnerable	-	0.0	Moderate	Open Karoo			
Martial Eagle	*Polemaetus bellicosus*	Vulnerable (Near-threatened)	-	16.5	High	Open Karoo	High	High	Moderate
Secretarybird	*Sagittarius serpentarius*	Near-threatened	-	32.9	Moderate	Open Karoo	High	-	Moderate
Peregrine Falcon	*Falco peregrinus*	Near-threatened	-	1.3	Low	Cliffs and rocky ridges	High	Moderate	-
Lanner Falcon	*Falco biarmicus*	Near-threatened	-	17.7	Low	Cliffs and rocky ridges	High	Moderate	-

Common name	Scientific name	SA conservation status/ (Global conservation status)	Regional endemism	Average reporting rate (*n* = 79 cards)	Estimated importance of local population	Preferred habitat	Risk posed by		
							Collision	**Electro-cution**	**Disturbance / habitat loss**
Lesser Kestrel	*Falco naumanni*	Vulnerable (Vulnerable)	-	6.3	Moderate	Open Karoo	Moderate	-	Moderate
Greater Flamingo	*Phoenicopterus ruber*	Near-threatened	-	0.0	Low	Wetlands, flying over	High	-	-
Black Stork	*Ciconia nigra*	Near-threatened	-	0.0	Low	Cliffs and rocky ridges, wetlands	High	Moderate	-
Cinnamon-breasted Warbler	*Euryptila subcinnamomea*	-	Endemic	0.0	Moderate	Rocky ridges	-	-	Moderate
African Rock Pipit	*Anthus crenatus*	-	Endemic	3.8	Moderate	Rocky ridges	-	-	Moderate

6. IMPACT ASSESSMENT

Impacts of the proposed REF are most likely to be manifest in the following ways:

(i) Disturbance and displacement of resident/breeding/visiting raptors (especially Verreaux's Eagle, Martial Eagle, Tawny Eagle, Secretarybird, Lesser Kestrel, and possibly Booted Eagle, Black Harrier, Peregrine Falcon and Lanner Falcon) from nesting and/or foraging areas by construction and/or operation of the facility, and /or mortality of these species in collisions with the turbine blades or associated new power lines while slope-soaring or hunting, or by electrocution when perched on power infrastructure.

(ii) Disturbance and displacement of seasonal influxes or resident populations of large terrestrial birds (especially Ludwig's Bustard and Blue Crane, but including Kori Bustard and Blue Korhaan) from nesting and/or foraging areas by construction and/or operation of the facility, and /or mortality of these species in collisions with the turbine blades or associated new power lines while commuting between resource areas (croplands, nest sites, roost sites/wetlands).

(iii) Disturbance and displacement of resident/breeding Karoo endemics – especially Cinnamon-breasted Warbler and African Rock Pipit on the higher-lying ridges fringing the study area by construction and/or operation of the facility.

(iv) Displacement of seasonal influxes of wetland birds from established flight lines in and out of resource areas either within or near to the development area, and/or mortality of these species in collisions with the turbine blades or associated new power lines.

Table 3. Assessment tables for construction impacts of the proposed Karoo Renewable Energy Facility on the local avifauna.

(A) Disturbance

Nature: Noise, movement and temporary occupation of habitat during the building process. Likely to impact all birds in the area to some extent, but sensitive, sedentary and/or habitat specific species will most adversely affected.

	Without mitigation	**With mitigation**
Extent	Medium (4)	Medium (4)
Duration	Short (1)	Short (1)
Magnitude	Medium-High (6)	Medium (5)
Probability	Definite (5)	Definite (5)
Significance	55 (Medium)	50 (Medium)
Status	Negative	Negative
Reversibility	Medium	Medium-High
Irreplaceable loss?	Possible	Probably not
Can impacts be mitigated?	Yes	

Mitigation: Abbreviating construction time, scheduling activities around avian breeding and/or movement schedules (timing to be determined after pre-construction monitoring), lowering levels of associated noise, and reducing the size of the inclusive development footprint.

Cumulative impacts: Likely, given that at least one other, large REF project is proposed for the adjacent property to the east.

Residual impacts: Some priority species may move away regardless of mitigation.

(B) Habitat loss

Nature: Destruction of habitat for priority species, either temporary – resulting from construction activities peripheral to the built area, or permanent - the area occupied by the completed development.

	Without mitigation	**With mitigation**
Extent	Medium (4)	Medium-Low (3)
Duration	Permanent (5)	Permanent (5)
Magnitude	Medium (4)	Medium (3)
Probability	Definite (5)	Definite (5)
Significance	65 (Medium-High)	55 (Medium)
Status	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss?	Possible	Possibly not
Can impacts be mitigated?	Yes	

Mitigation: Minimising habitat destruction caused by the construction of the facility by keeping the lay-down areas as small as possible, building as few temporary roads as possible, and reducing the final extent of developed area to a minimum.

Cumulative impacts: Yes, more renewable energy developments in the immediate area will increase habitat losses exponentially. At least one, large facility is proposed for neighbouring properties.

Residual impacts: Some species may be permanently lost to the area regardless of mitigation.

Table 4. Assessment tables for operational impacts of the proposed Karoo Renewable Energy Facility on the local avifauna.

(A) Disturbance

Nature: Noise and movement generated by operating turbines and maintenance activities associated with the turbines an/or the PV installation is sufficient to disturb priority species, causing displacement from the area, adjustments to commute routes with energetic costs, or otherwise affecting nesting success or foraging efficiency.

	Without mitigation	**With mitigation**
Extent	Medium (5)	Medium-Low (5)
Duration	Lifetime of the facility (4)	Lifetime of the facility (4)
Magnitude	Medium (7)	Medium (6)
Probability	Highly probable (4)	Highly probable (4)
Significance	64 (Medium-High)	60 (Medium)
Status	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss?	Possible	Possible
Can impacts be mitigated?	Slightly	

Mitigation: Abbreviating maintenance times, scheduling activities in relation to avian breeding and/or movement schedules (timing to be determined after pre-construction monitoring), and lowering levels of associated noise.

Cumulative impacts: Considerable potential, especially given that there is at least one large project proposed for the same general area.

Residual impacts: Some priority species may be permanently lost from the area.

(B) Mortality

Nature: Collision of priority species with the wind turbine blades, power lines, or electrocution of the same on new power infrastructure.

	Without mitigation	**With mitigation**
Extent	Medium (4)	Medium-Low (3)
Duration	Lifetime of the facility (4)	Lifetime of the facility (4)
Magnitude	High (8)	Medium-High (7)
Probability	Highly probable (4)	Probable (4)
Significance	64 (Medium-High)	56 (Medium)
Status	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss?	Yes	Possibly not
Can impacts be mitigated?	Yes	

Mitigation: Careful siting of turbines and PV array/s, painting turbine blades, bird friendly power hardware, monitoring priority bird movements and collisions, turbine management sensitive to these data – radar assisted if necessary.

Cumulative impacts: Yes, if more turbines, PV arrays and power lines are built in the same general area (which seems likely), more collision hot-spots are likely, and mortality rates may increase exponentially.

Residual impacts: Some casualties may be incurred regardless of mitigation.

Mitigation of these impacts will be best achieved in the following ways:

(i) On-site demarcation of 'no-go' areas identified during pre-construction monitoring (see below) to minimise disturbance impacts associated with the construction of the facility.

(ii) Minimizing the disturbance impacts associated with the operation of the facility by scheduling maintenance activities to avoid disturbances in sensitive areas (identified through operational monitoring).

(iii) Excluding development from:

(a) Within 500 m of any cliff lines or elevated ridges within the development area to reduce collision risk, primarily for slope soaring raptors.

(b) Within 1500 m of any known or suspected Verreaux's Eagle nest sites (Fig. 4) to reduce disturbance and collision risk for this species.

(c) Within 2500 m of any known or suspected Martial Eagle nest sites (Fig. 4) to reduce disturbance and collision risk for this species.

Note that these exclusion areas would probably only affect the location of substation 2 in the south-east, and possibly an outlying turbine placement in the south-west, both in order to distance these structures from Verreaux's Eagle sites (Fig. 4).

(iv) Painting one blade of each turbine black to maximize conspicuousness to oncoming birds. The evidence for this as an effective mitigation measure is not conclusive, but it is suggestive. It might be best to adopt an experimental approach to blade marking, identifying a sample of pairs of potentially high risk turbines in pre-construction monitoring, and marking the blades on one of each pair. Post-construction monitoring should allow empirical testing of efficacy, which would inform subsequent decisions about the need to mark blades more widely in this and other wind energy facilities.

(v) Ensuring that lighting on the turbines is kept to a minimum, and is coloured (red or green) and intermittent, rather than permanent and white, to reduce confusion effects for nocturnal migrants.

(vi) Minimizing the length of any new power lines installed, and ensuring that all new lines are marked with bird flight diverters (Jenkins *et al.* 2010), and that all new power infrastructure is adequately insulated and bird friendly in configuration (Lehman *et al.* 2007). Hence, the strongly preferred power line link options are the two short lines feeding directly into the nearby, existing transmission network (Fig.

1). Note that current understanding of power line collision risk in birds precludes any guarantee of successfully distinguishing high risk from medium or low risk sections of a new line (Jenkins *et al.* 2010). The relatively low cost of marking the entire length of a new line during construction, especially quite a short length of line in an area frequented by collision prone birds, more than offsets the risk of not marking the correct sections, causing unnecessary mortality of birds, and then incurring the much greater cost of retro-fitting the line post-construction. In situations where new lines run in parallel with existing, unmarked power lines, this approach has the added benefit of reducing the collision risk posed by the older line.

(vii) Carefully monitoring the local avifauna pre- and post-construction (see below), and implementing appropriate additional mitigation as and when significant changes are recorded in the number, distribution or breeding behaviour of any of the priority species listed in this report, or when collision or electrocution mortalities are recorded for any of the priority species listed in this report. An essential weakness of the EIA avifauna study, given the time constraints, is the dearth of knowledge about the actual movements of key species (bustards, cranes, eagles, other raptors, flamingo's, storks) through the impact area. Such knowledge must be generated as quickly and as accurately as possible in order for this and other wind energy proposals in the area to proceed in an environmentally sustainable way. Radar tracking systems, however expensive, may be the best and most practical solution to this problem.

(viii) Ensuring that the results of pre-construction monitoring are applied to project-specific impact mitigation in a way that allows for the potential cumulative effects on the local/regional avifauna of any other wind energy projects proposed for this area, including the proposed Karroo Renewable Energy Energy Facility proposed for properties to the south. Viewed in isolation, each of these projects may pose only a limited threat to the avifauna of the area. However, in combination they may result in the formation of significant barriers to energy-efficient travel between resource areas for regionally important bird populations, and/or significant levels of mortality in these populations in collisions with what may become a substantial array of many 100s of turbines (Masden *et al.* 2010).

(ix) Additional mitigation might include re-scheduling construction or maintenance activities on site, shutting down problem turbines either permanently or at certain times of year or in certain conditions, or installing a 'DeTect' or similar radar tracking system to monitor bird movements and institute temporary shut-downs as and when required.

(x) Committing this project for inclusion in a Birds & Wind Energy Specialist Group (BAWESG)/FitzPatrick Institute research programme, including exploration of the use of remote controlled gliders to map slope soaring potential of ridges targeted for wind energy development, and the long-term behavioural and demographic impacts of wind energy developments on Verreaux's Eagle populations.

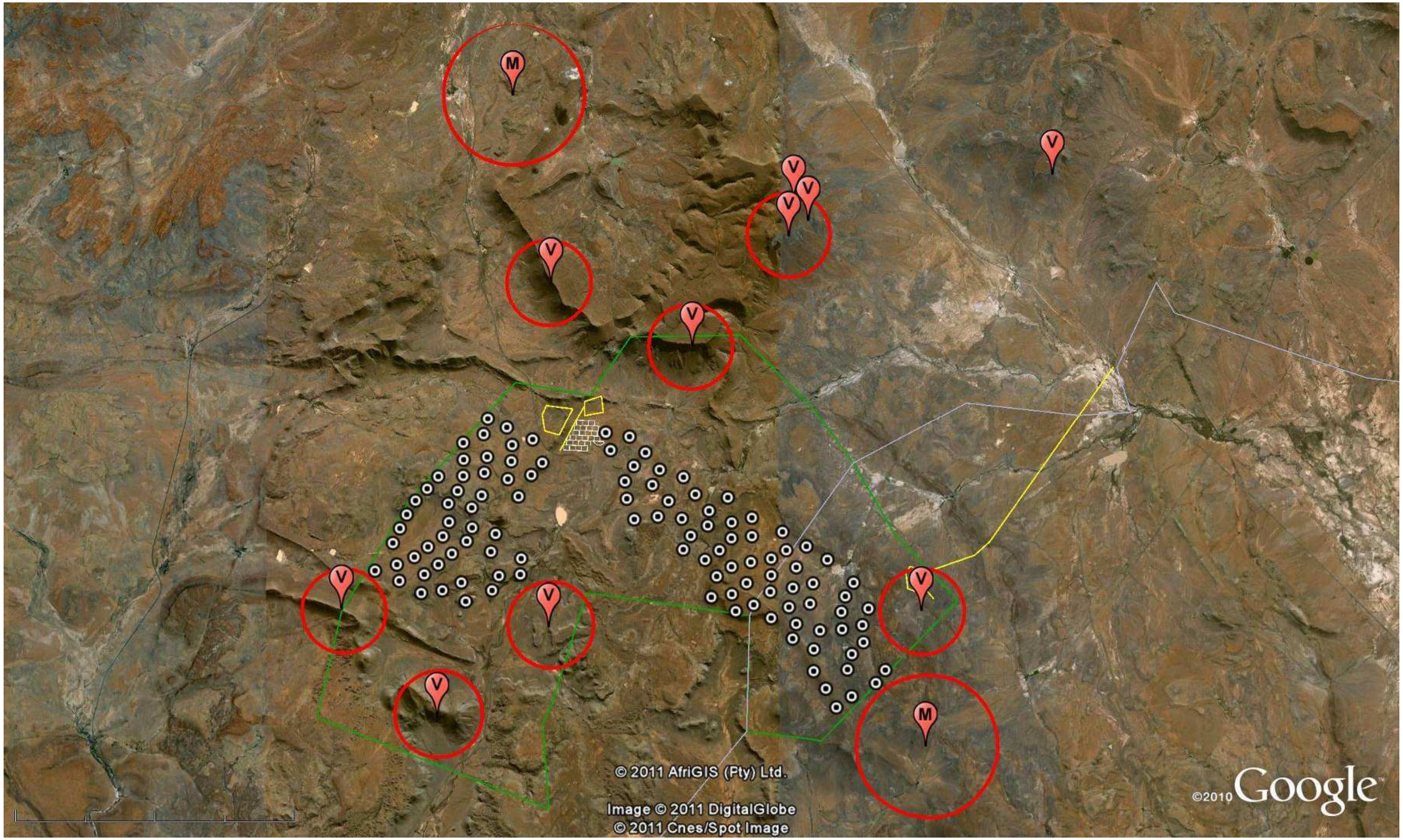


FIGURE 4. Development exclusion areas (red circles) around large eagle nest sites found or known in the vicinity of the proposed Karoo REF. "V" = Verreaux's Eagle, "M" = Martial Eagle.

AVISENSE CONSULTING

6.1 Impact statement

This proposal is for a large renewable energy installation, sited in an area on the fringes of a national Important Bird Area, known to support good populations of a number of threatened and/or endemic bird species, as well as high densities of other, ecologically valuable species. The proposed REF is likely to have a detrimental effect on these birds, during both the construction and operational phases of the development. The scale of the development renders these impacts potentially significant, and emphasises the need for full compliance with the stipulated mitigation and monitoring regimes.

The worst affected taxa are likely to be large raptors (Verreaux's and Martial Eagles) nesting on existing transmission pylons on the Karoo flats, or else on the cliffs of Gys Roosberg, the Horseshoe and some outlying ridge lines, and using these topographic features for slope soaring. The areas surrounding the locations or habitats most frequently used by these birds (known nesting areas, well defined ridge lines) should be considered as highly sensitive, and should be excluded from all development.

Another possible impact of the facility will be displacement effects on, and (in particular) collision mortality of Ludwig's Bustard and Blue Crane. The latter species is prone to erratic influxes to areas of the Karoo, apparently in response to past rainfall, but these factors are not well understood (Allan 1994). Compounding this unpredictability, recent studies of power line collisions by this bird (Jenkins *et al.* 2009, Jenkins *et al.* in prep.) have shown no detectable pattern in collisions in relation to landscape features. Hence, while bustards are likely to occur on the site in numbers, it is not possible to predict when such influxes are most likely to happen, or where these birds will be most susceptible to turbine collisions, precluding any useful input on where, and where not, to place turbines at this stage. Blue Cranes are almost equally collision prone (Jenkins *et al.* 2010, Shaw *et al.* 2010a). Pre- and post-construction monitoring will be vital to improve understanding of the risk posed by the REF on local bustards, and how best to mitigate this risk.

7. PROPOSED MONITORING PROGRAMME

The primary aims of a long-term monitoring programme would be to:

(i) Determine the densities of birds resident (especially large raptors, Blue Cranes, Ludwig's Bustards and Blue Korhaans) within the impact area of the renewable energy facility before construction of the facility, and afterwards, once the facility, or phases of the facility, become operational.

(ii) Document patterns of bird activity and movements in the vicinity of the proposed renewable energy facility before construction, and afterwards, once the facility is operational.

(iii) Identify sensitive and no-go areas for turbine placement to inform the final layout of the facility and the environmental management plan for both the construction and operational phases of the project.

(iv) Monitor patterns of bird activity and movement in relation to weather conditions, time of day and season for at least a full calendar year after the facility is commissioned.

(v) Register and as far as possible document the circumstances surrounding all avian collisions with the turbines for at least a full calendar year after the facility becomes operational.

Bird density and activity monitoring should focus particularly (but not exclusively) on rare and/or endemic, potentially disturbance or collision prone species, which occur with some regularity in the area (Table 2, Appendix 1). Ultimately, the study should provide much needed quantitative information on the effects of the facility on the distribution and abundance of birds, and the actual risk it poses to the local avifauna, and serve to inform and improve mitigation measures to reduce this risk. It will also establish a precedent and a template for research and monitoring of avian impacts at possible, future wind energy sites in the region. This programme outline is informed by monitoring studies established in other countries (e.g. Erickson *et al.* 1999, Scottish National Heritage 2005), but is based substantially on those developed for both the Darling and the Klipheuwel wind power demonstration facilities in South Africa (Jenkins 2003, Küyler 2004). The bulk of the work involved should be done by an expert ornithologist or under the supervision of such.

The protocols set out there pre-date the final drafting of the standard monitoring protocols for pre- and post-construction monitoring of birds at South African wind energy developments, as drawn up by the Birds & Wind Energy Specialist Group. Once the latter protocols have been finalised, they should supplement, and where necessary supercede, the measures stipulated here, as determined by the specialist advising the monitoring programme.

7.1 Monitoring protocols

7.1.1 Avian densities before and after

A set of at least 10 walk-transect routes, each of at least 1000 m in length, should be established in areas representative of all the avian habitats present within a 10 km radius of the centre of the development site. Each of these should be walked at least once every two-three months over at least 12 months immediately preceding construction, and with similar frequency over the same calendar period after the facility is commissioned. The transects should be walked after 06h00 and (ideally) before 09h00, and the species, number and perpendicular distance from the transect line of all birds seen should be recorded for subsequent analysis and comparison.

In addition, all major cliff-lines situated within or close to the development area (e.g. Gys Roosberg, Skeurberg) should be surveyed for cliff-nesting raptors at least once every six months using documented protocols (Malan 2009), all sightings of key species (Table 2) on site should carefully plotted and documented, and the major waterbodies/farm dams on and close to the development area should be surveyed for wetland species on each visit to the study area, using the standard protocols set out by the CWAC initiative (Taylor *et al.* 1999).

7.1.2 Bird activity monitoring

Monitoring of bird activity in the vicinity of the facility should be done over a 2-3 day period at least every two-three months for at least the 12 months preceding construction, and at least once per quarter for a full calendar year after the facility is commissioned. Each monitoring day should involve:

(i) Half-day counts of all priority species flying over or past the impact area (see passage rates below)

(ii) Opportunistic surveys of large terrestrial species and raptors seen when travelling around the site.

7.1.3 Passage rates of priority bird species

Counts of bird traffic over and around the proposed/operational facility should be conducted from suitable vantage points (and a number of these should be selected and used to provide coverage of avian flights in relation to all areas of the site), and extend alternately from before dawn to midday, or from midday to after dusk. This approach should provide an adequate (if minimal) sample of bird movements around the facility in relation to a representative cross-section of conditions and times of day, for all major variations in local conditions within the year.

Once in position at the selected count station, the observer should record (preferably on a specially designed data sheet) the date, count number, start-time and conditions at start - extent of cloud cover, temperature, wind velocity and visibility – and proceed with the count. The counts should detail all individuals or flocks of the stipulated priority bird species, all raptors, and any additional species of particular interest or conservation concern, seen flying within 500 m of the envisaged or actual periphery of the facility. Each record should include the following data: time, updated weather assessment, species, number, mode of flight (flapping, gliding, soaring), flight activity (commuting, hunting other), direction of flight, vertical zoning relative to the envisaged or actual turbine string (low – below or within the rotor arc, medium – within *c.*100 m of the upper rotor arc, high – >100 m above the upper rotor arc), and horizontal zoning relative to the envisaged or actual turbine string (near – through the turbine string or within the outer rotor arc, middle – within *c.*100 m of the outer rotor arc, distant - >100 m beyond the outer rotor arc) and, for post construction monitoring, notes on any obvious evasive behaviour or flight path changes observed in response to the renewable energy facility. The time and weather conditions should again be noted at the end of each count.

7.2 Avian collisions

Collision monitoring should have two components: (i) experimental assessment of search efficiency and scavenging rates of bird carcasses on the site, and (ii) regular searches of the vicinity of the wind farm for collision casualties.

7.2.1 Assessing search efficiency and scavenging rates

The value of surveying the area for collision victims only holds if some measure of the accuracy of the survey method is developed (Morrison 2002). To do this, a sample of suitable bird carcasses (of similar size and colour to the priority species – e.g. Egyptian Goose *Alopochen aegyptiacus*, domestic waterfowl and pigeons) should be obtained and distributed randomly around the site without the knowledge of the surveyor, some time before the site is surveyed. This process should be repeated opportunistically (as and when suitable bird carcasses become available) for the first two months of the monitoring period, with the total number of carcasses not less than 20. The proportion of the carcasses located in surveys will indicate the relative efficiency of the survey method.

Simultaneous to this process, the condition and presence of all the carcasses positioned on the site should be monitored throughout the initial two-month period, to determine the rates at which carcassess are scavenged from the area, or decay to the point that they are no longer obvious to the surveyor. This should provide an indication of scavenge rate that should inform subsequent survey work for collision victims, particularly in terms of the frequency of surveys required to maximise survey efficiency and/or the extent to which estimates of collision frequency should be adjusted to account for scavenge rate (Osborn *et al.* 2000, Morrison 2002). Scavenger numbers and activity in the area may vary seasonally so, ideally, scavenge and decomposition rates should be measured twice during the monitoring year, once in winter and once in summer.

7.2.2 Collision victim surveys

The area within a radius of at least 50 m of the outer rotor arc of each of the turbines at the facility should be checked regularly for bird casualties (Anderson *et al.* 1999, Morrison 2002). The frequency of these surveys should be informed by assessments of scavenge and decomposition rates conducted in the initial stages of the monitoring period (see above), but they should be done at least weekly for the first two months of the study. The area around each turbine, or a larger area encompassing the entire facility, should be divided into quadrants, and each should be carefully and methodically searched for any sign of a bird collision incident (carcasses, dismembered body parts, scattered feathers, injured birds). All suspected collision incidents should be comprehensively documented, detailing the precise location (preferably a GPS reading), date and time at which the evidence was found, and the site of the find should be photographed with all the evidence *in situ*. All physical evidence should then be collected, bagged and carefully labeled, and refrigerated or frozen to await further examination. If any injured birds are recovered, each should be contained in a suitably-sized cardboard box. The local conservation authority should be notified and requested to transport casualties to the nearest reputable veterinary clinic or wild animal/bird rehabilitation centre. In such cases, the immediate area of the recovery should be searched for evidence of impact with the turbine blades, and any such evidence should be fully documented (as above).

In tandem with surveys of the wind farm for collision casualties, sample sections of any new lengths of power line associated with the development should also be surveyed for collision victims using established protocols (see Jenkins *et al.* 2009, Jenkins *et al.* 2010, Shaw *et al.* 2010 a & b), as should the vicinity of the photovoltaic panels for signs of avian fatalities, and of impacts of the local avifauna on the condition of the solar power hardware.

7. INPUTS TO THE ENVIRONMENTAL MANAGEMENT PLAN

OBJECTIVE:	A renewable energy facility that is sustainable in terms of its impacts on local avifauna
Project components	Wind turbines Photovoltaic solar panels Access roads

	Substation linking the facility to the electricity grid Underground cabling Power lines
Activity/risk source	Starting pre-construction monitoring too late Appointment of unqualified personnel to do the monitoring Results of pre-construction monitoring not integrated into the final layout and/or the mitigation scheme Lack of clear communication between the scientist analysing the monitoring data and the client Misinterpretation of either the pre- or post-construction monitoring data
Mitigation: Target/Objective	The delivery of an effective impact mitigation scheme for the facility, informed initially by influence of pre-construction monitoring on final construction plans, and refined by post-construction monitoring of actual impacts, and resulting adjustments in management practices and mitigation measures applied

Mitigation: Action/control	**Responsibility**	**Timeframe**
Appoint advising scientist and agency to conduct pre- and post-construction monitoring	Client	As soon as possible / practical
Refine monitoring protocol and determine the extent of radar deployment required	Advising scientist, in negotiation with the client	As soon as possible / practical
Appoint radar technologists to service the project, and acquire/hire hardware, software and relevant expertise, IF radar use is approved	Advising scientist, in negotiation with the client	As soon as possible / practical
Start pre-construction monitoring	Monitoring agency	1 year before construction is due to start
Periodically collate an analyse pre-construction monitoring data	Advising scientist and radar specialist (if applicable)	Every 2-3 months of monitoring
Review report on the 6-12 months of pre-construction monitoring, and integrate findings into construction EMP and broader mitigation scheme	Advising scientist, monitoring agency and radar specialist (if applicable), in negotiation with the client	After a year of pre-construction monitoring
Ensure construction EMP is applied, with particular reference to minimising the temporary and permanent development footprint, and the extent and duration of noise and movement disturbance, and ensuring that stipulations re sensitive areas and times are adhered to.	Relevant Environmental Control Officer	During construction

Mitigation: Action/control	Responsibility	Timeframe
Refine post-construction monitoring protocol in terms of results pre-construction, and determine the extent of radar deployment required	Advising scientist, monitoring agency and radar specialist (if applicable), in negotiation with the client	As soon as possible / practical after construction completed
Start post-construction monitoring	Monitoring agency	Soon after construction is completed
Periodically collate and analyse post-construction monitoring data	Advising scientist and radar specialist (if applicable)	Every 2-3 months of monitoring
Review report on the full year of post-construction monitoring, and integrate findings into operational EMP and broader mitigation scheme	Advising scientist, monitoring agency and radar specialist (if applicable), in negotiation with the client	1 year post-construction
Review the need for further post-construction monitoring	Advising scientist, monitoring agency and radar specialist (if applicable), in negotiation with the client	1 year post-construction

Performance indicator	Regular provision of clearly worded, logical and objective information on the interface between the local avifauna and the proposed/operating renewable energy facility Clear and logical recommendations on why, how and when to institute mitigation measures to reduce avian impacts of the development, from pre-construction to operational phase Quantifiable reductions in avian impacts once the facility is operational
Monitoring	3-monthly and annual reports produced by the scientist advising the monitoring project

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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. Species seen during the March site visit appear in **bold**.

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 Swift	*Apus apus*	-	-					-	-	-
African Black Swift	*Apus barbatus*	-	-			X		-	-	-

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				Karoo veld	Drainage lines & alien trees	Cliffs, Screes and cuttings	Dams & ephemeral waterbodies	Collision	Electro-cution	Disturbance / habitat loss
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**
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**

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				Karoo veld	Drainage lines & alien trees	Cliffs, Screes and cuttings	Dams & ephemeral waterbodies	Collision	Electro-cution	Disturbance / habitat loss
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	-	-	-
Spotted Thick-knee	***Burhinus capensis***	**-**	**-**	**X**	**X**			**-**	**-**	**-**
Black-winged Stilt	***Himantopus himantopus***	**-**	**-**				**X**	**-**	**-**	**-**
Pied Avocet	*Recurvirostra avosetta*	-	-				X	-	-	-
Kittlitz's Plover	*Charadrius pecuarius*	-	-				X	-	-	-

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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	High	-
Cape Vulture	*Gyps coprotheres*	Vulnerable	Endemic					High	High	-
Black-chested Snake-Eagle	*Circaetus pectoralis*	-	-					High	Moderate	Moderate
Brown Snake-Eagle	***Circaetus cinereus***	**-**	**-**	**X**	**X**			**Moderate**		
Black Harrier	*Circus maurus*	Near-threatened	Endemic	X			X	Moderate	-	Moderate
African Harrier-Hawk	*Polyboroides typus*	-	-		X			Moderate	-	Moderate
Southern Pale Chanting Goshawk	***Melierax canorus***	**-**	**Near-endemic**	**X**	**X**			**Moderate**	**Moderate**	**Moderate**
Gabar Goshawk	*Melierax gabar*	-	-		X			-	-	Moderate
Rufous-chested Sparrowhawk	*Accipiter rufiventris*	-	-		X			-	-	Moderate

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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**
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**	**-**

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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**	**-**	**-**
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**

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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**
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

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				Karoo veld	Drainage lines & alien trees	Cliffs, Screes and cuttings	Dams & ephemeral waterbodies	Collision	Electro-cution	Disturbance / habitat loss
Karoo Eremomela	*Eremomela gregalis*	-	Endemic	X				-	-	Moderate
African Reed-Warbler	*Acrocephalus baeticatus*	-	-				X	-	-	Moderate
Lesser Swamp-Warbler	*Acrocephalus gracilirostris*	-	-				X	-	-	Moderate
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**

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Cinnamon-breasted Warbler	*Euryptila subcinnamomea*	-	Endemic	X				-	-	Moderate
Eastern Clapper Lark	***Mirafra fasciolata***	**-**	**Near-endemic**	**X**				**-**	**-**	**Moderate**
Sabota Lark	***Calendulauda sabota***	**-**	**-**	**X**				**-**	**-**	**Moderate**
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**

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Marico Flycatcher	*Bradornis mariquensis*	-	Near-endemic	X	X			-	-	Moderate
Fiscal Flycatcher	*Sigelus silens*	-	Endemic		X			-	-	Moderate
Spotted Flycatcher	*Muscicapa striata*	-	-		X			-	-	Moderate
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**
Red-winged Starling	***Onychognathus morio***	**-**	**-**	**X**		**X**		**-**	**-**	**-**

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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
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**

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**
Red-billed Firefinch	*Lagonosticta senegala*	-	-		X			-	-	Moderate
Pin-tailed Whydah	***Vidua macroura***	**-**	**-**		**X**			**-**	**-**	**Moderate**
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**

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