

PERDEKRAAL WIND ENERGY AREA



Avian impact risk assessment and mitigation scheme

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Summary

The Perdekraal Wind Energy Area includes two proposed medium-large wind farm developments (up to 62 turbines in each). The natural environment potentially affected by these two wind farms supports a moderate diversity of birds, including populations of a rare and/or threatened species. The present monitoring study was conducted after the issuing of an environmental authorisation for the aggregate project area, with the primary objective of refining the findings of the original avian impact assessment, chiefly by (i) generating a quantified and spatially explicit understanding of the avifauna present on and around the proposed development site, (ii) identifying any definable flight lines and/or key resource areas used routinely by birds in the area, and (iii) using the outcomes of (i) and (ii) to draw up a more informed assessment of likely impacts of the project, and a more explicit set of recommendations to manage and mitigate these impacts. The study was designed and conducted explicitly in terms of the BirdLife South Africa / Endangered Wildlife Trust guidelines for bird monitoring at proposed wind farm sites in South Africa. Teams of two observers visited the study area for 5-8 days at a time on four occasions spread over a 12-month monitoring period from February to November 2012, accumulating 50 person-days on site, and amassing 939 sightings describing the location, behavior and movements of 2186 individual birds of 88 species. The broader study included the collection of comparable data from a nearby and similar control or reference area in order to establish a benchmark against which to measure the actual impacts of the two wind energy projects post-construction.

Walked transect data revealed that the small terrestrial bird populations of the study area and the control site were comparable. Driven transect data also showed that the study area and the control supported similarly low densities of large terrestrial birds and raptors. Wetland counts were generally low, reflecting a prevailing lack of rainfall in the area over the study period.

Over 180 hrs of vantage point watches of bird movements were accumulated in the study area and control area combined, yielding broadly comparable average passage rates of flying birds (4.40 birds.hr⁻¹ in the study area, 2.80 birds.hr⁻¹ in the control). A short-list of red-listed and/or endemic and/or ecologically significant priority species made up <8% of the vantage point records obtained from the study area. Rough estimates of annual turbine collision rates at Perdekraal include a figure of <1700 birds overall (inflated by relatively large numbers of Barn Swallows *Hirundo rustica* observed during vantage point counts), but <30 casualties annually of priority species (including up to three Martial Eagles *Polemaetus bellicosus* and 15 Lanner Falcons *Falco biarmicus*). Given a general lack of predictability in observed distributions and movements of birds at the site, there is no anticipated benefit in adjusting the current project layout. However, careful management of nest site availability for a locally resident pair of Lanner Falcons may be necessary to ensure that impacts on these birds are minimized. Similarly, comprehensive post-construction monitoring, and a preparedness to make meaningful changes to the project in the event that high levels of displacement or mortality are detected, will be a requisite for ensured sustainability of the proposed wind farms.

Introduction

Wind farming offers a renewable means to generate much-needed electricity, but must be practiced responsibly in order to achieve its stated objective of environmental sustainability (Drewitt & Langston 2006, 2008, Kuvlevsky *et al.* 2007). One potential downside of populating landscapes with wind turbines is the effect that these structures have on the surrounding bird life. Documented impacts have included (i) disturbance of resident, breeding birds associated with the construction of the wind farm, and also the appearance and sound of the operational plant, which may depress feeding rates and breeding success at local nests, (ii) habitat loss to the construction footprint of the wind farm, and even broader scale displacement of resident populations or preferred flight-lines from turbine-occupied areas, and (iii) injury or mortality of birds flying through or resident in the development area, in collisions with turbine blades or associated power lines, or in electrocutions on live power infrastructure (Drewitt & Langston 2006, Lehman *et al.* 2007, Jenkins *et al.* 2010).

Studies of wind energy facility (WEF) impacts on birds done in North America and Western Europe have shown that the nature and severity of such impacts can be highly site- and taxon-specific, but simultaneously very difficult to predict (Drewitt & Langston 2006, Smallwood *et al.* 2009, Ferrer *et al.* 2012.). Poorly sited wind farms, or just one or two badly-placed turbines within a much bigger array, can have a significant detrimental effect on birds at the population level, and even threaten the regional, national or global conservation status of particularly impact susceptible species (e.g. Carrete *et al.* 2009). Hence, while wind energy development may offer an environmentally preferable alternative to many other sources of power generation, it is essential that the interface between a proposed wind farm and the avifauna of its receiving area is well understood before the project goes to construction.

Effective mitigation of potentially negative effects on birds of a proposed wind farm requires (i) the generation of spatially explicit information on the numbers and movements of key species within and around the development area, (ii) interpretation of these data to determine the optimal layout and management strategy for the wind farm to minimise bird impacts, and (iii) careful and responsible implementation of the recommendations stemming from this analysis (Kuvlevsky *et al.* 2007, Smallwood & Thelander 2008). Adherence to this three-step approach should reduce construction and operational phase impacts to tolerable and sustainable levels, especially if every effort is made to monitor impacts throughout the development process, adapting the impact mitigation scheme as required.

Clearly, the earlier that bird impact issues are addressed in the schedule of a wind farm project, the less the risk to both the environment and the developer. Ideally, avian issues should be addressed at the screening or site-selection phase of the process, with strategic reference to broad scale maps of avian sensitivity to wind farm impacts (e.g. Bright *et al.* 2005, Retief *et al.* 2012). Following this, active collection of data describing the avifauna of a selected site should be completed before the Environmental Impact Assessment (EIA) is done, and the results of such monitoring should inform the findings of the avian component of the resulting report (Jenkins *et al.* 2010). In this instance, the avian component of the EIA report and the issuing of an Environmental Authorisation (EA) preceded the start of monitoring, and the findings of the present pre-construction monitoring report are intended to

ensure that the final layout of the built project, and the mitigation plans put in place, are sufficient to keep bird impacts to a sustainable minimum.

The Perdekraal Wind Energy Area includes two medium-large wind farm projects, proposed for a site with some potentially conflicting issues in terms of its avifauna. The combined development area includes various portions of the farms Perdekraal (Lower Stinkfontein 245) and Rietpoort (Rietpoort 243), about 25 km north-east of Touwsrivier (Fig. 1). The two facilities will be spread over an area of about 60 km², and include up to 124 wind turbines (Fig. 2). Each of the turbines will stand up to 120 m high at hub-height, with a rotor diameter of up to 120 m, a rotor sweep extending to a maximum height of about 180 m, and a rotor swept area of up to about 11300 m². The facilities will also include at least one on-site substation each, at least 7 km of power line linking the sites with the national grid (these will run parallel with and in the same servitude as the existing Bachus-Droërivier 400 kV transmission line), a workshop, and a network of access and service roads.

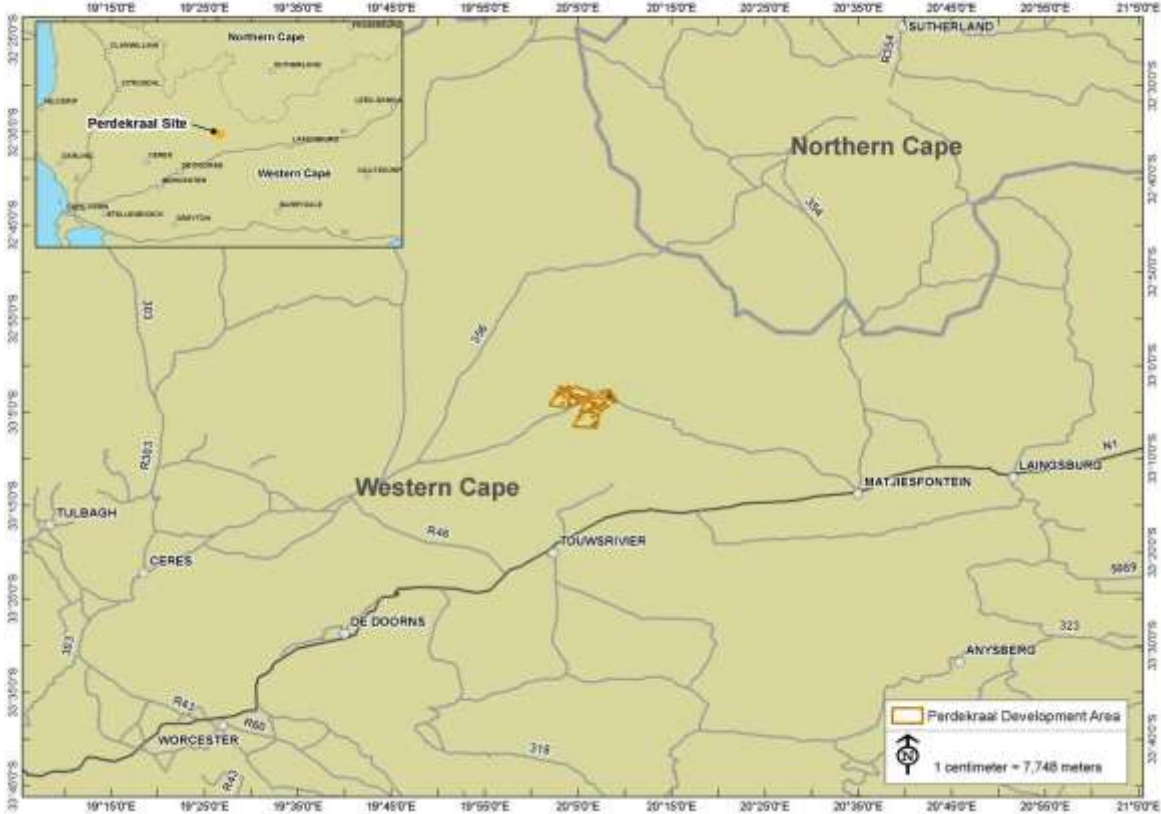


Figure 1. General location of the proposed Perdekraal Wind Energy Area.

The inclusive development area does not impinge significantly on any unique landscape features, or on any known, important bird fly-ways, but it is likely to affect populations of regionally or nationally threatened (and impact susceptible) bird species which may occur within or close to the proposed turbine arrays. The two facilities will probably have a detrimental impact on these birds, particularly during its operational phase, unless commitment is made to mitigating these effects.

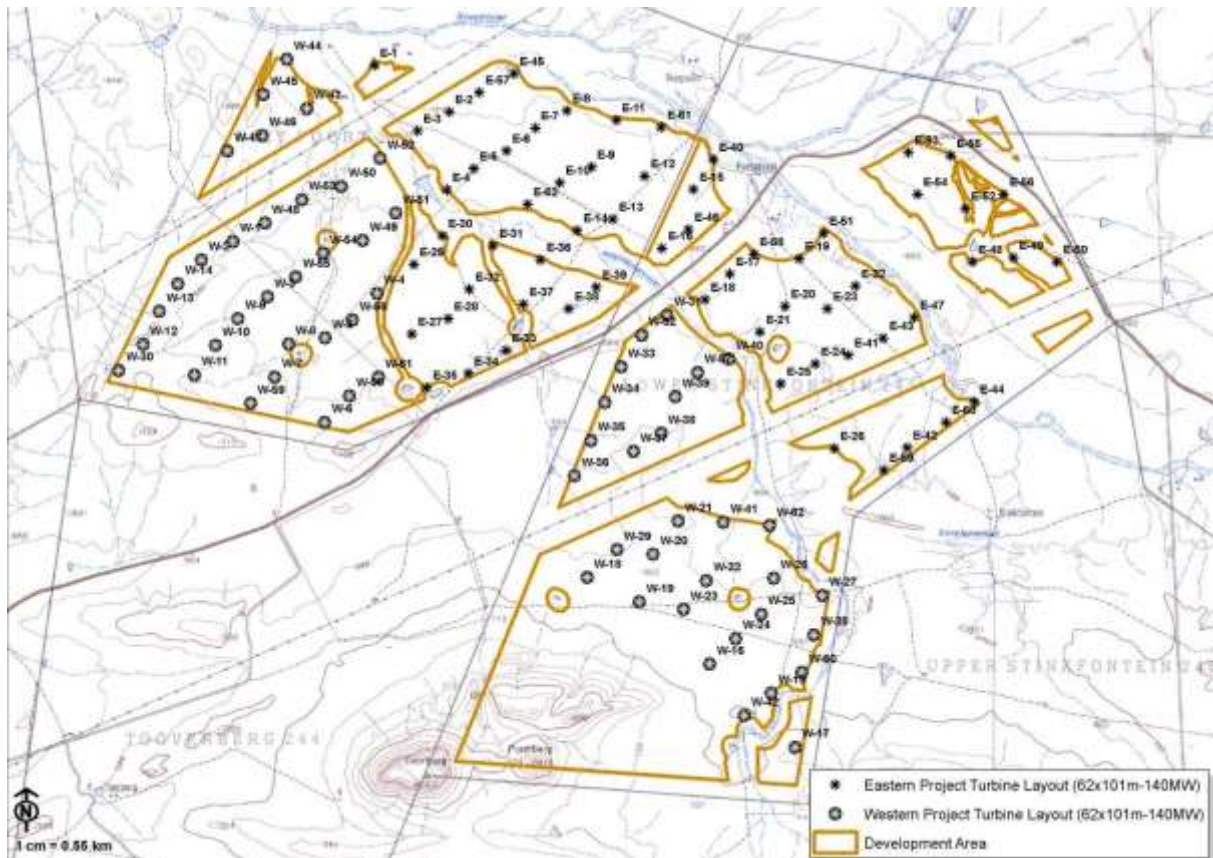


Figure 2. Layouts of the two proposed Perdekraal wind energy facilities.

The Avian Impact Assessment Report for the Perdekraal Wind Energy Facility (Jenkins 2010), which addressed the impacts of development across the entire project area, identified the following groups and species of birds as particularly relevant, in terms of their regional, national or global conservation importance, their known or suspected presence within the development area, and their relative susceptibility to the possible negative impacts of the wind energy facility:

- (i) Seasonal influxes of Ludwig’s Bustard. This is a nomadic, nationally ‘Vulnerable’ and globally ‘Endangered’, near-endemic species, highly susceptible to collision mortality on power lines (Jenkins *et al.* 2010), probably susceptible to turbine collision mortality, and possibly susceptible to disturbance and displacement by the wind farm.
- (ii) Resident and breeding raptors, in particular Martial Eagle (three pairs just outside the development area), Black Harrier (likely to occur regularly on site, and could breed within it in wet years – Curtis *et al.* 2004). Both are threatened species, the latter is endemic, and both are potentially susceptible to collision with and displacement from the area by the turbine arrays.
- (iii) Populations of Karoo endemics (e.g. Cinnamon-breasted Warbler, Black-eared Sparrowlark) which lose some habitat, and may be disturbed or displaced.

Methods

Study area

The proposed wind energy area is located in the Succulent Karoo biome, and more specifically, in the Rainshadow Valley Karoo bioregion (Mucina & Rutherford 2006). The natural vegetation is dominated by Tanqua Karoo (sparse, low shrublands on undulating basin plains, with medium-tall succulents on scattered koppies and ridges), Tanqua Wash Riviere (a mosaic of succulent shrubland and *Acacia karoo* gallery thickets) along the bed of the Groot River along the north-east edge of the site (Mucina & Rutherford 2006). The area is situated south-east of the Groot River, and just north-east of a fairly prominent koppie feature (Toorberg/Pramberg), so includes more topographic relief and is more densely vegetated than is typical of the Tanqua Karoo generally. Altitude averages about 660 m above sea level, rising to >900 m a.s.l. at Toorberg (Figs 2 & 3). The climate in the Tanqua Karoo features spatially variable rainfall (70->110 mm), falling mostly in winter, with mean winter minimum and summer maximum temperatures of 6°C and 40°C respectively (Mucina & Rutherford 2006).

The area is presently used mainly for small stock (sheep) farming, with very limited cultivation of crops along the river washes. There are two farmsteads – Perdekraal and Rietpoort - and a scattering of small farm dams, with one large, shallow impoundment in the centre of Rietpoort. The area is crossed by a minor gravel road which connects Matjiesfontein with Karoopoort, and Eskom's Droërivier-Muldersvlei and Bachus-Droërivier 400 kV transmission lines (Fig. 2). The habitat on site is relatively uniform, dominated by open Tanqua Karoo, with rocky ridges associated with the Toorberg and Pramberg outcrops in the south, and *Acacia* woodland along the course of the Groot River.

Artificial impoundments in the area, in particular the large dam on Rietpoort, 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). The Roosterberge, situated 8-10 km to the north of the wind farm site, feature some quite high cliff-lines, which probably support a community of cliff-nesting raptor species. The southern edge of the Cedarberg-Koue Bokkeveld Complex – a national Important Bird Area (Barnes 1998) - is located about 30 km to the north-west of the study area, while Verkeerdevlei, a locally important habitat for wetland birds, is situated about 30 km to the south-west (Taylor *et al.* 1999, <http://cwac.adu.org.za/>).

More than 200 bird species could possibly occur on the site (Appendix 1), including up to 12 red-listed species, 68 endemics or near-endemics, and three red-listed endemics (Ludwig's Bustard *Neotis ludwigii*, Blue Crane *Anthropoides paradiseus* and Black Harrier *Circus maurus*). The extensive tracts of open Tanqua Karoo on the site are likely to attract numbers of Ludwig's Bustard as seasonal visitors, and Black Harrier probably uses this habitat too, at least as a late summer/autumn visitor, and both these species could breed in the area after good rains (Allan 1994, Curtis *et al.* 2004). Limited areas of exposed rock on the Toorberg probably are not sufficient to support cliff-nesting raptors other than perhaps Cape Eagle Owl *Bubo capensis* and Rock Kestrel *Falco rupicolus*. However, Jackal Buzzard *Buteo rufofuscus*, Verreaux's Eagle *Aquila verreauxii*, Booted Eagle *Aquila pennatus*, Lanner Falcon *Falco biarmicus* and Peregrine Falcon *Falco peregrinus* may well to forage within the wind farm site from nesting areas in the mountains <10 km to the south and north. Additional important

restricted range and/or endemic species which are likely to occur in the area include Karoo Korhaan *Eupodotis vigorsii*, Cinnamon-breasted Warbler *Euryptila subcinnamomea*, Karoo Long-billed Lark *Certhilauda subcoronata*, Karoo Lark *Calendulauda albescens*, Black-eared Sparrowlark *Eremopterix australis*, Layard's Titbabbler *Parisoma layardii*, Namaqua Warbler *Phragmacia substriata* and Black-headed Canary *Serinus alario* (Appendix 1).

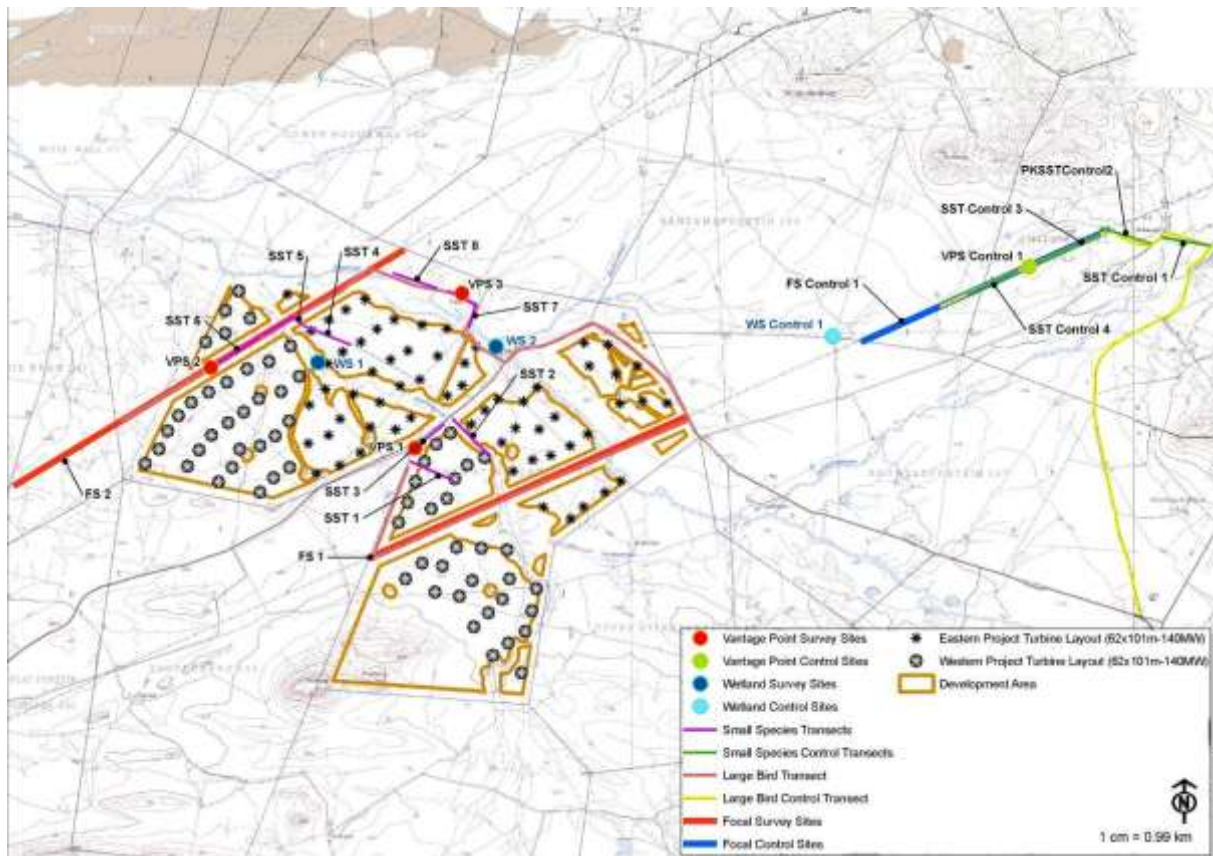


Figure 3. The distribution of bird survey and monitoring sites in relation to the proposed turbine layouts of the two Perdekraal wind energy facilities.

Thirteen priority species were recognized in the avian impact study (Jenkins 2010) as key in the assessment of avian impacts of the initial, inclusive Perdekraal wind farm proposal (Table 1). 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 wind farm project. Six species (Blue Crane, Martial Eagle *Polemaetus bellicosus*, Secretarybird *Sagittarius serpentarius*, Peregrine Falcon, Greater Flamingo *Phoenicopterus ruber*, Black Stork *Ciconia nigra*, Cinnamon-breasted Warbler and Black-eared Sparrowlark were included despite the fact that they were not recorded in either SABAP 1 or SABAP 2 data for the area, because the habitat on the site looked suitable and/or they occur in the nearby Cedarberg-Koue Bokkeveld Complex (Barnes 1998). Cinnamon-breasted Warbler and Black-eared Sparrowlark are range-restricted endemics (Barnes 1998). Verreaux's Eagle is not Red-listed or endemic, but is included because it is an uncommon species and, with Martial Eagle, probably fulfills an important ecological role as an apex predator in the area.

Table 1. Priority bird species considered central to the avian impact assessment process for the Perdekraal Wind Energy Area (edited Jenkins 2010), 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 = 14 cards)	Estimated importance of local population	Preferred habitat	Risk posed by		
							Collision	Electro-cution	Disturbance / habitat loss
Ludwig's Bustard	<i>Neotis ludwigii</i>	Vulnerable (Endangered)	Near-endemic	7.0	High	Open Karoo	High	-	Moderate
Karoo Korhaan	<i>Eupodotis vigorsii</i>	-	Endemic	14.0	High	Open Karoo	Moderate	-	Moderate
Blue Crane	<i>Anthropoides paradiseus</i>	Vulnerable (Vulnerable)	Endemic	0.0	Low	Open Karoo, wetlands	High	-	Moderate
Black Harrier	<i>Circus maurus</i>	Near-threatened (Vulnerable)	Endemic	14.0	Moderate	Open Karoo	Moderate	-	Moderate
Verreaux's Eagle	<i>Aquila verreauxii</i>	-	-	14.0	High	Rocky ridges, open Karoo	High	High	Moderate
Martial Eagle	<i>Polemaetus bellicosus</i>	Vulnerable (Near-threatened)	-	0.0	High	Open Karoo	High	High	Moderate
Secretarybird	<i>Sagittarius serpentarius</i>	Near-threatened (Vulnerable)	-	0.0	Low	Open Karoo	High	-	Moderate
Lanner Falcon	<i>Falco biarmicus</i>	Near-threatened	-	7.0	Moderate	Rocky ridges, open Karoo	High	Moderate	-
Peregrine Falcon	<i>Falco peregrinus</i>	Near-threatened	-	0.0	Low	Rocky ridges	High	Moderate	-

Common name	Scientific name	SA conservation status/ (Global conservation status)	Regional endemicity	Average reporting rate* (n = 14 cards)	Estimated importance of local population	Preferred habitat	Risk posed by		
							Collision	Electro-cution	Disturbance / habitat loss
Greater Flamingo	<i>Phoenicopterus ruber</i>	Near-threatened	-	0.0	Moderate	Wetlands	High	-	-
Black Stork	<i>Ciconia nigra</i>	Near-threatened	-	0.0	Low	Wetlands, rocky ridges	High	Moderate	-
Cinnamon-breasted Warbler	<i>Euryptila subcinnamomea</i>	-	Endemic	7.0	Low	Rocky ridges	-	-	Moderate
Black-eared Sparrowlark	<i>Eremopterix australis</i>	-	Endemic	0.0	Moderate	Open Karoo	-	-	Moderate

Data collection

The pre-construction monitoring work required to inform the final layout of and mitigation scheme for the proposed Perdekraal Wind Energy Area was conducted in terms of the best practice guidelines document (Jenkins *et al.* 2012), promoted by BirdLife South Africa and the Endangered Wildlife Trust, and endorsed by the South African Wind Energy Association (SAWEA) and the country's main electricity provider (Eskom). Monitoring included four data collection iterations (Iteration 1, Late summer: 22-29 February 2012, Iteration 2, Winter: 30 May to 03 June 2012, Iteration 3, Spring: 21-28 August 2012, and Iteration 4, Early summer: 19-24 November 2012, spread over the mandatory 12 month period (Jenkins *et al.* 2012), in addition to an initial visit to the site (30-31 January 2012) with the project ornithologist in order to orientate the monitoring team of four observers. A suitable control or reference area was located to the north-east of the proposed wind farm site (Fig. 3). This area features similar terrain and land use, and was considered to be far enough from the proposed development area (at least 6-7 km from the nearest planned turbine locations) to remain relatively unaffected by the construction and operation of the facility.

The overall monitoring effort included various aspects of the local avifauna, as determined by the guidelines document (Jenkins *et al.* 2012):

(i) Densities of small, terrestrial species

Survey transects (1155-1884 m long) were walked in the early to mid-morning through a representative variety of avian habitat types, intended to generate density estimates for small, sedentary terrestrial birds in the area occupied by the proposed development ($n = 8$ per iteration), and in the selected control or reference area ($n = 4$ per iteration). Such estimates will ultimately serve to determine whether or not there is any species-specific or community-wide displacement of small birds from the development area attributable to the construction and/or operation of the wind farm.

For the sake of expediency, and to limit aggregate costs per iteration, the full field team of four observers typically split into two teams of two, each working simultaneously on different survey objectives for much/all of each site visit. To further streamline each iteration, walked transects were aggregated around vantage point locations, and while one member of each team of two started the vantage point watch (see below for details), the other completed the attendant walked transects before joining his/her partner to assist with the rest of the vantage point watch.

Site-specific weather conditions - including temperature (°C) and wind speed and direction, measured using a hand-held Kestrel™ 4500 weather station - were recorded at the start of each transect. Transects were walked slowly, scanning the area on either side of a predetermined route for visible or audible birds, and stopping to locate, identify, classify the behavior, and count the number of birds involved in each confirmed sighting, using 10x40 binoculars. These details, together with the time, the approximate straight-line distance (m; estimated at least to the nearest 5 m with a laser rangefinder) from the observer to each sighting, the approximate angle of the sighting line off the designated line of the transect, and a GPS location, were recorded on Trimble™ Juno handheld computers, using customized CyberTracker™ software. Densities (for each species and for all species combined) were calculated in terms of the area

covered by each transect (distance covered or transect length x mean perpendicular sighting distance or transect width = area surveyed), with perpendicular sighting distance calculated in terms of the geometry of the sighting: $\text{Sine}(\text{sighting angle}) \times \text{sighting distance} = \text{perpendicular sighting distance}$, Bibby *et al.* 2000).

(ii) Densities of large terrestrial species and raptors

Survey transects (13-25 km long) were driven from the early morning onwards through representative swathes of countryside within and around each of the study area ($n = 1$ per iteration) and the control or reference area ($n = 1$ per iteration). The resulting density estimates for wide-ranging, large terrestrial birds and raptors, were used to document the relative importance of the study area for certain priority species (e.g. Ludwig's Bustard, Blue Crane, Martial Eagle and other raptors), and will ultimately serve to determine whether or not there is any species-specific or community-wide displacement of birds from the development area attributable to the construction and/or operation of the wind farm. The data were collected by two team members (a driver/observer and a second observer) driving slowly (about 60 km/h) along a predetermined route, searching both sides of the road for target species, and stopping every 10-15 mins at pre-selected points to scan the surrounding area with 10x40 binoculars (e.g. Young *et al.* 2003). Sightings were detailed, captured and analysed in much the same way as walked transect sightings (see above).

All sightings of priority large terrestrial birds and raptors made incidentally while travelling around the area (i.e. not during the course of more structured data collection exercises) were also recorded in detail, simply in order to developing as complete a picture as possible of the distribution and abundance of these key species (Jenkins *et al.* 2012). Each such record included comprehensive detail on number, location, activity, weather conditions, height and direction of travel for sightings of flying birds.

(iii) Numbers of wetland species

The largest wetlands (in all cases farm dams) in the study area ($n = 2$) and in the control area ($n = 1$) were identified during the orientation site visit, and each was surveyed once per iteration thereafter. The objective was to determine whether or any of these wetlands are used by substantial numbers of wetland birds, and possibly the extent to which regular traffic of waterbirds between these resource areas might be exposed to displacement or collision risk as a result of the construction and operation of the proposed wind farm. Each survey comprised a thorough count of all the wetland birds present at each site, conducted by two observers from a selected, prominent location which offered the best possible view of the entire wetland. In some instances, wetlands were counted from more than one viewpoint in order to achieve as close to complete coverage as possible.

(iv) Number and status of priority species at key resource areas

The only key resource areas or focal sites for priority species (Jenkins *et al.* 2012) identified within the Perdekraal development area were sections of the two 400 kV transmission power lines which traverse through both the development and control areas (Fig. 3), known to support nesting raptors (Boshoff 1993, Machange *et al.* 2005, Jenkins *et al.* 2013).

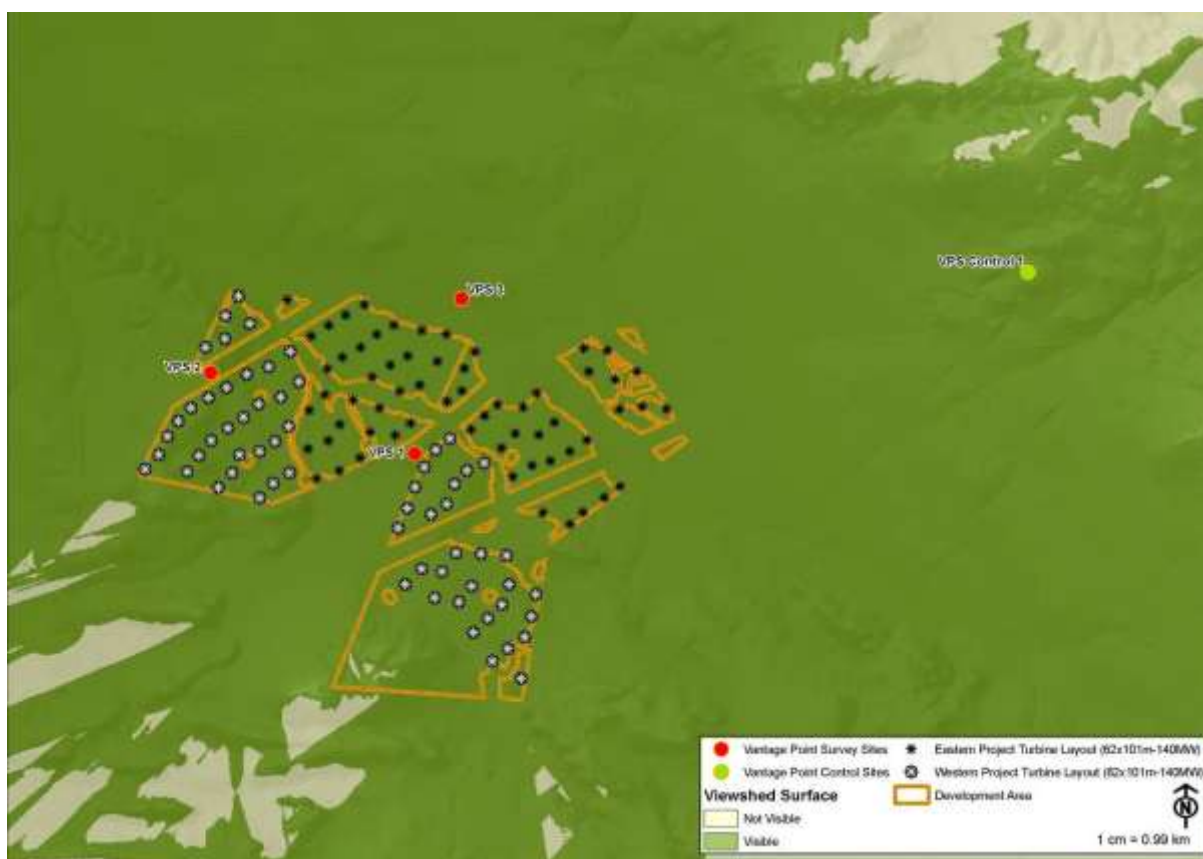


Figure 4. Combined viewshed surfaces of the four vantage points selected and used during the bird movement surveys in and around the proposed Perdekraal Wind Energy Area.

(v) Bird movements

Prominent vantage points with extensive views were selected in the proposed development area ($n = 3$) and in the control area ($n = 1$) (Figs 3 & 4), initially by generating virtual viewsheds using a digital elevation model for the area, and then by ground-truthing a selection of options in terms of practical suitability. Teams of two observers (although see issues around walked transects above) were deployed to these vantage points to accumulate at least a full daylight cycle (averaging 12 hrs) of observation time during each iteration (Jenkins *et al.* 2012). Vantage point watches required the observers to scan the airspace around them for flying birds, concentrating on the 180° arc overlooking the proposed development area (in the case of vantage points located within the study area), but including the remaining area too if possible. Details of all sightings, including species, number, temperature (°C) and current wind speed and direction (measured using a hand-held weather station- see above), approximate location (plotted by eye on a digital map), direction and mode of flight, underlying topography and vegetation type, estimated height above the ground (<30 m or below the rotor sweep, 30-150 m or within the rotor sweep, and >150 m or above the rotor sweep), were captured onto a Trimble™ Juno handheld computer, using customized CyberTracker™ software. Whenever possible, birds that moved through the scanned area were “tracked” as they did so, by means of

a sequence of annotated locations, including information on flying height, mode and direction with each plot. Occasionally, in high bird traffic situations, observers were forced to compromise data capture protocols, and focused on priority species at the expense of less threatened or impact prone birds, on large flocks over individuals, on recording each flight once rather than obtaining sequential tracks, and on recording essential data (species, number, flying height, mode and direction) at the expense of additional detail. Theoretically, the combined viewsheds of the selected vantage point locations provided almost total coverage of both the wind farm site and the control area (Fig. 4).

Vantage point data describe the extent to which the proposed development area of the wind energy facility (and the control area) is used by flying birds, and particularly informs the potential collision risk posed by the operating wind farm (Scottish Natural Heritage 2005, NWCC 2011). Analysis of these data focuses on the numbers of birds observed flying through the rotor swept area of each turbine, with the passage rate per unit time being converted to an anticipated mortality rate in light of various possible collision avoidance scenarios (Band *et al.* 2007, Krijgsveld *et al.* 2009). On this project, given the large extent of the proposed development area, it was not possible to achieve complete coverage of the total rotor swept area of all 115 possible turbine placements. Instead, we sampled the turbine array as effectively as we could, and have extrapolated our findings for a sample area to the entire development to derive very rough estimates of aggregate collision risk (Band *et al.* 2007).

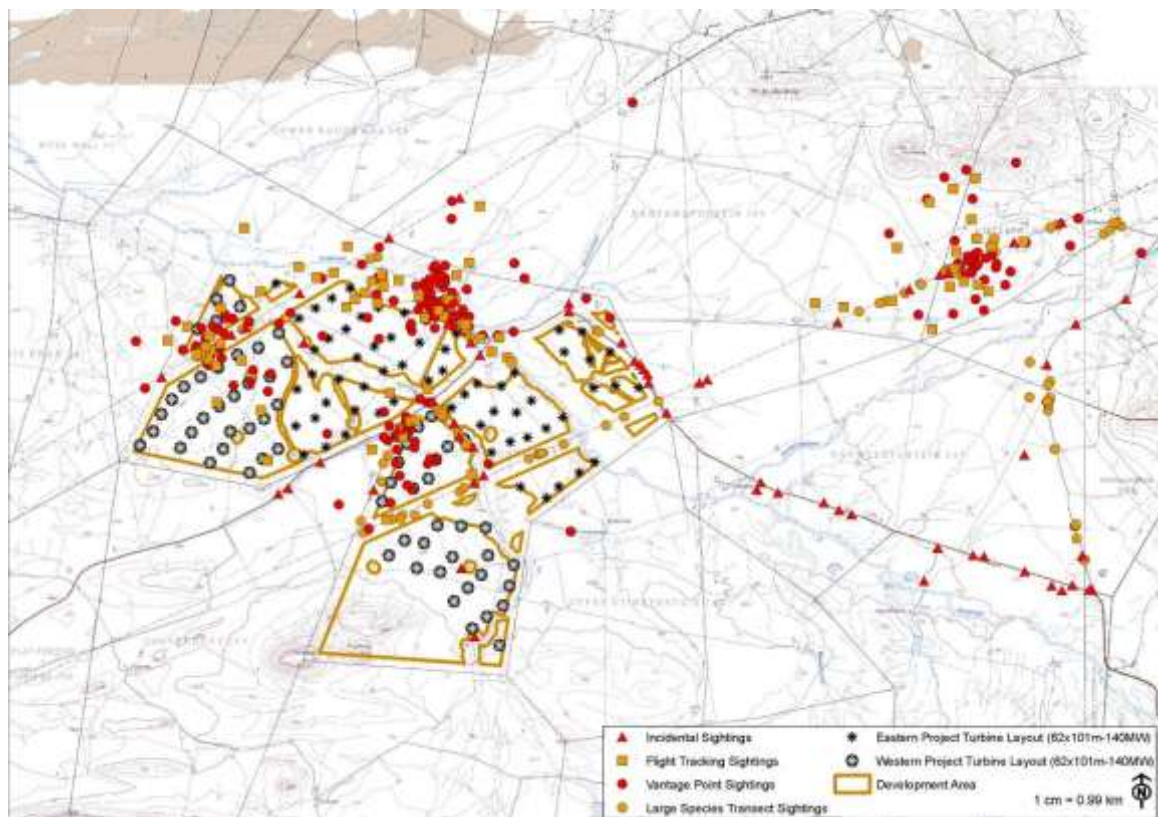


Figure 5. Distribution of all bird sightings recorded in and around the proposed Perdekraal wind farm development area over the study period February to November 2012.

Results & Discussion

General coverage

Overall, we accumulated 25 full days on site, or 50 person-days. Coverage of the site was not absolute, but given the constraints imposed by time, weather (extreme conditions occasionally interrupted time in the field), and existing infrastructure (which limited easy access to more remote parts of the site), was adequate for purpose. In total, 939 bird sightings were recorded in the proposed development area alone (Fig. 5), totaling 2186 individuals, of 88 species (Appendix 1).

Densities of small terrestrial birds

Thirty walked transects were completed within the proposed development area or study area, and 15 in the control or reference area (Appendix 2). Generally, the birdlife recorded in the study area and on the control site were directly comparable. Fifty-one species were recorded in total in the walked transect data collected in the two areas, although 20 species were unique to the development area transects, and five were unique to the control. For the most part, both areas featured open, dry Karoo veld with a woodland component along the watercourses, with the most abundant species in both the study area and the control generally either larks and chats, or flycatchers, warblers and shrikes (Appendix 2).

Table 2. Mean transect width and avian species richness, abundance and density for surveys walked in both the study area and the control area, in each of the data collection iterations (1 = Late summer, 2 = Winter, 3 = Spring, and 4 = Early summer).

Iteration	Transect width (m)		<i>n</i> species		<i>n</i> individuals		Density (birds.ha ⁻¹)			
	Study area	Control area	Study area	Control area	Study area	Control area	Study area		Control area	
							All	Endemics	All	Endemics
1	29.6	34.0	8.9	7.5	21.1	24.5	7.4	2.1	5.3	1.9
2	29.8	45.5	10.0	8.5	20.0	19.3	10.4	1.8	3.5	1.0
3	39.8	39.8	9.5	10.5	23.9	27.0	5.6	1.7	6.0	2.8
4	46.3	47.7	5.7	9.7	14.0	21.0	5.2	2.1	4.4	1.2
Overall	36.4	41.8	8.5	9.1	19.8	23.0	7.2	1.9	4.8	1.7

Sighting distances were comparable between the two areas, so mean transect width was not significantly different between the two samples (Appendix 2 & 3, Table 2, Mann-Whitney *U* Test, $z = -1.22$, $P = 0.11$, not significant). Similarly, species richness of small terrestrial birds (Table 2, $z = -0.52$, $P = 0.30$, n.s.), abundance ($z = -1.36$, $P = 0.09$, n.s.), and density of endemics (Table 2, $z = -0.48$, $P = 0.32$, n.s.) were all comparable between the two areas, while overall density was slightly higher in the study area than the control (Table 2, $z = 2.08$, $P = 0.02^*$). In combination these data confirm that the small bird fauna of the control area was sufficiently similar to that of the study area to allow for meaningful comparisons to be made of post-construction impacts on this community.

Table 3. Summary of driven transect properties and measured densities of large terrestrial birds and raptors in and around the Perdekraal development area (study area) and in a nearby control area, obtained during four data collection iterations between February and November 2012.

Iteration	Transect	Distance covered (km)	Start Temp (°C)	Start cloud cover	Start wind strength (m.s ⁻¹)	Start wind direction	Visibility	<i>n</i> species	Mean transect width (m)	<i>n</i> birds	Mean density of birds. km ⁻²	Mean number of birds.100 km ⁻¹
1 (Late summer)	Control area 1	14	25.5	0/8	2.8	South-east	Good	1	900	4	3.2	28.6
2 (Winter)	Study area 1	22	23.3	0/8	3.4	North-west	Good	4	256	11	2.0	50.0
2 (Winter)	Control area 1	14	19.5	1/8	2.8	South-east	Good	7	214	13	4.3	92.9
3 (Spring)	Study area 1	24	11.5	8/8	9.5	North	Good	9	764	11	0.6	45.8
3 (Spring)	Control area 1	14	10.8	0/8	4.1	South-east	Good	7	340	17	3.6	121.4
4 (Early summer)	Study area 1	24	22.1	0/8	2.1	South	Good	9	362	17	2.0	70.8
5 (Early summer)	Control area 1	13	30.1	2/8	3.3	South-east	Good	3	296	4	1.0	30.8

Densities and distributions of large terrestrial birds and raptors

Overall, 95 km of driven surveys were completed in and around the development or study area, and 55 km in the control area, over the four data collection periods (Table 3, Appendix 4). Mean aggregate, area-based densities for all target species combined were higher in the control area than in the study area (study area = 1.50 birds.km⁻², *n* = 3 surveys; control area = 3.02 birds.km⁻², *n* = 4 surveys, Mann-Whitney *U* Test, *z* = -1.81, *P* = 0.03*), while linear densities were more comparable (study area = 55.6 birds.100 km⁻¹, control area = 68.4 birds.100 km⁻¹, *z* = 0.53, *P* = 0.30 n.s.).

Generally, the measured densities of terrestrial birds and raptors within the study area were low but erratic and unpredictable and showed no obvious seasonal trend. Eighty-two incidental sightings were also accumulated during the study period, 14 of which were of priority species, comprising 21 birds of six species (Appendix 5), and including three sightings each of Martial Eagle and Black Harrier.

Table 4. Linear densities of priority large terrestrial birds and raptors in and around the Perdekraal wind farm development area, and in a nearby control area, as determined from drive transect data collected during each site visit from February to November 2012.

Species	Iteration	Transect	<i>n</i> birds	Maximum flock size	Mean flock size	Mean number of birds.100 km ⁻¹
Black Harrier	2 (Winter)	Control area 1	4	2	1	28.6
	3 (Spring)	Control area 1	1	1	1	7.1
	3 (Spring)	Study area 1	1	1	1	4.2
	4 (Early summer)	Control area 1	2	2	1	15.4
Lanner Falcon	4 (Early summer)	Study area 1	1	1	1	4.2
Ludwig's Bustard	3 (Spring)	Study area 1	1	1	1	7.1
Martial Eagle	2 (Winter)	Control area 1	1	1	1	7.1
Peregrine Falcon	3 (Spring)	Study area 1	1	1	1	4.2
	4 (Early summer)	Study area 1	1	1	1	4.2
Secretarybird	2 (Winter)	Control area 1	2	2	2	14.3
	3 (Spring)	Control area 1	1	1	1	7.1

Wetland birds

Six counts of wetland birds were completed over the study period, totaling only 70 birds. Very little rain fell before or during the study period, with the net result that the target wetlands were often dry, and only supported inconsequential numbers of wetland birds even when holding appreciable amounts of water (Table 5, Appendix 6).

Table 5. Summary of wetland bird counts conducted at sites within the Perdekraal development area, and at a nearby control site, between February and November 2012.

Iteration	Wetland	Start Time (hh:mm)	Temp (°C)	Cloud cover	Wind strength (m.s ⁻¹)	Wind direction	Visibility	<i>n</i> species	<i>n</i> birds
1 (Early summer)	Study area 1	16:30	34.0	0/8	2.0	South-east	Good	7	42
	Control area 1	10:46	33.5	0/8	1.5	South-east	Good	1	2
2 (Winter)	Study area 1	16:40	17.9	1/8	4.5	South-east	Good	4	8
3 (Spring)	Study area 1	14:50	22.3	0/8	6.3	North	Good	3	8
	Control area 1	12:10	14.1	0/8	2.2	North	Good	3	5
5 (Late summer)	Study area 1	10:03	15.0	8/8	7.5	North-east	Poor	1	5

Other focal sites – roost and nest sites of priority species

Surveys of the sections of the Droërvier-Muldersvlei and Bachus- Droërvier 400 kV transmission lines, located both within and outside of the study area, yielded multiple sightings of pairs of Rock Kestrel, Greater Kestrel *Falco rupicoloides* and Southern Pale Chanting Goshawk *Melierax canorus*, and confirmed /probable nest sites were located for single pairs of Greater Kestrel, Rock Kestrel and Lanner Falcon (all situated in old corvid nest structures) in these lattice pylons in the study area, and for a pair of Greater Kestrel in the control area (Fig. 7). The Lanner Falcon could require some level of mitigation in terms of the layout of the proposed wind farm, although they may already be protected by a development buffer around the transmission line imposed for engineering reasons. Three Martial Eagle nest sites are known in the area, all on pylons of these same transmission lines - Droërvier-Muldersvlei tower 667 (32 ° 59.240 S, 20 ° 10.210 E), about 9 km north-east of the wind farm area, Droërvier-Muldersvlei 728 (33 ° 05.390 S, 19 ° 58.250 E), about 5 km south-west of the study site, and Bachus- Droërvier 478 (33 °02.070 S, 20 °13.291 E), about 8 km east of the wind farm area. These nest sites were checked during the survey period, but neither of them was used by breeding eagles.

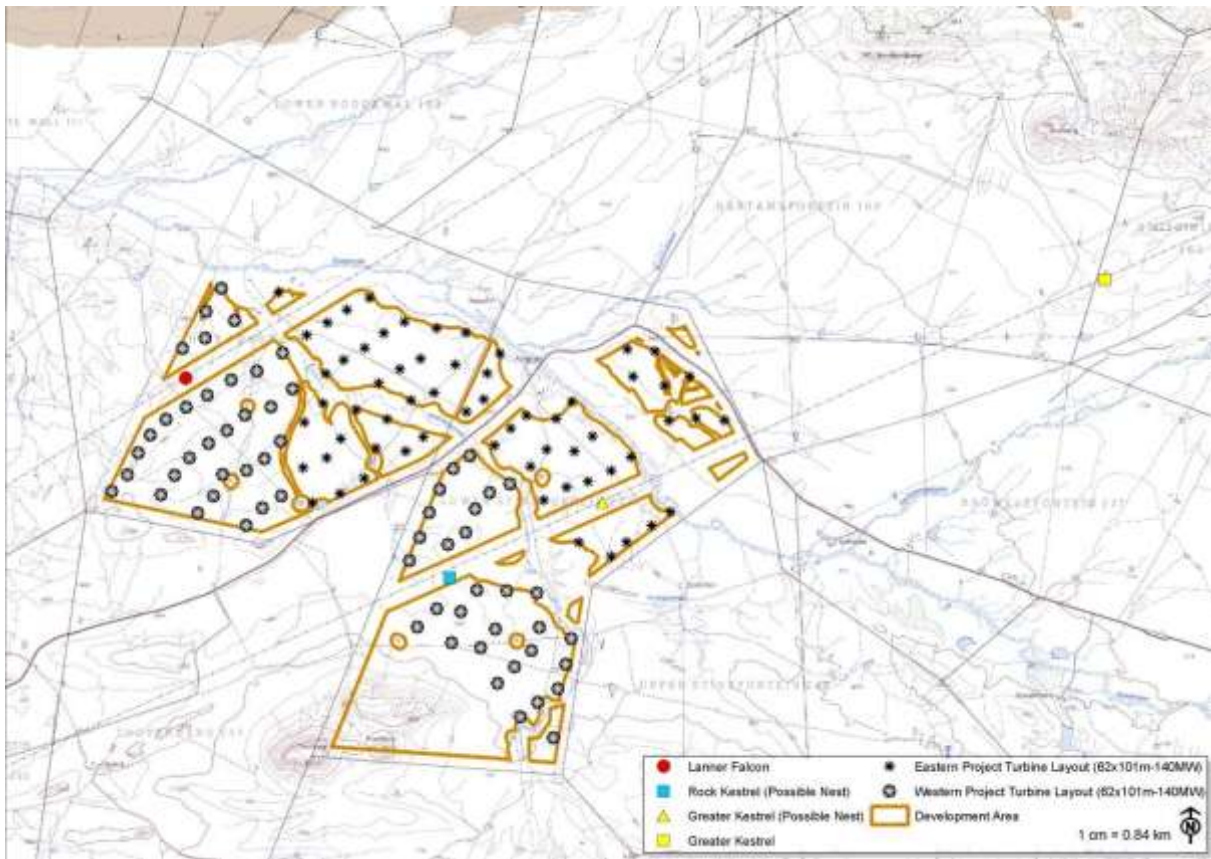


Figure 7. Plot of all nest sites of species of interest located during survey and monitoring work conducted within the Perdekraal development site.

Bird movements

In total, we accumulated 141.5 hrs of observations at the three vantage points selected within the proposed development area, and recorded 133 sightings, describing the movements of 794 individual birds flying over the study area. Similarly, we accumulated 42.3 hrs at the vantage point selected in the control area, and recorded 59 sightings, describing the movements of 208 flying birds. Of these aggregate samples, only sightings of birds flying below 150 m above the focal area (129 sightings, 792 birds, and 40 sightings, 165 birds respectively – Table 6, Appendix 7) are considered relevant to this study. Sightings of birds flying above this height – well above the rotor sweep of the turbines selected for this development - are not included in the tables and analyses presented here.

Average passage rates of birds through the two areas were not significantly different (Study area: mean = 4.40 ± 2.71 birds.hr⁻¹, range = 0.30-41.61, $n = 15$ observation periods; Control area: mean = 2.80 ± 1.80 birds.hr⁻¹, range = 0.48-13.55, $n = 7$ observation periods; Mann-Whitney U test, $z = -0.50$, $P = 0.31$). With was little to indicate any real seasonal pattern in bird movements through the area, although there was some reduction in numbers in the spring and winter and a possible increase in summer (Fig. 8), although this was greatly exaggerated by a passage of several hundred Barn Swallows *Hirundo rustica* past study area VP3 in early summer (Table 6, Appendix 7).

Table 6. Summary of conditions and data collected at vantage point watches conducted within the Perdekraal wind farm development area, and in a nearby control area, over four data collection iterations between February and November 2012.

Iteration	Date	Vantage point	Start Time (hh:mm)	Finish Time (hh:mm)	Duration (hh:mm)	Start Temp (°C)	Start cloud cover	Start wind strength (m.s ⁻¹)	Start wind direction	Visibility	<i>n</i> sightings <150m	<i>n</i> birds <150m	Birds.hr ⁻¹ <150m
1 (Late summer)	2012/02/22	Study area 1	14:00	19:30	05:30	29.8	0/8	9.5	North	Good	7	15	2.73
	2012/02/28	Study area 1	06:45	14:00	07:15	21.4	1/8	0.5	North-east	Good	6	8	1.10
	2012/02/27	Study area 2	01:00	19:30	06:30	35.0	0/8	1.1	South-east	Good	2	10	36.92
	2012/02/29	Study area 2	07:00	13:30	06:30	3.1	3/8	3.1	South-east	Good	8	13	2.00
	2012/02/23	Study area 3	06:30	19:40	13:10	13.0	0/8	0.6	East	Good	32	117	8.88
	2012/02/24	Control area 1	10:00	19:40	09:40	26.1	0/8	3.2	South-east	Good	16	131	13.55
	2012/02/25	Control area 1	06:55	10:15	03:20	19.2	0/8	2.3	North-west	Good	2	3	0.90
2 (Winter)	2012/06/03	Study area 1	07:30	15:00	07:30	11.2	0/8	3.5	South-east	Good	6	7	0.93
	2012/05/31	Study area 2	07:45	18:10	10:25	7.8	0/8	2.8	South-east	Good	5	8	0.77
	2012/05/30	Study area 3	07:30	18:00	10:30	0.5	0/8	1.8	East	Good	3	5	0.48
	2012/06/02	Control area 1	07:20	13:05	05:45	7.8	0/8	1.4	North-east	Good	5	9	1.57
3 (Spring)	2012/08/21	Study area 1	14:00	18:30	04:30	13.8	2/8	4.2	North-west	Good	3	4	0.89
	2012/08/25	Study area 1	07:20	14:00	06:40	8.0	8/8	7.8	North-east	Moderate	2	2	0.30

Iteration	Date	Vantage point	Start Time (hh:mm)	Finish Time (hh:mm)	Duration (hh:mm)	Start Temp (°C)	Start cloud cover	Start wind strength (m.s ⁻¹)	Start wind direction	Visibility	<i>n</i> sightings <150m	<i>n</i> birds <150m	Birds.hr ⁻¹ <150m
	2012/08/24	Study area 2	07:30	18:53	11:23	4.0	0/8	0.6	South-east	Good	9	10	0.88
	2012/08/22	Study area 3	07:25	18:30	11:05	0.0	1/8	1.2	South-east	Good	15	32	2.89
	2012/08/23	Control area 1	11:00	19:00	08:00	13.6	0/8	1.2	South	Good	6	6	0.75
	2012/08/26	Control area 1	07:30	11:00	03:30	8.0	7/8	3.4	North-east	Good	4	5	1.43
4 (Early summer)	2012/11/22	Study area 1	06:00	17:00	11:00	13.4	0/8	6.7	South-west	Good	6	9	0.82
	2012/11/24	Study area 2	06:00	10:30	04:30	13.0	7/8	6.2	North	Good	6	11	1.11
	2012/11/20	Study area 3	05:30	18:30	13:00	17.1	0/8	0.4	West	Good	19	541	41.62
	2012/11/23	Control area 1	06:00	18:00	12:00	18.5	3/8	2.2	South-east	Good	7	11	0.92

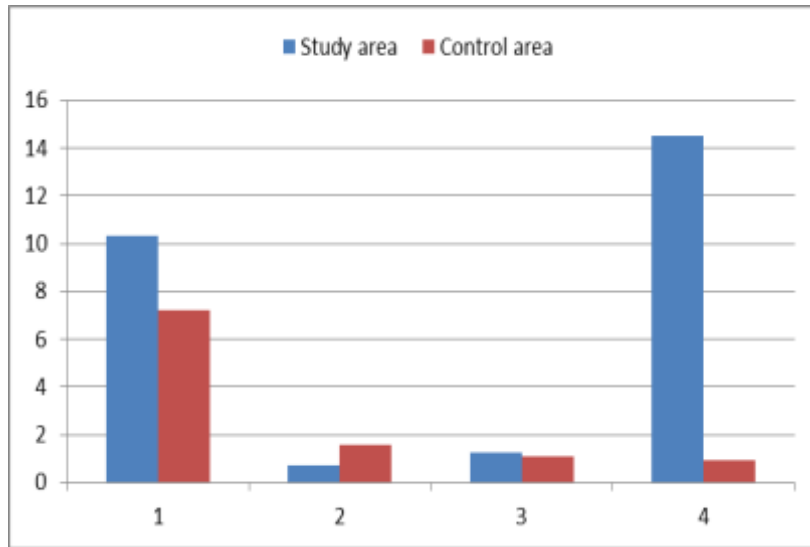


Figure 8. Average passage rates of birds.hr⁻¹ flying <150 m above ground level through either the study area or the control area, recorded from vantage point observations made in each of the four data collection iterations, from February to November 2012.

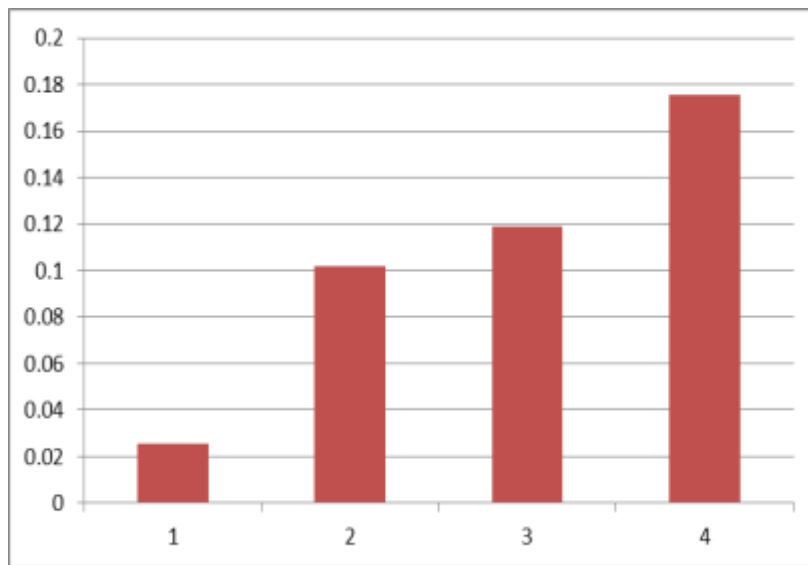


Figure 9. Average passage rates of all priority species.hr⁻¹ flying <150 m above ground level through the study area, recorded from vantage point observations made in each of the four data collection iterations, from February to November 2012.

Priority species made up only 7.8% of the sightings made of birds flying through the proposed development area, and 1.6% of the total number of birds recorded (Table 7). Although passage rates recorded for priority species seemed to escalate through the study (and into early summer – Fig. 9), this simply reflects a marginal increase in large falcon activity around a probable nest site on the transmission line, and remained very low overall (Fig. 10).

In reality, there was no defined seasonality in the perceived collision risk for birds overall or for any of the priority species, and there was nothing in the data collected over the study period to suggest any other temporal or spatial pattern in the movements of birds through the area (Figs 10 & 11) that could be used to usefully adjust the turbine layout, or to inform an effective collision mitigation plan.

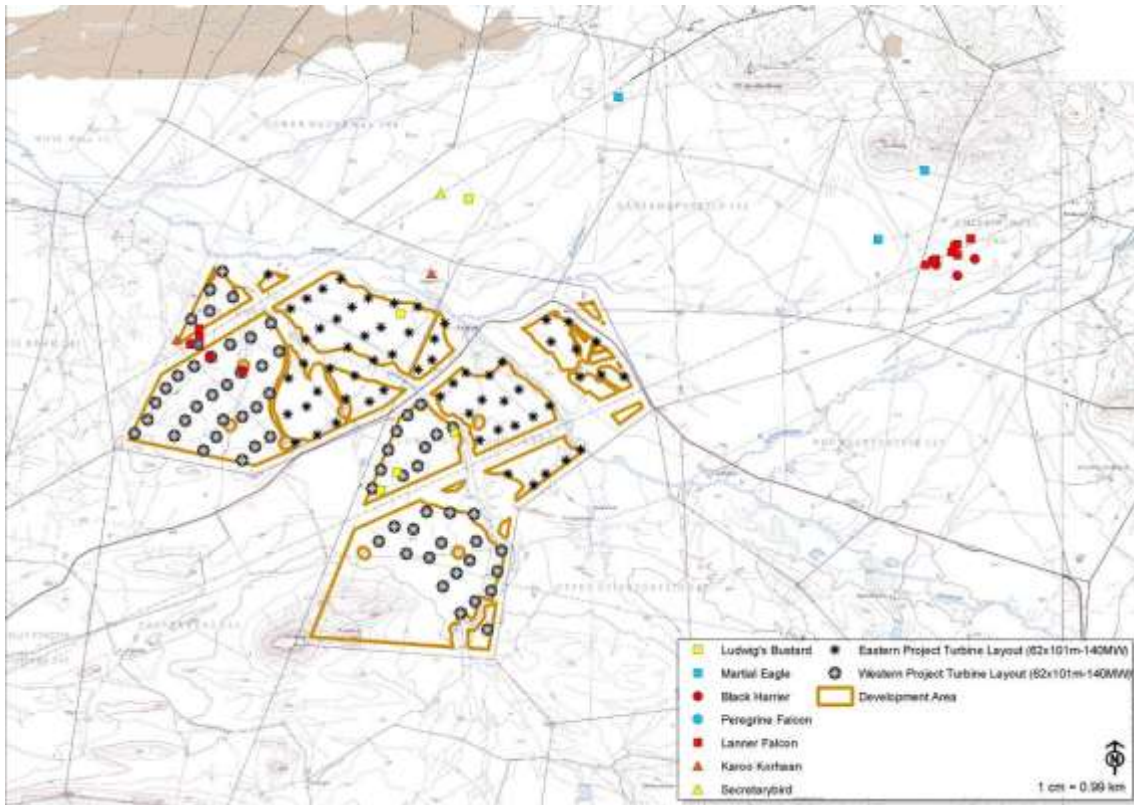


Figure 10. Plot of all vantage point sightings made of priority species over four iterations of data collection within the Perdekraal wind energy development area.

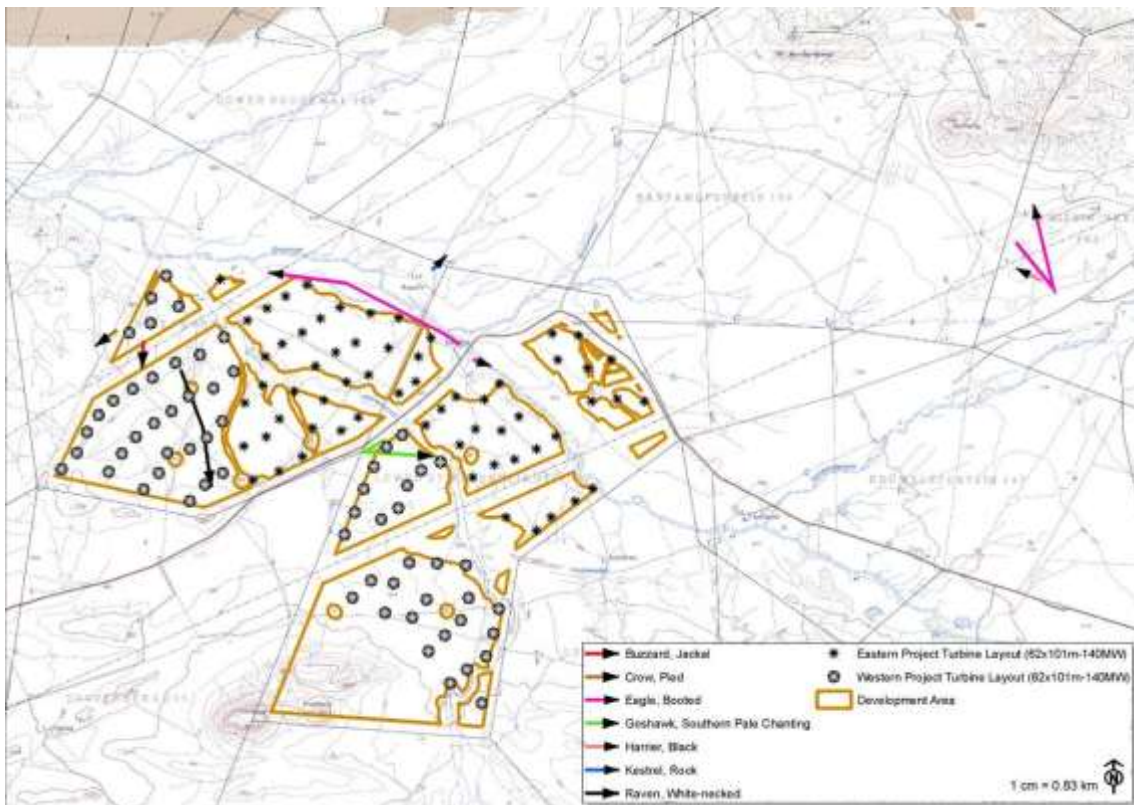


Figure 11. Plot of all flight tracks recorded over four iterations of data collection within the Perdekraal wind energy development area.

Table 7. Summary of vantage point sightings data for priority species observed during surveys conducted during four data collection iterations in the Perdekraal development area, between February and November 2012.

Species	Iteration	Vantage point	Total observation time (hrs)	<i>n</i> sightings <150m	<i>n</i> birds <150m	Birds.hr ⁻¹ <150m
Ludwig's Bustard	2 (Winter)	3	10.5	1	1	0.10
	3 (Spring)	1	11.2	1	1	0.09
	Overall		141.5	2	2	0.01
Karoo Korhaan	2 (Winter)	2	7.8	1	2	0.26
	Overall		141.5	1	2	0.01
Black Harrier	4 (Early summer)	2	12.0	1	1	0.08
	Overall		141.5	1	1	0.01
Martial Eagle	1 (Late summer)	3	13.2	1	1	0.08
	Overall		141.5	1	1	0.01
Lanner Falcon	3 (Spring)	2	11.4	2	3	0.26
	4 (Early summer)	2	12.0	3	4	0.33
	Overall		141.5	5	7	0.05

Collision risk assessment

Ultimately, we did not achieve adequate, direct coverage of the 124 possible turbine placements in this large site, especially given the lack of pattern or predictability in the data obtained, in order to make a detailed, quantitative collision risk assessment (as per Band *et al.* 2007). However, by assuming a number of quite reasonable conditions, we were able to generate working estimates of likely passage rates of birds through the development area. Firstly, we assumed that the radius effectively covered by observers working at each of the three vantage points approximated the average distance over which sightings were made at each (i.e. 833 m at vantage point 1, and 533 m at vantage point 2, and 536 m at vantage point 3), and that the coverage was approximately circular, with an area of πR^2 , 2.18 km², 0.89 km², and 0.90 km² respectively, and a total area of 3.97 km². Secondly, we assumed that the area of the wind farm directly implicated in collision risk is described by 2x the 60 m radius of the rotor of each turbine (to allow for the three-dimensionality of the “risk window” – Band *et al.* 2007) x 124 turbines, or a total area of 5.61 km². We further assumed that the area we surveyed from vantage points was fully representative of the area included by the aggregate risk window of the wind farm, and that average hourly passage rates for each taxon recorded at vantage points, could be extrapolated to derive annual passage rates through the wind farm, by correcting the former by a factor of 1.41 for both layout options (or 5.61/3.97). Lastly, following Band *et al.* (2007), we assumed that the majority of birds flying through the area would take some form of evasive action – either by avoiding the affected area

altogether (displacement) or by flying around the turbines (avoidance), and calculated our annual collision estimates as 5% of the corrected passage rate figure for each taxon. This yielded an overall turbine collision risk estimate of >1700 birds annually (Table 8, a figure rather inflated by numerous sightings of Barn Swallow flying through the proposed development area in both late and early summer), with equivalent figures for priority species including three casualties each annually for Martial Eagle and Black Harrier, and 15 collision per year for Lanner Falcon (Table 8). Clearly these are extremely very rough estimates, and thorough post-construction monitoring will be required to evaluate the accuracy and value of this method.

Conclusions

Avifauna and impacts

The observed avifauna of the study area complied broadly with the predictions of the avian impact study (Jenkins 2010), comprising a low-moderate diversity of Karroid species. The initial short-list of priority species was only partly confirmed, with large terrestrial birds (notably Ludwig's Bustard and Blue Crane) and wetland birds (including Greater Flamingo and Black Stork) relatively scarce in, or entirely absent from the area, perhaps because the study period coincided with very dry conditions, and large eagles, particularly Verreaux's Eagle, were seen less frequently than expected. Also, none of the study area proved adequate to support rocky-country endemics such as Cinnamon-breasted Warbler, and the dry conditions probably also precluded influxes to the area of nomadic Karoo endemics such as Black-eared Sparrowlark. Conversely, Booted Eagle *Hieraaetus pennatus* and Lanner Falcon were more abundant in the area than expected.

Lanner Falcon activity was focused on a likely nest site in an old crow nest structure on a transmission pylon in the north-west of the development area, close to vantage point 2, and proposed wind turbine placements 104, 105, 106 and 111. Should this pair of falcons remain in the area, they will certainly be exposed to disturbance, displacement and collision mortality impacts during the construction and operation of the proposed wind farm, and a dedicated mitigation scheme may be required (see below).

Table8. Possible annual turbine collision rates for all species, and for selected priority species, within the proposed Perdekraal Wind Energy Area, based on vantage point data describing hourly passage rates through a sampled area. See text for an explanation of how these figures were derived.

Species	Observed passage rate.hr ⁻¹	Observed passage rate.day ⁻¹	Observed passage rate.yr ⁻¹	Corrected passage rate.yr ⁻¹	Possible collision rate.year ⁻¹
Ludwig's Bustard	0.01	0.12	43.8	61.8	3
Karoo Korhaan	0.01	0.12	43.8	61.8	3
Martial Eagle	0.01	0.12	43.8	61.8	3
Black Harrier	0.01	0.12	43.8	61.8	3
Lanner Falcon	0.05	0.60	219.0	308.8	15
All priority species	0.09	1.08	394.2	555.8	28
All species	5.60	67.20	24528.0	34584.5	1729

A revised list of the most significant impacts on birds of these two proposed wind energy developments (adapted from Jenkins 2010) is as follows:

- (i) Disturbance and displacement of resident/breeding raptors (especially Lanner Falcon and Martial Eagle, possibly Black Harrier) 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 of large terrestrial birds (especially Ludwig's Bustard, possibly Blue Crane) 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.
- (iii) Disturbance and displacement of resident/breeding nomadic Karoo endemics, and possible disturbance, displacement and collision mortality of wetland birds frequenting the larger farm dams in the area, during years of relatively good rainfall.

Mitigation recommendations

Many of the mitigation requirements put forward in the original bird impact assessment (Jenkins 2010) remain broadly applicable:

- (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, and 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). The key species here are Lanner Falcon (a spring breeder) and possibly Martial Eagle (an autumn breeder), which are now known to breed on or close to the site. Ideally, the welfare of these and other sensitive species should be further catered for by a pre-construction walk-through, and by ongoing monitoring of the area throughout the construction period.
- (ii) Excluding development from:
 - (a) Within 500 m of the centre of the large dam on the farm Rietpoort (study area wetland 1 – Fig. 3), to reduce disturbance and collision risk for wetland species commuting between this wetland and other resource areas.
 - (b) Within 250 m of the centre of the Groot River bed, to reduce collision risk for birds commuting along this central drainage line.

Note that while no significant bird numbers or traffic were recorded around either of these proposed exclusion areas, they remain possible/likely foci of avian activity during and/or after good rainfall years.

- (iii) 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). 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 (Bevanger 1994, Jenkins *et al.* 2010, Barrientos *et al.* 2011). 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 line, 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.

- (iv) Carefully monitoring the local avifauna pre- and post-construction, 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.
- (v) Measure (iv) should determine whether or the Lanner Falcon pair recorded as resident and breeding on the site remain in residence in the same area. Should this be so, it may be advisable to clear the corvid nest structures in the transmission pylons used by this falcon pair, and to erect a suitable nest box for these birds to breed in located sufficiently far away from the development area to meaningfully reduce impact risks, but no so far as to fall outside of the home range of the falcon pair (perhaps 1500 m or 4-5 pylon spans?). This will have to be done with the assistance and cooperation of Eskom staff.
- (vi) Ensuring that the results of this study and of subsequent monitoring work are applied to project-specific impact mitigation in a way that allows for the potentially considerable cumulative effects on the local/regional avifauna of any other wind energy projects that may be proposed for this area.
- (vii) While the findings of this study are largely favourable for the development of the two proposed wind energy facilities at the Perdekraal site, and at this stage there is no perceived need to change the currently proposed layouts for these developments, should any impacts be detected either during construction or once the wind farm is operational that are deemed sufficiently detrimental to the regional avifauna, the developer must be prepared to apply mitigation options additional to those already listed here in order to render the developments sustainable.

References

- Allan, D.G. 1993. Aspects of the biology and conservation of the Blue Crane *Anthropoides paradiseus*, and the Ludwig's *Neotis ludwigii* and Stanley's *N. denhami stanleyi* Bustards in southern Africa. Unpublished MSc thesis. University of Cape Town, Cape Town.
- Band, W., Madders, M. & Whitfield, D.P. 2007. Developing field and analytical methods to assess avian collision risk at wind farms. In: De Lucas, M., Janss, G.F.E. & Ferrer, M. (eds). *Birds and Wind Farms – Risk Assessment and Mitigation*. Quercus, London.
- Barnes, K.N. (ed.) 1998. *The Important Bird Areas of southern Africa*. BirdLife South Africa, Johannesburg.

- Barnes, K.N. (ed.) 2000. The Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland. BirdLife South Africa, Johannesburg.
- Barrientos, R., Alonso, J.C., Ponce, C. & Palacín, C. 2011. Meta-analysis of the effectiveness of marked wire in reducing avian collisions with power lines. *Conservation Biology* 25: 893-903.
- Barrios, L. & Rodríguez, A. 2004. Behavioural and environmental correlates of soaring-bird mortality at on-shore wind turbines. *Journal of Applied Ecology* 41: 72-81.
- Bevanger, K. 1994. Bird interactions with utility structures: collision and electrocution, causes and mitigating measures. *Ibis* 136: 412-425.
- Bibby, C.J., Burgess, N.D., Hill, D.A. & Mustoe, S.H. 2000. Bird Census Techniques: 2nd edition. Academic Press, London.
- Boshoff, A. F. 1993. Density, breeding performance and stability of Martial Eagles *Polemaetus bellicosus* breeding on electricity pylons in the Nama-Karoo, South Africa. In: Wilson, R.T. (Ed.), Proceedings of the Eighth Pan-African Ornithological Congress. *Musee Royal de l'Afrique Centrale, Tervuren*. pp 95–104.
- Bright, J., Langston, R., Bullman, R. Evans, R., Gardner, S., & Pearce-Higgins, J. 2008. Map of bird sensitivities to wind farms in Scotland: A tool to aid planning and conservation. *Biological Conservation* 141: 2342-2356.
- Carrete, M., Sánchez-Zapata, J., Benítez, J.R., Lobon, M. & Donázar, J. A. 2009. Large scale risk-assessment of wind-farms on population viability of a globally endangered long-lived raptor. *Biological Conservation* 142: 2954-2961.
- Drewitt, A.L. & Langston, R.H.W. 2006. Assessing the impacts of wind farms on birds. *Ibis* 148: 29-42.
- Drewitt, A.L. & Langston, R.H.W. 2008. Collision effects of wind-power generators and other obstacles on birds. *Annals of the New York Academy of Science* 1134: 233-266.
- Ferrer, M., de Lucas, M., Janss, G.F.E., Casado, E., Muñoz, A.R., Bechard, M.J. & Calabuig, C.P. 2012. Weak relationship between risk assessment studies and recorded mortality in wind farms. *Journal of Applied Ecology* 49: 38-46.
- Jenkins, A.R. 2010. Perdekraal renewable energy facility: Avian impact assessment. Report to ERM Southern Africa Pty (Ltd).
- Jenkins, A.R., Smallie, J.J. & Diamond, M. 2010. Avian collisions with power lines: a global review of causes and mitigation with a South African perspective. *Bird Conservation International* 20: 263-278.
- Jenkins, A.R., Shaw, J.M., Smallie, J.J., Gibbons, B., Visagie, R. & Ryan, P. 2011. Estimating the impacts of power line collisions on Ludwig's Bustards *Neotis ludwigii*. *Bird Conservation International*. Published online, July 2011.
- Jenkins, A.R., van Rooyen, C.S., Smallie, J.J., Anderson, M.D. & Smit, H.A. 2012. Best practice guidelines for avian monitoring and impact mitigation at proposed wind energy development sites in southern Africa: 1st Revision. Endangered Wildlife Trust/BirdLife South Africa, Johannesburg.

- Jenkins, A.R., de Goede, J.H., Sebele, L. & Diamond, M. 2013. Brokering a settlement between eagles and industry: sustainable management of large raptors nesting on power infrastructure. *Bird Conservation International*. Published online on 03 May 2013.
- Krijgsveld, K.L., Akershoek, K., Schenk, F., Dijk, F. & Dirksen, S. 2009. Collision risk of birds with modern large wind turbines. *Ardea* 97: 357-366.
- Kuvlevsky, W.P. Jnr, Brennan, L.A., Morrison, M.L., Boydston, K.K., Ballard, B.M. & Bryant, F.C. 2007. Wind energy development and wildlife conservation: challenges and opportunities. *Journal of Wildlife Management* 71: 2487-2498.
- Lehman, R.N., Kennedy, P.L. & Savidge, J.A. 2007. The state of the art in raptor electrocution research: a global review. *Biological Conservation* 136: 159-174.
- Machange, R.W., Jenkins, A.R., & Navarro, R.A. 2005. Eagles as indicators of ecosystem health: Is the distribution of Martial Eagle nests in the Karoo, South Africa, influenced by variations in land-use and rangeland quality? *Journal of Arid Environments* 63: 223-243.
- Madders, M. & Whitfield, D.P. 2006. Upland raptors and the assessment of wind farms impacts. *Ibis* 148: 43-56.
- Mucina, L. & Rutherford, M.C. (Eds) 2006. The vegetation of South Africa, Lesotho and Swaziland. *Strelitzia* 19. South African National Biodiversity Institute, Pretoria.
- NWCC. 2011. Comprehensive guide to studying wind energy/wildlife interactions. Unpublished report to the National Wind Coordinating Collaborative, Washington.
- Retief, E.F., Diamond, M., Anderson, M.D., Smit, H.A., Jenkins, A.R. & Brooks, M. 2012. Avian wind farm sensitivity map: criteria and procedures used. BirdLife South Africa, Johannesburg.
- Scottish Natural Heritage. 2005. Survey methods for use in assessing the impacts of onshore windfarms on bird communities. Unpublished Report.
- Shaw, J., Jenkins, A.R. & Ryan, P.G. 2010a. Modelling power line collision risk in the Blue Crane *Anthropoides paradiseus* in South Africa. *Ibis* 152: 590-599.
- Shaw, J., Jenkins, A.R., Ryan, P.G. & Smallie, J. 2010b. A preliminary survey of avian mortality on power lines in the Overberg, South Africa. *Ostrich* 81: 109-113.
- Smallwood, K.S. & Thelander, C. 2008. Bird mortality in the Altamont Pass Wind Resource Area, California. *Journal of Wildlife Management* 72: 215-223.
- Smallwood, K.S., Ruge, L. & Morrison, M.L. 2009. Influence of behavior on bird mortality in wind energy developments. *Journal of Wildlife Management* 73: 1082-1098.
- Young, D.J., Harrison, J.A., Navarro, R.A., Anderson, M.D. & Colahan, B.D. (eds). 2003. Big birds on farms: Mazda CAR report 1993-2001. Avian Demography Unit, Cape Town.

Appendix 1. Annotated list of the bird species considered likely to occur within the impact zone of the proposed Perdekraal Wind Energy Area. Species seen during the time spent on site appear in **bold**.

Common name	Scientific name	Conservation status	Regional endemism	Local status					Susceptibility to		
					Rocky ridges	Open Tanqua Karoo	Wooded drainage lines	Wetlands	Collision	Electrocution	Disturbance / habitat loss
Cape Spurfowl	<i>Pternistis capensis</i>	-	Endemic	Common resident	X	X			Moderate	-	High
Common Quail	<i>Coturnix coturnix</i>	-	-	Common visitor		X			-	-	High
Grey-winged Francolin	<i>Scleroptila africanus</i>	-	Endemic	Uncommon resident		X			Moderate	-	High
Helmeted Guineafowl	<i>Numida meleagris</i>	-	-	Common resident		X	X		Moderate	-	High
Egyptian Goose	<i>Alopochen aegyptiaca</i>	-	-	Common resident				X	High	High	-
South African Shelduck	<i>Tadorna cana</i>	-	Endemic	Common resident				X	High	-	-
Spur-winged Goose	<i>Plectropterus gambensis</i>	-	-	Common resident				X	High	Moderate	-
Cape Teal	<i>Anas capensis</i>	-	-	Uncommon resident				X	Moderate	-	-
African Black Duck	<i>Anas sparsa</i>	-	-	Uncommon resident				X	Moderate	-	-
Yellow-billed Duck	<i>Anas undulata</i>	-	-	Common resident				X	Moderate	-	-
Cape Shoveler	<i>Anas smithii</i>	-	Endemic	Common resident				X	Moderate	-	-
Red-billed Teal	<i>Anas erythrorhyncha</i>	-	-	Common resident				X	Moderate	-	-
Southern Pochard	<i>Netta erythroptalma</i>	-	-	Uncommon visitor				X	Moderate	-	-

Common name	Scientific name	Conservation status	Regional endemism	Local status					Susceptibility to		
					Rocky ridges	Open Tanqua Karoo	Wooded drainage lines	Wetlands	Collision	Electrocution	Disturbance / habitat loss
Greater Honeyguide	<i>Indicator indicator</i>	-	-	Uncommon visitor			X		-	-	-
Lesser Honeyguide	<i>Indicator minor</i>	-	-	Uncommon visitor			X		-	-	Moderate
Ground Woodpecker	<i>Geocalaptes olivaceus</i>	-	Endemic	Uncommon resident	X				-	-	Moderate
Cardinal Woodpecker	<i>Dendropicos fuscescens</i>	-	-	Uncommon visitor			X		-	-	Moderate
Acacia Pied Barbet	<i>Tricholaema leucomelas</i>	-	Near-endemic	Common resident			X		-	-	Moderate
African Hoopoe	<i>Upupa africana</i>	-	-	Common resident			X		-	-	Moderate
Malachite Kingfisher	<i>Alcedo cristata</i>	-	-	Uncommon resident				X	-	-	-
Pied Kingfisher	<i>Ceryle rudis</i>	-	-	Uncommon resident				X	-	-	-
Giant Kingfisher	<i>Megaceryle maximus</i>	-	-	Uncommon resident				X	-	-	-
European Bee-eater	<i>Merops apiaster</i>	-	-	Uncommon migrant		X	X	X	-	-	-
White-backed Mousebird	<i>Colius colius</i>	-	Endemic	Common migrant			X		-	-	Moderate
Red-faced Mousebird	<i>Urocolius indicus</i>	-	-	Common resident			X		-	-	Moderate
Red-chested Cuckoo	<i>Cuculus solitarius</i>	-	-	Uncommon migrant			X		-	-	-
Klaas Cuckoo	<i>Chrysococcyx klaas</i>	-	-	Uncommon resident			X		-	-	-
Diderick Cuckoo	<i>Chrysococcyx caprius</i>	-	-	Uncommon visitor			X		-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Local status					Susceptibility to		
					Rocky ridges	Open Tanqua Karoo	Wooded drainage lines	Wetlands	Collision	Electrocution	Disturbance / habitat loss
Burchell's Coucal	<i>Centropus burchelli</i>	-	-	Uncommon resident				X	-	-	Moderate
Alpine Swift	<i>Tachymarptis melba</i>	-	-	Common resident	X	X			Moderate	-	-
Common Swift	<i>Apus apus</i>	-	-	Uncommon migrant	X	X			Moderate	-	-
African Black Swift	<i>Apus barbatus</i>	-	-	Common resident	X	X			Moderate	-	-
Little Swift	<i>Apus affinis</i>	-	-	Uncommon visitor		X			Moderate-	-	-
White-rumped Swift	<i>Apus caffer</i>	-	-	Common visitor	X	X			Moderate	-	-
Horus Swift	<i>Apus horus</i>	-	-	Uncommon visitor	X	X			Moderate	-	-
Barn Owl	<i>Tyto alba</i>	-	-	Common resident		X	X		-	Moderate	Moderate
Cape Eagle-Owl	<i>Bubo capensis</i>	-	-	Uncommon resident	X	X			-	High	Moderate
Spotted Eagle-Owl	<i>Bubo africanus</i>	-	-	Common resident		X	X		-	High	Moderate
Freckled Nightjar	<i>Caprimulgus tristigma</i>	-	-	Uncommon resident	X				-	-	Moderate
Rufous-cheeked Nightjar	<i>Caprimulgus rufigena</i>	-	-	Uncommon resident		X	X				
Rock Dove	<i>Columba livia</i>	-	-	Common visitor		X			-	-	Moderate
Speckled Pigeon	<i>Columba guinea</i>	-	-	Common resident	X	X			-	-	Moderate
Laughing Dove	<i>Streptopelia senegalensis</i>	-	-	Common resident		X			-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Local status					Susceptibility to		
					Rocky ridges	Open Tanqua Karoo	Wooded drainage lines	Wetlands	Collision	Electrocution	Disturbance / habitat loss
Cape Turtle-Dove	<i>Streptopelia capicola</i>	-	-	Common resident		X			-	-	Moderate
Red-eyed Dove	<i>Streptopelia semitorquata</i>	-	-	Uncommon visitor			X		-	-	Moderate
Namaqua Dove	<i>Oena capensis</i>	-	-	Common resident		X	X		-	-	Moderate
Ludwig's Bustard	<i>Neotis ludwigii</i>	Vulnerable	Near-endemic	Uncommon visitor		X			High	-	Moderate
Southern Black Korhaan	<i>Afrotis afra</i>	-	Endemic	Common resident		X			Moderate	-	Moderate
Karoo Korhaan	<i>Eupodotis vigorsii</i>	-	Endemic	Common resident		X			Moderate	-	Moderate
Blue Crane	<i>Anthropoides paradiseus</i>	Vulnerable	Endemic	Uncommon visitor		X		X	High	-	Moderate
Common Moorhen	<i>Gallinula chloropus</i>	-	-	Uncommon resident				X	Moderate-	-	-
Red-knobbed Coot	<i>Fulica cristata</i>	-	-	Common resident				X	Moderate-	-	-
Namaqua Sandgrouse	<i>Pterocles namaqua</i>	-	Near-endemic	Common visitor		X		X	Moderate	-	-
African Snipe	<i>Gallinago nigripennis</i>	-	-	Uncommon visitor				X	-	-	-
Marsh Sandpiper	<i>Tringa stagnatilis</i>	-	-	Uncommon visitor				X	Moderate	-	-
Common Greenshank	<i>Tringa nebularia</i>	-	-	Common visitor				X	Moderate	-	-
Wood Sandpiper	<i>Tringa glareola</i>	-	-	Uncommon visitor				X	Moderate	-	-
Common Sandpiper	<i>Actitis hypoleucos</i>	-	-	Uncommon visitor				X	Moderate	-	-
Little Stint	<i>Calidris minuta</i>	-	-	Uncommon visitor				X	Moderate	-	-

Common name	Scientific name	Conservation status	Regional endemism	Local status					Susceptibility to		
					Rocky ridges	Open Tanqua Karoo	Wooded drainage lines	Wetlands	Collision	Electrocution	Disturbance / habitat loss
Curlew Sandpiper	<i>Calidris ferruginea</i>	-	-	Common visitor				X	Moderate	-	-
Ruff	<i>Philomachus pugnax</i>	-	-	Uncommon visitor				X	Moderate	-	-
Water Thick-knee	<i>Burhinus vermiculatus</i>	-	-	Uncommon resident				X	Moderate	-	-
Spotted Thick-knee	<i>Burhinus capensis</i>	-	-	Uncommon resident		X	X		Moderate	-	-
Black-winged Stilt	<i>Himantopus himantopus</i>	-	-	Common resident				X	Moderate	-	-
Pied Avocet	<i>Recurvirostra avosetta</i>	-	-	Common resident				X	Moderate	-	-
Kittlitz's Plover	<i>Charadrius pecuarius</i>	-	-	Common resident				X	Moderate	-	-
Three-banded Plover	<i>Charadrius tricollaris</i>	-	-	Common resident				X	Moderate	-	-
Blacksmith Lapwing	<i>Vanellus armatus</i>	-	-	Common resident				X	Moderate	-	-
Crowned Lapwing	<i>Vanellus coronatus</i>	-	-	Common resident		X			Moderate	-	-
Double-banded Courser	<i>Rhinoptilus africanus</i>	-	-	Uncommon visitor		X			Moderate	-	-
Burchell's Courser	<i>Cursorius rufus</i>	-	Near-endemic	Rare visitor		X			Moderate	-	-
Whiskered Tern	<i>Chlidonias hybrida</i>	-	-	Uncommon visitor				X	Moderate	-	-
White-winged Tern	<i>Chlidonias leucopterus</i>	-	-	Uncommon visitor				X	Moderate	-	-
Black-shouldered Kite	<i>Elanus caeruleus</i>	-	-	Uncommon resident		X	X		Moderate	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Local status					Susceptibility to		
					Rocky ridges	Open Tanqua Karoo	Wooded drainage lines	Wetlands	Collision	Electrocution	Disturbance / habitat loss
Yellow-billed Kite	<i>Milvus aegyptiacus</i>	-	-	Uncommon migrant		X			-	-	-
African Fish-Eagle	<i>Haliaeetus vocifer</i>	-	-	Uncommon resident				X	-	High	-
Black-chested Snake-Eagle	<i>Circaetus pectoralis</i>	-	-	Uncommon visitor		X			-	Moderate	Moderate
African Marsh Harrier	<i>Circus ranivorus</i>	Vulnerable	-	Rare visitor				X	Moderate	-	-
Black Harrier	<i>Circus maurus</i>	Near-threatened	Endemic	Uncommon visitor	X	X		X	Moderate	-	Moderate
African Harrier-Hawk	<i>Polyboroides typus</i>	-	-	Uncommon visitor	X		X		-	-	Moderate
Southern Pale Chanting Goshawk	<i>Melierax canorus</i>	-	Near-endemic	Common resident		X	X		-	Moderate	Moderate
Gabar Goshawk	<i>Melierax gabar</i>	-	-	Uncommon resident			X		-	-	Moderate
Rufous-chested Sparrowhawk	<i>Accipiter rufiventris</i>	-	-	Uncommon visitor			X		-	-	Moderate
Black Sparrowhawk	<i>Accipiter melanoleucus</i>	-	-	Uncommon visitor			X		Moderate	-	Moderate
Steppe Buzzard	<i>Buteo vulpinus</i>	-	-	Common migrant	X	X			-	Moderate	Moderate
Jackal Buzzard	<i>Buteo rufofuscus</i>	-	Endemic	Common resident	X	X			-	Moderate	Moderate
Verreaux's Eagle	<i>Aquila verreauxii</i>	-	-	Uncommon resident	X	X			Moderate	High	Moderate
Booted Eagle	<i>Aquila pennatus</i>	-	-	Uncommon resident	X	X			-	-	Moderate
Martial Eagle	<i>Polemaetus bellicosus</i>	Vulnerable	-	Uncommon resident	X	X	X		Moderate	High	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Local status					Susceptibility to		
					Rocky ridges	Open Tanqua Karoo	Wooded drainage lines	Wetlands	Collision	Electrocution	Disturbance / habitat loss
Secretarybird	<i>Sagittarius serpentarius</i>	Near-threatened	-	Uncommon resident		X	X		High	-	Moderate
Lesser Kestrel	<i>Falco naumanni</i>	Vulnerable	-	Uncommon migrant		X	X		Moderate	-	Moderate
Rock Kestrel	<i>Falco rupicolus</i>	-	-	Common resident	X	X			-	-	Moderate
Greater Kestrel	<i>Falco rupicoloides</i>	-	-	Uncommon resident		X			-	-	Moderate
Lanner Falcon	<i>Falco biarmicus</i>	Near-threatened	-	Uncommon resident		X			High	Moderate	-
Peregrine Falcon	<i>Falco peregrinus</i>	Near-threatened	-	Uncommon visitor		X			High	Moderate	-
Little Grebe	<i>Tachybaptus ruficollis</i>	-	-	Common resident			X	X	-	-	-
African Darter	<i>Anhinga rufa</i>	-	-	Common visitor				X	-	-	-
Reed Cormorant	<i>Phalacrocorax africanus</i>	-	-	Common visitor				X	-	-	-
White-breasted Cormorant	<i>Phalacrocorax lucidus</i>	-	-	Common visitor				X	Moderate	-	-
Little Egret	<i>Egretta garzetta</i>	-	-	Common visitor				X	-	-	-
Grey Heron	<i>Ardea cinerea</i>	-	-	Common visitor				X	Moderate	Moderate	-
Black-headed Heron	<i>Ardea melanocephala</i>	-	-	Common resident		X		X	Moderate	Moderate	-
Cattle Egret	<i>Bubulcus ibis</i>	-	-	Common visitor				X	-	-	-
Hamerkop	<i>Scopus umbretta</i>	-	-	Uncommon resident			X	X	Moderate	-	-
Greater Flamingo	<i>Phoenicopterus ruber</i>	Near-threatened	-	Uncommon visitor				X	High	-	-

Common name	Scientific name	Conservation status	Regional endemism	Local status					Susceptibility to		
					Rocky ridges	Open Tanqua Karoo	Wooded drainage lines	Wetlands	Collision	Electrocution	Disturbance / habitat loss
Lesser Flamingo	<i>Phoenicopterus minor</i>	Near-threatened	-	Rare visitor				X	High	-	-
Glossy Ibis	<i>Plegadis falcinella</i>	-	-	Uncommon visitor				X	Moderate	-	-
Hadedda Ibis	<i>Bostrychia hagedash</i>	-	-	Common resident			X		Moderate	-	-
African Sacred Ibis	<i>Threskiornis aethiopicus</i>	-	-	Common visitor				X	Moderate	-	-
African Spoonbill	<i>Platalea alba</i>	-	-	Common visitor				X	Moderate	-	-
Black Stork	<i>Ciconia nigra</i>	Near-threatened	-	Rare visitor	X			X	High	Moderate	-
White Stork	<i>Ciconia ciconia</i>	-	-	Uncommon migrant				X	High	High	-
Fork-tailed Drongo	<i>Dicrurus adsimilis</i>	-	-	Uncommon resident			X		-	-	Moderate
African Paradise-Flycatcher	<i>Terpsiphone viridis</i>	-	-	Uncommon migrant			X		-	-	Moderate
Southern Tchagra	<i>Tchagra tchagra</i>	-	Endemic	Uncommon resident			X		-	-	Moderate
Southern Boubou	<i>Laniarius ferrugineus</i>	-	Endemic	Uncommon resident			X		-	-	Moderate
Bokmakierie	<i>Telophorus zeylonus</i>	-	Near-endemic	Common resident		X	X		-	-	Moderate
Pirit Batis	<i>Batis pririt</i>	-	Near-endemic	Uncommon resident		X			-	-	Moderate
Cape Crow	<i>Corvus capensis</i>	-	-	Common resident	X	X	X		-	-	Moderate
Pied Crow	<i>Corvus albus</i>	-	-	Common resident	X	X	X		-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Local status					Susceptibility to		
					Rocky ridges	Open Tanqua Karoo	Wooded drainage lines	Wetlands	Collision	Electrocution	Disturbance / habitat loss
White-necked Raven	<i>Corvus albicollis</i>	-	-	Common resident	X	X			-	-	Moderate
Red-backed Shrike	<i>Lanius collurio</i>	-	-	Rare migrant		X			-	-	-
Common Fiscal	<i>Lanius collaris</i>	-	-	Common resident		X	X		-	-	Moderate
Cape Penduline-Tit	<i>Anthoscopus minutus</i>	-	Near-endemic	Uncommon resident		X			-	-	Moderate
Grey Tit	<i>Parus afer</i>	-	Endemic	Common resident		X			-	-	Moderate
Brown-throated Martin	<i>Riparia paludicola</i>	-	-	Common resident				X	-	-	Moderate
Barn Swallow	<i>Hirundo rustica</i>	-	-	Common migrant		X		X	-	-	Moderate
White-throated Swallow	<i>Hirundo albigularis</i>	-	-	Uncommon resident				X	-	-	Moderate
Pearl-breasted Swallow	<i>Hirundo dimidiata</i>	-	-	Uncommon visitor			X		-	-	Moderate
Greater Striped Swallow	<i>Hirundo cucullata</i>	-	-	Common migrant		X	X	X	-	-	Moderate
Rock Martin	<i>Hirundo fuligula</i>	-	-	Common resident				X	-	-	Moderate
African Red-eyed Bulbul	<i>Pycnonotus nigricans</i>	-	Near-endemic	Common resident			X		-	-	Moderate
Cape Bulbul	<i>Pycnonotus capensis</i>	-	Endemic	Uncommon resident			X		-	-	Moderate
Fairy Flycatcher	<i>Stenostira scita</i>	-	Endemic	Uncommon visitor			X		-	-	Moderate
Long-billed Crombec	<i>Sylvietta rufescens</i>	-	-	Common resident			X		-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Local status					Susceptibility to		
					Rocky ridges	Open Tanqua Karoo	Wooded drainage lines	Wetlands	Collision	Electrocution	Disturbance / habitat loss
Yellow-bellied Eremomela	<i>Eremomela icteropygialis</i>	-	-	Common resident		X	X		-	-	Moderate
Karoo Eremomela	<i>Eremomela gregalis</i>	-	Endemic	Common resident		X			-	-	Moderate
Little Rush-Warbler	<i>Bradypterus baboecala</i>	-	-	Uncommon resident				X	-	-	-
African Reed-Warbler	<i>Acrocephalus baeticatus</i>	-	-	Uncommon resident				X	-	-	Moderate
Lesser Swamp-Warbler	<i>Acrocephalus gracilirostris</i>	-	-	Uncommon resident				X	-	-	Moderate
Willow Warbler	<i>Phylloscopus trochilus</i>	-	-	Uncommon migrant			X		-	-	Moderate
Layard's Tit-Babbler	<i>Parisoma layardi</i>	-	Endemic	Uncommon resident		X	X		-	-	Moderate
Chestnut-vented Tit-Babbler	<i>Parisoma subcaeruleum</i>	-	Near-endemic	Uncommon resident			X		-	-	Moderate
Cape White-eye	<i>Zosterops virens</i>	-	Endemic	Common resident			X		-	-	Moderate
Orange River White-eye	<i>Zosterops pallidus</i>	-	Endemic	Common resident			X		-	-	Moderate
Grey-backed Cisticola	<i>Cisticola subruficapilla</i>	-	Near-endemic	Common resident	X	X			-	-	Moderate
Levaillant's Cisticola	<i>Cisticola tinniens</i>	-	-	Common resident				X	-	-	Moderate
Neddicky	<i>Cisticola fulvicapilla</i>	-	-	Common resident		X			-	-	Moderate
Zitting Cisticola	<i>Cisticola juncidis</i>	-	-	Common resident				X	-	-	Moderate
Karoo Prinia	<i>Prinia maculosa</i>	-	Endemic	Common resident	X	X			-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Local status					Susceptibility to		
					Rocky ridges	Open Tanqua Karoo	Wooded drainage lines	Wetlands	Collision	Electrocution	Disturbance / habitat loss
Namaqua Warbler	<i>Phragmacia substriata</i>	-	Endemic	Common resident		X		X	-	-	Moderate
Rufous-eared Warbler	<i>Malcorus pectoralis</i>	-	Endemic	Common resident		X			-	-	Moderate
Cinnamon-breasted Warbler	<i>Euryptila subcinnamomea</i>	-	Endemic	Uncommon resident	X				-	-	Moderate
Bar-throated Apalis	<i>Apalis thoracica</i>	-	-	Uncommon resident		X	X		-	-	Moderate
Cape Clapper Lark	<i>Mirafra apiata</i>	-	Endemic	Common resident		X			-	-	Moderate
Karoo Lark	<i>Calendulauda albescens</i>	-	Endemic	Common resident		X			-	-	Moderate
Spike-heeled Lark	<i>Chersomanes albofasciata</i>	-	-	Common resident		X			-	-	Moderate
Karoo Long-billed Lark	<i>Certhilauda subcoronata</i>	-	Endemic	Common resident		X			-	-	Moderate
Black-eared Sparrowlark	<i>Eremopterix australis</i>	-	Endemic	Uncommon visitor		X			-	-	Moderate
Grey-backed Sparrowlark	<i>Eremopterix verticalis</i>	-	Near-endemic	Common visitor		X			-	-	Moderate
Red-capped Lark	<i>Calandrella cinerea</i>	-	-	Common resident		X			-	-	Moderate
Large-billed Lark	<i>Galerida magnirostris</i>	-	Endemic	Common resident		X			-	-	Moderate
Cape Rock Thrush	<i>Monticola rupestris</i>	-	Endemic	Common resident	X	X			-	-	Moderate
Sentinel Rock Thrush	<i>Monticola explorator</i>	-	Endemic	Uncommon resident	X				-	-	Moderate
Olive Thrush	<i>Turdus olivaceous</i>	-	Endemic	Uncommon resident			X		-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Local status					Susceptibility to		
					Rocky ridges	Open Tanqua Karoo	Wooded drainage lines	Wetlands	Collision	Electrocution	Disturbance / habitat loss
Chat Flycatcher	<i>Bradornis infuscatus</i>	-	Near-endemic	Uncommon resident		X			-	-	Moderate
Fiscal Flycatcher	<i>Sigelus silens</i>	-	Endemic	Common resident			X		-	-	Moderate
Spotted Flycatcher	<i>Muscicapa striata</i>	-	-	Uncommon visitor			X				
African Dusky Flycatcher	<i>Muscicapa adusta</i>	-	-	Uncommon resident			X		-	-	Moderate
Cape Robin-Chat	<i>Cossypha caffra</i>	-	-	Common resident			X		-	-	Moderate
Karoo Scrub-Robin	<i>Cercotrichas coryphoeus</i>	-	Endemic	Common resident		X	X		-	-	Moderate
African Stonechat	<i>Saxicola torquatus</i>	-	-	Common resident		X			-	-	Moderate
Mountain Wheatear	<i>Oenanthe monticola</i>	-	Near-endemic	Common resident		X			-	-	Moderate
Capped Wheatear	<i>Oenanthe pileata</i>	-	-	Common resident		X			-	-	Moderate
Sickle-winged Chat	<i>Cercomela sinuata</i>	-	Endemic	Common resident		X			-	-	Moderate
Karoo Chat	<i>Cercomela schlegelii</i>	-	Near-endemic	Common resident		X			-	-	Moderate
Familiar Chat	<i>Cercomela familiaris</i>	-	-	Common resident	X	X			-	-	Moderate
Tractrac Chat	<i>Cercomela tractrac</i>	-	Near-endemic	Uncommon resident		X			-	-	Moderate
Ant-eating Chat	<i>Myrmecocichla formicivora</i>	-	Endemic	Common resident		X			-	-	Moderate
Pale-winged Starling	<i>Onychognathus nabouroup</i>	-	Near-endemic	Common visitor	X		X		-	-	Moderate
Red-winged Starling	<i>Onychognathus morio</i>	-	-	Common resident	X		X		-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Local status					Susceptibility to		
					Rocky ridges	Open Tanqua Karoo	Wooded drainage lines	Wetlands	Collision	Electrocution	Disturbance / habitat loss
Pied Starling	<i>Spreo bicolor</i>	-	Endemic	Common resident		X			-	-	Moderate
Wattled Starling	<i>Creatophora cinerea</i>	-	-	Uncommon visitor		X			-	-	Moderate
Common Starling	<i>Sturnus vulgaris</i>	-	-	Common resident			X		-	-	Moderate
Orange-breasted Sunbird	<i>Anthobaphes violacea</i>	-	Endemic	Unommon visitor	X				-	-	Moderate
Malachite Sunbird	<i>Nectarinia famosa</i>	-	-	Common resident	X	X	X		-	-	Moderate
Southern Double-collared Sunbird	<i>Cinnyris chalybeus</i>	-	Endemic	Common resident		X	X		-	-	Moderate
Dusky Sunbird	<i>Cinnyris fuscus</i>	-	Near-endemic	Common resident		X			-	-	Moderate
Cape Weaver	<i>Ploceus capensis</i>	-	Endemic	Common resident			X	X	-	-	Moderate
Southern Masked-Weaver	<i>Ploceus velatus</i>	-	-	Common resident			X	X	-	-	Moderate
Southern Red Bishop	<i>Euplectes orix</i>	-	-	Common resident				X	-	-	Moderate
Yellow Bishop	<i>Euplectes capensis</i>	-	-	Common resident	X			X			
Common Waxbill	<i>Estrilda astrild</i>	-	-	Common resident			X	X	-	-	Moderate
Pin-tailed Whydah	<i>Vidua macroura</i>	-	-	Common resident			X		-	-	Moderate
House Sparrow	<i>Passer domesticus</i>	-	-	Common resident			X		-	-	Moderate

Common name	Scientific name	Conservation status	Regional endemism	Local status					Susceptibility to		
					Rocky ridges	Open Tanqua Karoo	Wooded drainage lines	Wetlands	Collision	Electrocution	Disturbance / habitat loss
Cape Sparrow	<i>Passer melanurus</i>	-	Near-endemic	Common resident		X	X		-	-	Moderate
Cape Wagtail	<i>Motacilla capensis</i>	-	-	Common resident		X		X	-	-	Moderate
African Rock Pipit	<i>Anthus cinnamomeus</i>	-	Endemic	Common resident	X	X			-	-	Moderate
Plain-backed Pipit	<i>Anthus leucophrys</i>	-	-	Uncommon resident		X			-	-	Moderate
African Pipit	<i>Anthus cinnamomeus</i>	-	-	Common resident		X			-	-	Moderate
Long-billed Pipit	<i>Anthus similis</i>	-	-	Uncommon resident	X	X			-	-	Moderate
Cape Canary	<i>Serinus canicollis</i>	-	Endemic	Common resident		X			-	-	Moderate
Black-headed Canary	<i>Serinus alario</i>	-	Endemic	Uncommon resident		X			-	-	Moderate
Black-throated Canary	<i>Crithagra atrogularis</i>	-	-	Uncommon resident		X			-	-	Moderate
Yellow Canary	<i>Crithagra flaviventris</i>	-	Near-endemic	Common resident		X			-	-	Moderate
Brimstone Canary	<i>Crithagra sulphuratus</i>	-	-	Uncommon visitor			X		-	-	Moderate
White-throated Canary	<i>Crithagra albogularis</i>	-	Near-endemic	Common resident		X			-	-	Moderate
Streaky-headed Seedeater	<i>Crithagra gularis</i>	-	-	Uncommon resident		X			-	-	Moderate
Lark-like Bunting	<i>Emberiza impetuani</i>	-	Near-endemic	Common visitor		X			-	-	Moderate
Cape Bunting	<i>Emberiza capensis</i>	-	Near-endemic	Common resident	X	X			-	-	Moderate

Appendix 2. Summary of walked transect properties and measured densities of small terrestrial birds in the Perdekraal development area (Study area) and in a nearby Control area, obtained during four data collection iterations between February and November 2012.

Iteration	Transect	Start Time (hh:mm)	Duration (hh:mm)	Distance (m)	Habitat	Slope gradient	Slope aspect	Temp (°C)	Start cloud cover	Wind strength (m.s ⁻¹)	Wind direction	<i>n</i> species	Mean transect width (m)	<i>n</i> birds	Density (birds.ha ⁻¹)
1 (Late summer)	Study area 1	07:40	00:28	1155	Karoo veld	Flat	None	25.5	1/8	0.5	South	8	33	18	4.7
1 (Late summer)	Study area 2	08:40	00:50	1300	Drainage lines & alien trees	Flat	None	28.5	1/8	1.5	North-west	10	40	40	7.6
1 (Late summer)	Study area 3	09:30	00:15	1190	Karoo veld	Gentle	North-east	30.6	1/8	1.3	North-west	3	21	3	1.2
1 (Late summer)	Study area 4	07:06	00:32	1243	Karoo veld	Flat	None	19	5/8	1.8	South-east	5	53	8	1.2
1 (Late summer)	Study area 5	07:40	00:35	1189	Karoo veld	Flat	None	19	6/8	2.4	South-east	8	20	8	3.3
1 (Late summer)	Study area 6	08:16	00:24	1199	Karoo veld	Gentle	East	22.7	6/8	0.8	South-east	2	36	5	1.2
1 (Late summer)	Study area 7	07:30	00:50	1352	Drainage lines & alien trees	Flat	None	17.1	0/8	1.3	South-east	19	17	45	19.3
1 (Late summer)	Study area 8	08:30	00:30	1165	Drainage lines & alien trees	Flat	None	20.2	0/8	2.1	South-east	16	17	42	20.9
1 (Late summer)	Control area 1	07:10	01:20	1211	Karoo veld	Gentle	None	20.5	0/8	0.6	North-east	7	34	42	10.2
1 (Late summer)	Control area 2	09:00	00:30	1329	Karoo veld	Flat	None	30.7	0/8	0.5	South-west	10	37	32	6.5
1 (Late summer)	Control area 3	09:35	00:22	1884	Karoo veld	Flat	None	33	0/8	1	South-east	8	42	17	2.1

Iteration	Transect	Start Time (hh:mm)	Duration (hh:mm)	Distance (m)	Habitat	Slope gradient	Slope aspect	Temp (°C)	Start cloud cover	Wind strength (m.s ⁻¹)	Wind direction	<i>n</i> species	Mean transect width (m)	<i>n</i> birds	Density (birds.ha ⁻¹)
1 (Late summer)	Control area 4	10:20	00:20	1385	Karoo veld	Flat	None	33	0/8	1.5	South-east	5	23	7	2.2
2 (Winter)	Study area 1	08:10	00:20	1155	Karoo veld	Flat	None	11.5	0/8	3.5	South-east	6	41	12	2.5
2 (Winter)	Study area 2	09:10	00:40	1300	Drainage lines & alien trees	Flat	None	14.5	0/8	4.2	South-east	9	11	20	13.4
2 (Winter)	Study area 3	10:00	00:15	1190	Karoo veld	Gentle	East	16.2	0/8	3	South-east	7	52	15	2.2
2 (Winter)	Study area 7	08:30	00:30	1352	Drainage lines & alien trees	Flat	None	3.8	0/8	1.5	South-east	18	13	35	19.2
2 (Winter)	Study area 8	09:10	00:35	1165	Drainage lines & alien trees	Flat	None	7.9	0/8	2.1	South-east	10	32	18	14.9
2 (Winter)	Control area 1	07:56	00:39	1211	Karoo veld	Gentle	South-west	7.4	0/8	1.4	North-east	10	44	28	5.2
2 (Winter)	Control area 2	08:40	00:30	1329	Karoo veld	Flat	None	14.2	0/8	1.4	East	11	43	24	4.2
2 (Winter)	Control area 3	09:15	00:15	1884	Karoo veld	Flat	None	16.4	0/8	0.4	South-east	9	21	15	3.7
2 (Winter)	Control area 4	09:43	00:42	1385	Karoo veld	Gentle	South-west	17.3	0/8	1.4	South-east	4	74	10	1.0
3 (Spring)	Study area 1	08:20	00:25	1155	Karoo veld	Flat	None	6.8	8/8	7	North	5	56	16	2.5
3 (Spring)	Study area 2	09:15	00:35	1300	Drainage lines & alien trees	Flat	None	9.5	6/8	6.5	North	13	21	33	11.8

Iteration	Transect	Start Time (hh:mm)	Duration (hh:mm)	Distance (m)	Habitat	Slope gradient	Slope aspect	Temp (°C)	Start cloud cover	Wind strength (m.s ⁻¹)	Wind direction	<i>n</i> species	Mean transect width (m)	<i>n</i> birds	Density (birds.ha ⁻¹)
3 (Spring)	Study area 3	10:00	00:15	1190	Karoo veld	Gentle	East	8.5	7/8	7.5	North	5	22	6	2.3
3 (Spring)	Study area 4	07:15	00:35	1243	Karoo veld	Flat	None	0.9	0/8	0.4	South-east	10	56	22	3.2
3 (Spring)	Study area 5	07:55	00:25	1189	Karoo veld	Gentle	West	1.1	0/8	0.6	South-east	10	36	16	3.7
3 (Spring)	Study area 6	08:25	00:20	1199	Karoo veld	Gentle	East	1.9	0/8	0.6	South-east	9	58	15	2.2
3 (Spring)	Study area 7	08:48	00:42	1352	Drainage lines & alien trees	Flat	None	6.3	0/8	1.2	South-east	9	30	35	8.6
3 (Spring)	Study area 8	09:40	00:30	1165	Drainage lines & alien trees	Flat	None	8	0/8	1.1	South-east	15	39	48	10.6
3 (Spring)	Control area 1	07:15	00:30	1211	Karoo veld	Gentle	South-west	7.7	5/8	3.2	North-east	15	31	35	9.4
3 (Spring)	Control area 2	07:50	00:20	1329	Karoo veld	Gentle	South-west	7.8	5/8	3.5	North-east	9	71	27	2.8
3 (Spring)	Control area 3	08:15	00:15	1884	Karoo veld	Gentle	South	8.5	5/8	4.2	North-east	9	33	15	2.4
3 (Spring)	Control area 4	10:00	00:40	1385	Karoo veld	Gentle	South-west	9	8/8	3.5	North-east	9	24	31	9.2
4 (Early summer)	Study area 1	07:00	00:30	1155	Karoo veld	Flat	None	13.5	0/8	9.5	South	4	37	7	1.6
4 (Early summer)	Study area 2	08:00	00:50	1300	Drainage lines & alien trees	Flat	None	16.2	0/8	3.5	South	7	16	14	6.8

Iteration	Transect	Start Time (hh:mm)	Duration (hh:mm)	Distance (m)	Habitat	Slope gradient	Slope aspect	Temp (°C)	Start cloud cover	Wind strength (m.s ⁻¹)	Wind direction	<i>n</i> species	Mean transect width (m)	<i>n</i> birds	Density (birds.ha ⁻¹)
4 (Early summer)	Study area 3	09:00	00:10	1190	Karoo veld	Gentle	East	20.3	0/8	3.5	South	6	17	8	3.9
4 (Early summer)	Study area 4	08:14	00:16	1243	Karoo veld	Gentle	West	22.3	0/8	2.1	South-east	5	45	12	2.1
4 (Early summer)	Study area 4	6	04:48	1243	Karoo veld	Flat	None	13	7/8	6.2	North	1	200	1	0.0
4 (Early summer)	Study area 5	6.22	02:38	1189	Karoo veld	Flat	None	13	8/8	6.2	North	4	19	11	4.6
4 (Early summer)	Study area 6	6.33	04:04	1199	Karoo veld	Gentle	East	13	8/8	6.5	North	3	40	4	0.8
4 (Early summer)	Study area 7	06:45	00:35	1352	Drainage lines & alien trees	Flat	None	20.3	0/8	0.5	West	11	18	48	19.9
4 (Early summer)	Study area 8	07:30	00:20	1165	Drainage lines & alien trees	Flat	None	24.5	0/8	0.5	West	10	25	21	7.1
4 (Early summer)	Control area 1	06:00	00:34	1211	Karoo veld	Flat	None	17.2	0/8	2.1	East	15	32	41	10.6
4 (Early summer)	Control area 2	06:40	00:12	1329	Karoo veld	Flat	None	18.5	0/8	2.5	East	5	63	10	1.2
4 (Early summer)	Control area 3	07:00	00:14	1884	Karoo veld	Flat	None	20.3	0/8	2.1	East	9	48	12	1.3

Appendix 3. Densities of endemic and near-endemic small terrestrial birds within the Perdekraal development area and in a nearby Control area, derived from walked transect data obtained during four data collection iterations between February and November 2012.

Species	Iteration	Transect	<i>n</i> birds	Mean transect width (m)	Density (birds.ha ⁻¹)
Acacia Pied Barbet	1 (Late summer)	Study area 5	1	2	4.205
		Study area 7	1	2	3.698
	1 (Late summer)	Study area 8	1	35	0.247
	4 (Early summer)	Control area 1	1	14	0.584
White- backed Mousebird	1 (Late summer)	Study area 7	7	5	10.355
		Study area 8	2	34	0.502
	2 (Winter)	Study area 7	1	50	0.148
	3 (Spring)	Study area 2	7	9	6.218
		Study area 8	5	35	1.214
	4 (Early summer)	Study area 7	13	85	1.127
Control area 1		5	10	4.129	
Bokmakierie	1 (Late summer)	Study area 2	3	150	0.154
		Study area 5	1	52	0.162
		Study area 7	2	173	0.085
		Study area 8	1	40	0.215
		Control area 1	1	2	4.129
		Control area 2	1	30	0.251
		Control area 3	1	156	0.034
	2 (Winter)	Study area 7	1	20	0.370
		Study area 8	1	71	0.121
		Control area 1	1	100	0.083
		Control area 3	1	10	0.531
	3 (Spring)	Study area 4	2	2	8.045
		Study area 5	3	2	12.616
		Study area 6	2	35	0.480
		Study area 7	2	2	7.396
		Study area 8	2	35	0.494
		Control area 2	4	171	0.176
		Control area 3	1	17	0.306
		Control area 4	2	2	7.220
	4 (Early summer)	Study area 2	1	2	3.846
		Study area 5	2	2	8.410
		Study area 6	2	60	0.278
		Control area 1	3	22	1.108
		Control area 3	1	14	0.375
Pirit Batis	1 (Late summer)	Study area 7	2	10	1.479
	2 (Winter)	Study area 2	2	19	0.796
		Study area 7	1	7	1.046
Cape Penduline- Tit	1 (Late summer)	Study area 2	2	9	1.776
	2 (Winter)	Control area 4	2	100	0.144
Grey Tit	1 (Late summer)	Study area 8	12	7	14.567
	2 (Winter)	Control area 2	1	2	3.762

Species	Iteration	Transect	<i>n</i> birds	Mean transect width (m)	Density (birds.ha ⁻¹)
	3 (Spring)	Study area 2	1	52	0.148
		Study area 4	1	173	0.046
		Control area 1	1	2	4.129
		Control area 2	1	2	3.762
	4 (Early summer)	Study area 3	2	20	0.840
African Red-eyed Bulbul	1 (Late summer)	Control area 1	4	2	16.515
Fairy Flycatcher	1 (Late summer)	Study area 7	4	8	3.791
		Study area 8	1	10	0.858
	2 (Winter)	Study area 7	1	7	1.046
		Study area 8	2	6	2.676
	3 (Spring)	Study area 2	2	10	1.538
Karoo Eremomela	1 (Late summer)	Control area 2	3	28	0.798
		Control area 3	5	14	1.877
	2 (Winter)	Control area 2	5	10	3.762
	3 (Spring)	Study area 5	2	10	1.682
	4 (Early summer)	Study area 2	1	20	0.385
		Study area 8	2	20	0.858
Control area 1		6	17	2.861	
Layard's Tit-Babbler	2 (Winter)	Study area 2	3	3	8.447
		Study area 7	1	7	1.046
Karoo Prinia	1 (Late summer)	Study area 2	4	11	2.832
		Study area 7	4	8	3.719
		Study area 8	2	12	1.431
		Control area 2	1	35	0.217
	2 (Winter)	Study area 2	1	26	0.296
		Study area 3	1	100	0.084
		Study area 7	1	3	2.615
		Study area 8	3	6	4.552
		Control area 1	2	53	0.311
		Control area 2	1	100	0.075
		Control area 3	1	5	1.019
	3 (Spring)	Study area 1	2	69	0.250
		Study area 2	4	12	2.565
		Study area 3	1	40	0.210
		Study area 4	2	79	0.205
		Study area 5	2	3	4.843
		Study area 6	2	85	0.195
		Study area 7	7	34	1.506
		Study area 8	3	24	1.062
		Control area 1	2	100	0.165
		Control area 2	1	87	0.087
		Control area 3	1	2	2.654
	4 (Early summer)	Study area 1	1	42	0.204
Study area 3		1	17	0.484	
Study area 4		1	200	0.040	

Species	Iteration	Transect	<i>n</i> birds	Mean transect width (m)	Density (birds.ha ⁻¹)	
		Study area 5	1	2	4.205	
		Study area 7	7	7	7.155	
		Study area 8	4	7	5.265	
		Control area 1	2	5	3.098	
		Control area 2	2	112	0.135	
		Control area 3	3	81	0.196	
Rufous-eared Warbler	1 (Late summer)	Study area 1	4	21	1.666	
		Study area 4	2	70	0.230	
		Study area 5	1	2	4.205	
		Study area 6	1	2	4.170	
		Control area 1	1	2	4.129	
		Control area 2	2	30	0.508	
		Control area 3	5	10	2.558	
		Control area 3	1	43	0.123	
	2 (Winter)	Study area 1	1	21	0.422	
		Study area 2	1	10	0.769	
		Control area 2	3	1866	0.012	
		Control area 3	1	15	0.354	
	3 (Spring)	Control area 2	1	10	0.752	
		Control area 4	2	2	7.220	
	4 (Early summer)	Control area 1	1	20	0.413	
		Control area 2	1	10	0.752	
		Control area 3	1	9	0.611	
	Karoo Lark	1 (Late summer)	Study area 1	1	20	0.433
		2 (Winter)	Study area 3	1	50	0.168
Control area 1			1	7	1.168	
3 (Spring)		Study area 4	3	32	0.745	
		Study area 6	1	52	0.161	
		Control area 1	2	14	1.168	
		Control area 3	1	60	0.088	
		Control area 4	1	35	0.208	
4 (Early summer)		Study area 2	7	18	3.050	
		Study area 3	1	20	0.420	
		Study area 4	1	21	0.379	
		Control area 2	1	42	0.177	
		Control area 3	2	17	0.626	
Spike-heeled Lark	1 (Late summer)	Study area 1	2	20	0.866	
	2 (Winter)	Study area 3	6	14	3.565	
	3 (Spring)	Study area 1	5	21	2.110	
Karoo Long-billed Lark	2 (Winter)	Study area 1	1	87	0.100	
		Study area 3	1	21	0.396	
		Control area 3	1	50	0.106	
	3 (Spring)	Study area 6	1	173	0.048	
		Control area 1	1	2	4.129	
		Control area 2	1	200	0.038	
		Control area 3	1	100	0.053	

Species	Iteration	Transect	<i>n</i> birds	Mean transect width (m)	Density (birds.ha ⁻¹)	
	4 (Early summer)	Control area 4	1	2	3.610	
		Study area 2	1	10	0.769	
		Control area 1	1	2	4.129	
		Control area 3	1	20	0.265	
Large-billed Lark	1 (Late summer)	Study area 1	2	53	0.325	
		Study area 4	1	173	0.046	
		Study area 5	1	99	0.085	
		Control area 1	4	19	1.771	
		Control area 3	1	141	0.038	
	2 (Winter)	Study area 1	3	35	0.750	
		Study area 3	2	84	0.201	
		Study area 4	2	2	8.045	
		Control area 1	1	52	0.159	
		Control area 2	3	26	0.868	
		Control area 3	1	52	0.102	
	3 (Spring)	Study area 2	1	17	0.443	
		Study area 4	1	42	0.190	
		Control area 1	1	2	4.129	
		Control area 2	1	100	0.075	
		Control area 3	1	60	0.088	
	4 (Early summer)	Study area 1	1	50	0.173	
		Control area 1	1	2	4.129	
	Fiscal Flycatcher	1 (Late summer)	Study area 5	1	2	4.205
			Study area 7	1	10	0.740
Study area 8			1	10	0.858	
2 (Winter)		Control area 2	1	68	0.110	
Karoo Scrub-Robin		1 (Late summer)	Study area 2	5	11	3.606
	Study area 3		1	34	0.246	
	Study area 7		3	10	2.219	
	Study area 8		3	8	3.389	
	2 (Winter)	Study area 7	1	10	0.740	
		Study area 8	2	12	1.451	
	3 (Spring)	Study area 2	3	30	0.769	
		Study area 3	2	14	1.188	
		Study area 7	6	18	2.521	
		Study area 8	3	84	0.306	
	4 (Early summer)	Study area 5	1	2	4.205	
		Study area 7	4	10	2.864	
		Study area 8	1	9	0.991	
Sickle- winged Chat	1 (Late summer)	Study area 4	1	2	4.023	
		Study area 7	1	9	0.854	
		Study area 8	1	10	0.858	
Karoo Chat	1 (Late summer)	Study area 1	1	20	0.433	
		Study area 2	1	4	1.923	
		Study area 3	1	10	0.840	
		Study area 4	3	27	0.895	
		Study area 6	4	36	0.927	

Species	Iteration	Transect	<i>n</i> birds	Mean transect width (m)	Density (birds.ha ⁻¹)
		Study area 8	1	25	0.343
		Control area 2	1	14	0.532
		Control area 3	2	61	0.174
		Control area 4	1	100	0.072
	2 (Winter)	Study area 1	2	68	0.254
		Study area 3	1	87	0.097
		Study area 7	1	2	3.698
		Control area 2	2	73	0.205
		Control area 4	5	84	0.432
	3 (Spring)	Study area 4	2	2	8.045
		Study area 5	1	17	0.484
		Study area 6	3	25	1.004
		Control area 1	1	20	0.413
		Control area 3	2	36	0.293
		Control area 4	4	101	0.286
		Control area 4	1	40	0.181
	4 (Early summer)	Study area 1	4	40	0.866
		Study area 2	1	50	0.154
		Study area 3	2	20	0.840
		Study area 6	1	2	4.170
Study area 6		1	57	0.147	
Study area 8		1	43	0.198	
Control area 1		1	87	0.095	
Control area 2		1	141	0.053	
Control area 3		1	34	0.155	
Southern Double- collared Sunbird	1 (Late summer)	Study area 7	3	6	3.698
		Study area 8	1	10	0.858
	2 (Winter)	Study area 2	3	15	1.573
		Study area 5	1	2	4.205
		Study area 7	8	10	6.199
		Study area 8	3	17	1.480
		Control area 1	1	10	0.826
	3 (Spring)	Study area 5	1	40	0.210
		Study area 7	6	41	1.087
		Study area 8	1	10	0.858
Control area 1		1	7	1.189	
Dusky Sunbird	1 (Late summer)	Study area 7	2	2	7.396
	2 (Winter)	Study area 5	1	21	0.396
Cape Weaver	1 (Late summer)	Study area 7	1	10	0.740
	2 (Winter)	Study area 7	1	17	0.427
Cape Sparrow	1 (Late summer)	Study area 2	2	10	1.538
		Study area 7	6	16	2.804
		Study area 8	11	37	2.528
		Control area 2	3	53	0.430
	2 (Winter)	Study area 7	4	15	1.972
		Study area 8	6	26	2.004
Control area 1		15	20	6.193	

Species	Iteration	Transect	<i>n</i> birds	Mean transect width (m)	Density (birds.ha ⁻¹)	
	3 (Spring)	Study area 2	2	40	0.385	
		Study area 5	2	40	0.421	
		Study area 8	5	35	1.214	
		Control area 1	12	29	3.457	
	4 (Early summer)	Study area 7	8	16	3.676	
		Control area 1	3	30	0.826	
Black-headed Canary	3 (Spring)	Study area 2	2	6	2.564	
		Study area 3	1	10	0.840	
		Study area 4	3	141	0.171	
		Study area 6	3	60	0.417	
		Study area 8	5	35	1.214	
Black-throated Canary	1 (Late summer)	Study area 8	1	9	0.991	
Yellow Canary	1 (Late summer)	Study area 1	1	35	0.250	
		Study area 2	16	23	5.427	
		Control area 1	25	68	3.031	
		Control area 2	15	43	2.607	
	2 (Winter)	Study area 3	3	20	1.261	
		Control area 2	3	22	1.021	
	3 (Spring)	Study area 1	6	87	0.600	
		Study area 2	5	12	3.186	
		Study area 4	4	63	0.511	
		Control area 1	5	20	2.064	
		Control area 2	12	20	4.487	
	4 (Early summer)	Control area 4	10	2	36.101	
Study area 4		3	20	1.207		
White-throated Canary	1 (Late summer)	Control area 4	1	10	0.722	
		2 (Winter)	Study area 2	1	10	0.769
			Study area 8	1	30	0.286
			Control area 1	1	14	0.584
			Control area 2	1	10	0.752
	3 (Spring)	Control area 3	1	26	0.204	
		Study area 2	1	40	0.192	
	4 (Early summer)	Study area 8	1	20	0.429	
		Study area 4	6	19	2.557	
	Cape Bunting	1 (Late summer)	Study area 8	6	14	3.589
			Study area 1	4	47	0.736
Study area 2			5	30	1.282	
Study area 3			1	20	0.420	
Study area 5			1	2	4.205	
Control area 1			5	51	0.810	
Control area 2			4	49	0.616	
Control area 3		1	3	1.877		
2 (Winter)	Control area 4	2	9	1.667		
		Study area 1	1	60	0.144	

Species	Iteration	Transect	<i>n</i> birds	Mean transect width (m)	Density (birds.ha ⁻¹)
		Study area 2	1	5	1.538
		Study area 6	2	14	1.219
		Study area 7	2	2	7.396
		Control area 1	4	19	1.738
		Control area 3	5	25	1.072
		Control area 4	2	71	0.203
	3 (Spring)	Study area 1	1	100	0.087
		Study area 5	1	71	0.119
		Study area 6	1	40	0.209
		Study area 7	1	2	3.698
		Control area 1	1	10	0.826
		Control area 3	2	26	0.415
	4 (Early summer)	Study area 2	2	2	7.692
		Study area 3	1	20	0.420
		Control area 1	1	100	0.083
		Control area 3	1	87	0.061

Appendix 4. Results of transect surveys of large terrestrial birds and raptors, driven through the Perdekraal development area, and through a nearby Control area, on each of four data collection iterations conducted between February and November 2012.

Iteration	Transect	Transect length (km)	Species	Time	<i>n</i> birds	Habitat	Gradient of slope	Aspect of slope	Activity	Flight direction	Flying height	Mean transect width (km)	Density of (birds.km ⁻²)
1 (Late summer)	Control area 1	14	Rock Kestrel	09:45:18	1	Karoo veld	Flat	None	Flying - hunting	None	< 30m	0.002	142.86
2 (Winter)	Study area 1	22	Greater Kestrel	14:47:46	2	Karoo veld	Flat	None	Flushed	None	30 - 150m	0.040	2.27
			Rock Kestrel	14:32:30	1	Karoo veld	Flat	None	Flying - soaring	None	30 - 150m	0.400	0.11
			Pied Crow	14:29:54	1	Karoo veld	Flat	None	Flushed	South-east	< 30m	0.400	0.11
			Southern Pale Chanting Goshawk	16:11:32	1	Karoo veld	Flat	None	Perched - foraging	None	None	1.400	0.23
	Control area 1	14	Egyptian Goose	11:16:58	2	Karoo veld	Flat	None	Flying - commute	None	< 30m	0.040	3.57
			Black-chested Snake-Eagle	11:11:09	1	Karoo veld	Flat	None	Perched - foraging	None	< 30m	0.103	0.70
			Black Harrier	12:47:35	2	Karoo veld	Flat	None	Flying - display	North	30 - 150m	0.002	142.86
			Jackal Buzzard	12:37:38	1	Cliffs, screes and cuttings	Gentle	North-west	Flushed	West	< 30m	0.200	0.71
			Martial Eagle	11:52:44	1	Karoo veld	Flat	None	Perched - foraging	None	None	0.002	35.71
			Secretarybird	12:54:39	2	Karoo veld	Flat	None	Flushed	South	30 - 150m	0.250	0.29

Iteration	Transect	Transect length (km)	Species	Time	<i>n</i> birds	Habitat	Gradient of slope	Aspect of slope	Activity	Flight direction	Flying height	Mean transect width (km)	Density of (birds.km ⁻²)	
			Rock Kestrel	12:09:56	1	Karoo veld	Flat	None	Perched - foraging	None	None	0.020	7.14	
3 (Spring)	Study area 1	24	Black Harrier	15:13:34	1	Karoo veld	Flat	None	Flying - hunting	None	< 30m	0.002	20.83	
			Jackal Buzzard	15:54:48	1	Karoo veld	Flat	None	Flying - soaring	None	< 30m	2.598	0.02	
			Greater Kestrel	14:49:22	1	Karoo veld	Flat	None	Flushed	None	< 30m	0.040	1.04	
			Rock Kestrel	14:31:46	1	Karoo veld	Flat	None	Flushed	None	< 30m	0.007	11.79	
			Peregrine Falcon	16:07:10	1	Karoo veld	Gentle	North	At nest	None	None	0.002	20.83	
			Pied Crow	14:52:22	1	Karoo veld	Flat	None	Flushed	None	< 30m	0.002	41.67	
			Pied Crow	15:53:58	1	Karoo veld	Flat	None	Flying - commute	None	< 30m	1.000	0.04	
			Southern Pale Chanting Goshawk	14:20:38	2	Karoo veld	Flat	None	Flushed	None	< 30m	1.600	0.03	
			Ludwig's Bustard	14:12:15	1	Karoo veld	Flat	None	Flying - commute	East	< 30m	0.002	20.83	
		Control area 1		Black Harrier	10:16:28	1	Karoo veld	Flat	None	Flying - hunting	None	< 30m	0.002	35.71
			Secretarybird	10:10:23	1	Karoo veld	Flat	None	Walking	None	None	0.866	0.08	
			Greater Kestrel	11:58:29	1	Karoo veld	Flat	None	Perched - foraging	None	None	0.100	0.71	
			Rock Kestrel	10:23:43	1	Karoo veld	Flat	None	Perched - foraging	None	None	1.039	0.07	

Iteration	Transect	Transect length (km)	Species	Time	<i>n</i> birds	Habitat	Gradient of slope	Aspect of slope	Activity	Flight direction	Flying height	Mean transect width (km)	Density of (birds.km ⁻²)
			Pied Crow	12:05:13	2	Karoo veld	Flat	None	Flying - commute	North-west	< 30m	0.433	0.33
			White-necked Raven	10:58:53	1	Karoo veld	Flat	None	Perched - calling	None	None	0.002	35.71
			Southern Pale Chanting Goshawk	12:03:34	1	Karoo veld	Flat	None	Flushed	West	< 30m	0.400	0.18
4 (Early summer)	Study area 1	24	Steppe Buzzard	11:22:36	1	Drainage lines & alien trees	Flat	None	Flying - soaring	None	< 30m	0.002	20.83
			Jackal Buzzard	10:01:54	1	Karoo veld	Flat	None	Flying - soaring	North	30 - 150m	0.684	0.06
			Booted Eagle	11:13:25	2	Drainage lines & alien trees	Flat	None	Flying - soaring	None	< 30m	0.520	0.08
			Greater Kestrel	12:19:30	1	Karoo veld	Gentle	East	Flushed	None	< 30m	0.200	0.42
			Rock Kestrel	10:43:48	1	Karoo veld	Flat	None	Flushed	None	< 30m	0.002	41.67
			Lanner Falcon	12:21:54	1	Karoo veld	Gentle	East	Flying - soaring	North-west	30 - 150m	0.173	0.24
			Peregrine Falcon	10:55:15	1	Karoo veld	Flat	None	Flushed	None	< 30m	0.002	20.83
			Pied Crow	10:58:11	1	Karoo veld	Flat	None	Flying - soaring	West	< 30m	2.121	0.08

Iteration	Transect	Transect length (km)	Species	Time	<i>n</i> birds	Habitat	Gradient of slope	Aspect of slope	Activity	Flight direction	Flying height	Mean transect width (km)	Density of (birds.km ⁻²)
			Southern Pale Chanting Goshawk	10:32:54	1	Drainage lines & alien trees	Flat	None	Perched - foraging	None	None	0.002	83.33
	Control area 1	13	Black Harrier	17:59:39	1	Karoo veld	Flat	None	Flushed	None	< 30m	0.500	0.31
			Booted Eagle	17:57:37	1	Karoo veld	Flat	None	Flushed	None	< 30m	0.400	0.19
			Pied Crow	18:25:10	2	Cliffs, screes and cuttings	Steep	South	Flying - soaring	South	> 150m	0.002	38.46

Appendix 5. Details of incidental sightings of priority species in and around the Perdekraal development area, during site visits made between February and November 2012.

Species	Date	Time	<i>n</i> birds	Activity	Flight direction	Flying height	Cloud cover	Wind strength (m.s ⁻¹)	Wind direction	Visibility	Dominant habitat	Slope gradient	Slope aspect
Southern Pale Chanting Goshawk	2012/01/30	12:13:23	1	Flushed	North-east	< 30m	6/8	4.50	North	Good	Karoo veld	Flat	None
Lanner Falcon	2012/01/30	13:18:56	2	Flying - soaring	South	30 - 150m	6/8	3.10	North	Good	Karoo veld	Flat	None
Rock Kestrel	2012/01/30	14:09:50	2	Flushed	None	< 30m	7/8	3.10	North	Good	Karoo veld	Gentle	South-east
Greater Kestrel	2012/01/30	14:22:00	2	Flushed	South	< 30m	5/8	3.10	North	Good	Karoo veld	Gentle	South-east
Martial Eagle	2012/01/30	15:45:21	1	Flushed	None	< 30m	7/8	1.60	North	Good	Karoo veld	Flat	None
Steppe Buzzard	2012/01/30	16:09:33	1	Flushed	None	< 30m	7/8	0.00	None	Good	Karoo veld	Flat	None
Steppe Buzzard	2012/01/30	16:12:07	1	Perched - foraging	None	< 30m	7/8	0.00	None	Good	Karoo veld	Flat	None
Ludwig's Bustard	2012/01/30	16:58:22	1	Walking	None	None	7/8	0.00	None	Good	Karoo veld	Flat	None
Jackal Buzzard	2012/01/31	07:14:34	1	Perched - foraging	None	< 30m	2/8	1.20	East	Good	Karoo veld	Gentle	East
Martial Eagle	2012/01/31	07:17:21	1	Flushed	None	< 30m	2/8	1.20	None	Good	Karoo veld	Gentle	East
Jackal Buzzard	2012/01/31	07:26:07	2	Perched - foraging	None	< 30m	2/8	1.20	None	Good	Karoo veld	Gentle	South-west
Martial Eagle	2012/01/31	08:40:47	1	Flushed	None	< 30m	2/8	2.30	South	Good	Karoo veld	Flat	None
Southern Pale Chanting Goshawk	2012/01/31	09:32:37	2	Flushed	None	None	2/8	2.50	South	Good	Karoo veld	Flat	None
Greater Kestrel	2012/01/31	09:33:34	2	Flushed	None	None	2/8	2.50	South	Good	Karoo veld	Flat	None
Southern Pale Chanting Goshawk	2012/01/31	09:42:47	1	Perched - foraging	None	None	2/8	2.50	South	Good	Karoo veld	Flat	None

Species	Date	Time	<i>n</i> birds	Activity	Flight direction	Flying height	Cloud cover	Wind strength (m.s ⁻¹)	Wind direction	Visibility	Dominant habitat	Slope gradient	Slope aspect
Southern Pale Chanting Goshawk	2012/01/31	10:17:28	1	Perched - foraging	None	None	2/8	0.90	South-east	Good	Karoo veld	Flat	None
Rock Kestrel	2012/01/31	10:36:59	1	Flushed	None	None	2/8	2.00	South-east	Good	Karoo veld	Flat	None
Southern Pale Chanting Goshawk	2012/01/31	10:52:35	1	Flushed	None	None	2/8	2.00	South-east	Good	Karoo veld	Flat	None
Rock Kestrel	2012/01/31	11:34:52	1	Flying - hunting	None	< 30m	5/8	2.00	South-east	Good	Karoo veld	Flat	None
Southern Pale Chanting Goshawk	2012/01/31	11:42:26	1	Flushed	None	< 30m	7/8	1.50	South	Good	Karoo veld	Gentle	North-east
Southern Pale Chanting Goshawk	2012/02/15	17:07:05	1	Flushed	None	< 30m	0/8	1.80	South-east	Good	Karoo veld	Flat	None
Greater Kestrel	2012/02/15	17:23:09	2	Flying - display	None	< 30m	0/8	1.80	South-east	Good	Karoo veld	Flat	None
Black-shouldered Kite	2012/02/23	17:24:42	1		North-west	< 30m		2.50	North-west	Good	Drainage lines & alien trees	Flat	None
Southern Pale Chanting Goshawk	2012/02/24	08:31:59	1	Perched - foraging	None	None	0/8	2.80	South-east	Good	Karoo veld	Flat	None
Southern Pale Chanting Goshawk	2012/02/24	08:34:48	1	Perched - foraging	None	None	0/8	2.50	South-east	Good	Karoo veld	Flat	None
Black Harrier	2012/02/24	09:03:59	1	Flying - hunting	North-west	< 30m	0/8	2.20	South-east	Good	Karoo veld	Flat	None
Southern Pale Chanting Goshawk	2012/02/24	09:05:28	1	Perched - foraging	None	None	0/8	2.30	South-east	Good	Karoo veld	Flat	None
Rock Kestrel	2012/02/24	19:20:36	1		None	< 30m		2.50	South	Good	Karoo veld	Flat	None
Spotted Eagle-Owl	2012/02/24	20:31:03	1	Flushed	None	None	0/8	4.00	South	Poor	Karoo veld	Flat	None
Karoo Korhaan	2012/02/25	06:22:25	2	Flushed	North-east	< 30m	0/8	2.50	North-west	Good	Karoo veld	Flat	None
Greater Kestrel	2012/02/25	06:23:49	1	Perched - foraging	None	None	0/8	2.50	North-west	Good	Karoo veld	Flat	None

Species	Date	Time	<i>n</i> birds	Activity	Flight direction	Flying height	Cloud cover	Wind strength (m.s ⁻¹)	Wind direction	Visibility	Dominant habitat	Slope gradient	Slope aspect
Steppe Buzzard	2012/02/25	06:28:23	1	Perched - foraging	None	None	0/8	2.50	North- west	Good	Karoo veld	Flat	None
Southern Pale Chanting Goshawk	2012/02/25	06:29:00	2	Perched - foraging	None	None	0/8	2.50	North- west	Good	Karoo veld	Flat	None
Rock Kestrel	2012/02/25	06:45:36	1	Flushed	None	< 30m	0/8	0.00	North- west	Good	Karoo veld	Flat	None
Southern Pale Chanting Goshawk	2012/02/25	06:46:36	2	Flushed	None	< 30m	0/8	0.00	North- west	Good	Karoo veld	Flat	None
Greater Kestrel	2012/02/25	06:47:25	1	Flushed	None	< 30m	0/8	0.00	North- west	Good	Karoo veld	Flat	None
Jackal Buzzard	2012/02/25	06:48:49	1	Flushed	None	None	0/8	1.30	North- west	Good	Karoo veld	Flat	None
Greater Kestrel	2012/02/25	08:19:51	2		None	None		0.30	South	Good	Karoo veld	Gentle	North- west
Southern Pale Chanting Goshawk	2012/02/25	11:36:32	2	Flushed	None	< 30m	0/8	2.00	South- east	Good	Karoo veld	Flat	None
Black-chested Snake-Eagle	2012/02/25	11:55:32	1	Flushed	None	30 - 150m	0/8	2.00	South- east	Good	Karoo veld	Flat	None
Southern Pale Chanting Goshawk	2012/02/25	12:12:38	1	Perched - foraging	None	None	0/8	0.00	None	Good	Karoo veld	Flat	None
Rock Kestrel	2012/02/27	13:35:24	2	Flushed	None	< 30m	0/8	1.10	South- east	Good	Karoo veld	Flat	None
Greater Kestrel	2012/02/27	13:37:43	2		None	None		9.80	South- east	Good	Karoo veld	Flat	None
Spotted Eagle-Owl	2012/02/27	20:27:24	1	Flushed	None	None	0/8	1.20	South- east	Good	Karoo veld	Flat	None
Greater Kestrel	2012/02/28	06:51:25	2	Flushed	None	None	1/8	0.50	North- east	Good	Karoo veld	Flat	None
Spotted Eagle-Owl	2012/02/28	09:31:23	1	Flushed	North	< 30m	1/8	1.50	North- west	Good	Drainage lines & alien trees	Flat	None

Species	Date	Time	<i>n</i> birds	Activity	Flight direction	Flying height	Cloud cover	Wind strength (m.s ⁻¹)	Wind direction	Visibility	Dominant habitat	Slope gradient	Slope aspect
Southern Pale Chanting Goshawk	2012/02/28	14:40:45	2	Flying - commute	North	< 30m	1/8	7.60	North-west	Good	Drainage lines & alien trees	Flat	None
Greater Kestrel	2012/02/28	17:06:32	2	Perched - foraging	None	None	2/8	7.60	North-west	Good	Karoo veld	Flat	None
Southern Pale Chanting Goshawk	2012/02/28	17:12:30	2	Perched - foraging	None	None	1/8	0.00	North-west	Good	Karoo veld	Flat	None
Rock Kestrel	2012/05/30	10:49:27	1		None	None		1.90	East	Good	Drainage lines & alien trees	Flat	None
Secretarybird	2012/05/30	17:01:18	2		None	None		2.10	North-east	Good	Karoo veld	Flat	None
Southern Pale Chanting Goshawk	2012/06/01	10:53:48	2	Perched - foraging	None	None	0/8	1.00	South-east	Good	Karoo veld	Flat	None
Greater Kestrel	2012/06/02	11:10:21	2		South	< 30m		1.60	South-east	Good	Karoo veld	Flat	None
Secretarybird	2012/06/02	13:43:34	2	Walking	None	None	0/8	1.90	South-east	Good	Karoo veld	Flat	None
Southern Pale Chanting Goshawk	2012/06/02	13:59:06	2	Flushed	South	< 30m	0/8	2.10	South-east	Good	Karoo veld	Flat	None
Karoo Korhaan	2012/06/02	16:37:27	3	Walking	None	< 30m	0/8	4.50	South-east	Good	Dams & ephemeral waterbodies	Flat	None
Southern Pale Chanting Goshawk	2012/06/03	08:42:46	1		None	None		2.30	South-east	Good	Karoo veld	Flat	None
Ludwig's Bustard	2012/08/21	17:06:24	1		None	None		2.30	North-west	Good	Karoo veld	Flat	None
Southern Pale Chanting Goshawk	2012/08/21	17:56:28	2		None	None		1.20	North-west	Good	Karoo veld	Flat	None
Karoo Korhaan	2012/08/22	08:33:40	2		None	None		2.30	South-west	Good	Karoo veld	Flat	None

Species	Date	Time	<i>n</i> birds	Activity	Flight direction	Flying height	Cloud cover	Wind strength (m.s ⁻¹)	Wind direction	Visibility	Dominant habitat	Slope gradient	Slope aspect
Rock Kestrel	2012/08/22	09:03:15	1		None	None		2.30	South- west	Good	Drainage lines & alien trees	Flat	None
Black-shouldered Kite	2012/08/22	09:11:09	1		None	None		2.30	South- west	Good	Drainage lines & alien trees	Flat	None
Southern Pale Chanting Goshawk	2012/08/22	13:27:34	2		South- east	< 30m		1.10	North	Good	Drainage lines & alien trees	Flat	None
Greater Kestrel	2012/08/23	13:27:08	1		North- west	< 30m		1.20	North	Good	Karoo veld	Flat	None
Greater Kestrel	2012/08/23	14:40:21	1		East	< 30m		3.50	North	Good	Karoo veld	Gentle	West
Southern Pale Chanting Goshawk	2012/08/25	10:45:15	1		None	None		9.00	North- east	Good	Drainage lines & alien trees	Flat	None
Spotted Eagle-Owl	2012/08/25	17:14:25	1	Flushed	West	< 30m	8/8	7.00	North	Good	Drainage lines & alien trees	Flat	None
Greater Kestrel	2012/08/26	10:27:33	1		None	< 30m		3.50	North- east	Good	Karoo veld	Flat	None
Black Harrier	2012/11/20	05:50:30	1	Flying - hunting	East	< 30m	0/8	0.40	West	Good	Karoo veld	Flat	None
Black-chested Snake-Eagle	2012/11/20	05:52:35	1	Perched - foraging	None	None	0/8	0.40	West	Good	Karoo veld	Flat	None
Rock Kestrel	2012/11/20	05:54:47	1	Perched - foraging	None	None	0/8	0.40	West	Good	Karoo veld	Flat	None
Black-shouldered Kite	2012/11/20	05:56:41	1		None	None		3.50	West	Good	Drainage lines & alien trees	Flat	None

Species	Date	Time	<i>n</i> birds	Activity	Flight direction	Flying height	Cloud cover	Wind strength (m.s ⁻¹)	Wind direction	Visibility	Dominant habitat	Slope gradient	Slope aspect
Southern Pale Chanting Goshawk	2012/11/20	09:21:55	3		None	< 30m		2.50	North	Good	Drainage lines & alien trees	Flat	None
Spotted Eagle-Owl	2012/11/22	09:18:11	2	Flushed	North	< 30m	0/8	3.50	South- east	Good	Drainage lines & alien trees	Flat	None
Rock Kestrel	2012/11/22	18:36:15	1		None	None		7.10	South- east	Good	Karoo veld	Flat	None
Greater Kestrel	2012/11/23	08:27:20	1	At nest	None	None	0/8	2.30	South- east	Good	Karoo veld	Flat	None
Greater Kestrel	2012/11/23	08:32:13	1	Perched - foraging	None	None	0/8	1.60	South- east	Good	Karoo veld	Flat	None
Rock Kestrel	2012/11/23	08:37:23	1	Perched - foraging	None	None	0/8	2.20	South- east	Good	Karoo veld	Flat	None
Rock Kestrel	2012/11/23	17:06:52	1	Flying - hunting	None	< 30m	0/8	5.70	North- east	Good	Karoo veld	Flat	None
Southern Pale Chanting Goshawk	2012/11/23	17:12:48	1	Flushed	None	< 30m	1/8	5.70	North- east	Good	Karoo veld	Flat	None
Rock Kestrel	2012/11/23	17:18:00	1	Flushed	None	< 30m	1/8	5.70	North- east	Good	Karoo veld	Flat	None
Black Harrier	2012/11/23	17:19:51	1	Flushed	East	< 30m	0/8	5.50	North	Good	Karoo veld	Flat	None

Appendix 6. Results of counts of wetland birds conducted at selected sites within the Perdekraal development area, and in a nearby control area, between February and November 2012.

Iteration	Wetland site	Species	<i>n</i> birds
1 (Late summer)	Study area 1	Egyptian Goose	2
		South African Shelduck	9
		Cape Teal	18
		Yellow-billed Duck	5
		Red-billed Teal	2
		Three-banded Plover	4
		Little Grebe	2
		ALL	42
2 (Winter)	Study area 1	Egyptian Goose	2
		South African Shelduck	2
		Black-winged Stilt	1
		Pied Avocet	3
		ALL	8
	Control area 1	Egyptian Goose	2
	ALL	2	
3 (Spring)	Study area 1	Egyptian Goose	4
		Pied Avocet	2
		Kittlitz's Plover	2
		ALL	8
	Control area 1	South African Shelduck	2
		Black-winged Stilt	1
		Pied Avocet	2
		ALL	5
4 (Early summer)	Study area 1	Pied Avocet	5
		ALL	5

Appendix 7. Counts of birds overflying selected vantage points in the Perdekraal development area, and vantage points in a nearby control area, obtained over four data collection iterations between February and November 2012. Data presented are for birds seen flying <150 m above the surrounding terrain only – i.e. those flying within or below the rotor sweep height of the wind turbines.

Iteration	Vantage point	Date	Time	Species	Wind strength (m.s ⁻¹)	Wind direction	Underlying habitat	Gradient of underlying slope	Aspect of underlying slope	Flight mode	Sighting distance (m)	Flight direction	Flying height	<i>n</i> birds
1 (Early summer)	Study area 1	2012/02/22	17:13:15	Alpine Swift	9.7	North	Karoo veld	Flat	None	Direct commute flapping		North	< 30m	1
1 (Early summer)	Study area 1	2012/02/22	15:41:36	Southern Pale Chanting Goshawk	9.6	North	Karoo veld	Flat	None	Direct commute flapping		West	< 30m	1
1 (Early summer)	Study area 1	2012/02/28	09:32:10	Southern Pale Chanting Goshawk	0.3	North-east	Karoo veld	Flat	None	Direct commute flapping		East	< 30m	2
1 (Early summer)	Study area 1	2012/02/28	10:43:27	Southern Pale Chanting Goshawk	3.2	North-west	Karoo veld	Flat	None	Thermaling		None	30 - 150m	2
1 (Early summer)	Study area 1	2012/02/28	10:49:48	Southern Pale Chanting Goshawk	3.2	North-west	Karoo veld	Flat	None	Displaying		South	30 - 150m	1
1 (Early summer)	Study area 1	2012/02/22	14:52:53	Barn Swallow	0.0	North	Karoo veld	Flat	None	Direct commute flapping		None	< 30m	2
1 (Early summer)	Study area 1	2012/02/22	15:23:17	Barn Swallow	0.0	North	Karoo veld	Flat	None	Direct commute flapping		East	< 30m	2

Iteration	Vantage point	Date	Time	Species	Wind strength (m.s ⁻¹)	Wind direction	Underlying habitat	Gradient of underlying slope	Aspect of underlying slope	Flight mode	Sighting distance (m)	Flight direction	Flying height	<i>n</i> birds
1 (Early summer)	Study area 1	2012/02/22	16:02:38	Barn Swallow	0.0	North	Karoo veld	Flat	None	Direct commute flapping		North-west	30 - 150m	1
1 (Early summer)	Study area 1	2012/02/22	16:53:30	Barn Swallow	0.0	North	Karoo veld	Flat	None	Direct commute flapping		North	< 30m	1
1 (Early summer)	Study area 1	2012/02/22	18:53:15	Barn Swallow	9.8	North-west	Karoo veld	Flat	None	Direct commute flapping		South-east	< 30m	7
1 (Early summer)	Study area 1	2012/02/28	08:54:22	Barn Swallow	0.3	North-east	Karoo veld	Flat	None	Direct commute flapping		None	< 30m	1
1 (Early summer)	Study area 1	2012/02/28	08:57:53	Barn Swallow	0.3	North-east	Karoo veld	Gentle	East	Direct commute flapping		None	< 30m	1
1 (Early summer)	Study area 1	2012/02/28	09:34:46	Barn Swallow	0.3	North-east	Karoo veld	Gentle	East	Direct commute flapping		West	< 30m	1
1 (Early summer)	Study area 2	2012/02/29	09:24:30	Greater Kestrel	3.2	South	Karoo veld	Gentle	South	Direct commute gliding		North	< 30m	1
1 (Early summer)	Study area 2	2012/02/29	10:50:32	Greater Kestrel	3.7	South-east	Karoo veld	Gentle	South	Slope soaring		North	< 30m	1
1 (Early summer)	Study area 2	2012/02/29	12:16:08	Greater Kestrel	3.5	South-east	Karoo veld	Gentle	West	Direct commute flapping		East	< 30m	1
1 (Early summer)	Study area 2	2012/02/29	07:20:25	Southern Pale Chanting Goshawk	3.1	South-east	Karoo veld	Gentle	South-west	Direct commute flapping		North-east	< 30m	1

Iteration	Vantage point	Date	Time	Species	Wind strength (m.s ⁻¹)	Wind direction	Underlying habitat	Gradient of underlying slope	Aspect of underlying slope	Flight mode	Sighting distance (m)	Flight direction	Flying height	<i>n</i> birds
1 (Early summer)	Study area 2	2012/02/29	10:10:16	Southern Pale Chanting Goshawk	3.5	South-east	Drainage lines & alien trees	Flat	None	Direct commute flapping		North	< 30m	1
1 (Early summer)	Study area 2	2012/02/29	12:46:14	Jackal Buzzard	1.1	South-east	Karoo veld	Gentle	East	Direct commute gliding		None	30 - 150m	1
1 (Early summer)	Study area 2	2012/02/29	11:08:48	White-necked Raven	2.1	South-east	Karoo veld	Gentle	East	Direct commute flapping		South	30 - 150m	2
1 (Early summer)	Study area 2	2012/02/27	15:19:20	Barn Swallow	2.2	North-west	Karoo veld	Flat	None	Other		None	30 - 150m	7
1 (Early summer)	Study area 2	2012/02/27	16:59:31	Barn Swallow	4.9	North-west	Karoo veld	Gentle	North	Direct commute flapping		None	30 - 150m	3
1 (Early summer)	Study area 2	2012/02/29	08:38:46	Barn Swallow	3.1	South-east	Karoo veld	Gentle	South-west	Direct commute gliding		None	< 30m	5
1 (Early summer)	Study area 3	2012/02/23	08:18:12	Namaqua Sandgrouse	0.6	East	Karoo veld	Flat	None	Direct commute flapping		None	< 30m	1
1 (Early summer)	Study area 3	2012/02/23	17:18:08	Namaqua Sandgrouse	2.5	North-west	Karoo veld	Flat	None	Direct commute flapping		North-east	30 - 150m	3
1 (Early summer)	Study area 3	2012/02/23	18:43:17	Namaqua Sandgrouse	2.6	North-west	Karoo veld	Flat	None	Direct commute flapping		South-east	30 - 150m	1
1 (Early summer)	Study area 3	2012/02/23	19:17:09	Namaqua Sandgrouse	2.5	North-west	Karoo veld	Flat	None	Direct commute flapping		East	< 30m	8

Iteration	Vantage point	Date	Time	Species	Wind strength (m.s ⁻¹)	Wind direction	Underlying habitat	Gradient of underlying slope	Aspect of underlying slope	Flight mode	Sighting distance (m)	Flight direction	Flying height	<i>n</i> birds
1 (Early summer)	Study area 3	2012/02/23	08:00:33	Black-shouldered Kite	0.6	East	Drainage lines & alien trees	Flat	None	Actively hunting		None	< 30m	1
1 (Early summer)	Study area 3	2012/02/23	17:24:42	Black-shouldered Kite	2.5	North-west	Drainage lines & alien trees	Flat	None	Direct commute flapping		North-west	< 30m	1
1 (Early summer)	Study area 3	2012/02/23	18:05:08	Black-shouldered Kite	2.5	North-west	Drainage lines & alien trees	Flat	None	Actively hunting		South-west	< 30m	1
1 (Early summer)	Study area 3	2012/02/23	10:43:54	Southern Pale Chanting Goshawk	2.6	South-east	Drainage lines & alien trees	Flat	None	Direct commute gliding		West	< 30m	1
1 (Early summer)	Study area 3	2012/02/23	14:46:52	Southern Pale Chanting Goshawk	2.3	North-west	Drainage lines & alien trees	Flat	None	Thermaling		East	< 30m	2
1 (Early summer)	Study area 3	2012/02/23	16:54:08	Southern Pale Chanting Goshawk	2.0	North	Drainage lines & alien trees	Flat	None	Direct commute flapping		North-west	< 30m	1
1 (Early summer)	Study area 3	2012/02/23	07:59:29	Steppe Buzzard	0.6	East	Karoo veld	Flat	None	Direct commute flapping		None	< 30m	1
1 (Early summer)	Study area 3	2012/02/23	09:25:22	Steppe Buzzard	0.6	East	Drainage lines & alien trees	Flat	None	Direct commute gliding		None	< 30m	1
1 (Early summer)	Study area 3	2012/02/23	09:38:36	Steppe Buzzard	2.3	South-east	Drainage lines & alien trees	Flat	None	Thermaling		East	30 - 150m	1

Iteration	Vantage point	Date	Time	Species	Wind strength (m.s ⁻¹)	Wind direction	Underlying habitat	Gradient of underlying slope	Aspect of underlying slope	Flight mode	Sighting distance (m)	Flight direction	Flying height	<i>n</i> birds
1 (Early summer)	Study area 3	2012/02/23	08:55:32	Booted Eagle	0.6	East	Drainage lines & alien trees	Flat	None	Direct commute flapping		None	< 30m	1
1 (Early summer)	Study area 3	2012/02/23	09:14:33	Booted Eagle	0.6	East	Drainage lines & alien trees	Flat	None	Actively hunting		None	30 - 150m	1
1 (Early summer)	Study area 3	2012/02/23	09:14:56	Booted Eagle	0.6	East	Drainage lines & alien trees	Flat	None	Actively hunting		None	< 30m	1
1 (Early summer)	Study area 3	2012/02/23	10:16:22	Booted Eagle	3.0	South-east	Karoo veld	Flat	None	Thermaling		North-west	30 - 150m	1
1 (Early summer)	Study area 3	2012/02/23	10:25:35	Booted Eagle	3.0	South-east	Karoo veld	Flat	None	Direct commute gliding		East	< 30m	1
1 (Early summer)	Study area 3	2012/02/23	11:01:13	Booted Eagle	2.3	South-east	Karoo veld	Flat	None	Direct commute gliding		West	30 - 150m	1
1 (Early summer)	Study area 3	2012/02/23	14:45:45	Booted Eagle	2.3	South-east	Drainage lines & alien trees	Flat	None	Thermaling		None	30 - 150m	1
1 (Early summer)	Study area 3	2012/02/23	16:53:35	Martial Eagle	2.0	North	Karoo veld	Flat	None	Thermaling		North	30 - 150m	1
1 (Early summer)	Study area 3	2012/02/23	10:54:38	White-necked Raven	2.3	South-east	Karoo veld	Flat	None	Direct commute gliding		South-east	30 - 150m	2
1 (Early summer)	Study area 3	2012/02/23	08:04:03	Barn Swallow	0.6	East	Drainage lines & alien trees	Flat	None	Direct commute flapping		West	< 30m	1
1 (Early summer)	Study area 3	2012/02/23	08:06:27	Barn Swallow	0.6	East	Drainage lines & alien trees	Flat	None	Direct commute flapping		West	< 30m	1

Iteration	Vantage point	Date	Time	Species	Wind strength (m.s ⁻¹)	Wind direction	Underlying habitat	Gradient of underlying slope	Aspect of underlying slope	Flight mode	Sighting distance (m)	Flight direction	Flying height	<i>n</i> birds
1 (Early summer)	Study area 3	2012/02/23	08:42:25	Barn Swallow	0.6	East	Karoo veld	Flat	None	Direct commute flapping		North	< 30m	2
1 (Early summer)	Study area 3	2012/02/23	09:01:52	Barn Swallow	0.6	East	Drainage lines & alien trees	Flat	None	Direct commute flapping		None	< 30m	8
1 (Early summer)	Study area 3	2012/02/23	09:05:15	Barn Swallow	0.6	East	Drainage lines & alien trees	Flat	None	Direct commute flapping		None	< 30m	8
1 (Early summer)	Study area 3	2012/02/23	11:37:16	Barn Swallow	2.3	South-east	Karoo veld	Flat	None	Direct commute flapping		East	< 30m	1
1 (Early summer)	Study area 3	2012/02/23	14:33:05	Barn Swallow	2.3	South-east	Karoo veld	Flat	None	Direct commute flapping		East	< 30m	7
1 (Early summer)	Study area 3	2012/02/23	15:43:06	Barn Swallow	2.3	North-west	Drainage lines & alien trees	Flat	None	Other		None	< 30m	10
1 (Early summer)	Study area 3	2012/02/23	16:25:49	Barn Swallow	2.1	South-east	Drainage lines & alien trees	Flat	None	Other		None	< 30m	35
1 (Early summer)	Study area 3	2012/02/23	18:08:06	Barn Swallow	2.5	North-west	Karoo veld	Gentle	South-west	Direct commute flapping		None	< 30m	11
1 (Early summer)	Control area 1	2012/02/24	11:02:10	Rock Kestrel	1.5	South-west	Karoo veld	Gentle	South-east	Actively hunting		None	< 30m	1
1 (Early summer)	Control area 1	2012/02/24	11:17:55	Rock Kestrel	1.2	South	Karoo veld	Flat	None	Direct commute gliding		South	< 30m	1
1 (Early summer)	Control area 1	2012/02/24	15:41:40	Rock Kestrel	2.0	East	Karoo veld	Gentle	South	Actively hunting		None	< 30m	1

Iteration	Vantage point	Date	Time	Species	Wind strength (m.s ⁻¹)	Wind direction	Underlying habitat	Gradient of underlying slope	Aspect of underlying slope	Flight mode	Sighting distance (m)	Flight direction	Flying height	<i>n</i> birds
1 (Early summer)	Control area 1	2012/02/24	17:27:37	Rock Kestrel	2.8	North-west	Cliffs, screes and cuttings	Steep	South-west	Actively hunting		West	< 30m	1
1 (Early summer)	Control area 1	2012/02/24	19:20:36	Rock Kestrel	2.5	South	Karoo veld	Flat	None	Direct commute flapping		None	< 30m	1
1 (Early summer)	Control area 1	2012/02/25	09:56:07	Rock Kestrel	0.3	North-east	Karoo veld	Gentle	East	Direct commute flapping		None	< 30m	2
1 (Early summer)	Control area 1	2012/02/25	08:36:14	Jackal Buzzard	0.3	South	Karoo veld	Gentle	South	Thermaling		None	30 - 150m	1
1 (Early summer)	Control area 1	2012/02/24	12:18:24	Booted Eagle	0.9	South-east	Karoo veld	Flat	None	Direct commute gliding		North	30 - 150m	1
1 (Early summer)	Control area 1	2012/02/24	13:48:45	Booted Eagle	2.0	North-west	Karoo veld	Flat	None	Direct commute gliding		West	30 - 150m	1
1 (Early summer)	Control area 1	2012/02/24	17:26:50	Booted Eagle	2.8	North-west	Cliffs, screes and cuttings	Gentle	South-west	Thermaling		None	30 - 150m	1
1 (Early summer)	Control area 1	2012/02/24	17:25:54	White-necked Raven	2.8	North-west	Cliffs, screes and cuttings	Steep	South	Direct commute gliding		South	30 - 150m	4
1 (Early summer)	Control area 1	2012/02/24	17:44:42	White-necked Raven	3.2	North-west	Karoo veld	Gentle	West	Direct commute gliding		West	30 - 150m	2
1 (Early summer)	Control area 1	2012/02/24	10:49:10	Barn Swallow	1.0	South-east	Karoo veld	Gentle	South	Other		None	< 30m	25
1 (Early summer)	Control area 1	2012/02/24	11:40:32	Barn Swallow	2.0	North-west	Karoo veld	Gentle	West	Direct commute flapping		South	< 30m	6

Iteration	Vantage point	Date	Time	Species	Wind strength (m.s ⁻¹)	Wind direction	Underlying habitat	Gradient of underlying slope	Aspect of underlying slope	Flight mode	Sighting distance (m)	Flight direction	Flying height	<i>n</i> birds
1 (Early summer)	Control area 1	2012/02/24	12:20:21	Barn Swallow	0.9	North-east	Karoo veld	Flat	None	Direct commute gliding		None	30 - 150m	30
1 (Early summer)	Control area 1	2012/02/24	13:36:49	Barn Swallow	2.5	North-west	Karoo veld	Gentle	West	Direct commute gliding		None	< 30m	30
1 (Early summer)	Control area 1	2012/02/24	18:47:47	Barn Swallow	4.1	North-west	Karoo veld	Gentle	South	Slope soaring		None	< 30m	25
1 (Early summer)	Control area 1	2012/02/24	10:49:30	Rock Martin	1.0	South-east	Karoo veld	Gentle	South	Direct commute flapping		South	< 30m	1
2 (Winter)	Study area 1	2012/06/03	10:23:38	Greater Kestrel	7.0	South-east	Karoo veld	Flat	None	Direct commute gliding	1500	East	30 - 150m	1
2 (Winter)	Study area 1	2012/06/03	09:21:01	Rock Kestrel	2.3	South-east	Karoo veld	Flat	None	Actively hunting	1500	None	< 30m	1
2 (Winter)	Study area 1	2012/06/03	10:24:27	Rock Kestrel	7.0	South-east	Karoo veld	Gentle	South-east	Slope soaring	1500	South-east	< 30m	2
2 (Winter)	Study area 1	2012/06/03	10:31:05	Rock Kestrel	7.0	South-east	Karoo veld	Gentle	South	Slope soaring	1500	East	30 - 150m	1
2 (Winter)	Study area 1	2012/06/03	10:20:59	Southern Pale Chanting Goshawk	7.0	South-east	Drainage lines & alien trees	Flat	None	Direct commute flapping	1500	South-west	< 30m	1
2 (Winter)	Study area 1	2012/06/03	11:05:31	Southern Pale Chanting Goshawk	7.2	South-east	Karoo veld	Gentle	South	Actively hunting	1500	South	< 30m	1
2 (Winter)	Study area 2	2012/05/31	14:50:08	Pied Crow	0.6	South-east	Karoo veld	Gentle	North	Direct commute gliding	1500	None	30 - 150m	2

Iteration	Vantage point	Date	Time	Species	Wind strength (m.s ⁻¹)	Wind direction	Underlying habitat	Gradient of underlying slope	Aspect of underlying slope	Flight mode	Sighting distance (m)	Flight direction	Flying height	<i>n</i> birds
2 (Winter)	Study area 2	2012/05/31	16:21:40	Karoo Korhaan	1.1	North-west	Karoo veld	Flat	None	Flushed	1500	North	< 30m	2
2 (Winter)	Study area 2	2012/05/31	10:45:22	Rock Kestrel	4.2	South-east	Karoo veld	Gentle	South-east	Actively hunting	1000	None	< 30m	1
2 (Winter)	Study area 2	2012/05/31	14:18:38	Pied Crow	0.6	South-east	Karoo veld	Gentle	North	Direct commute gliding	1500	North-west	30 - 150m	2
2 (Winter)	Study area 2	2012/05/31	12:29:19	Brown-throated Martin	0.5	South-east	Karoo veld	Gentle	South	Direct commute flapping	1000	None	< 30m	1
2 (Winter)	Study area 3	2012/05/30	10:11:28	Ludwig's Bustard	2.5	South-east	Karoo veld	Flat	None	Direct commute flapping		East	< 30m	1
2 (Winter)	Study area 3	2012/05/30	17:42:51	Rock Kestrel	2.2	South-east	Karoo veld	Flat	None	Direct commute flapping		North	< 30m	1
2 (Winter)	Study area 3	2012/05/30	15:00:32	Brown-throated Martin	2.6	East	Drainage lines & alien trees	Flat	None	Direct commute flapping		None	< 30m	3
2 (Winter)	Control area 1	2012/06/02	11:10:21	Greater Kestrel	1.6	South-east	Karoo veld	Flat	None	Direct commute flapping	1500	South	< 30m	2
2 (Winter)	Control area 1	2012/06/02	09:46:02	Rock Kestrel	1.2	South-east	Karoo veld	Gentle	South	Actively hunting	1500	South-east	< 30m	1
2 (Winter)	Control area 1	2012/06/02	09:42:50	Jackal Buzzard	0.6	South-east	Karoo veld	Gentle	South	Direct commute flapping	1500	East	< 30m	1
2 (Winter)	Control area 1	2012/06/02	11:27:25	Jackal Buzzard	1.4	South-east	Karoo veld	Flat	None	Direct commute gliding	1500	North-west	30 - 150m	2

Iteration	Vantage point	Date	Time	Species	Wind strength (m.s ⁻¹)	Wind direction	Underlying habitat	Gradient of underlying slope	Aspect of underlying slope	Flight mode	Sighting distance (m)	Flight direction	Flying height	<i>n</i> birds
2 (Winter)	Control area 1	2012/06/02	12:12:53	Jackal Buzzard	2.3	South-east	Karoo veld	Flat	None	Thermaling	1500	North-west	30 - 150m	3
3 (Spring)	Study area 1	2012/08/21	18:11:43	Ludwig's Bustard	1.2	North-west	Karoo veld	Flat	None	Flushed	1000	North-east	< 30m	1
3 (Spring)	Study area 1	2012/08/21	16:53:04	Greater Kestrel	2.3	North-west	Karoo veld	Flat	None	Direct commute flapping	2000	None	< 30m	2
3 (Spring)	Study area 1	2012/08/21	17:55:47	Southern Pale Chanting Goshawk	1.2	North-west	Karoo veld	Flat	None	Direct commute flapping	1000	North	< 30m	1
3 (Spring)	Study area 1	2012/08/25	09:32:03	Pied Crow	8.0	North-east	Karoo veld	Flat	None	Direct commute flapping	150	None	< 30m	1
3 (Spring)	Study area 1	2012/08/25	10:46:25	Pied Crow	9.0	North-east	Drainage lines & alien trees	Flat	None	Other	150	None	< 30m	1
3 (Spring)	Study area 2	2012/08/24	07:51:19	Rock Kestrel	2.3	South-east	Karoo veld	Flat	None	Flushed	100	None	< 30m	1
3 (Spring)	Study area 2	2012/08/24	12:01:55	Southern Pale Chanting Goshawk	2.5	North	Karoo veld	Gentle	South	Direct commute flapping	50	South-west	30 - 150m	1
3 (Spring)	Study area 2	2012/08/24	08:15:50	Lanner Falcon	2.3	South-east	Karoo veld	Flat	None	Direct commute flapping	100	None	< 30m	1
3 (Spring)	Study area 2	2012/08/24	18:13:41	Lanner Falcon	6.5	North	Karoo veld	Flat	None	Flushed	150	South-west	< 30m	2
3 (Spring)	Study area 2	2012/08/24	07:52:30	Pied Crow	2.3	South-east	Karoo veld	Flat	None	Direct commute flapping	100	North-west	< 30m	1

Iteration	Vantage point	Date	Time	Species	Wind strength (m.s ⁻¹)	Wind direction	Underlying habitat	Gradient of underlying slope	Aspect of underlying slope	Flight mode	Sighting distance (m)	Flight direction	Flying height	<i>n</i> birds
3 (Spring)	Study area 2	2012/08/24	09:33:24	Pied Crow	1.3	South-east	Karoo veld	Flat	None	Direct commute flapping	100	None	< 30m	1
3 (Spring)	Study area 2	2012/08/24	12:57:59	Pied Crow	3.5	North	Karoo veld	Gentle	South-west	Direct commute flapping	1000	North	< 30m	1
3 (Spring)	Study area 2	2012/08/24	15:50:16	Pied Crow	6.3	North	Karoo veld	Flat	None	Direct commute flapping	2500	North	< 30m	1
3 (Spring)	Study area 2	2012/08/24	11:49:08	Rock Martin	1.2	North-west	Karoo veld	Flat	None	Direct commute flapping	50	South	< 30m	1
3 (Spring)	Study area 3	2012/08/22	07:41:50	Egyptian Goose	1.2	South-west	Drainage lines & alien trees	Flat	None	Direct commute flapping	1000	North-west	< 30m	2
3 (Spring)	Study area 3	2012/08/22	08:30:03	Egyptian Goose	1.2	South-west	Drainage lines & alien trees	Flat	None	Direct commute flapping	1000	North-west	< 30m	2
3 (Spring)	Study area 3	2012/08/22	08:43:53	Egyptian Goose	2.3	South-west	Drainage lines & alien trees	Flat	None	Direct commute flapping	1000	West	< 30m	1
3 (Spring)	Study area 3	2012/08/22	11:50:05	Rock Kestrel	1.2	South-east	Drainage lines & alien trees	Flat	None	Direct commute flapping	500	North-west	< 30m	1
3 (Spring)	Study area 3	2012/08/22	14:41:49	Rock Kestrel	1.1	North-west	Drainage lines & alien trees	Flat	None	Direct commute flapping	200	North	< 30m	1
3 (Spring)	Study area 3	2012/08/22	10:24:24	Black-shouldered Kite	2.3	South-west	Drainage lines & alien trees	Flat	None	Direct commute flapping	1000	None	< 30m	1

Iteration	Vantage point	Date	Time	Species	Wind strength (m.s ⁻¹)	Wind direction	Underlying habitat	Gradient of underlying slope	Aspect of underlying slope	Flight mode	Sighting distance (m)	Flight direction	Flying height	<i>n</i> birds
3 (Spring)	Study area 3	2012/08/22	17:00:15	Black-shouldered Kite	0.9	North	Drainage lines & alien trees	Flat	None	Other	1000	None	< 30m	1
3 (Spring)	Study area 3	2012/08/22	13:27:34	Southern Pale Chanting Goshawk	1.1	North	Drainage lines & alien trees	Flat	None	Direct commute flapping	1000	South-east	< 30m	2
3 (Spring)	Study area 3	2012/08/22	13:29:14	Southern Pale Chanting Goshawk	1.1	North	Drainage lines & alien trees	Flat	None	Thermaling	1000	South	30 - 150m	2
3 (Spring)	Study area 3	2012/08/22	17:01:25	Southern Pale Chanting Goshawk	0.9	North	Drainage lines & alien trees	Flat	None	Direct commute flapping	1000	South-east	< 30m	2
3 (Spring)	Study area 3	2012/08/22	08:46:26	Black-headed Heron	2.3	South-west	Drainage lines & alien trees	Flat	None	Direct commute flapping	1000	North-west	< 30m	2
3 (Spring)	Study area 3	2012/08/22	17:02:07	Black-headed Heron	1.2	North	Drainage lines & alien trees	Flat	None	Direct commute flapping	1200	South-east	< 30m	2
3 (Spring)	Study area 3	2012/08/22	07:51:51	Hadeda Ibis	1.2	South-west	Drainage lines & alien trees	Flat	None	Direct commute flapping	1000	North-west	< 30m	2
3 (Spring)	Study area 3	2012/08/22	12:28:34	Rock Martin	2.2	South	Karoo veld	Flat	None	Direct commute flapping	500	South	< 30m	1
3 (Spring)	Study area 3	2012/08/22	13:32:23	Rock Martin	1.1	North-west	Drainage lines & alien trees	Flat	None	Actively hunting	200	North	< 30m	10

Iteration	Vantage point	Date	Time	Species	Wind strength (m.s ⁻¹)	Wind direction	Underlying habitat	Gradient of underlying slope	Aspect of underlying slope	Flight mode	Sighting distance (m)	Flight direction	Flying height	<i>n</i> birds
3 (Spring)	Control area 1	2012/08/23	13:27:08	Greater Kestrel	1.2	North	Karoo veld	Flat	None	Direct commute flapping	1200	North-west	< 30m	1
3 (Spring)	Control area 1	2012/08/23	14:40:21	Greater Kestrel	3.5	North	Karoo veld	Gentle	West	Direct commute flapping	1200	East	< 30m	1
3 (Spring)	Control area 1	2012/08/26	10:27:33	Greater Kestrel	3.5	North-east	Karoo veld	Flat	None	Flushed	150	None	< 30m	1
3 (Spring)	Control area 1	2012/08/23	17:58:53	Rock Kestrel	2.3	North	Karoo veld	Gentle	West	Direct commute flapping	100	North	< 30m	1
3 (Spring)	Control area 1	2012/08/23	17:40:51	Black Harrier	3.5	North	Karoo veld	Gentle	South-west	Actively hunting	500	North-west	< 30m	1
3 (Spring)	Control area 1	2012/08/23	15:57:23	Booted Eagle	3.5	North	Karoo veld	Gentle	North-west	Slope soaring	200	South	< 30m	1
3 (Spring)	Control area 1	2012/08/23	15:58:42	Booted Eagle	3.5	North	Karoo veld	Flat	None	Direct commute gliding	500	North	30 - 150m	1
3 (Spring)	Control area 1	2012/08/26	10:26:56	Lanner Falcon	3.5	North-east	Karoo veld	Flat	None	Flushed	150	None	< 30m	1
3 (Spring)	Control area 1	2012/08/26	10:28:27	Lanner Falcon	3.5	North-east	Karoo veld	Flat	None	Flushed	150	None	< 30m	1
3 (Spring)	Control area 1	2012/08/26	09:26:33	Pied Crow	3.5	North-east	Karoo veld	Flat	None	Direct commute flapping	150	North	< 30m	2
4 (Late summer)	Study area 1	2012/11/22	09:16:13	Southern Pale Chanting Goshawk	6.5	South-east	Karoo veld	Gentle	East	Direct commute flapping	200	North	< 30m	1

Iteration	Vantage point	Date	Time	Species	Wind strength (m.s ⁻¹)	Wind direction	Underlying habitat	Gradient of underlying slope	Aspect of underlying slope	Flight mode	Sighting distance (m)	Flight direction	Flying height	<i>n</i> birds
4 (Late summer)	Study area 1	2012/11/22	15:33:42	Southern Pale Chanting Goshawk	3.2	North	Karoo veld	Gentle	North-east	Direct commute flapping	200	South	< 30m	1
4 (Late summer)	Study area 1	2012/11/22	09:15:26	Pied Crow	6.5	North	Karoo veld	Gentle	West	Slope soaring	10	West	< 30m	1
4 (Late summer)	Study area 1	2012/11/22	10:06:34	Pied Crow	1.6	East	Karoo veld	Flat	None	Direct commute flapping	200	None	30 - 150m	3
4 (Late summer)	Study area 1	2012/11/22	12:43:42	Pied Crow	3.2	North-east	Karoo veld	Gentle	South	Direct commute gliding	50	South	< 30m	1
4 (Late summer)	Study area 1	2012/11/22	10:49:54	Barn Swallow	1.5	North-east	Karoo veld	Gentle	East	Slope soaring	200	None	< 30m	2
4 (Late summer)	Study area 2	2012/11/24	0	Rock Kestrel	7.5	North-east	Karoo veld	Flat	None	Direct commute flapping	100	North-east	< 30m	1
4 (Late summer)	Study area 2	2012/11/21	18:05:33	Black Harrier	5.5	South-west	Karoo veld	Flat	None	Direct commute flapping	100	South-west	< 30m	1
4 (Late summer)	Study area 2	2012/11/21	14:40:03	Lanner Falcon	2.5	South	Karoo veld	Gentle	South	Thermaling	200	North-west	< 30m	1
4 (Late summer)	Study area 2	2012/11/24	06:59:16	Lanner Falcon	7.2	North-east	Karoo veld	Gentle	East	Direct commute flapping	150	North-east	< 30m	1
4 (Late summer)	Study area 2	2012/11/24	08:27:34	Lanner Falcon	7.2	North-west	Karoo veld	Gentle	North-west	Slope soaring	100	South-east	< 30m	2
4 (Late summer)	Study area 2	2012/11/24	07:00:35	Black-headed Heron	6.2	North-east	Karoo veld	Flat	None	Direct commute flapping	150	North	< 30m	1

Iteration	Vantage point	Date	Time	Species	Wind strength (m.s ⁻¹)	Wind direction	Underlying habitat	Gradient of underlying slope	Aspect of underlying slope	Flight mode	Sighting distance (m)	Flight direction	Flying height	<i>n</i> birds
4 (Late summer)	Study area 2	2012/11/21	13:14:46	Pied Crow	2.2	South	Karoo veld	Gentle	North	Direct commute gliding	400	West	< 30m	1
4 (Late summer)	Study area 2	2012/11/21	15:13:34	Pied Crow	2.5	South	Karoo veld	Gentle	South-east	Thermaling	300	South	30 - 150m	1
4 (Late summer)	Study area 2	2012/11/21	16:42:45	Barn Swallow	3.5	South-west	Karoo veld	Gentle	South	Direct commute flapping	100	South-east	< 30m	2
4 (Late summer)	Study area 3	2012/11/20	06:12:07	Rock Kestrel	0.3	West	Drainage lines & alien trees	Flat	None	Other	150	None	< 30m	1
4 (Late summer)	Study area 3	2012/11/20	12:09:54	Rock Kestrel	6.0	North	Karoo veld	Flat	None	Direct commute flapping	1000	North-west	< 30m	1
4 (Late summer)	Study area 3	2012/11/20	13:40:58	Rock Kestrel	6.5	North	Drainage lines & alien trees	Flat	None	Thermaling	1000	East	30 - 150m	1
4 (Late summer)	Study area 3	2012/11/20	06:13:08	Black-shouldered Kite	0.3	West	Drainage lines & alien trees	Flat	None	Other	150	None	< 30m	1
4 (Late summer)	Study area 3	2012/11/20	09:32:38	Black-shouldered Kite	2.7	North	Drainage lines & alien trees	Flat	None	Other	100	North	< 30m	1
4 (Late summer)	Study area 3	2012/11/20	17:03:46	Black-shouldered Kite	6.5	North	Karoo veld	Gentle	West	Actively hunting	50	South	< 30m	1
4 (Late summer)	Study area 3	2012/11/20	17:08:34	Black-shouldered Kite	6.5	North	Karoo veld	Gentle	West	Actively hunting	10	None	< 30m	3

Iteration	Vantage point	Date	Time	Species	Wind strength (m.s ⁻¹)	Wind direction	Underlying habitat	Gradient of underlying slope	Aspect of underlying slope	Flight mode	Sighting distance (m)	Flight direction	Flying height	<i>n</i> birds
4 (Late summer)	Study area 3	2012/11/20	09:21:55	Southern Pale Chanting Goshawk	2.5	North	Drainage lines & alien trees	Flat	None	Thermaling	300	None	< 30m	3
4 (Late summer)	Study area 3	2012/11/20	09:23:31	Jackal Buzzard	2.5	North	Karoo veld	Flat	None	Direct commute gliding	300	North-west	< 30m	1
4 (Late summer)	Study area 3	2012/11/20	07:10:28	Booted Eagle	0.5	West	Karoo veld	Flat	None	Direct commute flapping	150	South-east	< 30m	1
4 (Late summer)	Study area 3	2012/11/20	09:20:27	Booted Eagle	2.5	North	Karoo veld	Flat	None	Thermaling	250	South	30 - 150m	1
4 (Late summer)	Study area 3	2012/11/20	09:31:00	Booted Eagle	2.7	North	Drainage lines & alien trees	Flat	None	Direct commute gliding	100	West	30 - 150m	1
4 (Late summer)	Study area 3	2012/11/20	12:07:18	Booted Eagle	6.0	North	Drainage lines & alien trees	Flat	None	Direct commute gliding	1000	East	30 - 150m	1
4 (Late summer)	Study area 3	2012/11/20	08:52:01	Black-headed Heron	2.5	West	Drainage lines & alien trees	Flat	None	Direct commute flapping	500	North-west	< 30m	1
4 (Late summer)	Study area 3	2012/11/20	05:51:38	Barn Swallow	3.5	West	Drainage lines & alien trees	Flat	None	Direct commute flapping	150	West	< 30m	12
4 (Late summer)	Study area 3	2012/11/20	05:53:06	Barn Swallow	3.5	West	Drainage lines & alien trees	Flat	None	Direct commute flapping	150	West	< 30m	4
4 (Late summer)	Study area 3	2012/11/20	05:59:54	Barn Swallow	0.3	West	Drainage lines & alien trees	Flat	None	Direct commute flapping	150	South-west	< 30m	500

Iteration	Vantage point	Date	Time	Species	Wind strength (m.s ⁻¹)	Wind direction	Underlying habitat	Gradient of underlying slope	Aspect of underlying slope	Flight mode	Sighting distance (m)	Flight direction	Flying height	<i>n</i> birds
4 (Late summer)	Study area 3	2012/11/20	11:48:21	Barn Swallow	2.7	North	Drainage lines & alien trees	Flat	None	Direct commute gliding	100	South-west	< 30m	2
4 (Late summer)	Study area 3	2012/11/20	17:04:29	Barn Swallow	6.5	North	Karoo veld	Gentle	West	Direct commute flapping	10	South-east	< 30m	5
4 (Late summer)	Control area 1	2012/11/23	09:38:59	Jackal Buzzard	3.5	North-west	Karoo veld	Gentle	South	Thermaling	1000	South-east	30 - 150m	1
4 (Late summer)	Control area 1	2012/11/23	08:10:15	Lanner Falcon	1.5	South-east	Karoo veld	Flat	None	Other	200	None	< 30m	3
4 (Late summer)	Control area 1	2012/11/23	10:22:22	Lanner Falcon	3.2	North-west	Karoo veld	Gentle	South	Thermaling	100	West	30 - 150m	3
4 (Late summer)	Control area 1	2012/11/23	15:08:20	Lanner Falcon	5.5	North-west	Karoo veld	Gentle	South	Direct commute gliding	200	South-west	< 30m	1
4 (Late summer)	Control area 1	2012/11/23	15:19:21	Lanner Falcon	4.5	West	Karoo veld	Gentle	West	Slope soaring	150	North	< 30m	1
4 (Late summer)	Control area 1	2012/11/23	07:58:31	Pied Crow	2.0	South-east	Karoo veld	Gentle	West	Direct commute flapping	200	North	< 30m	1
4 (Late summer)	Control area 1	2012/11/23	07:12:51	Barn Swallow	7.1	South-east	Karoo veld	Flat	None	Actively hunting	200	None	< 30m	1