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Wind energy's impacts on birds in South Africa:

A preliminary review of the results of operational monitoring at the first wind farms of the Renewable Energy Independent Power Producer Procurement Programme in South Africa

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Cover Photo: This Martial Eagle, *Polemaetus bellicosus*, was witnessed being struck by a turbine blade soon after Jackal Buzzards, *Buteo rufofuscus*, had mobbed it.
Image credit: M Martins: Birds & Bats Unlimited

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Samantha Ralston-Paton, Jon Smallie, Andrew Pearson and Ricardo Ramalho

2017

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Foreword

FROM THE SOUTH AFRICAN WIND ENERGY ASSOCIATION (SAWEA)

This post-construction monitoring report is a valuable tool in the ongoing effort to both avoid and successfully mitigate against bird fatalities on operating wind farms in South Africa. The SAWEA is committed to the development and operation of wind farms that function in a responsible manner in order to minimize the impact on avifauna.

The Wind Energy industry is relatively new in this country and the methods and ways of avoiding impacts on birds are still being determined and refined as more information is made available. It is for this reason that the SAWEA Environmental Working Group encourages all members to actively share data that is gathered during the life span of an operating asset. It is this data that will help to avoid fatalities going forward. The data from eight Round 1 wind farms formed the basis of this report and it is hoped that over time, this number will increase. SAWEA understands that it is in the best interests of the industry for there to be a healthy and productive relationship between the industry and groups such as BirdLife South Africa. The work that is done by this organisation is extremely valuable and is absolutely required.

The key factor in the sustainable management of a wind farm is the term "adaptive management" and this is best served through the continuous gathering of data throughout the lifecycle of a plant. To that end, SAWEA supports the sharing of data and the work that BLSA undertakes. As more projects come on line and the cumulative impacts are amplified, it will be increasingly important to work with groups such as BirdLife South Africa to minimize fatalities.

SAWEA agrees that the best mitigation technique is clearly the avoidance of any fatalities, however, this is not always possible and the importance of continuous monitoring during operation is therefore of utmost importance and, if done in a sensible way, supported by the industry.

With thanks
Ben Brimble
Chair of SAWEA Environmental Working Group

Abstract

Wind turbines can have both positive and negative environmental effects, and these impacts are likely to vary according to the lo cal context. This report is the first of its kind for South Africa – it summarises the results of monitoring birds at eight wind farms. Monitoring was largely conducted according to standard procedures outlined in BirdLife South Africa and the Endangered Wildlife Trust's *Best Practice Guidelines for assessing and monitoring the impact of wind-energy facilities on birds in southern Africa (Best Practice Guidelines)*. Post-construction phase monitoring was conducted for a minimum of one year, and for no more than two years at all wind farms in the study. No clear evidence for disturbance or displacement was found. However, there were a number of confounding factors – a meta-analysis of the raw data and further research on some species would be of value. The average estimated fatality rate at the wind farms (accounting for detection rates and scavenger removal) ranged from 2.06 to 8.95 birds per turbine per year. The mean fatality rate was 4.1 birds per turbine per year. This places South Africa within the range of fatality rates that have been reported for North America and Europe. The number of fatalities recorded decreased in the winter months, coinciding with the period where lower bird activity levels can be expected. Diurnal raptors accounted for most fatalities (36%), followed by songbirds (26%). Threatened species affected by collisions with wind turbines included Blue Crane (three), Verreaux's Eagle (five), Martial Eagle (two) and Black Harrier (five). A large number of Jackal Buzzard fatalities (24) also were reported. This species is not threatened, but it is endemic to southern Africa. No fatalities were reported for a number of species predicted to be vulnerable to the impacts of wind energy; however, this review is based on data from a limited number of wind farms and a short period of monitoring, and a precautionary approach remains warranted when assessing and mitigating impacts for these species.

Although preliminary, the results of this study point to a number of potential research questions. Recommendations are also made which could help build our understanding around how to minimise the negative effects of wind energy on birds in South Africa.

Glossary

Birds and Wind Energy Specialist Group	A groups of practicing avifaunal specialists and independent experts who guide, review and advise BirdLife South Africa and the Endangered Wildlife Trust's work towards a renewable energy industry that has minimal impacts on birds. This group has been renamed the Birds and Renewable Energy Specialist Group (BARESG).
Control area	An area that is similar to the development site, but far enough away not to be affected by activities on the site – a key part of any Before (pre-construction) – After (post-construction) – Control – Impact (development) (BACI) study.
Convention on the Conservation of Migratory Species (CMS)	CMS is a treaty of the United Nations Environment Programme (UNEP), which provides a global platform for the conservation and sustainable use of migratory animals and their habitats. South Africa has been a Party State since 1991. The CMS has two Appendices: Appendix I pertains to migratory species threatened with extinction and Appendix II that regards migratory species that need or would significantly benefit from international co-operation. CMS Parties strive towards strictly protecting these animals, conserving or restoring the places where they live, mitigating obstacles to migration and controlling other factors that might endanger them.
Cumulative impact	The sum of impacts on a species, ecosystem or resource associated with actions (e.g. development) in the past, present and foreseeable future (e.g. the sum of the impacts of multiple wind farms, or a wind farm in combination with other developments).
Rotor swept area	The area where birds are at risk of colliding with turbine blades. The area of the circle or volume of the sphere swept by the turbine blades.
Priority species	Threatened or rare birds (in particular those unique to the region and especially those which are possibly susceptible to wind-energy impacts), which occur in the given development area at relatively high densities or have high levels of activity in the area. These species should be the primary (but not the sole) focus of all subsequent monitoring and assessment.
Target species	A list of species defined by the Avian Specialist(s) which, based on their experience, are likely to occur on site and to be affected by the facility. Target species are the focus of some surveys (e.g. vantage point surveys) and subsequent assessment.

Wind energy's impacts on birds in South Africa:
A preliminary review of the results of operational monitoring at the first wind farms of the Renewable Energy Independent Power Producer Procurement Programme Wind Farms in South Africa

INTRODUCTION

Wind energy has the potential to play a significant role in reducing greenhouse gas emissions (Intergovernmental Panel on Climate Change 2012), but it can also have negative effects on birds and other biodiversity. Wind farms may cause the displacement of sensitive bird species from development areas, and collisions with the turbines and associated infrastructure can result in mortality. The nature and extent of these impacts is dependent on both site- and species-specific variables (Drewitt & Langston 2006; Drewitt & Langston 2008; Jordan & Smallie 2010; Strickland et al. 2011; Rydell et al. 2012; Gove et al. 2013, American Wind Wildlife Institute (AWWI) 2015 and references therein). The risk of collision, for example, may be related to particular characteristics of the species present in an area, or the topography (De Lucas et al. 2008; Ferrer et al. 2012). This suggests that while international experience can help predict potential risks, it is also important to study the effects of wind energy in a particular area or region.

The wind-energy industry is expanding rapidly in South Africa, and to date our experience of wind energy generation and its effects on birds has been extremely limited. Prior to the completion of the first wind farms of the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) in 2014, only eight wind turbines had been constructed in South Africa - three turbines at a demonstration facility at Klipheuwel in the Western Cape (2002 – 2003), four turbines at a site near Darling (Western Cape) and one at Coega (near Port Elizabeth, Eastern Cape). Only limited monitoring of the impacts on birds was conducted at Klipheuwel and Coega. Monitoring at Klipheuwel found two bird collisions and estimated a fatality of one bird per turbine per year (Küyler 2004). The single turbine at Coega was monitored for a year (three searches per week); one Little Swift (*Apus affinis*) collision victim was found during that period (Doty & Martin 2013).

With the introduction of the REIPPPP the South African Birds and Wind Energy Specialist Group (BAWESG) (now the Birds and Renewable Energy Specialist Group), convened by BirdLife South Africa and the Endangered Wildlife Trust, recognised the need to measure wind energy's effects on birds as quickly as possible, in order to identify and mitigate any detrimental impacts, particularly on threatened or potentially threatened species. *Best-practice guidelines for assessing and monitoring the impact of wind- energy facilities on birds in southern Africa* (Jenkins et al. 2011) were developed, with the intention of promoting the collection of data in a structured, methodical and scientific manner. The guidelines propose a multi-tiered approach, with the overarching aims of a) informing current environmental impact assessment processes; b) developing our understanding of the effects of wind energy on southern African birds; and c) identifying the most effective means to mitigate these impacts. These guidelines were updated in 2012 and then again in 2015, with the latter providing a more detailed framework to assess the operational phase impacts of projects.

At least one year of post-construction (operational-phase) monitoring of birds has now been completed at all eight wind farms constructed under the first phase of the REIPPPP. The surveys and data analyses were commissioned by the wind farms and undertaken by independent avifaunal specialists, either in accordance with the conditions of the Environmental Authorisation, as recommended in the impact assessment report, or voluntarily. Survey methods used largely followed the recommendations of the best-practice guidelines (Jenkins et al. 2011, 2012 and 2015). This report summarises the findings of these studies to help improve predictions made in impact assessments, provide an early warning of potential cumulative effects, and highlight the need for mitigation, additional conservation action and/or further research. It presents an overview of the key findings based on pre- and post-construction surveys, and makes some preliminary recommendations based on a preliminary analysis of the data. The studies were conducted over a limited period and thus conclusions should be treated as tentative.

METHODS

DATA SOURCES AND METHODS USED

The eight wind farms surveyed were all selected in the first window of the REIPPPP and are in the Western, Eastern and Northern Cape Provinces of South Africa. The wind farms are located in a range of biomes and habitats (see Figure 1 and Table 1 for further details). Together these wind farms have 294 turbines with a combined nameplate capacity of 625 MW. The two smallest wind farms had just nine turbines (total installed capacity of 27 and 30 MW), while the largest had 66 turbines and a capacity of 138 MW (Table 1). The nameplate capacity of individual turbines ranged from 1.8 to 3.3 MW (average 2.4 MW). The average hub height of the turbines was 87.8 metres (range: 80 - 115 m), and average rotor diameter was 102.4 m (range: 88 – 113).

Figure 1. *Location of wind farms included in this study.*

Table 1. *REIPPPP Round 1 wind farms included in this report. The table provides details on the range of different biomes in which the wind farms are located, as well as the total capacity, number of turbines, turbine capacity, hub height and rotor diameter of the wind turbines specific to each wind farm.*

Wind Farm	Province	Biome*	No. of Turbines	Total Capacity (MW)	Turbine capacity (MW)	Hub height (m)	Rotor diameter (m)	References**
Cookhouse	Eastern Cape	Grassland & Albany Thicket	66	136.6	2.1	80	88	Diamond, 2010, Inkululeko, 2016
Dorper	Eastern Cape	Grassland	40	100	2.5	80	100	Wildskies 2014 Wildskies, 2015
Hopefield	Western Cape	Fynbos	37	66.6	1.8	95	100	Jenkins 2009, Bio3 2013, Arcus 2016
Jeffreys Bay	Eastern Cape	Fynbos & Albany Thicket	60	138	2.3	80	101	Van Rooyen et al., 2011, Inkululeko 2015b,
Klipheuwel - Dassies-fontein	Western Cape	Fynbos	9	30	3.3	90	113	Jenkins 2013, Inkululeko 2015a
Kouga	Eastern Cape	Fynbos & Azonal	32	80	2.4	80	90	Diamond 2012, Endangered Wildlife Trust. 2014, Wildskies 2016
Noblesfon-tein	North-ern Cape	Nama-karoo	41	73.8	1.8	80	110	Avisense 2012, Bio3/Savannah Environmental 2013, BioInsight 2016
Van Stadens***	Eastern Cape	Albany thicket & Azonal	9	27	3	90	110	Martin 2013, Martin 2015

Information was gleaned from impact assessment reports, as well as pre- and post-construction avifaunal monitoring reports (see Table 1 for a list of references used). Monitoring was generally undertaken in accordance with BirdLife South Africa and the Endangered Wildlife Trust's *Best Practice Guidelines for assessing and monitoring the impact of wind-energy facilities on birds in southern Africa* (Best Practice Guidelines) (Jenkins et al., 2011, 2012 and 2015) – however it is important to note that these guidelines are not fully prescriptive and there is some scope for specialists to use their discretion. It was also not always possible to accommodate some of the changes or more specific recommendations that were included in the later editions of the guidelines.

Displacement, disturbance and avoidance

The eight wind farms listed in Table 1 measured species composition and abundance through walked transects (small birds), driven transects (large terrestrial birds), and focal point surveys. Bird movements were recorded through vantage point surveys. Surveys were conducted at least four times per year and it is assumed that survey effort before and after construction was the same, as is recommended in Jenkins et al. (2011 and updates thereof).

The use of different specialists to undertake pre- and post-construction surveys created some challenges. In many instances the handover of raw data and the details of survey methods appears to have been limited, or lacking entirely. Information pertinent to monitoring, but not to impact assessment, was not always included in pre-construction reports, and in some cases there was uncertainty with regards to survey and data collection methods used. New infrastructure (e.g. roads and fences) also made replicating the "before" surveys challenging during operational-phase monitoring.

There were also some difficulties experienced with control sites. In two instances landowners refused access to the control sites after the wind farms were constructed - apparently the pre-construction team had accessed one of these sites without the landowner's permission. It is not clear what the reasoning was in the other case. At another wind farm the control site that was used during the pre-construction surveys bordered the wind farm. The possibility of localised movement of birds between the two areas could not be excluded and there was therefore a risk that the wind farm could affect birds resident in the "control" site.

Most operational phase monitoring reports dealt with the subject of displacement, disturbance, as well as changes in bird communities very broadly, and while most specialists adopted similar survey methods, they reported on the results very differently, making comparisons across sites difficult. Species-specific data was not routinely supplied in the reports, and confidence intervals were not normally provided. There was little statistical analysis (e.g. of presence, absence, abundance, passage rates or functional groups) and little or no explicit comparison with data from control sites; as a result it is difficult to ascribe any changes that were observed to a wind farm.

Collisions with turbines and other infrastructure

For the most part, carcass surveys were conducted with a search interval of between one and two weeks, and square or circular plots were searched. The smallest search area was a circle with a radius of 80 meters; the largest was a square 210 meters by 210 meters (Table 2). One wind farm reported issues with surveying the area beneath the turbines, as the landowner had concerns about trampling crops. This meant that only hard stands and roads could be surveyed for a period (less than two months). This was eventually resolved with the landowner, and was taken into account in the model used to estimate fatality rates. Fences, woodpiles, and other obstacles also presented an obstacle to surveying the entire search area at some sites.

Table 1. *REIPPPP Round 1 wind farms included in this report. The table provides details on the range of different biomes in which the wind farms are located, as well as the total capacity, number of turbines, turbine capacity, hub height and rotor diameter of the wind turbines specific to each wind farm.*

Wind Farm	Survey area	Turbine Height (m)	Survey interval (days)	Percentage of turbines searched intensively*
Wind Farm B	Circle with 80 m radius	145	7	100
Wind Farm C	Circle with 99 m radius	146.5	7	100
Wind Farm D	200 x 200 m square	135	7	100
Wind Farm E	210 x 210 m square	130	8-13	80
Wind Farm F	200 x 200 m square	130.5	7	66
Wind Farm H	210 x 210 m square	125	8-13	100
Wind Farm I	186 x 186 m square	124	10	90

** The remaining turbines were searched one a month using less rigorous methods*

Surveys included searcher efficiency and scavenger removal trials, except at Van Stadens wind farm where monitoring for carcasses was not an objective of post-construction monitoring and carcass surveys were far less rigorous than recommended in the Best Practice Guidelines. This wind farm was therefore excluded from the analysis of fatality rates.

A landowner stopped scavenger removal trials at a wind farm out of concern for attracting scavengers or spreading disease by placing carcasses on site. This limited the sample size and season of trials, and therefore compromised the accuracy of the subsequent fatality rate estimates. This does not appear to have been resolved.

Obtaining suitable carcasses for scavenger removal and searcher efficiency trials was also a challenge; it was not always possible to find carcasses of large-bodied birds and raptors. Plastic decoys were sometimes used for searcher efficiency trials, and surrogate carcases (e.g. domestic species such as chickens) were used in some scavenger removal and searcher efficiency trials. This may compromise estimates as the detectability of decoys may differ from real birds, and certain bird species are also more palatable to scavengers than others, and may therefore be removed faster. Raptors, for example, appear to be scavenged less than other species (Smallwood 2007, Urquhart et al. 2015) and thus fatality rates for raptors may be overestimated. Given the number of wind farms and the requirement to conduct these trials at each site this is likely to remain a challenge.

At times, carcass searches were initiated some time after the first turbines had begun turning. It was therefore necessary for specialists to first sweep the wind farm for carcasses, or discard the results of the first carcass searches when estimating fatality rates. Fatality rates (both unadjusted and corrected for searcher efficiency and scavenger removal) were calculated based on the first, complete year of monitoring. These calculations excluded carcasses found during construction, carcasses found outside of formal searches, and carcasses found during an initial sweep of the wind farm. All additional fatalities (e.g. recorded during ad hoc surveys, construction, or during surveys in the second year) have been included in the analysis and discussion of species affected, as well as the table in Appendix 1, but should not be used to infer fatality rates.

Note on confidentiality

Most wind farms submitted monitoring reports to BirdLife South Africa voluntarily, or as a condition of their environmental authorisation. The reports for Cookhouse and Hopefield Wind Farms were obtained through the Promotion of Access to Information Act (Act No. 2 of 2000). There are different opinions regarding whether post-construction monitoring reports should be in the public domain. Some wind farm operators and developers are of the view that this information is sensitive and are concerned that the results may be taken out of context. Although BirdLife South Africa is of the opinion that the information can, and should be freely available, we also believe that there is little benefit to detailing specifics associated with each wind farm. In order to promote on-going cooperation with developers, our approach is therefore to summarise the results and pertinent details, without linking specific impacts to particular wind farms, unless the information is already in the public domain.

In order to respect this confidentially, we have not directly credited authors where results for individual wind farms are presented in this report.

RESULTS AND DISCUSSION

DISPLACEMENT, DISTURBANCE AND AVOIDANCE

Different species are likely to respond to wind farms in different ways. It is therefore not too surprising that no clear pattern was evident across wind farms when considering the total number of species, abundance of small or large birds, or passage rates of all priority species before and after construction.

Five of the eight wind farms studied did report an increase in the total number of species on site after construction (Figure 2), but this difference was not statistically significant (Wilcoxon-signed-ranks test, p= 0.117). It is possible that construction activities have increased the diversity of habitats on sites (e.g. roads, hard stand and disturbed areas), leading to an increase in the number of species. It is also possible that in some cases pre-construction monitoring could have covered a larger area, with a possibly greater diversity of habitats than the final footprint of the wind farm. In addition, the use of different observers may have confounded results as observers' skills and techniques used may vary. Observers' capabilities may also have improved over time.

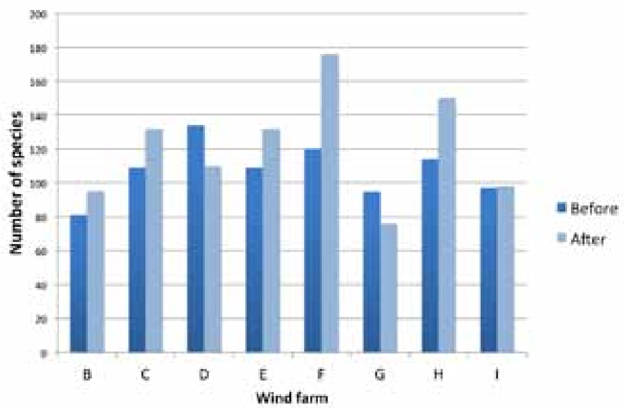

Figure 2: *Total number of species recorded before vs after the construction of the wind farms*

Species-specific responses and changes in functional groups would be more useful indicators of displacement or resilience, than the number of species, overall abundance or total passage rates. This requires more detailed statistical analysis than was available in most reports, and would preferably involve an analysis of data from multiple wind farms and control sites (this data was not available at the time of writing).

Priority species were the focus of most studies, but there would also be value in analysing data on common species, as any trends that are identified could point towards potential threats or possible resilience to effects on similar, rare and/or threatened species.

Although some species observed during pre-construction were not observed during the operational phase, and vice versa, there was little conclusive evidence for displacement of priority species from any sites. The studies were limited to a short period after construction (less than two years), and any effects are likely to change over time (e.g. Stewart et al.

2007). Longer-term studies and better analysis use of control sites would be necessary to confirm effects and shed light on the duration, extent and potential significance of any patterns observed. These limitations must be born in mind when considering the observations summarised below.

Raptors

As a group, it was difficult to identify a particular pattern in abundance and activity for raptors. One wind farm reported lower raptor flight activity and possible displacement. Contrary to this, two reports noted an increase in overall activity of raptors post-construction. One of the latter reports suggested that raptors such as Yellow-billed Kite, Booted Eagle, Rock Kestrel and Black-shouldered Kite might be attracted to the wind farm site, possibly due to some change in prey availability post-construction. This hypothesis requires further study.

Verreaux's Eagle (Aquila verreauxi)

One wind farm reported an apparent increase in Verreaux's Eagle (Vulnerable, Taylor et al., 2015) activity in the first year of construction, but this decreased during the second year. The same site reported multiple Verreaux's Eagle fatalities during the first year (see below). The results of a Generalized Linear Model for the occurrence of Verreaux's Eagle at another wind farm indicated that the species was recorded more frequently before operation of the wind farm (GLM: estimate= 0.042, standard error = 0.003, z = -14.59; p-value = 0.001). In the latter case, eagles continued to use the wind farm site, which suggests that if displacement did occur, it was not complete. It is possible the presence and activity levels of eagles varies between years and longer term studies would therefore be of value.

Martial Eagle (Polemaetus bellicosus)

No displacement or disturbance effects were recorded for Martial Eagles (Endangered, Taylor et al., 2015). One wind farm reported a nest located within the wind farm where Martial Eagles bred successfully. The birds were recorded frequently at this site, with multiple flights recorded close to active turbines. No displacement or disturbance effects were apparent. Another wind farm reported higher passage rates for Martial Eagle post-construction although the passage rates were low in both cases (10.5 passages per year compared to 4 pre-construction - this was not tested for significance).

Large terrestrial birds

Blue Crane (Anthropoides paradiseus)

The endemic and Near Threatened Blue Crane (Taylor et al. 2015) was present at most wind farms in this study, albeit in varying numbers. There was no clear evidence of displacement for this species. A wind farm with a high abundance of Blue Cranes reported that passage rates for the species decreased after construction (301 vs 157 passages per year). A visual comparison of the spatial location of flights at this site suggests the possible avoidance of the wind turbines by birds in flight, but this was not conclusive. Despite the apparent lower passage rates, there was no evidence of displacement of Blue Cranes at this wind farm. Given their affinity for agricultural areas (Taylor et al. 2015) and their apparent tolerance for disturbance in these areas, this finding is not too surprising.

CRAIG ADAM (CC BY NC 2.0, "BLUE CRANE" 2011 FROM FLICKER.COM)

Blue Cranes do not appear to be displaced by wind farms and have been recorded breeding near to wind turbines.

At least three pairs of Blue Crane were recorded with small chicks at this wind farm and it is likely they bred within 500 m of a turbine. One nest was approximately 120 m from a turbine, and although successful fledging could not be confirmed, the pair raised two chicks to at least eight weeks of age.

Denham's Bustard (Neotis denhami)

The risk of disturbance and/or displacement of Denham's Bustards (Vulnerable, Taylor et al. 2015) from wind farm sites has been raised as a concern in impact assessments. Possible displacement was noted in reports for two wind farms. Post-construction monitoring at one of these sites found 0.03 birds per km of driven transect, compared to 0.11 birds per km before the wind farm was built. At the other wind farm a small number of birds (one to two) was recorded during most (three out of four) pre-construction surveys, but this species was not recorded at all during post-construction surveys. Longer-term studies and comparison with control site data is required before displacement can be confirmed.

The post-construction monitoring report for a third wind farm reported that there was no displacement with 0.35 birds/km recorded pre-construction and 0.51 birds/km during the first year of operation. A lek site was present at this wind farm (but not the other two wind farms), and this may have been the reason behind this pattern. Few bustards were observed at the lek site during operational-phase monitoring, which was attributed to a significant amount of heavy truck activity in the vicinity of the lek (not related to the wind farm), which may have temporarily displaced displaying males from the lek, but not the broader area.

It is conceivable that the birds' greater affinity to the historic lek site reduces likelihood of displacement. Great Bustards *Otis tarda*, a species similar to Denham's Bustard in size and behaviour, have high fidelity to their lek and breeding sites (Alonso et al. 2000). It is therefore important to identify and protect these areas from land use change. Where leks were not present, inter-annual variation in abundance of the species may have been the reason for the decreases, but this warrants further investigation.


SAMANTHA RALSTON-PATON

COLLISIONS WITH TURBINES AND OTHER INFRASTRUCTURE

Minimum (unadjusted) fatality rates

In the first year of operation, 271 bird fatalities were recorded at the seven wind farms (285 turbines) that were regularly surveyed in accordance with the BirdLife South Africa/EWT Best Practice Guidelines. This represents an average of 0.95 birds per turbine per year (range 0.2 – 2 birds per turbine per year; Table 4). The actual number of fatalities is likely to be higher given that although all 285 turbines should have been checked, not all were subject to intensive surveys (Table 2). This estimate also does not take into account that scavengers may remove carcasses and searchers may not find all of the carcasses.

Estimated Fatality Rates

Using estimators developed by Jaine (2007), Huso et al. (2012) and/or Korner-Nievergelt et al. (2015), fatality rates were calculated, taking into account factors such as scavenger removal, searcher efficiency (detection rate), visibility class, carcass size and season. Table 3 summarises results of the scavenger removal and searcher efficiency trials.

Table 3. *Summary of the results of scavenger removal and searcher efficiency trials*

Wind Farm	Detection rate	Carcass persistence (avg. days)	Survey interval (days)
Wind Farm B	Average: 39.58% (n=48)	8.5 (n=18)	7
Wind Farm C	Average: 80% (n=42) Small: 47%. (n=15) Medium: 71% (n=14) Large: 85% (n=13)	10.1 (n=17)	7
Wind Farm D	Small: 12% Medium 21% Large. 58% (n=36)	1-2 (n=117)	7
Wind Farm E	Small: 24%, Medium 65%, Large: 91% (n=72)	8.65 (n=72)	8-13
Wind Farm F	24% (n=73)	7.93 (n=59)	7
Wind Farm H	Small 28% Medium: 83% Large: 39% (n=54)	8.82 (n=60)	10
Wind Farm I	Average 47% (n=54)	4.74 (n=60)	7

	UNADJUSTED		ADJUSTED			
	Fatalities/ turbine/ year	Fatalities/ MW/year	Fatalities/turbine/year Average	Range (95% confidence)	Fatalities/ MW/year (average)	Estimator used
Wind Farm B	1.95	1.09	3.7	2.4-8.5	2.07	K
Wind Farm C	2	0.6	4	2.1-7.6	1.2	H
Wind Farm D	0.2	0.11	5.5 11.1	not provided	3.0 5.9	H K
Wind Farm E	0.97	0.39	4.68	3.15-17.85	1.87	H
Wind Farm F	0.49	0.23	3.72	2.03 - 7.43	1.62	H
Wind Farm H	1.78	0.74	8.59	5.25-22.62	3.75	H
Wind Farm I	0.68	0.3	3.32 2.06	2.33-4.95 not provided	1.59 0.95	H J
Average	0.95		4.11			

Table 4. *Adjusted and unadjusted fatality rates for year one at 7 REIPPPP round one wind farms. The MW is nameplate capacity, not realised capacity. Esitimators: H=Huso et al. 2012, J=Jaine 2007, K= Korner-Nievergelt et al. 2015.*

Among the wind farms assessed, estimated fatality rates ranged from 2.1 to 8.6 birds per turbine per year, with a mean of 4.1 (Table 4). Correction factors between observed and estimated fatality rates varied greatly among wind farms (Figure 3). The wind farm with the highest rate of reported fatalities, was ranked fourth once scavenger removal and searcher efficiency was taken into account. The explanation for this may be in the methods employed on site. Sites where all turbines are searched regularly, where turbines are searched at a search interval lower than the rate of carcass removal, and where detection rates are high should show a smaller difference between observed and estimated fatality.

The models used to estimate fatality rates are sensitive to small changes in detection and scavenger removal rates, and there are a number of potential biases in these trials (discussed above). These limitations should be born in mind when comparing results between wind farms, and between regions. However, the figures do place South Africa within the range observed in Europe and North America. Rydell et al. (2012) reviewed studies from 31 wind farms in Europe and 28 in North America and found a range between 0 and 60 birds killed per turbine per year, with a median value of 2.3 (adjusted for detection and scavengers). European average bird fatality rates were 6.5 birds per turbine per year compared to 1.6 birds per turbine per year for North America.


SAMANTHA RALSTON-PATON

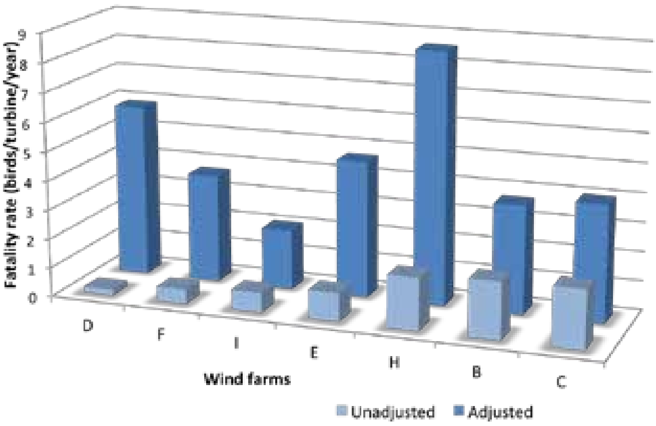

Figure 3: *The relationship between the adjusted and unadjusted fatality rates is not straightforward and is influenced by searcher efficiency, scavenger removal rates, proportion of turbines searched and search interval. (Where two fatality estimates were used, the lower estimate is represented here).*

It is also important to note that high fatality rates do not necessarily equate to a high number of threatened species affected. Wind Farm H, for example, has the highest estimated fatality rate, and third highest unadjusted fatality rate, but only one threatened species fatality was found.

SAMANTHA RALSTON-PATON

Location of carcasses

Most reports contained little detailed analysis of the location of carcasses. Table 5 summarises the data that was available. In all cases where the data were presented, the average distance from the turbine base was less than 60 m. However, the distribution of carcasses is likely to be skewed and the average tells little about the likely position of fatalities. Carcases were found as far as 152 m away. There would be benefit in analysing the exact locations of carcasses more rigorously as this would help inform the appropriate size of search areas in the future.

Table 5: *The location of carcasses relative to the base of the turbines.*

Wind Farm	Average distance from turbine (m)	Range
Wind Farm B	(<40)*	0-110
Wind Farm C	39.9	5 to 97
Wind Farm E	58.9	2-116
Wind Farm H	47.2	1 - 152
Wind Farm I	34.4	0 to 109**

** Most carcasses were < 40 m from turbine base.*
*** 80% of carcasses were found within 54 m of the turbine base.*

Relationship between turbine height, rotor swept area and fatality rates

No relationship between fatality rates (unadjusted or estimated) and the diameter of the rotor swept area or hub height was found. However, there was limited variation in the size of turbines - five wind farms had turbines with a hub height of 80 m and the difference between the smallest and largest rotor diameter was just 25 m.

Table 6: *Fatality rates, hub height of turbines and diameter of rotor swept area*

	Fatality rate (birds/turbine/year)		Hub height (m)	Diameter (m)
	Unadjusted	Estimated		
Wind farm I	0.68	2.06	80	88
Wind farm H	1.78	8.59	80	90
Wind farm E	0.97	4.68	80	100
Wind farm B	1.95	3.7	95	100
Wind farm F	0.49	3.72	80	101
Wind farm D	0.2	5.9	80	110
Wind farm C	2	4	90	113

Season

The number of fatalities recorded decreased in the winter months (Figure 4), coinciding with the period where lower bird activity levels and fewer species can be expected to be present. The number of fatalities recorded dipped in December, but rose sharply in January and peaked in February. This decrease in December is probably more likely to be due to the availability and work ethic of searchers over the festive season, rather than ecological factors.

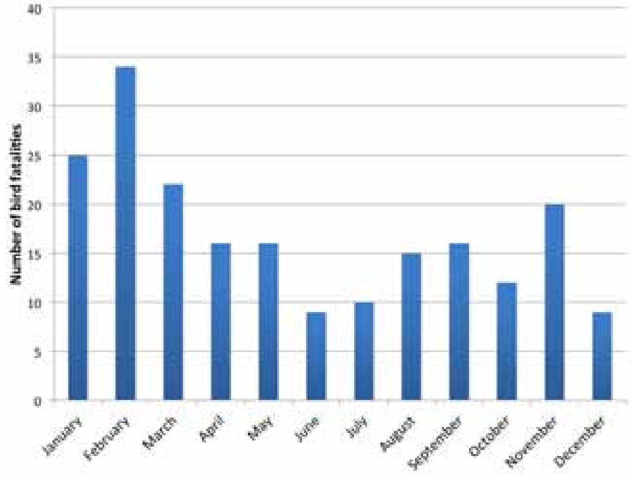

Figure 4: *Number of bird fatalities recorded each month at 6 wind farms (one report did not indicate the date carcasses were found, and was excluded from this analysis).*

Species affected

While fatality rates are of interest, it is perhaps more important to understand which groups of species have been affected, which have not, and what the conservation significance of impacts might be now and into the future. This is particularly important as wind energy is set to expand its footprint in South Africa and predicting and avoiding cumulative impacts will be crucial. A full list of fatalities can be found in Appendix 1. Species were divided into broad groups and the number affected by collisions in each group is summarised in Figure 5. Raptors and passerines are two groups most affected, echoing patterns observed elsewhere (Rydell et al., 2012). It is important to note that the figures listed in Appendix 1 should be interpreted with care. Not all turbines were searched regularly and rigorously. Results may therefore be skewed to larger species, which are likely to persist longer and are more visible than smaller species.

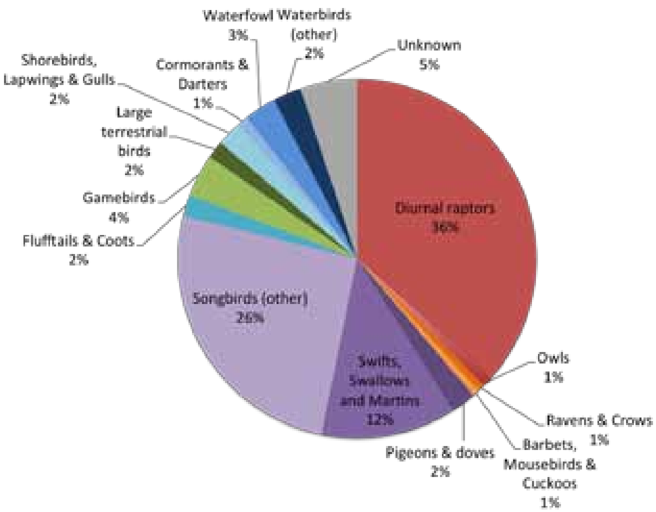

Figure 5: *Summary of species killed by wind turbines at REIPPPP Round 1 Wind Farms in South Africa*

Note: The results presented above include fatalities found during construction, the initial sweep for carcasses, ad hoc finds, and the first year monitoring, additional (year 2 interim) monitoring results, but excludes fatalities as a result of power lines and causes other than wind turbine collisions.

While raptors are usually the focus of impact assessments, a wide range of species including swifts, swallows, doves, larks and other songbirds were also recorded as turbine fatalities.

Threatened species affected by collisions with wind turbines include Cape Cormorant (*Phalacrocorax capensis*, regionally Endangered), Blue Crane (*Anthropoides paradiseus*, Near Threatened), Martial Eagle (*Polemaetus bellicosus*, Endangered), Verreaux's Eagle (*Aquila verreauxii*, Vulnerable), Lanner Falcon (*Falco biarmicus*, Vulnerable), Striped Flufftail (*Sarothrura affinis*, Vulnerable) and Black Harrier (*Circus maurus*, Endangered) (Taylor et al. 2015). Although not currently threatened, the high number of Jackal Buzzard (*Buteo rufofuscus*) fatalities is also of note. This species is near endemic to South Africa.

All wind farms reported at least one fatality of a threatened species during the first year of monitoring. The highest number of threatened species mortalities at a single wind farm during this period was four (all Verreaux's Eagle). Additional monitoring and mitigation has been implemented at this site.

Using methods outlined in Retief et al. (2011) the Birds and Renewable Energy Specialist Group has identified a suite of "priority species", species that were assessed to be collision-prone and likely to be vulnerable to the impacts of wind energy. The species were scored according to their conservation status, distribution, behaviour and size (Appendix 2 contains a list of the top 107 priority species and their assigned scores). This list of species is used to help screen potential wind farm sites and helps focus of avifaunal impact assessments and monitoring. The top 20 of these are listed in Table 7, alongside notes about their apparent vulnerability to impacts. Again, it must be emphasised that these results should be considered preliminary, and it is recommended that the list be reviewed once more data is made available.

Table 7. *The top 20 species assessed as likely to be vulnerable to the impacts of wind energy compared to the observed impacts.*

Species	Ranking	Fatalities likely?	Comments
Cape Vulture	1	?	Recorded at several wind farms, and two collisions reported. The risk of future collisions cannot be excluded.
Bearded Vulture	2	NA	Wind farms in this study are outside of the species' range.
Verreaux's Eagle	3	✓	Appears to be vulnerable to collisions.
Martial Eagle	4	✓	Recorded at several wind farms, and two collisions reported. The risk of future collisions cannot be excluded.
Wattled Crane	5	NA	Wind farms in this study are outside of the species' range.
Black Harrier	6	✓	An occasional visitor to many of the wind farms. Appears to be vulnerable to collisions
Great White Pelican	7	?	An occasional visitor to a few of the wind farms. No collisions recorded to date, but the risk cannot be excluded.
Southern Bald Ibis	8	NA	Wind farms in this study are outside of the species' range.
Yellow-billed Stork	9	NA	Not recorded at any of the wind farms assessed.
Black Stork	10	?	Uncommon and only recorded at a few of the surveyed wind farms.
Blue Crane	11	✓	Found regularly at most wind farms in this study. Although collisions have occurred, there are indications of possible flight avoidance.
White-headed Vulture	12	NA	Wind farms in this study are outside of the species' range.
Secretarybird	13	?	Occasional visitor to some sites, no collisions reported to date. The risk cannot be excluded.
Ludwig's Bustard	14	?	Limited overlap with wind farms in this study. Collisions with powerlines associated with wind farms likely.
Grey Crowned Crane	15	NA	Not recorded at any of the wind farms in this study.
Taita Falcon	16	NA	Wind farms in this study are outside of the species' range.
Southern Ground-Hornbill	17	NA	Not recorded at any of the wind farms in this study.
Cape Cormorant	18	✓	One fatality recorded, not regularly recorded at wind farms
Lappet-faced Vulture	19	NA	Wind farms in this study are outside of the species' range.
Pink-backed Pelican	20	NA	Wind farms in this study are outside of the species' range.

RAPTORS

Many raptors (for example eagles and vultures) are long-lived, with low reproductive rates, which make them vulnerable to increased mortality rates. As predators they also play an important role in many ecosystems, and the loss of raptors could have ecological effects. As has been observed in other parts of the world (e.g. Langston and Pullan, 2003; Rydell et al. 2012, Gove et al. 2013), a large proportion (37%) of fatalities recorded were nocturnal and diurnal raptors (Figure 5). A minimum (i.e. unadjusted) fatality rate of 0.3 raptors per turbine per year was calculated for the first year of monitoring. While the actual number is likely to be greater than this figure, raptors do appear to be scavenged less than other groups (Smallwood 2007; Urquhart et al. 2015) and all turbines were searched at least a few times a year. The observed fatality rates are therefore likely to be relatively close to actual fatality rates

KOSHY KOSHY (CC BY 2.0, AMUR FALCON, 2014, FROM FLICKER.COM)

*Raptors accounted over a third of the bird carcasses found beneath turbines. Approximately one quarter of the raptor fatalities recorded during the first year of monitoring were Amur Falcon (*Falco amurensis*).*

when compared to smaller species. Carcasses of nineteen raptor species were found, including buzzards, eagles, falcons, kestrels and kites (Appendix 1). Some of the more important incidents are discussed below.

*Amur Falcon (*Falco amurensis*)*

Amur Falcon was the most commonly affected raptor, with 22 fatalities recorded in the first year of monitoring. Four wind farms reported Amur Falcon fatalities (two of the wind farms which reported no fatalities are located outside of the range of the species). The two wind farms with the highest number of fatalities also reported large numbers (hundreds to thousands) of birds near the wind farms. A temporary roost of 1500 birds was reported at one of the sites. One study noted that approximately 35% of Amur Falcon flights were at the height of the rotor swept area. Not accounting for the number of turbines outside the species' range, the unadjusted (i.e. minimum) fatality rate for this species was 0.08 birds per turbine per year.

Given that the population of this migratory species is large (a national census on 2009 recorded approximately 111 000 individuals in South Africa (Symes & Woodborne, 2010) and the species is not currently threatened (BirdLife International, 2016) the impact on the species' population is unlikely to be significant at this stage. However, Amur Falcon is listed under the Convention of Migratory Species and its flocking behaviour may present a risk of multiple fatalities in a short space of time. The species may also provide valuable ecosystem services and impacts should therefore be monitored, and where possible mitigated. Where large numbers of birds are

PIM STOUTEN (CC BY-NC 2.0, SOARING JACKAL BUZZARD #1, 2010 FROM FLICKER.COM)

Jackal Buzzard, Buteo rufofuscus*, accounted for approximately 20% of raptor fatalities attributed to collisions with wind turbines.*

JESSIE WALTON

Although the results are preliminary, conservationists' concern that Verreaux's Eagles, Buteo rufofuscus*, are at risk of colliding with turbines appear to have been confirmed.*

recorded near a wind farm (or proposed wind farm), consideration should be given to operational phase mitigation (e.g. shutdown on demand during risk periods) to reduce the probability of collisions.

*Jackal Buzzard (*Buteo rufofuscus*)*

The second most commonly affected raptor was Jackal Buzzard. High fatality rates have been reported for other *Buteo* species including Common Buzzard (*B. buteo*) in Europe (Hötker et al. 2006), White-tailed Hawk (*B. albicaudatus*) in Latin America (Ledec et al., 2011) and Red-tailed Hawks (*B. jamaicensis*) in the United States (Smallwood and Thelander, 2008). Seventeen Jackal Buzzard fatalities were recorded in the first year of surveys (a minimum of 0.06 birds per turbine per year). Fatalities occurred at 5 of the 7 wind farms, reflecting the species wide distribution. A large proportion of this species' flights (66-77% according to two monitoring reports) are located at the risk height (i.e. at the height of the rotor swept area). The population in southern Africa is estimated to number in the tens of thousands (BirdLife International, 2016) and while this species is not threatened, it is endemic to southern Africa (Taylor et al. 2015). Impacts at the population level are unlikely to be significant at this stage, monitoring, mitigation, and further research is recommended to help ensure that this common species remains common, and that the ecological implications of any losses are understood.

*Rock Kestrel (*Falco rupicolus*)*

Rock Kestrel fatalities were also recorded with some frequency, with 14 fatalities recorded in the first year (0.05 fatalities per turbine per year). Rock Kestrel fatalities were recorded at five out of the seven wind farms assessed. Like the Jackal Buzzard, while these impacts may not be of immediate concern, further study is encouraged.

*Verreaux's Eagle (*Aquila verreauxii*)*

Verreaux's Eagle is ranked third on the South African Birds and Renewable Energy Specialist Group's priority list and concerns that this species is vulnerable to collisions appear to have been confirmed. One wind farm recorded four Verreaux's Eagle fatalities in the first year of operation. Three of these were adults and one was a juvenile. Two of the fatalities (one adult and one juvenile) occurred at the same turbine. These collisions probably took place 10-12 days apart and all the fatalities at the wind farm occurred in autumn. This period coincides with the time that the highest levels of flight activity were recorded, possibly relating to prey abundance (passage rates peaked to around 1.45 birds per hour in autumn, with most activity occurring in the afternoon). Prior to the construction of the wind farm, low flight activity of Verreaux's Eagle was recorded and the assessment did not predict that the species was particularly at risk at this site. The fatalities occurred a considerable distance (at least 3.5 km) from suitable Verreaux's Eagle breeding habitat, and on relatively flat ground (Smallie, 2015). In response to these fatalities additional research and monitoring activities were initiated, including a thorough survey for Verreaux's Eagle nests in the vicinity of the wind farm. This found nine confirmed and occupied eagle territories within a 15 km radius of the wind farm (ranging from 3.7 to 13.6 km from nearest turbine). A full time eagle monitor was employed on site with the aim of mitigating collision risk for eagles and other priority species, through the collection of additional data, assessment of collision risk, and if required, the monitor can advise shutdown on demand. No further incidents at the site have been reported, and flight activity appears to have reduced in the second year.

A single adult fatality occurred at another wind farm in August. The carcass was located 65 m from the nearest turbine. Again the fatality occurred some distance from a nest - a pair was reported to be breeding on a nest 3.8 km away. Additional monitoring was also initiated in response to the incident.

Eagle mortalities at wind farms are not unexpected. Fatalities at wind farms have been reported for Golden Eagle (*Aquila chrysaetos*) (e.g. Smallwood & Thelander, 2008; Smallwood, 2013), White-tailed Sea Eagle (*Haliaeetus albicilla*) (e.g. Hötker et al., 2006), Bald Eagle (*Haliaeetus leucocephalus*) (Pagel et al., 2013) and White-bellied Sea Eagle (*Haliaeetus leucogaster*) (Smales & Muir, 2005).

Verreaux's Eagle has recently been up-listed to Vulnerable and rough estimates of the population size are between 3500 and 3750 mature individuals (Taylor et al., 2015). Based on the limited information available, it does appear that a more precautionary approach to mitigating impacts is warranted,

WESSEL ROSSOUW

Just 500 to 1000 breeding pairs of Black Harrier, Circus maurus*, are thought to remain. Although only a small number of Black Harrier fatalities have been recorded thus far at wind turbines, the long-term effect of wind energy on this species is a potential cause for concern.*

CHRIS VAN ROOYEN

Although no fatalities of Cape Vulture, Gyps coprotheres*, were reported during the study period, it is anticipated that longer-term monitoring will confirm that this species is at risk of colliding with poorly located wind turbines.*

particularly when the cumulative risk of multiple wind farms within the species range is considered. Fortuitously, BirdLife South Africa had recognised the potential risk to the species and the need for more consistent and defensible mitigation measures and is finalising guidelines for impact assessment and mitigation for the species. It will be important to continue to study the species behaviour and risk factors.

*Black Harrier (*Circus maurus*)*
Ranked sixth on the priority list, concerns about the risk wind turbines pose to this species also appear to have been confirmed. A total of three Black Harrier fatalities were recorded in the first year of operational-phase monitoring (including one carcass found incidentally). One wind farm recorded a single fatality in January. The pre-construction monitoring report did not highlight collision risk for this species as of particular concern and relatively low flight activity (6 flights) for the species was recorded during the first year of post-construction monitoring. One third of the flights recorded were at the height of the rotor swept area.

Two fatalities were recorded at another wind farm during the first year of post-construction monitoring, with another two fatalities found during subsequent surveys. Again, the risk of collisions was not assessed to be high during preconstruction monitoring as the species was recorded infrequently and all flights were recorded below the height of the rotor swept area. After construction 47 flights were recorded during the first year of monitoring, with 34% of flight duration occurring at the height of the rotor swept area. A roost site was subsequently reported approximately 5 to 10 km from this wind farm. The significance of this roost in relation to wind farm fatalities is being investigated further and the wind farm is investigating options for operational phase mitigation.

Harriers elsewhere in the world do not appear to be particularly collision-prone (Hötker et al., 2006, Whitfield & Madders, 2006, Rydell et al., 2012) and while the current number of fatalities for Black Harrier may seem to be low, this near-endemic species is the most range restricted continental raptor in the world. It is classified as Endangered globally and regionally, and it is estimated that just 500 to 1000 breeding pairs remain, with further declines expected (Taylor et al., 2015). If the trend of wind farm mortalities continues, the proliferation of wind farms within the core breeding habitat and local migration routes could pose a significant threat to this species and must be mitigated. In response to this concern, BirdLife South Africa and the Endangered Wildlife Trust are developing guidelines to promote improved impact assessment and mitigation for this species.

*Martial Eagle (*Polemaetus bellicosus*)*
Ranked fourth on the priority list, Martial Eagle (Endangered, Taylor et al., 2015) was recorded regularly at two of the wind farms studied and was an occasional visitor to the rest of the sites. A breeding pair of Martial Eagles was found located within the footprint of one wind farm and the pair appears to have co-existed with the turbines for two years. However, a sub-adult Martial Eagle (approximately 3 years old) was subsequently struck by a turbine. Bird specialists working at the site witnessed the collision and reported that Jackal Buzzards had mobbed the eagle shortly before the incident occurred (Simmons & Martins, 2016). Another fatality was recorded at the same site later that year. The wind farm is investigating operational phase mitigation options.

*Cape Vulture (*Gyps coprotheres*)*
The Endangered Cape Vulture (Taylor et al., 2015) was ranked at the top of the priority list of species potentially vulnerable to the impacts of wind energy, but to date there have been no Cape Vulture fatalities reported. This species was recorded at two of the wind farms in this study, with a temporary roost with about 50 birds located approximately 12 km from one of these sites. Monitoring at both wind farms in question recorded relatively infrequent flights of small groups of birds (less than 8 birds at a time). Livestock carcass management plans are in place at both sites to limit food availability (and therefore the risk of collisions). Although this is encouraging, the risk of collisions cannot be eliminated as evidence from vultures and wind farms elsewhere suggests that vultures are vulnerable to colliding with turbines and associated infrastructure (García-Ripollés & López-López, 2011; de Lucas et al., 2012). At one of the wind farms mentioned above, 53.5% of flight duration was within the height of the rotor swept area. BirdLife South Africa had recognised the potential risk to the species and the need for more consistent and defensible mitigation measures recommended in impact assessments. Guidelines for impact assessment and mitigation for the species are being developed.

LARGE TERRESTRIAL BIRDS

Carcasses of large species are likely to be more obvious (resulting in high detection rates) (Table 3) and are likely to persist longer than smaller species (Ponce et al., 2010; Shaw et al., 2010; Schutgens et al., 2014). As with raptors, the number of large terrestrial species carcasses recorded is likely to be relatively close to actual fatality rates when compared to smaller species.

Blue Crane (Anthropoides paradiseus)

Ranked 11 on the priority list, Blue Cranes were recorded at all of the wind farms in this study, although abundances varied. This species was recently downgraded to Near Threatened (Taylor et al., 2015). No Blue Crane fatalities were recorded in the first year of monitoring. However, 3 fatalities (all adults) were reported at a wind farm in January/February 2016, after 21 months of monitoring (Smallie, 2016). Two of the cranes were found at the same turbine and it is suspected that they were killed in the same event, (i.e. they were flying together). The incident occurred in a field of cereal crop, and the area had high abundance of cranes. Cranes were regularly seen on site and were also breeding in the area. Coarse collision risk modelling in the pre-construction assessment predicted a possible fatality rate of 15 Blue Cranes per year. Less than this number of fatalities occurred across all wind farms during the period.

Operational phase monitoring of bird movements at the same wind farm suggested possible avoidance behaviour - some birds in flight appeared to avoid turbines several hundred meters away, while other birds seemed to show no sign of avoidance. The behaviour of Blue Cranes in and around turbines warrants further study.

Korhaans and bustards

One Karoo Korhaan (*Eupodotis vigorsii*) (Near Threatened - Taylor et al. 2015) and two Blue Korhaan (*E. caerulescens*) fatalities were reported. The Karoo Korhaan fatality was associated with a powerline (this had no bird flight diverters installed), while the Blue Korhaan carcasses were found near turbines.

Encouragingly no bustard fatalities were reported as a result of collisions with turbines. This may be due to the predominantly low flight height of this group. However, one Denham's Bustard carcass was found during preconstruction surveys - apparently killed in a collision with the supporting cables of the wind monitoring mast. The marking of guy wires is strongly encouraged to prevent similar incidents.

SHOREBIRDS, WATERFOWL AND WATERBIRDS

Shorebirds, waterbirds and waterfowl made up a small percentage of the fatalities. Most of the collision incidents for this group occurred at one wind farm, located a few kilometres from the coast. Impact assessment predictions of high collision rates for waterfowl at another wind farm did not materialise during the monitoring period.

CHRIS VAN ROOYEN

Although fatalities of Blue Crane, Anthropoides paradiseus, *have been recorded, preliminary results suggest that Blue Cranes may avoid flying near turbines.*

Cape Cormorant (Phalacrocorax capensis)

One Cape Cormorant fatality was reported at a wind farm located a few kilometres from the coast. The species was not recorded during pre- or post construction monitoring of live birds, suggesting that the species is only an occasional visitor to the site. A few fatalities of other cormorants (Reed Cormorant *Microcarbo africanus* and an unidentified cormorant species) were also reported (see Appendix 1).

OTHER GROUPS

While raptors and large-bodied birds generally receive the most attention at wind farms, a large proportion of fatalities recorded at wind farms are of passerines and other small birds (AWWI 2015). A similar pattern has emerged here, with passerines accounting for approximately one third of reported fatalities. Species affected included larks, finches, bushsrikes, warblers and cisticolas. Red-capped Lark (*Calandrella cinerea*) fatalities appear to have been associated with species' breeding display in the summer months. Although no threatened species in this group were affected, this does highlight the need for caution when considering developing wind farms within habitats of range-restricted, threatened or endemic passerines.

Pied Crows (*Corvus albus*) were regularly reported at wind farms, yet no fatalities were reported. Corvids do not appear to be immune to impacts though - two Cape Crow (*Corvus capensis*) fatalities were recorded.

Passage rates and collision risk

It was not possible to assess whether high passage rates correlated with an increase in fatalities (both between sites and between species), as the data were presented in such a way that made comparisons difficult. A more detailed analysis of flight activity and collision risk is required. However, it does appear that different species may be affected differently. Some species, for example Pied Crow, had no fatalities reported, despite high passage rates. This question warrants further investigation as high passage rates are often assumed to imply high fatality rates.

EMPLOYMENT BENEFITS AND SKILLS DEVELOPMENT

Often-overlooked benefits of avifaunal monitoring at wind farms are the employment and skills development opportunities this brings to the local community (particularly important in the South African context). Carcass surveys do not require specialised skills or expertise, and this has presented an opportunity for local employment, and semi-skilled staff (farm labourers or residents from surrounding communities within 50 km of the wind farm) have been employed to conduct the surveys. This has resulted in the creation of 27 full time positions (at least for the duration of monitoring) at the first window REIPPPP wind farms. These positions are in addition to the bird specialists and their field staff who are employed on a contractual basis. Further opportunities to develop birding skills and expand job opportunities in this field could be explored.

CONCLUSIONS AND RECOMMENDATIONS

The findings and recommendations contained in this report are based on monitoring over a short period, at a limited number of wind farms. Environmental systems are inherently variable and the wind farms in the study are distributed over a wide range of environmental conditions, but they do fall outside of the range of many priority species. While we encourage stakeholders to consider the results of this review during site screening and impact assessments, we also caution against drawing firm conclusions at this stage.

In terms of fatality rates, the study results suggest that South Africa falls within the range experienced in the United States and Europe. However, there is a wide range of potential values associated with the estimated fatality rates and further monitoring would allow for more accurate estimates. Sourcing a suite of carcasses more representative of the natural bird population for the carcass persistence trials would also be of benefit.

It is encouraging that many of species assessed to be most vulnerable to the impacts of wind energy have not been recorded, or have been recorded at low numbers at the wind farms in this study. This could suggest avoidance of high-risk sites through site screening and impact assessment, but could also be as a result of the small sample size. Steps would (or at least should) have been taken to minimise risk to birds through amendments to the wind farm location and layout during the impact assessment process, and subsequent refinement of the turbine layout in response to additional surveys. A precautionary approach therefore remains warranted for all priority species, including those seemingly unaffected so far.

The preliminary data do appear to confirm that raptors, including threatened species such as Martial Eagle, Verreaux's Eagle and Black Harrier are vulnerable to collisions. Extra care should therefore be taken when considering developing a wind farm within the habitat of these species. Further monitoring, research, and where necessary, adaptive management and operational phase mitigation, is encouraged at existing wind farms within their range.

Displacement effects are particularly challenging to assess. Any differences in presence, absence and abundance of species at an individual wind farm before and after construction could have been due to various factors including environmental variation on site, differing survey methodologies and/or skill differences between the teams. More detailed analysis of data, including from the control sites, would help establish if there were any changes in the bird communities associated with the development of wind farms. While none of the studies yielded conclusive results with regards to displacement or changes in the abundance and species composition, some possible trends were identified that warrant further interrogation.

A large amount of data is collected during pre- and post-construction monitoring, yet only a small portion of this was available, analysed in any detail and presented in the reports. A meta-analysis of the raw data is therefore recommended along with monitoring over a longer period. Data could be made available to students for more rigorous analysis, but ownership and usage rights would need to be resolved. Co-operation of wind farm operators and partnering with academic institutes is therefore strongly encouraged. More intensive academic research into specific questions could also complement existing approaches to monitoring.

RE SIMMONS: BIRDS & BATS UNLIMITED

Black Harriers were not expected to be particularly vulnerable turbine collisions. Operational-phase monitoring is an opportunity to test our assumptions and improve decision-making in the future. It is therefore important that the results of monitoring are shared with the conservation community.

While there is no immediate cause for alarm, we encourage all wind farms to strive to minimise negative impacts and maximise the environmental benefits, rather than wait for a pre-defined level of impact to be exceeded. This approach is critical if the intention is to expand wind energy in South Africa without cumulative negative impacts becoming a major obstacle to development, and without wind energy presenting a serious threat to bird conservation in the long term.

RECOMMENDATIONS FOR WIND FARMS OPERATORS AND DEVELOPERS

- Early consultation with NGOs and bird specialists is encouraged, particularly where a proposed wind farm may affect priority species.
- Wind farm developers/operators should ensure that the landowner understands the implications of monitoring throughout the lifespan of the wind farm, and should ensure the necessary arrangements and agreements are in place to allow monitoring to be conducted.
- Meteorological masts' guy wires and powerlines associated with wind farms should be fitted with bird flight diverters.
- If different specialists are used for monitoring pre- and post- construction, wind farms should ensure that there is adequate handover of raw data and that survey methods are clearly described.
- By making monitoring reports and data available, wind farms can make a major contribution to our understanding of the interactions between wind energy and birds. Wind farms could facilitate further analysis of existing data by academic institutes if raw data is also made available.
- Wind farms should also encourage and facilitate further academic research at their sites to investigate specific questions that standard monitoring protocols cannot address.

- As our understanding develops, wind farms (including existing and approved projects) are encouraged to revisit their mitigation strategies to ensure impacts are minimised as far as possible.

RECOMMENDATIONS FOR BIRD SPECIALISTS

- Although the data in this study are preliminary, the results of this review should be considered during avifaunal impact assessments, and when developing mitigation strategies.
- Specialists should ensure that their data and survey methods are clearly captured and easily handed over and interpreted by another specialist.
- Specialists should encourage the wind farm to have the necessary permissions in place to allow access to sites for monitoring throughout the life cycle of the project (including the control site).
- Specialists should endeavour to identify appropriate control sites that are beyond the influence of any wind farm.
- Statistical analysis of species abundance data could generally be improved, and should include comparisons with the control site. Specialists could consider working with university students to analyse data.
- Specialists should endeavour to use a suite of carcasses representative of the natural bird population for carcass persistence trials, as this will improve the accuracy of the results.

SAMANTHA RALSTON-PATON

Wind energy is a welcome alternative to coal, but its impacts on birds must be adequately assessed and mitigated. This report is the first of its kind for southern Africa and aims to help achieve this goal.

RECOMMENDATIONS FOR POLICY AND DECISION-MAKERS

- Monitoring provides valuable information that should feed back into impact assessments and mitigation strategies, including for projects that already have environmental authorisation.
- It would be useful if reporting key measures (including survey effort and confidence intervals) could be standardised across sites to facilitate comparisons across multiple wind farms.
- Issues around access to and use of raw data need to be resolved. Similarly a clear position regarding whether post-construction monitoring reports should be in the public domain is required.
- There are a number of questions that warrant further study, but are beyond the scope of monitoring and assessment at individual wind farms. Funding needs to be secured to facilitate this.

TOPICS THAT WARRANT FURTHER STUDY INCLUDE:

- How is the abundance and composition of small bird communities affected by the development of wind energy, and how does this change with time? Long-term studies are required to investigate if there are displacement effects on species, particularly priority species.
- Are small, endemic passerines with narrow distributions (e.g. larks) likely to be vulnerable to the impacts of wind energy (displacement, habitat loss and collisions) and can these impacts be mitigated?
- How is raptor activity affected by the construction of wind farms, and what is driving any observed changes?
- How does the presence of turbines affect the breeding, movement and flight activity of priority species (e.g. Blue Crane, Denham's Bustard, Verreaux's Eagle, Martial Eagle, Black Harrier and Jackal Buzzard)?
- How do landscape features, topography, abundance and passage rates influence collision-risk, and how does this differ between species?
- What is the most effective way to predict and minimise the collision risks for Black Harrier? Should the harrier roost influence the location of additional wind turbines in the area?
- What are potential ecological implications of the apparently high fatality rates for Jackal Buzzard? Is the location of territories affected by the presence of wind turbines?
- Based on the location of carcasses and primary purpose of surveys, what is an appropriate size of the search area?

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APPENDICES

APPENDIX 1. BIRD FATALITIES AT REIPPPP 1 WIND FARMS

	Scientific name	Red Data Book Status	Endemism	Turbines Year 1	Turbine (other)	Other/ unknown	Grand Total
Diurnal raptors				**84**	**30**	**1**	**115**
Buzzard, Common (Steppe)	*Buteo buteo*			5	1		6
Buzzard, Jackal	*Buteo rufofuscus*		(*)	17	6	1	24
Eagle, African Fish	*Haliaeetus vocifer*				1		1
Eagle, Booted	*Hieraaetus pennatus*		3	1			4
Eagle, Martial	*Polemaetus bellicosus*	EN, VU			2		2
Eagle, Verreaux's	*Aquila verreauxii*	VU, LC		4	1		5
Falcon, Amur	*Falco amurensis*			22	5		27
Falcon, Lanner	*Falco biarmicus*	VU, LC			1		1
Falcon, Peregrine	*Falco peregrinus*			1			1
Goshawk, Pale Chanting	*Melierax canorus*			2	2		4
Harrier, Black	*Circus maurus*	EN, VU	(*)	2	3		5
Hawk, African Harrier-	*Polyboroides typus*			1	1		2
Kestrel, Lesser	*Falco naumanni*			2			2
Kestrel, Rock	*Falco rupicolus*			14	5		19
Kite, Black-shouldered	*Elanus caeruleus*			6	1		7
Kite, Yellow-billed	*Milvus aegyptius*			1			1
Osprey, Western	*Pandion haliaetus*				1		1
Unknown				4	1		5
Owls				**1**	**2**		**3**
Owl, Spotted Eagle-	*Bubo africanus*			1	1		2
Owl, Western Barn	*Tyto alba*				1		1
Ravens & Crows					**2**		**2**
Crow, Cape	*Corvus capensis*				2		2
Barbets, Mousebirds & Cuckoos	`			**2**			**2**
Barbet, Black-collared	*Lybius torquatus*			1			1
Cuckoo, Great Spotted	*Clamator glandarius*		1			1	
Mousebird, Speckled	*Colius striatus*			1			1
Pigeons & doves				**4**	**3**	**2**	**9**
Dove sp.					1		1
Dove, Cape Turtle	*Streptopelia capicola*		1	1		2	
Dove, Red-eyed	*Streptopelia semitorquata*				1	1	
Dove, Rock	*Columba livia*					1	1
Pigeon, Speckled	*Columba guinea*			3	1		4
Swifts, Swallows and Martins				**27**	**11**		**38**
Swallow, Barn	*Hirundo rustica*			2			2
Swallow, Greater Striped	*Cecropis cucullata*			2			2
Swallow, Lesser Striped	*Cecropis abyssinica*				1		1
Swift sp.				10	1		11
Swift, Alpine	*Tachymarptis melba*		2			2	
Swift, Common	*Apus apus*			1	7		8
Swift, Horus	*Apus horus*			2			2
Swift, Little	*Apus affinis*			4			4
Swift, White-rumped	*Apus caffer*			4	2		6

	Scientific name	Red Data Book Status	Endemism	Turbines Year 1	Turbine (other)	Other/ unknown	Grand Total
Songbirds (other)				**64**	**16**	**3**	**83**
Bokmakierie	*Telophorus zeylonus*			8	5		13
Bulbul, Cape	*Pycnonotus capensis*	*	1			1	
Canary, Cape	*Serinus canicollis*			3			3
Chat, Ant-eating	*Myrmecocichla formicivora*		1			1	
Cisticola sp.				6			6
Cisticola, Lazy	*Cisticola aberrans*				1		1
Fiscal, Southern (Common)	*Lanius collaris*					2	2
Lark sp.				4	1		5
Lark, Cape Long-billed	*Certhilauda curvirostris*	*	1			1	
Lark, Red-capped	*Calandrella cinerea*			8	3		11
Lark, Spike-heeled	*Chersomanes albofasciata*		2			2	
Longclaw, Cape	*Macronyx capensis*			2			2
Pipit sp.				1			1
Pipit, African	*Anthus cinnamomeus*		3			3	
Pipit, Plain-backed	*Anthus leucophrys*			1			1
Quail-finch, African	*Ortygospiza fuscocrissa*		1			1	
Robin-chat, Cape	*Cossypha caffra*			1			1
Sparrow, Cape	*Passer melanurus*			2			2
Starling, Common	*Sturnus vulgaris*					1	1
Starling, Pied	*Lamprotornis bicolor*	SLS	1			1	
Stonechat, African	*Saxicola torquatus*			2			2
Sunbird, Malachite	*Nectarinia famosa*			1			1
White-eye, Cape	*Zosterops virens*		(*)	1			1
Whydah, Pin-tailed	*Vidua macroura*				1		1
Unknown				14	5		19
Flufftails & Coots				**5**	**1**		**6**
Coot, Red-knobbed	*Fulica cristata*				1		1
Flufftail, Buff-spotted	*Sarothrura elegans*			2			2
Flufftail, Red-chested	*Sarothrura rufa*			2			2
Flufftail, Striped	*Sarothrura affinis*	VU, LC		1			1
Gamebirds				**11**	**1**	**15**	**27**
Guineafowl, Helmeted	*Numida meleagris*			2		4	6
Quail, Common	*Coturnix coturnix*			1	1		2
Spurfowl, Cape	*Pternistis capensis*		(*)	7		11	18
Spurfowl, Red-necked	*Pternistis afer*			1			1
Large terrestrial birds				**2**	**3**	**2**	**7**
Bustard, Denham's	*Neotis denhami*	VU, NT				1m	1
Crane, Blue	*Anthropoides paradiseus*	NT, VU			3		3
Korhaan, Blue	*Eupodotis caerulescens*	LC, NT	SLS	2			2
Korhaan, Karoo	*Eupodotis vigorsii*	NT, LC				1p	1
Shorebirds, Lapwings & Gulls				**5**	**2**		**7**
Gull, Kelp	*Larus dominicanus*			1			1
Lapwing sp.				1			1
Lapwing, Crowned	*Vanellus coronatus*			2	2		4
Plover, Kittlitz's	*Charadrius pecuarius*		1			1	
Cormorants & Darters				**2**	**1**		**3**
Cormorant sp.				1			1

	Scientific name	Red Data Book Status	Endemism	Turbines Year 1	Turbine (other)	Other/ unknown	Grand Total
Cormorant, Cape	*Phalacrocorax capensis*	EN, EN		1			1
Cormorant, Reed	*Phalacrocorax africanus*			1		1	
Waterfowl				**6**	**3**		**9**
Duck, White-faced Whistling	*Dendrocygna viduata*		1			1	
Goose, Egyptian	*Alopochen aegyptiaca*		3	2		5	
Teal, Cape	*Anas capensis*				1		1
Teal, Red-billed	*Anas erythrorhyncha*		2			2	
Waterbirds (other)				**6**	**2**	**2**	**10**
Egret, Western Cattle	*Bubulcus ibis*					1	1
Egret, Yellow-billed	*Egretta intermedia*			4			4
Grebe, Black-necked	*Podiceps nigricollis*				1		1
Ibis sp.					1		1
Ibis, African Sacred	*Threskiornis aethiopicus*				1	1	
Ibis, Hadeda	*Bostrychia hagedash*		1			1	
Unknown				1			1
Unknown				**12**	**4**	**1**	**26**
Grand Total				**232**	**81**	**35**	**344**

Red Data book status: Regional, Global. CR = Critically Endangered, EN = Endangered, VU = Vulnerable, NT = Near Threatened, LC = Least Concern.
Endemism: (in South Africa): * = endemic, SLS = endemic to South Africa, Lesotho and Swaziland (*) = near endemic (i.e. ~70% or more of population in RSA). Threatened species are highlighted in red.
Turbines Year 1: indicates bird fatalities found at 7 REIPPPP 1 wind farms that conducted rigorous carcasses searches, largely in accordance with the BirdLife South Africa and the Endangered Wildlife Trust's Best Practice Guidelines (Jenkins et al., 2012 & 2015) and includes data from a full year of monitoring. These fatalities were likely as a result of collisions with wind turbines.
Turbines (other): indicates carcasses found during pre-construction monitoring, preparatory sweeps to clear the site of fatalities, incidental finds, carcasses found during the second (incomplete) year of monitoring, and fatalities at Van Stadens Wind Farm (where regular carcass searches where not conducted). These fatalities were also likely as a result of collisions with wind turbines.
Other/unknown: Fatalities that could not be ascribed to turbines collisions are. m=meteorological mast, p=powerline collisions.

APPENDIX 2. PRIORITY SPECIES LIST

Common Names	Scientific Names	Regional Threatened Status	Global Threatened Status	Conservation Status Score	Endemic	Near-Endemic	Endemic Score	Range Size	Conservation Score	Size	Soaring	Predatory	Ranging Behaviour	Flocking	Night Flying	Aerial Display	Habitat Preference	Sensitivity to Disturbance	Overlap with Wind Farms	Risk Score	Overall Priority Score	Rank
Cape Vulture	*Gyps coprotheres*	90	70	90	0	15	15	0	105	30	20	5	15	5	0	0	40	5	30	150	405	1
	Gypaetus barbatus	90	0	90	0	0	0	15	105	30	20	5	15	0	0	0	40	5	30	145	395	2
Verreaux's Eagle	*Aquila verreauxii*	70	0	70	0	0	0	0	70	30	15	10	5	0	0	10	40	5	30	145	360	3
Martial Eagle	*Polemaetus bel-licosus*	90	50	90	0	0	0	0	90	30	15	10	15	0	0	0	20	10	30	130	350	4
Wattled Crane	*Bugeranus carunculatus*	100	70	100	0	0	0	15	115	30	5	0	5	5	2	0	30	10	30	117	349	5
Black Harrier	*Circus maurus*	90	70	90	0	15	15	0	105	15	10	10	5	0	5	10	30	5	30	120	345	6
Great White Pelican	*Pelecanus onocrotalus*	70	0	70	0	0	0	0	70	30	15	0	10	10	0	0	30	5	30	130	330	7
Southern Bald Ibis	*Geronticus calvus*	70	70	70	20	0	20	0	90	15	5	0	10	10	5	0	40	5	30	120	330	8
Yellow-billed Stork	*Mycteria ibis*	90	0	90	0	0	0	0	90	30	10	0	5	10	0	0	30	5	30	120	330	9
Black Stork	*Ciconia nigra*	70	0	70	0	0	0	0	70	20	20	0	15	0	0	0	40	5	30	130	330	10
Blue Crane	*Anthropoides paradiseus*	50	70	70	20	0	20	0	90	20	5	0	10	10	5	0	30	5	30	115	320	11
White-headed Vulture	*Aegypius oc-cipitalis*	90	70	90	0	0	0	0	90	30	10	5	15	10	0	0	30	5	10	115	320	12
Secretarybird	*Sagittarius serpentarius*	70	70	70	0	0	0	0	70	30	10	10	5	0	0	5	30	5	30	125	320	13
Ludwig's Bustard	*Neotis ludwigii*	90	90	90	0	0	0	0	90	20	0	0	15	10	5	0	30	5	30	115	320	14
Grey Crowned Crane	*Balearica regu-lorum*	90	90	90	0	0	0	0	90	20	5	0	10	10	2	0	30	5	30	112	314	15
Taita Falcon	*Falco fasciinucha*	100	50	100	0	0	0	30	130	2	10	10	5	0	5	5	40	5	10	92	314	16
Southern Ground-Hornbill	*Bucorvus lead-beateri*	90	70	90	0	0	0	0	90	30	0	0	10	5	5	0	20	10	30	110	310	17
Cape Cormorant	*Phalacrocorax capensis*	90	90	90	20	0	20	0	110	15	0	0	10	10	5	0	30	0	30	100	310	18
Lappet-faced Vulture	*Aegypius trach-eliotus*	90	70	**90**	**0**	**0**	**0**	**0**	**90**	**30**	**15**	**5**	**15**	**0**	**0**	**0**	**30**	**5**	**10**	**110**	**310**	**19**
Pink-backed Pelican	*Pelecanus rufescens*	70	0	70	0	0	0	0	70	30	15	0	5	10	5	0	30	10	10	115	300	20
Denham's Bustard	*Neotis denhami*	70	50	70	0	0	0	0	70	30	0	0	5	10	5	0	30	5	30	115	300	21
Bateleur	*Terathopius ecaudatus*	90	50	90	0	0	0	0	90	20	15	10	15	0	0	5	20	10	10	105	300	22
White-backed Vulture	*Gyps africanus*	90	90	90	0	0	0	0	90	30	15	5	15	5	0	0	20	5	10	105	300	23
Lanner Falcon	*Falco biarmicus*	70	0	70	0	0	0	0	70	15	10	10	5	0	0	5	40	0	30	115	300	24
African Marsh-Harrier	*Circus ranivorus*	70	0	70	0	0	0	0	70	15	10	10	5	0	0	10	30	5	30	115	300	25
African Crowned Eagle	*Stephanoaetus coronatus*	70	50	70	0	0	0	0	70	20	10	10	5	0	0	10	20	5	30	110	290	26
White-winged Flufftail	*Sarothrura ayresi*	100	90	100	0	0	0	30	130	0	0	0	5	0	15	0	20	10	30	80	290	27
Lesser Flamingo	*Phoenicopterus minor*	50	50	50	0	0	0	0	50	20	0	0	10	10	15	0	30	5	30	120	290	28

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Greater Flamingo	*Phoenicopterus ruber*	50	0	50	0	0	0	0	50	20	0	0	10	10	15	0	30	5	30	120	290	29
Tawny Eagle	*Aquila rapax*	90	0	90	0	0	0	0	90	20	15	10	5	0	0	5	30	5	10	100	290	30
African Fish-Eagle	*Haliaeetus vocifer*	0	0	0	0	0	0	0	0	30	15	10	15	0	0	10	30	5	30	145	290	31
African Grass-Owl	*Tyto capensis*	70	0	70	0	0	0	15	85	2	0	10	5	0	15	0	30	10	30	102	289	32
Bat Hawk	*Macheiramphus alcinus*	90	0	90	0	0	0	15	105	15	5	10	10	0	15	0	20	5	10	90	285	33
Damara Tern		100	50	100	0	0	0	0	100	2	0	0	10	5	0	5	30	5	30	87	274	34
Blue Korhaan	*Eupodotis caerulescens*	0	50	50	20	0	20	0	70	20	0	0	5	10	0	0	30	5	30	100	270	35
White-bellied Korhaan	*Eupodotis senegalensis*	70	0	70	0	0	0	0	70	30	0	0	5	10	0	0	20	5	30	100	270	36
Southern Black Korhaan	*Afrotis afra*	70	70	70	20	0	20	0	90	15	0	0	5	0	0	5	30	5	30	90	270	37
Blue Swallow	*Hirundo atrocae-rulea*	100	70	100	0	0	0	30	130	0	0	10	0	5	2	0	30	10	10	67	264	38
Kori Bustard	*Ardeotis kori*	50	50	50	0	0	0	0	50	30	0	0	5	5	0	0	30	5	30	105	260	39
Red Lark	*Calendulauda burra*	70	70	70	20	0	20	30	120	0	0	0	0	0	0	5	30	5	30	70	260	40
Pallid Harrier	*Circus macrourus*	50	50	50	0	0	0	0	50	15	5	10	5	0	0	0	30	10	30	105	260	41
Cape Eagle-Owl	*Bubo capensis*	0	0	0	0	0	0	0	0	20	0	10	5	0	10	0	40	10	30	125	250	42
Jackal Buzzard	*Buteo rufofuscus*	0	0	0	0	0	0	0	0	15	15	10	5	0	0	10	40	0	30	125	250	43
Hooded Vulture	*Necrosyrtes monachus*	90	90	90	0	0	0	0	90	20	10	5	15	0	0	5	20	5	0	80	250	44
Botha's Lark	*Spizocorys fringillaris*	90	90	90	20	0	20	30	140	0	0	0	0	0	0	10	30	5	10	55	250	45
Yellow-breasted Pipit	*Anthus chloris*	70	70	70	20	0	20	15	105	0	0	0	0	0	0	5	30	5	30	70	245	46
Saddle-billed Stork	*Ephippiorhyn-chus senega-lensis*	90	0	90	0	0	0	0	90	30	5	0	0	0	0	0	30	0	10	75	240	47
Marabou Stork	*Leptoptilos crumeniferus*	50	0	50	0	0	0	0	50	30	15	0	5	5	0	0	30	0	10	95	240	48
Peregrine Falcon	*Falco peregrinus*	0	0	0	0	0	0	0	0	15	10	10	5	0	5	5	40	0	30	120	240	49
Sclater's Lark	*Spizocorys sclateri*	50	50	50	0	15	15	15	80	0	0	0	5	10	0	0	30	5	30	80	240	50
Karoo Korhaan	*Eupodotis vigorsii*	50	0	50	0	0	0	0	50	20	0	0	5	5	0	0	30	5	30	95	240	51
Caspian Tern		70	0	70	0	0	0	0	70	15	0	0	10	0	0	0	30	0	30	85	240	52
Hottentot But-tonquail	*Turnix hottentot-tus*	90	0	90	20	0	20	15	125	0	0	0	0	0	0	0	20	5	30	55	235	53

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Agulhas Long-billed Lark	*Certhilauda brevirostris*	50	0	50	20	0	20	15	85	0	0	0	0	0	0	10	30	5	30	75	235	54
Chestnut-banded Plover		50	50	50	0	0	0	0	50	0	0	0	10	10	5	0	30	5	30	90	230	55
Rudd's Lark	*Heteromirafra ruddi*	90	70	90	20	0	20	30	140	0	0	0	0	0	0	0	30	5	10	45	230	56
Osprey	*Pandion haliaetus*	0	0	0	0	0	0	0	0	20	10	10	5	0	0	0	30	10	30	115	230	57
Mountain Pipit	*Anthus hoeschi*	50	0	50	20	0	20	30	100	0	0	0	0	0	0	5	30	0	30	65	230	58
Booted Eagle	*Aquila pennatus*	0	0	0	0	0	0	0	0	15	15	10	5	0	0	5	30	5	30	115	230	59
Black-chested Snake-Eagle	*Circaetus pectoralis*	0	0	0	0	0	0	0	0	20	15	10	5	5	0	5	20	5	30	115	230	60
White Stork	*Ciconia ciconia*	0	0	0	0	0	0	0	0	20	10	0	5	10	0	0	30	5	30	110	220	61
Black Kite	*Milvus migrans*	0	0	0	0	0	0	0	0	15	15	10	15	5	0	0	20	0	30	110	220	62
Southern Banded Snake-Eagle	*Circaetus fasciolatus*	70	50	70	0	0	0	15	85	20	10	10	5	0	0	5	0	5	10	65	215	63
Lesser Kestrel	*Falco naumanni*	0	0	0	0	0	0	0	0	2	5	10	10	10	5	0	30	5	30	107	214	64
Verreaux's Eagle-Owl	*Bubo lacteus*	0	0	0	0	0	0	0	0	30	0	10	0	0	10	0	20	5	30	105	210	65
Amur Falcon	*Falco amurensis*	0	0	0	0	0	0	0	0	0	5	10	10	10	5	0	30	5	30	105	210	66
Steppe Buzzard	*Buteo vulpinus*	0	0	0	0	0	0	0	0	15	15	10	5	0	0	5	20	5	30	105	210	67
Montagu's Harrier	*Circus pygargus*	0	0	0	0	0	0	0	0	15	5	10	5	0	0	0	30	10	30	105	210	68
Burchell's Courser	*Cursorius rufus*	70	0	70	0	0	0	0	70	0	0	0	0	5	0	0	30	5	30	70	210	69
Barlow's Lark	*Calendulauda barlowi*	50	0	50	0	0	0	30	80	0	0	0	0	0	0	5	30	0	30	65	210	70
Cape Parrot		90	0	90	20	0	20	15	125	2	0	0	10	10	0	0	0	10	10	42	209	71
Double-banded Courser	*Rhinoptilus africanus*	50	0	50	0	0	0	0	50	2	0	0	0	0	5	0	30	10	30	77	204	72
Black-winged Pratincole	*Glareola nordmanni*	50	50	50	0	0	0	0	50	0	0	0	10	10	1	10	30	5	10	76	202	73
Black-bellied Bustard	*Lissotis melanogaster*	50	0	50	0	0	0	0	50	30	0	0	5	0	0	5	20	5	10	75	200	74
Southern Pale Chanting Goshawk	*Melierax canorus*	0	0	0	0	0	0	0	0	20	5	10	5	0	0	5	20	5	30	100	200	75
Knysna Warbler		70	70	70	20	0	20	30	120	0	0	0	0	0	0	0	0	10	30	40	200	76
Drakensberg Rock-jumper	*Chaetops aurantius*	0	0	0	20	0	20	30	50	0	0	0	0	0	0	0	40	5	30	75	200	77
African Rock Pipit	*Anthus crenatus*	50	0	50	20	0	20	0	70	0	0	0	0	0	0	5	30	0	30	65	200	78
Marsh Owl	*Asio capensis*	0	0	0	0	0	0	0	0	15	0	10	0	0	5	0	30	5	30	95	190	79
Grey-winged Francolin	*Scleroptila africanus*	0	0	0	20	0	20	0	20	15	0	0	5	0	0	0	30	5	30	85	190	80
Woolly-necked Stork	*Ciconia episcopus*	0	0	0	0	0	0	0	0	30	5	0	5	10	0	0	30	5	10	95	190	81

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Wahlberg's Eagle	*Aquila wahlbergi*	0	0	0	0	0	0	0	0	15	10	10	5	5	0	5	30	5	10	95	190	82
Striped Flufftail		70	0	70	0	0	0	0	70	0	0	0	0	0	0	0	20	10	30	60	190	83
Long-crested Eagle	*Lophaetus occipitalis*	0	0	0	0	0	0	0	0	15	10	10	5	0	0	0	20	5	30	95	190	84
African Harrier-Hawk	*Polyboroides typus*	0	0	0	0	0	0	0	0	15	5	10	5	0	0	5	20	5	30	95	190	85
Short-tailed Pipit	*Anthus brachyurus*	70	0	70	0	0	0	15	85	0	0	0	0	0	0	5	30	5	10	50	185	86
Buff-streaked Chat	*Oenanthe bifasciata*	0	0	0	20	0	20	15	35	0	0	0	0	0	0	0	40	5	30	75	185	87
African Hawk-Eagle	*Aquila spilogaster*	0	0	0	0	0	0	0	0	20	15	10	5	0	0	5	20	5	10	90	180	88
Rosy-throated Longclaw	*Macronyx ameliae*	50	0	50	0	0	0	30	80	0	0	0	0	0	0	0	30	10	10	50	180	89
Northern Black Korhaan	*Afrotis afraoides*	0	0	0	0	0	0	0	0	15	0	0	5	0	0	5	30	5	30	90	180	90
Melodious Lark	*Mirafra cheniana*	0	50	50	20	0	20	0	70	0	0	0	5	5	0	10	20	5	10	55	180	91
Brown Snake-Eagle	*Circaetus cinereus*	0	0	0	0	0	0	0	0	20	10	10	5	0	0	0	30	5	10	90	180	92
Yellow-throated Sandgrouse	*Pterocles gutturalis*	50	0	50	0	0	0	15	65	0	0	0	5	10	5	0	30	5	0	55	175	93
Black-shouldered Kite	*Elanus caeruleus*	0	0	0	0	0	0	0	0	2	0	10	0	5	5	5	30	0	30	87	174	94
Greater Kestrel	*Falco rupicoloides*	0	0	0	0	0	0	0	0	2	0	10	5	0	0	5	30	5	30	87	174	95
Red-footed Falcon	*Falco vespertinus*	50	50	50	0	0	0	0	50	2	10	10	5	0	0	0	20	5	10	62	174	96
Black-winged Lapwing	*Vanellus melanopterus*	0	0	0	0	0	0	0	0	2	0	0	5	10	0	5	30	5	30	87	174	97
Spotted Eagle-Owl	*Bubo africanus*	0	0	0	0	0	0	0	0	15	0	10	0	0	10	0	20	0	30	85	170	98
African Pygmy-Goose	*Nettapus auritus*	70	0	70	0	0	0	0	70	0	0	0	5	5	0	0	20	10	10	50	170	99
Victorin's Warbler	*Cryptillas victorini*	0	0	0	20	0	20	30	50	0	0	0	0	0	5	0	20	5	30	60	170	100
Rufous-chested Sparrowhawk	*Accipiter rufiventris*	0	0	0	0	0	0	0	0	15	10	10	5	0	5	5	0	5	30	85	170	101
Black Sparrowhawk	*Accipiter melanoleucus*	0	0	0	0	0	0	0	0	15	10	10	5	0	5	5	0	5	30	85	170	102
Palm-nut Vulture	*Gypohierax angolensis*	0	0	0	0	0	0	30	30	20	5	5	5	0	0	0	20	5	10	70	170	103
Lesser Spotted Eagle	*Aquila pomarina*	0	0	0	0	0	0	0	0	15	10	10	5	5	0	5	20	5	10	85	170	104

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Half-collared Kingfisher		50	0	50	0	0	0	0	50	0	0	0	0	0	0	0	20	10	30	60	170	105
Forest Buzzard	*Buteo trizonatus*	0	0	0	0	0	0	0	0	15	10	10	5	0	0	10	0	5	30	85	170	106
Black-rumped Buttonquail		70	0	70	20	0	20	0	90	0	0	0	0	0	0	0	20	10	10	40	170	107

For further details on the rationale and approach to the species prioritisation, please see Retief et al. 2011.

Scoring used in species prioritisation:

Conservation Value (Global and Regional)	Ranking
Near-threatened	50
Vulnerable	70
Endangered	90
Critical	100
Endemic Status	
Endemic	20
Near-Endemic	15
Range Size	
Limited range	15
Very limited range	30
Population trend	
Marked decrease in SABAP reporting rates	20
Susceptibility (Structural)	
Size	
Very large birds	30
Large	30
Medium	15
Small	2
Very Small	0
Susceptibility (Behaviour)	
Soaring	
always, including slope soaring	20
always	15
usually	10
regularly	5
never	0
Predatory	
highly	10
partially	5
never	0

Ranging Behaviour	
very wide	15
long, daily commuter	10
wide	5
sedentary	0
Flocking Behaviour	
always	10
sometimes	5
never	0
Night Flying	
nocturnal commuter	15
nocturnal	10
crepuscular	5
sometimes crepuscular	2
diurnal	1
Aerial Display	
frequent	10
occasional	5
never	0
Habitat Preference	
open with relief	40
open	30
semi-open	20
closed	0
Sensitivity to disturbance	
high	10
medium	5
low	0
Overlap with Wind Farms	
Major Overlap	30
Minor Overlap	10
No Overlap	0

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