

Cape Vulture and Wind Farms

Guidelines for impact assessment,
monitoring and mitigation

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Summary and key recommendations

The Cape Vulture is Endangered and endemic to southern Africa. Although to date there have been relatively few Cape Vulture fatalities reported at wind farms in South Africa when compared to other sources of vulture fatality, wind energy has been identified as a potential new threat. Globally, numerous vulture fatalities have been recorded from collisions with wind turbine blades and associated infrastructure. These guidelines therefore provide recommendations for site selection, monitoring, impact assessment and mitigation, to help ensure that expansion of wind energy in Africa does not present a new and serious threat to the species.

BirdLife South Africa recommends that if a wind farm is proposed within the range of Cape Vulture, a stepwise approach to site selection and mitigation should be adopted. The risks and feasibility of the wind farm should be regularly reviewed before deciding to proceed with the next step in the assessment (Figure 1).

Site Screening (location of wind farms)

The large foraging range of the Cape Vulture (thousands of square kilometres) and the potentially significant impact poorly planned wind farms could have on the species implies that large parts of the Cape Vulture's distribution may be unsuitable for the development of wind turbines. The importance of site screening cannot be overemphasised – negative impacts can be minimised by placing turbines well away from areas regularly used by Cape Vulture.

Site screening can begin with a desktop analysis using existing information but should be complemented by field work.

Site screening should take the following into account:

a) *The location of the proposed wind farm in relation to the distribution of the Cape Vulture*

See Figure 2, and refer to the Southern African Bird Atlas Project 1 and 2. Areas with high SABAP2 reporting rates for Cape Vulture should be assumed to be of high sensitivity.

b) *The proximity of the site to Cape Vulture colonies and roosts*

Cape Vultures can be expected to regularly use the air-space within 50 km around their roosts and breeding colonies. Vultures will occur well beyond these zones, but there is a lower probability of them occurring beyond these buffers. The location and status of known breeding colonies and roost sites should be confirmed, and the area surrounding the proposed wind farm should be thoroughly surveyed for previously unrecorded breeding and roost sites. A buffer of approximately 50 km around all colonies, and regular or seasonal/occasional roosts should be considered as high to very high sensitivity (with sensitivity influenced by distance from the roost/colony, as well as its size and location). A buffer of approximately 18 km around breeding colonies should be considered as very high sensitivity.

c) *Topography and wind-scape*

Increased flight activity and risky behaviour are likely along ridge tops, cliffs, steep slopes and wind corridors. These areas are likely to be of high sensitivity.

d) *The availability of food in the landscape (including existing vulture restaurants)*

Livestock management practices and the availability of carrion around the proposed wind farm should be considered, especially the location of existing vulture restaurants (supplementary feeding sites). Increased flight activity can be expected in the area around active vulture restaurants, and between vulture restaurants and roosts or colonies.

e) *Risk maps (once available)*

Spatial risk assessment models can be developed to predict the presence and flight height of birds. Once available for the Cape Vulture, these maps will provide an additional indication of potential collision-risk.

f) *The potential for cumulative negative impacts.*

The number of operational and potential wind farms within a radius of at least 100 km of the proposed wind farm should be considered, including the results of pre-construction and operational phase monitoring (where available).

Following consideration of all the above factors, the potential risks and limitations to development should be described and a preliminary indication of sensitivity (from low to very high) should be assigned. At this stage the risk assessment would largely be based on the probability of birds using the area and the risk of cumulative negative effects.

Data collection and analysis for impact assessment

Site screening relies primarily on existing data and the factors listed above must therefore be interrogated in more detail during the impact assessment process (see Figure 1). If a wind farm is proposed within the distribution of the Cape Vulture, the location and status of all known as well as potential breeding colonies, roost sites and supplementary feeding areas within at least 50 km of the site should be checked. This should first be done during site screening and repeated during the assessment process.

The duration and scope of fieldwork recommended for impact assessment must be guided by site screening (i.e. the preliminary assessment of risk to Cape Vulture) and as more data become available, the recommended approach to data collection and impact assessment should be revisited, and if necessary revised.

Avoidance of high sensitivity and particularly very high sensitivity areas is encouraged, but developers may decide to proceed with data collection to verify the risk. If a wind farm is proposed within high or very high sensitivity areas (i.e. if vultures are likely to occur regularly and/or there is a risk of cumulative negative impacts) data collection must extend beyond the minimum protocols recommend in the BirdLife South Africa/EWT Best Practice Guidelines (Jenkins et al. 2015):

- The duration of monitoring should be at least two years to allow for annual variation and increase statistical rigor.
- Surveys should include the pre-breeding season (late March to early May), and the breeding season (May to December).

- c) A minimum of 72 hours per vantage point per year should be surveyed, and site visits should be timed to account for as much seasonal variation as possible (i.e. a minimum of 6 site visits each year).
- d) All occupied and potential breeding colonies and roost sites within 50 km of the proposed wind farm must be monitored according to standard survey protocols.
- e) The use of technology to study the movements of vultures (e.g. radar, tracking devices, and/or wind current modelling) is strongly encouraged.
- f) The number of bird fatalities that might take place once the wind farm is operational should be estimated using a collision risk model (provided there is sufficient data from the site to support this). However, factors such as topography, bird behaviour, season, aggregation, wind direction and wind speed may also affect collision risk and should also be considered in the final assessment of risk.
- g) The risk of cumulative effects should be assessed.

If a site is found to be low or moderate sensitivity after screening, one year of data collection in accordance with the BirdLife South Africa/EWT Best Practice Guidelines (Jenkins et al. 2015), combined with surveys for potential colonies and roosts in surrounding area, may be sufficient. However the scope of data collection should be regularly reviewed and it may be necessary to increase the survey effort if new information suggests the initial sensitivity rating should be increased. Conversely, if data collection suggests that the initial assessment of sensitivity was too high (e.g. all known roosts/colonies are confirmed to be inactive, no new ones are found, and very low/no vulture passage rates are recorded), the duration of data collection could be reduced.

Mitigation

Mitigation measures must be designed to achieve no net loss of biodiversity. Limited options are available for mitigation once a wind farm is operational. It is therefore critical that the mitigation hierarchy (i.e. first seek to avoid and then minimise risk) is adhered to during planning.

- a) Wind farms and wind turbines should not be placed in areas with a high abundance of Cape Vulture, high passage rates, and where topographic features associated with risky flight are found.
- b) Free spinning of turbines under low wind conditions, when turbines are not generating power should be avoided.
- c) The design, location and alignment of new powerlines associated with the wind farm must be optimised to reduce vulture fatalities (collisions and electrocutions). No new powerlines should be permitted within 5 km of a colony. Where deemed necessary (i.e. following assessment by an avifaunal specialist), bird flight diverters should be installed and maintained to minimise collision risk. All new pylon structures must meet Eskom's 'bird-friendly' standards to minimise the risk of electrocution.
- d) Construction of associated infrastructure within 5 km of breeding colonies and roosts, particularly during the breeding season, should be avoided.
- e) Curtailment or shut-down-on-demand may help reduce the risk of collisions, but the feasibility and effectiveness of this approach for the Cape Vulture needs to be monitored and assessed. Shut-down-on-demand does not replace the



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Physical features such as their large wingspan, weight and narrow field of binocular vision compromise vultures' ability to perceive and response to obstacles in their flight path.

- need to first avoid and minimise impacts through the considered location a wind farm and its turbines but could be implemented to minimise the risk of residual negative impacts, or as part of an adaptive management strategy.
- f) The number of livestock and other animal carcasses must be minimised at the wind farm and within nearby areas (e.g. within 2 km). A carcass management plan should be implemented, and birthing of livestock near turbines should not be permitted (alternatively turbines should be curtailed during calving and lambing season).
- g) If the strategic location or removal of supplementary feeding sites is proposed as a mitigation in order to reduce the risk of collisions to acceptable levels a) the mitigation hierarchy must have been exhausted and b) the effectiveness of this approach must be verified during the preliminary avifaunal assessment and impact assessment process. Any new vulture restaurant must be located and managed so as not to increase risk to the birds.
- h) The effectiveness and desirability of reducing collision risk by stopping the supply of food at existing vulture restaurants must be verified during the preliminary avifaunal assessment or impact assessment process.

The Environmental Management Programme for any wind farm where there is a potential risk of vulture fatalities should include clear impact management objectives, outcomes and actions that may be necessary to address this risk.

Monitoring (construction and operational phase) and adaptive management

The duration and extent of operational phase monitoring should be increased for wind farms if there is a risk of multiple Cape Vulture fatalities (i.e. the site is located in a high or very high sensitivity area):

- a) Vantage point monitoring should continue through construction. Monitoring Cape Vulture presence and movements may be recommended throughout operation as part of an adaptive management strategy.
- b) Breeding colonies and roost sites should continue to be monitored (where possible in collaboration with NGOs, state conservation agencies, and other wind farm operators in the area).

- c) Carcass surveys must begin as soon as the first few turbines are turning (i.e. 10% of the turbines have been erected and are rotating) and should continue through the lifespan of the project.
- d) If new powerlines are built, operational phase monitoring should extend to include the powerline – bird flight diverters should be checked (and if necessary, replaced) and the area beneath the line should be surveyed for fatalities.

Cape Vulture fatalities should be photographed, the GPS coordinates and estimated wind speed recorded, and immediately reported to BirdLife South Africa, EWT, VulPro, the Department of Environmental Affairs (DEA) and relevant conservation authorities, and a mitigation strategy should be proposed. Injured birds must be transported to the nearest

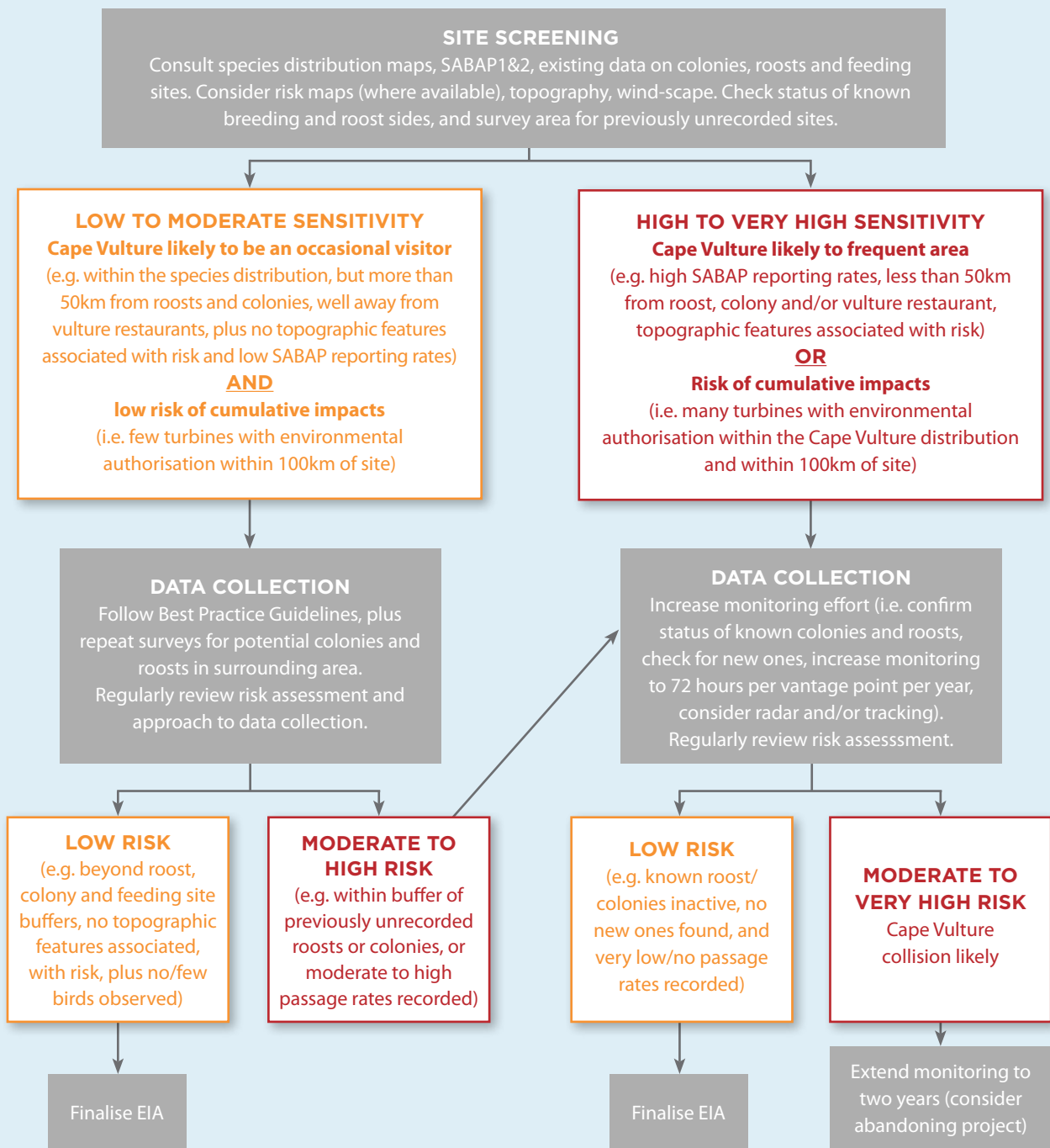
certified wildlife rehabilitation centre for treatment.

Wind farms are encouraged to go beyond demonstrating no net loss and should aim to achieve a net positive gain for the species. Once the mitigation hierarchy has been exhausted, residual impacts could be compensated through off-site conservation action.

Conclusion

These guidelines draw on our current understanding of the Cape Vulture, supplemented by research on vultures and wind farms in Europe. These recommendations will be periodically reviewed and updated. With the implementation of the guiding principles outlined in this document we believe it is possible to develop wind energy in South Africa without negatively affecting the conservation status of Cape Vulture.

Figure 1. Decision tree outlining the recommended approach to site screening, data collection and impact assessment.



Cape Vulture and Wind Farms: Guidelines for impact assessment, monitoring, and mitigation

1. INTRODUCTION

The demand to produce energy from renewable resources has increased alongside global energy consumption (Saidur et al. 2011). This form of energy production can help reduce carbon emissions – a long-term goal for many countries and an effective way to mitigate the effects of global climate change on biodiversity (Leung and Yang 2012). However, some renewable energy installations can have detrimental environmental impacts (Drewitt and Langston 2006, Gove et al. 2013, Loss et al. 2013, Rydell et al. 2016). Of particular concern is that threatened raptors may experience negative impacts if they collide with wind turbines and associated infrastructure (de Lucas et al. 2012a, Pagel et al. 2013).

The Cape Vulture *Gyps coprotheres* is considered a high priority species for impact assessment and mitigation at wind farms in South Africa. This is because of the predicted risk of collisions (due to their size, behaviour and habitat use), conservation status, and overlap with proposed and operational wind farms (Retief et al. 2013, Ralston-Paton et al. 2017).

The Cape Vulture is endemic to southern Africa (Mundy et al. 1992) and has the smallest distribution of any Old-World vulture species (i.e. vultures that inhabit Europe, Asia, and Africa) (Mundy et al. 1992, Piper 2005). In 2015, the Red List status of the Cape Vulture was up-listed to Endangered because the population had decreased by 50% over three generations (Allan 2015, Ogada et al. 2015b). The species currently faces numerous threats including collisions and electrocution with electrical infrastructure, inadvertent poisoning and poaching (Allan 2015, Botha et al. 2017).

There is growing interest in developing wind energy in the Eastern Cape Province, an important area for the Cape Vulture. A number of wind farms are planned, and some are already operational in areas where interactions with Cape Vulture are possible. Cape Vulture occur regularly in at least three Renewable Energy Development Zones (areas where the large-scale development of wind energy will be promoted) (Avisense 2015), as identified in the first phase of the Strategic Environmental Assessment for wind and solar photovoltaic energy in South Africa (SEA) (CSIR 2015).

To avoid adding further pressure to the species, which could contribute to irreversible population declines and local extinctions (Rushworth and Kruger 2014), guidelines are needed to help wind energy develop with the least negative effects on the species. This document provides an overview of our current understanding of the likely impact of wind turbines on the Cape Vulture and offers guidance on how the impacts should be assessed, avoided, mitigated and monitored.

These guidelines focus on a project-based approach, but the importance of thorough strategic environmental assessment cannot be overemphasised. *“The most effective way to detect and avoid severe environmental impacts of wind energy developments is to perform Strategic Environmental Assessments (SEAs) at large spatial scales. SEAs enable strategic planning and siting of wind energy developments in areas with least environmental and social impact whilst maintaining economic*



CHRIS VAN ROOYEN

Areas associated with increased flight activity and/or risky behaviour (for example ridge tops, cliffs, steep slopes) should be considered as high sensitivity.

benefits” (Botha et al. 2017). However, it must be noted that BirdLife South Africa does not endorse the outcome of the first phase of the SEA due to the failure of this process to address the cumulative risk to Cape Vulture and other species.

While the effects of wind farms on Cape Vultures have not been well studied, understanding the effect wind turbines have had on European and Asian vultures can provide valuable insights for their African counterparts. Wind farms have been operational in Spain for decades and several articles have been published on factors that might influence the risk of collision for Eurasian Griffon Vulture *Gyps fulvus* (e.g. Barrios and Rodríguez 2004, Carrete et al. 2012, de Lucas et al. 2012a). This species is similar to the Cape Vulture in regard to its flight patterns, behaviour, vision morphology, and colonial cliff breeding strategies (Mundy et al. 1992, Carrete et al. 2012, Martin et al. 2012). These guidelines draw on lessons from these examples, but it is important to note that there are differences in vulture population size, land use, food supply, and human population densities that must be taken into account. As our knowledge grows, the recommendations contained in these guidelines may be amended to reflect our improved understanding of how vultures can flourish alongside increased generation of renewable energy.

These guidelines expand on the recommendations in the BirdLife South Africa/Endangered Wildlife Trust Best Practice Guidelines for Birds and Wind Energy (Best Practice Guidelines) (Jenkins et al. 2015). These documents should therefore be read together.

2. POTENTIAL IMPACTS OF WIND ENERGY ON CAPE VULTURE

2.1 FATALITIES ASSOCIATED WITH WIND TURBINES AND ASSOCIATED INFRASTRUCTURE

The Cape Vulture is a large bird, weighing on average 9 kg with a wingspan of 2.55 m (Mundy et al. 1992). As a result, they have a high wing load and cannot respond rapidly to obstacles in the air. Gyps vultures (a genus of Old World vulture, which includes Cape Vulture) also have a small frontal binocular field that creates large blind spot areas in the direction of travel (Martin et al. 2012). Tracking data from two adult Cape Vultures captured in the Maluti-Drakensberg area indicate that 61.7% of the recorded flights were less than 100 m above ground level (i.e. potentially within the rotor swept area) (Rushworth and Kruger 2014). Their size, the slope-soaring behaviour, limited visual field, and large foraging range could make Cape Vulture particularly susceptible to collisions with man-made structures such as wind turbines and powerlines (Bamford et al. 2007, Martin 2011, Martin et al. 2012, Rushworth and Krüger 2014).

At the time of writing, few (five) wind farms were operational in areas Cape Vulture had previously been recorded. Cape Vulture fatalities as a result of turbine strikes have occurred at some of these wind farms, and preliminary monitoring data suggests an average fatality rate of approximately 0.03 vultures per turbine per year (Smallie, unpublished data).

Globally numerous vulture fatalities have been recorded from collisions with wind turbine blades and associated infrastructure (e.g. powerlines) (Smallwood and Thelander 2008, Tellería 2009, García-Ripollés and López-López 2011, Camiña 2011, de Lucas et al. 2012a) and it is expected that the Cape Vulture will face a similar risk of collisions (Retief et al. 2013, Rushworth and Krüger 2014). Old World Vultures that have died from collisions with wind turbines include Egyptian Vulture *Neophron percnopterus* and Eurasian Griffon Vulture *Gyps fulvus* (Carrete et al. 2009, Carrete et al. 2012, Ferrer et al. 2012, Martínez-Abraín et al. 2012). There is no evidence that Old World vultures learn to avoid turbine collisions (Johnston et al. 2014, Cabrera-Cruz and Villegas-Patracá 2016), which suggests that they are not only susceptible to collisions when turbines are first installed, but continuously throughout the lifetime of the wind farm (Carrete et al. 2012).

Cape Vulture is a relatively long-lived species, with low reproductive rates. At most a pair will raise one chick a year, and sexual maturity is only reached at 5 years of age (Mundy et al. 1992). The species already faces numerous threats and additional losses as a result of poorly planned wind farms are likely to accelerate population declines. Rushworth and Krüger (2014) calculated that just 80 wind turbines proposed in Lesotho could kill approximately 20-25 Cape Vulture a year. This increased the rate of decline of the local Maluti-Drakensberg Cape Vulture population from -2 % to -3 % per year and brought the predicted time to extinction forward by 80 years (from 220 to 140 years) (Rushworth and Krüger 2014).

The removal of vultures from an area could have negative consequences for the conservation status of the species and could also have implications for the local ecology and human health. The Cape Vulture is an obligate scavenger; it contributes to



SAMANTHA RALSTON-PATON

These guidelines draw on the best available information to help ensure the expansion of wind energy in southern Africa does not present a new threat to Cape Vulture.

nutrient recycling, prevents possible mammalian disease transmissions, and provides a carbon-neutral waste removal service (Dupont et al. 2012, Ganz et al. 2012, Ogada et al. 2012).

2.2 DISTURBANCE, HABITAT LOSS AND DISPLACEMENT

Cape Vulture have been recorded at a few operational wind farms in South Africa (albeit in low numbers) and at this stage there is no evidence of displacement (effective habitat loss) (Ralston-Paton et al. 2017). The large home ranges of the Cape Vulture is likely to buffer any effects of habitat loss associated with the development of wind farms. However, construction activities near a colony may affect breeding success and could lead to a colony being abandoned.

Construction (buildings and fences) and large-scale timber harvesting during the breeding season at the base of a Cape Vulture breeding colony in Botswana was thought to have contributed to low fledgling rates (Borello and Borello 2002). The Nooitgedacht colony (in the Magaliesberg) was abandoned in the 1960's after construction of microwave transmission towers near to the breeding cliffs (Tarboton & Allan 1984, Verdoorn 2004). While small numbers of Cape Vulture continued to use the site as a roost (Verdoorn 1997), no breeding was recorded again until 1991 (Verdoorn 2004). There are now approximately 140 breeding pairs at the site (Wolter and Hirschauer 2016), despite an access road located directly below the breeding cliffs that is still in use (C. Whittington-Jones pers. comm.).

The type and repetitiveness of the disturbance may influence how vultures respond to disturbance. For example, Cape Vulture at Potberg showed increasing agitation as the number of high velocity aircraft flights 5 km from the colony increased (K. Shaw pers. comm.). The quality of the site, availability of other suitable areas, and investment an individual has made in the site are all likely to affect how a species responds (Gill et al. 2001).

3. RECOMMENDATIONS FOR SITE SCREENING, IMPACT ASSESSMENT & MITIGATION

A stepwise approach to risk assessment is recommended (Figure 1). This should start with desktop screening where the broad-scale risks associated with developing a wind farm in the broader area are considered and landscape features likely to be associated with high risk are earmarked as sensitive, and preferably eliminated from further consideration for wind turbine development. This should be followed with preliminary data collection, and then detailed site surveys by an avifaunal specialist, where initial predications are tested, and the layout of turbines is finalised. The risks and feasibility of the proposed project should be regularly reviewed through the process.

3.1 SITE SCREENING

The most widely accepted and cost-effective method to prevent wind turbine related fatalities is to place wind turbines in areas where risks to birds is the lowest (de Lucas et al. 2012b, Gove et al. 2013, Marques et al. 2014). For the Cape Vulture this implies that large areas within the species' range may be unsuitable for the development of wind energy. In particular, placing turbines in areas associated with increased flight activity and/or risky behaviour of vultures should be avoided (de Lucas et al. 2012b, Rushworth and Krüger 2014).

If wind farm development is considered within the range of Cape Vulture (as per Figure 2 and the Southern African Bird Atlas Project 2) we recommend that before deciding to proceed with detailed data collection a coarse-scale assessment of the risk to Cape Vulture should be conducted (i.e. site screening). This will give an early indication of potential limitations to development and help reduce risks due to imperfect sampling and stochastic events. Site screening should also be used to determine the appropriate scope of subsequent avifaunal surveys.

Early consultation with the stakeholders (e.g. BirdLife South Africa, VulPro, the Endangered Wildlife Trust, ornithologists and conservation authorities) is encouraged, and this should help ensure that the most up-to-date information is considered during this critical step. It is anticipated that a National Vulture Working Group will soon be established and would help facilitate the dissemination of relevant information.

If the development of a wind farm is proposed within the range of Cape Vulture, the following should be considered during site screening:

- a) The location of the proposed wind farm in relation to the distribution of the Cape Vulture;
- b) The proximity to known colonies and roosts and characteristics of these sites;
- c) How the topography and wind-scape might affect collision risk;
- d) The availability of food in the landscape (including existing vulture restaurants);
- e) Risk maps (where available);
- f) The potential for cumulative negative impacts.

Species distribution

The distribution of the Cape Vulture is limited to southern Africa. The species predominantly occurs in South Africa and Lesotho where the regional population is separated into three

nodes, based on their geographical location (Figure 2). The south-eastern and south-western nodes are most likely to be affected by wind energy given the current spatial distribution of proposed wind farms and Renewable Energy Development Zones. The southwest-node comprises one remnant, isolated breeding colony at Potberg in the Western Cape, while the much larger south-eastern node spans Lesotho and the South African provinces of KwaZulu-Natal and the Eastern Cape. The south-eastern node supports approximately 40 % of the global population (Allan 2015).

Southern African Bird Atlas Project 1 and 2 (SABAP) data should be consulted. **Areas with high SABAP2 reporting rates for Cape Vulture should be assumed to be of high sensitivity**, although the number of atlas lists submitted for a pentad should always be taken into account. However, the converse may not be true – several parts of the species range have limited atlas data, especially in the Eastern Cape, KwaZulu-Natal and Limpopo (Wolter et al. 2017) and the number of checklists for an area must always be considered.

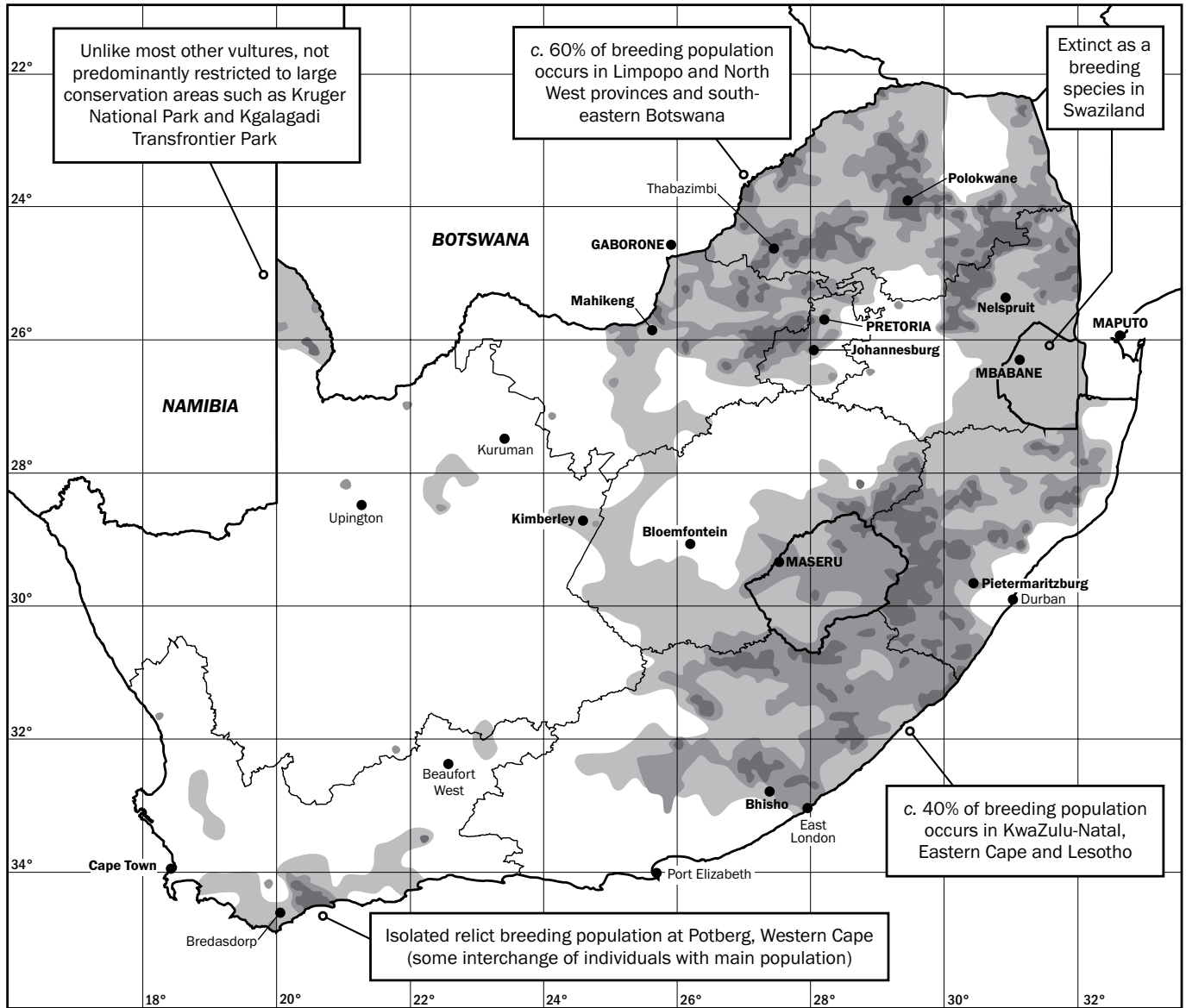
Proximity to vulture colonies and roosts

Cape Vultures travel large distances. The average foraging ranges of adult Cape Vultures captured at the Msikaba Cape Vulture Colony, Eastern Cape, covered an area of 16 887 km² (\pm 366 km²) (Pfeiffer et al. 2015). Adult Cape Vultures captured in the North West Province and Namibia covered much larger areas (121 655 \pm 90 845 km² and 21 320 km² respectively) (Bamford et al. 2007, Phipps et al. 2013b).

Vultures may be at risk of collisions throughout their entire foraging range. However, the Cape Vulture is a communal cliff-nesting raptor and can form large breeding colonies on suitable rock formations (Benson 2015). Vultures also gather in the afternoon to spend the night sleeping at roosts (these can be on a cliff, on pylons, or in trees) (Mundy et al. 1992, Dermody et al. 2011, Pfeiffer et al. 2015). As adult breeding Cape Vulture tend to be central place foragers (i.e. they usually forage within a certain area around a central colony) (Boshoff & Minnie 2011), the risk of collisions is likely to be greatest closest to these sites.

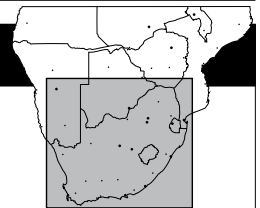
It is therefore useful to consider the core foraging range as the area of greatest risk (e.g. Tellería 2009, Vasilaki et al. 2016). Core ranges can be calculated using fixed kernel density estimates (KDE), a measure of the density of records. For Cape Vulture, 50% KDE has been taken to represent the core utilisation area (this is the area an individual is likely to occur 50% of the time). For example Phipps et al. (2013a) used 50% KDE to delineate the core foraging range of vultures that were fitted with GPS-GSM tracking units and reported that 56% of all known Cape Vulture mortalities caused by power line interactions overlapped with the combined core foraging range of the nine Cape vultures in the study.

Building on previous studies of core foraging areas for Cape Vulture which were limited by small sample size (e.g. Boshoff and Minnie 2011, Rushworth and Kruger 2014, Pfeiffer et al. 2015), Venter et al. (2018) analysed data from 18 adult vultures fitted with GPS/GSM transmitters. These birds occurred in both the northern and southern distribution nodes. The



CAPE VULTURE *Gyps coprotheres*

- High density distribution, based on SABAP2 data (2007-2014); reporting rate >14%.
- Low density distribution, based on SABAP2 data (2007-2014); reporting rate <14%.
- Smoothed distribution based on SABAP1 data (mainly 1987-1993).



mean radius for the 50% KDE was 49 km (breeding season) and 48 km (non-breeding season).

It is therefore recommended that a buffer of approximately 50km around all colonies, and regular or seasonal/occasional roosts is considered to be of high to very high sensitivity (with sensitivity influenced by distance from the roost/colony and of characteristics of the site).

At the time of writing, multiple Cape Vulture fatalities as a result of turbine strikes had occurred as far as 30 km from a seasonal roost. Three of the four of vulture carcasses that could be aged were sub-adult birds (Smallie, unpublished data).

The recommended buffer around colonies helps protect breeding vultures, as well as young, inexperienced birds. Juvenile Eurasian Griffon Vulture (i.e. less than 2 months from fledging) seem to have a harder time adjusting their flight performance during challenging conditions (such as high winds) and climb slower than adults (Harel et al. 2016). This

Figure 2. The distribution of Cape Vulture in South Africa, Lesotho and Swaziland (from Allan, 2015). This map is based on data from the Southern African Bird Atlas Project 1 and 2.

could contribute to an increased probability of collision with wind turbines (Barrios and Rodríguez 2004, de Lucas et al. 2012a). Juvenile birds accounted for the majority of Eurasian Griffon Vulture fatalities (51 % and 74 %) from wind turbine collisions in southern Spain (Barrios and Rodríguez 2004, de Lucas et al. 2012a). Although an opposite trend has been reported for northern Spain, where 75% of the vulture fatalities at wind turbines were adults (Camiña, 2011).

Martens et al. (2018) analysed the movement of juvenile Cape Vultures fitted with GPS/GSM devices in the Eastern Cape. The data indicated that juveniles tend to stay close to the colony for the first 100 days post-fledging; the core area (50% KDE) had an average radius of 18 km (Martens (2017)



also found that the density of roosts for juvenile vultures was highest within 20 kilometres from the breeding colony. A buffer of approximately 18 km around breeding colonies should therefore be considered as very high sensitivity.

A key step in site screening is therefore to **determine the proximity of a proposed wind farm to known breeding colonies or roost sites**. A literature review should be conducted and the appropriate experts (e.g. BirdLife South Africa, EWT, VulPro and other ornithologists) should be consulted. EWT and VulPro both maintain a database of colonies and roosts – to obtain a shape-file contact Gareth Tate (EWT; gareth@ewt.org.za) or Kerri Wolter (VulPro; Kerri.wolter@gmail.com).

Existing data on breeding colonies and roost sites is not always up-to-date and complete. Roosts are also more numerous than breeding colonies, and the sporadic use of these sites can make them difficult to document and monitor (Phipps et al. 2013b). **The status of known breeding colonies and roosts within at least 50 km of a proposed wind farm should therefore be confirmed, and the surrounding area (within approximately 50 km from the site) should be assessed for previously unrecorded sites.**

Potential roosts and colonies should be identified through a combination of a desktop-based GIS survey, local knowledge, and analysis of tracking data (where available). Extensive searching of suitable sites using a spotting scope should follow. Helicopters and drones could potentially be used to survey possible roost and colony sites, however, this should only be considered under the guidance of a vulture specialist, as it could disturb birds and affect breeding success. There are also Civil Aviation Authority restrictions that limit the use of drones. These should be considered and adhered to if this technology is to be used.

Roosts and colonies should be classified according to the following definitions (from Boshoff et al. 2009):

- inactive site (no birds present, no ‘whitewash’ or no fresh or recent ‘whitewash’);
- seasonal/occasional roost (birds present or not present; fresh or relatively fresh ‘whitewash’; used on a seasonal or occasional basis, e.g. summer only);
- regular roost (birds present, fresh ‘whitewash’; birds present throughout all or most of the year);
- roost (status uncertain – either ‘seasonal/occasional roost’ or ‘regular roost’);
- colony (nest building or presence of eggs, nestlings or fledglings).

They should also be described (e.g. man-made or natural). Pylon roosts may be difficult to categorize due to the absence of whitewash. For the purposes of these guidelines a precautionary approach to categorising roosts is therefore recommended.

Topography and wind-scape

The topography and wind-scape within the vicinity of the proposed wind farm should be assessed and areas associated with increased flight activity and/or risky behaviour (for example ridge tops, cliffs, steep slopes and wind current routes) should be considered as high sensitivity (de Lucas et al. 2012b, Rushworth and Krüger 2014).

Bearded Vultures *Gypaetus barbatus meridionalis* in Lesotho prefer upper slopes, mountain-tops, and high ridges

The use of colony and roost buffers for decision-making, and the relative importance of different colonies and roosts

The development of wind energy facilities within the recommended 50 km colony/roost buffer (and especially within the 18 km high sensitivity buffer around breeding colonies) is discouraged due to the risk of cumulative negative impacts. While these buffers do not automatically represent a ‘no go’ for wind farm development, they should be used to guide site selection, as well as the scope of data collection for impact assessment. The buffers indicate potential sensitivity; there are some limitations to the use of standard, circular buffers (discussed below), and there are also a number of other risk factors that must be considered in the impact assessment. The risks associated with developing wind turbines both within and outside of these buffers should therefore be subject to further interrogation throughout the process.

Size and shape of buffer:

Birds from different areas may have different foraging ranges (Bamford et al. 2007, Phipps et al. 2013b, Pfeiffer et al. 2015) and size of the core home ranges vary between years (Venter et al. 2018). It is also possible that Cape Vultures from larger colonies have larger core areas to compensate for increased competition close to the breeding colony, as has been observed in some colonial breeding gull species (Corman et al. 2016). Vultures are also unlikely to use a perfectly circular area around a colony or roost (López-López et al. 2013, Phipps et al. 2013b, Pfeiffer et al. 2015). It is therefore important to also consider the additional risk factors (e.g. topography, feeding sites and risk maps) as well as monitoring data gathered for the purposes of impact assessment.

Size and location of colonies and roosts:

The size of the colony or roost is likely to influence the probability of collisions. There also is evidence that breeding success is positively influenced by nest density (Pfeiffer et al. 2017) and large colonies may act as source populations (Boshoff & Minnie 2011). Large colonies therefore warrant the highest level of protection (i.e. very high sensitivity buffers).

The proposed buffers do not take into account the density of birds using a site. In southern Spain large-scale aggregation of vultures (i.e. a measure of the distance between the turbines and colonies or roosts, combined with the number of birds at each site) was found to be a more powerful predictor of collision risk than just distance from breeding colony or roost (Carrete et al. 2012). Spatial aggregation should therefore also be considered when assigning sensitivity.

Although large colonies may be the most critical to protect, it is important to preserve the maximum number of breeding colonies, regardless of the number of breeding pairs they contain. If vulture populations continue to decline, smaller breeding colonies may experience declines in breeding success then abandonment. Small colony desertions would cause range contractions and concentrate breeding attempts at only the biggest colonies, increasing their vulnerability.

A single mass-poisoning incident near one large remnant, breeding colony could further increase the likelihood of extinction (Ogada et al. 2015a). Reducing the number of breeding colonies may also constrict gene flow and produce a genetic bottleneck, which could further accelerate the decline of the species (Bonnell and Selander 1974).

Cape Vultures are also not restricted to roosting at the colony they breed at, and during both the breeding and non-breeding season adult vultures will roost at breeding colonies that are not their 'own' (Pfeiffer unpublished data). All colonies should therefore be regarded as important and warrant protection from the impacts of wind energy.

Breeding colonies vs. roost sites:

Colonies hold breeding populations and are therefore important for the persistence of the species and therefore warrant protection (Boshoff & Minnie 2011). Phipps et al. (2013a) argue that colonies are more important to protect than roosts, as roosts can be ephemeral and used by fewer vultures. However, small colonies, where no breeding activity occurs might be considered as roosts, and some historical roosting sites have a few breeding pairs (K. Wolter pers. comm.). Roosts may also enable birds to increase their foraging range, as they are not limited to foraging within flying distance of a colony (K. Shaw pers. comm.) Some roosts are likely to be more important than others based on their size, how regularly they are used, and how they are used. Roosts further away from colonies may be used differently to roosts close to a colony. Boshoff et al. (2009) reported evidence for the partial migration of Cape Vultures – roosts in the Eastern Cape Midlands were not used during the autumn–winter period (breeding season), but vultures were present during the spring–summer period (non-breeding season). It is unclear how this might affect collision risk or the significance of impacts.

Abandoned colonies and temporary roosts:

If colonies or roosts have not been used within the past five years, the appropriateness of implementing buffers should be considered based on the history, importance and potential of the site to be recolonized.

Roosts can be ephemeral and used sporadically (Phipps et al. 2013a). For the purposes of these guidelines it is proposed that the recommended high sensitivity buffers be applied to regular and seasonal roosts. However, temporary roosts may be important and the need for additional survey effort should be carefully considered and revisited throughout the assessment process.

Beyond buffers:

The buffers proposed above are unlikely to completely mitigate collision-risk. We know that both adult and juvenile Cape Vulture move much further than the proposed buffers around breeding colonies and roosts (Jarvis et al. 1974, Phipps et al. 2013a, Rushworth and Kruger 2014, Pfeiffer et al. 2015, Martens et al 2018). It is therefore important to also consider the additional risk factors (e.g. topography, feeding sites and risk maps).

(Rushworth and Krüger 2014, Reid et al. 2015). Eurasian Griffon Vultures follow wind currents, which are dictated by local changes in topography and allow the vultures to travel great distances with little energy (de Lucas et al. 2012b). These wind currents are often situated on ridges and cliffs, which provide orographic lift (de Lucas et al. 2012b, Katzner et al. 2012). It is along these wind currents that wind farms often find suitable conditions for generating power (de Lucas et al. 2012b), placing birds at risk of collisions. Collision risk for Eurasian Griffon Vulture also appears to increase with increasing elevation above sea level (de Lucas et al. 2008). The relationship between wind, topography and collision-risk is likely to be similar for Cape Vulture.

Food availability

The availability of food can affect the flight height and area used by vultures (Spiegel et al. 2013). The potential availability of carrion in and around the location of a proposed wind farm should be considered during site screening. This assessment should include the location of existing vulture restaurants, the type of livestock present in the landscape, management practices, land ownership and the availability of alternative food sources.

A mosaic of land uses is found within the vultures' foraging ranges including commercial and communal farmland, plantations, and protected areas (Pfeiffer et al. 2015). Adult Cape Vultures captured at the Msikaba Cape Vulture Colony, Eastern Cape, preferred communal farmland over commercial farmland and it is assumed that this is because communal farmland offers better foraging opportunities because of numerous livestock deaths (Vernon 1998, Pfeiffer et al. 2015). In contrast, the land use around the Potberg breeding colony in the Western Cape is dominated by commercial sheep farming operations and the breeding colony has persisted (Boshoff and Currie 1981, Boshoff et al. 1984). This suggests that while there may be a preference for communal land, commercial farmland does not preclude the Cape Vulture. The type of livestock present (e.g. cattle vs. sheep) and the potential availability of food as associated with different livestock



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The type of livestock present in an area, land management practices and land ownership (i.e. communal vs. commercial) all affect the availability of food for vultures, which in turn influences how they use the landscape.

management practices may also affect how vultures use the landscape (Kevin Shaw, pers. comm).

Vulture restaurants are used to provide a supplementary source of carrion to vultures and thus these sites may affect the likelihood of birds being present in an area, their behaviour, and the potential risk of collisions. López-López et al. (2013) found that vulture restaurants influenced the movement of Egyptian Vultures in Spain. Surprisingly, areas far away from nesting sites (20–30 km) were used more than some closer sites (< 5 km). The vultures in the study travelled long distances (250 km round trip) to some vulture restaurants. Wind farms should therefore not be established close to vulture restaurants (and conversely vulture restaurants should not be established close to wind farms) (López-López et al. 2013). The appropriate size and shape of the buffer around existing vulture restaurants should be influenced by how vultures travel to and from the site, how regularly the site is used, and the location of colonies and roosts in the surrounding area. **Areas between a breeding colony or roost and an established feeding site should therefore be considered as high sensitivity.**



A Cape Vulture feeds on carrion at a vulture restaurant in the Thomas River Conservancy, Eastern Cape. Vulture restaurants provide a supplementary source of food for vultures and influence the presence and behaviour of vultures in the area. The proximity of a proposed wind farm to vulture restaurants should therefore be considered during site screening and impact assessment.

Risk maps

Where available, risk maps can provide an additional layer for site screening but do need to be verified using data gathered on the ground. Pfeiffer (2016) used high-resolution tracking data from Cape Vultures in the Eastern Cape Province to predict the probability of vultures flying in the study area and flying at risk height. Average wind speed, distance from conservation priority sites (roost sites, breeding colonies, and supplementary feeding sites) were used to investigate their influence on Cape Vulture flight behaviour) and by using spatial variables to predict vulture presence, a probability map was generated to estimate relative collision risk across the landscape. Reid et al (2015) also developed a spatially explicit model to predict collision risk for Bearded Vulture. It is anticipated that initiatives to map risk collision will continue to improve.

Cumulative impacts

While it may be theoretically possible to develop wind farms within the foraging range of Cape Vultures, a precautionary approach is strongly advised. **The risk of cumulative negative effects must be considered during site screening (this should be repeated in more detail in the impact assessment**

process). As a guideline the number (and where possible impacts) of operational and potential wind turbines (i.e. that have environmental authorisation) within a radius of at least 100 km should be considered during site screening.

3.2. IMPACT ASSESSMENT

The duration and scope of fieldwork required to assess the impact should be guided by the potential risk to Cape Vulture as assessed during site screening (i.e. based on the proximity to colonies and roosts, topography, food availability, and risk of cumulative impacts).

If broad scale analysis suggests that there is potential for building a wind farm with minimal negative effects on Cape Vultures, but the site falls within the species' range, the applicant should proceed to detailed data collection for baseline monitoring and impact assessment. This should proceed in accordance with BirdLife South Africa/EWT Best Practice Guidelines (Jenkins et al. 2015) as well as the recommendations of the avifaunal specialist. In addition to this, surveys should be conducted to verify the absence of active (seasonal, occasional or regular) roost sites, colonies and/or supplementary feeding areas within 50km of the site.

Developers may decide to proceed with data collection in areas identified as high or even very high sensitivity during site screening, but these projects should be considered as high-risk investments and are unlikely to have a positive outcome for conservation. Subject to verification through data collection, high sensitivity areas should be considered “critical habitat” and thus most financial institutions should impose stringent requirements before they will support development in these areas (for more see IFC 2012). Data collection in high and very high sensitivity areas should follow the recommendations outlined below.

The assessment of the site sensitivity and the recommended data collection protocols should be regularly reviewed throughout the process, taking into consideration the frequency that Cape Vulture are recorded on site, the availability of food, and other features associated with risk.

All impact assessments should include consideration of the potential impact of associated infrastructure such as power lines and roads on vultures (Botha et al. 2017).

Data collection within areas of high and very high sensitivity

If a wind energy facility is proposed within a **high sensitivity area** (as assessed in site screening), data collection must extend beyond the minimum protocols recommend in the BirdLife South Africa/EWT Best Practice Guidelines (Jenkins et al. 2015), as outlined below. While these recommendations technically also apply to areas identified as **very high sensitivity** during screening, BirdLife South Africa strong advises against investing in further studies as it is unlikely that the wind energy can be developed sustainably in these areas.

Duration and timing of data collection

Vulture activity levels and use of the landscape may differ year on year (e.g. Venter et al 2018) and avifaunal surveys should preferably span several years to account for seasonal variation in flight activity, and inter-annual variation in the relative abundance of birds (de Lucas et al. 2008, de Lucas et al. 2012a, Jenkins



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et al. 2015). **BirdLife South Africa therefore recommends that the duration of monitoring should be extended to at least two years within areas of high and very high sensitivity.**

If the results of the first year of monitoring indicate that the assessment of sensitivity during screening was inaccurate (i.e. should have been lower), it may not be necessary to continue with data collection for two years. This should only be considered if: i) all previously recorded roosts and colonies within 50km of the site are confirmed to be inactive and unlikely to be recolonized, ii) no previously unrecorded roosts or colonies are found within 50km of the proposed wind farm, and iii) no or a very low number of vultures are recorded during the surveys.

It is also important to sample as much seasonal variability as possible. Vultures could be more susceptible to wind turbine collisions in particular seasons as movement patterns and behaviour may be affected by the time of year (Spiegel et al. 2013). In southern Spain the greatest number of vulture fatalities occurred between September and February – corresponding to the Northern Hemisphere winter when thermal generation was weakest (Barrios and Rodríguez 2004, de Lucas et al. 2008, de Lucas et al. 2012a). This pattern differs between regions – a study of 89 wind farms across eight provinces in northern Spain found that the number of fatalities peaked in March and then declined until September (Camiña 2011).

Cape Vultures also may demonstrate seasonal differences in behaviour and habitat use. For example in parts of the Eastern Cape increased numbers of vultures have been recorded in spring–summer (the non-breeding season) (Boshoff et al. 2009, Smallie, unpublished). Cape Vultures from the Msikaba Colony also showed seasonal variability in habitat use and birds in the non-breeding season had slightly larger home ranges than in the breeding season (Pfeiffer et al. 2015).

Vantage point survey fieldwork should therefore include the pre-breeding season (late March to early May), as well as

Roosts may be used sporadically and can be difficult to identify and monitor. An area of approximately 50 km around a proposed wind farm should therefore be surveyed for previously unrecorded roosts and colonies.

the breeding season (May to December). **Site visits should be timed to account for as much seasonal variation as possible (i.e. a minimum of 6 site visits each year).**

Focal point surveys

Accurate information on the status and location of each roost and colony is useful for the purposes of impact assessment and mitigation, and it will also help measure trends before and after the construction of the wind farm.

All (occupied and potential) breeding colonies and roosts within 50km of a proposed wind farm should be treated as focal points during monitoring and impact assessment. Breeding colonies should be monitored according to the standard survey protocols (e.g. Benson et al. 2007, Wolter et al. 2011), as far as is practically possible. Where access is possible, and taking care not to disturb breeding birds, the number of pairs and breeding success (productivity and fledgling rates) should be recorded. Colonies should be visited at least three times during the breeding season to count the number of pairs (May), the number of chicks (July/August) and the number of fledglings (September/October) (Wolter et al. 2011). Roosts should be visited more often (i.e. at least four times a year) and classified (as per Boshoff et al. 2009) and described (e.g. man-made vs. natural). As a minimum (i.e. where access is limited and at roost sites), notes should be taken on the number of vultures and direction of travel to and from these sites. Surveys should be done at dusk as vultures may leave a colony or roost when it is too dark to do counts at dawn (Kevin Shaw, pers. comm.).

Monitoring data for roosts and colonies could make a significant contribution to the study of the species and it is therefore recommended that these data are shared with relevant stakeholders (e.g. BirdLife South Africa, EWT, VulPro and DEA). Where possible, monitoring should be coordinated between neighbouring wind farms and local conservation organisations – there is no need to duplicate surveys. An efficient approach could be to appoint a local conservation organisation to continue, and if necessary expand existing monitoring programmes.

Vantage point surveys

It is important to ensure that a representative sample of vulture movements is sampled, particularly if a wind farm is proposed within a high-sensitivity area. This implies that time spent conducting vantage point surveys should be increased from the minimum recommend in BirdLife South Africa /EWT's Best Practice Guidelines (Jenkins et al. 2015). Enough time must be spent to be able to accurately quantify flight activity and predict risk. However, flight activity can be variable, and the ideal number of hours spent conducting vantage point surveys will be influenced by the site, species, flight activity levels, and the acceptable degree of uncertainty. Increasing the number of hours of vantage point surveys will decrease the variability in the collision risk assessment, and more hours of monitoring may be required to reduce variability (i.e. potential error) at sites with low levels of flight activity (Douglas et al. 2012). In the absence of statistical analysis of the uncertainty associated with a data set for Cape Vulture, **it is recommended that an absolute minimum of 72 hours per vantage point per year should be surveyed** (e.g. Scottish Natural Heritage, 2013). Vantage points watches should be conducted by a minimum of two persons (at the same time on the same vantage point). This will help minimise observer fatigue and distraction and promote accurate data collection.

Vantage points should be located to ensure maximum coverage of the proposed development site. The direction of flight and height of vultures should be recorded at the first sighting, and then every 15 seconds thereafter. Flight height should be recorded in bands of 10 meters, preferably by using clinometers and range finders. These data can later be categorised into three broad bands (i.e. below, within, and above the rotor-swept area), depending on the turbine specifications proposed. Flight paths of Cape Vultures should be sketched out on topographic maps. Wind velocity and wind direction should also be recorded.

Tracking devices

Tracking devices (e.g. GPS/GSM devices) can be a valuable tool for understanding the flight behaviour and habitat usage of individual birds, and tracking data can be scanned to help identify roosts (which can be costly to find and may escape detection otherwise) (Pfeiffer et. al 2017). However, the costs and benefits of using tracking devices to help inform the placement of wind turbines should be carefully thought through. Devices should be selected and programmed to meet the purpose of the study, with consideration given to accuracy, the need for data on flight height and the frequency of recording locations.

Cape Vulture are likely to move well beyond the boundaries of any single wind farm, and there is a risk that vultures fitted with tracking devices might not move through the area



KATE WEBSTER

A Cape Vulture flies dangerously close to a wind turbine in the Eastern Cape.

of interest. Furthermore, only individual birds can be monitored, which means that there is a risk the data collected will not be representative of all birds in an area. Age and overall health of the birds must also be considered when analysing data, this should include if the bird has been rehabilitated. Rehabilitated Cape Vultures have a lower survival rate than wild-caught birds (Monadjem et al. 2013), which may influence their movements.

Cape Vulture can also be extremely difficult to capture and handle, and this should only be done under the supervision of suitably qualified and experienced individuals. Relevant protocols (e.g. Wolter et al. 2015) for capturing, handling and fitting tracking devices must be consulted. While no accounts of Cape Vulture fatalities from harnesses or tracking devices have been published, handling birds and attaching devices may carry a risk to study animals (Marzluff et al. 1997). Skin irritations have been observed (M. Pfeiffer, pers. obs.), but the long-term effect of this condition remains unknown.

Before embarking on a project that involves capturing and tracking vultures, a permit must be obtained from DEA and/or the provincial conservation authority (as per the National Environmental Management: Biodiversity Act (10/2004): Threatened or protected species regulations). BirdLife South Africa also strongly recommends that ethical clearance be obtained. For more information please see BirdLife South Africa's position statement on the tracking of birds, available at www.birdlife.org.za.

Data gathered through tracking vultures can provide valuable information to guide the location of wind farms and powerlines. This approach is best suited to projects beyond the scale of most wind farms (e.g. strategic/regional planning and sensitivity maps). Collaboration and information sharing

among stakeholders is therefore strongly encouraged. In order to maximise the benefits of tracking and to avoid duplication Tracking data should be housed in a central repository (e.g. Movebank), and the results of the project should be published in a peer review journal.

Radar

Tracking devices are useful if the intention is to monitor the movements of individual birds over a wide area. In contrast, radar can be used to accurately record the movements of many birds in a limited area. Radar can record flight height and can eliminate some of the errors associated with human observation (Becker 2016). Some radar systems cannot differentiate between species, but it may be possible to correctly identify Cape Vulture using certain types of radar equipment (Becker 2016). Although night-time movements of vultures are relatively uncommon, radar can also record flights when visibility is limited by light (Becker 2016). Radar does not replace the need for vantage point monitoring, but it can help improve precision of measurements and possibly reduce the amount of human observation time at a site. **The use of radar in high sensitivity areas is encouraged**, but precision should not be confused with accuracy – radar studies must still be well-timed (as a minimum radar surveys should be timed to coincide with the period of highest risk).

Radar may also be a useful tool to use when mitigating impacts during the operational-phase (i.e. though shut-down-on demand).

Wind current modelling

Wind current modelling can be used to predict the likely flight behaviour of vultures at the scale of a wind farm (de Lucas et al. 2012b). This method involves constructing a topographic model of the study site and recording the movements of objects through the model at different wind directions. Although costly and time-consuming, this method could be useful for proposed development sites that experience a multitude of wind directions.

Assessment of collision risk

Impact assessments generally assume that collision risk is correlated to bird abundance and passage rates. However, there is conflicting evidence on the relationship between the abundance and/or passage rates of Eurasian Griffon Vulture and wind-farm fatalities in Spain (de Lucas et al. 2008, Ferrer et al. 2012). Barrios and Rodríguez (2004) reported that the highest number of vulture passes within 5 m of turbine blades were also near the turbines with the highest mortality rates. Another study found that although there may have been a trend between the predictive power of the EIAs (based on passage rates) and actual vulture fatalities, this relationship was not significant (Figure 3) (Ferrer et al. 2012). De Lucas et al. (2008) also did not find a simplistic linear relationship between abundance and collision mortality.

Table 1 summarises average Cape Vulture passage rates and fatality rates at operational wind farms in South Africa to date. This data is provided for comparative purposes only. The survey effort was lower than is recommended in these guidelines and post-construction monitoring has only been conducted for a short time in South Africa.

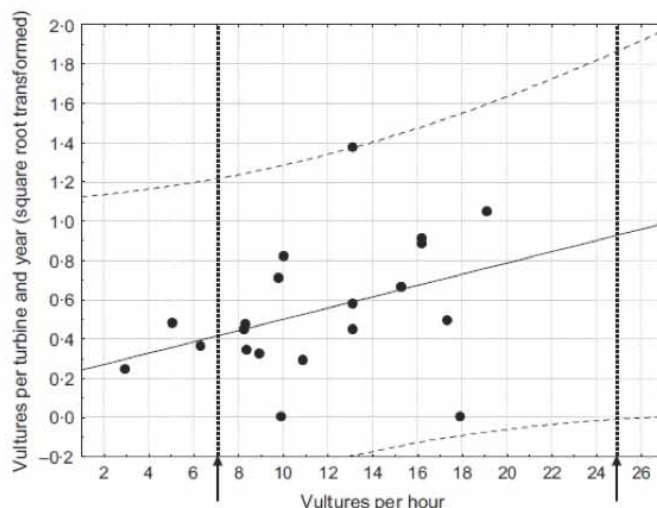


Figure 3. Non-significant correlation between Griffon Vulture mortality recorded in operating wind farms in Tarifa, Spain (square root transformed) and passage rates of vultures ($r=0.379$, $n=20$, $p=0.099$). The dotted curves represent 95% of prediction. Some wind farms in the study were not approved, the range of passage rates recorded in these projects is represented by the arrows and dotted lines. From Ferrer et al. (2012).

The number of vulture fatalities that might take place once the wind farm is operational should be estimated using a collision risk model (Band et al. 2007, Scottish Natural Heritage 2009, Strickland et al. 2011, United States Fish and Wildlife Service (USFWS) 2012, Masden 2015) at all sites where there is sufficient data to estimate the risk. Collision risk models provide a useful and objective indication of the relative risk of collisions (USFWS 2013) and take many factors in addition to passage rates into account, including the characteristics of the wind energy facility and its turbines, flight height and speed, and a correction factor is used to account for uncertainties and behaviour (e.g. avoidance) (Strickland et al., 2011). The results of collision risk modelling can be used to compare different wind farm locations or layouts and can help contextualise the predicted impacts on the local bird population. However, if collision risk models are to produce meaningful results it is important that the input data represents average conditions – this should be possible with

	Passage Rate (vultures/hour)		Distance to nearest known roost or colony (km)	Collision rate (vultures/turbine/year)
	Pre-construction	Post-construction Year 1 (Year 2)		
Wind Farm 1	0.02	0.26	24	0
Wind Farm 2	0.31	0	17	0
Wind Farm 3	0.13		22	0.45
Wind Farm 4	0.13	0.11	28	0.07
Wind Farm 5	0.34	0.64 (0.84)	12	0.03

Table 1. Average passage rates (measured using protocols outlined in Jenkins et al. 2015), distance to nearest nest and collision rate at operational wind farms in the Eastern Cape which have recorded the presence of Cape Vulture. Operational phase monitoring was conducted for as little as three months (Wind Farm 3) and much as 36 months (Wind Farm 5)

the extended monitoring protocols recommended in these guidelines for sites of high sensitivity. Collision risk models make a number of assumptions (Whitfield 2009) and there is no literature verifying fatality rate predictions for Cape Vulture. The results should therefore be interpreted with these limitations in mind.

Predicting collision risk is not straightforward. Wind farms placed in dangerous areas with low densities of vulnerable species may be more hazardous than wind farms located in relatively safe areas with high densities of vulnerable species (Ferrer et al. 2012). In addition to passage rates and flight height, factors such as topography, bird behaviour, season, aggregation, wind direction and wind speed may all be important (de Lucas et al. 2012a, Ferrer et al. 2012, Carrete et al. 2011) and should be taken into account during all stages of the assessment.

Assessment of cumulative impacts

The risk of cumulative negative effects must be considered during site screening and then again in more detail during the impact assessment processes. The World Bank Group (2015) recommends that cumulative impact assessments should be conducted when multiple wind farms are located in areas of high biodiversity value (e.g. core habitat for Cape Vulture). The appropriate spatial extent of the cumulative assessment should be determined by the avifaunal specialist, taking the receiving environment into consideration. As a guide we recommend that the cumulative effects of all established and potential wind farms (i.e. wind farms that have environmental authorisation) within a radius of at least 100 km be considered during screening, but if multiple fatalities have been predicted during the impact assessment, it would be more appropriate to assess cumulative impacts on the regional population (e.g. through population viability assessment). This assessment should take into consideration impacts over the lifetime of the proposed facilities.

For further guidance on cumulative impact assessments see DEAT 2004, SNH 2012 and IFC 2013. The cumulative effects study for wind energy in the Tafila Region in Jordan (IFC 2017) also provides a useful example.

Mitigation

There are limited options available for mitigation once a wind farm is operational and the mitigation hierarchy (i.e. first seek to avoid and minimise) should always be adhered to. Mitigation measures should be designed to achieve no net loss of biodiversity (IFC 2012).

Planning phase (location, layout and design)

The considered location and layout of a wind farm and its turbines is the most widely accepted and cost-effective approach to minimise impacts. Turbines should not be placed in areas with a high abundance of Cape Vulture, high passage rates, or where there are topographic features and other areas likely to be associated with a high risk of vulture collisions (as identified in site screening and verified by the impact assessment). This may require the avoidance of large areas of the landscape.

The location and alignment of new powerlines associated with the wind farm should also take the above factors into account. No new powerlines should be permitted within a 5

km radius of a colony or roost (C. Hoogstad pers comm.). In areas where there is a high risk of collisions, above ground power lines should be avoided wherever possible and all new power lines must be marked with bird flight diverters and these devices must be monitored and maintained throughout the lifetime of the line. All new powerlines installed must be of the 'bird-friendly' type in order to minimise the risk of collision and electrocution (Jenkins et al. 2010, Boshoff et al. 2011) (for more information contact the Eskom-EWT Strategic Partnership).

Although rarely proposed in South Africa, BirdLife South Africa recommends that old lattice type wind turbine towers should not be constructed, as these provide numerous perching areas for raptors and may increase the probability of collisions (Barrios and Rodríguez 2004).

The implications of varying the name-plate capacity, hub height and rotor swept area should be assessed on a case-by-case basis, informed by the predominant flight patterns on site. Some studies have found that fatalities increased with turbine height, but relationship between turbine height and collision risk is likely to be site- and species-dependent (Marques et al. 2014).

Free spinning of turbines under low wind conditions, when turbines are not producing power should be avoided (World Bank Group 2015).

Construction

Construction activities at or near breeding colonies and roosts should be avoided to minimise disturbing vultures at these sites (Tarboton and Allan 1984, Borello and Borello 2002, Verdoorn 2004). The extent of disturbance buffers has been debated internationally and little data exists to support recommended buffer sizes. To some extent this is a moot point for the Cape Vulture and wind farms, as the buffers proposed in these guidelines to minimise collision risk (for powerlines and turbines) are likely to exceed disturbance distances. However, it may be possible that construction or upgrades to other infrastructure associated with a wind farm (e.g. roads) is proposed closer to colonies or roosts. Construction directly below or on top of a breeding colony or roost should not be permitted, and construction activities should not take place within 500 m of a breeding colony or roost (Kaisanlahti-Jokimäki et al. 2008) (this value is based on eagle research and should be adjusted based on the vultures' use of the immediate area). Construction near colonies during the breeding season (i.e. from egg laying, until the chicks have fledged) should be avoided (Borello and Borello 2002).

Operational phase

Operational phase mitigation and adaptive management carries risks and uncertainties and should not be relied on at high-risk sites where avoidance would be more appropriate. However, short of excluding wind energy from vast areas of South Africa it will be impossible to reduce the risk of vulture collisions to zero. Where the level of risk is deemed acceptable, but there is still a small residual risk of collisions, provision for operational phase mitigation and adaptive management must be included in the Environmental Management Programme (EMPr) to further reduce the risk. **The EMPr should clearly describe impact management objectives, outcomes**

and actions required to address potential impacts on vultures. Before a project proceeds it is important that decision-makers understand, and the wind farm developer agrees to the potential operational and cost implications of an adaptive management strategy.

The following operational phase mitigation options could be considered:

1. Curtailment and shut-down on demand

Turbine operation may be restricted to certain times of the day, season, or in specific weather conditions that are associated with a high risk of collisions. This approach requires a clear understanding of the risk factors (Barrios and Rodríguez 2004, de Lucas et al. 2012a). The collision risk for Eurasian Griffon Vulture was found to be higher at lower wind speeds (see Figure 7 from Barrios and Rodríguez 2004). In this example, turbines could theoretically be curtailed during low wind conditions, when the impact on power generation would be low. However, curtailment may result in turbines being shut down for long periods. Turbines operating at night, for example, would have a very limited impact on Cape Vultures, but could have major implications for the amount of power generated by a facility.

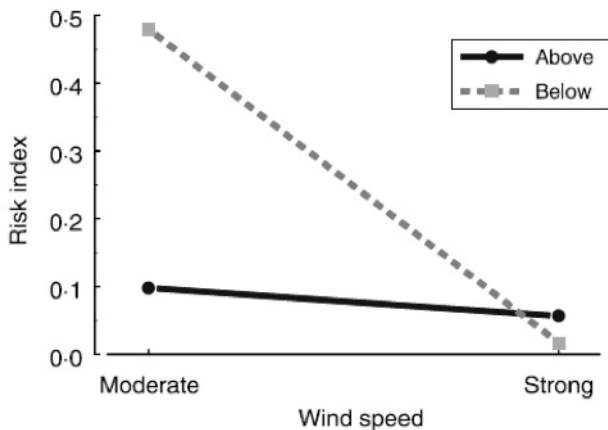


Figure 4. The interaction between height of flight at first contact with the observation area (i.e. above the turbines represented by the solid line vs. from below the turbines, dotted line) and wind speed on the putative risk index for Griffon Vulture (*Gyps fulvus*) at PESUR wind farm, Spain. Range of speeds of light/moderate winds: 4-6-12.5 m s⁻¹; strong winds: > 12.5 m s⁻¹. The risk index was defined as the frequency of risk situations (i.e. ratio between the number of birds observed within 5 m of the blades and the total number of passes or observations within 250 m of the turbine lines). From Barrios and Rodríguez 2004.

Shut-down-on-demand (i.e. stopping the movement of the turbines when there is a high risk of collisions) has been demonstrated to be an effective mitigation measure for reducing (but not eliminating) Eurasian Griffon Vulture mortalities in Spain (de Lucas et al. 2012a). Shut-downs can be triggered by human observers, or by using devices (i.e. radar or cameras) managed under human surveillance (Marques et al. 2014, BirdLife International 2015, World Bank Group 2015).

The effectiveness and feasibility of this approach for the Cape Vulture remains uncertain as the number of vultures

and daily passage rates will affect how often turbines need to be shut down. Shut-down-on-demand is likely to be most effective when there are clear peaks in collision-risk. In the above example of Griffon Vultures in Spain fatalities peaked during the migratory period (de Lucas et al. 2012a), while Cape Vulture are not migratory. Since most Old-World vulture species are resident, they may be exposed to risks associated with a wind farm throughout the year, not just during a specific period (e.g. migration) (Barrios and Rodríguez 2004).

Shut-down-on-demand or curtailment should not be relied on as the primary mitigation measure (BirdLife International 2015). However, it must be considered as part of the mitigation strategy if multiple Cape Vulture mortalities are expected to occur (or have been recorded) at a wind farm. The implementation of shut-down-on-demand should be adaptive, guided by a well-developed, post-construction monitoring program and the cost implications of this approach must be taken into account at an early stage of the project planning (World Bank Group 2015).

2. Food availability

If a wind farm is established within an area where Cape Vulture may occur it is important that the number of animal carcasses is minimised, both at the wind farm and within nearby areas, as carcasses could attract vultures and increase the risk of collisions. A dedicated full-time team should be tasked with detecting and removing any dead livestock or other animals within or near to wind turbines (e.g. within 2 km). All operational staff should also be required to report carcasses as soon as they are observed. Carcasses should be disposed of in a way that would not attract birds, or they should be transported to safe locations that are well away from the wind farm.

Calving and lambing near turbines (e.g. within 2km) is also strongly discouraged. This may require the wind farm to have agreements in place with the land owner and must be carefully considered during project planning. An alternative approach could be to curtail turbines during calving and lambing season.

If limiting the availability of food on site is proposed as mitigation and is required to reduce collision-risk to acceptable levels a) the mitigation hierarchy must have been exhausted and b) the effectiveness of this approach must be verified during the preliminary avifaunal assessment and impact assessment process.

Vulture restaurant

It has been suggested that strategic placement of new vulture restaurants could influence the movements of vultures and reduce collision risk. While the use of supplementary feeding sites does have conservation merit and may be appropriate in the context of addressing existing threats (including from operational wind farms), a precautionary approach should be adopted if this is considered as mitigation for new wind energy facilities.

In a study of Cape Vultures (largely from the northern-node population), Kane et al. (2015) found that the location of colonies and vulture restaurants are both significant predictors of vulture presence. However, they found a stronger



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The use of 'shut down-on-demand' may reduce the risk of turbine strikes in some circumstances, but the effectiveness and feasibility of this approach for Cape Vulture remains to be tested. Where it is proposed as mitigation, the cost implications must be taken into account by the applicant during the impact assessment process.

association with roosts and colonies than with vulture restaurants, and supplementary feeding sites not reduce foraging ranges. Vultures were found to range over large areas, including where there are no restaurants (Kane et al. 2016). A small percentage of the Cape Vulture population may be reliant on vulture restaurants for food, but there appears to be enough wild ungulate carcasses and livestock deaths in communal farmland to sustain vulture populations (Kane et al. 2015, Pfeiffer et al. 2015), particularly in areas with good wind resource (i.e. Eastern Cape). While vulture restaurants are used by adult Cape Vultures, they are not as dependent on vulture restaurants as younger birds (Pfeiffer et al. 2015, Reid et al. 2015).

A study in Asia showed that five tagged Oriental White-backed Vultures *Gyps bengalensis* reduced their home ranges (by up to 59%), time in flight, and daily travel distances after vulture restaurants were established (Gilbert et al. 2007). However, the sample size was not representative of the population, all vultures travelled beyond the feeding site (which was 1.4 km from the breeding colony), and there was no evidence that the direction of travel was changed (Gilbert et al. 2007). There are also a number of differences between Oriental White-backed Vultures and Cape Vulture, including the size of their home ranges.

Vulture restaurants must be located and managed so as not to unintentionally increase risks to the birds (EWT 2011, Cortes-Avizanda et al 2016). If a new supplementary feeding site is proposed, consideration must be given to the location of other wind farms (planned, as well as operational), and associated infrastructure. These facilities would also require management throughout the lifetime of the wind farm. The pros and cons of altering the foraging range of Cape Vultures should also be carefully considered as this may affect vulture ecology and the provision of ecosystem services.

Where existing vulture restaurants are located in such a way that they may increase the probability of vultures traveling across a proposed wind farm, collision risk could be reduced if the supply of food is stopped at the restaurant, or the feeding site is relocated. However, if a feeding site has been operational for some time (e.g. a year or more) it is likely to take some time for birds to unlearn the behaviour and vultures may continue to visit the site even once a restaurant has been discontinued (K. Wolter pers comm.). This approach would also require the agreement and cooperation of the vulture restaurant manager and the knock-on effects should be carefully considered. Vulture restaurants have many benefits including providing a safe feeding option, supplemental food in times of scarcity, and opportunities for tourism and research (Kane et al. 2015) which could benefit the overall conservation of the species. Vulture restaurants have increased the survival rate of first-year Cape Vultures in the Western Cape, and the number of breeding pairs at a colony in KwaZulu-Natal (although not breeding success) (Piper et al. 1999, Schabo et al. 2016).

If the strategic location or removal of supplementary feeding sites is proposed as a mitigation measure in order to reduce the risk of collisions to acceptable levels a) the mitigation hierarchy must have been exhausted and b) the effectiveness of this approach must be verified during the preliminary avifaunal assessment and impact assessment process.

3.3 MONITORING AND ADAPTIVE MANAGEMENT

If a wind farm is established in a high sensitivity area the duration and extent of construction and operational phase monitoring should be significantly increased from the minimum requirements outline in BirdLife South Africa and EWT's Best Practice Guidelines (Jenkins et al. 2015).

Given the uncertainty with regard to the potential effects of wind energy on Cape Vulture and how negative impacts could be minimised, before-and-after studies, combined with carcass surveys, will make a significant contribution to our knowledge.

Adaptive management is often proposed as a mitigation strategy in South Africa. It is an iterative decision-making process used in the face of uncertainty where the effectiveness of management policies and practices are continually reviewed and improved. As such, adaptive management relies heavily on monitoring data (USFWS 2012).

Wind farms are encouraged to go beyond demonstrating no net loss and should aim to achieve a net positive gain for the species. Once the mitigation hierarchy has been exhausted, residual impacts could be compensated through off-site conservation action.

Monitoring within high sensitivity areas

Data from vantage point monitoring can be useful when assessing options for operational-phase mitigation and vantage point monitoring should therefore continue through construction and into the operational phase, according to the frequency and duration recommended by the avifaunal specialist. It may be necessary to relocate vantage points to avoid construction activities.

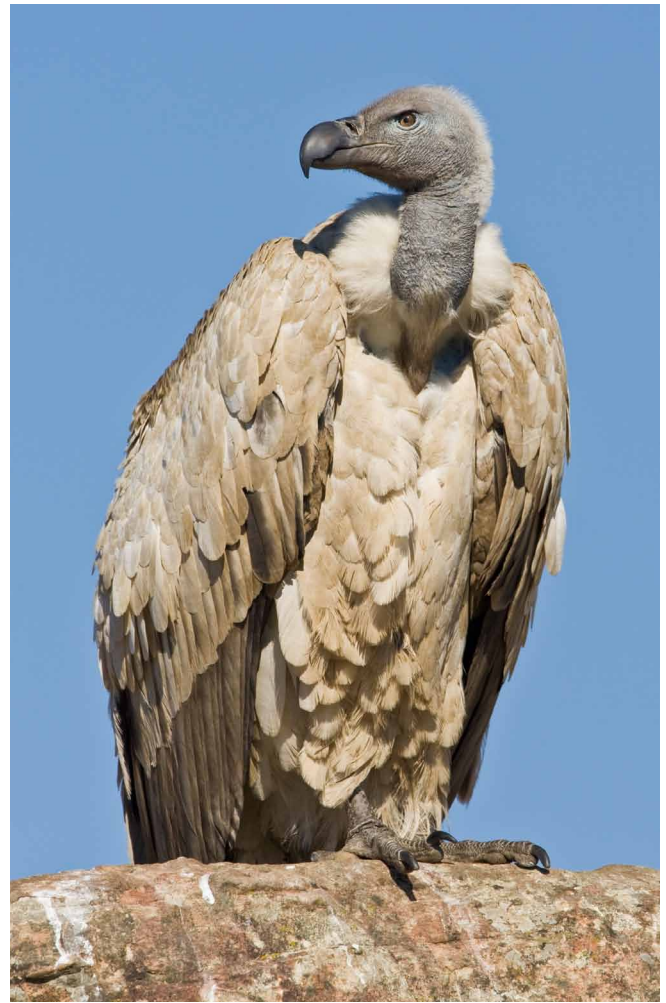
Breeding colonies and roost sites identified and surveyed during site screening and impact assessment should be monitored throughout the lifetime of the facility (as per the recommendations for focal surveys above), and where possible in collaboration with NGOs and state conservation agencies and other wind farm operators in the area.

Surveys for bird fatalities beneath the turbines must be initiated prior to the commercial date of operation and should continue throughout the lifespan of the project. These surveys should begin before 10% of the turbines have been erected and are rotating.

If new powerlines are built, operational phase monitoring should extend to include the powerline – bird flight diverters should be checked (and if necessary, replaced) and the area beneath the line should be surveyed for fatalities (with a frequency of approximately once a month, where feasible).

Injuries and fatalities

Fatalities of Cape Vulture (ad hoc or recorded during systematic surveys) should be carefully recorded and reported. The location of the carcass and estimated wind speed, the weight of the bird and approximate age (adult, immature or juvenile) should be recorded, and the carcass should ultimately be donated to a museum. Monitoring reports should normally be submitted to relevant stakeholders every quarter (Jenkins et al. 2015). In the event of a Cape Vulture fatality, this should be immediately reported to the bird specialist appointed by the



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Monitoring birds before and after the construction of a wind farm provides an opportunity to verify predictions made during EIA processes, and test the effectiveness of mitigation measures.

wind farm, BirdLife South Africa, VulPro, EWT and relevant conservation authorities (i.e. the DEA and provincial conservation authority). Following consultation with experts, and consideration of the as the EMPr (which should include impact management objectives, outcomes and actions relating to minimising risk to Cape Vulture), the avifaunal specialist should draft a report outlining the circumstances of the incident, the likely significance of the impact (including cumulative effects from that particular wind farm over the period of operation, and negative effects from other wind farms in the area), and if necessary a mitigation strategy should be proposed. Where necessary the specialist should propose amendments to the EMPr.

The nearest certified wildlife rehabilitation centre should be identified in the EMPr (VulPro will be able to assist in identifying suitable facilities) and if a bird is injured from a suspected collision with wind turbine blades, or related infrastructure, it should be transported to the facility where it can receive proper care. The injured birds should be examined, and the extent of the injuries documented.

4. CONSERVATION AND RESEARCH PRIORITIES

There are many gaps in our knowledge regarding the Cape Vulture, how they might be affected by wind energy facilities, and how these impacts could be managed. These include:

- A regular review of the location, size and status of Cape Vulture colonies and roosts (particularly in areas preferred by wind farm development, such as the Eastern Cape);
- A review of the size and effectiveness of the recommended buffer sizes proposed in these Guidelines (including a study of the relationship between proximity to roost and colony and collision risk);
- Ranking the importance of roost sites by vulture use, seasonality, type (man-made or natural) and risk of collisions (this analysis would need to include historical data; data on which individuals use roosts would also be of value);
- Assessing carrion availability in relation to foraging ranges and breeding colony size;
- Assessing the viability of locating vulture restaurants to reduce wind farm fatalities;
- Creating a habitat suitability model to predict potential roost sites or breeding colonies;
- Determine how hub height and rotor swept area of wind turbines influences collision risk for Cape Vulture;
- Ecological and economic significance of the species (e.g. implications of loss of species from an area);
- Is collision risk associated with vulture age or with the proportion of risky flights in the rotor swept area?
- Model Cape Vulture flight paths through wind development areas;
- A statistical analysis of the optimal duration and timing of vantage point surveys required to quantify flight activity (and risk of collisions);
- The effectiveness and feasibility of mitigation measures (e.g. curtailment and shut-down on demand using different techniques).
- Population Viability Analysis under different development scenarios.

5. CONCLUSION

South Africa is at an advantage with regard to wind energy development and Gyps vultures, because of the wealth of information produced in Spain on the topic. Furthermore, South Africa is fortunate to have about 2.5-fold more land than Spain, which provides numerous opportunities for wind energy development away from areas where the potential for vulture collisions is high. Over 80% of South Africa's land mass has enough wind resource for economic wind farms and can generate enough power to meet South Africa's electricity demand, with just 0.6% of the country's land area (CSIR 2016). While there are numerous other factors that constrain the area available wind energy development, we are optimistic that with careful site selection, rigorous monitoring, impact assessment and mitigation, it should be possible to develop wind energy in South Africa without negatively affecting the conservation status of Cape Vulture.

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USEFUL CONTACTS

BirdLife South Africa

Samantha Ralston-Paton: Birds and Renewable Energy Project Manager, 083 6733948, energy@birdlife.org.za

Hanneline Smit-Robinson: Terrestrial Bird Conservation Programme Manager, 011 789 1122, conservation@birdlife.org.za

Cape Nature

Kevin Shaw: ornithologist, 021 866 8000, shawka@capenature.co.za

Durban Natural Science Museum

David Allan: 031 3224214, David.Allan@durban.gov.za

Eastern Cape Parks & Tourism Agency

Dr Thabiso Mokotjomela: 043 492 0730, Thabiso.Mokotjomela@ecpta.co.za

Department of Economic Development & Environmental Affairs

Alan Southwood: 041 508-5813, Alan.Southwood@deaet.ecape.gov.za

Endangered Wildlife Trust

Constant Hoogstad: Wildlife and Energy Programme, 011 372 3600, constant@ewt.org.za

Gareth Tate: Bird of Prey Programme, 021 799 8459, gareth@ewt.org.za

Ezemvelo KwaZulu-Natal Wildlife

Sonja Kruger: 033 2391513, sonja.krueger@kznwildlife.com
Brent Coverdale: 033 8451449, Brent.Coverdale@kznwildlife.com

Free State Economic Development, Tourism & Environmental Affairs

Brian Colahan: ornithologist, 051 4004773, colahan@detea.fs.gov.za

Raptor Rescue

Ben Hoffman: 076 724 6846, kznraptorrescue@gmail.com

Dr Morgan Pfeiffer

United States Department of Agriculture, Wildlife Services, National Wildlife Research Center & Research Associate with School of Natural Resource Management, George Campus, Nelson Mandela University, Morgan.B.Pfeiffer@aphis.usda

Dr Jan Venter

School of Natural Resource Management, George Campus, Nelson Mandela University, Jan.Venter@mandela.ac.za

VulPro (Vulture Programme)

Kerri Wolter: 082 8085113, kerri.wolter@gmail.com
Kate Websters: 082 839 4716, kate@lcom.co.za