Cape Vultures and wind energy development in the Eastern Cape, South Africa.

Building Wind Turbine Encounter Risk models and investigating mitigation options to guide wind development.

Project Report

April 2022

Compiled for WindLab by the Birds of Prey Programme, Endangered Wildlife Trust (EWT)

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Introduction

Vultures are an intrinsic component of the environments they inhabit. They provide critical ecosystem services by cleaning up carcasses and other organic waste in nature. This has potential for reducing the spread of diseases in both wild and domestic animals, as well as the transmission of pathogens to humans. Vultures are equally important to people as they have social, cultural, and religious importance for many African communities. Currently, over sixty percent of vulture species worldwide are threatened with extinction, the most rapid population declines occurring in the vulture-rich regions of Africa. Over the last decade, the unnatural and accelerated mortality rates of vultures across Africa have led to the International Union for Conservation of Nature (IUCN) uplisting seven of the continent's 11 vulture species to Critically Endangered and Endangered, globally. We are facing a very real African vulture crisis.

The Cape Vulture, *Gyps coprotheres*, also known as the Cape Griffon, is a large-bodied vulture that is endemic to southern Africa. Most of its population is restricted to South Africa, Lesotho, and eastern Botswana, with an area of occupancy of 211,852 km^2. In late 2021, the IUCN downlisted the species from globally "Endangered" to "Vulnerable", a milestone outcome of the tireless conservation work that has been actioned for the species in southern Africa over the last 25 years. Currently, the population is estimated at 9600-12800 mature individuals. Thus, the population is still relatively small and undergoing severe declines in parts of its range, rendering it susceptible to local extinction, particularly in areas with elevated threats and mortality.

The demand for energy is increasing worldwide and wind turbines are considered a viable option for renewable energy production. However, concerns over the impacts on bird populations are increasing, as collisions with blades, and displacement of birds from their ranges are evident. An emerging threat for the Cape Vulture in South Africa, is its susceptibility to collide with wind turbines on operational wind energy facilities (WEFs). Indeed, the last five years have shown troubling numbers of mortalities recorded on wind farms in South Africa (24 reported mortalities to date, with many more likely not reported). The Cape Vulture is subsequently ranked as the highest priority bird species for mitigation of wind energy in South Africa. The Eastern Cape represents an important stronghold for Cape Vultures, with 20 large breeding colonies (of > 50 breeding pairs) and multiple roosting sites (Fig. 5). Tracking studies, monitoring, and research have also revealed that the species utilises the Eastern Cape's mountainous and coastal landscape extensively to forage and travel between breeding and roosting sites. Some parts of the Eastern Cape, particularly around breeding sites, are frequented by the birds all year round. Whereas some areas further away from breeding colonies, such as the Winterberg in the Bedford/Cookhouse region, are occupied more seasonally, with adult birds moving further distances outside of the breeding season to find food in areas outside of the winter breeding grounds.

The distribution of the Cape Vulture overlaps with wind energy development areas in South Africa, especially within the Eastern Cape Province. This is creating conflicts that can hinder both vulture conservation and a shift towards more sustainable energy sources. Cape Vulture collisions on WEFs are likely to be compounded by the rapid, cumulative development of wind energy in southern Africa driven by the necessary need for decarbonization mandates. Vultures are long-lived and reproduce slowly. Therefore, even seemingly small increases in mortality rates, such as fatalities associated with WEFs, can impact heavily on the survival of local populations. Conservation projects, research, and investigation into mitigation measures to reduce these fatalities on operational WEFs, as well as to inform future developments, are imperative for the survival in perpetuity of the species in the wild.

Movement Ecology and Collision Encounter Risk

Understanding the spatial distribution of collision prone species is critical to ensure wind energy development is restricted within their core use areas. For some raptors, tracking data have been used to develop predictive models for early identification of these core areas and high collision risk zones (Murgatroyd, Bouten, and Amar 2021; Reid *et al.* 2015; Katzner *et al.* 2012; Poessel *et al.* 2018; May *et al.* 2013). These models can be particularly useful during early development planning to facilitate cost-effective risk assessments. This is all important in the light of a significant node of WEF development in the Eastern Cape area, including WindLab

WEFs, which is predicted to have a cumulative impact on the species given their susceptibility of colliding with wind turbines.

In partnership with WindLab and Cennergi, the Endangered Wildlife Trust's Birds of Prey Programme (BOPP) initiated work, assisted by the University of Cape Town[1], to build an Encounter Risk Model for the Cape Vulture in the Eastern Cape region to help wind energy stakeholders identify high-risk areas, and plan developments accordingly. In collaboration with multiple stakeholders, the initiative was driven further by the University of Cape Town to expand and build an Encounter Risk Model for the entire distributional range of the Cape Vulture.

An Encounter Risk Model differs from a regular collision risk model in that it deals only with the potential of a bird encountering a turbine, and not with the probability of collision given that encounter (Masden and Cook 2016; Murgatroyd, Bouten, and Amar 2021). We follow the convention that risk arises from the interaction of a *hazard* with an *exposure* (see Cardona *et al.*, 2012). In this context, hazard represents likelihood of utilization, and it is defined by characteristics of the landscape and the behaviour of the species. In contrast, exposure is related to the number of vultures present in a region, which is in turn, influenced by the size and number of colonies/sources in the area. Risk is then calculated multiplying hazard by exposure, resulting in the number of vultures expected to encounter turbines if they were built in an area (Cervantes, Murgatroyd, Allan, Kemp, *et al.*, n.d.). To estimate hazard intensity across the landscape, Cervantes *et al.,* (n.d.) use tracking data to build a behavioural model based on habitat preferences and movement patterns of Cape Vultures. Using this model, Cervantes *et al.,* (n.d.) simulate movement around core breeding colonies and roosts, to estimate a steady-state distribution, commonly referred to as utilization distribution (UD), which in their context is used as a hazard (terms used interchangeably). Cervantes *et al.,* (n.d.) then scale this hazard by the exposure of the population, based on the different sizes of breeding colonies and large roosts (referred to as core colonies for simplicity), to estimate the overall risk to the global Cape Vulture population. In this report, we present results predominantly for the Eastern Cape. This work, its applied methods and the resulting risk maps, has been submitted for publication in *Ecological Applications* and is currently in review *(see Cervantes, Murgatroyd, Allan, Farwig, et al.*, n.d.). The full Encounter Risk Models manuscript covering the entire Cape Vulture range, co-authored by the EWT, will be made available once the paper is accepted for publication. Results

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[1] The University of Cape Town led the risk modeling and mapping for the entire Cape Vulture range, as part of a post-doctoral research position. Please see Cervantes, Murgatroyd, Allan, Farwig, *et al.*, (n.d.) for comprehensive breakdown of the modeling framework and methods used for the southern African Encounter Risk Maps.

in this report will be presented as per our manuscript submitted for publication.

We further investigate mitigation options for both operational wind farms in the Bedford, Cookhouse region of the Eastern Cape. The initial phase of the project was to consolidate historical and current roosting, breeding and tracking data. In concert with onsite carcass management and removal of carcasses from WEFs, we investigated supplementary feeding sites as a tool to encourage birds away from the wind energy facilities. Based on current Cape and White-backed vulture GPS-tracking data, we have strong evidence that supplementary feeding sites influence the daily foraging movements of vultures, attracting birds from colonies and roosts as far as 150 km away, although this needs to be analysed and modelled further. These supplementary feeding sites may therefore present an opportunity to influence behaviour, encouraging birds from areas of high risk, reducing their foraging time in high-collision risk sites, and subsequently lowering their probability of collisions in areas where wind turbines are present. We aim to use the Cape Vulture tracking data to assess the feasibility and effectiveness of using feeding sites as a mitigation measure.

Key activities conducted over project duration included:

1. Capture of 10 Cape Vultures within study site, using carcasses with noose strings, and walk in traps, and fit them with GPS/GSM tracking devices.
2. Develop a wind turbine encounter risk model and habitat-utilization models for the Eastern Cape WEF development region/node, to help wind energy stakeholders identify high-risk areas, and plan developments accordingly.
3. Consolidate all historical and current Cape Vulture colony, roosting and GPS tracking data. We will then use this data to identify potential roosting, and nesting sites; most notably based on the presence of cliffs and powerlines that birds are known to roost on.
4. Analysis of data, results and consolidation of key findings into a report for WindLab. We use our findings to investigate mitigation options, such as supplementary feeding sites, for operational wind farms and guide future wind farm development in the area.

Cape Vulture tracking and encounter risk – Eastern Cape

To help aid in the safe placement of wind energy facilities, we map the risk of this species encountering wind turbines across the Eastern Cape distributional range. We use tracking data from 42 Cape Vultures, collected over the last 10 years i.e. 2012-2022, (9 of which were trapped, and GPS tagged as part of the WindLab funded project; Fig. 1), to develop a spatially explicit habitat use model to estimate the expected utilisation distribution around each known colony within the species range. As per Cervantes *et al.*, (n.d.), utilization intensity is used as a measure of hazard, which is then scaled by the number of individuals using each colony (i.e., exposed to hazard) to calculate encounter risk. Cervantes *et al.*, (n.d.) further model the probability of a vulture flying within the sweep area of a wind turbine to complement our results. Cervantes *et al.*, (n.d.) illustrate how the maps can help planning by analysing the risk of the preferential areas for wind energy development in South Africa (Renewable Energy Development Zones; REDZs). This is a scalable procedure that can be applied at different planning phases, from strategic nation-wide planning to project-level assessments.

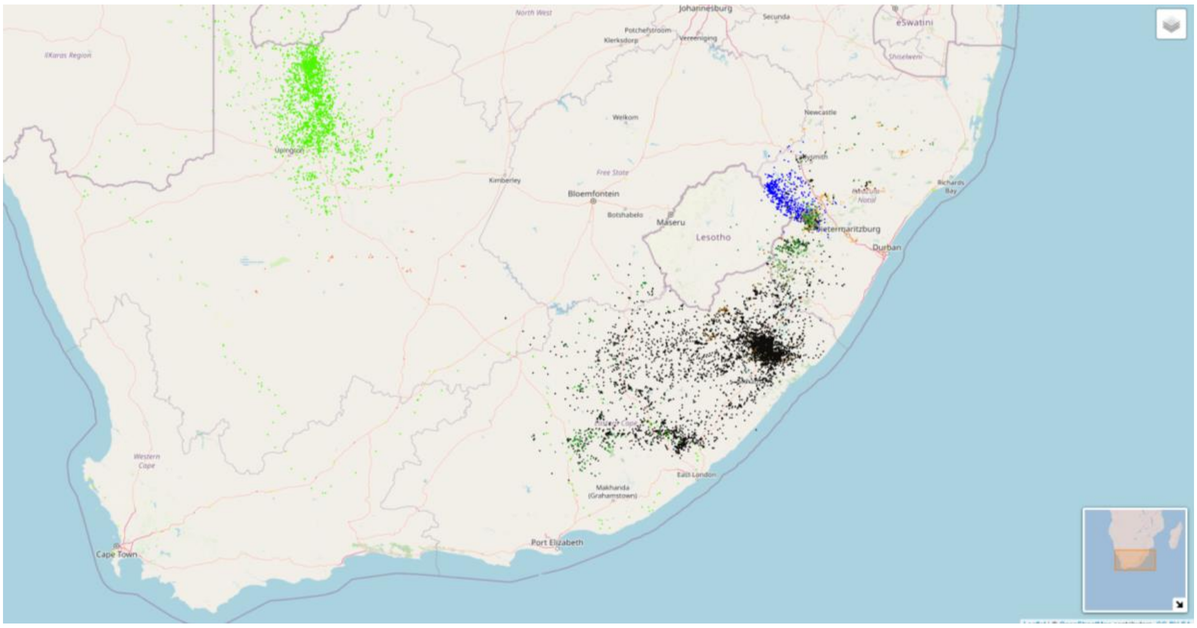

Figure 1. The coverage of the nine Cape Vultures tagged and tracked by the EWT as part of the project from 2018-2021. Note how some younger, juvenile, birds (green and pink points) left the Eastern Cape to spend extensive periods of time in the Kalahari, Northern Cape and even Namibia, demonstrating the impressive dispersal ranges displayed by the species.

Risk maps

Cervantes *et al.*'s, (n.d.) predictions suggest that the greatest hazard occurs in the Eastern Cape of South Africa, and in the south of Lesotho driven by the large concentration of colonies in these regions (Figure 2). In addition to these areas, the population-level risk map, also highlights the high risk around the large colonies in north-eastern South Africa and eastern Botswana, although not discussed further in this report.

Examining predicted encounter risk in the eleven South African REDZ, Cervantes *et al.*, (n.d.) found that only three of them overlap substantially with the Cape Vulture risk distribution (Table 1 and Figure 4). The highest number of Cape Vultures are predicted in the Stormberg Wind REDZ, where 267 individuals could be at risk at any given time, which represents 6.5 % of the Cape Vultures in the province (sum of encounter risk within the province), and 1.6 % of the global population (sum of encounter risk globally). The Cookhouse REDZ had lower risk, with 12 individuals at risk at any given time, which represents 0.3 % of the Cape Vultures in the province. This is still yet to be fully unpacked as there have been several fatalities in 2022 alone.

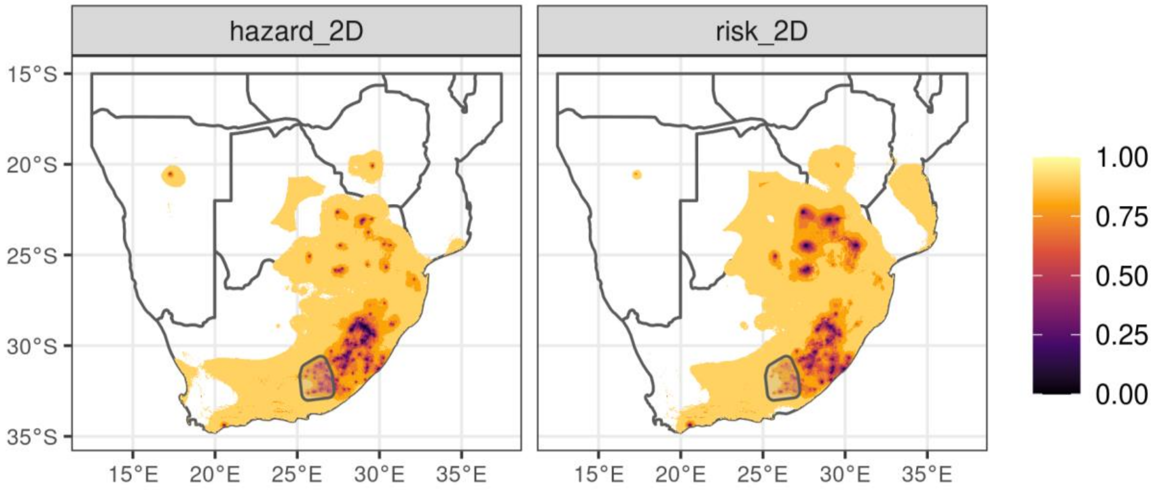

Figure 2. Two-dimensional hazard and encounter risk throughout the distribution range of the Cape Vulture. The colour gradient represents cumulative distribution levels, such that lighter colours enclose a larger proportion of the distribution than darker colours. The shaded polygon on the Eastern Cape province of South Africa encloses those colonies that were allocated a size equal to the median colony size for the country, due to lack of reliable colony size data for all colonies in this region. Within this region our risk estimates are less reliable (Cervantes, Murgatroyd, Allan, Farwig, *et al.*, n.d.).

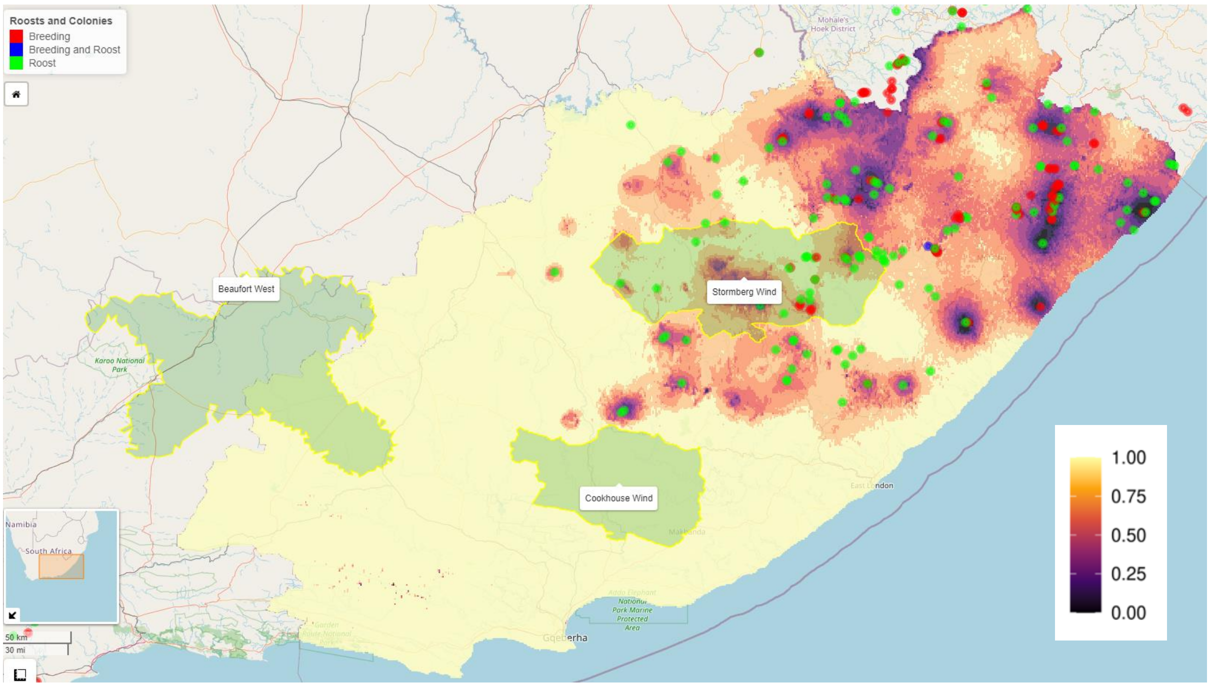

Figure 3. Two-dimensional hazard and encounter risk throughout the Eastern Cape distribution range of the Cape Vulture in relation to the Beaufort West, Stormberg and Cookhouse Wind REDZ. The colour gradient represents cumulative distribution levels, such that lighter colours enclose a larger proportion of the distribution than darker colours; Lighter colours represent areas of lower utilization distribution and encounter risk than darker colours, thus higher risk is flagged in darker areas. Cape Vulture breeding colonies (red icons) and roosts (green icons) are also indicated.

Table 1. Encounter risk analysis of the Renewable Energy Development Zones (REDZ) in the Eastern Cape. risk_total – sum of 2D risk of all pixels within each REDZ, risk_avg – mean risk across pixels, risk_sd – standard deviation of risk across pixels, % prov – percentage of total provincial risk accumulated by the REDZ i.e., percentage of the vulture population at risk in the province of which the majority of the REDZ falls into), % global - percentage of the global risk accumulated by the REDZ (i.e., percentage of the global population at risk); taken from Cervantes, Murgatroyd, Allan, Farwig, *et al.*, (n.d.).

Name	Province	risk_total	risk_avg	risk_sd	% prov	% global
Stormberg Wind	Eastern Cape	267,267	0,023	0,023	6,55	1,59
Cookhouse Wind	Eastern Cape	12,478	0,002	0,001	0,31	0,07
Beaufort West	Western/Eastern Cape	45,574	0,003	0,001	15,75	0,27

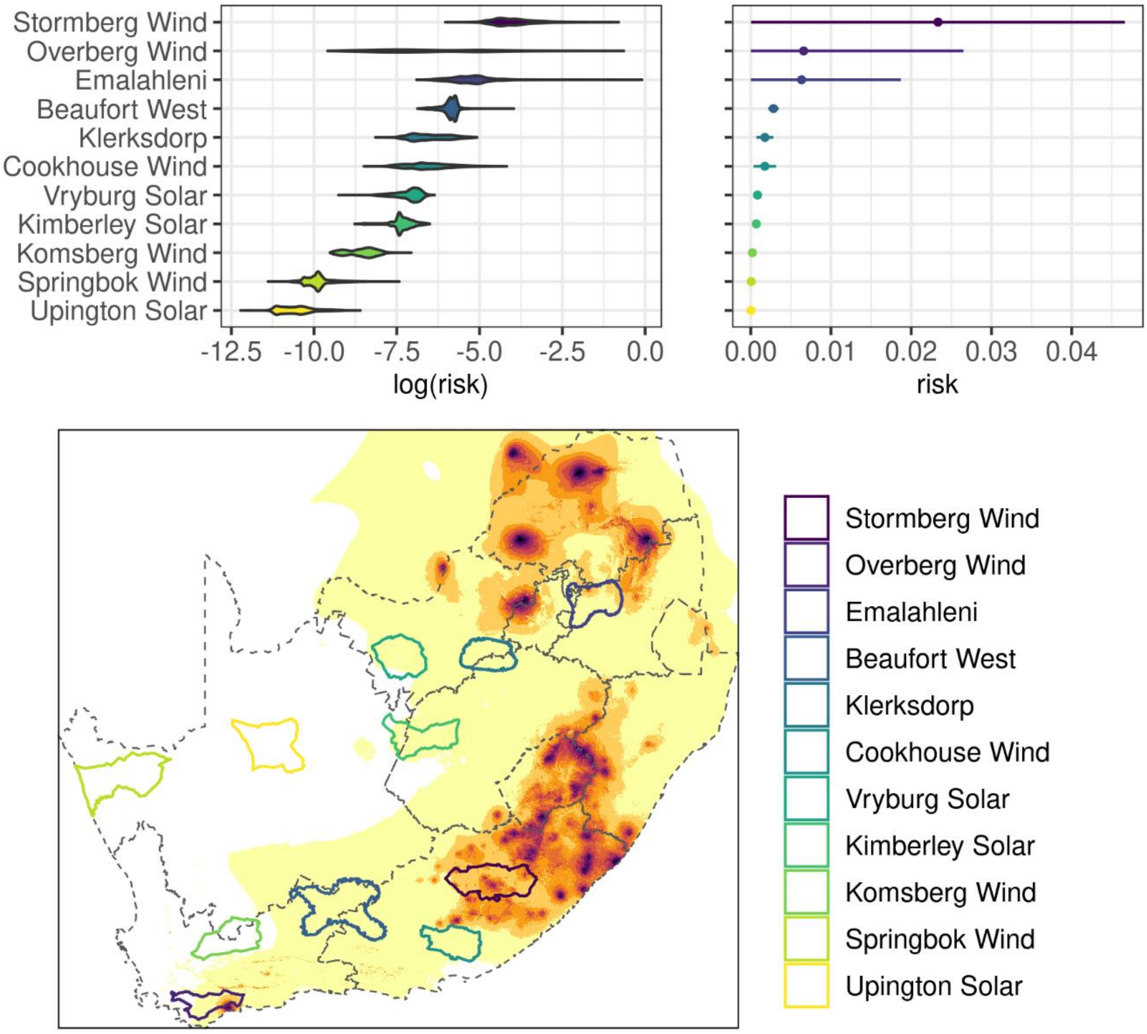

Figure 4. Cape Vulture encounter risk accumulated by South African REDZs. In the top panels, violin plots show the distribution of risk within each REDZ (left) and average risk ± standard deviation (right), to aid interpretation. Note that the minimum of the bars has been truncated at zero to emphasize that risk cannot be negative. In the lower panel, the location of REDZs overlaid with the estimated encounter risk (taken from Cervantes, Murgatroyd, Allan, Farwig, *et al.*, n.d.).

Using tracking data, as well as the location of core colonies, Cervantes *et al.*, (n.d.) estimated and mapped the expected hazard, and encounter risk relevant to wind turbines for the Cape Vulture. Cervantes *et al.*'s, (n.d.) habitat model, on which the encounter risk model was based, performed well at predicting Cape Vulture space use. It is also important to recognise that the opportunistic foraging strategy of the species may lead to unexpected encounters at low heights, even in areas predicted to generally be at relatively low risk for flights at risk height, if the right conditions occur (e.g., presence of carrion). Furthermore, because of their gregarious nature, these encounters may involve multiple individuals.

Cervantes *et al.*'s, (n.d.) model suggests that the main driver of vulture activity is the location of colonies, roosting sites and supplementary feeding sites. Similar patterns of association of Cape Vulture movements with colonies and supplementary feeding sites were described by Kane *et al.*, (2016), with the caveat that some of their data were also used in the present study. They described some variability in preference for areas close to colonies and supplementary feeding sites across individuals, which is also captured by our model. The distribution of activity, based on our simulations, incorporates variability across individuals by using a sample of random coefficients. However, other patterns discussed by Kane *et al.*, (2016) and Pfeiffer *et al.*, (2015), such as seasonal variation in home range size, are not incorporated in our maps because we focussed on the average distribution across all seasons to guide general wind energy planning, rather than aiming to create season- or condition-specific dynamic maps.

Although time of day is a dynamic variable that is averaged out in our model, it is important to note that differential step-lengths throughout the day also have an impact on the long-term distribution of activity around colonies and roosts. According to Cervantes *et al.*'s, (n.d.) model, step-length, which is indicative of displacement, tends to be longer towards midday and afternoon, and very often vultures will be found at colonies and roosts during the early and late hours of the day (see Borello & Borello, 2002). Shorter displacement during these hours results in the accumulation of activity around colonies and roosts. High-risk flights (under 300 meters) also tend to occur more frequently around breeding colonies, which is to be expected, given that vultures tend to land and embark on social interactions at these locations.

Currently, the guidelines for impact assessments for wind farms in relation to Cape Vultures (Pfeiffer and Ralston-Paton 2018), recommend South African Bird Atlas Project 2 (SABAP2) data as a screening tool, distinguishing between areas with reporting rates <14% (low-density), and areas with reporting rates >14% (high-density). Other areas close to colonies, roosts and/or supplementary feeding sites, together with topographical features that could increase collision risk, are also classified as high-density areas. Proposed wind energy projects in high-density areas require more intensive monitoring prior to approval. Cervantes *et al.*'s, (n.d.) tool offers an alternative screening tool combining all of this information balanced in a more parsimonious and tractable way, and at a finer resolution (ca. 1 km vs ca. 9 km).

Although, in general, there is a positive relationship between the estimated risk and SABAP2 reporting rates, some areas predicted to have a medium-high risk have low reporting rates. Notwithstanding the limitations of the comparison, our interpretation is that SABAP2 is more successful at detecting Cape Vultures close to known colonies and roosts than further away from these core areas (Cervantes, Murgatroyd, Allan, Farwig, *et al.*, n.d.). Thus, the agreement between estimated risk and detection rates would be better in areas close to colonies. If this were true, current assessments based on SABAP2 might be underestimating the risk for Cape Vultures in areas that are not in the immediate vicinity of colonies and roosts. However, it could also be that poor coverage of certain areas by SABAP2 decorrelate reporting rates from the underlying vulture activity. On the other hand, risk estimates are model based, and therefore subject to our assumptions that, if unrealistic, could also produce local disagreement between estimated risk and vulture activity. This highlights the importance for comprehensive monitoring of sites across seasons during pre-construction planning and assessment phases to detect seasonal roosts in the Eastern Cape, which need to be counted by monitors and developers. Recommended buffers, too, need to be applied to these as high-risk zones accordingly.

Whilst we believe that we have created a useful screening tool in the context of wind energy development for Cape Vultures, we also recognize that Cervantes *et al.*'s, (n.d.) maps have limitations. The hazard distribution generated by our models is influenced mainly by the location of core colonies, and the encounter risk also by the size of these colonies. Therefore, Cervantes *et al.*'s, (n.d.) predictions are highly sensitive to the accuracy of our colony data. Whilst we attempted to collate all known data on core colonies, the data within certain areas of the species range are less comprehensive. For example, we highlight that our predictions from the central Eastern Cape are likely to be less reliable, based on the mismatch between our colony data and field observations (Boshoff *et al.*, 2009 and G.T. pers. comms). We find two explanations for this: i) the area is heavily used by non-breeding individuals (Boshoff *et al.* 2009), which results in small breeding colonies, but seasonal, and possibly extensive, roosting in the area, and ii) these sites are more difficult to survey because they are smaller and more widespread than in other areas. We are hopeful for better data for some of these colonies in the future and strongly recommend initiatives to investigate and validate the true counts of all colonies and roosts throughout the Eastern Cape to improve the risk models for wind farms. We have recorded significant influxes of vultures in the Cookhouse Wind REDZ, particularly over summer periods and when carcasses were present in the landscape (G.T. pers. Comms), with a troubling number of vulure mortailites being recorded on operational wind farms here in 2022 alone (at least 7 fatalites reported in the Golden Valley II region) – likely as a poduct of this seasonal influx that should not be treated as stochastic behaviour in the species.

Another limitation that stems from the central role of core colony data in Cervantes *et al.*'s, (n.d.) model, is that all our records correspond to locations at cliffs. Although predominantly a cliff roosting species, Cape Vultures do occasionally also roost in trees and on power pylons in parts of their range (Bamford, Diekmann, and Monadjem 2007; Phipps *et al.* 2013). Ignoring this plasticity, may result in missing unusual roosts, potentially dispersed over large areas. Although these should represent a very small fraction of roosts, with the current model structure, risk maps could be improved by providing the centroid and the total count of areas with important concentrations of Cape Vultures that are not associated with a roosting site on a cliff face. We thus also recommend that we collaborate closely with specialists, developers and consultants to consolidate and understand all known powerline roosts that are recorded during pre- and post-WEF construction monitoring.

Finally, vulture counts at colonies focus primarily on counting adults and breeding pairs. The allocation of adult birds to the different colonies was based on recorded data, but the number of non-adults present at the colonies often had to be derived from adult counts, based on a simple ratio (3:1 adult to non-adult). In addition to the potential inaccuracy of this ratio, it is possible that the proportion of adult to non-adult birds in a colony is not a constant, but varies between colonies, for example depending on the size and location of the colony (Piper 1993). Therefore, any refinement in the data on adult to non-adult counts at core colonies, would also improve the accuracy of our estimates.

Cervantes *et al.*, (n.d.) demonstrate the application of our encounter risk maps analysing the current risk of the designated REDZs in South Africa. Cervantes *et al.*'s, (n.d.) analysis reveals that three REDZs (Stormberg Wind, Emalahleni and Overberg Wind) overlap substantially more than any others with Cape Vulture distribution, and together accumulate a potentially significant risk for both the provincial and global population. Unfortunately, what represents a *significant* risk is not well defined currently; research on population viability of the species would greatly enhance the utility of these risk assessments. For now, we conclude that the Stormberg REDZ on its own could affect as much as 1.6 % of the global population, and as much as 6.5 % of the provincial population of the species. A relatively large percentage of the provincial populations are exposed to the risk accumulated by the other two REDZs (11.7 % and 11.6 % for Overberg and Emalahleni, respectively). We note that some of the REDZs intersect with several provinces, and that we have allocated them to the province covered the most. Although ecologically it might not make sense to use administrative boundaries, we still believe that this application illustrates the intended use of our risk maps well.

The simple procedure Cervantes *et al.*, (n.d.) demonstrated for the REDZ areas, can be replicated for assessments at any scale, from local projects to strategic regional assessments. However, depending on the reference area and the map used for extracting risk/hazard values, the interpretation will differ. For example, hazard maps provide the probability that a vulture would use a locality of interest should it be found within a broad reference area. This type of metric is particularly useful for local assessments, where the global population is not the focus of the study.

We believe that the set of maps produced can be a valuable tool for planning not only wind energy developments, but also other forms of infrastructure and land use, such as the delineation of protected areas or vulture safe zones. Cervantes *et al.*, (n.d.) also hope that the work complements other quantitative analyses such as population viability assessments of the species. Lastly, we would like to underline the open-ended nature of this project and encourage further collaboration to improve these maps and build a more sustainable future for the Cape Vulture. We recommend that our approach could also be applied to other colonial vulture populations occupying areas where wind energy development is planned, for example for Rüppell's Vulture (*Gyps rueppelli*) in East Africa.

Cape Vulture roosts and colonies – Eastern Cape

Over the project duration from 2018-2021, the Endangered Wildlife Trust consolidated its long-term Cape Vulture roost and colony data and worked towards validating as many of the locations and counts of vultures present on roosts and the number of breeding pairs at key breeding colony sites across the Eastern Cape. We produced a comprehensive dataset and interactive online map of all significant roosts and colonies (Fig. 5) that will be submitted to WindLab along with this report and provide an important framework for the developers when deciding where to establish WEFs within safe proximity to these key vulture sites. The current Cape Vulture and Windfarms guidelines recommend that 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.

We identified a total of 75 breeding colonies and 129 roosting sites (Figure 5), of which 38 colonies and 5 roosts were considered core colonies. Colony size and roost size varied considerably, from colonies as small as 9 individuals to as large as 2,136 individuals (mean = 88.7, SD = 246). It is important to note our recommendation around the continuous validation and monitoring of roosts, especially those on powerlines within the Eastern Cape REDZ, as well as colonies, many of which are dynamic and changing in size – with many new colonies appearing from time to time. All of these roosts and colonies were used in the Encounter Risk Map built by Cervantes, *et al.*, (n.d.).

With the dissolving of the *Cape Vulture Task Force* into the developing *National Vulture Task Force*, many of the Cape Vulture colony counts have ended and are currently outdated. There is therefore a pressing need to re-establish provincial wide counts for key roosts and colonies to be able to closely monitor population trends and inform collision risk assessment for the species.

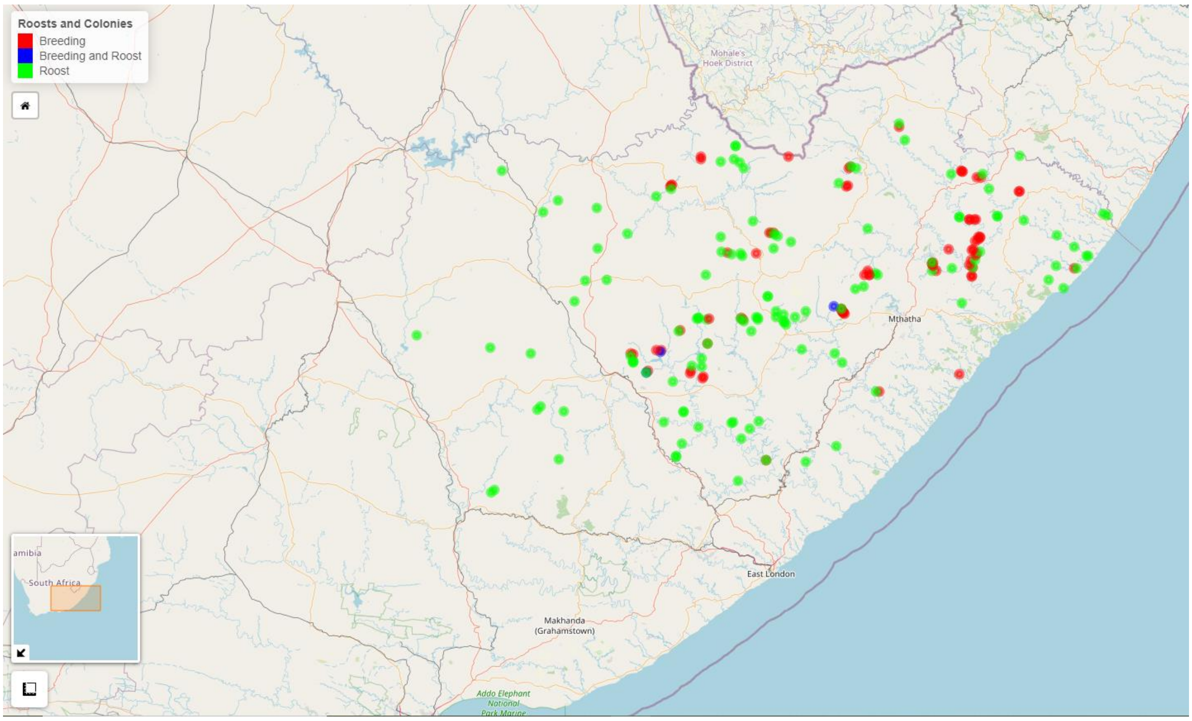

Figure 5. Cape Vulture breeding colonies (red icons) and roosts (green icons) within the Eastern Cape Province. The Eastern Cape is one of the most important breeding and foraging strongholds for the globally Endangered Cape Vulture and colonies, and regular or seasonal/occasional roosts should be considered as high to very high sensitivity areas. An interactive map will assist WindLab in making decisions around where and where not to develop WEFs.

Supplementary feeding sites: Investigation the application of feeding sites to reduce vulture foraging movements in high-risk WEF zones?

Over the duration of the project, we explored the potential of setting up supplementary feeding sites (SFSs), or vulture restaurants, at key sites in the Eastern Cape, with the aim of using them to attract birds away from high collision risk zones at wind farms within REDZ. We focused on two sites to establish SFSs within and outside of the Cookhouse Wind REDZ, however, encountered significant challenges around their sustainability and viability as a potential mitigation tool. After engaging with multiple landowners within our proposed sites in the Winterberg region and Baviaans River Conservancy, we determined that feeding sites came with a plethora of challenges, preventing their full implementation in this particular landscape:

Apart from the challenges of sourcing a reliable supply of contaminant and lead-free carcasses, local landowners were extremely hesitant to establish sites as they attract unwanted scavengers such as bush-pig and jackal, as well as present a potential vector for the spread of livestock disease. Further, many hunting operators leave carcasses and gut piles which vultures feed on extensively (and we believe rely on as a food source in some regions along with livestock carcasses), revealing that there is no limitation of food in the area. This of course raises some concerns around the uptake of lead fragments by vultures feeding on carcasses of animal shot with leaded ammunition, a heavy metal which is highly toxic to vultures and other scavengers. Symptoms of lead poisoning in vultures include liver and kidney failure, and death. Vultures have highly acidic stomachs, which dissolve more lead than the stomachs of other animals, increase the absorption of the heavy metal (Pain *et al.* 2009). In wild African vultures, elevated blood lead levels have been linked to areas and seasons that experience increases in hunting activity (Garbett *et al.* 2018). In South Africa, non-scavenging birds do not have elevated blood lead levels, while scavenging birds do. Interestingly, in South Africa, it was found that White-backed Vulture nestlings too had elevated lead levels, leading van den Heever *et al.* (2019) to conclude that nestlings are likely receiving food containing lead fragments from their parents. Based on these facts, the authors urged hunters to switch to non-lead ammunition (van den Heever *et al.* 2019). Similarly, Thompson, Blackmore, and Thompson (2020) recommended that South Africa should enact legislation banning the use of leaded ammunition for hunting and culling for the benefit of vultures and other scavengers.

Our utilization models indicate that SFSs are indeed a strong driver of vulture activity in the landscape, with increased activity in and around SFSs. Therefore, SFSs certainly do have potential to influence Cape Vulture foraging and spatial use across the landscape. Although not modelled and analysed yet, our tracking data from White-backed vultures in the Lowveld region of Mpumalanga and Limpopo Province, too, reveals that vultures appear to incorporate SFSs into their daily foraging routes, even within protected areas where natural food is available to them. Although our models indicate that SFSs have potential to encourage birds away from high-risk areas, we recognise that more comprehensive research is needed to identify ideal sites for SFS; that will effectively attract birds away from WEFs, and at the same time will not run the risk of attracting birds into a high collision risk landscape. This can certainly be the undesired result of SFSs, owing to the variable, stochastic spatial movements and landscape use typical to vultures. This is especially important in an area such as the Eastern Cape where future WEF development is on the rise. Additionally, these sites will need to be managed intensively and great care must be taken to exclude mammalian scavengers – such as Black-backed Jackals – from feeding sites. Current observations at Golden Gate Highlands National Park show that jackals can dominate a feeding site, preventing vultures from landing to feed, so they do not benefit as intended from the food provided. Further, safe food must be sourced for these sites, and carcasses cannot contain unsafe veterinary non-steroidal anti-inflammatory drugs (NSAIDs) as well as lead from lead ammunition. Until these challenges are resolved, and additional research is conducted, we do not recommend the use of SFSs as a mitigation tool at operational WEFs.

Conclusion and additional recommendations

The EWT recognises that South Africa is currently heavily dependent on energy from fossil fuel resources, notably coal, which contribute to global carbon dioxide emissions. We furthermore recognise the commitments made by South Africa, under the UNFCCC Paris Convention to reduce carbon emissions by 2050. We therefore support an urgent shift to a more diverse energy mix in South Africa, provided that this leads to a decrease in the consumption of fossil fuels, a reduction in the extraction of non-renewable resources, and does not result in new or additional forms of ecologically unsustainable environmental degradation and risk.

The demand for energy is increasing globally and Wind Energy Facilities are considered a viable option for renewable energy production. There are, however, concerns over the impacts of wind farms on wildlife in three key aspects: the disturbance or displacement of species from their habitats due to the construction of the associated WEF infrastructure; bird and bat collisions with turbine blades; and collisions and electrocutions on energy infrastructure associated with WEFs.

This concern is compounded by the potential cumulative impacts of ongoing wind energy developments posing a direct risk to collision-prone species across sensitive areas, and an amplified level of disturbance and loss of habitat for wildlife in areas that overlap with WEFs. This risk is particularly pertinent and concerning for threatened birds such as vultures, eagles, cranes, and bustards, which are long-lived and reproduce slowly, where small increases in mortality rates, such as fatalities associated with WEFs, can impact heavily on the survival and persistence of local populations.

The EWT acknowledges the growing urgency required to address the potential negative cumulative impact of high-risk WEFs, particularly on collision-prone and/or highly localised species. In addition, very little is known about the impact of these developments on terrestrial species, and we encourage urgent research to quantify potential WEF impacts. With escalating energy demands across South Africa, and a rising desire for cleaner energy, we acknowledge the need to work with renewable energy developers to ensure the construction of environmentally friendly WEFs; to enhance conservation in and around WEFs; and to develop effective measures to significantly reduce and prevent fatalities and disturbance on both operational and planned WEFs. This requires a high level of engagement between research institutions, conservation organisations, species specialists and wind energy developers. Continuous monitoring and applied research to understand the dynamics and impacts of this rapidly advancing energy sector on wildlife to develop innovative solutions to reduce and rapidly adapt to these impacts is also vital. An effective feedback loop based on sound scientific data will ensure that there are continued improvements to the technology, the application and positioning thereof, to continually improve the sustainability factor of the industry and technology as a source of true renewable energy for South Africa.

The EWT believes that some of the impacts of WEFs can be avoided and reduced using suitable remedial actions and mitigation measures. Accordingly, we recommend that the following measures must be considered and implemented to ensure minimum impact of wind energy on wildlife:

1. **Avoid WEF development in high collision risk and highly sensitive areas**
    - We recommend, from the outset, that WEFs are not constructed in areas of high risk for collision-prone raptor species such as the Cape Vulture, Verreaux's Eagle, Martial Eagle, Secretarybird, and Black Harrier, as well as large bird species including the Ludwig's Bustard, Lesser Flamingo, Great White Pelican, and the three indigenous crane species. These No-Go sites should include high "bird traffic" areas in core breeding, foraging, and migration habitat such as wetlands, mountain ridges, nesting, and roost sites. The same applies to any threatened terrestrial species that are confined to specific habitats, such as Riverine Rabbits and Karoo Dwarf Tortoises.
    - We recommend that the Cape Vulture Encounter Risk Model is applied to proposed WEF development areas to restrict development in high-risk sites, with the focus on areas utilised less frequently by vultures.
    - The national Environmental Screening Tool (EST) must be used to generate site-specific reports and will inform known and predicted threatened species presence. All highly sensitive areas identified using this online tool should be considered as No-Go areas for development. Further prospective WEF development assessments must follow the Terrestrial Animal Species Protocol and the Species Environmental Assessment Guideline (as gazetted on 30 October 2020).

2. **Operational mitigation for collisions and other considerations**

The EWT supports the use of all possible and relevant operational tools and technology to minimise potential impacts at operational facilities.

- **Black blade painting:** There is growing evidence that demonstrates the effectiveness of painting wind turbine blades black, improving their visibility and significantly reducing large bird collisions with turbines on operational wind farms. In concert with the turbine collision risk mapping, we aim to work with developers to use this mitigation tool on new WEF developments. The idea of a single black blade paired with two white blades is based on ex situ experiments by Hodos (2003). The hypothesis is that this decreases collision risk by increasing the visibility of the rotating blades and reducing "motion smear". Contrasting coloured blades (e.g. some black, some white) may also be more visible against different backgrounds (e.g. black will be more visible in overcast conditions, while white may be more visible against dark terrain). Marking blades may be an important means to reduce collision rates by making them as conspicuous as possible under poor visual conditions, particularly at facilities where raptors are known to be collision casualties. While Civil Aviation Authority (CAA) regulations stipulate white towers and turbine blades this could be avoided by using UV paint that is visible to birds but not to pilots. Norwegian CAA have already accepted black-painted blades. Marking turbine blades in this way, has been tested recently in a clever experiment in Norway where turbines were killing large numbers of White-tailed Eagles *Haliaetus albicilla* and other ground-dwelling species. Here, White-tailed Eagle fatalities fell by 100% to no eagles killed, relative to unpainted controls over two years. So successful has this experiment been that in a further six years no more eagle mortalities have been recorded, despite white blades still killing, on average, six eagles per year. Since this approach has yielded promising results, we recommend the same method, or as close as possible, be tested in South Africa – i.e. just one blade is painted. (Hodos 2003; May *et al.* 2020).
- **Carcass management:** Carcasses have been known to attract vultures on to operational WEFs, and in several cases have led to collisions and fatalities on sites in the Eastern Cape. Onsite carcass management and removal can be an effective way to ensure no vultures are drawn into high collision risk areas. We strongly recommend that all operational WEFs that overlap with vulture distributions, implement rigorous carcass search, management, and removal; either burying, burning, or completely removing any available carcasses on WEFs.
- **Shut down on demand.** Wind Farms across Africa are applying shut-down on demand as an effective means to reduce fatalities of collision prone species flying through WEFs. In its simplest form, observer-led shut down on demand systems are used for priority species. The system is implemented through notification by a team of bird

monitors to the wind farm's on-site operations room, where individual wind turbines are switched off when the priority species are in the vicinity and switched on again once the bird has passed by. BioTherm Energy's Excelsior WEF, in the Western Cape, is currently implementing observer-led shut down on demand with over 60 shut downs successfully called for. More sophisticated radar technology is also available and is being tested in France to trigger shut down of turbines when large birds approach WEFs. The French company Diadès Marine develops the 3DFlight Track™ Radar (DIADÈS MARINE, 2019) which has a 360° azimuthal detection and a 20° elevation detection. It can trigger some species of birds 10 km away. What makes it interesting in relation to bird monitoring is that it provides the 3D location (latitude, longitude, and altitude) but also the speed and direction of objects. With no cameras it cannot identify the bird species, but it will range the triggered objects by size and speed. This radar can be used during the pre-monitoring phase in order to get a thorough information about flight activity (coupled with direct observation we can link the information given by the radar and the species ID). During the operating phase, it can add the shut-down-on-demand with the radar when a dangerous situation is incoming, hence reduce the collision risk. Shut down on demand can be vital to reduce vulture mortalities, especially on WEFs that don't see frequent vulture activity. Seven Cape vultures were recently killed on a WEF in Golden Valley, Eastern Cape in early 2022, a region that doesn't experience all year vulture activity. These fatalities could have easily been avoided using shut down on demand.

EWT Vulture Safe Zones; reducing the threats across the Eastern Cape

The Eastern Cape is one of the most important breeding and foraging strongholds for the globally Endangered Cape Vulture. In light of the rise in Cape Vulture mortalities at WEFs, and the increasing demand for renewable energy in South Africa, wind energy developers and conservationists recognise a growing need for a collaborative approach to Cape Vulture conservation. Subsequently, in partnership with Cennergi Amakhala Emoyeni RE Project 1 and BioTherm Energy, the Endangered Wildlife Trust (EWT) aims to establish the first Vulture Safe Zone for the Eastern Cape region. The long-term goal of this Eastern Cape Vulture Safe Zone (EC VSZ) is to stabilise and recover Cape Vulture populations by creating a network of WEFs, in collaboration with over 300 properties (farmers, game breeders, and private reserves), that are developed and managed in a vulture-safe manner. The project was launched in July 2021 and has an initial scope of two years: during the first phase in year one, through landowner engagements and site assessments, the EWT project team will determine the current presence and extent of key threats to vultures, in cooperation with WEFs, farmers, and landowners in the area. Working actively with committed WEFs and landowners, these threats will be mitigated and where possible, removed from the landscape, in the second phase of the project in year two. Importantly, this approach encourages positive action for wildlife, focusing less on prohibition and negative messaging, and more on sound environmental practices that provide landowners with reputational and economic benefits. Over the reporting period, the EWT appointed a designated EC VSZ project coordinator to drive the establishment of the EC VSZ. Our EC VSZ Project coordinator will coordinate the revival of annual counts at key Cape Vulture colonies within the Eastern Cape, in particular, those closest to the Cookhouse REDZ, which are most likely to be impacted by wind developments is this region. These will be run in partnership with local farmers and the provincial conservation authority, the Eastern Cape Department of Economic Development, Environmental Affairs and Tourism (DEDEA). This information will be critical to measure local impact and trends of this population of Cape Vultures and importantly will also feed into the cumulative impact assessment. The project coordinator is currently undertaking strategic activities for the conservation of Cape Vultures to reduce fatalities on wind farms and support a viable population of Cape Vultures within the renewable development nodes and the surrounding landscape. Ultimately, our work will help develop sustainable land practices that benefit both the people and wildlife of the EC VSZ. The EWT is driven to establish more support from developers for the project to establish a larger conservation footprint across the Eastern Cape across all WEFs development.

Special considerations

We request that WindLab do not share this report to any outside parties until the paper has been accepted for publication. The EWT will alert WindLab once this has occurred.

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