ARCUS

BAT IMPACT ASSESSMENT FOR THE PROPOSED WIND GARDEN WIND FARM, EASTERN CAPE PROVINCE

On behalf of

Savannah Environmental (Pty) Ltd

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Prepared By:

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Regulation GNR 326 of 4 December 2014, as amended 7 April 2017, Appendix 6	Section of Report
(a) details of the specialist who prepared the report; and the expertise of that specialist to compile a specialist report including a *curriculum vitae*;	Appendix 1, Appendix 2
(b) a declaration that the specialist is independent in a form as may be specified by the competent authority;	Appendix 2
(c) an indication of the scope of, and the purpose for which, the report was prepared;	Section 2
(cA) an indication of the quality and age of base data used for the specialist report;	Section 3
(cB) a description of existing impacts on the site, cumulative impacts of the proposed development and levels of acceptable change;	Section 4.1, Section 5.3.3
(d) the duration, date and season of the site investigation and the relevance of the season to the outcome of the assessment;	Section 3
(e) a description of the methodology adopted in preparing the report or carrying out the specialised process inclusive of equipment and modelling used;	Section 3
(f) details of an assessment of the specific identified sensitivity of the site related to the proposed activity or activities and its associated structures and infrastructure, inclusive of a site plan identifying site alternatives;	Section 5
(g) an identification of any areas to be avoided, including buffers;	Section 4.4, Figure 2
(h) a map superimposing the activity including the associated structures and infrastructure on the environmental sensitivities of the site including areas to be avoided, including buffers;	Figure 2
(i) a description of any assumptions made and any uncertainties or gaps in knowledge;	Section 2.2
(j) a description of the findings and potential implications of such findings on the impact of the proposed activity, including identified alternatives on the environment, or activities;	Section 4
(k) any mitigation measures for inclusion in the EMPr;	Section 5
(l) any conditions for inclusion in the environmental authorisation;	Section 5
(m) any monitoring requirements for inclusion in the EMPr or environmental authorisation;	Section 5
(n) a reasoned opinion— i. as to whether the proposed activity, activities or portions thereof should be authorised; iA. Regarding the acceptability of the proposed activity or activities; and ii. if the opinion is that the proposed activity, activities or portions thereof should be authorised, any avoidance, management and mitigation measures that should be included in the EMPr or Environmental Authorization, and where applicable, the closure plan;	Section 6
(o) a summary and copies of any comments received during any consultation process and where applicable all responses thereto; and	None received as yet
(p) any other information requested by the competent authority	None received
Where a government notice gazetted by the Minister provides for any protocol or minimum information requirement to be applied to a specialist report, the requirements as indicated in such notice will apply.	Appendix 3

EXECUTIVE SUMMARY

Arcus Consultancy Services South Africa (Pty) Ltd (Arcus) was appointed to conduct the required 12-months of pre-construction bat monitoring and impact assessment for the proposed Wind Garden Wind Energy Facility (WEF), the results of which fed into the Impact Assessment Report for the Wind Garden WEF (this report).

Monitoring was conducted in accordance with the South African Good Practice Guidelines for Assessing Bats (2020) at WEFs, assessing bat activity across the area using static mast acoustic monitoring, field surveys, drive transects, roost searches and GIS modelling. The results were analysed and compiled into a baseline report of bat activity and used to assess potential impacts of the development on bats.

Of the twenty-one species that can potentially occur on site at least eleven species were recorded. Nine of these species exhibit behaviour that could bring them into contact with turbines, with five being high risk and at least two being medium – high risk. The impact assessment revealed that the overall risk to bats posed by wind energy development at the site is predominantly low to medium assuming that all mitigations outlined in the impact assessment and sensitivities mapped are adhered to. The current layout is in accordance with these stipulations.

Residual impacts from bat collisions with turbines may still occur and mitigations outlined in the curtailment plan must be implemented should bat fatalities reach unacceptable levels. Cumulative impacts are predicted to be high before mitigation and medium after mitigation. As such, the development of the Wind Garden WEF will not result in unacceptable impacts to bats and can be authorised provided these conditions are met.

1 INTRODUCTION

This report presents an assessment of predicted impacts to bats that may result from the proposed Wind Garden Wind Farm to assist the competent authority to make an informed decision regarding the development. The area of interest for Wind Garden Wind Farm (referred to as WEF (wind energy facility in the Report), proposed by Wind Garden (Pty) Ltd), is approximately 4, 336 hectares in extent. The WEF will consist of up to 47 turbines with a generation capacity of up to 264 MW.

As part of the environmental assessment for the project, Arcus were appointed to undertake pre-construction bat monitoring across a broad area earmarked for development (Figure 1). The approach adopted for this BA was to use site-specific data collected within the boundaries of the Wind Garden WEF (Figure 2) during this monitoring to assess impacts to bats. However, because bats are volant animals and move widely across landscapes, the site-specific data were placed within the context of data collected regionally during the pre-construction monitoring for comparison and reference against which to assess impacts more accurately.

Since the project is located within a REDZ, a Basic Assessment environmental authorisation (BA) process was followed. Savannah Environmental (Pty) Ltd (Savannah) appointed Arcus to undertake this impact assessment to feed into the BA process for bats.

This bat impact assessment report is based on bat activity monitoring undertaken between 13 March 2019 and 16 June 2020, and provides an indication of the current potential risk and impact of the project to bats.

2 SCOPE OF STUDY

2.1 Terms of Reference

The National Gazette, No. 43110 of 20 March, 2020: "National Environmental Management Act (107/1998) Procedures for the Assessment and Minimum Criteria for Reporting on Identified Environmental Themes in terms of sections 24 (5) (a) and (h) and 44 of the Act, when applying for Environmental Authorisation", where a specialist assessment is required and no specific environmental theme protocol has been prescribed, the impact assessment must be undertaken in line with Appendix 6 of the EIA Regulations 2014, as amended. This study was undertaken in accordance with these regulations.

The aim of this report is to present the baseline environment with respect to bats that may be influenced by the development of the WEF and associated infrastructure, including the 132 kV grid connection. Based on this baseline, a description and evaluation of the potential impacts the project may pose to bats is provided. The following terms of reference were utilised for the preparation of this report:

- Describe the baseline environment of the project and its sensitivity with regard to bats based on the outcomes of the pre-construction monitoring;
- Identify the nature of potential impacts (positive and negative, including cumulative impacts) of the proposed project on bats during construction, operation and decommissioning;
- Conduct a significance rating and impact assessment of identified impacts;
- Conduct an assessment of any alternatives where relevant;
- Identify information gaps and limitations; and
- Identify potential mitigation or enhancement measures to minimise impacts to bats.

This specialist report complies with Appendix 6 of the EIA Regulations 2014, as amended.

2.2 Assumptions and Limitations

The following assumptions and limitations relevant to this study are noted:

- The knowledge of certain aspects of South African bats including natural history, population sizes, local and regional distribution patterns, spatial and temporal movement patterns (including migration and flying heights) and how bats may be impacted by wind energy is very limited for many species.
- Bat echolocation calls (i.e. ultrasound) operate over ranges of metres therefore acoustic monitoring samples only a small amount of space (Adams et al. 2012). Recording a bat using sound is influenced by the type and intensity of the echolocation call produced, the species of bat, the bat detector system used, the orientation of the signal relative to the microphone and environmental conditions such as humidity. One must therefore be cautious when extrapolating data from echolocation surveys over large areas because only small areas are actually sampled.
- There can be considerable variation in bat calls between different species and within species. The accuracy of the species identification is also very dependent on the quality of the calls used for identification. Species call parameters can often overlap, making species identification difficult.
- Automatic bat classifiers in Kaleidoscope Pro Version 5.1.9g (Wildlife Acoustics, Inc) were used to identify bat species. Post-processing was used to manually verify the performance of the classifiers but owing to the large number of files recorded, not all recordings could be verified manually. There may be instances where the software was unable to identify species or made incorrect identifications.
- Bat activity recorded by bat detectors cannot be used to directly estimate abundance or population sizes because detectors cannot distinguish between a single bat flying past a detector multiple times or between multiple bats of the same species passing a detector once each (Kunz et al. 2007a). This is interpreted using the specialists' knowledge and presented as relative abundance.
- There is currently no standard scale to rate bat activity as low, medium or high. Activity was therefore classed based on Arcus' experience of bat activity at projects (including operational facilities) in South Africa.
- The potential impacts of wind energy on bats presented in this report represent the current knowledge in this field. New evidence from research and consultancy projects may become available in future, meaning that impacts and mitigation options presented and discussed in this report may be adjusted if the project is developed.
- While the data presented in this report provides a baseline of bat activity for the period sampled, it does not allow for an understanding of interannual variation in bat activity. It is therefore possible that during the lifespan of the facility, bat activity could be significantly different (lower or higher) compared to the baseline presented here.

2.3 Legislative Context

The following legalisation, policies, regulations and guidelines are all relevant to this report and the potential impact it may have on bats and habitats that support bats:

- Convention on the Conservation of Migratory Species of Wild Animals (1979)
- Convention on Biological Diversity (1993)
- Constitution of the Republic of South Africa, 1996 (Act No. 108 of 1996)
- National Environmental Management Act, 1998 (NEMA, Act No. 107 of 1998)
- National Environmental Management: Protected Areas, 2003 (Act No. 57 of 2003)
- National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004)
- Environmental Impact Assessment Regulations, 2014, as amended
- Ciskei Nature Conservation Act (1987)
- The Equator Principles (2013)
- The Red List of Mammals of South Africa, Swaziland and Lesotho (2016)

- National Biodiversity Strategy and Action Plan (2005)
- South African Good Practise Guidelines for Surveying Bats in Wind Energy Facility Developments – Pre-Construction (2017)
- South African Good Practise Guidelines for Operational Monitoring for Bats at Wind Energy Facilities (2020)
- South African Bat Fatality Threshold Guidelines for Operational Wind Energy Facilities (2018)

3 METHODOLOGY

The methodology adopted for, and findings of, the pre-construction monitoring is presented in Appendix B, the details of which are not repeated here. The full pre-construction monitoring had 25 monitoring locations that spanned almost 300,000 hectares. This area and monitoring locations were then split into an eastern cluster and a western cluster. This BA report extracts relevant information from this monitoring report to describe the baseline specific to the Wind Garden development. This includes data collected from the eastern cluster monitoring locations of the Choje study area, namely C8-C14, C24 and C25 (Figure 2).

The potential impacts were assessed based on the methodology provided by Savannah Environmental. A significance rating and impact assessment was done for each impact and mitigation measures provided where appropriate. For each impact, the significance was determined by identifying the extent, duration, magnitude, probability of occurrence, and reversibility of the impact (as well as the irreplaceability of resource loss) in the absence of any mitigation ('without mitigation'). Mitigation measures were identified and the significance was re-rated, assuming the effective implementation of the mitigation ('with mitigation').

Cumulative impacts were assessed as the incremental impact of the proposed activity on the baseline, when added to the impacts of other past, present or reasonably foreseeable future activities within a 50 km radius. 50 km is used because of the migratory behaviour of the Natal long-fingered bat found on site. This species can travel up to hundreds of kilometres and more than 50 km a day.

4 BASELINE ENVIRONMENT

4.1 Habitats

The study area is broadly separated into two ecoregions; Albany Thicket, and Fynbos Shrubland. Within this, vegetation diversity is high with at least 17 different vegetation types present in the study area (Figure 2). In the east, Grahamstown Grassland Thicket and Saltaire Karroid Thicket comprise most of the study area. A gradient of increasing mean annual precipitation runs from the western study area towards the east (where Wind Garden is located).

For foraging bats, one of the most important ecological constraints is clutter; objects (e.g. vegetation) that have to be detected and avoided by bats during flight (Schnitzler and Kalko 2001). Clutter presents perceptual and mechanical problems for bats. Perceptually, bats are constrained by their sensory capabilities to find prey amongst clutter (e.g. having an echolocation system adapted to find prey in dense vegetation versus in the open). Mechanically, bats are constrained by their flight ability (e.g. adaptations in wing morphology that enable flight in dense vegetation versus in the open). Habitats can therefore be defined according to clutter conditions. These include uncluttered space (open spaces, high above the ground and far from vegetation), background cluttered space (near the edges of vegetation, in vegetation gaps, and near the ground or water surfaces), and highly cluttered space (very close to surfaces such as leaves or the ground). Habitat complexity is therefore an important consideration for bats because areas that offer a variety of clutter conditions are more likely to support a greater diversity of bat species.

There is a range of suitable habitat for bats that can be used for roosting, foraging and commuting in the study area. This includes thicket and woodland habitats which provide a variety of clutter conditions and are known to be important for bats, particularly woodland (Cooper-Bohannon et al. 2016; Gelderblom et al. 1995). Land use in the study area is primarily agricultural including grazing, stock farming and game farming and bats are known to be attracted to areas with livestock for foraging (Downs and Sanderson 2010). Cultivated areas are found along the two river systems that bisect the study area namely the Little and Great Fish Rivers. Cultivated areas are important foraging areas as some species forage over monoculture agricultural fields and prey on insect pests (Noer et al. 2012; Taylor et al. 2011). Farmsteads in the study areas contain lighting which at night will attract insects and in turn bats to hunt for prey.

Water sources are important for bats as a direct resource for drinking and because these areas tend to attract insects and promote the growth of vegetation (e.g. riparian vegetation). Therefore, besides providing drinking water, bats can also be attracted to water sources as potential foraging and roosting sites (Greif and Siemers 2010; Sirami et al. 2013). There are numerous artificial and natural wetlands, reservoirs and farms dams in the study area that will be attractive to bats. Rivers, canals and drainage lines will be equally important for foraging and commuting. Bats are known to use linear landscape features such as these, in addition to tree lines, for commuting routes to get to and from foraging sites, roost sites, to access water sources and because they provide protection to bats from predators, shelter from wind, and orientation cues (Verboom 1998).

The suitability of habitat for bats is also dictated by the roosting potential. Habitats with roosting spaces are likely to be more favoured compared to areas where roosts are limited. The availability of roosting spaces is a critical factor for bats (Kunz and Lumsden 2003) and a major determinant of whether bats will be present in a landscape, and the diversity of species that can be expected. A major bat roost[1] is located within the eastern study area approximately 5 km south-east of the Wind Garden boundary. Rocky crevices are also used as roosts by some species and these features can be found in the mountainous parts of the study area. Man-made infrastructure in the study area may be used by bats as well [e.g. Cape serotine and Egyptian free-tailed bat, Monadjem et al. 2010)]. A number of free-tailed bats and plain-faced bats may roost in trees in woodland habitats, including in dead trees (Barclay 1985; Fenton et al. 1986; Monadjem et al. 2010). Evidence suggests that trees with larger trunks are preferentially selected by bats (Monadjem et al. 2010b) and therefore the existence of older, larger trees will increase the sensitivity of the site to wind energy development.

Five protected areas occur in the region; Ezulu Game Reserve, Kwandwe Private Game Reserve, Aylesbury Nature Reserve, Frontier Safaris Game Farm, and Rockdale Game Ranch. It is assumed that the habitat on these properties is of higher value to bats compared to the surrounding landscape because of the conservation efforts.

4.2 Bat Species

The Wind Garden WEF falls within the actual or predicted distribution range of approximately 21 species of bat (Table 1). However, the distributions of some bat species in South Africa, particularly rarer species, are poorly known so it is possible that more (or fewer) species may be present. Several echolocation calls characteristic of species in the Plain-faced bat family were recorded but these calls were unable to be separated into

[1] As defined by the South African Bat Assessment Association (Medium roost of 50-499 bats of low fatality and medium-high fatality risk)

distinct species. Since most of the species that these calls could belong to have a conservation status of Least Concern, and a risk rating from wind energy of Medium-High, these calls were grouped together and referred to as Unidentified plain-faced bat (Table 1). However, some calls could potentially be from *Myotis tricolor,* but its presence has not been confirmed.

The sensitivity of bat species to the proposed wind farm is a function of their conservation status and the likelihood of risk to these species from wind farm development. The likelihood of risk to impacts from wind farms is based on the foraging and flight ecology of bats and migratory behaviour (Sowler et al. 2017). Seven high risk and five medium-high risk species have distributions that overlap with the Wind Garden WEF and of these, fatalities at operational wind farms in South Africa are known for at least six, namely Cape serotine, Egyptian free-tailed bat, Natal long-fingered bat, Egyptian rousette, Egyptian slit-faced bat and Wahlberg's epauletted fruit bat (Doty and Martin 2012; MacEwan 2016) .

Table 1: Bat Species Occurrence within the Wind Garden WEF

Species	Code	# of Passes	Conservation Status			Risk from Wind Energy
			National	Global	Population Trend	
Egyptian free-tailed bat *Tadarida aegyptiaca*	EFB	174,090	Least Concern	Least Concern	Unknown	**High**
Little free-tailed bat *Chaerephon pumilus*	LFB	17,016	Least Concern	Least Concern	Unknown	**High**
Natal long-fingered bat *Miniopterus natalensis*	NLB	48,811	Least Concern	Least Concern	Unknown	**High**
Lessor long-fingered bat *Miniopterus fraterculus*	LLB	-	Least Concern	Least Concern	Unknown	**High**
Mauritian tomb bat *Taphozous mauritianus*	MTB	-	Least Concern	Least Concern	Unknown	**High**
Cape serotine *Neoromicia capensis*	CS	81,574	Least Concern	Least Concern	Stable	**High**
Roberts's flat-headed bat *Sauromys petrophilus*	RFB	3,810	Least Concern	Least Concern	Stable	**High**
Wahlberg's epauletted fruit bat *Epomophorus wahlbergi*	WFB	-	Least Concern	Least Concern	Stable	**Medium-High**
Egyptian rousette *Rousetus aegyptiacus*	ER	-	Least Concern	Least Concern	Stable	**Medium-High**
Yellow-bellied house bat *Scotophilus dinganii*	YHB	7	Least Concern	Least Concern	Unknown	**Medium-High**
Temminck's myotis *Myotis tricolor*	TM	-	Least Concern	Least Concern	Unknown	**Medium-High**
Unidentified plain-faced bat* *Vespertilionidae species*	VSP	2,739	-	-	-	**Medium-High**
Dusky pipistrelle *Pipistrellus hesperidus*	DP	16,199	Least Concern	Least Concern	Unknown	**Medium**
Long-tailed serotine *Eptesicus hottentotus*	LTS	2,551	Least Concern	Least Concern	Unknown	**Medium**
Cape horseshoe bat** *Rhinolophus capensis*	CHB	2,142	Least Concern	Least Concern	Stable	**Low**
Geoffroy's horseshoe bat *Rhinolophus clivosus*	GHB	49	Least Concern	Least Concern	Unknown	**Low**
Bushveld horseshoe bat *Rhinolophus simulator*	BHB	-	Least Concern	Least Concern	Decreasing	**Low**
Swinny's horseshoe bat *Rhinolophus swinnyi*	SHB	-	Vulnerable	Least Concern	Unknown	**Low**
Lesueur's wing-gland bat** *Cistugo lesueuri*	LWB	-	Least Concern	Least Concern	Decreasing	**Low**
Egyptian slit-faced bat *Nycteris thebaica*	ESB	-	Least Concern	Least Concern	Unknown	**Low**
Lesser woolly bat *Kerivoula lanosa*	LWB	-	Least Concern	Least Concern	Unknown	**Low**

*Not able to be assigned to a specific species therefore identified to Family level only.
** Endemic to South Africa.

4.3 Spatio-Temporal Bat Activity Patterns

4.3.1 Overall Patterns

Eleven bat species (including the unidentified plaine-faced bat species group) were detected and a total of 348,988 bat passes were recorded from 459 sample nights across all detectors.

There was a clear difference in bat activity with height above the ground; the vast majority of bat activity was recorded by microphones at 12 m (86 % of total activity) compared to at height; 50 m (6 % of total activity) and 80 m (7 % of total activity). Species diversity was also higher at 12 m (eleven species) compared to at height (eight species). At 12 m, there was a mean of 70.4 bat passes recorded per detector per night in the eastern cluster and 36.0 bat passes per detector per night in the western cluster. At height (i.e. at 50 m and 80 m), mean activity was 6.8 bat passes per night in the eastern cluster. The ground level detectors recorded bats on most sample nights whereas at height bats were recorded on fewer sample nights (Table 2).

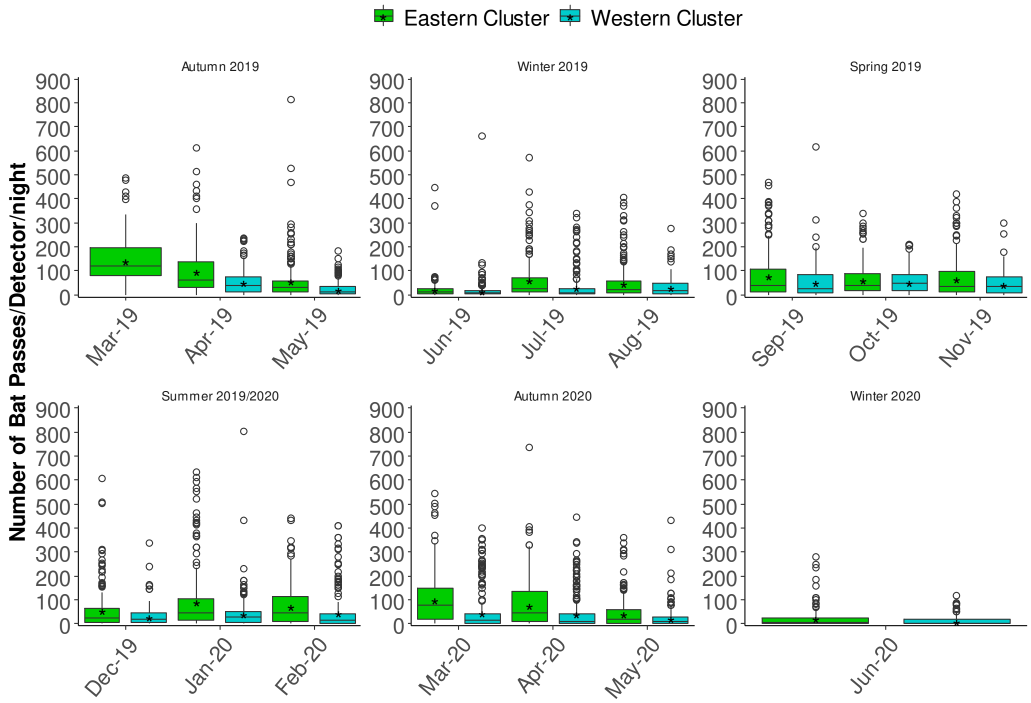
Table 2: Acoustic Monitoring Summary

Detector	Altitude* (masl)	Vegetation	# of Sample Nights	% of Sample Nights with Bat Activity	Mean Passes /night	Total Bat Passes
C1	819	Bedford Dry Grassland	270	92.9	25.7	6,951
C2	905	Bedford Dry Grassland	281	91.4	9.9	2,770
C3	759	Doubledrift Karroid Thicket	423	95.0	42.4	17,957
C4	718	Fish Valley Thicket	433	99.8	109.5	47,398
C5	523	Albany Valley Thicket	365	95.6	32.0	11,679
C6	677	Saltaire Karroid Thicket	430	72.8	20.8	8,937
C7	542	Albany Broken Veld	423	76.8	11.7	4,965
C8	417	Suurberg Quartzite Fynbos	429	97.4	60.0	25,757
C9	517	Saltaire Karroid Thicket	446	97.1	61.7	27,535
C10	593	Grahamstown Grassland Thicket	433	87.5	75.9	32,861
C11	558	Saltaire Karroid Thicket	459	96.1	37.4	17,183
C12	659	Albany Valley Thicket	269	87.7	69.4	18,679
C13	598	Saltaire Karroid Thicket	422	91.9	21.4	9,056
C14	551	Saltaire Karroid Thicket	415	96.9	167.2	69,385
C15_50m	1,063	Bedford Dry Grassland	174	45.5	3.1	543
C15_80m			174	7.5	0.3	49
C16_50m	831	Great Fish Thicket	170	45.1	3.1	531
C16_80m			170	33.5	1.6	275
C17_50m	1,013	Eastern Cape Escarpment Thicket	254	59.8	3.1	788
C17_80m			69	36.2	1.8	123
C18_50m	921	Great Fish Thicket	188	47.3	2.0	381
C18_80m			188	37.8	1.3	246
C19_50m	806	Great Fish Thicket	199	65.8	7.9	1,570
C19_80m			199	59.8	9.8	1,940
C20_50m	714	Great Fish Thicket	261	72.0	18.6	4,842
C20_80m			261	55.2	6.5	1,689
C21_50m	720	Great Fish Thicket	357	82.9	19.0	6,788
C21_80m			357	72.8	21.1	7,508
C22_50m	666	Great Fish Thicket	271	88.2	14.6	3,959
C22_80m			271	74.9	19.3	5,227
C23_50m	731	Kowie Thicket	252	59.9	4.9	1,228
C23_80m			252	51.6	3.0	745
C24_50m	728	Suurberg Quartzite Fynbos	310	48.4	4.0	1,242
C24_80m			310	46.8	3.0	936
C25_50m	618	Bhisho Thornveld	359	25.3	7.1	1,045
C25_80m			359	77.7	17.3	6,213

*Altitude measured at base of mast.

4.3.2 Ground Level Detectors

Activity was variable in the eastern cluster (including Wind Garden) as shown by the outliers and wider interquartile ranges in each month (Graph 1). Mean activity was highest during March 2019 with 146.9 bat passes per detector per night. In both 2019 and 2020 mean activity was lowest June. Seasonally, mean activity was highest during autumn in the eastern clusters followed by summer. The highest single night of activity at a detector happened in May 2020 at C10 (eastern cluster), with 816 bat passes in one night.



Graph 1: Box and Whisker plot of bat passes per month across the 14 short masts. * = mean.

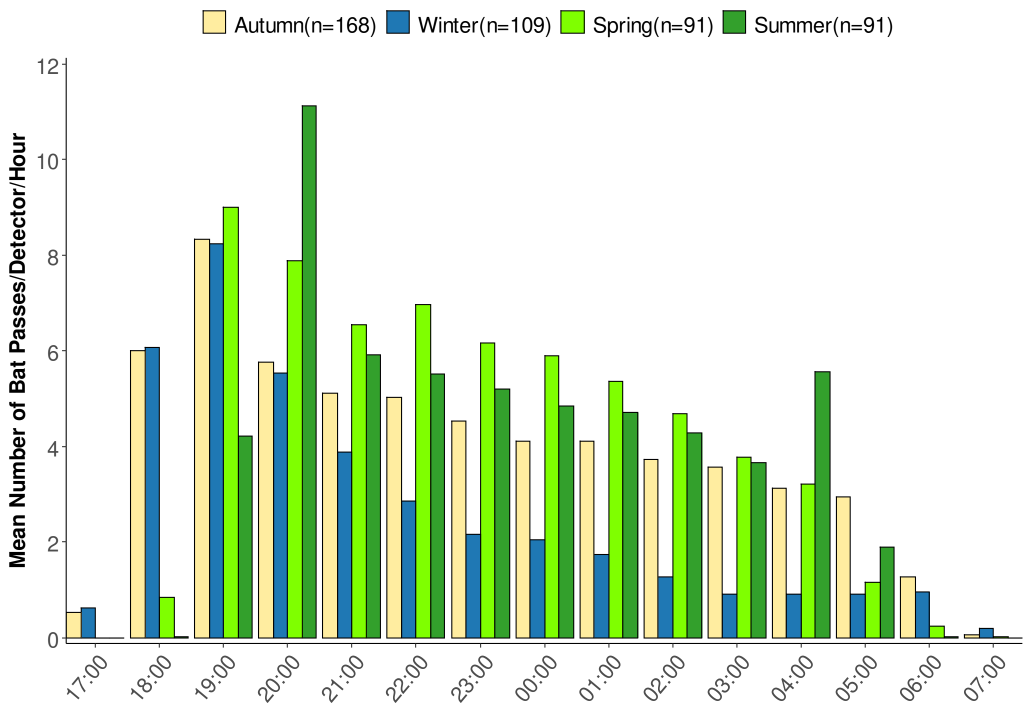
Data from ground level showed that in autumn and winter bat activity commenced between 17h00 and 18h00, an hour earlier than in spring and summer (Graph 2). Mean activity in autumn, winter and spring peaked between 19h00 and 20h00 with 8.5, 7.2 and 9.2 bat passes per hour per detector respectively. In summer mean activity peaked between 20h00 and 21h00 with 11.8 bat passes per hour per detector. In all seasons, activity declined throughout the night[2] after peaking but this varied at some locations. For example, at C4 and C11 activity increased slightly between 03h00 and 05h00, while at C5 and C8 activity only began to decrease from 01h00 and 02h00.

Among the ground level detectors, the eastern cluster mean activity was highest at C14 with 167.2 bat passes per night and lowest at C13 (which is within Wind Garden's boundary) with 21.4 bat passes per night.

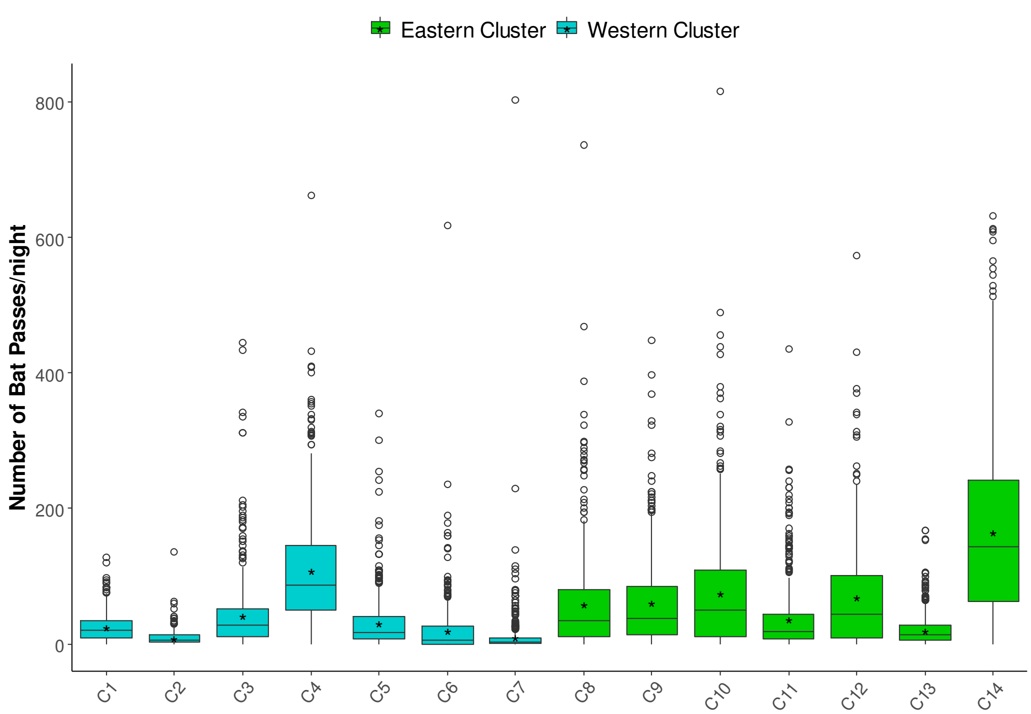
Eleven species were recorded by the ground level detectors. The Egyptian free-tailed bat was the most commonly recorded bat at all locations except at C3, C11 and C12 where the Cape serotine was recorded most often, and C4 where the Natal long-fingered bat was recorded most often (Graph 4). The Cape horseshoe bat was also recorded most often at C4 compared to other locations. The Cape serotine was recorded markedly more often at C12 and C14 relative to other ground level detectors and overall, made up 27 % of all recordings. The Egyptian free-tailed bat accounted for 45 % of all recordings, the Natal

[2] "Night" refers to the time period 17h00 to 07h00, when bats are active.

long-fingered bat accounted for 16 %, and the remaining species each accounted for less than 5 % of recordings (except for the Dusky pipistrelle which accounted for just over 5 %).

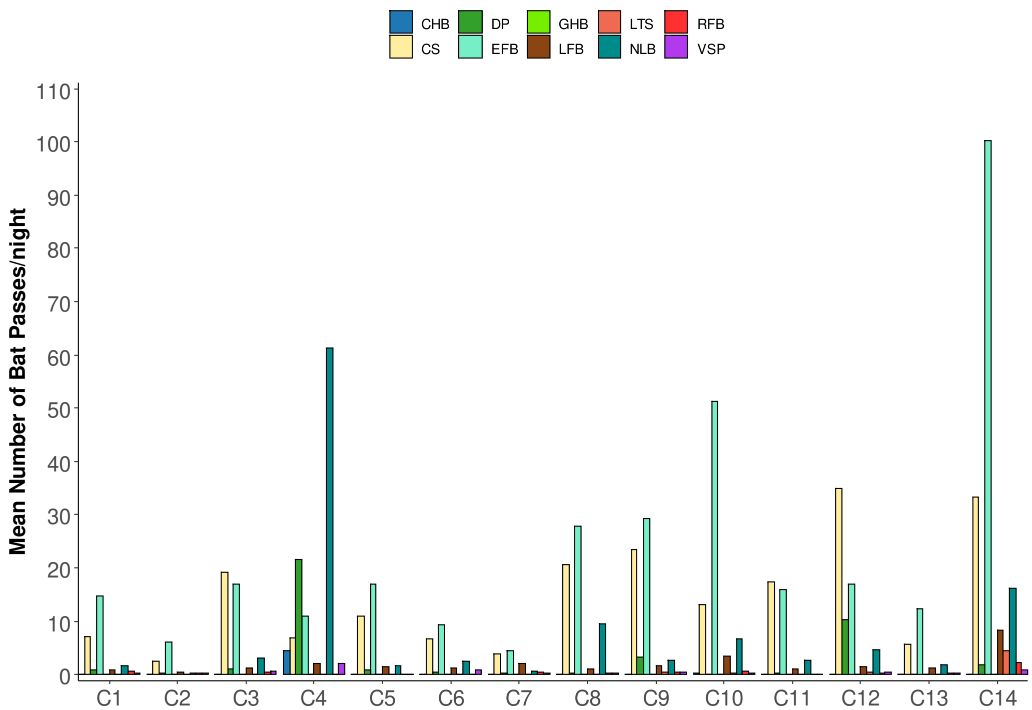


Graph 2: The mean number of bat passes/hour across all detectors at ground level per season. Each time on the x-axis represents a one hour period (i.e. 17:00 = 17:00 – 18:00).



Graph 3: Box and Whisker plot of bat passes/night at ground level per detector.

*** = mean.**



Graph 4: The mean number of bat passes/night at ground level per species per detector.

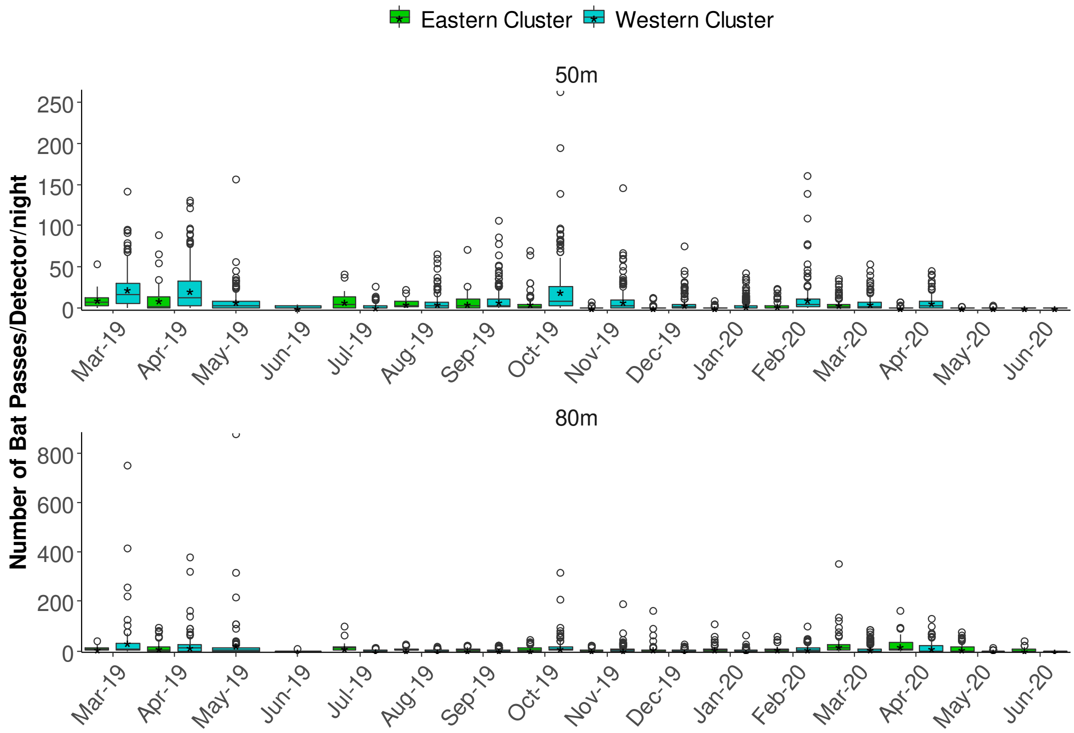
4.3.3 Meteorological Mast Detectors

Activity at ground level was far greater than at height for the monitoring period, with a total of 301,113 passes (86 % of activity) recorded at the short masts and 47, 868 passes (14 % of activity) at height. While bat activity at ground level was greater than at height, there was a small difference in bat activity among the at height data. Overall, 48 % (22, 917 passes) of at height bat activity was recorded at 50 m whereas 52 % (24, 951 passes) was recorded at 80 m.

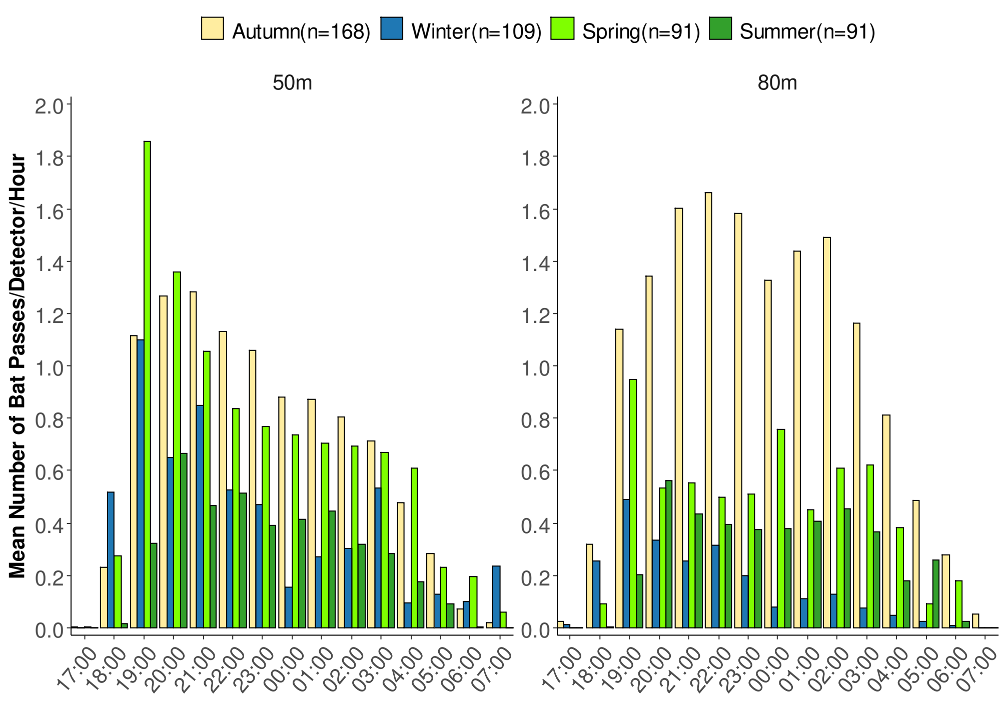
The seasonal pattern in bat activity across the site showed a greater mean activity during autumn, a reduction during winter, an increase into spring and a decrease into summer.

Despite lower bat activity at height compared to ground level, at height activity was still relatively high compared to ground level during some periods. For example, at 80 m, 828 bat passes were recorded on 21 March 2019 and 986 bat passes were recorded on 9 May 2019 (Graph 5) which is within the order of magnitude of most nights of activity recorded closer to ground level.

At 50 m during autumn, peak bat activity during the night occurred between 21h00 and 22h00 with a mean of 1.3 bat passes per hour per detector, following which activity declined steadily throughout the night. At 80 m during autumn, activity peaked between 22h00 and 23h00, did not decrease as rapidly through the night compared to 50 m and had a slight peak from 02h00 to 03h00 (Graph 6). For all time periods from 20h00 in autumn, mean activity was greater at 80 m compared to 50 m. In contrast, during spring activity was greater during all time periods at 50 m compared to 80 m except for between 00h00 and 01h00. Activity peaked at both 50 m and 80 m between 19h00 and 20h00 with a mean of 1.9 and 0.9 bat passes per hour per detector respectively, although at 50 m there was a more obvious peak in activity and subsequent decline during the night whereas at 80 m activity did not vary much. In winter, peak activity at 50 m and 80 m occurred between 19h00 and 20h00 with a mean of 1.1 and 0.5 bat passes per hour per detector respectively and in summer, activity peaked between 20h00 and 21h00 with a mean of 0.7 and 0.6 bat passes per hour per detector at 50 m and 80 m respectively.

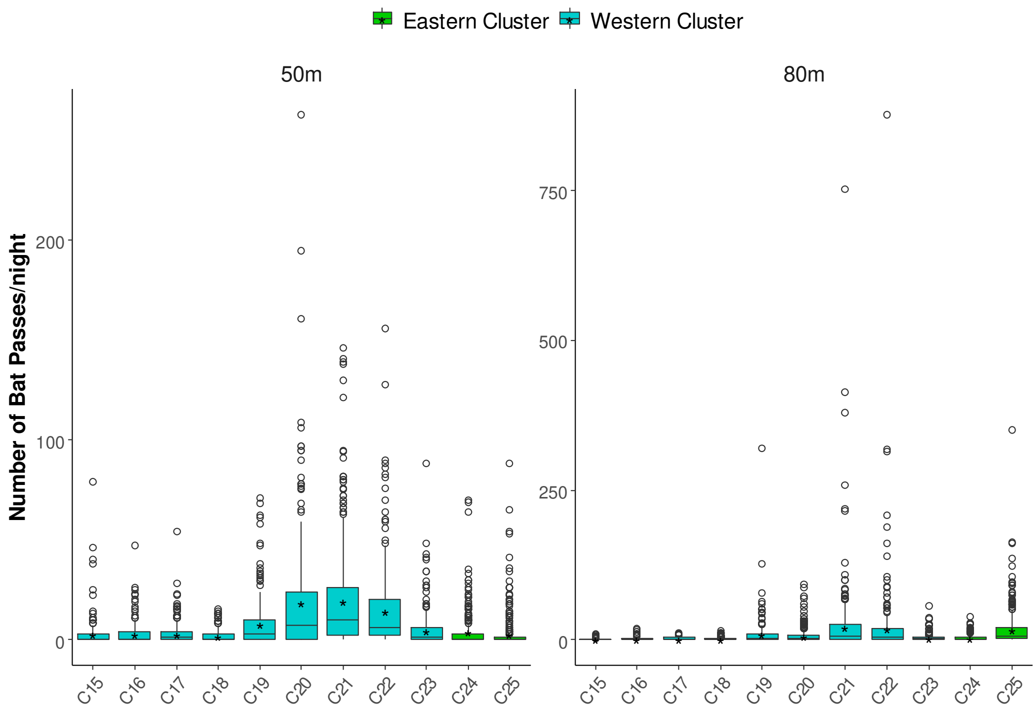


Graph 5: Box and Whisker plot of bat passes per month across the 11 meteorological masts. * = mean.



Graph 6: The mean number of bat passes/hour at height per season per detector. Each time on the x-axis represents a one hour period (i.e. 17:00 = 17:00 – 18:00).

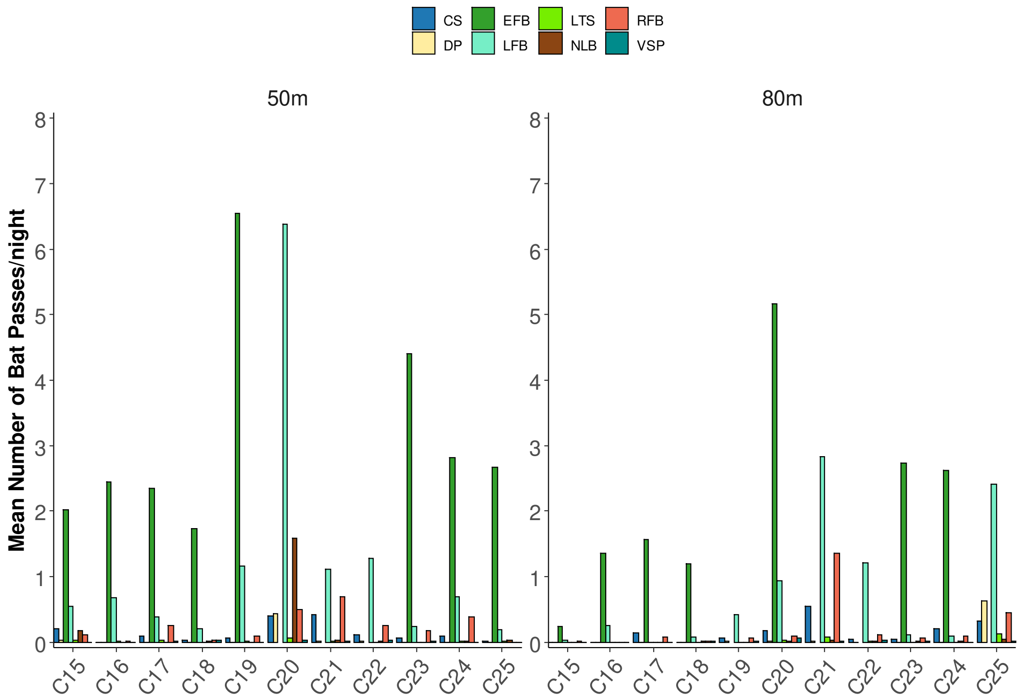
Spatially, bat activity was notably higher at C19, C20, C21 and C22 compared to the other meteorological masts both at 50 m and 80 m (Graph 7). Total activity was highest at C21 and C22 with 14,296 and 9,186 bat passes respectively. Mean activity was greater at 50 m than 80 m at seven of the eleven masts.



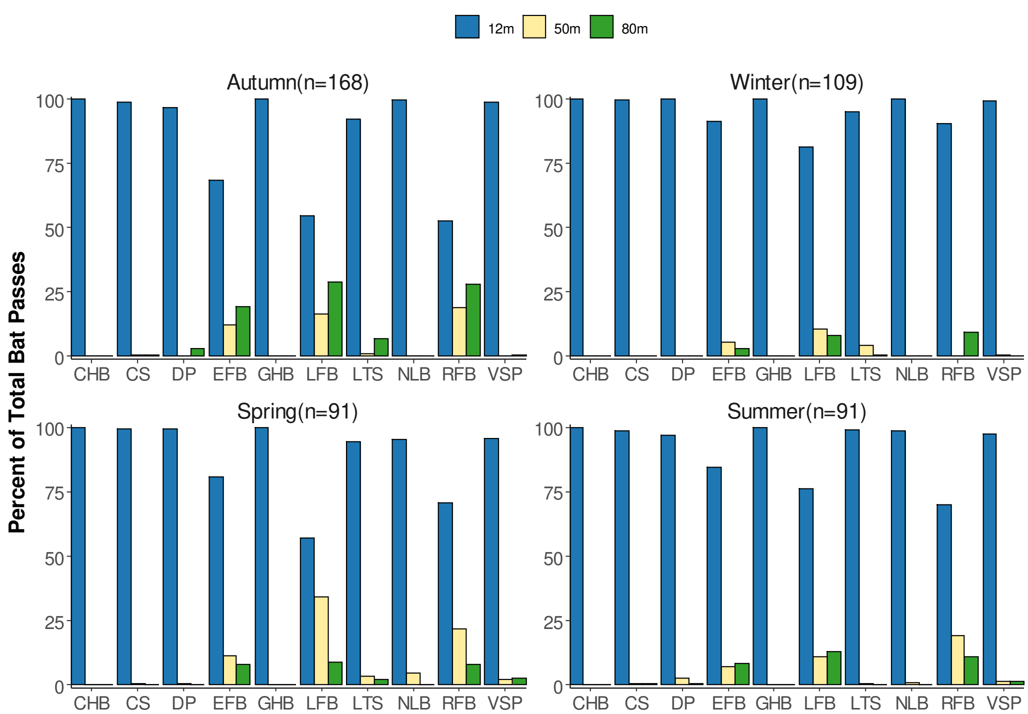
Graph 7: Box and Whisker plot of bat passes/night at height per detector. * = mean.

Of the eleven species recorded at ground level, only eight bat species were recorded at height (Graph 8). The two Horseshoe bat species were not recorded at height (Graph 9). The Egyptian free-tailed bat had a total of 135, 570 passes at ground level and 38, 520 passes at height, which accounted for 45 % of total ground level activity and 80 % of all at height activity. Little free-tailed bats had a total of 11, 034 passes at ground level and 5, 982 passes at height, which accounted for 4 % of all ground level activity and 12 % of all at height activity. Therefore together, free-tailed bats were responsible for 92 % of activity (44, 502 bat passes) at 50 m and 80 m. Proportionally to other species these two species spent less time at ground level (i.e. 12 m) and more time at height than other species, with only 78 % and 64 % of their activity recorded at 12 m respectively. Even though total bat passes of Egyptian free-tailed bats was greater than Little free-tailed bats, a greater proportion of total activity of Little free-tailed bats was at height, approximately 35 % compared to 22 % for Egyptian free-tailed bats. For most species, season did not influence activity in relation to height but for Egyptian free-tailed bats, activity was proportionally higher at height during autumn and spring compared to summer and winter (Graph 9). Similarly, Little-free tailed bats were more active at ground level during summer and winter compared to autumn and spring.

Mean activity at 12 m, 50 m and 80 m for Egyptian free-tailed bats was 23.8, 5.8, and 6.5 bat passes per detector per night respectively. For Little free-tailed bats, mean activity at 12 m, 50 m and 80 m was 1.9, 1.2 and 0.8 bat passes per detector per night respectively.

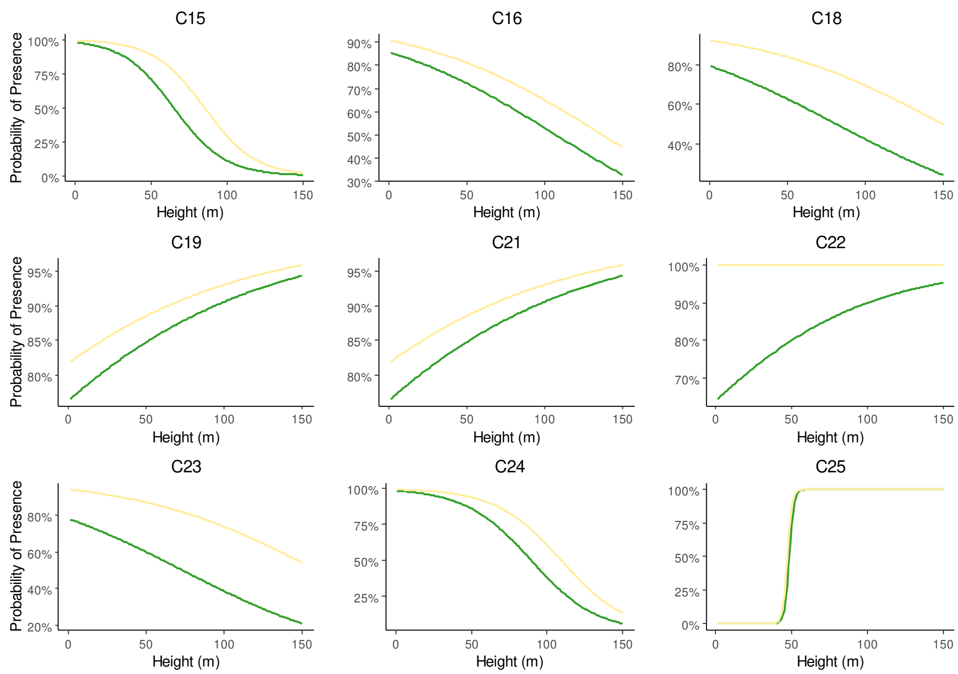


Graph 8: The mean number of bat passes/night at height level per species per detector.



Graph 9: The percentage of total bat activity spent at various heights across species per season.

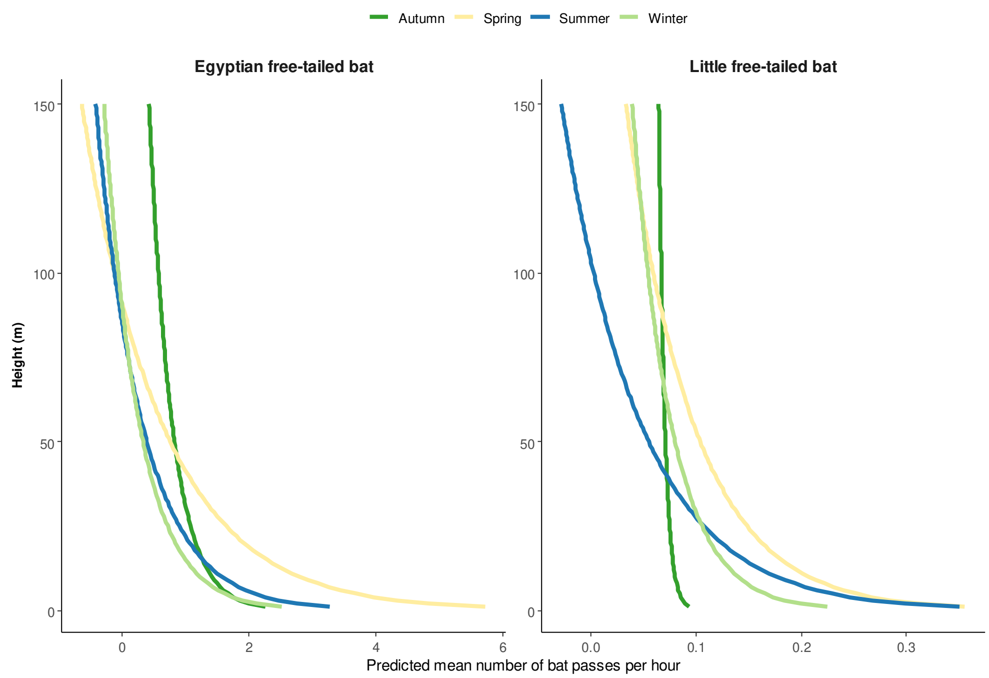
The results from the logistic regression models modelling the probability of occurrence of the Egyptian and Little free-tailed bats show that probability of bat presence varied markedly both spatially (across heights, and detector location) and temporally (between seasons), and there were also differences between species. For the most part the probability of bat presence decreased with increasing height up to 150 m (e.g. at C15, C16, C18, C23 and C24, which is within the boundary of Wind Garden; Graph 10). However, at this height and at these five locations, the probability of presence is still at least 20 %[3] apart from at C15 where free-tailed bats are not predicted to be very active beyond approximately 100 m. At C19, C21, C22 and C25 (which is within the boundary of Wind Garden) free-tailed bat presence is predicted to increase with height although at C22 this is not significant for the Egyptian free-tailed bat. However, some of these patterns break down when modelling presence as a function of season. For example, at C18 in autumn the relationship between height and the presence or absence of bats is not significant despite a decreasing trend when not considering season. Similarly, while the overall trajectory of bat presence appears to increase with height at C19, when modelled per season, this trend is either negative or not significant. Only at C25 was bat presence predicted to increase with height across all seasons.



Graph 10: The probability of presence of Egyptian (yellow) and Little (green) free-tailed bats with height modelled with data from meteorological masts.

The mean number of bat passes per hour is predicted to decrease exponentially with height across all seasons for free-tailed bats (Graph 11). At 150 m the mean number of passes is predicted to be highest in autumn for Egyptian free-tailed bats (approximately 0.3 passes per hour) and in winter for Little free-tailed bats (approximately 0.7 passes per hour).

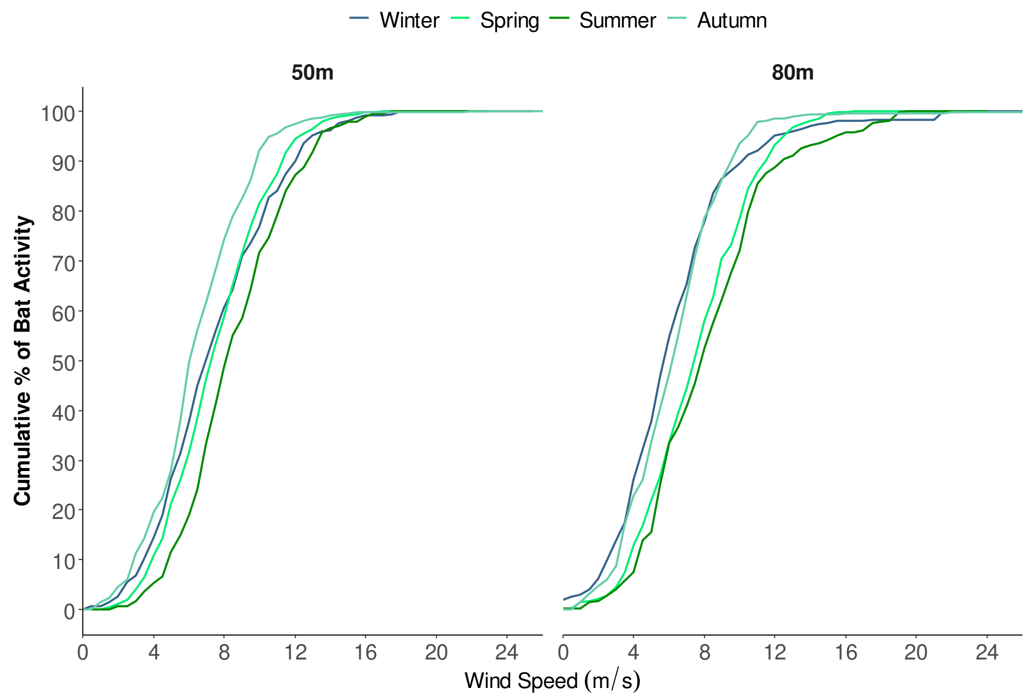
[3] This is based on a predictor model from the activity data collected over the sampling period and gives the probability of finding a bat at this height.



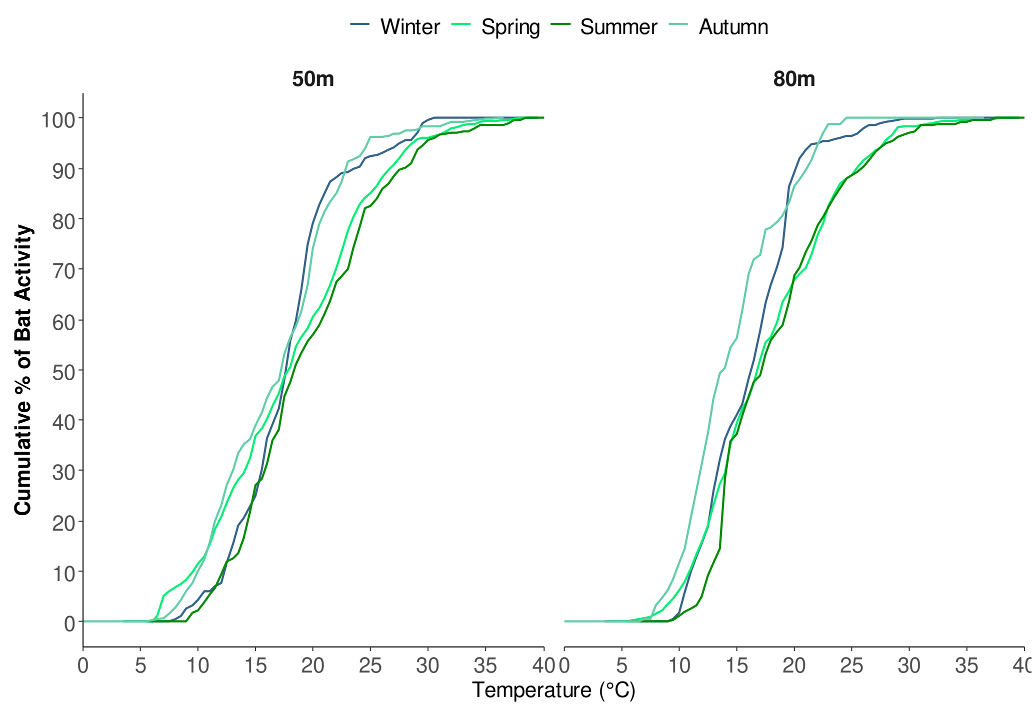
Graph 11: The predicted mean number of bat passes per hour with height modelled with data from meteorological masts.

No bats were recorded in wind speeds above 24.5 m/s in autumn, 17 m/s in spring, 26.5 m/s in winter and 19.5 m/s (Graph 12). In autumn and spring, half of accumulated bat activity had occurred in wind speeds below 8 m/s at 50 m while at 80 m half of accumulated activity occurred below 8 m/s in spring and 6.5 m/s in autumn. In winter, half of accumulated bat activity had occurred in wind speeds below 7 m/s at both 50 m and 80 m while half accumulated activity in summer occurred below 9 m/s at 50 m and 8.5 m/s at 80 m. Very little additional bat activity occurred above approximately 8.5 m/s in autumn and winter, or above 10.5 m/s in spring and 11 m/s in summer (Graph 12).

No bats were recorded in temperatures above 32.5 °C in autumn, 37 °C in winter, and 38.5 °C in spring and 39 °C in summer, nor were bats recorded below 6 °C in any season (Graph 13). In autumn half of accumulated bat activity had occurred in temperatures below 18.5 °C at 50 m and 17 °C at 80 m. In spring, this remained the same at 50 m and increased to 17.5 °C at 80 m and, in winter, decreased to 18 °C at 50 m and 14.5 °C at 80 m. The highest temperatures were in summer with half accumulated activity occurring below 19 °C at 50 m and 18 °C at 50 m.

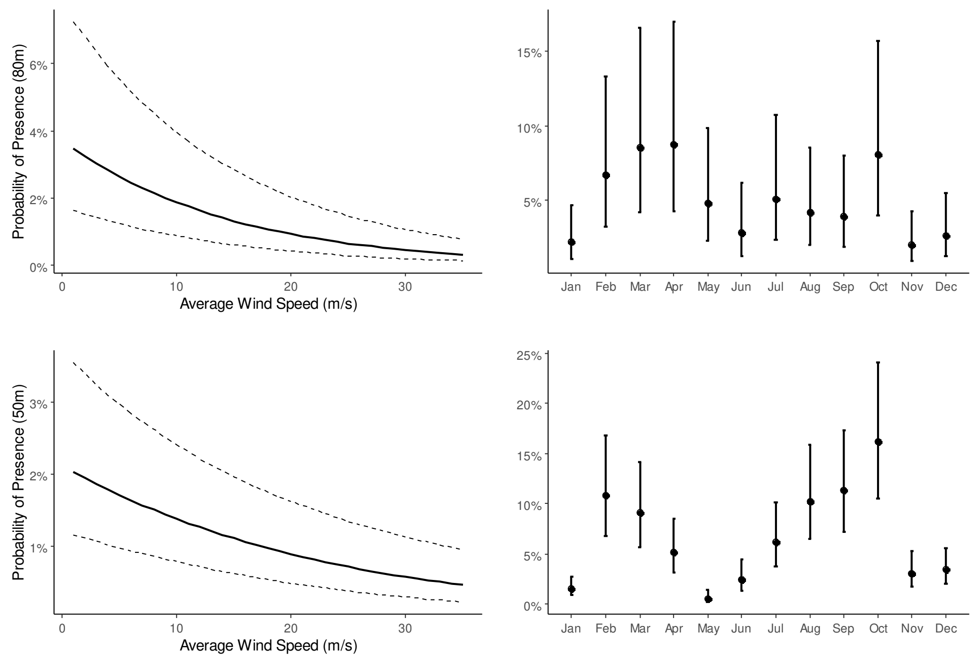


Graph 12: Accumulation curve of bat activity with wind speed



Graph 13: Accumulation curve of bat activity with temperature

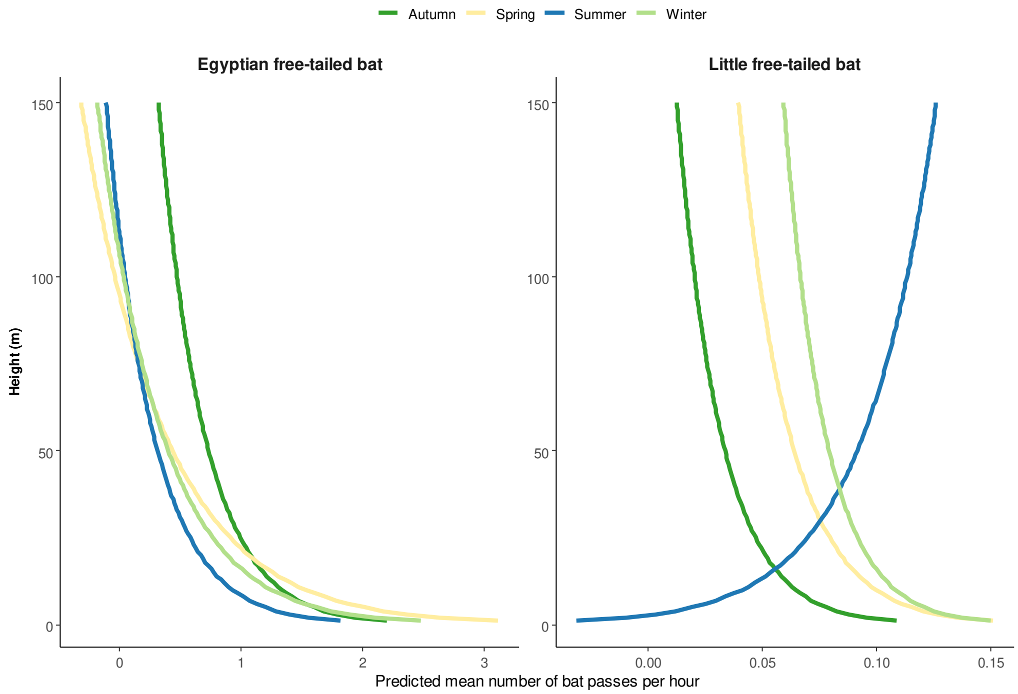
The average (and maximum) wind speed is a significant predictor of the probability of bat occurrence. The predicted probability of bat occurrence decreases as the wind speed increases (Graph 14). The probability of bat presence is higher at 80 m than 50 m and decreases as the average wind speed increases, with a larger decrease at 80 m. The model showed seasonal influence on bat activity at both 50 m and 80 m. At 50 m, there is a higher probability of presence in spring (particularly in October) which decreases into summer, peaks again in late summer/early autumn, decreases into winter and increases again into late winter (Graph 14). Alternatively, probability of presence at 80 m is low in spring, increases from early summer and is highest in autumn (particularly March and April). However, probability of presence also decreases into winter at this height.



Graph 14: Logistic regression using sites (C15, C16, C17, C18, C23) with wind data (random effect) with height and month at 80m and 50m.

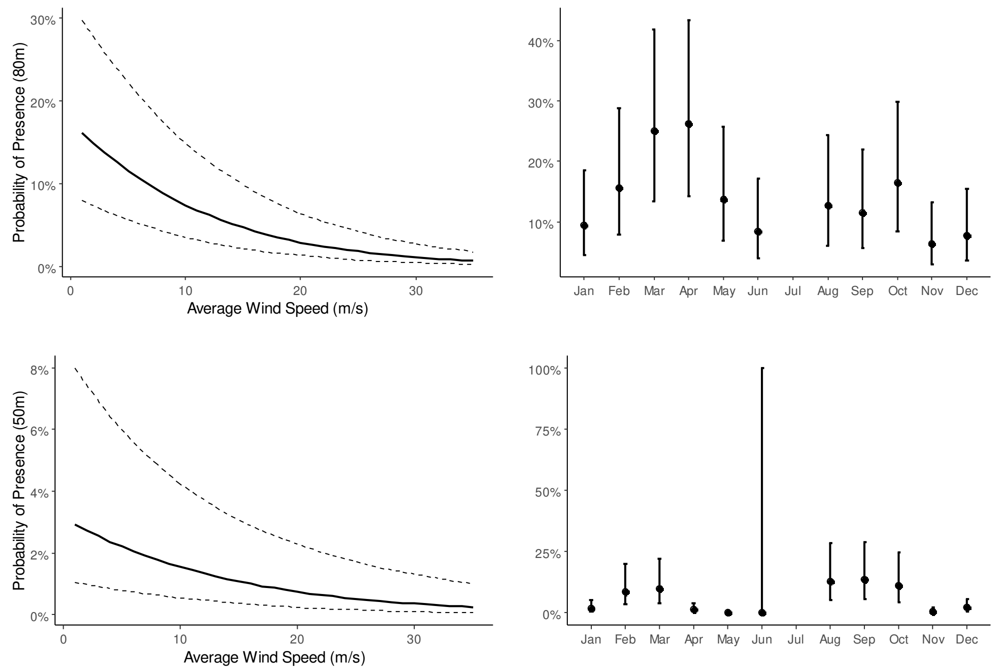
4.3.4 Statistical Analysis for Wind Garden

Vertical activity profiles for Wind Garden masts were in accordance with those seen across all masts in Choje for Egyptian free-tailed bats. Mean number of bat passes per hour is predicted to decrease exponentially with increasing height and this pattern is consistent across all seasons. Similarly, mean number of bat passes per hour for Little free-tailed bats is also predicted to decrease with increasing height, except for summer where activity is predicted to increase with height. However, none of the seasonal models were significant for either species.



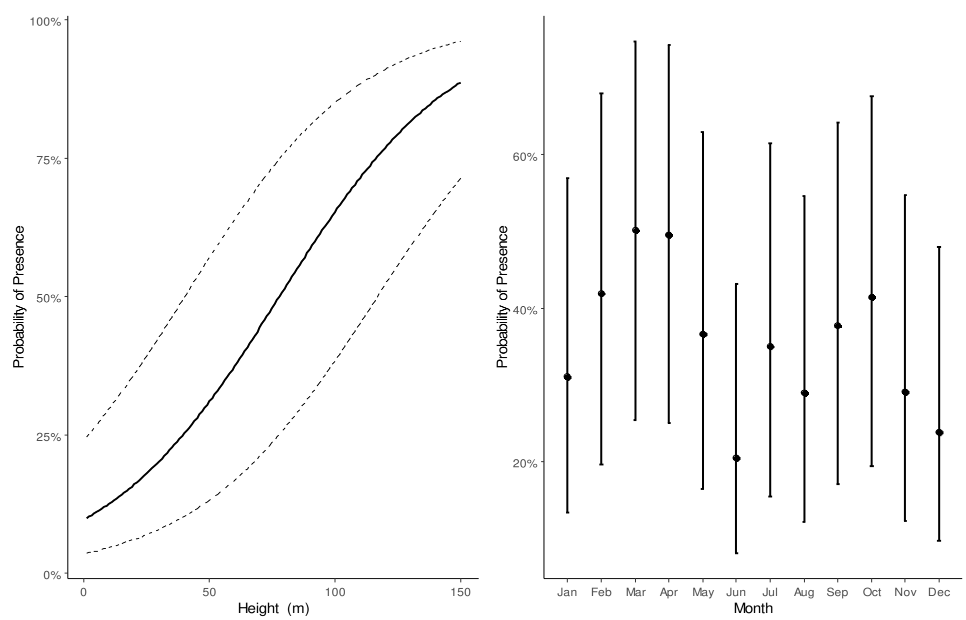
Graph 15: The predicted mean number of bat passes per hour with height modelled with data from masts C9, C11, C13, C24 and 25.

As seen from masts throughout the site, the predicted probability of bat occurrence decreases as the wind speed increases (Graph 16). The probability of bat presence is higher at 80 m than 50 m and decreases as the average wind speed increases, with a larger decrease at 80 m. Probability of presence at 80 m is also low in spring, increases from early summer and is highest in autumn (particularly March and April). Probability of presence also decreases into winter at this height. At 50 m, the pattern is similar to the full Choje site with only slight differences in peak months. There is a higher probability of presence in spring (particularly in September) which decreases into summer, peaks again in late summer/early autumn and decreases into winter.



Graph 16: Logistic regression using sites (C24 and 25) with wind data (random effect) with height and month at 80m and 50m.

The predicted probability of a bat being present in relation to Wind Garden increases at 2% per unit increase in height. The probability of a bat being present is highest in March and April with June having the lowest probability of presence. The model shows an increasing probability of presence with increasing height, which is unusual. This is due to the increased activity at C25 80 m.



Graph 17: Logistic regression using sites C24 and 25 with height and month at 80m and 50m.

4.4 Discussion

Several bat species that are susceptible to wind energy impacts are present in the study area. This includes five high risk species; Egyptian free-tailed bats, Little free-tailed bats, Natal long-fingered bats, Robert's flat-headed bat and Cape serotines. Several medium-high risk species are also present including at least two Plain-faced bat species that could not be identified using the acoustic data. Fatality records of most of these species mentioned above are known from operating wind farms in the region (unpublished data), and in other parts of South Africa (Doty and Martin 2012; Aronson et al. 2013; MacEwan 2016). All of these species have a Red List conservation status of least concern however wind energy is an emerging impact which may not be fully considered yet by the Red List of Mammals of South Africa and IUCN Red List.

Although the Natal long-fingered bat was recorded on site, there is little evidence of the site being a major migrational route. However, inter-annual variation of activity could still occur. The main finding of the monitoring is that Egyptian free-tailed bats were the most commonly recorded species across all heights which reflects the widespread and abundant status of this species in South Africa (Monadjem et al. 2010). This species is adaptable in roost selection and uses caves, rock crevices, exfoliating rock and bark, tree hollows, and buildings as roosts, all of which are present in the study area to varying degrees. No confirmed roosts of this species have been found and roosting potential across the site was low overall. These bats are adapted for flight in open areas, well above vegetation which appears to therefore not influence this species (Monadjem et al. 2010) and will also hunt insects around lights. Although recorded less than Egyptian free-tailed bats, Little free-tailed bats are also adapted for flight in open spaces high above the ground and spent proportionally more activity at height than Egyptian free-tailed bats. The remaining species were recorded very seldom at height with only 8 % of total activity attributable to other species. Therefore, risk to free-tailed bats is likely to be higher compared to other species although this will depend on turbine size.

Other key findings of the monitoring are that firstly activity was relatively very high during March and April (autumn) compared to June (winter), which was low, regardless of location or height. Outside of these months, activity ranged from high to moderate depending on the month and location. Secondly, bat activity is predicted to decrease with height although this is not uniform across space and time. For example, despite the overall decrease in activity from 150 m, there is still at least a 20 % chance that bats will occur at 150 m at some locations (e.g. C16, C19, C21 and C23) during some parts of the year (however this was not the case for C24 in Wind Garden where probability was below 20 %). Further, based on data from five meteorological masts, bat activity decreased with wind speed and very little bat activity occurred above approximately 10.5 m/s but this varied with season. No bats were recorded below 6 °C depending on season. Fourthly, bat activity was notably higher at C4, C19, C20, C21 and C22 (Graph 3 and Graph 7) all of which are located relatively near to each other. The higher activity at these detectors could be because they are situated between the Little and Great Fish Rivers which have extensive cultivated areas along their banks and the associated availability of foraging and roosting spaces. Increased bat activity was recorded in these cultivated areas during the drive transects. Activity was also notably higher at C14 in the eastern study area. Finally an active roost tunnel is present in the study area near C10 (which is within the boundary of Wind Garden). This roost near C10 was surveyed four times (in winter, spring, early- and late summer) and approximately 100 Cape horseshoe bats were roosting in this tunnel throughout the year. No other bat species were recorded at this roost although the Natal long-fingered bat was present in 2009 (Wood, 2012) and has historically been known to use it.

To analyse risk to bats, the empirical and predicted monitoring results were considered in relation to observed and estimated impacts at three operational wind farms near the proposed WEF, as well as referencing risk levels in the best practise guidelines for bat monitoring (Sowler et al. 2017). At the Waainek Wind Farm, the turbine blades sweep down to 28 m and up to 140 m and across two years, and most impacts were to high flying species. At the Amakhala Wind Farm, the turbine blades sweep between 32.5 m and 149.5 m above the ground and most bat fatality over a two-year period comprised high flying species. Bat fatalities at this facility exceed threshold levels proposed by MacEwan et al. (2018). At the Cookhouse Wind Farm, blades sweep down to 36 m and up to 124 m and over a year, most bat fatality comprised of high flying species.

These data clearly illustrate the free-tailed bats are likely to face the highest risk of impacts associated with the Wind Garden WEF since the majority of fatalities in the region are in this family and because they were the most active species at height. At the Wind Garden site, free-tailed bats are at high risk for impacts at 50 m and 80 m based on the mean number of bat passes per hour. Risk to these bats will also occur in the lower areas of the rotor swept zone too. There are no empirical data above 80 m for the study area but free-tailed bat activity is predicted to occur up to at least 150 m, and likely higher than this as free-tailed bats are known to be present at high altitudes (McCracken et al. 2008; Peurach et al. 2009). At 150 m, based on the predicted mean number of bat passes per hour, risk to the Egyptian free-tailed bat is low across the study area. Given that activity decreases with height, risk to this species at 200 m, the maximum tip height under consideration, is also likely to be low. The Little free-tailed bat is predicted to be at medium risk at 150 m, but only in summer. At 200 m, it is difficult to determine with the data available if this risk would still be medium or be reduced to low. These predicted risks are extrapolated to up to 200 m and should be viewed with caution.

The fatality data from the three operational wind farms also show that lower flying species may be impacted despite lower activity measured at 50 m and 80 m. There are no empirical data on bat activity between 12 m and 50 m but the activity of lower flying species is of such a magnitude that they would be at risk if turbine blades sweep down close to ground level, depending on the spatial location of the turbines. For example, the turbine blades at the three operational wind farms in the region sweep down to 28 m, 32.5 m and 36 m respectively and impacts to lower flying species do occur, particularly at the Cookhouse Wind Farm. Based on the mean number of bat passes per hour, the risk to lower flying bat species is likely to be medium. Given the potentially medium risk to bats near ground level it is important to maximise the minimum tip height to prevent blades from entering medium risk airspaces as much as feasible. There is no accepted definition of "ground level" with respect to flying bats and since mortality to lower flying species have occurred where blades sweep down to 36 m, it can reasonably be assumed that these individuals were at least flying 36 m above the ground.

Activity was higher for the meteorological mast C25 at 80 m than other areas in the overall study area, with probability of presence predicted to increase with height as a result of this. Risk for bats at height (particularly the Little free-tailed bat and Egyptian free-tailed bat) is thus predicted to be medium. Risk at ground level is also predicted to be medium as C9 also observed higher passes per hour than other areas. Mitigations are, therefore, important for this site.

Mitigation options that must be incorporated into the project to minimise impacts can be categorised into avoidance and minimisation techniques. Avoidance includes buffering key habitats and considering turbine design so that potential interactions between bats and wind turbines are spatially limited as much as possible. Minimisation relates to mitigating residual impacts to bats primarily through various forms of curtailment[4] or by using ultrasonic acoustic deterrents.

Avoidance mitigation techniques have been incorporated by buffering key habitat features for bats. These includes roosts (rocky crevices, tunnels, trees and buildings), foraging resources (trees, drainage areas, cultivated areas, and aquatic habitat) and commuting resources (drainage areas due to their linear nature). All features, except for drainage lines and some specific roosts, were buffered by 260 m to turbine base (i.e. 200 m to blade tip based on turbines with a hub height of 120 m (the lowest being considered) and blade lengths of 80 m (the longest being considered). Drainage lines were buffered by 100 m to blade tip. The tunnel roost entrance near C10 was buffered by 2.5 km. Even though only 100 least concern, low risk bats are currently present in the roost (which would require a 1 km buffer), the roost has been used in the past by Natal long-fingered bats, it is a regionally important roost, and it is an active site for bat research for a number of local and international universities. Therefore, a 2.5 km buffer has also been placed on the two entrances to this tunnel. A Sensitivity map was created for the Wind Garden WEF which capture these design constraints (Figure 2). No turbines are allowed inside these buffers, including blades.

Adherence to these buffers is the primary mitigation measure to avoid impacts. A secondary measure is the consideration of turbine design. Evidence of a relationship between turbine size and bat fatality is equivocal. Some evidence suggests that larger turbines kill more bats (Baerwald and Barclay 2009) or that as the distance between the blade tips and the ground increases, bat fatality decreases (Georgiakakis et al. 2012). However, other studies have found no evidence that turbine height or the number of turbines influences bat mortality (Berthinussen et al. 2014; Thompson et al. 2017). Due to this uncertainty, to avoid potential impacts to lower flying species the turbine blades at Wind Garden WEF should not sweep down past 36 m, and ideally higher than this. This height was chosen based on data from the Cookhouse Wind Farm where bat mortality has included a high proportion of lower flying species. This mitigation measure will primarily reduce impacts to lower flying species whereas high flying species, such as the Egyptian and Little free-tailed bat, will still be at risk independent of the minimum blade tip height because they are adapted to fly in open areas, high above the ground and are predicted to be present at 150 m albeit with a low to medium risk. Minimising the rotor swept area as a whole is the preferred measure to reduce impacts to these species. The minimum sweep considered for Wind Garden is 40 m and is acceptable in terms of bat fatality through collision reduction.

5 IMPACT ASSESSMENT

5.1 Description of Activity

The site identified for the Wind Garden WEF is 4, 336 hectares in extent. The proposed WEF will consist of up to 47 turbines with the entire WEF having a total generation capacity of up to 264 MW. The turbines will have a maximum hub height of 120 m a maximum blade length of 80m, and a blade tip height of up to 200 m.

The site will include a 132 kV switching station (expected to be 1.2 ha) and a 33/132 kV substation encompassing approximately 6.93 ha, as well as a 132kV power line. Associated infrastructure will include operations and maintenance buildings (including a gate house, security building, control centre, offices, warehouses, a workshop and visitors centre) and staff accommodation. Internal access roads will be approximately 4.5 m wide.

[4] Curtailment – the act restricting normal operation of a wind turbine by slowing or stopping blade rotation for a period of time.

5.2 Identification of Potential Impacts

WEFs have the potential to impact bats directly through collisions (with spinning turbine blades) and barotrauma resulting in mortality (Horn et al. 2008; Rollins et al. 2012), and indirectly through the modification of habitats (Kunz et al. 2007b; Millon et al. 2018). Similarly, the grid connection may also impact bats directly through collisions (with transmission lines), and indirectly through habitat modification. Modification of habitat includes roost destruction, roost disturbance, and displacement from foraging areas and/or commuting routes. Direct impacts pose the greatest risk to bats and, in the context of the project, habitat modification impacts should not pose a significant risk because the project footprint (i.e. turbines, roads) is small compared to the size of the project and because of limited roosting spaces at the site.

Direct impacts to bats posed by the turbines at the proposed WEF will be limited to species that make use of the airspace in the rotor-swept zone of the wind turbines. Five of the bat species (and potentially more unidentified species) that were recorded on site exhibit behaviour that may bring them into contact with wind turbine blades. They are thus potentially at risk of negative impacts if not properly mitigated. This includes three high risk species (Egyptian free-tailed bat, Natal long-fingered bat and Robert's free-tailed bat) and one medium-high risk species (Cape serotine). The Egyptian free-tailed bat, Natal long-fingered bat and Cape serotine have all suffered mortality at operational wind energy facilities in South Africa. Direct impacts of the grid connection transmission lines would primarily be limited to fruit bats.

5.3 Assessment of Impacts

The potential impacts of the construction and operation of the WEF and the grid connection are described in more detail and assessed in Section 5.3.1 and 5.3.2 below. A significance rating and impact assessment was done for each impact and mitigation measures for each provided where appropriate. The potential impacts are assessed based on the methodology provided by Savannah Environmental. The impacts to the bats during the decommissioning phase (for both the wind energy facility and the associated grid connection) are likely to be restricted to disturbance. This impact is expected to be low and therefore not assessed in any further detail.

For each impact, the significance was determined by identifying the extent, duration, magnitude, probability of occurrence, and reversibility of the impact (as well as the irreplaceability of resource loss) in the absence of any mitigation ('without mitigation'). Mitigation measures were identified and the significance was re-rated, assuming the effective implementation of the mitigation ('with mitigation').

For the WEF, the assessment 'without mitigation' assumes the worst case scenario in which all 47 proposed turbines are constructed. The assessment 'with mitigation' assumes that all turbines are constructed outside of bat no-go areas, and all additional mitigations are also adequately implemented. No-go areas (bat buffers) are presented in Figure 2 and no turbines, including their blades, should be placed inside these buffers. Construction of associated infrastructure is permitted in the no-go areas (except roost buffers, where no construction can take place), but should be avoided as much as possible. The current layout proposed adheres to no-go areas and is in accordance with current knowledge on how to promote bat conservation with respect to wind energy by minimizing risk.

Cumulative impacts were assessed as the incremental impact of the proposed activity on the baseline, when added to the impacts of other past, present or reasonably foreseeable future activities in 50 km radius, see Section 5.3.3.

5.3.1 Wind Energy Facility

5.3.1.1 Roost Disturbance

Impact Phase: Construction		
Possible Impact or Risk: Roost Disturbance		
Nature: WEFs have the potential to impact bats directly through the disturbance of roosts during construction. Relevant activities include the construction of roads, Operation and Maintenance (O&M) buildings, sub-station(s), internal transmission lines and installation of wind turbines. Excessive noise and dust during the construction phase could result in bats abandoning their roosts, depending on the proximity of construction activities to roosts. This impact will vary depending on the species involved; species that may roost in trees are likely to be impacted more (e.g. Cape serotine and Egyptian free-tailed bats; Monadjem et al. 2010) because tree roosts are less buffered against noise and dust compared to roosts in buildings and rocky crevices. Roosts are limiting factors in the distribution of bats and their availability is a major determinant in whether bats would be present in a particular location. Reducing roosting opportunities for bats is likely to have negative impacts. There are two major bat roosts found on site (with the one in the eastern study area being more important in the assessment of Wind Garden) and a number of smaller roosts in the western area. Roosting potential is also higher in the more mountainous areas on site and within woodland areas, especially in older and larger trees. Avoidance of known bat roosts and these high potential areas is critical for lowering the significance of this impact, with it unlikely that this impact will occur if mitigation measures are followed. Therefore, with mitigation the significance of this impact would be low and have a slight to no effect.		
	Without Mitigation	**With Mitigation**
Extent	Local (2)	Local (2)
Duration	Very short (1)	Very short (1)
Magnitude	Minor (3)	Minor (2)
Probability	Probable (3)	Improbable (2)
Significance	Low (12)	Low (10)
Status (Positive or Negative)	Negative	Negative
Reversibility	Medium	High
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes	
Mitigation: 1) It may be possible to limit roost abandonment by avoiding construction activities near roosts, specifically the major roost found near C10 (near Wind Garden) and large mature trees within 50 m of the turbine positions should be inspected for roosting bats. 2) It is recommended that potential roosts, specifically trees, buildings and rocky crevices, are buffered by 200 m, inside which no turbine infrastructure may be placed. These buffers have been mapped (Figure 2) and are to blade tip. No turbines should be installed within 50 m of large mature trees.		
Residual Risk:		

Even with all mitigation measures being implemented, undiscovered roosts close to construction may be disturbed due to noise and dust.

5.3.1.2 Roost Destruction

Impact Phase: Construction		
Possible Impact or Risk: Roost Destruction		
Nature: WEFs have the potential to impact bats directly through the physical destruction of roosts during construction. Relevant activities include the construction of roads, O&M buildings, sub-station(s), grid connection transmission lines and installation of wind turbines. Potential roosts that may be impacted by construction activities include trees, crevices in rocky outcrops and buildings. Roost destruction can impact bats either by removing potential roosting spaces which reduces available roosting sites or, if a roost is destroyed while bats are occupying the roost, this could result in bat mortality. Reducing roosting opportunities for bats or killing bats during the process of destroying roosts will have negative impacts and could be severe. There is one major bat roosts found on site (near C10). Roosting potential is also higher in the more mountainous areas on site and within woodland areas, especially in older and larger trees. Destruction of these roosts and roosting areas could be severe for bat populations and must be avoided. Therefore, mitigation is essential for lowering the significance and effect on bats.		
	Without Mitigation	**With Mitigation**
Extent	Local (2)	Local (2)
Duration	Permanent (5)	Permanent (5)
Magnitude	Moderate (6)	Low (5)
Probability	Improbable (2)	Improbable (2)
Significance	Low (26)	Low (24)
Status (Positive or Negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	
Mitigation: 1) The WEF must be designed and constructed in such a way as to avoid the destruction of potential and actual roosts, particularly large mature trees, buildings, rocky crevices (if blasting is required), and the major roost found on the eastern site (near Wind Garden). 2) It is recommended that potential roosts, specifically trees, buildings and rocky crevices, are buffered by 200 m, inside which no turbine infrastructure is allowed. These buffers have been mapped (Figure 2) and are to blade tip. No turbines should be installed within 50 m of large mature trees.		
Residual Risk: Marginally less spaces for roosting bats and decrease in population if roosts are destroyed.		

5.3.1.3 Habitat Modification

Impact Phase: Construction		
Possible Impact or Risk: Habitat Modification		
Nature: Bats can be impacted indirectly through the modification or removal of habitats (Kunz et al. 2007b) and can also be displaced from foraging habitat by wind turbines (Millon et al. 2018). The removal of vegetation during the construction phase can impact bats by removing vegetation cover and linear features that some bats use for foraging and commuting (Verboom and Huitema 1997). The modification of habitat could create linear edges which some bats use to commute or forage along. This modification could also create favourable conditions for insects upon which bats feed which would in turn attract bats. The woodland vegetation is important for bat ecology and foraging and clearing of this vegetation should be limited as much as possible. If mitigation measures are followed this impact will have a low significance and little effect on bats.		
	Without Mitigation	**With Mitigation**
Extent	Local (2)	Local (2)
Duration	Medium-term (3)	Medium-term (3)
Magnitude	Moderate (6)	Low (4)
Probability	Probable (3)	Improbable (2)
Significance	Medium (33)	Low (18)
Status (Positive or Negative)	Negative	Negative
Reversibility	Medium	High
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	
Mitigation: 1) During construction laydown areas and temporary access roads should be kept to a minimum in order to limit direct vegetation loss and habitat fragmentation. Construction of the infrastructure should, where possible, be situated in areas that are already disturbed. 2) This impact must be reduced by limiting the removal of vegetation, particularly large mature trees within 50 m of turbine positions. 3) Following construction, rehabilitation of all areas disturbed (e.g. temporary access tracks and laydown areas) must be undertaken and a habitat restoration plan must be developed by a specialist and included within the EMPr.		
Residual Risk: Habitat fragmentation and destruction of vegetation is could remain after construction, possibly impacting bats foraging and commuting.		

5.3.1.4 Bat Mortality during Commuting and/or Foraging

Impact Phase: Operation		
Possible Impact or Risk: Bat Mortality during Commuting and/or Foraging		
Nature: The major potential impact of wind turbines on bats is direct mortality resulting from collisions with turbine blades and/or barotrauma (Grodsky et al. 2011; Horn et al. 2008; Rollins et al. 2012). These impacts will be limited to species that make use of the airspace in the rotor-swept zone of the wind turbines. Five of the species of bat that were recorded at the project site are high risk and several are medium-high risk species that exhibit behaviour that may bring them into contact with wind turbine blades (Table 1), so they are potentially at risk of negative impacts that could be severe.		
	Without Mitigation	**With Mitigation**
Extent	Regional (4)	Local (3)
Duration	Long-term (4)	Long-term (4)
Magnitude	High (9)	Moderate (6)
Probability	Highly Probable (4)	Improbable (2)
Significance	High (68)	Low (26)
Status (Positive or Negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	
Mitigation: 1) Designing the layout of the project to avoid areas that are more frequently used by bats will reduce the likelihood of mortality and should be the primary mitigation measure. These areas include key microhabitats such as water features, trees, buildings, and rocky crevices. The current layout proposed adheres to no-go areas in accordance with bat conservation (Figure 2). All buffers are to blade tip. 2) The height of the lower blade swept area must be maximised, and should not be lower than 36 m. 3) Operational acoustic monitoring and carcass searches for bats must be performed, based on best practice, to monitor mortality and bat activity levels. Acoustic monitoring should include monitoring at height (from more than one location i.e. such as on turbines) and at ground level. 4) Apply curtailment during spring, summer and autumn based on Table 3 if mortality occurs beyond threshold levels as determined based on applicable guidance (MacEwan et al. 2018). The threshold calculations must be done at a minimum of once a quarter (i.e. not only after the first year of operational monitoring) so that mitigation can be applied as quickly as possible (according to the contracted appropriate bat specialist's timeframe) should thresholds be reached. This should be defined and monitored by an appropriate bat specialist.		

Residual Risk: Inevitably some bats may come into contact with turbines while commuting from nearby roosts or foraging. However, impacts will be far less severe with mitigation measures implemented.

5.3.1.5 Mortality during Migration

Impact Phase: Operation		
Possible Impact or Risk: Mortality during Migration		
Nature: It has been suggested that some bats may not echolocate when they migrate (Baerwald and Barclay 2009) which could explain the higher numbers of migratory species suffering mortality in WEF studies in North America and Europe. Therefore, the direct impact of bat mortality may be higher when they migrate compared to when they are commuting or foraging. This is considered here as a separate impact of the WEF on the Natal long-fingered bat, which is the only species recorded during pre-construction monitoring known to exhibit long-distance migratory behaviour. The majority of bat mortalities at WEFs in North America are migratory species. Evidence from the pre-construction monitoring may suggest migratory behaviour through the site due to the roost near C10, where there is historical evidence of this species. Mortality may, therefore, occur during migration periods. During the operating lifespan of the WEF it may be possible that migration patterns and species distributions may change in response to climactic and/or habitat shifts. There may also be inter-annual variation in bat movement patterns which cannot be observed with a single year of data collection. With the current data the effects on bats are predicted to be moderately severe without mitigation and have little effect with mitigation.		
	Without Mitigation	**With Mitigation**
Extent	Regional (5)	Regional (4)
Duration	Long-term (4)	Long-term (4)
Magnitude	High (8)	Low (6)
Probability	Probable (3)	Improbable (2)
Significance	Medium (51)	Low (28)
Status (Positive or Negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	
Mitigation: 1) Designing the layout of the project to avoid areas that are more frequently used by bats may reduce the likelihood of mortality and should be the primary mitigation measure. These areas include key microhabitats such as water features, trees, buildings, and rocky crevices. The current layout		

proposed adheres to no-go areas is in accordance with bat conservation (Figure 2). All buffers are to blade tip. 2) The height of the lower blade swept area must be maximised, and should not be lower than 36 m. 3) Operational acoustic monitoring and carcass searches for bats must be performed, based on best practice, to monitor mortality and bat activity levels. Acoustic monitoring should include monitoring at height (from more than one location i.e. such as on turbines) and at ground level. 4) Apply curtailment during spring, summer and autumn based on Table 3 if mortality occurs beyond threshold levels as determined based on applicable guidance (MacEwan et al. 2018) – refer to Section 5.3.3. The threshold calculations must be done at a minimum of once a quarter (i.e. not only after the first year of operational monitoring) so that mitigation can be applied as quickly as possible (according to the contracted appropriate bat specialist's timeframe) should thresholds be reached. This should be defined and monitored by an appropriate bat specialist.
Residual Risk: Although there is little evidence of a mass migration route through the site, migrations could still happen through the area and inter-annual changes in species migration could increase fatalities over different time periods of any given year.

5.3.1.6 Light Pollution

Impact Phase: Operation		
Possible Impact or Risk: Light Pollution		
Nature: Currently the local region experiences very little light pollution from anthropogenic sources and the construction of a WEF will marginally increase light pollution. This excludes turbine aviation lights which do not appear to impact bats (Baerwald and Barclay 2011; Horn et al. 2008; Jain et al. 2011; Johnson et al. 2003). During the operation of the WEF, it is assumed that the only light sources would be motion sensor security lighting for short periods and lighting associated with the substations. This artificial lighting would impact bats indirectly via the mortality of their insect prey thereby reducing foraging opportunities for certain bat species. Lighting attracts (Blake et al. 1994; Rydell 1992; Stone 2012) and can cause direct mortality of insects. These local reductions in insect prey may reduce foraging opportunities for bats, particularly for species that avoid illuminated areas. This impact is likely to be low after mitigation because, relative to the large area in the region that would not be developed that likely supports large numbers of insects, the prey resource for bats is likely to be sufficient. Other bat species actively forage around artificial lights due to the higher numbers of insects which are attracted to these lights (Blake et al. 1994; Rydell 1992; Stone 2012). This may bring these species into the vicinity of the project and indirectly increase the risk of collision/barotrauma particularly for species that are known to forage around lights. These include the Cape serotine and the Egyptian free-tailed bat (Fenton et al. 2004). This impact is likely to be low with mitigation but must be carefully considered because the consequence could be severe without mitigation. Lighting at the project should be kept to a minimum and appropriate types of lighting should be used to avoid attracting insects, and hence, bats. With mitigation this impact will have little effect.		
	Without Mitigation	**With Mitigation**
Extent	Local (2)	Local (2)
Duration	Medium-term (3)	Medium-term (3)

Magnitude	Low (5)	Low (4)
Probability	Improbable (2)	Improbable (2)
Significance	Low (20)	Low (18)
Status (Positive or Negative)	Negative	Negative
Reversibility	High	High
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	
Mitigation: 1) This impact can be mitigated by using as little lighting as possible, and only where essential for operation of the facility. 2) Where lights need to be used such as at the collector substation and switching station and elsewhere, these should have low attractiveness for insects such as low pressure sodium and warm white LED lights (Rydell 1992; Stone 2012). High pressure sodium and white mercury lighting is attractive to insects (Blake et al. 1994; Rydell 1992; Svensson & Rydell 1998) and should not be used as far as possible. 3) Lighting should be fitted with movement sensors to limit illumination and light spill, and the overall lit time. In addition, the upward spread of light near to and above the horizontal plane should be restricted and directed to minimise light trespass and sky glow. 4) Increasing the spacing between lights, and the height of light units can reduce the intensity and volume of the light to minimise the area illuminated and give bats an opportunity to fly in relatively dark areas between and over lights.		
Residual Risk: Lights that need to be kept on (e.g. for light when conducting maintenance in the dark) could bring opportunistic bats foraging into these lit areas on site that would increase their chance of coming into contact with turbine blades.		

5.3.2 Grid Connection

5.3.2.1 Roost Disturbance

Impact Phase: Construction
Possible Impact or Risk: Roost Disturbance
Nature: The grid connection infrastructure may impact bats directly through the disturbance of roosts during construction. Excessive noise and dust during the construction phase could result in bats abandoning their roosts, depending on the proximity of construction activities to roosts. This impact will vary depending on the species involved; species that may roost in trees are likely to be impacted more (e.g. Cape serotine and Egyptian free-tailed bats; Monadjem et al. 2010) because tree roosts are less buffered against noise and dust compared to roosts in buildings and rocky crevices. Roosts are limiting factors in the distribution of bats and their availability is a major determinant in whether bats would be present in

a particular location. Reducing roosting opportunities for bats is likely to have negative impacts. However, this impact is predicted to have a slight to no effect on bats.		
	Without Mitigation	**With Mitigation**
Extent	Low (2)	Low (1)
Duration	Very short-term (1)	Very short-term (1)
Magnitude	Low (5)	Low (4)
Probability	Improbable (2)	Improbable (2)
Significance	Low (16)	Low (12)
Status (Positive or Negative)	Negative	Negative
Reversibility	Medium	Medium
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes	
Mitigation: Adhere to the bat sensitivity and no-go zones by trying to avoid building the collector substation and switching station within these areas (especially in mountainous and woodland areas) and strictly avoiding roost buffered areas.		
Residual Risk: Undiscovered roosts close to construction may be disturbed due to noise and dust, but is unlikely to occur.		

5.3.2.2 Roost Destruction

Impact Phase: Construction		
Possible Impact or Risk: Roost Destruction		
Nature: The grid connection infrastructure may impact bats directly through the physical destruction of roosts during construction. Roosts are limiting factors in the distribution of bats and their availability is a major determinant in whether bats would be present in a particular location. Reducing roosting opportunities for bats is likely to have negative impacts. Potential roosts that may be impacted by construction activities include rocky crevices. Roost destruction can impact bats either by removing potential roosting spaces which reduces available roosting sites or, if a roost is destroyed while bats are occupying the roost, this could result in bat mortality. Reducing roosting opportunities for bats or killing bats during the process of destroying roosts will have negative impacts. However, no or a low number of roosts will likely need to be destroyed resulting in the significance of this impact being low and have a slight to no effect on bats.		
	Without Mitigation	**With Mitigation**

Extent	Low (2)	Low (1)
Duration	Long-term (4)	Long-term (4)
Magnitude	Low (5)	Low (4)
Probability	Improbable (2)	Very Improbable (1)
Significance	Low (22)	Low (9)
Status (Positive or Negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	
Mitigation: Adhere to the bat sensitivity and no-go zones by trying to avoid building the collector substation and switching station within these areas (especially in mountainous and woodland areas) and strictly avoiding roost buffered areas.		
Residual Risk: Roost destruction is very unlikely to occur so there should not be any residual impacts.		

5.3.2.3 Bat Mortality through Collision with Transmission Lines

Impact Phase: Operation		
Possible Impact or Risk: Bat Mortality through Collision with Transmission Lines		
Nature: Insectivorous bats are unlikely to collide with transmission lines due to their ability to echolocate. They are therefore able to detect and avoid obstacles in their path, such as electrical cabling. Fruit bats do not echolocate in the same manner and can collide and become electrocuted by transmission lines. There is no published evidence of this in South Africa but these events do occur globally. The existence of suitable caves for roosting and fruit trees along or across the power line route may increase the likelihood that fruit bats will be present however there are none of these features along the proposed grid connection route. Therefore, this impact is expected to have a slight to no effect on bats.		
	Without Mitigation	**With Mitigation**
Extent	Low (1)	Low (1)
Duration	Medium-term (3)	Medium-term (3)
Magnitude	Minor (3)	Minor (3)
Probability	Very Improbable (1)	Very Improbable (1)

Significance	Low (7)	Low (7)
Status (Positive or Negative)	Negative	Negative
Reversibility	No	No
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	
Mitigation: As this impact is unlikely to occur, no mitigation options are required.		
Residual Risk: No mitigation measures are recommended so residual risks will remain the same and unlikely.		

5.3.3 Residual Impacts

Residual impacts may still warrant additional mitigation measures and applying curtailment and using deterrents are the main options once turbines are operational. Curtailment or deterrents can be used to mitigate residual impacts to high-flying species such as the Egyptian free-tailed bat, or other species that are impacted upon. Given the relatively high bat activity recorded at times in parts of the study area and based on fatality patterns at three nearby operational wind farms, curtailment or deterrents may be needed during the operation phase depending on bat fatality. Both of these mitigation measures are known to reduce bat fatality (Arnett and May 2016; Arnett et al. 2011; Hayes et al. 2019; Romano et al. 2019; Weaver et al. 2020). Curtailment techniques that can be considered are blade-feathering, raising the cut-in speed and if needed, shutting down turbines. The exact choice will depend on the scale of the impact and this must be evaluated against threshold levels (MacEwan et al. 2018).

Because so little is known about migration routes, fecundity rates and population numbers of bats in South Africa the fatality threshold is an ongoing discussion, but is usually influenced by natural mortality of bat species, density dependent factors, activity levels per ecoregion, percent loss to natural declines and size of the site. Research suggests above 2% additional losses to bat populations from anthropogenic pressures in a particular ecoregion, bat populations start to decline. These losses can be calculated according to The South African Bat Assessment Association fatality threshold guidelines. Thresholds calculated for the Wind Garden WEF equate to an estimate of 150 bat fatalities[5] per least concern insectivorous bat species or family per annum. Should this value be exceeded, curtailment or deterrents must be applied. In addition, if one fatality for various conservation important species occurs during a 12 month period, these mitigation measures will also need to be applied (refer to MacEwan et al. 2020 for species list). The probability that a conservation important species will trigger mitigation is low since none have been recorded at the site thus far, and none have been reported for the neighbouring wind farms either.

If curtailment or deterrents are needed based on threshold values being exceeded, their use would be confined to specific periods of the year and under specific meteorological conditions. Based on the data available, these periods would initially be restricted to summer (February), autumn (March and April) and spring (October) and during specific wind speeds and temperatures. These parameters were combined into an overall

[5] Assuming an area of influence of 3,403 hectares, and a threshold of 0.44 bats per hectare for the Albany Thicket ecoregion.

curtailment algorithm (Table 3) and once these conditions are met, curtailment or deterrents must be implemented if threshold bat mortality values are exceeded. The threshold calculations must be done at a minimum of once a quarter (i.e. not only after the first year of operational monitoring) so that mitigation can be applied as quickly as possible should thresholds be reached.

Table 3: Preliminary Curtailment Parameters for the Wind Garden Wind Farm*

	October (Spring)	February (Summer)	March - April (Autumn)
Time Period	19h00 – 00h00	19h00 – 22h00	19h00 – 03h00
Temperature (°C)	Above 18	Above 18.5	Above 17.5
Cut in Wind Speed (m/s)	Below 8 m/s	Below 8.5 m/s	Below 8 m/s

*To be applied if more than 150 bat fatalities occur per least concern insectivorous bat species or family per annum, or if one fatality for a conservation important species occurs during a 12 month period.

Curtailment techniques that must be considered are blade-feathering, raising the cut-in speed and if needed, shutting down turbines. Alternative options include using deterrents which can also reduce bat fatalities (Arnett et al. 2011; Romano et al. 2019) or using a smart curtailment approach. Smart curtailment analyses bat activity and meteorological data to make near real-time curtailment decisions when bats are detected in an area and can reduce the curtailment time required to reduce impacts to bats (Hayes et al. 2019).

5.3.4 Cumulative Impacts

The cumulative impact on bats was considered by searching for current and potential future development of wind energy facilities within 50 km of the project. According to the Department of Environment, Forestry and Fisheries Renewable Energy Development Database (Quarter 2 2020) there are currently sixteen renewable energy facilities either planned or approved for development (with at least eleven being wind energy facilities within a 50 km radius. In addition, six WEFs are also in process (one of which shares a border with Wind Garden) and five are operational wind farms (Amakhala, Waainek, Golden Valley, Nxuba and Nojoli Wind Farms).

It is important to consider cumulative impacts across the entire scale that potentially affected animals are likely to move, especially mobile animals like bats. Impacts at a local scale could have negative consequences at larger scales if the movement between distant populations is impacted (Lehnert et al. 2014; Voigt et al. 2012). For example, Lehnert et al. (2014) demonstrated that among Noctule bats collected beneath wind turbines in eastern Germany, 28 % originated from distant populations in the Northern and North-eastern parts of Europe. This is particularly relevant to bats that migrate. Although the activity of one such migratory bat (the Natal long-fingered bat) was relatively low compared to free-tailed bats, cumulative impacts could be detrimental to this species.

The cumulative impacts could be lower for species that do not migrate over such large distances or resident species that are not known to migrate. All species recorded during the pre-construction monitoring (except for the Natal long-fingered bat) do not migrate over such large distances. The sphere of the cumulative impact would then likely be restricted to the home ranges and foraging distances of different species, which can range from 1 km to at least 15 km for some insectivorous bats (Jacobs and Barclay 2009; Serra-Cobo and Sanz-Trullen 1998) and up to at least 24 km for some fruit bats (Jacobsen et al. 1986).

Cumulative impacts on bats could increase as new facilities are constructed (Kunz et al. 2007b) but are difficult to accurately predict or assess without baseline data on bat population size and demographics (Arnett et al. 2011; Kunz et al. 2007b) and these data are lacking for many South African bat species. It is possible that cumulative impacts could be mitigated with the appropriate measures applied to wind farm design and operation at each respective facility. Cumulative impacts could result in declines in populations of even those species of bats currently listed as Least Concern, if they happen to be more susceptible to mortality from wind turbines (e.g. high-flying open air foragers such as free-tailed and fruit bats) even if the appropriate mitigation measures are applied. Further research into the populations and behaviour of South African bats, both in areas with and without wind turbines, is needed to better inform future assessments of the cumulative effects of WEFs on bats.

Possible Impact or Risk: Cumulative Bat Mortality Impacts

Nature:

Cumulative indirect impacts to bats, such as those relating to changes to physical environment (e.g. roost and habitat destruction) are likely to be low to medium across the cumulative impact regions. Cumulative direct impacts to bats, specifically related to bat mortality, are likely to be higher.

For non-migratory species, cumulative direct impacts could have a high significance before mitigation but could reduce to medium or low with appropriate turbine siting and operational mitigation if determined as being necessary based on operational monitoring. Direct impacts on migratory species (i.e. the Natal long-fingered bat) may be high before mitigation but could also reduce to low or medium with appropriate turbine siting and operational mitigation. However, these ratings would be dependent on all other surrounding wind energy facilities also adopting similar mitigation strategies to reduce impacts to bats.

There are currently five operational wind energy facilities in the cumulative impact area and at least eleven more that have been approved. At this time, impacts to bats would increase when more WEFs are constructed.

	Overall impact of the proposed project considered in isolation[6]	**Cumulative impact of the project and other projects in the area**
Extent	Local (2)	Regional (5)
Duration	Long-term (3)	Long-term (3)
Magnitude	Low (5)	High (10)
Probability	Distinct Possibility (3)	Distinct Possibility (3)
Significance	Medium (30)	Medium (54)
Status (positive or negative)	Negative	Negative
Reversibility	No	No
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes	

Mitigation:

1) At operational wind energy facilities where impacts to bats exceed threshold values[7], mitigation strategies such as curtailment or deterrents must be used.

[6] Assessed with the application of mitigation measures.

[7] MacEwan, K., Aronson, J., Richardson, E., Taylor, P., Coverdale, B., Jacobs, D., Leeuwner, L., Marais, W., Richards, L. 2018. South African Bat Fatality Threshold Guidelines for Operational Wind Energy Facilities – ed 2. South African Bat Assessment Association.

2) The operation of lights at substations should be limited to avoid attracting bats to the area. Where lights need to be used such as at the substation and switching station and elsewhere, these should have low attractiveness for insects such as low pressure sodium and warm white LED lights (Rydell 1992; Stone 2012). High pressure sodium and white mercury lighting is attractive to insects (Blake et al. 1994; Rydell 1992; Svensson & Rydell 1998) and should not be used as far as possible. 3) Lighting should be fitted with movement sensors to limit illumination and light spill, and the overall lit time. In addition, the upward spread of light near to and above the horizontal plane should be restricted and directed to minimise light trespass and sky glow. 4) Increasing the spacing between lights, and the height of light units can reduce the intensity and volume of the light to minimise the area illuminated and give bats an opportunity to fly in relatively dark areas between and over lights. 5) Siting of new WEFs and the layouts thereof should take cognisance of sensitivity and no-go areas enforced by the DEFF through the EIA process.
Residual Risk: Changes in inter-annual activity (especially for migratory bats) could increase mortalities at multiple wind farms despite curtailment regimes that may be implemented. Constant monitoring and carcass searching would increase the knowledge of inter-annual activity variation and would help to refine mitigation options (such as curtailment plans) to reduce this residual risk.

6 MEASURES FOR INCLUSION IN THE ENVIRONMENTAL MANAGEMENT PROGRAMME

6.1 Wind Energy Facility

6.1.1 Roost Disturbance

Objective	Limit disturbance to bat roosts.	
Project component/s	1) Construction of Turbines 2) Construction of Operational and Management Buildings 3) Clearing of Vegetation	
Potential Impact	Disturbance of bat colonies.	
Activity/risk source	Construction of WEF	
Mitigation: Target/Objective	Limit roost disturbances during construction phase.	
Mitigation: Action/control	**Responsibility**	**Timeframe**
1) It may be possible to limit roost abandonment by avoiding construction activities near roosts, specifically the major roost found near C10 (near Wind Garden) and large mature trees within 50 m of the turbine positions should be inspected for roosting bats. 2) It is recommended that potential roosts, specifically trees, buildings and rocky crevices, are buffered by 200 m, inside which no	Wind Relic (Pty) Ltd	Construction Phase

turbine infrastructure may be placed. These buffers have been mapped (Figure 2) and are to blade tip. No turbines should be installed within 50 m of large mature trees.		
Performance Indicator	No bat roosts are disturbed	
Monitoring	It is the responsibility of the Environmental Officer to report any roosts found during construction and avoid them as far as possible.	

6.1.2 *Roost Destruction*

Objective	Avoid destruction of bat roosts and limit bat fatalities.	
Project component/s	1) Construction of Turbines 2) Construction of Operational and Management Buildings 3) Clearing of Vegetation	
Potential Impact	Destruction of bat roosts and bat fatalities.	
Activity/risk source	Construction of WEF	
Mitigation: Target/Objective	Avoid roost destruction during construction phase.	
Mitigation: Action/control	**Responsibility**	**Timeframe**
1) The WEF must be designed and constructed in such a way as to avoid the destruction of potential and actual roosts, particularly large mature trees, buildings, rocky crevices (if blasting is required), and the major roost found on the eastern site (near Wind Garden). 2) It is recommended that potential roosts, specifically trees, buildings and rocky crevices, are buffered by 200 m, inside which no turbine infrastructure may be placed. These buffers have been mapped (Figure 2) and are to blade tip. No turbines should be installed within 50 m of large mature trees.	Wind Relic (Pty) Ltd	Construction Phase

Performance Indicator	Roost destruction and bat fatalities.
Monitoring	It is the responsibility of the Environmental Officer to report any roosts found during construction and avoid them as far as possible.

6.1.3 Habitat Modification

Objective	Limit changes to bat foraging and commuting opportunities.	
Project component/s	1) Construction of Turbines 2) Construction of Operational and Management Buildings 3) Vegetation clearance	
Potential Impact	Destruction or change of bat foraging habitats and commuting routes.	
Activity/risk source	Construction of WEF	
Mitigation: Target/Objective	Avoid destruction of vegetation and habitats essential for bat ecological processes during the construction phase.	
Mitigation: Action/control	**Responsibility**	**Timeframe**
1) During construction laydown areas and temporary access roads should be kept to a minimum in order to limit direct vegetation loss and habitat fragmentation. Construction should, where possible, be situated in areas that are already disturbed. 2) Limit the removal of vegetation, particularly large mature trees within 50 m of turbines. 3) Following construction, rehabilitation of all areas disturbed (e.g. temporary access tracks and laydown areas) must be undertaken and a habitat restoration plan must be developed by a specialist and included within the EMPr.	Environmental Officer	Construction Phase
Performance Indicator	Number of bat passes and prevalence,	
Monitoring	It is the responsibility of the Environmental Officer to limit and monitor vegetation clearance during construction.	

6.1.4 Bat Mortality during Commuting and/or Foraging

Objective	Prevent direct mortality of bats from collisions with wind turbines.

<table>
<tr><td>Project component/s</td><td colspan="2">Turbine Operation</td></tr>
<tr><td>Potential Impact</td><td colspan="2">Bat fatalities</td></tr>
<tr><td>Activity/risk source</td><td colspan="2">Operation of WEF</td></tr>
<tr><td>Mitigation: Target/Objective</td><td colspan="2">Use preventative measures and carcass searching during WEF operation to monitor and prevent bat mortalities. If fatalities exceed the threshold of allowed deaths for the facility, the curtailment plan (below) must be implemented:
<table>
<tr><th></th><th>October (Spring)</th><th>February (Summer)</th><th>March - April (Autumn)</th></tr>
<tr><td>Time Period</td><td>19h00 – 00h00</td><td>19h00 – 22h00</td><td>19h00 – 03h00</td></tr>
<tr><td>Temperature (°C)</td><td>Above 18</td><td>Above 18.5</td><td>Above 17.5</td></tr>
<tr><td>Cut in Wind Speed (m/s)</td><td>Below 8 m/s</td><td>Below 8.5 m/s</td><td>Below 8 m/s</td></tr>
</table>
*To be applied if more than 150 bat fatalities occur per least concern insectivorous bat species or family per annum, or if one fatality for a conservation important species occurs during a 12 month period.</td></tr>
<tr><td>Mitigation: Action/control</td><td>Responsibility</td><td>Timeframe</td></tr>
<tr><td>1) Implementation of the layout designed for the project to avoid areas that are more frequently used by bats will reduce the likelihood of mortality and should be the primary mitigation measure. These areas include key microhabitats such as water features, trees, buildings, and rocky crevices. The current wind turbine layout proposed adheres to no-go areas and is in accordance with bat conservation (Figure 2). All buffers are to blade tip.
2) The height of the lower blade swept area must be maximised, and should not be lower than 36 m.
3) Operational acoustic monitoring and carcass searches for bats must be performed, based on best practice, to monitor mortality and bat activity levels. Acoustic monitoring should include monitoring at height (from more than one location i.e. such as on turbines) and at ground level.
4) Apply curtailment during spring, summer and autumn based on Table 3 if mortality</td><td>Wind Relic (Pty) Ltd and <u>an appropriate bat specialist</u></td><td>Construction and Operation Phase</td></tr>
</table>

occurs beyond threshold levels as determined based on applicable guidance (MacEwan et al. 2018). The threshold calculations must be done at a minimum of once a quarter (i.e. not only after the first year of operational monitoring) so that mitigation can be applied as quickly as possible (according to the contracted appropriate bat specialist's timeframe) should thresholds be reached. This should be defined and monitored by an appropriate bat specialist.		
Performance Indicator	Number of bat carcasses found at WEF.	
Monitoring	It is the responsibility of the O&M Operator to monitor the number of bats killed at the WEF during operation and use these data to refine and update preventative measures and the curtailment plan. Activity and fatality data should be relayed to the specialist and included in operational monitoring reports.	

6.1.5 Mortality during Migration

<table>
<tr><td>Objective</td><td colspan="2">Prevent direct mortality of bats from collisions with wind turbines when migrating.</td></tr>
<tr><td>Project component/s</td><td colspan="2">Turbine Operation</td></tr>
<tr><td>Potential Impact</td><td colspan="2">Bat fatalities</td></tr>
<tr><td>Activity/risk source</td><td colspan="2">Operation of WEF</td></tr>
<tr><td>Mitigation: Target/Objective</td><td colspan="2">Use preventative measures and carcass searching during WEF operation to monitor and prevent bat mortalities. If fatalities exceed the threshold of allowed deaths for the facility, the curtailment plan (below) must be implemented:
<table>
<tr><th></th><th>October (Spring)</th><th>February (Summer)</th><th>March - April (Autumn)</th></tr>
<tr><td>Time Period</td><td>19h00 – 00h00</td><td>19h00 – 22h00</td><td>19h00 – 03h00</td></tr>
<tr><td>Temperature (°C)</td><td>Above 18</td><td>Above 18.5</td><td>Above 17.5</td></tr>
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*To be applied if more than 150 bat fatalities occur per least concern insectivorous bat species or family per annum, or if one fatality for a conservation important species occurs during a 12 month period.</td></tr>
<tr><td>Mitigation: Action/control</td><td>Responsibility</td><td>Timeframe</td></tr>
<tr><td>1) Designing the layout of the project to avoid areas that are more frequently used by bats</td><td><u>Wind Relic (Pty) Ltd and an appropriate bat specialist</u></td><td>Construction and Operation Phase</td></tr>
</table>

may reduce the likelihood of mortality and should be the primary mitigation measure. These areas include key microhabitats such as water features, trees, buildings, and rocky crevices. The current wind turbine layout proposed adheres to no-go areas and is in accordance with bat conservation (Figure 2). All buffers are to blade tip. 2) The height of the lower blade swept area must be maximised, and should not be lower than 36 m. 3) Operational acoustic monitoring and carcass searches for bats must be performed, based on best practice, to monitor mortality and bat activity levels. Acoustic monitoring should include monitoring at height (from more than one location i.e. such as on turbines) and at ground level. 4) Apply curtailment during spring, summer and autumn based on Table 3 if mortality occurs beyond threshold levels as determined based on applicable guidance (MacEwan et al. 2018) – refer to Section 5.3.3. The threshold calculations must be done at a minimum of once a quarter (i.e. not only after the first year of operational monitoring) so that mitigation can be applied as quickly as possible (according to the contracted appropriate bat specialist's timeframe) should thresholds be reached. This should be defined and monitored by an appropriate bat specialist.		
Performance Indicator	Number of bat carcasses found at WEF.	
Monitoring	It is the responsibility of the O&M Operator to monitor the number of bats killed at the WEF during operation and use this data to refine and update preventative measures and the curtailment	

	plan. Activity and fatality data should be relayed to the specialist and included in operational monitoring reports.

6.1.6 Light Pollution

Objective	Limit bat foraging and mortality of their insect prey at new infrastructure due to artificial lighting.	
Project component/s	1) Turbines 2) Associated infrastructure (e.g. Operational and Maintenance buildings)	
Potential Impact	Bat fatalities and loss of food source (insects)	
Activity/risk source	Operation of WEF	
Mitigation: Target/Objective	Lower impacts of artificial lighting to bats at new infrastructure during WEF operation through mitigation measures.	
Mitigation: Action/control	**Responsibility**	**Timeframe**
1) This impact can be mitigated by using as little lighting as possible, and only where essential for operation of the facility. 2) Where lights need to be used such as at the collector substation and switching station and elsewhere, these should have low attractiveness for insects such as low pressure sodium and warm white LED lights (Rydell 1992; Stone 2012). High pressure sodium and white mercury lighting is attractive to insects (Blake et al. 1994; Rydell 1992; Svensson & Rydell 1998) and should not be used as far as possible. 3) Lighting should be fitted with movement sensors to limit illumination and light spill, and the overall lit time. In addition, the upward spread of light near to and above the horizontal plane should be restricted and directed to minimise light trespass and sky glow. 4) Increasing the spacing between lights, and the height of light units can reduce the intensity and volume of the light to minimise the area	O&M Operator	Operation Phase

illuminated and give bats an opportunity to fly in relatively dark areas between and over lights.		
Performance Indicator	Bat fatalities and amount of activity around lit infrastructure.	
Monitoring	It is the responsibility of the O&M Operator to monitor activity and fatalities around infrastructure during WEF operation. Reports of activity and fatalities should be relayed to the specialist and included in operational monitoring reports.	

7 CONCLUSION

Bat activity at the proposed Wind Garden WEF was generally low during winter, very high during autumn (March and April) and moderate to high the rest of the year. Therefore, the significance ratings for the majority of the impacts to bats posed by the development are predicted to be medium or high before mitigation. After mitigation, all impacts are predicted to be low apart for cumulative impacts which are predicted to be of medium significance after mitigation. Impacts related to bat mortality and cumulative impacts are predicted to be of high magnitude and medium-high significance before mitigation. After mitigation, these impacts are predicted to be of low significance for bat mortality and medium significance for cumulative impacts.

Free-tailed bats are likely to face the highest risk of impacts associated with the Choje wind farms. This risk will be spatially variable and confined to high in the eastern study area (including Wind Garden) and low elsewhere. Sensitive design and mitigation will be needed to reduce risk to these bats. Sensitive areas including those used by bats for foraging, roosting and commuting should be avoided for turbine placement. These have been mapped and the current layout iteration adheres to avoidance of sensitive and no-go areas by wind turbines as per the recommendations of this report . The choice of turbine design, specifically, the hub height and rotor diameter, should be carefully selected to reduce potential interactions between bats and turbine blades. A minimum blade tip height of 36 m is proposed, as well as the overall minimisation of the rotor swept area as far as practicable. The current specifications have a lower swept height of 40 m and are in accordance with the specialists recommendations.

Residual impacts will still likely occur and must be evaluated against bat fatality thresholds and if these are exceeded, curtailment or deterrents must be applied. These would be implemented during specific seasons and time periods for specific turbines coincident with periods of increased bat activity and fatality. It is likely that residual impacts to bats will be greater in summer (February), autumn (March and April) and spring (October) as this was when bat activity was high. The curtailment plan must be revised based on additional bat activity and bat fatality data collected during the operation phase of the project by an appropriate bat specialist. These are proven measures that can contribute to residual impact reduction. The threshold calculations must be done at a minimum of once a quarter (i.e. not only after the first year of operational monitoring) so that mitigation can be applied as quickly as possible (at the specialist’s discretion) should thresholds be reached. The regular evaluations allow for any impacts to be identified quickly so that they can be addressed timeously.

Provided these mitigation measures are met, the development of the Wind Garden WEF will not result in unacceptable impacts to bats and can be authorised.

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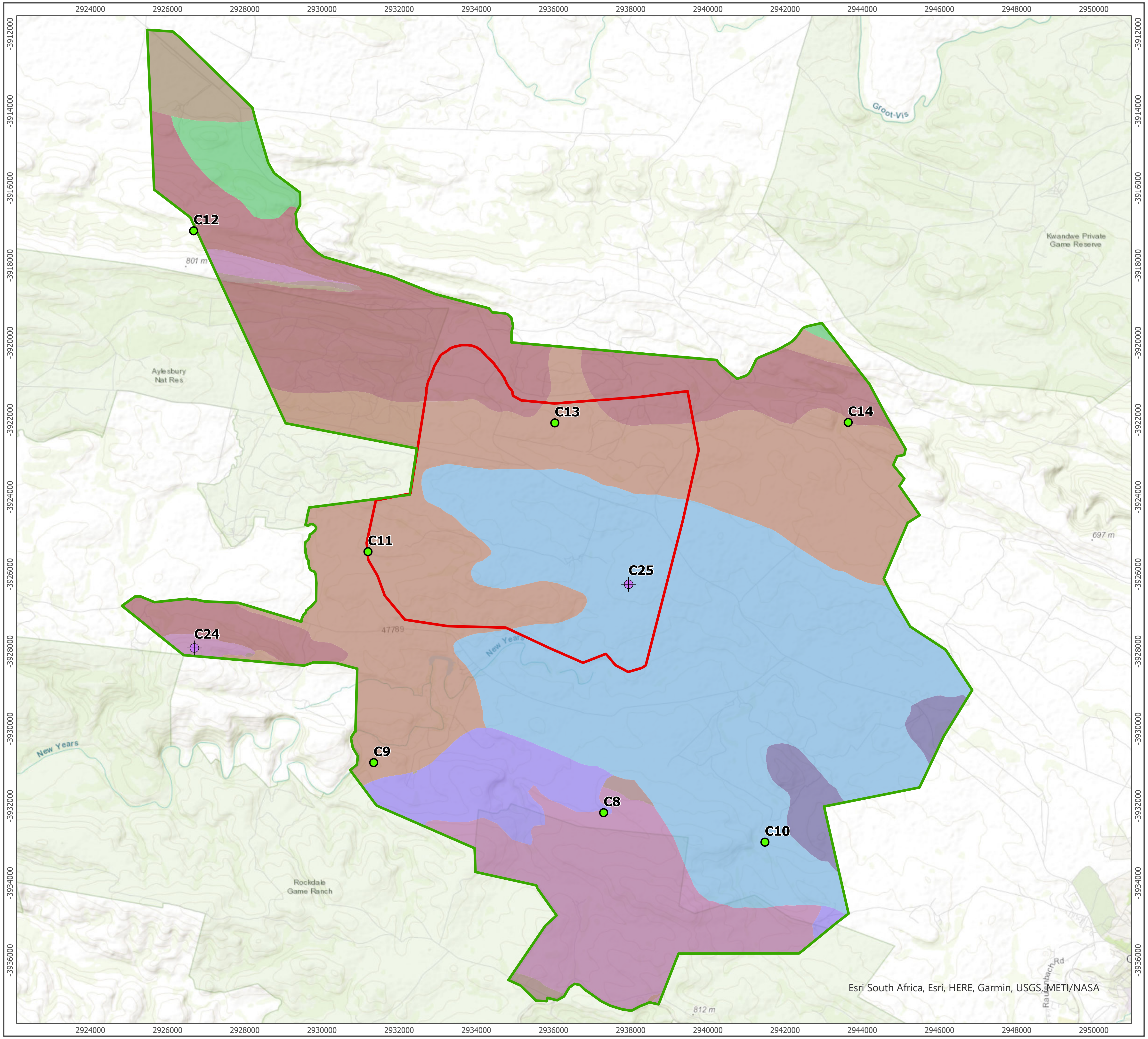

ARCUS

- Eastern Study Area
- Wind Garden WEF Boundary
- Met Mast
- Short Mast

Vegetation Types
- Albany Bontveld
- Albany Broken Veld
- Albany Valley Thicket
- Bhisho Thornveld
- Fish Arid Thicket
- Grahamstown Grassland Thicket
- Saltaire Karroid Thicket
- Southern Mistbelt Forest
- Suurberg Quartzite Fynbos
- Suurberg Shale Fynbos

1:95,000 Scale @ A3
0 1.5 3 km
NORTH

Produced By: MH	Ref: 3065-GIS-009
Checked By: MB	Date: 09/06/2021

Wind Garden Site Location
Figure 3

Wind Garden WEF Basic Assessment Report

S:\GIS\Projects\3065 Choje\3065 Choje.aprx\3065-GIS-009 Fig 09 Site Location Wind Garden

STATISTICAL SERVICES

PRE-CONSTRUCTION BAT MONITORING FOR THE PROPOSED CHOJE WIND FARM

Final Pre-Construction Monitoring Report

On behalf of

WIND RELIC (PTY) LTD

October 2020

Prepared By:

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1 INTRODUCTION

Wind Relic (Pty) Ltd ('Wind Relic') are proposing to develop six wind farms in the Cookhouse Renewable Energy Development Zone 3 (REDZ 3), in the Eastern Cape Province, consisting of up to 170 turbines in the West and 85 turbine in the East (a total of 255). The development envelopes have been identified as: Choje West 1, Choje West 2, Choje West 3, Choje West 4, Choje East 1, and Choje East 2. The turbines will have a hub height ranging from 105 m to 165 m and a rotor diameter ranging from 149 m to 162 m. The minimum and maximum tip heights are therefore 24 m and 246 m respectively (Figure 1).

As part of the environmental assessments for the project, Wind Relic have appointed Arcus to undertake pre-construction bat monitoring. The aim of the monitoring is to document bat activity in the study area and, based on this activity, assess the proposed wind farms with regards to potential impacts to bats and the risk to development consent.

The monitoring data will establish a pre-construction baseline of bat species diversity and activity and be used to undertake an environmental impact assessment. The monitoring data will also assist in providing solutions to mitigate impacts, if required, by informing the final design, construction and operational management strategy of the wind farms. The baseline should also be used to compare impacts to bats during the operational phase of the project.

This final monitoring report presents a summary of the key results from the bat activity monitoring undertaken between 13 March 2019 and 16 June 2020, and provides an indication of the current potential risk of the project to bats.

2 METHODOLOGY

The baseline environment was investigated by using acoustic monitoring to document bat activity. Bats emit ultrasonic echolocation calls for orientation, navigation and foraging. These calls can be recorded by bat detectors enabling bat species to be identified and their activity patterns quantified.

The monitoring is being undertaken in accordance with South African best practice (Sowler et al. 2017). Sampling of bat activity took place at 25 locations using Song Meter SM3 and SM4 bat detectors with SMM-U2 ultrasonic microphones (Wildlife Acoustics, Inc.). The sampling locations were clustered into an eastern and western study area (Figure 2). Fourteen locations comprised of 12 m masts at which microphones were mounted at approximately 12 m ("ground level"). Eleven locations comprised of meteorological towers upon which microphones were mounted at 50 m and 80 m ("at height"). All detectors were configured to record every night from 30 minutes before sunset until 30 minutes after sunrise.

In addition to the passive monitoring, drive transects were undertaken in winter, spring and summer. Transects commenced at sunset and continued for four hours. The vehicle travelled at a constant speed of 20 km/h along a set route while bats were recorded using an Echo Meter Touch 2 PRO bat detector (Wildlife Acoustics, Inc.) connected to a Samsung S3 Tablet. Sampling points were randomly established along the transect route at which bats were recorded for five minutes, before continuing along the route. The vehicle was turned off during these five minutes to avoid attracting insects to the vehicle lights.

Acoustic data from each bat detector were analysed using Kaleidoscope® Pro (Version 5.1.9g, Wildlife Acoustics, Inc.) to identify species present and to quantify their activity. Bat species were automatically identified from their echolocation calls using the embedded echolocation call library in the software. The results were vetted by randomly or selectively (for certain species) manually identifying echolocation calls.

A sequence of bat echolocation pulses is called a pass defined as two or more echolocation calls separated from other calls by more than 500 milliseconds (Hayes 1997; Thomas 1988). This was used as the basic unit for quantifying the relative magnitude of bat activity. The total number of files was used as a proxy for the number of bat passes. Meteorological data from the meteorological towers on site were analysed together by VLG Statistical Services and results incorporated into this report.

2.1 Assumptions and Limitations

The following assumptions and limitations relevant to this study are noted:

- The knowledge of certain aspects of South African bats including natural history, population sizes, local and regional distribution patterns, spatial and temporal movement patterns (including migration and flying heights) and how bats may be impacted by wind energy, including cumulatively, is very limited for many species.
- Bat echolocation calls (i.e. ultrasound) operate over ranges of metres therefore acoustic monitoring samples only a small amount of space (Adams et al. 2012). Recording a bat using sound is influenced by the type and intensity of the echolocation call produced, the species of bat, the bat detector system used, the orientation of the signal relative to the microphone and environmental conditions such as humidity. Extrapolating data from echolocation surveys over large areas has limited utility because only small areas are actually sampled.
- There can be considerable variation in bat calls between different species and within species. The accuracy of the species identification is also very dependent on the quality of the calls used for identification. Species call parameters can often overlap, making species identification difficult.
- Bat activity recorded by bat detectors cannot be used to directly estimate abundance or population sizes because detectors cannot distinguish between a single bat flying past a detector multiple times or between multiple bats of the same species passing a detector once each (Kunz et al. 2007a). This is interpreted using the specialists' knowledge and presented as relative abundance.
- The potential impacts of wind energy on bats presented in this report represent the current knowledge in this field. New evidence from research and consultancy projects may become available in future, meaning that impacts and mitigation options presented and discussed in this report may be adjusted if the project is developed.
- While the data presented in this report provides a baseline of bat activity for the period sampled, it does not allow for an understanding of interannual variation in bat activity. It is therefore possible that during the lifespan of the facility, bat activity could be significantly different (lower or higher) compared to the baseline presented here.
- While predictions of bat activity were made up to 150 m, this required an extrapolation of data significantly beyond the range of the empirical data sampled at 50 m and 80 m. In addition, height was treated as a continuous variable even though the study design only had two heights per meteorological tower.
- No sites had ground level and height recorders, so differences in activity between ground and height are confounded with site (and the spatial variability in the study area).
- Wind speed and temperature were only recorded for "height" sites.

2.2 Legislative Context

The following legalisation, policies, regulations and guidelines are all relevant to the project and the potential impact it may have on bats and habitats that support bats:

- Convention on the Conservation of Migratory Species of Wild Animals (1979)
- Convention on Biological Diversity (1993)
- Constitution of the Republic of South Africa, 1996 (Act No. 108 of 1996)

- National Environmental Management Act, 1998 (NEMA, Act No. 107 of 1998)
- National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004)
- The Equator Principles (2013)
- The Red List of Mammals of South Africa, Swaziland and Lesotho (2016)
- National Biodiversity Strategy and Action Plan (2005)
- South African Good Practise Guidelines for Surveying Bats in Wind Energy Facility Developments – Pre-Construction (2017)

3 BASELINE ENVIRONMENT

3.1 Habitat

The study area is broadly separated into two ecoregions; Albany Thicket, and Fynbos Shrubland. Within this, vegetation diversity is high with at least 17 different vegetation types present in the study area (Figure 1). Albany broken veld, Doubledrift Karroid Thicket and Fish Valley Thicket dominate the western study area. In the east, Grahamstown Grassland Thicket and Saltaire Karroid Thicket comprise most of the study area. A gradient of increasing mean annual precipitation runs from the western study area towards the east.

For foraging bats, one of the most important ecological constraints is clutter; objects (e.g. vegetation) that have to be detected and avoided by bats during flight (Schnitzler and Kalko 2001). Clutter presents perceptual and mechanical problems for bats. Perceptually, bats are constrained by their sensory capabilities to find prey amongst clutter (e.g. having an echolocation system adapted to find prey in dense vegetation versus in the open). Mechanically, bats are constrained by their flight ability (e.g. adaptations in wing morphology that enable flight in dense vegetation versus in the open). Habitats can therefore be defined according to clutter conditions. These include uncluttered space (open spaces, high above the ground and far from vegetation), background cluttered space (near the edges of vegetation, in vegetation gaps, and near the ground or water surfaces), and highly cluttered space (very close to surfaces such as leaves or the ground). Habitat complexity is therefore an important consideration for bats because areas that offer a variety of clutter conditions are more likely to support a greater diversity of bat species.

There is a range of suitable habitat for bats that can be used for roosting, foraging and commuting in the study area. This includes thicket and woodland habitats which provide a variety of clutter conditions and are known to be important for bats, particularly woodland (Cooper-Bohannon et al. 2016; Gelderblom et al. 1995). The western study area is dominated by grassland habitat which supports relatively high bat species richness (Gelderblom et al. 1995). Land use in the study area is primarily agricultural including grazing, stock farming and game farming and bats are known to be attracted to areas with livestock for foraging (Downs and Sanderson 2010). Cultivated areas are found along the two river systems that bisect the study area namely the Little and Great Fish Rivers. Cultivated areas are important foraging areas as some species forage over monoculture agricultural fields and prey on insect pests (Noer et al. 2012; Taylor et al. 2011). Farmsteads in the study areas contain lighting which at night will attract insects and in turn bats to hunt for prey.

Water sources are important for bats as a direct resource for drinking and because these areas tend to attract insects and promote the growth of vegetation (e.g. riparian vegetation). Therefore, besides providing drinking water, bats can also be attracted to water sources as potential foraging and roosting sites (Greif and Siemers 2010; Sirami et al. 2013). There are numerous artificial and natural wetlands, reservoirs and farms dams in the study area that will be attractive to bats. Rivers, canals and drainage lines will be equally important for foraging and commuting. Bats are known to use linear landscape features such as these, in addition to tree lines, for commuting routes to get to and from foraging sites, roost sites, to access water sources and because they provide protection to bats from predators, shelter from wind, and orientation cues (Verboom 1998).

The suitability of habitat for bats is also dictated by the roosting potential. Habitats with roosting spaces are likely to be more favoured compared to areas where roosts are limited. The availability of roosting spaces is a critical factor for bats (Kunz and Lumsden 2003) and a major determinant of whether bats will be present in a landscape, and the diversity of species that can be expected. The western study area is bordered on the north western edge by a major bat cave roost[1], and a second major bat roost is located within the eastern study area. Rocky crevices are also used as roosts by some species and these features can be found in the mountainous parts of the study areas. Additional known roosts occur inside the western study area; a farm building ca. 5 km west of the junction of the N10 and R400, and a tunnel, ca. 10 km west of Middleton. Other man-made infrastructure in the study areas may be used by bats as well [e.g. Cape serotine and Egyptian free-tailed bat, Monadjem et al. 2010)]. A number of free-tailed bats and plain-faced bats may roost in trees in woodland habitats, including in dead trees (Barclay 1985; Fenton et al. 1986; Monadjem et al. 2010). Evidence suggests that trees with larger trunks are preferentially selected by bats (Monadjem et al. 2010b) and therefore the existence of older, larger trees will increase the sensitivity of the site to wind energy development.

Five protected areas occur in region; Ezulu Game Reserve, Kwandwe Private Game Reserve, Aylesbury Nature Reserve, Frontier Safaris Game Farm, and Rockdale Game Ranch. It is assumed that the habitat on these properties is of higher value to bats compared to the surrounding landscape because of the conservation efforts, and therefore these areas should be avoided for turbine placement.

3.2 Bat Species Diversity

The study area falls within the actual or predicted distribution range of approximately 20 species of bat (Table 1). However, the distributions of some bat species in South Africa, particularly rarer species, are poorly known so it is possible that more (or fewer) species may be present. Several echolocation calls characteristic of species in the Plain-faced bat family were recorded but these calls were unable to be separated into distinct species. Since most of the species that these calls could belong to have a conservation status of Least Concern, and a risk rating from wind energy of Medium-High, these calls were grouped together and referred to as Unidentified plain-faced bat (Table 1). However, some calls could potentially be from *Myotis tricolor,* but it's presence has not been confirmed. *Myotis tricolor* has a national conservation status of Near Threatened and if this species is confirmed for the site, this would increase overall risk.

The sensitivity of bat species to the proposed wind farm is a function of their conservation status and the likelihood of risk to these species from wind farm development. The likelihood of risk to impacts from wind farms is based on the foraging and flight ecology of bats and migratory behaviour (Sowler et al. 2017). Seven high risk and five medium-high risk species occur in the study area and of these, fatalities at operational wind farms in South Africa are known for at least six, namely Cape serotine, Egyptian free-tailed bat, Natal long-fingered bat, Egyptian rousette, Egyptian slit-faced bat and Wahlberg's epauletted fruit bat (Doty and Martin 2012; MacEwan 2016; unpublished data).

[1] As defined by the South African Bat Assessment Association.

Table 1: Bat Species Occurrence within the Study Area

Species	Code	# of Passes	Conservation Status			Risk from Wind Energy
			National	Global	Population Trend	
Egyptian free-tailed bat *Tadarida aegyptiaca*	EFB	174,090	Least Concern	Least Concern	Unknown	**High**
Little free-tailed bat *Chaerephon pumilus*	LFB	17,016	Least Concern	Least Concern	Unknown	**High**
Natal long-fingered bat *Miniopterus natalensis*	NLB	48,811	Least Concern	Least Concern	Unknown	**High**
Lessor long-fingered bat *Miniopterus fraterculus*	LLB	-	Least Concern	Least Concern	Unknown	**High**
Mauritian tomb bat *Taphozous mauritianus*	MTB	-	Least Concern	Least Concern	Unknown	**High**
Cape serotine *Neoromicia capensis*	CS	81,574	Least Concern	Least Concern	Stable	**High**
Roberts's flat-headed bat *Sauromys petrophilus*	RFB	3,810	Least Concern	Least Concern	Stable	**High**
Wahlberg's epauletted fruit bat *Epomophorus wahlbergi*	WFB	-	Least Concern	Least Concern	Stable	**Medium-High**
Egyptian rousette *Rousetus aegyptiacus*	ER	-	Least Concern	Least Concern	Stable	**Medium-High**
Yellow-bellied house bat *Scotophilus dinganii*	YHB	7	Least Concern	Least Concern	Unknown	**Medium-High**
Temminck's myotis *Myotis tricolor*	TM	-	Least Concern	Least Concern	Unknown	**Medium-High**
Unidentified plain-faced bat* *Vespertilionidae species*	VSP	2,739	-	-	-	**Medium-High**
Dusky pipistrelle *Pipistrellus hesperidus*	DP	16,199	Least Concern	Least Concern	Unknown	**Medium**
Long-tailed serotine *Eptesicus hottentotus*	LTS	2,551	Least Concern	Least Concern	Unknown	**Medium**
Cape horseshoe bat** *Rhinolophus capensis*	CHB	2,142	Least Concern	Least Concern	Stable	**Low**
Geoffroy's horseshoe bat *Rhinolophus clivosus*	GHB	49	Least Concern	Least Concern	Unknown	**Low**
Bushveld horseshoe bat *Rhinolophus simulator*	BHB	-	Least Concern	Least Concern	Decreasing	**Low**
Swinny's horseshoe bat *Rhinolophus swinnyi*	SHB	-	Vulnerable	Least Concern	Unknown	**Low**
Lesueur's wing-gland bat** *Cistugo lesueuri*	LWB	-	Least Concern	Least Concern	Decreasing	**Low**
Egyptian slit-faced bat *Nycteris thebaica*	ESB	-	Least Concern	Least Concern	Unknown	**Low**
Lesser woolly bat *Kerivoula lanosa*	LWB	-	Least Concern	Least Concern	Unknown	**Low**

*Not able to be assigned to a specific species therefore identified to Family level only.
** Endemic to South Africa.

3.3 Spatio-Temporal Bat Activity Patterns

3.3.1 Overall Patterns

Eleven bat species (including the unidentified plane-faced bat species group) were detected and a total of 348,988 bat passes were recorded from 459 sample nights across all detectors.

There was a clear difference in bat activity with height above the ground; the vast majority of bat activity was recorded by microphones at 12 m (86 % of total activity) compared to 50 m (6 % of total activity) and 80 m (7 % of total activity). Species diversity was also higher at 12 m (eleven species) compared to at height (eight species). At 12 m there was also a clear difference in bat activity across the study area, with a mean of 70.4 bat passes recorded per detector per night in the eastern cluster compared to a mean of 36.0 bat passes per detector per night in the western cluster. In contrast, at height (i.e. at 50 m and 80 m), mean activity was higher in the western cluster (7.8 bat passes per night) compared to the eastern cluster (6.8 bat passes per detector per night). The ground level detectors recorded bats on most sample nights whereas at height bats were recorded on fewer sample nights (Table 2).

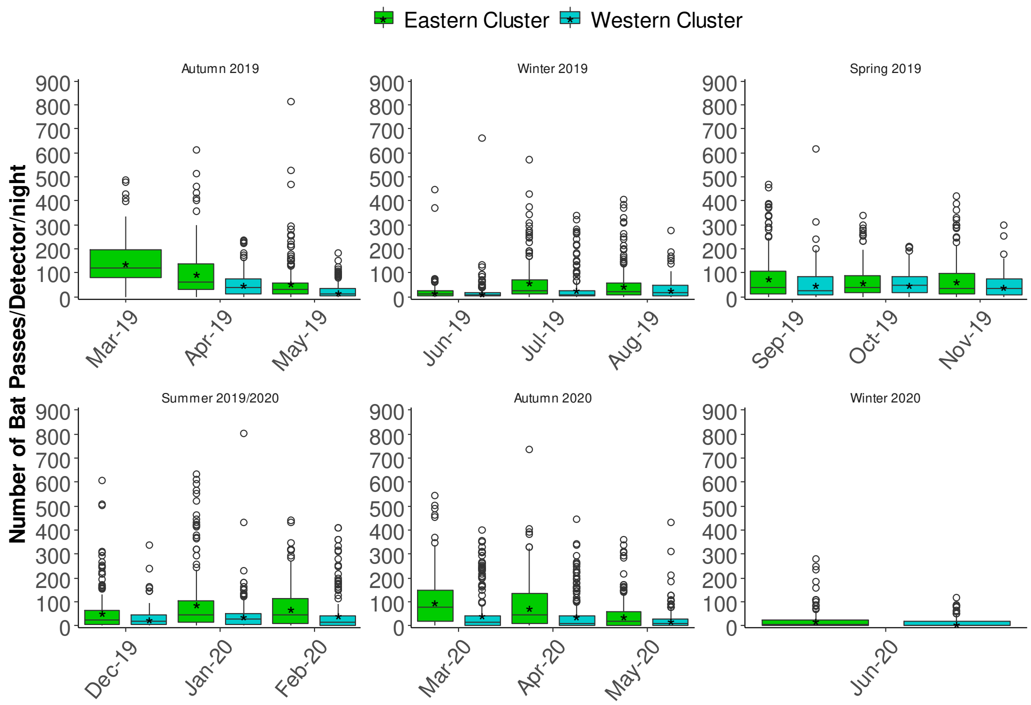
Table 2: Acoustic Monitoring Summary

Detector	Altitude* (masl)	Vegetation	# of Sample Nights	% of Sample Nights with Bat Activity	Mean Passes /night	Total Bat Passes
C1	819	Bedford Dry Grassland	270	92.9	25.7	6,951
C2	905	Bedford Dry Grassland	281	91.4	9.9	2,770
C3	759	Doubledrift Karroid Thicket	423	95.0	42.4	17,957
C4	718	Fish Valley Thicket	433	99.8	109.5	47,398
C5	523	Albany Valley Thicket	365	95.6	32.0	11,679
C6	677	Saltaire Karroid Thicket	430	72.8	20.8	8,937
C7	542	Albany Broken Veld	423	76.8	11.7	4,965
C8	417	Suurberg Quartzite Fynbos	429	97.4	60.0	25,757
C9	517	Saltaire Karroid Thicket	446	97.1	61.7	27,535
C10	593	Grahamstown Grassland Thicket	433	87.5	75.9	32,861
C11	558	Saltaire Karroid Thicket	459	96.1	37.4	17,183
C12	659	Albany Valley Thicket	269	87.7	69.4	18,679
C13	598	Saltaire Karroid Thicket	422	91.9	21.4	9,056
C14	551	Saltaire Karroid Thicket	415	96.9	167.2	69,385
C15_50m	1,063	Bedford Dry Grassland	174	45.5	3.1	543
C15_80m			174	7.5	0.3	49
C16_50m	831	Great Fish Thicket	170	45.1	3.1	531
C16_80m			170	33.5	1.6	275
C17_50m	1,013	Eastern Cape Escarpment Thicket	254	59.8	3.1	788
C17_80m			69	36.2	1.8	123
C18_50m	921	Great Fish Thicket	188	47.3	2.0	381
C18_80m			188	37.8	1.3	246
C19_50m	806	Great Fish Thicket	199	65.8	7.9	1,570
C19_80m			199	59.8	9.8	1,940
C20_50m	714	Great Fish Thicket	261	72.0	18.6	4,842
C20_80m			261	55.2	6.5	1,689
C21_50m	720	Great Fish Thicket	357	82.9	19.0	6,788
C21_80m			357	72.8	21.1	7,508
C22_50m	666	Great Fish Thicket	271	88.2	14.6	3,959
C22_80m			271	74.9	19.3	5,227
C23_50m	731	Kowie Thicket	252	59.9	4.9	1,228
C23_80m			252	51.6	3.0	745
C24_50m	728	Suurberg Quartzite Fynbos	310	48.4	4.0	1,242
C24_80m			310	46.8	3.0	936
C25_50m	618	Bhisho Thornveld	359	25.3	7.1	1,045
C25_80m			359	77.7	17.3	6,213

*Altitude measured at base of mast.

3.3.2 Ground Level Detectors

Mean activity per detector per night at 12 m was higher across all months in the eastern cluster compared to the western cluster (Graph 1). Activity was also more variable in the eastern cluster as shown by the outliers and wider interquartile ranges in each month. Mean activity was highest during March 2019 with 146.9 bat passes per detector per night. In both 2019 and 2020 mean activity was lowest in both clusters during June. Seasonally, mean activity was highest during autumn in the eastern clusters followed by summer while in the western cluster, mean activity was higher in spring compared to autumn and summer although activity was still lower in the western cluster compared to the eastern cluster during spring. The highest single night of activity at a detector happened in May 2020 at C10 (eastern cluster), with 816 bat passes in one night.



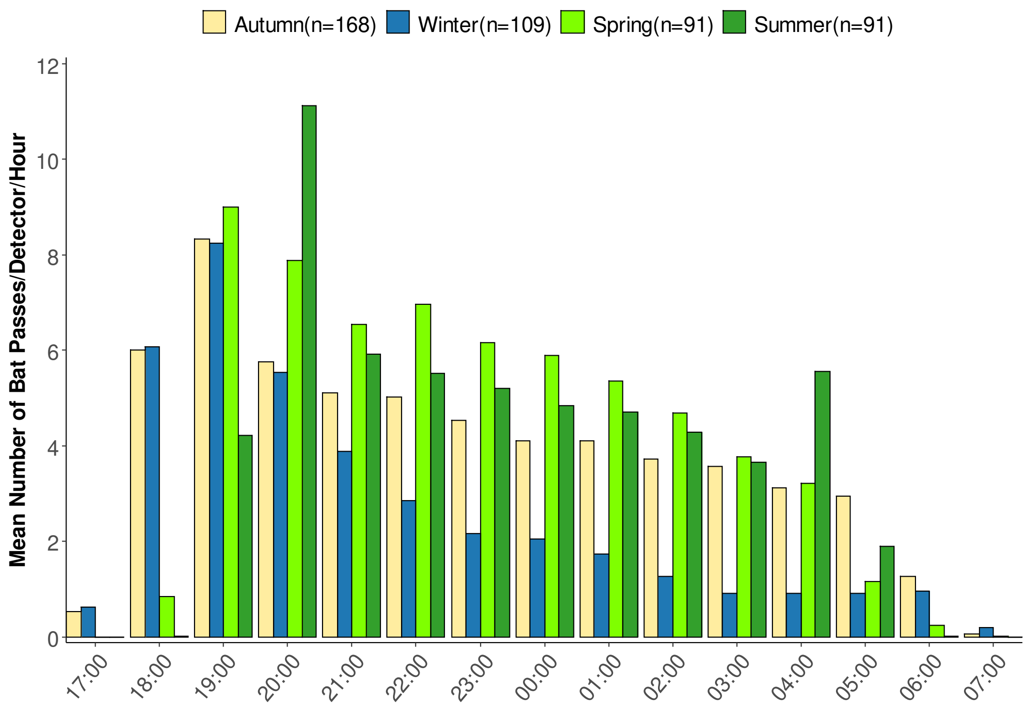
Graph 1: Box and Whisker plot of bat passes per month across the 14 short masts.
*** = mean.**

Data from ground level showed that in autumn and winter bat activity commenced between 17h00 and 18h00, an hour earlier than in spring and summer (Graph 2). Mean activity in autumn, winter and spring peaked between 19h00 and 20h00 with 8.5, 7.2 and 9.2 bat passes per hour per detector respectively. In summer mean activity peaked between 20h00 and 21h00 with 11.8 bat passes per hour per detector. In all seasons, activity declined throughout the night[2] after peaking but this varied at some locations. For example, at C4 and C11 activity increased slightly between 03h00 and 05h00, while at C5 and C8 activity only began to decrease from 01h00 and 02h00.

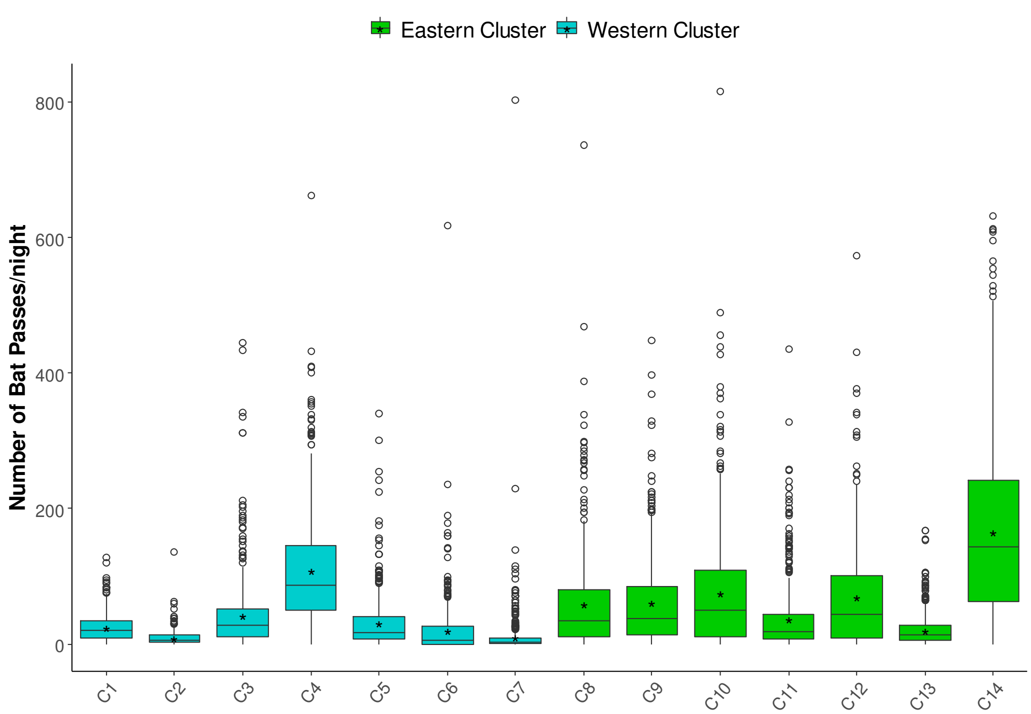
Among the ground level detectors, in the western cluster, activity was highest at C4 with a mean of 109.5 bat passes per night, and C2 and C7 had the lowest mean activity at 9.8 and 11.7 bat passes per night respectively (Graph 3). In the eastern cluster, mean activity was highest at C14 with 167.2 bat passes per night and lowest at C13 with 21.4 bat passes per night.

Eleven species were recorded by the ground level detectors. The Egyptian free-tailed bat was the most commonly recorded bat at all locations except for at C3, C11 and C12 where the Cape serotine was recorded most often, and C4 where the Natal long-fingered bat was recorded most often (Graph 4). The Cape horseshoe bat was also recorded most often at C4 compared to other locations. The Cape serotine was recorded markedly more often at C12 and C14 relative to other ground level detectors and overall, made up 27 % of all recordings. The Egyptian free-tailed bat accounted for 45 % of all recordings, the Natal long-fingered bat accounted for 16 %, and the remaining species each accounted for less than 5 % of recordings (except for the Dusky pipistrelle which accounted for just over 5 %).

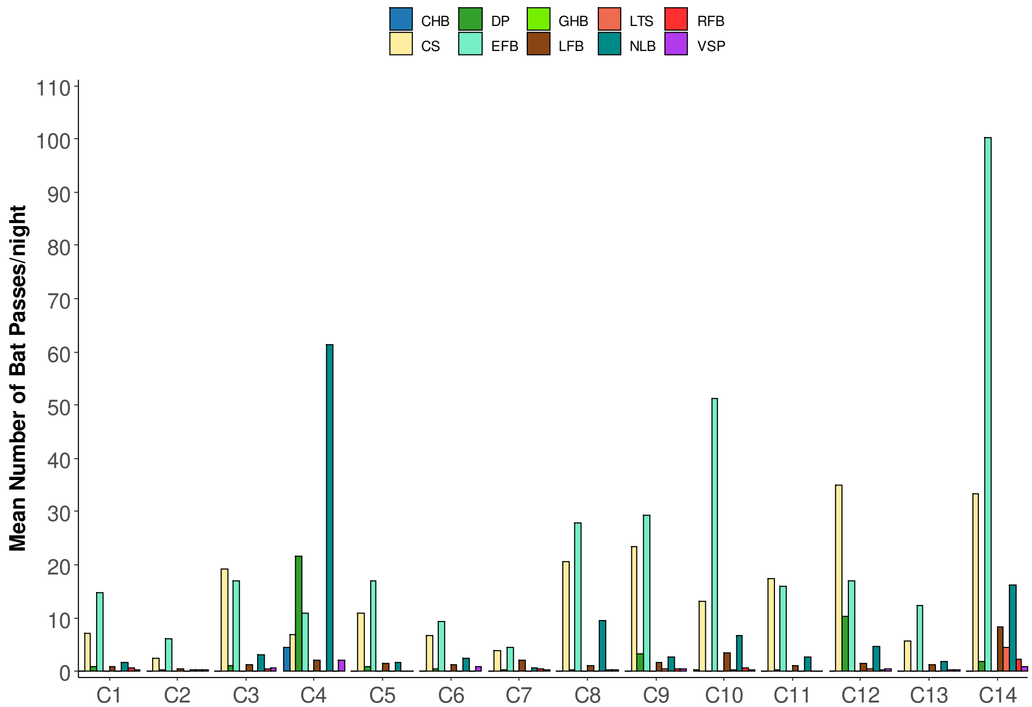
[2] "Night" refers to the time period 17h00 to 07h00, when bats are active.



Graph 2: The mean number of bat passes/hour across all detectors at ground level per season. Each time on the x-axis represents a one hour period (i.e. 17:00 = 17:00 – 18:00).



Graph 3: Box and Whisker plot of bat passes/night at ground level per detector. * = mean.



Graph 4: The mean number of bat passes/night at ground level per species per detector.

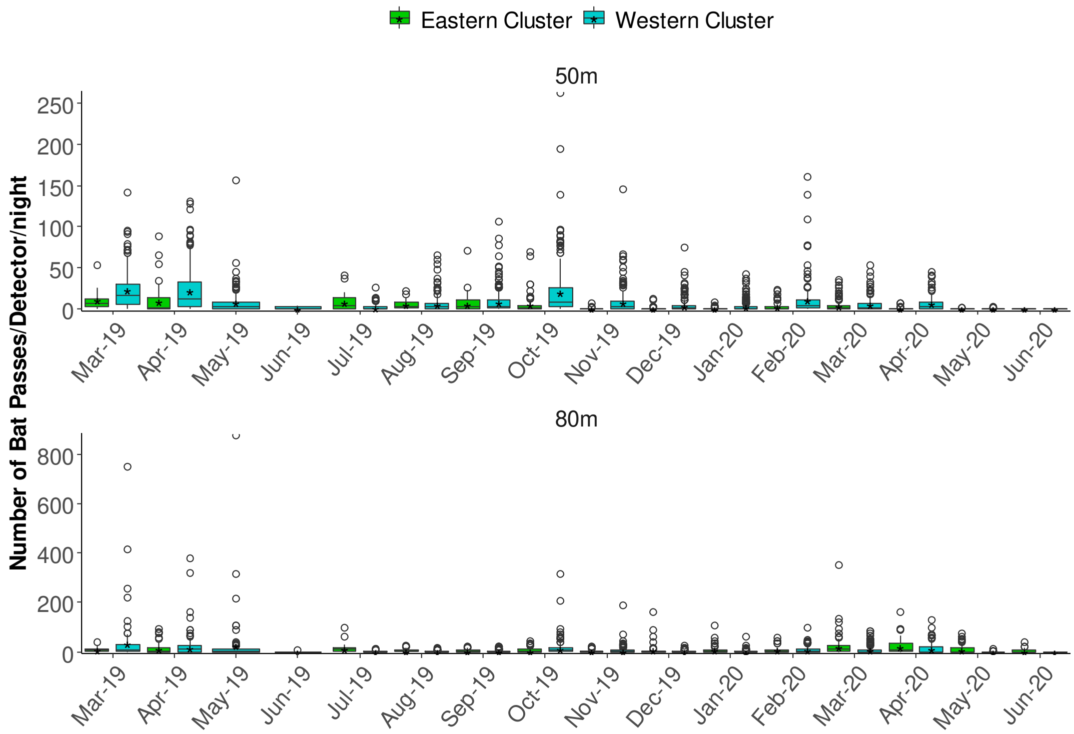
3.3.3 Meteorological Mast Detectors

Activity at ground level was far greater than at height for the monitoring period, with a total of 301,113 passes (86 % of activity) recorded at the short masts and 47, 868 passes (14 % of activity) at height. While bat activity at ground level was greater than at height, there was a small difference in bat activity among the at height data. Overall, 48 % (22, 917 passes) of at height bat activity was recorded at 50 m whereas 52 % (24, 951 passes) was recorded at 80 m.

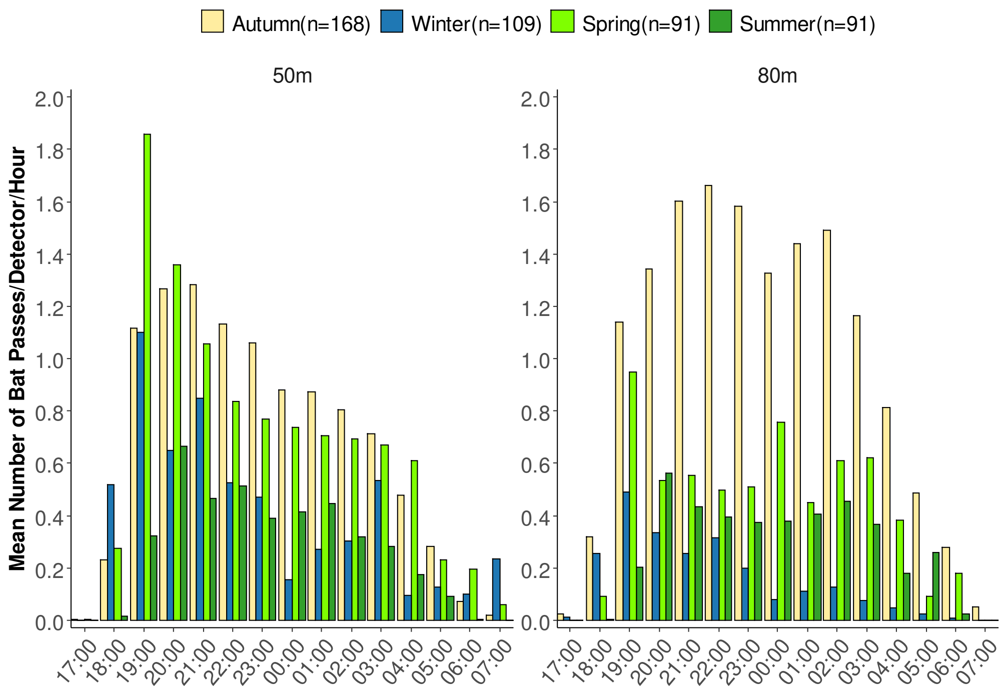
Mean activity at 50 m was greater in the western cluster compared to the eastern cluster across all months sampled except for during July 2019 whereas mean activity at 80m varied between sites and months (Graph 5). The seasonal pattern in bat activity across clusters was identical with greater mean activity during autumn, a reduction during winter, an increase into spring and a decrease into summer, however these differences were more pronounced in the west. At 50 m and 80 m, activity peaked in the western cluster in March with a mean of 24.1 and 35.0 bat passes per detector per night respectively.

Despite lower bat activity at height compared to ground level, at height activity, particularly at meteorological masts in the western cluster was still relatively high, compared to ground level, during some periods. For example, at 80 m, 828 bat passes were recorded on 21 March 2019 and 986 bat passes were recorded on 9 May 2019 (Graph 5) which is within the order of magnitude of most nights of activity recorded closer to ground level.

At 50 m during autumn, peak bat activity during the night occurred between 21h00 and 22h00 with a mean of 1.3 bat passes per hour per detector, following which activity declined steadily throughout the night. At 80 m during autumn, activity peaked between 22h00 and 23h00, did not decrease as rapidly through the night compared to 50 m and had a slight peak from 02h00 to 03h00 (Graph 6). For all time periods from 20h00 in autumn, mean activity was greater at 80 m compared to 50 m. In contrast, during spring activity was greater during all time periods at 50 m compared to 80 m except for between 00h00 and 01h00. Activity peaked at both 50 m and 80 m between 19h00 and 20h00 with a mean of 1.9 and 0.9 bat passes per hour per detector respectively, although at 50 m there was a more obvious peak in activity and subsequent decline during the night whereas at 80 m activity did not vary much. In winter, peak activity at 50 m and 80 m occurred between 19h00 and 20h00 with a mean of 1.1 and 0.5 bat passes per hour per detector respectively and in summer, activity peaked between 20h00 and 21h00 with a mean of 0.7 and 0.6 bat passes per hour per detector at 50 m and 80 m respectively.

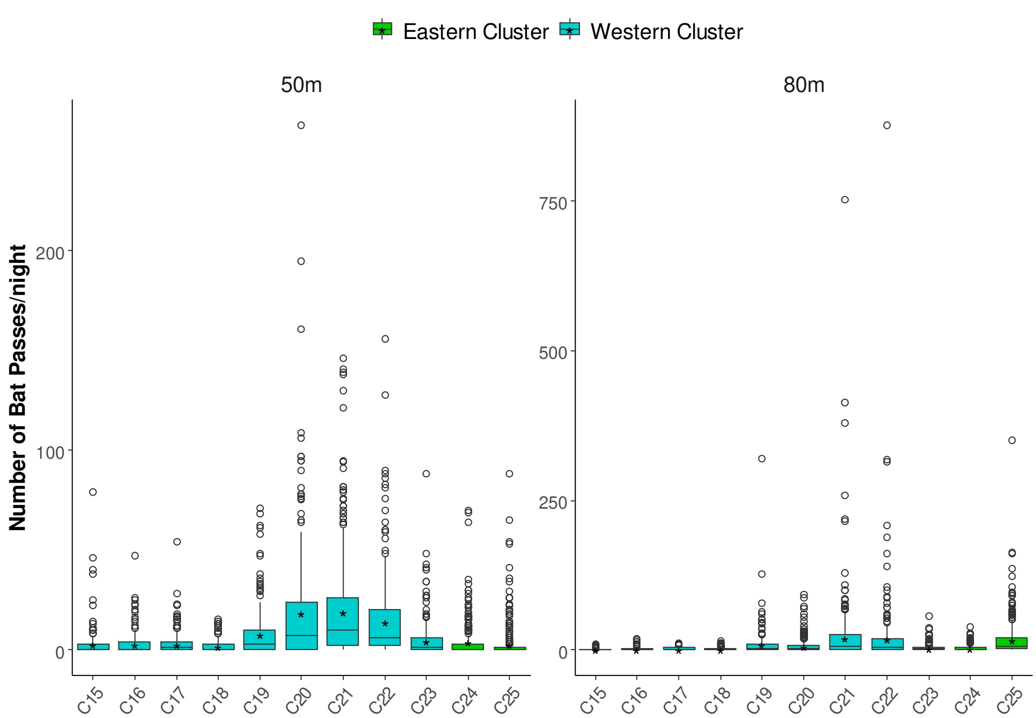


Graph 5: Box and Whisker plot of bat passes per month across the 11 meteorological masts. * = mean.



Graph 6: The mean number of bat passes/hour at height per season per detector. Each time on the x-axis represents a one hour period (i.e. 17:00 = 17:00 – 18:00).

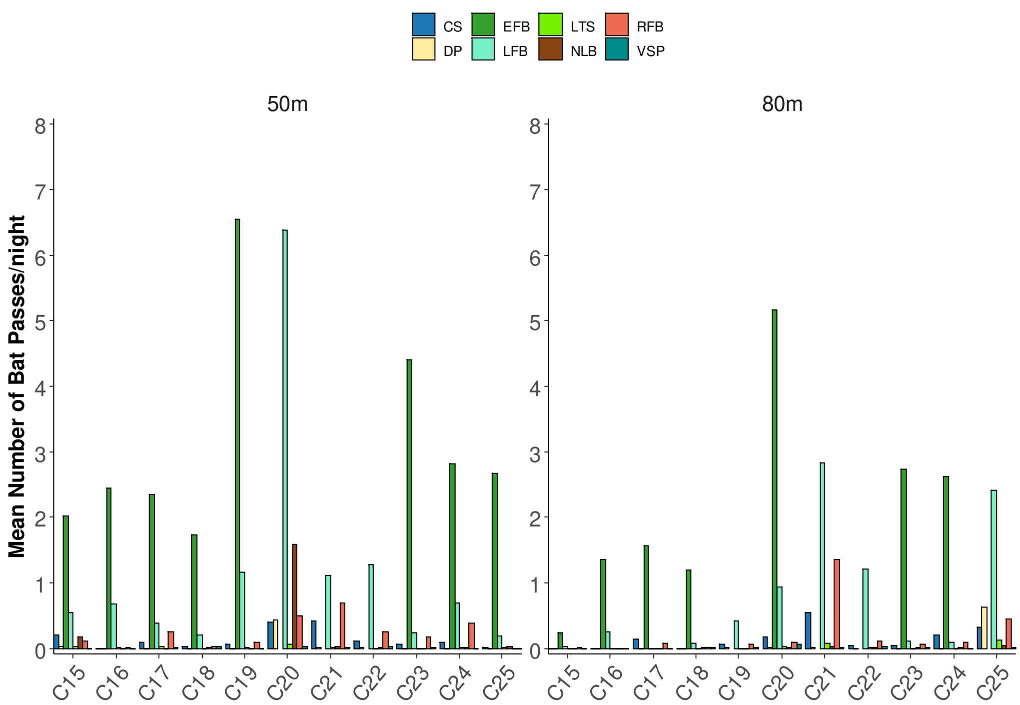
Spatially, bat activity was notably higher at C19, C20, C21 and C22 compared to the other meteorological masts both at 50 m and 80 m (Graph 7). Total activity was highest at C21 and C22 with 14,296 and 9,186 bat passes respectively. Mean activity was greater at 50 m than 80 m at seven of the eleven masts.



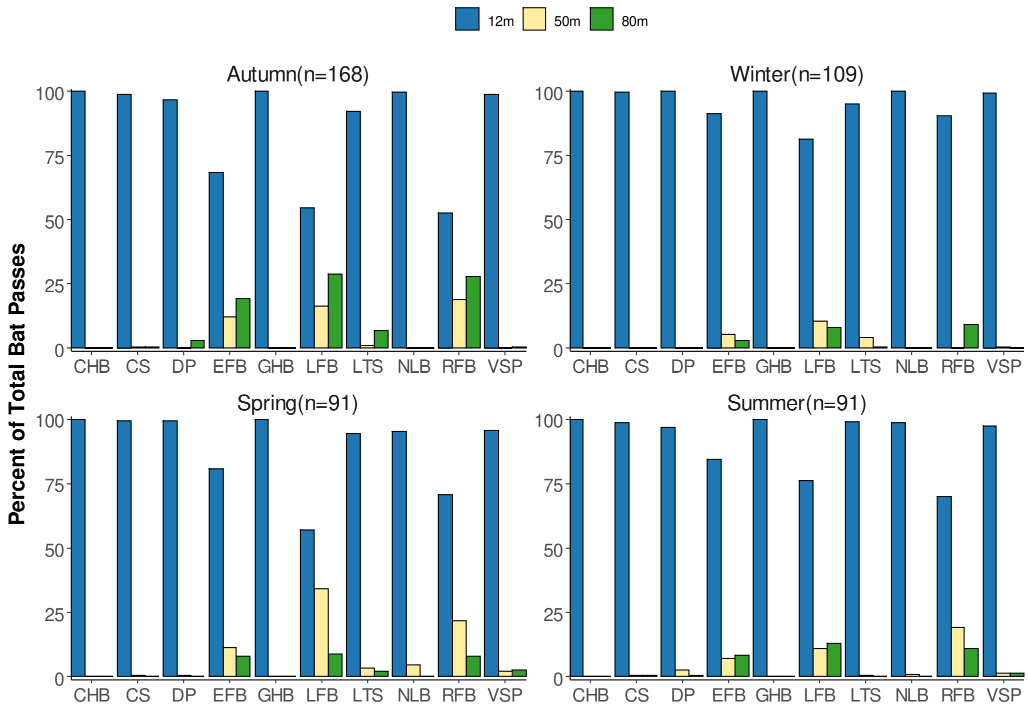
**Graph 7: Box and Whisker plot of bat passes/night at height per detector.
* = mean.**

Of the eleven species recorded at ground level, only eight bat species were recorded at height (Graph 8). The two Horseshoe bat species were not recorded at height (Graph 9). The Egyptian free-tailed bat had a total of 135, 570 passes at ground level and 38, 520 passes at height, which accounted for 45 % of total ground level activity and 80 % of all at height activity. Little free-tailed bats had a total of 11, 034 passes at ground level and 5, 982 passes at height, which accounted for 4 % of all ground level activity and 12 % of all at height activity. Therefore together, free-tailed bats were responsible for 92 % of activity (44, 502 bat passes) at 50 m and 80 m. Proportionally to other species these two species spent less time at ground level (i.e. 12 m) and more time at height than other species, with only 78 % and 64 % of their activity recorded at 12 m respectively. Even though total bat passes of Egyptian free-tailed bats was greater than Little free-tailed bats, a greater proportion of total activity of Little free-tailed bats was at height, approximately 35 % compared to 22 % for Egyptian free-tailed bats. For most species, season did not influence activity in relation to height but for Egyptian free-tailed bats, activity was proportionally higher at height during autumn and spring compared to summer and winter (Graph 9). Similarly, Little-free tailed bats were more active at ground level during summer and winter compared to autumn and spring.

Mean activity at 12 m, 50 m and 80 m for Egyptian free-tailed bats was 23.8, 5.8, and 6.5 bat passes per detector per night respectively. For Little free-tailed bats, mean activity at 12 m, 50 m and 80 m was 1.9, 1.2 and 0.8 bat passes per detector per night respectively.



Graph 8: The mean number of bat passes/night at height level per species per detector.



Graph 9: The percentage of total bat activity spent at various heights across species per season.

The results from the logistic regression models modelling the probability of occurrence of the Egyptian and Little free-tailed bats show that probability of bat presence varied markedly both spatially (across heights, and detector location) and temporally (between seasons), and there were also differences between species. For the most part the probability of bat presence decreased with increasing height up to 150 m (e.g. at C15, C16, C18, C23, C24; Graph 10). However, at this height and at these five locations, the probability of presence is still at least 20 %[3] apart from at C15 where free-tailed bats are not predicted to be very active beyond approximately 100 m. At C19, C21, C22 and C25 free-tailed bat presence is predicted to increase with height although at C22 this is not significant for the Egyptian free-tailed bat. However, some of these patterns break down when modelling presence as a function of season. For example, at C18 in autumn the relationship between height and the presence or absence of bats is not significant despite a decreasing trend when not considering season. Similarly, while the overall trajectory of bat presence appears to increase with height at C19, when modelled per season, this trend is either negative or not significant. Only at C25 was bat presence predicted to increase with height across all seasons.

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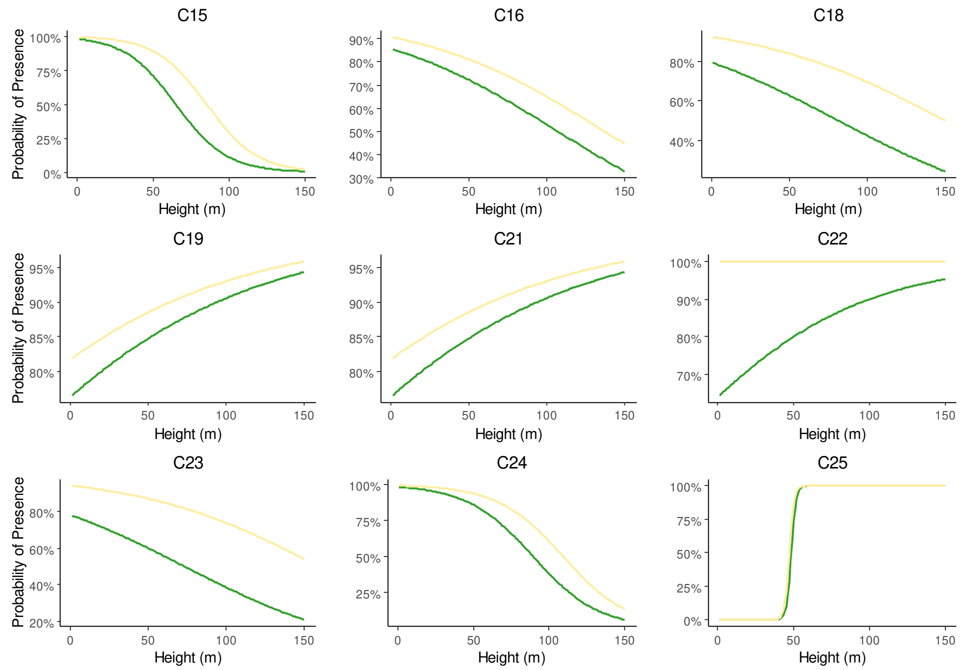
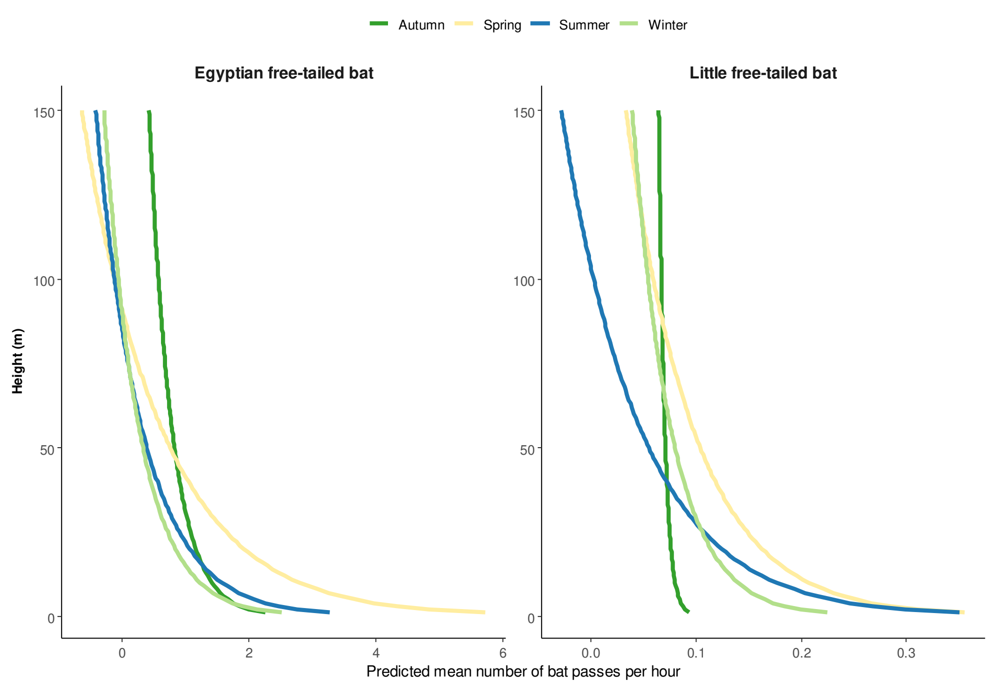
[3] This is based on a predictor model from the activity data collected over the sampling period and gives the percentage likelihood of finding a bat at this height.



Graph 10: The probability of presence of Egyptian (yellow) and Little (green) free-tailed bats with height modelled with data from meteorological masts.

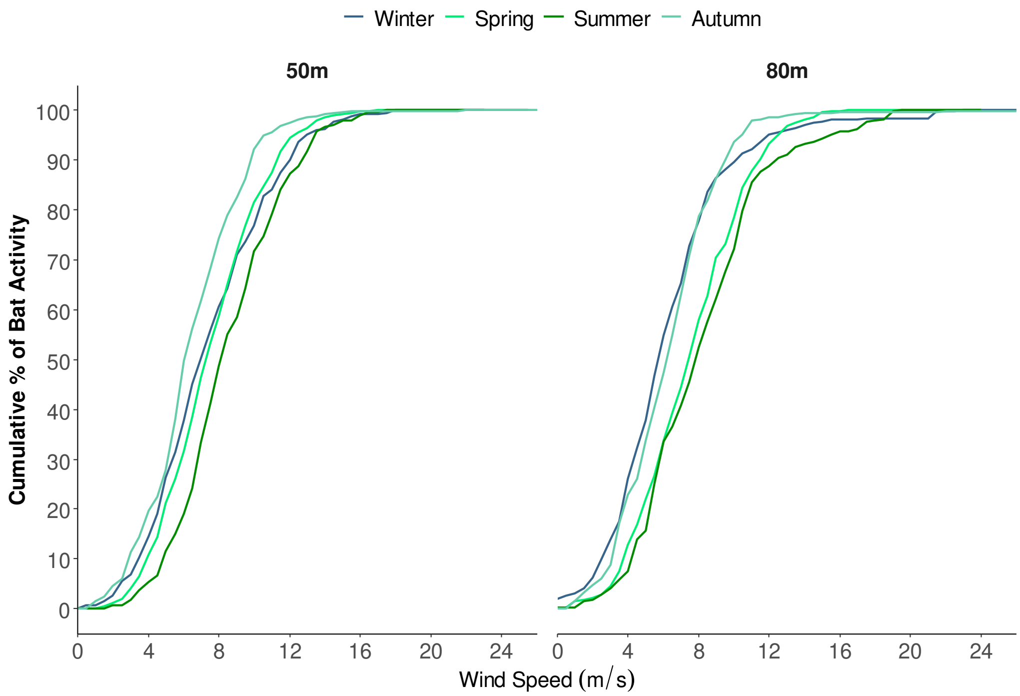
The mean number of bat passes per hour is predicted to decrease exponentially with height across all seasons for free-tailed bats (Graph 11). At 150 m the mean number of passes is predicted to be highest in autumn for Egyptian free-tailed bats (approximately 0.3 passes per hour) and in winter for Little free-tailed bats (approximately 0.7 passes per hour).



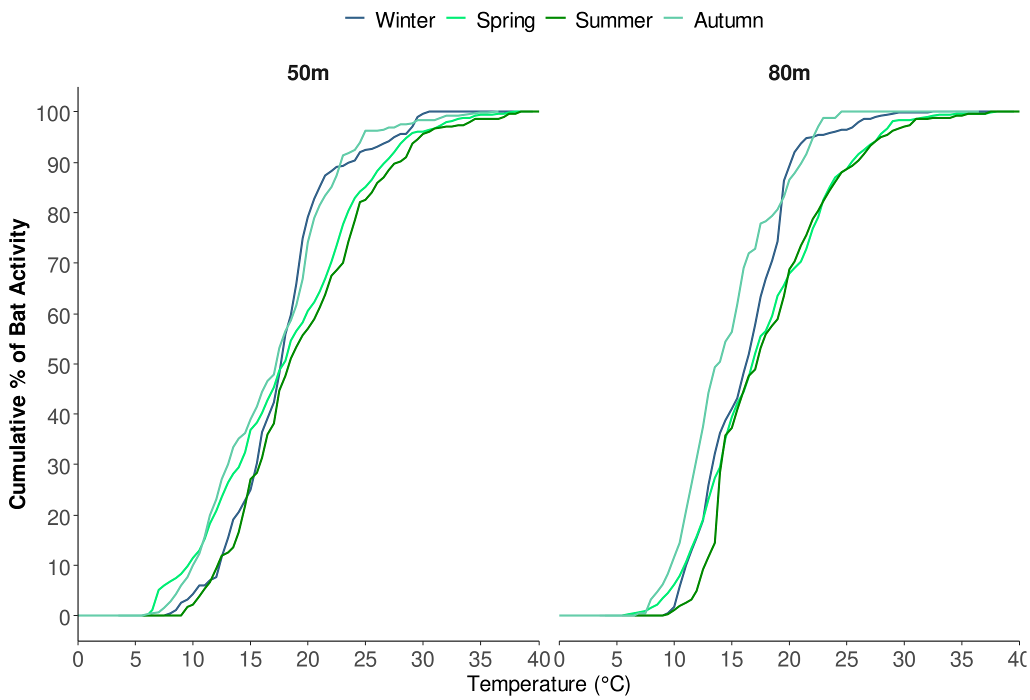
Graph 11: The predicted mean number of bat passes per hour with height modelled with data from meteorological masts.

No bats were recorded in wind speeds above 24.5 m/s in autumn, 17 m/s in spring, 26.5 m/s in winter and 19.5 m/s (Graph 12). In autumn and spring, half of accumulated bat activity had occurred in wind speeds below 8 m/s at 50 m while at 80 m half of accumulated activity occurred below 8 m/s in spring and 6.5 m/s in autumn. In winter, half of accumulated bat activity had occurred in wind speeds below 7 m/s at both 50 m and 80 m while half accumulated activity in summer occurred below 9 m/s at 50 m and 8.5 m/s at 80 m. Very little additional bat activity occurred above approximately 8.5 m/s in autumn and winter, or above 10.5 m/s in spring and 11 m/s in summer (Graph 12).

No bats were recorded in temperatures above 32.5 °C in autumn, 37 °C in winter, and 38.5 °C in spring and 39 °C in summer, nor were bats recorded below 6 °C in any season (Graph 13). In autumn half of accumulated bat activity had occurred in temperatures below 18.5 °C at 50 m and 17 °C at 80 m. In spring, this remained the same at 50 m and increased to 17.5 °C at 80 m and, in winter, decreased to 18 °C at 50 m and 14.5 °C at 80 m. The highest temperatures were in summer with half accumulated activity occurring below 19 °C at 50 m and 18 °C at 50 m.

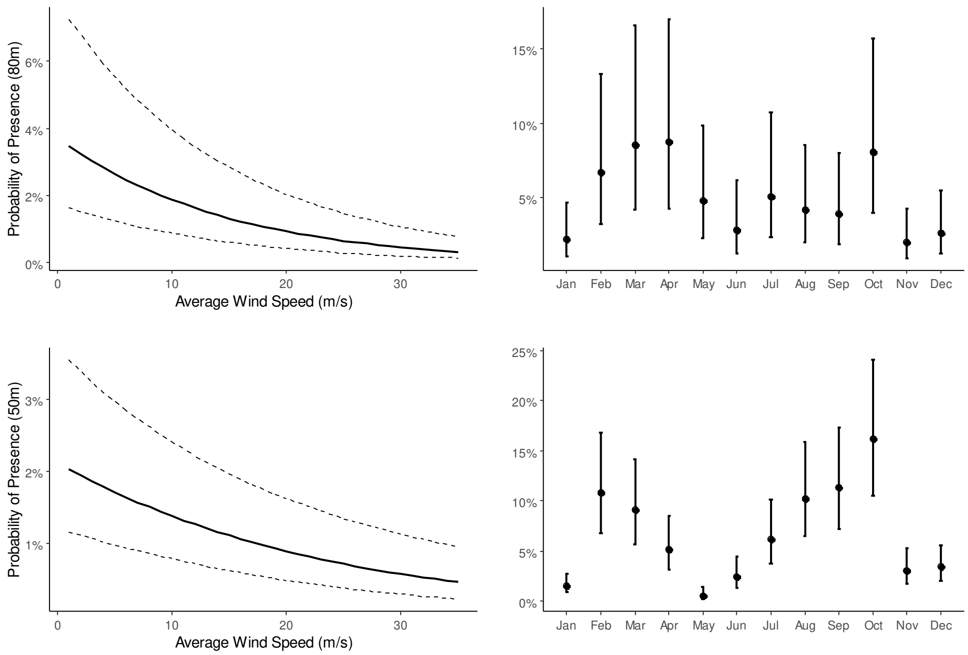


Graph 12: Accumulation curve of bat activity with wind speed



Graph 13: Accumulation curve of bat activity with temperature

The average (and maximum) wind speed is a significant predictor of the probability of bat occurrence. The predicted probability of bat occurrence decreases as the wind speed increases (Graph 14). The probability of bat presence is higher at 80 m than 50 m and decreases as the average wind speed increases, with a larger decrease at 80 m. The model showed seasonal influence on bat activity at both 50 m and 80 m. At 50 m, there is a higher probability of presence in spring (particularly in October) which decreases into summer, peaks again in late summer/early autumn, decreases into winter and increases again into late winter (Graph 14). Alternatively, probability of presence at 80 m is low in spring, increases from early summer and is highest in autumn (particularly March and April). However, probability of presence also decreases into winter at this height.



Graph 14: Logistic regression using sites (C15, C16, C17, C18, C23) with wind data (random effect) with height and month at 80m and 50m.

4 DISCUSSION

Several bat species that are susceptible to wind energy impacts are present in the study area. This includes five high risk species; Egyptian free-tailed bats, Little free-tailed bats, Natal long-fingered bats, Robert's flat-headed bat and Cape serotines. Several medium-high risk species are also present including at least two Plain-faced bat species that could not be identified using the acoustic data. Fatality records of most of these species mentioned above are known from operating wind farms in the region (unpublished data), and in other parts of South Africa (Doty and Martin 2012; Aronson et al. 2013; MacEwan 2016). All of these species have a Red List conservation status of least concern however wind energy is an emerging impact which may not be fully considered yet by the Red List of Mammals of South Africa and IUCN Red List.

The main finding of the monitoring is that Egyptian free-tailed bats were the most commonly recorded species across all heights which reflects the widespread and abundant status of this species in South Africa (Monadjem et al. 2010). This species is adaptable in roost selection and uses caves, rock crevices, exfoliating rock and bark, tree hollows, and buildings as roosts, all of which are present in the study area to varying degrees. No confirmed roosts of this species have been found. These bats are adapted for flight in open areas, well above vegetation which appears to therefore not influence this species (Monadjem et al. 2010) and will also hunt insects around lights. Although recorded less than Egyptian free-tailed bats, Little free-tailed bats are also adapted for flight in open spaces high above the ground and spent proportionally more activity at height than Egyptian free-tailed bats. The remaining species were recorded very seldom at height with only 8 % of total activity attributable to other species. Therefore, risk to free-tailed bats is likely to be higher compared to other species although this will depend on turbine size.

Other key findings of the monitoring are that firstly activity was relatively very high during March and April (autumn) compared to June (winter), which was low, regardless of location or height. Outside of these months, activity ranged from high to moderate depending on the month and location. Secondly, bat activity is predicted to decrease with height although this is not uniform across space and time. For example, despite the overall decrease in activity from 150 m, there is still at least a 20 % chance that bats will occur at 150 m at some locations (e.g. C16, C19, C21 and C23) during some parts of the year. Further, based on data from five meteorological masts, bat activity decreased with wind speed and very little bat activity occurred above approximately 10.5 m/s but this varied with season. No bats were recorded below 6 °C depending on season. Fourthly, bat activity was notably higher at C4, C19, C20, C21 and C22 all of which are located relatively near to each other. The higher activity at these detectors could be because they are situated between the Little and Great Fish Rivers which have extensive cultivated areas along their banks and the associated availability of foraging and roosting spaces. Increased bat activity was recorded in these cultivated areas during the drive transects. Activity was also notably higher at C14 in the eastern study area. Finally, two active roosts, both tunnels, are present in the study area, one near C4 and the other near C10. The roost at C4 could not be surveyed because the entrance is not safe to negotiate but bats were observed emerging from the roost. This is a known roost of Natal long-fingered bats are our data from C4 showed that activity of this species was higher near this roost which corroborates this. The Cape horseshoe bat was also recorded more often at this location which suggests that this species is also using this roost. The roost near C10 was surveyed four times (in winter, spring, early- and late summer) and approximately 100 Cape horseshoe bats were roosting in this tunnel throughout the year. No other bat species were recorded at this roost although the Natal long-fingered bat was present in 2009 (Wood, 2012) and has historically been known to use it.

To analyse risk to bats, the empirical and predicted monitoring results were considered in relation to observed and estimated impacts at three operational wind farms near the proposed Choje wind farms, as well as referencing risk levels in the best practise guidelines for bat monitoring (Sowler et al. 2017). At the Waainek Wind Farm, the turbine blades sweep down to 28 m and up to 140 m and across two years, and most impacts were to high flying species. At the Amakhala Wind Farm, the turbine blades sweep between 32.5 m and 149.5 m above the ground and most bat fatality over a two-year period comprised high flying species. Bat fatalities at this facility exceed threshold levels proposed by MacEwan et al. (2018). At the Cookhouse Wind Farm, blades sweep down to 36 m and up to 124 m and over a year, most bat fatality comprised of high flying species.

These data clearly illustrate the free-tailed bats are likely to face the highest risk of impacts associated with the Choje wind farms since the majority of fatalities in the region are in this family and because they were the most active species at height. At Choje West 1, Choje West 2, and in the eastern study area, free-tailed bats are at high risk for impacts at 50 m and 80 m based on the mean number of bat passes per hour. However, elsewhere in the western study area free-tailed bats are at lower risk. Risk to these bats will also occur in the lower areas of the rotor swept zone too. There are no empirical data above 80 m for the study area but free-tailed bat activity is predicted to occur up to at least 150 m, and likely higher than this as free-tailed bats are known to be present at high altitudes (McCracken et al. 2008; Peurach et al. 2009). At 150 m, based on the predicted mean number of bat passes per hour, risk to the Egyptian free-tailed bat is low across both the eastern and western study areas. Given that activity decreases with height, risk to this species at 246 m, the maximum tip height under consideration, is also likely to be low. The Little free-tailed bat is predicted to be at medium risk at 150 m, but only in summer, near Middleton and in the eastern area but at low risk in the rest of western study area and during other seasons, based on the predicted mean number of bat passes per hour. At 246 m, it is difficult to determine with the data available if this risk would still be medium or be reduced to low.

The fatality data from the three operational wind farms also show that lower flying species may be impacted despite lower activity measured at 50 m and 80 m. There are no empirical data on bat activity between 12 m and 50 m but the activity of lower flying species is of such a magnitude that they would be at risk if turbine blades sweep down close to ground level, depending on the spatial location of the turbines. For example, the turbine blades at the three operational wind farms in the region sweep down to 28 m, 32.5 m and 36 m respectively and impacts to lower flying species do occur, particularly at the Cookhouse Wind Farm. Based on the mean number of bat passes per hour, the risk to lower flying bat species is likely to be low at ground level for most of the western study area (except near C4 where it is medium), while in the eastern study area risk at ground level is medium. Given the potentially medium risk to bats near ground level it is important to maximise the minimum tip height to prevent blades from entering medium risk airspaces as much as feasible. There is no accepted definition of "ground level" with respect to flying bats and since mortality to lower flying species have occurred where blades sweep down to 36 m, it can reasonably be assumed that these individuals were at least flying 36 m above the ground.

Mitigation options that must be incorporated into the project to minimise impacts can be categorised into avoidance and minimisation techniques. Avoidance includes buffering key habitats and considering turbine design so that potential interactions between bats and wind turbines are spatially limited as much as possible. Minimisation relates to mitigating residual impacts to bats primarily through various forms of curtailment[4] or by using ultrasonic acoustic deterrents.

Avoidance mitigation techniques have been incorporated by buffering key habitat features for bats. These includes roosts (rocky crevices, tunnels, trees and buildings), foraging resources (trees, drainage areas, cultivated areas, and aquatic habitat) and commuting resources (drainage areas due to their linear nature). All features, except for drainage lines and some specific roosts, were buffered by 261 m to turbine base (i.e. 200 m to blade tip based on turbines with a hub height of 105 m (the lowest being considered) and blade lengths of 81 m (the longest being considered). Drainage lines were buffered by 100 m to blade tip. The tunnel roost entrances near C4 and C10 were each buffered by 2.5 km. At C4, the roost very likely contains at least 50 Natal long-fingered bats and since these bats have a medium to high fatality risk based on their ecology and activity near the roost, a 2.5 km buffer is needed based on best practise guidelines (Sowler et al. 2017). At C10, even though only 100 least concern, low risk bats are currently present in the roost (which would require a 1 km buffer), the roost has been used in the past by Natal long-fingered bats, it is a regionally important roost, and it is an active site for bat research for a number of local and international universities. Therefore, a 2.5 km buffer has also been placed on the two entrances to this tunnel. Sensitivity maps were created for each of the six proposed development envelops which capture these design constraints (Figures 3 through 8). No turbines are allowed inside these buffers, including blades.

Adherence to these buffers is the primary mitigation measure to avoid impacts. A secondary measure is the consideration of turbine design. Evidence of a relationship between turbine size and bat fatality is equivocal. Some evidence suggests that larger turbines kill more bats (Baerwald and Barclay 2009) or that as the distance between the blade tips and the ground increases, bat fatality decreases (Georgiakakis et al. 2012). However, other studies have found no evidence that turbine height or the number of turbines influences bat mortality (Berthinussen et al. 2014; Thompson et al. 2017). Due to this uncertainty, to avoid potential impacts to lower flying species the turbine blades should not sweep down past 36 m, and ideally higher than this. This height was chosen based on data from the Cookhouse Wind Farm where bat mortality has included a high proportion of lower flying species. This mitigation measure will primarily reduce impacts to lower flying species whereas high flying species, such as the Egyptian and Little free-tailed bat, will still be at

[4] Curtailment – the act restricting normal operation of a wind turbine by slowing or stopping blade rotation for a period of time.

risk independent of the minimum blade tip height because they are adapted to fly in open areas, high above the ground and are predicted to be present at 150 m albeit with a low to medium risk. Minimising the rotor swept area as a whole is the preferred measure to reduce impacts to these species.

Besides these avoidance mitigation measures, curtailment or deterrents can be used to mitigate residual impacts to high-flying species such as the Egyptian free-tailed bat, or other species that are impacted upon. Given the relatively high bat activity recorded at times in parts of the study areas and based on fatality patterns at three nearby operational wind farms, curtailment or deterrents may be needed during the operational phase depending on bat fatality, for limited periods if thresholds for fatality are exceeded.

Because so little is known about migration routes, fecundity rates and population numbers of bats in South Africa the fatality threshold is an ongoing discussion, but is usually influenced by natural mortality of bat species, density dependent factors, activity levels per ecoregion, percent loss to natural declines and size of the site. 2% additional losses to bat populations from anthropogenic pressures in an ecoregion can be calculated according to The South African Bat Assessment Association fatality threshold guidelines. Thresholds calculated for the Choje Wind Farms equate to an estimate of 1,949 bat fatalities[5] per least concern insectivorous bat species or family per annum (Calculated across the whole area of all wind farms). Should this value be exceeded, curtailment or deterrents must be applied. In addition, if one fatality for various conservation important species occurs during a 12 month period, these mitigation measures will also need to be applied (refer to MacEwan et al. 2020 for species list). The probability that a conservation important species will trigger mitigation is low since none have been recorded at the site thus far, and none have been reported for the neighbouring wind farms either.

If curtailment or deterrents are needed based on threshold values being exceeded, their use would be confined to specific periods of the year and under specific meteorological conditions. Based on the data available, these periods would initially be restricted to summer (February), autumn (March and April) and spring (October) and during specific wind speeds and temperatures. These parameters were combined into an overall curtailment algorithm (Table 3) and once these conditions are met, curtailment or deterrents must be implemented if threshold bat mortality values are exceeded.

Table 3: Preliminary Curtailment Parameters for the Choje Wind Farms*

	October (Spring)	**February (Summer)**	**March - April (Autumn)**
Time Period	19h00 – 00h00	19h00 – 22h00	19h00 – 03h00
Temperature (°C)	Above 18	Above 18.5	Above 17.5
Cut in Wind Speed (m/s)	Below 8 m/s	Below 8.5 m/s	Below 8 m/s

*To be applied if more than 1,949 bat fatalities occur per least concern insectivorous bat species or family per annum, or if one fatality for a conservation important species occurs during a 12 month period.

Curtailment techniques that must be considered are blade-feathering, raising the cut-in speed and if needed, shutting down turbines. Alternative options include using deterrents which can also reduce bat fatalities (Arnett et al. 2011; Romano et al. 2019) or using a smart curtailment approach. Smart curtailment analyses bat activity and meteorological data to make near real-time curtailment decisions when bats are detected in an area and can reduce the curtailment time required to reduce impacts to bats (Hayes et al. 2019).

5 CONCLUSION

Free-tailed bats are likely to face the highest risk of impacts associated with the Choje wind farms. This risk will be spatially variable and confined to high at Choje West 1, Choje West

[5] Assuming an area of influence of 44,300 hectares, and a threshold of 0.44 bats per hectare for the Albany Thicket ecoregion.

2, and in the eastern study area and low elsewhere. Sensitive design and mitigation will be needed to reduce risk to these bats. Sensitive areas including those used by bats for foraging, roosting and commuting should be avoided for turbine placement. These have been mapped and the current layout iteration adheres to avoidance of sensitive and no-go areas. The choice of turbine design, specifically, the hub height and rotor diameter, should be carefully chosen to reduce potential interactions between bats and turbine blades. A minimum blade tip height of 36 m is proposed, as well as the overall minimisation of the rotor swept area as far as practicable. Residual impacts will still be likely to occur and the use of curtailment and/or deterrents should be incorporated into project planning so that the financial implications can be understood as soon as possible.

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FIGURES