DEVELOPMENT OF THE THEMEDA PV FACILITY AND ASSOCIATED INFRASTRUCTURE, NORTH WEST PROVINCE

Avifauna Baseline and Impact Assessment Report

July 2022

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EXECUTIVE SUMMARY

Pachnoda Consulting cc was requested by Themeda PV (Pty) Ltd to compile an avifauna impact assessment report for a photovoltaic (PV) solar energy facility and associated infrastructure on Portion 7 of Farm Elandsfontein 34, near Lichtenburg, North West Province.

The objectives of the avifaunal study were to: (a) describe the avifauna associations in the study area according to species composition and richness prior to construction activities; (b) provide an inventory of bird species occurring in the project area including species prone towards collisions with the proposed infrastructure; (c) provide an impact assessment; and (d) provide an indication of the occurrence of species of concern (e.g. threatened and near threatened species).

Baseline avian data was obtained from point count sampling techniques during two independent sampling sessions (January 2022 and May 2022).

Four prominent avifaunal habitat types was identified on the site and consisted of open mixed dolomite grassland with bush clump mosaics, moist dense grassland, mixed woodland on dolomite outcrops and secondary grassland and pastures, with high bird richness and abundance values recorded at the mixed woodland. The bird richness and passerine densities on the remaining habitat units were relatively low. Approximately 183 bird species are expected to occur in the wider study area, of which 92 species were observed in the study area (during a wet and dry season survey). The expected richness included 10 threatened or near threatened species, 14 southern African endemics and 18 near-endemic species. The critically endangered White-backed Vulture (*Gyps africanus*) and endangered Cape Vulture (*G. coprotheres*) have a high probability of occurrence, mainly as foraging birds soaring overhead (both species have been observed from similar habitat adjacent to the study site). Eleven southern African endemics and 12 near-endemic species were confirmed on the study site.

The main impacts associated with the proposed PV solar facility included the following:

- The loss of habitat and subsequent displacement of bird species due to the ecological footprint required during construction.
- Direct interaction (collision trauma) by birds with the surface infrastructure (photovoltaic panels) caused by polarised light pollution and/or colliding with the panels (as they are mistaken for waterbodies).
- Collision with associated infrastructure (mainly for existing overhead power lines).

An evaluation of potential and likely impacts on the avifauna revealed that the impact significance was moderate to low after mitigation (depending on the type of impact). The study site is not located near any prominent wetland system or impoundment, and therefore the risk of waterbird collisions with the proposed infrastructure was considered to be low. In addition, the occurrence of collision-prone bird species (apart from vultures) such as korhaan taxa and birds of prey was relatively low. However, in the absence of sufficient information on the occurrence and rate of passing waterbirds and collision-prone bird species, it was recommended that supporting evidence be acquired by means of at least another pre-construction survey corresponding to the wet season.

The endangered Cape Vulture (*Gyps coprotheres*) and critically endangered White-backed Vulture (*Gyps africanus*) (and to a lesser degree also Lappet-faced Vulture *Torgos tracheliotos*) were identified as regular foraging visitors to the study area (according to SABAP2 reporting rates and observations from adjacent habitat). These species are highly prone to power line collisions, whereby any existing powerline (existing powerlines spanning the facility) could pose a collision and electrocution risk to vultures.

No fatal-flaws were identified during the assessment, although it is strongly recommended that the proposed mitigation measures and monitoring protocols (additional with pre- and post construction monitoring) be implemented during the construction and operational phase of the project.

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DECLARATION OF INDEPENDENCE

I, Lukas Niemand (Pachnoda Consulting CC) declare that:

- I act as the independent specialist in this application to Themeda PV (Pty) Ltd and Atlantic Renewable Energy Partners (Pty) Ltd;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have no vested financial, personal or any other interest in the application;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority; and
- All the particulars furnished by me in this form are true and correct.

Lukas Niemand (Pr.Sci.Nat)
20 July 2022

Lukas Niemand is registered with The South African Council for Natural Scientific Professionals (400095/06) with more than 20 years of experience in ecological-related assessments and more than 15 years in the field of bird interactions with electrical and renewable energy infrastructure. He has conducted numerous ecological and avifaunal impact assessments including Eskom Transmission projects, hydro-electric schemes, solar farms and other activities in South Africa and other African countries.

1. INTRODUCTION

1.1 Project Description

Pachnoda Consulting cc was requested by Themeda PV (Pty) Ltd to compile an avifauna impact assessment report for a photovoltaic (PV) solar energy facility and associated infrastructure (herewith referred to as the "Themeda PV facility") with a contracted capacity of up to 120MW located on a site approximately 5 km north west of the town of Lichtenburg in the North West Province (Figure 1). The development area is situated within the Ditsobotla Local Municipality within the Ngaka Modiri Molema District Municipality. The sites are accessible via the R503, located south east of the development area. The development area for the PV facility and associated infrastructure will be located on Portion 7 of Farm Elandsfontein 34.

An additional 120 MW PV facility (Aristida PV) is concurrently being considered on the project site (within Portion 7 of Farm Elandsfontein 34) and is being assessed through a separate Environmental Impact Assessment (EIA) process.

The PV facility will be located on a 190 ha assessment area[1], and the infrastructure associated with the 120 MW facility includes (Figure 2):

- PV modules and mounting structures (monofacial or bifacial) with fixed, single or double axis tracking mounting structures;
- Inverter-station, transformers and internal electrical reticulation (underground cabling where practical);
- Battery Energy Storage System (BESS);
- Site and internal access roads (up to 10 m wide[2])
- Auxiliary buildings (MV switch room, gate-house and security, control centre, office, warehouse, canteen & visitors centre, staff lockers etc.);
- Temporary and permanent laydown area;
- Perimeter fencing and security infrastructure;
- Rainwater Tanks; and
- Grid connection solution, including:
    - Medium-voltage cabling between the project components and the facility substation; and
    - Up to 132kV on-site facility substation.

The Themeda PV facility intends to connect to the National Grid via the Watershed Main Transmission Substation (MTS) approximately 5.5 km east of the facility. The grid connection infrastructure associated with this grid solution (i.e. the Elandsfontein collector switching station and an up to 132kV overhead powerline) is being assessed as part of a separate Environmental Authorisation Application.

[1] The area being assessed as part of this EIA process.

[2] The access and internal roads will be 8m, although the total width including all stormwater management structures will not exceed 10m wide.

1.2 Objectives and Terms of Reference

The main objectives of the avifaunal study were to: (a) describe the avifauna associations in the study area according to species composition and richness prior to construction activities; (b) provide an inventory of bird species occurring in the study area including species prone towards collisions with the proposed infrastructure; (c) provide an impact assessment; and (d) provide an indication of the occurrence of species of concern (e.g. threatened and near threatened species; sensu IUCN, 2022; Taylor et al., 2015; Marnewick et al., 2015).

A bird assessment is required as part of the Environmental Impact Assessment process to investigate the impacts of the proposed solar facility on the avian attributes at the study site and its immediate surroundings. The avifaunal attributes at the proposed PV facility will be determined by means of a desktop analysis of GIS based information, third-party datasets and a number of site surveys. It also provides the results from two independent pre-construction surveys as per the best practice guidelines of Jenkins *et al.* (2017).

The terms of reference are to:

- conduct a baseline bird assessment based on available information pertinent to the ecological and avifaunal attributes on the project area and habitat units;
- conduct an assessment of all information on an EIA level in order to present the following results:
    - typify the regional and site-specific avifaunal macro-habitat parameters that will be affected by the proposed project;
    - provide a shortlist of bird species present as well as highlighting dominant species and compositions;
    - provide an indication on the occurrence of threatened, near threatened, endemic and conservation important bird species likely to be affected by the proposed project;
    - provide an indication of sensitive areas or bird habitat types corresponding to the study area;
    - highlight areas of concern or "hotspot" areas;
    - identify and describe impacts that are considered pertinent to the proposed development;
    - highlight gaps of information in terms of the avifaunal environment; and
    - recommend additional surveys and monitoring protocols (*sensu* Jenkins et al., 2017).

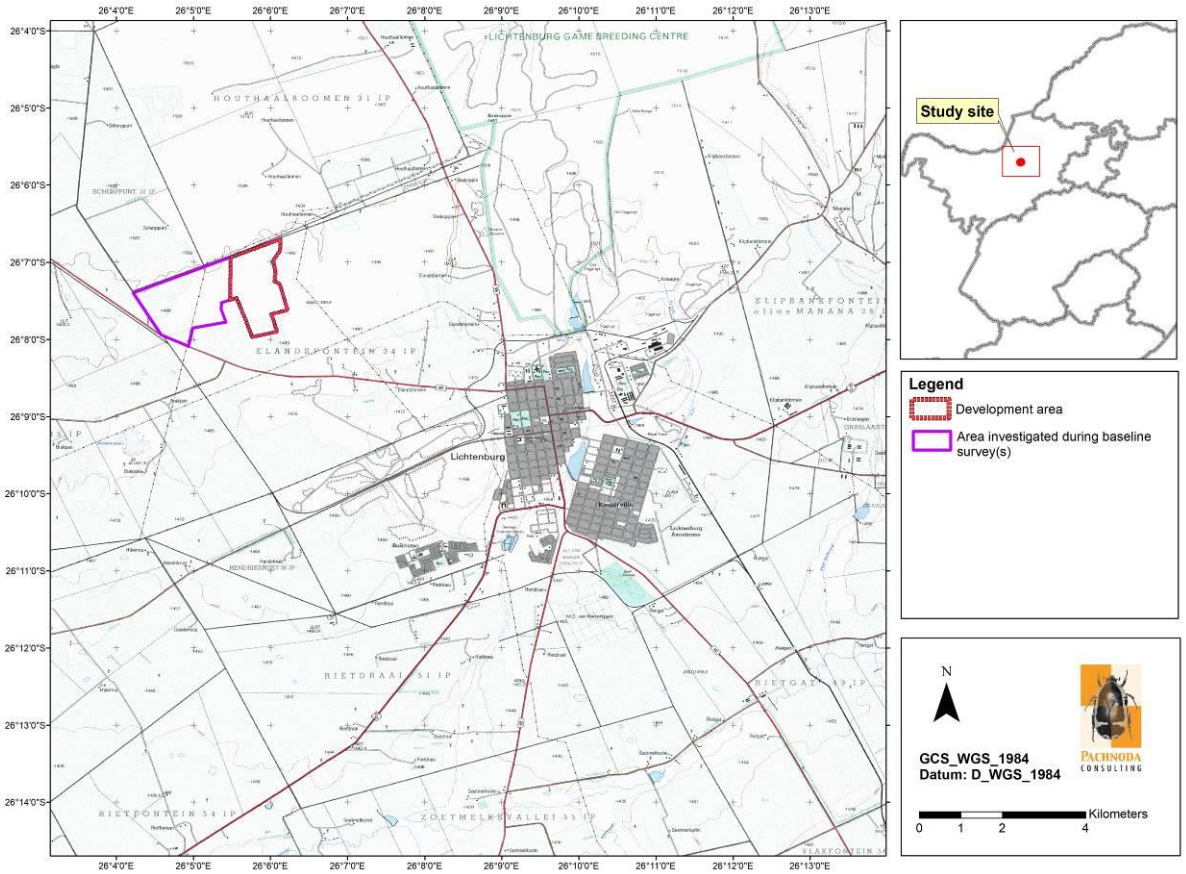


Figure 1: A topo-cadastral image illustrating the geographic position of proposed Themeda PV facility.

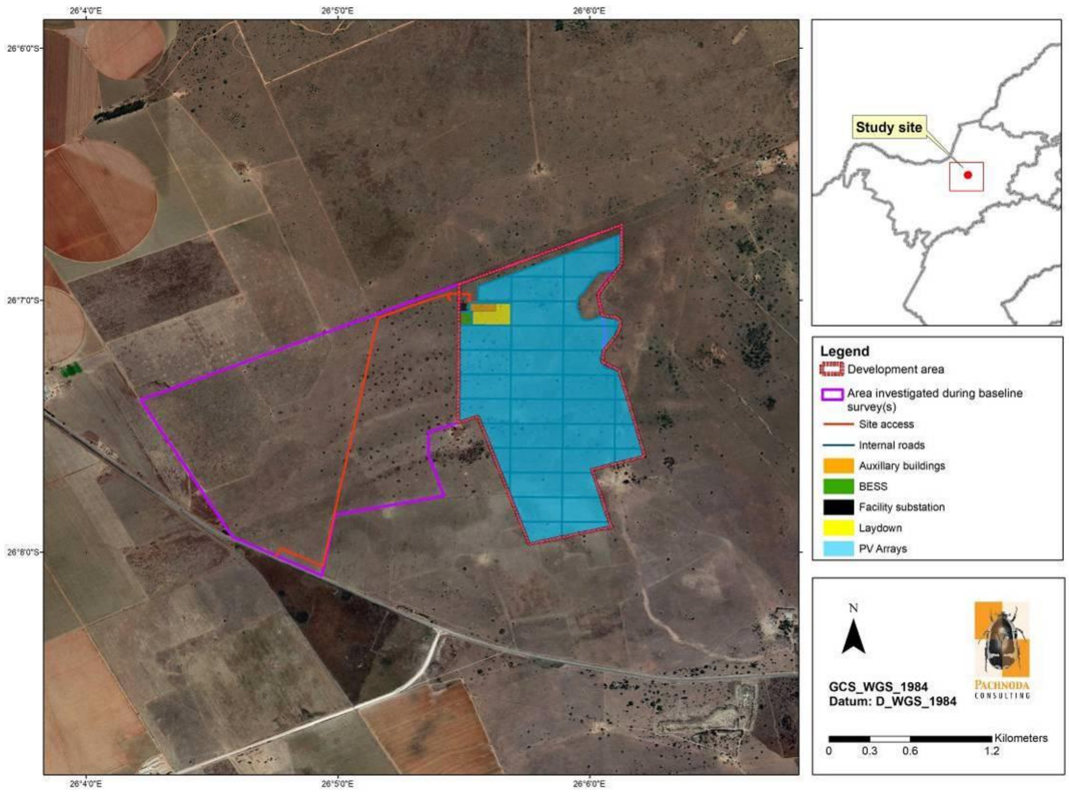


Figure 2: A satellite image illustrating the geographic position of the proposed Themeda PV facility and associated infrastructure.

1.3 Scope of Work

The following aspects form part of the Scope of Work:

- A desktop study of bird species expected to occur (e.g. species that could potentially be present), as well as species recorded in the past (e.g. SABAP1);
- A baseline survey of observed bird species according to ad hoc observations and two sampling surveys;
- A list of bird species historically recorded within the relevant quarter degree grid in which the study site occurs (SABAP1);
- Any protected or threatened bird species recorded in the past within the relevant quarter degree grid, their scientific names and colloquial names, and protected status according to IUCN red data lists; and
- The potential of these protected or threatened species to persist within the study area.

The following aspects will be discussed during this avifaunal assessment:

- Collision-prone bird species expected to be present and/or observed;

- A list of the dominant bird species;
- A list of observed and expected threatened and near threatened species (according to IUCN red data list);
- Possible migratory or nomadic species;
- Potential important flyways/ congregatory sites and/or foraging sites; and
- Avian impacts associated with the PV solar facility.

2. METHODS & APPROACH

The current report places emphasis on the avifaunal community as a key indicator group on the proposed study area, thereby aiming to describe the conservation significance of the ecosystems in the area. Therefore, the occurrence of certain bird species and their relative abundances may determine the outcome of the ecological sensitivity of the area and the subsequent proposed layouts of the solar facility infrastructure.

The information provided in this report was principally sourced from the following sources/observations:

- relevant literature – see section below;
- observations made during two site visits corresponding to the austral wet and dry seasons (17-21 January 2022 and 16-20 May 2022); and
- personal observations from similar habitat types in proximity to the study area (Pachnoda Consulting 2018, 2021).

2.1 Literature survey and Database acquisition

A desktop and literature review of the area under investigation was commissioned to collate as much information as possible prior to the detailed baseline survey. Literature consulted primarily makes use of small-scale datasets that were collected by citizen scientists and are located at various governmental and academic institutions (e.g. Animal Demography Unit & SANBI). These include (although are not limited to) the following:

- Hockey *et al*. (2005) for general information on bird identification and life history attributes.
- Marnewick *et al.* (2015) was consulted for information regarding the biogeographic affinities of selected bird species that could be present on the study area.
- The conservation status of bird species was categorised according to the global IUCN Red List of threatened species (IUCN, 2022) and the regional conservation assessment of Taylor *et al.* (2015).
- Distributional data was sourced from the South African Bird Atlas Project (SABAP1) and verified against Harrison et al. (1997) for species corresponding to the quarter-degree grid cell (QDGC) 2626AA (Lichtenburg). The information was then modified according to the prevalent habitat types present on the development area. The SABAP1 data provides a "snapshot"

of the abundance and composition of species recorded within a quarter degree grid cell (QDGC) which was the sampling unit chosen (corresponding to an area of approximately 15 min latitude x 15 min longitude). It should be noted that the atlas data makes use of reporting rates that were calculated from observer cards submitted by the public as well as citizen scientists. It therefore provides an indication of the thoroughness of which the QDGCs were surveyed between 1987 and 1991.

- Additional distributional data was also sourced from the SABAP2 database (http://www.sabap2.birdmap.africa). The information was then modified according to the prevalent habitat types present on the study area. Since bird distributions are dynamic (based on landscape changes such as fragmentation and climate change), SABAP2 was born (and launched in 2007) from SABAP1 with the main difference being that all sampling is done at a finer scale known as pentad grids (5 min latitude x 5 min longitude, equating to 9 pentads within a QDGC). Therefore, the data is more site-specific, recent and more comparable with observations made during the site visit (due to increased standardisation of data collection). The pentad grids relevant to the current project is 2605_2605 and 2605_2600 (although all eight pentad grids surrounding the central grid 2605_2605 were also scrutinised). (Figure 3).
- The choice of scientific nomenclature, taxonomy and common names were recommended by the International Ornithological Committee (the IOC World Bird List v. 12.1), unless otherwise specified (see www.worldbirdnames.org as specified by Gill et al, 2022).
- The best practice guidelines for assessing and monitoring the impact of solar power generating facilities on birds in southern Africa were also consulted (Jenkins *et al.,* 2017).

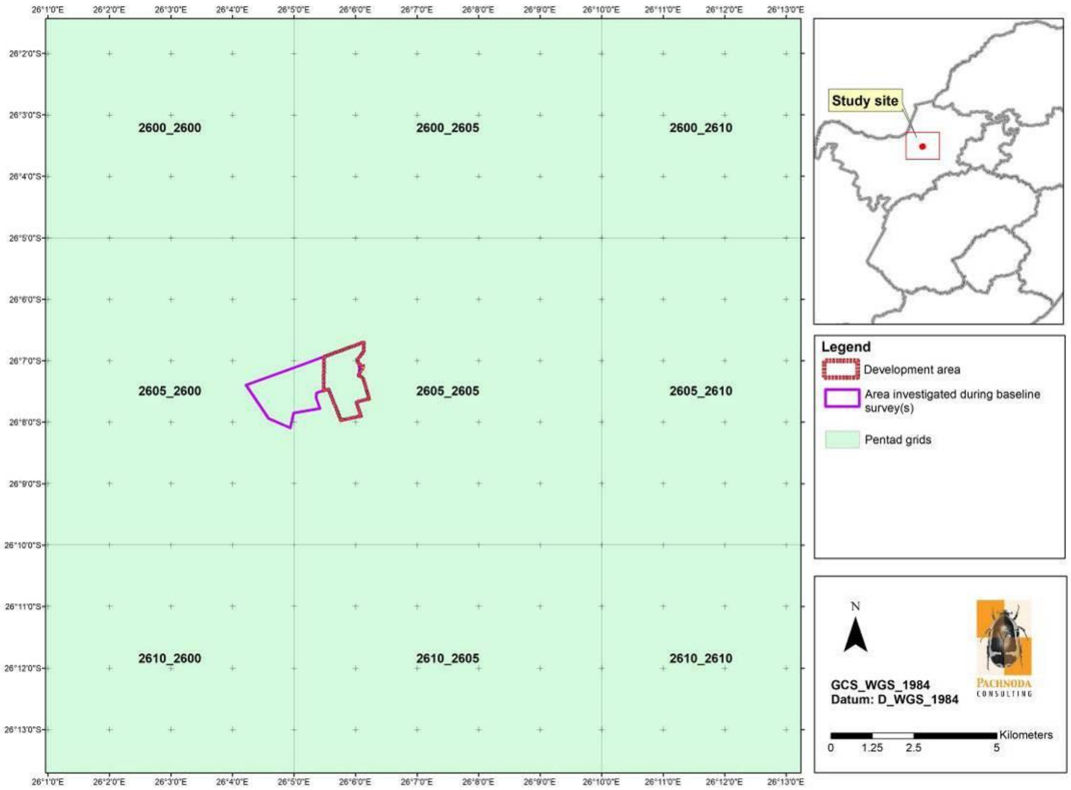


Figure 3: A map illustrating the pentad grids that were investigated for this project.

2.2 Field Methods

The avifauna of the study area was surveyed during two independent site visits representing a wet season (January 2022) and an early dry season survey (May 2022).

The baseline avifaunal survey was conducted by means of the following survey techniques:

2.2.1 Point Counts

Bird data was collected by means of 26 point counts (as per Buckland et al. 1993) from the study area. Data from the point counts has been analysed to determine dominant and indicator bird species (so-called discriminant species), relative densities and to delineate the different bird associations present.

The use of point counts is advantageous since it is the preferred method to use for skulking or elusive species. In addition, it is the preferred method to line transect counts where access is problematic, or when the terrain appears to be complex (e.g. mountainous). It is considered to be a good method to use, and very efficient for gathering a large amount of data in a short period of time (Sutherland, 2006). The spatial position of each point count is illustrated in Figure 4. The spatial placement of the point counts was determined through a stratified random design which ensures coverage of each habitat type and/or macro-habitat (Sutherland et al., 2004).

Therefore, the sampling approach was adapted so that all the bird species seen within approximately 50m from the centre of the point were recorded (resulting in an area of 0.78 ha) along with their respective abundance values (a laser rangefinder was used to delineate the area to be surveyed at each point). Each point count lasted approximately 20-30 minutes, while the area within the 50m radius of homogenous habitat was slowly traversed to ensure that all bird species were detected and/or flushed (as proposed by Watson, 2003). To ensure the independence of observations, points were positioned at least 200m apart. Observations were not truncated, and in order to standardise data collection, the following assumptions were conformed to (according to Buckland *et al.*, 1994):

- All birds on the point must be seen and correctly identified. This assumption is in practice very difficult to meet in the field as some birds in the nearby vicinity may be overlooked due to low visibility or were obscured by vegetation (e.g. graminoid cover). Therefore, it is assumed that the portion of birds seen on the point count represents the total assemblage on the point.
- All birds must be recorded at their initial location. All movements of the birds are random and therefore natural in relation to the movements of the observer. None of the birds moved in response to the presence of the observer, and birds flying past without landing were omitted from the analysis.
- In other words, no bird is recorded more than once.

2.2.2 Random (ad hoc) surveys

To obtain an inventory of bird species present (apart from those observed during the point counts), all bird species observed/detected while moving between point counts were identified and noted. Particular attention was devoted to suitable roosting, foraging and nesting habitat for species of conservation concern (e.g. threatened or near threatened species). In addition, the fly patterns of large non-passerine and birds of prey were recorded, as well as the locality of collision-prone birds.

2.2.3 Analyses

Data generated from the point counts was analysed according to Clarke & Warwick (1994) based on the computed percentage contribution (%) of each species, including the consistency (calculated as the similarity coefficient/standard deviation) of its contribution. Hierarchical Agglomerative Clustering (a cluster analysis-based group-average linkages; Clarke & Warwick 1994) was performed on calculated Bray-Curtis coefficients derived from the data. A cluster analysis is used to assign "species associations" between samples with the aim to objectively delineate groups or assemblages. Therefore, sampling entities that group together (being more similar) are believed to have similar compositions.

The species richness and diversity of each bird association was analysed by means of richness measures (such as the total number of species recorded (S) and Shannon Wiener Index) were calculated to compare the associations with each other.

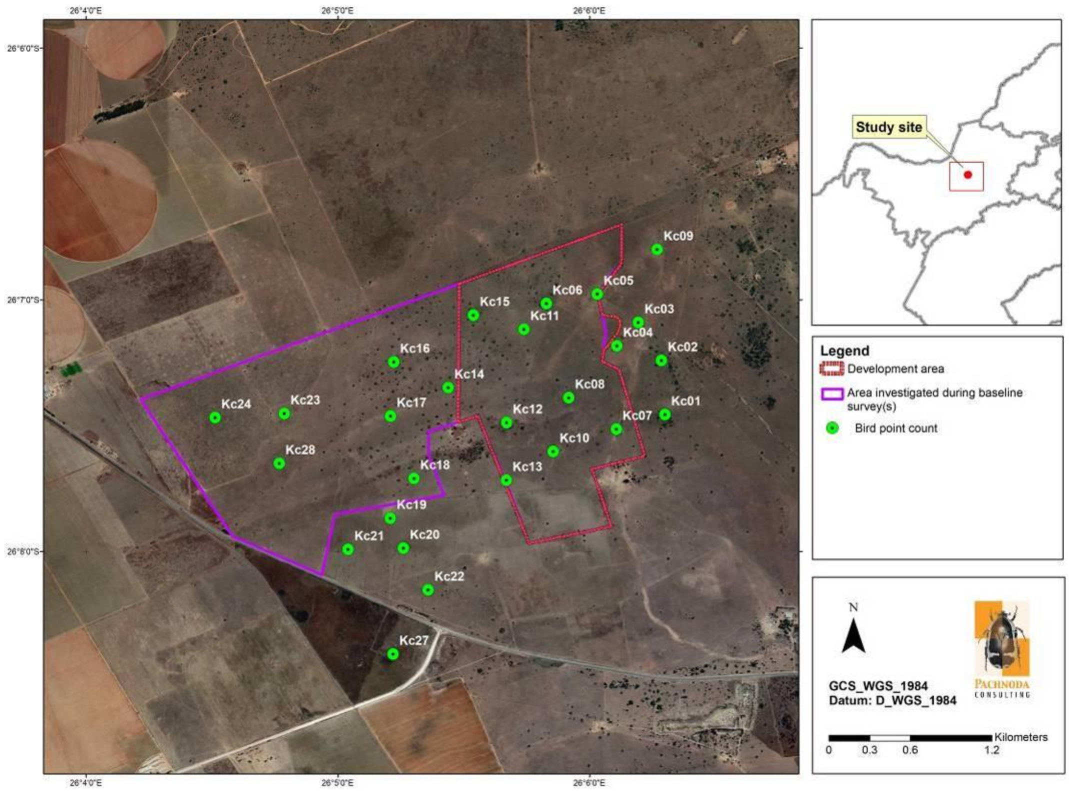


Figure 4: A map illustrating the spatial position of 26 bird point counts located within the study area.

2.3 Sensitivity Analysis

A sensitivity map was compiled based on the outcome of the baseline results.

The ecological sensitivity of any piece of land is based on its inherent ecosystem service (e.g. wetlands) and overall preservation of biodiversity.

2.3.1 Ecological Function

Ecological function relates to the degree of ecological connectivity between systems within a landscape matrix. Therefore, systems with a high degree of landscape connectivity amongst one another are perceived to be more sensitive and will be those contributing to ecosystem services (e.g. wetlands) or the overall preservation of biodiversity.

2.3.2 *Avifaunal Importance*

Avifaunal importance relates to species diversity, endemism (unique species or unique processes) and the high occurrence of threatened and protected species or ecosystems protected by legislation.

2.3.3 *Sensitivity Scale*

- *High* – Sensitive ecosystems with either low inherent resistance or low resilience towards disturbance factors or highly dynamic systems considered important for the maintenance of ecosystem integrity. Most of these systems represent ecosystems with high connectivity with other important ecological systems OR with high species diversity and usually contain high numbers of threatened, endemic or rare bird species. These areas should preferably be protected;
- *Moderately high* - Untransformed or productive habitat units (which can also be artificial) which contain high bird numbers and/or bird richness values. These areas are often fragmented OR azonal, and hence of small surface area that are often surrounded by habitat of moderate or low sensitivity. These habitat units also include potential habitat for threatened species. Development is often considered permissible on these areas if there is enough reason to believe that these areas are widespread in the region and future planned developments are unlikely to result in the widespread loss (>50 %) of similar habitat at a regional scale.
- *Medium* – These are slightly modified systems which occur along gradients of disturbances of low-medium intensity with some degree of connectivity with other ecological systems OR ecosystems with intermediate levels of species diversity but may include potential ephemeral habitat for threatened species; and
- *Low* – Degraded and highly disturbed/transformed systems with little ecological function and are generally very poor in bird species diversity (most species are usually exotic or weeds).

2.4 Limitations

- It is assumed that third party information (obtained from government, academic/research institution, non-governmental organisations) is accurate and true.
- Some of the datasets are out of date and therefore extant distribution ranges may have shifted although these datasets provide insight into historical distribution ranges of relevant species.
- The datasets are mainly small-scale and could not always consider azonal habitat types that may be present on the study area (e.g. artificial livestock watering points). In addition, these datasets encompass surface areas larger than the study area, which could include habitat types and species that are

not present on the study site. Therefore the potential to overestimate species richness is highly likely while it is also possible that certain cryptic or specialist species could have been be overlooked in the past.

- Some of the datasets (e.g. SABAP2) managed by the Animal Demography Unit of the University of Cape Town were recently initiated and therefore incomplete.
- This company, the consultants and/or specialist investigators do not accept any responsibility for conclusions, suggestions, limitations and recommendations made in good faith, based on the information presented to them, obtained from the surveys or requests made to them at the time of this report.

3. DESCRIPTION OF THE AFFECTED ENVIRONMENT

3.1 Locality

The Themeda PV development area is located approximately 5 km north west of the town of Lichtenburg in the North West Province. The development area is also located on Portion 7 of Farm Elandsfontein 34 (Figure 1).

3.2 Regional Vegetation Description

The proposed PV facility corresponds to the Grassland Biome and more particularly to the Dry Highveld Grassland Bioregion as defined by Mucina & Rutherford (2006). It comprehends an ecological type known as Carletonville Dolomite Grassland (Mucina & Rutherford, 2006) (Figure 5).

From an avifaunal perspective it is evident that bird diversity is positively correlated with vegetation structure, and floristic richness is not often regarded to be a significant contributor of patterns in bird abundance and their spatial distributions. Although grasslands are generally poor in woody plant species, and subsequently support lower bird richness values, it is often considered as an important habitat for many terrestrial bird species such as larks, pipits, korhaans, cisticolas, widowbirds including large terrestrial birds such as Secretarybirds, cranes and storks. Many of these species are also endemic to South Africa and display particularly narrow distribution ranges. Due to the restricted spatial occurrence of the Grassland Biome and severe habitat transformation, many of the bird species that are restricted to the grasslands are also threatened or experiencing declining population sizes.

Carletonville Dolomite Grassland is confined to the dolomite plains that stretch from Lichtenburg in the North West Province to sections of rocky grassland in Gauteng, especially between altitudes of 1 350 m and 1 450 m. It occurs on slightly undulating plains dissected by prominent chert ridges, thereby containing a grassland composition rich in floristic species forming a complex mosaic dominated by many plant species.

Currently, only 2 % of the remaining 76 % of untransformed Carletonville Dolomite Grassland is formally protected within the Cradle of Humankind World Heritage Site and various nature reserves such as Abe Baily and Krugersdorp Nature Reserves.

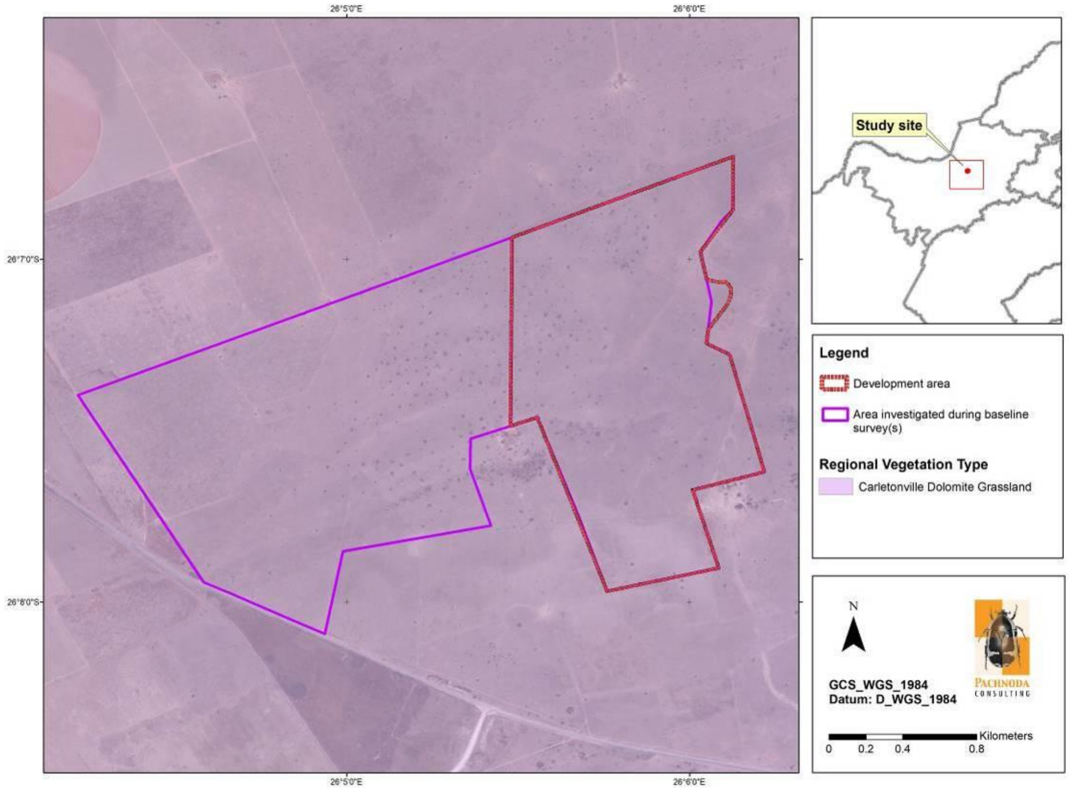


Figure 5: A satellite image illustrating the regional vegetation type corresponding to the study area. Vegetation type categories were defined by Mucina & Rutherford (2006).

3.3 Land cover, land use and existing infrastructure.

According to the South African National dataset of 2013-2014 (Geoterrainimage, 2015) the study site comprehends the following land cover categories (Figure 6):

Natural areas:

- Grassland; and
- Low shrubland.

From the land cover dataset it is evident that most of the study site is covered by natural grassland, while the south-western section consists of low shrubland. The study site is primarily used for livestock production and livestock grazing. The southern part of the proposed Themeda PV facility is covered in secondary grassland that was historically part of a cultivated land. Figure 6 also shows a number of small wetland features on the western part of the Themeda PV site, but it is believed that these features were erroneously digitised during the production of the national land cover dataset (these features were not observed during the recent site visit).

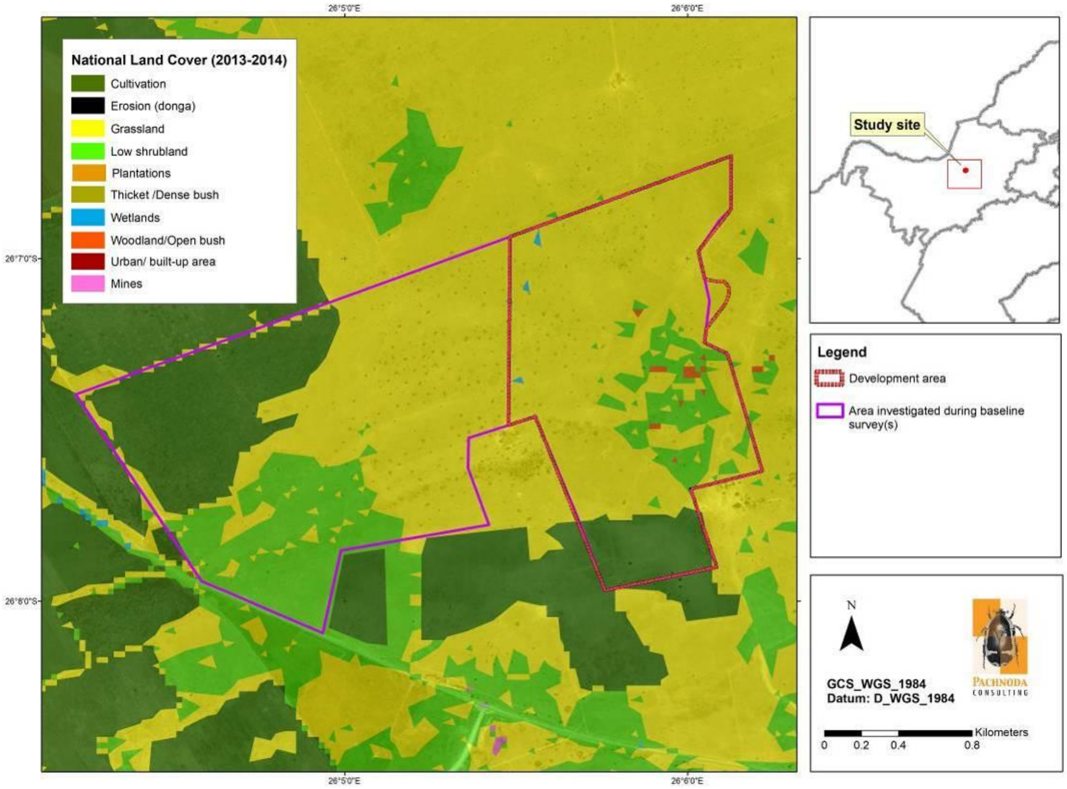


Figure 6: A map illustrating the land cover classes (Geoterrainimage, 2015) corresponding to the proposed development area.

3.4 Conservation Areas, Protected Areas and Important Bird Areas

The study area is located approximately 4.6 km west of the former Lichtenburg Game Breeding Centre (Figure 7). This conservation area contains a variety of game species, and the facility operates a vulture restaurant which attracts foraging vultures (c. three species) to the region. This area is currently under new management (by lease agreement with the municipality).

There are no other formal protected areas or any Important Bird and Biodiversity Areas in close proximity to the study site.

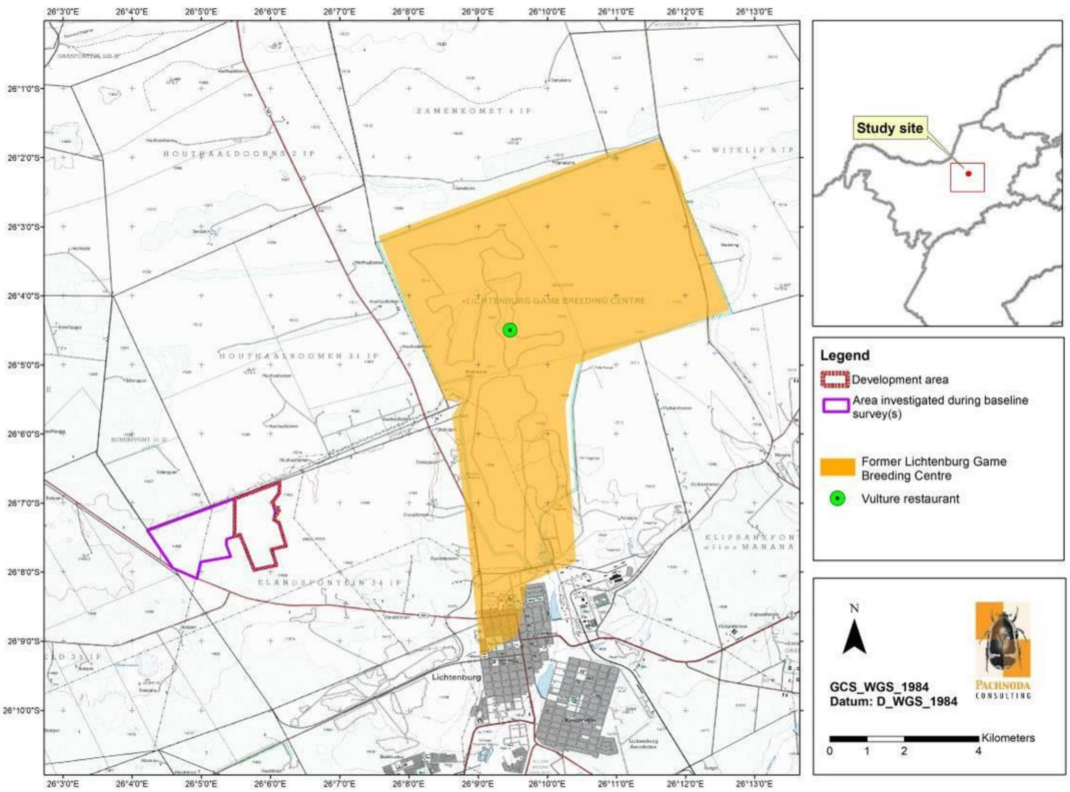


Figure 7: A map illustrating the locality of conservation areas in close proximity to the proposed study area.

3.5 Annotations on the National Web-Based Environmental Screening Tool

Regulation 16(1)(v) of the Environmental Impact Assessment Regulations, 20145 (EIA Regulations) provides that an applicant for Environmental Authorisation is required to submit a report generated by the Screening Tool as part of its application. On 5 July 2019, the Minister of Environmental Affairs, Forestry and Fisheries published a notice in the Government Gazette giving notice that the use of the Screening Tool is compulsory for all applicants to submit a report generated by the Screening Tool from 90 days of the date of publication of that notice.

The Screening Tool is intended to allow for pre-screening of sensitivities in the landscape to be assessed within the EA process. This assists with implementing the mitigation hierarchy by allowing developers to adjust their proposed development footprint to avoid sensitive areas. The Screening Tool report will indicate the (preliminary) environmental sensitivities that intersect with the proposed development footprint as defined by the applicant as well as the relevant Protocols.

As the Screening Tool contains datasets that are mapped at a national scale, there may be areas where the Screening Tool erroneously assigns, or misses, environmental sensitivities because of mapping resolution and a high paucity of available and accurate data. Broad-scale site investigations will provide for an augmented and site-specific evaluation of the accuracy and 'infilling' of obvious and large-scale inaccuracies. Information extracted from the National Web-based Environmental Screening Tool (Department of Environmental Affairs, 2020), indicated that the study site holds a **low** sensitivity with respect to the relative animal species protocol (Figure 8) (report generated 07/07/2022).

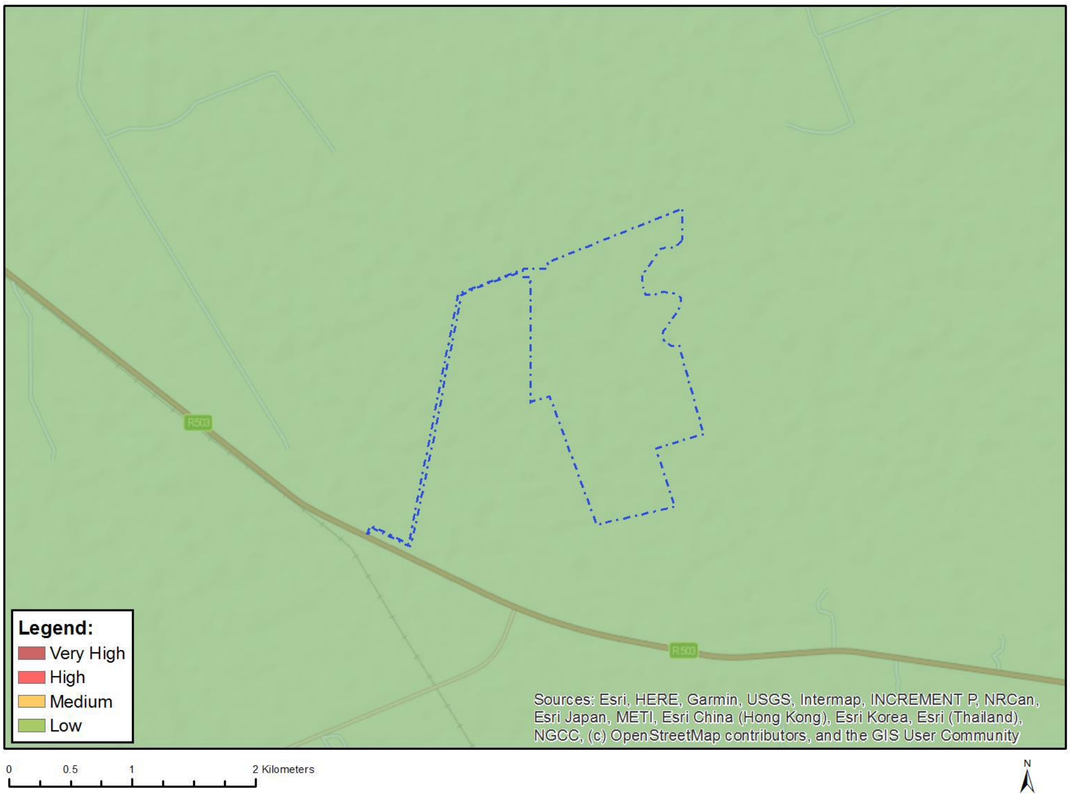


Figure 8: The animal species sensitivity of the study area according to the Screening Tool.

Sensitive features include the following:

Sensitivity	Feature(s)
Low	Subject to confirmation

It is evident from the results of the Screening Tool report that probability is low for any animal species of conservation concern to occur on the study site.

However, the study site holds a **high** sensitivity with respect to the relative avian theme (Figure 9) (report generated 07/07/2022):

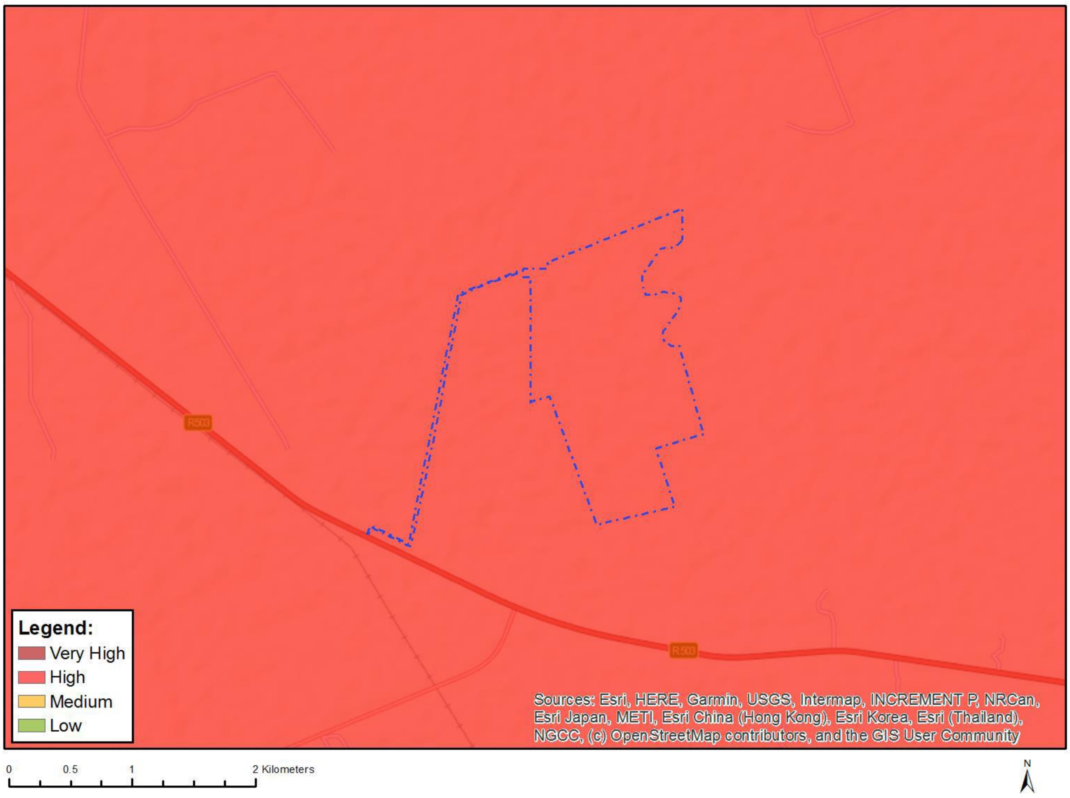


Figure 9: The relative avian sensitivity of the study area according to the Screening Tool.

It is evident from the results of the Screening Tool report that the study area is located within 20 km of known Cape Vulture (*Gyps coprotheres*) restaurant sites.

In addition, the study site holds a **very high** sensitivity with respect to the relative terrestrial biodiversity theme (Figure 10) (report generated 07/07/2022):

Figure 10: The relative terrestrial biodiversity sensitivity of the study area.

Sensitive features include the following:

Sensitivity	Feature(s)
Low	Low Sensitivity
Very High	Critical Biodiversity Area 2
Very High	Protected Area Expansion Strategy

It is evident from the results of the Screening Tool report that the study area forms part of a Critical Biodiversity Area 2 as per the North West Biodiversity Sector Plan (NWREAD, 2015). It is also considered to form part of the protected area expansion strategy.

4. RESULTS AND DISCUSSION

4.1 Avifaunal habitat types

Apart from the regional vegetation type, the local composition and distribution of the vegetation associations on the study area are a consequence of a combination of factors simulated by soil type, geology and grazing intensity (presence of livestock) which have culminated in three major broad-scale habitat units that deserve further discussion (Figure 11, Figure 12 and Figure 13):

1. *Open mixed dolomite grassland with bush clump mosaics:* This unit is prominent on the study site and covers a significant extent in surface area of the proposed PV facility. It is represented by two discrete floristic variations

which also provide habitat for two discrete avifaunal associations (see Pachnoda Consulting, 2018; 2021). The first floristic variation represented by untransformed to grazed Carletonville Dolomite Grassland, depending on grazing intensity, it is dominated by "late-successional" graminoids such a *Themeda triandra, Cymbopogon caesius, C. pospischilii, Trachypogon spicatus, Elionurus muticus* and *Andropogon schirensis*. It is occupied by a typical grassland bird composition dominated by insectivorous and granivore passerine bird species such as Desert Cisticola, (*Cisticola aridulus*), Eastern Clapper Lark (*Mirafra fasciolata*), Spike-heeled Lark (*Chersomanes albofasciata*), Ant-eating Chat (*Myrmecocichla formicivora*) and Rufous-naped Lark (*Mirafra africana*). Prominent non-passerine species include Orange River Francolin (*Scleroptila gutturalis*), Swainson's Spurfowl (*Pternistis swainsonii*), Northern Black Korhaan (*Afrotis afraoides*), Crowned Lapwing (*Vanellus coronatus*) and Helmeted Guineafowl (*Numida meleagris*).

The bush clumps form a prominent mosaic characterised by the dominance of a woody layer of *Searsia lancea, S. pyroides, Ziziphus mucronata* and *Diospyros lycioides*. The eminent increase in vertical heterogeneity provided by the woody layer is colonised by a "Bushveld" bird association consisting of insectivorous passerines such as Black-chested Prinia (*Prinia flavicans*), Chestnut-vented Warbler (*Curruca subcoerulea*), Kalahari Scrub Robin (*Cercotrichas paena*), Neddicky (*Cisticola fulvicapilla*) as well as granivores such as Yellow Canary (*Crithagra flaviventris*), Black-throated Canary (*Crithagra atrogularis*) and Southern Masked Weaver (*Ploceus velatus*). Non-passerine bird taxa are represented by Laughing Dove (*Spilopelia senegalensis*), Ring-necked Dove (*Streptopelia capicola*), Acacia Pied Barbet (*Tricholaema leucomelas*) and White-backed Mousebird (*Colius colius*).

2. *Mixed woodland on dolomite outcrops:* This unit is scattered on the study site. It is represented by open to dense woodland dominated by *Searsia lancea, S. pyroides, Ziziphus mucronata* and *Diospyros lycioides* that are similar in floristic composition to the bush clump mosaics, although it occurs on rocky soils. The vertical heterogeneity assists with the colonisation of a "Bushveld" bird association consisting of mainly insectivorous passerines. The latter composition is similar to the bird composition predicted for the bush clump mosaic habitat unit. Other noteworthy species include Spotted Flycatcher (*Muscicapa striata*), Crimson-breasted Shrike (*Laniarius atrococcineus*), Long-billed Crombec (*Sylvietta rufescens*) and Brown-crowned Tchagra (*Tchagra australis*).

3. *Moist dense grassland*: This habitat is highly localised and situated on the eastern part of the study site which is represented by dense, coarse grass including dense *Hyparrhenia, Themeda triandra, Imperata cylindrica* and *Andropogon appendiculatum*. It provides breeding and roosting habitat for Long-tailed Widowbird (*Euplectes progne*), Southern Red Bishop (*E. orix*) and

Zitting Cisticola (*Cisticola juncidis*). It is also provides potential breeding habitat for Marsh Owls (*Asio capensis*).

4. *Secondary grassland and pastures*: These are represented by secondary grassland and pastures that are dominated by tall coarse grass species such as *Hyparrhenia hirta* and *Chloris cf. gayana*. It is contains the same "grassland" composition found within the open mixed dolomite grassland with bush clump mosaics although Cloud Cisticola (*Cisticola textrix*) and Long-tailed Widowbird (*Euplectes procne*) were prominent.

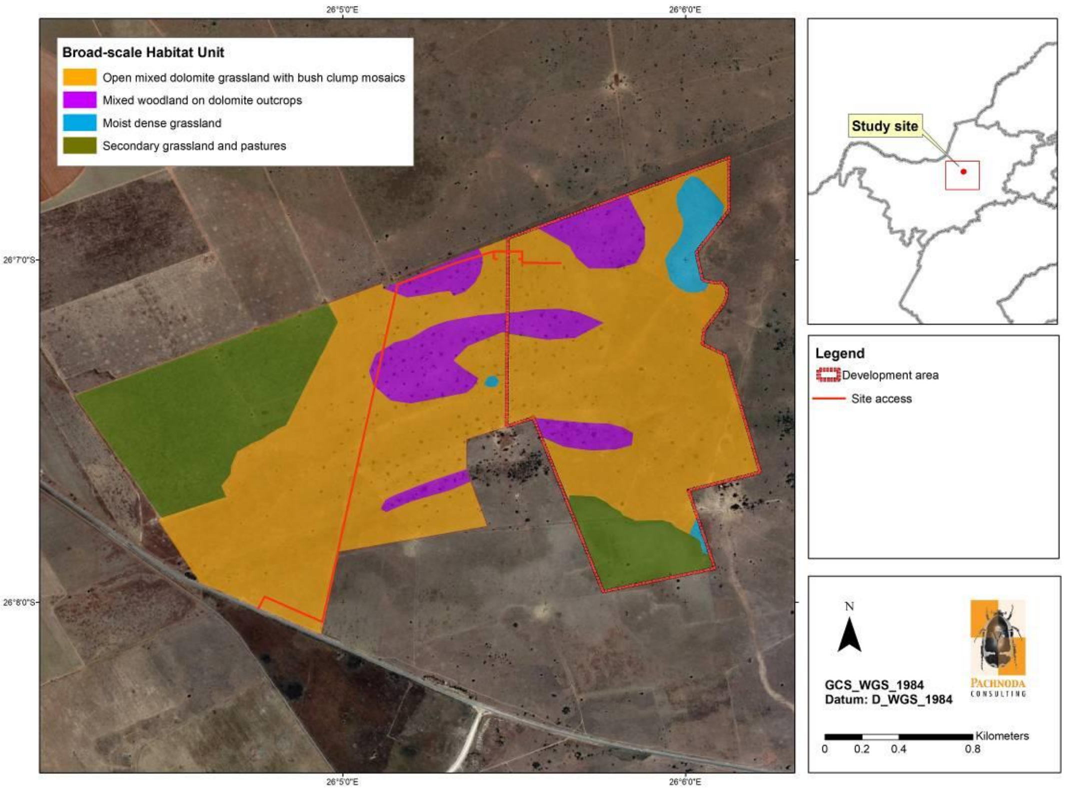
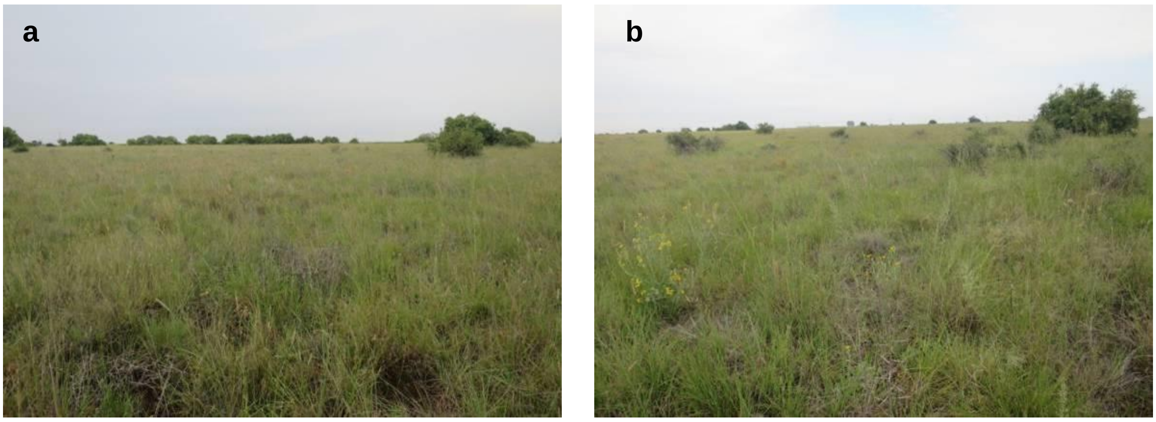


Figure 11: A map illustrating the avifaunal habitat types on the development area.



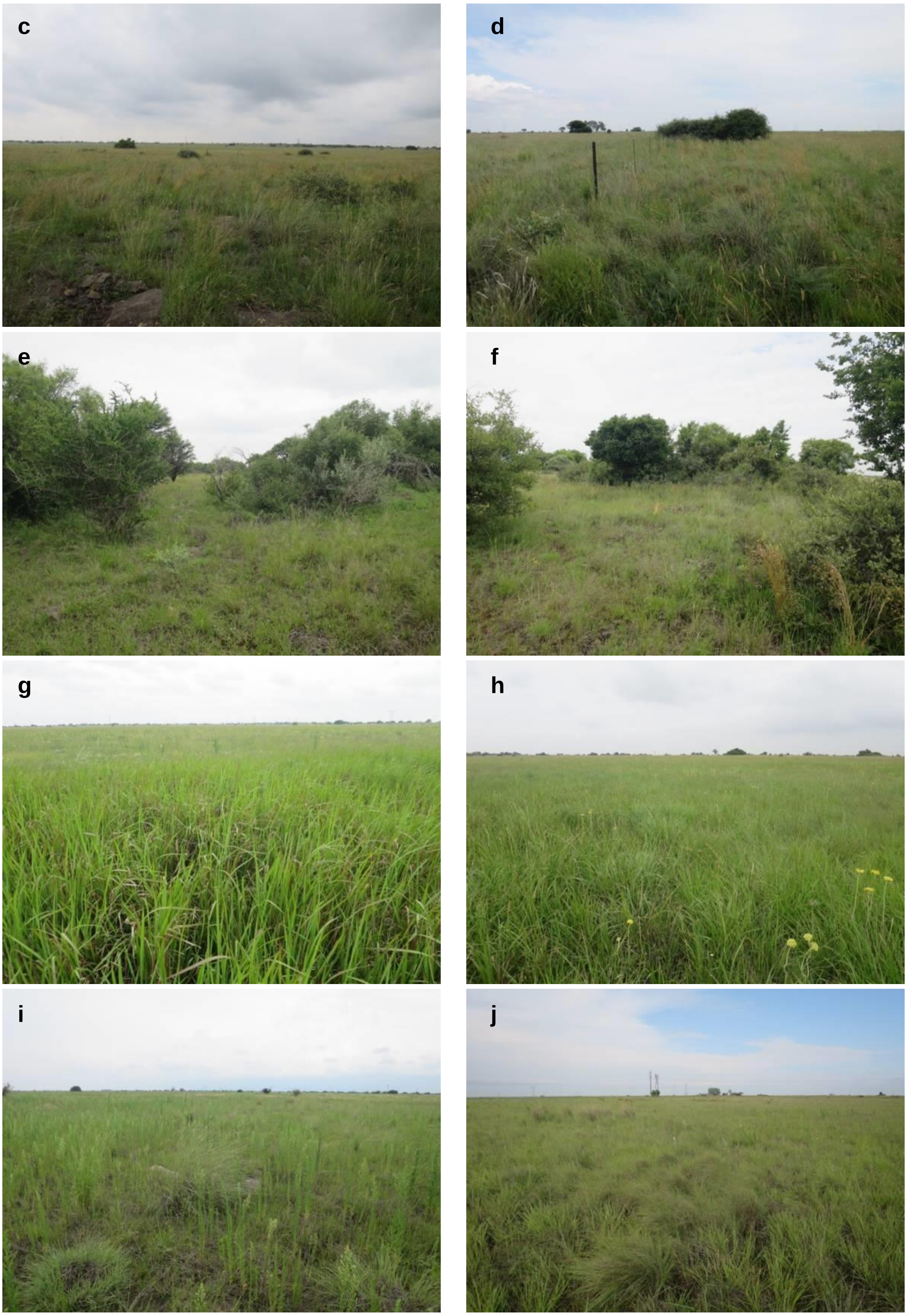


Figure 12: A collage of images illustrating examples of avifaunal habitat types on the study area observed during the austral summer season (January 2022): (a - d) open mixed dolomite grassland and bush clump mosaics, (e - f) mixed woodland on

dolomite outcrops, (g - h). moist dense grassland and (i - j) secondary grassland and pastures.

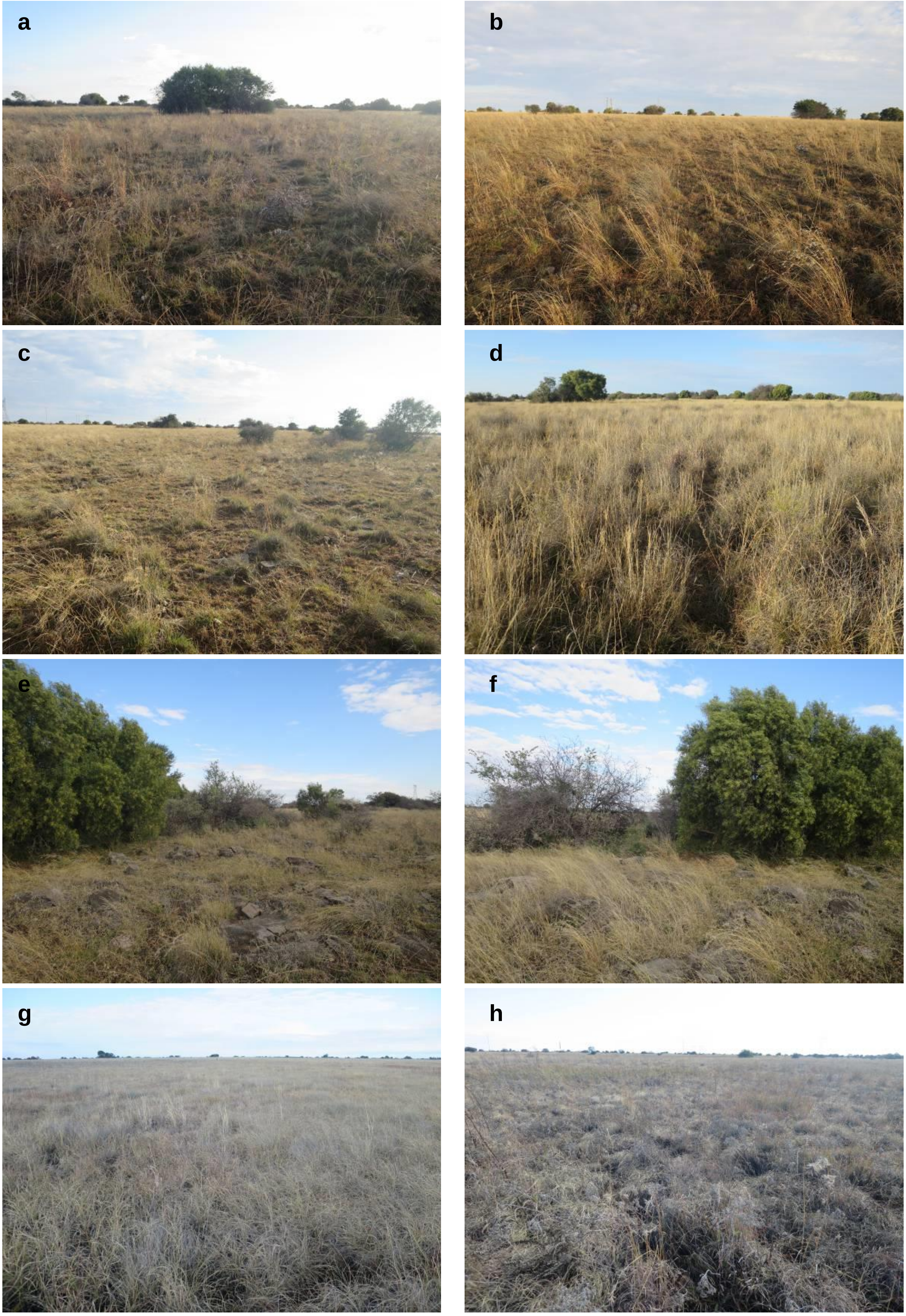


Figure 13: A collage of images illustrating examples of avifaunal habitat types on the assessment area observed during the austral dry season (May 2022): (a - d) open mixed dolomite grassland and bush clump mosaics, (e - f) mixed woodland on dolomite outcrops, (g - h). moist dense grassland and (i - j) secondary grassland and pastures.

4.2 Species Richness and Summary statistics

Approximately ~183 bird species are expected to occur in the study area (refer to Appendix 1 and Table 1). The expected richness was inferred from the South African Bird Atlas Project (SABAP1 & SABAP2)[3] (Harrison et al., 1997; www.sabap2.birdmap.africa) and the presence of suitable habitat in the study area. The expected richness is also strongly correlated with favourable environmental conditions (e.g. during good rains) and seasonality (e.g. when migratory species are present). This equates to 19 % of the approximate 987[4] species listed for the southern African subregion[5] (and approximately 21 % of the 871 species recorded within South Africa[6]). However, the species richness obtained from the pentad grids 2605_2600 and 2605_2605 corresponding to the study area[7] is slightly lower than the expected number of species with an average of 132 species recorded (range: 74-190 species). The average number of species for each full protocol card submitted (for observation of two hours or more) is 48.66 species (range = 16 - 125 species).

According to field observations, the total number of species observed on the study area is *ca*. 92 species (see Appendix 1). On a national scale, the species richness per pentad on the study area is considered to be high (refer to Figure 14).

According to Table 1, the study site is expected to be poorly represented by biome-restricted (see Table 2) and local endemic bird species with only two biome-restricted

[3] The expected richness statistic was derived from the pentad grid 2605_2605 (including adjacent 8 grids) totalling 241 bird species (based on 113 submitted cards, 82 being full protocol cards and 31 being ad hoc cards).
4 *sensu* www.zestforbirds.co.za (Hardaker, 2020) including four recently confirmed bird species (vagrants).
5 A geographical area south of the Cunene and Zambezi Rivers (includes Namibia, Botswana, Zimbabwe, southern Mozambique, South Africa, eSwatini and Lesotho).
6 With reference to South Africa (including Lesotho and eSwatini (BirdLife South Africa, 2022).
[7] Including observations made during the January and May 2022 surveys.

species and a single local endemic species present (observed). It is expected to support ca. 29.5 % of the near-endemic species present in the subregion. Of the 183 bird species expected to occur in the project area, 10 are threatened or near threatened species, 14 are southern African endemics and 18 are near-endemic species (Table 3). In addition, two threatened species (White-backed Vulture *Gyps africanus* and Cape Vulture *G. coprotheres*) were observed on similar habitat immediately north of the study site (on the Farm Houthaalboomen 31) and have a high probability to occur on the study site (Table 3). Waterbird species were highly irregular and predominantly absent from the study area owing to the absence of any surface water features on the study area.

Table 1: A summary table of the total number of species, Red listed species (according to Taylor *et al*., 2015 and the IUCN, 2022), endemics and biome-restricted species (Marnewick *et al*., 2015) expected (*sensu* SABAP1 and SABAP2) to occur in the study site and immediate surroundings.

Description	Expected Richness Value (study area and surroundings)***	Observed Richness Value (study area)****
Total number of species*	183 (21 %)	92 (50.3 %)
Number of Red Listed species*	10 (7.1 %)	2 (20 %)[8]
Number of biome-restricted species – Zambezian and Kalahari-Highveld Biomes*	4 (29 %)	2 (50 %)
Number of local endemics (BirdLife SA, 2022)*	2 (5.1 %)	1 (50 %)
Number of local near-endemics (BirdLife SA, 2022)*	5 (16.7 %)	4 (80 %)
Number of regional endemics (Hockey *et al.,* 2005)**	14 (13.3 %)	11 (79 %)
Number of regional near-endemics (Hockey *et al.,* 2005)**	18 (29.5 %)	12 (67 %)

* only species in the geographic boundaries of South Africa (including Lesotho and eSwatini) were considered.

** only species in the geographic boundaries of southern Africa (including Namibia, Botswana, Zimbabwe and Mozambique south of the Zambezi River) were considered

*** Percentage values in brackets refer to totals compared against the South African avifauna (*sensu* BirdLife SA, 2022).

**** Percentage values in brackets refer to totals compared against the expected number of species in the project area.

[8] These two species were not observed on the study site itself but from similar habitat immediately to the north of the site on the Farm Houthaalboomen 31 during 2021. The probability that these species could occur on the study site is high.

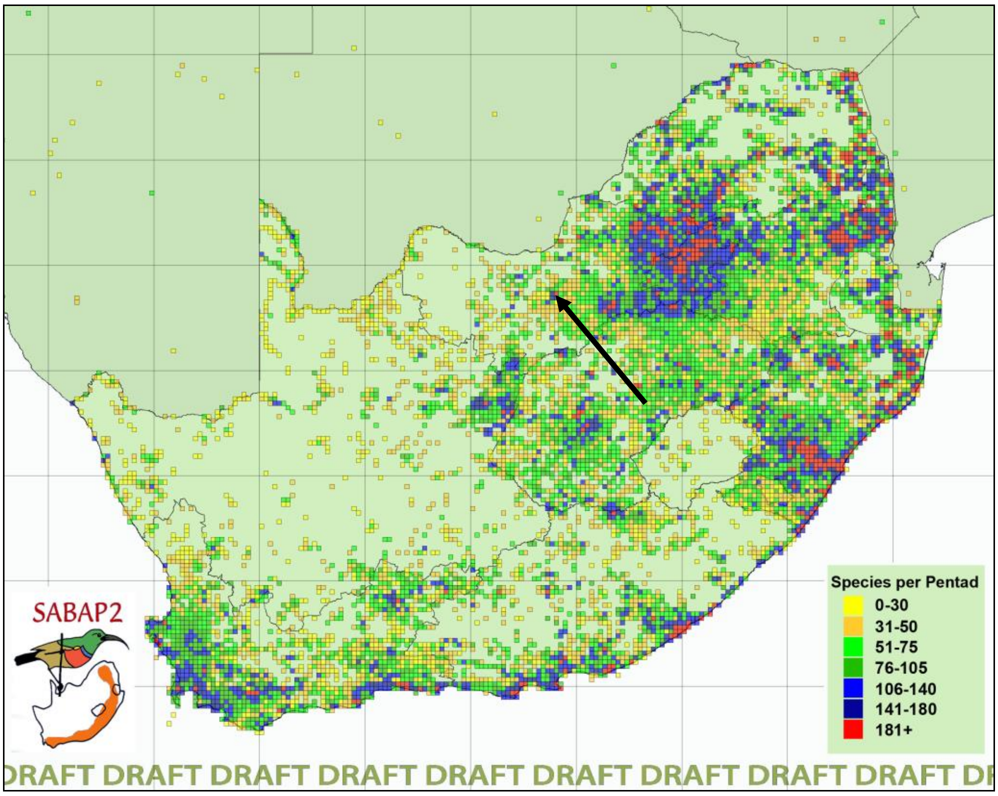


Figure 14: The bird species richness per pentad grid in comparison to the broader study area (see arrow) (map courtesy of SABAP2 and the Animal Demography Unit). According to the SABAP2 database, the study area hosts between 141 and 180 bird species.

Table 2: Expected biome-restricted species (Marnewick *et al*, 2015) likely to occur on the study area.

Species	Kalahari-Highveld	Zambezian	Expected Frequency of occurrence
Kalahari Scrub-robin (*Cercotrichas paena)*	X		Common and present
Kurichani Thrush (*Turdus libonyana*)		X	Uncommon to rare
White-throated Robin-chat (*Cossypha humeralis*)		X	Uncommon bur present
White-bellied Sunbird (*Cinnyris talatala*)		X	Uncommon to rare

Table 3: Important bird species occurring in the broader study area which could collide and/ or become displaced by the proposed PV infrastructure.

Common Name	Scientific name	Regional Status	Global Status	Observed (Jan. & May 2022)	Collision with power lines	Collision with PV panels	Displacement (disturbance & loss of habitat)
White-backed Vulture	*Gyps africanus*	CR	CR	1	1		
Cape Vulture	*Gyps coprotheres*	EN, End	EN	1	1		
Lapped-faced Vulture	*Torgos tracheliotos*	EN	EN		1		
Martial Eagle	*Polemaetus bellicosus*	EN	EN		1		
Secretarybird	*Sagittarius serpentarius*	EN	EN		1		1
Cloud Cisticola	*Cisticola textrix*	N-end		1			1
Cape Longclaw	*Macronyx capensis*	End		1			1
South African Shelduck	*Tadorna cana*	End			1	1	
Northern Black Korhaan	*Afrotis afraoides*	End		1	1		1
White-backed Mousebird	*Colius colius*	End		1			1
Karoo Thrush	*Turdus smithi*	End		1			1
Ant-eating Chat	*Myrmecocichla formicivora*	End		1			1
Fiscal Flycatcher	*Sigelus silens*	End					1
Pied Starling	*Lamprotornis bicolor*	End					1
Orange River White-eye	*Zosterops pallidus*	End		1			1
Cape White-eye	*Zosterops virens*	End		1			1
Cape Weaver	*Ploceus capensis*	End					1
South African Cliff Swallow	*Petrochelidon spilodera*	End		1			1
Orange River Francolin	*Scleroptila gutturalis*	N-end		1	1		1
Acacia Pied Barbet	*Tricholaema leucomelas*	N-end		1			1
Eastern Clapper Lark	*Mirafra fasciolata*	N-end		1			1
Ashy Tit	*Parus cinerascens*	N-end					1
Cape Penduline-tit	*Anthoscopus minutus*	N-end					1
African Red-eyed Bulbul	*Pycnonotus nigricans*	N-end		1			1
Kalahari Scrub Robin	*Cercotrichas paena*	N-end		1			1
Chestnut-vented Warbler	*Curruca subcoerulea*	N-end		1			1
Marico Flycatcher	*Bradornis mariquensis*	N-end					1
Crimson-breasted Shrike	*Laniarius atrococcineus*	N-end		1			1
Bokmakierie	*Telophorus zeylonus*	N-end		1			1

Common Name	Scientific name	Regional Status	Global Status	Observed (Jan. & May 2022)	Collision with power lines	Collision with PV panels	Displacement (disturbance & loss of habitat)
Great Sparrow	*Passer motitensis*	N-end					1
Cape Sparrow	*Passer melanurus*	N-end		1			1
Scaly-feathered Weaver	*Sporopipes squamifrons*	N-end		1			1
Red-headed Finch	*Amadina erythrocephala*	N-end					1
Mountain Wheatear	*Oenanthe monticola*	N-end					1
Yellow Canary	*Crithagra flaviventris*	N-end		1			1
Red-footed Falcon	*Falco vespertinus*	NT	NT		1		1
Black-winged Pratincole	*Glareola nordmanni*	NT	NT				1
Marabou Stork	*Leptoptilos crumenifer*	NT			1		
Abdim's Stork	*Ciconia abdimii*	NT			1		
Falcon, Lanner	*Falco biarmicus*	VU			1		
	Totals:	**40**	**7**	**22**	**12**	**1**	**32**

Threatened and near threatened species are indicated in red
CR - Critically endangered, EN - endangered, VU - vulnerable, NT - near threatened
End - southern African endemic
N-end - southern African near-endemic

Prior to further analyses where species richness values are considered, it is imperative to determine if all bird species present were sufficiently sampled. Species accumulation curves (SAC) provide a means to examine data and sampling efficacy. For this project the species accumulation curves (SAC) for the point count data were generated using the software program Estimates S (version 9) with 100 randomizations (as recommended in Colwell, 2013). Curves were generated for the full data set (all point counts). Sampling sufficiency was determined by establishing whether a point had been reached where a line representing one new sample adding one new species was tangent to the curve (Brewer & McCann, 1982). The Michaelis-Menten equation (Soberôn & Llorente 1993) was fitted to the predicted number of species using Estimates S (Raaijmakers, 1987). A satisfactory level of sampling was achieved if 90 % of the bird species were detected, and hence predicted by the model (Moreno & Halffter, 2000).

The species accumulation curve (SAC) reached an asymptote at approximately 14 point counts (Figure 15). The sampling captured approximately 69.44% of the number of species predicted by the Michaelis-Menten model at 14 point counts. Approximately 89.66% of the species was captured by 51 counts. Therefore, sampling effort was considered sufficient and recorded most of the species present on the study area during the respective survey sessions.

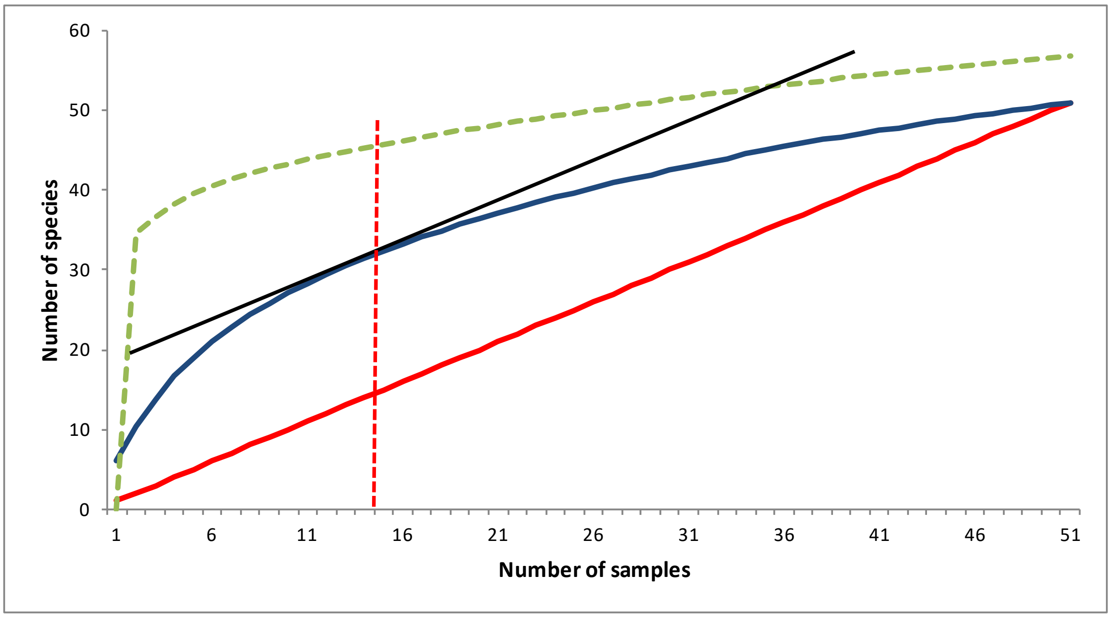
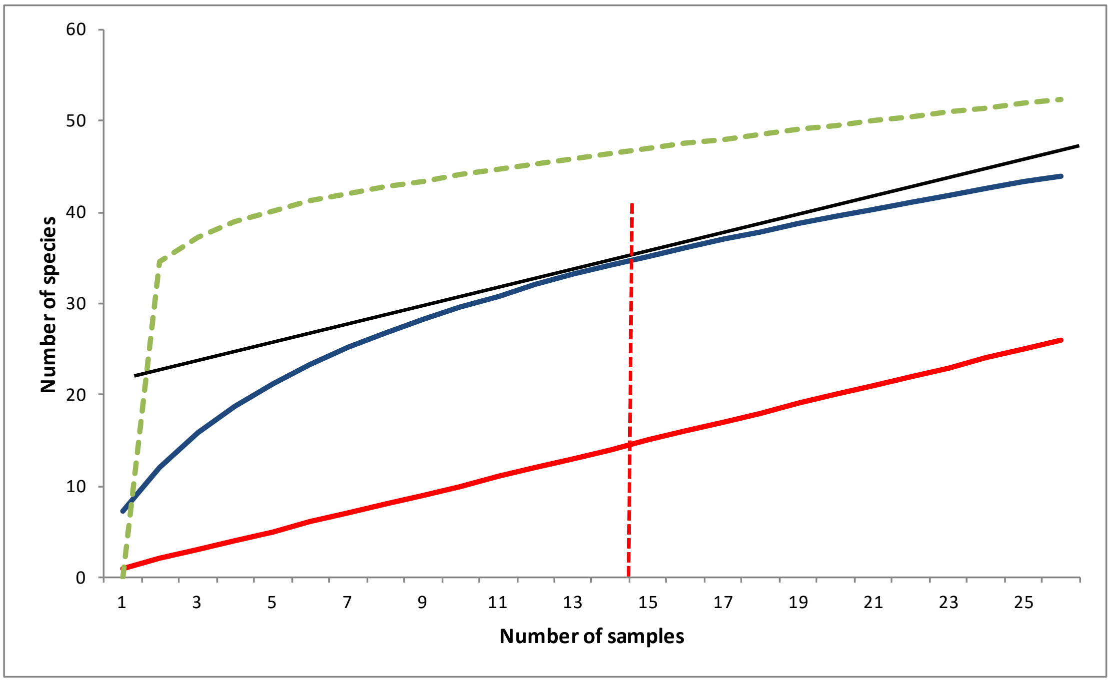


Figure 15: The species accumulation curve (SAC) (red line) for bird points sampled during the January 2022 and May 2022 survey sessions. The blue line represents an accumulation of one species for every additional point count. The black line is parallel to the blue one and is tangent to the SAC approximately after 14 counts (as represented by the vertical red stippled line). The green stippled line represents the Michaelis-Menten curve.

The species accumulation curve (SAC) for each survey (season) also reached an asymptote at approximately 13 to 14 point counts (Figure 16). The sampling captured approximately 73.49% of the number of species predicted by the Michaelis-Menten model at 14 point counts during the wet season and 66.71% of the species during the dry season at 13 counts. Between 78.55% and 83.94% of the species was captured by 26 counts respectively. Therefore, sampling effort was considered sufficient and recorded most of the species present on the study area during the respective survey sessions, although the predicted number of species was lower. However, it was evident during the dry season that bird numbers were naturally lower than expected which explains the species accumulation curve for the dry season.



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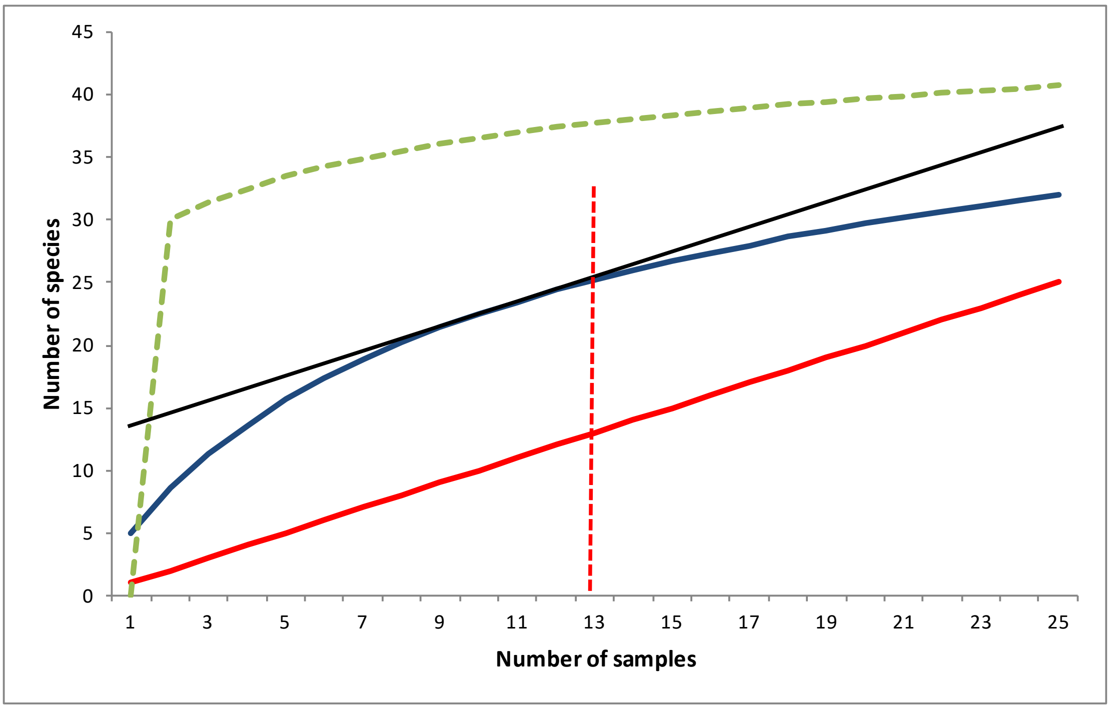

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Figure 16: The species accumulation curve (SAC) (red line) for bird points sampled during (a) January 2022 and the (b) May 2022 survey sessions. The blue line represents an accumulation of one species for every additional point count. The black line is parallel to the blue one and is tangent to the SAC approximately after 13-14 counts for both surveys (as represented by the vertical red stippled line). The green stippled line represents the Michaelis-Menten curve.

4.3 Bird species of conservation concern

Table 4 provides an overview of bird species of conservation concern that could occur on the study site based on their historical distribution ranges and the presence of suitable habitat. According to Table 4, a total of 10 species could occur on the study site which includes six globally threatened species, one globally near threatened species, one regionally threatened species and two regionally near-threatened species.

It is evident from Table 4 that the highest reporting rates (>10%) were observed for the globally endangered Cape Vulture (*Gyps coprotheres*) and the globally critically endangered White-backed Vulture (*Gyps africanus*). These species have a high likelihood of occurrence pending the presence of suitable food (livestock carcasses). Although these species were not observed during the 2022 surveys on the study site, both species are known to be regular foraging victors to the wider study area with at least six observations of White-backed Vulture observed during 2021 from similar habitat on adjacent Farm Houthaalboomen 31 (Portions, 1, 10 and 18) (Figure 17). The Lappet-faced Vulture (*Torgos tracheliotos*) shows reporting rates higher than 4% and was previously recorded from similar habitat on the Farm Zamenkomst No 04 located to the north-east of the study area (approximately 9km north east assessment area; pers. obs., Pachnoda, 2018). The Lappet-faced Vulture is regarded as a fairly regular foraging visitor to the area.

The remaining species have low reporting rates (<3%) and are regarded as irregular foraging visitors. However, during the site visits it was noticed that extensive areas of suitable foraging habitat persists for some of these species (e.g. Secretarybird *Sagittarius serpentarius*) despite being ominously absent from the area. It is possible that the low reporting rates reflect the poor coverage of the study area by citizen scientists (e.g. birdwatchers), and some of these species could occur in higher numbers due to being overlooked. As an example, Red-footed Falcons (*F. vespertinus*) often occur in flocks of the similar-looking Amur Falcon (*F. amurensis*), which based on reporting rates (c. 22.22%) appears to be a common summer visitor to the area. Therefore, it is highly possible that Red-footed Falcons were previously overlooked or misidentified.

Table 4: Bird species of conservation concern that could utilise the study area based on their historical distribution range and the presence of suitable habitat. Red list categories according to the IUCN (2022)* and Taylor et al. (2015)**.

Species	Global Conservation Status*	National Conservation Status**	Mean Reporting rate: SABAP2	Preferred Habitat	Potential Likelihood of Occurrence
Ciconia abdimii (Abdim's	-	Near threatened	3.13 (according to one ad	Open stunted grassland, fallow land	An uncommon summer foraging visitor to areas

Species	Global Conservation Status*	National Conservation Status**	Mean Reporting rate: SABAP2	Preferred Habitat	Potential Likelihood of Occurrence
Stork)			hoc card)	and agricultural fields.	consisting of open grassland and/or arable land.
Glareola nordmanni (Black-winged Pratincole)	Near threatened	Near threatened	3.12 (based on a single ad hoc card)	Varied, but forages over open short grassland, pastures and agricultural lands (especially when being tilled)	An uncommon summer foraging visitor to the study area. A flock of approx. 35 birds were observed 6km north of the study site on 15 October 2018 (on Portion 23 of the Farm Houthaalboomen 31).
Falco vespertinus (Red-footed Falcon)	Vulnerable	Near threatened	2.47	Varied, prefers to hunt open arid grassland and savannoid woodland, often in company with Amur Falcons (*F. amurensis*).	An occasional summer foraging visitor to the area. Not recorded post-2007 from the study area (pentad grid scale), although known from two observations made in 2009 from neighbouring pentad grid 2605_2610.
Falco biarmicus (Lanner Falcon)	-	Vulnerable	3.70	Varied, but prefers to breed in mountainous areas.	An occasional foraging visitor to the study area. It was last recorded during 2016 in the study area.
Gyps coprotheres (Cape Vulture)	Endangered	Endangered	11.11	Mainly confined to mountain ranges, especially near breeding site. Ventures far afield in search of food.	A regular foraging/scavenging visitor to the study site pending the presence of food (e.g. livestock carcasses).
Gyps africanus	Critically Endangered	Critically Endangered	13.58	Breed on tall, flat-topped	A regular foraging/scavengin

Species	Global Conservation Status*	National Conservation Status**	Mean Reporting rate: SABAP2	Preferred Habitat	Potential Likelihood of Occurrence
(White-backed Vulture)				trees. Mainly restricted to large rural or game farming areas.	g visitor to the study site pending the presence of food (e.g. livestock carcasses).
Leptoptilos crumeniferus (Marabou Stork	-	Near threatened	1.23	Varied, from savanna to wetlands, pans and floodplains – dependant of game farming areas	An irregular scavenging visitor to the area. It was last recorded during 2010 from the study area.
Polemaetus bellicosus (Martial Eagle)	Endangered	Endangered	1.23	Varied, from open karroid shrub to lowland savanna.	An irregular foraging visitor. It was last recorded from pentad 2605_2605 on 28 Jan 2012.
Sagittarius serpentarius (Secretarybird)	Endangered	Endangered	2.47	Prefers open grassland or lightly wooded habitat.	Regarded as an irregular foraging visitor to the study site despite the widespread presence of suitable foraging habitat. It was last recorded during 2015.
Torgos tracheliotos (Lapped-faced Vulture)	Endangered	Endangered	4.94	Lowveld and Kalahari savanna; mainly on game farms and reserves.	A fairly regular foraging/scavenging visitor to the study site pending the presence of food (e.g. livestock carcasses). It was confirmed from similar habitat approx. 9km north-east to the study site (soaring over Portion 02 of the Farm Zamenkomst No 04 during July 2018, and from at least another three

Species	Global Conservation Status*	National Conservation Status**	Mean Reporting rate: SABAP2	Preferred Habitat	Potential Likelihood of Occurrence
					observations corresponding to pentad grid 2600_2605). It is regarded as a regular passage visitor (soaring overhead) to the nearby vulture restaurant.

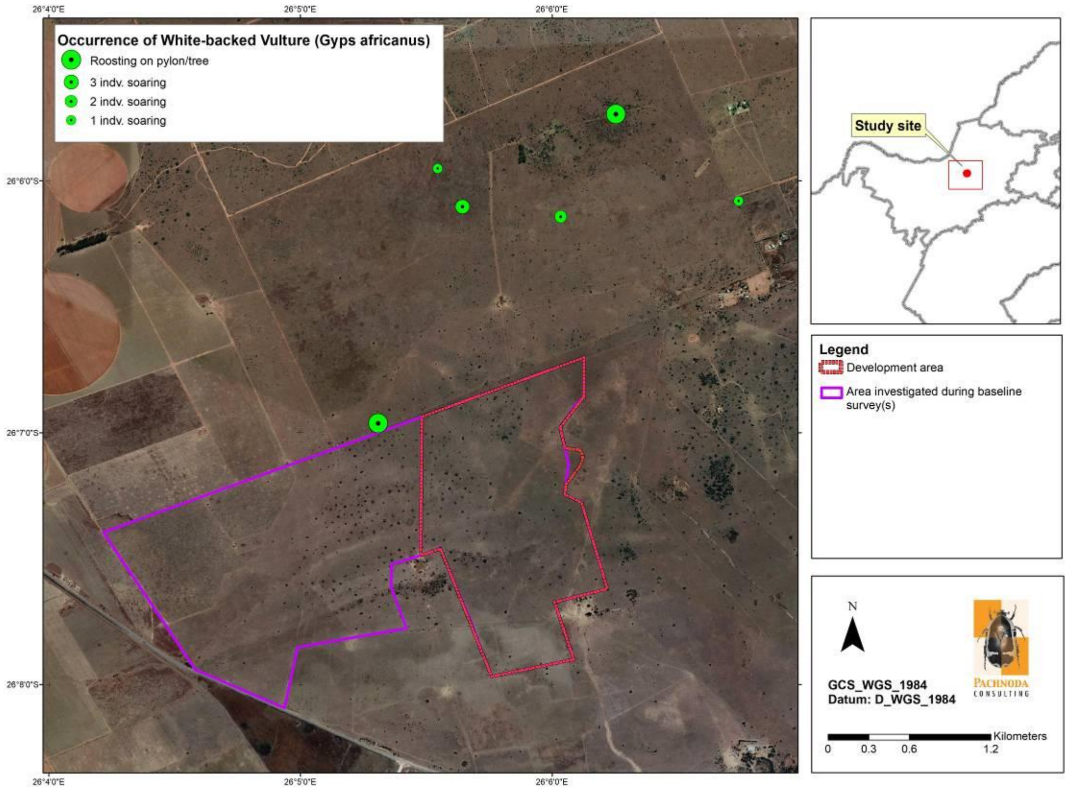

Figure 17: A map illustrating the occurrence of the critically endangered White-backed Vulture (*Gyps africanus*) in close proximity to the study area during August and November 2021 (Pachnoda, 2021).

4.3.1 Notes on the occurrence of Cape Vulture (Gyps coprotheres)

The globally endangered Cape Vulture (*G. coprotheres*) is known to occur in the study area and its presence is related to the occurrence of a nearby vulture restaurant (see Section 3.4). It is of international significance and any mortality of adult individuals could have a negative effect on its species' population recruitment. Most of these suffer from a shortage of food supplies which is responsible for low reproductive rates (Taylor *et al*., 2015). In addition, Cape Vultures also typically search for food in groups. It is such congregations which increase the risk of mortalities whenever these individuals forage or roost in close proximity to overhead power lines. The proposed study site is also in close proximity to the foraging rangeland of Cape Vultures as evidenced by dispersal data obtained from vulture individuals fitted with satellite tracking devices (Figure 18).

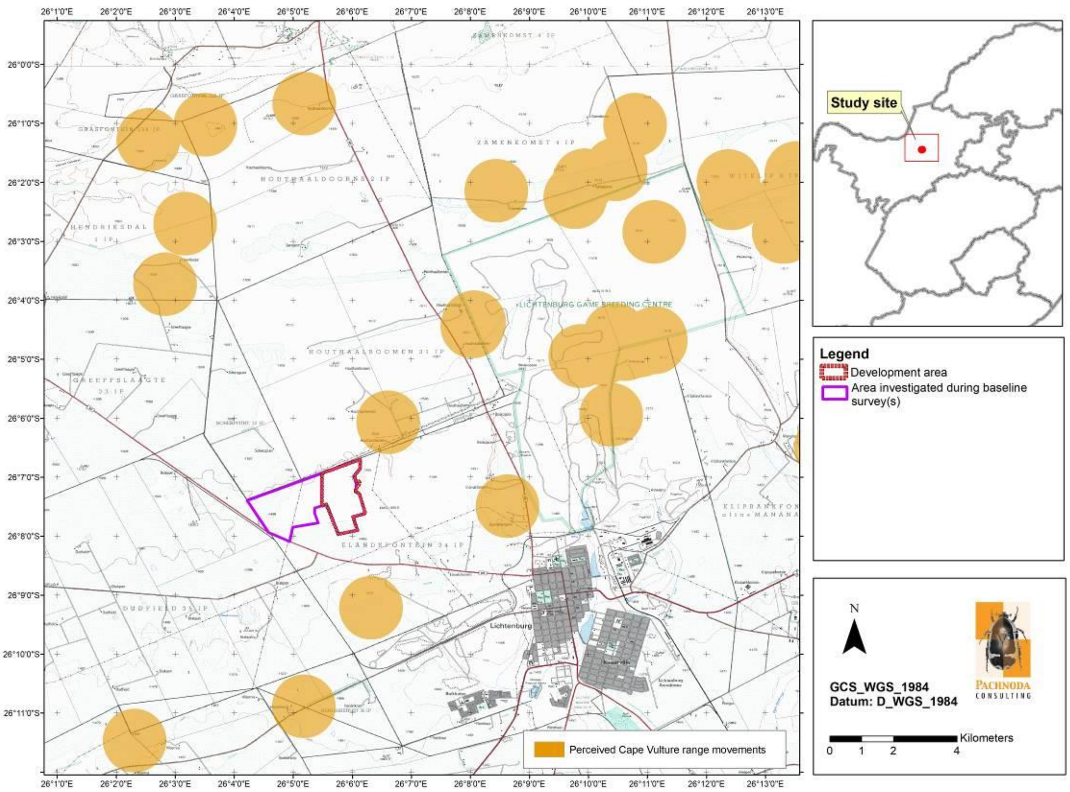

Figure 18: The occurrence of Cape Vultures (*Gyps coprotheres*) within the study region fitted with satellite trackers.

4.3.2 Notes on the occurrence of Secretarybird (Sagittarius serpentarius)

The conservation status of this species was upgraded from Vulnerable to Endangered since recent evidence suggested that it has experienced rapid declines across its entire range due to habitat loss, anthropogenic disturbances, and intensive grazing (Birdlife International, 2020). Secretarybirds are widespread in Africa south of the Sahara, but have declined over most of their geographic distribution range due to the loss of suitable habitat caused by inappropriate grazing regimes (resulting in the expansion of woody vegetation), cultivation and urbanization. The expansion of woody vegetation often results in a reduction of suitable foraging habitat and foraging efficacy (Birdlife International, 2020). In addition, it is also highly susceptible to collision with electrical cables of powerlines, with over 94 powerline fatalities recorded over the past 20 years in South Africa. Based on reporting rates, this species appear to be uncommon on the study area with only two observations corresponding to grid 2605_2605 since 2007. High reporting rates occur to the east (mainly the North West-Gauteng border) and south (grids 2610_2610 and 2615_2615 - an area between Lichtenburg and Coligny) (Figure 19). The low reporting rates (or absence) of Secretarybirds on the study site remains unclear and is probably correlated with disturbances (displacement) associated with widespread cattle ranching in the area.

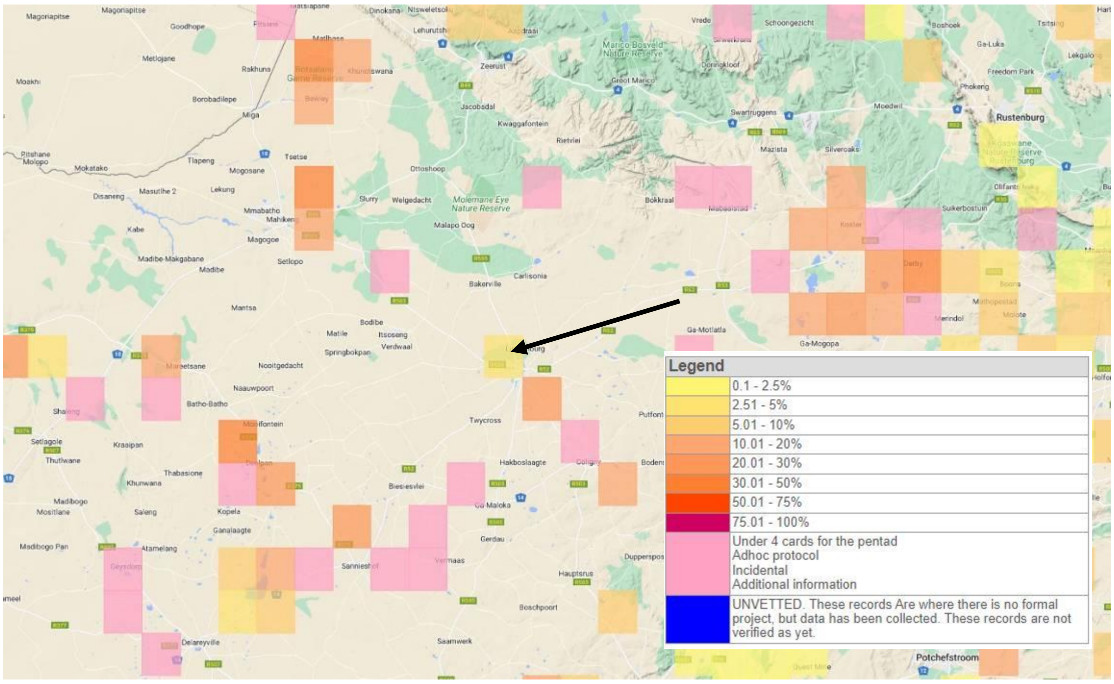

Figure 19: The occurrence of Secretarybirds (*Sagittarius serpentarius*) on the study area according to SABAP2 reporting rates (the arrow indicates the position of the study area). Note the presence of Secretarybirds to the south-west and east of the study region (map courtesy and copyright of SABAP2 and Animal Demography Unit).

4.4 Bird Assemblage Structure and Composition

4.4.1 Summary of point counts

A total of 51 bird species and an average abundance of 259 individuals were recorded from 26 bird points (representing two replicative counts during two seasons) located on the study area. The data provides an estimate of the bird richness and their numbers on the study site and immediate surroundings obtained during two independent survey sessions. A mean of 9.04 species and 9.96 individuals were record per point count. The highest number of species and individuals recorded from a point count was 22 species and 31 individuals (mainly mixed woodland on dolomite outcrops). The lowest number of species and individuals was respectively three species and 2-3 individuals (from open untransformed dolomite grassland with a monotonous structure). The mean frequency of occurrence of a bird species in the study area was 17.72 % and the median was 7.69%, while the most common value (mode) was 3.85%. The latter represents those species (c. 17 species) that were encountered in only one point count. One species occurred in all the point counts (c. Desert Cisticola *Cisticola aridulus),* while two species occurred (c. Black-chested Prinia *Prinia flavicans* and Rufous-naped Lark *M. africana*) occurred in 50% or more of the counts (Table 5).

Table 5: Bird species with a frequency of occurrence greater than 40% observed on the study area (according to 26 counts).

Species	Frequency (%)	Species	Frequency (%)
Desert Cisticola (*Cisticola aridulus*)	100.00	Cloud Cisticola (*Cisticola textrix*)	46.15
Rufous-naped Lark (*Mirafra cheniana*)	61.54	Eastern Clapper Lark (*Mirafra fasciolata)*	42.31
Black-chested Prinia (*Prinia flavicans*)	50.00	Southern Masked Weaver (*Ploceus velatus*)	42.31

4.4.2 Summary of richness and average abundance (per point count)

Displacement of birds by the proposed infrastructure is one of the impacts that is anticipated to occur. By mapping the spatial distribution of the number of species and average abundance values obtained from each point count, it is possible to predict where displacement of birds will be more intensive. According to Figure 20 and Figure 21 it is evident that moderate to high bird numbers (as well as a moderate - high number of bird species) occur on mixed woodland on dolomite outcrops. It was also evident the remainder of the habitat units poor in species richness and hold low bird numbers. These habitat types were primarily represented by monotonous seres of open untransformed dolomite grassland, which were dominant on the study site. In addition, the presence of well-defined bush clumps was also responsible for higher bird numbers (as opposed to open grassland). Therefore, the potential displacement of birds due to the loss of habitat during construction is likely to occur at habitat which features a prominent tree canopy as opposed to the surrounding open grassland mosaics.

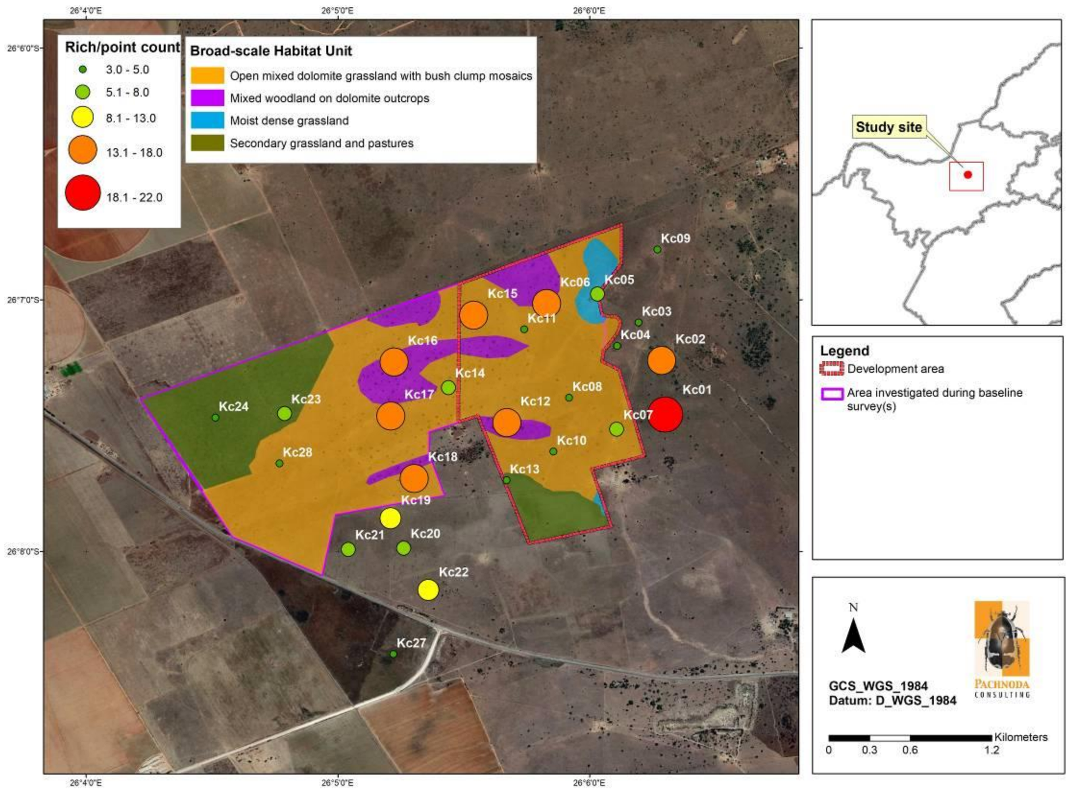

Figure 20: A map of the study area illustrating the spatial distribution of bird richness values (number of species) obtained for each point count.

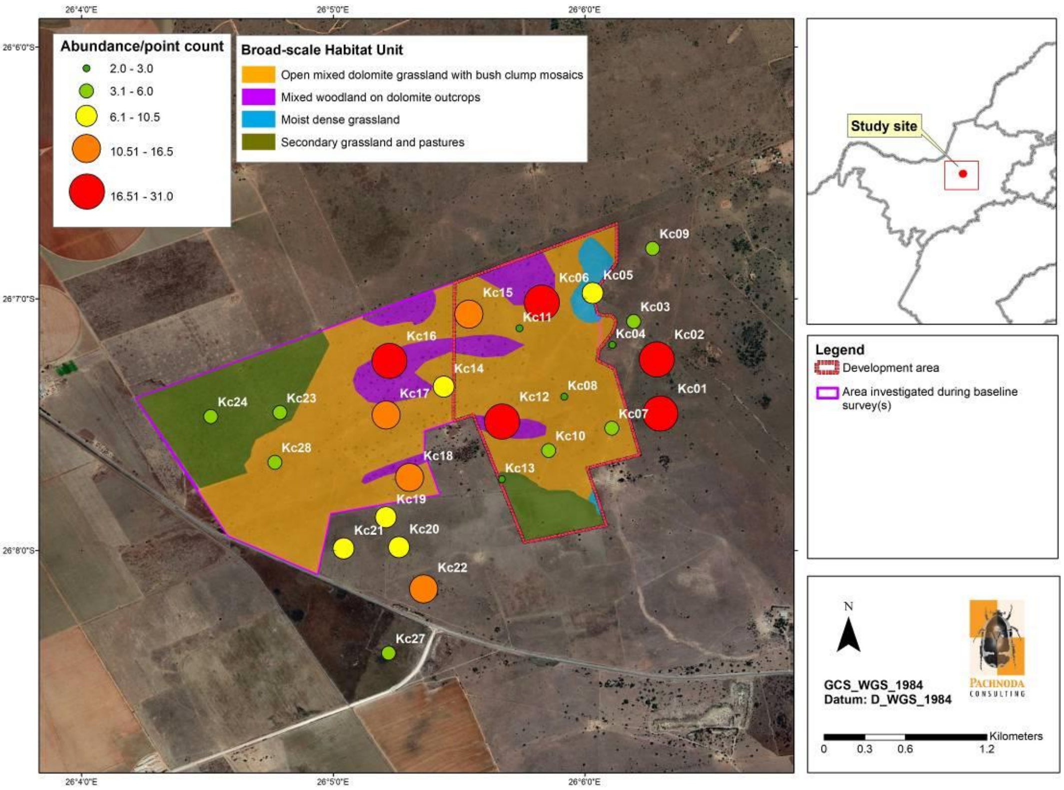

Figure 21: A map of the study area illustrating the distribution of bird abundance values (average number of individuals) obtained for each point count.

4.4.3 Dominance and typical bird species

The dominant (typical) species on the study area are presented in Table 6. Only those species that cumulatively contributed to more than 90% to the overall similarity between the point counts are presented.

The three most typical bird species on the study area include the Desert Cisticola (*Cisticola aridulus*), Cloud Cisticola (*C. textrix*) and Rufous-naped Lark (Mirafra africana). These species are considered widespread species in the broader study area and occur in most of the habitat types that are present. It is also evident from Table 6 that the typical bird assemblage is predominantly represented by insectivores (insect-eating taxa) and by granivores (seed-eating taxa) which are predominantly cryptic and grassland-associated species.

Table 6: Typical bird species on the study area.

Species	Av.Abundance	Consistency (Sim/SD)	Contribution (%)	Primary Trophic Guild
Desert Cisticola (Cisticola aridulus)	1.25	1.88	39.59	Insectivore: upper canopy foliage gleaner
Cloud Cisticola (*C. textrix*)	0.40	0.46	9.61	Insectivore: upper canopy foliage gleaner

Rufous-naped Lark (*Mirafra africana*)	0.46	0.69	9.26	Granivore/Insectivore: ground gleaner
Long-tailed Widowbird (*Euplectes progne*)	0.35	0.39	6.37	Granivore: ground gleaner
Black-chested Prinia (*Prinia flavicans*)	0.96	0.53	6.13	Insectivore: upper canopy foliage gleaner
Eastern Clapper Lark (*Mirafra fasciolata*)	0.27	0.40	5.05	Granivore/Insectivore: ground gleaner
Southern Masked Weaver (*Ploceus velatus*)	0.63	0.42	3.97	Granivore/Insectivore: upper to lower canopy gleaner
Zitting Cisticola (*Cisticola juncidis*)	0.23	0.29	3.57	

4.4.4 Composition and diversity

Multidimensional scaling and hierarchical agglomerative clustering ordination of bird abundance values obtained from 26 point counts on the study area could differentiate between four discrete bird associations (Global R= 0.752, p=0.01; Figure 22), with strong statistical differences between bush clumps on outcrops vs. moist grassland (R=1.00, p=0.001), open dolomite grassland (R=929, p=0.001) and secondary grassland (R=0.808, p=0.001). Weak correlations were obtained from bird compositions in open dolomite grassland and secondary grassland, which often have similar compositions. Similarly, the bird composition on secondary grassland also showed a higher similarity to the composition on moist grassland. The four associations include (1) an association on open dolomite grassland (2) an association pertaining to moist grassland, (3) an association confined secondary grassland (rehabilitating grassland) and an (4) association confined to tall bush clumps and outcrops (predominantly on woody vegetation).

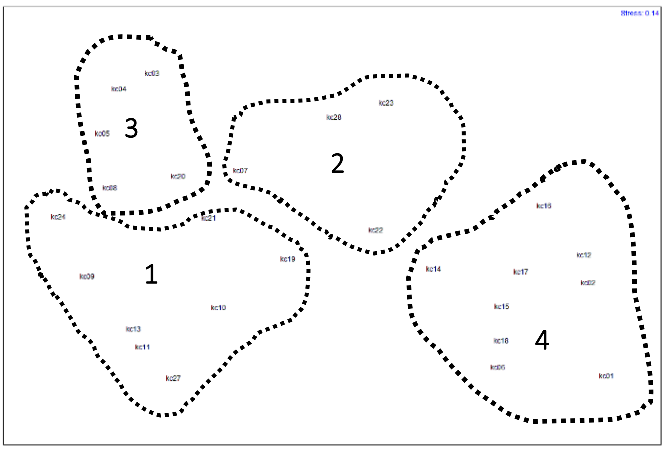

Figure 22: A two-dimensional non-metric multidimensional scaling ordination (stress=0.14) of the relative abundances of bird species based on Bray-Curtis similarities obtained from 26 point counts on the project area. It differentiates between four bird associations: (1) an association on open dolomite grassland, an (2) association pertaining to moist grassland, (3) an association confined to secondary

grassland (rehabilitating grassland) and (4) and association confined to tall bush clumps and outcrops (predominantly on woody vegetation).

The following bird associations are relevant to the study site and immediate surroundings:

1. Association on open dolomite grassland (mainly monotonous untransformed grassland)

Dominant species: Desert Cisticola (*Cisticola aridulus*), Cloud Cisticola (*C. textrix*), Eastern Clapper Lark (*Mirafra fasciolata*), and African Pipit (*Anthus cinnamomeus*).

Indicator species[9]: Orange River Francolin (*Scleroptila gutturalis*).

2. Association on moist grassland

Dominant species: Desert Cisticola (*Cisticola aridulus*), Cloud Cisticola (*C. textrix*), Zitting Cisticola (*C. juncidis*), Cape Longclaw (*Macronyx capensis*) and Long-tailed Widowbird (*Euplectes progne*).

Indicator species: Common Waxbill (*Estrilda astrild*) and Marsh Owl (*Asio capensis*), while Cape Longclaw (*Macronyx capensis*), Long-tailed Widowbird (*Euplectes progne*) and Quailfinch (*Ortygospiza atricollis*) occur in high numbers.

3. Association on secondary grassland (rehabilitating grassland)

Dominant species: Desert Cisticola (*Cisticola aridulus*), Long-tailed Widowbird (*Euplectes progne*), Cloud Cisticola (*C. textrix*), Rufous-naped Lark (Mirafra *africana*) and Black-chested Prinia (*Prinia flavicans*).

Indicator species: Speckled Pigeon (Columba guinea) and Cinnamon-breasted Bunting (*Emberiza tahapisi* - rare).

4. Association on bush clumps and outcrops (predominantly on woody vegetation)

Dominant species: Chestnut-vented Warbler (*Curruca subcoerulea*), Black-chested Prinia (*Prinia flavicans*), Desert Cisticola (*Cisticola aridulus*), African Red-eyed Bulbul (*Pycnonotus nigricans*), Kalahari Scrub-robin (*Cercotrichas paena*), Acacia Pied Barbet (*Tricholaema leucomelas*) and Neddicky (*Cisticola fulvicapilla*).

Indicator species: Chestnut-vented Warbler (*Curruca subcoerulea*), Kalahari Scrub-robin (*Cercotrichas paena*), Neddicky (*Cisticola fulvicapilla*), Red-faced Mousebird (*Urocolius indicus*), White-backed Mousebird (*Colius colius*), Dark-capped Bulbul

[9] Indicator species refers to a species with high numbers that is restricted to a particular habitat.

(Pycnonotus tricolor), Black-crowned Tchagra (*Tchagra senegalus*), Brown-crowned Tchagra (*T. australis*), Common Whitethroat (*Curruca communis*) and Long-billed Crombec (*Sylvietta rufescens*).

The highest number of bird species on the study area was observed from bush clump vegetation, especially woody vegetation on outcrops with approximately 42 species recorded (Table 7). The lowest number of bird species was recorded from the moist and open dolomite grassland units with respectively 8 and 10 species each. It clearly illustrates that vertical heterogeneity (e.g. woody vegetation) markedly increase bird richness in a landscape dominated by grassland.

Table 7: A summary of the observed species richness and number of bird individuals confined to the bird associations on the study area.

Bird Association	Number of species	Number of Individuals	Shannon Wiener Index H'($\log_e$)
Tall bush clumps and outcrops	42	18.56	3.20
Moist grassland	8	4.67	1.94
Open dolomite grassland	10	3.42	2.06
Secondary grassland	21	8.70	2.72

4.5 Passerine bird densities

Thirty-five passerine bird species were recorded from 26 point counts on the study area. The study area comprises of approximately 9.66 species.ha^{-1} (Appendix 2). The average density per hectare is 10.45 birds.ha^{-1} and ranges between 2.56 birds.ha^{-1} to 30.13 birds.ha^{-1}.

4.6 Movements/dispersal of Collision-prone birds

The occurrence of collision-prone bird species on the study area was low, especially when compared to similar habitat adjacent to the study area (e.g. Farm Houthaalboomen 31) where the numbers of large terrestrial birds (e.g. Northern Black Korhaan (*Afrotis afraoides*) was significantly higher. It is possible that historical disturbance events such as agricultural activities (e.g. the conversion of grassland into cultivation) have displaced many large-bodied bird species from the area. Deterministic daily dispersal of birds (Figure 23 and Figure 24) was obscured, although many of the Pied Crows (*Corvus albus*) tend to disperse from an easterly to a westerly direction in the mornings (probably when commuting from their roosting sites) (Figure 23). However, it appears that most of the crows occur in pairs and many pairs tend to visit nearby artificial watering points, probably to drink/bath or to search for food.

The occurrence of birds of prey was regarded as highly occasional, although foraging vultures occurred to the north of the study area pending the availability of carcasses or food at a nearby vulture restaurant (Pachnoda, 2021).

Furthermore, the home ranges of approximately two pairs of Northern Black Korhaans correspond to the project area, although these occurred to the west od the Themeda PV site (Figure 25). It is evident that the density of korhaan individuals on the assessment area was low.

The absence of any nearby water bodies, dams and drainage lines explains the general absence of waterbirds passing through the area.

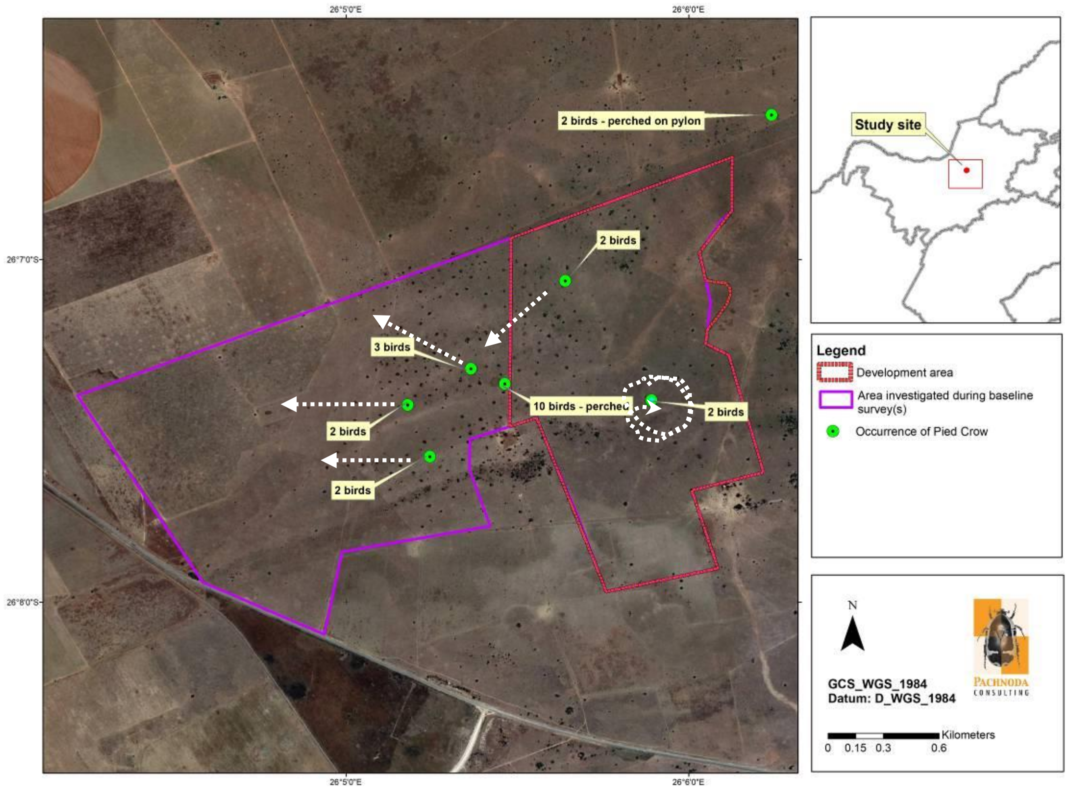

Figure 23: A map of the study site illustrating the occurrence and movements of Pied Crows (*Corvus albus*).

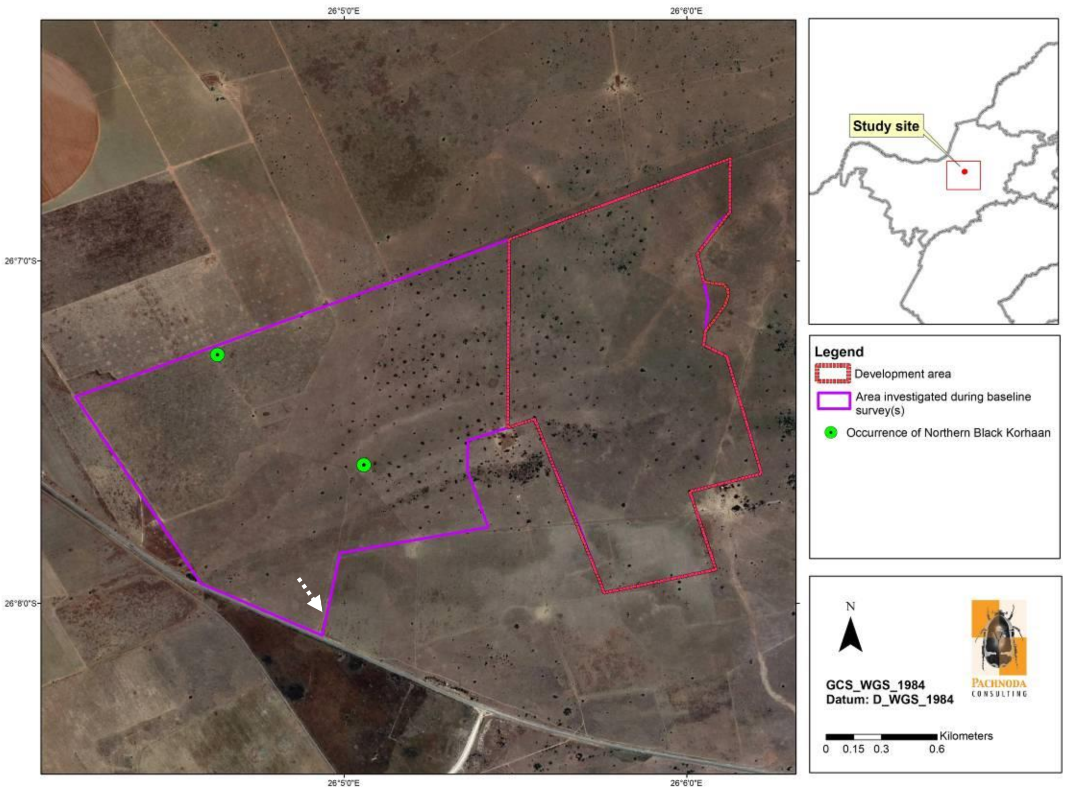

Figure 24: A map of the study site illustrating the occurrence of Northern Black Korhaan (*Afrotis afraoides*):

4.7 Avifaunal sensitivity

A sensitivity map was compiled, illustrating habitat units comprising of potential sensitive elements based on the following arguments (Figure 25 and Figure 26):

Areas of high sensitivity

This habitat unit is represented by moist dense grassland which contains a distinct avifaunal composition that are primarily absent from the other habitat units, even though the avian richness and density of birds was low. It is considered to be of high sensitivity since it represents a wetland unit with important ecological function (e.g. drainage, aquifer supply and local dispersal of facultative wetland-associated bird species) and has the potential to provide both roosting and foraging habitat (especially the areas dominated by *Imperata cylindrica* grass) for the regionally vulnerable African Grass-owl (*Tyto capensis*).

Areas of medium sensitivity

It includes the mixed woodland on outcrops, secondary grasslands and the extensive open grassland dolomite grassland mosaics. The mixed woodland provides potential roosting platforms for vultures (observed during the dry season survey in August

2021 from adjacent Farm Houthaalboomen 31) and supported a higher number of bird species.

The extensive open grassland provide potential suitable foraging habitat for some collision-prone bird species, including the Northern Black Korhaan (*Afrotis afraoides*) with the potential to interact (e.g. collide) with the proposed electrical infrastructure. However, the density and occurrence of these species were significantly low when compared to similar habitat adjacent to the study site. In addition, reporting rates for threatened and near threatened bird species are also relatively low, thereby suggesting a medium sensitivity rating instead of a high sensitivity even though the majority of the habitat is natural. In addition, the open grassland and bush clump mosaics are widespread in the region.

Although the secondary grassland are considered as transformed habitat units, they both provides ephemeral foraging habitat for large terrestrial bird species (e.g. Northern Black Korhaan) and should be treated with a medium avifaunal sensitivity.

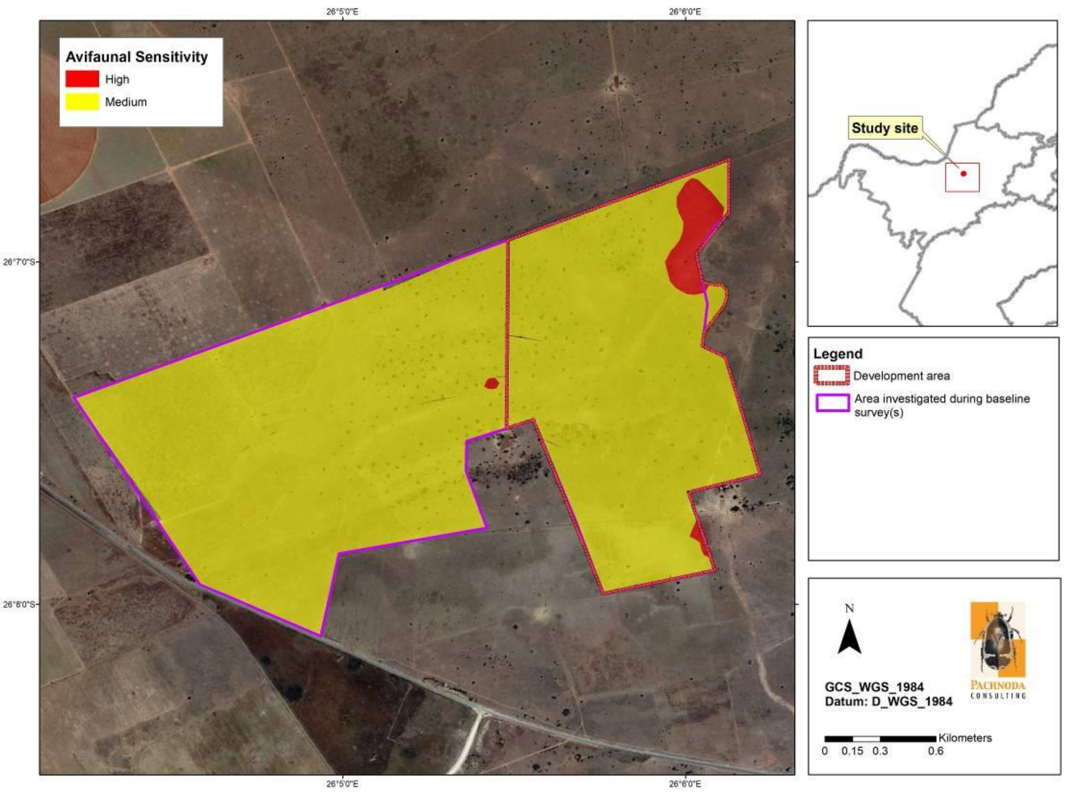

Figure 25: A map illustrating the avifaunal sensitivity of the development areas based on habitat types supporting bird taxa of conservation concern and important ecological function.

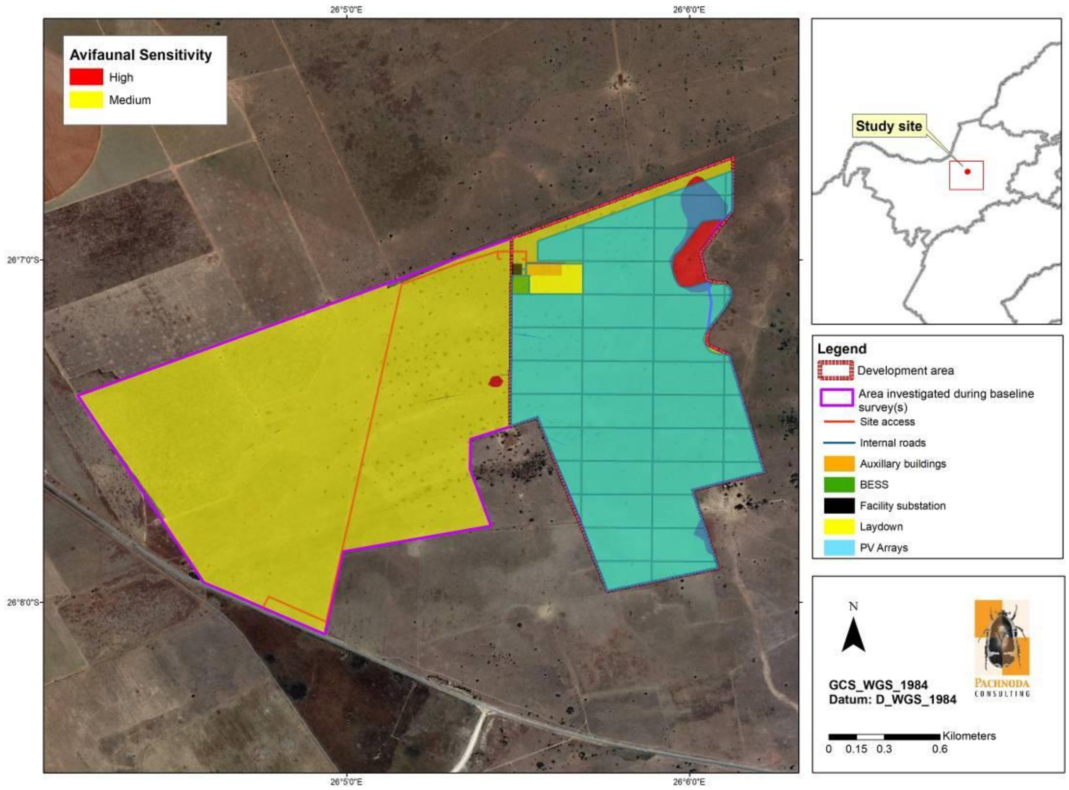

Figure 26: A map illustrating the avifaunal sensitivity of the development areas relative to the proposed facility infrastructure (for clarity the yellow area south of the auxiliary buildings is the “Laydown”. The other yellow areas refer to “medium sensitivity”).

4.8 Overview of Avian Impacts at Solar Facilities

4.8.1 Background to solar facilities and their impact on birds

Birds are mobile, and are therefore also more readily affected by solar facilities than other taxonomic groups (e.g. mammals). In fact, birds are also vulnerable to impacts caused by other types of energy facilities such as overhead power lines and wind farms. Little information is available on the impacts of solar energy facilities on birds although Gunerhan *et al.* (2009), McCrary *et al.* (1986), Tsoutsos *et al.* (2005) and the recent investigation reports on bird fatalities in the USA by Kagen *et al*. (2014) and Walston *et al*. (2016) provide discussions thereof. These studies have shown that avian fatalities vary greatly between the geographic positions of the solar facilities and also depend on the type of solar facility. In addition, very few of the large solar facilities in operation undertake systematic monitoring of avian fatalities, which explains the lack of detailed information of avian impacts. According to these studies conducted at both Concentrated Solar Power (CSP) and PV facilities, avian incidental fatalities range from 14 to over 180 birds which were summarised over a survey period conducted during one to three years. According to the Walston *et al.* (2016) assessment, the average annual mortality rate for known utility-scale solar facilities (the annual number of estimated bird deaths per megawatt of electrical capacity) is 2.7, and 9.9 for known and unknown fatalities (which include carcasses found on the project site of which the death is not known). McCrary *et al.* (1986) found an average rate of mortality of 1.9-2.2 birds per week affecting 0.6-0.7% of the local bird population. However, most of the avian fatalities at these solar facilities are also probably underestimated since 10-30% of dead birds are removed by scavengers before being noted. From these analyses and assessments it was evident that:

- Medium levels of bird fatalities occur at PV sites when compared to CSP sites (due to solar flux-based mortalities associated with CSP sites).
- Approximately 81 % of all avian mortalities were caused by collisions, including collisions with electrical distribution lines.
- Most of the mortalities were small passerines (especially swallows).
- Fatalities at these solar facilities also include waterbirds (e.g. grebes, herons and gulls) which were probably attracted by the apparent "lake effect" caused by the reflective surface of the PV panels.
- Approximately 10-11 % of the fatalities consists of waterbirds, but could be as high as 49 % at certain facilities.
- It is unclear if the "lake effect" caused by the panels (at PV facilities) or mirrors (at CSP facilities) are the main cause of birds colliding or interacting with the infrastructure (since both waterbirds and other passerines are colliding with the infrastructure).
- Most of the fatalities are of resident birds as opposed to migratory species.

In a review report by Harrison *et al.* (2016), an attempt was made to provide evidence of the impacts caused by solar PV facilities alone (not combined with CSP facilities) on birds in the UK. These authors reviewed approximately 420 scientific documents, including 37 so-called "grey" literature from non-government and government organisations for any evidence relating to the ecological impacts of solar PV facilities. Their main findings were as follows:

- The majority of the documents were not relevant and peer-reviewed documents of experimental scientific evidence on avian fatalities were non-existent.
- Results based on carcass searches suggest that the bird collision risk at PV developments are low, although these studies did not take collision by overhead power lines into account.
- Many of the documents recommended that PV developments in close proximity to protected areas should be avoided.
- The PV panels reflect polarised light, which can attract polarotactic insects with potential impact to their reproductive biology. In addition, the polarising effect of the PV panels may also induce drinking behaviour in some birds, which may mistake the panels for water.

- They conclude that impact assessment reports should consider taxon-specific requirements of birds and their guilds.

4.9.2 Impacts of PV solar facilities on birds

The magnitude and significance of impacts to birds caused by solar facilities will depend on the following factors:

- The geographic locality of the planned solar facility;
- The size or surface extent of the solar facility;
- The type of solar facility (according to the technologies applied, e.g. PV or CSP); and
- The occurrence of collision-prone bird species (which are often closely related to the locality of the solar facility).

Any planned solar facility corresponding to an area with many threatened, range-restricted or collision-prone species will have a higher impact on these birds. In addition, any planned solar facility located in close proximity to important flyways, wetland systems or roosting/nesting sites used by the aforementioned species will have a higher impact.

The main impacts associated with PV solar facilities include (Jenkins *et al*., 2017):

- The loss of habitat and subsequent displacement of bird species due to the ecological footprint required during construction;
- Disturbances caused to birds during construction and operation;
- Direct interaction (collision trauma) by birds with the surface infrastructure (photovoltaic panels) caused by polarised light pollution and/or waterbirds colliding with the panels (as they are mistaken for waterbodies);
- Collision with associated infrastructure (mainly overhead power lines and reticulation); and
- Attracting novel species to the area (owing to the artificial provision of new habitat such as perches and shade) which could compete with the residing bird population.

4.9 Impacts associated with the Themeda PV Facility

Table 8 provides a summary of the impacts anticipated and quantification thereof (see Appendix 3 for methods used during the assessment of impacts).

4.9.1 Loss of habitat and displacement of birds

Approximately 190 ha of the site will be cleared of vegetation and habitat to accommodate the panel arrays and associated infrastructure. Clearing of vegetation will inevitably result in the loss of habitat and displacement of bird species. From the results, approximately 9.66 species.ha^{-1} and 10.45 birds.ha^{-1} will become displaced should the activity occur across all the habitat types on the study site (as per Jenkins et al., 2017). Displacement will mainly affect passerine and smaller non-passerine species inhabiting the taller bush clump mosaics as opposed to the open grasslands. In addition, the displacement of larger terrestrial bird species is also considered to be low due to the low frequency of occurrence of these species (e.g. korhaan taxa and other collision-prone species).

The following bird species are most likely to be impacted by the loss of habitat due to their habitat requirements, endemism and conservation status (although not limited to) due to the proposed development:

- Kalahari Scrub Robin (*Cercotrichas paena*);
- Potentially also Northern Black Korhaan (*Afrotis afraoides*)
- Orange River Francolin (*Scleroptila gutturalis*) and potentially also small to medium birds of prey such as:
- Black-winged Kite (*Elanus caeruleus*);
- Yellow-billed Kite (*Milvus aegyptius*); and
- Amur Falcon (*Falco rupicolus*).

When considering the number of displaced bird species and their widespread occurrence in the region, the predicted impact due to the overall displacement and habitat loss is moderate without mitigation measures.

4.9.2 Creation of "new" avian habitat and bird pollution

It is possible that the PV infrastructure (during operation) could attract bird species which may occupy the site or interact with the local bird assemblages in the wider region. These include alien and cosmopolitan species, as well as aggressive omnivorous passerines which could displace other bird species from the area:

- House Sparrow (*Passer domesticus*);
- Common Myna (*Acridotheres tristis*);
- Pied Crow (*Corvus albus*); and
- Speckled Pigeon (*Columba guinea*).

The infrastructure may attract large numbers of roosting columbid taxa, especially Speckled Pigeons (*Columba guinea*), which may result in avian "pollution" through excreta, thereby fouling the panel surfaces. The impact is manageable and will result in a low significance.

4.9.3 Collision trauma caused by photovoltaic panels (the "lake-effect")

The study site is not located in close proximity to any major wetland system or water body. The nearest wetland system is approximately 3.4 km south east of the site, which explains the low occurrence of waterbird taxa at the study site. These wetland habitat types are often utilised by waterbirds which could accidentally mistake the reflective panels for waterbodies, thereby resulting in bird collisions with the panel surfaces. The impact is considered to be low although predictions regarding the occurrence of waterbird species and their numbers (e.g. density) in the area inconceivable.

However, desktop results and site observations show that the following species could interact with the panel infrastructure:

- Yellow-billed Duck (*Anas undulata*);
- Red-billed Teal (*Anas erythrorhynchus*);
- South African Shelduck (*Tadorna cana*);
- Spur-winged Goose (*Plectropterus gambiensis*);
- Egyptian Goose (*Alopochen aegyptiaca*);
- Black-headed Heron (*Ardea melanocephala*); and probably also
- Grey Heron (*Ardea cinerea*);
- African Sacred Ibis (*Threskiornis aethiopicus*) and
- White-faced Duck (*Dendrocygna viduata*).

In the absence of sufficient information on the occurrence of waterbird taxa in the area, as well as the lack of data on bird mortalities caused by collisions, the precautionary principle was applied which results in an impact of moderate significance (in the absence of any mitigation measures).

4.9.4 Interaction with overhead powerlines

Overhead powerlines are not part of the facility infrastructure and all internal cabling and MV corridors will be placed underground. However, a single or double circuit 132 kV overhead powerline is proposed to be constructed between the Elandsfontein collector switching station and the Watershed Main Transmission Substation (MTS). This proposed powerline could result in bird collisions and electrocutions, and these impacts will be assessed as part of a separate Environmental Application (separate EIA report).

However, it is highly recommended that all existing overhead powerlines (irrespective of size) that span the proposed Themeda PV site be retrofitted with bird guards and appropriate bird flight diverters to reduce any potential collision trauma in birds due to birds attracted to the facility by the PV panels.

Table 8: The quantification of impacts associated with the proposed PV facility and its infrastructure.

1. Nature:

Losses of natural habitat and displacement of birds through physical transformation, modifications, removals and land clearance. This impact is mainly restricted to the construction phase and is permanent.

PV Layout (and associated infrastructure)	**Without mitigation**	**With mitigation**
Extent	Local (2)	Local (2)
Duration	Permanent (5)	Permanent (5)
Magnitude	Moderate (6)	Moderate (6)
Probability	Definite (5)	Highly Probable (4)
Significance	**High (65)**	**Medium (48)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes, to some extent	Yes, to some extent

Mitigation:

It is difficult to mitigate against the loss of habitat since clearing of vegetation (or habitat) will be required for the infrastructure associated with the project. Both the PV facility and also the access road contain the same habitat types of medium sensitivity. The best practicable mitigation will be to consolidate infrastructure to areas where existing impacts occur.

Residual:

It is anticipated that during rehabilitation (after removal of the panels) that the vegetation will revert to secondary grassland and shrubland resulting in a decreased bird species richness with low evenness values on a local scale. The residual impact of the PV facility will be medium.

2. Nature:

The creation of novel or new avian habitat for commensal bird species or superior competitive species. This is expected to occur during the operation phase of the facility.

PV Layout (and associated infrastructure)	**Without mitigation**	**With mitigation**
Extent	Footprint (1)	Footprint (1)
Duration	Medium-term (3)	Medium-term (3)
Magnitude	Minor (2)	Minor (2)
Probability	Probable (3)	Improbable (2)
Significance	**Low (18)**	**Low (12)**
Status (positive or negative)	Negative	Negative
Reversibility	Moderate	Moderate
Irreplaceable loss of resources?	No	No
Can impacts be mitigated?	Yes, with experimentation	Yes

Mitigation:

Apply bird deterrent devices and remove nest structures constructed on infrastructure associated with the PV facility under the guidance of the ECO.

Residual:

Secondary displacement by completive bird species such as crows and increased fecundity rate for commensal bird species that are adapted to anthropogenic activities. The impact is regarded as low.

3. Nature: Avian collision impacts related to the PV facility during the operation phase (collision with the PV panels).		
PV Layout (and associated infrastructure)	**Without mitigation**	**With mitigation**
Extent	Local (2)	Local (2)
Duration	Long-term (4)	Long-term (4)
Magnitude	Low (4)	Minor (2)
Probability	Probable (3)	Improbable (2)
Significance	**Medium (30)**	**Low (16)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	No, although threatened species are present in the wider area, these are likely to become displaced while waterbirds are uncommon due to the absence of prominent water/wetland features in the area.	No
Can impacts be mitigated?	Yes, to some extent	Yes, to some extent
Mitigation: Apply bird deterrent devices such as rotating flashers/reflectors to the panels for birds that may mistake the panels for open water and to prevent them from landing on the panels. Security/CCTV cameras may be installed to quantify mortalities (cameras are also installed along the perimeter fence for security measures and may also proved effective to quantify mortalities). If post- and pre-construction monitoring predicts and/or confirms any bird mortalities, an option is to employ video cameras at selected areas to document bird mortalities and to conduct direct observations and carcass searches on a regular and systematic basis.		
Residual: Direct mortality is possible and may still occur irrespective of applied mitigation measures. Regular and systematic monitoring is proposed to assess the efficacy of applied mitigation and further research and testing is suggested to improve mitigation measures (e.g. bird deterrent devices). The residual impact is regarded as low.		

4.10 Cumulative Impacts

Cumulative impacts are defined as impacts that result from additional or incremental activities caused by past or present actions together with the current project. Therefore, cumulative impacts are those that will affect the general avifaunal community in the study area due to other planned solar farm projects and electrical infrastructure in the region.

The Themeda PV facility is one of two similar facilities located in the project area. The other facility includes the Aristida PV facility which is also located on Portion 7 of Farm Elandsfontein 34. These two solar facilities will cumulatively occupy an area of approximately 441 ha.

In addition, three other PV facilities (Dicoma, Setaria and Barleria PV facilities) are planned on Portions 1, 9 and 10 of the Farm Houthaalboomen 31 which are adjacent (north) to the proposed Aristida PV and Themeda PV facilities. These three solar facilities will cumulatively occupy an area of approximately 542 ha.

Three facilities (Euphorbia, Hillardia and Verbena PV facilities) which are located on Portions 2, 3 and 4 of the Farm Houthaalboomen 31 are planned approximately 4km to the north of the Themeda PV facility. These three solar facilities will cumulatively occupy an area of approximately 595 ha.

Another three PV facilities (Lichtenburg 1 - 3 PV facilities) are planned on the Remaining Extent of Portion 02 of the Farm Zamenkomst No 04, Portion 06 of the Farm Zamenkomst No 04 and Portion 23 of Farm Houthaalboomen No 31 respectively, which are approximately 5.6km north east of the Themeda PV facility. These three solar facilities will cumulatively occupy an area of approximately 784 ha.

Other solar projects are also proposed in the region which includes the 75MW Tlisitseng PV Facilities (covering a maximum of 600 ha in total on Portion 25 of the Farm Houthaalboomen No. 31), the Watershed Solar Energy Facility and the Lichtenburg Solar Park.

The cumulative impacts are likely to exacerbate the displacement and loss of habitat.

A summary of the cumulative impacts is provided in Table 9.

Table 9: A summary of the cumulative impacts.

1. Nature: Regional losses of natural habitat and subsequent displacement of birds.		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**
Extent	Local (2)	Local (2)
Duration	Permanent (5)	Long-term (4)
Magnitude	Moderate (6)	High (8)
Probability	Highly Probable (4)	Definite (5)
Significance	**Medium (48)**	**High (70)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Loss of resources?	Yes	Yes
Can impacts be mitigated?	Yes, to some extent	Yes
Confidence in findings: High.		
Mitigation: The best practicable mitigation will be to consolidate infrastructure to areas where existing impacts occur. The development footprint of the various individual facilities must be kept as small as possible and sensitive habitats must be avoided.		

2. Nature: Avian collision impacts related to the PV facility during the operation phase (collision with the PV panels).		
	Overall impact of the proposed project considered in isolation	**Cumulative impact of the project and other projects in the area**

Extent	Local (2)	Local and immediate surroundings (3)
Duration	Long-term (4)	Long-term (4)
Magnitude	Minor (2)	Low (4)
Probability	Improbable (2)	Probable (3)
Significance	**Low (16)**	**Medium (33)**
Status (positive or negative)	Negative	Negative
Reversibility	Low	Low
Irreplaceable loss of resources?	No, although threatened species are present in the area, these are likely to become displaced while waterbirds are uncommon due to the absence of prominent water/wetland features in the area.	No, although threatened species are present in the area, these are likely to become displaced while waterbirds are uncommon due to the absence of prominent water/wetland features in the area
Can impacts be mitigated?	Yes, to some extent	Yes, to some extent
Confidence in findings: Low.		
Mitigation: Apply bird deterrent devices to the panels for birds that may mistake the panels for open water and to prevent them from landing on the panels.		

4.11 Recommended avifaunal mitigation

4.11.1 Loss of habitat and displacement bird taxa

It is difficult to mitigate against the loss of habitat when fixed infrastructure is applied. However, proper site selection of the facility is key to reducing the predicted impacts.

The following mitigation measures are proposed:

- Concentrate all surface infrastructure on habitat of medium to low avifaunal sensitivity. The development footprint of the various individual facilities must be kept as small as possible and sensitive habitats must be avoided.
- Where possible, existing access roads should be used and the construction of new roads should be kept to a minimum.
- Prevent an overspill of construction activities into areas that are not part of the proposed construction site.
- Use indigenous plant species native to the study area during landscaping and rehabilitation.
- All internal electrical reticulation should be placed underground.

4.11.2 Creation of "new" avian habitat and bird pollution

The following mitigation measures are proposed:

- Apply bird deterrent devices at selective areas (for example at the corners and middle part of the facility) to the PV panels to discourage birds from colonising the infrastructure or to discourage birds from constructing nests. These could include visual or bio-acoustic deterrents such as highly reflective rotating devices, anti-perching devices such as bird guards, scaring or chasing activities involving the use of trained dogs or raptors and/or netting. Nests should be removed when nest-building attempts are noticed under the guidance of the ECO.

- Reduce or minimise the use of outdoor lighting to avoid attracting birds to the lights or to reduce potential disorientation to migrating birds.
- Use indigenous plant species native to the study area during landscaping and rehabilitation.

4.11.3 Collision trauma caused by photovoltaic panels (the "lake-effect")

The following mitigation measures are proposed:

- Implement at least one additional bird survey (pre-construction surveys - see section dealing with monitoring and EMP) during the peak wet season to obtain additional quantified data on the occurrence or flyways of waterbird and collision-prone bird taxa. The data will enable informed decisions regarding the use of deterrent devices.
- Apply bird deterrent devices to the panels at selective areas (for example at the corners and middle part of the facility) to discourage birds from colonising/colliding with the infrastructure. These could include visual or bio-acoustic deterrents such as highly reflective rotating devices, anti-perching devices such as bird guards, scaring or chasing activities involving the use of trained dogs or raptors and/or netting.
- Apply systematic reflective/dynamic markers to the boundary fence to increase the visibility of the fence for approaching birds (e.g. korhaan taxa) and to avoid potential bird collisions with the fence structure.
- Reduce or minimise the use of outdoor lighting to avoid attracting birds to the lights or to reduce potential disorientation to migrating birds.

4.11.4 Existing powerlines (spanning the facility)

The following mitigation measures are proposed:

- All internal electrical infrastructure and cabling should be placed underground.
- Install bird guards/spikes above conductors at pylons.
- Fit powerline spans with bird flight diverters (see Figure 27).

Figure 27: Examples of bird flight diverters to be used on existing power lines: Double loop bird flight diverter (left) and Viper live bird flapper (right).

4.11.5 General mitigation measures

- All construction sites/areas must be demarcated on site layout plans (preferably), and no construction personnel or vehicles may leave the demarcated area except those authorised to do so. Those areas surrounding the construction sites that are not part of the demarcated development area should be considered as "no-go" areas for employees, machinery or even visitors.
- All road networks must be planned with care to minimise dissection or fragmentation of important avifaunal habitat type. Where possible, the use of existing roads is encouraged.
- Open fires is strictly prohibited and only allowed at designated areas.
- Killing or poaching of any bird species should be avoided by means of awareness programs presented to the labour force. The labour force should be made aware of the conservation issues pertaining to the bird taxa occurring on the study site. Any person found deliberately harassing any bird species in any way should face disciplinary measures, following the possible dismissal from the site.
- Checks must be carried out at regular intervals to identify areas where erosion is occurring. Appropriate remedial action, including the rehabilitation of eroded areas should be undertaken.

4.12 Suggested monitoring and Environmental Management Plan

Information on collision trauma (bird mortalities) and the displacement of birds caused by PV solar facilities is insufficient. Therefore, as per the guidelines of Jenkins *et al.* (2017) it is highly recommended that additional pre- and post construction monitoring be implemented to augment existing data:

- At least one additional pre-construction survey is recommended, consisting of a minimum of 2 days which is necessary to inform the final EMPr during operation. The survey should coincide with the peak wet season when most of the nearby wetland features in the wider study region are inundated. This will enable the observer to obtain quantified data on waterbird richness and potential flyways, which will contribute towards the understanding of impacts related to collision trauma with the panels.

- A post-construction survey during operation (with a minimum of 2-3 x 3 day surveys during a six month period (including the peak wet season)). The surveys aim to obtain mortality data from birds colliding with the panels to advise on appropriate mitigation measures to be implemented to reduce potential bird mortalities. The surveys should be conducted in a regular and systematic manner by means of direct observations and carcass searches. A management programme must be compiled to assess the efficacy of applied mitigation measures and consult or change measures to reduce on-going mortalities when detected. Additional mitigation measures should be tested or applied, especially if mortalities include birds of prey and species of conservation concern.
- It is possible that bird mortalities due to collision will occur at **existing** power lines even after mitigation. The post-construction monitoring (during operation) should also quantify mortalities (especially vulture mortalities) caused by the existing power line network. The information could then be used to inform the electrical infrastructure mortality incident register. It is suggested that monitoring should be implemented once a month for at least one year when in operation. All searches should be done on foot. A management programme must be compiled to assess the efficacy of applied mitigation measures and consult or change measures to reduce on-going mortalities when detected. Additional mitigation measures should be tested or applied, especially if mortalities include birds of prey and species of conservation concern.

OBJECTIVE 1: Minimise potential collision trauma with infrastructure and augmenting existing information on bird interactions with solar infrastructure

Project Component/s	» PV panel arrays
Potential Impact	» Collision trauma caused by photovoltaic panels (the "lake-effect")
Activity/Risk Source	» Operation of PV infrastructure
Mitigation: Target/Objective	» Zero bird mortalities due to collision trauma caused by PV panels

Mitigation: Action/Control	**Responsibility**	**Timeframe**
1. Apply bird deterrent devices to the PV panels to discourage birds from colonising the infrastructure or to discourage birds from constructing nests. These could include visual or bio-acoustic deterrents such as highly	ECO & OM	Operation (on-going)

reflective rotating devices, anti-perching devices such as bird guards, scaring or chasing activities involving the use of trained dogs or raptors and/or netting. Nests should be removed when nest-building attempts are noticed.		
2. Reduce or minimise the use of outdoor lighting to avoid attracting birds to the lights or to reduce potential disorientation to migrating birds.	ECO & OM	Operation (on-going)
3. Use indigenous plant species native to the study area during landscaping and rehabilitation.	CER & ECO	Construction phase
4. Implement pre-construction monitoring protocols (as per Jenkins et al., 2017).	ECO & EM	Prior to construction - At least 1 survey of 2 days (during wet season)
5. Implement post-construction monitoring and carcass surveys (as per Jenkins et al., 2017)	OM & CER	Post- construction - At least 2-3 surveys, each 3 days during a 6 month period
6. Compile management programme to assess efficacy of mitigation and on-going research/trials	EM & OM	Operation (on-going)

Performance Indicator	Reduced statistical detection/observation of bird mortalities
Monitoring	1. Implement at least one pre-construction survey consisting of a minimum of 2 days. 2. Surveys should coincide with the peak wet season when most of the drainage lines and wetland features in the wider study region are inundated. 3. Obtain quantified data on waterbird/collision-prone bird richness and potential flyways, which will contribute towards the understanding of impacts related to collision trauma with the panels. 4. Monitor terrestrial birds at the fixed point counts by using the exact protocol applied during this report. 5. Implement post-construction survey during operation with a minimum of 2-3 x 3 day surveys during a six month period (including the peak wet season). 6. Obtain mortality data from birds colliding with the panels and advise on appropriate mitigation measures to be implemented to reduce potential bird mortalities. 7. Conduct post-construction monitoring in a systematic manner by means of direct observations (an option is the use of installed video cameras at selected areas) and carcass searches. 8. Implement management programme to assess the efficacy of applied mitigation measures and consult or change measures to reduce on-going mortalities when detected. Additional mitigation measures should be tested or applied, especially if mortalities include birds of prey and species of

	conservation concern.

OBJECTIVE 2: Minimise collisions and electrocution associated with existing power lines

Project Component/s	» Existing overhead power lines
Potential Impact	» Collision and electrocution caused by existing power lines
Activity/Risk Source	» Overhead power lines
Mitigation: Target/Objective	» Reduced bird mortalities due to collision/electrocution

Mitigation: Action/Control	Responsibility	Timeframe
1. Apply bird deterrent devices to all existing power lines spanning the facility	ECO & CER	Construction
2. Implement post-construction monitoring and carcass surveys	OM	Operation - daily
3. Compile management programme to assess efficacy of mitigation and on-going research/trials	OM & CER	Operation - monthly for at least one year
4. Report mortalities (number, locality and species) to Electrical Energy Mortality Register at EWT	OM	Operation (on-going)

Performance Indicator	Reduced statistical detection/observation of bird mortalities
Monitoring	1. Implement surveys for carcasses. 2. Implement post-construction monitoring to quantify bird mortalities caused by the power line network. All searches should be done on foot. 3. Compile a management programme to assess the efficacy of applied mitigation measures and consult or change measures to reduce on-going mortalities when detected. Additional mitigation measures should be tested or applied, especially if mortalities include birds of prey and species of conservation concern.

4.13 An opinion regarding the feasibility of the project

Pachnoda Consulting cc was requested by Themeda PV (Pty) Ltd to compile an avifauna impact assessment report for a photovoltaic (PV) solar energy facility and associated infrastructure on Portion 7 of Farm Elandsfontein 34, near Lichtenburg, North West Province.

Four prominent avifaunal habitat types was identified on the site and consisted of open mixed dolomite grassland with bush clump mosaics, moist dense grassland, mixed woodland on dolomite outcrops and secondary grassland and pastures, with high bird richness and abundance values recorded at the mixed woodland. The bird richness and passerine densities on the remaining habitat units were relatively low. Approximately 183 bird species are expected to occur in the wider study area, of which 92 species were observed in the study area (during a wet and dry season survey). The expected richness included 10 threatened or near threatened species, 14 southern African endemics and 18 near-endemic species. The critically endangered White-backed Vulture (*Gyps africanus*) and endangered Cape Vulture (*G. coprotheres*) have a high probability of occurrence, mainly as foraging birds soaring overhead (both species have been observed from similar habitat adjacent to the study site). Eleven southern African endemics and 12 near-endemic species were confirmed on the study site.

An evaluation of potential and likely impacts on the avifauna revealed that the impact significance was moderate to low after mitigation (depending on the type of impact). The study site is not located near any prominent wetland system or impoundment, and therefore the risk of waterbird collisions with the proposed infrastructure was considered to be low. In addition, the occurrence of collision-prone bird species (apart from vultures) such as korhaan taxa and birds of prey was relatively low. However, in the absence of sufficient information on the occurrence and rate of passing waterbirds and collision-prone bird species, it was recommended that supporting evidence be acquired by means of at least another pre-construction survey corresponding to the wet season.

The endangered Cape Vulture (*Gyps coprotheres*) and critically endangered White-backed Vulture (*Gyps africanus*) (and to a lesser degree also Lappet-faced Vulture

Torgos tracheliotos) were identified as regular foraging visitors to the study area (according to SABAP2 reporting rates and observations from adjacent habitat). These species are highly prone to power line collisions, whereby any existing powerline (existing powerlines spanning the facility) could pose a collision and electrocution risk to vultures.

No fatal-flaws were identified during the assessment, although it is strongly recommended that the proposed mitigation measures and monitoring protocols (additional with pre- and post construction monitoring) be implemented during the construction and operational phase of the project.

5. REFERENCES

BirdLife International. 2020. *Sagittarius serpentarius*. The IUCN Red List of Threatened Species 2020: e.T22696221A173647556. https://dx.doi.org/10.2305/IUCN.UK.2020-3.RLTS.T22696221A173647556.en.

Birdlife South Africa. 2022. *BirdLife South Africa Checklist of Birds in South Africa*, 2022.

Brewer, R. & Mccann, M.T. 1982. *Laboratory and field manual of ecology*. Saunders Publishing, Philadelphia.

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L. 1993. *Distance Sampling: Estimating abundance of biological populations*. Chapman and Hall, London.

Clarke, K.R. & Warwick, R.M. 1994. *Changes in marine communities: An approach to statistical analysis and interpretation*. Natural Environmental Research Council, United Kingdom.

Colwell, R.K. 2013. *EstimateS: Statistical estimation of species richness and shared species from samples. Version 9*. User's Guide and application published at: http://purl.oclc.org/estimates.

Del Hoyo, J., Elliott, A. & Christie, D.A. eds. 1992-2011. *Handbook of the Birds of the World.* Vol 1-16. Lynx Edicions, Barcelona.

Geoterrainimage. 2015. *The South African National Land cover Dataset*. Version 05.

Gill, F, Donsker, D., & Rasmussen, P. (Eds). 2022. *IOC World Bird List* (v 12.1). Doi 10.14344/IOC.ML.12.1. http://www.worldbirdnames.org/.

Gunerhan, H., Hepbasli, A. & Giresunlu, U. 2009. Environmental impacts from the solar energy systems. Energy Sources, Part A: *Recovery, Utilization and Environmental Effects* 31: 131-138.

Hardaker, T. 2020. Southern African Bird List - Version 10 - 22 December 2020.

Harrison, C., Lloyd, H. & Field, C. 2016. *Evidence review of the impact of solar farms on birds, bats and general ecology*. NEER012 report, Manchester Metropolitan University, UK.

Harrison, J.A., Allan, D.G., Underhill, L.G., Herremans, M., Tree, A.J., Parker, V. & Brown, C.J. (eds.). 1997. *The Atlas of Southern African Birds. Vol. 1 & 2*. BirdLife South Africa, Johannesburg.

Hockey, P.A.R., Dean, W.R.J. & Ryan, P.G. (eds.) 2005. *Roberts – Birds of Southern Africa*, VIIth ed. The Trustees of the John Voelker Bird Book Fund, Cape Town.

IUCN Red List of Threatened Species. Version 2022. http://www.iucnredlist.org/.

Jenkins, A.R, Ralston-Paton, S & Smit-Robinson, H.A. 2017. Best practice guidelines: Birds and Solar Energy. Guidelines for assessing and monitoring the impact of solar power generating facilities on birds in southern Africa. BirdLife South Africa.

Kagen, R.A., Verner, T.C., Trail, PW & Espinoza, E.O. 2014. Avian mortality at solar energy facilities in southern California: A preliminary analysis. Unpublished report by the National Fish and Wildlife Forensics Laboratory, USA.

Marnewick, M.D., Retief, E.F., Theron, N.T., Wright, D.R. And Anderson, T.A. 2015. *Important Bird and Biodiversity Areas of South Africa*. Johannesburg: BirdLife South Africa.

McCrary, M.D., McKernan, R.L., Schreiber, R.W., Wagner, W.D. & Sciarotta, T.C. 1986. Avian mortality at a solar energy power plant. *Journal of Field Ornithology* 57: 135-141.

Moreno, C. E. & Halffter, G. 2000. Assessing the completeness of bat biodiversity inventories using species accumulation curves. *Journal of Applied Ecology* 37, 149–158.

Mucina, L. & Rutherford, M.C. (eds.). 2006. The vegetation of South Africa, Lesotho and Swaziland. *Strelitzia 19*. South African National Biodiversity Institute, Pretoria.

North West Department of Rural, Environment and Agricultural Development (NWREAD). (2015) North West Biodiversity Sector Plan. North West Provincial Government, Mahikeng. December 2015.

Pachnoda Consulting. 2018. Development of the Lichtenburg 2 PV solar energy facility and associated infrastructure on a site near Lichtenburg, North West Province. A report compiled for Savanna Environmental.

Pachnoda Consulting. 2021. Development of the Barleria PV solar energy facility and associated infrastructure on a site near Lichtenburg, North West Province. A report compiled for Savanna Environmental.

Raaijmakers, J.G.W. 1987. Statistical analysis of the Michaelis-Menten equation. *Biometrics* 43: 793-803.

Soberón, J., & J. Llorente. 1993. The use of species accumulation functions for the prediction of species richness. *Conservation Biology* 7 , 480-488.

Sutherland, W.J. 2006. *Ecological census techniques. A handbook*. 2nd Edn. Cambridge University Press.

Sutherland, W.J., Newton, I. and Green, R. E. 2004. *Bird Ecology and Conservation. A handbook of techniques*. Oxford University Press.

Taylor, M.R., Peacock, F. & Wanless, R. (eds.). 2015. *The Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland*. BirdLife South Africa, Johannesburg

Tsoutsos, T., Frantzeskaki, N. & Gekas, V. 2005. Environmental impacts from solar energy technologies. *Energy Policy* 33: 289-296.

Walston Jr. L.J., Rollins, K.E., LaGory, K.E., Smith, K.P. & Meyers, S.A. 2016. A preliminary assessment of avian mortality at utility-scale solar energy facilities in the United States. *Renewable Energy* 92 (2016) 405-414.

Watson, D.M. 2003. The ‘standardized search’: An improved way to conduct bird surveys. *Austral Ecology* 28: 515-525

www.sabap2.birdmap.africa

Appendix 1: A shortlist of bird species expected to be present on the study area. The list provides an indication of the species occurrence according to SABAP2 reporting rates. The list was derived (and modified) from species observed in pentad grid 2605_2605 and the eight surrounding grids. The reporting rates include submissions made during the January and May 2022 surveys.

#	Common Name	Scientific Name	Observed (Jan & May 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
78	Abdim's Stork	*Ciconia abdimii*		0.00	0	3.13	1
432	Acacia Pied Barbet	*Tricholaema leucomelas*	1	41.98	34	3.13	1
171	African Harrier-Hawk	*Polyboroides typus*		2.47	2	0.00	0
418	African Hoopoe	*Upupa africana*		40.74	33	0.00	0
387	African Palm Swift	*Cypsiurus parvus*	1	37.04	30	0.00	0
682	African Paradise Flycatcher	*Terpsiphone viridis*		7.41	6	0.00	0
692	African Pipit	*Anthus cinnamomeus*	1	41.98	34	3.13	1
544	African Red-eyed Bulbul	*Pycnonotus nigricans*	1	46.91	38	0.00	0
606	African Reed Warbler	*Acrocephalus baeticatus*		18.52	15	0.00	0
81	African Sacred Ibis	*Threskiornis aethiopicus*		9.88	8	0.00	0
576	African Stonechat	*Saxicola torquatus*		40.74	33	0.00	0
247	African Wattled Lapwing	*Vanellus senegallus*		1.23	1	0.00	0
772	Amethyst Sunbird	*Chalcomitra amethystina*		4.94	4	0.00	0
119	Amur Falcon	*Falco amurensis*		22.22	18	3.13	1
575	Ant-eating Chat	*Myrmecocichla formicivora*	1	46.91	38	9.38	3
533	Arrow-marked Babbler	*Turdoides jardineii*	1	3.70	3	0.00	0
514	Ashy Tit	*Melaniparus cinerascens*		4.94	4	0.00	0
510	Banded Martin	*Riparia cincta*	1	17.28	14	3.13	1
493	Barn Swallow	*Hirundo rustica*	1	37.04	30	6.25	2

#	Common Name	Scientific Name	Observed (Jan & May 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
159	Black Sparrowhawk	*Accipiter melanoleucus*		2.47	2	0.00	0
650	Black-chested Prinia	*Prinia flavicans*	1	69.14	56	6.25	2
146	Black-chested Snake Eagle	*Circaetus pectoralis*		3.70	3	0.00	0
431	Black-collared Barbet	*Lybius torquatus*	1	32.10	26	3.13	1
715	Black-crowned Tchagra	*Tchagra senegalus*	1	3.70	3	0.00	0
55	Black-headed Heron	*Ardea melanocephala*		24.69	20	3.13	1
521	Black-headed Oriole	*Oriolus larvatus*		2.47	2	0.00	0
245	Blacksmith Lapwing	*Vanellus armatus*		69.14	56	3.13	1
860	Black-throated Canary	*Crithagra atrogularis*	1	41.98	34	0.00	0
130	Black-winged Kite	*Elanus caeruleus*		30.86	25	28.13	9
282	Black-winged Pratincole	*Glareola nordmanni*		0.00	0	3.13	1
839	Blue Waxbill	*Uraeginthus angolensis*		23.46	19	3.13	1
405	Blue-cheeked Bee-eater	*Merops persicus*		9.88	8	0.00	0
722	Bokmakierie	*Telophorus zeylonus*	1	48.15	39	3.13	1
145	Brown Snake Eagle	*Circaetus cinereus*		1.23	1	0.00	0
714	Brown-crowned Tchagra	*Tchagra australis*	1	16.05	13	6.25	2
509	Brown-throated Martin	*Riparia paludicola*		8.64	7	0.00	0
731	Brubru	*Nilaus afer*		3.70	3	3.13	1
695	Buffy Pipit	*Anthus vaalensis*	1	2.47	2	0.00	0
4131	Burchell's Coucal	*Centropus burchellii*		16.05	13	0.00	0
703	Cape Longclaw	*Macronyx capensis*	1	34.57	28	3.13	1
531	Cape Penduline Tit	*Anthoscopus minutus*		2.47	2	0.00	0
581	Cape Robin-Chat	*Cossypha caffra*	1	20.99	17	0.00	0
786	Cape Sparrow	*Passer melanurus*	1	75.31	61	12.50	4

#	Common Name	Scientific Name	Observed (Jan & May 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
737	Cape Starling	*Lamprotornis nitens*	1	32.10	26	6.25	2
316	Ring-necked Dove	*Streptopelia capicola*	1	28.40	23	12.50	4
106	Cape Vulture	*Gyps coprotheres*		11.11	9	0.00	0
686	Cape Wagtail	*Motacilla capensis*	1	54.32	44	0.00	0
799	Cape Weaver	*Ploceus capensis*		4.94	4	0.00	0
1172	Cape White-eye	*Zosterops virens*	1	29.63	24	0.00	0
568	Capped Wheatear	*Oenanthe pileata*		9.88	8	0.00	0
484	Chestnut-backed Sparrow-Lark	*Eremopterix leucotis*		11.11	9	9.38	3
658	Chestnut-vented Warbler	*Curruca subcoerulea*	1	43.21	35	6.25	2
673	Chinspot Batis	*Batis molitor*	1	9.88	8	0.00	0
872	Cinnamon-breasted Bunting	*Emberiza tahapisi*	1	9.88	8	3.13	1
631	Cloud Cisticola	*Cisticola textrix*	1	23.46	19	3.13	1
154	Common (Steppe) Buzzard	*Buteo buteo vulpinus*		4.94	4	6.25	2
	Common Buttonquail	*Turnix sylvaticus*	1	n/a			
734	Common Myna	*Acridotheres tristis*	1	66.67	54	6.25	2
421	Common Scimitarbill	*Rhinopomastus cyanomelas*		14.81	12	0.00	0
843	Common Waxbill	*Estrilda astrild*	1	18.52	15	0.00	0
594	Common Whitethroat	*Curruca communis*	1	2.47	2	0.00	0
	Common Quail	*Coturnix coturnix*	1	n/a			
173	Coqui Francolin	*Peliperdix coqui*	1	9.88	8	0.00	0
439	Crested Barbet	*Trachyphonus vaillantii*	1	65.43	53	0.00	0
711	Crimson-breasted Shrike	*Laniarius atrococcineus*	1	19.75	16	0.00	0
242	Crowned Lapwing	*Vanellus coronatus*	1	71.60	58	6.25	2
545	Dark-capped Bulbul	*Pycnonotus tricolor*	1	30.86	25	0.00	0

#	Common Name	Scientific Name	Observed (Jan & May 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
630	Desert Cisticola	*Cisticola aridulus*	1	25.93	21	6.25	2
352	Diederik Cuckoo	*Chrysococcyx caprius*	1	33.33	27	3.13	1
1183	Eastern Clapper Lark	*Mirafra fasciolata*	1	23.46	19	0.00	0
89	Egyptian Goose	*Alopochen aegyptiaca*		20.99	17	0.00	0
404	European Bee-eater	*Merops apiaster*		25.93	21	0.00	0
570	Familiar Chat	*Oenanthe familiaris*		3.70	3	0.00	0
665	Fiscal Flycatcher	*Melaenornis silens*	1	39.51	32	6.25	2
517	Fork-tailed Drongo	*Dicrurus adsimilis*		1.23	1	0.00	0
874	Golden-breasted Bunting	*Emberiza flaviventris*		2.47	2	3.13	1
447	Golden-tailed Woodpecker	*Campethera abingoni*		2.47	2	0.00	0
603	Great Reed Warbler	*Acrocephalus arundinaceus*		3.70	3	0.00	0
785	Great Sparrow	*Passer motitensis*		2.47	2	0.00	0
440	Greater Honeyguide	*Indicator indicator*		3.70	3	0.00	0
122	Greater Kestrel	*Falco rupicoloides*		3.70	3	3.13	1
502	Greater Striped Swallow	*Cecropis cucullata*	1	46.91	38	0.00	0
419	Green Wood Hoopoe	*Phoeniculus purpureus*		8.64	7	0.00	0
830	Green-winged Pytilia	*Pytilia melba*	1	13.58	11	3.13	1
339	Grey Go-away-bird	*Crinifer concolor*		18.52	15	0.00	0
54	Grey Heron	*Ardea cinerea*		16.05	13	0.00	0
557	Groundscraper Thrush	*Turdus litsitsirupa*		6.17	5	0.00	0
84	Hadada Ibis	*Bostrychia hagedash*	1	61.73	50	3.13	1
72	Hamerkop	*Scopus umbretta*		3.70	3	0.00	0
192	Helmeted Guineafowl	*Numida meleagris*	1	46.91	38	9.38	3
784	House Sparrow	*Passer domesticus*	1	53.09	43	9.38	3

#	Common Name	Scientific Name	Observed (Jan & May 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
348	Jacobin Cuckoo	*Clamator jacobinus*		1.23	1	0.00	0
835	Jameson's Firefinch	*Lagonosticta rhodopareia*		2.47	2	0.00	0
586	Kalahari Scrub Robin	*Cercotrichas paena*	1	39.51	32	6.25	2
1104	Karoo Thrush	*Turdus smithi*	1	53.09	43	0.00	0
114	Lanner Falcon	*Falco biarmicus*		3.70	3	0.00	0
108	Lappet-faced Vulture	*Torgos tracheliotos*		4.94	4	0.00	0
317	Laughing Dove	*Spilopelia senegalensis*	1	90.12	73	25.00	8
706	Lesser Grey Shrike	*Lanius minor*		16.05	13	0.00	0
442	Lesser Honeyguide	*Indicator minor*	1	4.94	4	0.00	0
125	Lesser Kestrel	*Falco naumanni*	1	17.28	14	3.13	1
646	Levaillant's Cisticola	*Cisticola tinniens*		40.74	33	0.00	0
413	Lilac-breasted Roller	*Coracias caudatus*		1.23	1	0.00	0
410	Little Bee-eater	*Merops pusillus*	1	8.64	7	3.13	1
385	Little Swift	*Apus affinis*	1	34.57	28	3.13	1
621	Long-billed Crombec	*Sylvietta rufescens*	1	11.11	9	0.00	0
852	Long-tailed Paradise Whydah	*Vidua paradisaea*		4.94	4	0.00	0
818	Long-tailed Widowbird	*Euplectes progne*	1	43.21	35	12.50	4
73	Marabou Stork	*Leptoptilos crumenifer*		1.23	1	0.00	0
661	Marico Flycatcher	*Melaenornis mariquensis*		4.94	4	0.00	0
361	Marsh Owl	*Asio capensis*	1	2.47	2	0.00	0
607	Marsh Warbler	*Acrocephalus palustris*		4.94	4	3.13	1
142	Martial Eagle	*Polemaetus bellicosus*		1.23	1	0.00	0
564	Mountain Wheatear	*Myrmecocichla monticola*		2.47	2	0.00	0
318	Namaqua Dove	*Oena capensis*	1	18.52	15	0.00	0

#	Common Name	Scientific Name	Observed (Jan & May 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
637	Neddicky	*Cisticola fulvicapilla*	1	22.22	18	3.13	1
1035	Northern Black Korhaan	*Afrotis afraoides*	1	38.27	31	6.25	2
179	Orange River Francolin	*Scleroptila gutturalis*	1	24.69	20	3.13	1
1171	Orange River White-eye	*Zosterops pallidus*	1	30.86	25	3.13	1
838	Orange-breasted Waxbill	*Amandava subflava*		3.70	3	0.00	0
	Pearl-breasted Swallow	*Hirundo dimidiata*	1	n/a			
522	Pied Crow	*Corvus albus*	1	49.38	40	9.38	3
746	Pied Starling	*Lamprotornis bicolor*		6.17	5	9.38	3
846	Pin-tailed Whydah	*Vidua macroura*		25.93	21	0.00	0
694	Plain-backed Pipit	*Anthus leucophrys*		6.17	5	0.00	0
844	Quailfinch	*Ortygospiza atricollis*	1	24.69	20	3.13	1
642	Rattling Cisticola	*Cisticola chiniana*		9.88	8	0.00	0
708	Red-backed Shrike	*Lanius collurio*	1	22.22	18	0.00	0
837	Red-billed Firefinch	*Lagonosticta senegala*		13.58	11	0.00	0
805	Red-billed Quelea	*Quelea quelea*	1	39.51	32	6.25	2
97	Red-billed Teal	*Anas erythrorhyncha*		23.46	19	0.00	0
488	Red-capped Lark	*Calandrella cinerea*	1	12.35	10	3.13	1
813	Red-collared Widowbird	*Euplectes ardens*		4.94	4	0.00	0
314	Red-eyed Dove	*Streptopelia semitorquata*	1	79.01	64	15.63	5
392	Red-faced Mousebird	*Urocolius indicus*	1	54.32	44	6.25	2
120	Red-footed Falcon	*Falco vespertinus*		2.47	2	0.00	0
820	Red-headed Finch	*Amadina erythrocephala*		29.63	24	0.00	0
940	Rock Dove	*Columba livia*		17.28	14	3.13	1
506	Rock Martin	*Ptyonoprogne fuligula*		6.17	5	3.13	1

#	Common Name	Scientific Name	Observed (Jan & May 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
458	Rufous-naped Lark	*Mirafra africana*	1	40.74	33	3.13	1
	Rufous-cheeked Nightjar	*Caprimulgus rufigena*	1	n/a			
460	Sabota Lark	*Calendulauda sabota*		7.41	6	3.13	1
789	Scaly-feathered Weaver	*Sporopipes squamifrons*	1	30.86	25	0.00	0
105	Secretarybird	*Sagittarius serpentarius*		2.47	2	0.00	0
504	South African Cliff Swallow	*Petrochelidon spilodera*	1	30.86	25	0.00	0
90	South African Shelduck	*Tadorna cana*		14.81	12	0.00	0
707	Southern Fiscal	*Lanius collaris*	1	74.07	60	12.50	4
4142	Southern Grey-headed Sparrow	*Passer diffusus*		27.16	22	3.13	1
803	Southern Masked Weaver	*Ploceus velatus*	1	77.78	63	3.13	1
808	Southern Red Bishop	*Euplectes orix*	1	60.49	49	3.13	1
390	Speckled Mousebird	*Colius striatus*	1	16.05	13	3.13	1
311	Speckled Pigeon	*Columba guinea*	1	71.60	58	12.50	4
474	Spike-heeled Lark	*Chersomanes albofasciata*	1	32.10	26	0.00	0
368	Spotted Eagle-Owl	*Bubo africanus*		2.47	2	0.00	0
654	Spotted Flycatcher	*Muscicapa striata*	1	17.28	14	0.00	0
275	Spotted Thick-knee	*Burhinus capensis*		8.64	7	0.00	0
88	Spur-winged Goose	*Plectropterus gambensis*	1	11.11	9	0.00	0
867	Streaky-headed Seedeater	*Crithagra gularis*		3.70	3	0.00	0
185	Swainson's Spurfowl	*Pternistis swainsonii*	1	44.44	36	0.00	0
411	Swallow-tailed Bee-eater	*Merops hirundineus*		1.23	1	0.00	0
649	Tawny-flanked Prinia	*Prinia subflava*		6.17	5	0.00	0
840	Violet-eared Waxbill	*Granatina granatina*		4.94	4	0.00	0
735	Wattled Starling	*Creatophora cinerea*	1	46.91	38	0.00	0

#	Common Name	Scientific Name	Observed (Jan & May 2022)	SABAP2 Reporting Rate			
				Full Protocol (%)	Number of cards	Ad Hoc Protocol (%)	Number of cards
359	Western Barn Owl	*Tyto alba*	1	4.94	4	0.00	0
61	Western Cattle Egret	*Bubulcus ibis*	1	49.38	40	3.13	1
391	White-backed Mousebird	*Colius colius*	1	48.15	39	3.13	1
107	White-backed Vulture	*Gyps africanus*		13.58	11	0.00	0
763	White-bellied Sunbird	*Cinnyris talatala*		12.35	10	0.00	0
780	White-browed Sparrow-Weaver	*Plocepasser mahali*		69.14	56	15.63	5
	White-throated Robin-Chat	*Cossypha humeralis*	1	n/a			
100	White-faced Whistling Duck	*Dendrocygna viduata*		18.52	15	0.00	0
409	White-fronted Bee-eater	*Merops bullockoides*		9.88	8	0.00	0
383	White-rumped Swift	*Apus caffer*	1	27.16	22	0.00	0
495	White-throated Swallow	*Hirundo albigularis*		27.16	22	0.00	0
814	White-winged Widowbird	*Euplectes albonotatus*		19.75	16	3.13	1
599	Willow Warbler	*Phylloscopus trochilus*	1	11.11	9	3.13	1
866	Yellow Canary	*Crithagra flaviventris*	1	67.90	55	6.25	2
96	Yellow-billed Duck	*Anas undulata*		32.10	26	3.13	1
129	Yellow-billed Kite	*Milvus aegyptius*	1	13.58	11	6.25	2
	Yellow-bellied Eremomela	*Eremomela icteropygialis*	1	n/a			
812	Yellow-crowned Bishop	*Euplectes afer*		9.88	8	0.00	0
859	Yellow-fronted Canary	*Crithagra mozambica*		2.47	2	0.00	0
629	Zitting Cisticola	*Cisticola juncidis*	1	35.80	29	0.00	0

Appendix 2: Preliminary density estimates of birds recorded from the study area during two independent surveys conducted during January 2022 and May 2022.

Species	kc01	kc02	kc03	kc04	kc05	kc06	kc07	kc08	kc09	kc10	kc11	kc12	kc13	kc14	kc15
African Pipit	0	0	0	0	0	0	0.5	0	0	0.5	0.5	0	0	0	0
African Red-eyed Bulbul	1	0.5	0	0	0	2	0	0	0	0	0	0.5	0	1	0.5
Black-chested Prinia	2	2	0	0	0	4	0	0	0	0	0	2	0	2	2
Brown-crowned Tchagra	2	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0
Black-crowned Tchagra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5
Black-throated Canary	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Cinnamon-breasted Bunting	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cloud Cisticola	0	0	0	0	1	0	0	0.5	0.5	0.5	0.5	0	1	0	0
Cape Longclaw	0	0	0	1.5	0.5	0	0	0	1	0	0	0	0	0	0
Chestnut-vented Warbler	2	2	0	0	0	2	0	0	0	0	0	2	0	2	2
Crimson-breasted Shrike	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chinspot Batis	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Common Waxbill	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
Cape White-eye	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Common Whitethroat	0.5	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0
Dark-capped Bulbul	1.5	1	0	0	0	0	0	0	0	0	0	0.5	0	0	0
Desert Cisticola	0.5	1	2	1	0.5	1	1	1	1.5	1	0.5	0.5	1	1.5	1.5
Eastern Clapper Lark	0	0	0	0	0	0.5	1	0	0	1	0.5	0	0.5	0.5	0.5
Kalahari Scrub-robin	2	1	0	0	0	1	0	0	0	0	0	1.5	0	0	0.5
Long-billed Crombec	0	2	0	0	0	1	0	0	0	0	0	0	0	0	0
Long-tailed Widowbird	0	0	0.5	0.5	1	0	0.5	0.5	0	0	0	0	0	0	0
Neddicky	1	1	0	0	0	0	0	0	0	0	0	0.5	0	0	0

Species	kc01	kc02	kc03	kc04	kc05	kc06	kc07	kc08	kc09	kc10	kc11	kc12	kc13	kc14	kc15
Quailfinch	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0
Red-billed Quelea	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0
Red-backed Shrike	0.5	0	0	0	0	0.5	0	0	0	0	0	0	0	0	1
Rufous-naped Lark	0	0.5	0	0	0	1	0.5	0	0	0.5	0	1.5	0	0.5	0.5
Scaly-feathered Weaver	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Southern Fiscal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Southern Masked Weaver	5	1.5	0	0	0	2	0	0	0	0	0	1	0	1	1
Spotted Flycatcher	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0
White-throated Robin-chat	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Willow Warbler	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yellow-bellied Eremomela	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0
Yellow Canary	1.5	1	0	0	0	0	0	0	0	0	0	1.5	0	0	0
Zitting Cisticola	0	0	1.5	0	1.5	0	0.5	0.5	0	0	0	0	0	0	0
Number of individuals	23.5	15.5	4	3	7.5	17.5	4	2.5	4	3.5	2	13.5	2.5	8.5	10
Number of species	15	14	3	3	7	13	6	4	4	5	4	12	3	7	10
Number of birds/ha	**30.13**	**19.87**	**5.13**	**3.85**	**9.62**	**22.44**	**5.13**	**3.21**	**5.13**	**4.49**	**2.56**	**17.31**	**3.21**	**10.90**	**12.82**
Number of species/ha	**19.23**	**17.95**	**3.85**	**3.85**	**8.97**	**16.67**	**7.69**	**5.13**	**5.13**	**6.41**	**5.13**	**15.38**	**3.85**	**8.97**	**12.82**
Average number of birds/ha	**10.45**														
Average number of species/ha	**9.66**														

Species	kc16	kc17	kc18	kc19	kc20	kc21	kc22	kc23	kc24	kc27	kc28	Mean Birds/ha
African Pipit	0	0.5	0	0.5	0	0.5	0	0	0	0	0	**0.006**
African Red-eyed Bulbul	1	1.5	1	0	0	0	1.5	0	0	0	0	**0.020**
Black-chested Prinia	3	2	1	1	0	0	2	1	0	0	1	**0.047**
Brown-crowned Tchagra	0	0	0	0	0	0	0	0	0	0	0	**0.005**
Black-crowned Tchagra	0.5	0.5	0	0	0	0	0	0	0	0	0	**0.003**
Black-throated Canary	0	1	0	0	0	0	0	0	0	0	0	**0.004**
Cinnamon-breasted Bunting	0	0	0	0	0	0	0	0.5	0	0	0	**0.001**
Cloud Cisticola	0	0	0	0.5	2.5	0.5	0.5	0	0.5	2	0	**0.020**
Cape Longclaw	0	0	0	0	0.5	0	1	0.5	0	0	0	**0.009**
Chestnut-vented Warbler	2	2	2	0	0	0	0	0	0	0	0	**0.034**
Crimson-breasted Shrike	0	0	0	0	0	0	0	0	0	0	0	**0.002**
Chinspot Batis	0	0	0	0	0	0	0	0	0	0	0	**0.004**
Common Waxbill	0	0	0	0	0	0	0	0	0	0	0	**0.004**
Cape White-eye	0	0	0	0	0	0	0	0	0	0	0	**0.002**
Common Whitethroat	0	0	0	0	0	0	0	0	0	0	0	**0.004**
Dark-capped Bulbul	0	0	0	0	0	0	0	0	0	0	0	**0.006**
Desert Cisticola	1.5	2	1	2	1.5	2	2	1.5	1.5	1	1	**0.062**
Eastern Clapper Lark	0.5	0	1	0.5	0	0.5	0	0	0	0	0	**0.013**
Kalahari Scrub-robin	0	1	1.5	0	0	0	0	0	0	0	0	**0.016**
Long-billed Crombec	0	0	0	0	0	0	0	0	0	0	0	**0.006**
Long-tailed Widowbird	0	0	0	1	1	2	1.5	0	0.5	0	0	**0.017**
Neddicky	0.5	1	0.5	0	0	0	0.5	0	0	0	0	**0.009**
Quailfinch	0	1	2	0	0	1	0	0	0	0	0	**0.013**
Red-billed Quelea	0	0	0	0	0	0	0	0	0	0	0	**0.001**

Species	kc16	kc17	kc18	kc19	kc20	kc21	kc22	kc23	kc24	kc27	kc28	Mean Birds/ha
Red-backed Shrike	0	0	0	0	0	0	1	0	0	0	0	**0.006**
Rufous-naped Lark	0.5	0.5	1	1.5	1	1	0.5	0.5	0	0	0.5	**0.023**
Scaly-feathered Weaver	0	0	0	0	0	0	0	0	1	0	0	**0.002**
Southern Fiscal	0.5	0	0	0.5	0	0	0	0	0	0	0	**0.002**
Southern Masked Weaver	1.5	0.5	0	0	0	0	1.5	0.5	0	1	0	**0.031**
Spotted Flycatcher	0	0	0	0	0	0	0	0	0	0	0	**0.001**
White-throated Robin-chat	0.5	0	0	0	0	0	0	0	0	0	0	**0.003**
Willow Warbler	0	0	0.5	0	0	0	0	0	0	0	0	**0.001**
Yellow-bellied Eremomela	0	0	0	0	0	0	0	0	0	0	0	**0.001**
Yellow Canary	0	1	1	0	0	0	1.5	0	0	0	0	**0.014**
Zitting Cisticola	0	0	0	0	0.5	0.5	0.5	0	0	0	0.5	**0.011**
Number of individuals	12	14.5	12.5	7.5	7	8	14	4.5	3.5	4	3	
Number of species	11	13	11	8	6	8	12	6	4	3	4	
Number of birds/ha	**15.38**	**18.59**	**16.03**	**9.62**	**8.97**	**10.26**	**17.95**	**5.77**	**4.49**	**5.13**	**3.85**	
Number of species/ha	**14.10**	**16.67**	**14.10**	**10.26**	**7.69**	**10.26**	**15.38**	**7.69**	**5.13**	**3.85**	**5.13**	
Average number of birds/ha	**10.45**											
Average number of species/ha	**9.66**											

Appendix 3: Assessment of Impacts

Direct, indirect and cumulative impacts of the issues identified through the scoping study, as well as all other issues identified in the EIA phase must be assessed in terms of the following criteria:

- The **nature**, which shall include a description of what causes the effect, what will be affected and how it will be affected.
- The **extent**, wherein it will be indicated whether the impact will be local (limited to the immediate area or site of development) or regional, and a value between 1 and 5 will be assigned as appropriate (with 1 being low and 5 being high).
- The **duration**, wherein it will be indicated whether:
    - the lifetime of the impact will be of a very short duration (0–1 years) – assigned a score of 1;
    - the lifetime of the impact will be of a short duration (2-5 years) - assigned a score of 2;
    - medium-term(5–15 years) – assigned a score of 3;
    - long term(> 15 years) - assigned a score of 4; or
    - permanent - assigned a score of 5;
- The **consequences (magnitude)**, quantified on a scale from 0-10, where 0 is small and will have no effect on the environment, 2 is minor and will not result in an impact on processes, 4 is low and will cause a slight impact on processes, 6 is moderate and will result in processes continuing but in a modified way, 8 is high (processes are altered to the extent that they temporarily cease), and 10 is very high and results in complete destruction of patterns and permanent cessation of processes.
- The **probability** of occurrence, which shall describe the likelihood of the impact actually occurring. Probability will be estimated on a scale of 1–5, where 1 is very improbable (probably will not happen), 2 is improbable (some possibility, but low likelihood), 3 is probable (distinct possibility), 4 is highly probable (most likely) and 5 is definite (impact will occur regardless of any prevention measures).
- The **significance**, which shall be determined through a synthesis of the characteristics described above and can be assessed as low, medium or high; and
- the status, which will be described as either positive, negative or neutral.
- the degree to which the impact can be reversed.
- the degree to which the impact may cause irreplaceable loss of resources.
- the degree to which the impact can be mitigated.

The significance is calculated by combining the criteria in the following formula:
S=(E+D+M)P

S = Significance weighting
E = Extent

D = Duration
M =Magnitude
P = Probability

The significance weightings for each potential impact are as follows:

- < 30 points: Low (i.e. where this impact would not have a direct influence on the decision to develop in the area),
- 30-60 points: Medium (i.e. where the impact could influence the decision to develop in the area unless it is effectively mitigated), and
- 60 points: High (i.e. where the impact must have an influence on the decision process to develop in the area).