PRE-CONSTRUCTION BAT MONITORING FOR THE PERDEKRAAL WIND ENERGY FACILITIES

FINAL REPORT

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All pictures taken on site

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ACRONYMS, ABBREVIATIONS & TERMS

AGIS	Agricultural Geo-referenced Information System
Barotrauma	Barotrauma involves tissue damage to air- containing structures caused by rapid or excessive pressure change. Pulmonary barotrauma is lung damage due to expansion of air in the lungs that is not accommodated by exhalation (Baerwald *et al*. 2008)
CI	Conservation Important
CIMMYT	International Maize and Wheat Improvement Center
CoP	Conferences of the Parties
CR	Critically Endangered – a classification used for describing species in serious danger of facing extinction
CSIR	Council for Scientific and Industrial Research
Curtailment	When a turbine is kept stationary at a very low wind speed, and is then allowed to rotate once the wind exceeds a specific speed
DBIG	Durban Bat Interest Group
DEAT	Department of Environmental Affairs and Tourism
DD	Data Deficient – a classification used for describing species for which there is inadequate data available to assess their danger of facing extinction
DWA	Department of Water Affairs
EM3	Echo Meter 3 bat detector
EMP	Environmental Management Plan
EMPR	Environmental Management Programme Report
EWT	Endangered Wildlife Trust
FEPA	Freshwater Ecosystem Priority Area
Foraging	Searching for food
GDARD	Gauteng Department of Agriculture and Rural Development
GNorBIG	Gauteng & Northern Regions Bat Interest Group
HD-CF	High duty-cycle, constant frequency (echolocation pulses)
IUCN	International Union for Conservation of Nature and Natural Resources, based in Gland, Switzerland
JPoI	Johannesburg Declaration and Plan of Implementation
LD-CF	Low duty-cycle, constant frequency (echolocation pulses)
LD-FM	Low duty-cycle, frequency-modulated (echolocation pulses)
LD-QCF	Low duty-cycle, shallow frequency-modulated (echolocation pulses)
LoO	Likelihood of Occurrence
MAP	Mean Annual Precipitation
Met.	Meteorological
MoP	Meeting of the Parties
Nacelle	The head/hub of a wind turbine
NBSAP	National Biodiversity Strategy and Action Plan
NEMA	National Environmental Management Act (Act 107 of 1998)
NEMAA	National Environmental Management Amendment Act (Act 8 of 2004)
NEM:BA	National Environmental Management: Biodiversity Act (Act 10 of 2004)
NEPAD	New Partnership for Africa’s Development
NFEPA	National Freshwater Ecosystem Priority Areas project

NSBA	National Spatial Biodiversity Assessment
NSS	Natural Scientific Services CC
NT	Near Threatened – a classification used for describing species not yet in danger of facing extinction, but close to such a state
NWA	National Water Act (Act 36 of 1998)
NWCC	National Wind Co-ordinating Collaborative
PrNatSci	Professional Natural Scientist
RHP	River Health Programme
SAAO	South African Astronomical Observatory
SANBI	South African National Biodiversity Institute
SASS	South African Scoring System
SAWEA	South African Wind Energy Association
SD	Standard deviation
SMP	Strategic Management Plan
ToPS	Threatened (Critically Endangered, Endangered or Vulnerable) or Protected Species listed by NEM:BA
UN	United Nations
UNCED	UN Conference on Environment and Development
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UP	University of Pretoria
USA	United States of America
VU	Vulnerable – a classification used for describing species in danger of facing extinction
WEF	Wind Energy Facility
WHS	World Heritage Site
WITS	University of the Witwatersrand
WNS	White Nose Syndrome
WRC	Water Research Commission
WSSD	World Summit on Sustainable Development
WWF	World Wildlife Fund

1. Project Introduction

Mainstream Renewable Power South Africa (Pty) Ltd (Mainstream) proposes to develop two Wind Energy Facilities (WEFs) at Perdekraal (**Figure 1-1**). The sites include the Rietpoort 243 and Lower Stinkfontein 245 farms, and are situated approximately 26km north of Touws River on the N1 Highway, and 45km north-west of Matjiesfontein, in the Western Cape (**Figure 1-2**).

The proposed layouts of 62 turbines at both the Perdekraal East and Perdekraal West WEF sites are shown in **Figure 1-3**. Based on e-mail correspondence received from Mainstream on 20 February 2013, the dimensions of the turbines will include a 120m hub height and a 120m rotor diameter.

As specified by the South African Good Practice Guidelines for Surveying Bats in Wind Farm Developments (Sowler & Stoffberg 2012), long-term bat monitoring is required to predict impacts of a proposed WEF on bats, and to devise effective mitigation measures against these.

Mainstream consequently commissioned Natural Scientific Services CC (NSS) to assess potential impacts of the proposed WEFs on local bats through appropriate long-term monitoring. This commenced for both WEF sites on 30 January 2012 and ended on 6 February 2013, during which period, NSS submitted two monitoring progress reports to Mainstream on 8 June and 28 September 2012. In this report, results from the complete 12-month monitoring period are presented, and potential impacts of the proposed WEFs on local bats are discussed, together with recommendations on measures to mitigate these.

Figure 1-1 View over Perdekraal

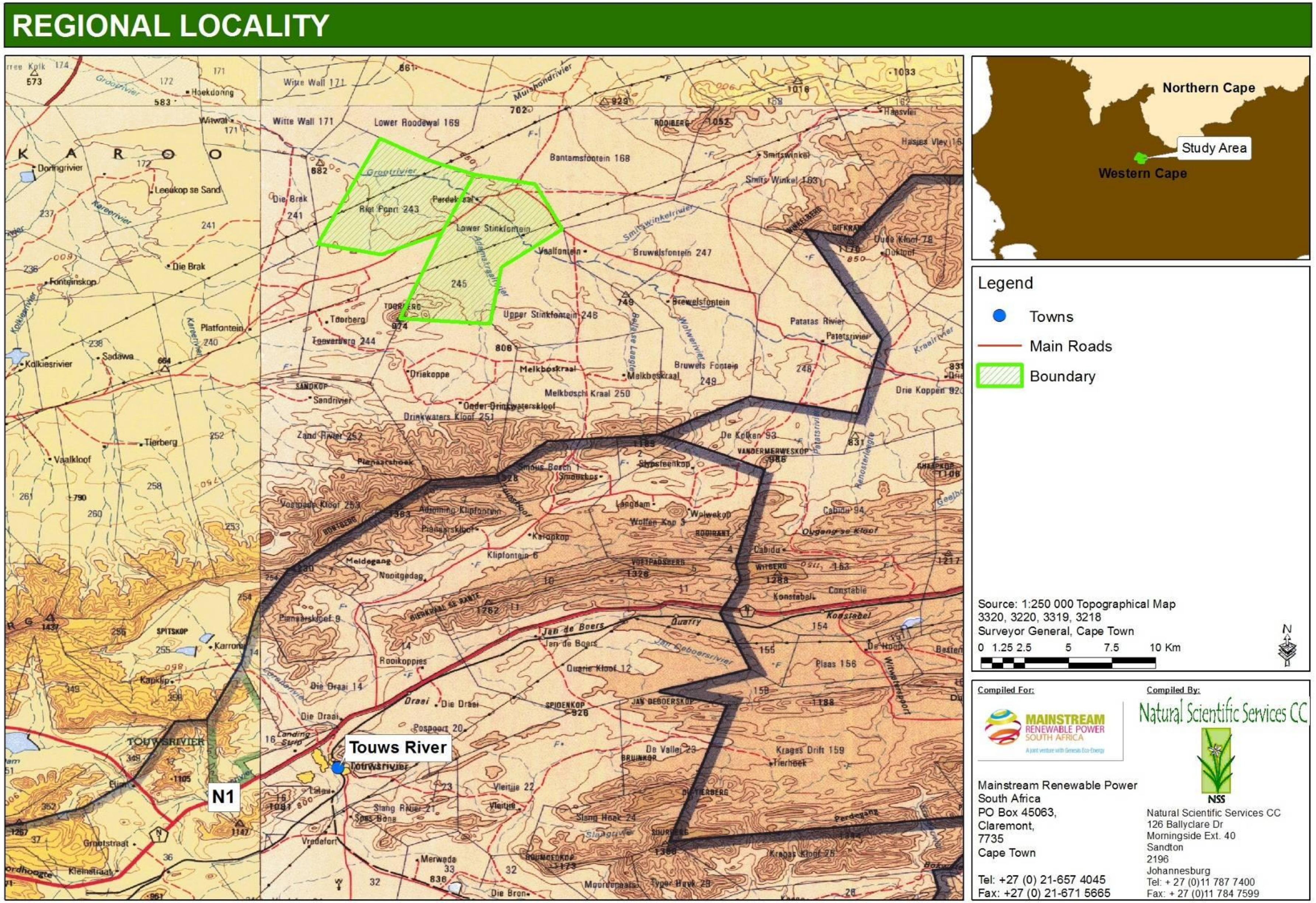

Figure 1-2 Regional location of Perdekraal

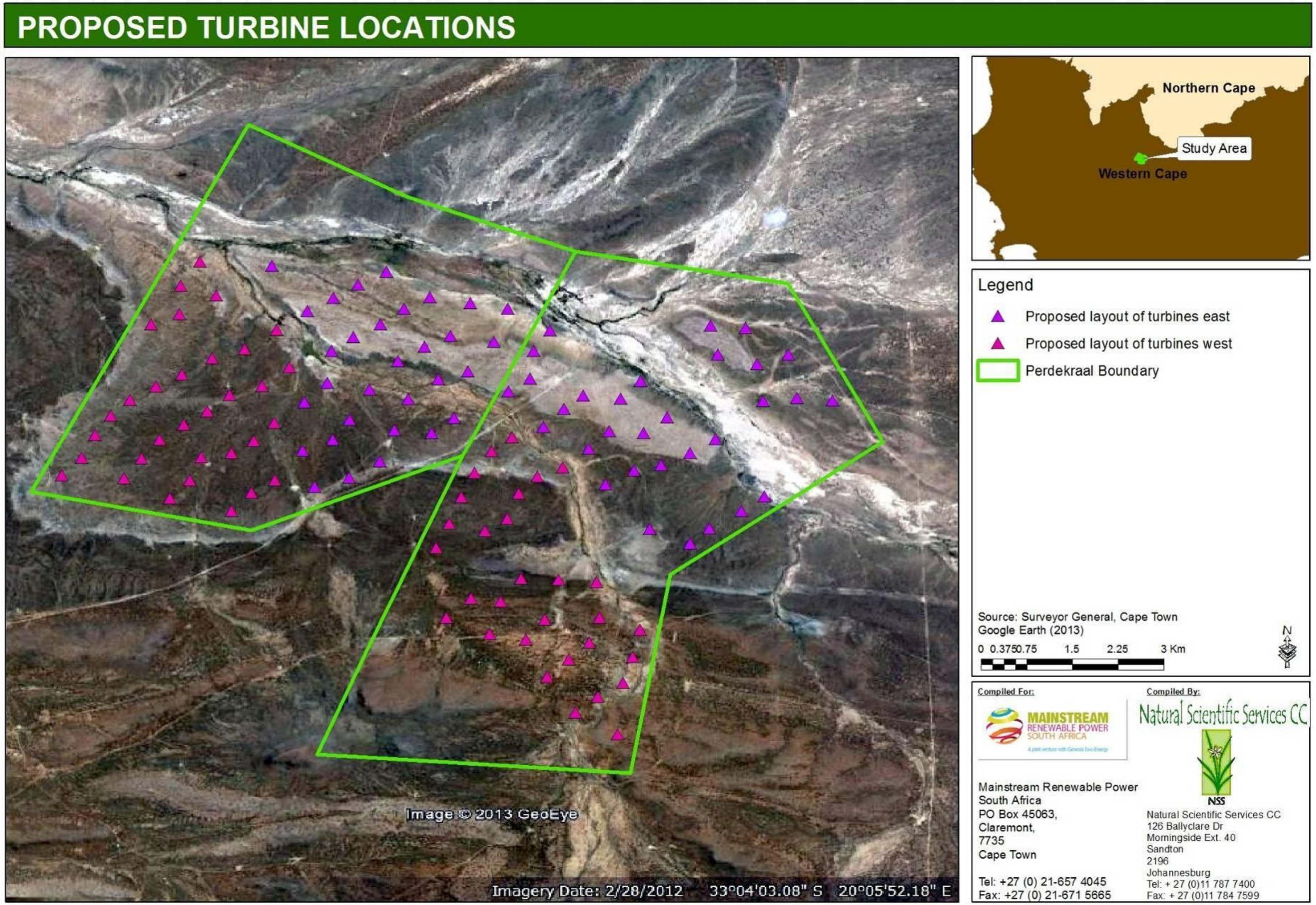

Figure 1-3 Proposed wind turbine locations at Perdekraal

2. Best Practice Guidelines

The South African Good Practice Guidelines for Surveying Bats in Wind Farm Developments (Sowler & Stoffberg 2012) were developed by (mainly South African) bat scientists and experts through an initiative facilitated by the Endangered Wildlife Trust (EWT). These Best Practice Guidelines are similar to existing international guidelines and provide technical guidance for consultants charged with carrying out Environmental Impact Assessments (EIAs) for proposed WEFs. Furthermore, the Guidelines ensure that pre-construction monitoring studies produce the required level of detail to assist authorities with evaluating WEF applications.

To correctly assess potential impacts of proposed WEFs on bats, the Best Practice Guidelines specify that it is important to investigate:

- The assemblage of bat species using a site.
- Variation in the use of a site by different species through the year.
- Bat activity times and locations in the context of proposed turbine locations (where these are known).
- The location of bat roosts within and close to the site.
- The presence of rarer bat species on site (using appropriate methods).
- How the site is used by bats for foraging, commuting, migrating and roosting, at and away from proposed turbine locations (where these known).

Although the Best Practice Guidelines cover single large wind turbines and WEFs (multiple large wind turbines), it is important that any assessment involves a proportionate approach in evaluating the likely impacts of turbines on bats. To date, only three experimental wind farms have been constructed in South Africa, *viz*. at Klipheuwel and Darling in the Western Cape, and at Coega in the Eastern Cape (**Figure 2-1**). Published research at the Coege facility revealed 18 bat fatalities for one turbine over a 12 month period (Doty & Martin 2012). This finding suggested that the impacts of WEFs on bat populations are of real concern for this alternative energy source.


Darling, Western Cape

Coega, Eastern Cape

Figure 2-1 **Wind turbines in South Africa**

3. Relevant Regional Biophysical Information

3.1. Climate

The greater Tanqua (Tankwa) Karoo region wherein Perdekraal is situated is characterized (Mucina & Rutherford 2006) by an arid to hyper-arid climate, with mean annual precipitation (MAP) ranging between 72mm and 170mm. Overall MAP is approximately 163mm, mainly falling in autumn and winter (i.e. between May and August). Mean daily maximum and minimum temperatures in the study area for January and July, are approximately 34°C and 4°C, respectively. Overall mean annual temperature is approximately 17°C. Due to basin macro-topography the occurrence of frost is fairly frequent (15-20 days per annum).

3.2. Land Types

The greater Tanqua landscape features slightly undulating intra-mountain basins, sheltered by steep slopes of mountain ranges. Permian Volkrust Formation mudrocks of the Ecca Group, Carboniferous Dwyka Group diamictites and Ceres Subgroup sandstones, and sandy-loamy soils of various depths predominate.

Land types represent areas that are uniform with respect to soil, climate and terrain. The Agricultural Geo-referenced Information System (AGIS 2010) indicates that six different land types occur in Perdekraal, namely Ia60, Ia145, Fc55, Fc56, Fc115 and Fc121 (**Figure 3-1**). Local plains (featuring land type Fc121) are interrupted by a series of solitary dolerite butts and elevated ridges, extensive, flat sheet-washes and deeper incised channels of intermittent rivers (featuring land types Ia60, Ia145, Fc55, Fc56 and Fc115). Drainage lines are filled with recent sediments mostly from eroded Karoo Supergroup sediments.

Any one land type may be commonly associated with a number of vegetation types and any one vegetation type may be associated with a number of land types or soils. Specific floral and faunal taxa may, however, be restricted to specific soil or land types.

3.3. Hydrology

Perdekraal is situated almost exclusively within the E22B quaternary catchment, and includes two small, seasonal drainage lines, namely, the Groot and the Adamskraal streams (**Figure 3-2**). The Groot stream enters the eastern boundary, runs across the northern region, and exits near the north-western corner of Perdekraal. The smaller Adamskraal stream enters near the south-eastern corner, runs across the centre, and joins the Groot stream near the north-western corner of Perdekraal. The Adamskraal stream represents a national Freshwater Ecosystem Priority Area (FEPA) and the Groot stream forms part of the upper management area of the E22B quaternary catchment (**Figure 3-3**). A number of Category 6 FEPA wetlands occur in and around Perdekraal in the form of small, seasonal farm dams.

3.4. Vegetation

Perdekraal is situated <10km from the Cape Floristic Region Priority Area (**Figure 3-4**). The Cape Floristic Region is one of six recognised floral kingdoms of the world, which boasts extra-ordinarily high floristic diversity and endemism. Much of this diversity is associated with the fynbos biome (**Figure 3-5**), which has an estimated economic worth of R77 million / annum based on harvested products (e.g. wildflowers) and eco-tourism.

Perdekraal, however, is itself situated within the Tanqua Karoo, which is one of the driest forms of the Succulent Karoo Biome (**Figure 3-5**). The appearance of the landscape resembles desert rather than semi-desert during most of the year. Two vegetation types classified by Mucina & Rutherford (2006) occur within Perdekraal, namely, the SKv 5 Tanqua Karoo and AZi 7 Tanqua Wash Riviere vegetation types (**Figure 3-6**).

The southern-most three quarters of Perdekraal features SKv 5 Tanqua Karoo vegetation, where plains are very sparsely vegetated, appearing barren in extreme precipitation-poor years. The slopes of koppies and adjacent mountain piedmonts support well-developed medium-tall succulent shrubland. Annual floral species become conspicuous with sufficient precipitation, while geophytes and grasses play a subordinate role.

The northern-most quarter of Perdekraal features AZi 7 Tanqua Wash Riviere vegetation, where intermittent drainage lines support a mosaic of succulent shrublands and *Acacia karoo* gallery thickets. The broad sheet-wash plains support sparse vegetation. Occasional rainfalls in early winter result in localized displays of annuals and early flowering geophytes along washes.

Neither the SKv 5 Tanqua Karoo nor the AZi 7 Tanqua Wash Riviere vegetation type has a threatened conservation status. However, the Tanqua Karoo (including the extensive sheet-wash plains) is an important local centre of plant endemism housing two endemic genera (*Didymaotus* and *Eurystigma*) and three near-endemic genera (*Braunsia, Hammeria* and *Tanquana*) – all of the family Aizoaceae.

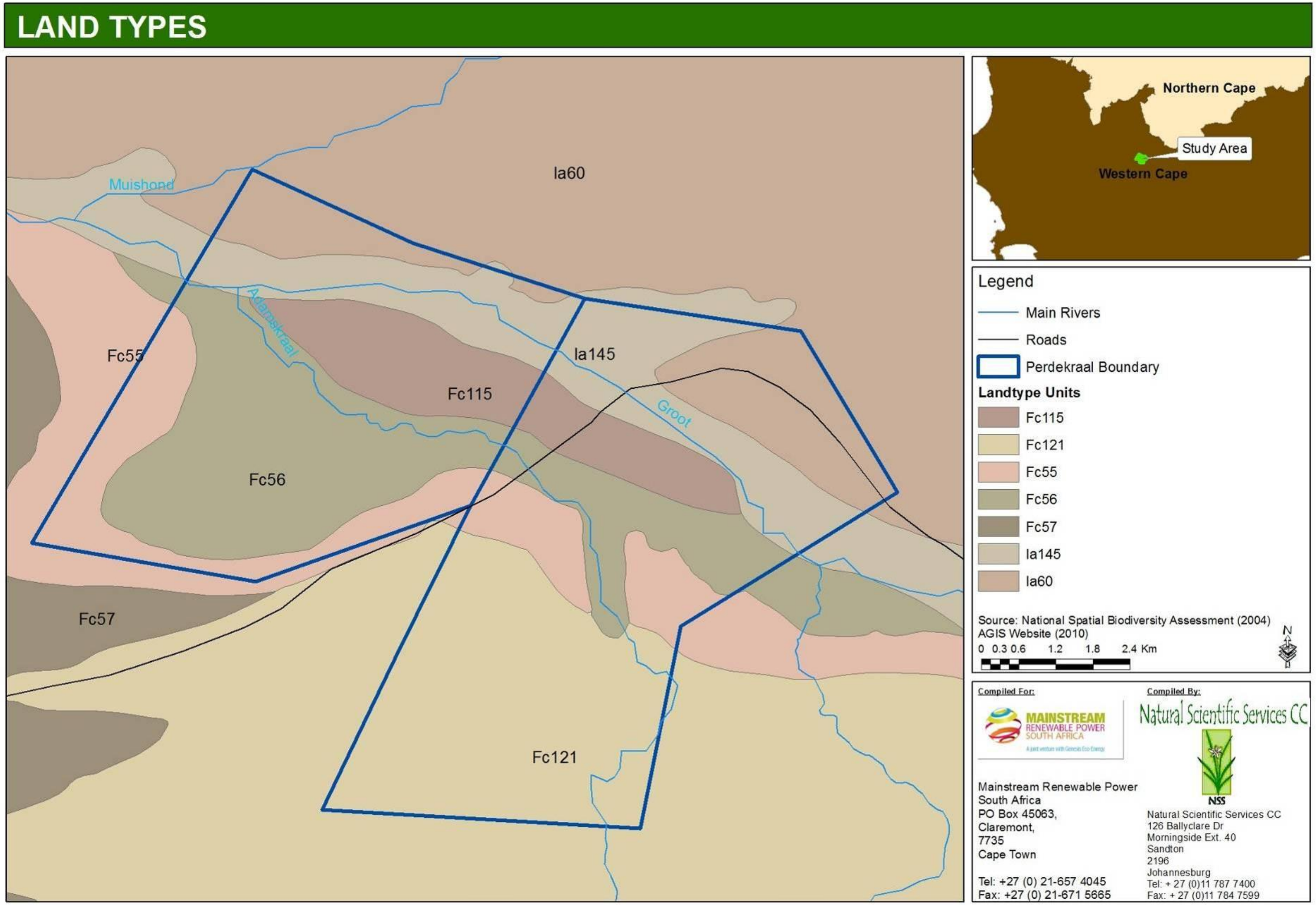

Figure 3-1 Land Types in the study area

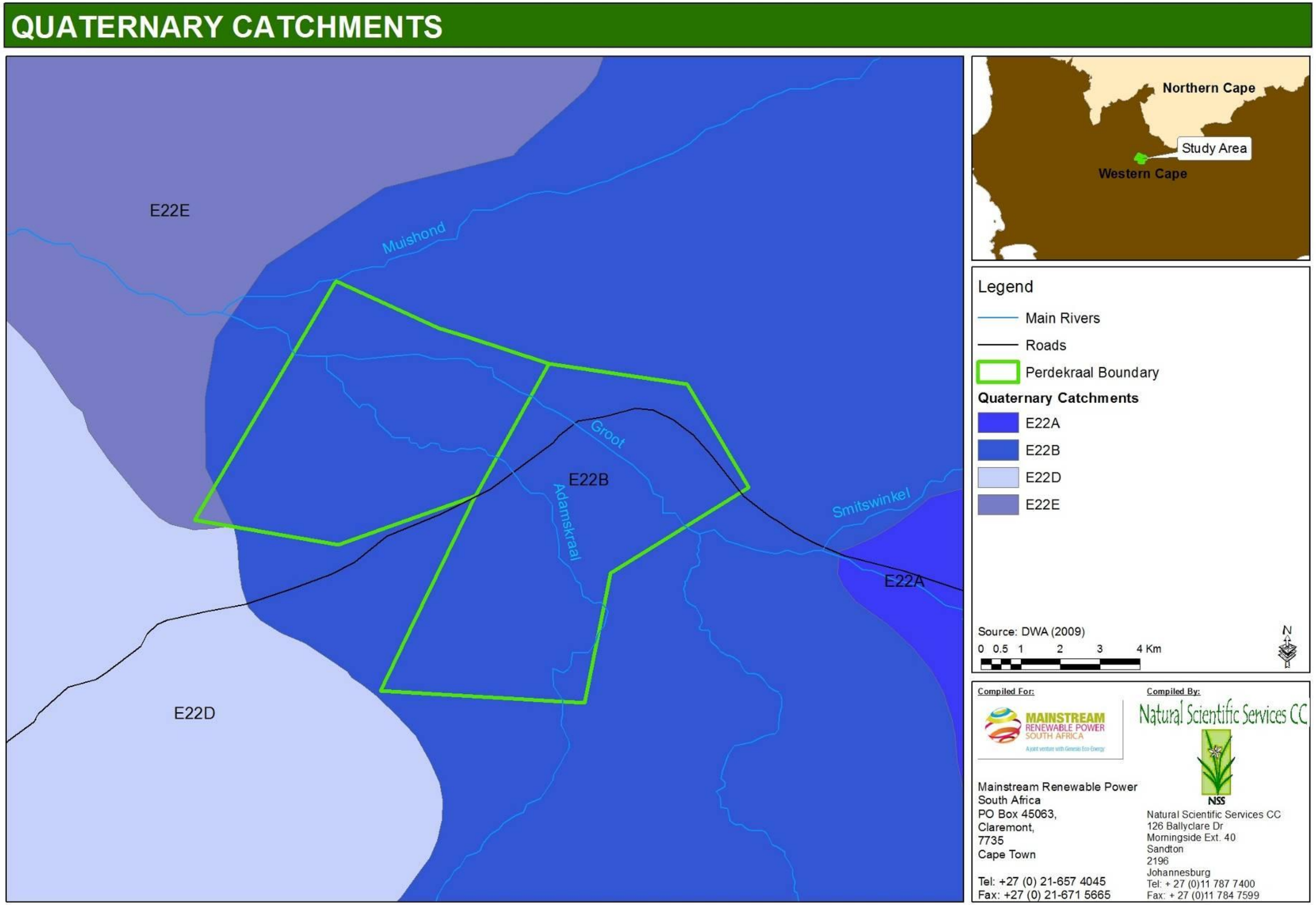

Figure 3-2 Quaternary catchments and major rivers in the study area

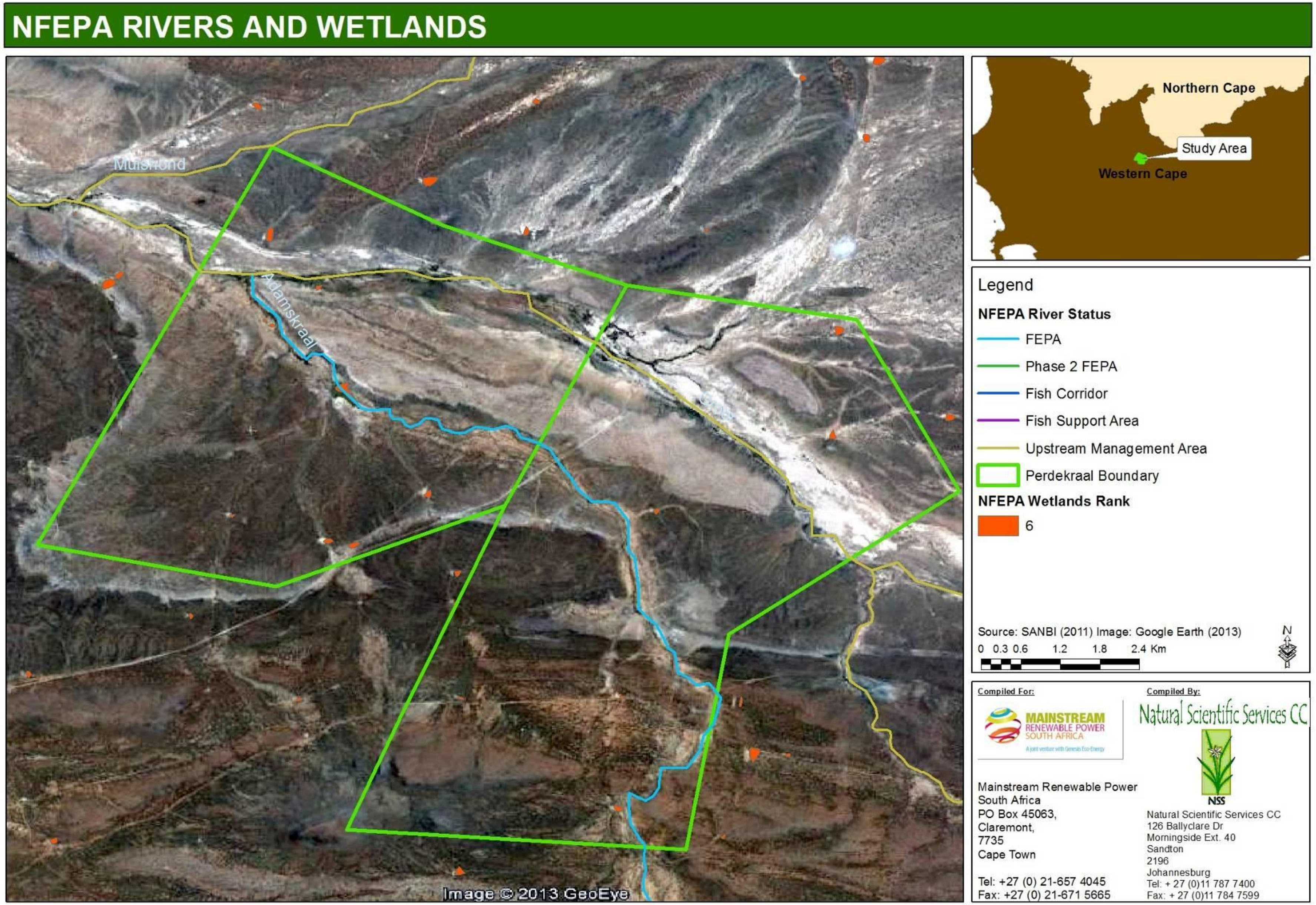

Figure 3-3 National Freshwater Ecosystem Priority Areas in the study area

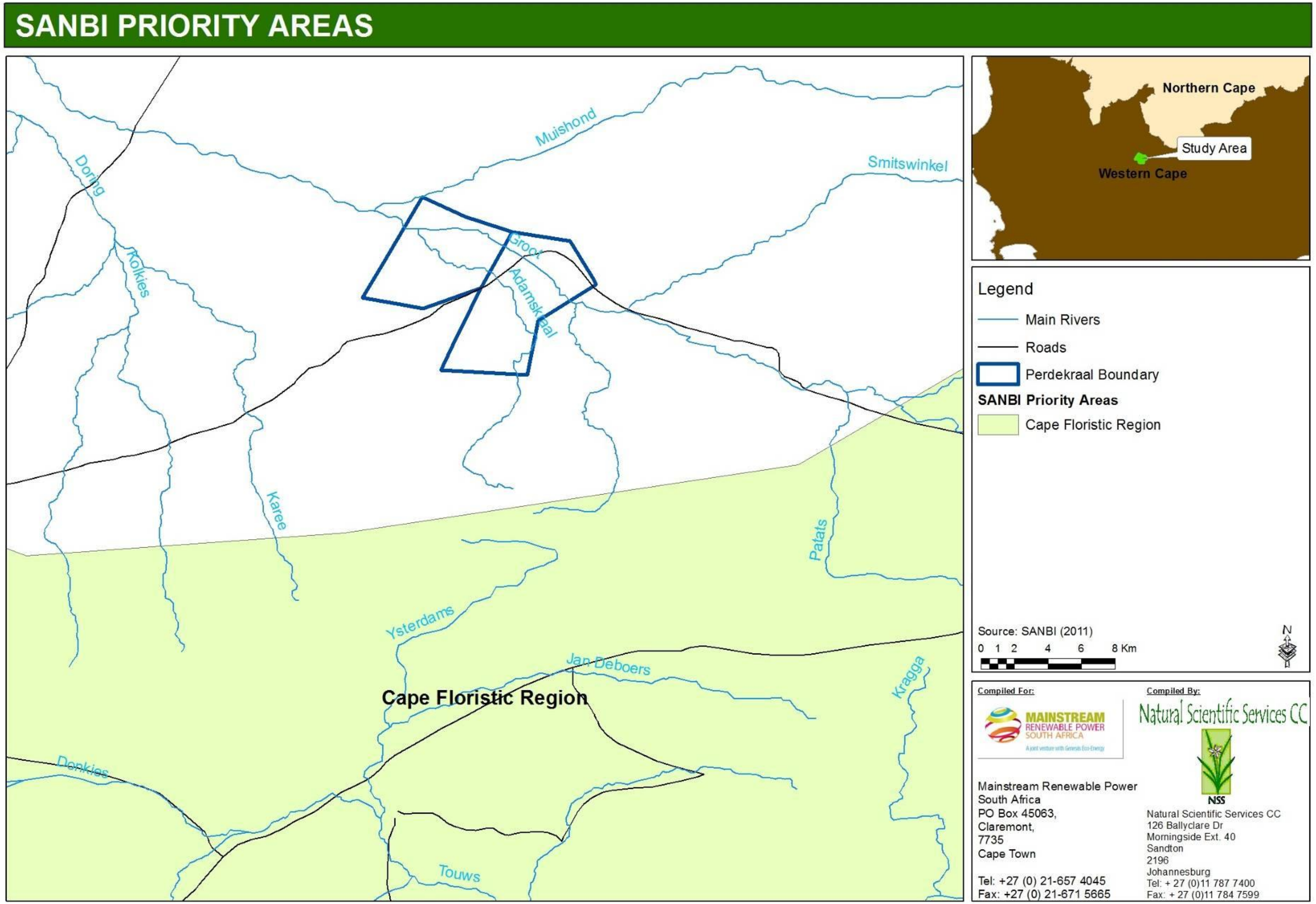

Figure 3-4 Location of Perdekraal near the national Cape Floristic Region Priority Area

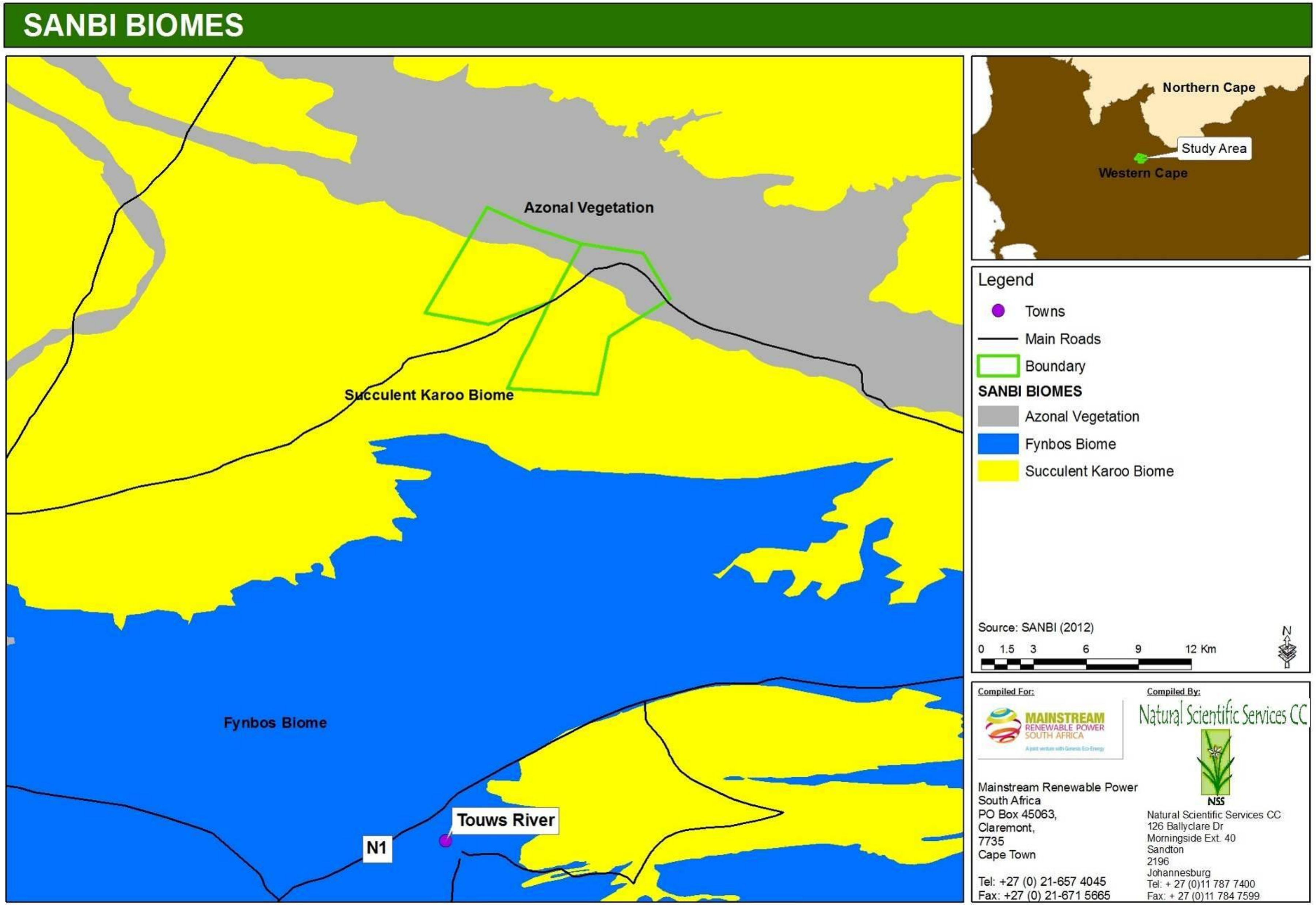

Figure 3-5 Location of Perdekraal in the Fynbos Biome

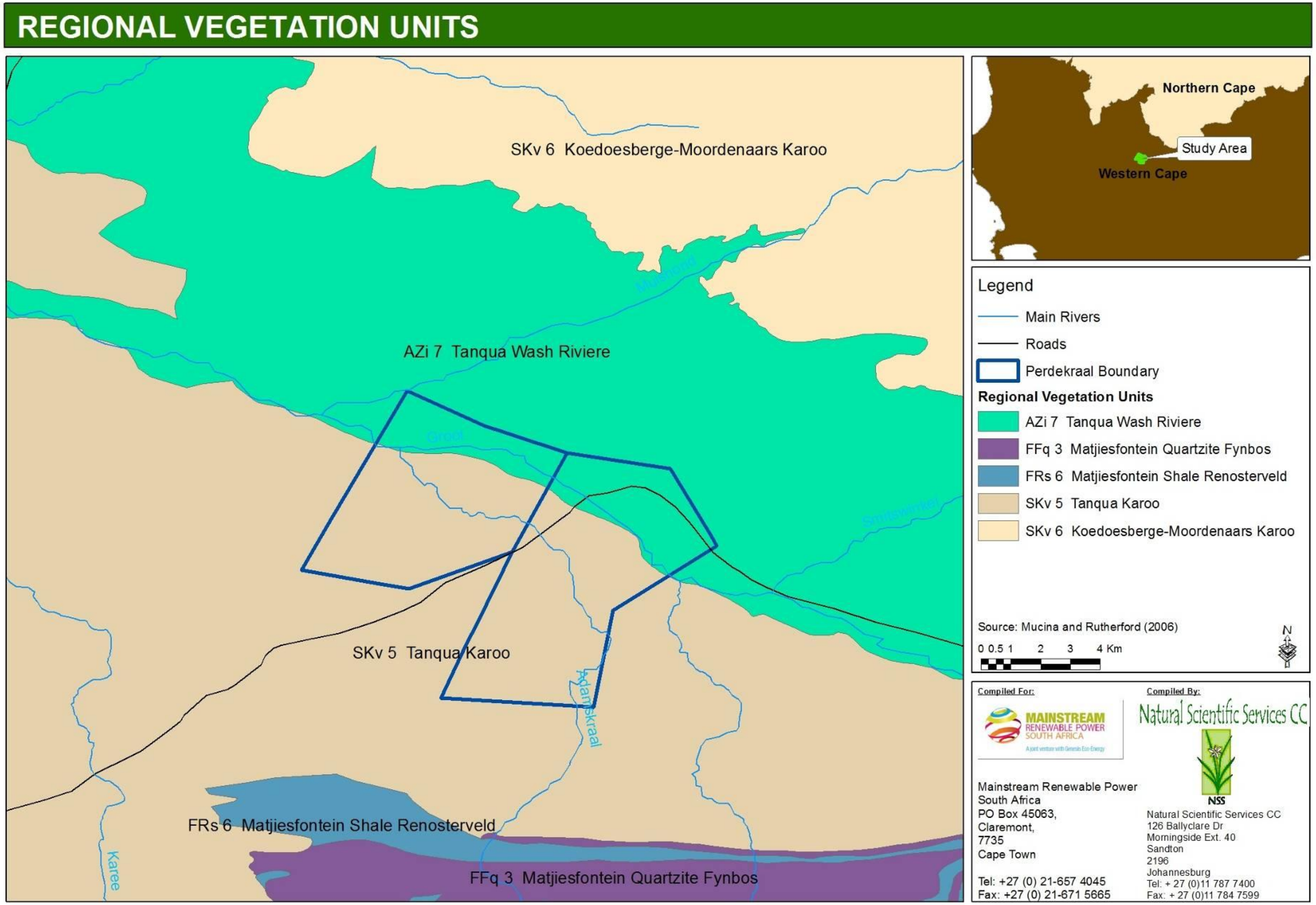

Figure 3-6 **Vegetation types in the study area**

4. Bats & Wind Energy

4.1. Bat Echolocation & Flight

Bats use echolocation for orientation in space and many, especially those that hunt for flying insects, use echolocation to detect, identify, and localize prey (Schnitzler & Kalko 2001). Insectivorous bat species have evolved different echolocation and flight behaviours relating to differences in their foraging habitat (Schnitzler & Kalko 2001). While some species may catch prey in flight (aerial mode), others catch mostly stationary prey from the ground or foliage (gleaning mode), or from water (trawling mode).

Bats are perceptually constrained by their sensory capacities (echolocation, vision, olfaction and passive listening) to detect, classify and locate prey in the vicinity of clutter-producing background (such as vegetation). Two different echolocation systems – high and low duty-cycle echolocation – evolved independently in the Chiroptera (Eick *et al*. 2005).

Low duty-cycle echolocation bats emit narrowband or broadband sound pulses separated by inter-pulse intervals that are much longer than the duration of the emitted pulses. High duty-cycle bats emit long, narrowband pulses that are separated by much shorter inter-pulse intervals.

Broadband, low duty-cycle, frequency-modulated (LD-FM) echolocation pulses typically sweep downward through as much as an octave for a short duration of time (Schnitzler & Kalko 2001). LD-FM signals are less suited for the detection of distant and/or weak echoes, because the neuronal filters are activated for only a short time (Schnitzler & Kalko 2001). Narrowband, low duty-cycle pulses composed of constant frequency (LD-CF) or shallow frequency-modulated (LD-QCF) components are not suitable for localisation of a hunted target, but are well suited to detection, because they activate the neuronal filters of the corresponding narrow frequency band during the entire echo (Schnitzler & Kalko 2001).

In contrast to low duty-cycle bats, Doppler-shift compensation combined with a specialised auditory system enables high duty-cycle constant frequency (HD-CF) echolocating bats to localise and classify fluttering insects in dense (cluttered) habitats (Schnitzler & Kalko 2001).

Bats are mechanically constrained by their motor capacities such as flight ability (Norberg & Rayner 1987). For instance, bats that forage in or near clutter require manoeuvrability to catch insects while avoiding collisions with the background clutter. Conversely, bats that forage high above the tree canopy are highly adapted for speed and agility. As such, bats can be classified into three foraging groups: clutter, clutter-edge and open-air bats (Monadjem *et al*. 2010). Neuweller (2000) illustrates the adaptations of wing shape and the resulting flight style to different foraging habitats in **Figure 4-1**.

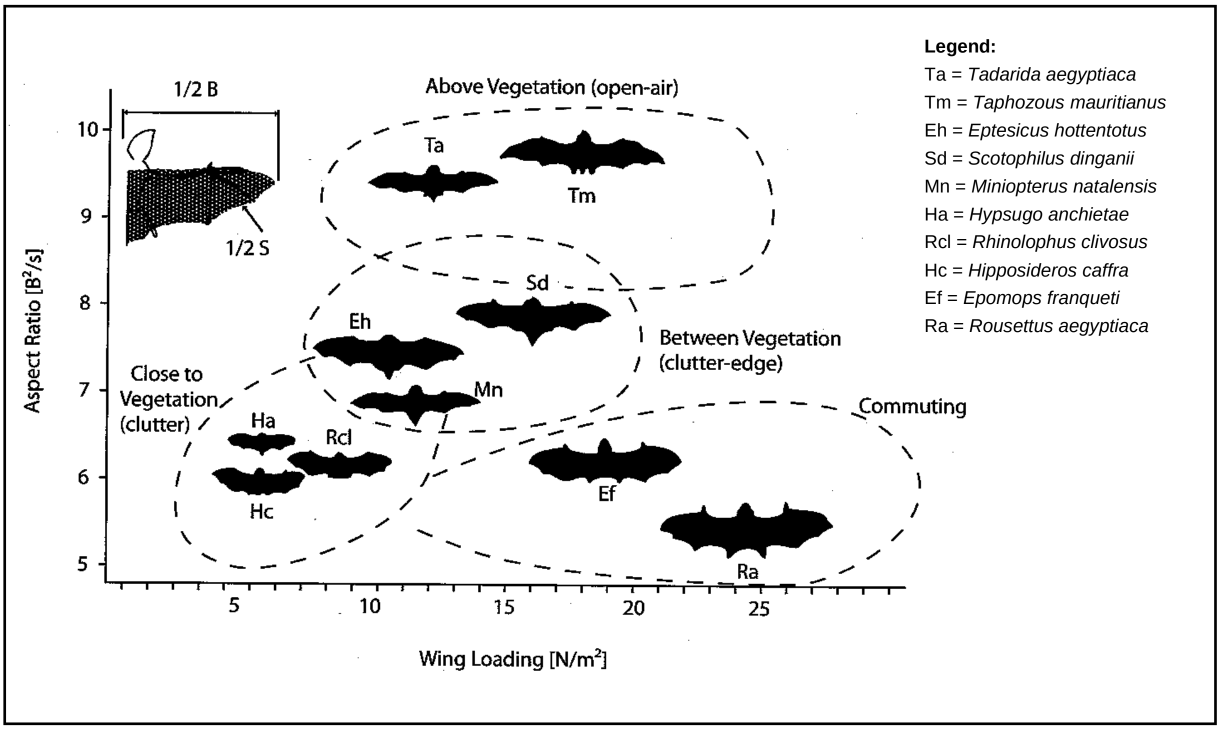

Figure 4-1 Adaptations of bat wing shape to foraging habitat (adapted from Neuweller 2000)

Foraging insectivorous bats must detect, classify, and localize an insect and discriminate between echoes of prey and echoes of unwanted targets such as twigs, foliage, or the ground, referred to as clutter echoes, or simply “clutter.” Schnitzler & Kalko (2001) have categorized microchiropteran bats into guild structures according to habitat type, foraging mode, and diet.

Bat monitoring programmes for proposed WEFs in South Africa are currently focussed on insectivorous, aerial-foraging bats. Particular attention is given to those bat species which hunt or migrate in open, uncluttered space, high above the ground and which, therefore, are most likely to be affected by wind turbine developments. Ideally, however, fruit bats should also be monitored. No fruit bats are expected to occur at Perdekraal. Elsewhere in the Western Cape the Egyptian Rousette (*Rousettus aegyptiacus*) may be found.

4.2. Bat Flying Heights

There is limited detailed information available on bat flight heights both internationally and in South Africa. Results from studies conducted in the USA, Canada and Europe indicate that there is immense variation in flight height among different bat species, for example:

- Molissid bats and *Taphozous mauritianus* have been reported by Fenton & Griffin (1997) to forage at over 500m above the ground.
- Menzel *et al*. (2005) showed that within forested areas and clear-cut areas, Vespertilionidae activity was higher above the canopy height recorded at 30m than

below the canopy recorded at 10m and 2m respectively. Only in riparian areas were the lower recordings higher.

- Jensen & Miller (1999) recorded the European Serotine Bat (*Eptesicus serotinus*) foraging at average heights of 6.8m and 10.7m at two different sites in Europe.
- Some groups of bats have been reported to migrate at altitudes greatly exceeding 100m (Altringham 1996).
- Allen (1939) reported that bats, which were observed migrating by day over Washington D.C., flew at heights of 46-140m.
- Van De Sijpe (2008) reported that trawling Pond Bats (*Myotis dasycneme*) and Daubenton's Bats (*M. daubentonii*) flew at median heights of 43 and 24cm, respectively.
- Williams *et al*. (1973) recorded the Mexican Free-tailed Bat (*Tadarida brasiliensis*) flying in groups at heights of over 3000m.

A review of available information on bat flight heights by Mitchell-Jones & Mitchell-Jones (date unknown) indicated that:

- Commuting bats may fly higher than when foraging.
- Bats that are flying high may not be echo-locating.
- Heights reported in the literature were mostly observed and rarely measured.
- On average, most small bats in cluttered habitats have been found to fly under 10m.
- Anecdotal records for large bats ranged from 10-120m.

4.3. Bat Foraging Movements & Migration

There is limited information available on distances moved by foraging or migrating bats. However, the following information was found:

From South Africa:

- Jacobs & Barclay (2009) have shown that *Scotophilus* species can cover 1–3km during foraging.
- The Natal Long-fingered Bat (*Miniopterus natalensis*) has been cited to travel up 22km during a night's foraging.
- A 9km movement has been recorded for a male Egyptian Slit-faced Bat (*Nycteris thebaica*; Monadjem 2005).
- As cited in Monadjem *et al*. (2010), recent telemetry work in the Kruger National Park by Bonaccorso *et al.* (unpublished data) has revealed that Wahlberg's Epauletted Fruit Bat (*Epomophorus wahlbergi*) may travel over 13km in a night between roosting and feeding sites.
- The Natal Long-fingered Bat (*Miniopterus natalensis*) is known to migrate up to 260km (Van der Merwe 1975) between summer maternity caves and winter hibernation caves.

- Temminck's Myotis (*Myotis tricolor*) may undertake seasonal migrations similar to that of *M. natalensis* (Monadjem *et al*. 2010) although details are unclear.
- One frugivorous bat species, the Egyptian Rousette (*Rousettus aegyptiacus*) is a gregarious cave-dweller, also thought to migrate distances of 50-500km (Herselman & Norton 1985; Monadjem *et al*. 2010).

Internationally:

- Leisler's bats (*Nyctalus leisleri*) commuted directly to foraging sites up to 13.4km away, at speeds often exceeding 40km/h (Shiel *et al*.1999; Shiel *et al*. 2006).
- The Gray Bat (Myotis grisescens) tends to forage over extensive distances, averaging 12.5km but ranging from 2.5km to 35.4km (LaVal *et al*. 1977).
- In a study wherein 21 female Schreiber's long-fingered bats (*Miniopterus schreibersii*) were tracked during four nights, for about 6 hours each bat flew far (4.1-29.2km) from their roost to forage at several small feeding areas (Vincent *et al*. 2011).
- Radio-telemetry revealed intense bat foraging activity in urban areas as well as in broad-leaved woodlands, as far as 30km from a roost (Lugon *et al*. 2004).
- In a lowland agricultural area where the habitat suitable for foraging was extensive, the mean distance between the roost and marked bats during pregnancy was 1.8km and the maximum recorded distance was 5.1km. These distances were reduced to 1.3km and 3.7km, respectively, during lactation (Racey & Swift 1985).

4.4. Bats & Weather

There is no doubt that weather patterns can influence bat activity. The following literature is available on the subject:

- Bats restrict their flight activity during periods of rain, low temperatures, and strong winds (Eckert 1982; Erickson & West 2003).
- Studies at proposed and operating WEFs have also documented lower bat activity during high (usually >6.0m/s) wind speeds (Reynolds 2006; Horn *et al*. 2008).
- Fenton *et al*. (1977) found that rain tended to suppress bat activity, although the timing of the rain was important. Since insects remained active in the rain, they suspected that the responses of the bats to rain reflected problems of thermoregulation associated with wet fur, and the effect of multiple echoes and attenuation of high-frequency sound on echolocation.
- Voigt *et al*. (2011) found that flight metabolism increased twofold when bats were wet, or when they were additionally exposed to rain. Therefore, they concluded that bats may not avoid rain only because of sensory constraints imposed by raindrops on echolocation, but also because of energetic constraints.
- Most species have distinct preferred foraging areas, which they abandon only when seasonal insect scarcities or major changes in prey populations force them to move to a different foraging habitat (Neuweiler 1989).

- Paige (1995) showed that the seasonal cave-dwelling Eastern Pipistrelle (*Pipistrellus subflavus*), tracks barometric pressure metabolically and it uses pressure as a cue for predicting the relative abundance of aerial insect prey outside the roost. Barometric pressure tracking affords bats an opportunity to conserve limited energy and make appropriate foraging decisions. Barometric pressure tracking is viewed as an alternative evolutionary strategy to torpor and may be a widespread phenomenon among insect-feeding bats that roost deep within caves.
- Whether moonlight/moon illumination levels can have an effect on bat activity patterns is uncertain, it appears to be species and habitat dependant – studies vary (e.g. Hecker & Brigham 1999; Elangovan & Marimuthu 2001).

4.5. Wind Farm Impacts on Bats

Wind energy is emerging as a noticeable component of energy markets in a number of regions, with the USA, Spain and China being the biggest players (SAWEA 2010). However, it has been estimated that by 2020, 33,000-111,000 bats may be killed annually by wind turbines in the Mid-Atlantic Highlands, USA alone (Boyles *et al*. 2011). The cumulative impacts of such fatality on affected populations could have long-term effects on bat species (Kunz *et al*. 2007), especially considering other impacts currently on bats, such as White Nose Syndrome (WNS) in Europe and the USA (Boyles *et al*. 2011) and worldwide habitat threats (Mickleburgh *et al*. 2002). If mortality of bats associated with WNS and wind turbines continues unabated, we can expect noticeable economic losses to North American agriculture in the next 4 to 5 years (Boyles *et al.* 2011). Furthermore, in Europe, isotope analysis has revealed that wind farms don’t only affect local bat populations but may also cause fatalities of bats from geographically distant populations – up to and possibly beyond 1000km away (Voigt *et al*. 2012).

Although considerable progress has been made in recent years towards better understanding the problem, bat fatalities at wind turbines is still a major concern for this energy alternative. During a study by Arnett *et al*. (2009), 10 turbines monitored over a period of three months showed 124 bat fatalities in South-central Pennsylvania (USA). Cumulatively, turbines may have a catastrophic long term effect on bat populations if such a collision rate persists. It is, however, important to note, that the number of fatalities will vary greatly depending on the habitat and area where the wind farm is located, and the number can also be significantly decreased by effective mitigation measures.

Documented impacts of turbines on bats most often include:

- Direct collision.
- Barotrauma (fatality due to lung damage caused by sudden change in air pressure near turning blades; Baerwald *et al*. 2008)
- Loss of foraging habitat (by construction of WEFs and/or their avoidance by bats).
- Barrier effects of WEFs along bat commuting and migratory routes.
- Ultrasound production (although this is probably limited).

Potential barrier effects of WEFs, barotraumas and direct collision of bats with blades are considered to present the greatest threats, especially to migratory species and open-air foragers. The very latest research from Iowa, USA strongly suggests, from forensic pathology examinations, that traumatic injury (collision) is the major cause of bat mortality at wind farms and, at best, barotrauma is a minor etiology (Rollins *et al*. 2012). Results from Horn *et al*. (2008) indicate that bats:

- approached both rotating and non-rotating blades.
- followed or were trapped in blade-tip vortices.
- investigated the various parts of the turbine with repeated fly-bys.
- were struck directly by rotating blades.

If bats can echolocate, why can they not avoid the turbines and ultimately death caused by them? Cryan & Barclay (2009) reviewed hypothesized causes of bat fatalities at turbines, with all falling into two general categories—proximate and ultimate. Proximate causes explain the direct means by which bats die at turbines and include collision with towers and rotating blades, and barotrauma. Ultimate causes explain why bats come close to turbines and include three general types: random collisions, coincidental collisions, and collisions that result from attraction of bats to turbines (Horn *et al*. 2008). The random collision hypothesis posits that interactions between bats and turbines are random events and that fatalities are representative of the bats present at a site. Coincidental hypotheses posit that certain aspects of bat distribution or behaviour put them at risk of collision and include aggregation during migration and seasonal increases in flight activity associated with feeding or mating.

Kunz *et al*. (2007) identified eleven hypotheses regarding how, when, where and why bats are being killed at WEFs. These are further discussed in Strickland (2011) and are summarised below:

- Linear Corridor Hypothesis
  Modifications of landscapes during installation of wind energy facilities, including the construction of roads and power-line corridors, and removal of trees to create clearings (usually 0.5–2.0ha) around each turbine site may create favourable conditions for the aerial insects upon which most insectivorous bats feed (Grindal & Brigham 1998).
- Roost Attraction Hypothesis
  Tree roosting bats may mistake the turbines for large trees and be attracted to them for roosting purposes.
- Landscape Attraction Hypothesis
  Modifications of landscapes needed to install WEFs, such as the construction of wide-access power corridors and the removal of trees to create clearings around each turbine site, create conditions favourable for insects upon which bats feed (Grindal & Brigham 1998). Thus, bats that are attracted to and feed on insects in these altered landscapes may be at an increased risk of being killed by wind turbines.

- Low Wind Velocity Hypothesis

  Fatalities of aerial feeding and migrating bats are highest on nights during periods of low wind velocity (Arnett 2005; Baerwald *et al*. 2008). Horn *et al*. (2008) showed that blade rotational speed was a significant negative predictor of collisions with turbine blades, suggesting that bats may be at higher risk of fatality on nights with low wind speeds.
- Insect Attraction Hypothesis

  Flying insects are attracted to the heat produced by nacelles of wind turbines (Ahlén 2003). As bats respond to high densities of flying insects near wind turbines (Ahlén *et al*. 2007), the risk of being struck by turbine blades may increase.
- Visual Attraction Hypothesis

  Bats and their insect prey are attracted to lights placed on wind turbines as required by the United States Federal Aviation Administration, or to the reflection from white turbines under moonlit conditions, thus increasing the chances of collision and fatality as bats feed on insects (Arnett *et al*. 2005).
- Acoustic Attraction Hypothesis

  It is possible that bats are attracted to the swishing sounds produced by the rotating blades. However, there is no literature to support this. Alternatively, bats may become acoustically disoriented upon encountering these structures during migration or feeding.
- Echolocation Failure Hypothesis

  Migrating and foraging bats may fail to detect wind turbines by echolocation, or miscalculate rotor velocity (Ahlén 2003). If bats are unable to detect the moving turbine blades, they may be struck and killed directly.
- Electromagnetic-Field Distortion Hypothesis

  Bats rely on a magnetic compass to return to their home roost (Holland *et al*. 2006). If wind turbines produce complex electromagnetic fields in the vicinity of the nacelle, the flight behaviour of bats may be altered by these fields and thus increase the risk of being killed by rotating turbine blades.
- Decompression Hypothesis

  Bats flying in the vicinity of turbines may also become trapped in blade-tip vortices and experience rapid decompression due to changes in atmospheric pressure as the turbine blades rotate downward.
- Thermal Inversion Hypothesis.

  The altitude at which bats migrate and or feed may be influenced by thermal inversions, forcing them to the altitude of rotor swept areas (Arnett *et al*. 2005). The most likely impact of thermal inversions is to create dense fog in cool valleys, possibly concentrating both bats and insects on ridges, and thus encouraging bats to feed over the ridges on those nights, if for no other reason than to avoid the cool air and fog. Most turbines proposed for South Africa are situated on ridges; hence, this hypothesis could apply here.

South Africa is following the world trend and has made considerable progress in establishing potential sites for WEFs. Most biologists support clean and renewable energy production, however, the impacts that wind farms may have on South African bats are largely unknown. Although there is still a lack of research on bats and turbines, a more fundamental problem is the paucity of information on the population densities, roost site locations, and the foraging and migratory behaviour of South African bats. Bat monitoring for proposed WEFs in South Africa should, therefore, be performed pre- and post-construction, and should follow a very strong pre-cautionary approach.

4.6. Turbine Dimensions

The question of whether many smaller or fewer bigger turbines cause less impacts on bats was posed to NSS. NSS's desktop review has revealed that there is evidence to suggest that larger turbines cause higher mortalities in bats, however, site specific location of turbines in terms of sensitive habitats cannot be overlooked. The following literature refers:

- Rydell *et al.* (2010) found that bat fatalities increased with turbine tower height and rotor diameter, but was independent of the distance from the ground to the lowest rotor point.
- According to NWCC (2010), early turbines featured 18-25m tall towers, and rotors with a 15-18m diameter, which turned 60–80 revolutions per minute (rpm). Today's land-based wind turbines are mounted on towers 60-80m in height with rotors 45-80 m in diameter, resulting in blade tips that can reach 120m above ground level. Rotor swept areas now exceed 1 acre and are expected to reach nearly 1.5 acres within the next several years. Even though the speed of rotor revolution has significantly decreased to 11–28 rpm, blade tip speeds have remained about the same; under normal operating conditions, blade tip speeds range from 138–182 mph. Wider and longer blades produce greater vortices and turbulence in their wake as they rotate, posing a potential problem for bats in terms of barotrauma.
- Turbines with 65m high towers caused more fatalities of migratory bats than turbines of 50m even when bat activity was lower at the high towers than at the low towers (Baerwald & Barclay 2009).

Preliminary, unpublished research has revealed bat fatalities from turbines in South Africa, indicating that certain species e.g. the Egyptian Free-tailed Bat (*Tadarida aegyptiaca*) and Cape Serotine Bat (*Neoromicia capensis*) fly within rotor sweep height.

4.7. Conservation Significance of Bats in South Africa

Bats are among the most overlooked, yet economically important, non-domesticated animals, and their conservation is important for the integrity of ecosystems and in the best interest of both national and international economies (Boyles *et al*. 2011). Insectivorous bats provide essential pest control service to farmers, while frugivorous bats facilitate plant pollination and seed dispersal and, thus, habitat regeneration. Since bats are long-lived, highly mobile animals that fill numerous ecological and trophic roles, they are excellent indicators of habitat disturbance (Fenton & Ratcliffe 2010). The potential loss of these ecosystem services is thus a fundamental consideration when assessing the environmental impact of wind farms. The loss of bat colonies could, for example, potentially result in increased costs in pesticides and reduced agricultural productivity. Chiroptera is also the second most specious order of mammals (second to Rodentia) with upwards 1200 species worldwide (Simmons 2005) hence they are extremely valuable in terms of biodiversity.

Many bat species roost in large aggregations and concentrate in small geographical areas. Therefore, any major disturbance to such an area could adversely affect many individuals of a population (Hester & Grenier 2005). The Natal Long-fingered Bat (*Miniopterus natalensis*), for example, is a gregarious, cave-roosting species that can number in the thousands of individuals. Therefore, if a WEF coincides with a migratory route between cave roosts of this species, the impact of the WEF would be much greater than the sum of all individual fatalities.

Bats have much lower reproduction rates compared to most other small mammals since usually only one or two pups are born per female annually. Furthermore, the females of some bat species may only reproduce biennially. Bats are also long-lived, reaching up to 30 years of age (O'Shea *et al*. 2003). Due to their high longevity and low mortality from predation, under natural circumstances a population's size can increase greatly with time. However, because their generation turn-over is slow, populations have low resilience and a slow recovery rate from major die-offs.

Whilst the exact numbers of bat species change as research continues, Monadjem *et al*. (2010) report that there are approximately 117 species of bats in the Southern African sub-region, of which 5 species have a global IUCN Red List status of Vulnerable and 12 are classified as Near Threatened (IUCN 2012). Almost 60 bat species are known to occur in South Africa (Taylor 2000; Friedmann & Daly 2004; Monadjem *et al*. 2010) of which:

- 2 are Critically Endangered (CR)
- 2 are Endangered (EN)
- 6 are Vulnerable (VU)
- 17 are Near Threatened (NT)
- 3 are Data Deficient (DD)
- 8 are Not Evaluated (NE)
- 20 are Least Concern (LC)

In other words, 66% of South African bat species are of conservation concern. Prior to 1994 only a few dedicated scientists were involved in bat conservation efforts in South Africa. Since then, experts and amateurs have become increasing involved in bat conservation and research through the Durban, and Gauteng and Northern Regions Bat Interest Groups (DBIG and GNorBIG), and the Cape Bat Action Team (Cape BAT). The EWT's Bat Conservation Group is also dedicated to bat conservation in southern Africa through generating increased public participation in bat conservation, and education and awareness programmes.

5. Applicable Legislation & Guidelines

There is considerable international, national and provincial legislation, regulations, policies and guidelines regarding the protection of biodiversity and the environment, which includes bats and their habitat. The list below includes legislation and regulations that are most applicable to the Perdekraal study area, wind energy developments and the impact of these on bats and their habitat. Additional legislation, policies and guidelines that have not been mentioned may also apply.

5.1. International Agreements

Convention on the Conservation of Migratory Species of Wild Animals

This Convention, also known as the Bonn Convention, aims to conserve terrestrial, marine and avian migratory species throughout their range. The treaty was signed in 1979 in Bonn, France, and entered into force in 1983. It is an intergovernmental treaty, concluded under the aegis of the United Nations Environment Programme (UNEP), which is concerned with the conservation of wildlife and habitats on a global scale. South Africa is a party to this Convention, and several bat species in South Africa are known or suspected to be migratory, e.g. the Natal Long-fingered Bat (*Miniopterus natalensis*), which was detected at Perdekraal.

Convention on Biological Diversity (CBD)

This Convention, also referred to as the Biodiversity Convention, was established during the 1992 UN Conference on Environment and Development (UNCED), also known as the 1992 Earth Summit, held in Rio de Janeiro, Brazil. It represented the first global, comprehensive, legally-binding agreement to address all aspects of biological diversity ranging from genetic resources to species and ecosystems. It is regarded as the key document regarding sustainable development. The CBD has three main goals: conservation, sustainable use of biodiversity and equitable sharing of benefits arising from genetic resources. South Africa signed the treaty in 1998 showing further commitment to the conservation of biodiversity, including inter- and intra-specific bat diversity and bat habitat.

United Nations Framework Convention on Climate Change (UNFCCC)

The UNFCCC or FCCC, which was also established during the 1992 Earth Summit, is an international agreement to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climatic system. The treaty itself sets no mandatory limits on greenhouse gas emissions for individual countries and contains no enforcement mechanisms. It is, therefore, non-binding. However, it does provide for updates called "protocols," which set mandatory emission limits. The principal update is the Kyoto Protocol. The UNFCCC entered into force in 1994 and has approximately 194 parties including South Africa. The parties to the Convention have met annually from 1995 in Conferences of the Parties (CoP) to assess progress in dealing with climate change.

Johannesburg Declaration and Plan of Implementation (JPoI)

The Johannesburg Declaration and JPoI originated from the 2002 UN Conference on Sustainable Development in Johannesburg, which was convened as the World Summit on Sustainable Development (WSSD), otherwise known as the 2002 Earth Summit. The Declaration builds on earlier declarations made during the UN conferences at Stockholm in 1972 and Rio de Janeiro in 1992. A general target to achieve by 2010 is a significant reduction of the current rate of biodiversity loss at global, regional and national levels, as a contribution to poverty alleviation and to benefit all life on Earth. South Africa uses the National Biodiversity Strategy and Action Plan (NBSAP) as a means to achieve the JPoI biodiversity targets.

Copenhagen Accord

The 2009 UNFCCC in Copenhagen, also referred to as the Copenhagen Summit, included the 15th Conference of the Parties (CoP 15) to the UNFCCC and the 5th Meeting of the Parties (MoP 5) to the Kyoto Protocol. A framework for climate change mitigation beyond 2012, the Copenhagen Accord, was drafted during the Summit by the United States, China, India, Brazil and South Africa. It was "taken note of," but not "adopted," in a debate of all the participating countries, and it was not passed unanimously.

The Accord recognizes that climate change is one of the greatest challenges of the present day and that actions should be taken to keep any temperature increases to below 2°C. The document is not legally binding and does not contain any legally binding commitments for reducing CO_2 emissions. Many countries and non-governmental organisations were opposed to this agreement, but since 2010 >138 countries have formally signed the agreement. South Africa has agreed to cut emissions by 34% below current expected levels by 2020. As wind farms produce no or little greenhouse gases, there is growing interest in this form of energy production in South Africa. However, potential impacts of wind turbines on the environment and biodiversity in South Africa have not yet been comprehensively assessed.

18th Conference of the Parties (CoP 18)

The 2012 UNFCCC in Qatar, Doha Durban was held to establish a new treaty to limit carbon emissions. This Convention reached an agreement to extend the life of the Kyoto Protocol, which had been due to expire at the end of 2012, until 2020, and to reify the 2011 Durban Platform, meaning that a successor to the Protocol is set to be developed by 2015 and implemented by 2020. Wording adopted by the conference incorporated for the first time the concept of "loss and damage", an agreement in principle that richer nations could be financially responsible to other nations for their failure to reduce carbon emissions.

5.2. Regional Agreements

Action Plan of the Environmental Initiative of NEPAD

This New Partnership for Africa's Development (NEPAD) Action Plan was established during the 2003 African Convention on Conservation of Nature and Natural Resources held in Maputo. As a contracting state, South Africa has undertaken to adopt measures to ensure the conservation, utilization and development of soil, water, floral and faunal resources in accordance with scientific principles and with due regard to the best interests of the people. The Action Plan encourages sustainable development and associated conservation and wise use of biodiversity in Africa. It has been recognised that a healthy and productive environment is a prerequisite for the success of NEPAD, together with the need to systematically address and sustain ecosystems, biodiversity and wildlife.

5.3. National Legislation

Unlike in the UK and the USA, bats are not directly protected in South Africa. However, there are various Acts and Regulations relevant to the protection of fauna, including bats.

Environmental Conservation Act (ECA; Act 73 of 1989)

The ECA is mentioned here because it is necessary to ensure that, for the remainder of its phasing out period, it is enforced in terms of the new enforcement provisions in the current National Environmental Management Act (NEMA), which were added to NEMA under the National Environmental Management Amendment Act (NEMAA; Act 8 of 2004). ECA is already partially repealed, and although it is envisaged that ECA will eventually be repealed in its totality, it is still being applied for a number of reasons. For example, regulations are being applied for authorisation of activities in certain coastal areas, which were published in terms of Sections 26 and 28 of the ECA in Government Notice R. 1528 of 27 November 1998.

Constitution of the Republic of South Africa (Act 108 of 1996)

According to South Africa's Constitution, South African citizens have the right to have the environment protected for the benefit of present and future generations.

National Environmental Management Act (NEMA; Act 107 of 1998)

NEMA is an umbrella Act covering broad principles of environmental management. NEMA can be regarded as the most important piece of general environmental legislation covering three main areas namely: Land, planning and development; Natural and cultural resources use and conservation; Pollution control and waste management. According to NEMA sustainable development requires the consideration of all relevant factors including:

- That the disturbance of ecosystems and loss of biological diversity are avoided, or, where they cannot be altogether avoided, are minimised and remedied;

- That the development, use and exploitation of renewable resources and the ecosystems of which they are part, do not exceed the level beyond which their integrity is jeopardised.

Sensitive, vulnerable, highly dynamic or stressed ecosystems require specific attention in management and planning procedures, especially where they are subject to significant human resource usage and development pressure.

National Environmental Management: Biodiversity Act (NEM:BA; Act 10 of 2004)

One of the objectives of NEM:BA is to provide for the management and conservation of South Africa's biodiversity within the framework of NEMA and to ensure the sustainable use of indigenous biological resources. Chapter 4, Part 2 of NEM:BA provides for listing of species that are threatened or in need of protection to ensure their survival in the wild while regulating the activities, including trade, which may involve such listed threatened or protected species and activities which may have a potential impact on their long-term survival. According to Section 56(1) of NEM:BA, in February 2007 the Minister of Environmental Affairs and Tourism published a list of Threatened (Critically Endangered, Endangered and Vulnerable) or Protected Species (referred to as TOPS). According to the NEM:BA TOPS Regulations a person may not carry out a restricted activity involving a specimen of TOPS without a permit. The Regulations fail, however, to recognise most Conservation Important (CI) bat species, as only the Large-eared Free-tailed Bat (*Otomops martiensseni*) is included on the ToPS List.

5.4. National Policies & Guidelines

National Biodiversity Strategy and Action Plan (NBSAP)

The development of the NBSAP is part of South Africa's obligations as a signatory to the CBD, and was compiled by the Department of Environmental Affairs and Tourism (DEAT 2005). The NBSAP is based on the recognition that South Africa is extremely rich in terms of biodiversity, but is also a developing country where the majority of the population resides in poverty. It provides an overarching framework for the conservation and sustainable use of South Africa's biodiversity, and equitable sharing of benefits from use of genetic resources. As far we know South Africa is the first country to include a comprehensive spatial assessment of biodiversity (the NSBA) as part of its NBSAP. Through the NBSAP it is recognized that biodiversity cannot be conserved through protected area networks only. All stakeholders, from private landowners and communities to business and industry must get involved in biodiversity management.

National Spatial Biodiversity Assessment (NSBA) Priority Areas & Threatened Ecosystems

The NSBA, which is part of the NBSAP, was led by the SANBI (Driver *et al*. 2011). Its main focus was on mainstreaming biodiversity priorities and making links between biodiversity and socio–economic development in South Africa. The NSBA represents South Africa's first national assessment of spatial priorities for conservation action, integrating terrestrial, river, estuarine and marine ecosystems, using available spatial data, biodiversity planning software and a series of expert and stakeholder workshops.

The NSBA involved systematic biodiversity planning based on three principles:

- The need to conserve a representative sample of biodiversity pattern, such as species and habitats (the principle of representation).
- The need to conserve the ecological and evolutionary processes that allow biodiversity to persist over time (the principle of persistence).
- The need to set quantitative biodiversity targets that tell us how much of each biodiversity feature should be conserved in order to maintain functioning landscapes and seascapes.

During the NSBA, nine geographic Priority Areas were identified for conservation in South Africa (Driver *et al*. 2004). Priority Areas were allocated where broad-scale habitat remained unprotected, or was inadequately conserved.

A national list of Threatened Terrestrial Ecosystems was gazetted on 9 December 2011 in the NEM:BA. The identified Threatened Ecosystems occupy 9.5% of South Africa and were selected according to six criteria including:

- Irreversible habitat loss;
- Ecosystem degradation;
- Rate of habitat loss;
- Limited habitat extent and imminent threat;
- Threatened plant species associations; and
- Threatened animal species associations.

Freshwater Ecosystem Priority Areas (FEPAs) were similarly identified during the National Freshwater Ecosystem Priority Areas project (NFEPA). This was based on a range of criteria dealing with the maintenance of key ecological processes and the conservation of ecosystem types and species associated with rivers, wetlands and estuaries. FEPAs should be regarded as ecologically important and as generally sensitive to changes in water quality and quantity, owing to their role in protecting freshwater ecosystems and supporting sustainable use of water resources.

The location of Perdekraal in relation to National Terrestrial and Aquatic Priority Areas is described under **Section 3**.

National Red Data Species Listings

Lists of National Red Data Species have been produced for all five vertebrate classes. The National Red Data conservation status of mammals, including bat species, in South Africa was most recently assessed in 2004 (Friedmann & Daly 2004).

5.5. Provincial Legislation & Guidelines

General provincial biodiversity guidelines are provided by Cape Nature (www.capenature.co.za) and specify among other things, that permits are required for work that involves hunting, transport or captive housing of wild animals.

5.6. Buffer Zones

Although well intended for conservation purposes, the issue of placing a standardised buffer on conservation important habitats, plant or animal localities is a controversial one. The controversy is sparked by the following challenges:

- Buffer distances are often based on educated guesses, and little scientific research.
- If a buffer is placed on a particular habitat, the success of that buffer working is dependent on the requirement of all species and ecosystems utilizing that habitat. Different species and ecosystems usually have different needs.
- If enough pressure exists for a particular development, buffers will be relaxed to accommodate that development.
- For non-linear conservation important areas, a radial buffer is presumed; however, often habitats will be far more suitable on one side of the area than the other. Therefore, a radial buffer may not be appropriate – it may be more appropriate to select specific patches of suitable habitat around the sensitive ecological entity that will ensure its survival.
- Not all South African provinces have developed policies or guidelines on buffers.
- There are no South African guidelines for the consideration of bats in relation to wind farm developments. Therefore, one can extrapolate from other provinces and other country's guidelines, for instance:
    - The Gauteng Department of Agriculture and Rural Development (GDARD 2009) recommends a 500m buffer on natural caves systems, a 200m buffer on Class 1 ridge systems, a 200m buffer on conservation important vegetation, and a 50m buffer on riparian edges. All of these represent important bat habitats.
    - Guidelines such as the Eurobats Guidance and the Natural England Technical Note (Mitchell-Jones & Carlin 2009) give some indication of buffer zones which may be applicable, in the absence of limits in South Africa:
        - The Eurobats Guidance (Rodrigues *et al*. 2008) proposes a minimum distance of 200m to forest edges where forest clearing and tree felling is necessary to establish a wind farm.
        - The Natural England Interim Guidance suggests a 50m buffer from wind turbine blade tip to the nearest feature (tree top or house).

In conclusion on buffers and bats, appropriate site-specific buffers need to be selected by a qualified specialist for bat conservation important habitat (whether it is for foraging or roosting) that will meet the requirements of the particular species or populations occurring in the area.

6. Project Team

NSS has extensive experience in project management and field work by having performed numerous environmental and biodiversity assessments, including 13 long-term bat monitoring studies. NSS has also been involved in the management of Environmental Impact Assessments (EIAs), Environmental Management Programme Reports (EMPRs), Strategic Management Plans (SMPs) and Environmental Management Plans (EMPs) for the Conservation, Mining, Waste, Commercial and Industrial sectors.

The following South African accreditations and professional registrations apply to NSS personnel:

- Senior members are registered Professional Natural Scientists in the environmental, ecological and/or zoological fields.
- Aquatic specialists are accredited with DWA to perform the SASS for aquatic macro-invertebrate monitoring.
- Wetland specialists are accredited through DWA to perform Wetland Delineations.

NSS personnel who were involved with the long-term bat monitoring at Perdekraal (**Figure 6-1**) included:

6.1.1. Kate MacEwan

Kate is a founding member of NSS and a registered Professional Natural Scientist (Zoological and Environmental Sciences) with 14 years of biodiversity experience. She obtained a B.Sc. Honours in Zoology and is currently completing an M.Sc. in Bat Conservation Biology (both through the University of the Witwatersrand/Wits).

As a practicing zoologist, conservation biologist and consultant, Kate has:

- Performed numerous EIA, EMP and other assessments for fauna including bats.
- Performed various Specialist Bat Assessments for, example:
    - A proposed automobile production factory near Bon Accord, Pretoria.
    - The Management and Action Plan for a cave on Driefontein Gold Mine.
    - Seven proposed WEFs in the Northern and Western Cape – under Environmental Resources Management.
    - A proposed WEF in Namaqualand, Western Cape – under DJ Environmental Consultants.
    - Mining through old adits containing bats at Pilanesburg Platinum Mine, North West Province.
    - Long-term pre-construction monitoring for 13 proposed WEFs in the Western, Northern and Eastern Cape, and in Kwa-Zulu Natal.
- Been involved with EWT on bat conservation related projects.

- Served on the Gauteng & Northern Regions Bat Interest Group (GNorBIG) Executive Committee for >10 years. Her duties have included bat scientific research and educational talks to the public.
- Hand-reared >25 individual bats during her career.
- Obtained Fall Arrest certification for climbing heights over 3m.

6.1.2. Caroline Lötter

Caroline is a registered Professional Natural Scientist (Zoological Sciences) with several scientific peer-reviewed publications and 15 years of tertiary academic experience. She obtained a B.Sc. Honours in Zoology, an M.Sc. in African Mammalogy, and a Ph.D. in Amphibian Conservation Biology (through the University of Pretoria/UP).

As a post-graduate student and practicing zoologist, conservation biologist and consultant, Caroline has:

- Acquired considerable mark-recapture, radio-tracking, histological, molecular, GIS, species distribution modelling, statistical, lecturing, and public speaking experience.
- Been involved for >5 years with EWT through the Giant Bullfrog Project.
- Performed numerous Specialist Giant Bullfrog Assessments in South Africa.
- Performed various faunal assessments in South Africa, and in Sierra Leone.
- Been involved with long-term pre-construction monitoring for 10 proposed WEFs in the Western, Northern and Eastern Cape, and in Kwa-Zulu Natal.
- Obtained Fall Arrest certification for climbing heights over 3m.

6.1.3. Trevor Morgan

Trevor has served as an active member on the Executive Committee of the GNorBIG for several years. He is very knowledgeable on South African bats and has extensive experience with bat detectors, their related software, mist-netting and harp-trapping. By trade, Trevor is an electrician and an inventor, and has constructed his own harp trap and heterodyne bat detector. Trevor's considerable field-based involvement in all long-term bat monitoring studies performed by NSS has been invaluable.

6.1.4. Michael Pierce

Michael has obtained both a B.Sc. Honours and an M.Sc. in Zoology (through Wits). For his M.Sc. Michael used multiple sampling techniques (mist-netting, harp-trapping, roost searches and echolocation monitoring) to assess bat diversity and assemblage structure in different vegetation types on a game farm north of Pretoria. Michael thereby acquired useful knowledge on the general ecologies of the different bat functional groups, and advanced experience with both frequency division (Anabat SD2) and time expansion (Pettersson D240X) bat detectors and the AnalookW and Batsound Pro software programmes for identifying and analysing bat calls. Michael has thus provided valuable assistance with data analysis for the long-term bat monitoring studies performed by NSS.

6.1.5. Megan Baumgartner

Megan has obtained a B.A. Honours in Geography (through UP). Her primary role at NSS is compiling Environmental Impact Assessments and other environmental authorization documents under the NEMA, NEM:WA, NWA and MPRDA. However, Megan has also spent considerable time improving the efficacy of analyzing large volumes of data from various long-term bat monitoring studies.

12.5. Lloyd Mhlongo

Lloyd is completing a B.Sc. in Environmental Management and Botany with the University of KwaZulu Natal, and is a voluntary Honorary Officer with KZN Ezemvelo Wildlife. He is Fall Arrest certified and has mainly assisted NSS with bat monitoring work in KwaZulu Natal.

Kate MacEwan Trevor Morgan Caroline Yetman

Michael Pierce Megan Baumgartner Lloyd Mhlongo

Figure 6-1 NSS personnel involved with the Perdekraal bat monitoring study

7. Methodology

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7.1. Study Objectives

Specific objectives of the long-term bat monitoring study performed at Perdekraal by NSS were, to investigate:

- The assemblage and Conservation Importance of bats in the study area.
- The location of bat roosting habitat in the study area.
- Differences in the assemblage and activity of bats between monitoring heights.
- Differences in the assemblage and activity of bats between monitoring localities and habitat types.
- Seasonal variation in the assemblage and activity of bats during the 12-month monitoring period.
- The incidence of bat migration in the study area.
- Variation in the assemblage and activity of bats between sunset and sunrise.
- Meteorological conditions associated with bat activity (including wind speed, air temperature, relative humidity, atmospheric pressure and moon light).
- Potential impacts of the Perdekraal WEFs on bats.
- Effective bat impact mitigation measures.

7.2. Desktop Review

A desktop review of literature, legislation and the Likelihood of Occurrence (LoO) of specific species was conducted. The LoO was done according to the species distribution maps provided in Monadjem *et al*. (2010). The LoO was categorised as follows:

- High LoO – the species has been historically confirmed on or near the site.
- Moderate LoO – the species is within the higher probability modelled distribution of potential occurrence (Monadjem *et al*. 2010).
- Low LoO – the species is within the lower probability modelled distribution of potential occurrence (Monadjem *et al*. 2010).
- Species known to definitely not occur within the study area were not listed.

7.3. Field Work

In accordance with the Best Practice Guidelines (Sowler & Stoffberg 2012), the long-term bat monitoring at Perdekraal covered more than the minimum required 15–25% of the total active bat season (**Figure 7-8**), and involved the following methods and materials:

7.3.1. Roost Surveys

To determine the location of bat roosts in and near the Perdekraal WEF sites, potential suitable habitat was investigated during the day on foot, using torches where necessary. Localities that were inspected are shown in **Figure 7-1** and mapped in **Figure 7-2**, and included:

- Farm buildings in the north-central region of the site.
- Small mountains in the southern region of the site.
- The Witberg Mountains situated approximately 30km south-east of Perdekraal.

Farm buildings Farm buildings

Mountains on site Mountains on site

Witberg Mountains ca. 30km away Witberg Mountains ca. 30km away

Figure 7-1 Localities that were surveyed for bat roosts at or near Perdekraal

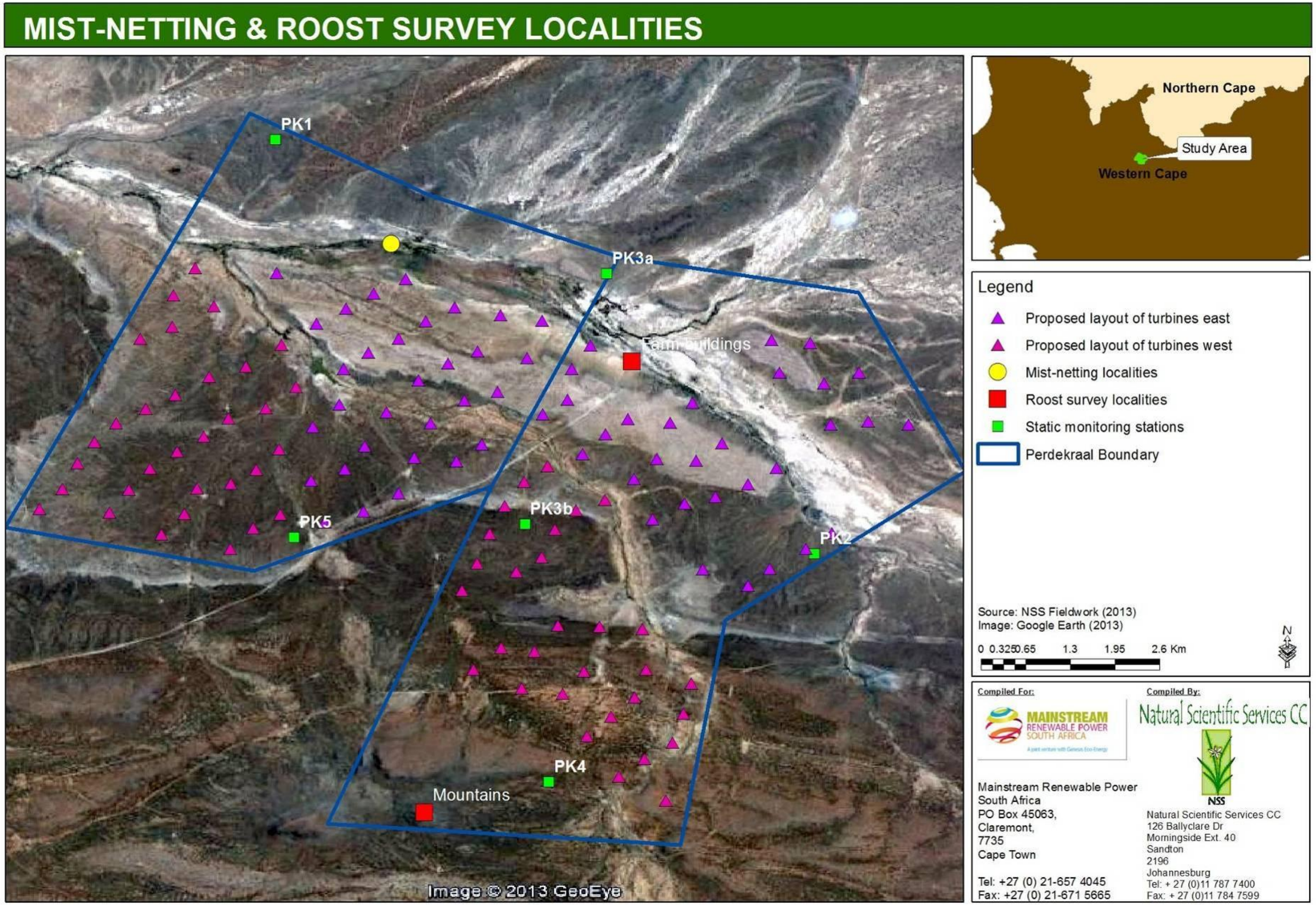


Figure 7-2 Bat roost survey and mist-netting localities at or near Perdekraal

7.3.2. *Mist-netting*

To investigate the presence of rarer bat species, and for unequivocal identification of more common bat species in the study area, mist-netting was performed during summer on 3 December 2012 in the then dry, seasonal drainage line that ran through the northern region of Perdekraal (**Figure 7-3**). Additional mist-netting in a dry, seasonal drainage line among mountains in the southern region of Perdekraal was intended, but windy weather at the time prevented this. The only other suitable locality for mist-netting at Perdekraal would have been outside an observed bat roost in the roof of a house in the north-central region of the site. Unfortunately the entrance to this roost was sealed by someone before mist-netting could be performed.

Figure 7-3 Mist-netting for bats in a dry, seasonal drainage line at Perdekraal

7.3.3. *Manual Bat Activity Surveys*

To investigate differences in the assemblage and activity of bats in different localities/habitats at Perdekraal, an Echo Meter 3 (EM3) detector (**Figure 7-4**; Wildlife Acoustics, Inc., USA) was used to record bat calls at ground level while driving 10-20km/h along selected “transect” routes shown in **Figure 7-6**. Transects were driven during autumn on 1 April and 14 May 2012, during winter on 3 June, 25 July and 28 August 2012, and during summer on 3 and 4 December 2012 and 5 and 6 February 2013.

Figure 7-4 **The EM3 detector used for manual bat activity surveys**

7.3.4. Passive Bat Activity Monitoring at Ground Level & Height

Long-term passive/static monitoring of bat activity at Perdekraal was performed at six localities (referred to as PK1, PK2, PK3a, PK3b, PK4 and PK5) and two approximate heights: near ground level (i.e. at 10m) and in rotor sweep height (i.e. at approximately 60m). The six monitoring locations are shown in **Figure 7-2**. PK1 and PK3a were located in Tanqua Wash Riviere vegetation. PK2 was situated in a transitional area between Tanqua Wash Riviere and Tanqua Karoo vegetation. PK3b, PK4 and PK5 were located in Tanqua Karoo vegetation. Equipment that was used at these localities is shown in **Figure 7-7** and described below.

The equipment at each static monitoring station included a SongMeter SM2BAT+ detector (Wildlife Acoustics, Inc., USA), which was powered by a solar panel and 12V 7 Amp/hour battery, and which was connected to one or two ultra-sonic, multi-directional SMX-US microphones (Wildlife Acoustics, Inc., US). The detector, battery, and separate solar and battery power regulators were housed inside a plastic electrical box. At PK1, PK2, PK3a, PK4 and PK5, the electrical box and one microphone were, respectively, attached at eye-level and on top of a 10m aluminium mast. To monitor bat activity within rotor sweep height, on 26 July 2012 monitoring equipment from PK3a was re-located to the newly-constructed meteorological (met.) mast (referred to as PK3b) on site. At PK3b the electrical box was attached to the met. mast at approximately 10m above ground level. Separate microphones were connected with cables to the SM2 detector’s right and left channels and, respectively, attached to the met. mast at 10m and 60m. Microphones detected bat calls within 30-50m in all directions, and plastic spikes were secured around the microphones to prevent damage from birds.

To prolong the battery life of each SM2 detector without significantly compromising the data obtained on bat activity, a number of changes were made to the detectors' recording schedule. The period over which each unique recording schedule was applied at Perdekraal is shown in **Figure 7-5**. Wherever possible, data were corrected for differences between the recording schedules prior to analysis.

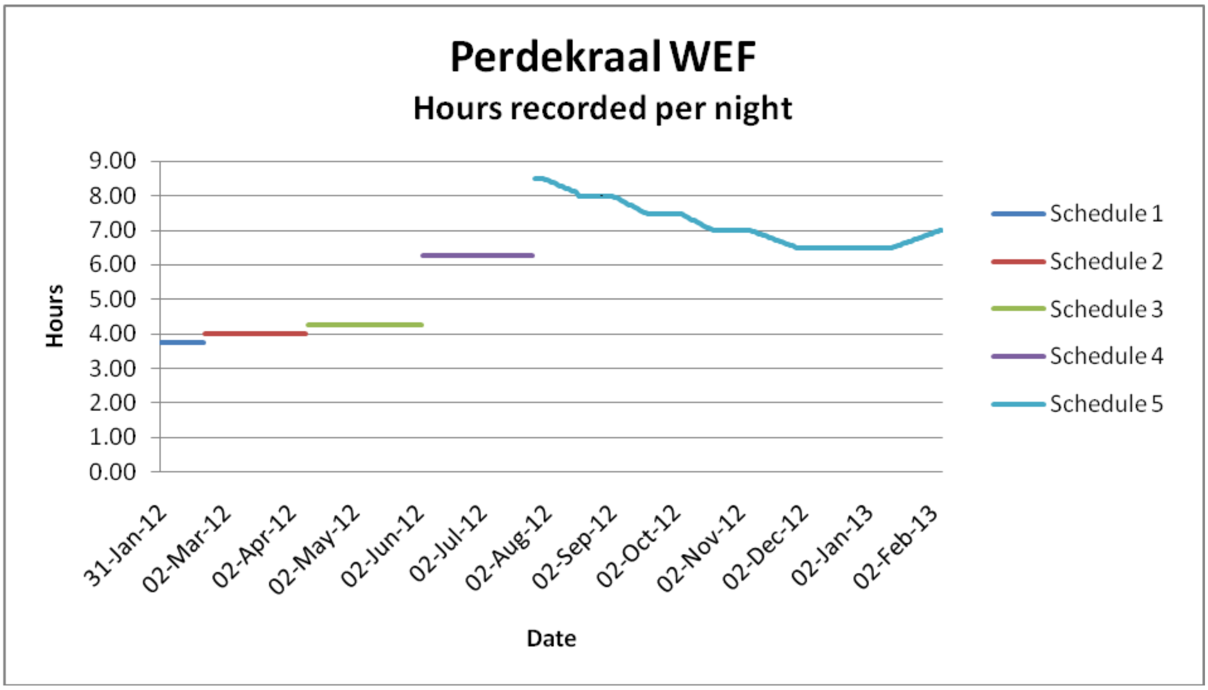


Figure 7-5 **Perdekraal SM2 detector recording schedules**

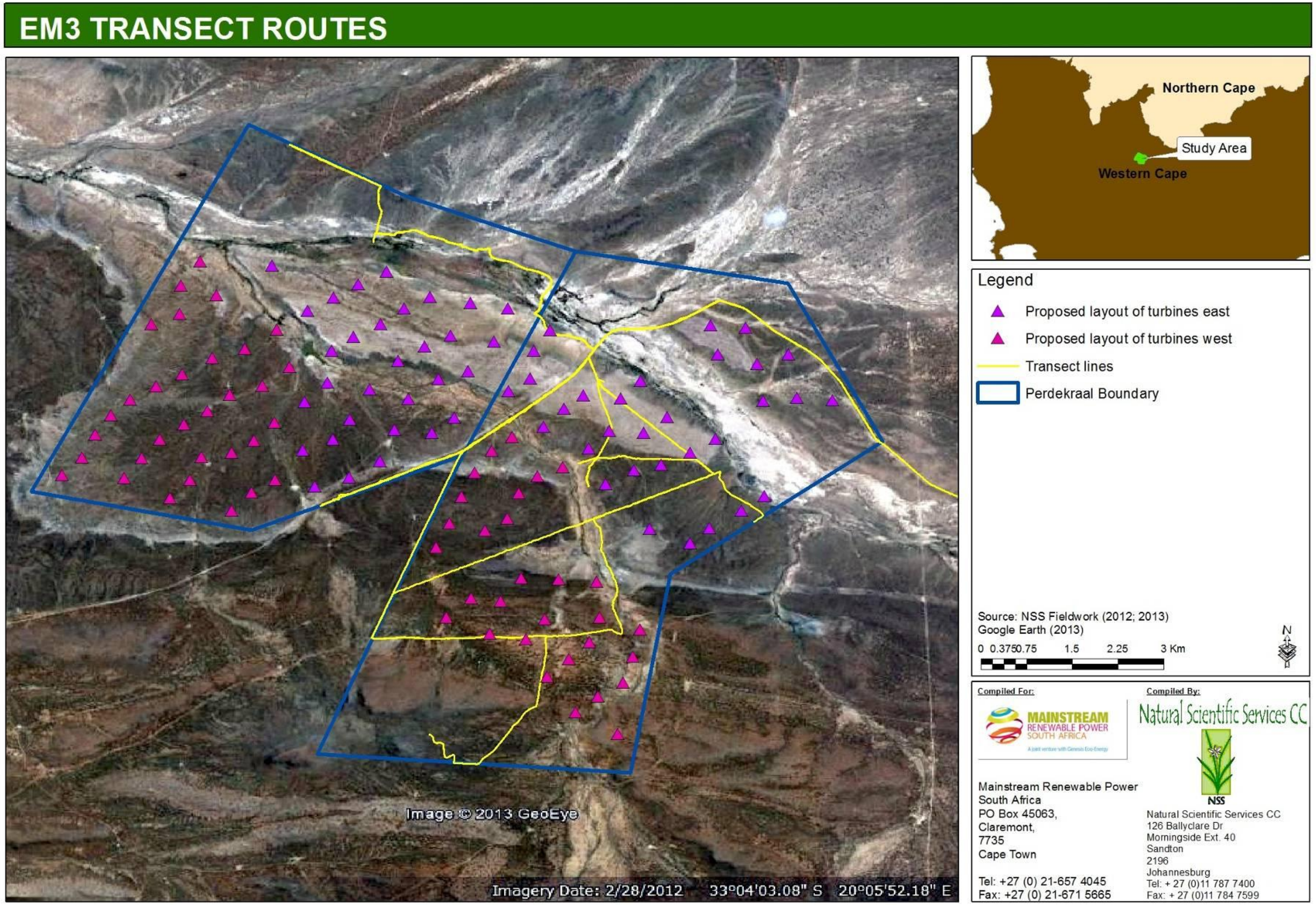
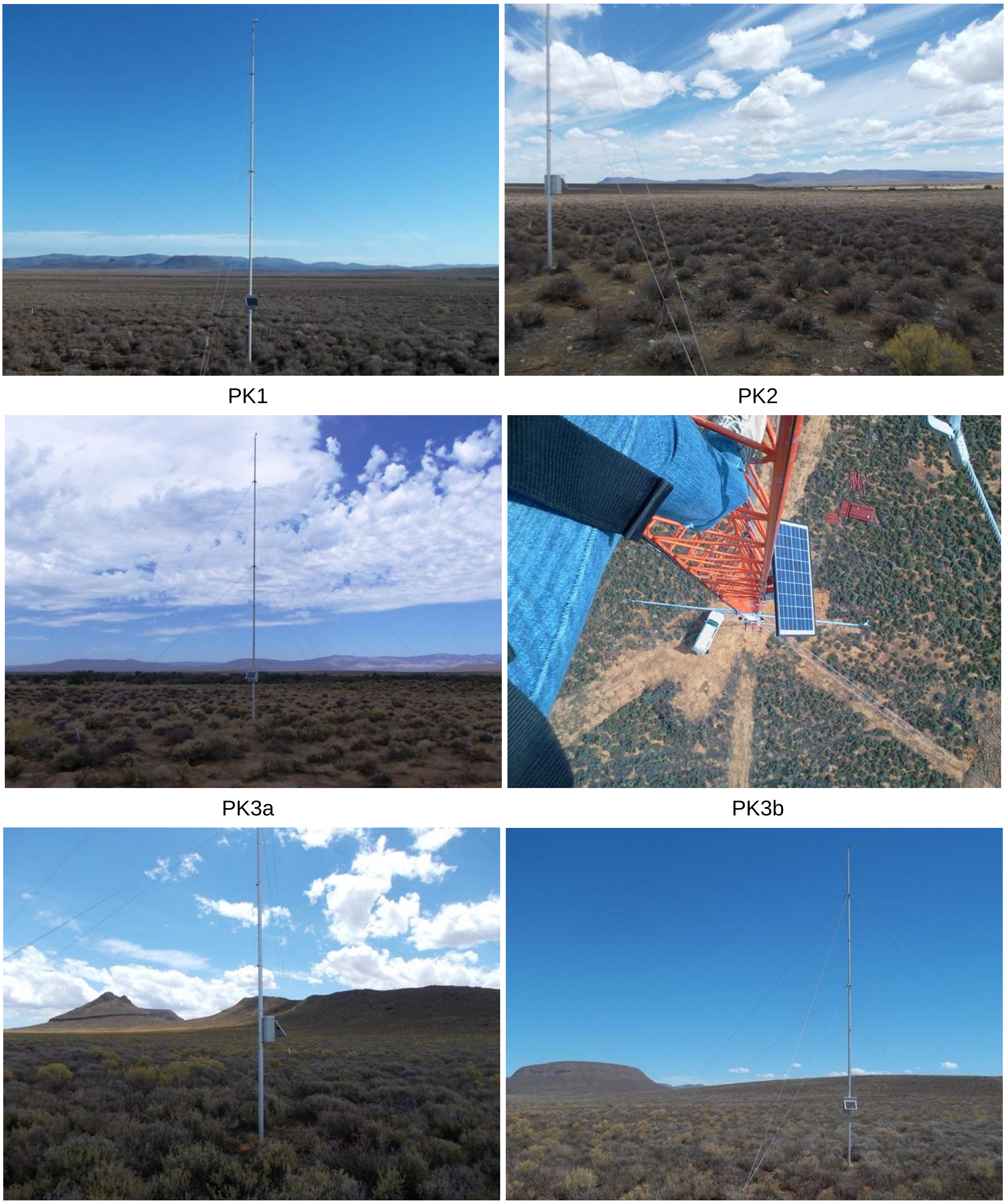


Figure 7-6 EM3 transect routes at Perdekraal



PK1

PK2

PK3a

PK3b

PK4

PK5

Figure 7-7 **Long-term passive bat monitoring stations at Perdekraal**

7.4. Species Groups & Fatality Risk

Long-term bat monitoring studies generate huge volumes of data that can take days or weeks to analyze. NSS, therefore, analyzes long-term bat monitoring data for *functional groups* of bat species that produce similar echolocation calls and have similar foraging ecologies. Species within each functional group are thus at similar risk of fatality from wind turbines. In the Best Practice Guidelines (Sowler & Stoffberg 2012) the risk of fatality from turbines of different bat taxa is defined by their flight ecology and geographical distribution (but unfortunately not their poorly known migratory habits), as shown in **Table 7-1**.

Table 7-1 Risk of bat fatality from wind turbines based on broad ecological factors excluding bat migration (Sowler & Stoffberg 2012)

FAMILY/ GENUS	ECOLOGY	RISK OF IMPACT FROM TURBINES (DIRECT COLLISION /BAROTRAUMA)
Pteropodidae	Common – restricted distributions. Some species known to move large distances.	**Medium – High**
Molossidae	Common – widespread. Species fly high enough to come into contact with turbine blades.	**High**
Emballonuridae	Common – restricted distributions. Species fly high enough to come into contact with turbine blades.	**High**
Rhinolophidae	Species with restricted distributions.	**Low**
Hipposideridae	Species with restricted distributions.	**Low**
Nycteridae	Common – widespread and restricted distributions.	**Low**
Miniopteridae	Common – widespread and restricted distributions. Some species known to move large distances.	**Medium – High**
Vespertilionidae	Common – widespread and restricted distributions.	
Pipistrellus	Species with wide or restricted distributions.	**Medium**
Hypsugo	Wide, but sparse distribution.	**Low**
Nycticeinops	Common throughout restricted distribution.	**Medium**
Neoromicia	Species with wide or restricted distributions.	**Medium – High**
Kerivoula	Species with wide but sparse distributions.	**Low**
Scotoecus	Sparse distributions.	**Medium – High**
Cistugo	Restricted distributions – species endemic to South or Southern Africa.	**Low**
Laephotis	Species with restricted distributions.	**Low**
Glauconycteris	Species with restricted distributions.	**Medium – High**
Myotis	Species with wide or restricted distributions; some species may move large distances.	**Medium – High**
Scotophilus	Some with widespread or restricted distributions	**Medium – High**
Eptesicus	Wide, but sparse distribution	**Medium**

The five NSS bat Species Groups (labelled A-E) are defined as such:

Species Group A: Bats with echolocation calls having 10-32 kHz peak frequencies, a narrow bandwidth, and intermediate to long duration. Most species are at a high risk of fatality from turbines. Examples include:

- The Molossidae family, e.g. *Tadarida aegyptiaca* (Egyptian Free-tailed Bat) and *Chaerephon pumilus* (Little Free-tailed Bat).
- The Emballonuridae family, e.g. *Taphozous mauritianus* (Mauritian Tomb Bat).

Species Group B: Bats with echolocation calls having 29-42 kHz peak frequencies, a narrow to intermediate bandwidth, and intermediate duration. Most species are at a medium to high risk of fatality from turbines. Examples include, but are not limited to:

- *Neoromicia capensis* (Cape Serotine Bat)
- *Scotophilus dinganii* (Yellow-bellied House Bat)
- *Eptesicus hottentotus* (Long-tailed Serotine)

Species Group C: Bats of the families Miniopteridae and Vespertilionidae, with echolocation calls having 40-75 kHz peak frequencies, a narrow to broad bandwidth, and short duration. Most species are at a medium to high risk of fatality from turbines AND several species are conservation important (CI). Where CI species are suspected, calls must be carefully analysed and mist-netting must be performed to try to confirm their presence. Examples include, but are not limited to:

- *Cistugo leseuri* (Leseur's Wing-gland Bat)
- *Myotis tricolor* (Temminck's Myotis)
- *Pipistrellus hesperidus* (Dusky Pipistrelle)
- *Miniopterus natalensis* (Natal Long-fingered Bat)

Species Group D: Bats of the Rhinolophidae and Hipposideridae families, with echolocation calls having 34-200 kHz peak frequencies. Most species are at a low risk of fatality from turbines BUT several of these bats are CI. Where CI species are suspected, calls must be carefully analysed, and mist-netting must be performed to try to confirm their presence. Examples include, but are not limited to:

- *Cleotis percirvali* (Percival's Short-eared Trident Bat)
- *Hipposideros caffer* (Sundevall's Leaf-nosed Bat)
- *Rhinolophus capensis* (Cape Horseshoe Bat)
- *Rhinolophus clivosus* (Geoffroy's Horseshoe Bat)
- *Rhinolophus swinnyi* (Swinny's Horseshoe Bat)

Species Group E: Bats, excluding those of the Rhinolophidae and Hipposideridae families, with echolocation calls having 85-160 kHz peak frequencies. Most species are at a low risk of fatality from turbines. Examples include:

- *Kerivoula lanosa* (Lesser Woolly Bat)
- *Nycteris thebaica* (Egyptian Slit-faced Bat)

7.5. Data & Software

Wildlife Acoustics Compressed (.wac) files of bat calls recorded by the SM2 and EM3 detectors were converted to wave (.wav) and zero crossing (.zc) files using the WAC2WAV and Kaleidoscope programmes (Wildlife Acoustics, Inc., USA). The converted data were subsequently processed using the BatSound Pro (Pettersson Elektronik, Sweden) and AnalookW (Titley Scientific, Australia) programmes. BatSound Pro was used to identify bat taxa from detailed examination of the peak frequency, duration and band width of calls. Examples of bat call images in BatSound Pro are presented in **Appendix 13.1.** AnalookW was used to obtain counts of passes by different bat Species Groups per unit time for further analysis in Microsoft Office Excel 2007.

7.6. Bat Activity

Bat activity can be estimated, for example, as the number of bat passes per night (Hayes 1997; Kalcounis *et al*. 1999), the number of bat passes per hour (Lloyd *et al*. 2006; Hein *et al*. 2011), or the number of bat individuals per minute (Miller 2001). The appropriate choice of activity index is dependent on the monitoring methodology used.

For the Perdekraal study, the number of bat passes per hour was considered to be the most appropriate estimate of bat activity. Passes/night was considered to be an inappropriate index of bat activity because at every passive monitoring station, the nightly duration of acoustic recording varied with deliberate technical adjustments (**Figure 7-5**) and unforeseen equipment problems. Bats/minute was also considered an inappropriate activity index because multiple calls could be made by one or several individual bats.

Hein *et al*. (2011) defined a bat pass as an echolocation sequence of .2 echolocation calls with a minimum duration of 10ms (Thomas 1988; Hayes 2000; Sherwin *et al*. 2000; Gannon *et al*. 2003; Parsons & Szewczak 2009). Weller & Baldwin (2012) defined a bat pass as either a series ≥2 echolocation calls each with a duration of ≥2ms or a single echolocation call with a duration of ≥5ms. An echolocation call is defined as a single pulse in a sequence of several call pulses.

In South Africa, however, bat monitoring has revealed that an echolocation “sequence” (especially from Molossid bats) may comprise only a single call pulse. NSS, therefore, defines a bat pass as a sequence of ≥1 echolocation calls where the duration of each pulse is ≥2 ms. Only completed single pulses and not single call fragments, are considered valid. Where there is a gap between pulses of >500ms in one file, this is treated as a new bat pass.

It is critical to note that because multiple recorded passes could be made by one or several individual bats, estimates of activity do **NOT** necessarily reflect the abundance of different bat species or Groups (Hayes 2000; Milne 2006). To obtain estimates of bat abundance, detailed monitoring work would have to be performed involving e.g., thermal imagery or mark-recapture sampling.

7.7. Analyses & Graphs

In this study the assemblage of bats at Perdekraal and, more specifically, at each monitoring locality and height, was deduced from the percentage of passes by each Species Group recorded through the seven microphones (i.e. at PK1:10m, PK2:10m, PK3a:10m, PK3b:10m, PK3b:60m, PK4:10m and PK5:10m) combined, or treated separately.

Bat activity at each monitoring locality and height was quantified as the average number of passes per hour for the Species Groups combined, or treated separately. To identify differences in bat activity between habitat types, for each Species Group the average number of passes per hour was determined for PK1, PK2 and PK3a (situated in the northern region of Perdekraal in/near Tanqua Wash Riviere vegetation, ≤2km from the Groot stream and ≥5km from mountains), and for PK3b, PK4 and PK5 (situated in the southern region of Perdekraal in Tanqua Karoo vegetation, ≥3km from the Groot stream and ≤3km from mountains). Where possible, these hourly estimates were corrected for differences between recording schedules, and gaps in the monitoring that were caused by equipment failures and other technical issues.

To examine seasonal variation in bat activity and to identify possible bat migration events at Perdekraal, on each date during the 12-month study the average number of passes per hour per microphone was calculated for the three Species Groups combined, or treated separately. To examine variation in bat activity at each monitoring locality and height, on each date during the 12-month study the total number of passes was determined for the three Species Groups combined, or treated separately.

Key activity periods between 17:30 and 05:30 were identified for all bats and each separate Species Group by examining the total number of passes recorded through all microphones during the 12-month study in each 10 minute interval of the night. Note that this data could not be corrected for gaps in recording by the SM2 detectors that were caused by technical problems, or which were programmed deliberately to prolong detector battery life. The data were also not corrected for variation in time at sunset and sunrise. As a result, regular apparent dips in night time bat activity are not genuine, and actual numbers of passes were probably greater than they appear, especially near sunrise.

To quantify meteorological conditions associated with bat activity at Perdekraal, the mean (average), standard deviation (SD), minimum and maximum values of wind speed (measured at 15.6m above ground level in m/s), air temperature (measured at 5m in °C), relative humidity (%) and atmospheric pressure (measured at 3m in mbar) were calculated using values of these variables measured on site and supplied by Mainstream, for all 10 minute intervals during the 12-month monitoring period when at least one pass of any or each Species Group was detected by a microphone near ground level (10m) and/or in rotor sweep height (60m). Weather conditions associated with the bulk of recorded bat activity at

Perdekraal, were quantified by the addition of one SD to the mean value of each weather variable measured for all bats or each Species Group, near ground level and/or in rotor sweep height.

To determine the influence of moon light on bat activity, an online lunar calendar of the South African Astronomical Observatory (http://www.saao.ac.za/) was used to determine the number of days since full moon on specific dates. Days since full moon were assigned to one of eight lunar phases, ranked from 0-4 depending on the amount of moonlight, where:

- 0 = New Moon
- 1 = Waxing / Waning Moon
- 2 = First / Third Quarter
- 3 = Waxing / Waning Moon
- 4 = Full Moon

For each of these moon phases the activity of each Species Group was calculated as the average number of passes per hour in rotor sweep height (at 60m on PK3b) or near ground level (at 10m on PK1, PK2, PK3a, PK3b, PK4 and PK5).

7.8. Impact & Risk Assessment

Both an overall impact assessment for construction and operation of the proposed Perdekraal WEFs, and a turbine-specific bat fatality risk assessment were completed.

7.8.1. Impact Assessment

Potential impacts of the proposed Perdekraal WEFs were evaluated in terms of bat roosting, foraging and migration.

- Roosting impacts:
    - roosting habitat destruction or disturbance.
    - attraction of bats to towers for roosting and due to curiosity and therefore fatalities due to collision or barotrauma.
- Foraging impacts:
    - displacement from foraging habitat due to wind turbine operation.
    - bat fatalities due to collision or barotrauma during foraging activity.
- Migration impacts:
    - bat fatalities due to collision or barotrauma during long distance seasonal migrations.

A standard Impact Assessment Methodology was used, which involved ranking different impact parameters as per **Table 7-2,** and calculating a Significance value for the impact as (Extent + Duration + Intensity) x Probability. This calculated value was then used to classify the Significance of the impact as Low, Medium or High as per **Table 7-3**. In addition to this, cumulative impacts were assessed using the criteria outlined in **Table 7-4**.

Table 7-2 Impact ranking matrix

PARAMETER	RANKING				
	0	1	2	3	4
EXTENT	None	Localised	Study Area	Regional / National	International
DURATION	None	Short- term	Medium-term	Long-term	Permanent
INTENSITY	None	Low	Medium	High	Very High
PROBABILITY	None	Improbable	Probable	Highly Probable	Definite

Table 7-3 Classification of significance

NATURE OF IMPACT	SIGNIFICANCE		
	Low	**Medium**	**High**
Negative	Impact will not have an influence on the decision or require to be significantly accommodated in the project design	Impact could have an influence on the environment which will require modification of the project design and/ or alternative mitigation	Impact could have a 'no-go' implication for the project unless mitigation and/ or re-design is practically achievable.
	1 - 16	**17 - 32**	**33 - 48**

Table 7-4 Cumulative impacts

CUMULATIVE IMPACTS	
Additive	*"where it adds to the impact which is caused by other similar impacts"*
Countervailing Interactive	impacts that combine to form a new kind of impact: "*the net adverse cumulative impact is less than the sum of the individual impacts"*
Synergistic Interactive	impacts that combine to form a new kind of impact: "*the net adverse cumulative impact is greater than the sum of the individual impacts"*

7.8.2. Bat Fatality Risk Assessment

For each proposed turbine location the:

- Importance/sensitivity of habitat *for bats*;
- Distance to the nearest wetland, dam or stream;
- Distance to the nearest building roost;
- Distance to the nearest cave roost;
- Distance to the nearest other proposed turbine;
- Fatality risk of bats at the nearest microphone near ground level; and
- Fatality risk of bats at the nearest microphone in rotor sweep height;

was determined and scored as described in **Table 7-5**, and used to obtain an overall score to rate the fatality risk of bats as described in **Table 7-6**. The scoring of parameters was based on the best information that was available from results of the 12-month monitoring study, published information and/or discussions with bat specialists.

Table 7-5 Bat fatality risk parameters

PARAMETER		SCORE					
No.	DESCRIPTION	0	1	2	3	4	5
1	Importance/Sensitivity of habitat *for bats* (based on results of the 12-month monitoring study) wherein a turbine would be situated	-	Low importance/ sensitivity	-	Medium importance/ sensitivity	Medium-High importance/ sensitivity	High importance/ sensitivity
2	Distance (m) of a turbine to the nearest wetland, dam or stream (measured in Google Earth/ArcGIS)	>500	350-500	200-350	100-200	50-100	≤50
3	Distance (m) of a turbine to the nearest building roost (measured in Google Earth/ArcGIS)	>1000	800-1000	700-800	600-700	500-600	≤500
4	Distance (km) of a turbine to the nearest cave roost (measured in Google Earth/ArcGIS)	>100	80-100	60-80	40-60	30-40	≤30
5	Distance (m) of a turbine to the nearest other turbine (measured in Google Earth/ArcGIS)	>750	700-750	650-700	600-650	360-600	≤360
6	Fatality risk of bats at the nearest microphone, near ground level and in rotor sweep height, and calculated for each microphone as the average score of parameters 5.1-5.5.	-	Negligible risk	Low risk	Medium risk	High risk	Very high risk
6.1	Importance/Sensitivity of habitat wherein a microphone was situated, as revealed by the 12-month study	-	Low importance/ sensitivity	-	Medium importance/ sensitivity	-	High importance/ sensitivity
6.2	Status of the most Conservation Important bat species detected by a microphone during the 12-month study.	-	LC	NT	VU	EN	CR
6.3	Relative size of peaks in bat activity at a microphone during times of the year when bats may migrate	No activity	Low activity during relevant times of year	-	Medium activity during relevant times of year	High activity during relevant times of year	Very high activity during relevant times of year
6.4	Mean (average) wind speed (m/s) when bat activity was recorded at a microphone during the 12-month study	≤4m/s	4-5m/s	5-6m/s	6-7m/s	7-8m/s	>8m/s
6.5	Portion (%) of the 12-month study when monitoring at a microphone occurred successfully	>80%	70-80%	60-70%	50-60%	40-50%	≤40%

Table 7-6 **Risk ratings and mitigation**

SCORE	BAT FATALITY RISK	RISK DESCRIPTION & MITIGATION
5	Very high	Impacts on bats would be devastating. Turbines with this rating must not be constructed.
4	High	Impacts on bats would definitely occur and high fatality rates are expected. Turbines with this rating should not be constructed.
3	Medium	Impacts on bats would definitely occur and medium fatality rates are expected. Recommended mitigation measures should be implemented, and post-construction monitoring must be performed to quantify fatality rates and adjust mitigation measures.
2	Low	Impacts on bats could occur and few fatalities are expected. Recommended mitigation measures should be implemented, at least where and when bat activity is highest (e.g. near water or during migrations). Post-construction monitoring should be performed to quantify fatality rates and adjust mitigation measures.
1	Negligible	Impacts on bats would be negligible and very few fatalities are expected. Post-construction monitoring should be performed to quantify fatality rates and adjust mitigation measures.

7.9. Approach to Mitigation

The approach taken in this study for devising appropriate mitigation recommendations was based on results from the 12-month pre-construction bat monitoring study, international literature, and discussions with bat specialists. The most in-depth discussions were held during the first “Bats and Wind Energy Mitigation Workshop,” which was convened on 1 October 2012 in Johannesburg by NSS. The objectives of this workshop were to assess how bat monitoring has proceeded since implementation of the 2011 Best Practice Guidelines, to refine certain methodologies in the Guidelines, and to discuss certain approaches to mitigation. In this regard please refer to **Table 7-6** and the Minutes of the Workshop, which are included in **Appendix 13.4.** at the end of this report.

Results from the 12-month pre-construction bat monitoring study were used to determine a **RECOMMENDED CUT-IN WIND SPEED** for curtailment of **TURBINES IN IMPORTANT BAT HABITAT** during **PEAK BAT ACTIVITY PERIODS**.

The **RECOMMENDED CUT-IN WIND SPEED** was calculated by the addition of 1 standard deviation (SD) to the mean value of wind speeds associated with all records of bat activity specifically in rotor sweep height. Assuming that this data were Normally distributed, the recommended cut-in wind speed should theoretically curtail turbine operation during wind speeds associated with 50-84% of the pre-construction bat activity in rotor sweep height (http://en.wikipedia.org/wiki/Standard_deviation).

Curtailment is when a turbine is only allowed to rotate once the wind exceeds a specific speed. The theory behind curtailment is based on the negative correlation between bat activity and wind speed i.e., that bat activity decreases as wind speed increases. Rydell *et al*. (2010), for example, found that 90% of bat fatalities at wind farms in north-western Europe occurred during nights with low wind speeds. Conversely, Arnett (2005) reported nights of high wind speeds to be associated with extremely low observed bat fatalities, regardless of the level of other measured variables.

Baerwald *et al*. (2008) reported a 60% reduction in bat fatalities when the cut-in speed of 15 turbines was increased to 5.5m/s during periods of peak bat activity at a site in south-western Alberta, Canada. Another strategy used in the same study involved altering blade angles to reduce rotor speed, meaning the blades were near motionless in low wind speeds which resulted in a 57.5% reduction in bat fatalities. Similarly, Arnett *et al*. (2010) reported reductions in nightly average bat fatalities ranging from 44–93%, with marginal annual power loss, when the cut-in speed of turbines was increased to 5.0m/s at a site Pennsylvania, USA.

TURBINES IN IMPORTANT BAT HABITAT were identified from analysis of the pre-construction bat activity data in relation to monitoring location, habitat type, the resulting Habitat Sensitivity Map (including recommended No-Go areas), and the turbine-specific risk assessment. **PEAK BAT ACTIVITY PERIODS** (i.e. selected hours of the night on specific nights in the year) were identified from analysis of the pre-construction bat activity data in relation to time of year, moon phase and hours of the night.

Most importantly, NSS recommends a 12-month post-construction bat monitoring study to inform an adaptive mitigation management plan involving successive phases. During each phase, results from the post-construction monitoring should be used to modify (decrease or increase) the cut-in speed and hours of curtailment of selected turbines to minimize bat impacts and maximize energy production. Turbine shut-down would only be recommended where exceptionally high levels of unexpected and unpredictable bat mortality are recorded throughout most of the year.

7.10. Study Limitations

The following problems were experienced during this study:

- No bat monitoring was performed in rotor sweep height between 30 January and 26 July 2012 (for six months) due to the absence of a climbable met. mast on site.
- Regrettably, between 14 May and 3 June 2012 (for 3 weeks) the SM2 detector at PK1, PK2, PK3a and PK4 was inadvertently switched off after data were downloaded.
- Due to the harsh climate at Perdekraal, there was unexpected, premature failure of the 12V battery at PK1 in December 2012, at PK2 in April 2012 and in January 2013, and at both PK3a and PK5 in June 2012. Since the nightly recording duration of an SM2 detector decreased with progressive loss of battery life, bat activity at affected monitoring stations would have been ***slightly under-estimated***.
- Microphones stopped working or were damaged by birds at PK3a (in May 2012), at PK4 (in May and in August 2012) and at PK5 (in January 2013).

Gaps in the passive recording of bat activity at different localities and heights at Perdekraal are depicted in **Figure 7-8**. Despite these gaps, the bat monitoring at Perdekraal far exceeded the 15-25% seasonal coverage recommended by Sowler & Stoffberg (2012).

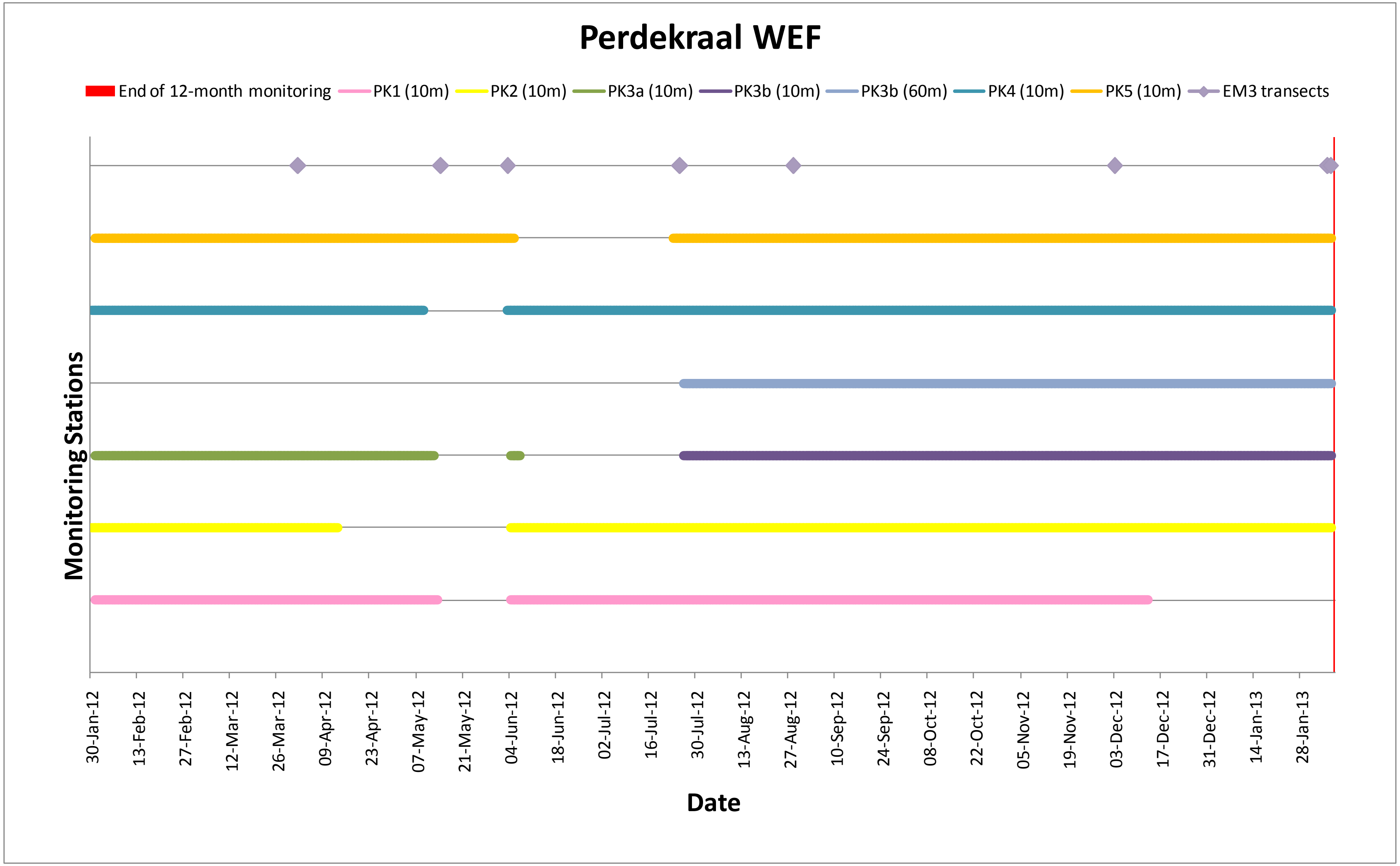


Figure 7-8 **Recording periods (coloured bars) at each bat monitoring locality and height**

8. Results

8.1. Potentially Occurring Bat Species

Eleven bat species that potentially occur at Perdekraal, according to the known and predicted distributions of bat species published in Monadjem *et al*. (2010), are listed in **Table 8-1**, together with their current national and global (IUCN) conservation status. The listed species differ in their Likelihood of Occurrence (LoO) at Perdekraal depending on their habitat requirements and other factors, such as roost limitations. Conservation Important (CI) bat species that potentially occur at Perdekraal include the globally Vulnerable (VU) and nationally Near Threatened (NT) Lesueur's Hairy Bat (*Cistugo lesueuri*), the nationally VU and globally NT Angolan Hairy Bat (*C. seabrae*), the globally and nationally NT Natal Long-fingered Bat (*Miniopterus natalensis*) and Cape Horseshoe Bat (*Rhinolophus capensis*), and the nationally NT Geoffroy's Horseshoe Bat (*R. clivosus*) and Temminck's Myotis (*Myotis tricolor*).

8.2. Regionally Important Bat Roosts

The locations of some well-known caves and regionally important bat roosts relative to Perdekraal are shown in **Figure 8-1**. Of these, Montagu Cave is the closest to (approximately 80km south of) Perdekraal. More importantly perhaps, are the hundreds of rocky overhangs and caves in e.g., the Cederberg and Witberg mountains (roughly 30km west and south-east of Perdekraal, respectively). Other well-known bat caves in the Western Cape include those at De Hoop, Elands Bay, and the Cango Caves. Unfortunately, the movement of bats between these caves and Perdekraal is difficult to determine without marking and tracking individual bats.

Table 8-1 Potentially occurring bat species at Perdekraal

SPECIES GROUP	FAMILY	SPECIES	COMMON NAME	LoO	SA RED LIST STATUS	IUCN STATUS
A	MOLOSSIDAE	*Tadarida aegyptiaca*	Egyptian Free-tailed Bat	High	LC	LC
B	VESPERTILIONIDAE	*Neoromicia capensis*	Cape Serotine Bat	High	LC	LC
C	MINIOPTERIDAE	*Miniopterus natalensis*	Natal Long-fingered Bat	Medium	**NT**	**NT**
A	MOLOSSIDAE	*Sauromys petrophilus*	Robert's Flat-headed Bat	Medium	LC	LC
E	NYCTERIDAE	*Nycteris thebaica*	Egyptian Slit-faced Bat	Medium	LC	LC
B	VESPERTILIONIDAE	*Cistugo seabrae*	Angolan Hairy Bat	Medium	**VU**	**NT**
B	VESPERTILIONIDAE	*Eptesicus hottentotus*	Long-tailed Serotine Bat	Medium	LC	LC
D	RHINOLOPHIDAE	*Rhinolophus capensis*	Cape Horseshoe Bat	Low	**NT**	**NT**
D	RHINOLOPHIDAE	*Rhinolophus clivosus*	Geoffroy's Horseshoe Bat	Low	**NT**	LC
C	VESPERTILIONIDAE	*Cistugo lesueuri*	Lesueur's Hairy Bat	Low	**NT**	**VU**
C	VESPERTILIONIDAE	*Myotis tricolor*	Temminck's Myotis	Low	**NT**	LC

Conservation status: LC = Least Concern; NT = Near Threatened; VU = Vulnerable

Sources: Monadjem *et al*. (2010); IUCN (2012)

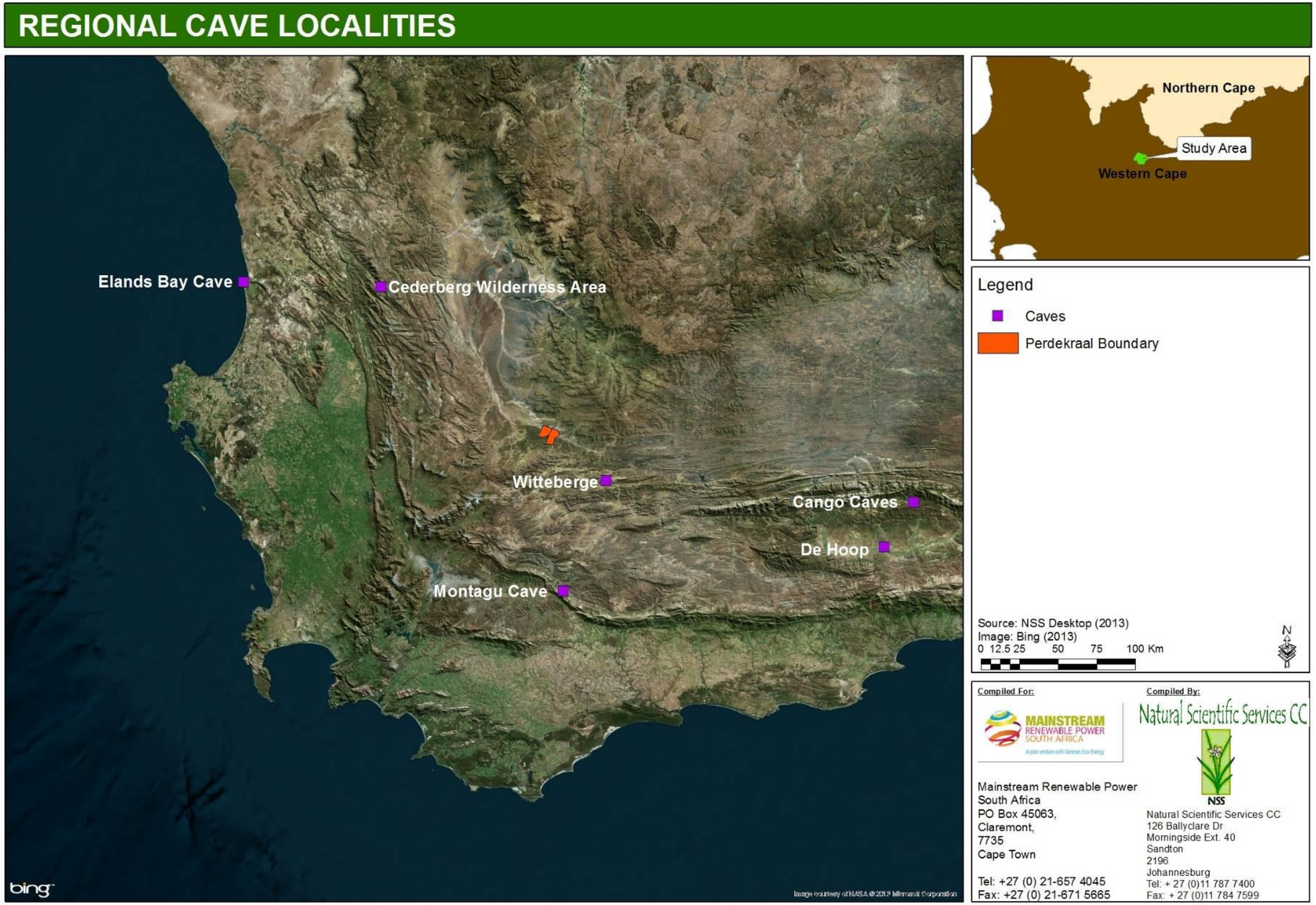


Figure 8-1 **Location of regionally important bat roosts relative to Perdekraal**

8.3. Bats on Site

During the 12-month monitoring study at Perdekraal, three bat species from three Species Groups were identified, which included the Egyptian Free-tailed Bat (*Tadarida aegyptiaca*) in Species Group A, the Cape Serotine Bat (*Neoromicia capensis*) in Species Group B, and the Natal Long-fingered Bat (*Miniopterus natalensis*) in Species Group C.

Habitat that is used by the above-mentioned bat species is described in **Table 8-2**. *T. aegyptiaca* in Species Group A is at a **High** risk, and the Species Group B and C bats are at a **Medium to High** risk of fatality from turbines (**Table 7-1**). Furthermore, *Miniopterus natalensis* in Species Group C is globally and nationally **Near Threatened** (**Table 8-1**).

The percentage of all bat passes recorded by the passive monitoring stations at Perdekraal, which belonged to each Species Group, is shown in **Figure 8-2**. Evidently, the majority of all calls were made by bats in Species Group A. Less than 20% of recorded calls were made by Species Group B and C bats. No calls of bats in Species Group D were recorded. Species Group E was not represented because the low-intensity echolocation calls of the "whispering" *N. thebaica* are seldom passively recorded with bat detectors.

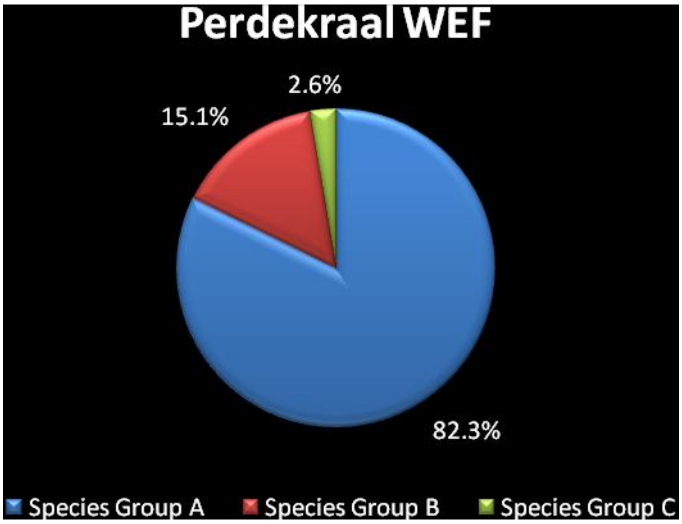


Figure 8-2 Percentage of passes from different bat Species Groups for all stations

Table 8-2 Recorded bat species at Perdekraal

SPECIES GROUP	FAMILY	SPECIES	COMMON NAME	HABITAT	METHOD OF CONFIRMATION
A	MOLOSSIDAE	*Tadarida aegyptiaca*	Egyptian Free-tailed Bat	Forages over desert, semi-arid scrub, savanna, grassland and agricultural land. Avoids forests	Calls recorded
B	VESPERTILIONIDAE	*Neoromicia capensis*	Cape Serotine Bat	Arid semi-desert to montane grassland, forests and savanna. Less abundant in low-lying hot savannas	Calls recorded, & specimens were observed roosting & flying
C	MINIOPTERIDAE	*Miniopterus natalensis*	Natal Long-fingered Bat	Temperate or subtropical species; savannas and grasslands; cave-dependent	Calls recorded

8.4. Bat Groups & Species at Different Localities & Heights

No bats were observed, and limited potential evidence of bats (in the form of a few droppings) was found during a roost survey in the mountains in the southern-most corner of Perdekraal (**Figure 7-1**). A few Cape Serotine Bats (*N. capensis*) were observed roosting in the roof of a house in the north-central region of the site (**Figure 7-1**), but the entrance to this roost was eventually sealed by someone. When mist-netting was performed in the Groot seasonal drainage line in the northern region of Perdekraal (**Figure 7-3**), several bats were seen flying overhead, but none were caught probably because moonlight made the net visible to the bats. Additional suitable locations for mist-netting or roost surveys were limited at Perdekraal.

During driven transects through Perdekraal, the EM3 detected calls that belonged almost exclusively to Species Group A bats, with the exception of two recorded passes by Species Group B bats (**Figure 8-4**). Although the combined EM3 data suggest that there was greater activity or a greater abundance of (Species Group A) bats in the northern region of Perdekraal, weather conditions strongly influenced the number of bat calls recorded during different transects.

Figure 8-3 indicates that Species Group A bats contributed approximately 70-100% of the bat calls recorded at each passive monitoring location and height. Within rotor sweep height (i.e. at 60m on PK3b) Species Group A bats contributed 99.8% of the recorded bat calls, whereas near ground level (i.e. at 10m on PK1, PK2, PK3a, PK3b, PK4 and PK5) Species Group A, B and C bats, respectively, contributed 68-89%, 8-29% and 1-24% of the recorded calls. Species Group C bats made an exceptionally large (24%) contribution to overall bat activity at PK3a. Potentially occurring Species Group D and E bats e.g., Geoffroy's Horseshoe Bat (*Rhinolophus clivosus*) and Egyptian Slit-faced Bat (*Nycteris thebaica*), were not recorded possibly because these bats produce high frequency calls that attenuate rapidly.

The apparent predominance of aerial-foraging Species Group A bats at Perdekraal was likely due to the limited availability of suitable habitat for the clutter-edge and clutter foraging Species Group B, C, D and E bats in the mostly barren Karoo landscape. Indeed, the smallest and largest respective contributions by Species Group A and C bats was at PK3a, where large bushes and trees were growing in the vicinity of the Groot seasonal drainage line.

Potentially occurring conservation important bat species that were not recorded at Perdekraal included the globally VU and nationally NT Lesueur's Hairy Bat (*Cistugo lesueuri*), the nationally VU and globally NT Angolan Hairy Bat (*C. seabrae*), the globally and nationally NT Cape Horseshoe Bat (*R. capensis*), and the nationally NT Geoffroy's Horseshoe Bat (*R. clivosus*) and Temminck's Myotis (*Myotis tricolor*). These species were not detected at Perdekraal because they are rare, less likely to be detected and/or may be absent for the study area. Efforts to detect these species should continue during post-construction monitoring for the proposed Perdekraal WEFs.

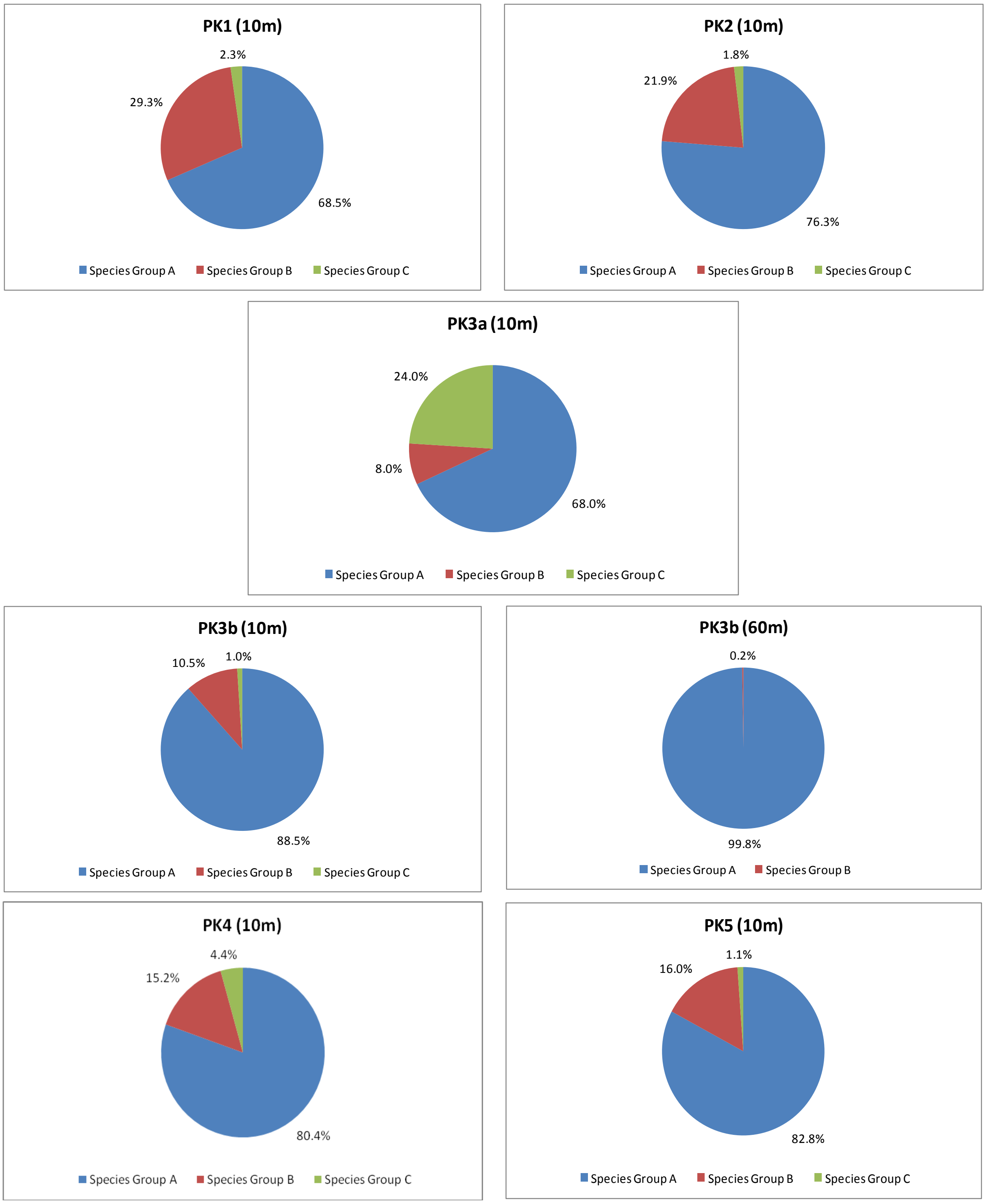


Figure 8-3 Percentage of passes from different bat Species Groups recorded at each monitoring station and height

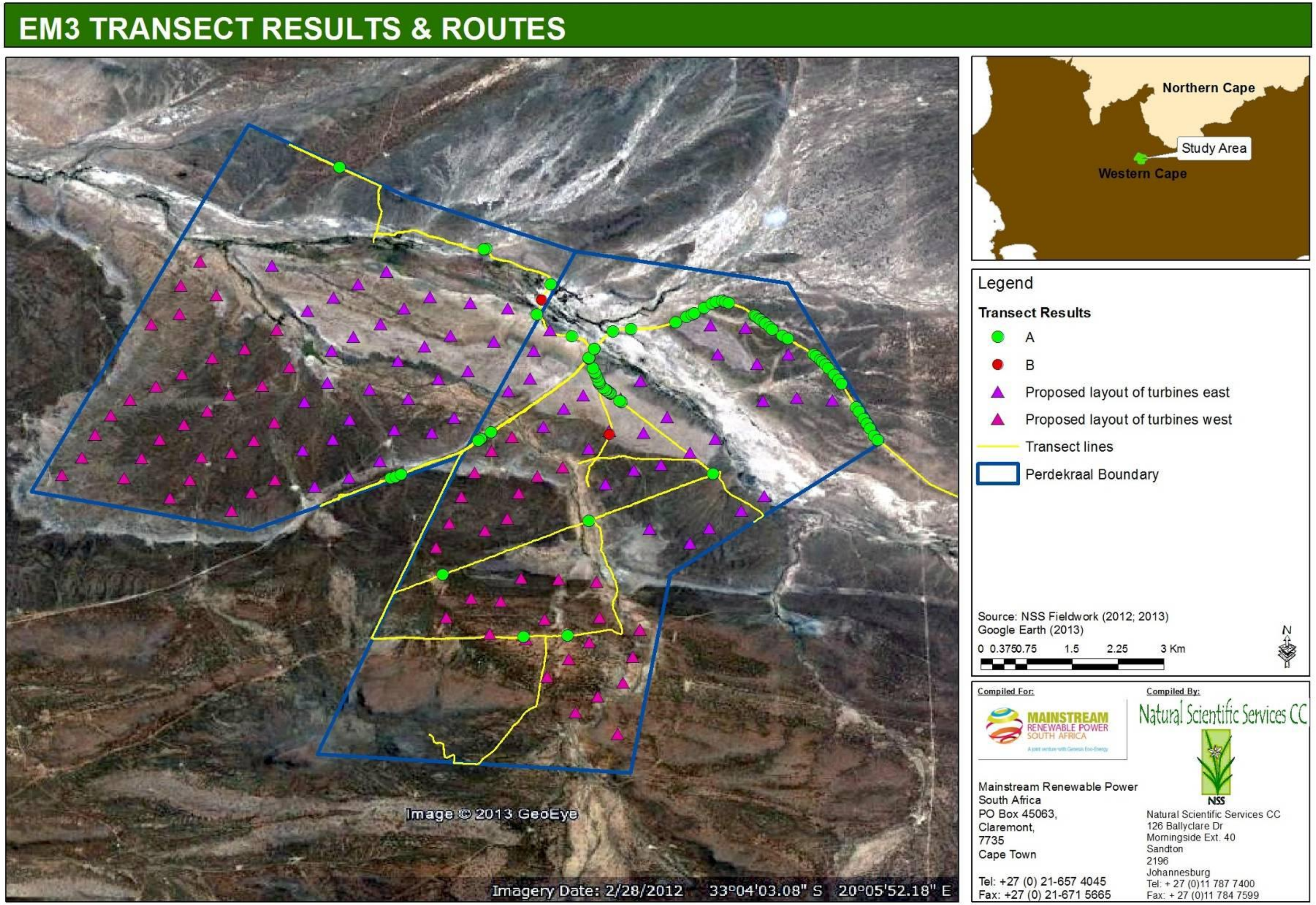


Figure 8-4 Localities of calls by different bat Species Groups recorded during EM3 transect surveys

8.5. Bat Activity at Different Localities & Heights

Figure 8-5 indicates that the lowest average hourly number of (0.06) bat passes was recorded at PK3a, and the highest average hourly number of (0.89) bat passes was recorded at PK4. At PK3b there was, on average, 20% less bat activity (or 0.07 fewer passes per hour) at the 60m microphone compared to the 10m microphone. Overall, 0.36 hourly bat passes were recorded, on average, per microphone at Perdekraal, and the nightly recording duration of an SM2 bat detector was 5.95 hours ± 1.00 hour (range: 4.11-7.18 hours, *n* = 6 SM2 detectors). The nightly recording duration of the Perdekraal SM2 detectors was therefore, on average, approximately half the duration of a 12 hour night.

If each value in **Figure 8-5** is multiplied by 6 hours, the average number of bat passes per microphone for an average recording night is obtained - which represents an under-estimate of bat activity. If each value in **Figure 8-5** is multiplied by 12 hours, the average number of bat passes per microphone for a 12-hour night is obtained - which represents an over-estimate of bat activity. **Therefore, the actual number of bat passes per microphone per night ranged between a minimum of 0.3 at PK3a and a maximum of 11 at PK4.**

Figure 8-6 indicates that differences in the average hourly number of bat passes recorded between the different monitoring locations and heights were mainly due to differences in the recorded activity of Species Group A, and to a smaller extent, Species Group B bats. The highest average hourly number of passes for Species Group A, B and C bats was recorded at PK4. At PK3a the lowest average hourly number of Species Group A passes, and the second-highest average hourly number of Species Group C passes, was recorded. No Species Group C passes were recorded by the 60m microphone at PK3b.

Figure 8-7 indicates that a greater average hourly number of Species Group A, B and C bat passes was recorded at monitoring stations (PK3b, PK4 and PK5) situated in Tanqua Karoo vegetation in the southern region of Perdekraal, compared to those stations (PK1, PK2 and PK3a) situated in/near Tanqua Wash Riviere vegetation in the northern region of Perdekraal. These differences were likely at least partly due to:

- the greater proximity of PK1, PK2 and especially PK3a (vs PK3b, PK4 and PK5), to large bushes and trees in the vicinity of the Groot seasonal drainage line in the northern region of Perdekraal, where habitat conditions were less favourable for the aerial-foraging Species Group A bats, and more favourable for the clutter-edge foraging Species Group B and C bats.
- the greater proximity of PK3b, PK5 and especially PK4 (vs PK1, PK2 and PK3a), to mountains in the southern region of Perdekraal, where habitat conditions were potentially suitable for roosting by Species Group A, B and C bats.

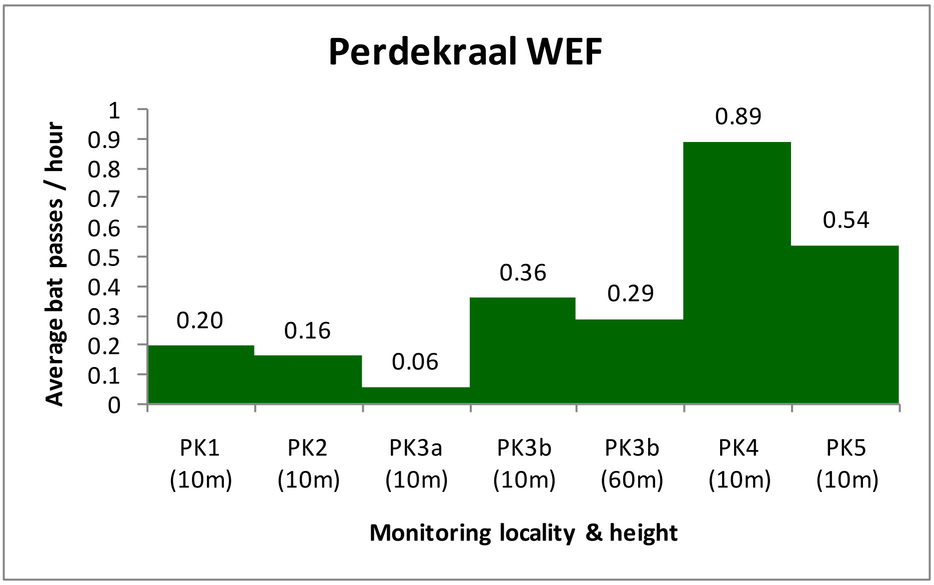


Figure 8-5 Activity of bats at each monitoring locality and height. Extrapolation of this activity data over 6-12 hours indicates that the number of bat passes per night per microphone ranged between a minimum of 0.3 at PK3a and a maximum of 11 at PK4 (refer to Section 8.5).

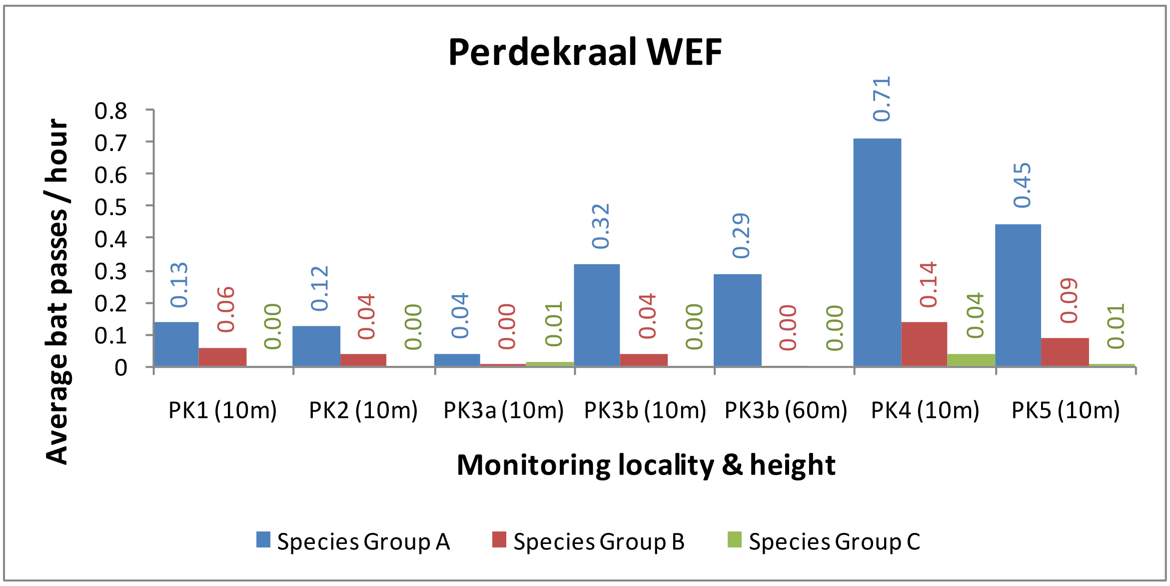


Figure 8-6 Activity of each Species Group at each monitoring locality and height

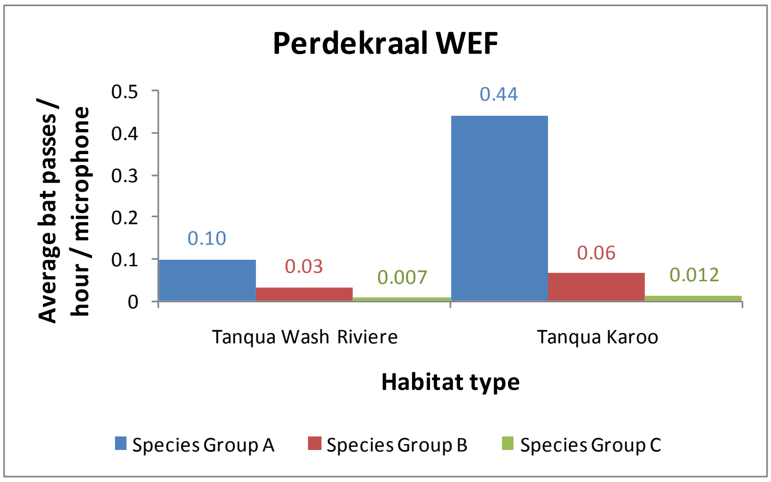


Figure 8-7 Activity of each Species Group between habitat types

8.6. Seasonal Variation in Bat Activity

Figure 8-8 indicates that at Perdekraal, there was bat activity throughout most of the 12-month monitoring period. The lowest numbers of bat passes / hour / microphone were recorded in February, March and August. During May, June and July there were brief, intermittent peaks of activity. Between the start of September and the end of January there was a protracted increase in bat activity, and the highest numbers of bat passes / hour / microphone were recorded during mid- and late-December.

Figure 8-9 shows that the seasonal variation in bat activity at Perdekraal as depicted in **Figure 8-8** was mainly attributable to seasonal variation in the activity of Species Group A, represented by the Egyptian Free-tailed Bat (*Tadarida aegyptiaca*). Evidently these bats were most active during the warmer spring and summer months. The pronounced peak in activity of these bats during December (which was consistent across the various monitoring locations) was likely due to increased foraging by females, which give birth and require extra energy for lactation at this time of year (Bernard & Tsita, 1995; Le Grange *et al.*, 2011). However, the possibility of migration should not be ruled out considering, for example, that at PK4 and PK5, respectively, >60 and >180 passes were recorded in a night.

Figure 8-10 indicates that at Perdekraal, Species Group B also exhibited activity least often in February, March and August, and most frequently during the warm spring and summer months. The highest numbers of Species Group B bat passes / hour / microphone were recorded, however, on isolated dates in May, June and July. Species Group B was represented by the Cape Serotine Bat (*Neoromicia capensis*). The protracted activity of this species at Perdekraal during spring and summer may in part reflect increased foraging by females, which give birth and require extra energy for lactation at this time of year (Monadjem *et al*,. 2010). High peaks of activity during autumn and winter (which were not consistent across the various monitoring localities) were possibly due to isolated episodes of foraging by this species in response to sporadic increases in insect availability perhaps following rainfall.

Figure 8-11 shows that at Perdekraal, Species Group C was active for brief periods during autumn, winter and spring (i.e. between March and November). The lowest numbers of Species Group C passes / hour / microphone were recorded in December, January and February, and the highest numbers of passes / hour / microphone were recorded on isolated dates in May, July and August/September. Species Group C was represented by the Near Threatened and migratory Natal Long-fingered Bat (*Miniopterus natalensis*). The late August/early September peak in activity of this species (which was consistent across the various monitoring locations) was potentially due to migration of adults to spring roosts, where females give birth during October-December (Rodrigues & Palmeirim, 2007). On 30 August, for example, 14 Species Group C passes were recorded at PK4. Continued and more detailed monitoring would be required to confirm this.

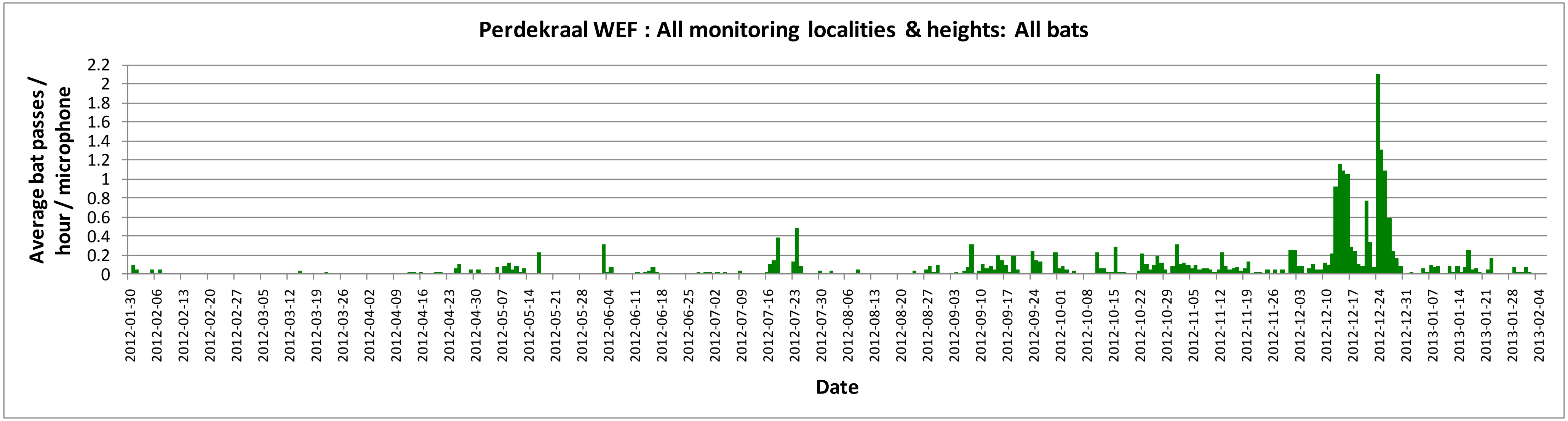


Figure 8-8 Seasonal variation in bat activity at Perdekraal during the 12-month monitoring period.

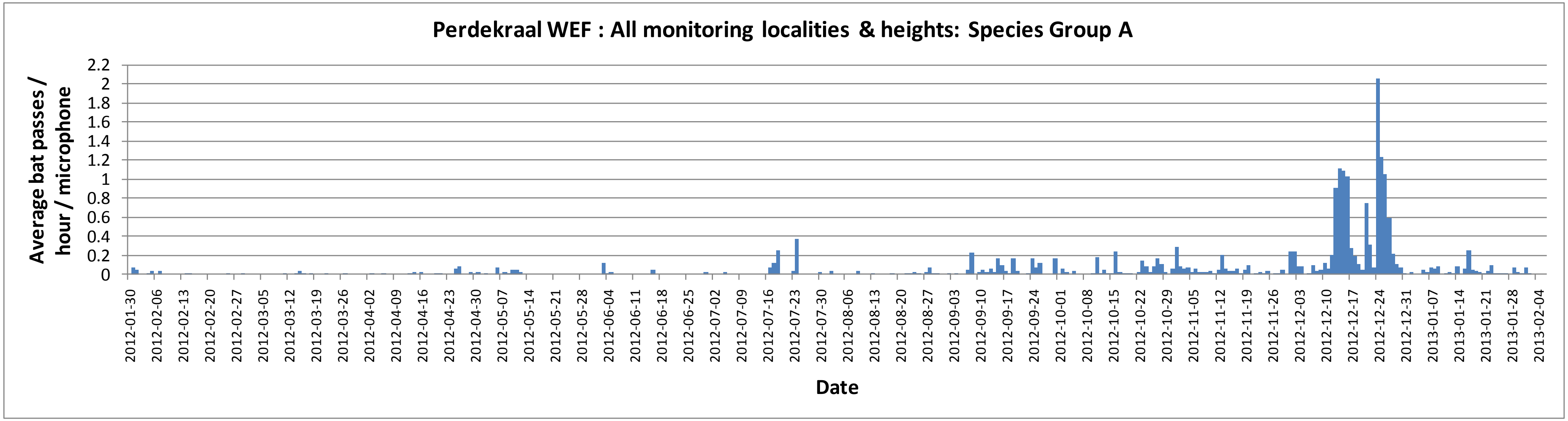


Figure 8-9 Seasonal variation in the activity of Species Group A at Perdekraal during the 12-month monitoring period.

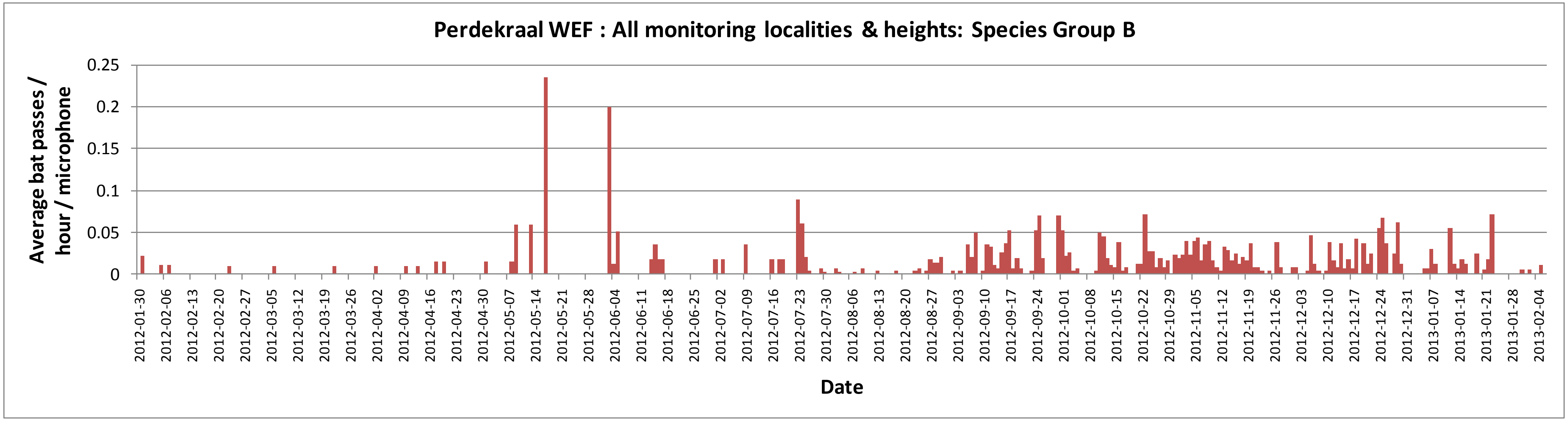


Figure 8-10 Seasonal variation in the activity of Species Group B at Perdekraal during the 12-month monitoring period.

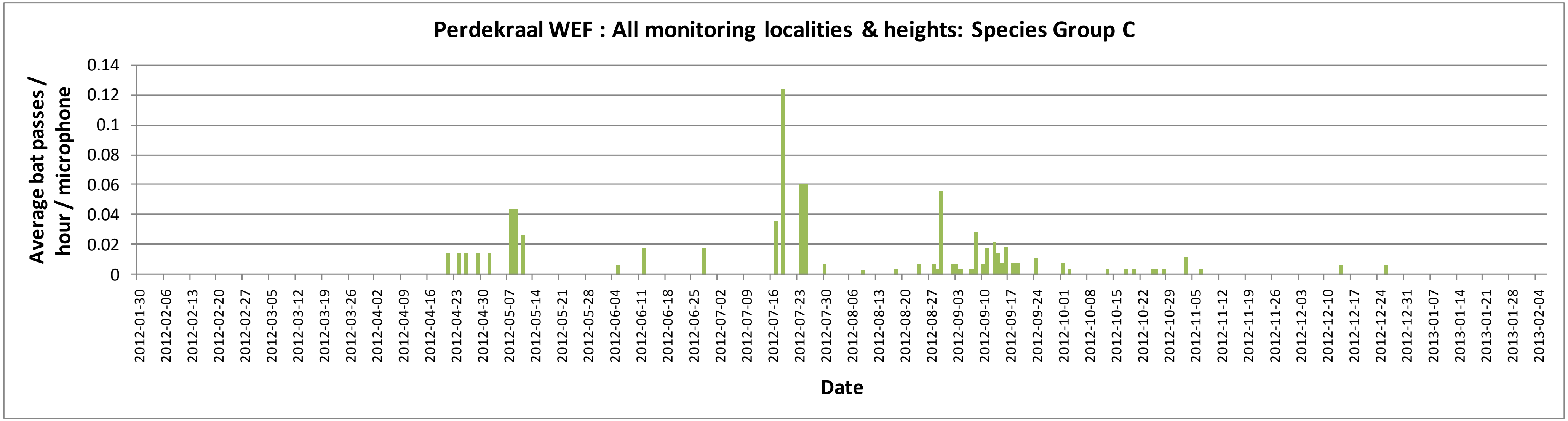


Figure 8-11 Seasonal variation in the activity of Species Group C at Perdekraal during the 12-month monitoring period.

8.7. Key Bat Activity Times

Figure 8-12 shows that bat passes were recorded throughout the night at Perdekraal, but a smaller proportion of passes were recorded after, as opposed to before, midnight.

Figure 8-13 indicates that the overall night time activity pattern of bats at Perdekraal was largely attributable to Species Group A, which showed a rapid peak in activity after sunset, followed by a gradual decline in activity until sunrise.

Figure 8-14 shows that Species Group B on the other hand, exhibited a bimodal pattern of night time activity. This comprised a large activity peak after sunset and a small but significant activity peak before sunrise, with an almost complete lack of activity between midnight and 02:00 am.

Figure 8-15 shows that Species Group C exhibited a similar night time activity pattern compared to Species Group A, but with a more rapid decrease in activity from approximately two hours after sunset.

Note that regular apparent dips in the activity of bats in **Figures 8-12** to **8-15** were due to gaps that were deliberately programmed into the recording schedule of the SM2 detectors, to prolong their battery life.

8.8. Bat Activity & Weather

Table 8-3, **Table 8-4**, **Table 8-5** and **Table 8-6,** respectively, provide for all bats, and Species Groups A, B and C, the mean (average), standard deviation, minimum and maximum values of wind speed (m/s), air temperature (°C), relative humidity (%) and atmospheric pressure (mbar) measured during every 10 minute interval in the 12-month monitoring period when at least one pass was recorded by a microphone near ground level, in rotor sweep height, in Tanqua Wash Riviere or in Tanqua Karoo vegetation (where n represents the number of records).

Assuming that the bat activity data from the passive monitoring were Normally distributed, the addition of 1SD to the mean value of a weather variable would include values of that weather variable that were associated with 50-84% of the recorded bat activity (refer to http://en.wikipedia.org/wiki/Standard_deviation).

For each weather variable in **Table 8-3**, the mean value plus one standard deviation (mean + 1SD) indicates that at Perdekraal, Species Group A, B and C bats were mostly active (n=1450 records) during:

- Wind speeds of ≤7.1m/s.
- Temperatures of ≤24.3°C.
- Relative humidity of ≤67.8%.
- Air pressures of 935.8mbar ± 3.5mbar (range: 928.0-949.0mbar)

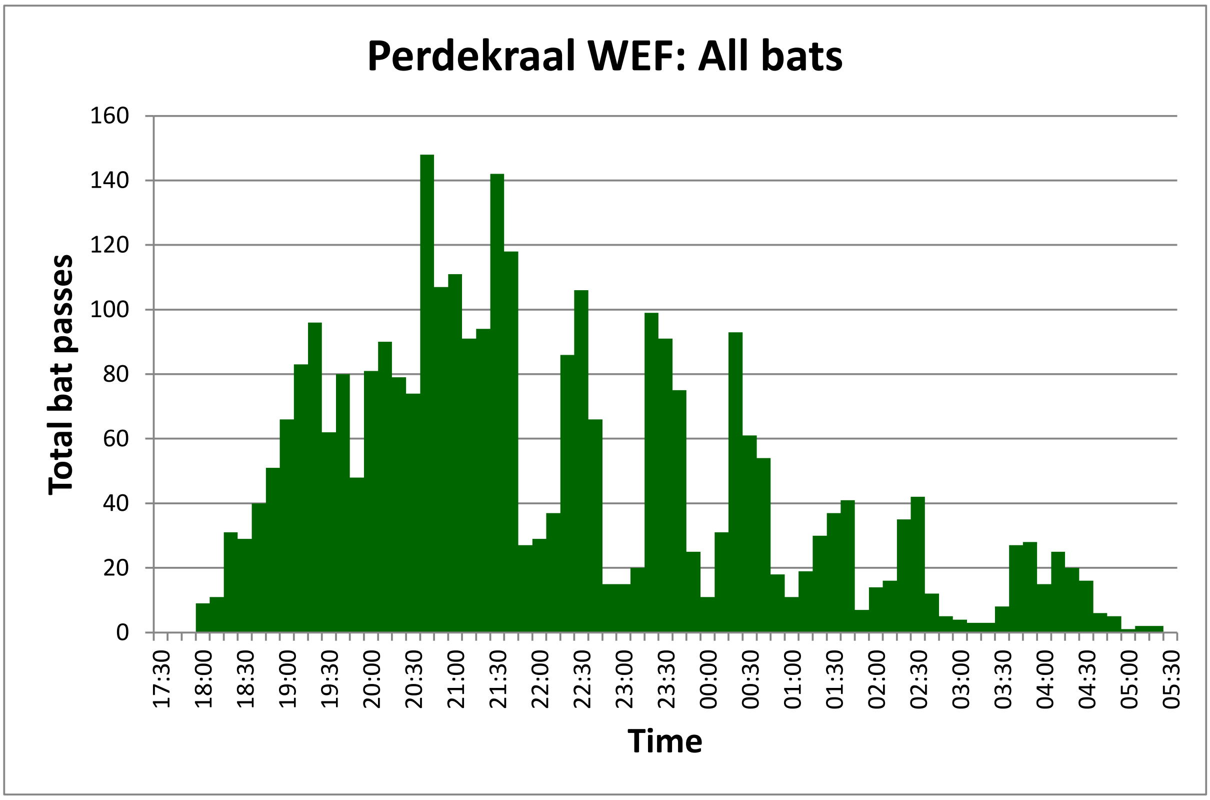


Figure 8-12 **Total passes of all Species Groups in each 10 minute interval of the night**

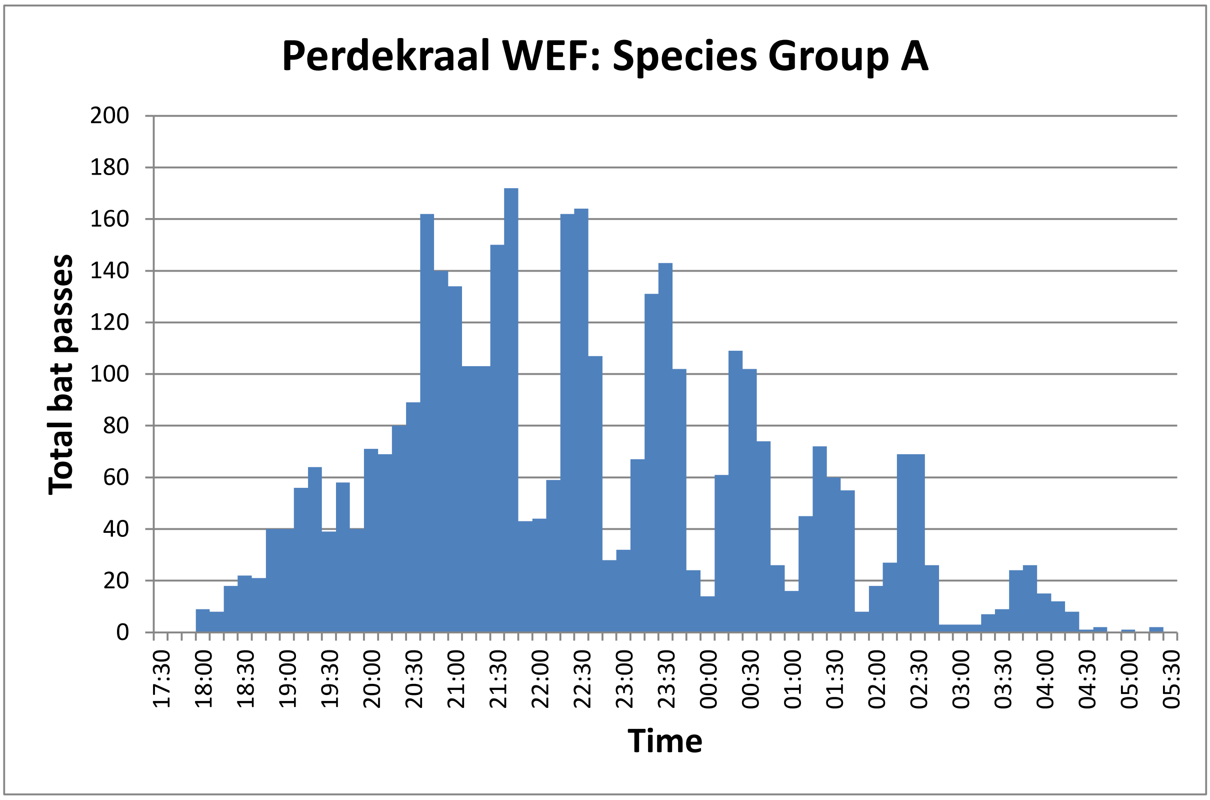


Figure 8-13 **Total passes of Species Group A in each 10 minute interval of the night**

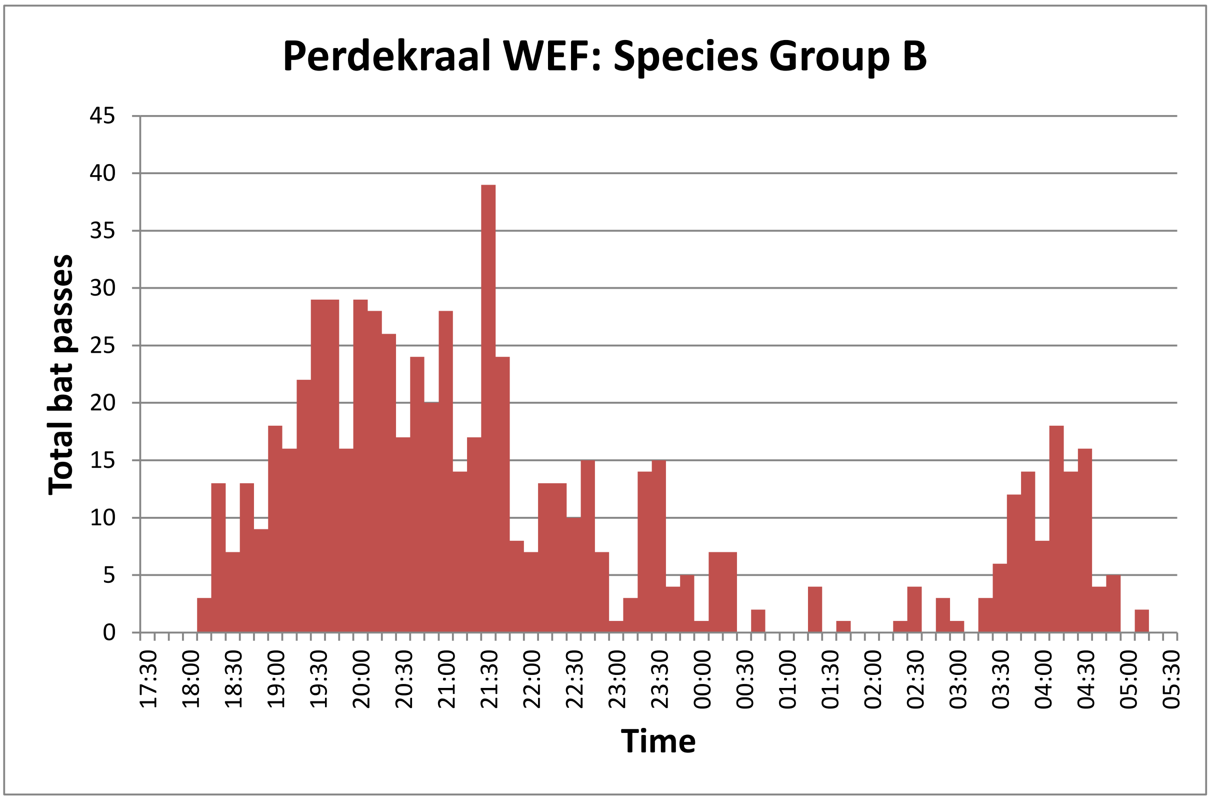


Figure 8-14 Total passes of Species Group Bin each 10 minute interval of the night

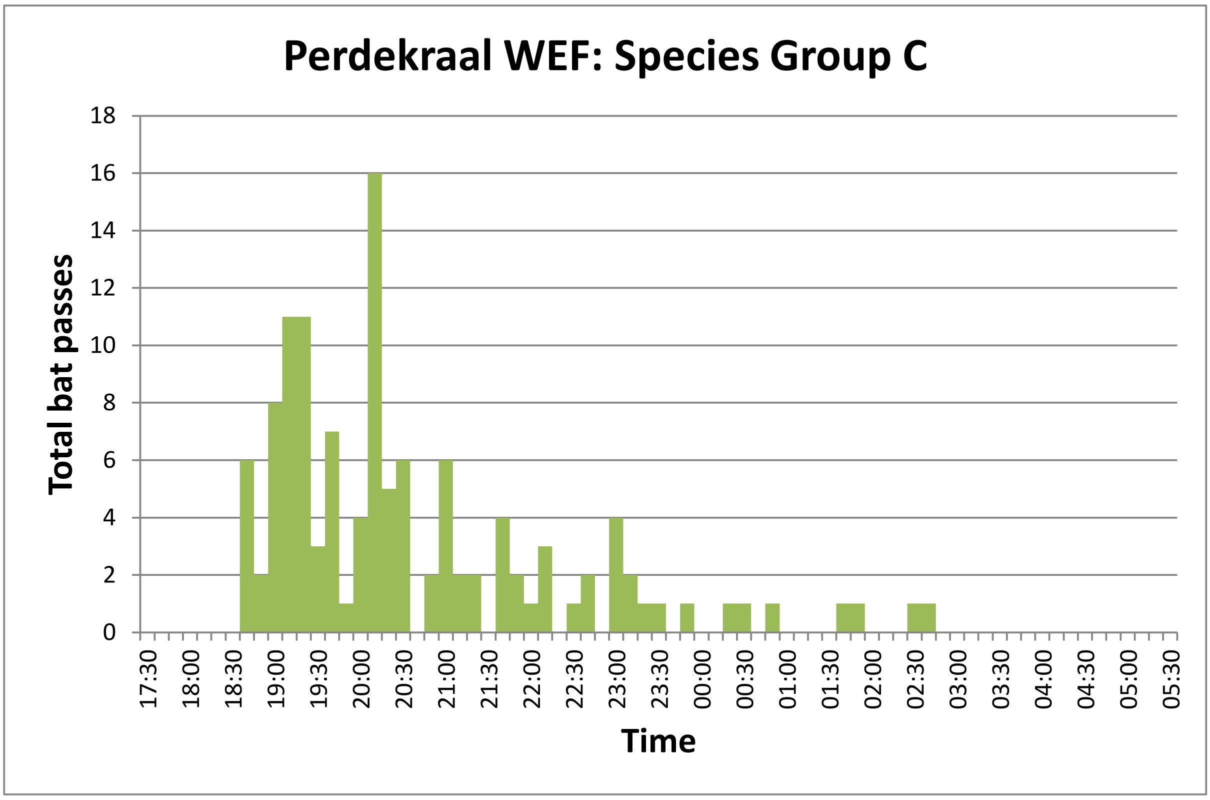


Figure 8-15 Total passes of Species Group C in each 10 minute interval of the night

Table 8-4 indicates that Species Group A bats were active (n=1548 records) during:

- Wind speeds of 4.9m/s ± 2.3m/s (range: 0.1-15.4m/s)
- Temperatures of 20.5°C ± 4.5°C (range: 7.0-33.0°C)
- Relative humidities of 51.6% ± 19.7% (range: 12.6-94.2%)
- Air pressures of 935.5mbar ± 3.2mbar (range: 928.0-948.0mbar)

Table 8-5 indicates that Species Group B bats were active (n=458 records) during:

- Wind speeds of 5.1m/s ± 2.1m/s (range: 0.3-11.1m/s)
- Temperatures of 19.4°C ± 4.9°C (range: 7.8-32.8°C)
- Relative humidities of 42.5% ± 17.1% (range: 12.7-92.9%)
- Air pressures of 936.5mbar ± 3.5mbar (range: 930.0-949.0mbar)

Table 8-6 indicates that Species Group C bats were active (n=84 records) during:

- Wind speeds of 4.3m/s ± 2.4m/s (range: 0.6-10.1m/s)
- Temperatures of 15.6°C ± 3.8C (range: 9.5-26.4°C)
- Relative humidities of 42.9% ± 17.4% (range: 7.4-86.0%)
- Air pressures of 938.0mbar ± 4.2mbar (range: 930.0-948.0mbar)

Weather conditions associated with the activity of Species Groups A, B and/or C did not differ substantially between the two main habitat types, although Species Group A and B bats were active during slightly less windy and warmer conditions over Tanqua Karoo, as opposed to Tanqua Wash Riviere vegetation. Conversely, Species Group C bats were active during slightly more windy and cooler conditions over Tanqua Karoo, as opposed to Tanqua Wash Riviere vegetation. This was possibly a consequence of differences between the Species Groups in their foraging behaviour, habitat preferences and times of year when each was most active.

Weather conditions associated with the activity of Species Groups A and B also did not differ substantially between the two monitoring heights, although slightly lower wind speeds were associated with the activity of each Species Group in rotor sweep height, as opposed to near ground level. This was because wind speed and other weather variables were measured between 3m and15.6m above ground level, and not at 60m in rotor sweep height.

Assuming that the bat activity data were Normally distributed, the addition of 1SD to the mean value of wind speeds measured at 15.6m during all 10-minute intervals when Species Group A passes were recorded near 60m on PK3b, suggests that the majority (between 50 and 84%) of those passes were recorded during wind speeds (at 15.6m) of ≤7.37m/s (http://en.wikipedia.org/wiki/Standard_deviation). Assuming neutral atmospheric conditions, a wind speed of 7.37m/s at 15.6m would be associated with a wind speed of approximately 8.94m/s at 60m (estimated using the Wind Profile Power Law; http://en.wikipedia.org/wiki/Wind_profile_power_law).

Table 8-3 Weather statistics for all bats

	WIND SPEED [M/S]	TEMPERATURE [°C]	RELATIVE HUMIDITY [%]	PRESSURE [MBAR]
All monitoring localities/habitat types & heights				
Mean	4.8	19.5	48.7	935.8
SD	2.3	4.8	19.1	3.5
Min	0.1	7.0	7.4	928.0
Max	15.4	33.0	94.2	949.0
n	1450.0	1450.0	1450.0	1450.0
Rotor sweep height (60m at PK3b)				
Mean	4.7	20.5	50.0	934.7
SD	2.6	4.9	17.9	2.8
Min	0.1	7.0	14.3	928.0
Max	15.4	31.9	89.2	944.0
n	198.0	198.0	198.0	198.0
Ground level (10m at PK1, PK2, PK3a, PK3b, PK4 & PK5)				
Mean	4.9	19.4	48.4	936.0
SD	2.3	4.9	18.9	3.6
Min	0.3	7.0	7.4	928.0
Max	12.5	33.0	94.2	949.0
n	1252.0	1252.0	1252.0	1252.0
Ground level (10m) in Tanqua Wash Riviere vegetation (at PK1, PK2 & PK3a)				
Mean	5.2	18.8	49.3	936.0
SD	2.3	4.5	19.6	3.3
Min	0.3	7.6	12.9	928.0
Max	11.3	31.2	89.6	946.0
n	446.0	446.0	446.0	446.0
Ground level (10m) in Tanqua Karoo vegetation (at PK3b, PK4 & PK5)				
Mean	4.6	19.6	47.9	936.0
SD	2.2	4.9	19.2	3.7
Min	0.3	7.0	7.4	929.0
Max	12.5	33.0	94.2	949.0
n	806.0	806.0	806.0	806.0

Table 8-4 **Species Group A weather statistics**

	WIND SPEED [M/S]	TEMPERATURE [°C]	RELATIVE HUMIDITY [%]	PRESSURE [MBAR]
All monitoring localities/habitat types & heights				
Mean	4.9	20.5	51.6	935.5
SD	2.3	4.5	19.7	3.2
Min	0.1	7.0	12.6	928.0
Max	15.4	33.0	94.2	948.0
n	1548.0	1548.0	1548.0	1548.0
Rotor sweep height (60m at PK3b)				
Mean	4.7	20.5	50.0	934.7
SD	2.6	4.9	17.9	2.8
Min	0.1	7.0	14.3	928.0
Max	15.4	31.9	89.2	944.0
n	197.0	197.0	197.0	197.0
Ground level (10m at PK1, PK2, PK3a, PK3b, PK4 & PK5)				
Mean	5.0	20.5	51.9	935.6
SD	2.2	4.4	20.0	3.2
Min	0.3	7.0	12.6	928.0
Max	12.7	33.0	94.2	948.0
n	1337.0	1337.0	1337.0	1337.0
Ground level (10m) in Tanqua Wash Riviere vegetation (at PK1, PK2 & PK3a)				
Mean	5.2	19.5	50.5	935.8
SD	2.3	4.4	20.3	3.2
Min	0.3	7.6	12.9	928.0
Max	11.3	31.2	89.6	944.0
n	306.0	306.0	306.0	306.0
Ground level (10m) in Tanqua Karoo vegetation (at PK3b, PK4 & PK5)				
Mean	4.9	20.8	52.2	935.5
SD	2.2	4.4	19.9	3.2
Min	0.8	7.0	12.6	929.0
Max	12.7	33.0	94.2	948.0
n	1045.0	1045.0	1045.0	1045.0

Table 8-5 **Species Group B weather statistics**

	WIND SPEED [M/S]	TEMPERATURE [°C]	RELATIVE HUMIDITY [%]	PRESSURE [MBAR]
All monitoring localities/habitat types & heights				
Mean	5.1	19.4	42.5	936.5
SD	2.1	4.9	17.1	3.5
Min	0.3	7.8	12.7	930.0
Max	11.1	32.8	92.9	949.0
n	458.0	458.0	458.0	458.0
Rotor sweep height (60m at PK3b)				
Mean	3.2	13.3	50.6	930.0
SD				
Min				
Max				
n	1.0	1.0	1.0	1.0
Ground level (10m at PK1, PK2, PK3a, PK3b, PK4 & PK5)				
Mean	5.1	19.4	42.5	936.5
SD	2.1	4.9	17.1	3.5
Min	0.3	7.8	12.7	930.0
Max	11.1	32.8	92.9	949.0
n	457.0	457.0	457.0	457.0
Ground level (10m) in Tanqua Wash Riviere vegetation (at PK1, PK2 & PK3a)				
Mean	5.4	17.8	46.8	936.3
SD	2.3	4.8	18.0	3.5
Min	0.7	7.8	13.8	930.0
Max	11.1	31.2	86.1	946.0
n	130.0	130.0	130.0	130.0
Ground level (10m) in Tanqua Karoo vegetation (at PK3b, PK4 & PK5)				
Mean	5.0	20.0	40.8	936.6
SD	2.0	4.8	16.5	3.5
Min	0.3	9.3	12.7	930.0
Max	10.7	32.8	92.9	949.0
n	327.0	327.0	327.0	327.0

Table 8-6 Species Group C weather statistics

	WIND SPEED [M/S]	TEMPERATURE [°C]	RELATIVE HUMIDITY [%]	PRESSURE [MBAR]
Ground level (10m at PK1, PK2, PK3a, PK3b, PK4 & PK5)				
Mean	4.3	15.6	42.9	938.0
SD	2.4	3.8	17.4	4.2
Min	0.6	9.5	7.4	930.0
Max	10.1	26.4	86.0	948.0
n	84.0	84.0	84.0	84.0
Ground level (10m) in Tanqua Wash Riviere vegetation (at PK1, PK2 & PK3a)				
Mean	4.1	16.4	42.7	937.1
SD	2.2	3.5	20.0	3.5
Min	1.2	10.6	14.6	933.0
Max	7.8	21.6	81.2	945.0
n	18.0	18.0	18.0	18.0
Ground level (10m) in Tanqua Karoo vegetation (at PK3b, PK4 & PK5)				
Mean	4.4	15.4	42.9	938.3
SD	2.4	3.8	16.8	4.4
Min	0.6	9.5	7.4	930.0
Max	10.1	26.4	86.0	948.0
n	66.0	66.0	66.0	66.0

8.9. Bat Activity & Moon Light

Figure 8-16 indicates that within rotor sweep height, Species Group A bats were least active during New Moon and most active during Full Moon. Conversely, **Figure 8-17** shows that near ground level, Species Group A bats were most active during New Moon. These differences in the activity of Species Group A between moon phases and monitoring heights were perhaps related to the improved visibility of aerial insect prey in rotor sweep with increased moonlight, and the reduced visibility of these bats to predators near ground level during New Moon.

In contrast to Species Group A, Species Groups B and C did not show substantial variation in activity with variation in moonlight. This is possibly related to the clutter-edge foraging behaviour of the Species Group B and C bats, compared to the aerial-foraging behaviour of Species Group A.

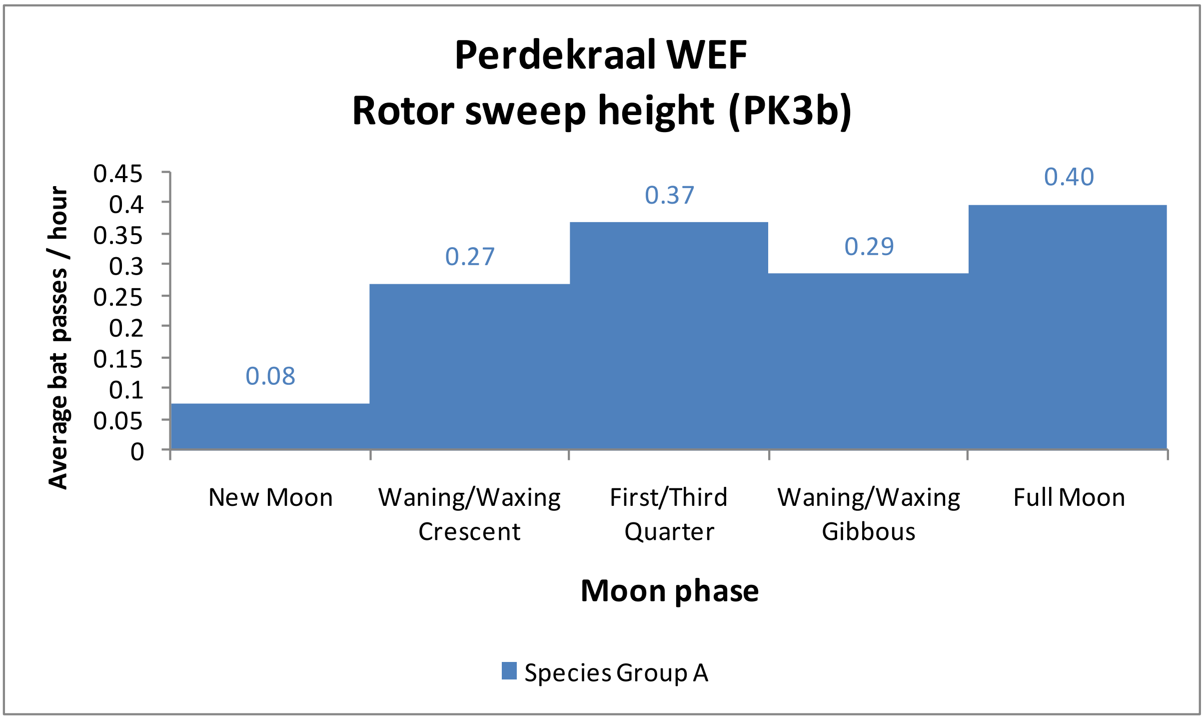


Figure 8-16 Activity in rotor sweep height of Species Group A during each moon phase.

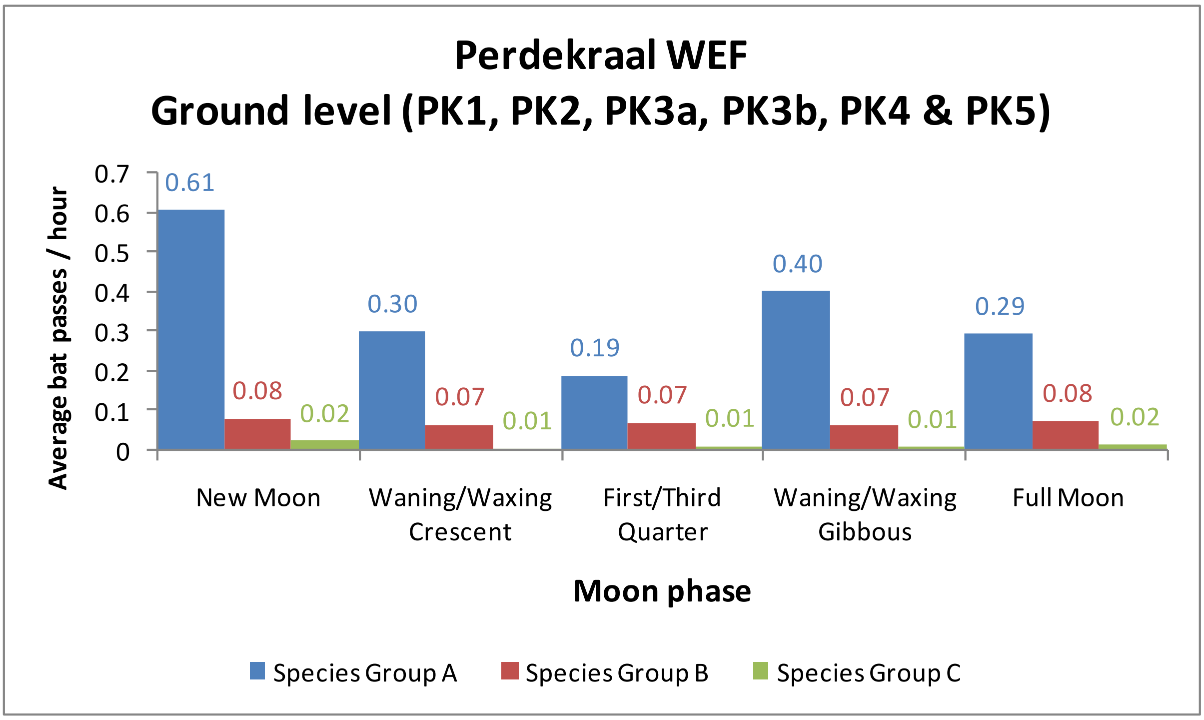


Figure 8-17 Activity near ground level of each Species Group during each moon phase.

8.10. Results Summary

Species Group A bats (including *T. aegyptiaca*), which are at a **High** risk of fatality from turbines, were generally most active:

- In the southern region of Perdekraal over Tanqua Karoo vegetation.
- In spring and summer (early September-late January), and in December especially.
- Near ground level during New Moon.
- In rotor sweep height around Full Moon.
- Between 18:00 and 22:00.
- Under wind speeds (at 15.6m) of 4.9m/s + 2.3m/s = 7.2m/s (= mean + 1SD).

Species Group B bats (including *N. capensis*), which are at a **Medium to High** risk of fatality from turbines, were generally most active:

- In the southern region of Perdekraal over Tanqua Karoo vegetation.
- In spring and summer (early September-late January).
- Near ground level.
- Between 18:30 and 23:20, and between 03:30 and 05:00.
- Under wind speeds (at 15.6m) of 5.1m/s + 2.1m/s = 7.2m/s.

Species Group C bats (including the **Near Threatened** *M. natalensis*), which are at a **Medium to High** risk of fatality from turbines, were generally most active:

- Near PK3a and PK4.
- For brief periods in autumn, winter and spring (May, July and August/September).
- Near ground level.
- Between 18:30 and 21:00.
- Under wind speeds (at 15.6m) of 4.3m/s + 2.4m/s = 6.7m/s

Potentially occurring Species Group D bats (e.g. *Rhinolophus capensis* and *R. clivosus*), and Species Group E bats (including *N. thebaica*), which are all at a Low risk of fatality from turbines, are *expected* to be most active:

- Near PK3a and PK4.
- Near ground level.

9. Areas of Bat Conservation Importance

Based on results from the 12-month monitoring study, a Habitat Sensitivity Map was compiled for the proposed Perdekraal WEFs (**Figure 9-1**). The following points are important in understanding the map:

- The mountains situated in the southern region of Perdekraal were assigned a **High** sensitivity and should be treated as a No-Go area. This is because the activity of Species Groups A, B and C was highest at monitoring stations (PK3b, PK4 and PK5) near the mountains, where rock crevices may provide significant roosting habitat in a landscape where alternative roost sites (e.g. buildings, caves and trees) are scarce. Around the mountains concentric buffer zones of **Medium-High** sensitivity (from 0 to 1km), **Medium** sensitivity (from 1 to 2km) and **Low** sensitivity (from 2 to 3km) have been assigned, based on the finding by Jacobs & Barclay (2009) that House Bats (*Scotophilus* spp.) typically make foraging movements of 1-2km and occasionally up to 3km from their roosts.
- The Groot and Adamskraal streams and their flood plains, other smaller FEPAs, and 50m buffers around all of these were assigned a **High** sensitivity, and should be treated as No-Go areas. This is because bats rely heavily on aquatic habitat for navigation, foraging and drinking (Serra-Cobo *et al*., 2000; Akasaka *et al*., 2010; Hagen & Sabo, 2012), especially in barren, arid environments such as the Tanqua Karoo where Perdekraal is situated. Along the Groot and Adamskraal streams, bushes and trees provide important (and otherwise limited) habitat, which the clutter-edge foraging Species Group B, C, D and E bats are dependent on. The 50m buffer recommendation was based on the Natural England Interim Guidance (which suggests a 50m buffer from a turbine blade tip to the nearest important bat habitat feature), the GDARD (2009) 50m buffer regulation, the Fynbos Forum 30m buffer regulation (De Villiers *et al.* 2005) for wetland/riparian habitat, and our observation of concentrated bat activity during mist-netting in the Groot stream.
- A few isolated buildings and a 50m buffer around these were assigned a **Medium** sensitivity based on the confirmed or potential presence of house-dwelling Species Group B bats. Confirmed roosts were only represented by a few individual *N. capensis*, which is an abundant and widespread species in South Africa. This buffer recommendation was also based on the afore-mentioned Natural England Interim Guidance.
- *All remaining areas in **Figure 9-1** were assigned a **Low** sensitivity* because these mainly include flat, open and barren Tanqua Karoo vegetation, where bats are expected to exhibit low, wide spread activity throughout most of the year.

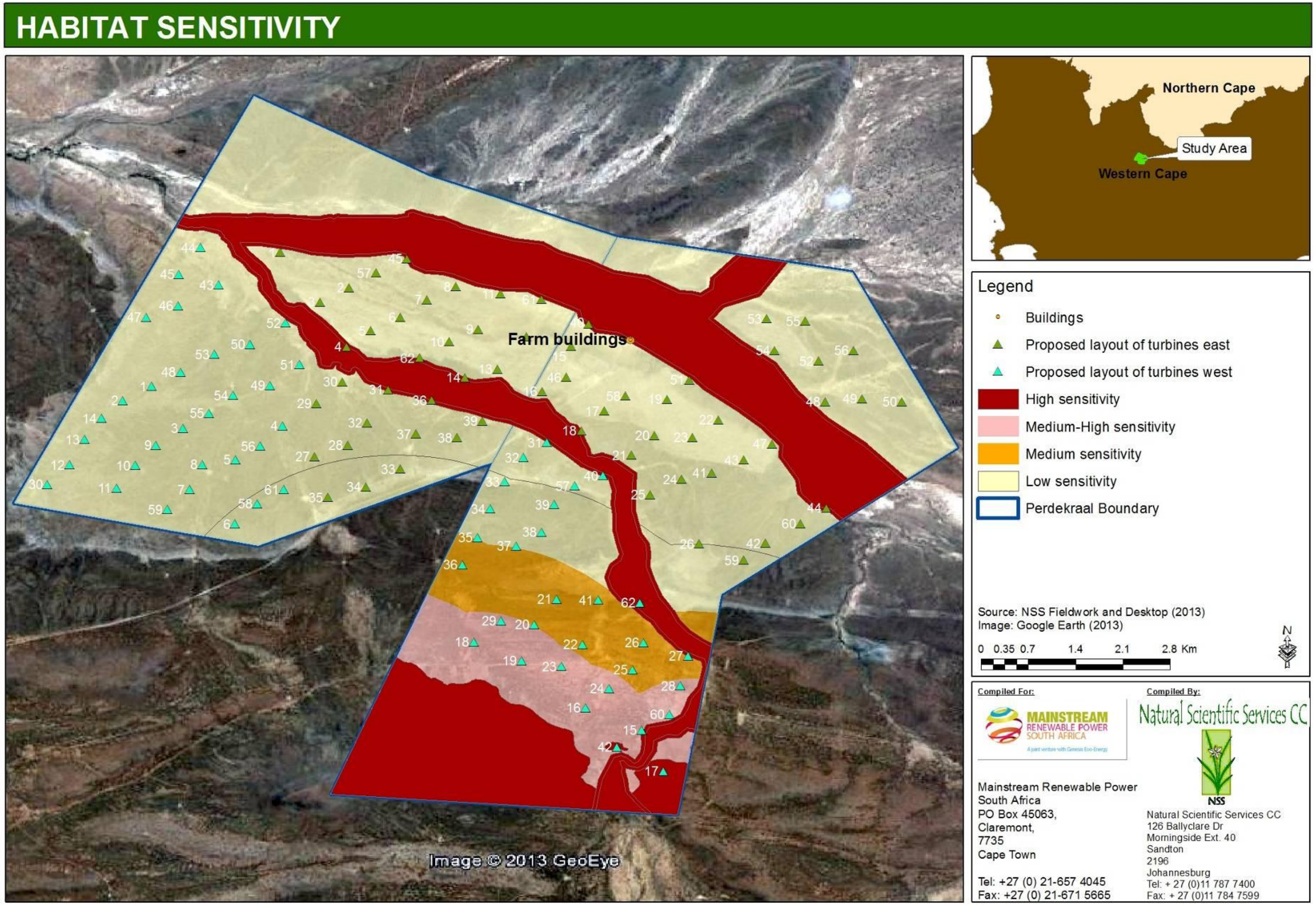


Figure 9-1 Habitat Sensitivity Map for bats at Perdekraal

10. Impact & Risk Assessment & Mitigation

The impact and risk assessment matrices for the proposed Perdekraal WEFs are shown in **Table 10-1** and **Table 10-2**, respectively.

10.1. Impact 1: Roost disturbance or destruction due to construction activities

10.1.1. Cause & Significance

Disturbance or destruction of a few small farm buildings on site would affect only a small number of house-dwelling bats. However, if construction of the proposed Perdekraal WEFs causes destruction and disturbance of bat roosts in the mountains in the southern region of Perdekraal, or in woody vegetation along the Groot and Adamskraal streams, their floodplains and other FEPAs, this would have a significant impact on local bats. This potential impact has, therefore, a **Medium** Significance rating, which can reduced to **Low** by the following recommended mitigation measures.

10.1.2. Mitigation & Management

- Keep turbines away from the mountains in the southern region of Perdekraal (where bats may roost in rock crevices and overhangs). This includes the Perdekraal West turbine locations 17 and 42, which should be re-positioned by 200m and 80m, respectively, from **High** sensitivity into **Medium-High** sensitivity habitat.
- Keep turbines away from the Groot and Adamskraal streams, their floodplains, other FEPAs, and a 50m buffer around these (where bats may roost under the bark of trees). This includes the Perdekraal East turbine locations 4, 14, 18, 31, 36, 40, 44 and 45 and Perdekraal West turbine locations 27 and 40, which should be re-positioned by one rotor blade length (60m), and Perdekraal West turbine location 62, which should be re-positioned by 100m, from **High** to **Medium** or **Low** sensitivity habitat.
- Minimize disturbance and destruction of farm buildings on site (where bats were observed roosting in a roof).

10.2. Impact 2: Fragmentation to and displacement from foraging habitat due to wind turbine construction and operation

10.2.1 Cause & Significance

Construction of the proposed Perdekraal WEFs could cause destruction and fragmentation of woody habitat (bushes and trees) along the Groot and Adamskraal streams, which would have a significant impact on the clutter-edge foraging Species Group B, C, D and E bats. This impact, therefore, has a **Medium** Significance rating, which can be reduced to **Low** by the following mitigation measures.

10.2.2 Mitigation & Management

- Keep turbines away from the Groot and Adamskraal streams, their floodplains, other FEPAs, and a 50m buffer around these (where clutter-edge foraging Species Group B, C, D and E bats are concentrated). This includes the Perdekraal East turbine locations 4, 14, 18, 31, 36, 40, 44 and 45 and Perdekraal West turbine locations 27 and 40, which should be re-positioned by one rotor blade length (60m), and Perdekraal West turbine location 62, which should be re-positioned by 100m, from **High** to **Medium** or **Low** sensitivity habitat.
- Minimize artificial lighting at night, especially high-intensity lighting, steady-burning, or bright lights such as sodium vapour, quartz, halogen, or other bright spotlights. Lights should be hooded downward and directed to minimize horizontal and skyward illumination. All internal turbine nacelle and tower lighting should be extinguished when unoccupied.

10.3. Impact 3: Bat fatalities due to collision or barotrauma during foraging activity

10.3.1. Cause & Significance

Deaths caused by moving turbine blades are well documented but the reason for why bats are unable to avoid moving turbine blades is unknown. Bates & Simmons (2011) found that bats have a perceptual mechanism for rejecting echoes from peripheral clutter in order to focus on targets directly in front of them. Hence, bats may not “see” wind turbines when concentrating on catching food.

Although there is a low diversity of bats at Perdekraal, fatal collisions and barotrauma would have a definite, permanent (fatal) impact and, therefore, have a **Medium** Significance rating. Fortunately, certain measures to mitigate this impact have been proven to work, and could potentially reduce the Significance rating of this impact to **Low**.

10.4.2 Mitigation & Management

- Turbines should be spaced ≥250m apart from blade tip to blade tip. Based on correspondence with Mainstream on 11 January and 20 February 2013, as a rule-of-thumb, “turbines are arranged four rotor diameters from each other in the non prevailing wind direction and eight rotor diameters in the prevailing wind direction.” For the Perdekraal project the rotor diameter of turbines is likely to be approximately 120m. Turbines at Perdekraal would, consequently, be spaced ≥360m apart from blade tip to blade tip, which meets our recommendation.
- Maximize turbine hub height (since most bat activity at Perdekraal was measured near ground level) and minimize rotor diameter (to minimize the mortality of Species Group A bats in rotor sweep height). NSS does, however, realize that this may not be possible as turbine dimensions are dependent on local wind conditions and the class of machines that turbine suppliers are willing to guarantee under those conditions.

- A turbine cut-in wind speed of **7.2m/s at 15.6m** is recommended for curtailment of all turbines in **Medium-High** sensitivity habitat (i.e. within 1km of the mountains in the southern region of Perdekraal) **during periods when Species Group A bats are most active** i.e., between 18:00 and 22:00 throughout December and during two nights before and after every Full Moon. This includes the Perdekraal West turbine locations 15, 16, 18, 19, 23, 24, 28, 29 and 60, and re-positioned Perdekraal West turbine locations 17 and 42. This would cause a **VERY SMALL LOSS** in operation time (<324 hours or 3.6% of a maximum 8760 hours / turbine / annum) for only a small proportion (18%) of turbines comprising only the Perdekraal West WEF.
- Implement comprehensive long-term post-construction bat monitoring to inform *adaptive* mitigation management, as described next.

Post-construction monitoring and adaptive mitigation

Post-construction bat monitoring MUST be performed involving a 12-month study to determine the most effective cut-in wind speed for turbines at Perdekraal. For this, different cut-in wind speeds (of e.g. 3m/s, 5m/s, 7m/s, 9m/s and 11m/s at 15.6m) should be tested for groups of e.g. 20 randomly selected turbines. Bat fatalities should be monitored by week-long, monthly fatality searches along transects spaced 10m apart across a 120m x 120m area around each turbine. For each encountered bat carcass, a record must be kept of the date, time, location, species, sex, age, estimated time and cause of death. Carcasses should also be photographed and used for searcher efficiency and (scavenger) carcass removal trials. These trials are required to determine the average percentage of bats detected by surveyors, the persistence of bat carcasses in the field, and ultimately, to obtain estimates of actual bat mortality. The lowest cut-in speed that demonstrates a statistically significant reduction in bat mortality, would be selected as the default cut-in speed during periods of peak bat activity on site.

In addition to the post-construction monitoring study, adaptive management of mitigation measures would be required to ensure that potentially significant levels of bat mortality (bat mortality thresholds) from operation of the WEFs are effectively mitigated. Methods to determine species-specific mortality thresholds are detailed by e.g. SWCA (2010). The adaptive mitigation management plan would involve successive phases. During each phase, results from the post-construction monitoring should be used to modify (decrease or increase) the cut-in speed and hours of curtailment of selected turbines to minimize bat impacts and maximize energy production. Turbine shut-down would only be recommended where exceptionally high levels of unexpected and unpredictable bat mortality are recorded throughout most of the year.

10.4. Impact 4: Bat fatalities due to collision or barotrauma during migration

10.4.1 Cause & Significance

Research indicates that migrating bats are at higher risk of fatality due to their higher flights or some other reason. To date, most bats killed by turbines in the USA have been migratory species, and the highest fatality events appear to coincide with autumn migration. Cryan & Brown (2007) found that low wind speeds, low moon illumination, and high cloud cover were important predictors of bat arrivals and departures, and that low barometric pressure was an additional variable that helped predict bat arrivals.

The species most likely to exhibit mass-migration in the study area is the Natal Long-fingered Bat (*Miniopterus natalensis*), although migration by the Egyptian Free-tailed Bat during December could not be ruled out. Given the uncertainty around this issue, the potential impact of the proposed Perdekraal WEFs on migrating bats has been given a **Medium** Significance rating. This could be reduced to **Low** by implementing the mitigation measures described under **Sections 10.1.2., 10.2.2.** and **10.3.2.**

10.5. Impact 5: Bat fatalities due to collision or barotrauma due to attraction of bats to towers for roosting

10.5.1. Cause & Significance

Bats have been shown, through thermal imagery studies, to be attracted to wind turbines, either looking for potential roost sites, or out of curiosity, and are often struck by the moving blades (Horn *et al.* 2008). This has been further confirmed by Rollins *et al.* (2012).

Unfortunately, no mitigation measure has been found to effectively prevent this. Whilst ultrasonic sound emitters are currently being investigated as a deterrent for bats from wind turbines, this research has not yet produced enough evidence to support this measure. Hence, we cannot yet recommend this. The most well documented measure is curtailment, which is discussed below, and which would be prescribed if post-construction monitoring revealed unacceptably high numbers of bat fatalities.

10.6. Impact 6: Loss or population disturbances to Conservation Important Bat Species from the greater area due to construction and operation activities

10.6.1 Cause & Significance

One of the three species confirmed for the Perdekraal study area is of Conservation Importance, namely the globally and nationally **Near Threatened** Natal Long-fingered Bat (*Miniopterus natalensis*) (**Table 8-1**). Given the low activity and probable abundance of this species at Perdekraal, this impact has a **Low** Significance rating, which would be maintained by the mitigation measures described under **Sections 10.1.2.** and **10.2.2**.

10.7. Impact 7: Reduction in the size, genetic diversity, resilience and persistence of bat populations

10.7.1 Cause & Significance

Bat population sizes are likely to be reduced by the fatality of bats at WEFs. This is because bats have low reproductive rates, slow generation turn-over and low population resilience against mass die-offs. Smaller populations also contain less genetic diversity, and are more susceptible to genetic drift and inbreeding. WEFs may, therefore, reduce the long-term persistence of local and even regional bat populations. Given the low activity and abundance of bats at Perdekraal relative to other sites in South Africa where NSS has performed long-term monitoring for proposed WEFs, this potential impact has a **Low** Significance rating.

10.8. Cumulative Impacts

When assessing impacts, it is important to also consider what other pressures could be on the bats to cause a greater cumulative impact. If other WEFs are developed in the greater study area, these will have an additive cumulative impact on bats at a regional scale. In addition, the greater the area of wind turbine development, the greater the risk of this clashing with bat migration routes.

Table 10-1 Impact assessment matrix for the proposed Perdekraal WEFs

No	Impact Description		Status	Extent		Duration		Intensity		Probability		Significance		Confidence	
				Details	Rating	Details	Rating	Details	Rating	Details	Rating	Details	Total	Details	Rating
1	Roost disturbance or destruction due to construction activities	Without Mitigation	Negative	Study Area	2	Permanent	4	High	3	Probable	2	Medium	18	High	3
		With Mitigation	Negative	Localised	1	Short Term	1	Low	1	Probable	2	Low	6	High	3
2	Fragmentation to and displacement from foraging habitat due to wind turbine construction and operation	Without Mitigation	Negative	Study Area	2	Permanent	4	High	3	Highly Probable	3	Medium	27	High	3
		With Mitigation	Negative	Study Area	2	Long Term	3	Medium	2	Probable	2	Low	14	High	3
3	Bat fatalities due to collision or barotrauma during foraging activity	Without Mitigation	Negative	Study Area	2	Permanent	4	Medium	2	Definite	4	Medium	32	High	3
		With Mitigation	Negative	Study Area	2	Permanent	4	Low	1	Probable	2	Low	14	High	3
4	Bat fatalities due to collision or barotrauma during migration	Without Mitigation	Negative	Regional / National	3	Permanent	4	High	3	Probable	2	Medium	20	High	3
		With Mitigation	Negative	Regional / National	3	Permanent	4	Low	1	Probable	2	Low	16	Medium	2
5	Bat fatalities due to collision or barotrauma due to attraction of bats to towers for roosting	Without Mitigation	Negative	Study Area	2	Permanent	4	Medium	2	Probable	2	Low	16	Medium	2
		With Mitigation	Negative	Study Area	2	Permanent	4	Low	1	Probable	2	Low	14	Low	1
6	Loss of Conservation Important Bat Species from the area due to construction and operation activities	Without Mitigation	Negative	Study Area	2	Permanent	4	Low	1	Probable	2	Low	14	Medium	2
		With Mitigation	Negative	Study Area	2	Long Term	3	Low	1	Probable	2	Low	12	Medium	2
7	Reduction in the size, genetic diversity, resilience and persistence of bat populations	Without Mitigation	Negative	Study Area	2	Long Term	3	Medium	2	Probable	2	Low	14	High	3
		With Mitigation	Negative	Study Area	2	Long Term	3	Low	1	Improbable	1	Low	6	High	3

Table 10-2 Risk assessment matrix for the proposed Perdekraal WEFs

Turbine no.	Habitat	Score	Distance (m) to nearest wetland, dam or stream	Score	Distance (m) to nearest building roost	Score	Distance (km) to nearest cave roost	Score	Distance (m) to nearest other turbine	Score	Nearest microphone near ground level	Score	Nearest microphone in rotor sweep height	Score	Risk near ground level	Risk in rotor sweep height
EAST																
1	Tanqua Karoo	1	345	2	4625	0	40-60	3	860	0	PK1 (10m)	1.16	PK3b (60m)	1.36	**Negligible**	**Negligible**
2	Tanqua Karoo	1	555	0	3670	0	40-60	3	420	4	PK1 (10m)	1.16	PK3b (60m)	1.36	**Low**	**Low**
3	Tanqua Karoo	1	215	2	4000	0	40-60	3	465	4	PK1 (10m)	1.16	PK3b (60m)	1.36	**Low**	**Low**
4	Tanqua Karoo	5	135	3	1535	0	40-60	3	385	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Medium**	**Medium**
5	Tanqua Karoo	1	480	1	3225	0	40-60	3	425	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
6	Tanqua Karoo	1	795	0	2925	0	40-60	3	400	4	PK3a (10m)	1.56	PK3b (60m)	1.36	**Low**	**Low**
7	Tanqua Karoo	1	1015	0	2665	0	40-60	3	460	4	PK3a (10m)	1.56	PK3b (60m)	1.36	**Low**	**Low**
8	Tanqua Karoo	1	805	0	2415	0	40-60	3	445	4	PK3a (10m)	1.56	PK3b (60m)	1.36	**Low**	**Low**
9	Tanqua Karoo	1	805	0	1905	0	40-60	3	395	4	PK3a (10m)	1.56	PK3b (60m)	1.36	**Low**	**Low**
10	Tanqua Karoo	1	585	0	2260	0	40-60	3	395	4	PK3a (10m)	1.56	PK3b (60m)	1.36	**Low**	**Low**
11	Tanqua Karoo	1	755	0	1755	0	40-60	3	580	4	PK3a (10m)	1.56	PK3b (60m)	1.36	**Low**	**Low**
12	Tanqua Karoo	1	745	0	1300	0	40-60	3	565	4	PK3a (10m)	1.56	PK3b (60m)	1.36	**Low**	**Low**
13	Tanqua Karoo	1	180	3	1710	0	40-60	3	410	4	PK3b (10m)	1.24	PK3b (60m)	1.36	**Low**	**Low**
14	Tanqua Karoo	5	80	4	1230	0	40-60	3	415	4	PK3b (10m)	1.24	PK3b (60m)	1.36	**Medium**	**Medium**
15	Tanqua Karoo	1	645	0	750	2	40-60	3	405	4	PK3a (10m)	1.56	PK3b (60m)	1.36	**Low**	**Low**
16	Tanqua Karoo	1	215	2	1325	0	40-60	3	365	4	PK3b (10m)	1.24	PK3b (60m)	1.36	**Low**	**Low**
17	Tanqua Karoo	1	640	0	1105	0	40-60	3	345	5	PK3b (10m)	1.24	PK3b (60m)	1.36	**Low**	**Low**
18	Tanqua Karoo	5	270	2	1465	0	40-60	3	455	4	PK3b (10m)	1.24	PK3b (60m)	1.36	**Medium**	**Medium**
19	Tanqua Karoo	1	525	0	985	1	40-60	3	390	4	PK3b (10m)	1.24	PK3b (60m)	1.36	**Low**	**Low**
20	Tanqua Karoo	1	475	1	1440	0	40-60	3	395	4	PK3b (10m)	1.24	PK3b (60m)	1.36	**Low**	**Low**
21	Tanqua Karoo	1	255	2	1695	0	40-60	3	395	4	PK3b (10m)	1.24	PK3b (60m)	1.36	**Low**	**Low**
22	Tanqua Karoo	1	360	1	1625	0	40-60	3	405	4	PK2 (10m)	1.32	PK3b (60m)	1.36	**Low**	**Low**
23	Tanqua Karoo	1	735	0	1630	0	40-60	3	400	4	PK2 (10m)	1.32	PK3b (60m)	1.36	**Low**	**Low**
24	Tanqua Karoo	1	440	1	2170	0	40-60	3	380	4	PK2 (10m)	1.32	PK3b (60m)	1.36	**Low**	**Low**
25	Tanqua Karoo	1	325	2	2300	0	40-60	3	445	4	PK3b (10m)	1.24	PK3b (60m)	1.36	**Low**	**Low**
26	Tanqua Karoo	1	845	0	3120	0	40-60	3	595	4	PK2 (10m)	1.32	PK3b (60m)	1.36	**Low**	**Low**
27	Tanqua Karoo	1	600	0	4270	0	40-60	3	425	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**

Turbine no.	Habitat	Score	Distance (m) to nearest wetland, dam or stream	Score	Distance (m) to nearest building roost	Score	Distance (km) to nearest cave roost	Score	Distance (m) to nearest other turbine	Score	Nearest microphone near ground level	Score	Nearest microphone in rotor sweep height	Score	Risk near ground level	Risk in rotor sweep height
28	Tanqua Karoo	1	830	0	3815	0	40-60	3	410	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
29	Tanqua Karoo	1	770	0	4020	0	40-60	3	435	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
30	Tanqua Karoo	1	250	2	3635	0	40-60	3	455	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
31	Tanqua Karoo	5	105	3	3095	0	40-60	3	550	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Medium**	**Medium**
32	Tanqua Karoo	1	665	0	3495	0	40-60	3	385	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
33	Tanqua Karoo	1	295	2	3410	0	40-60	3	485	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
34	Tanqua Karoo	1	675	0	3925	0	40-60	3	490	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
35	Tanqua Karoo	1	150	3	4420	0	40-60	3	500	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
36	Tanqua Karoo	5	205	2	2630	0	40-60	3	520	4	PK3b (10m)	1.24	PK3b (60m)	1.36	**Medium**	**Medium**
37	Tanqua Karoo	1	175	3	3015	0	40-60	3	505	4	PK3b (10m)	1.24	PK3b (60m)	1.36	**Low**	**Low**
38	Tanqua Karoo	1	495	1	2590	0	40-60	3	385	4	PK3b (10m)	1.24	PK3b (60m)	1.36	**Low**	**Low**
39	Tanqua Karoo	1	280	2	2205	0	40-60	3	390	4	PK3b (10m)	1.24	PK3b (60m)	1.36	**Low**	**Low**
40	Tanqua Karoo	5	180	3	560	4	40-60	3	400	4	PK3a (10m)	1.56	PK3b (60m)	1.36	**Medium**	**Medium**
41	Tanqua Karoo	1	785	0	2195	0	40-60	3	380	4	PK2 (10m)	1.32	PK3b (60m)	1.36	**Low**	**Low**
42	Tanqua Karoo	1	870	0	3435	0	40-60	3	360	5	PK2 (10m)	1.32	PK3b (60m)	1.36	**Low**	**Low**
43	Tanqua Karoo	1	540	0	2260	0	40-60	3	430	4	PK2 (10m)	1.32	PK3b (60m)	1.36	**Low**	**Low**
44	Tanqua Karoo	5	90	4	3460	0	40-60	3	390	4	PK2 (10m)	1.32	PK3b (60m)	1.36	**Medium**	**Medium**
45	Tanqua Karoo	5	290	2	3015	0	40-60	3	430	4	PK3a (10m)	1.56	PK3b (60m)	1.36	**Medium**	**Medium**
46	Tanqua Karoo	1	405	1	960	1	40-60	3	360	5	PK3b (10m)	1.24	PK3b (60m)	1.36	**Low**	**Low**
47	Tanqua Karoo	1	125	3	2325	0	40-60	3	405	4	PK2 (10m)	1.32	PK3b (60m)	1.36	**Low**	**Low**
48	Tanqua Wash Riviere	1	100	4	2565	0	40-60	3	455	4	PK2 (10m)	1.32	PK3b (60m)	1.36	**Low**	**Low**
49	Tanqua Wash Riviere	1	235	2	2990	0	40-60	3	455	4	PK2 (10m)	1.32	PK3b (60m)	1.36	**Low**	**Low**
50	Tanqua Wash Riviere	1	845	0	3475	0	40-60	3	490	4	PK2 (10m)	1.32	PK3b (60m)	1.36	**Low**	**Low**
51	Tanqua Karoo	1	125	3	935	1	40-60	3	390	4	PK3a (10m)	1.56	PK3b (60m)	1.36	**Low**	**Low**
52	Tanqua Wash Riviere	1	430	1	2355	0	40-60	3	460	4	PK2 (10m)	1.32	PK3b (60m)	1.36	**Low**	**Low**
53	Tanqua Wash Riviere	1	695	0	1740	0	40-60	3	475	4	PK3a (10m)	1.56	PK3b (60m)	1.36	**Low**	**Low**
54	Tanqua Wash Riviere	1	525	0	1800	0	40-60	3	465	4	PK3a (10m)	1.56	PK3b (60m)	1.36	**Low**	**Low**
55	Tanqua Wash Riviere	1	1045	0	2190	0	40-60	3	475	4	PK3a (10m)	1.56	PK3b (60m)	1.36	**Low**	**Low**
56	Tanqua Wash Riviere	1	665	0	2775	0	40-60	3	460	4	PK2 (10m)	1.32	PK3b (60m)	1.36	**Low**	**Low**

Turbine no.	Habitat	Score	Distance (m) to nearest wetland, dam or stream	Score	Distance (m) to nearest building roost	Score	Distance (km) to nearest cave roost	Score	Distance (m) to nearest other turbine	Score	Nearest microphone near ground level	Score	Nearest microphone in rotor sweep height	Score	Risk near ground level	Risk in rotor sweep height
57	Tanqua Karoo	1	725	0	3300	0	40-60	3	390	4	PK1 (10m)	1.16	PK3b (60m)	1.36	**Low**	**Low**
58	Tanqua Karoo	1	350	2	825	1	40-60	3	345	5	PK3b (10m)	1.24	PK3b (60m)	1.36	**Low**	**Low**
59	Tanqua Karoo	1	1235	0	3545	0	40-60	3	360	5	PK2 (10m)	1.32	PK3b (60m)	1.36	**Low**	**Low**
60	Tanqua Karoo	1	410	1	3430	0	40-60	3	385	4	PK2 (10m)	1.32	PK3b (60m)	1.36	**Low**	**Low**
61	Tanqua Karoo	1	270	2	1250	0	40-60	3	505	4	PK3a (10m)	1.56	PK3b (60m)	1.36	**Low**	**Low**
62	Tanqua Karoo	5	235	2	2625	0	40-60	3	435	4	PK3b (10m)	1.24	PK3b (60m)	1.36	**Medium**	**Medium**
WEST																
1	Tanqua Karoo	1	1975	0	5990	0	40-60	3	405	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
2	Tanqua Karoo	1	1525	0	6355	0	40-60	3	375	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
3	Tanqua Karoo	1	735	0	5715	0	40-60	3	385	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
4	Tanqua Karoo	1	1065	0	4490	0	40-60	3	405	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
5	Tanqua Karoo	1	305	2	5215	0	40-60	3	360	5	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
6	Tanqua Karoo	1	945	0	5630	0	40-60	3	405	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
7	Tanqua Karoo	1	355	1	5900	0	40-60	3	400	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
8	Tanqua Karoo	1	150	3	5625	0	40-60	3	400	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
9	Tanqua Karoo	1	790	0	6090	0	40-60	3	395	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
10	Tanqua Karoo	1	935	0	6435	0	40-60	3	390	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
11	Tanqua Karoo	1	1190	0	6755	0	40-60	3	400	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
12	Tanqua Karoo	1	1745	0	7210	0	40-60	3	395	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
13	Tanqua Karoo	1	1635	0	6935	0	40-60	3	370	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
14	Tanqua Karoo	1	1570	0	6685	0	40-60	3	370	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
15	Tanqua Karoo	4	115	3	5755	0	40-60	3	395	4	PK4 (10m)	1.96	PK3b (60m)	1.36	**Medium**	**Medium**
16	Tanqua Karoo	4	835	0	5460	0	40-60	3	410	4	PK4 (10m)	1.96	PK3b (60m)	1.36	**Low**	**Low**
17	Tanqua Karoo	5	285	2	6400	0	40-60	3	660	2	PK4 (10m)	1.96	PK3b (60m)	1.36	**Low**	**Low**
18	Tanqua Karoo	4	1250	0	4885	0	40-60	3	455	4	PK4 (10m)	1.96	PK3b (60m)	1.36	**Low**	**Low**
19	Tanqua Karoo	4	1765	0	4935	0	40-60	3	505	4	PK4 (10m)	1.96	PK3b (60m)	1.36	**Low**	**Low**
20	Tanqua Karoo	3	1440	0	4370	0	40-60	3	410	4	PK3b (10m)	1.24	PK3b (60m)	1.36	**Low**	**Low**
21	Tanqua Karoo	3	1015	0	3955	0	40-60	3	465	4	PK3b (10m)	1.24	PK3b (60m)	1.36	**Low**	**Low**
22	Tanqua Karoo	3	1080	0	4530	0	40-60	3	415	4	PK4 (10m)	1.96	PK3b (60m)	1.36	**Low**	**Low**

Turbine no.	Habitat	Score	Distance (m) to nearest wetland, dam or stream	Score	Distance (m) to nearest building roost	Score	Distance (km) to nearest cave roost	Score	Distance (m) to nearest other turbine	Score	Nearest microphone near ground level	Score	Nearest microphone in rotor sweep height	Score	Risk near ground level	Risk in rotor sweep height
23	Tanqua Karoo	4	1475	0	4900	0	40-60	3	415	4	PK4 (10m)	1.96	PK3b (60m)	1.36	**Low**	**Low**
24	Tanqua Karoo	4	1075	0	5170	0	40-60	3	395	4	PK4 (10m)	1.96	PK3b (60m)	1.36	**Low**	**Low**
25	Tanqua Karoo	3	700	0	4870	0	40-60	3	395	4	PK4 (10m)	1.96	PK3b (60m)	1.36	**Low**	**Low**
26	Tanqua Karoo	3	350	2	4475	0	40-60	3	425	4	PK4 (10m)	1.96	PK3b (60m)	1.36	**Low**	**Low**
27	Tanqua Karoo	5	115	3	4735	0	40-60	3	455	4	PK2 (10m)	1.32	PK3b (60m)	1.36	**Medium**	**Medium**
28	Tanqua Karoo	4	245	2	5150	0	40-60	3	440	4	PK4 (10m)	1.96	PK3b (60m)	1.36	**Low**	**Low**
29	Tanqua Karoo	4	1130	0	4450	0	40-60	3	405	4	PK3b (10m)	1.24	PK3b (60m)	1.36	**Low**	**Low**
30	Tanqua Karoo	1	2020	0	7560	0	40-60	3	395	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
31	Tanqua Karoo	1	185	3	1845	0	40-60	3	360	5	PK3b (10m)	1.24	PK3b (60m)	1.36	**Low**	**Low**
32	Tanqua Karoo	1	535	0	2190	0	40-60	3	360	5	PK3b (10m)	1.24	PK3b (60m)	1.36	**Low**	**Low**
33	Tanqua Karoo	1	920	0	2610	0	40-60	3	425	4	PK3b (10m)	1.24	PK3b (60m)	1.36	**Low**	**Low**
34	Tanqua Karoo	1	650	0	3040	0	40-60	3	440	4	PK3b (10m)	1.24	PK3b (60m)	1.36	**Low**	**Low**
35	Tanqua Karoo	1	415	1	3495	0	40-60	3	435	4	PK3b (10m)	1.24	PK3b (60m)	1.36	**Low**	**Low**
36	Tanqua Karoo	3	240	2	3935	0	40-60	3	435	4	PK3b (10m)	1.24	PK3b (60m)	1.36	**Low**	**Low**
37	Tanqua Karoo	1	915	0	3355	0	40-60	3	370	4	PK3b (10m)	1.24	PK3b (60m)	1.36	**Low**	**Low**
38	Tanqua Karoo	1	1040	0	3050	0	40-60	3	370	4	PK3b (10m)	1.24	PK3b (60m)	1.36	**Low**	**Low**
39	Tanqua Karoo	1	780	0	2615	0	40-60	3	370	4	PK3b (10m)	1.24	PK3b (60m)	1.36	**Low**	**Low**
40	Tanqua Karoo	5	105	3	2040	0	40-60	3	385	4	PK3b (10m)	1.24	PK3b (60m)	1.36	**Medium**	**Medium**
41	Tanqua Karoo	3	535	0	3855	0	40-60	3	510	4	PK3b (10m)	1.24	PK3b (60m)	1.36	**Low**	**Low**
42	Tanqua Karoo	5	150	3	6035	0	40-60	3	395	4	PK4 (10m)	1.96	PK3b (60m)	1.36	**Medium**	**Medium**
43	Tanqua Karoo	1	490	1	5180	0	40-60	3	515	4	PK1 (10m)	1.16	PK3b (60m)	1.36	**Low**	**Low**
44	Tanqua Karoo	1	320	2	5505	0	40-60	3	475	4	PK1 (10m)	1.16	PK3b (60m)	1.36	**Low**	**Low**
45	Tanqua Karoo	1	725	0	5690	0	40-60	3	455	4	PK1 (10m)	1.16	PK3b (60m)	1.36	**Low**	**Low**
46	Tanqua Karoo	1	975	0	5645	0	40-60	3	425	4	PK1 (10m)	1.16	PK3b (60m)	1.36	**Low**	**Low**
47	Tanqua Karoo	1	600	0	6035	0	40-60	3	425	4	PK1 (10m)	1.16	PK3b (60m)	1.36	**Low**	**Low**
48	Tanqua Karoo	1	713	0	5605	0	40-60	3	415	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
49	Tanqua Karoo	1	790	0	4540	0	40-60	3	475	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
50	Tanqua Karoo	1	655	0	4725	0	40-60	3	470	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
51	Tanqua Karoo	1	310	2	4135	0	40-60	3	480	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**

Turbine no.	Habitat	Score	Distance (m) to nearest wetland, dam or stream	Score	Distance (m) to nearest building roost	Score	Distance (km) to nearest cave roost	Score	Distance (m) to nearest other turbine	Score	Nearest microphone near ground level	Score	Nearest microphone in rotor sweep height	Score	Risk near ground level	Risk in rotor sweep height
52	Tanqua Karoo	1	140	3	4290	0	40-60	3	535	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
53	Tanqua Karoo	1	540	0	5180	0	40-60	3	465	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
54	Tanqua Karoo	1	125	3	5010	0	40-60	3	400	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
55	Tanqua Karoo	1	505	0	5365	0	40-60	3	400	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
56	Tanqua Karoo	1	670	0	4855	0	40-60	3	365	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
57	Tanqua Karoo	1	390	1	2275	0	40-60	3	370	4	PK3b (10m)	1.24	PK3b (60m)	1.36	**Low**	**Low**
58	Tanqua Karoo	1	605	0	5225	0	40-60	3	400	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
59	Tanqua Karoo	1	765	0	6275	0	40-60	3	400	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
60	Tanqua Karoo	4	230	2	5550	0	40-60	3	415	4	PK4 (10m)	1.96	PK3b (60m)	1.36	**Low**	**Low**
61	Tanqua Karoo	1	315	2	4825	0	40-60	3	385	4	PK5 (10m)	1.52	PK3b (60m)	1.36	**Low**	**Low**
62	Tanqua Karoo	5	160	3	3875	0	40-60	3	520	4	PK3b (10m)	1.24	PK3b (60m)	1.36	**Medium**	**Medium**

11. Conclusions

From the 12-month bat monitoring study conducted for the proposed Perdekraal WEFs, the following conclusions can be made:

- Of 11 potential bat species for the Perdekraal study area (**Table 8-1**), three were detected on site (**Table 8-2**).
- One of the three detected species is of Conservation Importance, namely the globally and nationally **Near Threatened** Natal Long-fingered Bat (*Miniopterus natalensis*) (**Table 8-1**).
- At Perdekraal, bats in Species Groups A, B and C were generally most active:
    - In the southern region of Perdekraal over Tanqua Karoo vegetation.
    - During spring and summer (early September to late January).
    - Near ground level.
    - For approximately 2-4 hours after sunset.
    - In wind speeds (at 15.6m) of ≤7.1m/s.
- Between 50 and 84% of Species Group A passes were recorded during wind speeds (at 15.6m) of ≤7.4m/s, which would be associated with estimated wind speeds of approximately ≤8.9m/s at 60m (assuming neutral atmospheric conditions).
- Very little international or national literature is available for comparing bat activity levels at different sites. However, bat activity levels at Perdekraal are considerably lower than at sites where NSS has been monitoring bat activity for proposed WEFs on the southern Cape coast, and in Kwa-Zulu Natal.
- The Perdekraal study area is a **Low to Medium** Sensitive site in terms of bats, with the areas of highest sensitivity being associated with the Groot and Adamskraal streams, and mountains in the southern region of Perdekraal.
- Seven potential impacts have been assessed. The significance of these impacts varies from **Low to Medium**. Should the recommended mitigation measures be implemented, the significance of these impacts can be reduced to **Low**. However, should the mitigation measures recommended not be implemented or only partially implemented, NSS will need to reassess the residual impact after mitigation.
- The following key mitigation measures have been recommended:
    - Keep turbines away from the mountains in the southern region of Perdekraal.
    - Keep turbines away from the Groot and Adamskraal streams, their floodplains, other FEPAs, and a 50m buffer around these.
    - Minimize disturbance and destruction of farm buildings on site.
    - Minimize artificial lighting in the WEFs at night.
    - Space turbines ≥250m apart from blade tip to blade tip.
    - Maximize turbine hub height and minimize rotor diameter.
- To mitigate destruction and disturbance of bat roosts and foraging habitat along the Groot and Adamskraal streams during construction of the Perdekraal East WEF,

turbine locations 4, 14, 18, 31, 36, 40 and 45 should be re-positioned by one rotor blade length (60m) from **High** to **Low** sensitivity habitat.

- To mitigate destruction and disturbance of bat roosts and foraging habitat along the Adamskraal stream during construction of the Perdekraal West WEF, turbine locations 27 and 40 should be re-positioned by one rotor blade length (60m), and turbine location 62 should be re-positioned by 100m, from **High** to **Medium** or **Low** sensitivity habitat.
- To mitigate destruction and disturbance of bat roosts near the mountains in the southern region of Perdekraal during construction and operation of the Perdekraal West WEF, turbine locations 17 and 42 should be re-positioned, respectively, by 200m and 80m from **High** to **Medium-High** sensitivity habitat.
- To mitigate mortality of foraging and potentially migrating Species Group A bats near mountains in the southern region of Perdekraal during operation of the Perdekraal West WEF, turbine operation at locations 15, 16, 18, 19, 23, 24, 28, 29 and 60, and re-positioned locations 17 and 42, should be curtailed at wind speeds under 7.2m/s at 15.6m between 18:00 and 22:00 throughout December and during two nights before and after every Full Moon. This would cause a **<u>VERY SMALL LOSS</u>** in operation time (<324 hours or 3.6% of a maximum 8760 hours / turbine / annum) for only a small proportion (18%) of turbines comprising only the Perdekraal West WEF.
- Implement comprehensive long-term post-construction bat monitoring to inform adaptive mitigation management. The adaptive mitigation management plan would involve successive phases. During each phase, results from the post-construction monitoring should be used to modify (decrease or increase) the cut-in speed and hours of curtailment of selected turbines to minimize bat impacts and maximize energy production. Turbine shut-down would only be recommended where exceptionally high levels of unexpected and unpredictable bat mortality are recorded throughout most of the year.

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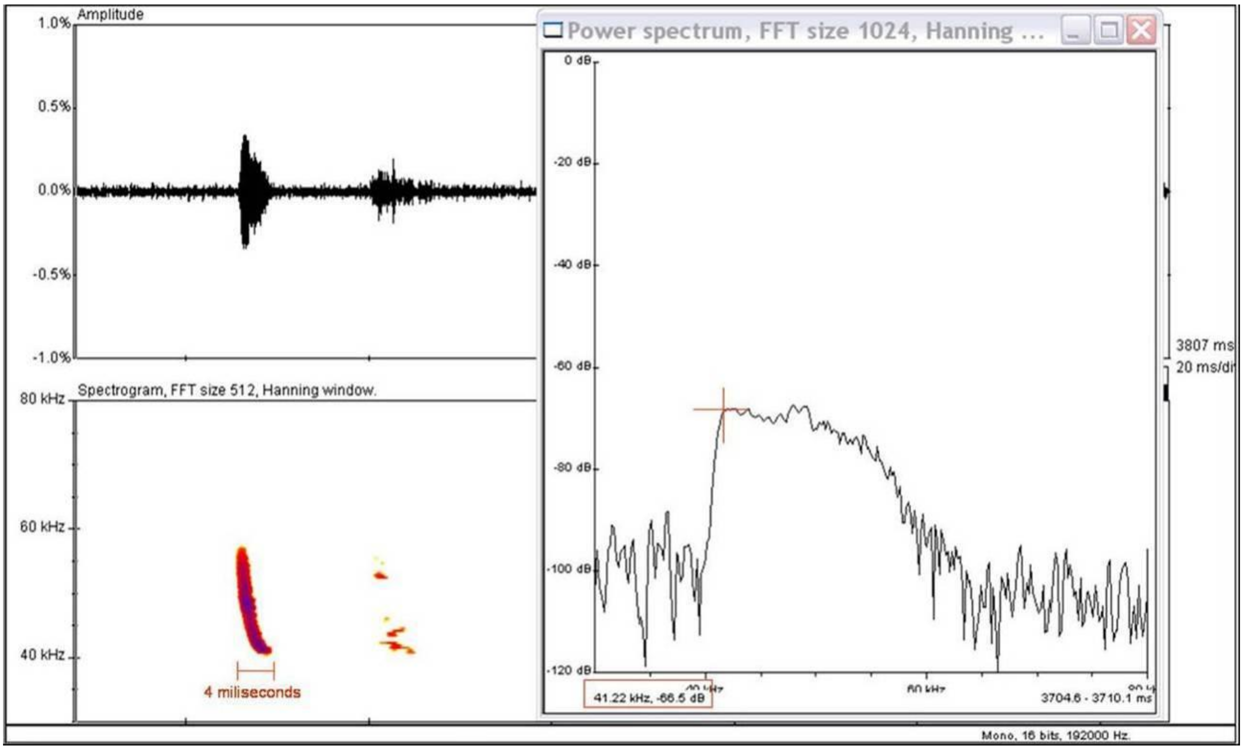
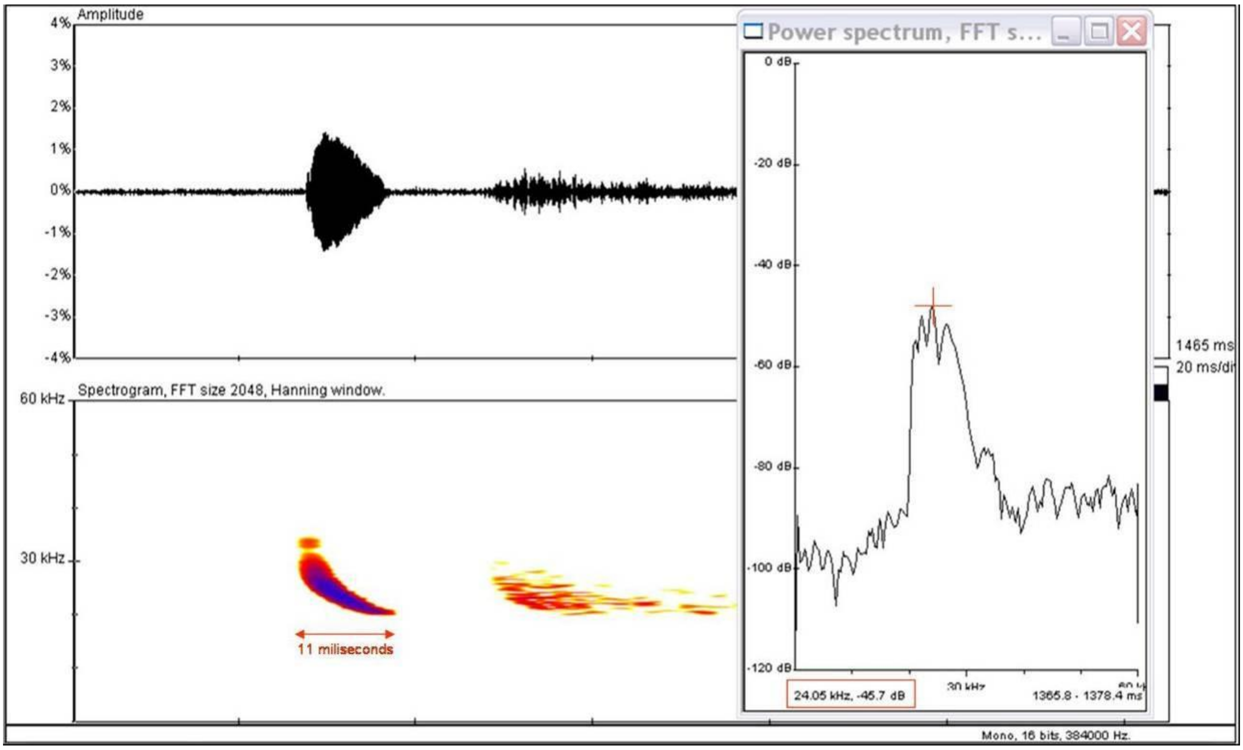
13. Appendices

13.1. Bat calls as seen in BatSound Pro and AnaLook

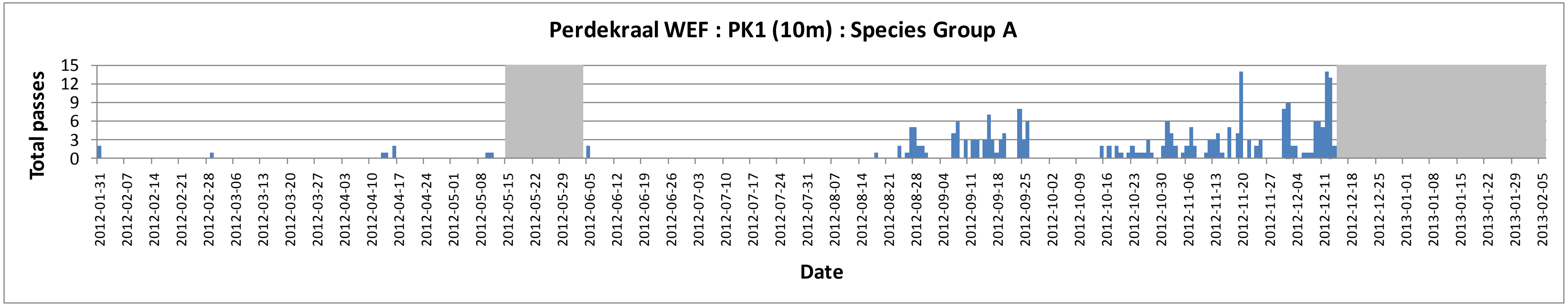


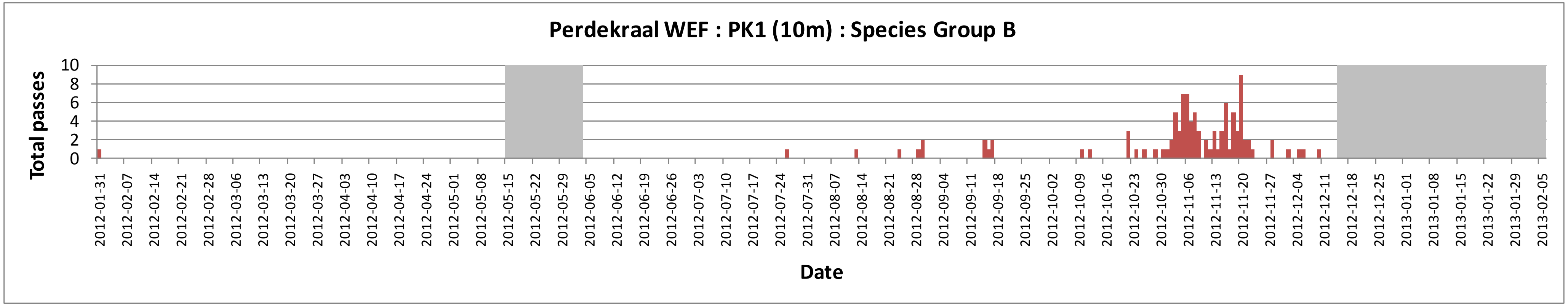
Neoromicia capensis **(Cape Serotine Bat) in BatSound Pro**

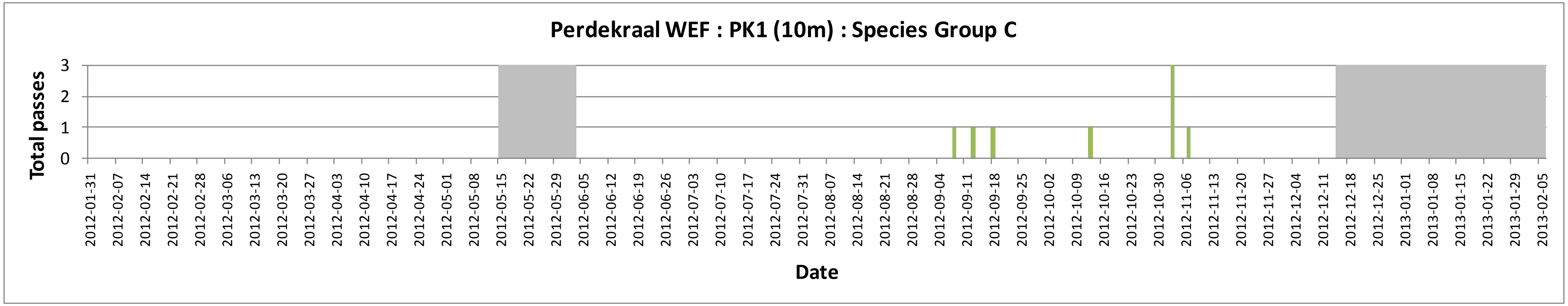


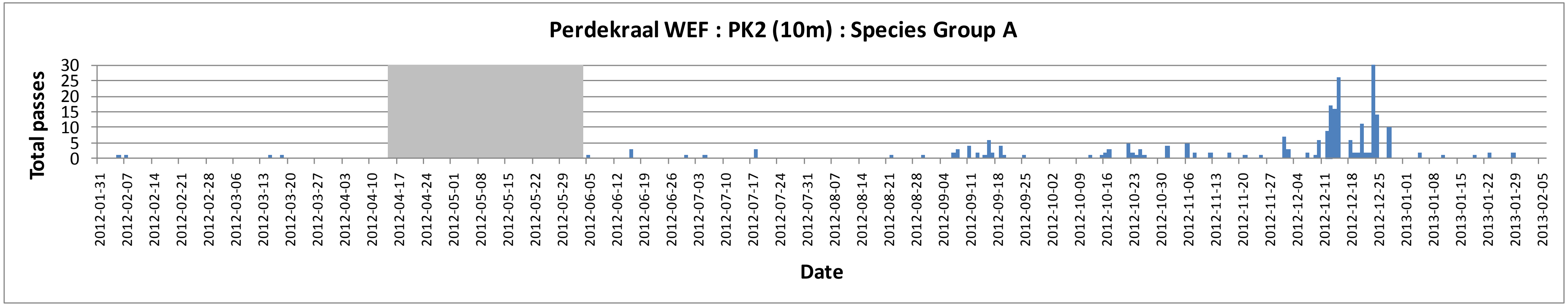
Tadarida aegyptiaca **(Egyptian Free-tailed Bat) in BatSound Pro**

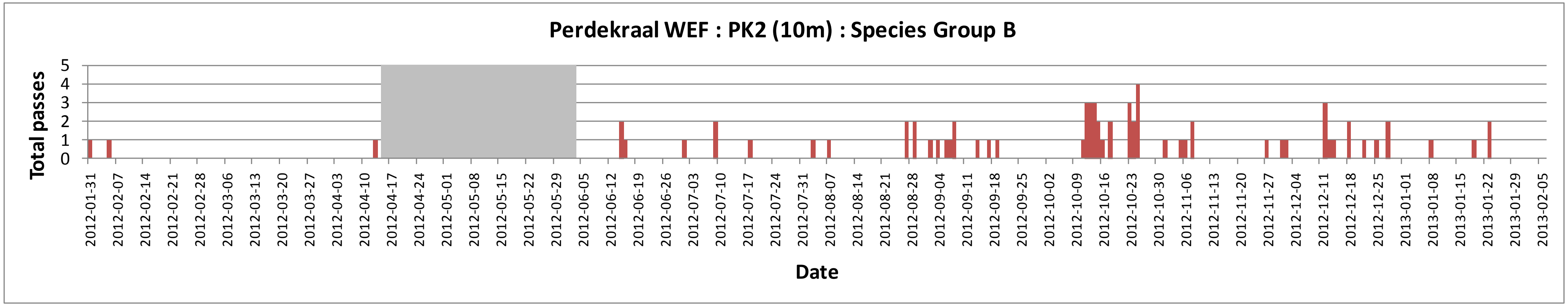
13.2. Activity of each Species Group at each monitoring station during the 12-month monitoring period (■ = no recording).








Perdekraal WEF : PK2 (10m) : Species Group A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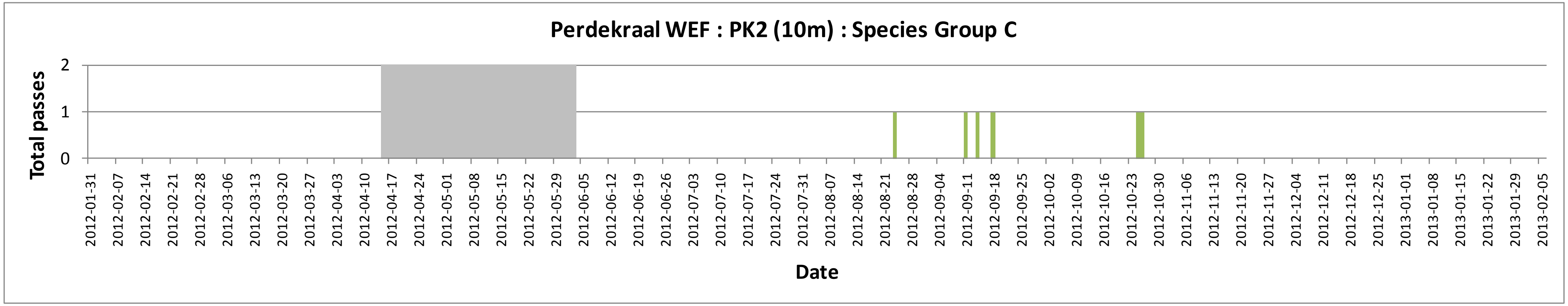
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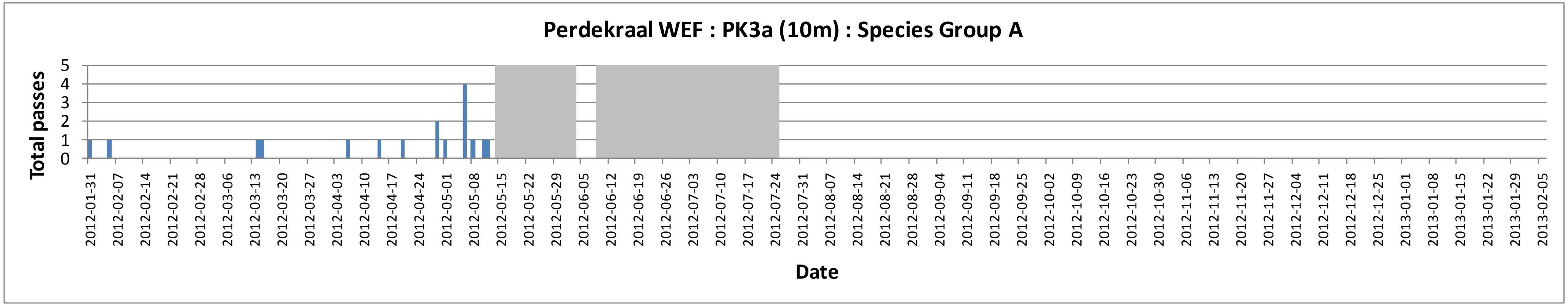
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2
3
4
5
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2012-02-07
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2012-02-21
2012-02-28
2012-03-06
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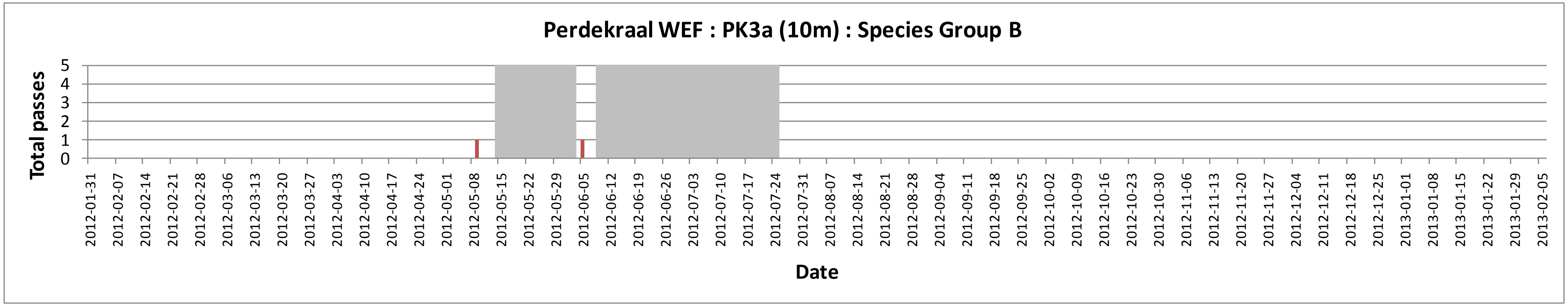
Date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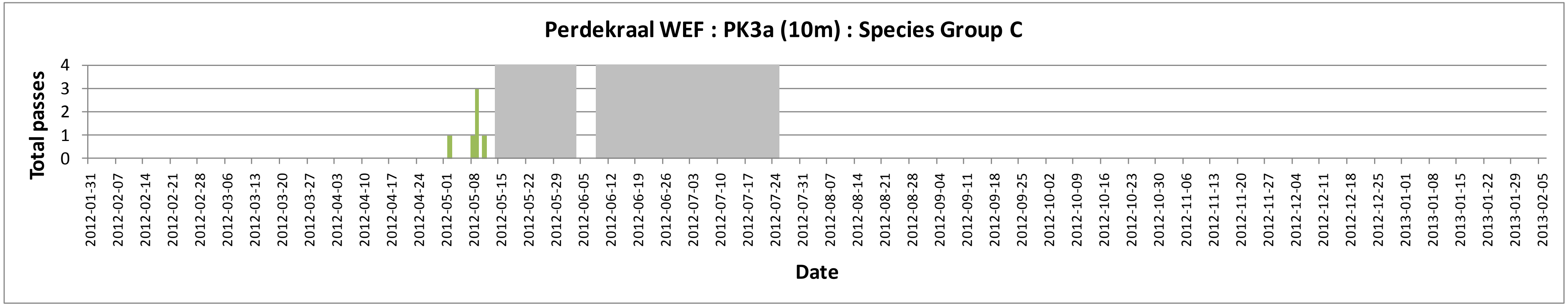
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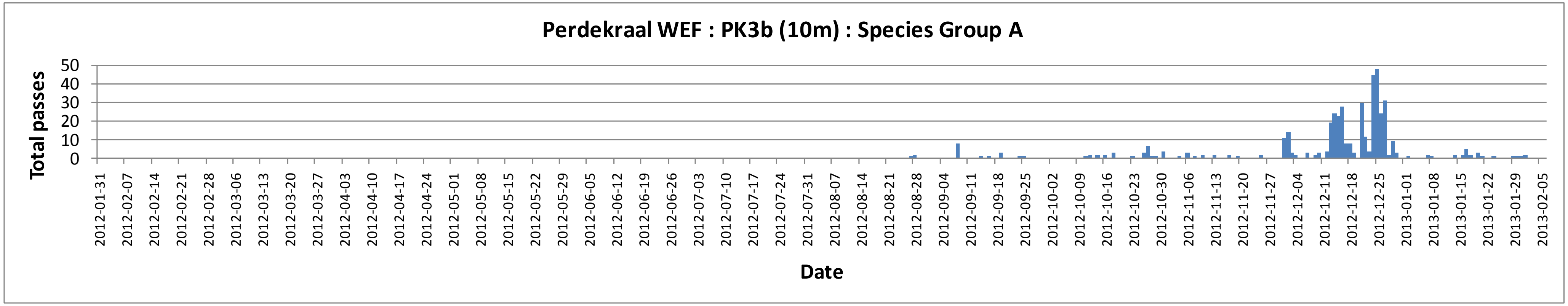
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Total passes
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30
20
10
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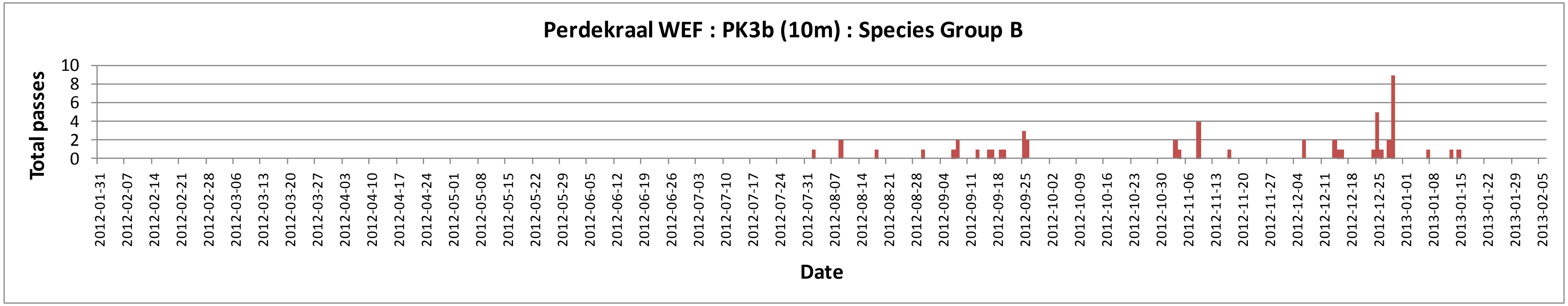
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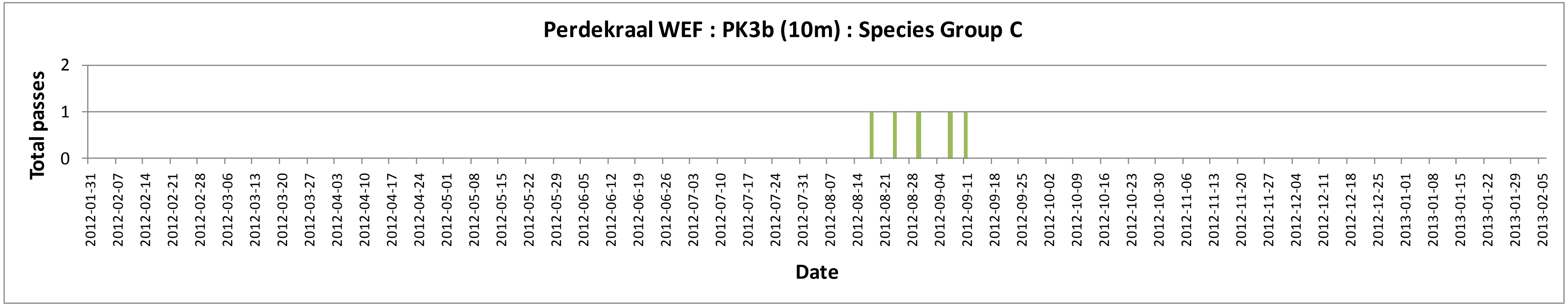
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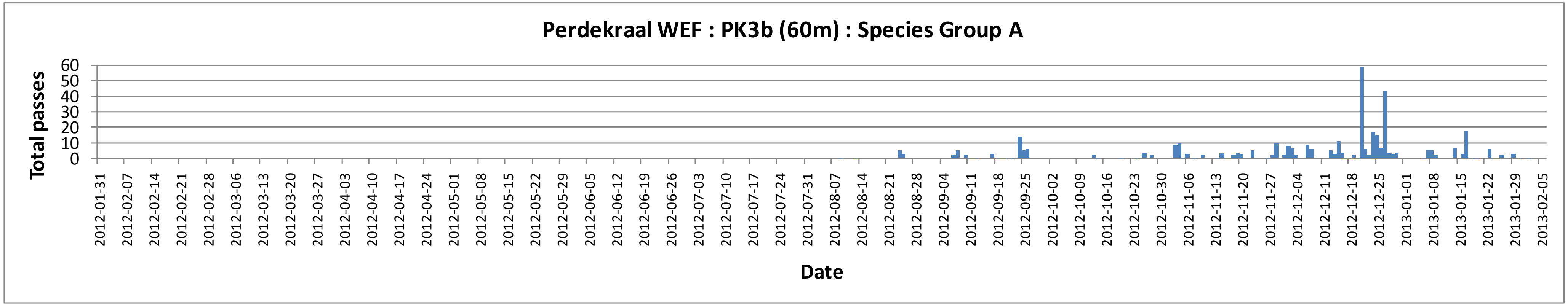
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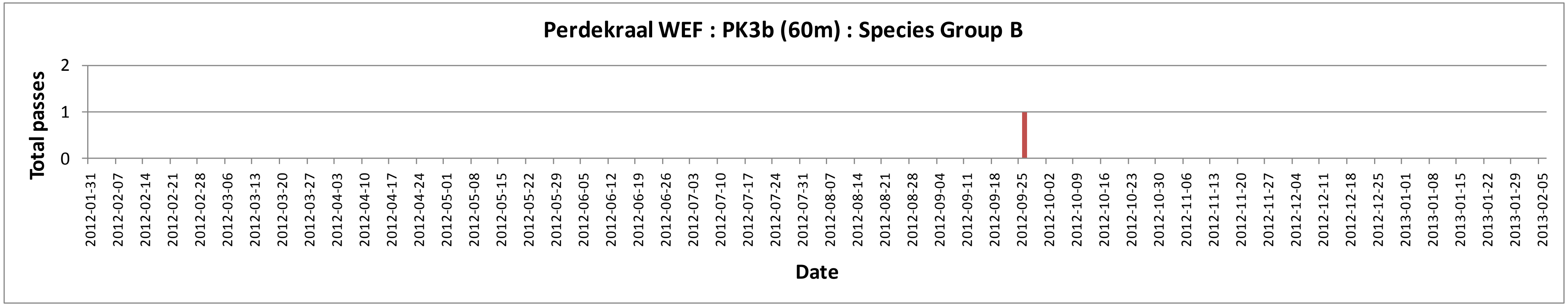
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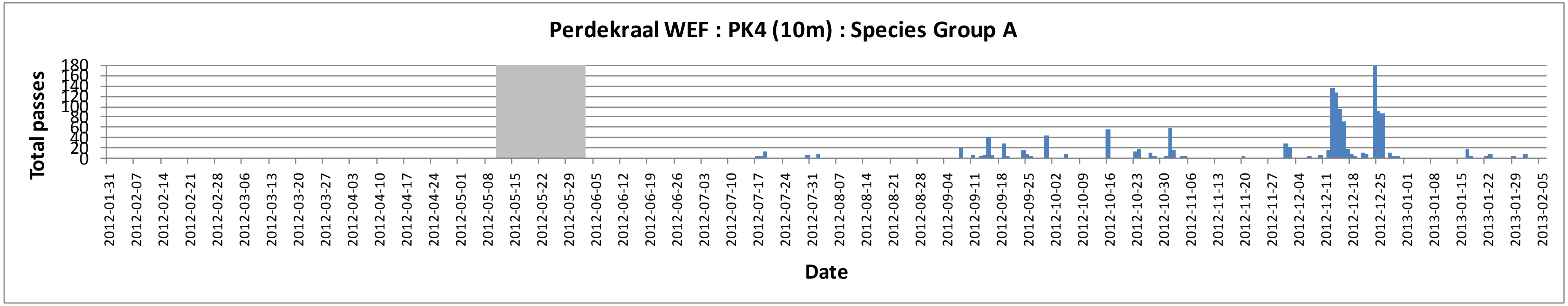
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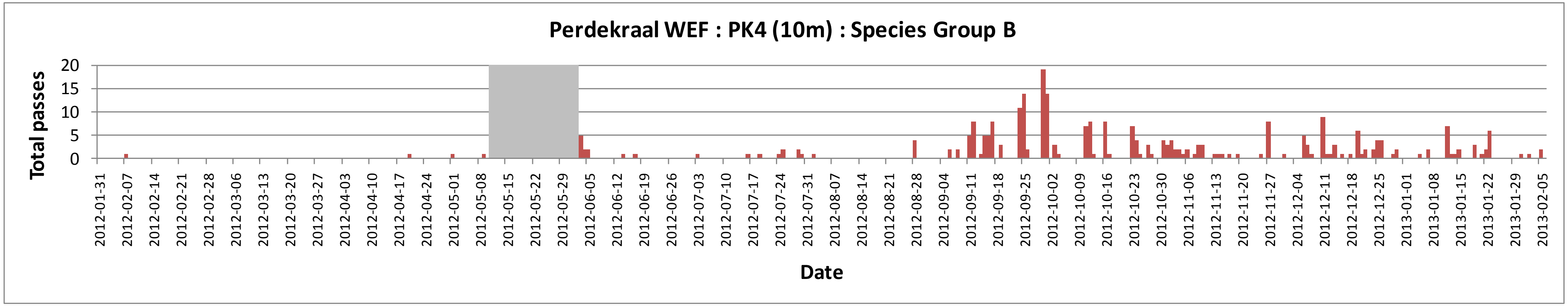
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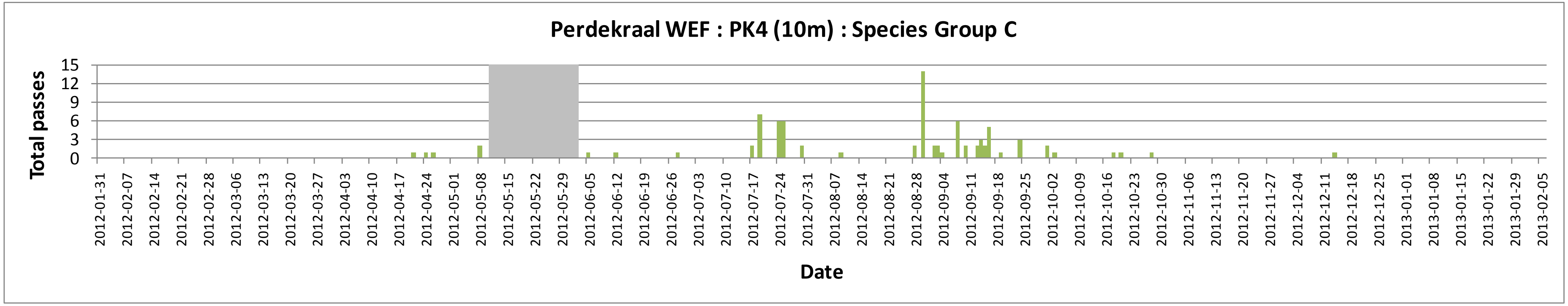
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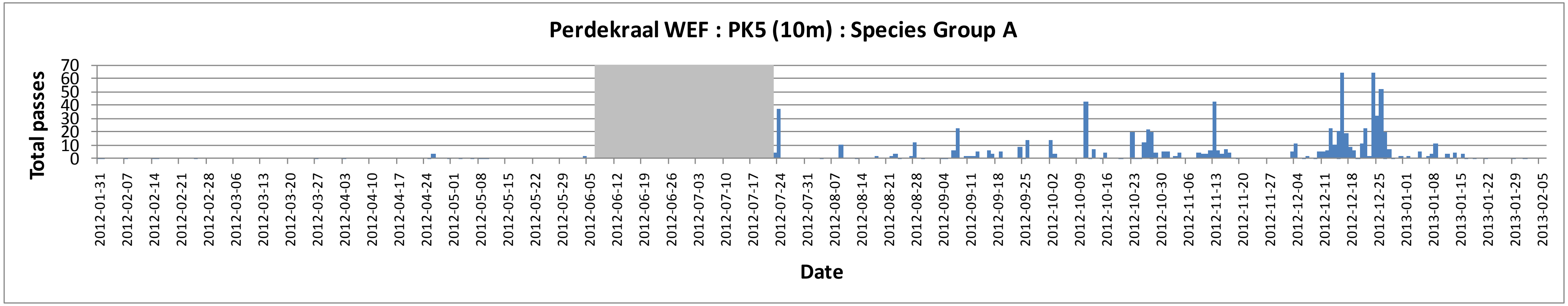
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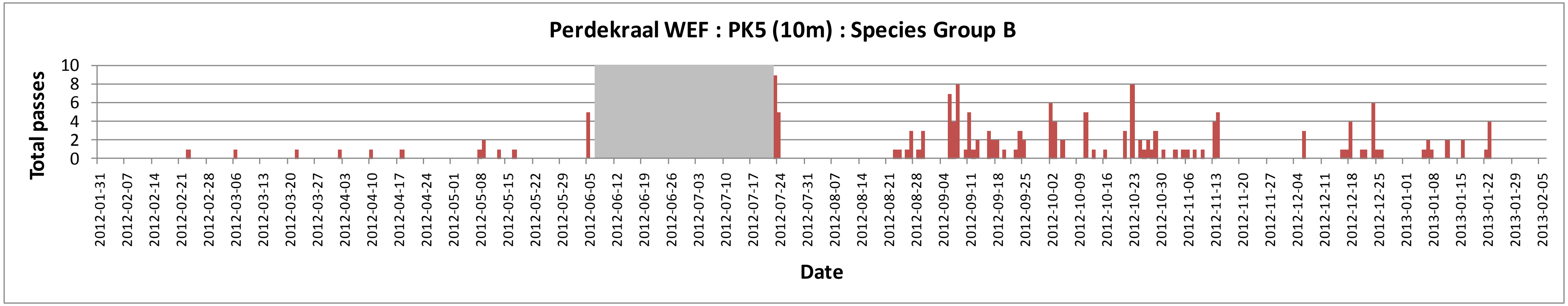
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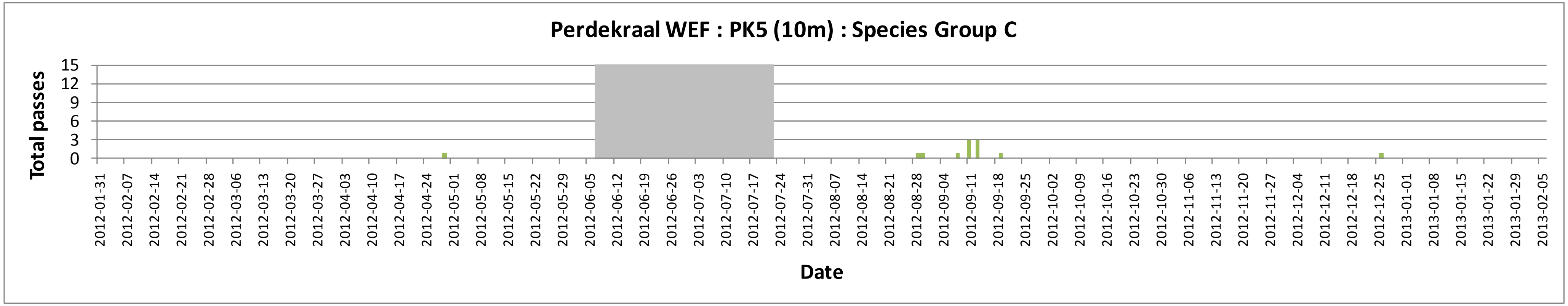
Perdekraal WEF : PK5 (10m) : Species Group C
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2013-01-01
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2013-01-29
2013-02-05
Date

13.3. Weather statistics associated with bat activity at Perdekraal

All bats				
	WIND SPEED [M/S]	TEMPERATURE [°C]	RELATIVE HUMIDITY [%]	PRESSURE [MBAR]
PK1 (10m)				
Mean	5.5	17.8	49.4	936.1
SD	2.4	4.0	18.5	3.3
Min	0.4	7.6	12.9	928.0
Max	11.3	29.7	86.7	944.0
n	234.0	234.0	234.0	234.0
PK2 (10m)				
Mean	5.0	19.9	51.0	936.0
SD	2.3	4.9	20.6	3.3
Min	0.3	7.8	13.8	930.0
Max	10.2	31.2	89.6	946.0
n	190.0	190.0	190.0	190.0
PK3a (10m)				
Mean	3.8	21.1	34.0	935.5
SD	1.7	4.1	17.1	3.0
Min	1.2	13.7	14.1	930.0
Max	6.9	29.5	80.9	943.0
n	22.0	22.0	22.0	22.0
PK3b (10m)				
Mean	4.7	21.3	53.2	934.8
SD	2.1	4.2	19.8	2.8
Min	0.3	11.9	12.8	929.0
Max	11.8	32.8	91.4	944.0
n	236.0	236.0	236.0	236.0
PK3b (60m)				
Mean	4.7	20.5	50.0	934.7
SD	2.6	4.9	17.9	2.8
Min	0.1	7.0	14.3	928.0
Max	15.4	31.9	89.2	944.0
n	198.0	198.0	198.0	198.0
PK4 (10m)				
Mean	4.6	20.3	45.5	936.0
SD	2.4	5.2	18.8	3.9
Min	0.5	9.5	7.4	929.0
Max	12.5	33.0	94.2	949.0
n	372.0	372.0	372.0	372.0
PK5 (10m)				
Mean	4.6	16.5	46.2	937.6
SD	2.1	3.8	18.0	3.5
Min	0.8	7.0	13.2	930.0
Max	10.5	26.4	92.4	945.0
n	198.0	198.0	198.0	198.0

SPECIES GROUP A	WIND SPEED [M/S]	TEMPERATURE [°C]	RELATIVE HUMIDITY [%]	PRESSURE [MBAR]
PK1 (10m)				
Mean	5.6	18.4	49.3	936.0
SD	2.3	4.1	19.5	3.3
Min	0.4	7.6	12.9	928.0
Max	11.3	29.7	86.7	944.0
n	163.0	163.0	163.0	163.0
PK2 (10m)				
Mean	4.8	20.7	53.2	935.7
SD	2.4	4.5	21.0	3.0
Min	0.3	10.7	14.5	931.0
Max	10.2	31.2	89.6	943.0
n	129.0	129.0	129.0	129.0
PK3a (10m)				
Mean	4.3	21.9	38.1	935.2
SD	1.6	4.4	17.4	3.5
Min	2.0	14.9	17.2	930.0
Max	6.9	29.5	80.9	943.0
n	14.0	14.0	14.0	14.0
PK3b (10m)				
Mean	4.7	21.7	55.8	934.8
SD	2.1	4.0	19.5	2.8
Min	0.9	11.9	12.8	929.0
Max	11.8	32.8	91.4	944.0
n	199.0	199.0	199.0	199.0
PK3b (60m)				
Mean	4.7	20.5	50.0	934.7
SD	2.6	4.9	17.9	2.8
Min	0.1	7.0	14.3	928.0
Max	15.4	31.9	89.2	944.0
n	197.0	197.0	197.0	197.0
PK4 (10m)				
Mean	5.1	20.9	51.6	935.7
SD	2.3	4.1	20.8	3.2
Min	0.8	9.8	12.6	929.0
Max	12.5	33.0	94.2	948.0
n	477.0	477.0	477.0	477.0
PK5 (10m)				
Mean	4.6	20.1	51.0	935.8
SD	2.1	4.7	18.6	3.3
Min	0.9	7.0	13.2	929.0
Max	12.7	31.4	92.4	945.0
n	369.0	369.0	369.0	369.0

SPECIES GROUP B				
	WIND SPEED [M/S]	TEMPERATURE [°C]	RELATIVE HUMIDITY [%]	PRESSURE [MBAR]
PK1 (10m)				
Mean	5.3	16.7	48.7	936.1
SD	2.6	3.6	16.4	3.3
Min	1.1	10.0	15.7	930.0
Max	11.1	24.9	86.1	944.0
n	68.0	68.0	68.0	68.0
PK2 (10m)				
Mean	5.5	19.0	45.0	936.5
SD	1.8	5.7	19.3	3.7
Min	0.7	7.8	13.8	930.0
Max	9.4	31.2	81.2	946.0
n	60.0	60.0	60.0	60.0
PK3a (10m)				
Mean	3.3	18.3	35.9	935.5
SD	1.9	6.4	30.8	0.7
Min	1.9	13.7	14.1	935.0
Max	4.7	22.8	57.6	936.0
n	2.0	2.0	2.0	2.0
PK3b (10m)				
Mean	4.5	20.3	41.3	934.8
SD	1.9	4.5	17.1	2.6
Min	0.3	12.7	13.4	930.0
Max	8.9	30.4	79.6	943.0
n	35.0	35.0	35.0	35.0
PK3b (60m)				
Mean	3.2	13.3	50.6	930.0
SD				
Min				
Max				
n	1.0	1.0	1.0	1.0
PK4 (10m)				
Mean	5.2	20.8	38.8	936.7
SD	2.2	4.5	15.7	3.7
Min	0.5	10.6	12.7	930.0
Max	10.7	32.8	92.9	949.0
n	177.0	177.0	177.0	177.0
PK5 (10m)				
Mean	4.7	18.7	43.9	937.0
SD	1.8	4.9	17.1	3.3
Min	1.0	9.3	13.4	930.0
Max	9.1	32.5	85.4	945.0
n	115.0	115.0	115.0	115.0

SPECIES GROUP C

	WIND SPEED [M/S]	TEMPERATURE [°C]	RELATIVE HUMIDITY [%]	PRESSURE [MBAR]
PK1 (10m)				
Mean	4.1	14.6	55.4	937.7
SD	2.3	2.9	19.4	4.2
Min	1.3	10.6	33.1	933.0
Max	7.2	18.6	81.2	943.0
n	6.0	6.0	6.0	6.0
PK2 (10m)				
Mean	5.4	14.7	49.1	937.3
SD	1.9	2.1	14.9	4.3
Min	2.7	11.5	29.6	933.0
Max	7.8	17.6	62.9	945.0
n	6.0	6.0	6.0	6.0
PK3a (10m)				
Mean	2.7	20.1	23.6	936.2
SD	1.6	2.3	8.7	2.0
Min	1.2	15.6	14.6	934.0
Max	5.4	21.6	35.2	940.0
n	6.0	6.0	6.0	6.0
PK3b (10m)				
Mean	4.0	15.9	34.9	935.8
SD	2.0	1.5	6.3	2.6
Min	0.6	13.9	26.3	933.0
Max	5.9	17.6	43.1	939.0
n	5.0	5.0	5.0	5.0
PK3b (60m)				
Mean				
SD				
Min				
Max				
n				
PK4 (10m)				
Mean	4.5	15.4	42.4	938.7
SD	2.6	4.0	17.7	4.4
Min	1.2	9.5	7.4	933.0
Max	10.1	26.4	86.0	948.0
n	50.0	50.0	50.0	50.0
PK5 (10m)				
Mean	3.9	15.1	48.9	937.6
SD	2.0	4.1	15.0	4.9
Min	0.8	11.1	24.4	930.0
Max	8.7	25.0	69.5	945.0
n	11.0	11.0	11.0	11.0

13.4. Minutes of the first South African Bats and Wind Energy Mitigation Workshop (next page)

WORKSHOP MINUTES

FIRST SOUTH AFRICAN BATS & WIND ENERGY MITIGATION WORKSHOP

1 October 2012

Hosted by:

Natural Scientific Services

NSS

126 Ballyclare Drive
Morningside
Sandton
2196
Johannesburg

Tel: (011) 787-7400
Fax: (011) 784-7599

All pictures taken by NSS

TABLE OF CONTENTS

MINUTES AND NOTES FROM THE FIRST SOUTH AFRICAN BATS & WIND ENERGY MITIGATION WORKSHOP

Held on the 1st October 2012 at the WITS Campus
(Olive and Plate Conference Venue)

1 ATTENDANCE REGISTER

REF	NAME	ORGANISATION	E-MAIL & TELEPHONE NO.
ATTENDEES			
KM	Kate MacEwan	Natural Scientific Services / GNorBIG / WITS University	T:079 175 1758 E: kate@nss-sa.co.za
MB	Megan Baumgartner	Natural Scientific Services	T: 011 787 7400 E:megan@nss-sa.co.za
CY	Caroline Yetman	Natural Scientific Services	T: 011 787 7400 E: caroline@nss-sa.co.za
MP	Mike Pierce	Natural Scientific Services	T: 082 661 5150 E: mikepierce.86@gmail.com
TM	Trevor Morgan	Natural Scientific Services / GNorBIG	T:011 787 7400 E: trevor@nss-sa.co.za
KR	Kate Richardson	Bats KwaZulu Natal	T: 082 559 7681 E: ejrichardson@worldowine.co.za
WW	Wendy White	Bats KwaZulu Natal	T: 083 226 2772 E: wendywhite@telkomsa.net
ES	Ernest Seamark	African Bats	T: 082 335 6879 E: ernest.seamark@africanbats.org

REF	NAME	ORGANISATION	E-MAIL & TELEPHONE NO.
TT	Tiffany Thwaits	Nelson Mandela Metropolitan University	T: 082 459 9682 E: s209025810@live.nmmu.ac.za
RK	Robyn Kadis	Savannah	T: 072 999 8581 E: robyn@savannahsa.com
BM	Bárbara Monteirp	Savannah / Bio3	T: 083 207 2393 E: barbara.monteiro@bio3.pt
JA	Joel Avni	Bird’s-eye View	T: 021 783 2079 / 079 403 8969 E: office@beview.co.za
LC	Lientjie Cohen	Mpumalanga Tourism and Parks Agency	T: 083 309 3283 E: lientjiec@mweb.co.za
WM	Werner Marais	Animalia / Gauteng Bat Interest Group	T: 078 190 3316 E: werner@animalia-consult.co.za
JonA	Jonathan Aronson	Gaia Environmental Services	T: 079 932 8840 E: jonathan.aronson@gaiaenvironmental.co.za
MD	Megan Diamond	Endangered Wildlife Trust	T: 011 372 3600 E: megand@ewt.org.za
KP	Kath Potgieter	Endangered Wildlife Trust	T: 082 336 2632 E: kathp@ewt.org.za
MK	Mark Keith	WITS University	T: 083 649 1093 E: mark.keith@wits.ac.za

APOLOGIES

Alan Southwood	Eastern Cape Environmental Affairs
Andre Fourie	Fourie, de Villiers & Associates
Coral Birss	Cape Nature
Corrie Schoeman	UKZN
David Jacobs	University of Cape Town
Dean Peinke	Eastern Cape Parks and Tourism Agency
Felecity Eliott	KZN Ezemvelo Wildlife
James Harrison	JAH
John Power	NW Parks
Julio Balona	GNorBIG

REF	NAME	ORGANISATION	E-MAIL & TELEPHONE NO.
	Leigh Richards	Durban Museum	
	Marienne de Villiers	MAD Ventures	
	Peter Taylor	University of Venda	
	Samantha Stoffberg	BAWESG	
	Sandy Sowler	Training Consultant/ BCT	
	Stephanie Dippenaar	Independent Consultant	

2 OBJECTIVES OF WORKSHOP

An interactive workshop to:

- Review bat monitoring progress to date
- Ensure results are presented in a comparable manner
- Can pre-construction activity surveys be used to predict post-construction fatalities?
- Decide on a united approach towards mitigation measures
- Formulate ways to get the buy in of government and developers

3 AGENDA

TIME	DISCUSSION POINT	PARTICIPANT INVOLVEMENT
09h00	*Arrival*	
09h45	Welcome & Introductions	Kate MacEwan to lead but all to participate
10h10	Brief overview of bat monitoring in SA and internationally	Kate MacEwan & Megan Diamond
10h50	Feedback on the implementation of the guidelines	Megan Diamond to lead discussions but all to participate
11h30	*Tea Break*	
11h50	What are we as specialist consultants on projects finding - results from various parts of the country.	Kate MacEwan Jonathan Aronson Kath Potgieter Robyn Kadis Werner Marais
12:20	How do these results compare with sites in the USA, Canada, Australia and Europe?	Kate MacEwan to lead discussions but all to participate
13h30	*Lunch*	
14h00	What are we proposing as mitigation measures to date?	All
14h30	What measures are being proposed internationally?	Kate MacEwan to lead discussions but all to participate
15h10	Development of thresholds and buffers for bats in SA - is this possible?	All
16h00	Summary of decisions reached and our approach going forward.	Kate MacEwan to lead discussions but all to participate
16h30	*Workshop Close*	

4 WELCOME AND INTRODUCTION

Kate MacEwan (KM) welcomed everyone to the workshop and apologised for people who could not be present. **KM** noted that it was unfortunate that only the only government organisation represented was Mpumalanga Tourism and Parks Agency.

Everyone present had a turn to introduce themselves to the group before **KM** continued with the presentation.

5 PURPOSE OF WORKSHOP

The purpose for the workshop is to enable specialists to be proactive in determining the best mitigation measures for protecting bat populations with regards to wind energy in South Africa, through a scientific, yet realistic approach. It is important that the South Africa gets this issue right from the start.

Specialists have been fortunate enough to have the EWT guidelines for long term bat monitoring as a guidance tool, with the main purpose of the workshop being to take the guidelines to next level, so that the effective and practical mitigation measures are implemented.

6 BRIEF OVERVIEW OF BAT MONITORING IN SOUTH AFRICA AND INTERNATIONALLY

KM and **Megan Diamond (MD)** presented a brief overview of bat monitoring and the relevant guidelines in South Africa. **MD** presented EWT's involvement with developing the long-term monitoring guidelines as well as the recent changes the guidelines since their conception. The history of the SA guidelines is as follows:

- 2010: EWT initiated discussions
- March 2011: EWT issued a position statement on bat and bird impacts in relation to wind turbines
- April 2011: 1st draft of the South African Good Practice Guidelines for Surveying Bats in Wind Farm Developments (Sowler & Stoffberg, 2011).
- December 2011: 2nd draft of the South African Good Practice Guidelines for Surveying Bats in Wind Farm Developments (Sowler & Stoffberg, 2011).
- January 2012: Bats & Wind Energy and Anabat Training Workshop in the Western Cape
- May 2012: 3rd draft of the South African Good Practice Guidelines for Surveying Bats in Wind Farm Developments (Sowler & Stoffberg, 2011) (hereafter referred to as "the guidelines). The three key changes to the 3rd draft are as follows:
  - Only one year of pre-construction monitoring required, not one year in Scoping Phase and another year in the EIA Phase.
  - Ground level manual surveys (transects) to be performed twice in each of the four main seasons.
  - Because turbine layouts are often uncertain, the entire project footprint is to be monitored effectively.

Important points from **MD** presentation:

- "Location, location, location" is the way in which specialist need to approach impacts to birds and bats.
- Cannot be too reactive in approach meaning specialists can't wait for turbines to go up before being proactive in determining where these windfarms should be established.
- Sites have already been selected based on wind regimes and specialists must now get involved through pre-construction monitoring to determine what the impacts of these windfarms are going to be.
- Possibility to convince developers to do their wind studies and pre-construction monitoring at the same time to indicate at an early stage whether the site is not preferable for bats (and birds).

7 FEEDBACK ON THE IMPLEMENTATION OF THE EWT GUIDELINES

MD presented the feedback that EWT and specialists have received regarding the guidelines. These have been summarised as follows:

- From the Wind Energy Industry:
    - Question regarding confidence in surveyor experience.
    - Can guidelines provide range in bat detectors used?
    - Mitigation measures considered to be ultraconservative due to lack of knowledge about South African bats and what height the bats are truly flying at.
    - Getting relaible knowledge from monitoring regarding bat passes. Bat Passes representing a single bat flying past a number of times, or many bats?
    - Increasing cut-in speeds is a drastic step and should only be used if the need is identified.
    - Disparity in quotations.
- From Specialists
    - Obvious difference in quoting and quality of work
    - Who purchases the detectors – specialist or client?
    - How much monitoring is enough?
    - Recommending mitigation is difficult
    - Cumulative impacts and how to address these
    - Mist Netting, is this advisable?
- From Department of Environmental Affairs:
    - Minimum standards or terms of reference for specialist impact assessment
    - Recommended conditions of authorisation

7.1 Discussion on the implementation of the guidelines

7.1.1 Poor placement of windfarms

Wendy White (WW) began the discussion by indicating that some municipalities are placing windfarms in areas that have insufficient wind. **MD** agreed with **WW** and said that it is an issue and municipalities are using the windfarms as “window dressing”. Everyone agreed that it is unnecessary and something that needs to be looked at by governent departments.

7.1.2 Inexperience / bad practice

Joel Avni (JA) raised a concern about unexperienced specialists winning tenders by competing with lower costs. He is concerned because the guidelines leave too much to interpretation and therefore, the lowest common denominator is becoming standard practice. **JA** has seen this change over the past year. Requested that specialists complete their work in a similar manner so that studies can be compared to eachother.

Examples of bad practice brought forward by attendees were:

- placing too few detectors on site
- placing detectors on ground level only and not at height
- placing detectors to run during the day
- moving static detectors during the monitoring period

JA mentioned that there are activists that are proactive in appealing the proposed wind farm developments (mentioned a Sunday Times article in late September) and it is therefore important for specialists to standardise their approach and mitigation measures, so that the bat community can stand together on this matter.

7.1.3 Monitoring at height

JA indicated that in the US studies are showing the low frequency migrating bats are most at risk. He indicated that there is an order of magnitude difference from 10m to 52m, getting 10 times more calls from low frequency bats at 52m.

Mike Pierce (MP) suggested that monitoring at height should be a set requirement as the data between canopy level and at height (50-60m) differs considerably, as well as the impacts are occuring at height, not at ground level.

Jonathan Aronson (JonA) commented that the problem is the cost. It costs a lot more to monitor at height. **JA** mentioned that one cannot gather the valuable data without spending that cost, and that is why it needs to be come standardised.

JonA suggested that monitoring at height should become a minimum standard. The guideline need to change from a “suggestion” to a requirement.

KM commented that all onsite met masts should be used for monitoring at height. **JA** commented that he is now recommending that developers place pulleys on non-latice met masts so that microphones can be hoisted and attached through the use of a pulley system. **KM** commented that it is better to climb the met masts so the the microphone and cable can be secured the entire length, to prevent unneccessary noise recordings due cables hitting the pole in high wind conditions.

Werner Marais (WM) indicated the importance of monitoring at canopy level and at height at the met mast, Indicating that the differences in the activity can show that bats are not within the zone of impact. **KM** included that it is all dependent on the size of the turbine and the sweep of the blade. Some blade sweeps are going as low as 30m from the ground, indicating that bats recorded at 10m will most likely be impacted on.

JonA also commented that turbines are now getting taller and that specialists should make project specific decisions regarding the height of the nacelle monitoring dependent on the height of the nacelle.

Bárbara Monteirp (BM) indicated that it’s difficult to know what height the microphones should be placed at because there isn’t enough literature on the ecology and behaviour of SA migratory bats.

WM indicated that migratory bats may not even be echolocating while migrating. **JonA** agreed with this. **KM** also added that NSS’s results were showing long spaces between call pulses for Molissid bats flying at height.

It was then agreed by all attendees that two (2) heights should be used for the long-term monitoring at the met mast:

- For recording ground and canopy height – 10m.
- For height monitoring - a minimum 55m, but Nacelle height is preferable.

7.1.4 Fruitbats

MP and **Kate Richardson (KR)** brought up the discussion that static acoustic monitoring excludes non-echolocating fruit bats. Fruit bats contribute massively to forest eco-systems and pollination of crops. Fruit bats could be wiped out and this could affect the whole of the east coast of Africa.

It was then decided that mist netting is very important to determine the presence of fruitbats. Roost surveys should also be more intensive should fruitbats have the potential to occur onsite.

7.1.5 Mist netting is importent in monitoring surveys

KR indicated that mist netting is ground truthing the data recorded on by the detectors as the bat call identification isn’t always 100% accurate. **Ernest Seamark (ES)** indicated from his experience that acoustic monitoring had a 70% error. **ES** recommends mist netting for all surveys to get an accurate picture of what is happening onsite.

KM and **WM** indicated that mist netting isn’t always possible, but should be done at all site where it is possible.

7.1.6 Mist netting qualifications

KR raised the concern about people needing to be qualified in mist netting and harp trapping techniques. Inexperienced people will harm the bats. **JA** mentioned that he will not sell mist nets or any form of trap to someone who hasn't got a permit. It was agreed that mist netting should only be conducted if the specialist has a permit and has experience in handling bats.

7.1.7 Qualified specialists

MD indicated that for the bird specialists, they have compiled a list of qualified specialists that is used by the developers and authorities as part of the minimum standards. It is possible to compile a list of qualified bat specialists in the same manner. There are flaws with this approach, as it is not EWT's responsibility to regulate the specialists.

7.1.8 Density of detectors

KM asked the question of how many detectors is sufficient? **KM** recommended that there should be enough to cover habitat types and enough to cover the four cardinal directions. She also indicated that detectors should not move throughout the year, as it will scew the change in seasonal activity.

JA indicated that overseas studies use more detectors than SA studies, in some cases a detector per turbine. As mentioned before, guidelines should stipulate a minimum number of detectors according to area.

KM indicated that for a string of turbines (linear), 2kms should be the maximum distance between detectors.

Megan Baumgartner (MA) and **ES** agreed to look at the best density for an SA context based on experience and other guidelines. The first version of the detector density table available for comment has been included in **Appendix A.** The table in **Appendix A,** has been calculated based on current practise in SA, international practise, financial and practical considerations and professional judgement. It is a guideline, site specific considerations must still be taken into consideration by the specialist.

7.1.9 Running time of detectors

KM raised and all agreed that the current guideline statement: "data should be collected for 15-25% of one year (spread evenly throughout the year) and should include the spring/autumn migration period" is not sufficient and that increased effort is required, especially considering the gaps in bat activity patterns in South Africa. The agreement reached during the workshop and in comments following from the draft workshop minutes is that the following monitoring effort should be aimed for (with the understanding that due to certain limitations, there may be gaps):

- In summer, data to be collected 75% of the season
- In Autumn, data to be collected 100% of the season
- In Winter, data to be collected 50% of the season
- In Spring, data to be collected 100% of the season

Ideally static detectors should remain in the same localties during the 12 month monitoring period.

7.1.10 Type of dectectors and conversion method

JA brought up the topic that different types of detectors have different results. The two main types of detectors are the Wildlife Acoustics SM2 and the Anabat SD2. The majority of specialists at the workshop indicated that the SM2 was the better product due to the omni-directional microphones, good customer service and cost.

It was recommended that a list of detectors not be included in the guidelines, as better technology will come out in the furture.

It was agreed that the new Kaleidoscope sound file conversion program should be used instead of WAC2WAV method.

NB: SM2 detectors cannot pick up all frequencies on both channels. This must be taken into account when placing microphones at height. Two detectors may be required at one station, if high frequency bat species have a high likelyhood of occurance on site.

7.1.11 Other technologies

WW indicated that key developers should come together to provide the funds for thermal imagery and a Merlin radar studies. **JA** indicated that he will be brining in modified yatch radars for specialists to hire as well as thermal imagery. **KM** indicated that thermal imagery will be more useful for post-construction monitoring.

8 WHAT ARE WE AS SPECIALIST CONSULTANTS ON PROJECTS FINDING - RESULTS FROM VARIOUS PARTS OF THE COUNTRY.

8.1.1 Why are losses important

KM continued with presentation. The following points were made on why bat losses are important:

- Loss of Conservation Important Species
  - This is what the authorities usually look at
- Mass loss of migrating bats
- Cumulative affects on total bat populations
- Loss of eco-system services
  - Insect control – pest and vector carrying species
  - Pollination and seed dispersal
  - Economic loss to agricultural industry.

Mark Keith (MK) indicated that specialists should move away from focussing on only Conservation Important species and instead focus on ecosystem services and the total picture. The loss of bats will have an economic impact due to their important ecosystem services. More studies need to be done in this regard. **KM** referred to Peter Taylor's unpublished work.

It was agreed that *Table 1. The likelihood of the risk of fatalities affecting bats, based on broad ecological features, excluding migratory behaviour* of the guidelines should include a coloumn stating the importance of the specific bats species to different ecosystem services, such as agriculture, mosquitos, etc.

Lientjie Cohen (LC) indicated that from a government perspective, they are moving towards a more ecosystem based approach when evaluating EIA documents. It is important that specialists look at these impacts in their reports.

WW indicated that using a small number example for a bat population, eg. 100, assuming 50 males and 50 females, a mortality rate of 20% per year would result in the population becoming exinct after a few years due to the sensitivty of the bat's reproductive cycle. A similar principal could be applied to larger populations, but we don't yet have this science.

8.1.1.1 <u>Control sites</u>

It was indicated that control sites are needed to determine whether there the existing populations are already under stress or not. **KM** indicated that control sites are difficult for large hetrogenous sites. **ES** indicated that protected areas can serve as control sites and it is a project he is about to embark on in Africa. **JonA, WM, WW** and **KM** indicated such data will be useful for natural sites, but also indicated that areas of intesive agriculture are likely to attract bats and that control sites in protected areas may not be a true refelction for all sites. Anyway, the work that **ES** will be doing is going to be into Africa, not necessarily in South Africa.

8.1.2 How can the guidelines become more legalised?

KM asked the question on how can the 12 month monitoring become more enforced prior to the issuing of a Record of Decision. **MD** replied with reference to the bird monitoring guidelines. She indicated that it is unlikely that the government will gazette the guidelines, but they are prepared to attach it to the renewable energy guidelines that they themselves are developing, The monitoring guideline will be appended to support their guidelines, this way it will become a legal document without going through the gazetting process. That is why they need a terms of reference for specialists and a minimum standards. **MD** indicated that it is a long process and won't help specialists now.

MD indicated that now EWT is in contact with the developers and trying to get them to volunteer compliance with the guidelines.

Currently, windfarm operators can get environmental authorisation for a windfarm without 12 month pre-construction monitoring, which is the major problem.

LC recommended that most Provinces have minimum requirements for biodiversity and on a provincial scale, these requirements should be updated to include the guidelines.

8.1.3 How are specialists monitoring and analysising data?

KM expressed the concerns of certain absentee specialists regarding the anlaysis of the data for large sites. This is an issue as there is huge amounts of data produced. **KM** indicated that is important to have a species inventory for each site, however, to get through the huge volumes of data, by grouping species of bats according to their ecology, behaviour, risk levels and conservation status, then specialists should be able to analyse the whole year of data. There will already be gaps in data due to limitations such as birds destroying microphones or equipment theft, specialist should aim at recording and analysing the whole year to pick up any patterns in the bat activity. This also goes back to the guidelines of 15-25% monitoring time not being sufficient.

8.1.4 Difficulties with Roost surveys

WM brought up the topic that it is near impossible to survey all the roosts on and around site. **WM** would like the guidelines to mention habitats that are considered to be prime roosting habitats are to be mapped as sensitive. Identification of roosting habitat will always be done with some of margin of doubt.

8.1.5 Bat passes / unit time?

KM recommends that bat passes over unit time is the best way to interpret the data instead of counting individual pulses. Bat pulse numbers will vary greatly depending on what the bat is doing – feeding, searching, migrating, etc. In the same way, bat pass data can be skewed by a single bat flying past a microphone several times, however, the time interval data can be converted to determine a relative abundance – an approximate number of actual bats. **MP** cited a paper that describes such relative abundance calculations. NSS has done a brief review of methods for calculating bat activity and relative abundance and has made some recommendations (**Appendix D**). For now bat passes per night will be the values used for comparison across the country, but relative abundance important for site specific study output.

WM agreed that the average bat passes per night for a site is a good number to use when comparing sites and other studies. **KM** said that some stations have high numbers and may skew the data, therefore, min and max need to be considered as well in comparison.

Everyone agreed that areas need to be compared to come up with a baseline.

8.1.6 Which areas are showing the highest and lowest activity?

KM indicated from NSS's findings that KZN has the highest bat activity, Southern Cape (coastal) comes in second, with Western, Eastern and Northern Cape (interior) showing the lowest activity to date.

JonA said from their experience in the Overberg (10m monitoring), most agricultural sites have low activity but 1 site has relatively high activity. Natural sites in the Overberg had high activity. On the West Coast, bat activity was much higher at 58m than at 10m in semi-disturbed areas.. **KM** indicated that she is mostly getting more bat activity at the lower microphones than at height, with some exceptions and **WM** agreed with **KM**.

WM shared some of his findings which were done per month. Some of the months were low and some were average.

KM would like to ensure we are analysing the same way so that we can compare results for establishing a baseline knowledge for the country. This will assist in determing higher risk areas and mitigation measures.

9 WHAT ARE WE PROPOSING AS MITIGATION MEASURES TO DATE?

9.1 Can specialist be aiming for zero loss?

KM says that ideally mitigation measures should aim for zero loss, however, this will be very difficult to achieve. Government is pushing for these windfarm developments and specialists are getting resistance in terms of mitigation measures proposed. **JonA** agreed and added that the best mitigation measure is to not put a wind farm where bat activity is high. There are sites that have low bat activity that are suitable for developmen

Data are showing that bats are flying at high wind speeds and achieving zero loss would mean high curtailment cut-in speeds, which isn't feasible. **KM** indicated there is high value in pre-construction monitoring due to the data showing variation in temporal and seasonal activity. There seems to be a strong correlation between wind speed and bat activity, as well as time of the evening. Do specialists recommend high cut-in speeds for only short durations in an even, eg. 2 hours after sunset?

Developers are saying that reducing blade length and having cut-in speeds is not feasible. This is a problem, as it means that specialist can't recommend operational mitigation measures?

Monitoring is important and specialists need to come up with site/ region specific mitigation measures.

Prior to the workshop **KM** had sent an email to both David Jacobs, Associate Professor at the Department of Zoology, University of Cape Town and Robert Barclay, Professor and Department Head of Biological Sciences at the University of Calgary, Canada for their views on bat losses in SA due to Wind Energy Facilities. Their replies can be viewed in **Appendix B**. Pertinent points from their emails are as follows:

- In order to accurately determine acceptable losses, we would need to know population estimates, reproductive rates, mortality rates, etc. Information we don't yet have.
- If we simply assume that bat populations are at best stable (given climate change, habitat loss and disturbance, this seems unlikely to me), then additional mortality from new sources such as turbines, will cause populations to decrease unless reproductive rates increase in response. Given the slow reproductive rate of bats, any response would be slow.
- Therefore, we need to try get as close to losses of 0 as possible.
- There is not a magic number (threshold) of fatalities that is acceptable.
- There are clearly two basic options to deal with potential bat fatalities:
    - do pre-construction surveys and determine where high risk sites are and do not put wind facilities there; or,
    - put them up with the recognition that if fatalities turn out to be "high", mitigation measures, such as changing cut-in speeds or operational shut-down during peak risk times will be necessary and these conditions are thus built in to the development permits.
- There have to be regulations in place.

10 HOW DO THESE RESULTS COMPARE WITH SITES IN THE USA, CANADA, AUSTRALIA AND EUROPE?

KM indicated that in international pre-construction monitoring surveys have the luxury of using post-construction data to compliment their findings and provide more certain measures. Some studies are finding that acoustic monitoring activity data are comparable with fatality data. We don't yet have robust post-construction data in South Africa, therefore need to be preventative and proactive in our approach, We have the opportunity to be proactive from the start. Based on international studies and based on the bat activity levels we are already seeing, fatalities are ineveitable. Unpublished findings from Darling and Coega are showing fatalities of medium to high risk bats.

WM indicated that results from Europe and US mainly focuses on tree dwelling migrating bats that are at risk, looking at peak periods. This is not applicable to SA context, as well find bat activity at height throughout the year. **WM** consideres micro siting according to buffer zones the most affective mitigation.

11 DEVELOPMENT OF MITIGATION TRIGGERS AND BUFFERS FOR BATS IN SA - IS THIS POSSIBLE?

11.1 Biomes and mitigation triggers

KM showed an example of developing standardised mitigation triggers for different areas based on bat passes per night or relative abundance. All were in support of developing some sort of guidance in this area.

ES gave the suggestion that because we are focussing on ecosystem services that specialists should develop thresholds for each biome.

Data from all the specialists active in monitoring will be collected and different ranges in BP/night will be developed for each biome, as baseline data. Mitigation triggers will then be developed for each biome. . NSS, Gaia and Animalia to come up with these measures based on the data collected. **KM** recommended that certain areas, based on their abundance and biodiversity should be made “no-go” areas. All participatnts were in agreement that certain areas within SA will be required to be “no-go” wind turbine areas.

MB to develop spreadsheet for collection of biome specific bat activity data (**Appendix C**).

It is important to note: The mitigation tables developed from these data will be living tables that are updated regularily, as more data are captured. These are simply guidance tables for now, to assist specialists in recommending mitigation measures and for providing some level of understanding of the relative activity at sites in relation to the rest of the country.

11.2 Buffers

KM raised the point regarding establishing standarised suitable buffer zones on key bat habitats. These habitats could be either roosting habitats, foraging habitats, or movement corridors. She gave examples of habitats, inluding but not retricted to the following:

- Rivers
- Open water bodies
- Wetlands
- Ridges and rocky outcrops
- Caves
- Irrigated fields

WM also raised cliff top edges as an area of high bat activity, due to updraft winds and insect accumulation.

Discussions around existing SA and international buffers continued. There is very little guidance on SA buffers and international literature on buffer zones differs considerably. Discussion regarding applicable buffers did not reach concensus. Savannah was then tasked with providing a list of applicable buffer distances from international literature. This will be decided on at a later stage, until then, specialists are to use their discretion based on monitoring results and habitats on site.

11.3 Permits

There was some discussion over permitting a threshold number of fatalities, with penalties or legal action being implemented if thresholds are exceeded. This discussion did not reach any consensus, however some extra post-meeting notes can be found in **Box 1** below.

Box 1: Notes on the Regulation of Bat Fatalities at Wind Energy Facilities

At the Convention on Biodiversity, the world recognized the growing concern for sustainable development, as well as the global value of the world's biodiversity to present and future generations for economic and social development. From this convention the most comprehensive Multilateral Environmental Agreement came into being. This agreement covers all plant and animal species, genetic variability and all ecosystems and is a legally binding international treaty that commits all signatories to its objectives. South Africa is a signatory to this treaty and must uphold the following objectives:

- The Convention of Biological Diversity
- The Sustainable Use of South Africa's Biodiversity
- The Fair and Equitable sharing of benefits arising out of the use of our natural Genetic Resources.

This implies that the State have sovereign rights over South Africa's natural resources. The National Environmental Management: Biodiversity Act 10 of 2004 (NEMBA) provides for the protection of species and ecosystems that warrant national protection and the sustainable use of indigenous biological resources. Provincial permitting also acts towards the regulation of hunting, harvesting of and research on biodiversity.

As there will not be zero loss in bats with the development of wind energy in South Africa, government have the responsibility to regulate losses in bats through either permits, provincial ordinances, management plans and monitoring. Some level of monitoring to ensure license/ permit conditions are being met would need to be for the life of the wind energy facility and not just for the two years post-construction, likened to Water Use License monitoring for mines.

12 SUMMARY OF DECISIONS REACHED AND OUR APPROACH GOING FORWARD.

The following points were agreed upon in the workshop overall:

1. It was agreed by all attendees that two (2) heights should be used for the long-term monitoring at the met mast:
    a. For recording ground and canopy height – 10m.
    b. For height monitoring - a minimum 55m, but Nacelle height is preferable.
2. Where fruit bats are likely, it was decided that mist netting is very important to determine the presence of fruitbats. Roost surveys should also be more intensive should fruitbats have the potential to occur onsite.
3. Mist netting to be employed where possible for all surveys, however, only by experienced bat handlers.
4. Table 1 of the guidelines - *The likelihood of the risk of fatalities affecting bats, based on broad ecological features, excluding migratory behaviour* should include a coloumn stating the ecological and/or economic importance of the specific bats species to different ecosystem services, such as agriculture, mosquitos, etc.
5. List of qualified specialists to be considered by EWT as part of a minimum requirement standard, as has been done for birds.
6. **MB** and **ES** agreed to look at the best density for an SA context based on experience and other guidelines (**Appendix A**).
7. The current guideline statement: “data should be collected for 15-25% of one year (spread evenly throughout the year) and should include the spring/autumn migration period” is not sufficient and that increased effort is required, especially considering the gaps in bat activity patterns in South Africa. The agreement reached during the workshop and in comments following from the draft workshop minutes is that the following monitoring effort should be aimed for (with the understanding that due to certain limitations, there may be gaps):
    - In summer, data to be collected 75% of the season

    - In Autumn, data to be collected 100% of the season
    - In Winter, data to be collected 50% of the season
    - In Spring, data to be collected 100% of the season
8. Wildlife Acoustics’ SM2 detectors are preferable for static monitoring, but not compulsary.
9. Wildlife Acoustics’ Kaleidoscope conversion method to be used so results are comparable.
10. Start with the process of developing minimum standards from guidelines
11. Activity Index and Relative Abundance calulation methodologies to be standarised. **NSS** proposes the method described in **Appendix D** to be agreed upon by key companies conducting the monitoring on acceptance of the workshop minutes.
12. **MB** to develop spreadsheet for collection of activity data (**Appendix C**). Specialists to include data to develop a baseline for Biome specific activity ranges and mitigation triggers. NSS, Gaia and Animalia to initially come up with these triggers based on the data collected to date. This will be a living spreadsheet to be updated regularily as further data becomes available.
13. Savannah was tasked with providing a list of applicable buffer distances from literature.

KM thanked everyone for attending the workshop and closed the meeting.

Appendix A: No. of Static Bat Monitoring Stations/ Microphones per Area

km²	ha	Ground / Canopy (10m)	Height** (Met Mast 10 & minimum 55m)	Total
0-5	0-500	1	1	2
10	1000	2	1	3
15	1500	3	1	4
25	2500	4	1	5
35	3500	6	1	7
45	4500	7	1	8
55	5500	8	1	9
65	6500	9	1	10
75	7500	10	1	11
85	8500	11	1	12
95	9500	12	1	13
100	10000	15	2*	14
150	15000	16	2*	15
200	20000	17	2*	16
250	25000	18	2	20
300	30000	19	2	21
350	35000	20	2	22
400	40000	21	2	23
450	45000	22	2	24
500	50000	25	2	27
600	60000	30	3	33
700	70000	35	3	38
800	80000	40	3	43
900	90000	45	4	49
1000	100000	50	4	54

Notes:

NB	The above table is based on the use of the Wildlife Acoustics SM2BAT ultrasonic bat detector. Should other detectors be employed, that dont have dual channels for two microphones to be employed at two heights, then the numbers above represent the number of detectors with single microphones.
▨	The number of microphones in these areas is minimum, more stations are required should more than one major habitat type be present on site.
**	Single/ mono channel 384kHz SM2BAT setting with one microphone at 55m to be used if high frequency (>96kHz) bats are expected to occur. Dual/ stereo channel 192kHz SM2BAT setting with two microphones at 10m and 55m respectively on the same mast to be used if only low frequency (<96kHz) are expected to occur.
*	Two detectors recording at height are preferable for these site sizes, but one is acceptable.

Appendix B: Responses from two well respected Bat Scientists with regard to bat losses and mitigation measures in South Africa

Question posed by Kate MacEwan on the 31st August 2012:

What are acceptable potential losses of South African bats due to wind turbines?

I would like us as specialists to discuss some of the recommendations that are coming out of the pre-construction bat monitoring. It is vital we are on the same page in terms of the types of recommendations we are making. I realise that each site is site specific, and the findings I am getting to date very much indicate different levels of activity across the country. I also know that all of our findings and recommendations can only be verified post-construction. However, the purpose of conducting the pre-construction monitoring is to come up with starting recommendations for the WEF developments we are working on. Based on these findings, we can determine the potential sensitivity of the site and predict the potential risks to the bats utilizing the site. So, in my mind it is clear that Highly sensitive sites should receive strict mitigation measures. But suppose we have Low to Moderately sensitive sites with common bat species utilizing the site, open-air foragers that are resilient to high wind speed, these are at high risk of fatality. Here we need to recommend mitigation measures according to our nightly and seasonal findings and unless we apply strict measures, there may be some loss in bats. However, what is an acceptable potential loss? Obviously, we are aiming at Zero Loss, however this is not reality and the developers may ignore our recommendations and lose respect for the specialists. So, are we going to accept a % potential loss of Least Concern species for Low to Moderately sensitive sites??????

This is a threat bats have not yet faced in SA and we need to make sure we are doing the best for them but still being realistic in our approach from the start. This is so important, I feel we should even get together in person to discuss this. I look forward to everyone's view on this. If a meeting is needed, I will arrange it. Please let me know.

Email from Professor David Jacobs dated 7 October 2012:

Hi Kate,

Robert Barclay and I discussed this question while he was visiting my lab. Our conclusion isn't very helpful viz that it is impossible to answer this question. Even if we define an "acceptable loss" as loss of a number of individuals on a regular basis that will not impact on the long term survival of the species in that area, it would be impossible to gather the data that would allow us to determine this number. Amongst other things we would need population estimates, reproductive rates, mortality rates not due to wind turbines, etc. Information that no one has yet been able to collect for any natural vertebrate population let alone bats. As I said not very helpful. So what we are left with is to try can get as close to losses of 0 as possible and keep an eye on mortality rates to ensure that they are at least not increasing.

Regards,

David J.

Email from Professor Robert Barclay dated 7 October 2012:

Kate,

Many thanks for your email a couple of weeks ago. Sorry I did not get back to you right away. I realize you have had your meeting, but thought I would respond anyway.

The problems are many. We/you do not know the population sizes of the various species that may be at risk of turbine fatalities. That is the starting point for any population viability analysis.

Essentially, you do not really know what are "common" or less common species. Second, we do not know the natural mortality rates and thus can not assess how important any additional mortality rate will be. Third, we do not know what species will be at risk in South Africa, and what the mortality rates will be at different wind-energy sites. Lastly, we do not know what the genetic structure of the species are and thus whether populations in specific areas are genetically connected to or isolated from other populations. So...all we can do is use best judgement based on studies elsewhere. The species at risk will be open-air foragers and migrating species for the most part, but not entirely. Increasing cut-in speeds reduce fatality rates significantly and at low costs, as demonstrated now in three studies in North America (the costs are not publicized in two cases, but are in our initial study). The companies can calculate, not merely estimate, the cost of increasing cut-in speed because they have data on wind speeds over a typical year. So if they claim it is too costly, they need to show the data to justify their claim.

If we simply assume that bat populations are at best stable (given climate change, habitat loss and disturbance, this seems unlikely to me), then additional mortality from new sources such as turbines, will cause populations to decrease unless reproductive rates increase in response. Given the slow reproductive rate of bats, any response would be slow.

There are clearly two basic options to deal with potential bat fatalities: do pre-construction surveys and determine where high risk sites are and do not put wind facilities there; or, put them up with the recognition that if fatalities turn out to be "high", mitigation measures such as changing cut-in speeds or operational shut-down during peak risk times will be necessary and they are thus built in to the development permits.

Is there a magic number of fatalities that would trigger mitigation. NO. The risk depends on the number of turbines, the number of turbine sites that impact a particular population or species, the natural mortality and reproduction rates of different species, the population size and geographic extent. Thus coming up with a single magic number of fatalities per turbine that is acceptible seems illogical to me; a simple and therefore bad idea for a complex problem. That being said, companies will demand such a solution. They will not like turning it around and saying, a simple solution is to increase cut-in speed at all sites and not put turbines in sites that have high risk.

Not sure this helps! However, given all the research that has taken place outside SA, you are in a much better position to do things right than many other jurisdictions. My sense, however, is that government needs to be involved. There have to be regulations in place.

Robert

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Appendix C: Biome database

Good day All,

As discussed in the workshop on the 1 October 2012, it was proposed that bat activity thresholds be developed for the different biomes of South Africa. The thresholds will be developed based on bat activity data that has been collected by various companies/ individuals at various sites. These can be reviewed regularly, as more data becomes available. **As discussed in the meeting, it is important that we are comparing results that have been collected and analysed in a similar way. For decisions reached on the methods for collection and anlysis of data going forward, please refer to the minutes of the 1 October 2012 workshop. However, seeing that monitoring has been done differently by different people to date, please complete the data input table as per the collection and analysis methods you have been using for inputting into the current worksheet. We will consider the differences when considering threshold determinations.**

Please note that all the data made available in this format will only be distributed to the specialists who have contributed. The threshold results calculated from the data, will hopefully be included in the 4th draft best practise guidelines for all to use.

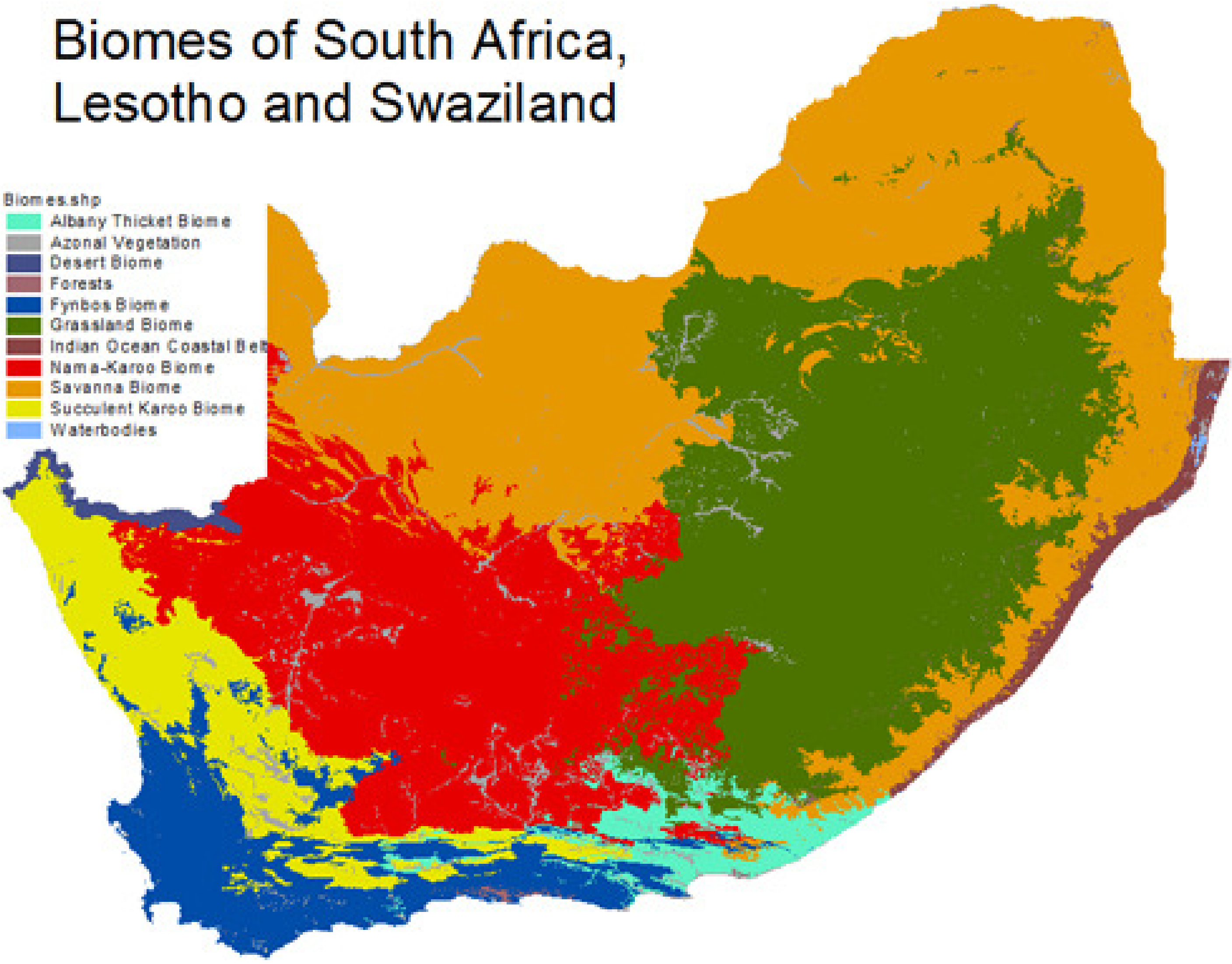
The second worksheet titled "data" is where each specialist can include monthly bat pass averages. For the most acurate results this should be done per project site grouped according to height. The SE column refers to the "standard error of the mean". This will need a statistical program other than excel. (For free downloads see: http://statpages.org/javasta2.html)

There are 11 different biomes to choose from, as can be found on http://bgis.sanbi.org/vegmap/biomes.asp The map below is a low resolution example of this map, but we recommend you correctly map your site against the GIS data files provided on the website.

The data needed for each month:
1) the minimum bat passes per night,
2) the average bat passes per night and
3) the maximum bat passes per night.
(The min and max figures refer to the lowest and highest bat passes per night for each monitoring station)

Once all the data has been received, the data will be distributed amongst the specialists who provided data. Please leave any comments in the comments section. Please resave excel workbook with your name and date before sending back so that we can keep record of who has submitted info when.

Megan Baumgartner
From Natural Scientific Services



Biomes of South Africa, Lesotho and Swaziland

SITE NO	BIOME	PROVINCE	HEIGHT	DETECTOR TYPE	CONVERSION METHOD	BAT PASSES PER NIGHT								TOTAL AVERAGE
						January				February				
						SE	Min	Average	Max	SE	Min	Average	Max	
eg	Fynbos Biome	Eastern Cape	6-10m	Wildlife Acoustics SM2	Kaleidoscope	4	1	12	22	4	1	12	22	
1														
2														
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Appendix D: Activity Indices and Relative Abundance of bats from Acoustic Monitoring Data

Firstly, it is critical to note that monitoring bat activity with detectors cannot provide measures of absolute abundance (Hayes, 2000, Milne, 2006). However, since their application can quickly yield large amounts of data on the activity of bats and can be automated for long-term use, there are methods for estimating relative abundance of bats from echolocation data in order to assess activity levels and monitor population trends (Rainey *et al.*, 2009). There is still variation in the ways researchers express bat activity, for example some report number of passes per night (Hayes, 1997; Kalcounis *et al.*, 1999), while others report passes per hour (Lloyd *et al*., 2006; Hein *et al.,* 2011) and still others create activity indices using bats per minute (Miller, 2001). Despite the differences, each method defines bat activity as passes/ per unit time and recognises that echolocation data can only provide **relative** abundance data. If we are to define a bat pass, it is important for us to ensure we define the terms used in the calculation first. For the purposes of this document, it is important that the following definition are standardised:

- Echolocation call = one single call pulse within a sequence of call pulses

For definitions of a bat pass, the following most recent international literature is available to guide:

- Hein *et al.* (2011) defined a bat pass as an echolocation sequence of .2 echolocation calls with a minimum duration of 10 ms (Thomas 1988, Hayes 2000, Sherwin et al. 2000, Gannon et al. 2003; Parsons and Szewczak 2009).
- Weller & Baldwin (2012) defined a bat pass as either a series ≥2 echolocation calls each with a duration of ≥2 ms or a single echolocation call with a duration of ≥5 ms.

However, the bat monitoring conducted to date in South Africa is showing that single echolocation calls in one sequence is quite possible and valid, especially with Mollosid bats. Also, the duration of some bat species calls can be very short, yet the full single call is present. Therefore, it is recommended that we apply the following definition for a bat pass in South Africa, until such time as we have more data to amend this:

- Bat Pass = a sequence of ≥1 echolocation calls where the duration of each pulse is ≥2 ms. Single call fragments do not apply, only completed single pulses. Where there is a gap between pulses of >500ms in one file, this then represents a new bat pass.

The potential to either over- or underestimate the actual abundance of bats active in an area is ever-present, but researchers recognise that they are always dealing with **estimates**. However, in order for such estimates to provide us with meaningful information about the status of bat populations, the inherent biases need to be minimised as much as possible. Miller (2001) showed that an activity index using species/species-group presence within one minute intervals reflected subtle changes in bat activity, undetectable at greater time-scales. It follows then, that this time-interval should be the most appropriate from which to infer the relative abundance of bats. Efforts should, of course, be made to place detectors in areas that maximise the chance of recording commuting bats while minimising the likelihood of an individual repeatedly passing the microphone. A general description of the method for calculating relative abundance is given at the end of this document.

Considering the varied methods in the literature of calculating activity indices (e.g. Hayes, 1997; Kalcounis *et al.*, 1999; Miller, 2001; Lloyd *et al*., 2006), producing bat activity indices based on the number of passes per unit time should be appropriate for guiding mitigation measures at wind farms. This is particularly so if the unit of time used is the same as that used for measurements of weather data. Whether the bat passes are produced by the same individual passing the microphone repeatedly or numerous individuals, is relatively unimportant, as the activity index provides us with a measure of the likelihood of a certain species/species-group being active (and thus susceptible to impact) during certain weather conditions.

Methodology:

- Using a program such as AnalookW (www.hoarybat.com), recordings may be given species/species-group labels.
- Then using the Count Labels tool, text files can be created that contain information about how many of which species/species-group (i.e. Labels) were present within each minute interval.
- These text files should then be opened in excel and every number (in the column representing the number of recordings with a specific label) converted to "1". This is done as individuals may be recorded more than once within a minute interval, hence converting all outputs to "1" makes the assumption that only one bat of a particular species is present in any given minute interval. While this assumption will not eliminate all bias from relative abundance estimates it provides a means to limit any biases as much as possible.
- Finally, according to your specific needs, time data can then be converted in excel to whatever time interval is required and the corresponding minute abundances added together to provide relative abundance per the new time interval (pivot tables can be used to do this rapidly for large data sets).

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