BirdLife South Africa / Endangered Wildlife Trust

Birds and Wind-Energy Best-Practice Guidelines

Best-Practice Guidelines for assessing and monitoring the impact of wind-energy facilities on birds in southern Africa

Third Edition, 2015 (previous versions 2011 and 2012)

Compiled by:

A.R. Jenkins[1], C.S. van Rooyen[2], J.J. Smallie[3], J.A. Harrison[4], M. Diamond[5], H.A. Smit-Robinson[6] and S. Ralston[7]

[1] *Avisense Consulting (andrew@avisense.co.za)*
[2] *Chris van Rooyen Consulting (vanrooyen.chris@gmail.com)*
[3] *WildSkies Ecological Services (jon@wildskies.co.za)*
[4] *JAH Environmental Consultancy (hare@worldonline.co.za)*
[5] *Feathers Environmental Services (megandiamond7@gmail.com)*
[6] *Terrestrial Bird Conservation Programme Manager, BirdLife South Africa (conservation@birdlife.org.za)*
[7] *Birds and Renewable Energy Manager, BirdLife South Africa (energy@birdlife.org.za)*

Reviewed by: Professor Peter Ryan[1] and Dr Rowena Langston[2]

[1] *Director, Percy FitzPatrick Institute of African Ornithology, University of Cape Town (Peter.Ryan@uct.ac.za)*
[2] *Principal Conservation Scientist, Centre for Conservation Science, Royal Society for the Protection of Birds (Rowena.Langston@rspb.org.uk)*

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Executive summary

The wind-energy industry is expanding rapidly in southern Africa. While experiences in other parts of the world suggest that this industry may be detrimental to birds (through the destruction of habitat, the displacement of populations from preferred habitat, and collision mortality with wind turbines, guyed masts and associated power lines), these effects are highly site- and taxon-specific. Raptors, large terrestrial species and wetland birds are likely to be most vulnerable, and areas of higher topographic relief are often implicated in negative impact scenarios.

In order to fully understand and successfully mitigate the possible impacts of wind energy on the region's birds (and to bring the local situation into line with international best practice in this field), it is essential that objective, structured and scientific monitoring of both resident and migrating birds be initiated at all proposed wind-energy development sites.

The Birds and Renewable Energy Specialist Group (BARESG), convened by the Wildlife and Energy Programme of the Endangered Wildlife Trust, and BirdLife South Africa, proposes the following guidelines and monitoring protocols for evaluating wind-energy development proposals, including a tiered assessment process as listed below.

(i) **Scoping** – a brief site visit informs a desk-top assessment of likely avifauna present, possible impacts, and the design of a site-specific survey and monitoring protocols.

(ii) **Pre-construction monitoring and impact assessment** – a full assessment of the significance of likely impacts and available mitigation options, based on the results of systematic and quantified monitoring.

(iii) **Construction-phase monitoring** - not always necessary, but can help determine if proposed mitigation measures are implemented and are effective, and identify triggers of any observed changes.

(iv) **Post-construction monitoring** – repetition of the pre-construction monitoring, plus the collection of mortality data, to develop a complete before and after picture of impacts, and refine mitigation measures.

(v) If warranted, more detailed and intensive research on affected threatened or potentially threatened species.

To streamline this approach, a shortlist of priority species should be drawn up at the scoping stage. Priority species should include threatened or rare birds, in particular those unique to the region, and especially those that may be susceptible to wind-energy impacts. These species should be the primary (but not the sole) focus of subsequent monitoring and assessment.

Similarly, the amount of monitoring effort required at each site should be set in terms of the anticipated sensitivity of the local avifauna and the prevalence of contributing environmental conditions (for example, the diversity and relative abundance of priority species present, proximity to important flyways, wetlands or other focal sites, and topographic complexity).

On-site work should be coupled with the collection of directly comparable data at a nearby, closely-matched reference (control) site where possible. This will provide much-needed context for the analysis of pre- vs. post-construction monitoring data.

In some situations, where proposed wind-energy developments are likely to impinge on flyways used by relatively large numbers of threatened and impact-sensitive birds, and particularly where these movements are likely to take place at night or in conditions of poor visibility (e.g. the Cape Columbine Peninsula), it may be necessary to use radar to gather sufficient information on flight paths to fully evaluate the development proposal and inform mitigation requirements.

Pre-construction monitoring will require periodic surveys of both the development and reference sites. These surveys should be sufficiently frequent to adequately sample all major variations in environmental conditions, with no fewer than four surveys spanning the annual cycle. Variables measured/mapped on each survey should include (i) density estimates for small terrestrial birds (in most cases not priority species, but potentially affected on a landscape scale by multiple developments in one area), (ii) census counts, density estimates or abundance indices for large terrestrial birds and raptors, (iii) passage rates of birds flying through the proposed development area (including nocturnal movements, where appropriate), (iv) evidence of breeding at any focal species sites, (v) bird numbers at any focal wetlands, and (vi) full details of any incidental sightings of priority species.

Post-construction monitoring should effectively duplicate the pre-construction monitoring work, with the addition of surveys for avian collision victims under the turbines, and collision and electrocution victims under the ancillary power infrastructure. Estimates of fatality rates should take into account scavenger removal and searcher efficiency.

While analysis and reporting on an individual development basis will be the responsibility of the relevant avifaunal specialist, all data emanating from the above process should also be housed centrally by BARESG and/or the South African National Biodiversity Institute (SANBI) to facilitate the assessment of results on a multi-project, landscape and national scale.

These guidelines will be revised periodically as required, based on experience gained in implementing them, and on-going input from various sectors. This is the third edition.

A list of qualified avian specialists who have agreed to adhere to these guidelines is available at www.birdlife.org.za and www.ewt.org.za.

Forewords:

The South African Wind Energy Association and the Best Practice Guidelines

The South African Wind Energy Association (SAWEA) has been involved as a stakeholder in 2015 revision of the Birds and Wind-Energy Best-Practice Guidelines. SAWEA supports the development (and periodic revision) of a best practice guideline that is in line with international best practice standards in avian monitoring and impact assessment for wind farm projects, and is practical and pragmatic in its approach.

The Birds and Wind-Energy Best-Practice guidelines have been designed over a number of years with the specific objective of ensuring that wind farm developments are done with full care for birds and responsibility towards their wellbeing. Specific attention has been afforded to species that may be sensitive to the potential impacts of wind farms, and those of conservation concern. In order for wind energy projects to be developed in a sustainable manner it is important that the objective of protecting these species is met.

The continued development of a sustainable and environmentally sensitive wind energy industry in South Africa can only be achieved through responsible and careful development. In order to ensure wind development that is harmonious with bird life populations the implementation of a robust pre-construction (baseline) bird monitoring programme is required to highlight potential development risks, to inform development design, and also to inform any Environmental Impact Assessment process. In many cases, with robust baseline data and a good understanding of the site-specific conditions with regards to bird populations and activity, potential impacts can be mitigated through designing a development with a focus on removing, reducing or avoiding potential impacts to birds as far as possible. Appropriate data collection during construction and during the first years of wind farm operation are also important.

As such, SAWEA supports the implementation of these guidelines at all proposed wind energy developments.

Johan Van den Berg, SAWEA CEO

BirdLife South Africa and the Best Practice Guidelines

Our country is in an energy crisis. We need to increase our capacity to generate electricity and at the same time we must to reduce our dependence on non-renewable forms of energy generation. Harnessing the wind's energy is an obvious and attractive option. A growing wind energy industry in South Africa is now a reality and the Renewable Energy Independent Power Producer Procurement Programme has won international acclaim.

BirdLife South Africa welcomes the positive contribution wind energy can make towards climate change mitigation; climate change is a significant threat to the environment, and will affect many of our bird species. However, wind energy is not without environmental impacts and we remain concerned about the potential impacts our birds may face as a result of this technology. Data from a handful of European and American sites demonstrate clearly that wind farms can adversely affect bird populations if they are built in the wrong places.

Despite these concerns, we believe that if we apply the lessons learned by our colleagues in other parts of the world, and work openly with the relevant stakeholders, we can substantially reduce these negative effects. We have obtained advice and assistance from our partners in European countries where wind energy development is already quite advanced. We have also collaborated with the Wildlife and Energy Programme of the Endangered Wildlife Trust (EWT-WEP), and engaged directly with local developers, environmental assessment practitioners and specialist ornithologists alike in our efforts to address this looming problem. In particular, we sincerely appreciate the ongoing inputs of the experts on the Birds and Renewable Energy Specialist Group who contributed to these Best Practice Guidelines and continue to guide our work.

What we have learned is that effective mitigation of the impacts of wind energy on birds is largely about understanding bird movements through the affected area, and the corresponding placement of turbines in the landscape to avoid high-risk areas. These Best Practice Guidelines outline what is required to develop this understanding.

Wind energy is new in South Africa and our ability to accurately predict and prevent impacts on birds is likely to be imperfect. It is therefore critical that we gather data at operational facilities so that any unanticipated negative impacts are identified and dealt with. This will also allow us to develop our knowledge around how best to ensure the sustainability of future wind farms. Post-construction monitoring was therefore a major focus in this revision of the Guidelines.

BirdLife South Africa is committed to provide up-to-date advice to help ensure that wind energy South Africa is as sustainable as possible. The Best Practice Guidelines, which are regularly updated and draw heavily on international best practice and research, demonstrate this commitment. In turn, we believe that a commitment from stakeholders to adhere strictly to these Guidelines, and to engage in an open and transparent manner, will help ensure that impacts on birds are limited to acceptable levels. The quality of environmental impact assessments for proposed wind energy developments has increased dramatically since the first edition of these Guidelines was released and we look forward to this positive trend continuing.

Mark Anderson, CEO Birdlife South Africa

The Endangered Wildlife Trust and the Best Practice Guidelines

The Endangered Wildlife Trust (EWT) has been pioneering Conservation in Action since 1973. In this time, the EWT has been at the forefront of developing innovative, strategic partnerships with various industries to develop proactive mitigation measures to reduce harmful impacts on our environment, and to catalyse best management practices throughout the sector which reduce wildlife losses.

With the emergence of wind generated power as a key element in our future energy mix, we have the perfect opportunity to stay ahead of the game, and to apply best practice proactively in the development of wind farms and their associated infrastructure. This latest edition of the guidelines will further expand our scope to include operational challenges faced by the industry such as mortality estimates and mitigation and we will continue to adapt as we learn more about the impact of wind energy.

We acknowledge the importance of wind generated power as a crucial component of a climate friendly energy production mix, but also recognise the potential negative impacts of the infrastructure on certain species of birds and bats. Unfortunately, the emergence of this possible new threat to our avifauna comes at a time when birds globally are declining in conservation status and where South Africa has among the highest number of birds at risk of extinction in Africa. We therefore continue working tirelessly to ensure that wind farm development and operation in South Africa poses as little threat as possible to our birds and to the environment at large.

In this context, the EWT is proud to be working with long-standing partner BirdLife South Africa and a range of new collaborators in the wind energy sector to develop these best practice guidelines, which aim to ensure that the development and operation of wind energy facilities takes place sustainably, and without detrimentally affecting the region's birds.

Yolan Friedmann, CEO Endangered Wildlife Trust

Glossary of terms and acronyms

Accuracy	The degree to which the result of a measurement and/or calculation aligns with the true value (accuracy is different to precision, which is a measure of how close different measurements are to each other).
Adaptive management	An iterative decision-making process used in the face of uncertainty where management policies and practices are continually improved through monitoring and learning from the outcomes of previous approaches.
BARESG	The Birds and Renewable Energy Specialist Group, a group of bird specialists who guide the work of BirdLife South Africa and the Endangered Wildlife Trusts relevant to birds and wind energy (formerly the Birds and Wind Energy Specialist Group, BAWESG).
Bird habitats	Habitats available and important to birds, usually shaped by factors such as vegetation, topography, land use and sources of food and water.
BIRP	Birds in Reserves Project, a project run by the Animal Demography Unit (University of Cape Town) that collects bird occurrence data inside South African protected areas. For more information visit http://birp.adu.org.za.
Broader impact zone	The area in which potentially impacted birds are likely to occur. This will extend beyond the development footprint/development area, but should be included in monitoring and impact assessment surveys. This could include the considerable space requirements of large birds of prey.
CAR	Coordinated Avifaunal Roadcounts, a programme where large terrestrial birds are monitored from vehicles along fixed routes. See http://car.adu.org.za for more information.
Commercial Operation Date	The date on which all of the turbines and associated infrastructure necessary to put the WEF into operation and transmit power have been tested and commissioned, and the WEF is authorized and able to start producing electricity for sale.
Cumulative impact	Impacts on a species, ecosystem or resource as a result of the sum of actions in the past, present and foreseeable future, from multiple WEFs or a WEF in combination with other developments.
CWAC	Coordinated Waterbird Counts, a programme of bird censuses at a number of South African wetlands. See http://cwac.adu.org.za for more information.
Developable area	The area in which wind turbines, and associated road and power infrastructure might be located.
Impact zone	Usually taken to mean the area directly impacted by development, e.g. the development footprint (compare to “broader impact zone”)
IBA	Important Bird and Biodiversity Area (formally know as Important Bird Area).
Important Bird (and	Part of a global network of sites that are critical for the long-term

Biodiversity) Area	viability of bird populations. Now known as Important Bird and Biodiversity Areas. See www.birdlife.org.za/conservation/important-bird-areas for more information.
Large WEF	The number and installed capacity of wind turbines, as well as their spatial distribution influence the size of a WEF. For the purposes of this guideline, a large WEF is considered to be greater than 140 MW.
Priority species	Threatened or rare birds (in particular those unique to the region and especially those which are possibly susceptible to wind-energy impacts), which occur in the given development area at relatively high densities or have high levels of activity in the area. These species should be the primary (but not the sole) focus of all subsequent monitoring and assessment.
Red flag	A warning signal, which in the context of these guidelines would indicate that the impacts of a WEF on birds (or their habitats) are likely to be unsustainable.
Reference site	An area that is similar to the development site and that is monitored together with the development site in order to provide a baseline against which the impacts of the development can be compared. A reference (or control) site is a critical part of a Before (pre-construction)-After (post-construction) –Control (reference site)-Impact (development) (BACI) approach.
Rotor-swept area	The area of the circle or volume of the sphere swept by the turbine blades
SABAP	The Southern African Bird Atlas Project. A project in which data on bird distribution and relative abundance are collected by volunteers. There have been two SABAP projects; i.e. SABAP1 (completed in 1991) and SABAP2 (started in 2007 and on-going). The unit of data collection for SABAP2 is a pentad (five minutes of latitude by five minutes of longitude). See http://sabap2.adu.org.za for more information.
Significant impacts	Impacts the effects of which are likely to persist for a long time, will affect a large area, or extend far beyond the area in which the activity occurs. Where species are concerned, significant impacts would be those that negatively affect the conservation status of a population at a given scale. Where possible, impacts should be contextualised in terms of the distribution, abundance, population size and current mortality rates or levels of threat of bird species. Population modelling (beyond the scope of these guidelines) may be useful to help determine the significance of impacts for some species.
Small WEF	A WEF that does not require environmental authorisation for electricity generation. At the time of writing this threshold is 10MW.
Wind-energy facility	A power plant that uses wind to generate electricity, also colloquially known as a wind farm.
WEF	A wind-energy facility.

1. Introduction

KEY POINTS

- Renewable energy has the potential to play a significant role in mitigating global climate change, but renewable energy can also have negative environmental impacts.
- Wind energy can impact on birds directly by injuring or killing birds that collide with the wind turbines and associated infrastructure. It can also impact on birds indirectly, for example by creating a barrier to movement, displacing sensitive species, affecting breeding success and/or altering habitat.
- These guidelines were developed to ensure that negative impacts on threatened or potentially threatened bird species are identified and mitigated using structured, methodical and scientific methods.
- A multi-tiered approach is proposed with the overarching aims of: 1) informing current environmental impact assessment processes, 2) developing our understanding of the effects of wind-energy facilities on southern African birds, and 3) identifying the most effective means to mitigate these impacts.

Human-induced climate change is increasingly recognised as a significant threat to the natural environment (e.g. Thomas et al., 2004; Foden et al., 2013). Renewable energy has the potential to play a significant role in mitigating global climate change and can therefore make a positive contribution to the conservation of birds and other biodiversity. However, renewable energy can also have negative environmental impacts.

The wind-energy industry is in the process of rapid expansion in southern Africa. Credible, scientific studies in other parts of the world have established that the most prevalent impacts of wind-energy facilities (WEFs) on birds are displacement of sensitive species from development areas, and mortality of susceptible species, primarily in collisions with development hardware (for reviews of these studies see Drewitt & Langston 2006; Drewitt & Langston 2008; Jordan & Smallie 2010; Strickland et al. 2011; Rydell et al. 2012; Gove et al. 2013).

The nature and extent of these impacts is highly dependent on both site- and species-specific variables (Drewitt & Langston 2006; Jordan & Smallie 2010; Gove et al. 2013 and references therein). At this stage, there is no empirically based understanding of the likely effects of wind-energy development on southern African birds. The South African Birds and Renewable Energy Specialist Group (BARESG) therefore recognizes the need to measure these effects as quickly as possible, in order to identify and mitigate any detrimental impacts on threatened or potentially threatened species. BARESG also recognizes the need to gather these data in a structured, methodical and scientific manner, in order to arrive at tested and defensible answers to critical questions (Stewart, Pullin & Coles, 2007).

Data collection should be done by means of an integrated programme of pre-construction (baseline) monitoring and impact assessment, and post-construction (operational-phase) monitoring set up at all the proposed development sites. Given the rate and extent of proposed wind-energy development, these studies should be done as quickly as possible, but using scientific methods to generate accurate, comparable information. The current set of best-practice guidelines presents the means and standards required to achieve these aims.

These guidelines propose a multi-tiered approach, with the overarching aims of:

a) informing current environmental impact assessment processes;
b) developing our understanding of the effects of wind energy on southern African birds; and
c) identifying the most effective means to mitigate these impacts.

These guidelines are intended to be a living document that will be updated and supplemented over time, as local specialists and research practitioners gain much-needed experience in this field.

This is the third edition of the guidelines. Changes from the previous version are summarised below.

a) The layout of the text has been changed; summaries to highlight critical points have been added at the beginning of each section.
b) The use of terminology is more consistent.
c) The recommended timing of monitoring and link to the environmental impact assessment process has been clarified.
d) It has been clarified that the guidelines set out the minimum requirements for most WEFs and in many cases the scope of work may need to be extended.
e) Additional detail has been provided with regards to vantage-point monitoring. The recommendation with regards to distance between vantage points has been corrected (areas surveyed from vantage points should have a radius of 2 km, not be 2 km apart as was indicated in the previous edition).
f) Recommendations with regards to tracking birds with satellite devices have been included.
g) Additional detail has been provided on collision-risk modelling.
h) Recommendations with regards to construction-phase monitoring have been clarified.
i) Additional detail has been provided on post-construction monitoring (the timing, duration and nature of monitoring).
j) Recommendations with regards to fatality estimates have been included.
k) Recommendations on peer review have been included.
l) Appendices have been added (minimum requirements for impact assessment and recommended (generic) conditions of approval).

2. Recommended protocols

KEY POINTS

- Monitoring and decision-making should follow a tiered approach:
  - *Stage 1,* ***scoping****, should inform project screening or the scoping phase of the impact assessment.*
  - *Stage 2,* ***pre-construction monitoring and avifaunal impact assessment,*** *informs the impact assessment and decision-making process and provides a baseline against which post-construction monitoring can be compared.*
  - *Stage 3,* ***construction-phase monitoring****, may be necessary to monitor and mitigate impacts during construction.*
  - *Stage 4,* ***post-construction monitoring*** *is necessary to document impacts and identify if additional mitigation is required.*
  - *Stage 5, detailed research to address specific questions, may be required where there is a need to understand and mitigate particular impacts.*
- Monitoring effort should be proportional to the size of the proposed WEF, topographic and/or habitat heterogeneity on site, the relative importance of the local avifauna, and the anticipated susceptibility of the relevant birds to the potential negative impacts.
- These guidelines set out the minimum requirements for monitoring; in some instances more work may be necessary to provide sufficient information for decision-making. The designated avifaunal specialist should determine the scope of work, based on site-specific information, best available science, and stakeholder input.
- Monitoring should focus mainly on a shortlist of priority species, although it is also necessary to monitor the distribution, abundance and potential displacement effects on populations of small birds.
- Each project should provide quantitative information on the abundance, distributions and risk to key species or groups of species, and serve to inform and improve mitigation measures.

A tiered approach to survey and monitoring should be adopted, similar to that that has been applied in both Europe and North America (e.g. Scottish Natural Heritage 2005; Kuvlesky et al. 2007; U.S. Fish and Wildlife Service 2012).

The first tier, scoping, could be undertaken as part of the project screening (i.e. before the EIA process), but must be included in the scoping phase of the impact assessment process. Should the scoping report endorse the development, a full avian impact assessment should then be based on the second tier of work (i.e. pre-construction monitoring). Pre-construction monitoring is central to the impact assessment process (i.e. the impact assessment is based on information collected during pre-construction monitoring) and should be used to determine: 1) if the project should proceed, 2) what mitigation measures are necessary, and 3) the nature and extent of construction-phase and post-construction (operational-phase) monitoring.

Should the avian impact assessment also endorse the proposed development and it goes ahead, a third tier of work could consist of construction-phase monitoring (where required). Post-construction monitoring must follow this.

At selected sites where bird impacts are expected to be particularly direct and severe (in terms of the relative biodiversity value of the affected avifauna, and/or the inherent risk potential of the proposed facility), additional, more customized and experimental research initiatives may be required, such as intensive, long-term monitoring of populations (Strickland et al., 2011), for example using satellite tags (e.g. Nygård et al. 2010). However, these additional studies may not always help reduce potential impacts to acceptable (sustainable) levels.

Monitoring should also be undertaken at a minimum of one nearby reference (control) site, matched as closely as possible to the proposed development site, to validate before-after comparisons of bird populations.

2.1. Stage 1: Scoping

KEY POINTS

- The aim of scoping is to: 1) define the study area, 2) characterise the site, 3) provide an initial indication of the likely impacts of the facility, and 4) determine the scope of pre-construction monitoring/avifaunal impact assessment.
- Scoping should include a desktop study using existing information, as well as a short site visit.
- The study area should be defined during scoping and should extend beyond the boundaries of the development footprint itself.
- Bird abundance and activity monitoring should focus data collection on priority species, but potential impacts on small and/or common species should not be overlooked.
- The resulting scoping report should describe birds potentially impacted and the nature of that risk. It should also highlight if there are any obvious red flags to development.
- The scoping report should describe the effort required for pre-construction monitoring and impact assessment.
- The avifaunal scoping report must be included in the scoping phase of impact assessment, but could also be used in project screening, before initiating a formal EIA.

2.1.1. Aims of scoping

The main aims of a scoping study are discussed below.

i. **To define the study area** - the area covered by each proposed development is determined by the project developer, and comprises the inclusive area on which development activities (the construction of turbines and associated road and electrical infrastructure) are likely to take place. However, because birds are highly mobile animals, and because an important potential impact is the effect of the WEF on birds that move through the proposed development area, as well as those which are resident within it, the avian impact zone of any proposed WEF extends well beyond the boundaries of this central core. Of particular concern is that monitored areas are large enough to include the considerable spatial requirements of large birds of prey, which may reside tens of kilometres outside of the core development area, but regularly forage within it (Walker et al. 2005; Madders & Whitfield 2006). How far the study area extends in each case should be determined by the avifaunal specialist, and should be defined at the scoping stage of the assessment process, perhaps with opportunity for subsequent refinement during the impact assessment.

   Generally, the extent of the broader impact zone of each project will depend on the dispersal abilities and distributions of important populations of priority species that are likely to move into the core impact area with some regularity. It is important that the delineation of this impact zone, which is the area within which all survey and monitoring work will be carried out (not including the reference site), is done realistically and objectively, balancing the potential impacts of the WEF with the availability of resources to conduct the monitoring.

ii. To **characterize the site** in terms of:

- the bird habitats present (habitats available and important to birds, usually shaped by factors such as vegetation structure, surface water, topography, land use and food sources),
- a list of species likely to occur in those habitats,
- a list of priority species likely to occur, with notes on the value of the site and surrounding areas for these birds,
- input on likely seasonality of presence/absence and/or movements for key species, and
- any obvious, highly sensitive, no-go areas to be avoided by the development from the outset (these could be landscape-scale features that may influence the location of the entire WEF, or finer-scale features that should guide micro-siting of turbines).

iii. To provide an initial estimation of **likely impacts** of the proposed WEF.

iv. To **determine the nature and scale of pre-construction monitoring** required to measure these impacts, and to provide input on mitigation.

In summary, scoping should yield a scoping report, which should describe the avifauna at risk, detail the nature of that risk, and discuss options for mitigation. The report should also outline the pre-construction monitoring effort required to inform the avian impact assessment report and highlight any red flags to development.

2.1.2. Information sources used in scoping

Scoping should be based on data sources such as those presented below.

i. A **desktop study** of the local avifauna, using relevant, pre-existing information and datasets - for example

   a. *Roberts Birds of Southern Africa, 7th Edition* (Hockey, Dean & Ryan, 2005) and other relevant avian handbooks, field guides and publications;
   b. The *Eskom Red Data Book of Birds of South Africa, Lesotho and Swaziland* (Taylor, 2015);
   c. The BirdLife South Africa/Endangered Wildlife Trust avian wind farm sensitivity map for South Africa (Retief et al., 2012);
   d. The Southern African Bird Atlas data (SABAP 1 - (Harrison et al., 1997), and SABAP 2, http://sabap2.adu.org.za);
   e. Coordinated Waterbird Counts (CWAC, http://cwac.adu.org.za, Taylor et al. 1999);
   f. Coordinated Avifaunal Roadcounts (CAR, http://car.adu.org.za, Young et al. 2003);
   g. Birds in Reserves Project (BIRP, http://birp.adu.org.za);
   h. Important Bird Areas initiative (Barnes, 1998); (IBAs, http://www.birdlife.org.za/conservation/important-bird-areas,
   i. Data from the Endangered Wildlife Trust's programmes (www.ewt.org.za) and associated specialist research studies; and
   j. Monitoring and impact assessment reports for nearby wind farms that are in the public domain.

ii. A short (2-4 day) **site visit** to the area to search for key species and resources, and to develop an on-site understanding of where (and possibly when) priority species (see section 2.1.3) are likely to occur and move around the site. Note that such a single visit will not allow for investigation of seasonal variation in the composition and behaviour of the local avifauna, and such variation must therefore be estimated in terms of existing information for the site or region, and the experience of the consulting specialist.

2.1.3. Priority species

Bird abundance and activity monitoring should focus data collection on a shortlist of priority species, defined in terms of (i) threat status or rarity (see Barnes 2000 and Taylor 2014), (ii) uniqueness or endemism, (iii) susceptibility to disturbance or collision impacts, and (iv) relative use of the site. High relative use could be as a result of usage by a relatively small number of individuals of a priority species, (e.g. breeding raptor), or use by large numbers of different bird species. These species should be identified in the scoping/avian impact assessment specialist report and/or by the BirdLife South Africa/EWT sensitivity mapping exercise (Retief et al. 2012 or updates thereof). This will generally result in a strong emphasis on large, Red-Data species (e.g. cranes, bustards and raptors – Drewitt & Langston 2006; 2008; Jenkins et al. 2010).

While immediate conservation imperatives and practical constraints encourage focus on priority species, it is also important to account for subtler, systemic effects of wind-energy developments, which may be magnified over very large facilities, or by multiple facilities in the same area. For example, widespread, selective displacement of smaller, more common species by WEFs may ultimately be detrimental to the status of these birds and, perhaps more significantly, may upset the balance and effective functioning of the local ecosystem. Similarly, the loss of relatively common but ecologically pivotal species (e.g. non-threatened predators such as Jackal Buzzard (*Buteo rufofuscus)*, Rock Kestrel (*Falco rupicolus*) and Black-shouldered Kite (*Elanus caeruleus*) from the vicinity of a WEF may also have a substantial, knock-on ecological effect. Hence, some level of monitoring of small-bird and ecologically pivotal bird populations will be required at all sites, and certain non-threatened, but impact-susceptible species will emerge as priority species by virtue of their perceived value to the ecosystem. Also note that quantitative surveys of small-bird populations may be the only way in which to adequately test for impact phenomena such as displacement (Devereux, Denny & Whittingham, 2008; Farfán et al., 2009), given that large-bodied target species occur so sparsely in the environment that it may not be possible to submit density or abundance estimates to rigorous statistical examination.

Ultimately, each monitoring project should provide much-needed quantitative information on the numbers, distributions and risk profiles of key species or groups of species within the local avifauna at a given development site, and serve to inform and improve mitigation measures designed to reduce this risk, including possible identification of unsuitable areas for WEFs.

2.1.4. Timing

Whilst the avifaunal scoping study could coincide with and serve as the scoping study for the purposes of EIA, it is not necessary to wait until the formal EIA starts in order to start monitoring. It may prove to be valuable for developers to commission an avifaunal scoping study (or screening study) prior to initiating a formal impact assessment process as this might help avoid unnecessary investment in unsuitable sites. Developers are also encouraged to consult with BirdLife South Africa, EWT, and other experts, as early on in the project development cycle as possible.

2.1.5. Reporting (Avifaunal Scoping Report)

The Avifaunal Scoping Report should include a description of the nature and extent of the study area, a preliminary indication of the potential impacts and any no-go areas, and outline the proposed approach to monitoring and impact assessment. The Avifaunal Scoping Report should be included in the formal Scoping Report for the WEF.

2.2. Stage 2: Pre-construction monitoring and impact assessment

KEY POINTS

- Pre-construction monitoring provides: 1) a basis for avifaunal impact assessment and 2) a baseline against which the results of post-construction (operational phase) monitoring can be compared.
- Bird species richness and passage rates should also be monitored at a reference (control) site to help understand the causes of any changes observed (i.e. environmental conditions vs. impacts of the WEF itself).
- Pre-construction monitoring data should be collected over a 12 months period and should include samples representative of the full spectrum of environmental conditions likely to occur within the annual cycle. Surveys should be as frequent as practically possible, with a minimum of four surveys a year.
- Before monitoring commences, the avian habitats present at the project and reference sites should be mapped using available information (e.g. satellite images and GIS data).

Number and density of small birds:

- The species richness, density and/or relative abundance of small birds can be surveyed using walked transects, fixed-point counts and checklist surveys. All major habitat types within the impact zone should be sampled in proportion to their availability on site. Checklist surveys are suitable for monitoring species in the broader impact zone of the affected area of the WEF, but must be complemented by transect or fixed-point counts.

Number of large terrestrial birds:

- The numbers of large terrestrial birds should be estimated on each visit, using census counts (small WEFs) or by road counts (large WEFs). Any breeding pairs and/or nest sites of priority species located during this survey work must be plotted and treated as focal sites for subsequent monitoring.

Focal point surveys:

- Nest sites of large terrestrial species and any habitats likely to support nest sites of key raptors should be surveyed and carefully checked on each site visit to confirm occupancy. Any signs of breeding should be recorded.
- Wetlands should be identified, mapped and surveyed for waterbirds on each survey, using the standard protocols set out by the CWAC initiative.
- Guyed masts (and powerlines) should be checked for signs of bird collisions; the findings should be recorded as with collision-victim surveys in the post-construction phase.
- Incidental sightings of priority species, particularly if suggestive of breeding, important feeding or roosting sites, or flight paths, should be recorded.

Bird movements:

- Understanding bird movements at a site requires significant time and effort, but it can be critical to inform the impact assessment and mitigation strategy.

- Vantage-point surveys should provide information on the time spent flying over the development area, the relative use of different parts of the area, and the proportion of time different species spend flying at different heights (e.g. above, below and through the rotor-swept area).
- A maximum radius of 2 km should be surveyed from each vantage point.
- Vantage points should be positioned to aim for maximum coverage of the developable area. Overlapping viewsheds should be avoided, or accounted for in the later analysis.
- A minimum of 12 hours should be spent at each vantage point each season (winter, spring, summer and autumn) and should include all times of day (dawn, midday, late afternoon). This time may need to be increased if collision-prone priority species may be impacted.
- The use of radar or other technology to record bird movements should be considered, particularly where detailed data on bird movements is required, or where movements occur at night or in conditions of poor visibility (e.g. fog). Radar cannot easily distinguish between different species, however, and should be used in combination with direct observations (wherever possible).
- The use of bird-borne tracking devices (e.g. satellite/GSM) could also be considered as this can provide valuable data on the preferred foraging ranges and movement corridors of individual birds. Devices must be deployed prudently to minimise impacts on the subject.

Impact assessment:

- The avifaunal impact assessment should include an analysis of the data collected from scoping and pre-construction monitoring surveys.
- The results of this analysis should inform the turbine layout, as well as the assessment of the significance of the potential impacts of the proposed project alternatives (with and without mitigation).
- The impact assessment should detail the nature and extent of monitoring required during construction and operation of the facility.
- Sufficient data should be gathered on bird movements, to enable the use of the data in collision-risk modelling to provide an indication of the potential mortality rates of priority species.

2.2.1. Aims of pre-construction monitoring and impact assessment

The six primary aims of pre-construction monitoring and impact assessment are listed below.

i. To determine the species richness and abundance of birds regularly present or resident within the broader impact area of the WEF before its construction.
ii. To document patterns of bird movements in the vicinity of the proposed WEF before its construction.
iii. To estimate predicted collision risk (the frequency with which individuals or flocks fly through the future rotor-swept area of the proposed WEF – Morrison 1998; Band et al. 2007) for key species.
iv. To inform the environmental impact assessment report and related decisions.
v. To mitigate impacts by informing the final design, construction and management strategy of the development.
vi. To establish a baseline of bird species richness, abundance, distributions and movements.

Pre-construction monitoring serves a dual function. It is necessary to inform the impact assessment process, but it also provides a baseline against which the results of post-construction monitoring can be assessed. Data on species richness, abundance and distribution are necessary to assess the sensitivity of birds to disturbance and displacement. Data on species' movements will give an indication of collision risk and potential displacement.

2.2.2. Timing of study

Scoping and pre-construction monitoring are required to guide and inform the avian impact assessment report. Pre-construction monitoring should therefore be completed before the impact assessment is finalised.

If there is a significant gap (i.e. more than three years) between the completion of the initial pre-construction monitoring and impact assessment, and the anticipated commencement of construction, it may be advisable to repeat the pre-construction monitoring (or parts thereof) to assess whether there have been any changes in species abundance, movements and/or habitat use in the interim.

2.2.3. Reference (control) sites

Reference (control) sites are essential for a Before-After-Control-Impact (BACI) approach and to enable a distinction to be made between effects likely attributable to a wind farm and those stemming from other factors (Anderson et al., 1999). Identifying suitable reference sites may be challenging, but monitoring of bird species richness, relative abundance, and passage rates, should be undertaken for both the broader impact zone of the proposed WEF and for one or more comparable reference sites. In this way, a comparison of data from pre-construction and post-construction monitoring can be calibrated in terms of an equivalent comparison for a suitable reference area, and the effects of regional variation in environmental conditions can be filtered out of the resulting quantification of the actual impacts of the WEF (Anderson et al. 1999; Stewart et al. 2007; Pearce-Higgins et al. 2009; Scottish Natural Heritage 2009). Proposed WEF sites in close proximity to one another could use a common reference site (or sites) to minimize time and effort in this regard

Reference sites should match as closely as possible the impact site in all respects, most notably suitable reference sites should:

i. be located on ground with a similar mix of habitats (e.g. vegetation, wetlands, etc.), altitude, topography and slope aspects (Pearce-Higgins et al., 2009);
ii. host a similar mix of bird species to those present on the WEF site;
iii. be at least half the size of the WEF; and
iv. be situated as close as possible to the WEF area, but far enough away to ensure that resident birds on the reference site are not directly affected by the wind farm operations once they start, and also that there is little, if any, localised movement of key species between the two areas.

2.2.4. Duration

Fieldwork should be conducted over a period spanning at least 12 consecutive calendar months to include sample counts representative of the full spectrum of prevailing environmental conditions likely to occur on each site in that period (Drewitt & Langston, 2006). While fieldwork need not span a full 365 days, the duration should be timed to ensure that the full annual cycle is represented. This time-span may not have direct biological relevance, but presents a compromise between the extremes of either attempting to accommodate inevitable and probably significant variation between years (of particular relevance in arid environments), or distilling the process into a very short sampling window.

The duration of fieldwork should be extended where there is a high risk of significant impacts on priority species and:

i. there is likely to be strong inter-annual variation in the presence and movement of priority species (see for example Gove et al. 2013); or
ii. there is a high degree of uncertainty related to the potential impacts and/or mitigation measures required, and further monitoring would help reduce this uncertainty.

2.2.5. Frequency and timing of surveys

Surveys should be timed to include sample counts representative of the full spectrum of prevailing environmental conditions likely to occur in a 12 month period (Drewitt & Langston, 2006). The quality and utility of the monitoring data is generally proportional to sampling frequency, so the number of iterations of each sampling technique per survey, and the number of surveys per year, should always be kept at a practical maximum. Practical constraints (e.g. human capacity, size and accessibility of the site, time, and finances) may modulate the frequency of surveys; four visits to the site within an annual cycle should be considered as an absolute minimum for achieving adequate coverage. No less than 20% of the total time spent in the field should occur in any three consecutive calendar months.

2.2.6. Habitat classification and mapping

Before sampling and counting commence, the study area should be defined and avian habitats available on both the project and the reference sites should be mapped using a combination of satellite imagery (Google Earth) and GIS tools. These maps should later be subject to ground-truthing and refinement according to on-site experience and/or the findings of scoping phase botanical and wetland surveys.

2.2.7. Bird species richness and abundance

Bird population monitoring may present some challenges. Proposed developments can cover very large areas, many of the priority species are large birds (e.g. cranes, bustards, eagles and vultures) that have proportionally large spatial requirements and sparse distributions (Jenkins, 2011) and some of the key species are nomadic, with fluctuating densities related to highly stochastic weather events that drive local habitat conditions. Furthermore, some of the proposed development sites are situated in remote and rugged terrain, and access limitations may preclude uniform and/or random sampling of all habitats. Hence sampling methods and sample sizes may be determined as much by what is practically possible as by what is required for statistical rigour. However every effort should be made to cover a representative cross-section of the available habitats, or at least to sample those areas most likely to hold priority species.

In this context, and within these limitations, it remains a stringent requirement that bird species richness, abundance, distributions and activities are monitored as accurately as possible at all proposed WEF and reference sites, including data for a representative range of avian guilds.

The main concern for comparative studies is that the same techniques are used throughout the pre- and post-construction monitoring at any given site. It is therefore important that the details of the survey protocols are carefully and clearly documented.

Note that a heavy reliance on recording bird species by their vocalizations in pre-construction surveys may preclude direct comparison of such data with that collected in post-construction monitoring, when the noise of the operating turbines may significantly reduce an observer's ability to hear, locate and identify calling birds. It is therefore important to document whether birds recorded were heard or seen in order to facilitate later analysis of pre- and post-construction data in the face of such a potential difficulty.

(a) Small terrestrial species

While the emphasis of any monitoring project should be on the priority species identified at the scoping stage (and any other threatened and/or restricted-range endemics seen and added to this list subsequently), it is also necessary to monitor the distribution, abundance and potential displacement effects on populations of small birds, even when these do not include species prioritized by the scoping exercise. This is more to further our understanding of the general effects of WEFs, and in particular the possible cumulative impacts of widespread WEF development on the broader avifauna, than to fulfil any immediate and localized conservation requirement. Given the potentially very large area that will be devoted to wind-energy development in 10-20 years' time (http://www.sawea.org.za/), we need to assess now whether or not components of communities of small birds are likely to be displaced, before these developments result in potential landscape-scale distributional and abundance changes, with the longer-term ecological damage that such changes could bring.

The abundance of small birds can be determined either by estimating actual measured densities, i.e. absolute abundance, or, more crudely, by merely measuring relative abundance. The latter does not provide a measure of the actual numbers/densities of birds present; rather it provides a relative measure of abundance to compare bird abundances across different sites or time periods. Walked transects and fixed-point counts are examples of techniques producing estimates of densities/actual numbers. A so-called 'Kilometric Abundance Index' (KAI) and relatively crude checklist surveys are examples of techniques generating relative measures of abundance. It should be noted that techniques producing absolute-abundance estimates are typically more complex to carry out, both in the field and in subsequently analysing the data, than techniques generating relative-abundance measures. As a general statement, techniques designed for measuring relative abundances are suitable for monitoring species in the broad "affected area" of the WEF, but should be complemented by walked-transect or fixed-point counts conducted within the turbine-development area.

It is also critically important to appreciate that the relationship between absolute densities/numbers and measures of relative abundance of birds is unlikely to be linear in nature (e.g. Jakob and Ponce-Boutin 2013 and references therein). This means that changes as gauged by measuring relative abundances likely represent far greater changes in terms of absolute densities/populations (i.e. monitoring initiatives rooted in measures of relative abundances are more likely to under-estimate, and even fail to detect, changes as estimated by techniques based on estimates of absolute abundance).

(i) Walked transects

Small birds can be monitored by means of walked, linear transect methods in open habitats (Leddy et al. 1999; Bibby et al. 2000). The length, number and distribution of these transects on each site may vary according to site size, habitat diversity, and the richness and relative significance of the small terrestrial avifauna. Ideally all the major habitat types present should be sampled approximately in proportion to their availability on site. Transects should be positioned at varying distances away from the proposed turbine arrays to maximize the value of the data in comparison with results from surveys made during the post-construction phase. It is preferable to have many fairly short (e.g. 200 m) transects than few long (e.g. 2 km) transects.

Transects should be surveyed according to standard procedures (for example, as described by Emlen 1977; O'Connor & Hicks 1980; Ralph and Scott 1981; Bibby et al. 2000). These procedures should take into account possible biases caused by factors such as different observers, time of day, bird song activity, weather conditions, seasonality, differences in interspecific detectability, etc. As a general rule, transects should not be walked in adverse conditions, such as heavy rain, strong winds or thick mist.

Transect counts aimed at estimating the density/absolute numbers of birds present at a site typically require measurement/estimation of the perpendicular distance from the transect line of all birds recorded. This should either be measured by range-finder, estimated by eye (in which case calibration is necessary), or estimated in terms of pre-selected distance bands (e.g. 0-10 m, 11-50 m, 51-200 m, >200 m), and recorded for subsequent analysis using the computer programme DISTANCE (Buckland et al. 2001; Thomas et al. 2010), or equivalent approaches (Bibby et al. 2000; Newson et al. 2008).

Alternatively, transects can be done with a fixed maximum width, and only birds seen or heard within this distance on either side of the transect line should be recorded (e.g. Leddy et al. 1999). These methods yield estimates of density (birds/km^{-2}), but do not take the probability of detection into account. The 'Kilometric Abundance Index' (KAI) (Vincent, Gaillard & Bideau, 1991; Acevedo et al., 2008; Preatoni et al., 2012) is an example of a 'transect-count-type' method that provides a relative measure of bird.

WALKED TRANSECTS
Recommended variables to record for each transect include*:

- Project name
- Transect number
- Date
- Observer/s
- Start/finish time
- GPS location at start and finish or track log
- Orientation of transect
- Distance covered (m)
- Habitat type/mix of habitat types
- Gradient of slope (flat, gentle, steep)
- Aspect of slope (none, north, north-east, east…)
- Temperature at start
- Cloud cover at start
- Wind strength/direction at start
- Visibility at start and end of survey (good, moderate, poor)

- Position of sun relative to direction of walk (ahead, above, behind)

And, whenever possible, variables to record for each observation should include:

- Time
- Species
- Number (number of adults/juveniles/chicks)
- Activity (flushed, flying-display, flying-commute, perched-calling…)
- Seen or heard?
- GPS on transect line
- Distance and direction from observer
- Perpendicular distance off transect line (m) (if required)
- Distance band off the transect line (if required)
- Fixed transect width (if required)
- Plot on map
- Additional notes

** Many of these variables can be recorded before or after the site visit using GIS.*

(ii) Fixed-point counts

Another acceptable way to measure the densities of small birds, especially in densely vegetated habitats such as forest, is to use fixed-point counts (Bibby et al., 2000). For fixed-point counts the observer is positioned at one fixed location (chosen either randomly or systematically to ensure coverage of all available habitats), and records the species and sighting distance of all birds seen and heard over a prescribed period of time. (Bibby et al., 2000)

Again, survey locations should be selected to represent the habitats covered more or less in proportion to their availability. The duration of each count period should be long enough to detect a representative sample of birds within the survey area, but short enough to avoid including birds that were not present in the area at the start (e.g. 5-10 minutes). As with line transects, the distance from the static observer to each bird or flock of birds registered can either be measured directly (by estimation or using a laser range-finder), or allocated to a range of circular bands of distance from the observer, or else the count can be done with a fixed-detection radius, including only the birds seen within this distance (Bibby et al., 2000). It is important to record whether birds are seen or heard, as it may be difficult to hear birds once the WEF is operational.

FIXED POINT COUNTS
Recommended variables to record for each such fixed-point count include:

- Project name
- Fixed-point number
- Date
- Observer/s
- Start/finish time
- GPS location
- Habitat type/mix of habitats
- Gradient of slope (flat, gentle, steep)
- Aspect of slope (none, north, north-east, east…)
- Temperature at start
- Cloud cover at start
- Wind strength/direction at start
- Visibility at start (good, moderate, poor)

And, whenever possible, variables to record for each observation should include:

- Time
- Species
- Number (number of adults/juveniles/chicks)

- Activity (flushed, flying-display, flying-commute, perched-calling…)
- Seen or heard?
- Distance to bird (m) (if required)
- Distance band containing bird (if required)
- Fixed radius of count (m) (if required)
- Additional notes

(iii) Checklist surveys

A further method of documenting the occurrence and relative abundance of small terrestrial species (although in this instance, all species are included in the data-collection protocol) is the "checklist survey". This method does not measure the absolute abundance (density) of species, but provides a measure of relative abundance based on the "reporting rate". In its simplest form, the reporting rate is the proportion of checklists for a particular area that record a particular species relative to the total number of relevant checklists completed for the area expressed as a percentage.

The objective of checklist surveys and analysis is to provide a simple comparison of relative abundance, per species, between the pre- and post-construction phases. The advantage of the checklist survey is that the method is easy to implement in situations where methods of counting birds may be difficult to apply in a consistent manner, for example, where habitats are diverse or visibility limited, and the survey area is very large (Royle & Nichols, 2003; Joseph et al., 2006). A disadvantage is that it is dependent on not one, but a series of checklists (preferably at least 10), recorded at different times, so that a robust relative-abundance statistic can be calculated. Checklist surveys are suitable for monitoring species in the broad "affected area" of the WEF, but must be complemented by transect and/or fixed-point counts conducted at varying distances from the turbines. The latter counts will provide a more sensitive measure of density at the localities most likely to be impacted by the turbines.

The protocol for a checklist survey requires (a) the definition of a survey area (to permit comparable repeat visits), (b) the application of a constant amount of survey effort, and (c) coverage of all habitat types within the survey area. All species encountered are recorded as present only, i.e. individuals of each species are not counted. In addition, the order in which species are first observed is recorded, as well as the total number of new species per hour of observation. The minimum amount of time allocated to each checklist should be sufficient to permit coverage of all the habitat types in the survey area (two hours is the specified minimum in the SABAP2 protocol, with a maximum of five days). Note that while larger species and priority species should be included in checklist surveys, these do not replace other methods of measuring the density of these birds, which include the capture of critical information on absolute rather than relative abundance (although see Wenger & Freeman 2008).

Where possible and appropriate, the protocols used by SABAP2 (the second Southern African Bird Atlas Project) should be used. Details of these protocols are available on the project's website (http://sabap2.adu.org.za/). For SABAP2, the survey area is the "pentad", a 5x5-minute grid resulting in a cell of roughly 8x9 km. The size of a pentad makes it advisable to survey it using a vehicle to cover the area. Pentads could be suitable survey areas for large WEFs, particularly if the WEF is located centrally within the pentad, and the data collected will be compatible with the SABAP2 database. Every pentad that includes a portion of the WEF should be surveyed, as a minimum.

Relatively small WEFs would perhaps be better served by transect or point counts, or by using grid cells smaller than those used by SABAP2.

(b) Large terrestrial species and raptors

Large terrestrial birds (e.g. cranes, bustards, storks, and most raptors) cannot be adequately surveyed using walked transects. Populations of such birds should be estimated on each visit to the project area either by means of a census (only possible at relatively small proposed WEFs) or by means of road counts (vehicle-based sampling; best applied at relatively large proposed WEFs, especially those with good networks of roads and tracks). Any obvious breeding pairs and/or nest sites located during this survey work should be plotted and treated as focal sites for subsequent monitoring (see below). Malan (2009) provides particularly comprehensive coverage of raptor surveying techniques within a South African context. The road infrastructure and accessibility of the site is likely to change if the WEF becomes operational. It is therefore important to carefully record the survey methods and survey effort to allow for later comparison.

(i) Census counts

Census counts of priority species involves searching as much of the broader impact area of the WEF (or the reference site) as possible in the course of a day, using the available road infrastructure and prominent vantage points to access and scan large areas, and simply tallying all the individuals observed. This is only practical for the largest and most conspicuous species, and probably is only effective for cranes and bustards. If necessary, counts can be standardized for observer effort (time, area scanned, methods used), but ideally they will be working estimates of the total number of each target species present within the study area on that sampling day.

CENSUS COUNTS OF LARGE PRIORITY SPECIES

Recommended variables to record for each count of large, priority species include:

- Project name
- Count number
- Date
- Observer/s
- Start/finish time
- Temperature at start
- Cloud cover at start
- Wind strength/direction at start
- Visibility at start (good, moderate, poor)

And, whenever possible, variables to record for each observation should include:

- Time
- Species
- Number (number of adults/juveniles/chicks)
- Activity (flushed, flying-display, flying-commute, perched-calling…)
- Flight direction (if required)
- Flying height (if required - above, below or within rotor-swept area)
- GPS location of observer
- Distance and direction from observer
- Plot birds sighted on map and/or record GPS points
- Habitat type/mix of habitats
- Gradient of slope (flat, gentle, steep)
- Aspect of slope (none, north, north-east, east…)
- Seen close to (feedlot, dam, river-course, ridge or cliff-line…)
- Seen while driving/walking/scanning
- Additional notes

(ii) Road counts

Road counts of large terrestrial birds and raptors require that one or a number of driven transects be established (depending on site size, terrain and infrastructure), comprising one or a number of set routes, limited by the existing roadways but as far as possible directed to include a representative cross section of habitats within the impact zone. These transects should be driven at a constant and slow speed, and all sightings of large terrestrial birds and raptors should be recorded in terms of the same data-capture protocols used for walked transects (above), and in general compliance with the road-count protocols described for large terrestrial species (Young et al., 2003) and raptors (Malan, 2009). In addition, each transect should include a number of stops at vantage points to scan the surrounding area. If sighting distance is used to delineate the area sampled, this method will yield estimates of density (birds/km^{-2}) for all large terrestrial species and birds of prey. Alternatively, variation in sighting distances (perhaps associated with variable terrain or habitat) may preclude the use of this method, and it may only be possible to determine a simple index of abundance, expressed as the number of birds seen per kilometre driven (birds/km).

ROAD COUNTS

Recommended variables to record for driven transect counts of large terrestrial species and raptors include:

- Project name
- Transect number
- Date
- Observer/s
- Start/finish time
- GPS location at start/finish
- GPS location of vantage points
- Odometer reading at start/finish
- Distance covered (km)
- Temperature at start
- Cloud cover at start
- Wind strength/direction at start
- Visibility at start (good, moderate, poor)

And, whenever possible, variables to record for each observation should include:

- Time
- Species
- Number (number of adults/juveniles/chicks)
- Activity (flushed, flying-display, flying-commute, perched-calling…)
- Flight direction (if required)
- Flying height (below, above or within rotor-swept area)
- Seen while driving/scanning?
- Habitat type/mix of habitat types
- Gradient of slope (flat, gentle, steep)
- Aspect of slope (none, north, north-east, east…)
- Seen close to (feedlot, dam, river course, ridge or cliff-line…)
- GPS on transect line
- Perpendicular distance off transect line (m) (if required)
- Distance band off the transect line (if required)
- Fixed transect width (if required)
- Plot on map
- Additional notes

(iii) Focal-site surveys and monitoring

Nest sites

Any habitats within the broader impact zone of the proposed WEF, or an equivalent area around the reference site, deemed likely to support nest sites of key raptor species (including owls) - cliff-lines or quarry faces, power lines, stands of large trees, marshes and drainage lines - should be surveyed following protocols in Malan (2009) in the initial stages of the monitoring project. All such sites should be mapped accurately, and checked on each visit to the study area to confirm continued occupancy, and to record any evidence of breeding, and where possible, the outcomes of such activity, that may take place over the survey period (Scottish Natural Heritage, 2010). Disturbance of breeding birds must be kept to a minimum during surveys.

Any nest sites of large terrestrial species (e.g. bustards and especially cranes) that may be located should be treated in the same way, although out of season surveys are unlikely to yield results as these birds often do not hold year-round territories.

Evidence of breeding should be assigned the same status categories as used in SABAP2.

NEST SITE SURVEYS
Recommended variables to record for each nest site survey should include:

- Project name
- Date
- Observer/s
- Species
- Site name, number or code
- Type of site (nest, roost, foraging…)
- Time checked
- Temperature
- Cloud cover
- Wind strength/direction
- Visibility (good, moderate, poor)
- Signs of occupation (e.g. fresh droppings, fresh food remains, freshly moulted feathers)*
- Signs of breeding activity (e.g. adults at nest, adult incubating or brooding, eggs or nestlings)*
- Number of adults/eggs/nestlings/juveniles seen*
- Additional notes

** Evidence of breeding should be summarised and reported using SABAP2 codes (i.e. CDP – courtship display, CAN - adult bird carrying nesting material, ANB - active nest building, NCN – newly completed nest, NWE - nest with eggs, NWC - nest with chicks, PFY – parents feeding young in nest, PFS - parents with fecal sac, PAY - parents and young not in nest, JUV – juvenile birds).*

Wetlands

The major wetlands on and close to the development area should also be identified, mapped and surveyed for waterbirds on each visit to the site, using the standard protocols set out by the CWAC initiative (Taylor et al., 1999). Some priority species (e.g. Blue Cranes, *Anthropoides paradiseus*) may only occupy wetland roosts at night; suspected roosts should therefore be visited late in the day to tally the numbers of birds as they accumulate into the evening.

WETLAND SURVEYS
Recommended variables to record for each wetland survey should include:

- Project name
- Date
- Observer/s
- Wetland name, number or code
- Time at start/finish of count
- GPS location at observation point
- Temperature
- Cloud cover
- Wind strength/direction
- Visibility (good, moderate, poor)

- Tidal state (if wetland is tidal)

And, whenever possible, variables to record for each species counted should include:
- Species
- Number (number of adults/juveniles/chicks)
- Direction of arrival/departure from wetland (if applicable)
- Activity (e.g. feeding, roosting, transit)
- Additional notes

Guyed masts and power lines

As an extension of the focal-site monitoring, any guyed masts within the proposed development area should be checked each survey iteration for signs of bird collisions, and the findings should be recorded as per post-construction collision-victim surveys (see below). Other infrastructure that may pose a collision risk (for example power lines) should also be checked as far as possible, particularly where collision-prone priority species are potentially affected. Any carcasses found beneath power lines should be reported to the Eskom / EWT Incident Reporting Hotline (0860 111 535, email wep@ewt.org.za)

(iv) Incidental observations

All other, incidental sightings of priority species (and particularly those suggestive of breeding or important feeding or roosting sites or flight paths) within the broader study area should be carefully plotted and documented. These could include details of nocturnal species (especially owls) heard calling at night.

INCIDENTAL OBSERVATIONS
Recommended variables to record for each incidental observation of priority species should include:
- Project name
- Date
- Observer/s
- Time
- Temperature
- Cloud cover
- Wind strength/direction
- Visibility (good, moderate, poor)
- Species
- Number (number of adults/juveniles/chicks)
- Activity (flushed, flying-display, flying-commute, perched-calling…)
- Flight direction (if required)
- Flying height (if required - <30m, 30-150m, >150m)
- GPS location of observer
- Plot birds sighted on map
- Habitat type/mix of habitats
- Gradient of slope (flat, gentle, steep)
- Aspect of slope (none, north, north-east, east…)
- Seen close to (feedlot, dam, river course, ridge or cliff-line…)
- Seen while driving/walking/scanning
- Additional notes

2.2.8. Bird movements

A spatially explicit understanding of bird movements in and around a proposed WEF site may be more important to determine the sustainability of the project (and identify an effective mitigation strategy) than knowledge of the species richness and abundance of birds present. Developing such an understanding requires a significant investment of time and effort. Vantage-point surveys are the primary means of gathering data on bird movements, but in some instances these direct observations may benefit from supplementary data from remote sensing equipment (e.g. radar) and bird-tracking devices. The designated avifaunal specialist should determine the need for supplementary data, with input from relevant experts and stakeholders (e.g. EWT and BirdLife South Africa).

(a) Direct observation/vantage point surveys

The purpose of vantage point watches is to collect data on priority species to allow estimation of:

i. the time spent flying over the proposed development area;
ii. the relative use of different parts of the development area;
iii. the proportion of flying time spent within the upper and lower height limits as determined by the rotor diameter and rotor-hub height of the turbines to be used (rotor-swept area); and
iv. the flight activity of other bird species using the development area.

Counts of bird traffic over and around a proposed/operational facility should be conducted from suitable vantage points. The same vantage-point locations should be used for each subsequent survey, as even small changes in observer position can affect results (Scottish Natural Heritage, 2013).

Vantage-point watches should be designed so as to obtain a representative sample of bird movements across a development site. The vantage points chosen should provide an overview of as much of the development area as possible using the minimum number of vantage points (Scottish Natural Heritage 2013). GIS can be used to facilitate the identification of vantage points with the best inclusive viewsheds. Overlapping viewsheds should be avoided, or where this is not possible, any overlap should be accounted for in later analysis.

Ideally, to achieve seamless coverage, all areas of the potential development area of the WEF should be within a 2 km radius of a vantage point (Gove et al., 2013; Scottish Natural Heritage, 2013). This distance may be stretched if conditions (visibility) allow, although the accuracy of the height and distance estimates may be compromised, and smaller species may be overlooked. Where complete coverage is not possible (e.g. some very large and topographically varied sites) a minimum of 75% of the potential developable area should be surveyed.

As an absolute minimum, each vantage point should be surveyed for 12 hours per season, spread across the period from before dawn to after dusk. Vantage point watches should be divided into three or more shifts (e.g. dawn, midday and dusk), and these shifts should be between two to three hours each. Ideally vantage point watches should be spread over multiple days (i.e. the same vantage point should not be surveyed more than once a day). This will allow activity between different days to be accounted for and will increase the representativeness of the data. This may however prove impractical at vantage points that are difficult to reach. Scheduling should always take the detrimental effects of observer fatigue on data quality into consideration.

Where flight activity is very varied, or if there is a risk of significant negative impacts to a priority species more observation time is likely to be necessary to obtain a representative sample of flight patterns. This is especially important in areas where flocking species such as vultures, cranes or pelicans are present, or where turbines are placed within the territory of a priority species.

Additional observation time may be necessary to obtain a clear indication of collision risk (Gove et al., 2013).

It may be useful to schedule additional vantage-point monitoring at particular times of day or seasons to coincide with the times a particular species of concern is most active, if a particular risk has been identified that requires further investigation. Night-time watches, coincident with clear, moonlit conditions, might be valuable at sites where nocturnal activity is considered potentially relevant. Kunz et al. (2007) provide a good overview of methods and tools to study nocturnal movements of birds.

Observation and data collection should ideally be focused in the direction of the proposed development area from the vantage point, extending to 90° on either side of that focal point, i.e. an 180° field of observation. Bird movement taking place outside this view ('behind') the observers may be relevant, and should be included at the discretion of the site specialist or the fieldworkers at the time, but not at the expense of effective 'forward' coverage. Where a team of two observers are working together at a single vantage point, a viewshed larger than 180° (even up to 360°) may be possible. Where the activity of target species is low and visibility is good, it may also be possible for a single observer to accurately cover 360°. As with all survey methods, clearly written documentation, describing what has been done, is essential.

Vantage-point surveys require many hours on site collecting data and the resulting tedium can constrain the quantities of data that can be accumulated. Other challenges include the inability to gather meaningful movement data at night or in daytime conditions of low visibility, and the risk that the relatively limited sampling periods will miss or under-represent episodic mass movements of birds (Scottish Natural Heritage, 2013).

VANTAGE POINT SURVEYS

Recommended variables to record for each vantage point survey should include:

- Project name
- Vantage point name/number
- Date
- Observer/s
- Start/finish time
- GPS location
- Temperature at start
- Cloud cover at start
- Wind strength/direction at start[#]
- Visibility at start (good, moderate, poor)

And, whenever possible, variables to record for each observation should include:

- Time sighted and time bird moved out of view
- Species
- Number (number of adults/juveniles/chicks) at start and end of observation
- Temperature
- Cloud cover
- Wind strength/direction[#]
- Visibility (good, moderate, poor)
- Initial sighting distance (m)
- Flight mode (direct commute-flapping, direct commute-gliding, slope soaring…)*
- Underlying habitat*
- Gradient of underlying slope (flat, gentle, steep)*
- Aspect of slope (none, north, north-east, east…)*
- Flight direction*

- Flying height (below, above or within rotor swept area))*
- Identifiable flight path indicators (valley, neck or saddle, ridge line, thermal source…)
- Plot on map
- Additional notes

**These variables should ideally be recorded at 15-30 second intervals from the initial sighting, or at least with every change in flight mode, until the bird/flock of birds is lost.*
 # Wind data can be measured directly using a hand-held anemometer, and/or sourced from the wind data collected on-site by the developer for the relevant date and time.

(b) Radar

The state of the art in monitoring bird movements in relation to WEFs involves the use of custom-built radar installations (e.g. http://www.detect-inc.com/wind.html and http://echotrack.com). When set up correctly, these systems can provide round-the-clock coverage of a sizeable area in all weather conditions. Radar systems cannot easily distinguish between different species, types or even sizes of birds, but when used in combination with direct observation to calibrate remotely collected information, they can provide comprehensive and accurate data describing the frequency, height and direction of bird flight paths through a proposed or operational wind farm.

While costly, use of a radar system is likely to add significant value to any monitoring project, and may be essential at certain sites where it is critical to obtain accurate data on large-scale movements of birds, or movements of significant numbers of highly threatened species, that are thought (or known) to take place at night or in conditions of poor visibility. For example, many of the larger-scale movements made by waterbirds typically occur at night and our current understanding of the routes followed is extremely poor. The Cape West Coast area between Langebaan, Vredenburg and Velddrif is one example where radar monitoring may provide valuable additional data on the night-time movements of waterbirds. Such information can be vital to ensuring that wind-energy development in such areas proceeds sustainably.

(c) Tracking devices

The use of tracking devices (e.g. satellite/GSM devices) attached to birds can help provide a better understanding of the flight behaviour and habitat usage of individual birds. Data arising from bird-borne telemetry could be useful in determining the placement of wind turbines and may also provide useful insights into flight behaviour of individual birds before and after construction (Gove et al., 2013).

It is, however, important to be cognisant of the limitations of tracking data, particularly with regards to accuracy of the data, the frequency with which location data is recorded, the duration of study, and the number of individual birds tracked in relation to the size of the affected population. For example, if location data is recorded every 30 minutes this may give a good indication of the bird's range/territory size, but is unlikely to give a good indication of the actual flight patterns and whether the bird was travelling within the rotor-swept area. Further, only individual birds can be monitored, meaning that typically not all birds using an area are assessed. It is therefore important that the appropriate technology is selected, and that it is able to provide adequate data to meet the objectives of the study (Strickland et al., 2011).

Handling birds and attaching devices to them carries an inherent risk to study animals. There is some evidence of negative impact on birds fitted with tracking devices (Marzluff et al., 1997; Gregory, Gordon & Moss, 2003; Phillips, Xavier & Croxall, 2003). These risks must be minimised as far as possible and deployment of devices must be justified in terms of the science and conservation outcomes expected. Consideration should also be given to alternative methods to obtain the data (U.S. Fish and Wildlife Service, 2013).

Permits for fitting tracking devices must be obtained from the relevant provincial conservation authority. It is recommended that ethical clearance should also be obtained for the project from a relevant ethics committee. When projects are linked to academic institutions, ethical clearance can be obtained directly from the ethics committee of the particular academic institution. Should the project not be linked to an academic institution, it is recommended that the research proposal is submitted to the BirdLife South Africa Ethics Committee for review.

A competent person who is experienced in the fitting of tracking devices must be involved in the project. It is the responsibility of both the specialist and person fitting the device to ensure that the impact on the bird be kept to a minimum, both during the fitment process and subsequently. A device should never weigh more than 2-3% of the body weight of the individual bird on which it is deployed (Phillips, Xavier & Croxall, 2003). The device should be tested prior to deployment and attachment systems (e.g. use of harnesses) should first be tested on captive birds before a bird in the wild is fitted with a tracking device if the relevant species has not been tracked before or a novel harness fitting is considered.

For more information please see BirdLife South Africa's position statement on the tracking of birds, available at www.birdlife.org.za.

2.2.9. Impact assessment

The avifaunal impact assessment should be based on data collected from the pre-construction surveys detailed above. The impact assessment must include consideration of the eight key aspects presented below (with appropriate mapping and statistical analyses, where relevant).

i. A comprehensive list of the bird species recorded (or expected to occur) at the relevant sites (including control sites), including details of local distribution (with spatial mapping where appropriate), confirmed and predicted breeding status (again with spatial mapping where appropriate), gross habitat preferences, seasonality, endemism and Red-data status (both globally and nationally). This information should clearly differentiate between species positively recorded at the site by the specialist team, recorded in the general or specific area by other projects (e.g. SABAP, CWAC, CAR, etc.) and species not yet recorded in the area at all, but predicted to occur or possibly occur. This information should also identify and justify priority species.
ii. Absolute and relative abundance estimates and measures for small terrestrial birds, through linear transect surveys and fixed-point counts, and checklist surveys.
iii. Counts, density estimates and abundance indices for large terrestrial birds and raptors;
iv. Flight behaviour of priority species flying above, below or through the rotor swept area and associated risk of collisions (see below).
v. Evidence of breeding at any focal nest sites.
vi. Bird numbers at any focal wetlands and local movements between waterbodies.
vii. Full details of any incidental sightings of priority species.
viii. Collision mortalities related to any existing guyed lattice masts and existing power lines.

This information should be used to cover six primary requirements as outlined below.

i. Determine whether or not the proposed development (or parts thereof) is fatally flawed and should not be recommended for approval.
ii. Develop a topographical map indicating the area that is expected to be impacted by the proposed development alternatives, and the location of key habitats and flyways that should not be developed or otherwise transformed.
iii. Inform the final turbine layout (or where the layout cannot be finalized within the EIA, the assessment should be used to define no go areas and areas that should be sufficiently buffered).
iv. Assess the significance of the potential impact of the proposed project alternatives and related activities - with and without mitigation - on avifaunal species and communities (with regards to potential disturbance, displacement, habitat loss and mortality through collision), including consideration of the spatial and temporal extent of these impacts.
v. Inform actions that should be taken to avoid or, if avoidance is not feasible, to mitigate and minimize negative impacts during the planning, construction and operational phases of the development.
vi. Inform the nature and extent of monitoring required during the post-construction phase.

The framework used for assigning significance values should be clearly described in the report, and should include consideration of the probability, extent, duration, magnitude and certainty of impacts. Unacceptable negative impacts would be those impacts that diminish the conservation status of a species or population. Where possible, impacts on a given taxon should be contextualised in terms of the size and distribution of the affected population, and any known trends in key demographic parameters. This may require the use of population models.

A map indicating the location of vantage points and the viewshed from each vantage point should be provided, together with a map of the proposed turbine layout.

The avifaunal impact assessment must include a description of the limitations and assumptions of the assessment.

Where other developments are proposed in a region, the impact assessment must include consideration of cumulative impacts. Bellebaum et al. (2013), for example, indicated that while collision risk at each turbine was small and relatively low levels of mortality were observed at individual wind farms, the cumulative impact of wind farms in Germany could negatively influence the local population of Red Kites (*Milvus milvus)*. When considering cumulative impacts, the distribution, spatial requirements and population dynamics of potentially affected priority species should be considered, together with the likelihood of impacts from other proposed developments.

(a) Collision risk

Assessment of collision risk may be qualitative or quantitative. Data from vantage-point surveys can be used to develop an index of collision risk for different areas within the developable area. Alternatively, if sufficient data are available the number of bird fatalities that might take place once the wind farm is operational could be estimated using a collision-risk model (Band, Madders & Whitfield, 2007; Scottish Natural Heritage, 2009; Strickland et al., 2011; U.S. Fish and Wildlife Service, 2012). There are different approaches to modelling collision risk (e.g. Podolsky 2004; Band et al.

2007), but most models take into account characteristics of the wind facility and its turbines, as well as the passage rate, height and speed of flight, and use a correction factor to account for uncertainties and behaviour (avoidance) (Strickland et al., 2011). The latter approach (i.e. estimating fatalities) is strongly recommended where there is a high risk of priority species being affected, but input data must represent average conditions if the output is to be meaningful. Input data must represent the range of conditions/seasonal variation in usage and it may be appropriate to run the collision model several times to account for marked spatial or temporal variation in bird presence/behaviour.

Collision-risk models make a number of assumptions, including predictions of species-specific bird behaviour (Madders & Whitfield, 2006). They assume that mortality risk increases with flight activity and bird abundance, but evidence to support this assumption is equivocal (Gove et al., 2013) and a number of other factors are likely to influence collision risk (de Lucas et al., 2008; Ferrer et al., 2012). For example, collision risk might be reduced if birds are displaced by the WEF (U.S. Fish and Wildlife Service, 2013). Flights of large bird species below the rotor-swept area could also be 'at-risk' flights, as large birds may change flying trajectories and go into the rotor-swept area quite quickly (Á. Camiña. pers. comm.).

Collision-risk models can provide a useful basis on which to compare different wind farms (Chamberlain et al., 2006; Gove et al., 2013) or different layouts. However, the limitations of the input data (for example, the degree to which the data represent average conditions, or the accuracy of the flight-height estimates) and the limitations of the model should always be borne in mind (Chamberlain et al., 2006). The outputs of collision-risk models must be compared with fatality data collected on site after construction to validate the model (U.S. Fish and Wildlife Service, 2012) and improve correction factors/avoidance rates used.

2.3. Stage 3: Construction-phase monitoring

The construction phase of a WEF is likely to be the most intense period in terms of disturbance and displacement of birds. It is important to gain a better understanding of how WEF construction impacts on birds, and how these impacts can be minimised (Pearce-Higgins et al., 2012).

Construction-phase monitoring can be used to:

a) determine if the proposed mitigation measures (e.g. buffers) are implemented by the developer, and whether or not they are effective in minimising impacts on sensitive birds during construction;
b) provide insights into the triggers and duration of any observed changes in species presence, abundance and behaviour; and
c) provide an opportunity to gather additional data on priority species and focal points (particularly where nest sites have been identified).

Construction-phase monitoring will not be necessary for all wind farms, but could be recommended by the specialist in the impact assessment if there is a focal site of specific interest or concern, and/or if there is a need to gather additional data on a species potentially affected by the WEF. Construction-phase monitoring is likely to be recommended if there are anticipated impacts on the breeding of priority species.

If the specialist recommends construction-phase monitoring, the duration, frequency and scope of work should be outlined in the impact assessment report and included in the environmental management plan. Without pre-empting the recommendations of the specialist, surveys of approximately three days per season, with a particular focus on focal-point surveys, could be anticipated.

Specialists are also encouraged to check for carcases beneath turbines and other infrastructure. These searches do not necessarily need to follow the rigorous protocols outlined for post-construction monitoring, but may shed valuable insights into the impacts of the facility before the Commercial Operation Date is reached.

Depending on the nature and scope of the work required the avifaunal specialist team and/or a suitably qualified environmental control officer could undertake construction-phase monitoring. The results of this monitoring should inform any additional mitigation that may be required and should be included in revisions of the environmental management programme.

2.4. Stage 4: Post-construction monitoring

KEY POINTS

- Post-construction monitoring is necessary to: a) determine the actual impacts of the WEF, b) determine if additional mitigation is required at the WEF, and c) improve future assessments.
- Post-construction monitoring does not negate the need to first avoid, then minimise and lastly mitigate negative impacts during the project-development stage.
- Post-construction monitoring should start on, or soon after the Commercial Operation Date.
- Post-construction monitoring can be divided into three categories: a) habitat classification, b) quantifying bird abundance and movements (replicating pre-construction monitoring), and c) quantifying bird mortalities.
- There are three components to estimating fatality rates: a) estimation of searcher efficiency and scavenger removal rates, b) carcass searches, and c) estimation of collision rates.
  - *All turbines should be searched for fatalities, with a search interval determined by scavenger-removal trials and objectives monitoring. Two complementary search protocols should be applied: 1) intensive and regular searches of a minimum of 30% or 20 turbines at a WEF (which ever is greater), and 2) extensive, less frequent sampling of the remaining turbines to record fatalities of large-bodied birds. The search area must be defined and consistently adhered to throughout monitoring. As a minimum, the radius of the search area be should equal to 75% of the turbine height (ground to blade-tip).*
  - *Observed mortality rates must to be adjusted to account for searcher efficiency, scavenger removal and the probability that some carcasses may be outside the search area.*
- The duration and scope of post-construction monitoring should be reviewed annually Post-construction monitoring of bird abundance and movements should span a minimum of two years. Surveying the WEF for fatalities should also be done for a minimum of two years after construction, and should be repeated again at year five, and every five years thereafter. The outcomes of the previous years monitoring, together with the sensitivity of the receiving environment should guide if specific components of monitoring should be extended beyond the prescribed minimum.

2.4.1. Aim of post-construction monitoring

Avifaunal impact assessments rely on a number of assumptions. The pre-construction monitoring protocols outlined in this document represent a compromise between practicality (time and cost) and statistical rigour. Relying on imperfect data and research findings from different regions (and often different species) means that there will always be a degree of uncertainty and risk associated with assessments.

Post-construction monitoring is therefore critical to:

i. determine the actual impacts of the WEF;
ii. determine if additional mitigation is required (adaptive management); and
iii. improve future assessments.

By committing to post-construction monitoring developers will help facilitate the development of a sustainable wind-energy industry and reduce risks and costs to both the environment and the industry in the long run.

Post-construction monitoring should assess if there are any changes in: a) habitat available to birds in and around the WEF, b) abundance and species composition of birds, c) movements of priority species, and d) breeding of priority species. It should also provide an indication of fatality rates as a result of collisions with the turbines and associated infrastructure, and if there are spatial, temporal or conditional patterns to the frequency of collisions. Lastly, post-construction monitoring should highlight if additional mitigation is required to reduce impacts to acceptable levels.

Commitment to post-construction monitoring does not negate the need to firstly avoid, secondly minimise and finally mitigate negative impacts identified in the impact assessment, but it can help lessen unanticipated negative impacts. Post-construction monitoring is particularly important given the heavy reliance on adaptive management that characterises many environmental impact assessments for WEFs in South Africa.

Post-construction monitoring can be divided into three categories: a) habitat classification, b) quantifying bird numbers and movements (replicating pre-construction monitoring), and c) quantifying bird mortalities. It may be necessary to introduce a fourth category of monitoring should there be a need to investigate and resolve a specific impact.

2.4.2. Timing

In order to ensure that the immediate effects of the WEF on resident and passing birds are recorded, before they have time to adjust or habituate to the development, post-construction monitoring should start on, or soon after the Commercial Operation Date. If there is a particularly high risk of collision associated with any of the turbines during commissioning and testing the designated avifaunal specialist may advise that monitoring should begin sooner.

While monitoring immediate effects is valuable, it is equally important to obtain an understanding of the impacts of the WEF as they are manifest over the lifespan of the facility. Over time, the habitat within the WEF and the composition and behaviour of the avifauna within it can be expected to change. Consideration must therefore be given to how impacts might vary over the lifespan of the facility and it may be necessary to repeat certain aspects of monitoring at different time intervals.

2.4.3. Duration and scope

The duration of post-construction monitoring should be determined by the sensitivity of the environment and the potential risk to birds. The avifaunal specialist report should provide a preliminary indication of the likely duration and scope of post-construction monitoring, but this should be reconsidered at the end of each year of post-construction monitoring. Extended monitoring will permit short-term and long-term effects to be distinguished.

As a minimum, survey protocols used in the pre-construction monitoring should be repeated during the first two years of operation and should be combined with monitoring of fatalities. The need for further monitoring of bird abundance and movements should be reviewed at the end this period to determine if it is necessary to continue with some, or all, components of this work. The need for further monitoring of fatalities shold also be reviewed after the first two years, and then again on an annual basis. Carcass searches must, however, be repeated in the fifth year, and again every five years thereafter at all facilities.

Although post-construction monitoring is unavoidably onerous, there may be substantial benefits to maximising the duration and frequency of post-construction monitoring (or parts thereof). There is evidence that the abundance of birds at wind farms changes over time and short-term studies may not provide a true indication of the impacts over the lifespan of the facility (Stewart, Pullin, and Coles 2007). Studies in North America also point to high inter-annual variation in fatality rates for raptors; relying on a single year's monitoring can lead to estimates that are not representative of actual fatality rates (Smallwood, 2013). Where collision rates are low (e.g. less than one bird per annum), it may take years before a casualty is recorded, yet even low collision rates can be significant for some species (Scottish Natural Heritage, 2009).

Where there is a low confidence in the findings of the impact assessment, adaptive management is commonly relied on as a mitigation measure. Adaptive management can be an important tool should there be unanticipated negative impacts. By its nature, adaptive management necessitates a significant commitment to post-construction monitoring.

The duration of post-construction monitoring (or parts thereof) should be extended where:

i. significant inter-annual variation in the presence of some species is expected (e.g. wet and dry periods in arid areas),
ii. there is likely to be inter-annual variation in crops,
iii. where the data point to significant operational-phase impacts,
iv. there is a need to distinguish between impacts relating to construction and impacts of a more permanent nature, and/or
v. additional monitoring may help point to appropriate mitigation measures.

As the site-specific issues at each WEF become apparent over time, the scope of post-construction monitoring can be tailored to address the primary impacts of concern.

2.4.4. Habitat classification

Any observed changes in bird numbers and movements at a WEF could be linked to changes in the available habitat (as well as changes in weather conditions, rainfall, etc.). The avian habitats available on both the project and reference sites should therefore be mapped at least once a year (at the same time every year), using the same methodology used in the reconnaissance/scoping phase of monitoring.

2.4.5. Bird abundance and movements

In order to determine if there are any impacts relating to displacement, disturbance, habitat change, changes in mortality rates, changes in breeding success, etc., all methods used to estimate bird abundance and movements during pre-construction monitoring should be applied in exactly the same way (and under similar environmental conditions) in the post-construction phase in order to ensure the comparability of these two data sets. This includes sample counts of small terrestrial species, counts of large terrestrial species and raptors, focal site surveys and vantage point surveys. To minimise the impacts of observer bias, the same observers should ideally be used for pre- and post-construction.

If pre-construction monitoring included areas no longer considered for development, the broader impact zone can be redefined and the extent of post-construction monitoring may be reduced.

There may be instances where replicating pre-construction monitoring exactly is not possible or desirable (for example where pre-construction monitoring did not follow Best Practice, did not focus adequately on key issues, and/or certain areas are no longer accessible or comparable). The specialist may adjust and enhance the survey protocols if this will help meet the objectives of monitoring.

2.4.6. Fatality estimates

The primary aims of monitoring fatalities are to meet four key objectives as identified below.

a) Estimate the number and rate of fatalities at a WEF.
b) Describe the species composition of fatalities (as well as the age and sex where possible).
c) Record and document the circumstances and site characteristics surrounding avian fatalities at turbines and ancillary infrastructure of the WEF (this could aid understanding the cause of fatalities, and hence possible mitigation).
d) Mitigate impacts by informing final operational planning and on-going management.

There are normally three separate components to estimating fatalities:

a) experimental assessment of search efficiency and scavenging rates of bird carcasses on the site;
b) regular searches for collision casualties (Morrison, 2002; Barrios & Rodríguez, 2004; Krijgsveld et al., 2009); and
c) estimating fatality rates based on these data (Smallwood, 2007, 2013; Bernardino et al., 2013).

(a) Searcher efficiency and scavenger removal

The value of surveying the area for collision victims only holds if some measure of the accuracy of the survey method is developed (Morrison, 2002; Bernardino et al., 2013). The search area, the probability of a carcass being detected, and the rate of removal/decay of the carcass must be accounted for when estimating collision rates and when designing the monitoring protocol (Korner-Nievergelt et al., 2011; Strickland et al., 2011; Bernardino et al., 2013).

Scavenging rates, carcass persistence and searcher efficiency may differ for different sizes of birds (and for bats). It may therefore be necessary to use separate estimates for small, medium and large birds (Strickland et al., 2011).

Searcher efficiency and scavenger removal trails should be repeated at least twice a year (i.e. once in summer and once in winter) to account for different conditions.

(i) Searcher efficiency

In order to estimate the probability of an observer detecting a carcass, a sample of suitable bird carcasses should be obtained and distributed randomly around the search area. The number and location of the paced carcasses should be recorded and these carcasses should be of similar size and colour to the priority species. The proportion of the carcasses located in surveys will indicate the relative efficiency of the survey method (Morrison, 2002; Barrios & Rodríguez, 2004; Krijgsveld et al., 2009). These trials should be done under the supervision of the avian specialist during the scheduled carcass searches, without the knowledge of the field teams. Separate trials should be conducted for each individual searcher or search team.

The location of all carcasses not detected by the survey team should be checked subsequently to discriminate between error due to search efficiency (those carcasses still in place which were missed) and scavenge rate (those immediately removed from the area).

(ii) Scavenger removal

In order to determine the rates at which carcasses are scavenged, or decay to the point that they are no longer obvious to the field workers, fresh carcasses of bird of similar size and colour to a variety of the priority species should be placed randomly around the search area and the location of each carcass recorded. As far as possible, carcasses used in trials should mimic the species characteristics and state of carcasses from wind-turbine collisions (Smallwood, 2013). However, it is acknowledged that obtaining suitable material may be challenging. Care should be taken to avoid tainting carcasses with human scent (Whelan et al., 1994) and the total number of carcasses set out should not be less than 20, but not so plentiful as to saturate the food-supply for the local scavengers (Smallwood, 2007).

These sites should be checked daily for the first week to record any changes in the presence, location and condition of each carcass. After the first week, the search interval can be increased and searches should continue for up to a month (Gove et al., 2013). This should provide an indication of scavenge rate (average persistence time) that should inform subsequent survey work for collision victims, particularly in terms of the frequency of surveys required to maximise survey efficiency and/or the extent to which estimates of collision frequency should be adjusted to account for scavenge rate (Osborn et al., 2000; Morrison, 2002; Strickland et al., 2011). There are different models to predict the probability of a carcass persisting over time (see Bispo et al., 2012) and the approach used should be clearly defined. Scavenger numbers and activity in the area may also vary seasonally (Smallwood, 2007). Scavenge and decomposition rates should therefore be measured at least twice over a monitoring year, once in winter and once in summer. Scavenger removal rates may also differ according to ground-cover (Á. Camiña, pers. comm.); it may be necessary to stratify surveys to account for this.

(iii) Integrated detection trials

An alternative approach could be to conduct integrated detection trials, where trial carcasses of a suitable range of birds are placed on random days each week, at random locations within the search areas. Trial carcasses and fatalities caused by wind turbines should be carefully recorded, but left in place and monitored. Carcasses detection rates (ideally related to body mass) can then be calculated at the end of the study (Smallwood et al., 2015).

(b) Carcass searches

(i) Search effort

The accuracy of estimates of fatality rates is influenced by survey effort. If only a small proportion of turbines within a WEF are surveyed, there is a risk that the set of turbines sampled are not representative of the entire wind farm. If monitoring is only conducted over a short timespan, key events may be missed (Peron et al., 2013). If only a small area beneath each turbines is surveyed, some carcasses may fall outside the search area and may not be detected (Smallwood, 2013). While there are practical and cost implications of increasing search effort, this must be weighed against the risks of introducing various sources of bias. Maximising search effort (e.g. by increasing the frequency and duration of surveys, and the proportion of turbines surveyed) will reduce the risk of inaccurate results.

The developer, specialist and landowner may need to negotiate the timing and extent of surveys in croplands. Monitoring will require access to the wind farm and a substantial area beneath the turbines, which may interfere with farming operations. This should be clearly dealt with in lease agreements so monitoring is not compromised.

(ii) Search area

The area below each of the turbines should be checked regularly for bird casualties. Turbine characteristics (e.g. rotor length) may affect the area in over which carcasses fall (Anderson et al., 1999; Morrison, 2002; de Lucas et al., 2008; Smallwood & Thelander, 2008). Some studies have attempted to determine the ideal search area (e.g. Hull & Muir 2010), but these recommendations are often tempered by financial and practical constraints (Bernardino et al., 2013).

As a minimum, the radius of the search area should be equal to 75% of the turbine height (ground to vertical blade-tip). In many early studies, a search radius of 50-60 m was used (Smallwood & Thelander, 2008; Bernardino et al., 2013); an area similar to that recommended in the equivalent guidelines for bats in South Africa (which recommends a radius of at least half the distance from the maximum blade tip height to the ground) (Aronson et al., 2014). While adequate for bats, this area has been found to be insufficient to accurately assess bird mortalities (Smallwood, 2013). More recent guidelines (e.g. Strickland et al. 2011) recommend a search radius equal to 100% of the maximum distance between the ground and the tip of the blade. The recommended 75% of the turbine height represents a compromise between these two approaches. A proportion of carcasses are likely to fall outside of the recommended search area and avian fatality rates can therefore be expected to be underestimated (Smallwood, 2013).

The size of the search area should remain the same throughout the study. The area around each turbine should be searched using transects located no more than 10 m apart; this width should be reduced where thick groundcover hampers visibility. Transects should be walked slowly, and the target area searched carefully and methodically for any sign of a bird-collision incident (carcasses, dismembered body parts, scattered feathers, injured birds).

It may be acceptable to search only a subset of the search area if the habitat is such that surveying the entire area is not possible (e.g. steep slope, thick, shrubby vegetation, tall crops), although such circumstances should be carefully documented.

Where visibility (ground cover) within the search plot is highly variable these areas should be mapped and assigned visibility classes to control for varying probabilities of detection (Strickland et al., 2011; Smallwood, 2013). The groundcover and terrain will influence the time spent searching each turbine.

In tandem with surveys of the wind farm, all guyed masts and sample sections of any new lengths of power line associated with the development should also be surveyed for collision and/or electrocution victims using established protocols (Anderson, 2001; Shaw, Jenkins, Ryan, et al., 2010; Shaw, Jenkins, Smallie, et al., 2010).

(iii) Search interval

The period between searching individual turbines, the 'search interval', should be informed by assessments of scavenge and decomposition rates conducted in the initial stages of the monitoring period. As a rule of thumb, a search interval of two weeks could be expected, although this may vary according to the objectives of the study and environmental conditions at the WEF.

Strickland et al. (2011) suggested that the search interval should ideally be shorter than the average carcass removal time. However scavenger trials in the Karoo indicated that large bird carcasses either were removed within a few days (although feathers may remain for longer), or persisted for a long time (Schutgens, Shaw & Ryan, 2014). There may therefore be limited value in sampling every two weeks versus every month. It is unclear if a similar pattern can be expected for small birds or for different environments. Further information in this regard relevant to South African conditions is required.

The primary objective of fatality searches also should influence the search interval. For example, carcass-removal rates are likely to be low and searcher efficiency high for large-bodied raptors. If these birds are of primary concern, longer search intervals (up to 30 days) may be acceptable. However, this may compromise fatality estimates for smaller birds (Strickland et al., 2011) and would not be appropriate where there is a potential risk of collisions for small species of conservation concern. Bearing this in mind, it may be necessary to have two complementary approaches to sampling, and two different search intervals: 1) intensive, regular sampling of a subset of turbines and 2) extensive, less frequent sampling for large-bodied bird carcasses. While this approach is not ideal for determining average fatality rates (Smallwood, 2013), it does represent a compromise where significant mortalities of large birds at a particular turbine, or group of turbines, can be identified with limited resources.

(iv) Which turbines should be searched?

It is recommended that all turbines at each wind farm are surveyed, if necessary using the two different survey methods (intervals) as described above. This approach will help ensure impacts on priority species are recorded as collision rates vary greatly between wind farms and between turbines (Drewitt & Langston, 2008) and collision rates are also not well correlated with anticipated risk (Ferrer et al., 2012).

No fewer than 30% or 20 turbines (whichever is greater) at any single WEF should be surveyed using the more rigorous (intensive) sampling methods. These turbines should be selected randomly, or through stratified random sampling where habitat variation is pronounced. Most estimators of fatalities assume that the same turbines are searched at regular intervals; once the subset of turbines has been selected, these should be fixed for the rest of the monitoring period, unless there is good reason to change this.

(v) Combining bat and bird carcass searches

In most instances carcass surveys will be required for both birds and bats. There is no clear reason for not combining the two searches into a single effort, although there are some inherent challenges to aligning the survey protocols for these two groups. Bird carcasses typically may be found further away from turbines than those of bats (Strickland et al., 2011; Smallwood, 2013), so birds require a larger search area. Conversely, bats are normally small and their carcasses may not persist for long in a detectable state. Bats are also less likely to leave evidence of a fatality compared to birds the feather puffs of which may provide an indication of a collision. Bats therefore call for particularly frequent and intensive searches (Smallwood, 2013). There has already been an attempt to integrate the protocols (e.g. by minimising the recommended search area for birds), but it is recognised that a flexible approach is required to do this adequately. Search protocols should be designed with input from both bird and bat specialists, who would need to agree on the priorities for each particular site. Where survey protocols favour bats and small birds, this must be supplemented with less intensive, less frequent surveys of the remaining turbines to maximise the chances of recording fatalities of scarce large-bodied priority species, the carcasses of which are likely to be more visible and persist for longer than those of bats (see iii above).

RECORDING AND REPORTING MORTALITIES:
All suspected collision incidents should be comprehensively documented, detailing the following recommended variables:

- Observer name
- Project name
- Date
- Time
- Species
- Age class (where possible)
- Sex (where possible)
- GPS location/s
- Condition of remains
- Nearest turbine number
- Distance to nearest turbine
- Compass bearing to nearest turbine
- Habitat type/mix of habitats
- Gradient of slope (flat, gentle, steep)
- Aspect of slope (none, north, north-east, east…)
- Plot on map
- Photograph the collision site as it was located

(vi) Carcass management

All physical evidence associated with located carcasses should be photographed, referenced (including accurately geo-referenced using a GPS), checked for age and sex (where possible). Carcasses should be collected, bagged and carefully labelled (label inside and outside the bag(s) - if double-bagged, put one label inside the outer bag), and refrigerated or frozen to await further examination and possible post-mortem (not applicable where integrated carcass detection trails are underway, see section 2.4.6.(a)(iii)). Where there is any doubt with regards to species affected, an expert should be consulted to verify the identification. Handling of carcasses should be limited, particularly if these are to be used in scavenger-removal trials.

The landowner's permission must be obtained to collect, store and transport carcasses. The provincial conservation authority should also be consulted to confirm which, if any, permits are required to keep and transport carcasses. They should also be consulted to help determine what should ultimately happen to the carcasses (e.g. if they should be used in searcher-efficiency/scavenger-removal trials, or lodged with a museum, or otherwise disposed of).

If an injured bird is recovered, it should be contained in a suitably sized cardboard box. The local conservation authority should be notified that the bird will be transported to the nearest veterinary clinic or wild-animal/bird rehabilitation centre. In such cases, the immediate area of the recovery should be searched for evidence of impact with the turbine blades, and any such evidence should be fully documented (as above), including outcome and possible post-mortem.

(vii) Ad hoc recording of collisions

Maintenance staff should be required to report bird mortalities through a formalised reporting system throughout the lifespan of the facility. This should be additional to post-construction monitoring and does not replace formal carcass searches. All information outlined in the box above (particularly the GPS position) should be recorded as far as possible.

Where there are incidental carcass finds at turbines that are being formally monitored they should be left in place where they may be detected during formal searches (Smallwood, 2013).

Details of incidental carcass finds should be included in post-construction monitoring reports. Where bird carcasses are found in years where there is no formal monitoring, carcasses should be labelled, bagged and frozen. Fatalities should be reported annually to BirdLife South Africa, EWT and the Department of Environmental Affairs/SANBI (more often if significant incidents occur).

(viii) Alternative survey methods

Trained dogs can be used to assist in the detection of collision carcases (Bevanger et al., 2010; Paula et al., 2011) and could be considered as an alternative search method. Dogs can increase searcher efficiency, reduce observer bias and reduce the amount of time required to search (Paula et al., 2011). This technique may be particularly useful where visibility is poor due to vegetation cover (e.g. in croplands), but does require significant levels of skill on the part of handlers and dogs, and training must be on-going. The use of dogs for carcass searches is encouraged as this can help reduce margins of error when estimating fatality rates.

A variety of remote devices have also been developed to aid the detection of collision incidents, although many of these were designed with offshore environments in mind (for further details see Collier et al. 2011). These devices may be useful as a trigger for additional carcass searches, but should not replace the above protocols until their effectiveness has been tested.

Cameras mounted on mobile devices such as drones may also assist with carcass detection. Once again, until their efficacy has been proven, these tools should supplement, not replace standard survey protocols.

(c) Fatality estimators

Observed mortality rates need to be adjusted to account for searcher efficiency, scavenger removal and the probability that some carcasses may be outside the search area (Korner-Nievergelt et al., 2011; Strickland et al., 2011; Bernardino et al., 2013). There have been many different formulas proposed to estimate mortality rates (e.g. Erickson et al. 2004; Smallwood 2007; Korner-Nievergelt et al. 2011; Smallwood 2013; Péron et al. 2013). Strickland et al. (2011) and Bernardino et al. (2013) provide a good overview of the different estimators. It is recommended that more than one formula be considered for use, depending on their applicability to each circumstance (Bernardino et al., 2013). There are tools available to assist with fatality estimates, e.g. http://www.wildlifefatalityestimator.com and fatality CMR (Péron & Hines 2013).

2.4.7. Reporting

Quarterly interim monitoring reports should be completed for each site, summarising the results of that previous three months monitoring. A post-construction monitoring report, analysing these results, should be completed at the end of each year of monitoring.

As a minimum, the annual report should attempt to answer the questions listed below.

a) Has the habitat available to birds in and around the WEF changed?
b) Has the abundance of birds and/or species composition changed?
c) Have the distributions and/or movements of priority species changed?
d) Is there evidence that the breeding success at focal nest sites may have changed?
e) Where the answer is yes to any of the above four questions, what is the nature of the observed changes? (Compare these changes before (during) and after construction).
f) What is the nature, and likely drivers, of any changes observed?
g) What is the likely demographic and ecological significance of any observed changes in bird populations at the site (including consideration of the magnitude and direction of change) at both the local and broader population scale?
h) What are the collision rates and total number of bird fatalities at the WEF? (Collision rates should be reported per MW (nameplate capacity) and per turbine. Data should be reported in both raw and corrected forms).
i) What is the species and, as far as possible, age and sex composition of fatalities?
j) What proportion of fatalities is likely to be due to collisions with wind turbines?
k) Are there any factors (e.g. site characteristics and proximity to wind turbines) that may contribute to these fatalities?
l) Is additional monitoring and/or mitigation necessary and if so, what needs to be done?

The post-construction monitoring report should include a comparison of the predicted and observed impacts, as this may provide useful insights for future impact assessments. If additional mitigation was implemented on the basis of previous post-construction monitoring, the report should include an assessment of the effectiveness of these measures. The need for further post-construction monitoring and the scope of any further work should also be reviewed.

The findings and recommendations of the post-construction monitoring report should be included in the updated Environmental Management Programme. Should significant impacts be observed, mitigation and/or compensation options should be discussed with the developer, the Department of Environmental Affairs, BirdLife South Africa, EWT, and other relevant stakeholders.

3. Implementation

KEY POINTS

- These guidelines are aimed at all WEFs that require environmental authorisation for electricity generation. They were not intended for small wind turbines or small wind farms (although a specialist input will be required for both).
- The scope of monitoring required will vary from site to site; these guidelines set out the minimum effort that is likely to be required. Any deviation from the minimum, or enhanced protocols, should be well motivated and clearly justified.
- A bird specialist must oversee the monitoring and hire capable and competent field staff.
- Pre-construction monitoring is a critical component of avifaunal impact assessment and must be included in the EIA.
- Peer review of monitoring reports is encouraged. This should be done transparently and all reports should be made available for review.
- Monitoring data and reports should be made publically available, as this will help support the sustainable development of renewable energy.

3.1. Applicability of these guidelines to small wind farms

The sensitivity of birds to the impacts of wind energy does not appear to be strongly correlated to the size of the WEF, or the number and capacity of turbines (Hötker, Thomsen & Jeromin, 2006; Pearce-Higgins et al., 2012). It is therefore recommended that these guidelines be applied to all WEFs that require environmental authorisation for electricity generation. The extent of monitoring required (for example number of vantage points and transects) would, however, be influenced by the size of the project.

A single poorly placed wind turbine potentially could cause more damage than a large, well-located wind farm. For smaller facilities (fewer turbines), an avifaunal specialist must therefore be consulted to determine the scope of the assessment necessary. In these cases, the level of monitoring required should be dictated by the complexity and sensitivity of the receiving environment (e.g. conservation priority of species potentially affected).

These guidelines were not intended for small wind turbines (i.e. less than 50 kW and/or less than 25 m high). These facilities should also be assessed on a case-by-case basis.

3.2. Monitoring masts and other infrastructure

Prospective developers normally erect a number of guyed lattice wind-monitoring masts around a proposed development area in order to gather wind data for the project. An avifaunal specialist should be consulted before the installation of these masts, particularly with regards to the need to attach markers to the guy wires in order to reduce collision risk for birds. In the event that guy wires of existing guyed masts have not been marked, the specialist should provide input in scoping reports on the need to do so retrospectively. From the onset of pre-construction monitoring until the completion of post-construction monitoring, all such masts should be checked for collision mortalities during each site visit.

While the more general development impacts (for example construction of roads, sub-stations and power lines, etc.) associated with the actual construction of each WEF are not a primary focus of this document, these may be severe. The scale and mitigation of these impacts should be referred to explicitly in scoping level and avifaunal specialist reports should be integral to the ultimate decision to proceed with the project.

3.3. Survey effort

Each project should broadly comply with the guidelines provided here, although the scale of each project, the level of detail and technical input, and the relative emphasis on each survey and monitoring component, will vary from site to site in terms of the risk potential identified by the initial scoping or environmental impact assessment (EIA) studies. In principle, each investigation should be as inclusive and extensive (both spatially and temporally) as possible, but be kept within reasonable cost constraints, consistent with the anticipated conservation significance of the site and its avifauna. Time, human capacity and finances are all legitimate constraints on the extent and intensity of monitoring work possible, but cannot at any stage be allowed to override the need to maintain the levels of coverage required to thoroughly evaluate the sustainability of a proposed WEF.

In general, the detail and rigour required in any given monitoring project will be proportional to the size of the proposed WEF (number of turbines and spatial extent), topographic and/or habitat heterogeneity on site, the relative importance of the local avifauna (in terms of diversity, abundance and threat status) and their habitats (e.g. wetlands and flyways), and the anticipated susceptibility of these birds to the potential negative impacts of a wind-energy development. These guidelines set out the minimum effort that is likely to be required in most instances. Any deviations from this minimum should be carefully considered, well motivated and clearly justified.

Monitoring effort should be intensified if there are factors that add substantially to the potential impact of a development, e.g. high densities or diversity of threatened and/or endemic species, or the close proximity of known and important avian flyways or wetlands.

3.4. Specialists and field teams

The bulk of the work outlined in these guidelines should be done by trained observers, under the guidance and supervision of a qualified and experienced specialist ornithologist. A list of avifaunal specialists who have agreed to follow these guidelines is available at www.birdlife.org.za and www.ewt.org.za. Alternatively please email energy@birdlife.org.za.

The specialist and their team must be independent (i.e. have no business, financial, personal or other interest in the WEF, other than fair remuneration for work performed in connection with that activity or application).

The Natural Scientific Professions Act of 2003 provides for the establishment of the South African Council of Natural Scientific Professions (SACNASP) and for the registration of professional, candidate and certified natural scientists. This Act states that only a registered person may practice in a consulting capacity. The specialist ornithologist should therefore be registered with SACNASP.

While field staff need not be registered with a professional body, it is the specialist's responsibility to ensure that the team has the necessary skills (for example bird identification and map reading) to undertake the required work. An avifaunal specialist familiar with the site should always oversee monitoring.

Ideally, field workers should operate in pairs on the assumption that two people working together are likely to see and record more, and maintain higher health and safety standards, than one person working alone, but without the significant additional costs that may be incurred by the deployment of larger teams. On occasion, it may be possible for experienced observers to effectively survey alone.

The field team undertaking carcass searches do not need the same skills as the team monitoring bird populations and movements (although some training is likely to be required).

Specialists are encouraged to provide the field staff an opportunity to study the monitoring reports. This will help ensure no valuable observations are missed, as field staff will be most familiar with the site.

The role of the developer and the operational staff at the WEF should not be underestimated. Specialists are encouraged to help the developer and their staff gain a clear understanding of the conservation issues on site, and developers are encouraged to familiarise themselves with these guidelines and specialists' reports.

3.5. Equipment

Field teams will require specialized equipment in order to gather monitoring data accurately, quickly and efficiently. In many cases, especially before the WEF is operational, an off-road vehicle (ideally a 4x4) will be required to make maximum use of the available road infrastructure on site. Each team member will need a pair of good quality binoculars and a recent regional bird identification guide. A spotting scope may prove useful and a GPS, a digital camera and a means to capture data – a notebook, datasheets, or generic or customized PDA – are essential equipment. Electronic data capture devices, digital video cameras, hand-held weather stations and laser range-finders are useful, optional extras, that will facilitate the rapid acquisition, collation and processing of the maximum amount of relevant and accurate information on each survey.

Each field team should have at least one set of hard-copy maps (at a minimum scale of 1:50 000) covering the full study area for accurate navigation and plotting of sightings. Digital maps of the area, on which sightings can be plotted directly in digital format, are useful, optional extras, which should facilitate the accurate capture of spatially explicit information. The importance of accurately and clearly recording data cannot be overemphasised. The text boxes throughout this document should provide the basis for standard recording forms for each project.

3.6. The EIA process and best practice

The stages outlined in these guidelines should be aligned with the similarly named stages of a formal EIA process, although a more proactive approach is also encouraged. For example, the scoping stage as outlined in these guidelines should coincide with, and serve as, the scoping study for the purposes of EIA. However, it may prove to be valuable for developers to commission an avifaunal scoping study as part of their project screening, prior to initiating a formal impact assessment process, as this might help avoid unnecessary investment in unsuitable sites. However, the full scoping report should always include the avifaunal scoping report to afford stakeholders an opportunity to provide comment at an early stage. Similarly, there may be value in starting pre-construction monitoring prior to beginning the formal EIA process. However, the results of both scoping and pre-construction monitoring should substantially inform the avian impact assessment report, and be the basis upon which the decision whether of not an environmental authorisation should be issued. Pre-construction monitoring must therefore be completed before the impact assessment is finalised (although, as indicated above, further pre-construction monitoring may be required if there is a prolonged period of time between the granting of environmental authorisation and the commencement of construction).

It is the responsibility of both the environmental assessment practitioner and the avifaunal specialist to ensure that the specialist's work is reflected appropriately in the Scoping and Environmental Impact Assessment reports. This should be reflected in the relevant contracts. It is recommended that avifaunal specialists be sent material distributed to registered interested and affected parties, so that they can be kept abreast of the progress of proposed developments in which they have been involved.

3.7. Peer review

Peer review is the evaluation of a specialist's work by another expert (or experts) in the field in order to maintain or enhance the quality of work. Peer review can be a valuable tool in avifaunal specialist reporting as it can help to maintain standards and increase consistency of recommendations across projects. It can also help to improve and strengthen the end product and add credibility to the process.

The use of professional peer review for renewable energy applications therefore is encouraged, subject to the five points listed below.

i. The original author should be advised that a peer review will be conducted.
ii. Ideally, the original author should be requested to provide a list of potential candidates to conduct the review, but the final choice of reviewers should lie with the relevant environmental assessment practitioner under whose supervision the specialist is operating.
iii. The 'reviewer' must be given clear terms of reference, explaining the context of the review.
iv. The results of the peer review must be made available to the original author for right of response.
v. The reviewer must complete and submit his/her own declaration of interest with the application to DEA.
vi. Both the original report and the peer review report should be made available for public review and decision-making.

3.8. Data management and data sharing

Monitoring reports and supporting data should be made publically available and shared with BirdLife South Africa, EWT, provincial authorities, Department of Environmental Affairs, the South African National Biodiversity Institute and any other relevant body (e.g. a national database, when this is established). While analysis and reporting at individual WEFs will be the responsibility of the relevant avifaunal specialist, reports and data emanating from the above process should ultimately be housed centrally to facilitate the assessment of results on a multiple WEF, landscape and national scale. Permission to publish the findings of such analyses in the relevant media by EWT/BirdLife South

Africa, BARESG, or by accredited academic institutions should be obtained from the developer before the onset of monitoring. This pooling of information is in the interests of collective understanding and building a sustainable renewable-energy industry in southern Africa.

Specialists are also encouraged to submit findings (whether positive, negative or inconclusive) to peer-reviewed scientific journals to promote wider dissemination of results and experience. Among other things, this will help improve study design and knowledge of possible impacts. Developers are encouraged to give permission to use data from their facilities for this purpose.

SABAP1 and 2 data are utilised extensively in the scoping and impact assessment processes for WEFs. Specialists are therefore encouraged to register with the SABAP2 project and contribute to this project. This can be done by either submitting incidental records or, preferably, full protocol atlas cards completed for all the pentads (5 x 5 minute squares) making up each development site. These cards should be submitted on every survey (including those made during pre-construction and post-construction monitoring). If necessary, this can be done as a completely separate contribution to ornithology, generated as a by-product of monitoring, rather than as a direct component of the data collected for the client. For more information on SABAP2 please refer to http://sabap2.adu.org.za.

Where birds have been fitted with tracking devices, specialists are encouraged to submit their data to www.movebank.org.

Any carcasses found beneath power lines should be reported to the Eskom / EWT Incident Reporting Hotline (0860 111 535, email wep@ewt.org.za)

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APPENDICES

1. A step-wise approach to impact assessment and bird monitoring at a proposed wind-energy site

The following are key steps in the successful design and implementation of bird monitoring at a proposed wind-energy development site:

1. A qualified advising scientist, and a capable monitoring agency, are appointed to conduct pre-construction monitoring/impact assessment (and preferably post-construction phase monitoring).
2. A scoping study is undertaken, based on a short site visit and desktop information.
3. Monitoring protocols are established and agreed to. Generic guidelines are customised to suit the specific issues at each site. Proposed protocols are discussed with key stakeholders (e.g. BirdLife South Africa and Endangered Wildlife Trust), particularly if consideration is being given to undertaking less than the minimum outlined in these guidelines.
    a. Consideration is given to using technology for monitoring bird movements (e.g. radar or transmitters). If the use of technology is warranted, the budget must be secured and hardware, software, relevant expertise, permits and ethical clearance must all be obtained (where applicable).
4. Pre-construction monitoring begins.
    a. Pre-construction monitoring data are periodically collated and analysed to permit necessary changes to be made at the earliest opportunity. Data-collection protocols and schedules are adapted to ensure that sufficient data are accumulated, and sufficient coverage is achieved, to adequately inform development decisions. The use of transmitters and radar is reconsidered, if not already in use.
    b. There is regular communication between the specialist, developer and other consultants, particularly if there are any potentially significant issues encountered. Where there are potentially significant issues, stakeholders (e.g. BirdLife South Africa and Endangered Wildlife Trust) should also be consulted.
5. A report reviewing the full year of pre-construction monitoring is compiled and the findings integrated into the EIA and Environmental Management Programme (EMPr) for the project. Protocols for construction-phase monitoring (where required) and for post-construction monitoring are outlined.
6. The final EIA is submitted to the Department of Environment for environmental authorisation.

For those projects for which environmental authorisation is granted and construction proceeds:

7. The need for further pre-construction monitoring is assessed, particularly if considerable time elapses between collection of data for impact assessment and the commencement of construction.
8. The EMPr is applied during construction and, if necessary, construction-phase monitoring is conducted.
9. The post-construction monitoring protocols are refined and post-construction monitoring is initiated as soon as the wind turbines are operational.
    a. Post-construction monitoring data are periodically analysed and, if necessary, data-collection protocols are adjusted to ensure that sufficient data are accumulated and sufficient coverage is achieved to adequately inform operational decisions.

10. A report reviewing the full year of post-construction monitoring is compiled and submitted to the relevant authorities and stakeholders. The findings of monitoring are integrated into the EMPr for the operating wind farm and the broader mitigation scheme. The need for, and scope of, further post-construction monitoring is reviewed.

2. Minimum requirements for avifaunal impact assessment

An avifaunal impact assessment for a WEF should follow a two-tier process:

1) Scoping – a review of existing literature and data, as well as a site visit to inform the design of a site-specific survey and pre-construction monitoring plan.
2) Impact assessment – systematic and quantified monitoring over four seasons that will inform a full Environmental Impact Assessment (EIA) detailing and analysing the significance of likely impacts and available mitigation options.

1) Scoping

The scoping assessment should be based on a review of existing literature and bird-atlas data, the BirdLife South Africa and Endangered Wildlife Trust Avifaunal Wind Farm Sensitivity Map, distance from protected areas and recognized Important Bird and Biodiversity Areas, as well as avifaunal data collected during a brief site visit to the proposed wind-farm site. The Scoping Report should contain the information listed below.

a. A description of the site in terms of the avifaunal habitats present.
b. A list of bird species likely to occur on the proposed site, with information on the relative value (in terms of breeding, nesting, roosting and foraging) of the site for these birds with a particular focus on priority bird species.
c. A description of the likely seasonal variation in the presence/absence of priority species and preliminary observations of their movements.
d. A preliminary delineation of areas that are potentially highly sensitive, no-go areas that may need to be avoided by the development.
e. A preliminary description of the nature of the impacts that the proposed development may have on the bird species present.
f. A description of any mitigation measures that may be required to manage impacts related to the monitoring and assessment of the site.

The results of the scoping study, particularly information regarding the diversity and abundance of priority species that are likely to be present, proximity to important flyways, wetlands or other focal sites, and topographic complexity, should be used to:

a. highlight if there are any obvious red flags to the proposed development on all or parts of the site; and
b. inform the required scope, effort, intensity and design of the pre-construction monitoring and impact assessment.

2) Impact assessment

The avifaunal impact assessment should be based on data collected from detailed site surveys, undertaken in accordance with the *BirdLife South Africa/Endangered Wildlife Trust best-practice guidelines for avian monitoring and impact mitigation at proposed wind-energy development sites in southern Africa*. Site surveys must be of sufficient frequency to adequately sample all major variations in environmental conditions/habitat types, with no fewer than four visits to ensure all four seasons are sampled. The degree of effort during each survey should be informed by the likely sensitivity of the site and the species it contains, as well as the size of the proposed wind farm.

The impact assessment must include (with appropriate mapping and statistical analyses where relevant) consideration of the eight key aspects presented below.

a. A comprehensive list of the bird species recorded (or expected to occur) at the relevant sites (including control sites), including details of local distribution (with spatial mapping where appropriate), confirmed and predicted breeding status (again with spatial mapping where appropriate), gross habitat preferences, seasonality, endemism and Red-data status (both globally and nationally). This information should clearly differentiate between species positively recorded at the site by the specialist team, recorded in the general or specific area by other projects (e.g. SABAP, CWAC, CAR, etc.) and species not yet recorded in the area at all but predicted to occur or possibly occur. This information should also identify and justify priority species.
b. Absolute and relative abundance estimates and measures for small terrestrial birds through linear transect surveys and fixed-point counts, and checklist surveys.
c. Counts, density estimates and abundance indices for large terrestrial birds and raptors, through censuses, road transects and vantage-point monitoring.
d. Flight behaviour of priority species flying in or near the future rotor-swept area and associated risk of collisions.
e. Evidence of breeding at any focal raptor sites.
f. Bird numbers at any focal wetlands and local movements between waterbodies.
g. Full details of any incidental sightings of priority species.
h. Collision mortalities related to any existing guyed lattice masts and existing power lines.

This information should be used to cover six primary requirements as outlined below.

a. Develop a topographical map indicating the area that can be expected to be impacted by the proposed development alternatives and the location of any key habitats and flyways that should not be developed or otherwise transformed.
b. Inform the final turbine layout (or where the layout cannot be finalized within the EIA, the assessment should be used to define any no go areas and areas that should be sufficiently buffered).
c. Assess the significance of the potential impact of the proposed project alternatives and related activities - with and without mitigation - on avifaunal species and communities (with regards to potential disturbance, displacement, habitat loss and mortality through collision), including consideration of the spatial and temporal extent of these impacts.
d. Inform actions that should be taken to avoid or, if avoidance is not feasible, to mitigate negative impacts during the planning, construction and operational phases of the development.
e. Inform the nature and extent of monitoring required during construction and the operational phase.
f. Highlight if the proposed development is fatally flawed and should not be recommended for approval.

The avifaunal impact assessment must include a description of the limitations, assumptions and measures of uncertainty relating to the assessment. Where other proposed facilities are proposed in or near to the development in question, the impact assessment must include consideration of cumulative impacts.

The more general development impacts associated with the actual construction of each WEF are not the primary focus of this document. However, these impacts may be severe and should be included in the scoping and impact assessment. Mitigation measures relating to construction-phase impacts should also be outlined in the environmental authorisation and environmental management programme.

3. Recommended conditions of approval

While each development should be considered on a case-by-case basis, the conditions listed below are likely to be appropriate for most wind-farm developments. These recommendations do not preclude the need for additional site-specific conditions.

1. No-go and buffer areas should be clearly defined in the environmental authorisation and indicated on a topographical map. (Condition)
2. Monitoring must be implemented in accordance with BirdLife South Africa/Endangered Wildlife Trust: best-practice guidelines for avian monitoring and impact mitigation at proposed wind-energy development sites in southern Africa. This includes, but is not limited to, the following four aspects.
    a. Post-construction monitoring should use the same methodology as pre-construction monitoring to ensure comparability of results, but should also include the collection of mortality data. (Condition)
    b. Post-construction monitoring should start on, or soon after the Commercial Operation Date. The duration and scope of post-construction monitoring should be informed by the outcomes of the previous year's monitoring, and should be reviewed annually. Post-construction monitoring of bird abundance and movements should span a minimum of two years. Surveying the WEF for fatalities should also be done for a minimum of two years after construction, and must be repeated again at year five, and every five years thereafter.(Condition)
    c. BirdLife South Africa and any other relevant party identified by DEA should be given the opportunity to review and approve the methodology. (Recommendation)
    d. Avifaunal monitoring reports, as well as the raw monitoring data, should be made publically available and forwarded to the Department of Environmental Affairs, BirdLife South Africa, the Endangered Wildlife Trust, and any other relevant party identified by DEA. Post-construction monitoring reports should be forwarded to relevant parties within two months of the completion of an annual monitoring cycle. Relevant data should be entered into a central repository/database (once this is available). (Condition)
3. The results of post-construction monitoring may highlight the need for additional mitigation measures that may need to be incorporated in the environmental management programme. The applicant should be required to take all feasible and reasonable steps to reduce significant impacts on avifauna. (Condition)
4. If deemed necessary by the avifaunal specialist during the EIA, construction-phase monitoring should be conducted and the results of this should inform any additional mitigation that may be required. (Recommendation)
5. The environmental management programme should be reviewed annually for the first five years of the operational phase of the facility. BirdLife South Africa and EWT (and any other party nominated by DEA) should be given the opportunity to comment on the bird-monitoring specifications every year for as long as post-construction monitoring continues. (Recommendation)

6. If turbines are to be lit at night, lighting should be kept to a minimum and should preferably not be white light. Flashing strobe-like lights should be used where possible (provided this complies with Civil Aviation Authority regulations). (Recommendation)
7. Lighting of the wind farm (for example security lights) should be kept to a minimum. Lights should be directed downwards (provided this complies with Civil Aviation Authority regulations). (Recommendation)
8. Where possible applicants should be encouraged to conduct controlled experiments to test the effectiveness of potential mitigation measures that may increase birds perception of wind turbines and associated infrastructure, and hence reduce bird-collision rates. (Recommendation)
9. Clearing of natural vegetation during construction should be kept to a minimum. (Condition)
10. Sufficient drainage should be provided along access roads to prevent erosion and pollution of adjacent watercourses and wetlands. (Condition)
11. Hunting of birds should be prohibited on site. (Condition)
12. All power lines linking wind turbines to each other and to the internal substation must be buried and should follow access roads. Only power lines linking the WEF to the grid may be above ground. Where new power lines cross rivers, other movement corridors or habitat capable of supporting sensitive species, the power lines should also be buried below ground (where feasible).
13. New above-ground power lines should be fitted with bird flight diverters; as a minimum diverters must be fitted in all high-risk areas (durable static bird flight diverters are preferable to dynamic devices which are prone to failure). Bird flight diverters should be visible to birds at night as waterbirds in particular often undertake nocturnal movements, typically in flocks, which increases the risk of collisions. Only Eskom-approved bird-friendly power line pole structures may be used (Condition)
14. The use of guyed towers (for example for wind monitoring or communication) should be minimised and if necessary steps should be taken to increase the visibility of the guy wires through the use of markers. (Recommendation)
15. Maintenance staff should be encouraged to keep noise and other disturbances to a minimum, where priority species may be affected.
16. Routine maintenance should take place outside the breeding season of priority bird species. (Recommendation or, in some cases condition)
17. Maintenance staff should report bird mortalities through a formalised reporting system. (This should be additional to, not replace, formal carcass searches). (Condition)
18. Land-management practices beneath the towers should not increase the attractiveness of these areas to raptors or other species vulnerable to collisions. Structures should be designed to reduce the availability of perching sites. (Recommendation)

While the applicant may contract individuals or organisations to assist them in undertaking the necessary tasks, it is ultimately the applicant’s responsibility to ensure compliance with the conditions of authorisation.