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MAINSTREAMING WILDLIFE INCIDENT MANAGEMENT INTO UTILITIES IN **SOUTHERN AFRICA**

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ACRONYMS

APLIC	Avian Power Line Interaction Committee
BACI	Before-after-control-impact
BFD	Bird Flight Diverter
BIL	Basic Insulation Level
CIR	Central Incident Register
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CSP	Concentrated Solar Plant
DX	Distribution
EIA	Environmental Impact Assessment
EKZN	Ezemvelo KwaZulu Natal Wildlife
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management System
EWT	Endangered Wildlife Trust
EWT-WEP	Endangered Wildlife Trust Wildlife and Energy Programme
HSI	Habitat Suitability Index
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
I-STRING	Insulator String
IUCN	International Union for the Conservation of Nature
KenGen	Kenya Electricity Generating Company
KNP	Kruger National Park
kV	Kilovolts
KZN	KwaZulu Natal
LED	Light Emitting Diode
MV	Medium Voltage
NGO	Non-governmental Organization
NNF	Namibia Nature Foundation
PHVA	Population Habitat Viability Analysis
PV	Photovoltaic
RPAS	Remotely Piloted Aircraft System
RLI	Red List Index
SAEP	Southern Africa Energy Program
SANParks	South African National Parks
SDM	Species Distribution Models
TOPS	Threatened or Protected Species
TSC	Technical Service Centre
TX	Transmission
USA	United States of America
USAID	United States Agency International Development
UVA	Ultraviolet
V-STRING	V-Configured Insulator String
WMS	Wildlife Management System

GLOSSARY

TERM	DEFINITION
Basic Insulation Level Gap	A section removed from an earth/terminal wire to prevent perching bird electrocutions while still protecting the pole in the event of a lightning strike
Collision	When birds or large mammals make contact with hardware inadvertently
Creosote	A tar-like wood preservative solution used on exterior timber to protect against fungal decay and attacks by termites and other wood-boring insects
Electrocution	When birds or mammals fatally bridge the gap between live phases or earthed components and live phases
Excretion	Fecal matter evacuated from the cloaca of a bird
Flapper	A disk shaped bird flight diverter attached to a clamp by a swivel mechanism enabling movement
Flashover	An arc of electricity between live phases or earthed components and live phases, often resulting in marks on hardware or damage to certain components
Hardware	Fixed infrastructure associated with electricity generation, transmission, and distribution
Heliostat	A mirror that can be controlled and moved in order to reflect sunlight in a desired direction
Hot Stick	An insulated pole used by utility staff to attach mitigation products to live electricity components from ground level
Insulation	The covering of live components
Isolation	Preventing wildlife from perching or climbing in close proximity to phases
IUCN Red List/ Red List Index	The IUCN Red List Index (RLI) shows trends in overall extinction risk for species and assigns each species a conservation status, which governments use to track their progress towards reducing biodiversity loss
Outage	When the supply of electricity is interrupted
Pollution	Repeated pre-deposition of excreta on hardware components
Reticulation	A pattern or arrangement of interlacing power lines
Roosting	Animal behaviour associated with resting, sleeping, or settling on infrastructure
Streamer	A solid stream of electrically conductive excreta emitted with some force by a large bird
Whitewash	A milky white stain from bird feces visible on electrical infrastructure

ICONS

- Bird collision
- Mammal collision
- Electrocution
- Nesting
- Streamers
- Pollution
- Rubbing/Scratching
- Damage to poles
- Distribution Division
- Transmission Division
- Generation Division
- Renewable Energy Division

Photo credit: Constant Hoogstad

PURPOSE

This manual is a collaboration between the Endangered Wildlife Trust (EWT) and the USAID Southern Africa Energy Program (SAEP), a Power Africa initiative. Through detailing the variety and severity of wildlife interactions with electrical infrastructures, we aim to shine a spotlight on this much understated problem faced by power utilities in southern Africa. In the pages to follow, examples of wildlife interactions are listed, classified, and explained and solutions to these incidents are provided in a clear, practical manner. By providing a strategy to address these challenges, the goal is to minimize negative interactions between wildlife and electrical infrastructure in southern Africa, thereby reducing operational costs to utilities, improving the quality of electricity supply to economies, and minimizing the impact on wildlife in the region.

RECOMMENDED CITATION:

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CONTENTS

01 AN OVERVIEW OF WILDLIFE INTERACTIONS WITH ELECTRICAL INFRASTRUCTURE IN SOUTHERN AFRICA

Energy infrastructure such as power lines, power stations, substations, wind turbines, and solar developments are important interfaces between people and wildlife, particularly in Africa's growing economies. These structures are tall (standing out in any landscape) and linear (crossing vast distances), presenting extensive opportunities for wildlife interactions. When wildlife interacts with electrical infrastructure, there is a knock-on effect, costly for utilities and disruptive to end-users. When there is infrastructure damage, utilities can incur significant costs related to hardware replacement, travel to incident sites, human resources for investigations and repairs, and loss in revenue if there are power outages.

Unpacking the true cost of wildlife interactions can be challenging. To do so, a data set of historic interactions must be available, and even then, the estimate can only be as reliable as the quality of the data. The effectiveness of mitigation must also be considered to derive an accurate cost estimate.

Landscapes, species, voltage, network reach, location, design, topography, season, and procedures are all factors that could potentially influence the outcome of such an exercise, and perhaps this is why estimates are not well documented. A report prepared for the California Energy Commission in 2005 estimated that the cost of wildlife interactions in California, USA, is between $32 million and $317 million per year, with a base case value of $34 million.[1] These estimates emphasize the importance of recognizing wildlife interactions with electrical infrastructure as significantly impacting utility performance and profitability. Using incidents reported to the Eskom/Endangered Wildlife Trust (EWT) Strategic Partnership over three years, it was calculated that wildlife interactions in South Africa's Eskom distribution division amounted to approximately $3.2 million per year.[2] The study only considered incidents reported to the Eskom/EWT partnership, for which an incident report was generated; a best-case scenario considering some linesmen do not log wildlife mortalities or hardware damages and many incidents are not reported as a result. The study also omitted the cost of replacing wooden power poles damaged by woodpeckers, termites, and large mammals. The calculations focused on the monetary cost to the utility in terms of resource deployment, hardware damage, and loss of income during outages. They did not cover the costs to the local economy resulting from outages, production losses etc., nor did they discuss the cost of environmental losses such as ecosystem services provided by vultures that were killed in energy-related incidents. The figure quoted above can thus only be considered a minimum cost, and there may be significant indirect financial implications resulting from wildlife interactions with electrical infrastructure.

Photo credit: Chantelle Melzer

Wildlife and energy interactions have historically been addressed both reactively and proactively in southern Africa. Two prime examples of this are the Eskom-EWT Strategic Partnership in South Africa and the NamPower-NNF Partnership in Namibia. Now considered world leaders in managing wildlife interactions with electrical infrastructure, Eskom and the EWT formalized their long-standing relationship by entering into a partnership in 1996. The partnership was established to systematically address the wildlife interactions with electrical infrastructure and establish an integrated management system to minimize these negative interactions. One of the main activities of the partnership is the maintenance of a national incident register that monitors trends in wildlife injuries and mortalities on Eskom's infrastructure. Incidents are reported by landowners, the EWT's volunteer network, and Eskom staff.

Once an incident is reported to the EWT, a fieldworker visits the incident location to compile a detailed report of all the relevant information. The EWT then uses this information to develop recommendations for implementing solutions by Eskom at the incident site to prevent repeat interactions.

The Eskom/EWT Partnership has developed an incident management system with various key performance indicators that help track the status and progress of incident investigations, incident recommendation reports, and the implementation of recommendations. Based on the status of incidents reported to Eskom, scores for the different operating units (Eskom Distribution) and grids (Eskom Transmission) are reported monthly to assess their performance related to implementing incident recommendations.

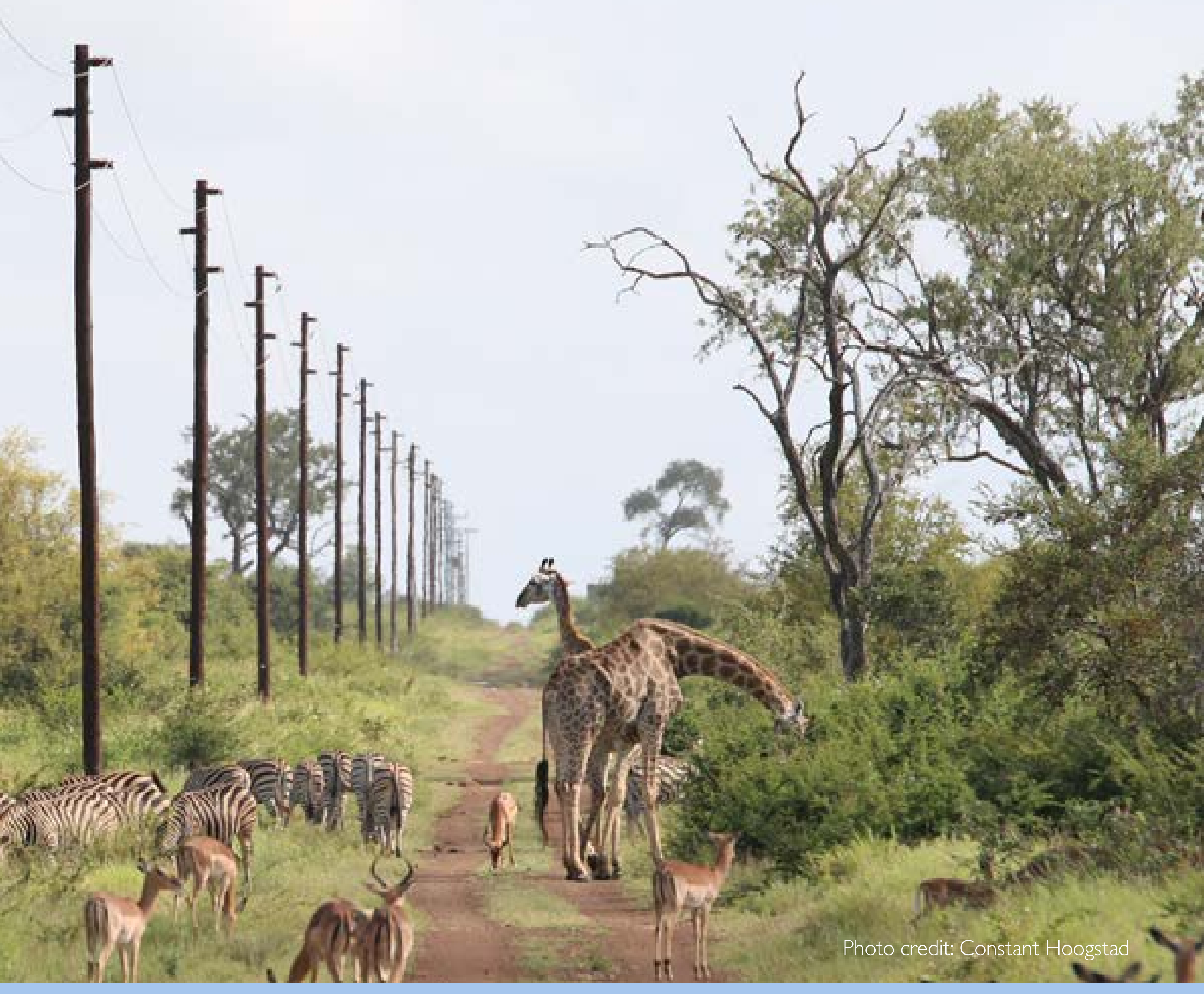


Photo credit: Constant Hoogstad

The database includes over 3,828 incidents involving Eskom power lines, mostly medium voltage (MV) distribution lines. With an average of 2.94 individual animals per incident, nearly 11,847 individual mortalities have been added to the database over the past 25 years. Over 95% of these mortalities were birds, including 169 different species. Certain taxa are far recorded more frequently than others. Vultures and cranes, for example, comprise 23% and 26% of all power line mortalities registered on the database, respectively.

The EWT's Wildlife & Energy Programme (WEP) is continuously working on mitigating power lines, and 95% of the incidents on the database (1996-2021) have been closed-out. There has been a steady increase in the annual number of power line mortalities reported on the database over the past five years, although this could also be attributed to an increased awareness of the problem, which leads to an increased recording. In 2010, WEP initiated a nationwide training program to help improve the reporting of power line incidents by linemen. More than 11,500 Eskom employees have received the training and the ratio of incidents reported by Eskom vs those reported by the public has increased.

Over the years, the Eskom/EWT Partnership evolved to include numerous other Eskom business units, including Eskom Research. This collaboration has led to testing the effectiveness of mitigation measures for minimizing utility impact on wildlife (and vice versa), tracking of Red List bird species of concern, the development of new mitigation devices like the "OWL" nocturnal Bird Flight Diverter (BFD) for birds, and assisting with risk maps. The EWT also assists Eskom Generation with biodiversity management at all power stations and Eskom renewable energy sites.

Africa is on the cusp of an energy revolution. The need to connect people, services, and resources translates into a complex network of energy generation and distribution infrastructure. South Africa has progressed well past this stage of development over 40 years and has experienced a range of electrical infrastructure and wildlife challenges and interactions. Through adaptive management and the development of pioneering and innovative techniques, South Africa is now recognized as one of the world leaders in managing the challenges of wildlife impacts on electrical infrastructure, and in addressing the threats posed to wildlife. These processes are made possible through the implementation of a Wildlife Management System (WMS) at Eskom and the partnership between the Southern African Energy Program (SAEP) and the EWT that recently integrated a similar system into Mozambique`s state owned power utility, Electricidade de Moçambique (EDM).

Photo credit: Constant Hoogstad

By implementing a comprehensive WMS, utilities can monitor and manage negative wildlife interactions and optimize utility performance.

SAEP works to advance energy policy and regulatory reform and accelerate investment to increase power generation and access to electricity in 5 countries: Angola, Botswana, Eswatini, Lesotho, Madagascar, Malawi, Mozambique, Namibia, South Africa, and Zambia.

SAEP addresses key constraints to energy sector investment, by i) strengthening regulation, ii) improving planning and procurement, iii) improving management of electricity trade, iv) demonstrating and scaling renewable energy and energy efficient technologies and practices, and v) providing capacity building to institutions and human resources for energy sector management.

SAEP is funded by USAID, in support of the U.S. Government's Power Africa initiative. Power Africa harnesses the collective resources of over 170 public and private sector partners to double access to electricity in sub-Saharan Africa. Since 2013, Power Africa-supported projects have added more than 12,000 megawatts (MW) of cleaner and more reliable electricity and more than 25 million new power connections for homes and businesses. Power Africa's goal is to add at least 30,000 MW and 60 million connections by 2030. USAID supports Power Africa through programs that bring together technical and legal experts, the private sector, and governments from around the world to work in partnership to increase the number of people with access to power.

Damage to infrastructure and interruptions to energy supply caused by wildlife are among the many operational challenges faced by utilities in southern Africa and SAEP has identified this as a key intervention point to reduce costs and optimize network performance in the region. Leaning on the experience of the EWT, SAEP continues to disseminate information about wildlife interactions with electrical infrastructure throughout southern Africa, preventing countless wildlife mortalities and improving the profitability of utilities. This is achieved by documenting and addressing wildlife interactions, supplementing the Environmental Impact Assessment (EIA)/Environmental and Social Impact Assessment (ESIA) processes with internal due diligence, deploying wildlife, friendly designs and installing mitigation products on hardware where appropriate.

Photo credit: Constant Hoogstad

1.1 ADDRESSING WILDLIFE INTERACTIONS

In the context of energy infrastructure, the term 'wildlife interactions' includes many possible negative and positive impacts involving a range of species and possible scenarios. Positive interactions include birds using pylons or buildings as nesting sites, perches, or roosts. These interactions may contribute to the survival of threatened species and, in some cases, may help them expand their distribution ranges.[3]

However, many interactions negatively affect energy infrastructure, utilities performance, and wildlife. For instance, collisions with conductors and shield wires kill flying birds.[4] Larger bird species are also at risk of electrocution when coming into contact with two live phases or live and earthed phases on distribution lines and substation components.[5] Although large birds such as vultures are most affected, mammals such as Vervet Monkeys, baboons, genets, leopards, and bats are also at-risk during interactions with electrical infrastructure, as are reptiles such as snakes. Several case studies detailing these have been included in Chapter 7.

Larger mammals are also at risk of electrocutions and collisions and can cause serious damage to infrastructure. Research by the EWT in protected areas indicates that elephants, rhino, and buffaloes regularly use wooden power poles to rub against and clean/sharpen their horns or tusks, which leads to pole damage and ultimately pole failure, and results in the conductor being suspended only a few meters from the ground.[6] Giraffes and elephants are tall enough to come into contact with sagging live phases and get electrocuted, and incidents such as these turn into death traps as vultures and other scavengers are attracted to the large carcasses.

Some interactions, such as bird excreta accumulating on critical hardware components, can lead to poor performance over time and result in flashovers.[7] Some woodpecker species can damage wooden poles by simply exhibiting their natural behavior, while smaller taxa such as termites can slowly degrade the integrity of wooden poles that are not correctly treated. Other interactions include bird nests on structures causing line trips and fires. Some nests can be large and heavy enough to break wooden poles.

Photo credit: Constant Hoogstad

Electricity interruptions resulting from these negative interactions impact industry and domestic households, reducing productivity. Extrapolating cost estimates from South Africa to other African countries where the extent of the electricity network is known, it is estimated that wildlife interactions can cost African utilities over $100 million annually through various mechanisms, including revenue loss and costs of repairing damaged infrastructure.

Southern Africa is included in the electrification drive currently unfolding across Africa. Like most other regions in Africa, southern Africa is increasing its generation capacity to expand the reach of its networks and meet its electrification targets. This introduces more opportunities for wildlife interactions, the cumulative effect of which could be devastating if left unchecked. To ensure high performing electricity networks, support growing economies, and protect biodiversity in the region, existing mechanisms should be revised and new mitigation strategies should be adopted by utilities.


Photo credit: Constant Hoogstad

1.2 SUPPLEMENTING THE IMPACT ASSESSMENT PROCESS IN SOUTHERN AFRICA

ESIA and EIA studies have a dual purpose to identify the impact of the infrastructure on the environment, to guide the placement and design of electrical infrastructure in southern Africa, and to influence the Environmental and Social Management system (ESMP) Environmental Management Plan (EMP) to ensure mitigation measures are identified and implemented in the project life cycle. Therefore, the quality of the ESIA, EIA, ESMP, or EMP will to some degree determine the impact that electrical infrastructure will have on wildlife and suggested mitigation actions to reduce or eliminate the impact on wildlife (specifically birds) from energy infrastructure. Utilities and developers should therefore expect and ensure that the Environmental practitioners develop comprehensive ESIAs/EIAs and practical ESMP/EMPs.

Key factors that are to be included in an ESIAs and EIAs to understand as to where the birds occur, fly, and roost in relation to the proposed development, and what mitigation measures will be beneficial to the development. While the utilities and developers can use the EIA to inform the design and infrastructure type, not all mitigation measures for wildlife and energy interactions are covered in the ESMP/EMP or the infrastructure may not even need an ESIA/EIA and ESMP/EMP and therefore the utilities and the developers should recruit an energy and wildlife expert to guide interventions.

However, to enhance the effectiveness of an ESMPs/EMPs, utilities should thoroughly review these documents internally for alignment with the environmental requirements, accuracy and practicality of implementation. Such a review will ensure that internal knowledge regarding wildlife interactions are captured, thereby accounting for all scenarios where wildlife could be negatively impacted, and importantly, ensuring that mechanisms to minimize faults related to wildlife interactions (such as wildlife-friendly designs and mitigation products) are included. However, in some cases the environmental legislation cannot guide a utility or developer and in that case in house knowledge is the key to minimizing the impact of wildlife on energy or energy on wildlife.

Environmental legislation in southern Africa does not always completely cater for the impact of all energy infrastructure on wildlife and in some cases, there is a lack of knowledge on the impact of energy infrastructure on wildlife. The requirements for EIA/ESIAs and EMPs and ESMPs also vary between countries, with some not requiring ESIA/EIA processes and avifaunal assessments for lower voltage feeders, or not having the relevant expertise available. Some interactions do not negatively affect wildlife at all, but impact the network's performance. These interactions fall outside of the scope of these specialist assessments and utilities must then use internalized processes to anticipate and avoid these incidents/interactions.

Photo credit: Constant Hoogstad

1.3 WILDLIFE-FRIENDLY PRACTICES AND DESIGNS

Southern African utilities use a combination of wooden and concrete poles when constructing reticulation lines. More recently, concrete poles have been used for new lines, or during wooden pole replacement projects. However, they are often fitted with steel cross arms in T-Pole configurations, resulting in poor clearances between live conductors.

This is seen as an ideal solution to avoid maintenance as concrete's durability exceeds that of wood, which makes concrete a practical, long-lasting choice for power line poles. However, pole durability and pole structure should be the primary consideration when replacing or placing low voltage power line poles. An added concern is that concrete poles are also reinforced with steel and can become conductive under certain environmental conditions. Therefore, planners should consider pole top design carefully where concrete poles are preferred, allowing adequate clearance between the concrete and live phases to allow medium and large raptors to perch on the structure safely.

Pole top design is critically important and should be wildlife-friendly. Over the last 50 years, utilities in southern Africa have identified pole designs that are problematic for energy and wildlife interaction and have phased-out pole top designs that pose the greatest risk to wildlife. Engineers and environmental practitioners should work closely to create pole designs that reduce wildlife interactions with energy infrastructure. Chapter 6 covers this, and other approaches to reducing negative wildlife interactions in detail.

1.4 THE DEPLOYMENT OF SUITABLE MITIGATION PRODUCTS

Utilities can improve network performance by installing appropriate mitigation products on hardware. These products can prevent contact with live phases through insulation (covering the live component) or isolation (preventing wildlife from perching or climbing close to phases). Bird Flight Diverters (BFD), such as flappers or OWL nocturnal bird flight diverters, can improve the visibility of overhead cables to birds in flight, reducing the risk of collisions.[8] Southern African utilities are world leaders in testing, implementing, and developing suitable mitigation products through scientific research and collaboration between engineers and conservationists. In South Africa, the effectiveness of various BFDs are continuously tested, while the suitability of insulation products are reviewed annually by an internal committee at Eskom, where environmental practitioners and engineers have an opportunity to weigh in on the benefits and limitations of each design. Where new incidents arise, the committee also reviews potential solutions before these are field tested. Some of the case studies in Chapter 7 illustrate how mitigation products can be used effectively to reduce or eliminate unique wildlife interactions.

It is important to ensure that, once a suitable product has been identified for installation, these products are fitted correctly to avoid undue maintenance and repeat incidents. Some products have additional specialized fixings or are specifically designed according to conductor size, bushing diameter, or voltage, and suppliers must be provided with as much information about the infrastructure as possible before orders are placed. Suppliers are expected to provide clear and concise instructions for the installation of products to ensure maximum performance.

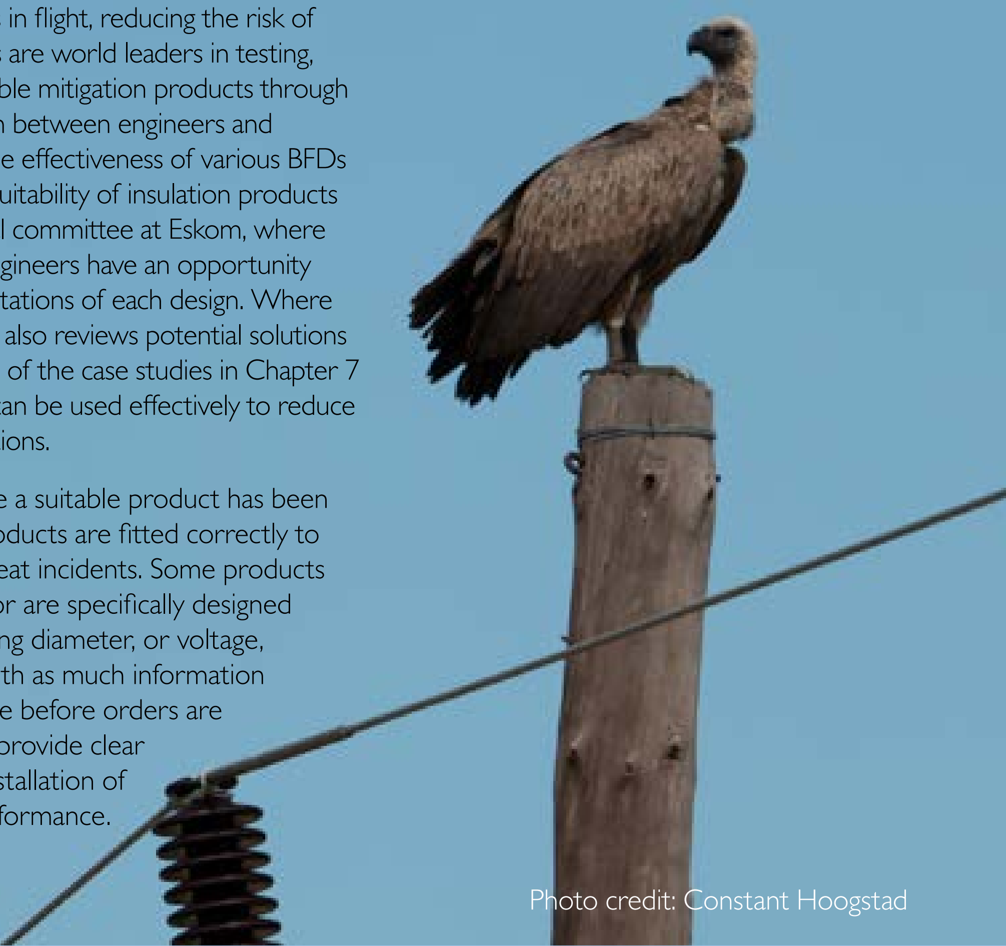


Photo credit: Constant Hoogstad

1.5 THE CORRECT INSTALLATION OF MITIGATION PRODUCTS

Mitigation products must be correctly installed to ensure that hardware is adequately protected against wildlife interactions. Several examples of incorrect applications have been recorded, where utilities have procured mitigation products but incorrectly selected, placed, and/or installed the products. This also occurs where linesmen modify mitigation products, either by cutting, joining, or adding additional measures to secure these to infrastructures. Incorrect installations and/or placement of mitigation products will be largely ineffective and may require additional resources for reattachment, replacement, or maintenance. As suppliers often do not support utilities with the correct selection and application of these products, building capacity to implement mitigation methods correctly is critical. This should be managed through the utility WMS from where the compilation and distribution of technical instructions can be coordinated. The audit process forming part of such a system provides an opportunity to physically inspect installations, closing the feedback loop and accumulating a record of product performance and installation challenges. The incident audit process should be applied to selected incidents at the end of the incident management process, discussed in further detail under section 5.1.1.

Installation of bird flight diverters from a helicopter by live-line personnel. Photo credit: Constant Hoogstad

1.6 THE MANAGEMENT OF WILDLIFE INCIDENTS

Although negative wildlife interactions can be greatly reduced through appropriate line routing, structure design, and mitigation, utilities will likely have existing lines that were historically poorly placed or designed. Utilities can systematically address this shortcoming and improve network performance by documenting wildlife interactions and implementing a system to correct problematic designs and prevent further losses. Such systems have been successful in South Africa and Namibia, and should be duplicated across all utilities in southern Africa. Chapter 5 details the content and implementation of a management process to record, classify, and mitigate infrastructure to prevent further negative interactions, a crucial starting point for any utility in understanding the extent of the challenge they face.

Photo credit: Constant Hoogstad

Photo credit: Matt Pretorius

02 CLASSIFICATION OF WILDLIFE INTERACTIONS WITH ELECTRICAL INFRASTRUCTURE

As mentioned in the previous chapter, wildlife interaction is a broad term capturing various wildlife behaviors, usually associated with trees or other prominent topographical features in the landscape. Birds and primates, in particular, do not necessarily perceive electrical infrastructure as a threat, as their instinct to climb, perch, roost or nest dominates. Birds have not evolved to avoid overhead infrastructure, and early warning systems (such as BFDs) must be installed to prevent collisions. Utilities need to understand how, why, and where incidents occur and classify them to inform the appropriate actions to prevent reoccurrence.

TYPES OF WILDLIFE INTERACTIONS AND WHY THEY OCCUR

2.1 COLLISIONS

A collision occurs when an animal, usually a bird, physically strikes either the conductor or an overhead power line's earth (shield) wire.[9] Collisions can occur on both distribution and transmission power lines. In general, birds usually collide with the shield wire on the distribution/transmission line rather than with the conductors, which are thicker or bundled and therefore easier to see. Larger bird species such as vultures, flamingos, bustards, storks, and cranes are more susceptible to collisions due to their larger, sometimes heavier bodies, combined with broad wings evolved for long-distance flights, soaring, or gliding. Therefore, when comparing the manoeuvrability of large bird species (see Vissershok example on page13) to species such as falcons, which are equipped with narrow, elliptical wings designed for hunting and fast-flying, the larger birds are inadequately designed to avoid energy infrastructure. These and other biological factors contributing to collision risk are discussed further in Chapter 3. As a power line's location, size, and structure can cause animals and birds to collide with the lines, so can renewable energy structures.

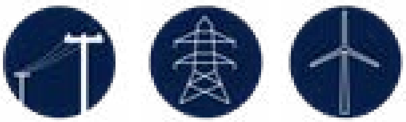
Wind turbines, Concentrated Solar Plants (CSP) and Solar Photovoltaic (PV) Plants in South Africa all have an impact on wildlife where birds collide with the structures, bats succumb to barotrauma, and habitat is altered or lost. Still, these effects on wildlife, often fatal for animals, have little to no impact on the infrastructure itself.

Black-headed Heron that collided with a transmission line in the Western Cape, South Africa. Photo credit: Lourens Leeuwner.

Kori Bustard that collided with an unmarked distribution power line. Photo credit: Matt Pretorius (left). Lesser Flamingo that collided with a power line close to a dam. Photo credit: Constant Hoogstad (right)

COLLISIONS

Divisions affected



Common species

Large terrestrial birds (storks, bustards, cranes, Secretarybirds, waterbirds (ducks, geese, herons, and flamingos), raptors (both large/heavy and smaller/fast flying), vultures, giraffes, birds, and bats (wind turbines).

Typical injuries to animal

Impact injuries such as a broken neck, broken wings, and legs.

Typical impact on infrastructure

On lower voltage lines, collisions often lead to the conductors breaking and hanging low, increasing the risk of electrocutions to large mammals tall enough to touch the line. If the actual conductor snaps, it will result in the line shorting out and an outage for customers.

Identifying collisions

Carcass is usually found mid-span, under or close to conductors/earth wires.

EXAMPLE FROM THE FIELD

Vissershok

In January 2017, a member of the public informed the EWT of a pelican mortality underneath a transmission line near the Vissershok landfill in the Western Cape. The incident occurred under three parallel transmission lines traversing a servitude parallel to the N7 national route and the Vissershok landfill site.

The incident coincided with the establishment of new municipal landfill cells between the power line servitude and the N7. After investigating the incident, the EWT discovered several additional pelican carcasses under the power lines in the same area, and that numerous bird species had made a roost at the new Vissershok landfill cells. EWT, therefore, concluded that the increased collisions resulted from the establishment of the new Visserhok landfill cells In response to a report from the EWT, the South African utility, Eskom, attached experimental bird flight diverters to the shield wires on the power lines along several high-risk spans. The `Rotamarka` device was selected for its large size, contrast, and dynamicm properties. The power lines were then monitored over a12-month period following the installation of the diverters. After the 12-month monitoring was completed, Eskom and the EWT noticed that there was a significant reduction in mortalities recorded as a result of the bird diverters installed on the Vissershok power lines.

The Rotamarka device installed at Vissershok landfill site (top). The Eskom live-line team installing Rotamarka devices by helicopter (bottom). Photo credits: Lourens Leeuwner (top and bottom)

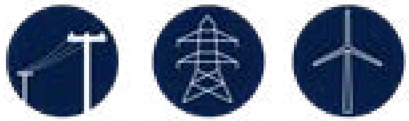
2.2 ELECTROCUTION

Birds, mammals, and reptiles often get electrocuted when they come into contact with live components of electrical equipment. Electrocution is an incident in which an animal causes an electrical short circuit by physically bridging the air gap between the live line and/or other live and grounded/ earth components.[10] This, causes a lethal current to flow through the animal's body. Electrocutions may lead to a voltage dip and some even cause outages, which ultimately result in a loss of income for the utility. An example of an electrocution can be seen in the Balule Private Nature Reserve case study where giraffes collided with low hanging conductors. See the Balule Private Nature Reserve example on page 15.

Cape Vulture electrocution fatality. Photo credit: Marianne Golding

ELECTROCUTION

Divisions affected



Voltage size
11 kV to 400 kV

Common species
Vultures, large eagles, owls, guineafowl, primates, genets, civets, and giraffes.

Typical injuries to the animals
Burn marks and contracted claws (or feet) are typical signs of electrocution.

Typical impact on infrastructure
Flashovers, which impact on systems reliability and customer supply.

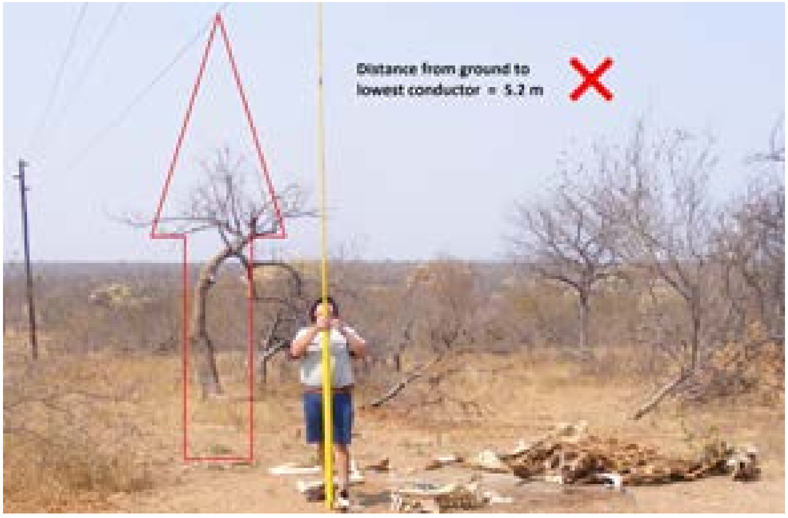
Identifying electrocutions
The dead bird/animal is often found at the base of the pole/tower.

Photos of Cape Vulture electrocution fatalities. Photo credits: Kevin Shaw

EXAMPLE FROM THE FIELD

Giraffe electrocutions in Balule Private Nature Reserve

Large mammals, particularly giraffes, are at risk of being electrocuted by low-hanging power lines or transformers that are installed too low to the ground. In 2009, three electrocuted giraffe mortalities were identified in Balule Private Nature Reserve (within the Greater Kruger National Park). The cause of death related to the power line span being well below the minimum height of 6.5 m recommended for lines in areas occupied by giraffes.



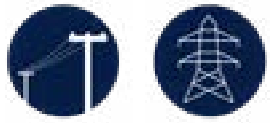
2.3 NESTING

Where there is a lack of natural nest sites such as trees, birds tend to nest on energy infrastructure. Electrical structures provide a sturdy nesting sites, safe from potential predators (for small birds) and a good hunting or taking-off positions for birds of prey. Different birds create different types of nests, and each of these has a distinct impact on energy infrastructure. Some nests cause flashovers and fires, while others are so large that they result in structural damage or even complete collapse of the power line pole (see Eskom Sociable Weavers Research Project example on page 17 and case study 6 in Chapter 7). The management of nests on electrical infrastructure is discussed in Chapter 6, section 6.3.2.

Sociable Weaver nest on a transmission tower. Photo credit: Jon Smallie

NESTING

Divisions affected



Voltage size
N/A

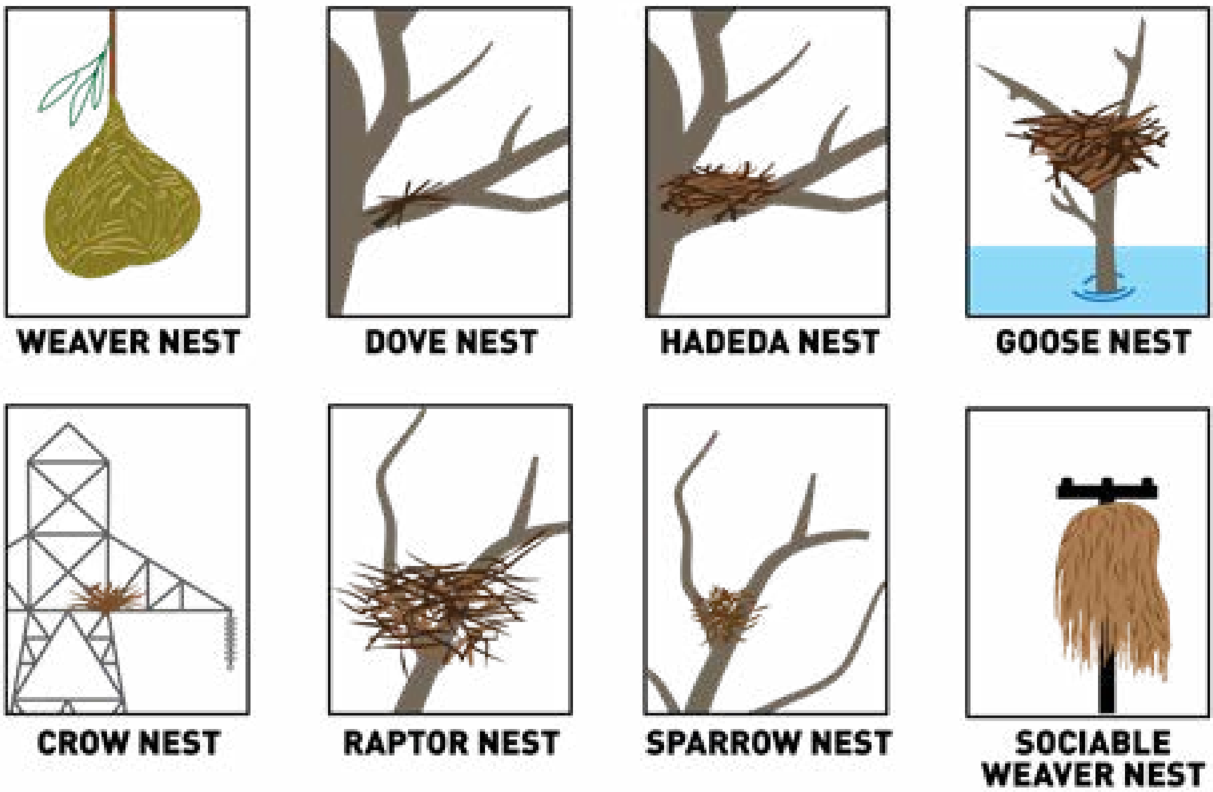
Common species
White-backed Vulture, Martial Eagle, storks, herons, weavers, geese, and crows.

Typical injuries to the animals
Burn marks as nests can ignite during flashovers.

Typical impact on infrastructure
Fire damage, as nests catch alight from flashovers.

Identifying nesting
Presence of nests and nest materials, and feces pollution.

EXAMPLES OF TYPES OF BIRD NESTS



Birds that commonly nest on electrical infrastructure include White-backed Vulture, Black Eagle, Martial Eagle, Tawny Eagle, various kestrels, falcons, storks, herons, weavers, geese, and crows.

EXAMPLE FROM THE FIELD

Eskom Sociable Weavers research project

Sociable Weavers have expanded their range due to the availability of artificial nesting sites, such as electricity and telephone poles. Electricity poles provide free access from below and a strong horizontal cross-arm support, ideal for nesting structures due to no obstruction by branches and leaves. They also offer numerous crevices for the firm attachment of grass straws.

The use of power line poles as nesting sites negatively impacts Eskom's ability to supply power reliably.

In rainy conditions, wet nests are likely to cause phase-to-earth and phase-to-phase outages, which may damage insulators and cross-arms. The nests may also pose a fire hazard when catching alight and potentially causing bush fires. In May 2001, the technical service center in the Northern Cape calculated the cost of repairing or replacing infrastructure damaged by Sociable Weaver nesting. The result of the study concluded that Sociable Weaver nests on poles cost Eskom approximately $7,46,568.00 a year.[11] A number of mitigation actions were then prescribed for Sociable Weaver nests, such as moving the nest onto droppers positioned below the cross-arms. Once the nests were moved onto droppers, the sites were monitored every six months to establish the nest status and if the original nests were still in place on the droppers. Overall, the simple dropper installation process reduced the annual costs of monitoring the power lines and replacing the damaged materials to approximately $148,000. In addition, all problems associated with the nests, such as fires and damage to poles and conductors, were reduced.

Sociable Weaver nest.
Photo credit: Matt Pretorius

Photo credit: Matt Pretorius

2.4 POLLUTION AND STREAMERS

There are two ways in which bird excretions can cause electrical faults on overhead lines: pollution and streamers.[12]

POLLUTION

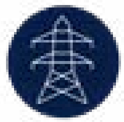
Pollution faulting occurs:

- As a result of an accumulation of bird feces on an insulator string over time
- When the build-up of pollution reaches a critical point, resulting in line faults under moist or humid conditions
- When a flashover occurs because an insulator string gets coated with pollutants, which compromises the insulation properties of the string. When the pollutant is wet, the coating becomes conductive and insulation breakdown occurs, resulting in a flashover. Flashmarks are evident at the dead-end of the string and along the string itself

Faults do not show the same diurnal patterns as streamer faulting since they are caused by a pre-deposition of pollution and coincide with certain weather conditions. Pollution is caused as much by smaller flocking bird species as by larger species, as it results from a build-up of feces over a long period. Chapter 4 discusses this phenomenon in further detail.

POLLUTION

Divisions affected

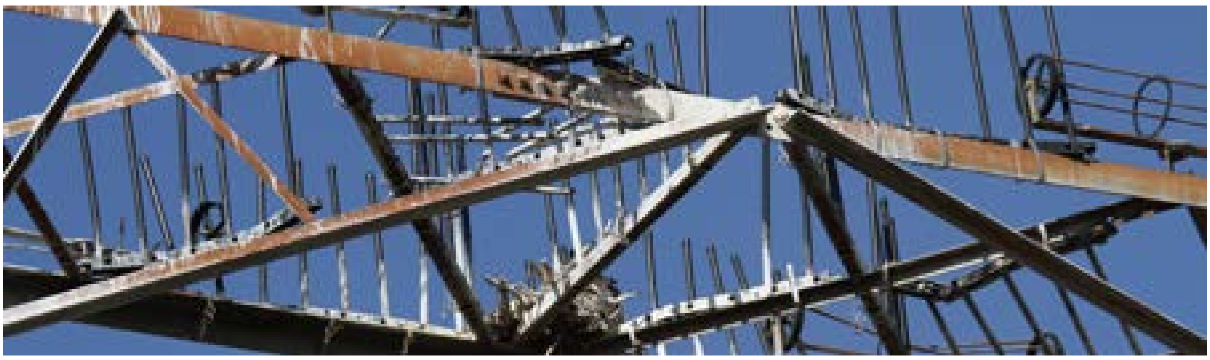


Voltage size
11 kV 765 kV

Common species
Various species of vultures, herons, ibises, stork, eagles and large hawks. Smaller species like Speckled pigeons, Indian Myna, etc.

Typical injuries to the animals
No impact on animals.

Typical impact on infrastructure
Pollution can cause extensive line trips, and the cleaning and maintenance of insulators can become costly.



Reed Cormorants polluting insulators while nesting or roosting on a transmission line.
Photo credit: Matt Pretorius

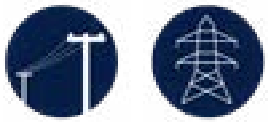
Reed Cormorants that are nesting, roosting, and polluting insulators on a transmission power line.
Photo credits: Matt Pretorius

STREAMERS

A streamer refers to a length of electrically conductive excrement from a bird. The streamer can bridge (or partially bridge) the air insulation gap (the space between a live conductor and the tower structure), acting as a fuse and causing an electrical fault.[13]

STREAMERS

Divisions affected

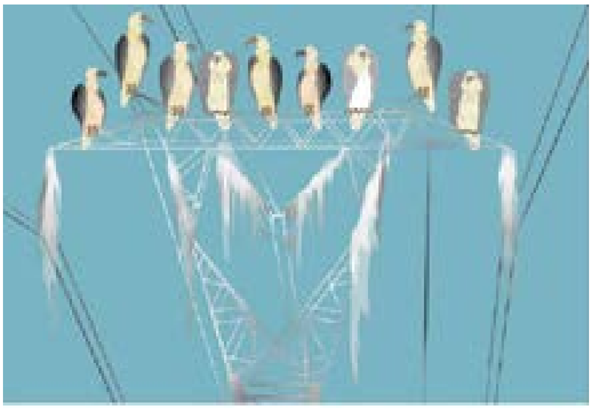


Voltage size
11 kV 765 kV

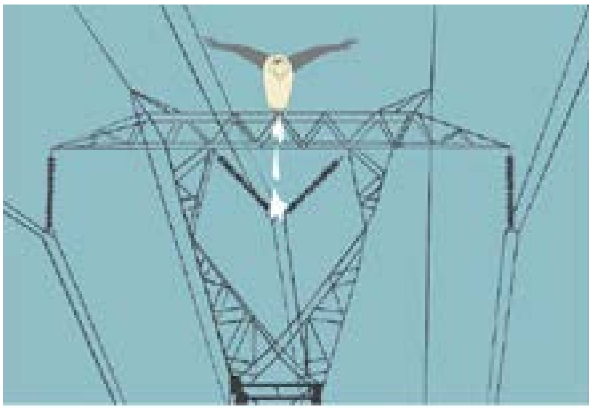
Common species
Herons, pelicans, vultures, and eagles.

Typical injuries to the animals
Although electrocutions are rare, they have been recorded, especially on the lower voltage lines.

Typical impact on infrastructure:
Streamers can cause line trips and are responsible for a lot of unexplained outages.



Bird pollution



Bird streamer

2.5 RUBBING AND DAMAGE TO WOODEN POLES

Larger mammals such as rhino, elephants, and buffaloes cause damage to infrastructure, particularly wooden poles. The animals use these poles as rubbing posts to scratch and rid themselves of excess parasites, or for territorial marking.[6] In addition elephants commonly uproot and push over the poles in the same way they break down trees. This section focuses on structural instability of energy infrastructure and potential electrocutions resulting there from (as mentioned above).

RUBBING AND DAMAGE TO WOODEN POLES

Divisions affected

Voltage size
11 kV 22 kV

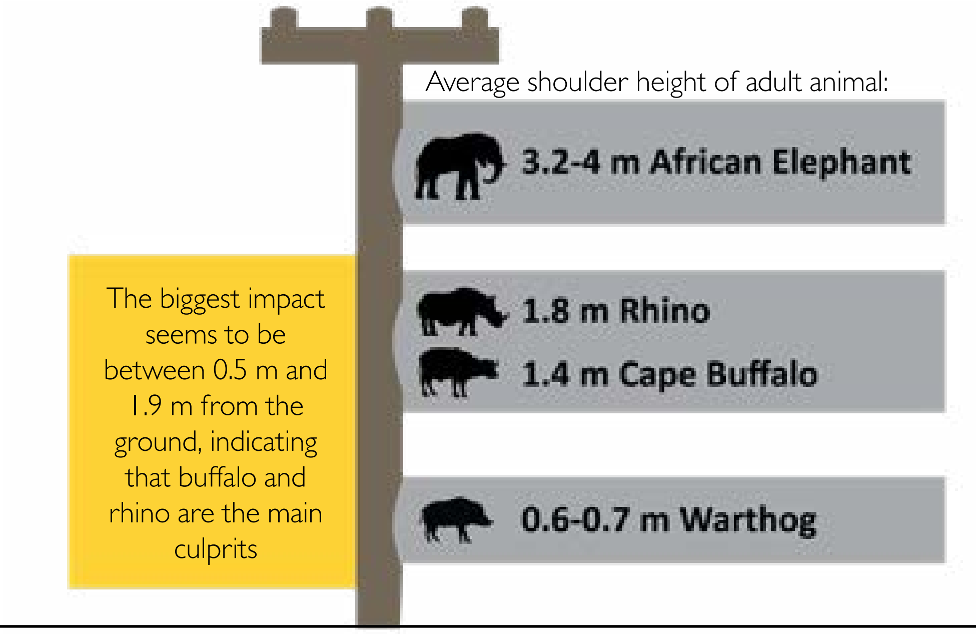
Common species
Cape Buffalo, African Elephant, White Rhino, Black Rhino, and Warthog.

Typical injuries to the animals
Electrocutions are common as a secondary impact to a pole snapping or breaking. Once an electrical pole breaks, the conductors sag and can lead to the electrocution of numerous mammal species at the incident site.

Typical impact on infrastructure
Continuous rubbing exposes poles to the elements, insects, etc., and compromises the stability and longevity of the wooden pole. (see example on page 21 and case study 7 in chapter 7)

Identifying rubbing interactions
There will be markings on the poles that indicate rubbing, and it is usually possible to identify the species involved by the heights and nature of the markings.

Photo credit: Constant Hoogstad



EXAMPLE FROM THE FIELD

Damage to electrical infrastructure by different species in the Kruger National Park, South Africa

The EWT's Wildlife and Energy Programme conducted a special investigation of electrical infrastructure in the Kruger National Park (KNP) to determine the damage to structures caused by wildlife, the impact they have on power supply, the costs utilities endure to repair damaged infrastructure, and the loss of life for species involved.

Important findings from the study showed that:

1. There are a variety of mammal and bird species that interact with power lines in the park, from termites to elephants
2. Wildlife interactions, particularly those involving large mammals, weaken or break wooden poles, resulting in low hanging conductors, which can electrocute other mammals and pose a health and safety risk to people
3. These interactions are costly to utilities and require many person-hours as poles have to be replaced continually


Camera trap photos of large mammals interacting with wooden poles in the Kruger National Park. Photo credits: Constant Hoogstad and EWT

Cape Buffaloes using wooden poles as rubbing posts. Photo credits: Constant Hoogstad

Photo credit: Constant Hoogstad

2.6 BURROWING ANIMALS

Small mammals such as squirrels or mongooses often use substations as nesting sites. They dig large holes in the substation yard, climb up transformers, and often bridge gaps between live phases/live and earth components, which can cause substantial damage to structures within the substation. Warthogs have been known to turn up/delve the soil in substations in search of food, creating tripping hazards for staff but posing no real risk to infrastructure. However, porcupines dig under transmission towers in the areas where the soil is less compacted around the foundations and compromise the towers' stability. An example of such porcupine activity can be seen in South Africa`s Mpumalanga province under the Matla/ Benburg transmission line. Solutions to this incident are discussed in case study 3 in Chapter 7.

Porcupine burrows under transmission pylons in a maize field. Photo credit Constant Hoogstad

2.7 CHEWING OF INSULATORS

Certain crow and vulture species are known for chewing composite insulators on both energized and non-energized lines. Utilities use composite insulators to replace old glass/porcelain insulators and on new lines during the construction phase), before lines are energized. Utilities are advised to avoid using composite insulators in areas with high vulture activity, unless the line will be energized shortly after installing these components.

It is evident that birds are often implicated during incidents. According to the Eskom/EWT central incident register (a record of all reported wildlife incidents on electrical infrastructure in South Africa), more than 95% of mortality incidents recorded on Eskom`s network involve birds. Although this statistic may differ in other countries, birds are likely to be responsible for most interactions with electrical infrastructure in southern Africa. Therefore, utility staff should understand how different bird species interact with hardware, and the biological risk factors associated with different groups of birds that makes them prone to energy interactions.


Photo credit: Lourens Leeuwner

03 SPECIES-SPECIFIC IDENTIFICATION AND MITIGATION GUIDELINES

Bird behavior such as flying, perching, roosting and nesting is the leading cause of supply interruptions and hardware damage to electrical infrastructure in southern Africa. Like birds, other wildlife also exhibits specific physical traits and behaviors, increasing the chances of interacting with electrical infrastructure in a way that compromises utility operations and often results in mortality. Before incidents involving wildlife can be prevented, we need to understand why certain species interact with electrical infrastructure so readily, and what the contributing factors. In this chapter we provide some guidance on species identification and explore wildlife features and behaviors which lead to interactions with infrastructure.

3.1 BIRDS

Birds are a group of endothermic (warm-blooded) vertebrates (have a backbone) constituting the class Aves, characterized by feathers, toothless beaked jaws, the laying of hard-shelled eggs, a high metabolic rate, a four-chambered heart, and a strong yet lightweight skeleton.

3.1.1 BIRD ANATOMY: IDENTIFYING FEATURES

Birds are a group of endothermic (warm-blooded) vertebrates (have a backbone) constituting the class Aves, characterized by feathers, toothless beaked jaws, the laying of hard-shelled eggs, a high metabolic rate, a four-chambered heart, and a strong yet lightweight skeleton.

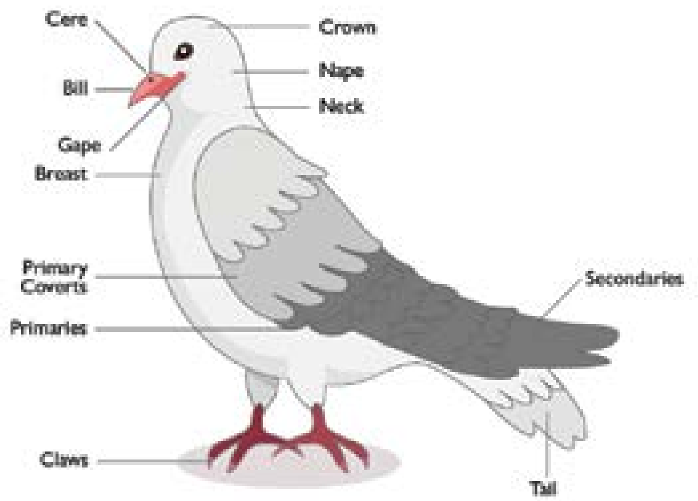


Figure1:The identifying features of a bird

SIZE

Many of the birds regularly involved in power line interactions are large and easy to identify as opposed to small, sparrow-sized species. The first step to identifying a bird is to estimate its size.

The body size of a bird is measured from the tip of the toe to the tip of the beak

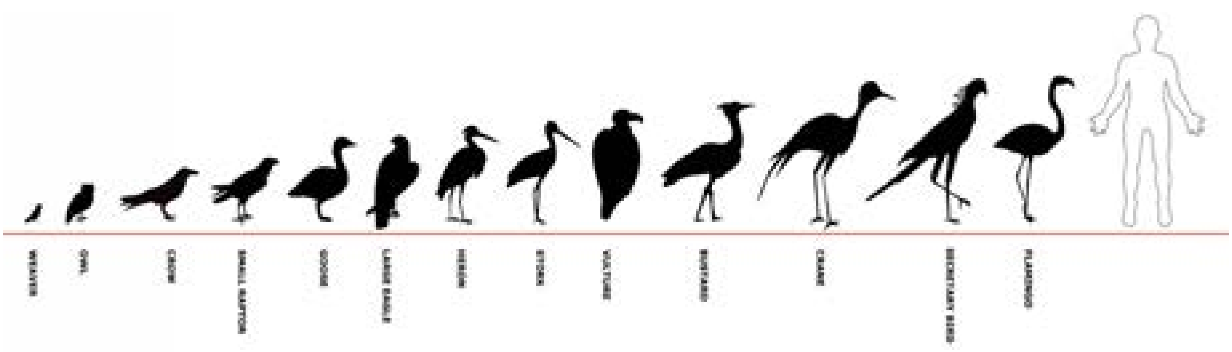


Figure 2:The size and profiles of common birds

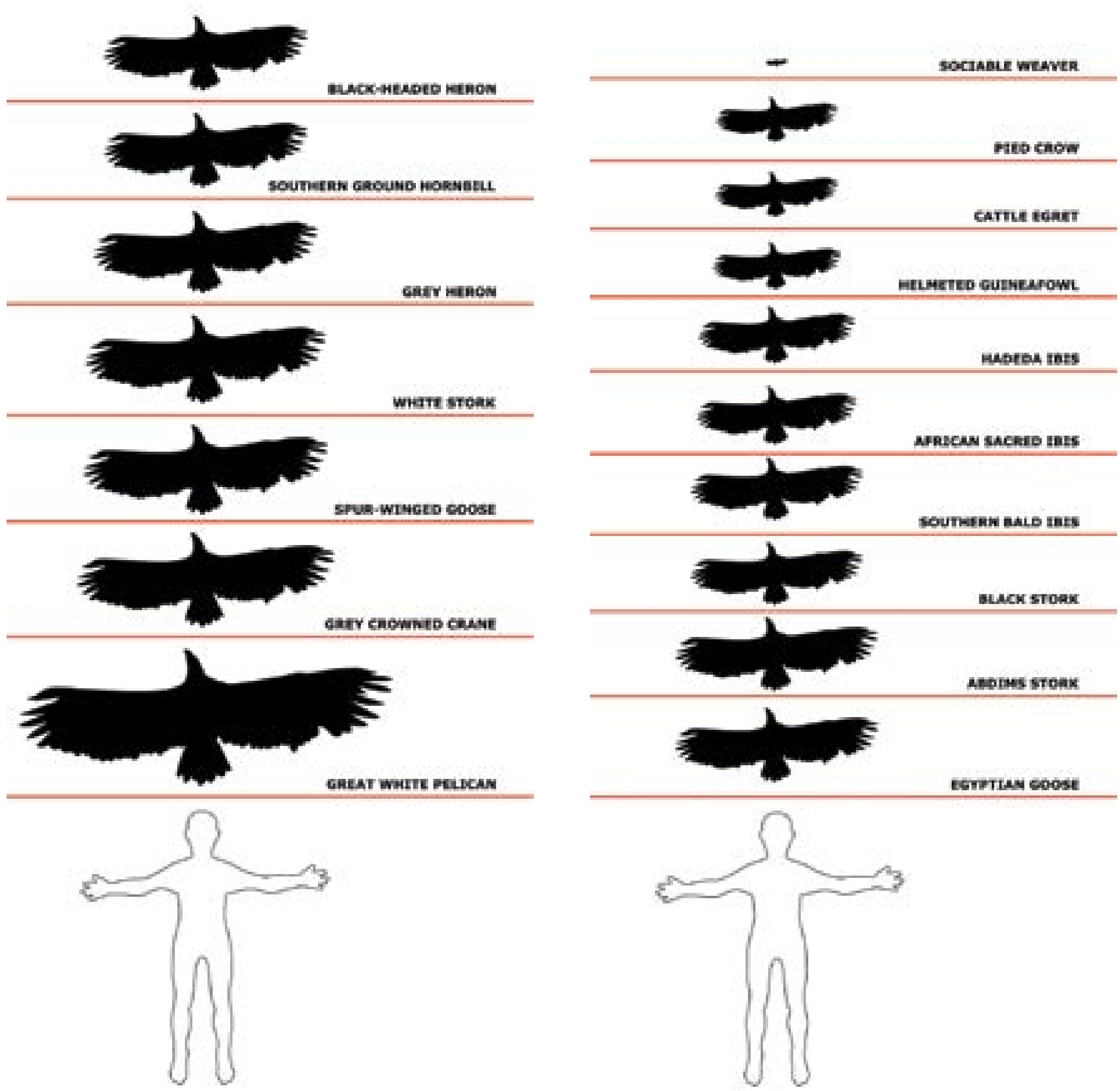


Figure 3:Wingspans of different types of birds

BILL SHAPE, LENGTH, AND COLOR

A wide variety of shapes, sizes, and colors assist in identification. Bills can be short, medium, long, straight, curved or hooked, or flattened like ducks.

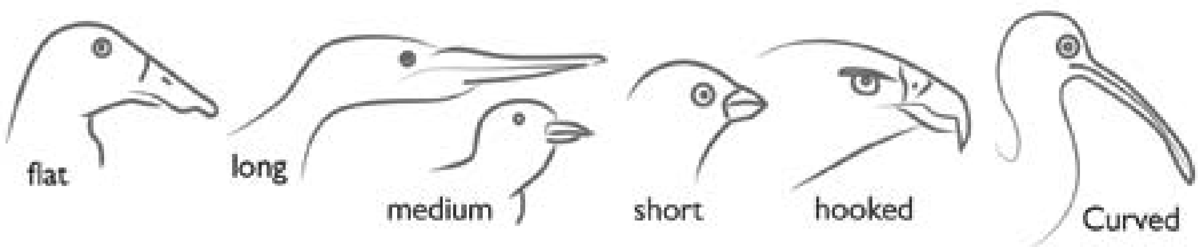


Figure 4:Types of bird bill shapes

SHAPE OF LEGS AND FEET

The legs may be classed as long (i.e., storks, cranes and herons), medium (e.g., ibises, korhaans and eagles) or short (e.g., ducks). Ducks have webs between their toes, while owls, eagles and falcons have sharp, curved claws at the end of their toes. Some birds of prey (also called raptors) have bare legs, others have feathers to the knee, while some have feathers down to their feet and toes.

PLUMAGE AND COLOR

A wide variety of colors and patterns occur in birds, additional features to help identify species. Sometimes the feathers on the head are modified to form a crest (e.g., Grey Crowned Crane) or ears (e.g., Spotted Eagle-Owl). The bare skin on the face and around the eyes may also be a definite feature of the bird's identity. However, these features may be unusable if the bird has decomposed or burnt due to electrocution.

3.1.2 BIRD COLLISIONS: BIOLOGICAL AND ECOLOGICAL RISK FACTORS

As described in Chapter 2, bird collisions that occur on both transmission and distribution lines are increasing as energy infrastructure is rapidly extending to meet the electricity demands across southern Africa. Collisions generally happen when a bird fails to see the conductor or overhead shield wire while in flight. All overhead lines pose a collision risk to birds, but research conducted in South Africa suggests a correlation between the physical size of the overhead line structure and its collision risk potential, with mortality rates rising with voltage magnitude. However, the cumulative impact is relative as the distribution line network of low- and medium-voltage power lines is significantly more extensive than the transmission line network.

The birds most commonly involved in collisions include vultures, flamingos, bustards, storks, cranes, and various waterbirds. Birds with a smaller wing surface compared to their body weight and that spend a lot of time on the ground, are less agile flyers and prone to collisions – the same applies to are younger, inexperienced birds. Other species commonly involved include gregarious, rapid-flying species, such as water birds that congregate in large flocks. Flocking does not leave much space for maneuvering around obstacles and reduces visibility. The height at which a bird flies and its flight behavior also affect the likelihood of a collision. Most larger birds fly well above overhead lines during long-distance migration flights and collisions appear to occur more during short distance, low altitude flights with many overhead line crossings.[14] Migratory birds foraging in unfamiliar areas are also more likely to collide with lines than resident species, particularly for species that leave roost sites in low light conditions or migrate at night, such as flamingos.[15]

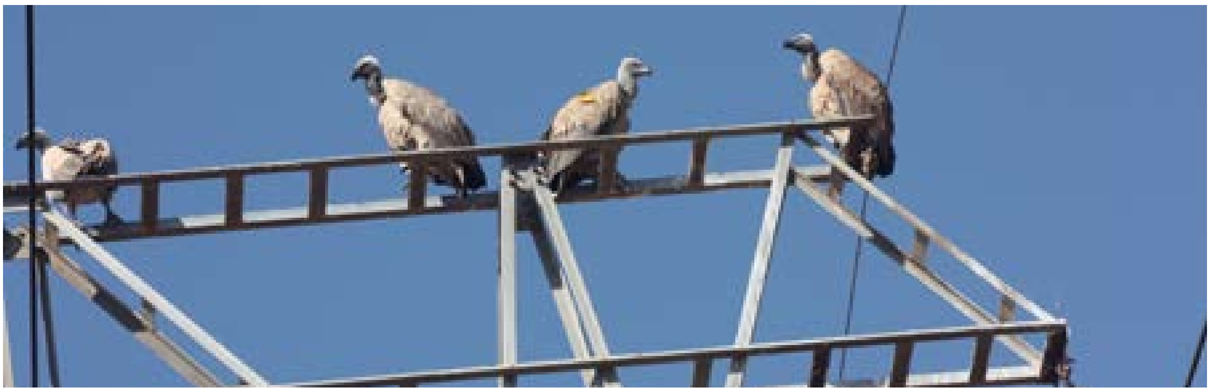
The food birds eat and their foraging habits are additional factors that may place a particular bird or species at risk of collision due to the abundance of the food source, such as wheat in cultivated fields attracts crane species. The bird species' risk for collision increases due to the birds' low-altitude movements across these food sources. When power lines are in direct sight of the food source, the potential of colliding with the lines increases. Alternatively, if the birds are on the ground already feeding and need to flee the field unexpectedly, they are also likely to collide with the power lines.

Photo credit: Constant Hoogstad

3.1.3 BIRD ELECTROCUTIONS: BIOLOGICAL AND ECOLOGICAL RISK FACTORS

A bird's body size is the primary physical characteristic influencing the likelihood of it being electrocuted on an electrical structure. Larger birds with large wingspans are more prone to electrocution as they are more likely to bridge the air gap between live components. Climatic factors can also increase electrocution risk, particularly wet conditions. Water increases conductivity, so wet feathers render a bird more likely to be electrocuted by lower voltages. Birds often "sun" themselves after the rain by perching on a structure and opening their wings to let the sun dry their wet feathers, greatly increasing the probability of them being electrocuted should the wet wings touch live components. Gregarious birds such as guineafowl and vultures tend to sit in groups on the same structure, and this increases the likelihood of the air gap being bridged, as do other social behaviors such as fighting or mating that may cause birds to lose their balance or for flapping wings to come into contact with live components.

The availability of food or prey items in the vicinity of the electrical infrastructure encourages birds to perch nearby, invariably on the pole top, which provides an excellent vantage point from which to hunt and devour prey.



A White Stork electrocuted on a distribution power pole (top left). Photo credit: Ronelle Visagie
A Brown Snake Eagle nest on a power line pole (top right). Photo credit: Andre Botha
Cape Vultures roosting on a distribution tower (bottom). Photo credit: Constant Hoogstad

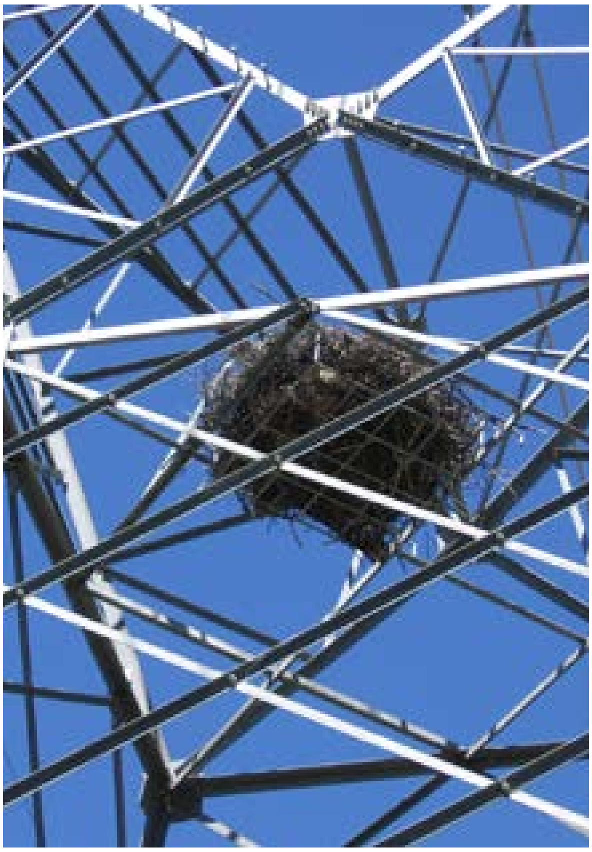
3.1.4 BIRD NESTING: BIOLOGICAL AND ECOLOGICAL RISK FACTORS

Certain electrical infrastructures are better suited as nest sites, particularly in areas where natural nest sites are scarce. Power poles and pylons provide safe and sturdy nest sites difficult for natural predators to reach. They are great vantage points from which birds can monitor threats, hunt, and teach their young to fly, making electrical structures more advantageous than natural structures in the area. The types of nests (See Chapter 2), materials used to build nests, and the risks associated with nesting vary depending on the species. Larger birds such as vultures, storks, and eagles build their nests using large sticks, sometimes more than a meter in length, making for very sturdy and long-lasting nests that are used annually. However, these sticks sometimes protrude from the nests into the air gap between the conductor and the grounded structure and cause a flashover in wet conditions. Crows will often use man-made materials such as wire and rope in their nests, increasing the risk of a flashover.[16]

Weaver species that live in large colonies, such as Sociable Weavers, build large compound nests. Electrical structures are ideal sites for these nests as they give solid horizontal support, no hindrances to access from below the nest (as there are in trees), and are less accessible to predators. These nests can cover large parts of structures and can weigh up to 1,000 kg.

Birds such as woodpeckers and barbets also damage wooden poles as they drill holes and nest inside the poles, particularly when they drill multiple holes or drill near the cross-arms.[17] Many of these species roost communally, with up to 11 birds occupying one hole that may extend up to 25 cm deep from the entrance hole to the bottom of the tunnel.

Nesting on electrical infrastructure increases bird activity on and around structures and power lines, particularly during the breeding season, which increases the likelihood of other interactions such as collisions, electrocutions, insulator pollution, and streamer-related incidents.




Bird nesting box (left) used to relocate a nest from a critical area at the top of tower to the mast. Photo credit: Constant Hoogstad. This Pied Crow nest removed from a tower (right) was made entirely of steel. Photo credit: Oscar Mohale

3.1.5 BIRD STREAMERS AND POLLUTION: BIOLOGICAL AND ECOLOGICAL RISK FACTORS

An inevitable consequence of birds using electrical infrastructure to nest or perch on is that they produce high levels of excrement, resulting in negative implications for utility operations. Issues related to bird excretions on power lines are classified into two interactions: pollution and streamers. Excessive pollution is often visible as a 'white wash' of bird feces. Both large and small birds are responsible for problems associated with pollution.

The minimum length of streamers that result in flashovers excludes smaller taxa from the possible list of culprit species. Such species-specific differences have not yet been simulated, but it is assumed that larger perching birds such as eagles, herons, cormorants, and vultures are primarily responsible for streamer faults. These differences, and those in perching behavior, affect levels of risk when considering bird-related interactions with overhead power lines. Large birds of prey like to perch and nest on tall transmission towers, and this increased activity increases the risk of streamer-related faults.

Amur Falcons roosting on a transmission structure. Photo credit: Andre Botha

Cape Vultures roosting on a distribution structure. Note the 'white wash' on the structure from birds defecating. Photo credit: Constant Hoogstad

3.2 REPTILES

3.2.1 REPTILE ELECTROCUTIONS: BIOLOGICAL AND ECOLOGICAL RISK FACTORS

Reptiles are ectothermic (cold-blooded) vertebrates attracted to electrical infrastructure to warm themselves by climbing onto transformers, which emit a fair amount of heat. Reptiles also enter substations in pursuit of prey such as rats, mice, and birds, which nest or reside in substations. This search for food sources increases reptiles' risk of being electrocuted by energy infrastructure and the risk of hardware (between the phases or where bushings/jumpers are exposed) in the substation becoming damaged. See case study 2 in Chapter 7, where such an incident was addressed in a substation in South Africa`s Limpopo province.

An African Rock Python posed to strike (top). Photo credit: Constant Hoogstad.
An African Rock Python electrocuted in a substation (bottom). Photo credit: Eskom

3.3 MAMMALS

Mammals are vertebrate, endothermic (warm-blooded) animals, usually insulated by fur or hair, named for their mammary glands that, in females, produce milk for feeding (nursing) their young. While not as commonly affected by electrical infrastructure as birds, mammals sometimes interact with supporting structures, which can have significant consequences for the animal involved and the utility.

3.3.1 MAMMAL ELECTROCUTIONS: BIOLOGICAL AND ECOLOGICAL RISK FACTORS

PRIMATES

Baboons and monkeys are often electrocuted on various types of electrical infrastructure, because they use pole tops, transformers, and towers as vantage points and roosting sites. The problems with primates are most common in agricultural areas where animals raid crops, or in areas close to human settlements where food is readily available.

GENETS

Genets are cat-like animals with long, slender bodies, short legs, and long tails. Genets are predominantly nocturnal and climb onto equipment to reach nesting and roosting birds to eat. Their activities have been known to cause flashovers within substation yards, on transformers, and pole-mounted switch-gears.

GIRAFFE

Characterized by their long necks, these mammals frequently fall victim to electrocution on reticulation networks where the ground clearance is less than 6.5 m. In some circumstances, giraffe electrocutions can occur when infrastructure is compromised in the form of low hanging conductors, transformers placed too low on the pole, or when hardware fails.



Baboons (top left), genet (top right). Photo credits: Shutterstock.
Giraffe (bottom). Photo credit: Constant Hoogstad

3.3.2 MAMMALS AND STRUCTURAL DAMAGE: BIOLOGICAL AND ECOLOGICAL RISK FACTORS

RHINO, ELEPHANTS, AND BUFFALO

Pole rubbing, a common behavior amongst large mammals, can cause wooden poles to collapse and conductors to sag. Due to continuous rubbing of wooden power line poles, the pole's outer protective layer becomes compromised, which can lead to termite infestations and damage to the poles themselves. This can result in the electrocution of rhino, elephants, buffalo, or other mammals that pass under the now low-hanging conductors. Please see case study 7 in Chapter 7.

Elephant (left) and a buffalo (right) interacting with wooden power poles in Kruger National Park.
Photo credits: Constant Hoogstad

SMALL MAMMALS

As mentioned in Chapter 2, small mammals such as squirrels or mongooses often use substations as nesting sites. Small mammals dig burrows in the substation and often climb up transformers and bridge air gaps that can, on occasion, cause substantial damage.

Porcupines, like other small mammals, often dig near tower foundations where the soil is less compacted, compromising the stability of towers (see Section 4.5.2).

Photo credit: Shutterstock

3.4 DESCRIPTIONS OF SPECIES THAT COMMONLY INTERACT WITH ELECTRICAL INFRASTRUCTURE IN SOUTHERN AFRICA

3.4.1 BIRDS[18]

GREY-CROWNED CRANE

Balearica regulorum

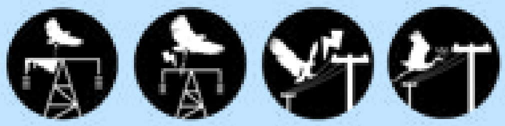
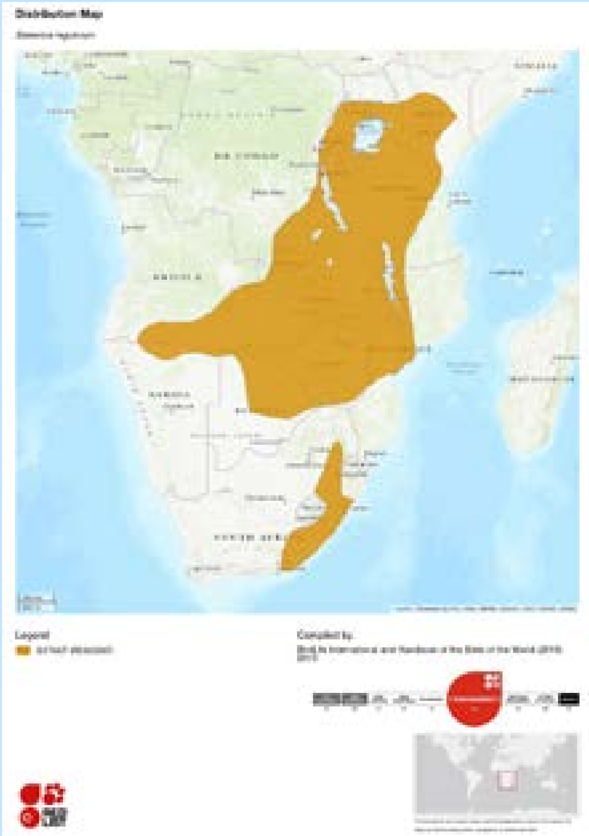


Photo credit: Shutterstock



Size and body shape

Height: 100–110 cm
Weight: 3–5.5 kg
Wingspan: 180–200 cm

Food and feeding habits:
Forage extensively in agricultural lands, eating insects, frogs, lizards, crabs, and grain.

Habitat, nesting, and breeding

Habitat: Utilize wetland habitats for breeding and are commonly seen in intensively farmed areas.

Nest: Roost on infrastructure

Breeding: October–June

Behavior relevant for utilities

Their daily low altitude movements across reticulation power lines in intensively farmed areas make them prone to collisions, and perching on pole tops exposes them to electrocution risks.

IUCN Red List Conservation Status

Endangered

DID YOU KNOW?

The Grey-crowned Crane is the only crane species affected by electrocution because it is the only crane that perches and roosts in trees and on power line infrastructure

WATTLED CRANE

Bugeranus carunculata

Photo credit: Andre Botha

Size and body shape

Height: 172 cm
Weight: 7.8 kg
Wingspan: 230–260 cm

Food and feeding habits

Forage extensively in agricultural lands for wetland tubers and rhizomes, grain, insects, frogs, and small reptiles.

Habitat, nesting, and breeding

Habitat: Commonly seen in intensively farmed areas and wetland habitats.

Breeding: In wetlands year-round

Behavior relevant for utilities

Large slow-flying birds with little maneuverability and a high likelihood of collisions.

IUCN Red List Conservation Status

Critically Endangered

DID YOU KNOW?

The mortality of Wattled Cranes through power line collisions is of very high biological significance due to their high propensity for collisions and the significant impact this has on their low population numbers.

Photo credit: Shutterstock

BLUE CRANE
Anthropoides paradiseus

Photo credit: Constant Hoogstad

Size and body shape

Height: 100–120 cm
Weight: 4–5.5 kg
Wingspan: 180–210 cm

Food and feeding habits

Blue Cranes are omnivorous with a varied diet consisting of plant material such as small bulbs, seeds and roots, and animals such as insects (especially grasshoppers), small reptiles, frogs, fish, crustaceans, and small mammals.

Habitat, nesting, and breeding

Habitat: Blue Cranes live in open grasslands, semi-deserts, and human-made pastures and agricultural fields.

Nest: In open areas where adults can easily detect predators. Eggs are mostly laid on dry ground.

Breeding: Blue Cranes congregate in flocks during winter, and split off into breeding pairs in spring to nest. They mostly lay two eggs, occasionally one.

Behavior relevant for utilities

During dusk and dawn, these birds often fly to and from their roost and feeding grounds. Flying in poor light conditions during these times increases the risk of colliding with power lines.

IUCN Red List Conservation Status

Vulnerable

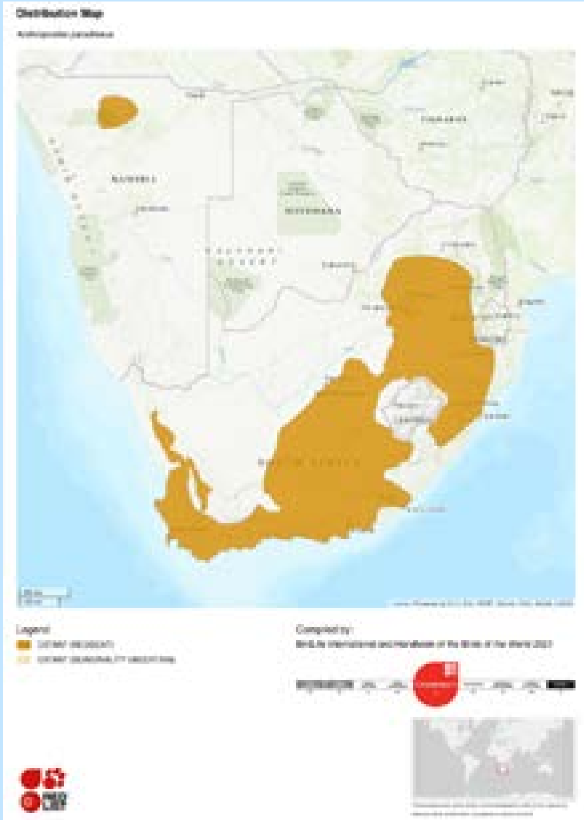


Photo credit: Matt Pretorius

GREAT WHITE PELICAN

Pelecanus onocrotalus

Photo credit: Shutterstock

Size and body shape

Height: 140–178 cm
Weight: 8–11 kg
Wingspan: 200–350 cm

Food and feeding habits

Great White Pelicans are surface feeders and feed mostly on fish. Contrary to popular belief, they do not dive underwater to catch fish but rather use their huge bill to scoop fish from the surface. Pelicans are also opportunistic feeders, especially when breeding, often feeding on other birds' eggs and chicks.

Habitat, nesting, and breeding

Habitat: lakes, pans, dams, and estuaries

Nest: on the ground

Breeding season: Year-round, peak in spring in the west and late summer in the east of their range

Behavior relevant for utilities

Pelicans are large, heavy flying birds that often occur close to water sources. Due to their size, they are very susceptible to power line collisions. When roosting on Transmission towers, they often cause streamer and pollution issues on insulators.

IUCN Red List Conservation Status

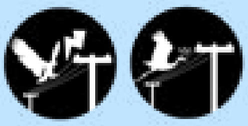
Vulnerable

Photo credit: Shutterstock

SECRETARYBIRD

Sagittarius serpentarius

Photo credit: Shutterstock



Size and body shape

Height: 125–150 cm
Wingspan: 102–132 cm
Weight: 4 kg

Food and feeding habits

Secretarybirds have hunting territories of 20km^2, wherein they search for a variety of prey, including snakes, lizards, amphibians, rodents, bird's eggs, and even insects. They are known for their unique hunting behavior, as they stomp their prey to death and will often throw the prey around before eating it. They are known to hunt and eat venomous snakes, but they are not immune to snake venom, contrary to popular belief.

Habitat, nesting, and breeding

Habitat: grassland, open savanna

Nest: in trees

Breeding season: Year-round

Behavior relevant for utilities

Due to their choice of open grassland habitat, Secretarybirds often fall victim to power line collisions.

IUCN Red List Conservation Status

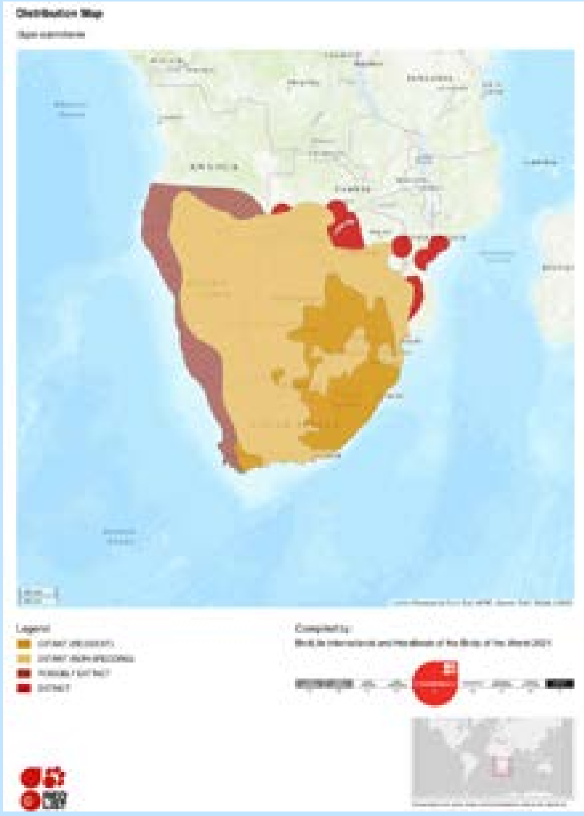
Endangered

Photo credit: Shutterstock

CAPE VULTURE

Gyps coprotheres

Photo credit: Constant Hoogstad



Size and body shape

Length: 100–118 cm
Weight: 7.4–9.5 kg
Wingspan: 2.55 m

Food and feeding habits

As a scavenger, the Cape Vulture feeds mainly on carrion. Vultures are gregarious birds, nesting and roosting in colonies on cliffs. When searching for food, vultures spread out across the sky, watching each other as they search large areas in hope of locating a suitable carcass. Vultures, food sourcing behavior can require traveling great distances, as the death of animals is unpredictable, both in timing and location, and farmers in southern Africa often bury carcasses to avoid the spread of disease.

Habitat, nesting, and breeding

Habitat: Inhabits open grassland, savanna, and scrubland, and is often found roosting on crags in mountainous regions.

Nest: Cape Vulture nests are built in colonies, with some harboring over 1,000 breeding pairs building stick platforms lined with grass on cliff ledges.

Breeding season: A single egg is laid between April and July, and both parents take turns caring for the egg and the chick. The nestling period lasts 120–128 days, and Cape Vultures are known to live for over 23 years.

Behavior relevant for utilities

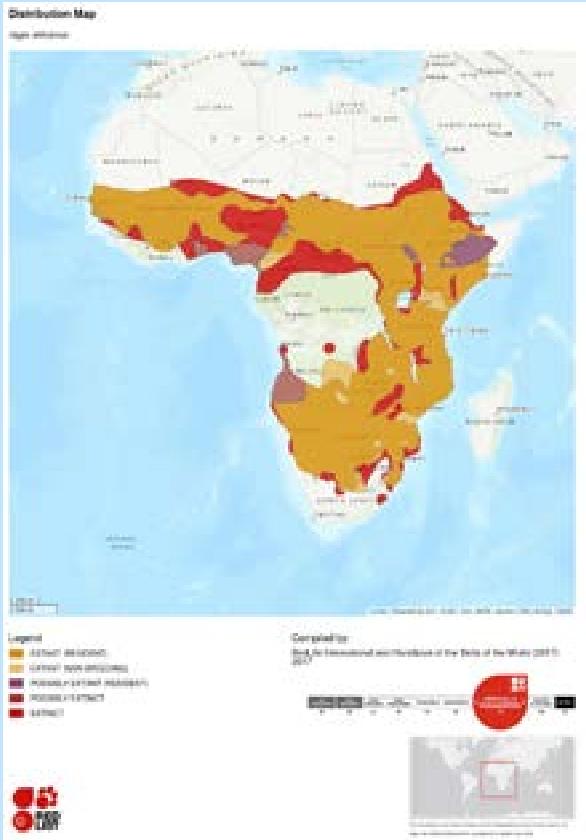
Due to their body size, wingspan, and gregarious nature, Cape Vultures are often victims of power line electrocutions and collisions with power lines while foraging for food. Vulture "restaurants" are often an attraction for these birds, which causes the species to congregate in large numbers, increasing both electrocution and collision risks. More recently, wind turbines have been recognized as an additional threat to vultures, due to collisions with turbine blades.

IUCN Red List Conservation Status

Critically Endangered

WHITE-BACKED VULTURE
Gyps africanus

Photo credit: Andre Botha



Size and body shape

Height: 90–100 cm
Weight: 5.5 kg
Wingspan: 220 cm

Food and feeding habits

Congregates in large numbers to feed on carrion

Habitat, nesting, and breeding

Habitat: Lightly wooded savanna and grasslands

Nest: In trees and extensively on power lines in loose colonies

Breeding: June–November

Behavior relevant for utilities

This species is the only vulture species that uses towers to nest on. This behavior and their gregarious nature increase the likelihood of collisions and electrocutions on pole tops/structures. Due to their massive wingspans, these vultures are prone to electrocutions, particularly on lower voltage lines due to the spacing between earth and live components.

IUCN Red List Conservation Status

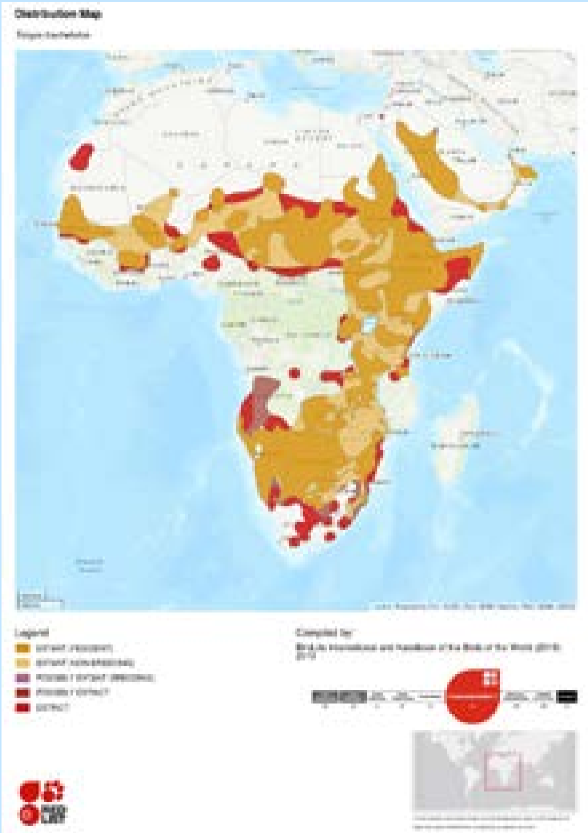
Critically Endangered

Photo credit: Andre Botha

LAPPET-FACED VULTURE

Torgos tracheliotos

Photo credit: Andre Botha



Size and body shape

Height: 98–105 cm
Weight: 6.5 kg
Wingspan: 280 cm

Food and feeding habits

Congregates in large numbers to feed on carrion

Habitat, nesting, and breeding

Habitat: Lightly wooded savanna and grasslands

Nest: In trees

Breeding: May–October

Behavior relevant for utilities

The Lappet-faced Vulture is the largest vulture species and is prone to electrocutions, especially on lower voltage lines with smaller clearances. The vultures use the pole tops as perches near carcasses before descending to eat, particularly in treeless environments with a lack of natural perches. With a wingspan of 2.8 m, they can bridge all three live components on a standard distribution pole top and their gregarious nature increases this risk significantly. Their size also places them at risk of collisions with power lines, another common cause of mortality.

IUCN Red List Conservation Status

Endangered

Photo credit: Andre Botha

BROWN SNAKE-EAGLE

Circaetus cinereus

Photo credit: Andre Botha

Size and body shape

Height: 71–76 cm
Weight: 2 kg
Wingspan: 155–180 cm

Food and feeding habits

Feeding on snakes and other reptiles, the Brown Snake Eagle carries its prey by the head while flying to a suitable place to eat it. These snake eagles spend most of their time sitting in trees, performing short flights from one perch to another and hunting from these perches. More powerful but less agile than other snake eagles, it catches prey on the ground, often by dropping on it from a perch.

Habitat, nesting, and breeding

Habitat: Woodland areas

Nest: In trees. The nest is a platform constructed of pencil-thin sticks (60–70 mm in diameter).

Breeding: They breed successfully on transmission and sub-transmission structures from September to April

Behavior relevant for utilities

Brown Snake Eagles often use pole tops and structures to roost on and hunt from, especially in treeless environments. On lower voltage lines, this often leads to electrocutions on pole tops. Due to their behavior, there is also a risk of collision with lines while hunting and traveling between poles.

IUCN Red List Conservation Status

Least Concern

Photo credit: Andre Botha

MARTIAL EAGLE

Polemaetus bellicosus

Photo credit: Andre Botha

Size and body shape

Height: 78–96 cm
Weight: 3.3–4.7 kg
Wingspan: 190–240 cm

Food and feeding habits

Martial Eagles spend much of their days searching for food. The species soars high, barely visible to the naked eye.

During these flights, the Martial Eagle covers hundreds of square kilometers, using various hunting techniques, such as swooping down from afar using cover to mask its approach, gliding through openings in foliage of trees, and waiting in concealed trees, ready to ambush the prey at a waterhole or game path. If a Martial Eagle is unable to move the prey away, which is the case when catching mammals over 8 kg, it will intermittently eat its prey on the ground, returning to feed for up to five days.

Photo credit: Chris van Rooyen

Habitat, nesting, and breeding

Habitat: Wooded savanna and thorn bush.

Breeding: March–September

DID YOU KNOW?

Martial Eagles and other species have actually expanded their range by utilizing power line towers as nesting platforms in the Karoo, South Africa.

Behavior relevant for utilities

Martial Eagles are a single-perching species and often use pole tops/structures as perches to identify potential prey. The behavior and size of the Martial Eagle and it breeding extensively on energy infrastructure in southern Africa increases the likelihood of electrocutions. The Martial Eagles behavior of moving between breeding, roosting, and feeding sites, sporadically increases their risk of colliding with power lines.

IUCN Red List Conservation Status

Endangered

LESSER FLAMINGO

Phoeniconaias minor

Photo credit: Andre Botha

Size and body shape

Height: 113–122 cm
Weight: 1.2–2.7 kg
Wingspan: 95–100 cm

Food and feeding habits

Feeds primarily on Spirulina, algae that only grow in very alkaline lakes.

Habitat, nesting, and breeding

Habitat: Primarily in open, eutrophic wetlands, shallow lakes, salt pans, and coastal mud flats. Also known to feed at sewage treatment works.

Nest: A mud mound

Breeding: Etosha Pan (Namibia), Sua Pan (Botswana), and Kamfers Dam in Kimberley. Lays one egg on nest, year-round.

Behavior relevant for utilities

Lesser Flamingos are known to fly mostly at night, increasing the risk of collision with power lines. It is for this reason that the standard diurnal mitigation products/methods are not appropriate for Lesser Flamingos. Special nocturnal anti-collision devices need to be installed to prevent the Lesser Flamingo from colliding with power lines.

IUCN Red List Conservation Status

Near Threatened

Photo credit: Shutterstock

GREATER FLAMINGO

Phoenicopterus ruber

Photo credit: Shutterstock

Size and body shape

Height: 145–165 cm
Weight: 2.6–3.5 kg
Wingspan: 140–165 cm

Food and feeding habits

Greater Flamingos stir up mud, suck water through their bills, and filter out small shrimp, seeds, blue-green algae, microscopic organisms, and mollusks.

Habitat, nesting, and breeding

Habitat: Greater Flamingos reside in freshwater lakes and pans, mudflats, and shallow coastal saltwater lagoons.

Nest: Greater Flamingos nest in large dense colonies on mudflats or islands of large water bodies, the distance between the closest neighboring nests is around 35 cm.

Breeding: Lays one egg on a mud mound November – August

Behavior relevant for utilities

Like the Lesser Flamingo, Greater Flamingos fly mostly at night, increasing the risk of collision with power lines. It is also essential to note that the standard diurnal mitigation products/methods are not appropriate for Greater Flamingos and special nocturnal anti-collision devices need to be installed to prevent the Greater Flamingo from colliding with power lines.

IUCN Red List Conservation Status

Least Concern

Photo credit: Shutterstock

LUDWIG'S BUSTARD

Neotis ludwigii

Photo credit: Matt Pretorius

Size and body shape

Height: 76–97 cm
Weight: 2.2–6 kg
Wingspan: 1.5–1.8 m

Food and feeding habits

Ludwig's Bustards have a varied diet consisting of insects and small vertebrates, but favor locusts.

Habitat, nesting, and breeding

Habitat: Ludwig's Bustards prefer open grasslands and semi-arid regions of southern Africa.

Nest: A shallow scrape in the ground, sometimes ringed by pebbles and typically located amidst vegetation, close to the male's display site.

Behavior relevant for utilities

Ludwig's Bustard, like most other bustard species, are at risk of colliding with power lines due to its large body size. No current mitigation methods or products effectively reduce power line collisions for the Ludwig`s Bustard.

IUCN Red List Conservation Status

Endangered

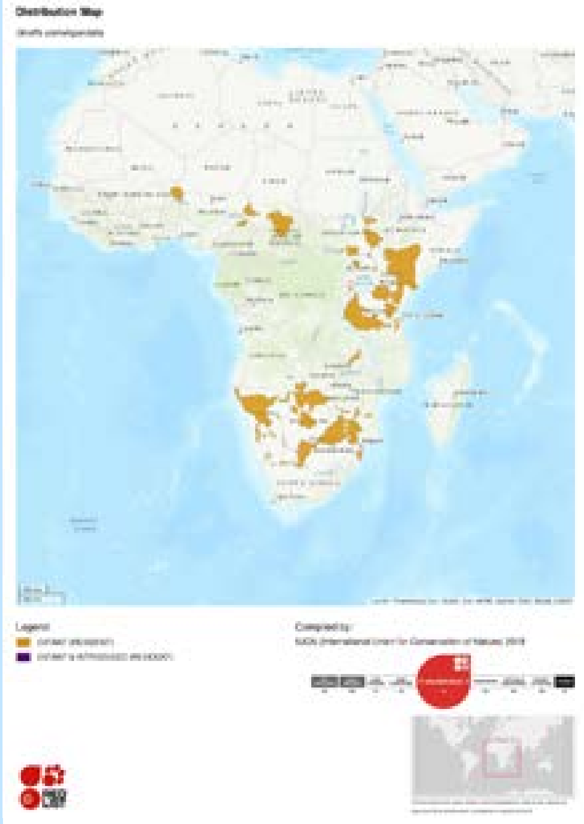
Photo credit: Matt Pretorius

3.4.2 MAMMALS[19]

GIRAFFE

Giraffa camelopardalis

Photo credit: Constant Hoogstad



Size and body shape

Male weight: 973–1,395 kg
Female weight: 703–950 kg
Average male height: 4.8 m
Average female height: 4.1 m

Food and feeding habits

Giraffes rip the thorny leaves from *Acacia* and *Combretum* trees and eat as many as 100 other plant species. Reaching vegetation higher than any other mammal, the giraffe can eat up to 134 kg of leaves a day.

Habitat and breeding

Giraffes inhabit savanna, scrub, open acacia woodlands, and subtropical and tropical grasslands with trees and bushes. Mating occurs year-round, peaking in the rainy season, and results in pregnancies lasting 457 days. The single calf begins life with a two-meter drop, as females give birth standing up.

Behavior relevant for utilities

Due to a giraffes, height, they are often electrocuted by low hanging conductors and transformers on distribution lines.

IUCN Red List Conservation Status

Vulnerable

DID YOU KNOW?

The tallest giraffe on record measured was an impressive 5.88 m tall! (by Shortridge in Kenya during 1934).

Photo credit: Shutterstock

WHITE RHINO

Ceratotherium simum

Photo credit: Constant Hoogstad

Size and body shape

Male weight: : 2,000–2,400 kg
Female weight: 1,600 kg
Male shoulder height: 1.7–1.86 m
Female shoulder height: 1.6–1.77 m

Food and feeding habits

White Rhino are grazers, feeding on large quantities of grasses that they crop with their wide, square front lips.

Habitat and breeding

Habitat: Found in grasslands and open savanna woodlands.

Breeding: Breeding occurs throughout the year. After the courtship and mating period, which lasts from one to three weeks, the female may leave the bull's territory. Gestation lasts around 16 months, after which a single calf is active soon after birth.

Photo credit: Constant Hoogstad

Behavior relevant for utilities

All rhino species are known to rub against wooden distribution poles, causing damage to, and ultimately collapse of, the poles.

IUCN Red List Conservation Status

Near Threatened

CHACMA BABOON

Papio ursinus

Photo credit: Andre Botha

Size and body shape

Height: 50–114 cm
Male weight: 20–44 kg
Female weight: 11–20 kg

Food and feeding habits

The Chacma Baboon has a varied and opportunistic diet, feeding off a range of plant material, including bulbs, roots, shoots, seeds, fruit, fungi, lichen, crabs, fish, invertebrates, and other small prey. Larger prey species such as young antelope or small livestock are also occasionally taken. The Chacma Baboon may even raid crops in settled areas, with most of the foraging taking place on the ground during the day.

Habitat and breeding

Habitat: Woodland, savanna, semi-desert, scrubland, and montane habitats, at elevations of up to 2,100 m above sea level. Chacma Baboons roost on cliffs, hills, or trees at night, and are dependent on daily access to drinking water.

Breeding: It is suspected that Chacma Baboons' breeding is dependent on the availability of food and not seasonality. The female Chacma Baboon gives birth to a single baby, rarely twins, after a gestation period of around six months.

Behavior relevant for utilities

Chacma Baboons often use distribution pole tops and transmission towers when threatened and escaping danger, which can lead to electrocutions. Chacma Baboons are also known to roost on towers at night.

IUCN Red List Conservation Status

Least Concern

Photo credit: Constant Hoogstad

VERVET MONKEY

Chlorocebus pygerythrus

Photo credit: Marianne Golding

Size and body shape

Weight: 3.4–8 kg
Head-body length: 35–66 cm
Tail length: 48–75 cm

Food and feeding habits

Vervet Monkeys feed on a wide range of items, including fruit, seeds, buds, leaves, roots, grasses, insects, crustaceans, birds' eggs and chicks, and other small vertebrates such as lizards. The Vervet Monkeys will also bite and chew branches of trees such as *acacias* to feed on the sap.

Habitat and breeding

Habitat: Vervet Monkeys are highly adaptable and occupy a variety of habitats, including savanna, open woodland, forest edges, cultivated areas, and urban environments.

Breeding: The female Vervet Monkey gives birth annually to a single young, rarely twins, after a gestation period of 165 days. In any given vervet population, there is typically a peak of births that coincides with the season when resources are most available.

Behavior relevant for utilities

Vervet Monkeys are often electrocuted on poles or conductors due to the length of their bodies and tails. Gaps between live conductors can easily be bridged if a Vervet Monkey climbs on top of a structure or moves between conductors. Vervet Monkeys often use substations, a safe place away from most of their natural predators, for roosting sites or sleeping.

IUCN Red List Conservation Status

Least Concern

Photo credit: Shutterstock

Photo credit: Constant Hoogstad

04 THE IMPACTS OF WILDLIFE INTERACTIONS ON UTILITY OPERATIONS

As covered in Chapter 3, certain wildlife species are likely to interact with utility hardware due to their behavioral or physical characteristics. When wildlife interacts with electrical infrastructure, utilities experience a knock-on effect of faults that ultimately impact the end-users. Besides the obvious detrimental impacts of energy infrastructure on wildlife, these incidents have financial implications for utilities; for example, hardware components are often damaged during wildlife interactions, resulting in power line trips and unplanned outages that require repairs. When a power line trip occurs, utilities are obligated to trace the fault and physically inspect the hardware, often requiring hours on the road or even deploying an aircraft.

Interruptions in electrical supply caused by these incidents can impact industry and domestic households alike, reducing overall productivity in the economy and impacting people's quality of life. To fully grasp the impact of wildlife interactions on utility operations, it is important to use the previously categorized impacts and discuss how they affect utilities' hardware, maintenance requirements, and repair costs.

4.1 BIRD COLLISION IMPACTS

In general, the direct impact of collisions on electricity infrastructure is minimal. Outages caused by birds colliding with power lines are relatively rare, except on reticulation lines where the secondary electrocution effect can cause electricity interruptions. This may result in a fire as the burning bird falls to the ground, costing the utility money to repair the damage caused to the infrastructure and possibly to the landowner's property.

A collision between heavy birds, such as bustards, pelicans, and storks, and distribution lines may cause a flashover between live phases as the conductor sways inward. This arc of electricity can damage and weaken the conductor, causing it to fray or snap completely.

4.2 BIRD ELECTROCUTION IMPACTS

Bird electrocutions resulting in line trips, dips, or blown fuses can incur costs to utility. These incidents affect system reliability and customer supply, and the mandatory investigations by maintenance staff present additional unnecessary expenses. Although most power lines will automatically reconnect after a flashover, customers with sensitive industrial equipment may have their equipment compromised as brief voltage dips can cause damage.[20]

In almost all electrocution cases, the affected bird will die immediately, and in some cases, the carcass will partially ignite during the incident. When the carcass falls to the ground, it may result in a fire, causing damage to private property and the utility's hardware. In rare cases, the carcass remains on the pole top and may cause a pole-top fire.

A Cape Vulture electrocuted on a T-pole distribution structure. Photo credit: Constant Hoogstad

4.2.1 SUBSTATION ELECTROCUTIONS

In southern Africa, numerous birds, mammals, and rodents will enter substations for shelter, roosting, feeding, and breeding. Substations attract animals due to the vast space and good lighting within the substation, making it an ideal place for species to find refuge and, out of breeding season, to roost, perch or hunt. The substations are ideal for reptiles and other animals in winter due to the warmth generated by the transformers. However, animals are not the only sources of damage within a substation environment. Plants often grow in poorly maintained substations, providing an additional attraction as a food source for animals and encouraging them to occupy the substations. Animals attracted to the substations cause significant problems, including electrocutions, the attraction of predators to the substations when birds and rodents breed, flashovers on transformers, and bird pollution on hardware, resulting in required maintenance by the substation staff. Some of these interactions may also lead to serious outages and substantial revenue loss.[21] Please refer to case study 2 in Chapter 7.

Small mammals such as this squirrel can contact live phases in substations and cause damage to hardware components. Photo credits: Hilton Westman

4.2.2 TRANSFORMER ELECTROCUTIONS

Transformers are mostly located on distribution pole tops and inside substations. They pose a significant electrocution risk because the casings are earthed, have numerous jumpers, exposed bushings, and other live components in close proximity to one another. Primates, snakes, and birds favor pole-top transformers for roosting and nesting. Owls, in particular, use these platforms for hunting and feeding purposes. When transformers are not elevated high enough from ground level, tall animals such as giraffes and elephants are often impacted when they encounter these live components.

From a business perspective, these interactions cause outages to end-users (customers) and, in extreme cases, cause transformers to blow, leading to oil leaks or transformer replacement, which is a costly exercise for the utility and will interrupt the supply to customers during repair operations.

4.3 BIRD NESTING IMPACTS

As discussed in Chapter 3, many bird species nest on electrical infrastructure when there is a lack of natural nesting opportunities such as trees or cliffs or because it provides a sturdy platform that is perceived to be safer than natural alternatives. The many types of bird nests on electrical structures can cause significant negative impacts for the utility through flashovers or physical damage to the structures. The presence of birds and their nests can also impede the maintenance of structures, particularly if there are chicks or eggs in the nests. Without regular maintenance, the network will be at a higher risk of experiencing faults, causing interruption of power supply to consumers, and the utility will incur additional costs for incident investigations and repairs. Please see case study 6 in chapter 7.

Eagle nest on 400 kV tower (left). Photo credit: Ronelle Visagie
Eagle nest on 5-pole structure (right). Photo credit: Matt Pretorius

4.3.1 FLASHOVERS AND FIRE

Nesting materials used in birds' nests, such as large sticks in eagle nests or wire in crows' nests, may cause flashovers if they infringe the phase-earth air gap. On smaller reticulation structures, pieces of wires and other nest material can also straddle two conductors simultaneously, resulting in a phase-phase flashover, especially in wet conditions. The densely-packed grass nests of sociable birds such as weavers can cover hardware on a reticulation structure and, during wet conditions, the damp nest material becomes conductive, and flashovers occur. In some cases, these incidents can cause the nest material to ignite, resulting in fires and causing poles to burn down completely or, in the case of transmission towers, causing damage to hardware components. Such fires can also lead to bush fires with significant ecological and economic consequences. Apart from the cost of physically replacing the pole, the resultant bush fire may lead to damage claims from landowners.

4.3.2 DAMAGE TO POLES

The weight of some weaver nests can cause poles to sag, usually in wet conditions when the earth becomes soaked. In extreme cases, poles have been known to collapse entirely, creating serious safety risks.

Certain bird species can cause structural damage to electricity structures through their nesting behavior. The biggest culprits in this regard are certain woodpecker and barbet species. These birds naturally excavate holes in dead trees that they use as nesting chambers. Wooden poles and cross arms are readily used by these species, even when other natural alternatives are available and, over time, multiple excavations in a pole can seriously compromise its structural integrity. In the case of woodpeckers, the birds also make excavations searching for insects within the woodwork. According to some authorities, the birds favor poles that are already in a state of decay, as it is easier for the birds to penetrate the wood, and they are more likely to find insects within. However, field services staff report that even new poles are utilized. Abroad, especially in the USA, much research into the problem has been conducted and it was observed that woodpeckers prefer solid wood that is not too hard.

When a woodpecker starts to excavate a hole and perceives the wood to be too hard, it will move to another area on the pole and try again. Woodpeckers may return to finish a hole initially abandoned when decay has entered the cavity and softened the wood. Woodpeckers seldom reuse a hole, which means that one bird can create multiple cavities and cause significant damage. Other species make regular use of woodpecker holes as nesting sites.[22]

Sociable Weaver nests on 5-pole structure (left). Photo credit: Ronelle Visagie
A Sociable Weaver nest on a wooden electricity pole (right). Photo credit: EWT

4.4 STREAMER AND POLLUTION IMPACTS

Electricity structures have become important roosting, perching, and nesting sites for many bird species, and as detailed in Chapters 2 and 3, excreta from birds using the electricity structures can cause electrical faults. Until 1996, it was generally believed that bird pollution, i.e., bird excreta covering insulator strings, was the sole reason for these faults. However, subsequent research showed that this mechanism is not the only cause of faults related to bird excreta but that the so-called bird streamers are another mechanism. For the distinctions between the two, please see Chapter 2. The flashovers and instability in the network resulting from streamers are not easily detected, and often, linesmen are dispatched to investigate line trips without success, incurring costs in terms of time and travel, which is a waste of resources considering these efforts could be avoided through appropriate mitigation on the structures. The interruption also costs the utility lost revenue and any necessary repair costs. Streamers account for most voltage dips recorded in transmission line networks and the installation of bird guards to prevent birds from perching on transmission towers has constituted a significant investment since the turn of the century.

4.5 MAMMAL IMPACTS

4.5.1 LARGE MAMMAL IMPACTS ON WOODEN POLES AND OTHER STRUCTURES

A report produced in 2016 by the EWT, Eskom Research Testing & Development, and Eskom Distribution Limpopo Operating Unit indicated that the integrity of the distribution network in the KNP, South Africa, is compromised continually due to the rubbing and horning behavior displayed by the park's large mammals. It was noted that two different types of electrical infrastructure were used within the study area; wooden poles treated with creosote and steel poles. The steel poles showed no impact or signs of animal interaction, but the wooden poles were more severely impacted than the trees around them.

When planted, the wooden poles used for power lines are treated with creosote to protect them from the weather and invasions from termites and other insects. Once animals such as Cape Buffalo and White Rhino, or birds, remove the creosote by rubbing against the pole or building nests, the pole's core is exposed, and termites can enter it and cause extensive damage that further compromises the stability and longevity of the structure. Following this, it is only a matter of time before the pole's core becomes brittle and the pole has to be replaced. The report revealed that an average of 400 poles need to be replaced in the KNP each year due to large mammal damage, costing Eskom approximately $800,000 a year, including travel, material, labor, and specialized vehicle costs. The report's purpose was to determine whether implementing mitigation measures on the poles would save costs in the long run. After testing several mitigation measures (see Chapter 5), it was concluded that placing mitigation at 400 poles could save Eskom up to $755,514 for the first year as mitigation costs will be highest during this time, with savings likely to increase after that.[6]

Large mammal interactions with electricity are common inside protected areas. In this case, a male elephant was electrocuted due to pole breakage and a conductor that sagged too low to the ground.
Photo credits: SANParks

4.5.2 OTHER MAMMAL IMPACTS ON INFRASTRUCTURE

Chapter 3 described the different impacts mammals of all sizes have on electrical infrastructure and a utility's ability to provide a stable supply of power to consumers. Mammals such as monkeys and baboons sometimes get electrocuted when climbing on structures and using pole tops, transformers, and towers as vantage points and roosts. In 2016, a monkey entered a power station in Kenya and caused a trip. For 15 minutes, the entire country (4.7 million households) was left without power. According to the Kenya Electricity Generating Company (KenGen), the monkey fell onto a transformer at the Gitaru hydroelectric power station, the country's largest generator, and caused a total blackout.

Like birds, small mammals such as squirrels or mongooses often use substations as breeding sites. They dig burrows in the substation footprint and climb up transformers, bridging gaps that could cause substantial damage. Porcupines also burrow under towers where the soil is softer due to construction disturbances, which, in turn, compromises the stability of towers. These excavations around the foundations of steel lattice towers have actually caused some of these large towers to collapse. Please see case study 3 in Chapter 7.

Small mammals can also cause pollution and flashovers, as can some of their predators, such as genets, if they gain access to substation yards, transformers, and pole-mounted switch-gears. In 2013, the Eskom Transmission: Free State Grid requested the EWT's Wildlife and Energy Programme to initiate a project to determine the extent of genet activity within the Perseus substation.

The request was made after a genet had been electrocuted on top of one of the transformers and destroyed the transformer, costing the utility more than $2.6 million.

Porcupine excavations around a lattice tower foundation. Photo credit: Ndzalama Chauke

4.6 IMPACTS ON RENEWABLE ENERGY INSTALLATIONS

While renewable energy impacts on wildlife are relatively well studied,[23] examples of how wildlife impacts renewable energy installations are scarce. For example, birds and bats are negatively impacted by poorly placed wind farms, but when they collide with the infrastructure, there is no direct impact on utility performance. Similarly, birds collide with solar panels and heliostats at solar installations, but the force of these collisions is not sufficient to cause damage to infrastructure and live components are not affected, resulting in continued operation despite wildlife interactions.

Severe environmental impacts by renewable energy developments may draw the attention of authorities, which could affect operations. Site selection is important in this regard, but this is often guided by natural resource availability, with environmental considerations secondary to this. Responsible site selection for solar PV installations should avoid sensitive habitats, as solar panels cause unnatural shade all year round, resulting in complete habitat transformation throughout the footprint. This may alter the food availability for a range of species or enable new plant and animal species to inhabit the area, affecting countless other ecosystem functions locally. Wind energy developers should gather information on the movement patterns of birds and bats before the final site layout is confirmed. Birdlife South Africa and the Endangered Wildlife Trust have developed comprehensive guidelines in this regard, which are available for download at https://www.birdlife.org.za/wp-content/uploads/2020/03/BLSA-Guidelines-Birds-and-Wind.pdf [24] Adhering to these guidelines will avoid a situation where production losses are incurred later due to severe environmental impacts.

From a maintenance perspective, small bird species have been known to nest and roost around electrical infrastructure hardware. Renewable energy is no exception, with small bird species readily nesting underneath solar panels, between electrical components. Although faults caused by these nests are not well documented, the dry nesting material poses a fire risk and maintenance is needed to remove unwanted vegetation from hardware. Bird nests are a common occurrence where shelter and substrate are available, and any transformer, building, or other infrastructure associated with renewable energy installations can be affected in this way.

Photo credit: Shutterstock

4.7 APPROACHING HOLISTIC AND SUSTAINABLE SOLUTIONS

By now it should be evident that a range of wildlife interactions can potentially impact utility operations and profitability, a challenge which can be difficult to address if the underlying causes are not identified and communicated within the organization. By emphasizing the benefits of a WMS to utilities, the aim is to effect change from within. Whatever the figure may be, cost reduction should be the main driver when considering wildlife during the design and operational phases of a transmission or distribution network. When considering wildlife interactions, the focus should be on operational efficiency, improving electricity supply, and effectively communicating how these changes will reduce wildlife mortality. Chapter 5 explores ways and means of achieving this, providing practical guidance on the mitigation of wildlife interactions with electrical infrastructure.

Photo credit: Shutterstock

Photo credit: Constant Hoogstad

Addressing the impact of wildlife interactions on operational performance can be a daunting task for any utility, especially in situations where the cause of line faults cannot be clearly defined. Utilities in southern Africa typically have existing problematic infrastructure, erected long before the impact of wildlife interactions became apparent. Although new infrastructure can be designed to avoid similar operational interruptions caused by wildlife, most utilities will need to employ a multi-pronged approach to managing wildlife related faults, catering for historic infrastructure as well as intervening during the planning phase of new projects to avoid designs that could lead to excessive wildlife mortality and supply interruptions.

5.1 AN OVERVIEW OF DIFFERENT APPROACHES TO MITIGATE WILDLIFE INTERACTIONS WITH ELECTRICAL INFRASTRUCTURE

Most negative wildlife interactions with electrical infrastructure can be prevented by proactively implementing mitigation measures before, during, or after construction, before an incident has taken place. Most power utilities have only recently started to seriously consider the impacts of negative wildlife interactions with electrical infrastructure; therefore, utilities will implement most mitigation measures at locations where incidents are occurring or have occurred in the past. This response is known as a "reactive mitigation approach", for which various mitigation measures and devices exist to either retrofit existing hardware or replace it with safer options. For successful reactive mitigation approach implementation, utilities must have or develop an effective incident management system to prioritize incidents.

EWT field officers conducting a power line collision investigation with volunteers and Eskom. Photo credits: the EWT

5.1.1 BEST PRACTICE GUIDELINES FOR IMPLEMENTING, MONITORING, AND REPORTING ON WILDLIFE INCIDENTS – A REACTIVE APPROACH

To effectively protect hardware and prevent reoccurring negative wildlife interactions, utilities must properly document and classify incidents when they are reported. Although incident reports can originate from various sources, the utility is often best placed to record and manage incidents due to servitude access, line fault indicators on the network, and time spent around infrastructure during routine maintenance. Before this vital component of a WMS can be effective, utilities should consider several key factors:

1. Utility staff must be able to distinguish between different types of incidents and accurately report this to a central point.

2. Utilities must provide adequate resources to effectively capture and record all incidents in a database. The database should be neatly managed and standardized for data to be effectively extracted later.

3. Utilities should inform the public of the reporting system and encourage them to report all incidents to the utility directly.

4. Incident reports should be standardized and, at a minimum, should contain the following:
   - The date of the incident
   - The location of the incident (GPS coordinates)
   - The pole or tower number
   - The structure type/design
   - The species involved
   - The classification of the incident
   - Contributing factors (watercourses, agricultural fields, wetlands, weather, etc.)
   - Photographs to support the incident report

5.1.2 FINDINGS AND RECOMMENDATIONS

Once an incident has been captured in the system, utilities can determine whether to investigate it further or to close it out. If the incident report contains enough relevant information during the reporting stage, an investigation may not be necessary. However, an on site assessment could add valuable insight for incident management, and other structures in the area can also be assessed for risk at the same time.

The on site investigation serves to:
- Verify information received through the incident report
- Inspect the carcass to understand the nature of the incident
- Search the area for any more carcasses
- Inspect the hardware for damage
- Agree on the recommendation for mitigation to prevent recurring incidents

Bird-friendly structure (left). Photo credit: Constant Hoogstad. Raptor guards fitted to a T-pole to prevent a potential electrocution on the pole top (top right). Photo credits: Power Line Sentry. Bird flight diverter fitted to a conductor on a transmission line to make the line more visible and reduce bird collisions (bottom right). Photo credit: Marianne Golding

Upon completing the investigation, a recommendation report should be produced detailing the findings and recommended mitigation products or hardware modifications as appropriate. These recommendations should be practical, achievable, and aligned with internal budgets and resources available to complete the work. A variety of mitigation products are available for procurement.

These products should be internally approved for use by the utility before installation. See https://powerlinesentry.com/products/ for a comprehensive list of mitigation solutions.

After the implementation of mitigation, the incident should be closed on the system for record purposes. The utility can choose to track the closure of these incidents alongside other performance targets to ensure timely action from the responsible managers affected by the incident. An example of how such a process would work can be seen in figure 5.

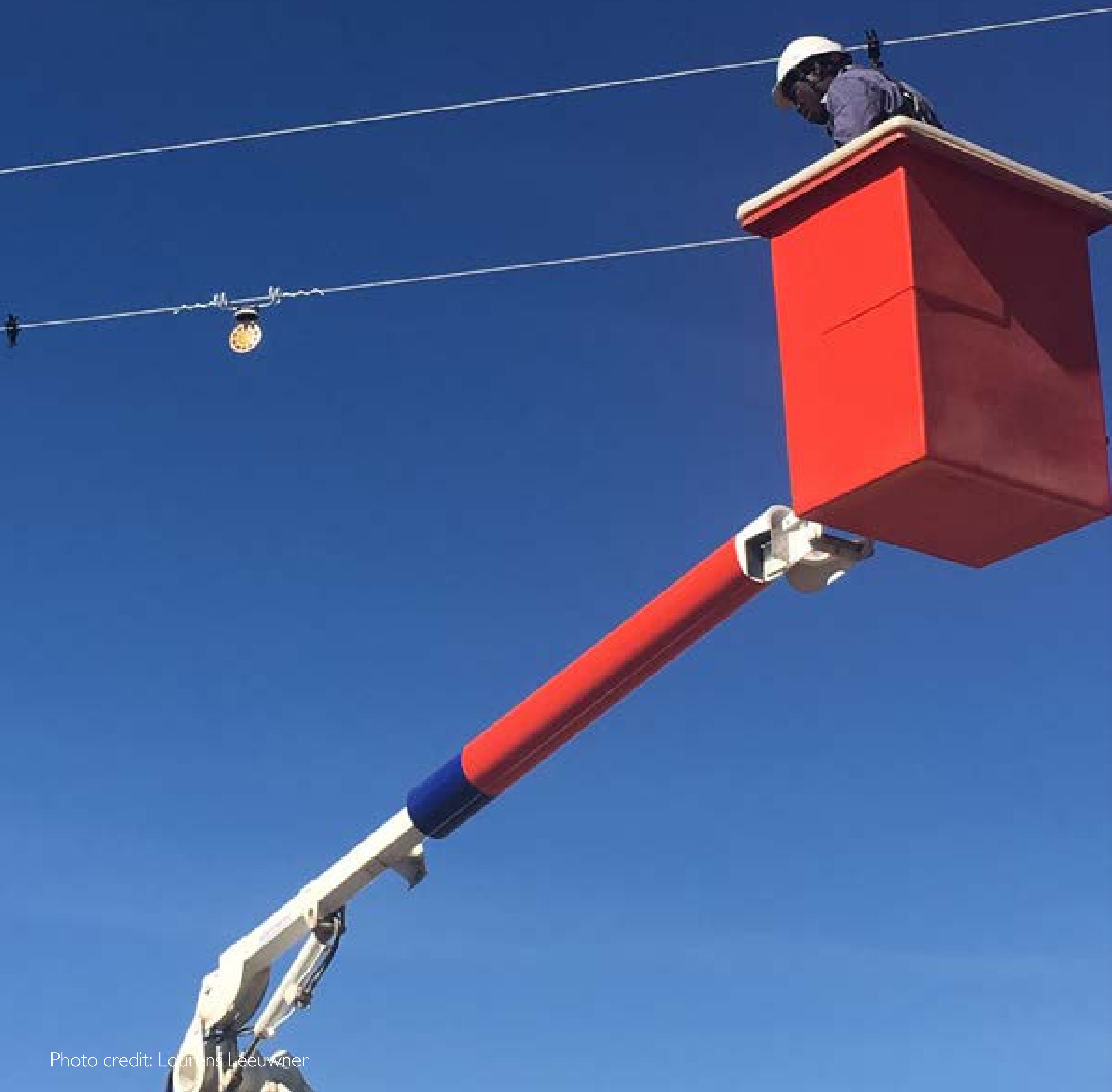


Photo credit: Lourens Leeuwner

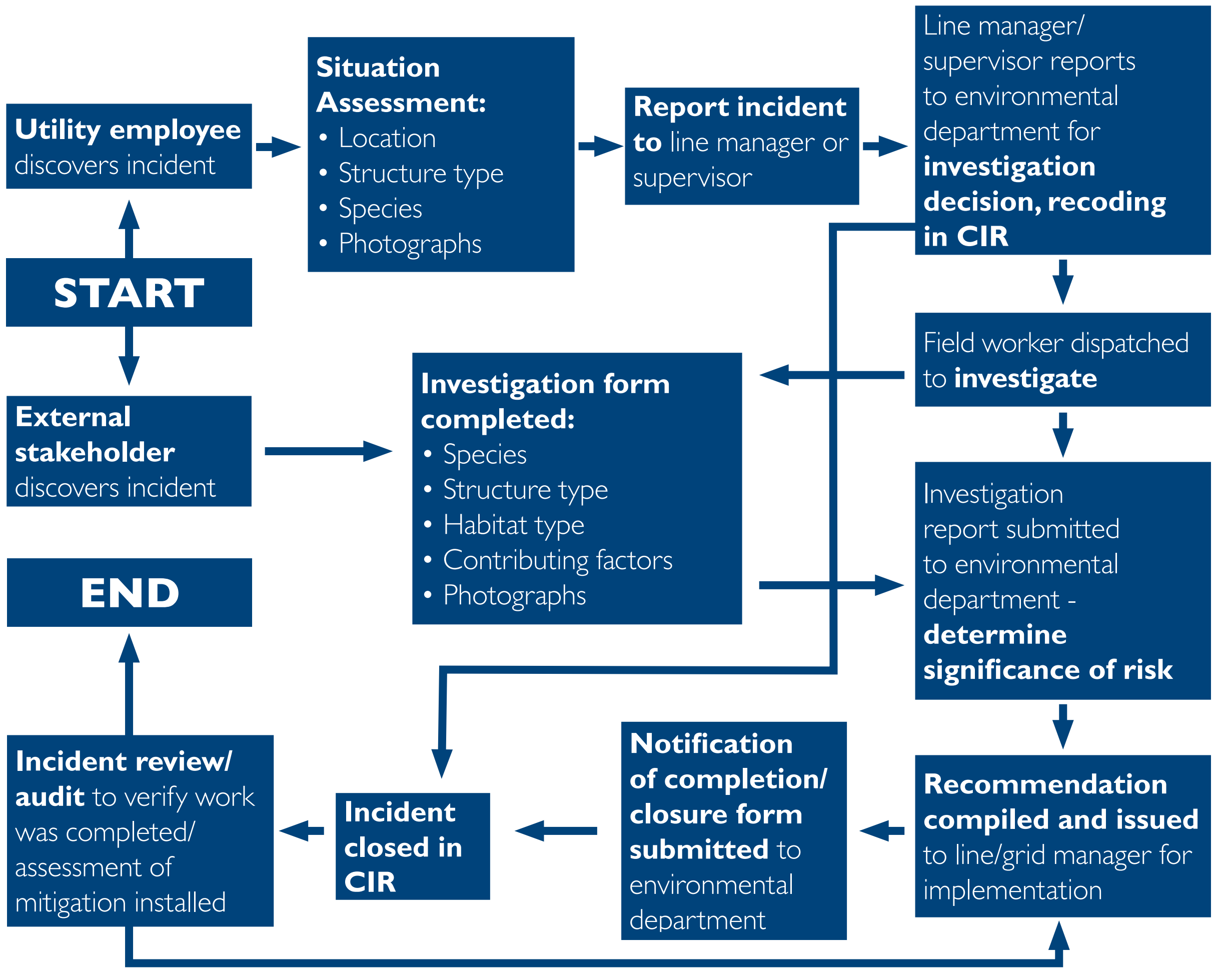


Figure 5: An example of a Wildlife Incident Management System for utilities

5.2 ELECTRICAL INFRASTRUCTURE

When required, a country's environmental impact assessment protocols must consider not only the environmental impact that new electrical infrastructure will have on a site in terms of habitat destruction (e.g., the clearing of servitudes), but also the impact they will have on wildlife related to potential electrocution and collision incidents. In the case of renewable energy generation developments, specialists should not underestimate the impacts of auxiliary infrastructure such as distribution lines and meteorological masts. Renewable energy auxiliary infrastructure can have a greater direct impact on local wildlife than the generation sites themselves.

The most effective proactive mitigation measure for electrocutions is to ensure that design standards include an adequate separation between phases and between energized and earthed components. Some countries have adopted the stance that all new builds shall conform to these 'wildlife-friendly' design standards – a principle that ensures effective proactive mitigation if implemented correctly.

The correct implementation of mitigation mechanisms is critical during construction. Small omissions, such as neglecting to add a Basic Insulation Level gap, can cause fatal errors, turning what should have been safe structures into structures with high electrocution risks for wildlife.

To proactively mitigate against wildlife collisions with power lines, utilities must ensure that routing avoids important habitats and areas regularly occupied by species at risk of collision, particularly threatened species. This can be achieved by overlaying power line route options onto species distribution models (SDM) for collision-sensitive species and classifying species-specific collision risk according to morphological and behavioral aspects.[25] Some of the most important areas to avoid are breeding colonies and nesting sites, as these are the core areas of most frequent use within an animal's territory during certain times of the year.

Species that make daily use of a particular roost site throughout the year are especially vulnerable to new power line developments near that site, as they employ a central-place foraging strategy with the roost at the core of their home range.

There is evidence that some species' collision rates are highest immediately after construction, suggesting that birds may eventually learn the location of new power lines and navigate them successfully over time. Alternatively, if collision rates are density-dependent, the comparatively higher initial impact could be because too few birds maintain that collision rate later on. Whatever the reason for this observation, it is important to note that, if avoiding high risk is impossible or has not been done, mitigation against wildlife collisions with power line cables should, ideally, be implemented proactively. Installing mitigation measures, such as power line markers, during construction, presents a significant potential cost saving compared to post-construction installation, especially where the post-construction installation requires the use of a helicopter or drone and live line crew.

Utilities should, however, be cautious about installing mitigation on all new power line spans if the most likely impacts are predicted to be on species for which the mitigation has not yet been proven to be effective. For example, bustards (*Otididae*) are good examples of birds for which an effective mitigation solution has yet to be found.[26] Alternatively, certain sections of the spans can be marked as an experiment to determine marker effectiveness, provided there is a commitment to monitor collision incidents both pre-and post-mitigation to achieve a true Before-after-control-impact (BACI) study. This could be especially useful for testing promising novel mitigation measures/devices yet untested for species severely impacted by collisions with overhead power lines.

However, in areas where a variety of threatened species are affected by collisions, some of which are known to respond positively to existing mitigation measures/devices, a more comprehensive proactive mitigation strategy (e.g., where all spans are marked) may be a more prudent approach.

Raptor protectors fitted to a distribution pole top where bird electrocutions occurred (top left). Photo credit: the EWT. Raychem insulation products fitted to distribution pole top to reduce the amount of bird electrocutions. (bottom left). Photo credit: the EWT. An RPAS in flight attaching bird flight diverters to a live power line. (right). Photo credit: Eskom


Photo credit: Constant Hoogstad

5.2.1 PROACTIVE MITIGATION AGAINST NEGATIVE WILDLIFE INTERACTIONS WITH EXISTING ELECTRICAL INFRASTRUCTURE

Knowledge of the species negatively affected by electrical infrastructure and the interactions that lead to incidents must inform a proactive mitigation strategy. Utilities require at least some knowledge of previous and existing incidents, and these data should be collated and recorded in a national database. There are, however, morphological and behavioral aspects of species that could, when considered in parallel with detailed species distribution and habitat niche models, provide a baseline for determining their sensitivity to electrocutions or collisions within an area. There are also aspects of power line structure configurations and design standards that could help predict the level of expected exposure to the threat of negative power line interactions. The risk of the threat should not only be modeled by mapping species distribution or habitat suitability, nor by only quantifying aspects of the danger posed by the type of electrical infrastructure and morphological and behavioral traits of the species involved. Instead, these aspects should be combined to model the total risk of the threat, as suggested in the following conceptual model (adapted).[27]

$$R = HSI + Exposure_{species} + Exposure_{threat}$$

- Where R represents the risk (of electrocution or collision) posed to a species
- HSI is a habitat suitability index (identified by species distribution models)
- Exposure species represents morphological and behavioral aspects related to the species
- Exposure threat quantifies the distribution, density, and nature of the threat itself (e.g., the voltage and height of power lines, inclusion of shield wires, phase-to-phase separation between conductors, design standards, etc.)

Photo credit: Shutterstock

HABITAT SUITABILITY AND SPECIES DISTRIBUTION

Species distribution maps/models are informed by recorded sightings and encounters with species and are vital for understanding where negative interactions with electrical infrastructure are likely to occur. For most countries, national or regional databases of such records exist, gathered from various sources. The contributions of citizen scientists have bolstered these databases in recent decades, with the caveat that there should be a vetting system for information from untrained data collectors. The main benefit of databases using data from citizen scientists (using GPS enabled smartphones with cameras and data collection apps) is that a much larger area can be surveyed continuously and at a finer resolution than ever before. The spatial resolution affords a relatively reliable atlas of species distributions, while the temporal resolution allows for determining trends in species occurrence (e.g., when considering migrants).

These grid-based atlases should be converted into finer models of spatial use, which can be achieved through various algorithms used in computer modeling software packages. A good example is Maximum Entropy, on which the machine learning algorithms of the program MaxEnt are based.[28] Programs such as MaxEnt can use presence-only data to make spatial inferences about the distribution of a species based on correlations with environmental variables and thus can extrapolate detailed SDMs. While presence-only data are likely to be more available than presence-absence data, programs such as MaxEnt assume that the presence-only data used to train fine-scale SDMs were recorded accurately in two-dimensional space (latitude and longitude). While a grid-based atlas affords relatively inaccurate records compared to the actual GPS coordinates of sightings, the accuracy required is determined by the scale at which SDMs are generated.

Perch guards fitted above the insulators on a transmission line to reduce the amount of streamer and pollution faults (top left). Photo credit: the EWT. Pied Crows nest built between perch guards fitted on a transmission tower (bottom left). Photo credit: Constant Hoogstad. Ground Hornbills perching on a structure above a transformer in Mabula game reserve, Limpopo Province, South Africa (right). Photo credit: Lucy Kemp / Mabula Ground Hornbill project.

If SDMs are required to prioritize mitigation in proactive electrical infrastructure mitigation plans at a national scale, then national atlas data may be appropriate. In this case, the centroids of the grid cells give the coordinates of latitude and longitude. Because a species will not be present in all grid cells wherein it has been recorded with equal frequency, a measure of occupation likelihood may be applied. For atlases that are well surveyed, this may take the form of a 'reporting rate' for that species in a given grid cell.

Some countries or species may be poorly surveyed, in which case global distribution maps such as those in the IUCN Red List of Threatened Species may be used as surrogates for SDMs. These may be appropriate for an initial proactive mitigation plan but should be treated as the first iteration of a continuously improving system as more data are collected. Data from other sources, such as satellite telemetry data from animals/birds fitted with GPS devices, may help create detailed SDMs where the sample of tagged individuals represents the national population. However, this is rarely possible given the significant financial resources required to tag such a large sample of animals, and tracking data should often only supplement national atlas data. Whatever the source of the data, it is imperative that the methodology used to collect it, as well as the statistical methods used to create SDMs, are applied as consistently as possible for all species considered in a proactive mitigation plan, thereby ensuring spatial prioritization is not biased towards species with better/more complete data.

Verraux's Eagle nest located in a high risk area above an insulator on a transmission line.
Photo credit: Constant Hoogstad

BIOLOGICAL AND ECOLOGICAL RISK FACTORS FOR THE ELECTROCUTION AND COLLISION OF SPECIES

Certain morphological traits affect the probability that a bird species will be affected by power line electrocutions and/or collisions. Electrocution probability is mostly determined by body size, as larger birds are more likely to bridge the gaps between energized and grounded components.[29] For collisions, other morphological traits may play an important role in determining risk. These include wing loading – the ratio of body mass to wing area – as well as aspects of eye morphology that affect the visual acuity of a species; binocular visual fields may severely impact the ability of certain species to detect overhead power line cables in time to avoid a collision.[30] Wing loading plays a role in collision risk as it affects the maneuverability of a species; those with a high wing loading ratio are considered less maneuverable and thus more at risk of collision than those with a small wing loading ratio. Birds with a high wing loading ratio include large terrestrial species such as cranes and bustards.

Behavioral aspects may play an equally important role in determining electrocution and collision risk. Certain behaviors exhibited by some species contribute more significantly than morphological traits. For example, large scavengers such as vultures are more at risk of electrocution when they congregate at animal carcasses, vying for positions on nearby power poles. Having physical contact with one another, vultures bunched together on a pole may increase the likelihood of bridging the gap between energized and grounded components, thereby increasing electrocution risk. Some raptors employ a perch-hunting strategy, using poles as vantage points to spot prey. This strategy places them at greater risk of electrocution than species that hunt on the wing, as they spend far more time on potentially dangerous structures. For other species, nesting habits play an important role in electrocution risk. Crows, for example, often use conductive materials such as fencing wire to construct their nests, which places them at risk of electrocution on the nest or when bringing material during nest construction, as discussed in previous chapters.

The weight of a Sociable Weavers, nest caused this telecommunications pole to break (top). Photo credit: EWT. White Backed Vulture nest located in a high risk area for streamers and pollution above an insulator on a distribution tower (bottom left). Photo credit: John Ledger. Jackal Buzzard nest on a transmission tower (bottom right). Photo credit: Ronelle Visagie. The start of a Sociable Weaver nest on a distribution pole. Photo credit: the EWT

STRUCTURAL RISK FACTORS AFFECTING ELECTROCUTION AND COLLISION OF SPECIES

The location of electrical infrastructure in the distribution and transmission power grids plays an important role in determining wildlife exposure to the threats of electrocution and collision. The presence of power lines potentially places wildlife at risk, and power pole density has been shown to correlate to electrocution risk in some species.[31] As previously mentioned, aspects such as voltage, design and phase configuration play an important role in determining the electrocution risk posed by a particular power pole.

Martial Eagle (left) and vulture (right) on power poles.
Photo credits: Andre Botha (left) and Constant Hoogstad (right)

5.2.2 PRIORITIZATION OF ELECTRICAL INFRASTRUCTURE FOR PROACTIVE MITIGATION

The prioritization of infrastructure for mitigation will vary across countries, regions, and even specific feeders. Line performance, species distribution, location of hardware, and historical incidents are all factors that would affect the prioritization outcome.

LINE PERFORMANCE

To simultaneously address quality of supply and wildlife mortality issues, line performance is possibly the most appropriate starting point to prioritize which areas of the network should be targeted for mitigation first. Where several factors are present, line performance should be weighted most heavily during the prioritization process.

SPECIES DISTRIBUTION

In instances where little information about historical faults and line performance is available, utilities should focus on areas where problematic species occur. The species highlighted in Chapter 3 can guide this decision, but the regional and global conservation status of the species in question should also be considered. This would simultaneously address line performance concerns and safeguard the utility against high profile incidents involving endangered species that would result in poor publicity and media coverage.

LOCATION OF INFRASTRUCTURE

Accurate spatial data on power pole locations is critical for determining the resources required to execute a proactive mitigation plan. Concurrently, utilities should record mitigation already installed to avoid prioritizing these mitigated areas. As design standards improve and to incorporate the threats posed by different configurations, utilities should upgrade some poles to a different design when replaced. Utilities should prioritize obtaining information about existing infrastructure from linesmen and validate models predicting electrocution and collision risk in the field.

Great White Pelicans roosting on a transmission tower.
Photo credit: Lourens Leeuwner

HISTORIC INCIDENTS

Possibly the most accurate way of deciding where to initiate a proactive strategy is to comprehensively assess historically recorded wildlife interactions and identify hot spots across the network. This type of data can take years to obtain, which is why establishing a "Central Incident Register" will save resources. By establishing an incident reporting system and raising awareness around wildlife interactions, the utility can increase reporting rates from the general public, utility staff, and landowners. Partnering with an in country NGO or other wildlife specialists can bolster the utility's capacity and ability to manage incidents and correctly organize the information for later use. Using these data in conjunction with species distribution and line fault reports would greatly improve the line selection accuracy for implementation.

Although the factors described above would guide a utility towards the most appropriate starting point, the situation on the ground will, in some cases, require institutional knowledge and employee experience to execute the work practically. Suppose, for example, a feeder consisting of 50 spans has been identified as a collision risk at a desktop level. Perhaps some of the spans run directly parallel to a forested area, negating the requirement for bird flight diverters, as the collision risk is absent. Similarly, a transmission line prioritized for perch deterrents may have several strain towers included. In some cases, where insulators are horizontal rather than vertical, perch deterrents would have no purpose.

Therefore, utilities should verify prioritized areas and consult responsible maintenance staff during the planning of the strategy.

5.2.3 DEVELOPMENT AND IMPLEMENTATION OF A PROACTIVE MITIGATION PLAN

Once sensitive species and high-risk power lines have been overlaid, utilities can identify priority areas for strategic implementation. The preferred approach is to integrate the work with existing maintenance schedules to minimize disruption to the utility and use available resources. In this regard, sector managers should be consulted well before starting new maintenance cycles, which is likely the beginning of the fiscal year. To ensure the success of such a strategy it is advised that:

- The strategy should be explained in detail to sector managers and buy-in obtained before implementation begins.
- Maintenance staff should have ample time to adjust work schedules, order materials, and plan carefully as some mitigation may require live-work teams or specialized equipment.
- Utilities should establish regional steering committees to review and approve proactive plans for the fiscal year where realistic targets can be agreed on.
- The priority maps should guide the efforts of the various sectors; however, more detailed planning will be required in some cases where problematic feeders are known to exist.

Implementation costs of such a strategy will vary greatly depending on the existing infrastructure, species affected, and faults experienced. For instance, in areas where streamer faults and collisions are prevalent, simple mitigation such as perch deterrents and bird flight diverters would be sufficient to render the line bird-friendly. Retrofitting structures or pole top replacements will be required when electrocutions and line faults have been identified as a priority (see a Handy Checklist for Proactive Mitigation). These interventions are far more costly and disruptive to the utility's day-to-day work schedule, highlighting the importance of detailed planning with clear, realistic targets. A proactive strategy is a long-term endeavor with many role-players who will need to adapt their current workflow and take on additional responsibilities. The most preferable way to avoid costs associated with retrospective mitigation, is of course through proper planning, starting with the EIA/ESIA process.

Photo credit: Constant Hoogstad

5.2.4 THE ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT PROCESS

Some countries require the implementation of a full Environmental/Social Impact Assessment for new high-voltage power lines. Consequently, many low- and medium-voltage distribution lines have impacted certain species in areas where developments would have been flagged if similar protocols to those for high-voltage lines had been implemented. Desktop-based assessments may contribute significantly to predicting the impact of smaller power line developments. These screening tools use spatial data on online platforms that rapidly assess the potential impact of new developments on the species present in an area, given the nature of the development. Utilities looking to proactively mitigate their impacts on wildlife may contribute to developing similar tools.

Another important consideration is the scope of an EIA/ESIA. As mentioned in chapter 1, these studies are designed to minimize the environmental and social impacts of developments and do not necessarily account for the impacts of wildlife on infrastructure. Utilities should not rely on these processes to account for operational impacts and supply interruptions, as many interactions with electricity infrastructure do not impact wildlife itself and, as such, are overlooked in the EIA/ESIA. In terms of assuring optimal line performance and reduced maintenance cost, the utility should identify high-risk areas through internal processes during the planning phase of any new project.

Photo credit: Lourens Leeuwner

A HANDY CHECKLIST FOR PROACTIVE MITIGATION

1. There is an understanding in the business that wildlife interactions can cause power supply interruptions, additional maintenance costs, hardware damage and ultimately a loss of revenue for the utility.

2. There is an agreement that the management and prevention of wildlife incidents will result in increased quality of supply, reduced maintenance costs to the business, and lead to an increase in revenue.

3. Wildlife incidents applicable to the business have been identified, defined, and categorized.

4. There is a system in place to report and record wildlife incidents in a central incident register (CIR).

5. Utility staff have the capacity to identify and report incidents, and the required resources are available to investigate and categorize incidents to the CIR when required.

6. Utility staff can identify and have a basic knowledge of species likely to interact with infrastructure in their region.

7. There is an understanding of how certain wildlife interacts with hardware and how these interactions will affect the utility's business.

8. Mitigation solutions applicable to the species have been identified, and systems are in place to procure and apply these if required.

Photo credit: Shutterstock

9 When new lines are designed, the relevant information is used to determine the wildlife species in the area that can potentially interact with the infrastructure, and with what impact.

10 The utility uses the information gathered to determine appropriate structure types, line heights (elephant and giraffe), line routing (bird migration paths), and identify and implement proactive mitigation measures to minimize wildlife interactions with infrastructure.

11 High-risk portions of the network are proactively protected/retrofitted to prevent energy losses by preventing wildlife interactions.

12 A system is in place to investigate wildlife interaction incidents, determine the root cause of the problem, and determine appropriate recommendations to avoid reoccurrence.

13 Key performance indicators are put in place to ensure that wildlife incidents are closed out quickly and efficiently.

14 Annual audits are conducted to ensure the efficiency of mitigation measures/devices and determine if there were any reoccurrence of incidents and confirm closeout.

15 In the case of transmission lines, a proper ESIA is conducted, taking wildlife interactions into account, and proactive mitigation measures are implemented to avoid interruptions in supply.

16 Company policies and technical standards are developed or revised to include the most up to date wildlife interaction solutions.

17 Company policies and technical standards comply with local environmental legislation

Photo credit: Shutterstock

Photo credit: Shutterstock

Once wildlife interactions have been classified, recorded and managed through a dedicated process within the utility, efforts to prevent repeat incidents or incidents on similar infrastructure in other parts of the network, should be prioritized. Understanding how to react to an incident is not always easy, and various products from numerous suppliers promise unrealistic results without always taking into account the species involved. Institutional knowledge is a crucial part of selecting the best method or product to mitigate the threat of wildlife interactions. Although each utility will amass the required knowledge pertaining to their unique situations over time, several approaches have proven effective in reducing or eliminating wildlife related faults. These are detailed below.

6.1 MITIGATION METHODS FOR BIRD COLLISIONS

As detailed in previous chapters, avian collisions with man-made structures such as communication towers, buildings, wind turbines, meteorological masts, and power lines result in millions of bird mortalities each year. Many studies identify and record mortalities resulting from power line collisions, but few focus on mitigation, specifically on measuring the efficacy of mitigation mechanisms. BACI experiments can address this gap but have rarely been implemented in avian power line collision mitigation studies.

Published reviews have classified mitigation measures of bird collisions with power lines under five main strategies:

6.1.1 REMOVAL OF THE EARTH/SHIELD WIRE

Several studies identify the earth wire of transmission lines as the primary cause of collisions and that removing it can effectively reduce bird collisions.[32] Earth wires are always situated above conductors in positions that optimize lightning coverage around them. Removing the wires is usually not feasible as they are required to shield a power line from lightning strikes, hence the alternative name 'shield wire'. Conductors are generally thicker cables than shield wires and strung in bundles in the case of higher voltage lines. These conductor bundles are more visible to most birds in flight, and they more commonly collide with the much thinner shield wires when maneuvering over conductors.

6.1.2 CHANGING OR REVIEWING THE PLACEMENT AND ROUTING OF A POWER LINE

Power line routing is an important consideration for any EIA/ESIA related to birds but is mainly feasible as a proactive measure only. In southern Africa, full EIAs/ESIAs are only required for higher voltage power lines above 132 kV thus, line routing is not as thoroughly considered across all new builds. However, there have been notable examples of power lines rerouted post-construction in response to severe bird collision mortality events.

6.1.3 BURYING CABLES UNDERGROUND

Burying power lines is the most effective way of preventing bird collision mortalities but is often not economically viable. However, overall impacts within a region can be reduced if small sections in key bird habitats can be buried.[33] Apart from cost, another restriction is that magnetic shielding is challenging for underground cabling with greater than medium voltage.

6.1.4 MODIFYING HABITAT TO REDUCE THE ATTRACTIVENESS OF THE AREA TO BIRDS

Habitat modification to lure certain birds away from power lines is not recommended without understanding how it will affect other species, and land-use change requires support from landowners. However, specific sites that attract birds daily, such as vulture supplementary feeding sites (or 'vulture restaurants'), could be used to lure birds away from power lines. However, the efficacy of this technique is still being tested, and the development of vulture restaurants should be done responsibly and under the guidance of experts such as the EWT Birds of Prey Programme.

6.1.5 FITTING MARKERS TO THE EARTH WIRE OR CONDUCTORS TO IMPROVE THEIR VISIBILITY TO BIRDS IN FLIGHT

Due to the constraints of other mitigation strategies, wire marking is often the only viable option, particularly for existing power lines. Power line markers are intended to alert approaching birds to the line so that they have sufficient warning to avoid the shield wire or conductor. Many different markers have been used on distribution (11–132 kV) and transmission (132–765 kV) power lines across South Africa. Some of these include aviation balls, thickened wire coils (or 'spirals'), and various other devices that flap (e.g., 'flappers'), shine, or flash to improve the line's visibility. Several studies report relatively successful post-mitigation results on power lines that have been fitted with such devices, although evidence for comparative marker effectiveness is rare.[34] A reduction in collision rates (number of collision mortalities/per unit of line distance/per unit of time) of up to 92% and 93.5% have been reported for certain vulnerable species on transmission lines and distribution lines, respectively.

Bird flappers on t-pole (left). Blue Cranes flying over marked line (right)
Photo credits: Marianne Golding

6.1.6 ILLUMINATING CONDUCTORS AND EARTH WIRES

The nocturnal behavior of birds that fly during periods of low light may contribute to recurring power line collision mortality where power lines have already been marked, as traditional markers are not visible to night-flying species. Such species include waterfowl such as ducks and flamingos, which undertake long-range flights at night and Gruiformes (e.g., cranes), which tend to fly between feeding areas and roost sites at dusk and dawn. Special markers have been developed for nocturnal activity with phosphorescent strips that glow in the dark; some even include light-emitting-diodes (LEDs). The latter are effective in reducing Greater and Lesser flamingo power line collisions.[7] An alternative mitigation measure is to illuminate the conductor and/or earth wire cables themselves, thereby improving their visibility to night-flying birds. Using near-ultraviolet (UV-A) light for this purpose has reduced crane collisions by 98%.[35] Birds perceive a wider range of colors than humans because they have tetrachromatic vision, i.e., they can perceive wavelengths in the near-ultraviolet and violet spectrum.

6.2 MITIGATION METHODS FOR BIRD ELECTROCUTIONS

As is the case with collisions, electrocution is a well-documented cause of mortality in wild birds. Electrocutions have impacted bird populations nearly anywhere where electricity is distributed via overhead power lines and is a significant cause of bird mortality.[36] Bird electrocutions occur when the air gap between two energized components, is physically breached by a bird, leading to a short-circuit. Mitigation measures are thus aimed at reducing the probability of a breakdown in the air gap by either (1) modifying the pole to increase the distance between live phases,[37] (2) retrofitting energized components with various types of insulating covers,[38] (3) installing perch deterrents over critical components[39], or (4) by providing more attractive, supplementary perches or nesting platforms.[40] A combination of two or more of these mitigation measures is often used to improve bird protection.

For most species, sufficiently increasing the distance between live phases may be effective, as the probability of electrocution could become virtually zero. Such modified poles are sometimes known as 'bird friendly' structures, and design standards have been modeled around achieving this ideal.

Electrocutions do not only impact birds but also a great variety of mammal and reptile species. In some cases, even terrestrial mammals may be impacted when power poles are felled, causing conductors to break or sag. However, electrocutions more commonly affect those species able to access electrical hardware at the top of power poles, transformers, or switchgear, where clearances are insufficient, or components are not adequately covered and/or insulated. The length of separation between phases influences the electrocution risk of a particular structure. Larger birds may, in some instances, be particularly prone to phase-to-phase electrocutions, where their wingspan is greater than the horizontal separation between phases. Here only the conductive parts of the animal are considered - the wingtips of a bird are less conductive than its fleshy parts. There are several options for reducing the threat of electrocution.

6.2.1 CHANGING OR REPLACING EXISTING ELECTRICAL COMPONENTS WITH SAFER DESIGNS

Wildlife 'friendly' power structures maximize the separation between phases and earthed components. For horizontally configured phase designs (e.g., a distribution T-pole), suspending the outer phases below the cross-arm of a power pole greatly improves phase-to-phase separation.

For vertical configurations, the vertical separation between phases should be increased to safe levels. Utilities can use angled beams or brackets to make it difficult for birds to perch near energized or earthed components comfortably, thereby discouraging their use of the pole/tower. However, caution should be taken when using these, as they may also provide an angle where nests can be built next to the main pole.

Bird friendly structure.
Photo credit: Constant Hoogstad

6.2.2 RETROFITTING EXISTING ELECTRICAL COMPONENTS

Changing a dangerous power pole to a configuration that adequately increases phase-to-phase or phase-to-earth clearances is preferred over retrofitting the structure, as these devices may perish and fail over time and may not be very effective when installed incorrectly. However, various devices are available for retrofitting a power pole when replacing a structure is not feasible or when a temporary solution is needed to mitigate against electrocution until the pole structure can be changed. These devices include insulating covers for phase conductors, transformers, jumper cables, switchgear, and other electrical components.

These covers must comply with the utility's minimum standards and should also be guided by international guidelines such as Suggested Practices for Avian Protection on Power Lines (2006) produced by The Avian Power Line Interaction Committee (APLIC).[41] Retrofitting devices should have sufficient isolation and insulation properties, where isolation refers to the device's ability to provide adequate (phase-to-phase or phase-to-earth) separation for the wildlife species in the area, and insulation refers to the device's ability to prevent contact with grounded and energized components.

Retrofitting devices should also comply with minimum manufacturing standards regarding materials used and their compatibility with the environmental conditions prevalent at the location of the incident(s). For example, plastic polymers used in retrofitting devices will be exposed to some level of ultraviolet radiation, the intensity of which depends on different stratospheric ozone levels, cloud cover, and altitude. Degradation can occur when the materials used are insufficiently modified to improve their resistance to ultraviolet rays. This may cause the plastic to become brittle in the sun and ultimately fail.

Retrofitting devices should also consider other aspects of the environment in which they will be installed. For example, conductor covers should be designed so that water cannot collect inside, and they should not create safe, dry spaces that may encourage smaller creatures to roost, nest, or colonize them.

Selecting products that are designed to be fitted from ground level using a hot stick represents a significant cost saving opportunity to utilities, as specialized vehicles, additional live line resources, or outages will not be required.

6.2.3 SUPPLEMENTAL PERCHES

Supplemental perches can be used to lure birds away from parts of a tower or pole where phase-to-phase electrocutions are likely, or where their presence introduces a risk of an air gap breakdown.

This strategy has been used to some effect throughout the world, especially for birds of prey, although their efficacy can differ significantly between species. Supplemental perches should be used in the appropriate situations, e.g., they will not prevent birds nesting on towers but could prevent electrocutions of perch-hunting birds that use them as vantage points.

A White-breasted Cormorant nesting on a transmission structure.
Note the supplemental perch installed nearby. Photo credit: Matt Pretorius

6.3 MEASURES FOR REDUCING BIRD-RELATED FAULTS

While bird electrocution is an example of a more obvious interaction, some bird-related faults are more cryptic, and solving these problems may require a certain level of expertise and local knowledge. Thankfully, many of these problems have been experienced in other parts of the world and solutions are available. Some of these options are discussed below.

6.3.1 STREAMERS: PERCH DETERRENTS AND INSULATOR COVERS

Bird-related faults on transmission lines can be classified into three categories: streamer-, pollution-, and nest-related faults. Bird streamers are known to be responsible for more than half of all faults reported from transmission grids in South Africa, and affect both High Voltage Alternating Current (HVAC) lines and High Voltage Direct Current (HVDC) lines.[42] In South Africa, line faults cost Eskom an estimated $1,6 million per annum.

PERCH DETERRENTS

Perch deterrents, such as 'bird guards', prevent birds from perching over critical components such as insulator strings and are, to some extent, successful when implemented correctly. Some utilities have reported a reduction in bird-related faults where these perch deterrents have been installed because they prevent birds from creating streamers that cause a breakdown of the air gap. Again, the effectiveness of perch deterrents is likely to be species-specific. Certain birds find a perch foothold despite the presence of bird guards, while others benefit from additional support for their nests. Other birds (e.g., large herons) may even be able to perch over the bird guard spikes, where these spikes are shorter than their long legs.

Bird guards made from plastic may easy bend and larger birds can manipulate them to their advantage. However, many products are available in more rigid non-conductive materials. No perch deterrent caters equally well for all species, and utilities must first identify the culprit species in a specific area before deciding on the perch deterrent to use.

Wire bird guards (left) and raptor guards (right). Photo credits: Constant Hoogstad

INSULATOR CAPS AND COVERS

Some caps and covers are specifically designed to reduce bird pollution on high-voltage insulator strings. These can clip onto the top of the insulator string and essentially act as a roof that prevents streamers from reaching the insulators. They work best on I-string insulators as V-string insulators create an angle that prevents coverage of the area in which the insulators are attached to the conductor. In South Africa, Eskom is currently researching the use of an angled roof that can cover the entire air gap on most high-voltage towers. This product is still in development, and utilities must ward against creating dry, safe spaces that birds could end up favoring as nest sites.

6.3.2 NESTS: MANAGEMENT OF NESTS

A variety of bird species nest on power line structures, and the impact of these on the quality of electricity supply is dependent on various factors, such as the nest material used, the amount of pollution resulting from the nesting attempt, and perhaps most importantly, the position of the nest on the tower/pole. Nests built directly above any of the live phases are problematic, as an excessive accumulation of pollution (feces) coating the insulators may result from nesting activity. The nesting material (e.g., branches or fencing wire) may also cause a breakdown of the air gap, as described in Chapter 3.

A Cape Crow nesting on a A-frame structure. Photo credit: Matt Pretorius

Utilities must consider the following factors to mitigate nesting impacts:

- The species of bird
- The nature and severity of the impact on infrastructure and supply
- The national and local legislative conditions around the disturbance (including maintenance activities nearby), alteration, or movement of nests. This is particularly important for threatened species, and conditions may depend on the time of year and the breeding habits of nesting birds
- The likely cause of the bird selecting to nest on electrical infrastructures, such as a lack of natural nesting structures in open habitats

Nest management strategies may include one or a combination of the following measures:

NEST REMOVAL

Due to increased pollution and the risk of flashovers from conductive materials, the removal of bird nests may be necessary where they have been constructed on or above critical components of power pole/tower structures. The removal of bird nests from structures should be guided by the internal best practice guidelines for each power utility and general guidelines recommended in documents such as those by the Avian Power Line Interaction Committee (APLIC) (2006). These suggest that active bird nests should not be removed unless the species involved have been positively identified and the utility has the necessary permits to do so.

Some species may not be specifically protected by law to the same extent as other species (e.g., raptors), and the nests of these species may be removed without a permit, should the law provide for this. However, removal is not recommended for active nests without confirmation of the species by an ornithologist, as some protected species may use the nests of other unprotected species.

MOVING A NEST TO A MORE FAVORABLE LOCATION ON THE STRUCTURE

When nest removal is not possible and not recommended due to the species involved, a nest may be moved to another, more favorable location on a pole or tower. As suggested above, is it not recommended that this be done when a nest is still active, as birds are known to abandon their brood in the event of such significant disturbance.

NEST BOXES, PLATFORMS, OR BASKETS

There is often a lack of sufficient support structure when moving a nest to a different location on a power pole or tower. Birds tend to choose the safest and most stable platforms to build their nests, which is often only afforded at the top of a power pole or tower. Nest boxes, platforms, or baskets may be used to facilitate moving a nest to a different location.[43] There are many examples of these; however, a species-specific solution may be necessary to accommodate the specific nest size and the material used to construct the nest. This is particularly relevant when considering the mesh size for nest platforms and baskets – a large mesh size would not support a nest constructed from grass and thin twigs well, but it would be sufficient for the larger branches of an eagle's nest. Nest boxes, platforms, and baskets should be positioned far enough off the ground to avoid easy access for terrestrial predators while remaining below critical components such as the conductors and insulators. Nest boxes should also be positioned to allow live-line worker access to the top of the pole/towers. Nest platforms are readily accepted by weaver species, such as the Red-billed Buffalo Weaver and Sociable Weaver.

Red-billed Buffalo Weaver nesting on a structure close to critical hardware (top left) and on a nesting platform (top right). Photo credit: Werner Sieburg.
Cape Crow nest on an A-frame strain structure (bottom). Photo credit: Matt Pretorius.

NEST DETERRENT DEVICES

A nest deterrent is a device intended to prevent birds from building or rebuilding a nest on critical positions of a pole/tower, such as directly above a conductor insulator or insulator string. There are examples of nest deterrent devices that should be used in combination with nest removal or relocation of nests to a nest box/platform in a more favorable location on the structure. Specific devices are not appropriate for all structure designs, nor all bird species; thus, tailor-made solutions may be necessary. Crow nests, for example, are not effectively managed with bird deterrents unless installed correctly.

PROVISION OF ALTERNATIVE NEST STRUCTURES

When a nest must be completely removed from a power pole or tower, but the species involved is of conservation priority, then an alternative structure may be erected to hold the nest. These 'dummy' poles have been used for large weaver nests, and, in some cases, raptors have adopted alternative structures provided to them. Again, it is important not to remove or move the nest when it is still active, as there may be species-specific considerations in terms of the suitability of this option.

NEST MANAGEMENT IN SUBSTATIONS

Bird nests in substations pose significant challenges for utilities, as they lead to pollution and may attract animals that feed on the birds, such as snakes, monkeys, and small mesopredators (e.g., feral cats and genets). These events result in costly outages and financial losses to the utility, and so, in most cases, it is advisable to remove bird nests from substations. There are, however, also a variety of nest and perch deterrents designed specifically for substation hardware, and these should also be used as preventative measures.

Photo credit: Shutterstock

6.4. REACTIVE MITIGATION MEASURES AGAINST MAMMAL IMPACTS

The previous chapters identified interactions between large mammals and electrical infrastructure and their impacts on power utilities. These impacts are often very costly and may result in secondary impacts such as electrocution by low-hanging conductors.

6.4.1 REDUCING DAMAGE CAUSED TO WOODEN POLES BY LARGE MAMMALS

The most common impacts include damages to the (usually wooden) power poles of low and medium voltage distribution lines caused by large mammals such as Cape Buffalo (*Syncerus caffer*), African Elephant (*Loxodonta africana*), White Rhino (*Ceratotherium simum*), and Black Rhino (*Diceros bicornis*) when rubbing against the base of the pole. One previous study tested different mitigation measures to prevent large mammals from rubbing directly against wooden power poles in the KNP. Of the different coverings tested, a 'grating box' was the most cost-effective and successful option. A brief summary of the different products tested during the research can be seen below. Utilities should note that pole coverings may create favorable habitats for insects such as termites, which may ultimately speed up the deterioration of the base of a pole.

In some cases, African Elephants will push or lean against wooden poles, causing them to tilt or break completely. Once the pole is compromised in this way, the conductor hangs low to the ground, often leading to secondary electrocutions of ungulates, lions, hyenas or other elephants. This behavior leads to an immediate impact and differs from pole rubbing, an impact which occurs over time. The best way to prevent elephants from impacting infrastructure in this manner is to upgrade the poles to larger more robust structures, using materials such as concrete or steel. However, site specific interventions can be implemented, as can be seen in case study 1 in Chapter 7.

Photo credit: Constant Hoogstad

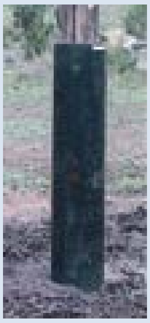
Product	Advantages	Disadvantages	Recommendations	Prevents contact with
Steel pole clamp 	• Cheapest • Lasts > three years • Easy to transport • Easy to install	• Elephants affect the area above the product • Difficult to inspect the pole	• Use in low impact areas	• Buffalo • Rhino
Polefix Industrial Cast 	• Easy to apply • Cheap • Lasts > two years • Easy to transport • Easy to install	• Does not decrease the number of animals that visit the poles • Elephants affect the area above the product • Will need to check product regularly • Will need to reapply product when worn down	• Use in areas with high risk of termite infestations after removal of creosote • Use in areas with rhino and buffalo damage but regular checks are required	• Termites • Rhino
Grating Box 	• Prevented direct contact with poles by buffalo and rhino • Grating allows easy inspection of the pole • Lasts > three years • Easy to transport • Easy to install	• Elephants could potentially affect the area above the product	• Use in areas with high buffalo impact	• Buffalo • Rhino
VB Rhino 	• Prevented all animal contact • Will last in the long term	• Most expensive • Aesthetically unpleasing • Intensive set-up required • Difficult to inspect the pole • Difficult to transport • Difficult to install • Requires crane and heavy truck	• Use in areas with high elephant impact	• Buffalo • Elephant • Rhino

Figure 6: A brief comparison of the four mitigation products used to decrease the impacts on wooden distribution poles from large mammals.[4]

COLLISION AND BREAKAGE OF CONDUCTOR CABLES

Some large mammals, such as giraffes, are tall enough to collide with the conductor cables of low voltage distribution lines. When colliding with live power lines, giraffes usually get electrocuted. They may also break conductor cables in the process, which present a significant threat to other animals such as scavengers coming to the carcass. Power utilities should maintain minimum above-ground conductor clearances and ensure that the appropriate minimum standards, written in their technical and engineering instructions, are implemented accordingly (See Chapter 3). These above-ground clearances should be greater than six meters, as tall giraffe bulls can reach a height exceeding five meters.

INDIRECT IMPACTS

Large mammals, particularly elephants, may indirectly impact power lines by pushing trees down onto the conductor cables or the power poles themselves. Utilities should give due consideration to this in their vegetation management standards where elephants are present, although threatened or protected tree species should not be removed or moved unless necessary. Instead, correct power line routing should avoid areas occupied by protected tree species.

6.5 REACTIVE MITIGATION MEASURES FOR SMALL MAMMALS

Climbing mammals pose a significant risk to infrastructure as they readily make contact with multiple phases simultaneously when climbing a pole or transformer. Pole-top transformers and distribution pole tops may be preferred vantage points or roosting opportunities, and many arboreal mammal species can easily climb these poles and contact live phases. Utilities can do very little to prevent these incidents in terms of structural design as distribution poles, specifically, strain or turn structures, and transformers inherently have minimal clearance, between phases and earthed components. Larger climbing mammals, such as baboons and monkeys, have an extensive reach, and some species have prehensile tails, exacerbating the problem.

The most effective reactive mitigation would be to insulate exposed jumpers, bushings and cutout fuses where climbing mammals cause line faults. Several products are available for this purpose, many of which can be cut to length and ordered to accommodate various conductor sizes. Examples of these can be seen at www.powerlinesentry.com/.

Aside from this direct intervention, utilities can minimize climbing mammal interactions immediately by:

- Clearing vegetation around poles and terminating structures, which prevents animals from climbing onto the structure from branches.
- Moving waste areas, food storage areas, and other potential attractants away from infrastructure as mammals may prefer a height advantage when approaching these areas and use the structures as perches or lookout points.
- Completely protect access to high-risk areas, such as substations, through adequate electric fencing.
- Maintain vegetation around these fenced areas to restrict access.

In summary, there are many ways in which wildlife can negatively interact with electrical infrastructure, and many ways to reduce the severity or prevent these. Incidents can vary greatly depending on the infrastructure, biodiversity, and topography in the region and some products offered by suppliers may be more appropriate as a result. Utilities are encouraged to keep a record of incidents and develop a thorough understanding of what is applicable to their operations to ensure that measures taken to reduce impacts on infrastructure and wildlife are tailor-made. Chapter 7 contains a number of case studies from South Africa, where unique incidents were documented and resolved by the Eskom/EWT Strategic Partnership.

Photo credit: Shutterstock

Photo credit: Shutterstock

07 CASE STUDIES

7.1 INTRODUCTION

The EWT-WEP was formed in 1994, and in 1996 a formal strategic partnership was established between the EWT and Eskom, the state-owned utility in South Africa. Initially, the partnership focused on endangered birds killed through interactions with power lines, notably vultures electrocuted on reticulation structures in South Africa's North West Province. Over the years, the EWT-WEP has expanded the partnership to work across seven of Eskom's business divisions, addressing numerous issues around biodiversity-related impacts. Investigations and recommendations by the EWT-WEP have not been limited to South Africa but have also included the United States of America, Australia, Botswana, Lesotho, Namibia, United Arab Emirates, Hungary, Poland, and Jordan.

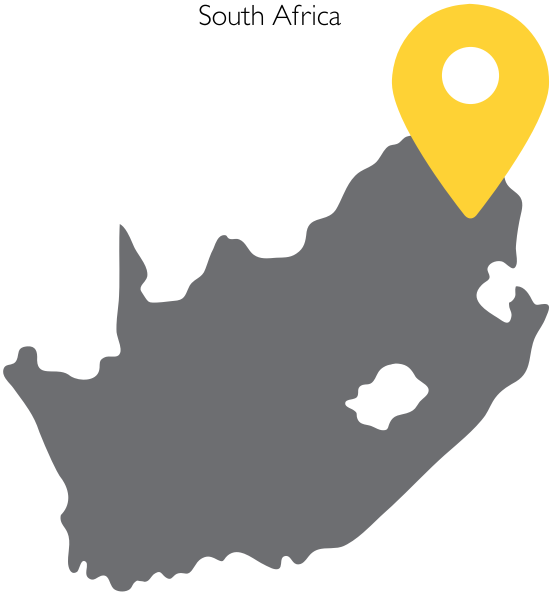
Due to the varying nature of incidents, the partnership does not treat all incidents equally, and some warrant a more detailed or "special investigation". These special investigations are documented in the form of special investigation reports and sometimes lead to the launch of research projects. These projects and reports enable the partnership to maintain a comprehensive record of these unique incidents. Additionally, the information is disseminated globally so that utilities across the world can avoid similar incidents and improve network performance while reducing their impact on biodiversity. This approach also prevents duplication and "reinventing the wheel" for incidents of a similar nature that might occur elsewhere and leaves a lasting legacy for future reference.

This chapter contains a selection of the cases that have stood out and contributed to over 30 years of institutional knowledge and experience. The South African partnership has fundamentally changed how energy utilities approach their impacts on biodiversity and has turned every incident into a learning opportunity.

Photo credit: John Smallie

7.2 CASE STUDY 1: AFRICAN ELEPHANT ELECTROCUTED IN KRUGER NATIONAL PARK

Place
Punda Maria, Kruger National Park, South Africa



Date

Interaction
Electrocution

Species
African Elephant

Class
Mammalia

Photo credit: Constant Hoogstad

Type of infrastructure
Distribution power line, T-pole

Background

The EWT-WEP conducted a special investigation into the electrocution of two elephants on the MMI – Mala Mulele Technical Service Centre (TSC) distribution line in Punda Maria, Kruger National Park, Limpopo Province, South Africa.

Incident reports

June 2011

Two elephant carcasses were discovered by Eskom personnel during an investigation into a flash report received from the local TSC.

Elephant remains after they were electrocuted. Photo credit: Constant Hoogstad

Biological and ecological risk factors

The African Elephant is the largest living land mammal, consuming an average of 5% of its body weight and drinking 30 to 50 gallons of water per day. They eat an extremely varied vegetarian diet, including grass, leaves, twigs, bark, fruit, and seed pods. It is difficult for elephants to live outside protected parks as they are pressured by poachers and habitat loss resulting from increasing human settlement.

Due to their shoulder height, elephants often get electrocuted when they come into contact with low hanging conductors. They are also known to rub or push against wooden electricity poles, causing significant damage to infrastructure.

Investigation and findings

11 June 2011

A field investigation was conducted by EWT and Eskom.

"After consulting with the Eskom employee and SANParks field staff, it was noted that the electricity pole located at the top of the hill was tilted, causing the conductors to sag to a height of 3.8 meters. In addition, the terrain where the pole was located is very rocky and unstable. Elephants have been known to rub and push against Eskom electricity poles, potentially contributing to the tilting of the pole. Two flash marks were also clearly visible on the conductors, indicating where these elephants came into contact with the conductors." (EWT report).

One of the flash marks on the conductor.
Photo credit: Constant Hoogstad

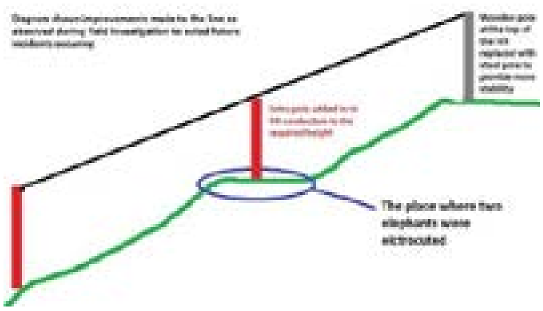


Diagram indicating improvements made to stop incidents from reoccurring at this site.

A pole demonstrating the height of the conductor where the elephants were electrocuted.
Photo credit: Constant Hoogstad.

Recommendations

It was recommended that a steel pole be installed at the top of the hill for improved stability. An additional pole should be added mid-span, where the electrocution occurred, to increase the conductor height and prevent incidents such as this from reoccurring.

Additional information

Age: The age of an elephant can be determined by looking at its molars (teeth). Judging by the evidence seen at the site, these elephants were not very old.

The molars of elephant 2. Note some flesh remains still on the skull.
Photo credit: Constant Hoogstad

The molars of elephant 1. Still deemed to be in good condition and of reasonable age.
Photo credit: Constant Hoogstad

- Poaching: The tusks of the elephants were intact and removed by SANParks officials when the carcasses were discovered. This was not a poaching incident.
- Other natural causes: Although lightning would be a possible cause of death for a large animal in an elevated location, it is unlikely that two elephants would be struck on the same spot at different times.
- Fighting: The carcasses vary too much in age for this to be considered as a cause of death.
- Electrocution: The evidence and information collected strongly suggest that these two elephants were electrocuted by the Eskom power line.

Example of installation.
Photo credit: Constant Hoogstad

Elephant with power lines in the background.
Photo credit: Constant Hoogstad

References and resources

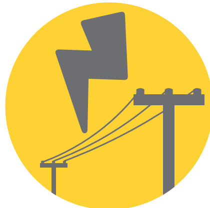
EWT Special investigation report: Elephant fatalities - Punda Maria, Kruger National Park.

7.3 CASE STUDY 2: PYTHON ELECTROCUTED AT TABOR SUBSTATION

Place
Tabor Substation, South Africa

Date

Interaction
Electrocution



Species
Python

Class
Reptilia

Photo credit: Eskom

Type of infrastructure
Substation

Background

The substation is located within a protected area in Limpopo Province, South Africa and surrounded by savanna bushveld. This area provides ideal habitat for snakes and many southern African snake species occur in this area.

Incident reports

A python was electrocuted on the Tabor-Flurian 132 kV breaker.

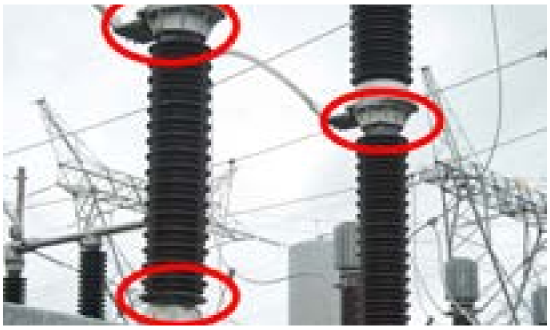
Biological and ecological risk factors

Pythons are large snakes (average length is 4 m) able to bridge multiple phases on substation components.

African Rock Python electrocuted in a substation. Photo credit: Eskom

Investigation and findings

A field investigation was conducted on 10 February 2011 by the EWT. During the site visit, two live snakes were observed within the substation footprint (python and boomslang), which indicates that snakes move freely through the perimeter fence of the substation. Snakes are attracted to the area because it is safe and there is ample food in the form of rodents, small mammals, and several bird species nesting in the substation.



Flash marks shown on hardware inside the substation where the python was electrocuted. Photo credit: Eskom

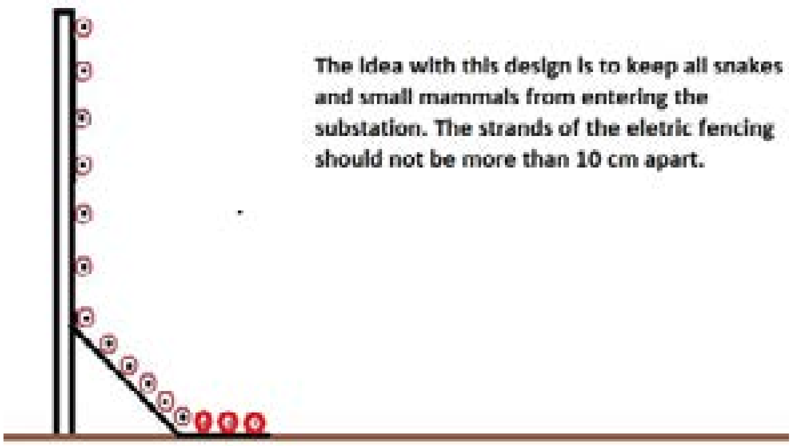
Recommendations

Pythons are protected species, and special care must be taken to avoid such incidents. The African Rock Python is listed as a CITES Appendix II species, Schedule 3 Protected Wild Animal, Protected in TOPS. This particular python measured at 2.42 m and would have been a breeding adult.

1. It is recommended that the perimeter fencing of the Tabor substation be improved/upgraded. Below is a suggestion for improving the fencing. This design may also help keep other damage-causing animals such as genets and Vervet Monkeys out of the substation.
2. In addition to this, all existing gaps in the fencing and structure should be filled to prevent snakes from entering.
3. Another option to reduce the risk of electrical faulting would be to add 3M Animal Guards on all the bushings inside the substation.
4. It is further recommended that a thorough research project is launched into the mitigation methods specific to snakes in this substation.
5. Bird nests should be removed from substation components regularly, as this is a major attractant for snakes.

References and resources

EWT Special investigation report: Python electrocution; Tabor substation



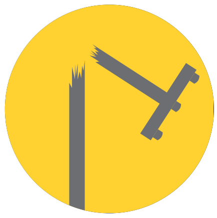
The suggested upgrade for the TABOR perimeter electric fencing.

7.4 CASE STUDY 3: PORCUPINES BURROWING UNDER A TRANSMISSION TOWER FOUNDATION

Place
Matla/Benburg
Transmission line

Date

Interaction
Damage to poles



Species
Porcupine

Class
Mammalia

Photo credit: Constant Hoogstad

Type of infrastructure
Transmission tower

Background

African Porcupines are the largest rodents in the region. Females are, on average, about one kilogram heavier than males and both sexes are more than half a meter long. They also have long life spans, surviving 12 to 15 years in the wild. These porcupines are covered with flat, bristly hairs and have quills and spines on the posterior back and flanks.

African Porcupines are mostly herbivorous, using their strong digging claws to get access to roots, tubers, and bulbs. They are also fond of fallen fruits and sometimes gnaw on the bark of trees.

Their anterior large intestine and enlarged appendix contain microorganisms that break down undigested plant fibers. They have also been reported to eat carrion in some instances. In areas deficient in phosphorous, they practice osteophagia (gnawing on bones) and often accumulate large piles of bones in their dens. These porcupines are found from sea level to 2,000 m above sea level in most areas with vegetation. They prefer rocky hills and outcrops, as they require shelter during the day.

Incidents reported

Porcupines were burrowing under a transmission tower in December 2010.

Biological and ecological risk factors

Porcupines den and have offspring between October and March. The incident was reported during the denning season. Porcupines build dens up to 20 m long with a 2 m deep living chamber.

Investigation and findings

Porcupines were burrowing at the base of the transmission towers along the Matla/Benburg line. According to Eskom engineers, these towers became unstable and were at risk of collapse during strong winds. A road was located in the vicinity of Tower 179 (the tower where the porcupines were burrowing), presenting a significant safety risk to any person using this road should the tower collapse.

Porcupines burrowed at the base of the transmission towers along the Matla/Benburg line. Photo credit: Constant Hoogstad

Recommendations

Option 1: Catch and relocate porcupines from the hole

- The process can be very time consuming
- Porcupines should be relocated as far as possible from the den site
- Free Me (Wildlife Rehabilitation Centre) can be contacted to capture the porcupines.

Option 2: Excavate the area and manually remove the porcupines.

- Very labor-intensive
- Very costly
- High risk of the animals being injured
- The stability of the tower could be compromised.

Additional information

Option 2 was not considered due to the likely presence of porcupines

References and resources

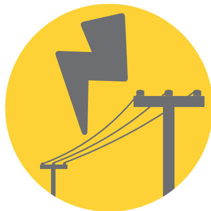
EWT Special investigation report: Matla/Benburg line Tower 179

7.5 CASE STUDY 4: SOUTHERN GROUND HORNBILL ELECTROCUTED IN MABULA GAME RESERVE

Place
Raasblaar, Mabula Game Reserve

Date

Interaction
Electrocution



Species
Southern Ground Hornbill

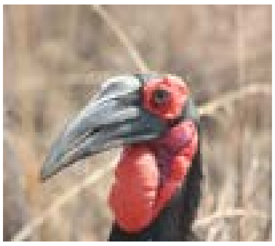


Photo credit: Constant Hoogstad

Class
Aves

Type of infrastructure
Distribution

Background

The project at Mabula plays a vital role in the survival and the re-wilding project for the Southern Ground Hornbill. The project was started in 1999 when three 'redundant' chicks from the KNP were brought to Mabula to be raised and released back into the wild. The last decade was spent learning how to hand-rear a very sensitive bird species, release them successfully, and trial several other conservation interventions such as nest box provision. A Population and Habitat Viability Assessment (PHVA) conducted in 2008 found that, in areas outside of formal protection, these birds would be extinct in 50 years. The first sign of success was when the birds at Mabula (both hand-reared and rehab birds) bred successfully in the wild.

Incidents reported

A Southern Ground Hornbill was electrocuted close to a transformer on the Raasblaar property inside Mabula Game Reserve. The EWT, the Ground Hornbill Research & Conservation Project, and Eskom investigated the incident on 23 August 2011.

Biological and ecological risk factors

Due to the nature of the project, the Southern Ground Hornbills are in regular close contact with humans and move around areas frequented by humans more often than wild birds, increasing the risk of them coming into contact with electrical infrastructure.

Investigation and findings

During the field investigation, it was evident that the risk to the hornbills from electrical infrastructure was significant. Hornbills are known to roost on transformers, and as such, the jumpers on the transformers in the area had previously been insulated, but this was not sufficient to prevent electrocution.

Transformer box (left) with exposed jumpers where Ground Hornbill was electrocuted (right). Photo credit: Constant Hoogstad (left) and Lucy Kemp and Mabula Ground Hornbill project (right)

A post-mortem was done to verify that electrocution was the cause of death. Blood samples were taken for biochemistry and showed a severe increase in gamma glutamate 589 U/l (the normal range in a hornbill is 13–21 U/l) and lactate dehydrogenase 5,083 U/l (400¬–1,800 U/l), indicating liver damage, most likely from electrocution.

Southern Ground Hornbill. Photo credit: Constant Hoogstad

Southern Ground Hornbill with power lines. Photo credit: Constant Hoogstad

Recommendations

It was recommended that a full assessment of infrastructure in the area be completed to determine the following:

1. Network of electrical infrastructure
2. The number of transformers in the area
3. The different designs of structures located in the area and whether they are bird-friendly or not
4. Structural changes and possible mitigation solutions to avoid future electrocutions around the transformers as the current measures are not effective

References and resources

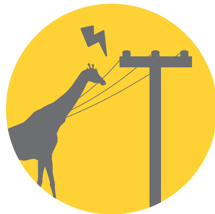
Southern Ground Hornbill Electrocution Report: Mabula Game Reserve

7.6 CASE STUDY 5: SOUTHERN GIRAFFE ELECTROCUTED IN MARLOTH PARK

Place
Marloth Park, Mpumalanga Province, South Africa

Date

Interaction
Electrocution



Species
Southern Giraffe

Class
Mammalia

Photo credit: Constant Hoogstad

Type of infrastructure
Distribution

Background

The demand for electricity within Marloth Park has grown significantly, and to meet this demand, Eskom installed additional transformers on the property that were not positioned at the appropriate height to accommodate the resident giraffes. This increased the likelihood of possible negative interactions and caused the electrocution of four giraffes.

Incidents reported

In June 2011, the EWT received a report of giraffe electrocution in Marloth Park, a property that borders KNP in the Mpumalanga Province

Biological and ecological risk factors

The tallest giraffe on record measured 5.88 m (Shortridge 1934, Kenya), but the average height is between 4.8 m for males and 4.1 m for females. As the height of giraffes may vary, aspects such as topography, structure type, and conductor height must be taken into account during the design of infrastructure.

Transformer in Marloth Park. Photo credit: Marloth Park

Investigation and findings

The EWT investigated the incident. It was found that several transformers posed a threat to the resident giraffes, as they were located too low on the electricity poles. Some of the transformers were as low as 3.6 m from the ground.

Electrocuted giraffes. Photo credit: Marloth Park

Recommendations

A minimum height of at least 6.5 m is recommended for all electrical infrastructure in areas where giraffes occur. All live components (including transformers) should also be positioned above the recommended height.

References and resources

EWT Special investigation report: Giraffe electrocutions in Marloth Park

Transformers at Marloth Park (left & right). Photo credit: Constant Hoogstad

7.7 CASE STUDY 6: SOCIABLE WEAVER NESTING ON POWER POLES

Place
Northern Cape Province, South Africa

Date

Interaction
Nesting on power poles

Species
Sociable Weaver

Class
Aves

Type of infrastructure
Distribution power poles and transmission towers

Photo credit: Matt Pretorius

Background

Sociable Weavers are known to nest in colonies on electrical infrastructure. Lattice towers and wooden electricity poles offer excellent nesting opportunities in landscapes where large trees are scarce. In addition, these structures are preferred to natural trees as they provide a safer nesting platform that is difficult for predators such as snakes to access.

Incidents reported

Multiple locations on transmission and distribution infrastructure

Biological and ecological risk factors

Sociable Weavers build the largest nests of any bird, accommodating over 100 breeding pairs. The nests can weigh up to 1 ton and reach 7 m in diameter, posing a significant risk to electrical infrastructure. Nests can also become conductive in the rainy season, causing outages. When these faults occur, there is a risk of infrastructure damage and bush fires.

Investigation and findings

Even though maintenance staff regularly remove nests from infrastructure, the weavers quickly rebuild on the same structure. Aside from causing faults and fires, a nest located at the top of wooden poles can result in complete pole failure.

Recommendations

Option 1: Relocating the nest

Place 1 m long droppers horizontally across the pole at least 3 m below the cross arm, and relocate the nest to this position.

1. The droppers proved to be the cheapest effective mitigation tool.
2. Brackets are also effective but more time consuming to install

Option 2: Insulation
When birds nest on cross arms and cause phase to phase/earth faults, insulation of live components has proved to be successful. Insulation eliminates flashovers, prevents nests from catching alight, cross arms from burning, and bush fires from starting. However, this will not prevent wooden poles from breaking under the weight of the nest, and ongoing maintenance in the form of nest removals will be required..

References and resources

EWT Central Incident Register

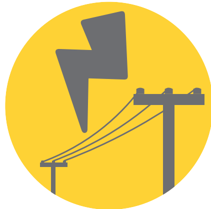
Sociable Weaver nest in Pofadder. Photo credit: Matt Pretorius

7.8 CASE STUDY 7: LARGE MAMMALS RUBBING AGAINST POLES IN KRUGER NATIONAL PARK

Place
Kruger National Park, South Africa

Date

Interaction
Electrocution



Species
Large Mammals

Class
Mammalia

Photo credit: Constant Hoogstad

Type of infrastructure
Distribution

Background

Large mammals such as buffalo, rhino, and elephants readily use wooden electricity poles as rubbing posts in protected areas. Once animals start targeting a pole as a rubbing post, it is almost certain that it will eventually be damaged and require replacement. This has various consequences, including a supply interruption for the utility. Infrastructure within protected areas often stretches over long distances, which means that locating and repairing faults are costly and time-consuming. In some cases, poles need to be replaced at six-month intervals, resulting in increased maintenance costs.

Incidents reported

Mammal electrocutions

Biological and ecological risk factors

Large mammals interact with wooden electricity poles for several reasons:

- Territorial marking (Rhino)
- Behavioral displays (Rhino, buffalo, elephant)
- Rubbing posts (Rhino, buffalo, elephant)

Investigation and findings

Eskom Distribution - Northern Region contacted the Eskom-EWT Strategic Partnership to conduct a special investigation in KNP.

Initial observations indicated that the damage caused to poles was through the rubbing behavior of rhino. It was later discovered that elephants and buffalo also use these poles as rubbing posts and affect different areas of the pole due to their different shoulder heights. Elephants are the tallest, impacting the area between 2 and 4 m, rhino between 1.5 and 1.9 m, and buffalo between 1.3 and 1.5 m. In addition to this, a wildebeest male was observed in the northern region of Kruger rubbing his horns at the base of one of the poles. Warthogs also damage the poles, although this is minimal as they only use the bottom 1 m as a rubbing post.

These interactions all contribute to poles becoming unstable/breaking, which can cause conductors to sag to the ground, posing an electrocution risk to any animals in the vicinity of the line.

Rhino Impact: The initial impact on the poles is caused by male rhino rubbing their horns against the pole, which roughens the surface and makes it an attractive rubbing post for other rhino and buffalo. Rhino bulls also use rubbing posts as territorial markers and often have middens located in close proximity, attracting other rhino.

Buffalo Impact: Buffalo also use the poles as rubbing posts and were observed rubbing their horns and bodies against the poles during the field investigation. It was observed that poles are mostly damaged at approximately 1.4 m from the ground, which is the average shoulder height of a buffalo, suggesting that they contribute significantly to the problem.

Elephant Impact: Elephants seem to use the poles as rubbing posts around waterholes. Evidence of rubbing was found between 2.2 and 3.2 m, which could only be caused by an elephant. Although they only appear to use the poles for rubbing very occasionally, the sheer size and weight of the animal could result in an immediate impact. If there is significant damage lower down on a pole, elephants applying their weight to the top section of the pole often causes the pole to break, fall over, and conductors to sag to a dangerous height for all animals.

Termite impact: When planted, the poles are treated with creosote to protect them from the weather and invasions from termites and other insects. By exposing the surface of the pole through rubbing, the creosote is removed, allowing termites to enter. Once termites have invaded a pole, the pole becomes weak and prone to failure.

Recommendations

Several solutions to this problem were tested in the KNP. Different animals impact poles differently and different products are more suited to different circumstances. The advantages, disadvantages, and recommendations for optimal use of the products are summarized on pg. 87.

References and resources

Page-Nicholson, et al. 2018. Mitigating the impact of large mammals on wooden electrical distribution poles in the Kruger National Park, South Africa. African Journal of Wildlife Research 48(2).

Various examples of wooden pole damage. Photo credits: Constant Hoogstad

7.9 CASE STUDY 8: AFRICAN CROWNED EAGLE PERCHED ON A POLE TOP

Place
Estcourt, KwaZulu Natal Province, South Africa

Date

Interaction
Perch

Species
African Crowned Eagle

Class
Aves

Photo credit: Geoff Lockwood

Type of infrastructure
Distribution

Background

The African Crowned Eagle is a large forest-dwelling eagle inhabiting dense woodland, riparian forest, and gum and pine plantations. The eagle will lay two eggs in a large nest, but the first chick to hatch will inevitably kill the second one, a phenomenon known as siblicide. The chick remains with the parents until the following breeding season, which may be up to two years. Reductions in the population size due to habitat destruction associated with commercial plantations and persecution (poisoning) by stock farmers have led to its Red List classification of 'Near Threatened'.

Incidents reported

In June 2009, the Ezemvelo KZN Wildlife (EKZN) contacted the Eskom-EWT Strategic Partnership regarding a pair of African Crowned Eagles and their newly fledged juvenile in the Estcourt area. The juvenile was using an Eskom pole-mounted transformer to practice its flying skills. Juvenile birds are notoriously clumsy when learning to fly, and there was a high likelihood of the bird coming into contact with the exposed jumper cables of the box transformer and the overhead conductor wires.

Biological and ecological risk factors

Crowned Eagles have a wingspan of up to 1.8 m, larger than the phase clearance on terminating structures.

Investigation and findings

The landowner reported that the juvenile that had fledged the year before had been electrocuted on the very same structure. It was observed that the electrocution risk was still present, and quick action was required to prevent a repeat incident.

Recommendations

It was recommended that the exposed phases and bushings on the terminating structure be insulated with approved insulation material.

Additional information

Shortly after the investigation, Eskom field services staff installed the necessary insulation material on the structure, mitigating the electrocution risk.

References and resources

Lessons Learnt Nov 2009 Issue 7 African Crowned Eagle KZN.

Insulated box transformer. Photo credit: Marianne Golding

08 CONCLUSION

As the southern African electricity network slowly expands its reach, various landscapes, including sensitive habitats, will be traversed by a web of power line infrastructure. Utilities responsible for the operation and maintenance of these networks should be well informed about the potential impacts that wildlife in the region could have on their assets and the local wildlife. As discussed in the handbook, it is crucial for utilities to plan and action best practice from the start of a project to manage wildlife and energy interaction, which will reduce wildlife losses and eliminate outages from the get-go. Aside from the cost saving associated with upfront mitigation, countless biodiversity loss can be avoided through the installation of carefully designed hardware. Existing infrastructure is a different matter, and retrospectively addressing high-risk infrastructure can be a daunting task. Utilities will do well to remember that every step taken to protect hardware against wildlife interactions will eventually translate into improved network performance, reduced maintenance costs, and increased profitability. Only when a utility truly understands how, why, and where wildlife interactions occur can the correct actions be taken. To achieve this, information regarding incidents should be recorded continuously, using the steps for data management outlined in Chapter 5. By building up a repository of information, regional interaction hot spots will become apparent over time and utilities can target these areas to gain maximum return on their intervention input costs. Where third party mitigation products such as conductor covers or perch deterrents are considered, utility engineers should be consulted regarding the most suitable products to install as they will be most familiar with the specific infrastructure in use. Where BFDs are required to prevent avian collisions, only products with a proven effectiveness and durability track record should be considered, as many iterations of these devices have been prone to failure in the past. Examples of procedures, mitigation solutions, and interactions provided herein may not be equally applicable to utilities across southern Africa. However, the basic guidance in the handbook should be enough to change the way utilities think about and react to wildlife interactions. Unique interactions will certainly be recorded and incidents not previously documented will surely arise. However, by referring to the handbook, utilities should be able to respond accordingly while building institutional knowledge pertaining to their infrastructure, species, and resulting interactions. If a WMS is adopted and integrated into utility operations, wildlife-related power interruptions will undoubtedly be reduced, as will maintenance requirements. Furthermore, if these practices are adopted throughout the region, southern Africa will contribute greatly to the reduction of wildlife impacts in Africa, save utilities thousands of USD, and reduce maintenance as utilities across the continent work towards achieving a wildlife friendly electricity network.

Photo credit: Shutterstock

Photo credit: Constant Hoogstad

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