MAINSTREAMING WILDLIFE INCIDENT MANAGEMENT INTO UTILITIES IN EAST 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
DX	Distribution
EAEP	East Africa Energy Programme
EIA	Environmental Impact Assessment
ENEP	Ethiopia National Electrification Program
ESIA	Environmental and Social Impact Assessment
EWT	Endangered Wildlife Trust
EWT-WEP	Endangered Wildlife Trust Wildlife and Energy Programme
GPS	Global Positioning System
HSI	Habitat Suitability Index
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
IUCN	International Union for the Conservation of Nature
KenGen	Kenya Electricity Generating Company
LED	Light Emitting Diode
NGO	Non-governmental Organization
MG	Megawatt
SDM	Species Distribution Models
SEIAS	Strategic Environmental Impact Assessment Study
TX	Transmission
USAID	United States Agency International Development
WMS	Wildlife Management System

GLOSSARY

Term	Definition
Collision	When birds or large mammals make contact with hardware inadvertently
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
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
Insulation	The covering of live components
Isolation	Preventing wildlife from perching or climbing close 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
Streamer	A solid stream of electrically conductive excreta emitted with some force by a large bird

ICONS

 Collision

 Rubbing/Scratching

 Mammal Collision

 Damage to poles

 Electrocution

 Distribution Division

 Nesting

 Transmission Division

 Streamers

 Generation Division

 Pollution

 Renewable Energy Division

Photo credit: Volodymyr Burdiak

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

Africa is on the cusp of an energy revolution. Connecting people, services, and resources requires a web of energy generation and power line infrastructure. Two out of three people in sub-Saharan Africa lack access to electricity, and approximately 230 million people live in East Africa. USAID's Power Africa-funded East Africa Energy Program (EAEP)[1] seeks to improve energy sector outcomes across nine countries through four objective areas:

- Optimize power supply
- Increase grid-based power connections
- Strengthen utilities and other power sector entities
- Increase regional power trade

Nearly all of EAEP's focus areas involve energy infrastructure either through the provision of technical advisory support, capacity building, and/or coordination of partners with host-country or regional counterparts. EAEP seeks to support utilities in improving operational and financial performance, enhancing cost recovery and quality of service, and reducing technical, commercial, and collection losses.

Energy infrastructure such as power lines, power stations, wind turbines, and solar developments are an important interface between people and wildlife, particularly in Africa's growing economy. These structures are often 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 substantial costs related to hardware replacement, travel to incident sites, human resources for investigations and repairs, and significant 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 data itself. The effectiveness of mitigation must also be considered if an accurate figure is sought. Landscapes, species, voltage, network reach, design, 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[1] estimated that

[1]EAEP is a four-year task order operating from December 2018–December 2022 with offices in Kenya, Ethiopia, Rwanda, Tanzania, and Uganda. EAEP also has staff operating in Somalia and Zanzibar and covers implementation for USAID's on-grid support in Burundi, Djibouti, and the DRC.

Photo credit: Shutterstock

the cost of wildlife interactions in California, USA, is around $317 million to $317 million per year, with a base case value of $34 million. These estimates emphasize the importance of recognizing wildlife interactions with electrical infrastructure as a significant influence on utility performance and profitability. Using incidents reported to the Eskom/Endangered Wildlife Trust (EWT) Strategic Partnership over a three-year period, we calculated that wildlife interactions in South Africa's Eskom distribution division amounted to approximately $3.2 million per year. The EWT only considered incidents reported to the partnership, for which an incident report was generated; a best case scenario considering some linesmen do not log wildlife mortalities or hardware damages. The EWT also omitted wood pole replacements 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 and did not cover the costs to the local economy resulting from outages, production losses etc., nor did it discuss the cost of environmental losses such as ecosystem services offered by vultures that were killed in energy-related incidents.

African power utilities, typically parastatals, are responsible for providing electricity to meet the ever-increasing demands as economies continue to grow. As a result, the environmental footprint of power lines and other accompanying electrical infrastructure continues to expand inexorably. According to the Ethiopia National Electrification Program (ENEP), the government aims to achieve 100% access to electricity for the population by 2025.[2] On the other hand, Kenya aims to add an additional 7,200 MW to their grid by 2030 as the demand for energy increases.[3] If electricity networks in East Africa are expected to perform consistently and with minimal maintenance, new infrastructure should be designed and routed with the surrounding environment and wildlife taken into consideration. By selecting wildlife-friendly designs and applying suitable mitigation to critical areas on the network, a utility can effectively manage the burden of wildlife impacts on electrical infrastructure, while addressing the threats to wildlife.

Photo credit: Constant Hoogstad

The reality, however, is that many new infrastructure projects in East Africa have already been completed without integrating these considerations. In many cases, the Environmental and Social Impact Assessments (ESIA) that are conducted report only broad, generic measures for environmental protection and do not consider the potential impact on the infrastructure itself. The habitual roosting and nesting by many bird species is a prime example of interactions that do not result in wildlife fatalities but can have devastating effects on network performance through insulator pollution and line trips caused by nests. At present, the ESIA process will likely not solve this issue, even if the quality of these assessments is improved. The process is designed for environmental protection, which will only translate into higher quality of supply benefits in selected cases. Medium voltage feeders also do not trigger ESIA requirements, and structure design is in no way influenced by legislation. It follows that these considerations will be left entirely up to the utilities and their internal understanding of how wildlife can affect their business and vice versa. By implementing a comprehensive Wildlife Management System (WMS), utilities can monitor and manage negative wildlife interactions and optimize utility performance. This guide will assist utilities in East Africa to correctly identify these interactions, understanding why they occur, and provide mitigation solutions to prevent further losses and improve the quality of supply to their customers.

A flock of pigeons can add significant weight to conductors and cable recoil caused by the flock taking off could cause a fault.
Photo credit: Maximillian Cabinet

1.1 WILDLIFE INTERACTIONS

In the context of energy infrastructure, the term 'wildlife interactions' captures many possible negative and positive impacts involving a range of species and possible scenarios. On the positive side, birds can use pylons or buildings as nesting sites, perches, or roosts, in some cases expanding their ranges. However, many interactions have negative consequences for energy infrastructure, utilities' performance, and wildlife. For instance, collisions with conductors and shield wires kill flying birds. 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. Although large bird species 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. See *case studies* in Chapter 7.

Aside from the climbing species mentioned, larger mammals are also at risk and can cause serious damage to infrastructure, an important factor to consider in East Africa. Research by the EWT in protected areas indicates that elephants, rhinos, and buffalo regularly use gum poles to rub against and clean/sharpen their horns or tusks, which leads to damage of wood poles and ultimately pole breakage, resulting in the conductor being suspended only a few meters from the ground. Giraffes and elephants are the most vulnerable when this happens as they easily come into contact with live phases. Incidents such as these turn into death traps as vultures and other scavengers are attracted to the carcasses, and multiple species are affected.

Baboons on a pylon. Photo credit: Constant Hoogstad

Elephant electrocuted by a low-hanging conductor. Photo credit: The EWT

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

Aside from these obvious detrimental impacts on wildlife, these kinds of incidents are costly for utilities as well. For instance, hardware components are often damaged during the resulting line trip and require repairs. The interruption in electrical supply impacts industry and domestic households alike, reducing productivity. In Africa, these wildlife interactions can cost utilities in excess of $100 million annually[1] through various mechanisms, including revenue loss and costs to repair damaged infrastructure. Furthermore, utilities are faced with continuous negative publicity, affecting their reputational value and market share.

Chapter 2 covers each of these interactions in detail.

1 This figure is based on conservative estimates made by the ESKOM-EWT strategic partnership relating to wildlife interactions in South Africa and extrapolating this figure to include other African countries where the extent of the electricity network was known

Photo credit: The EWT

1.2 STATUS QUO

East Africa has not been excluded from the electrification drive currently unfolding across Africa. Each East African country has set electrification targets and is increasing generation capacity and expanding the reach of their networks. Information regarding interactions with electricity infrastructure is scattered amongst in-country NGOs, bird watchers, utilities, and the general public, making it very difficult to piece together the true impact of wildlife on network performance. Numerous examples of negative interactions are available, but the cost of these incidents has not been calculated, and the cumulative effect of these incidents is unknown.

East African energy stakeholders rely on experience gained in other countries to predict how utilities will be affected by wildlife interactions and focus on critical intervention points to minimize losses, both to the utility and the natural environment. This approach requires a closer look at the status quo in East Africa before unpacking the challenges and solutions.

1.2.1 THE LINK BETWEEN WILDLIFE INTERACTIONS AND QUALITY OF SUPPLY

ESIA studies are required to guide the placement and design of electrical infrastructure. Utilities and developers should expect a comprehensive ESIA to address where birds occur, fly, and roost in relation to the proposed development. While this process may mitigate wildlife interactions to some extent, utilities must consider lower voltage feeders and account for all types of interactions. As some interactions do not affect wildlife but only the network's performance, utilities must internalize processes to anticipate and avoid these incidents. Utilities and developers should not expect environmental practitioners to account for these cases in an ESIA report, given that many practitioners do not have a thorough understanding of specific areas and how wildlife affects utility performance.

1.2.2 WOOD POLE REPLACEMENT PROGRAMS AND CONCRETE POLE PREFERENCE

From a maintenance perspective, concrete is more durable and practical than wood, but it should not be the only consideration for lower voltage power line designs. Concrete poles are steel reinforced and can become conductive under certain environmental conditions. Planning teams should carefully design the pole top if concrete poles are preferred, allowing adequate clearance between the concrete and live phases to allow medium and large raptors to perch safely. East African utilities readily use concrete poles for new lines or during wood pole replacement projects. However, they are often paired with steel cross arms, resulting in poor clearances between live conductors as all three phases are supported on top of the cross arm

Steel crossarm on a concrete pole. A common structure found across East Africa. Photo credit: Stoyan C Nikolov

1.2.3 THE DEPLOYMENT OF SUITABLE MITIGATION PRODUCTS

Utilities can improve network performance through the correct installation of 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, such as flappers or OWL nocturnal bird flight diverters, fitted to overhead lines can also improve infrastructure visibility, thereby reducing the risk of collisions. Presently, very few structures in East Africa are protected in this manner, despite the clear benefits and myriad options available.

The OWL nocturnal bird flight diverter with flashing LED lights, intended to be visible to nocturnal flying birds so that they can avoid colliding with the power line. Photo credit: Matt Pretorius

1.2.4 THE CORRECT INSTALLATION OF MITIGATION PRODUCTS

To ensure the adequate protection of hardware against wildlife interactions, mitigation products must be correctly installed. Several examples of incorrect application have been observed in the few cases where utilities have procured mitigation products. This relates to the selection, placement, and attachment/installation of the products. Incorrectly placed/installed products will be largely ineffective and might also require additional maintenance through reattachment or replacement. As suppliers often do not support utilities with the correct selection and application of these products, building capacity to implement mitigation methods correctly is crucial.

Example of bird guards installed using incorrect cable ties, causing the product to fail. Photo credit: Constant Hoogstad

A live line team installing bird flight diverters on a distribution line. Photo credit: Megan Diamond

1.2.5. THE MANAGEMENT OF WILDLIFE INCIDENTS

Although negative wildlife interactions can be greatly reduced through appropriate line routing, structure design, and mitigation, all utilities will likely have existing lines that were poorly placed and designed. Utilities can systematically address this hardware and improve network performance by documenting wildlife interactions and implementing a system to correct problematic designs and prevent further losses. Currently, there are no processes or resources to achieve this within utilities across East Africa.

Photo credit: Shutterstock

02 CLASSIFICATION OF WILDLIFE INTERACTIONS WITH ELECTRICAL INFRASTRUCTURE

TYPES OF WILDLIFE INTERACTIONS AND WHY THEY OCCUR

2.1 COLLISIONS

A collision incident occurs when an animal, usually a bird, physically strikes either the conductor or the earth (shield) wire of an overhead power line. Collisions can occur on both distribution and transmission power lines. In general, birds more commonly collide with the earth wire on distribution or transmission lines than with the overhead conductors, which are generally thicker or bundled and therefore easier to see.

Birds and bats also collide with the blades and towers of wind turbines and, although the collisions are often fatal for the animals, they often have little to no impact on the infrastructure itself.

Photos of collision fatalities taken by field investigators

COLLISIONS

Divisions affected

Common species

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

Typical injuries to animal

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

Typical impact on infrastructure

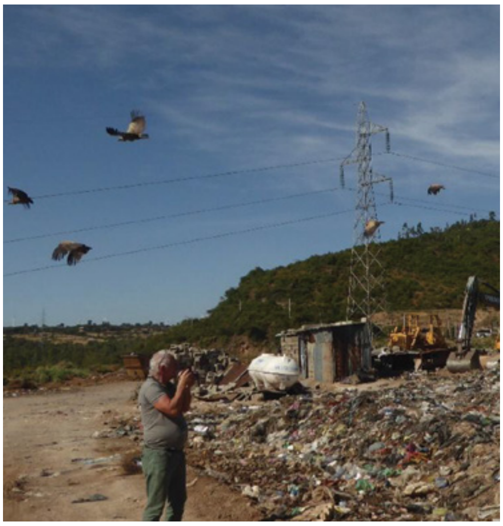
On lower voltage lines, collisions often lead to the conductors breaking and hanging low, increasing the risk of electrocutions to large mammals tall enough to encounter the line. When the actual conductor snaps, it will result in the line shorting out and an outage for customers.

Identifying collisions

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

EXAMPLE OF BIRD COLLISIONS FROM ADAMA, EAST OROMIA REGION, ETHIOPIA[4]

A survey conducted in 2020 (Bakari et al.) in Adama reported a high voltage transmission line next to the rubbish dump west of Adama that posed a very high collision risk. The surveyors observed several vultures narrowly missing the lines and one White-backed Vulture flying into the lines and falling down the cliff. Hundreds of different species of vultures and Marabou Storks feed on the rubbish dump and are routinely exposed to the danger of collision with the transmission line, which is invisible against the valley background. As they take flight from the rubbish dump, they can easily collide with any of the four cables. Bird carcasses were found at the base of the cliff, where the birds landed after colliding with the transmission line.



Vultures leaving the Adama rubbish dump are at extremely high risk of colliding with the adjacent power transmission line Photo credit: S. Oppel.

2.2 ELECTROCUTION

An electrocution incident refers to the scenario where an animal causes an electrical short circuit by physically bridging the air gap between live components and/or other live and grounded/earth components. Electrocution causes a lethal current to flow through the body of the animal. Mammals such as feral and wild cat species, baboons, monkeys, elephants, giraffes, and rhinoceros often get electrocuted when they come into contact with live components of the equipment. An electrocution event will often lead to a dip/trip on the power line system, which can cause outages and loss of income for the utility and associated businesses.

ELECTROCUTION

Divisions affected

Voltage size

11–400 kV

Common species

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

Typical injuries to the animals

Burn marks and contracted claws or curled toes are typical signs of electrocution.

Typical impact on infrastructure

Flashovers, which impact system reliability and customer supply.

Identifying electrocutions

The dead animal is often found at the base of the pole or tower.

Direct costs to the utility include the impacts on system reliability and customer supply when collisions result in flashovers, or secondary electrocutions of animals may cause electricity outages. Although most power lines will automatically reconnect after a flashover, many customers in the agricultural community with single-phase pumps will be affected by the electricity trip.

Further costs to utilities are to their reputations when there are impacts on threatened species through power line collisions.

A White-backed Vulture electrocuted on a distribution line structure. Note the burn marks on with wings, with singed feathers. Photo credit: Ronelle Visagie.

GIRAFFE ELECTROCUTIONS IN BALULE PRIVATE NATURE RESERVE

While most electrocutions on power lines involve large birds, it is not uncommon for large mammals, particularly giraffes, to get electrocuted if the power lines are too low. Balule Private Nature Reserve is located within the Greater Kruger National Park and falls under the Savannah Biome. In 2009, assessments confirmed that three giraffe mortalities were due to electrocution by power lines that were below the minimum recommended height of 5.8 m for lines in areas where there are giraffe. Please see Chapter 7 for more details on this incident and another example of giraffe electrocutions in Kenya. The image below shows a line, measuring at 5.2 m from the ground that caused a giraffe electrocution in Greater Kruger National Park in South Africa.

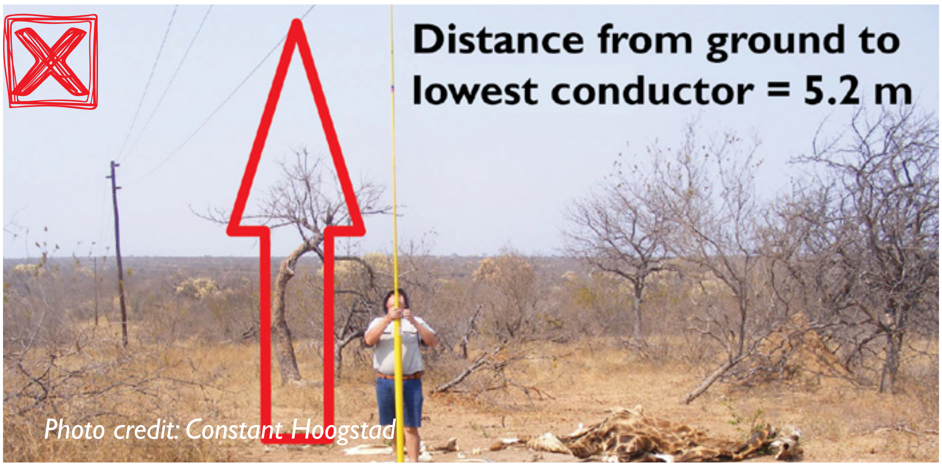


Photo credit: Constant Hoogstad

2.3 NESTING

Birds nest on energy infrastructure for several reasons: a lack of natural nest sites such as trees; electrical structures are safe, sturdy, and out of reach of potential predators; and they provide advantageous positions for hunting or taking off. Different birds create different types of nests, and each has different impacts on the infrastructure, including flashovers, structural damage, fires, and pole sagging or collapse (See Chapter 4).

NESTING

Divisions affected

Voltage size

N/A

Common species

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

Typical injuries to the animals

Burns from fire as nests catch alight from flashovers.

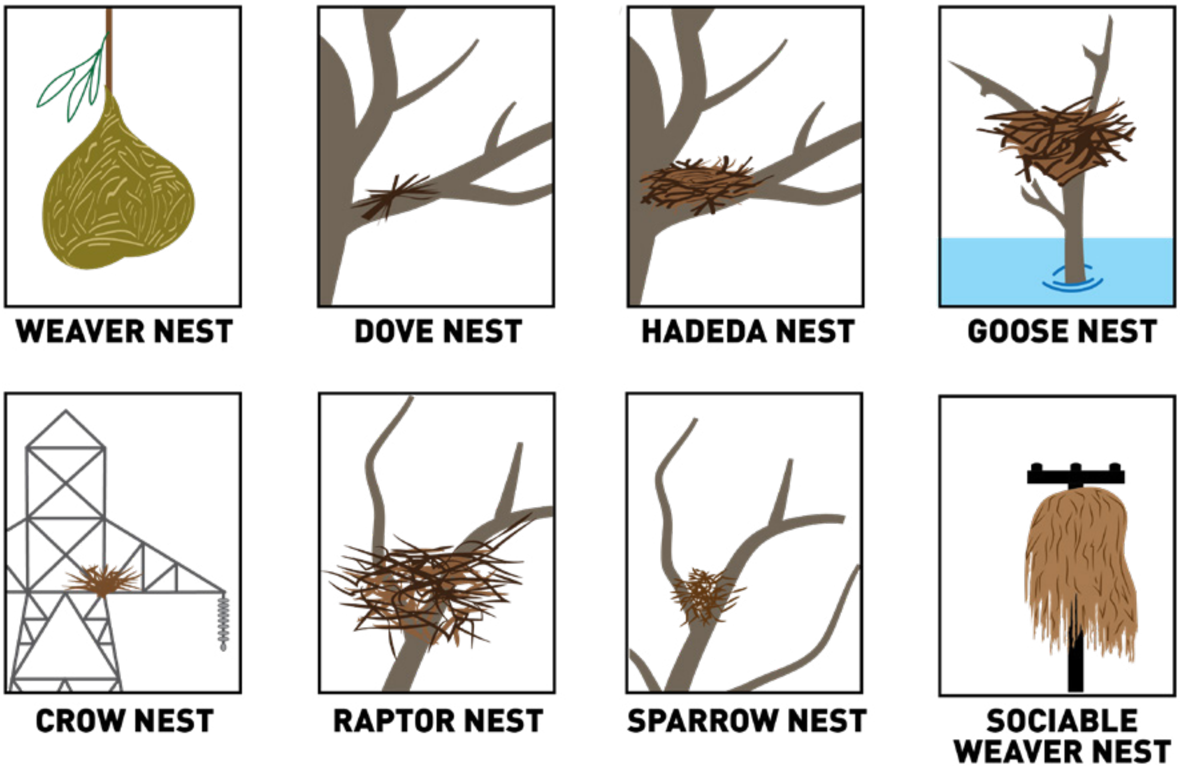
Typical impact on infrastructure

Fire 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 African White-backed Vulture, Black Eagle, Martial Eagle, Tawny Eagle, various kestrels, falcons, storks, herons, weavers, geese, and crows.

White Stork on its nest on a distribution pole.
Photo credit: Mauro Rodrigues

2.4 STREAMERS AND POLLUTION

There are two ways in which bird excretions can cause electrical faults on overhead lines: through pollution and streamers

POLLUTION

Pollution is the result of repeated deposition of excreta on ceramic line insulators. 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, and this coincides with moist or humid conditions.
- When a flashover occurs because an insulator string gets coated with pollutant, which compromises the insulation properties of the string. When the pollutant is wetted, the coating becomes conductive, insulation breakdown occurs, and a flashover results. Flash marks 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 accumulated 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.

POLLUTION

Divisions affected

Voltage size

11–765 kV

Common species

Various species of vultures, herons, ibises, stork species, eagles, and large hawks.

Smaller species like Speckled Pigeons, Indian Myna, etc.

Typical injuries to animals

No impact on animals.

Typical impact on infrastructure

Pollution can cause extensive line trips, and the cleaning and maintenance of insulators can become expensive.

STREAMERS

Bridging or (partial bridging) of the air insulation (live conductor to the tower structure) through a continuous long ejected streamer of electrically conductive excreta.

An electrical fault is caused by a bird streamer, i.e., a solid stream of excreta emitted with some force by a large bird, when it bridges the entire distance, or a sufficient part thereof, between the earth plane (the steel tower and the bird perched above a conductor) and the nearest live hardware point. The streamer acts as a fuse and an electrical fault occurs when the air gap is bridged.

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. These differences, and those in perching behavior, affect levels of risk when considering bird-related interactions with overhead power lines[5].

Build up of pollution (bird feces) on insulator strings.
Photo credit: Eskom

An example of a streamer, a solid stream of excreta emitted with some force by a large bird, sometimes long enough to bridge the air gap and cause a fault.
Photo credit: Shutterstock

Birds perching on electrical structures results in a build-up of pollution on the structure and live components.

Photo credit: The EWT

STREAMERS

Divisions affected

Voltage size

66–765 kV

Common species

Herons, pelicans, vultures, eagles, etc.

Typical injuries to the animals

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

Typical impacts on infrastructure

Streamers can cause line trips and are responsible for a lot of unexplained outages.

STREAMERS AND POLLUTION ON THE TABOR LINES (LIMPOPO, SOUTH AFRICA)

The Endangered Wildlife Trust's Wildlife and Energy Programme (EWT-WEP) was first alerted to an unexplained excessive faulting problem on the Tabor lines in August 2010. A special investigation task order was issued to the EWT and a field investigation was conducted. The Tabor lines run in a north-easterly direction through an area consisting of typical savannah bushveld, falling within the Savannah Biome and the Central Bushveld Bioregion. With ideal nesting and breeding sites and plentiful food resources, the area is rich in bird species.

This line is also located in close proximity to Cape Vulture, White-backed Vulture, and Lappet-faced Vultures colonies (Blouberg, Soutpansberg, and Marakele). The line is also elevated above tree level which makes it the ideal roosting/perching spot for vultures and other raptors. These elevated structures give the birds a great vantage point from which to hunt or detect possible food sources in the vicinity.

During the site visit, the EWT investigators saw numerous eagle and vultures species in the vicinity and there were clear indicators that they habitually roost on the lines. On three different occasions, raptors, including Martial Eagles, Brown Snake Eagles, and Cape Vulture, were seen roosting or perching on the line. Faulting appeared to have occurred mostly at the strain posts all along the Tabor line. A technician pointed out that there seems to be significant problems associated with a specific pole, where data show faulting on more than one occasion. The technician had previously found a dead vulture under the same pole's line and it is likely that a bird streamer was the cause of the mortality.

The most probable cause of faulting on the line was deemed to be a streamer-related fault at the corner/strain poles and, to a lesser degree, the pollution of insulators. For lessons learned see Chapter 7.

2.5 RUBBING AND DAMAGE TO WOODEN POLES

Larger mammals such as rhinoceros, elephants, and buffalo cause damage to infrastructure, particularly wooden poles, by using them as rubbing posts to scratch and rid themselves of excess parasites or for territorial marking. Elephants commonly uproot and push trees over, and can do the same with poles. These actions compromise the structural stability of infrastructure and can cause electrocutions when poles and lines are unstable or fall within reach of wildlife.

Birds such as woodpeckers and barbets also cause damage to wooden poles by drilling holes and nesting inside the poles, particularly in the cross-arms.

RUBBING AND DAMAGE TO WOODEN POLES

Divisions affected

Voltage size

11–22 kV

Common species

Cape Buffalo, African Elephant, White Rhinoceros, Black Rhinoceros, and Warthog.

Typical injuries/impacts to the animals

Electrocutions are common as secondary impacts from a pole snapping or breaking, which causes conductors to sag and can result in the electrocution of numerous species if they come within reach of the conductors.

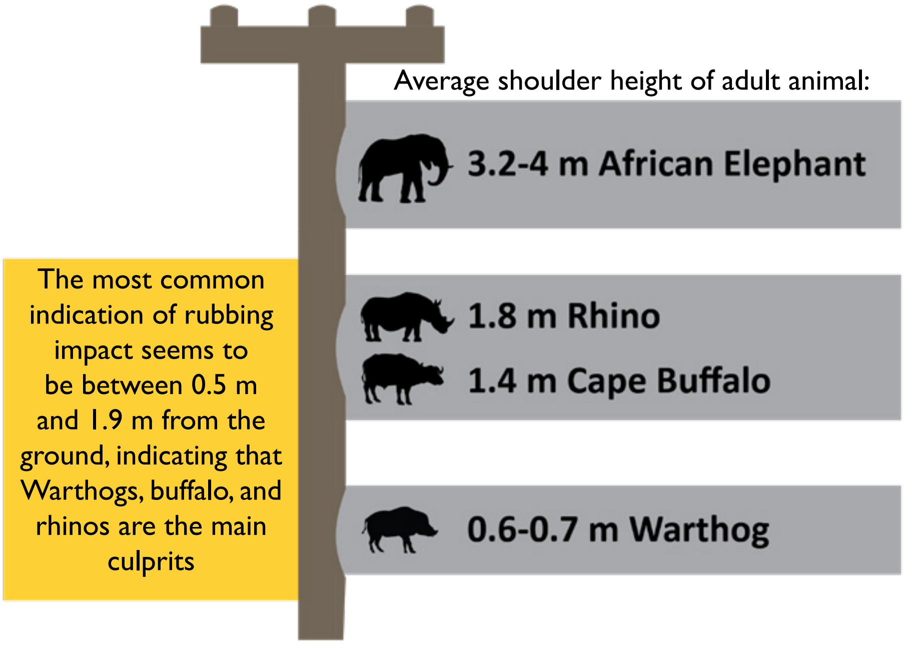
Typical impact on infrastructure

Continuous rubbing exposes poles to the elements and insects and compromises the stability and longevity of wood poles.

Identifying rubbing interactions

There will be markings on the poles that indicate rubbing, and it is generally possible to identify which species was involved by the height and nature of the markings.

Buffalo use wood poles as rubbing posts to scratch and get rid of parasites such as ticks.
Photo credit: Constant Hoogstad



2.6 BURROWING ANIMALS

Small mammals such as squirrels or mongoose often use substations as nesting sites. They dig large holes in the substation, climb up transformers, and often bridge gaps that can cause substantial damage to structures within the substation.

Porcupines also often dig under towers where the soil is a bit softer around the buried structures, which, in turn, compromises the stability of towers.

Porcupines digging holes next to the base of a Transmission line, compromising the integrity of the structure. Photo credit: Constant Hoogstad

2.7 CHEWING OR TEARING OF INSULATORS

It has recently emerged that some bird species are tearing composite insulators on both energized and non-energized lines. Utilities often replace old glass and porcelain insulators with new composite insulators, which causes major problems, often during the construction phase before lines are energized.

DAMAGE TO ELECTRICAL INFRASTRUCTURE BY DIFFERENT SPECIES IN THE KRUGER NATIONAL PARK

The Endangered Wildlife Trust's Wildlife and Energy Programme (EWT-WEP) conducted a special investigation of electrical infrastructure in the Kruger National Park to determine what damage is being caused by wildlife, what the consequences are in terms of power supply, cost to utilities of repairs, and loss of life for species involved. Important findings were that:

1. There is a wide variety of animal species that interact with power lines in the park, from termites to elephants.
2. Wildlife interactions, particularly those of large mammals, weaken or break wood 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 man hours as poles have to be replaced on a continual basis.

For lessons learned see Chapter 7.

Camera trap photos of large mammals interacting with wood poles in the Kruger National Park (left). Giraffe standing under distribution line (right)
Photo credits: The EWT (top left and bottom), Constant Hoogstad (right)

Photo credit: Shutterstock

03 SPECIES IDENTIFICATION AND INTERACTIONS

This manual focuses on species in East Africa that are commonly involved in some or other interaction with electrical structures and equipment. The purpose of this chapter is to provide information that will enable you to identify wildlife species you may encounter in East Africa, what interactions they have with electricity infrastructure, and contributing factors to the prevalence of these interactions. While this chapter outlines species from other orders that interact with energy infrastructure, birds are involved in the majority of incidents and are discussed in more detail.

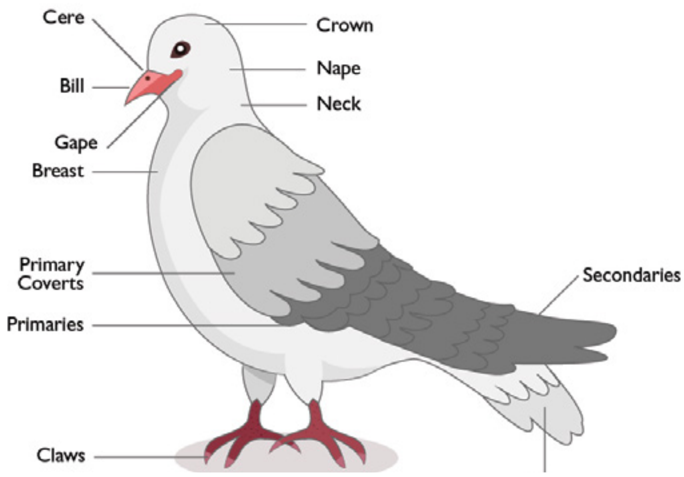
3.1 BIRDS

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.

BIRD ANATOMY:

IDENTIFYING FEATURES

The size, shape, and length of the bill, length of legs and neck, and the color of the plumage (feathers) are the most useful characteristics in identifying birds, and a combination of these characteristics will lead you to the correct family or species. In some species, their distribution is restricted, which can sometimes help in identification.

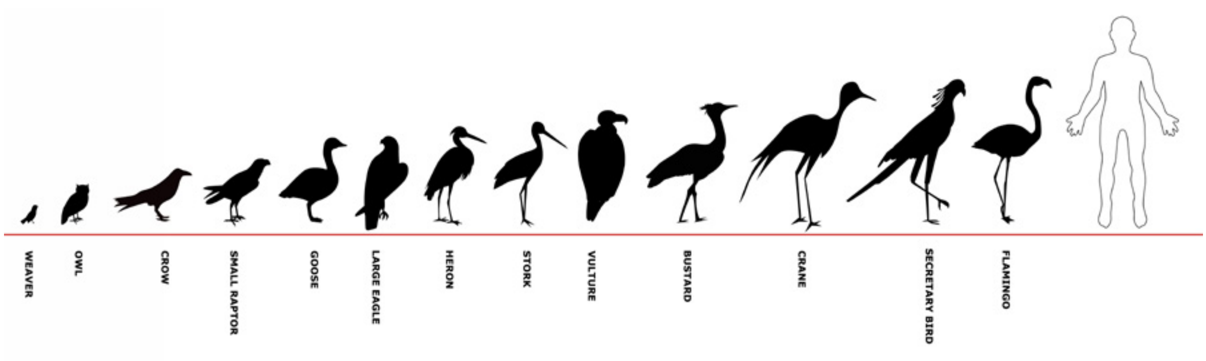


The identifying features of a bird

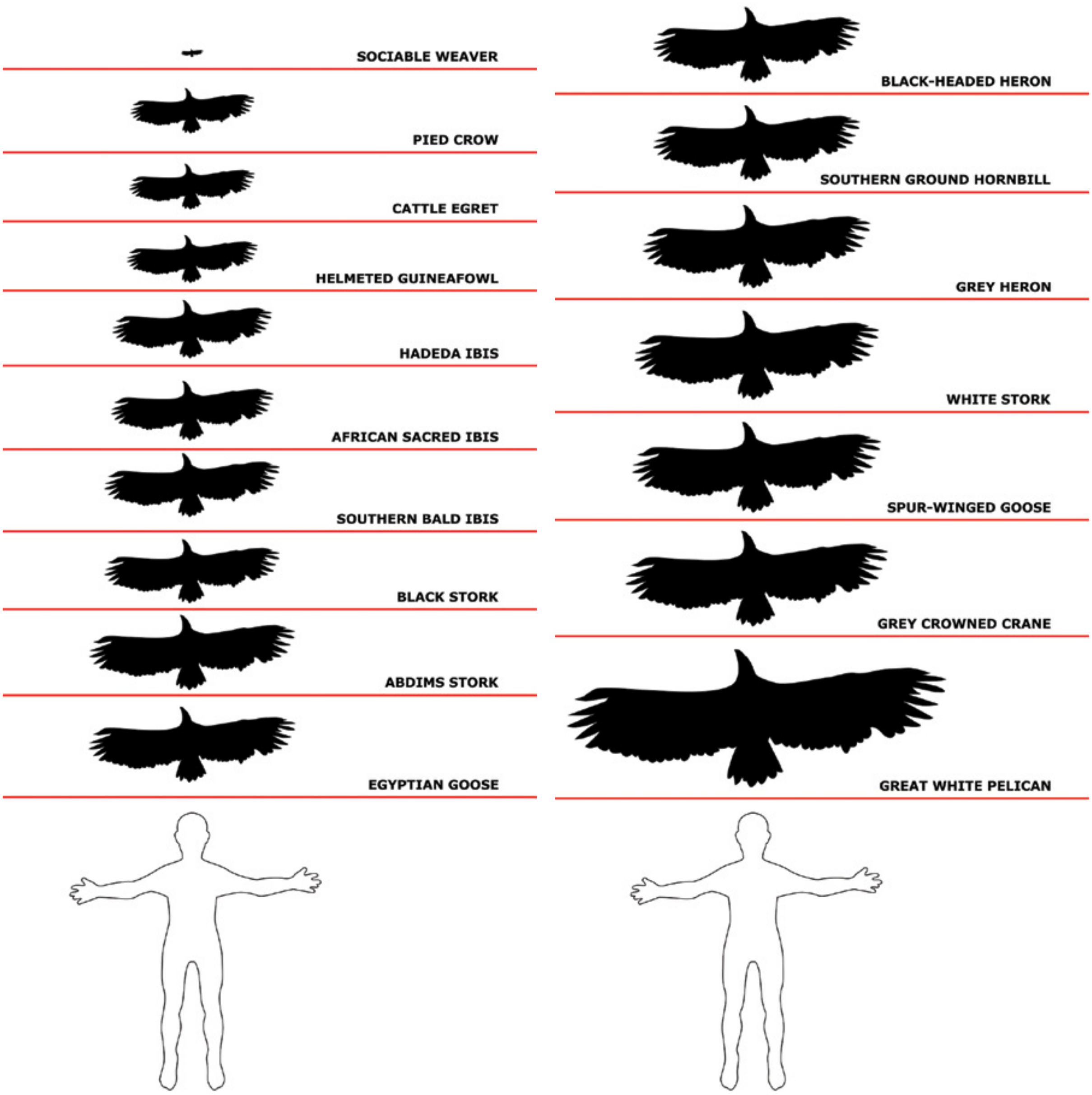
SIZE

Many of the birds regularly involved in power line interactions are large, and these are generally easier to identify than small, sparrow-sized species that can be extremely confusing. One of the first things that help identify birds is a simple estimate of their size.

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



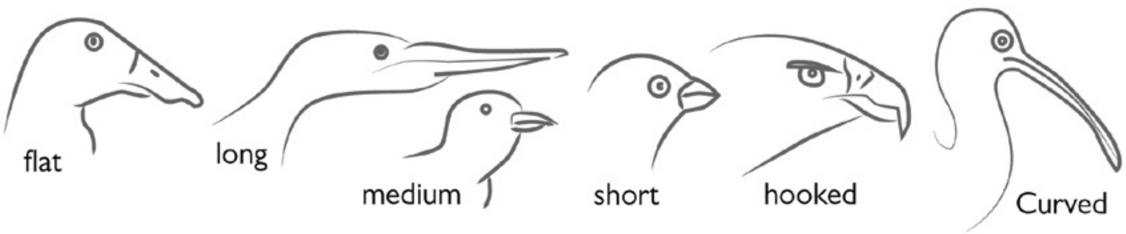
The sizes and shapes of different kinds of birds



Wingspans of different types of birds

BILL SHAPE, LENGTH, AND COLOR

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



Bird Bill types

SHAPE OF LEGS AND FEET

The legs may be classified 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, while others have feathers to the knee, or feathers down to their feet and toes.

PLUMAGE AND COLOR

A wide variety of colors and patterns occur in birds, additional features to help in identification. 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 has been burnt due to electrocution.

3.1.1 BIRD COLLISIONS: BIOLOGICAL AND ECOLOGICAL RISK FACTORS

Bird collisions that occur on both transmission and distribution lines are increasing as energy infrastructure is rapidly extended to meet the electricity demands across East Africa. Collisions generally occur when a bird fails to see the conductor or overhead shield wire while in flight[6]. 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.

The birds most commonly involved in collisions include large birds such as vultures, flamingos, bustards, storks, cranes, and various waterbird species. Birds with a small wing surface compared to their body weight and who spend a lot of time on the ground are less agile flyers and prone to collisions, as are younger, less experienced birds. Other species commonly involved include gregarious, rapid-flying species, such as water birds that congregate in large flocks, as flocking does not leave much space for maneuvering around obstacles and also blocks line of sight of structures. The height at which a bird flies and its flight behavior also factor into the likelihood of a collision. During long-distance migration flights, most larger birds fly well above overhead lines, and collisions appear to occur more during short distance, low altitude flights, where there are many overhead line crossings. 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.

The food birds eat and their foraging habits are other factors to consider, particularly if birds are drawn to areas where food is abundant, such as agricultural areas traversed by power lines. The increased low-altitude movements across these lines during foraging significantly increase the potential for collisions, and if there are also disturbances on the ground, such as livestock grazing, that can cause the birds to flush into the air unexpectedly, increasing the risks further.

Photo credit: Shutterstock

3.1.2 BIRD ELECTROCUTIONS: BIOLOGICAL AND ECOLOGICAL RISK FACTORS

Body size is the primary biological characteristic that influences the likelihood of a bird 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. Weather, particularly rainy weather, is another factor increasing electrocution risk. Water increases conductivity so wet feathers render a bird more likely to be electrocuted by lower voltages than when it is dry. Combining large wingspans and wet weather compounds this risk as birds "sun" themselves by perching on a structure and opening their wings to let the sun dry their wet feathers, greatly increasing their chances of being electrocuted should their wet wings touch live components. Gregarious birds such as guineafowl and vultures tend to sit close together on the same structure, which also increases the likelihood of the air gap being bridged. Other social behaviors such as fighting or mating that may cause birds to lose their balance or for their 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 a safe place to devour their prey. Sources of food include outbreaks of insects or rodents, open-air abattoirs, and vulture restaurants.

Ruppell's Vulture electrocuted on a power line in Ethiopia.
Photo credit: Stoyan C.

3.1.3 BIRD NESTING: BIOLOGICAL AND ECOLOGICAL RISK FACTORS

Certain types of electrical infrastructure are well suited as nest sites, particularly in areas with no natural structures such as trees on which to nest or where the natural substrate is unsuitable or scarce. These electrical structures provide safe and sturdy nest sites that are more difficult for natural predators to reach, and also provide platforms from which to watch for potential threats, hunt, and teach their young to fly. For these reasons, birds may choose to build their nests on electrical structures even when there are suitable natural structures available.

The types of nests (See Chapter 2), materials used to build them, and the risks associated with them 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, which increase the risk of a flashover even further.

Weaver species that live in colonies such as Red-billed Buffalo Weavers (*Bubalornis niger*) and Grey-capped Social Weavers (*Pseudonigrita arnaudi*) build large compound nests similar to those of the Sociable Weavers of southern Africa. Electrical structures are the ideal sites for these nests, with strong horizontal support, no hindrances to access from below the nest as there are in trees, and are safer from predators. These nests can expand to cover large parts of structures, may be a few meters wide and can weigh up to 1,000 kg.

Birds such as woodpeckers and barbets also cause damage to wood poles as they drill holes and nest inside the poles, particularly when they drill multiple holes or near the cross-arms. 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. It has also recently emerged that numerous bird species are tearing composite insulators on both energized and non-energized lines. Old glass/porcelain insulators are often replaced with new composite insulators, which causes major problems, often during the construction phase before lines are energized.

In all cases, nesting on electrical infrastructure increases bird activity on and around structures and power lines, particularly during breeding seasons, and this, in turn, increases the likelihood of other interactions such as collisions and electrocutions and increases pollution and streamer-related incidents.

Photograph of a crow's wire nest (left) and Sociable Weaver nest (right). Photo credits: Matt Pretorius (left) and the EWT (right)

3.1.4 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, which itself results in negative consequences for utility operations. Issues related to bird excretions on power lines are classified into two interactions: pollution and streamers.

Pollution is the buildup of excreta on structures caused by both large and small bird species. Faults occur when pollution builds to a critical point and coincides with moist or humid conditions. If a nest is situated above an insulator string and the strings and discs are heavily polluted with excreta, it may compromise the insulation, resulting in the bridging of the air gap between earth and live components.

An electrical fault is also often caused by a bird streamer, a solid stream of excreta emitted with some force by a large bird that bridges the entire distance between the earth plane (the steel tower and the bird perched above a conductor) and the nearest live hardware point. The streamer acts as a fuse, and an electrical fault occurs. The presence of large predatory birds on the towers ultimately increases the risk of streamer-related faults. Birds commonly associated with streamers include vultures, eagles, herons, storks, and certain ibis species.

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

Vultures roosting on a distribution structure. Note the whitewash on the structure from birds defecating. Photo credit: Constant Hoogstad

3.2 REPTILES

3.2.1 REPTILE ELECTROCUTIONS: BIOLOGICAL AND ECOLOGICAL RISK FACTORS

Reptiles belong to a group of ectothermic (cold-blooded) vertebrates which may be attracted to electrical infrastructure while pursuing prey such as rats, mice, and birds that often nest or stay in substations. Reptiles attempt to warm themselves by climbing onto transformers that give off a fair amount of heat. In doing so, they often get electrocuted between the phases or where there are exposed bushings/jumpers.

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

African Rock Python. Photo credit: Constant Hoogstad

3.3 MAMMALS

Mammals are vertebrate, endothermic animals, usually insulated by fur or hair. Mammals possess mammary glands, which in females produce milk for feeding (nursing) their young. While not as commonly affected by electrical infrastructure as birds, mammal interactions do occur, which can have significant consequences for them and utilities.

3.3.1 MAMMAL ELECTROCUTIONS: BIOLOGICAL AND ECOLOGICAL RISK FACTORS

Primates

Baboons and monkeys often get electrocuted on various types of electrical infrastructure. They use pole tops, transformers, and towers as vantage points to look out for predators, escape them, and roost. The problem is most common in agricultural areas where the animals raid crops close to human settlements where food is readily available.

Genets

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

Giraffe

Characterized by their long neck, this mammal frequently falls victim to electrocution on reticulation networks where the ground clearance is less than 5.8 meters. In some circumstances, giraffe electrocutions can occur when infrastructure is compromised in the form of low hanging conductors, transformers that are placed too low, and failure of hardware.

Baboons (top left), genet (top right). Photo credits: Shutterstock.

Two male giraffe electrocuted at a distribution transformer (left). Photo credit: Marloth Park.

3.3.2 MAMMALS AND STRUCTURAL DAMAGE: BIOLOGICAL AND ECOLOGICAL RISK FACTORS

RHINOCEROS, ELEPHANTS, AND BUFFALO

Pole rubbing, a common behavior amongst large mammals, causes poles to collapse and conductors to sag. Due to the continuous rubbing, the outer protective layer of the pole gets compromised, which can then lead to termite infestations and further damage to the pole and its structural integrity. This can result in the electrocution of rhinoceros, elephants, buffalo, or other mammals that pass under the low-hanging conductors.

A rhinoceros using a wood pole to scratch and rub parasites from its body. Photo credit: The EWT

A buffalo using a wood pole as a rubbing post in Kruger National Park. Photo credit: Constant Hoogstad

SMALL MAMMALS

Small mammals such as squirrels or mongoose often use substations as nesting sites. They dig large, deep holes in and around the substation and often climb up transformers and bridge air gaps, which can cause substantial damage to structures within the substation.

Porcupines also often dig under towers where the soil is a bit softer around buried structures, which, in turn, compromises the stability of towers (See case study on genets in Chapter 7)

Slender Mongoose. Photo credit: Shutterstock

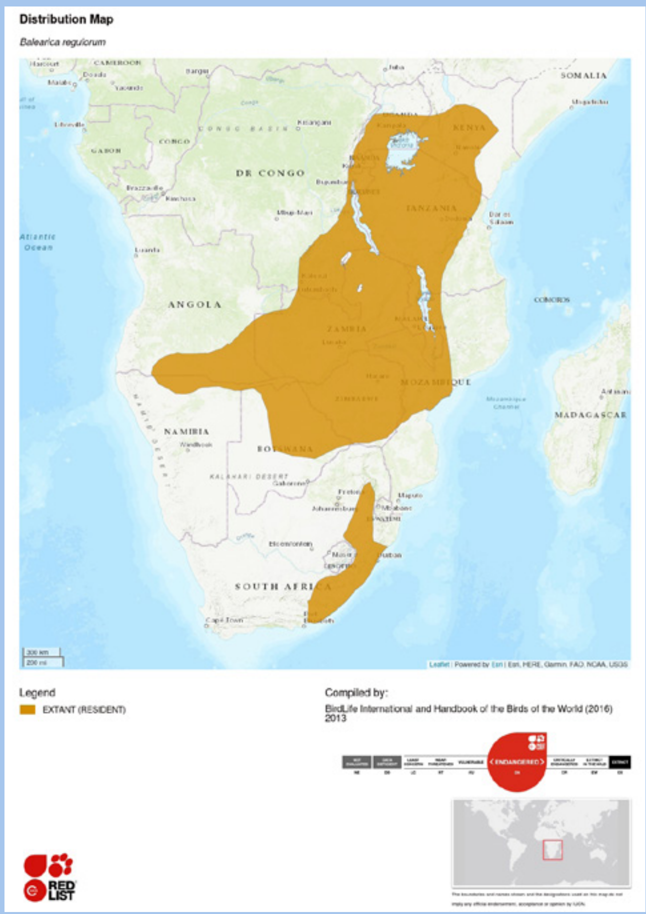
3.4 DESCRIPTIONS OF SPECIES THAT COMMONLY INTERACT WITH ELECTRICAL INFRASTRUCTURE IN EAST AFRICA

3.4.1 BIRDS

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 and breeding

Habitat: Utilize wetland habitats for breeding, and are commonly seen in intensively farmed areas.
Nest: Roost on infrastructure
Breeding: October–June

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.

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

WATTLED CRANE

Grus 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 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

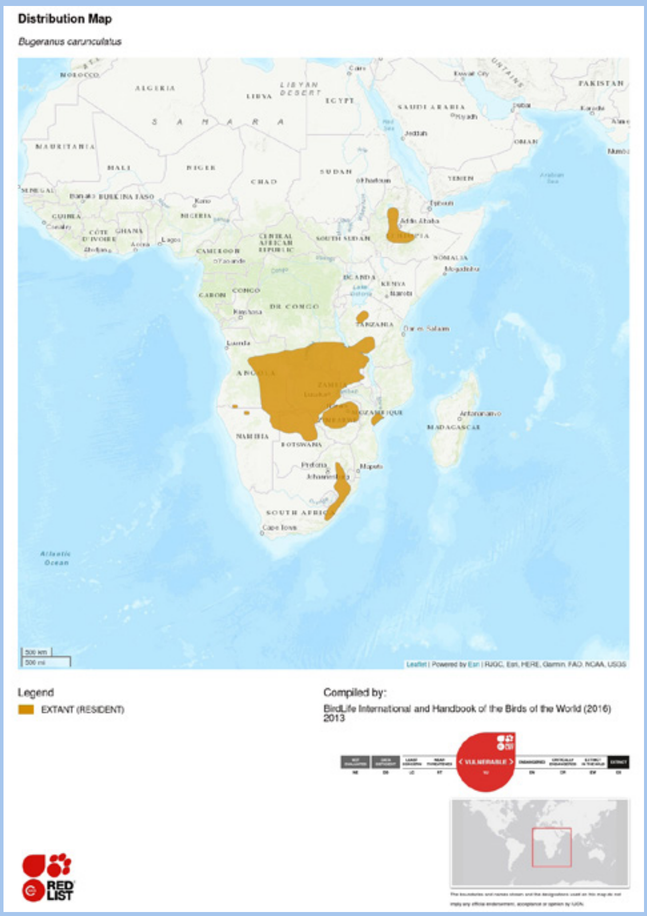


Photo credit: Shutterstock

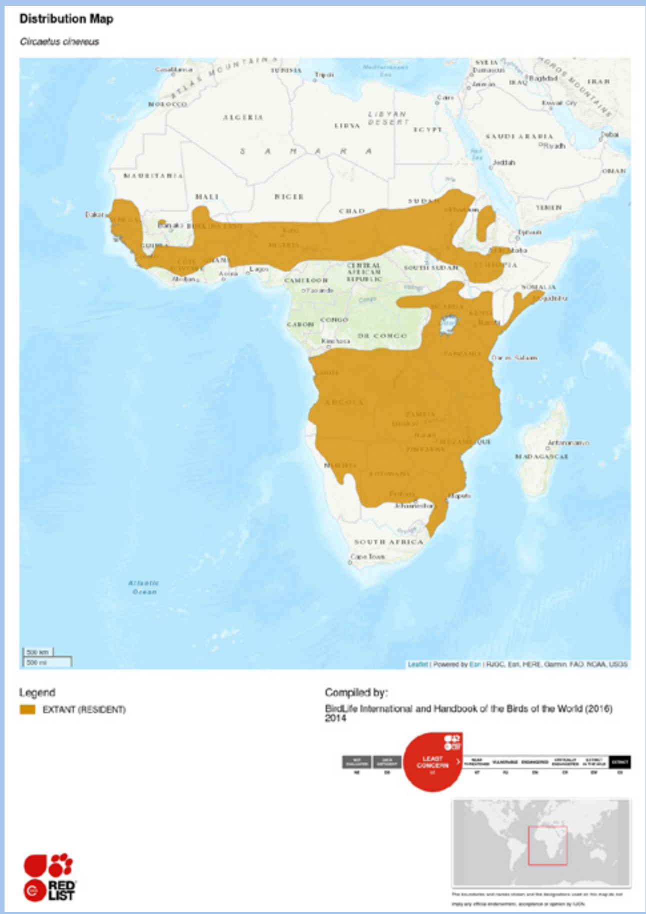
DID YOU KNOW?

Wattled Crane mortality is impacted significantly by power line collisions due to their high propensity for collisions. As a result, power line collisions have a significant impact on their low population numbers.

BROWN SNAKE-EAGLE

Circaetus cinereus

Photo credit: Andre Botha



Size and body shape

Height: 71–76 cm
Weight: 2 kg
Wingspan: 164 cm

Food and feeding habits

Feed on snakes and other reptiles, carrying them by the head while flying. They spend most of their time perched in trees, performing short flights from one to another, and hunting from these perches. More powerful but less agile than other Snake-eagles, it often drops snake prey from a perch[7].

Habitat and breeding

Habitat: Woodland areas
Nest: In trees. The nest of sticks is relatively small for an eagle
(60–70 mm in diameter).
Breeding: They breed successfully on transmission and sub-transmission structure from July–April

Photo credit: Andre Botha

Behavior relevant for utilities

These birds 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.

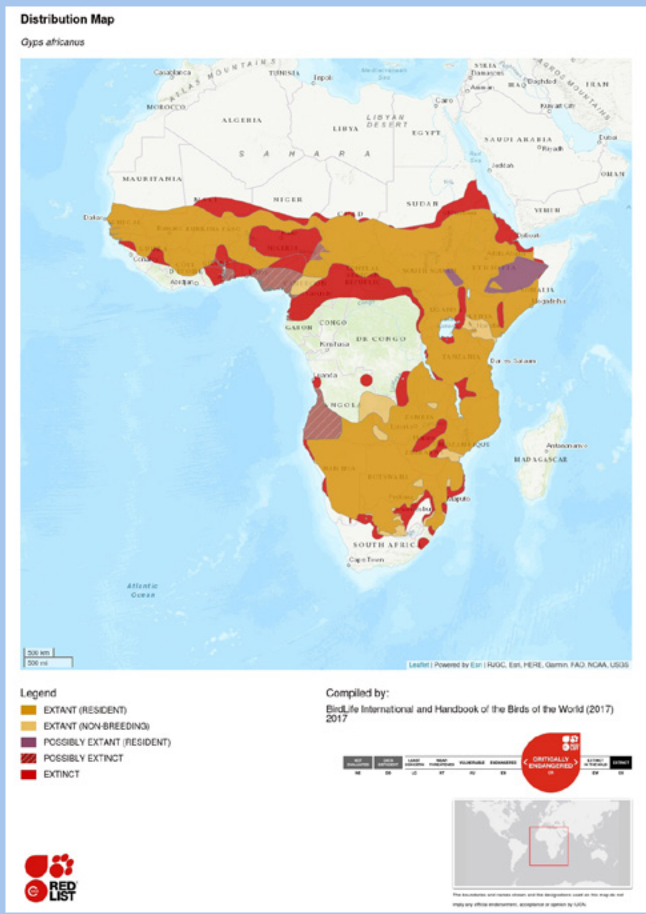
IUCN Red List Conservation Status

Least Concern

AFRICAN WHITE-BACKED VULTURE

Gyps africanus

Photo credit: Andre Botha



Size and body shape

Height: 90–100 cm
Weight: 5.5 kg
Wingspan: 212–228 cm

Food and feeding habits

Congregate in large numbers to feed on carrion

Habitat and breeding

Habitat: Lightly wooded savannah 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 nests on towers. This behavior and their gregarious nature increase the likelihood of collisions and electrocutions on pole tops/structures. Due to their massive wingspans African White-backed Vultures are prone to electrocutions, particularly on lower voltage lines due to the spacing between earth and live components.

IUCN Red List Conservation Status

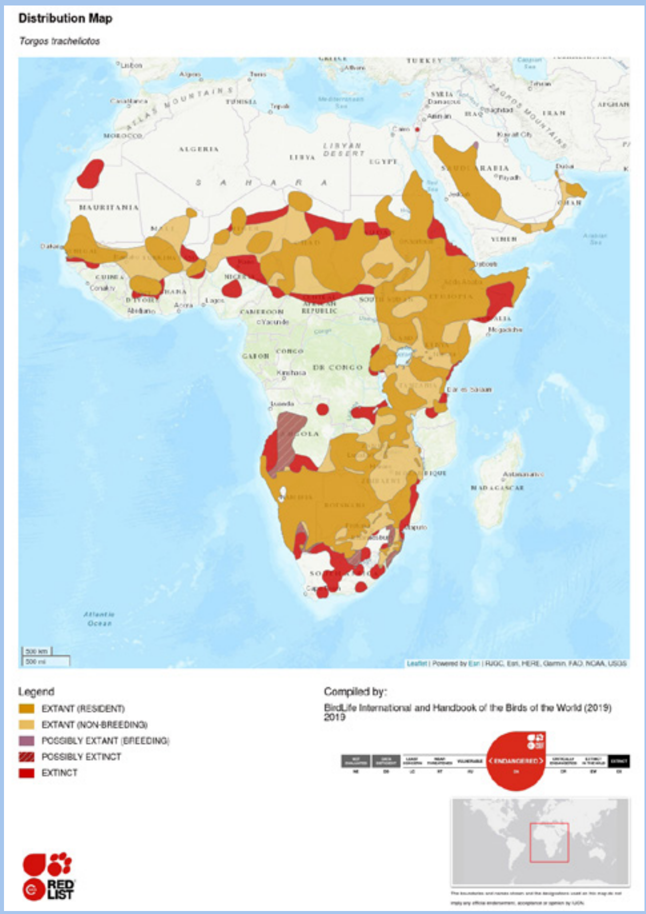
Critically Endangered

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: 258–280 cm

Food and feeding habits

Congregates in large numbers to feed on carrion

Habitat 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 almost 2.8 meters, 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.

Photo credit: Andre Botha

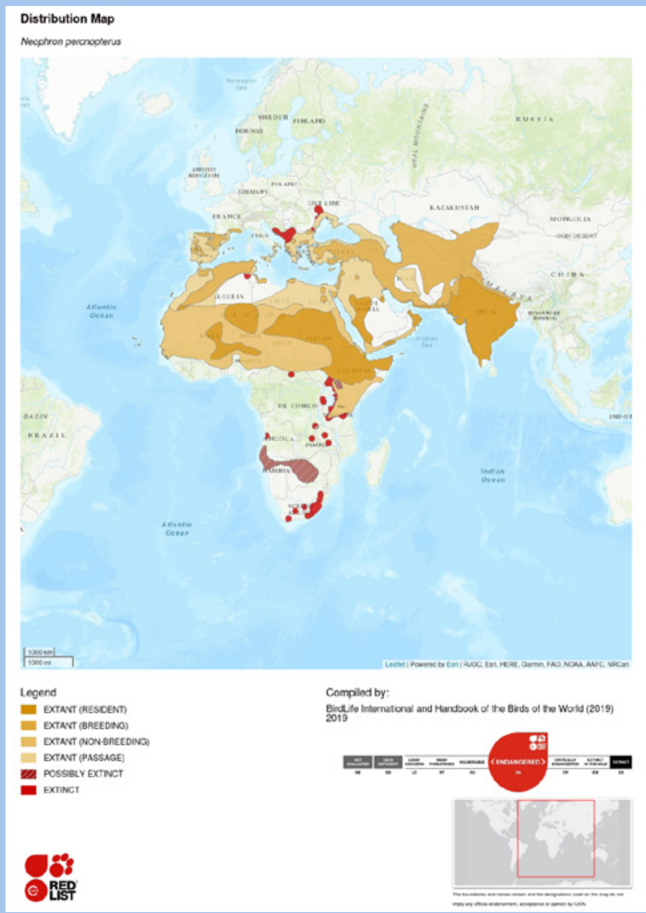
IUCN Red List Conservation Status

Endangered

EGYPTIAN VULTURE

Neophron percnopterus

Photo credit: Shutterstock



Size and body shape

Height: 58–70 cm
Weight: 1.6–2.2 kg
Wingspan: 155–170 cm

Food and feeding habits

Congregate in large numbers to feed. Egyptian Vultures are opportunists and have varied diets, consisting mainly of carrion, but also small mammals, young birds, fish, eggs, and even rotting fruit. The species can fly up to 80 km a day in search of food. Due to their smaller size, Egyptian Vultures must often wait for other vultures species and scavengers to finish eating before they do so. Their thin beaks are perfectly adapted to reach small pieces of leftover meat on carcasses that other species cannot. They also break eggs open by repeatedly dropping stones on them[8].

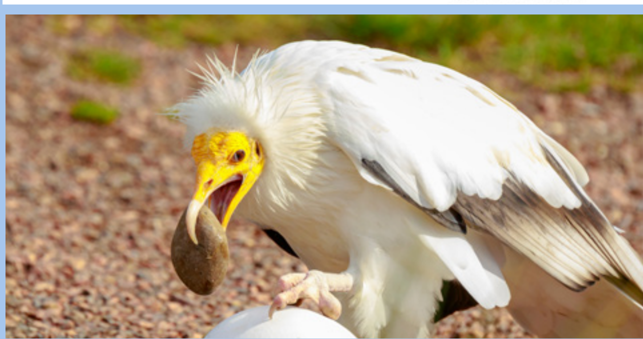


Photo credit: Shutterstock

Habitat and breeding

Habitat: The Egyptian Vulture is the only European vulture that migrates to Africa in winter.
Nest: Pairs build nests together in rocky areas; often on cliffs.
Breeding: They breed later in the year than other vulture species and lay on average two eggs in April or May.

Behavior relevant for utilities

Electrocution-prone like most vultures. They will often use pole tops or towers to perch and roost on and, due to their gregarious nature, multiple birds often perch on the same structure, increasing the risk of electrocution. Collisions are always a risk when these birds move between feeding and roosting sites.

IUCN Red List Conservation Status

Endangered

RÜPPELL'S VULTURE

Gyps rueppelli

Photo credit: Andre Botha

Size and body shape

Height: 84–103 cm
Weight: 6.4–9 kg
Wingspan: 250 cm

Food and feeding habits

Congregates in large numbers with other vulture species and scavengers at carcasses to feed on carrion.

Habitat and breeding

Habitat: Open areas of Acacia woodland, grassland, and montane regions[9].
Nest: Open ledge, building nests in the form of a platform of sticks and grass.
Breeding: Breed on cliff faces, with pairs historically numbering in the thousands. They lay a single egg, usually after the rainy season.

Behavior relevant for utilities

Rüppel's Vultures regularly interact with electrical infrastructure, like most vultures. These birds often need to travel vast distances between breeding and feeding sites, increasing their risk of colliding with power lines. Their gregarious nature, roosting behavior, and perching on pole tops increase the risk of electrocution.

IUCN Red List Conservation Status

Endangered

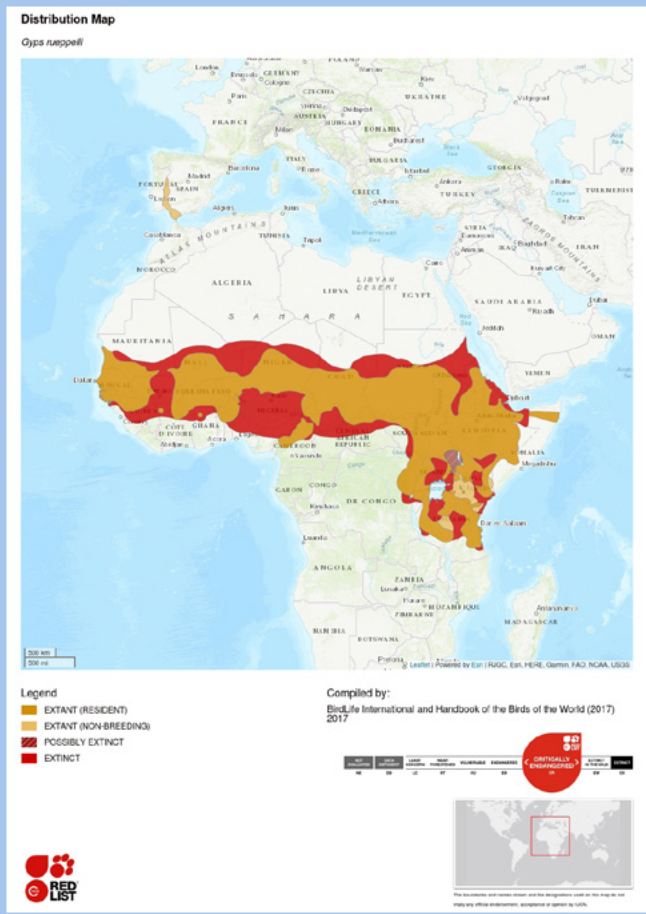


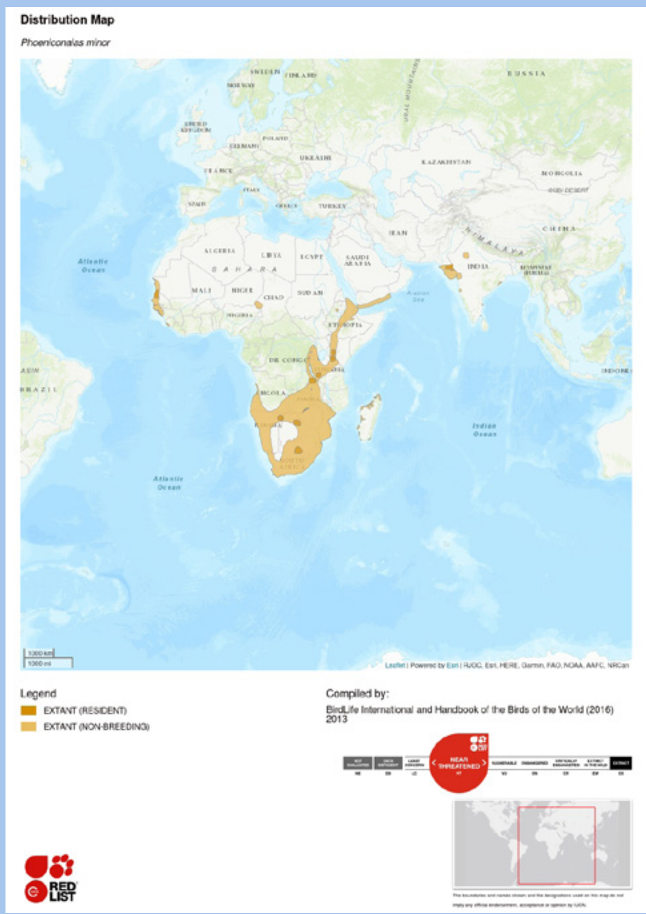
Photo credit: Andre Botha

Photo credit: Andre Botha

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 which grow only in very alkaline lakes.

Habitat and breeding

Habitat: Primarily in the Rift Valley lakes of East Africa. Feeding flocks of 1–2 million birds gather outside of breeding season.
Nest: A mud mound
Breeding: Lake Natron (Tanzania), Etosha Pan (Namibia), Sua Pan (Botswana) and Kamfers Dam in Kimberley (South Africa). 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 also essential to note that the standard diurnal mitigation products/methods won't work because these interactions occur at night. Special nocturnal anti-collision devices need to be used.

IUCN Red List Conservation Status

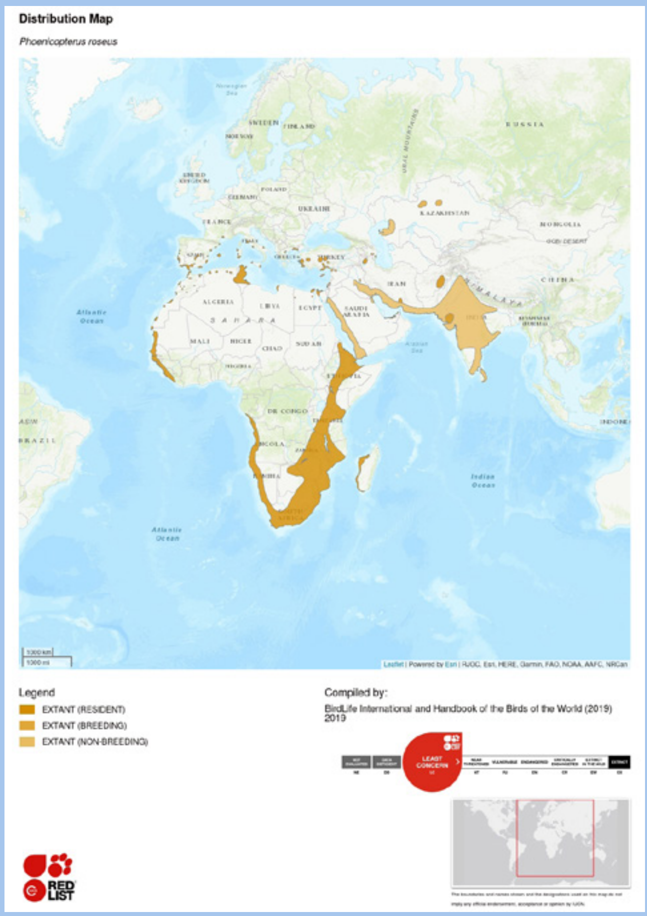
Near Threatened

Photo credit: James Lees

GREATER FLAMINGO

Phoenicopterus ruber

Photo credit: Shutterstock



Size and body shape

Height: 110–150 cm
Weight: 2–4 kg
Wingspan: 140–165 cm

Food and feeding habits

Stirs up the mud, sucks water through its bill and filters out small shrimp, seeds, blue-green algae, microscopic organisms, and mollusks.

Habitat and breeding

Habitat: Resides in mudflats and shallow coastal lagoons with saltwater.
Nest: in large dense colonies on mudflats or islands of large water bodies, the distance between neighboring nests between 20 and 50 cm
Breeding: Lays one egg on a mud mound year-round.

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 standard diurnal mitigation products/methods won't work because these interactions most commonly occur at night. Special nocturnal anti-collision devices need to be used

IUCN Red List Conservation Status

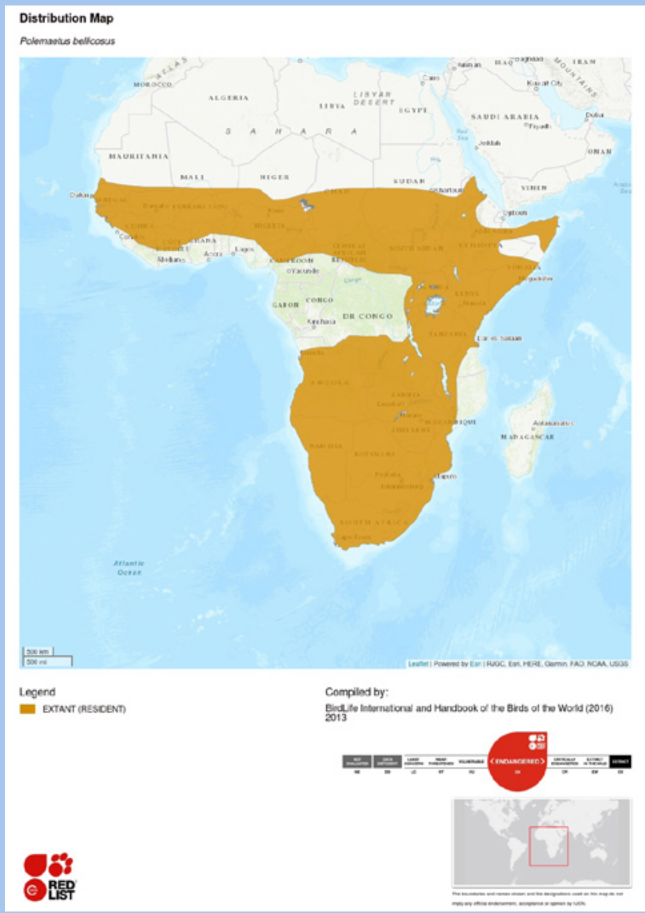
Least Concern

Photo credit: Shutterstock

MARTIAL EAGLE

Polemaetus bellicosus

Photo credit: Andre Botha



Size and body shape

Height: 78–96 cm
Weight: 3.9 kg
Wingspan: 188–270 cm

Food and feeding habits

Martial Eagles spend much of their days searching for food. They soar extremely high and are often barely visible from the ground. During these flights, they cover hundreds of square kilometers. The Martial Eagle uses various hunting techniques: swooping down from afar using cover to mask its approach, gliding through openings of foliage in trees, and waiting, concealed in a tree, to ambush at a waterhole or game path. If a Martial Eagle cannot carry its prey away, which is the case with mammals over 8 kg, it will eat it there on the ground, returning to feed for up to five days[10].

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

Photo credit: Chris van Rooyen

Habitat and breeding

Habitat: Wooded savannah and thornbush.
Breeding: February–August

Behavior relevant for utilities

Martial Eagles are a single perching species and often use pole tops/structures as perches to hunt from. This behavior and their size increase the likelihood of electrocutions. This species is also known to breed extensively on infrastructure in southern Africa. When moving between breeding, roosting, and feeding sites, their risk of colliding with lines is also high.

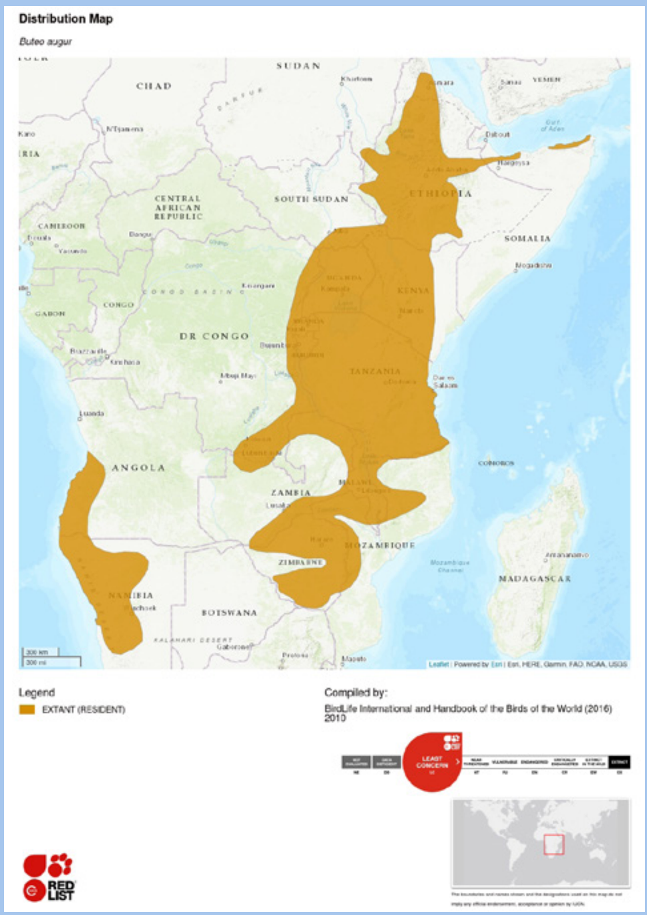
IUCN Red List Conservation Status

Endangered

AUGUR BUZZARD

Buteo augur

Photo credit: Shutterstock



Size and body shape

Height: 48–60 cm
Weight: 1.1–1.3 kg
Wingspan: 120–149 cm

Food and feeding habits

Varied and opportunistic diet, catching most of its prey on the ground, either by still-hunting from a perch, swooping down from a soaring flight, or, occasionally, from a hovering flight. Diet primarily consists of small, terrestrial mammals or reptiles, chiefly snakes and lizards.

Habitat and breeding

Habitat: Elevated savannah grasslands, high moorland, cropland, and sometimes open forest or desert edges. Augur Buzzards in East Africa usually live between 400 and 4,600 meter elevation but normally occur above 1,500 meter and have been recorded living at 5,000 meter in Ethiopia.
Nest: Large (up to one meter-wide) stick nests built in a tree or on a crag, often reused and enlarged in subsequent seasons
Breeding: Year-round

Behavior relevant for utilities

Their use of pole tops as perches puts them at risk of electrocution. They also travel at high speed when hunting prey, increasing the risk of colliding with lines.

IUCN Red List Conservation Status

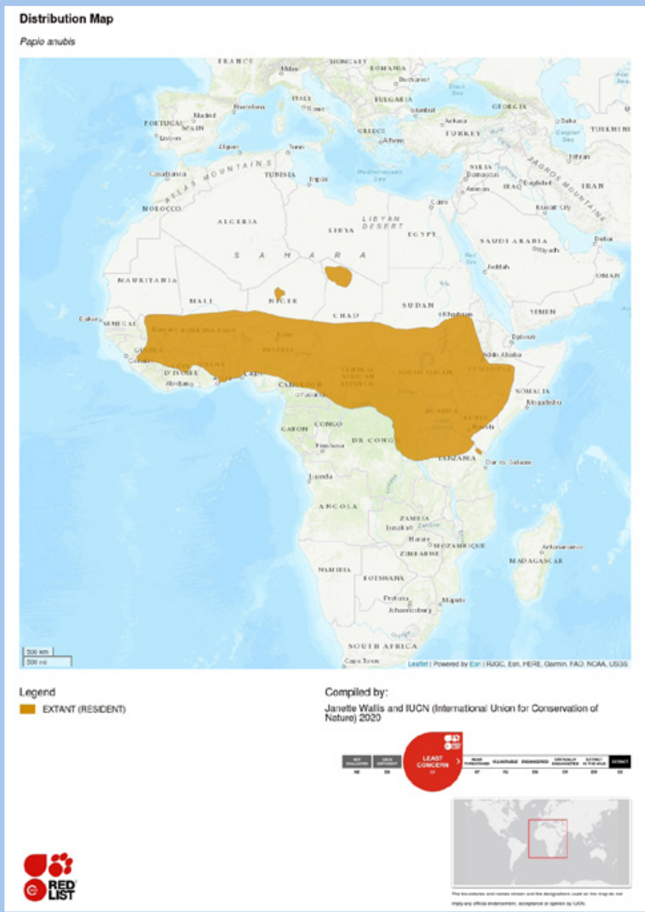
Least Concern

3.4.2 MAMMALS

OLIVE BABOON[11,12]

Papio anubis

Photo credit: Nataly Reinch



Size and body shape

Weight: 10–37 kg
Height: 60–70 cm
Length: 50–114 cm

Large, heavily built mammals, walking predominantly on all four legs.

Food and feeding habits

Omnivorous – fruits, tree gum, insects, eggs, seeds, flowers, grass, rhizomes, roots and tubers, small vertebrates, and carrion.

Habitat and breeding

Habitat: Savannah, grassland steppe, tropical rain forest, agricultural land, and human settlement areas.

Behavior relevant for utilities

Naturally, baboons use trees to climb for food, to rest, or for safety. They also use electrical infrastructure, including towers, substations, transformers, and pole tops, to sit or sleep on and as vantage points to look out for predators. This is often when they get electrocuted by touching both phases or earth and live phases on these structures. Please see case study on page 81.

IUCN Red List Conservation Status

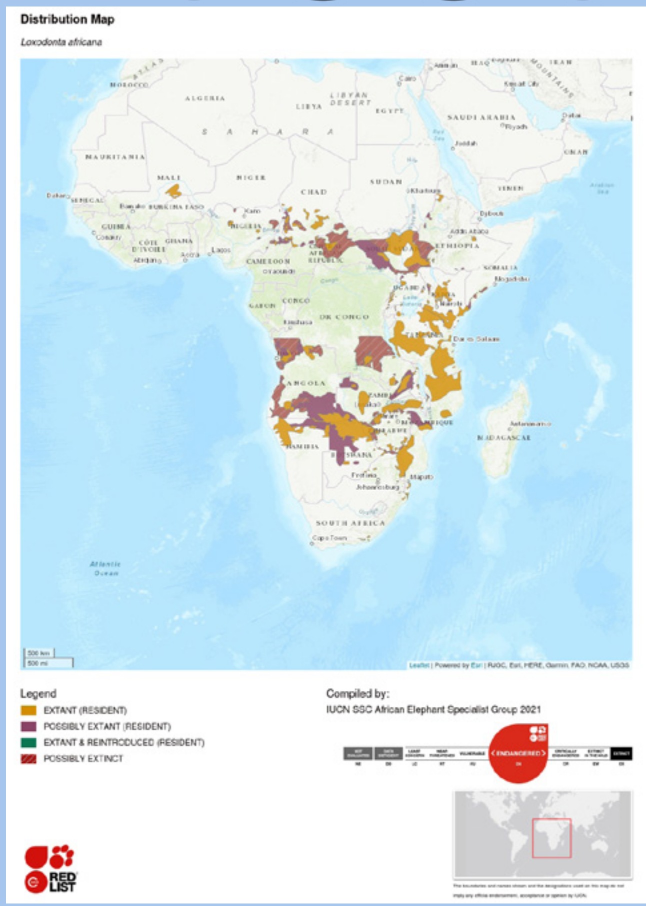
Least Concern

Photo credit: Stu Porter

AFRICAN ELEPHANT

Loxodonta africana

Photo credit: Andre Botha



Size and body shape

<u>Cows</u>
Weight: 2,160–3,232 kg
Height: 2.2–2.6 m (at the shoulder)
<u>Bulls</u>
Weight: 4,700–6,048 kg
Height: 3.2–4 m (at the shoulder)

Food and feeding habits

Herbivores - use their trunks to pull leaves off trees and gather large bundles of grass

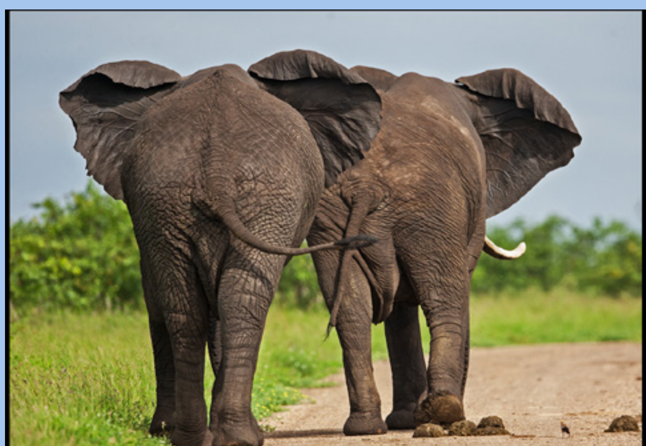


Photo credit: Andre Botha

Habitat and breeding

Habitat: Elephants occupy various habitats ranging from montane forest, miombo, and mopane woodland, thicket, savannah, and grasslands to arid deserts and a wide altitudinal range from mountain slopes to oceanic beaches[13].
Breeding: Cows start reproducing between 10 and 12 years old and will reproduce at any time of the year, provided environmental conditions are suitable.

Behavior relevant for utilities

Elephants often rub against wood poles, compromising their stability and likely causing the poles to tilt and conductors to sag to a level accessible to large mammals and resulting in electrocution incidents.

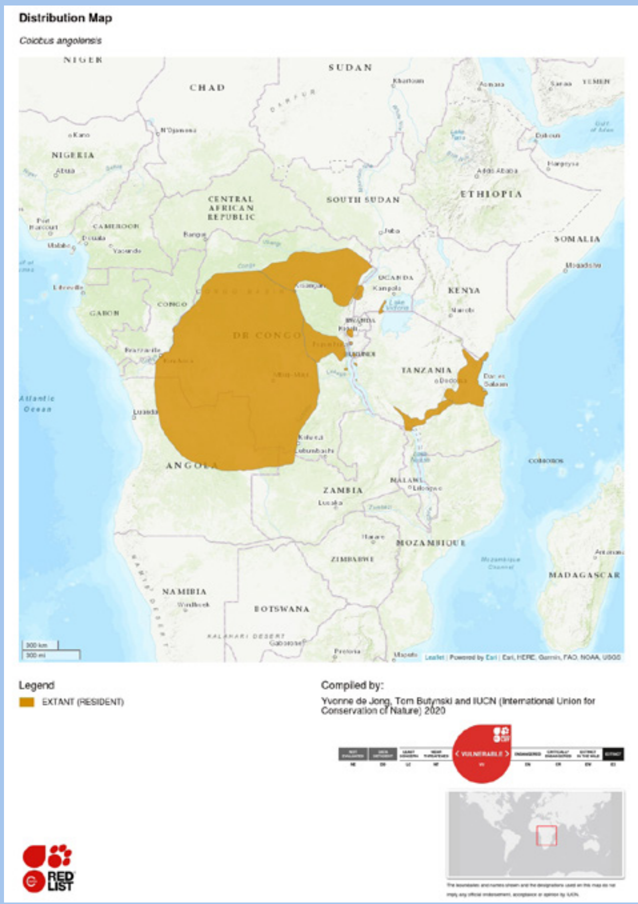
IUCN Red List Conservation Status

Endangered

PETER'S ANGOLA COLOBUS[14]

Colobus angolensis subsp. Palliatus

Photo credit: Vladislav T. Jirousek



Size and body shape

Weight: 9–20 kg
Height: 50–70 cm

Food and feeding habits

Feed primarily on leaves and seeds as well as fruit pulp, flowers, and lichens.

Habitat

Habitat: Evergreen and semi-deciduous forest, including gallery forests, swamp forest, coastal forest, montane forest, and seasonally flooded forests.

Behavior relevant for utilities

Commonly electrocuted on power lines and transformers

IUCN Red List Conservation Status

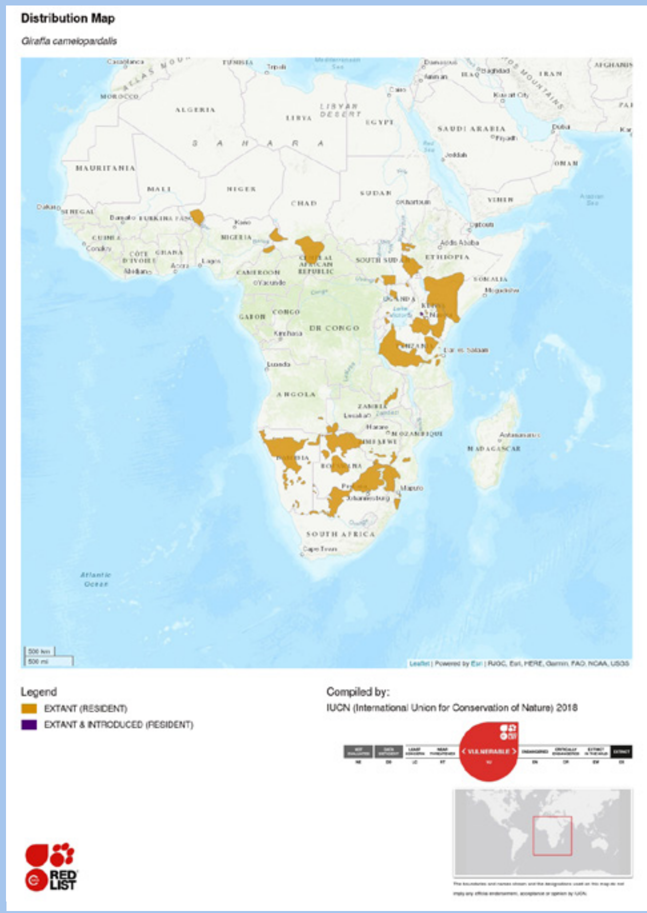
Endangered

Photo credit: Shutterstock

GIRAFFE[15]

Giraffa camelopardalis
(Subspecies G. reticulata, G. rothschildi, G. tippelskirchi)

Photo credit: Shutterstock



Size and body shape

Weight: 828–1,192 kg
Height: 4.3–5.7 m

Food and feeding habits

Browsers with a varied diet that includes leaves, stems, flowers, and fruits.

Habitat and breeding

Habitat: Giraffes are most often found in savanna/woodland habitats but range widely throughout Africa.
Breeding: Females reproduce throughout the year.

Behavior relevant for utilities

Collide with power lines and get electrocuted if conductors are below the minimum height for areas where giraffes occur. Please see case studies on pages 12 and 93.

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 in 1934).

East Africa is home to four subspecies of Giraffes: *G. c. camelopardalis* occurs in both South Sudan and Ethiopia; *G. c. reticulata* occur in north-eastern Kenya and across the borders in south-eastern Ethiopia and south-western Somalia; *G. c. rothschildi* live in Uganda and was introduced to central and southwest Kenya (categorized by the IUCN Red List as Endangered in 2010; and *G. c. tippelsckirchi* occurs in southern Kenya and large tracts of Tanzania.

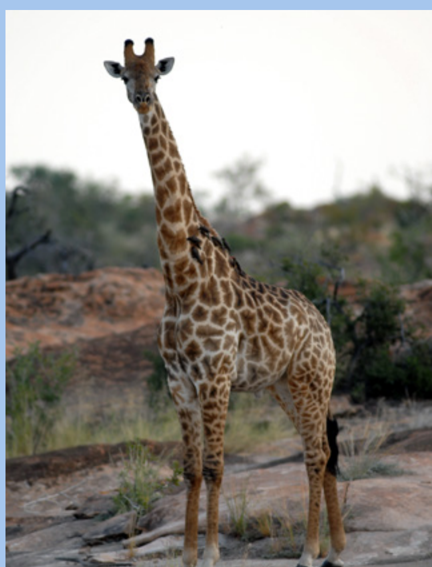
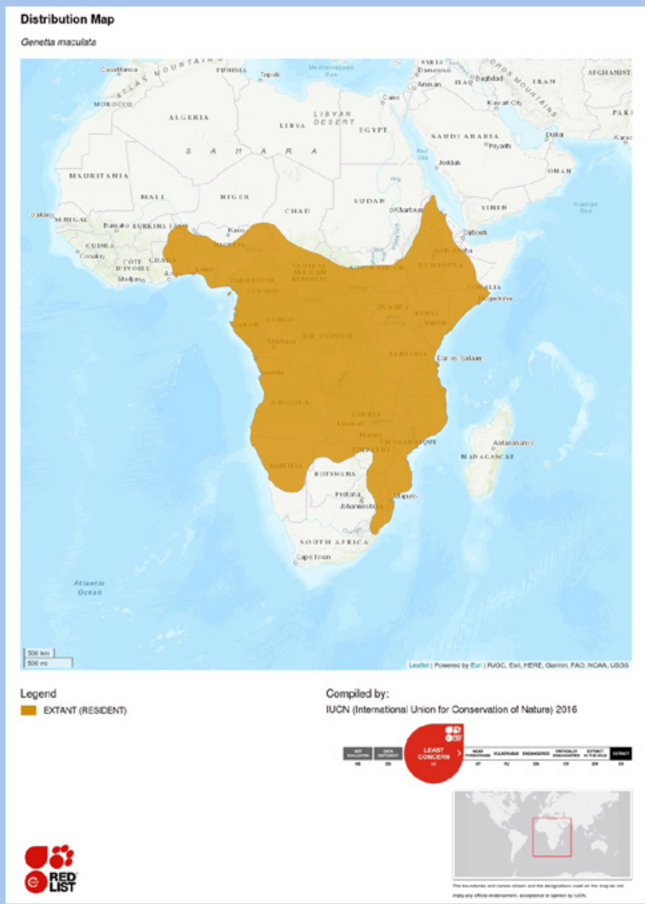


Photo credit: Rob Till

LARGE-SPOTTED GENET

Genetta maculata

Photo credit: David Camps



Size and body shape

Weight: 1.3–1.8 kg
Height: 21 cm (shoulder height)
Length: 35–46 cm

Food and feeding habits

Genets are opportunistic omnivores, feeding on rodents, birds, bats, insects, spiders, scorpions, fish, seeds, leaves, and grass.

Habitat and breeding

Habitat: Occupy various, mostly moist habitats, including rain forest, swamps, riverine vegetation, woodlands, moist forests, savannah-forest mosaics, thickets, and even grassy savannah areas. They also occur in cultivated areas, farmlands, and suburban areas.
Den in hollow trees, in holes, caves, or between boulders.
Breeding: Breed in summer

Behavior relevant for utilities

Genets are attracted to substations because it is common for their prey species to nest inside and on top of these structures. They are excellent climbers and can squeeze their slender, flexible bodies through any opening larger than their head. Therefore, they can access most parts of the substations, including high-risk areas. Please see Perseus case study on page 83.

IUCN Red List Conservation Status

Least Concern

Photo credit: Shutterstock


Photo credit: Constant Hoogstad

04 THE IMPACTS OF WILDLIFE INTERACTION ON UTILITY OPERATIONS

A wildlife interaction with electrical infrastructure creates a domino effect on utilities and, ultimately, the end-users. Besides the obvious detrimental impacts energy infrastructure has on wildlife, these incidents can also be expensive for utilities. For example, wildlife interactions often damage hardware components resulting in line trips and unplanned outages that are costly to repair. Incidents can cause interruptions in electrical supply, impacting industry and domestic households alike, reducing productivity in the economy. In Africa, these wildlife interactions can cost utilities in excess of $100 million annually through losses in revenue, damage to infrastructure, and associated costs of repairs. Furthermore, utilities are faced with continuous negative publicity, affecting their reputational value and market share.

4.1 BIRD COLLISION IMPACTS

In general, bird collisions have a minimal impact on electricity infrastructure. Outages caused by birds colliding with power lines are relatively rare, except on reticulation lines, where the secondary electrocution effect can cause electricity interruptions.

Heavy birds - such as bustards, pelicans, and storks - colliding with distribution lines may cause a flashover between live phases as the conductor sways inward. This arc of electricity often damages the aluminum, weakening the conductor and causing it to fray or snap completely.

4.2 BIRD ELECTROCUTION IMPACTS

Bird electrocutions can incur direct costs to the utility due to line trips, dips, or blown fuses. These incidents affect system reliability and customer supply as well as costs associated with maintenance staff investigations. Although most power lines will automatically reconnect after a flashover, many customers in the agricultural community with single-phase pumps will be affected by the electricity trip.

In almost all electrocution cases, the affected bird may 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 as well as utility hardware. In rare cases, the carcass remains on the pole top and can cause a pole top fire.

Additionally, bird electrocutions can incur reputational damage to utilities when power line collisions impact on threatened species.

Juvenile Martial Eagle electrocuted. Photo credit: Constant Hoogstad

4.2.1 SUBSTATION ELECTROCUTIONS

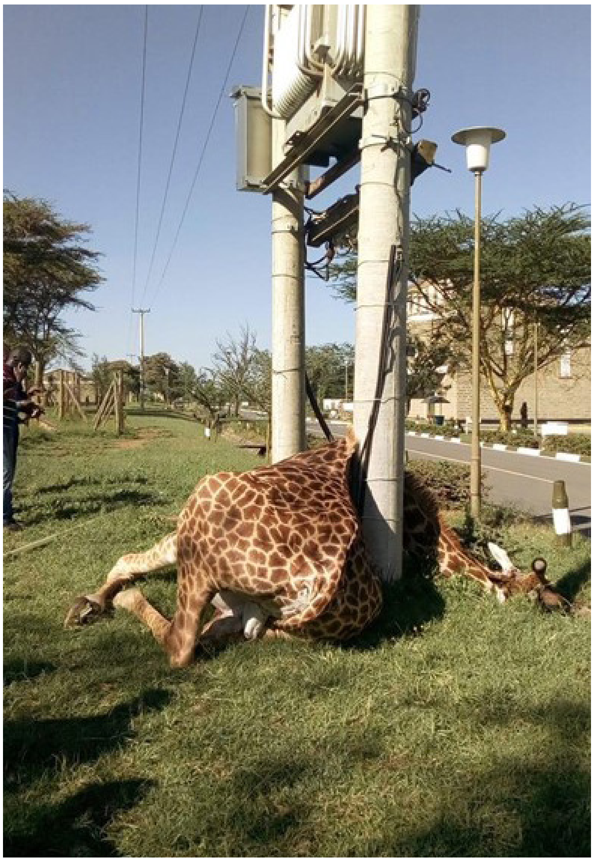
In Africa, numerous birds, reptiles, and mammals such as rodents will enter substations for shelter, roosting, feeding, and breeding. Substations are generally well lit, provide open spaces and perches for hunting, safe places for breeding/roosting, warmth generated from the transformers in the winter, and often plants that grow inside poorly maintained substations provide food for animals. Occupation of substations by wildlife can cause major problems, including electrocutions on infrastructure; the attraction of predators to the substations when birds and rodents breed; flashovers on transformers; bird pollution on hardware; and continuous maintenance requirements for substation staff. Some of these interactions may also lead to serious outages and substantial revenue loss. Please see the case study on page 83.

4.2.2 TRANSFORMER ELECTROCUTIONS

Transformers are mostly found on pole tops (distribution) and inside substations. These pose a significant electrocution risk because the casings are earthed, have numerous jumpers, exposed bushings, and other live components close 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, species such as giraffe and elephant 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 very costly exercise for the utility and will interrupt the supply to customers during repair operations.

Typical substation in Africa which often provides a safe haven for wildlife. Photo Credit: Constant Hoogstad



Rothschild's Giraffe electrocuted at a transformer in Nairobi National Park, Kenya. Photo credit: The Star

4.3 BIRD NESTING IMPACTS

As discussed in Chapter 3 (page 21), 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 and interruption of power supply to consumers, and the utility will incur additional costs for incident investigations and repairs.

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 on 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 wet nest material becomes conductive, and flashovers occur. In some cases, these incidents can cause the nest material to ignite, resulting in fires, and can cause poles to burn down completely or, in the case of transmission towers, cause damage to hardware components. These fires can also lead to bush fires that may have significant ecological and economic consequences. Apart from the cost of physically replacing the pole, the resultant veld fire may lead to expensive damage claims from landowners.

Crow's nest located above insulator on a transmission line. This nest has the potential to be problematic and cause outages. Photo credit: Constant Hoogstad

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, through their nesting behavior, cause structural damage to electricity structures. 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. Wood 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 in search of 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 the woodwork. However, field services staff report that even brand new poles are utilized. Abroad, especially in the USA, a lot of research on the problem has been conducted. There it was observed that woodpeckers prefer solid wood that is not too hard. When a woodpecker starts to excavate a hole and finds the wood 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. The fact that woodpeckers seldom reuse a hole means that one bird can create multiple cavities and cause significant damage.

Woodpeckers often make multiple holes in poles, severely compromising their stability. Photo credit: the EWT

Sociable Weavers build nests that often weigh up to 1,000 kg, causing wood distribution poles to break due to the weight. Photo credit: the EWT

Wood distribution pole destroyed by termites. This is due to the removal of the outer protective layer of creosote as a result of large mammals repeatedly using the pole as a rubbing post. Photo credit: Constant Hoogstad

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. Often linesmen are dispatched to investigate line trips without success, incurring costs in terms of time and travel, and this is a waste of these resources considering efforts could be avoided through appropriate mitigation measures. The interruption also costs the utility in terms of lost revenue and any necessary repair costs.

4.5 MAMMAL IMPACTS

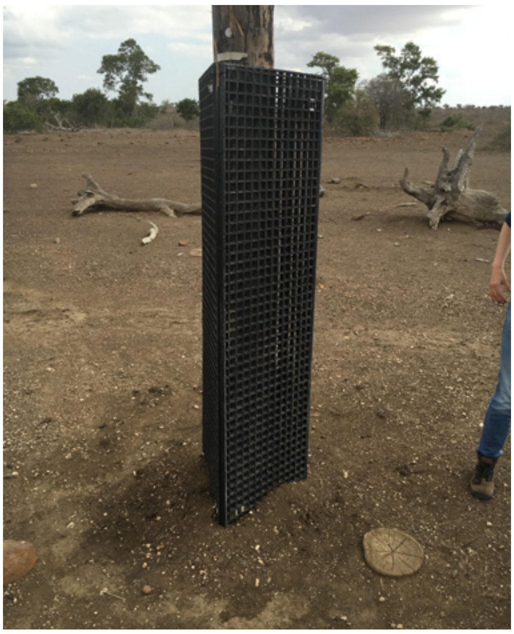
4.5.1 LARGE MAMMAL IMPACTS ON WOOD POLES AND OTHER STRUCTURES

A report produced in 2016 by the Endangered Wildlife Trust, Eskom Research Testing & Development, and Eskom Distribution Limpopo Operating Unit detailed the results of several assessments outlining impacts to the integrity of the distribution network in the Kruger National Park, South Africa. The distribution network was continually compromised due to the rubbing and horning behavior displayed by the park's large mammals. The report noted that two different types of electrical infrastructure were used within the study area; wood poles treated with creosote and steel poles. The steel poles showed no impact or signs of animal interaction, but the wood poles showed more impact than the trees around them.

Wood distribution pole compromised due to rubbing by large mammals. Note the earth wire being ripped off the structure.
Photo credit: Constant Hoogstad

A kraal being built around a wood distribution pole to protect this pole in a high impact area.
Photo credit: Constant Hoogstad

When planted, the poles used for power lines are treated to protect them from the weather, termites, and other insect invasions. Once animals such as buffalo, rhinoceroses, or birds start to 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. Once the creosote is removed, it is only a matter of time before the pole's core becomes brittle and the pole must be replaced. The report revealed that an average of 400 poles needs to be replaced in the park each year due to large mammal damage (such as rubbing), costing Eskom approximately $800,000 a year, including travel, material, labor, and specialized vehicle costs. The purpose of the report was to determine whether it would save Eskom money to implement mitigation measures on the poles, and assess the efficacy of several mitigation measures (see Chapter 5). The report concluded that placing mitigation at 400 poles can save Eskom up to $755,514 for the first year (when mitigation costs will be highest during this time) with savings likely to increase after that.



A grating box designed in South Africa to discourage large mammals from rubbing on wood distribution poles.
Photo credit: Constant Hoogstad

4.5.2 OTHER MAMMAL IMPACTS ON INFRASTRUCTURE

Chapter 3 described the different impacts that mammals of all sizes can have on electrical infrastructure and on a utility's ability to provide a stable supply of power to the 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 got into a power station in Kenya and, for 15 minutes, the entire country was left without power. That's 4.7 million households and businesses. According to 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.

> *"This monkey tripped a transformer. This triggered a cascading effect on the other generators, which ended up disrupting power generation and distribution in the whole country,"*
>
> - Kenya Power spokesman Eric Kathenya

Like birds, small mammals such as squirrels or mongoose often use substations as nesting sites. They dig large holes in the substation footprint and often climb up transformers and bridge gaps which could cause substantial damage within the substation. Porcupines also often dig under towers where the soil is a bit 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 these large towers to collapse in some cases.

Some mammals can also cause pollution and flashovers, as can some of their predators, such as genets, if they can gain access to substation yards, transformers, and pole-mounted switchgears. In 2013, the Eskom Transmission: Free State Grid requested the EWT-WEP to initiate a project to determine the extent of genet activity within the Perseus substation. A genet had been electrocuted on top of one of the transformers and destroyed the transformer, costing the utility more than $2.6 million. Please see the Perseus case study in Chapter 7.

Porcupines making burrows underneath transmission lines, as the disturbed soil is easier to dig up than surrounding areas. Photo credit: Constant Hoogstad

Photo credit: Shutterstock

4.6 IMPACTS ON RENEWABLE ENERGY INSTALLATIONS

While renewable energy impacts on wildlife are relatively well studied, examples of how wildlife impacts renewable energy installations are less common. Birds and bats for example 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 do collide with solar panels and heliostats at solar installations, but the force of these collisions is not enough to cause damage to infrastructure and live components are not affected, resulting in continued operation despite wildlife interactions.

Although the same could be said for any electricity generation plant, severe environmental impacts may draw the attention of authorities and activists, which could certainly affect operations. Site selection is important in this regard, but this is often guided by resource availability. 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. Wind energy developers should gather information on the movement patterns of birds and bats across all seasons before the final site layout is confirmed to avoid a situation where production losses are incurred later because of 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 material poses a fire risk, and maintenance time is needed to remove unwanted vegetation from hardware. Nest-related faults are common where shelter and substrate are available, and any transformer, building, or other infrastructure associated with renewable energy installations can be affected.

4.7 OVERALL COSTS OF WILDLIFE INTERACTIONS WITH ELECTRICAL INFRASTRUCTURE

When considering the financial impacts of negative wildlife interactions with electrical infrastructure, it is important to remember the process an electrical utility needs to follow when a line trip or other interruption is experienced on the network. Most of these processes are designed to ensure the safety of people in the vicinity of the hardware, and it is mandatory for the utility to investigate any incidents. In many cases, when wildlife causes a fault, there is no hardware damage and no mortality, but the utility is still required to drive out to the feeder/tower to confirm this. It is the accumulation of this hidden cost of wildlife interaction that we aim to avoid by encouraging wildlife-friendly structure designs and placement on new projects and mitigation products on existing troublesome infrastructure. This proactive strategy will help to avoid the costs of unnecessary investigations of line faults and reduce wildlife mortality and damage to hardware that would have been experienced during more severe incidents.

Unpacking the true cost of wildlife interactions can be challenging. A data set of historic interactions must be available, and even then, the estimate can only be as reliable as the data itself. The effectiveness of mitigation must also be considered if an accurate figure is sought. Landscapes, species, voltage, network reach, design, 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 study in 2005 estimated that the cost of wildlife interactions in California was between $32 million and $317 million a year, with a base case value of $34 million. These findings once again emphasized the importance of recognizing the significant influence wildlife interactions with electrical infrastructure have on utility performance and profitability.

A CASE STUDY FROM SOUTH AFRICA

Using incidents reported to the Eskom/EWT Strategic Partnership over a three-year period, it was calculated that wildlife interactions in Eskom`s distribution division amounted to approximately R48 million ($3,200,000) a year. Only incidents that were reported to the partnership and for which incident reports were generated were considered. It follows that this is a best-case scenario figure, as call-outs for linesman when no wildlife mortalities or hardware damage were logged were not included. Wood pole replacements due to woodpecker damage, termites and large mammal interactions were omitted from the assessment. The report focused on the monetary cost to the utility from resource deployment, hardware damage, and loss of income during outages. It did not cover the cost to the local economy due to outages, production losses, etc., nor did it include the cost of environmental losses such as ecosystem services offered by vultures. The report concluded that over a three year period, the cost of wildlife interactions totaled $3.4 mil per annum.

4.8 APPROACHING HOLISTIC AND SUSTAINABLE SOLUTIONS

Whatever the figure may be, utilities will likely be driven by cost reduction when considering wildlife during the design and operational phase of a transmission or distribution network. When considering wildlife interactions, utilities should focus on operational efficiency, improving the supply of electricity, and how to effectively communicate how these changes will reduce wildlife mortality.

Photo credit: Andre Botha

05 A REACTIVE APPROACH TO REDUCING WILDLIFE IMPACT ON ELECTRICAL INFRASTRUCTURE IN EAST AFRICA

5.1 INTRODUCTION TO A REACTIVE MITIGATION APPROACH

Most negative wildlife interactions with electrical infrastructure can be prevented by proactively implementing mitigation measures before, during, or after construction, but 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", and 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.

5.1.1 IDENTIFYING, RECORDING, AND REPORTING OF INCIDENTS

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 itself 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 wildlife management system 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 capture and record all incidents in a database effectively. The database should be neatly managed and standardized so that data can 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, 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

Please see *figure* on page 56 for how a customized process might work.

5.1.2 FINDINGS AND RECOMMENDATIONS

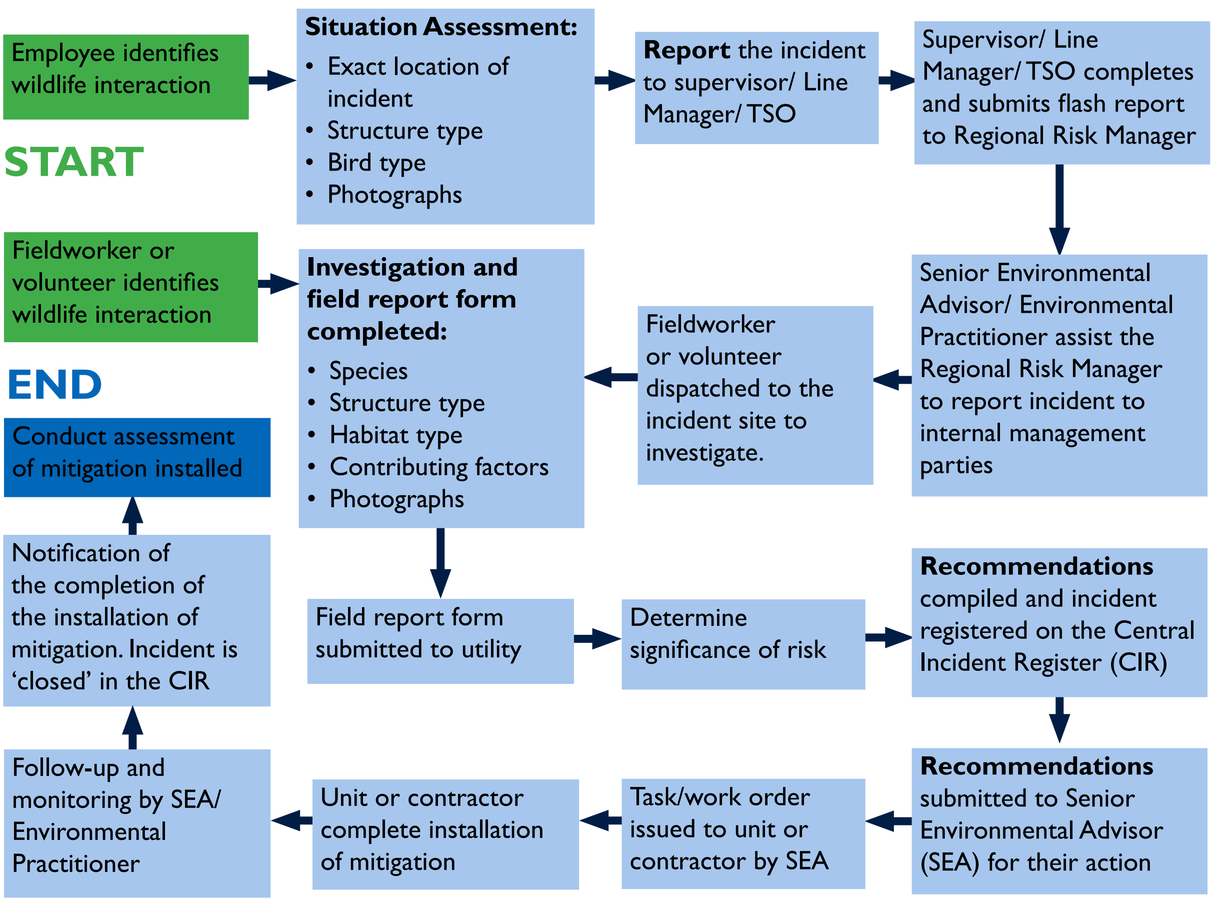
Once an incident has been captured in the system, utilities can decide to investigate the incident further or close it out. If the incident report contains enough relevant information during the reporting stage, an investigation may not be necessary. An on-site assessment could add valuable insight for 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

Upon completing the investigation, a recommendation report should be produced detailing the findings and recommended mitigation products or modifications of the hardware as appropriate. These recommendations should be practical, achievable, and aligned with internal budgets and resources available to complete the work. A variety of products is available for procurement. These products should be internally approved for use by the utility before installation takes place. See *https://powerlinesentry.com/products/* for a comprehensive list of mitigation solutions.

After mitigation has been implemented, 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.



Example of a customized incident reporting and management process

5.2 REACTIVE MITIGATION METHODS FOR BIRD COLLISIONS

As detailed in previous chapters, bird collisions with man-made structures such as communication towers, buildings, wind turbines, meteorological masts, and power lines, result in millions of avian mortalities each year. Countless studies identify and record mortalities resulting from power line collisions, but few focus on mitigation, specifically on how to measure the efficacy of mitigation mechanisms[16]. Before-after-control-impact (BACI) experiments[17] can address this gap but have rarely been implemented in avian power line collision mitigation studies.

The causes and mitigation of avian collisions with power lines can be classified under five main strategies:

5.2.1 REMOVAL OF THE EARTH WIRE, WHICH IS THE MOST PROBLEMATIC COMPONENT

Several studies identify the earth wire of transmission lines as the primary cause of collisions and that removing it can effectively reduce bird collisions[18]. However, removing the earth wire is not often feasible as it is required to shield a power line from lightning strikes.

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

Power line routing is an important consideration for any environmental impact study related to birds but is mainly feasible as a proactive measure only.

5.2.3 BURYING CABLES UNDERGROUND

Burying power lines is the most effective way of preventing bird collision mortalities but is often not economically viable.

5.2.4 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 knowing how it would affect other species, and land-use change requires support from landowners.

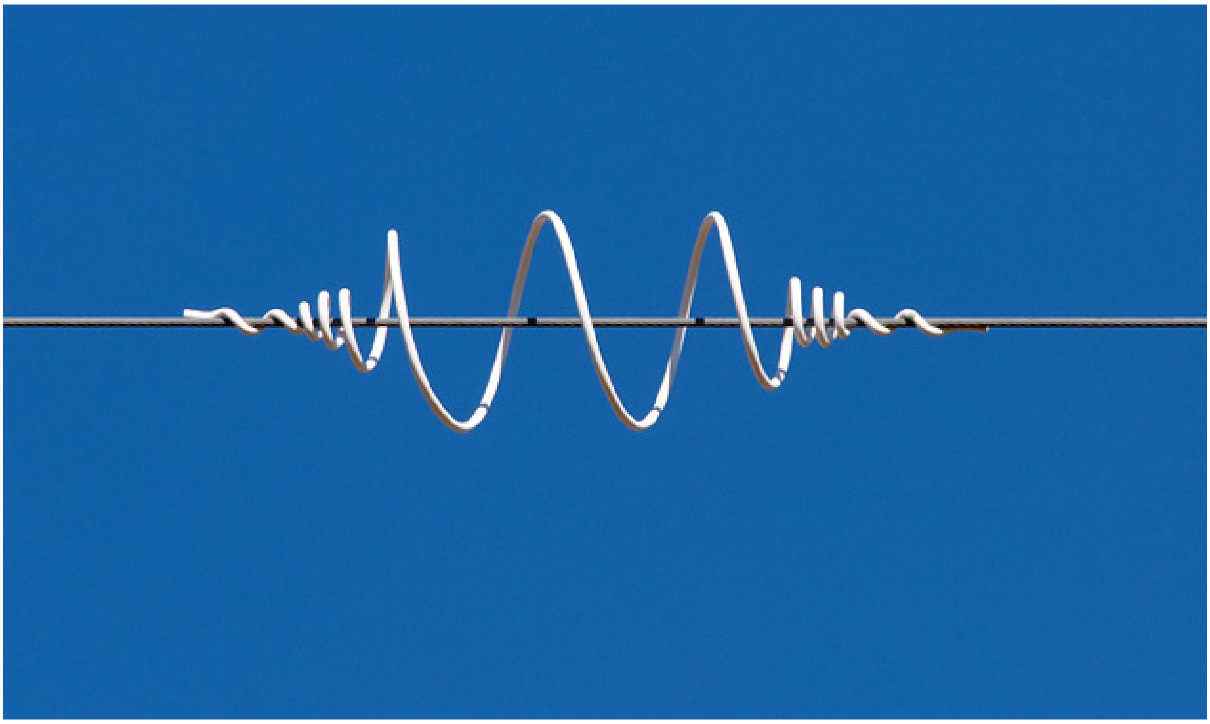
5.2.5 FITTING MARKERS TO THE EARTH WIRE OR CONDUCTORS TO IMPROVE THEIR VISIBILITY TO BIRDS IN FLIGHT

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 earth 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[19]. 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. 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[20] and distribution lines, respectively.

5.2.6 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, as discussed in Chapter 3, include waterfowl such as ducks, and flamingos, which undertake long-range flights at night[21] and Gruiformes (e.g., cranes), which tend to fly between feeding areas and roost sites at dusk and dawn. Special types of markers have been developed for nocturnal activity with phospholuminescent strips that glow in the dark or light-emitting-diodes (LEDs). The latter is effective in reducing Greater and Lesser Flamingo power line collisions.[22] 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%.

Blue Cranes passing over a Distribution line marked with bird flappers. Photo credit: Marianne Golding



A spiral bird flight diverter fitted to a Transmission line. Photo credit: Constant Hoogstad

5.3 REACTIVE MITIGATION METHODS FOR BIRD ELECTROCUTION

Electrocutions are perhaps the most well-known examples of how electrical infrastructure impacts wildlife. Here wildlife extends not only to birds but a great variety of mammal and reptile species as well. In some cases, even the most terrestrial mammals may be impacted when power poles are felled, causing conductors to break or sag. Electrocutions more commonly affect those species able to access electrical hardware at the top of structures (e.g., power poles or towers), 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, and grounded components and events are known as either phase-to-phase or phase-to-ground electrocution events. 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 we consider only the conductive parts of the animal; the wingtips of a bird are less conductive than its fleshy parts. Phase-to-earth electrocutions occur between a phase conductor and an earthed object such as a steel power pole. Phase-to-phase and phase-to-earth electrocutions can be mitigated through retrofitting existing components or by changing/replacing existing components to ones designed to increase the separation between phases and earthed components.

Raptor guards on a wooden distribution line in the USA. Photo credit: Lourens Leeuwner

5.3.1 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 to a power pole when replacing a structure is not feasible or when a temporary solution is needed to mitigate against electrocution until such time that the pole structure can be changed. These devices include insulating covers for phase conductors, transformers, jumper cables, switchgear, and various other electrical components. These covers must comply with the minimum standards of the utility and should also be guided by international guidelines such as APLIC (2006).

Raptor protectors fitted to a steel A-frame structure. Photo credit: Lourens Leeuwner

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 present 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.

Raptor protectors and insulated jumpers on a distribution pole.
Photo credit: Constant Hoogstad

5.3.2 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, 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, these should be used cautiously as they may also provide an angle where nests can be built next to the main pole.

White-backed Vulture perching on an unsafe T-pole structure with a very high electrocution risk.
Photo credit: Constant Hoogstad

5.4 REACTIVE MITIGATION MEASURES FOR BIRD STREAMERS, NESTING, AND ROOSTING

5.4.1 STREAMERS: PERCH DETERRENTS

Bird-related faults on transmission lines can be classified into three categories: streamer-, pollution-, and nest-related faults (*Chapter 2*). Bird streamers are known to be responsible for up to 38% of all faults reported from Transmission grids[23] for High Voltage Alternating Current (HVAC) lines and High Voltage Direct Current (HVDC) lines.[24]

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 grids noticed a reduction in bird-related faults where these types of perch deterrents have been installed. However, the overall fault performance statistics of transmission lines in some countries have consistently cited bird faults as the single-most frequently recorded cause. 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. Therefore, utilities must first identify the culprit species before deciding on the perch deterrent to use.

Reed Cormorant nesting on a transmission tower, causing pollution and streamer problems. Photo credit: Matt Pretorius

Bird guards placed above the center phase on a transmission tower to minimize streamer and pollution problems. Photo credit: Matt Pretoruis

5.4.2 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) may also bridge the air gap between conductors or between the conductors and the grounded structure, as described in Chapter 2.

Eagle nest on a transmission tower column. Photo credit: Ronelle Visagie

White Stork nesting on a distribution pole at the entrance to a substation. Photo credit: Eskom

To mitigate nesting impacts, utilities must consider several factors:

1. The species of bird
2. The nature and severity of the impact on infrastructure and supply
3. 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
4. The likely cause of the bird selecting to nest on infrastructure, such as a lack of natural nesting structures.

Sociable weaver nest on mast of a transmission tower.
Photo credit: John Smallie

Verreaux's Eagle on an artificial nest. This nest was successfully relocated from the top of the transmission tower to the mast.
Photo credit: Constant Hoogstad

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

i. 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 APLIC. These suggest that active bird nests should not be removed unless the species involved has been positively identified and that 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. This is, however, not recommended for active nests without confirmation of the species by an ornithologist, as some protected species may make use of the nests of other unprotected species.

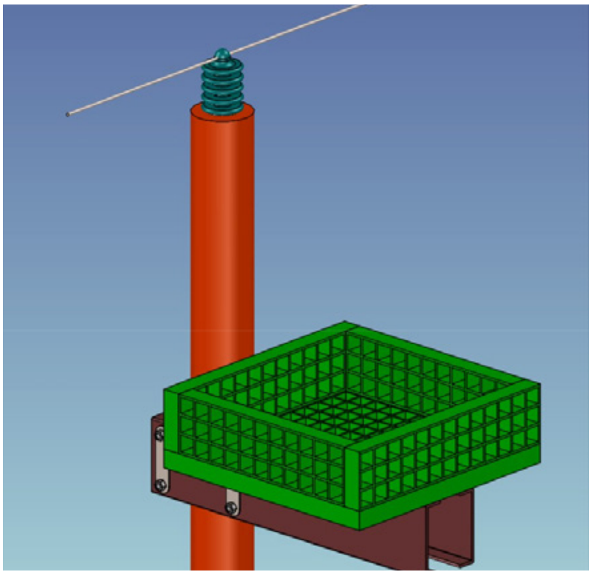
ii. Moving a nest to a more favorable location on the structure

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.

iii. 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 to them 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. 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 nest constructed from grass and thin twigs would not be well supported by a large mesh size, 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.

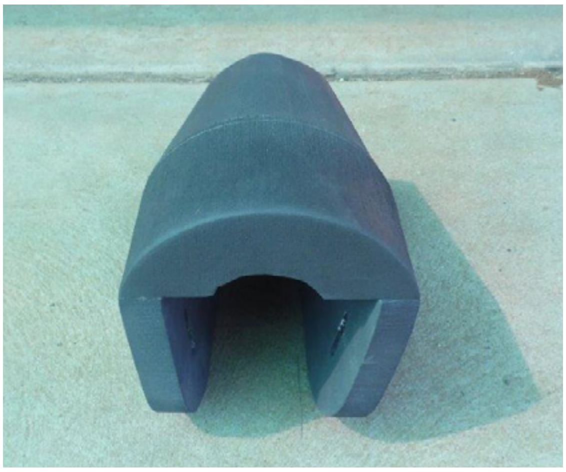
Kestrel nest located above center phase in between bird guards. It is important to ensure that products are fitted correctly and that routine maintenance is carried out. Photo credit: Constant Hoogstad



Nesting box design. Image credit: FRP Grating

iv. 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 a few examples of *nest deterrent devices*, which should be used in combination with nest removal or moving the nest to a more favorable location on the structure, such as to a nest box/platform. Specific devices are not appropriate for all structure designs, nor for all species of bird, thus tailor-made solutions may be necessary. Crow nests, for example, are not effectively managed with bird diverters.



Anti-bird nest covers to discourage the building of bird nests in substations.
Photo credit: Lourens Leeuwner

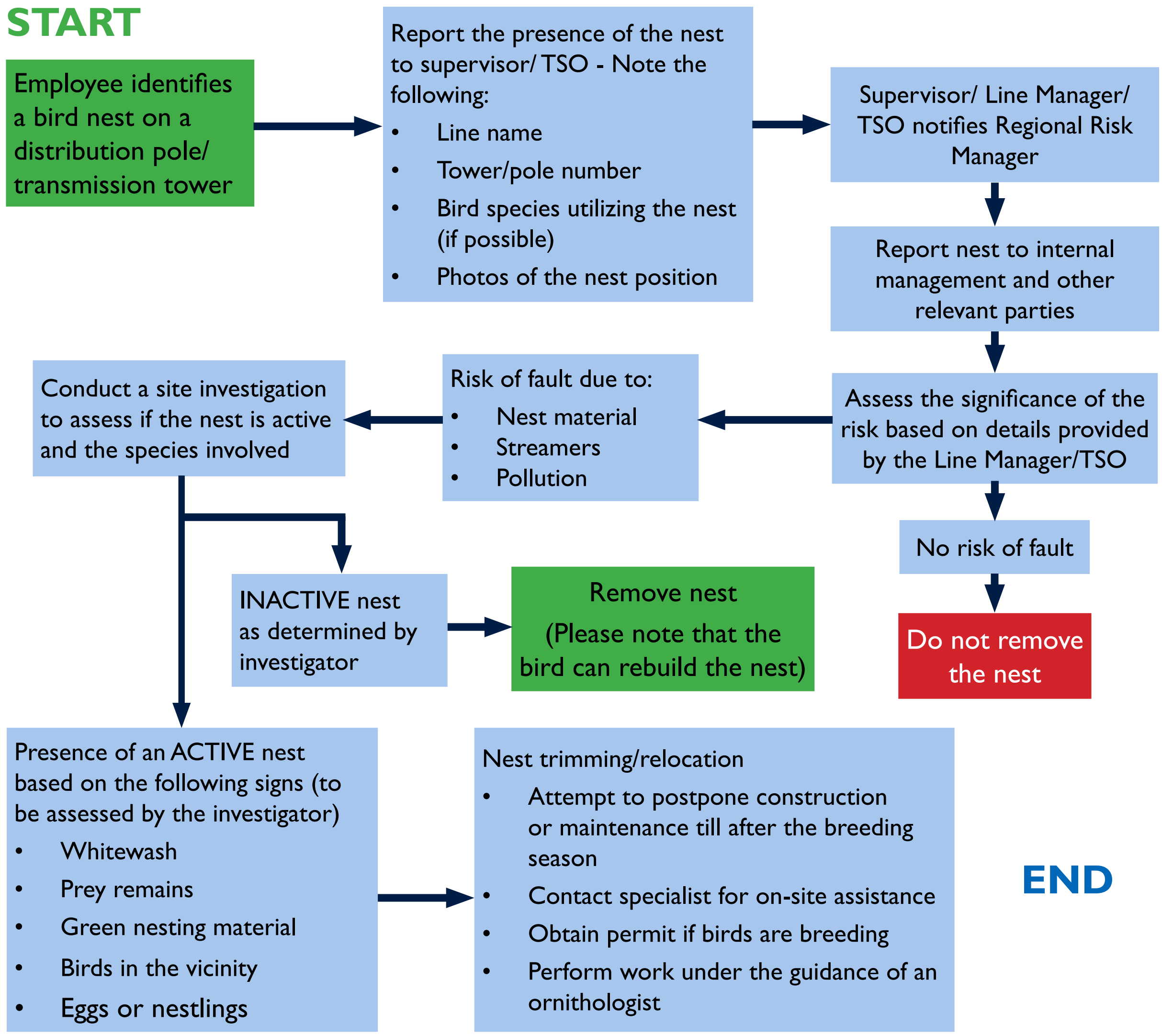
v. Provision of alternative nest structures

When a nest has to 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 still active, and there may be species-specific considerations in terms of the suitability of this option.

vi. Nest management in substations

Bird nests in substations cause significant challenges to utilities, as they lead to pollution and may draw animals that feed on them, such as snakes, monkeys, and small mesopredators (e.g., feral cats and genets), into the area (please see the *Perseus case study*). These events result in significant 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 a preventative measure. See examples of these *here*.

Bird nests are often found in substations as they provide a safe and secure location for breeding birds.
Photo credit: Constant Hoogstad



A process recommending actions to be taken when a nest is found on a power pole or transmission tower

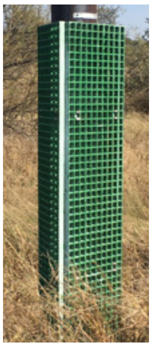
5.5 REACTIVE MITIGATION MEASURES AGAINST MAMMAL IMPACTS

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

5.5.1 REDUCING DAMAGE CAUSED TO WOOD POLES BY LARGE MAMMALS

The most obvious common impacts include damages to the (usually wood) power poles of low and medium voltage distribution lines caused by large mammals such as Cape Buffalo (*Syncerus caffer*), African Bush Elephant (*Loxodonta africana*), White Rhinoceros (*Ceratotherium simum*), and Black Rhinoceros (*Diceros bicornis*) directly impact wood power poles by rubbing against the base of the pole. One previous study[25] tested different mitigation measures to prevent large mammals from rubbing directly against wood power poles. Of the different types of coverings tested, a 'grating box' was the most cost-effective and successful option. Utilities should consider 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.

Brief comparison of the four mitigation products used to decrease the impacts on wooden distribution poles from large mammals

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 product • Difficult to inspect the pole	• Use in low impact areas	• Buffalo • Rhinoceros
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 rhinoceros and buffalo damage but needs regular checks	• Termites • Rhinoceros
Grating Box 	• Prevented direct contact with poles by buffalo and rhino • Grating allows easy inspection of the pole • Lasts > 3 years • Easy to transport • Easy to install	• Elephants could potentially affect the area above the product	• Use in areas with high buffalo impact	• Buffalo • Rhinoceros
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 • Rhinoceros

i. **Collision and breakage of conductor cables**

Some large mammals, such as giraffe, 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 consider 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. In light of reclassifications of giraffe taxonomy and recognizing distinct species and several subspecies, some threatened, utilities should prioritize minimum above-ground conductor clearance in areas occupied by giraffes.

Giraffe under power lines
Photo credit: Constant Hoogstad

ii. **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.

5.6 REACTIVE MITIGATION MEASURES FOR SMALL MAMMALS

Climbing mammals pose a significant risk to infrastructure as they readily contact multiple phases simultaneously once a pole or transformer has been climbed. 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 structure designs, 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 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 are known to 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. See *https://powerlinesentr.wpengine.com/product-category/all-line-hose/line-hose/* for examples.

Insulation covers for distribution poles.
Photo credit: Lourens Leeuwner

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

- Clearing vegetation around poles and terminating structures to prevent animals from climbing onto the structure from branches.
- Move 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.

Please see *Theewater case study* for examples of small mammal interactions with electrical infrastructure and mitigation methods used in South Africa.

Photo credit: Shutterstock

6.1 PROACTIVE MITIGATION PRIOR TO AND DURING CONSTRUCTION OF ELECTRICAL INFRASTRUCTURE

A country's environmental impact assessment (EIA) 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 in terms of potential electrocution and collision incidents. Regarding generation site developments, utilities should not underestimate the impacts of auxiliary infrastructure such as distribution lines, as with some renewable energy developments. Renewable energy auxiliary infrastructure can have a greater direct impact on local wildlife than the generation sites themselves.

The most effective proactive mitigation against 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 should it be implemented correctly. The correct implementation of mitigation mechanisms is critical during construction, as small omissions, such as forgetting to add a Basic Insulation Level (BIL) gap, can be 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 (see section 6.2.1). Some of the most important areas to avoid include 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.

Power line through a wetland
Photo credit: The EWT

A utility crew retrofitting a power line with markers
Photo credit: Constant Hoogstad

There is some evidence that collision rates of some species 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, then mitigation against wildlife collisions with power line cables should, ideally, be implemented proactively. Installing mitigation measures such as power line markers can be done during construction, which presents a significant potential cost saving when compared to post-construction installation, especially where 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. 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 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 there is a variety of threatened species 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.

Some countries require that full EIA protocols/studies only be implemented for new high voltage power lines. Consequently, many low-and medium-voltage distribution lines have significantly impacted certain species in areas where developments would have been flagged if similar protocols to those implemented 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 provide a means of rapidly assessing the potential impact of new developments on the species present in an area, given the nature of the development. Utilities looking to mitigate their impacts on wildlife proactively may contribute to the development of similar tools.

An example of a proactive approach to the placement and construction of wind energy infrastructure is the comprehensive Strategic Environmental Impact Assessment Study (SEIAS) for all wind power projects in Kenya. The study, funded by Power Africa and conducted by an NGO consortium led by The Biodiversity Consultancy (TBC), focused on the impacts of wind energy infrastructure on birds. Power Africa and USAID Kenya also facilitated a Biodiversity Action Plan to understand, reduce, and compensate for the possible impact of wind turbines on vultures and other raptors at the Kipeto site in 2018; the project was commissioned in 2021. Please see Chapter 7 for a case study on these processes in Kenya.

6.2 PROACTIVE MITIGATION AGAINST NEGATIVE WILDLIFE INTERACTIONS WITH EXISTING ELECTRICAL INFRASTRUCTURE

6.2.1 UNDERSTANDING WILDLIFE INTERACTIONS WITH ELECTRICAL INFRASTRUCTURE

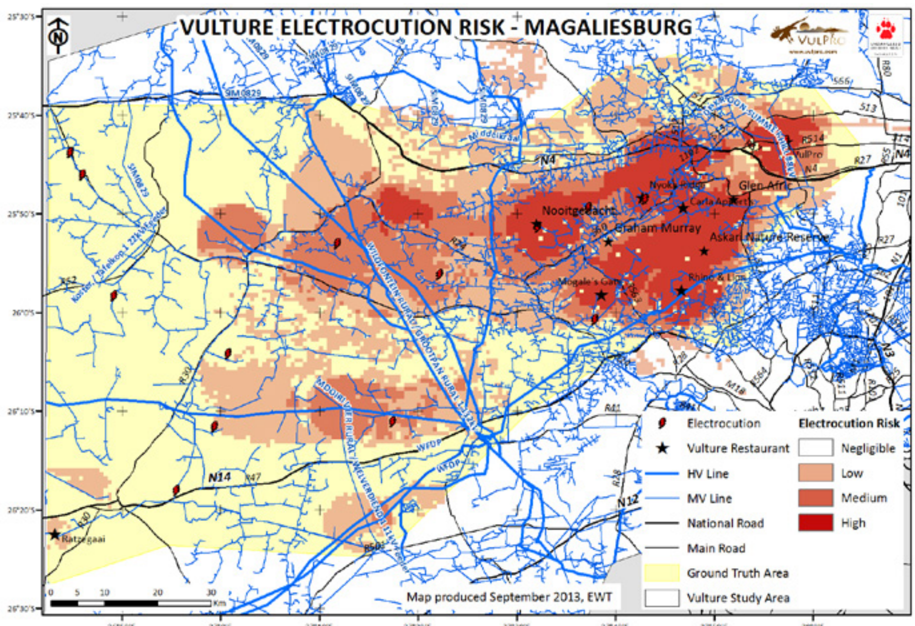
A proactive mitigation strategy must be informed by existing knowledge of the species negatively affected by electrical infrastructure and the interactions that lead to incidents. Utilities require at least some knowledge of previous and existing incidents, and these data should be collated and recorded in a national database (for more information about this, see Chapter 5). 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 distributions 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[26]:

$$R = HSI + \text{Exposure}_{\text{species}} + \text{Exposure}_{\text{threat}}$$

- Where R represents the risk (of electrocution or collision) posed to a species
- *HSI* is a habitat suitability index (identified by species distribution models)
- $\text{Exposure}_{\text{species}}$ represents morphological and behavioral aspects related to the species
- $\text{Exposure}_{\text{threat}}$ 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.)

Habitat suitability and species distribution

SDM maps/models are informed by records of sightings and encounters with the species in question, and these 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).



A map developed by the Endangered Wildlife Trust and Vulpro in 2013 to quantify the electrocution risk that the types of power lines pose to the existing vulture populations within the Great Magaliesburg Area in South Africa.

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[27], on which the machine learning algorithms of the program MaxEnt are based. 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 only affords relatively inaccurate records than the actual GPS coordinates of sightings, the accuracy required is determined by the scale at which SDMs are generated. 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.

A Cape Vulture fitted with a GPS tracking device to collect movement data that can help to supplement national atlas data for developing Species Distribution Models and electrocution risk maps for the species. Photo credit: the EWT

Bird guards fitted to a transmission tower by a live line team.
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[28]. 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[29]. 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[30]. 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 from which to spot prey. This strategy places them at greater risk of electrocution than species that hunt on the wing, as the time they spend on potentially dangerous structures is far greater. 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.

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. 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.

A power line through a wetland in south-western Uganda. Photo credit: The EWT

Aviation balls are fitted to power lines to make the line more visible for aircraft but are also effective in preventing bird collisions. Photo credit: Marianne Golding

6.2.2 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 are known to 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 are critical for determining the resources required to execute a proactive mitigation plan. Concurrently, utilities should record mitigation already installed to avoid prioritizing areas previously mitigated. As design standards improve with respect to the threat 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.

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 the establishment of 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 accuracy of line selection for implementation.

Maintenance on wood distribution poles in a National Park. Photo credit: Constant Hoogstad

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 and 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.

6.2.3 DEVELOPMENT AND IMPLEMENTATION OF A PROACTIVE MITIGATION PLAN

1. 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.

2. 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 can 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.

3. Depending on the existing infrastructure, species affected, and faults experienced, implementation costs will vary greatly. 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. When electrocutions and line faults have been identified as a priority, retrofitting structures or pole top replacements will be required. 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.

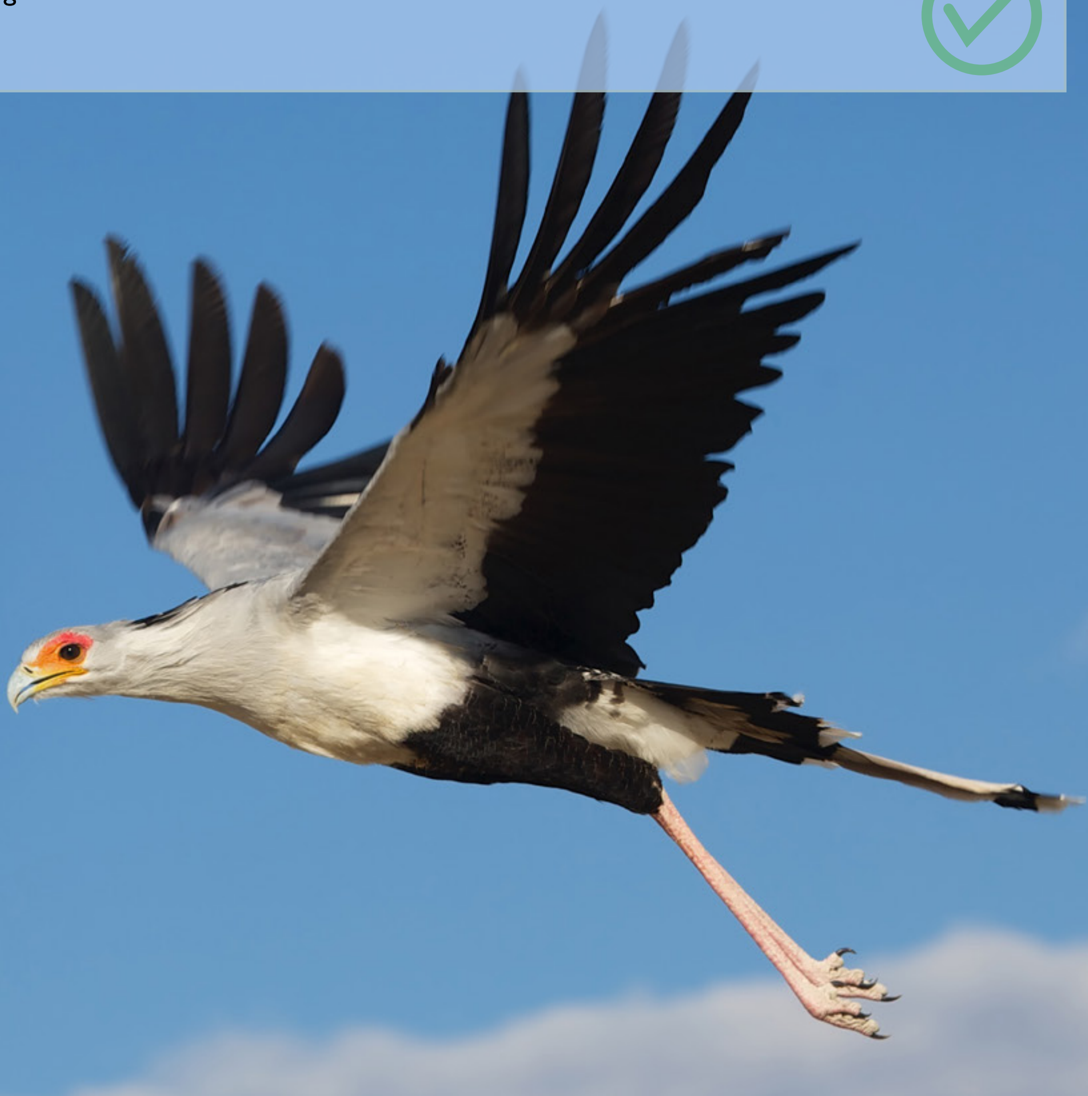
To track the performance of respective sectors, utilities should review proactive targets annually and adapt as required. Detailed records of mitigation completed will assist the utility in tracking the strategy's progress and aid in future planning. Line performance should be monitored across feeders where mitigation has been completed to illustrate the improvement in line performance, which could be used to motivate for additional budget and acceleration of the strategy

Photo credit: Marianne Golding

A HANDY CHECKLIST FOR PROACTIVE MITIGATION

1	There is an understanding in the business that wildlife interactions can cause interruptions to power supply, additional maintenance costs, damage to hardware 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.	✓
9	When new lines are designed, the relevant information is used to determine what wildlife species in the area 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	✓



07 CASE STUDIES AND LESSONS LEARNED

7.1 INTRODUCTION

The EWT-WEP was established in 1994, and in 1996 a formal strategic partnership was established between the EWT with the local utility in South Africa, Eskom. Initially, the partnership focused on Endangered birds killed on 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 and addresses numerous issues around biodiversity-related impacts. As of 2021, more than 3,800 wildlife and energy-related incidents have been reported to the partnership, encompassing 160 different species. Of these reported incidents, 2,345 were investigated, and 1,771 recommendations were issued by the EWT to Eskom, as mentioned in the chapters above and the case studies that follow. 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 of Emirates, Hungary, Poland, and Jordan.

Due to the varying nature of incidents, the partnership cannot treat every incident equally, and some

warrant a more detailed or "special investigation". These special investigations often lead to the launch of research projects where the reports and write-ups are given in lessons learned/special investigation documents. These documents enable the partnership to ensure that these unique incidents are captured. Additionally, the information is distributed so that utilities across the globe can learn to improve utility performance and reduce their impacts on biodiversity. The EWT-WEP also prevents duplication and "reinventing the wheel" for incidents of a similar kind that might occur and leave a lasting legacy for future use.

This chapter contains only a sample 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 to implement measures to reduce their conservation impact from the start of a project and monitor those long-term to adapt their management actions accordingly.

7.2 CASE STUDIES

CASE STUDY: BABOON ELECTROCUTED AT SUBSTATION

Place

Theewater Substation, Grabouw, Western Cape, South Africa

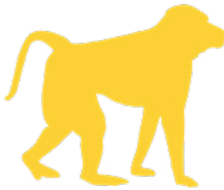
Date

Interaction

Electrocution

Class

Mammal



Type of infrastructure

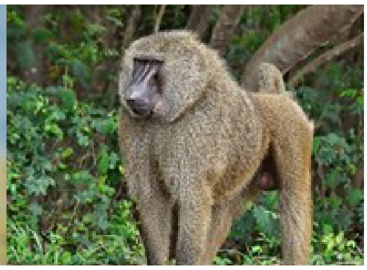
Substation

Species

Chacma Baboon

Similar species in East Africa

Olive Baboon



Background

The EWT-WEP conducted a special investigation to assess the Chacma Baboon electrocutions in South Africa's Theewater substation – Grabouw CNC.

Incident reports

<u>27 May 2012</u>

"*A baboon was found dead below the transformer. Klue was dispatched to a fault and, on arrival, he found the 66 kV load break switch and MV transformer breaker open.*" (Eskom report)

<u>21 June 2012.</u>

"*The 66 kV bank breaker opened, 11 kV breaker and 66 kV load breaker transformer 2 at Theewater substation tripped. The operators found a live female baboon with electrical burns marks on the right front limb. She ran away as the operator got there.*" (Eskom report)

Baboon fur remaining after the baboon was electrocuted.

Biological and ecological risk factors

Baboons climb trees to give themselves a vantage point to see and some protection from predators. Transformers and electricity poles and towers serve the same purpose and so are often used where trees are scarce.

Baboons are omnivorous and, under natural conditions, they feed on wild fruits, seeds, insects, scorpions, and sometimes small mammals and birds. Because troops are inclined to raid commercial crops, baboons are not popular with maize and fruit farmers.

Baboons also often enter substations to feed and, in some cases, may even roost/sleep in substations as they provide safety from natural predators.

Investigation and findings

Perimeter fencing: There was a lot of evidence that the baboons entered the substation by climbing over the fence at fence post/gates. Additionally, there was evidence of the baboons crawling underneath the fence.

Insulation: There is currently no insulation on the live components within the substation.

Vegetation found inside the substation: It was discovered that there was quite a lot of vegetation inside the substation. Upon closer investigation, it became evident that the baboons actively dig up a certain thistle species inside the substations to consume the roots. This could be one of the reasons the baboons are attracted to the substation.

The section of the fence the baboons use to enter and exit the substation.

There is currently no insulation on the live components within the substation.

The thistle plant that the baboons seem to be after inside the substation

Recommendations

Based on the investigation results, it was recommended that a combination of all the mitigation methods mentioned above be used to eliminate the risk of future electrocutions.

1. Vegetation management inside the substation: The large amount of vegetation inside the substation was assumed to be the main reason for the baboons entering the substation. The baboons appeared to prefer some of the vegetation types inside the substation as a food source and these should be eliminated. Utilities should provide maintenance of the substation on a more frequent basis, using herbicides to eliminate the vegetation where needed.

2. Electric fencing: The fence around the Theewater Substation is up to standards. A possible improvement would be to add a tripwire structure along the outside of the internal electric fence. This could prevent baboons from crawling underneath the fence. It is recommended that the tripwire be placed one meter above the ground, extending from the electric fence at a 45-degree angle from the pole.

3. Insulation of live components: This is generally an expensive but effective exercise. Please see below several examples of insulation installed in substations in different areas around South Africa.

4. Using animal guards: Animal guards have also been used successfully across South Africa to avoid small mammal and primate electrocutions. These products are available from 3M.

CASE STUDY: GENETS ELECTROCUTED AT SUBSTATION

Place

Perseus Substation, North-West Transmission Region, South Africa

Date

Interaction

Electrocution

Class

Mammal

Type of infrastructure

Substation

Species

Small-spotted Genet

Similar species in East Africa

Large-spotted Genet

Background

Genet electrocutions in South African substations are common and cost the utility millions of Rand annually. Eliminating or reducing the electrocution of animals such as genets could lead to significant savings in equipment repair costs and fewer outages.

Incidents report

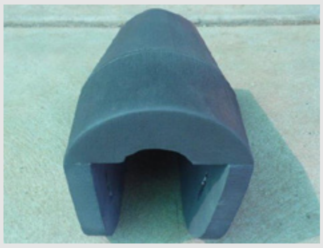
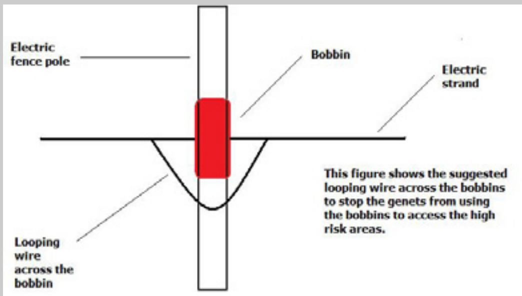
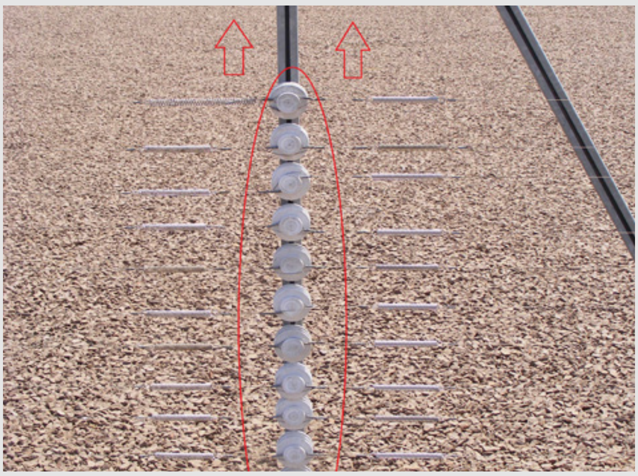
During October 2013, the EWT-WEP was requested by Eskom Transmission: Free State Grid to initiate a project to determine the extent of genet activity within the Perseus Substation located 1 km outside Dealesville, Free-State Province, South Africa.

Biological and ecological risk factors

Genets are cat-like animals with long, slender bodies, short legs, and long tails, which easily squeeze through any opening larger than their head and spend much of their time on the ground hunting prey and taking shelter in escarpments and rocky outcrops. Genets are also effective climbers and climb trees to find food in the form of nesting birds. It can be reasonably assumed that the genets are attracted to the electricity infrastructure due to the presence of roosting and nesting sparrows and pigeons, as these form part of their natural prey. They are predominantly nocturnal and climb onto equipment, as they would climb a tree, to reach nesting and roosting birds, causing flashovers within substation yards, on transformers and pole-mounted switch-gears.

Investigation and findings

Part of the problem appears to be the presence of prey in the substations, specifically bird nests, as the substations provide a safe and ideal nesting site for many bird species and small mammals such as bats and rodents.

Contributing factors	Description of the problem	Recommendation
NESTING OF BIRDS	Both Rock Pigeons and Cape Sparrows prefer to nest on top of the electrical infrastructure itself. The nests lure the genets onto the high-risk areas, often resulting in electrocution and an electrical fault.	Bus bar outages have been identified across substations. There is a direct correlation between bus bar outages and bird nests. Some business units installed anti-bird nest covers (shown below) in a number of 275 and 400 Kv TFZ type isolators with great success. The insert below is fitted into the female part of the contact head and takes up space to prevent any bird from constructing a nest. The insert is fire retardant and must not come into contact with any grease or oil. Handling and inserting the inset must be done with clean hands. The anti-bird nest covers can be adjusted to meet various requirements and target specific areas where birds nest 
PERIMETER FENCES	The gap between the ground and the bottom strand of the electric fence allows genets to move freely into the substation with their slender and flexible bodies.	The perimeter fence meets all required regulations, but because of its size it will be difficult to keep genets out on a continual basis. As the genets may climb the bobbins to enter the substation, it is recommended that the electrified steel strands be looped around the bobbins to impede the genet's ascent of the fence. 
INTERNAL FENCES	The internal electric fences have bobbins on each strand at certain sections of the fence. Genets use these bobbins to climb the fence as they are insulated from the electrical current.	The internal fences within the Perseus Substation yard are up to standards. A possible improvement would be to add a tripwire structure along the outside of the internal electric fence. 

Contributing factors	Description of the problem	Recommendation
BUILDINGS WITHIN THE SUBSTATION	The buildings within the substation have electric fencing over them to protect high-risk areas. However, there are gaps between the fencing and the building itself. As genets are agile climbers, they may be able to reach the roof and then use their flexibility to slip underneath the fencing.	Decrease the gaps between the fencing on the building. As shown below, a thorough assessment around every yard needs to be conducted in order to determine potential gaps in the fencing. 
LIGHTS	There are floodlights providing lighting within the substation. The lights would attract many insects, and because insects also form part of the staple diet of genets, they may be an additional attraction.	A potential solution to the problem would be to use yellow bulbs that have been designed to stop insects from flying to the light. Low color temperatures are red-yellow and exhibit a long wavelength, while high color temperatures are blue-violet and exhibit a short wavelength. Using a yellow bulb decreases the color temperature and the wavelength to a spectrum unseen by insects. These have been proven to be effective and, although they won't eliminate the problem, they are an option to decrease the numbers of bugs. 
BATS	Bats are actively roosting in the buildings within the substation. Bats are a known food source for genets, which may also attract genets to the substation.	The option of bat boxes can be explored, but there is no guarantee that the bats will move into these bat boxes. In order to get the bats to relocate to these boxes they would need to be evicted from their current roosts in the roofs. There are strict protocol for the eviction of bats that differ between countries. Consult your national guidelines before moving or touching bats.

Photo credit: Shutterstock

Photo credit: Steve Samoray

Additional recommendations

Installing animal deterring fences

TransGard animal deterrent system. Photo credits: The EWT

Bird-proofing the substation's infrastructure would address the root cause of the problem, however, this is a difficult task, and there are currently no products that are proven to be effective in South Africa. Therefore, utilities should install specialized animal deterring fences to prevent genets, cats, and other animals from entering the substation. The existing fences can be upgraded using TransGard Systems (http://www.transgardfence.com/), which provides animal deterring fences that can be placed within the existing perimeter fencing. It is important to note that the fences should, at a minimum, surround any infrastructure (e.g., support cables) that could provide a bridge into the area containing the critical components such as the breakers and transformers. These systems have a proven track record of excluding similarly-sized arboreal and terrestrial mammals from nearly 2,000 substations in the United States of America. Perseus Substation would be the ideal site to be the first to test these systems in South Africa.

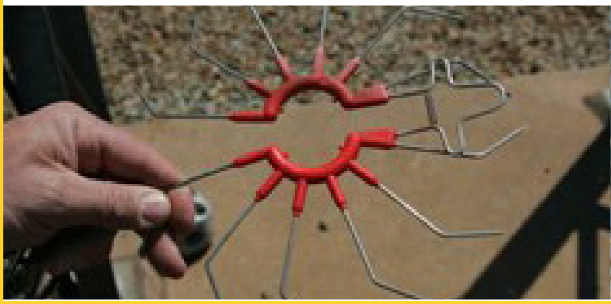
Insulation

Insulation of the bushings inside a substation. Photo credit: The EWT

Insulation is also an effective remedy, provided it is applied correctly. The insulation must extend beyond the bushings and also cover part of the conductor to prevent a genet from reaching across and causing a short circuit. There is a range of products available from various suppliers, including 3M and TYCO. However, since utilities cannot predict where a genet is likely climb, it will be necessary to insulate most of the critical live hardware in the substation, which will be a costly exercise. Insulation of this type has been employed at substations in the Eastern region with huge success. Due to the sheer size of Perseus, it is recommended that the region engages with the suppliers directly to determine the best way forward at the least cost.

Electrostatic Animal Guard or Squirrel Guard

The effectiveness of the 3M Electrostatic Animal Guard (see below) may be influenced by the position of guard placement on the bushings. It is recommended that the guard be placed near the top of the bushings to prevent an animal from reaching across it. The addition of squirrel guards may add to the device's effectiveness by preventing the animals from reaching across the bushing.



CASE STUDY: AMANDEL-THABAZIMBI POWER LINE, VULTURE INTERACTION

Place
Northern Region,
Thabazimbi Technical Service Centre,
South Africa

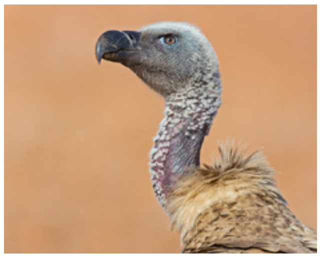
Date
December 2009

Interaction
Roosting and streamers (suspected)

Class
Birds

Type of infrastructure
Amandel-Thabazimbi 132 kV

Species
Cape, Lappet-faced, and African White-backed vultures



Background

The EWT was first alerted to the unexplained excessive faulting problem on the Amandel-Thabazimbi 132 kV power line in May of 2001.

Biological and ecological risk factors

- An active vulture restaurant is less than 1 km from the Thabazimbi Combined substation, where hundreds of vultures (Cape, Lappet-faced, and African White-backed vultures) and other large scavenging birds (i.e.,Marabou Storks) are fed regularly.
- Portions of the line are located on cattle and game farming properties where an abundance of carcasses is available year-round. Furthermore, the vulture restaurant at Thabazimbi is a dependable, year-round source of food that draws hundreds of vultures to the vicinity of the line weekly.
- The Amandel-Thabazimbi Combined 132 kV power line is located within one of the densest vulture populations in the country and is within easy reach of foraging Cape Griffons from at least three breeding colonies at Marakele, Nooitgedacht and Scheerpoort.

Birds can cause faulting on sub-transmission lines in three major ways: (i) through streamers, (ii) by polluting insulators, and (iii) by getting electrocuted.

Following an investigation of the daily fault reports and a site visit to the area, the following conclusions were reached[31]:

- The most likely cause of unexplained, night-time faulting on the Amandel-Thabazimbi Combined 132 kV power line was bird streamers produced by large birds, particularly vultures, perching, and roosting on the towers. Streamers that bridge the entire distance, or sufficient part thereof, between the earth plane (the steel tower and the bird perched on it above the insulator) and the nearest live hardware point, acts as a fuse and a transient earth fault occurs.

The investigation team recommended that:

The Amandel-Thabazimbi Combined 132 kV power line be fitted with bird guards to prevent vultures from perching and roosting on the structures.

Subsequent investigations in 2003 and 2006 in response to continued faulting concluded that the bird guards installed had failed, likely for the following reasons:

- Incorrect initial placement of the bird guards left perching space for vultures between the guards, with areas that should have been covered left open.
- The plastic bird guards fitted were not able to withstand the impact of these large birds.

Three mitigation options were then recommended:

- Relocate the vulture restaurant
- Use steel bird guards that are bolted to the tower
- Improve insulation of live components

Further incidents reported in 2009

- Two major faults were recorded on the Amandel-Thabazimbi Combined 132 kV power line in August 2009 and September 2009 due to an insulator failure and subsequent loss of one phase and the loss of both earth/shield wires, respectively.
- It was reported that the failure of the earth/shield wires was an ongoing problem on this line.
- Daily fault reports for the last three months (September, October, and November 2009) do not include the Amandel-Thabazimbi Combined 132 kV power line. Fault data obtained from the customer (Anglo Platinum) referred to the Amandel 11 kV and 33 kV power lines, and not the Amandel-Thabazimbi Combined 132 kV power line.
- It was reported that the failure of the earth/shield wires was an ongoing problem on this line.

The EWT investigated again in December 2009 and found that:

It was evident that the line was being used by roosting and perching vultures and other large birds.

- Indications of vulture presence recorded included feathers found along the line at several places, damaged bird guards (Figure 1), verbal accounts from the staff.
- Approximately five towers near to the substation showed evidence of bird pollution. However, the insulators on the previously mitigated section of the Amandel-Thabazimbi Combined 132 kV did not appear to be as heavily polluted as these others structures, suggesting that the previously installed bird guards were having some effect (Figure 2).
- The earth/shield wire appeared burnt upon inspection (Figure 3), supporting reported failure of these wires

Figure 1: The bird guards supplied by Mission Technologies were not able to withstand the impact of large vultures. Photo credit: the EWT

Figure 2: The insulator stings were not heavily polluted, suggesting that the bird guards were at least somewhat effective. Photo credit: the EWT

After considering the characteristics that manifest when bird streamer faults take place, the following conclusions were drawn:

Figure 3: The earth/shield wire appears burnt. Vulture activity is unlikely to cause this type of damage.

- Seasonal faulting: Without reliable fault data for the line over the full period in question, it was impossible to assess the seasonal faulting pattern.
- Due to the lack of fault data available, the section(s) of the power line that experiences most faults could not be identified.
- Distinctive fault marks: Unfortunately, time constraints did not allow for careful inspection of each tower, and many of the towers were very old and badly coated with bird excreta, making the identification of flash marks very difficult.
- Tower design: The existing bird guards still provided ample space for vultures to perch above the conductors where streamers can easily bridge the air gap. Being 132 kV lines, the air gap would have been a maximum of 1.2 meters, which can easily be bridged by a vulture that produces streamers of over two meters. Even a vulture sitting on top of the tower would be able to flash the line in this manner. A Cape Vulture has been recorded on film producing a streamer of 2.4 meters (Piper 2004).
- A vulture could perch above the earth peak unhindered and even sit further down on the bird guards, some of which had been unnecessarily fitted to the sides of the towers (Figure 4).
- The earth/shield wire(s) failure could not be attributed to vulture activity on the power line. The burn marks on the wire suggested that this may be an electrical issue rather than a biological one.

Figure 4: Bird guards were not been installed on the top cross arm to protect the earth peaks. Also note that the bird guards have not been installed at the end of the structure to protect the insulator string. Photo credit: The EWT

Figure 5: Vultures perching on the Amandel-Thabazimbi power line structure. Photo credit: The EWT

In summary, neither of the 2009 faults reported could be attributed to vultures roosting on the line.

Recommendations

Based on the results of the 2009 investigation, the following recommendations were put forward:

- **Reinstall bird guards above critical spaces.** The EWT recommended that the bird guards currently installed be removed and replaced with a stronger product, e.g.,those manufactured by Bee Tee Projects. The EWT strongly advised that this be done in close collaboration with the EWT to ensure that all critical areas on each tower was adequately covered. Bird guards were to be installed on both the top and bottom cross arms.
- **Insulate** a two-meter section of the conductor on both sides of the insulator strings and provide additional protection from streamers by fitting shields over the insulator strings. This option had been tried in Israel with success, where a similar problem was experienced with Black Storks on a 160 kV line.
- **Relocate the vulture restaurant.** This option would not be easy to implement as the mine has invested in a permanent hide where people can view the vultures, and this may hamper the restaurant's relocation.

References and resources

Piper S.E. 2004. Electrical, chemical and biological characteristics of excreta streamers produced by large birds. Report No. RES/RR/00/. Eskom Resource and Strategy Division.

Van Rooyen, C.S. Vosloo, H.F. & R.E. Harness. 2002. Eliminating bird streamers as a cause of faulting on transmission lines in South Africa. IEEE 46th Rural Electric Power Conference. May 2002. Colorado Springs. Colorado.

CASE STUDY: KIPETO WIND FARM COLLISIONS

Place

Kipeto Wind Farm, Kenya

Date

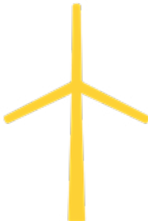
Interaction

Collision

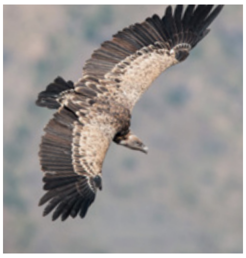
Class

Birds and bats

Type of infrastructure



Rüppell's Vulture



White-backed Vultures

Background

In late 2015, two vulture species native to the Kipeto Wind Farm project site in Kenya, the Rüppell's and White-backed vultures, were upgraded to Critically Endangered on the IUCN Red List of Threatened Species. The presence of these species within Kipeto's project area qualifies the area as critical habitat. To align with International Finance Corporation's Performance Standard 6, the project was required to apply a mitigation hierarchy to avoid, minimize, restore, and, where necessary, offset the biodiversity impacts. At the request of the developer, *Power Africa and USAID Kenya facilitated a Biodiversity Action Plan* to understand, reduce and compensate for the possible impact of wind turbines on vultures and other raptors at the Kipeto site. Coupled with a Power Africa-funded *Strategic Environmental Impact Assessment Study (SEIAS)* for all wind power projects in Kenya, focused on the impacts on birds, this action plan was instrumental for Kipeto to foster goodwill and secure necessary community and environmental approvals. The SEIAS will also benefit the planned phases two and three of the Kipeto project, as well as all the other wind power projects in Kenya based on the lessons learned from the action plan.

Investigation and findings

With Power Africa's support, an NGO consortium led by TBC on behalf of the Kenyan Ministry of Energy (MoE) released a public draft of the Strategic Environmental Assessment (SEA) for Wind Energy and Biodiversity in Kenya. Conducted over the past year, the SEA assessed the biodiversity-related impacts of wind energy development nationally, considering current, planned and potential projects, to ensure that the developments are aligned with the relevant Kenyan national policy, plans, and programs, while functioning as a proactive decision support instrument with recommended mitigation and monitoring strategies for current and future wind power developments. The SEA drew upon the expertise and resources of bird and bat experts (notably from BirdLife International, National Museums of Kenya, Nature Kenya and The Peregrine Fund) to collate existing data and generate supplementary new data through field surveys and bird tagging. Through sensitivity mapping of bird and bat habitats and flight patterns, the SEA demonstrated that most areas where wind farms are feasible display biodiversity risk of low or manageable thresholds, predominantly in the northern and eastern counties of the country. However, there are also areas with planned wind developments of very high sensitivity for flying species in some key counties where wind power development is prominent.

The SEA represents a major first step in advancing our understanding of the environmental risks of wind power development in Kenya while also providing key tools and resources for safeguarding flying species. Stakeholders across the African energy sector can now employ the insights from this assessment to advance wind power planning and development that minimizes risk to vulnerable birds and bats while also increasing access to electricity more sustainably.

Recommendations

An SEA of potential wildlife impacts in areas slotted for wind development can provide maps that reveal to government and industry which sites will achieve the highest wind resources and lowest wildlife impacts. In this way, utilities can reduce project risk to reach the financial close of new projects and achieve greater project sustainability through reduced long-term mitigation costs.

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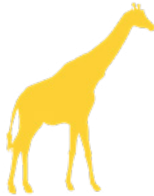
CASE STUDY: SOYSAMBU CONSERVANCY ELECTROCUTION OF ROTHSCHILD'S/NUBIAN GIRAFFE

Place	Date	Interaction	Class
Soysambu Conservancy, Kenya		Electrocution	Mammal



Rothschild's/Nubian Giraffe

Type of infrastructure

Distribution Power lines

Background

In 2010, Rothschild's Giraffe was classified as Endangered and of high conservation importance on the IUCN Red List. According to a recent genetic study by the Giraffe Conservation Foundation, the Rothschild's Giraffe is now considered the Nubian Giraffe *G. c. camelopardalis*, a subspecies of the Northern Giraffe. Before the inclusion of Rothschild's Giraffe, the Nubian Giraffe was classified as Critically Endangered. Since Rothschild is now classified as Nubian Giraffe, a new assessment of the species will need to be done. The current estimate of Nubian Giraffes is 2,160 individuals, ranging across eastern South Sudan, western Ethiopia, northern Uganda, and west-central Kenya, with approximately 650 in Kenya.

Soysambu Conservancy currently hosts a population of approximately 140 giraffes. In 2011, eight Soysambu Rothschild's giraffes were successfully translocated to Ruko Conservancy on Lake Baringo. In 2016, a further eight giraffes were translocated to Rimoi National Reserve in the Kerio Valley and, in 2020, two giraffes were translocated to Solai Sanctuary. As of February 2021, there were 57 males, 56 females, and 27 juveniles. Soysambu Conservancy is improving Kenya's Nubian Giraffe population.

Incidents reported

On 19 February 2021, two of the male Soysambu giraffes were found electrocuted. The next day, another male was found electrocuted at the same location.

Biological and ecological risk factors

As discussed in Section 2.2, giraffes can be electrocuted by power lines less than 5.8 m above the ground for a 22 kV

Soysambu Conservancy - Rothschild's Giraffe Electrocution Deaths (2003–present)

Giraffe ID	Year	Cause	Structure	Location
Adult Male	2003	Translocation	Power line	Undisclosed
Adult Male	01.08.2007	Electrocuted	Pipeline/Powerline	Undisclosed
Adult Male	01.08.2007	Electrocuted	Pipeline/Powerline	Undisclosed
Adult Male	01.08.2007	Electrocuted	Pipeline/Powerline	Undisclosed
M032_Mbugua	07.12.2014	Electrocuted	Pipeline/Powerline	Undisclosed
M052_James	27.09.2017	Electrocuted	Pipeline/Powerline	Undisclosed
M031_Argos	27.08.2018	Electrocuted	Pipeline/Powerline	Undisclosed
M012 Fabrice	29.04.2020	Electrocuted	Pipeline/Powerline	Undisclosed
Juvenile	01.06.2020	Electrocuted	Cultivation Fence	Undisclosed
M080 Lentloia	20.07.2020	Electrocuted	Cultivation Fence	Undisclosed
M049 Ole Sanoe	19.02.2021	Electrocuted	Pipeline/Powerline	Undisclosed
M057 Kondoayo	19.02.2021	Electrocuted	Pipeline/Powerline	Undisclosed
M047 Boundary	20.02.2021	Electrocuted	Pipeline/Powerline	Undisclosed

Investigation and findings

- On the evening of 21 February 2021, Kenya Wildlife Service (KWS) and Kenya Power representatives visited the site.
- On 22 February 2021, Kenya Power raised the line where the giraffes were killed.
- The dead giraffes were moved away from the power lines to prevent further electrocutions of other mammals and birds of prey drawn to the carcasses. Trail cameras were placed at the site to record carnivore abundance and interactions, and identifications, and giraffe behavior in relation to the carcasses.

In a statement by Kenya Power on 22 February

"*The Company is undertaking this exercise in partnership with the KWS, Soysambu Conservancy's management, and other stakeholders, which will also involve an audit of the entire infrastructure within the Conservancy to make any other rectifications that may be required.*"

Recommendations

- Soysambu will regularly monitor the height of the power lines and report to KP for necessary action.
- The incidents have demonstrated the need for mitigation measures in all infrastructure developments in the Soysambu Conservancy and other conservation areas containing giraffes. It is critically important to ensure that all power line conductors have at least 5.8 meters clearance from the ground, taking into consideration variations in conductor height resulting from the topography, terrain, and vegetation of an area.

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