Identification of High-Risk Power Lines for Collisions and Electrocution within the range of Griffon Vulture in Cyprus.

LIFE WITH VULTURES: SAVING GRIFFON VULTURES IN CYPRUS THROUGH CONCRETE CONSERVATION ACTIONS (LIFE18 NAT/CY/001018)

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About the project

LIFE with Vultures is a targeted conservation project for the protection of the Griffon Vulture in Cyprus. In this four-year endeavor (2019-2023), BirdLife Cyprus, the Game and Fauna Service, Terra Cypria – The Cyprus Conservation Foundation and the Vulture Conservation Foundation have joined forces to tackle the main threats facing the Griffon Vulture and prevent Cyprus' most threatened bird of prey from going extinct. The project has a €1,375,861 budget and is co-funded (60%) by the EU's LIFE programme. Find out more at: www.lifewithvultures.eu

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Preparatory Action A8:

Identification of High-Risk Power Lines for Collisions and Electrocution within the range of Griffon Vulture in Cyprus.

Introduction to the Problem

Overhead electricity wires are a major cause of non-natural mortality of birds throughout the world (Jenkins *et al.* 2010). Mortality estimations from collation and review of data from many studies show that 12 million to 64 million birds of various species are killed annually in the United States through interactions with power lines; the majority of which is attributed to collisions with these structures (Loss *et al.* 2014). Collision with overhead power lines and electrocution are considered key threats that have the potential to negatively affect vulture populations and their conservation globally (Botha *et al.* 2017). Mortality from power lines is considered one of the leading factors responsible for the dramatic decline in numbers and range of habitat for two protected vulture species in South Africa; the Endangered Cape Vulture (*Gyps coprotheres*), and the Critically Endangered African White backed Vulture (*G. africanus*). Population modelling studies (e.g. Boshoff *et al.* 2011), have shown that in areas with high density of power lines populations of Cape Vultures are likely to be completely exterminated due to electrocution within a period of 20-35 years.

In Cyprus there have been two collision incidents recorded (December 2018 & April 2023), and even the death of a small number of individuals constitutes a significant blow to conservation efforts for the recovery of the species, as the Cyprus Griffon Vulture population is severely depleted. In the later stages of the LIFE with Vulture project, the Cyprus population has been bolstered with the release of imported individuals, increasing the vulture population density of the island. Therefore, as expected, the area of overlap between the vultures' range and high-risk power lines has increased. Consequently, with the increase of the Griffon Vulture population through the release of inexperienced and foreign to this island individuals from Spain, collision and/or electrocution incidents have also increased, with two mortality incidents recorded involving individuals imported from Spain (one collision and one electrocution incident).

As the power line network is expanding with a rate of 5% annually and worldwide (Jenkins *et al.* 2010), it is expected that the mortality of birds due to collisions and electrocution will continue to increase. Scientists started exploring mitigation measures for this anthropogenic cause of bird mortality since the 1970s, when they realized the extent of the problem (e.g. Lehman *et al.* 2007). Most of the mitigation approaches are based around the aim of making the power lines themselves more visible to birds using different forms of wire markers; e.g. thickened wire coils, shiny, luminescent, flashing or flapping devices, brightly colored "aviation" balls (Jenkins *et al.* 2010). Studies that review the results of other studies in which bird diverters were placed on power lines to be tested for their effectiveness, are highly essential in evaluating the overall effectiveness of anti-collision and anti-electrocution. Barrientos *et al.* (2011) showed that the placement of flight diverters/ markers on power lines led to a marked decrease in bird collisions. Specifically, the mortality rate at marked power lines was much lower than the mortality rate at power lines without markers (Barrientos et al. 2011). Another review study indicated that a variety of anti-collision measures as referred above, can reduce the frequency of bird collisions by at least 50-60 %. However, the efficacy of such devices varies depending on the target species that needs to be protected by the threat and the local environmental conditions. Habitat use, movement patterns and distribution varies across different bird species and these are aspects that need to be considered and analysed in order to identify areas of high overlap between birds and power lines.

Due to the budget available for the installation of "Firefly" markers to power lines (EURO 74,100) and the extensive network of both high and medium tension power lines which is contained within the Griffon Vulture range, the identification of those parts of power lines in Cyprus that are the most dangerous for collision or electrocution is an essential prerequisite for targeted marking.

Methods & Materials

In order to identify the most dangerous power lines we overlaid vulture GPS tracking data (both GPS localisations and track lines) and the power line network of the island. The two main data sources - GPS localisations and tracking routes of a total of 17 birds were analyzed in the same way. Specifically, as the main aim was to identify locations of high overlap between the two – i.e. high density of GPS tracks or localization points overlapping with high power line density (Figure 1). The GPS tracking data were derived from 17 individuals tagged with GPS transmitters and consisted of individuals imported from Spain and released in Cyprus as well as all other free flying vultures on the island that were fitted with a GPS tracker (Table 1)). GPS tag data fitted on vultures that recently died were also used in the analysis. The dataset used in this analysis consists of a subsample of localizations from 15-minute intervals and tracking routes from November 16th 2022 to April 4th 2023, and were retrieved from Movebank (www.movebank.org/cms/movebank-main). The spatial information of the power line network was provided by the Electricity Authority of Cyprus. The principal software used for data analysis was Esri's ArcMap (ArcGIS 10.7.1).

Table 1: Griffon Vulture individuals fitted with GPS tags that were used in the identification of high collision risk powerlines

Number	GPS Tag ID	Griffon Vulture name/ code
1	223258	Molly_LLL
2	223257	Artemis_LLM
3	223256	Zenonas_JRJ
4	223255	Ramon_JJK
5	223254	CAC
6	223253	Pakis_LLF
7	223251	Apollonas_LLA
8	223250	Poco_CAL
9	223249	Minimoni_JNJ

10	223248	Iris_JFJ
11	203502	Aurora_LLO
12	203498	Phoebe_CAF
13	194232	Kostis
14	194230	Jojo_JOJ
15	190492	CAA
16	190484	Ikaros
17	190478	Pablo_CAV

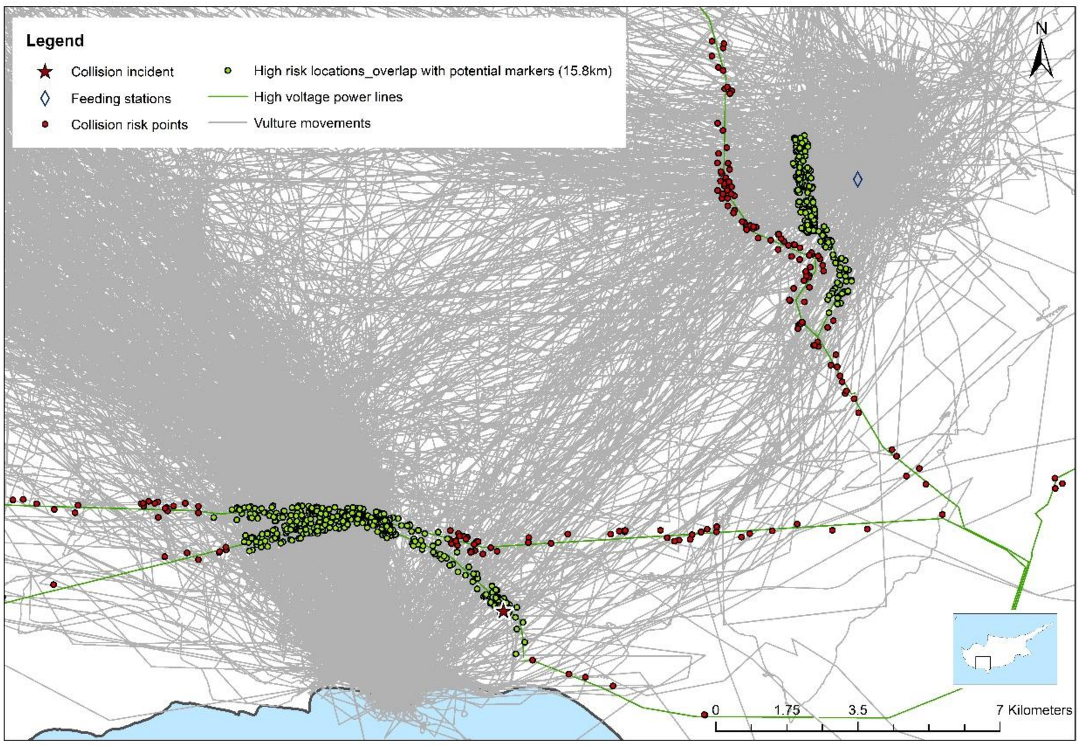

Figure 1: High overlap between vulture movements and high voltage powerlines. High voltage powerlines tend to be supported by pylons and rise high above the ground, increasing probability that the flight altitude of Griffon Vultures overlaps with the altitude of the powerline,

Focus was especially given to high-voltage powerlines found within the home range of the Griffon Vultures as the vast majority of GPS locations were within the merged home and core ranges of the vultures.. Additional information incorporated into the overlap maps include the relevant SPAs targeted by the Life with Vultures project (Table 2), for which Griffon Vulture is a designation species, recent nesting sites and key roosting sites, the vulture pre-release acclimatization cages and the supplementary feeding stations.

Table 2: Protected areas which the project 'LIFE with Vultures' focuses on

Type of protected area	Protected area name
Natura 2000	Akamas Peninsula
Natura 2000	Ezousas Valley
Natura 2000	Chanoutaris Cliffs
Natura 2000	Xeros River Valley
Natura 2000	Diarizos River Valley
Natura 2000	Cha Potami River
Natura 2000	Paramali River
Natura 2000	Limnatis River Valley
Special Protected Area equivalent under SBAs	Episkopi Cliffs

"Near" Approach

The spatial analysis included the GPS localizations in close proximity to any power lines, in order to identify those lines that are potentially used by the vultures for perching, and to identify areas used by vultures in very close proximity from power lines. The relevant tool ("Near (Spatial Analyst)") was used on ArcMap to identify those points that fall within 200m from power lines (Figure 2). These points were converted to a rasterized format of $1km^2$ grid cells to enable better identification of overlap areas with the power line network. The grid cells' values were then classified into density quartiles. High density grid cells were identified as those containing numbers of GPS points falling within the 3^{rd} and 4^{th} density quartile.

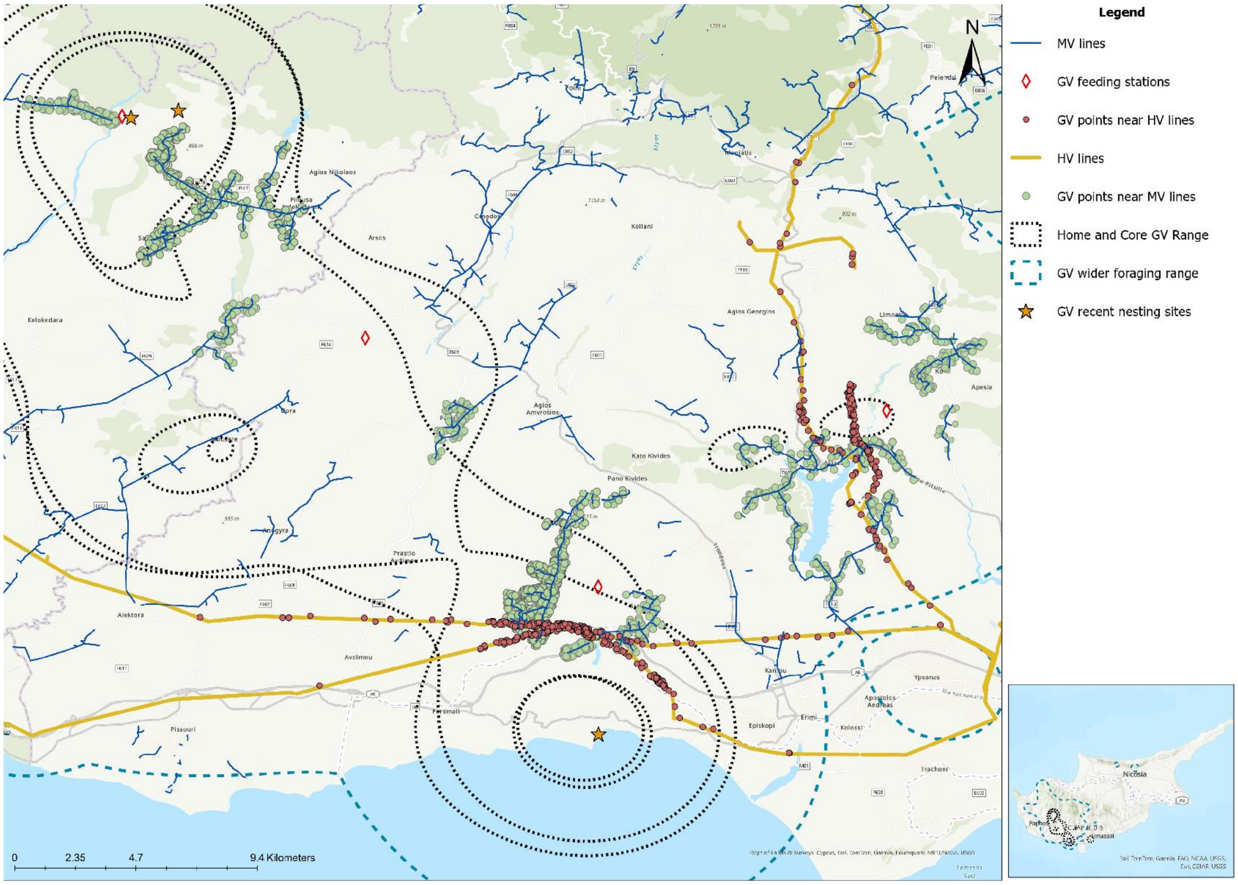

Figure 2: Map depicting the GPS locations identified within maximum 200m distance from either high-voltage or medium-voltage power lines. GV = Griffon Vulture, MV = Medium Voltage, HV = High Voltage.

Medium- and high-voltage power lines were treated differently and analyzed separately in different overlap maps in order to identify high-risk power lines of each type.

Identification of high-risk medium-voltage lines.

For the identification of the dangerous medium-voltage lines the line density was calculated as the total length of lines falling in 1 km^2 grid cells. These were then reclassified into density Quartiles following a selection of the high density values as the ones falling within the 4^{th} density quartile (Supporting material S.M.3). The same extent (Home & Core range), grid cell size, as well as the same selection of values and process was followed to calculate the density of GPS tracking data (measured as the number of GPS tracks per km^2). Consequently, high risk medium-voltage power lines were identified in a new rasterized layer showing the overlap in 1 km^2 grid cells at the locations where there were both GPS track density and power line density with high values (Figures 3 & 4).

Identification of high-risk high-voltage lines.

No density was calculated for high-voltage lines. This is because the line densities for each grid cell would be wrongly calculated using the "Line Density Tool" in ArcMap, probably due to a problem of the high-voltage power lines' dataset. Furthermore, it was suitable not to calculate any power line density for this part of the analysis as the high-voltage lines are concentrated in only one area of the home and core range of the Griffon Vultures. In addition, the area with higher density of high-voltage power lines (as roughly calculated manually with the measure toolbar in the software for verification purposes) was also the area where there were grid cells with high GPS track density, thus the overlap between the two parameters could be visualized without calculating the power line density. Through this method we may have identified a larger total distance of these high-voltage power lines as dangerous, however, this is not a problem due to the great importance of this area as a key flying route for vultures.

Therefore, only the GPS track density was calculated to a rasterized format layer in the same way as for the medium-voltage lines. The density values were reclassified in four density quartiles following a selection of the high density values which were set as the ones falling above a certain threshold; in this case, above the 2nd quartile. Consequently, the low GPS track density values were considered the ones equal to the boundary value of the 2nd quartile and smaller than that. The newly formed values of GPS tracks were incorporated with the high-voltage power lines within the home and core range of Griffon Vultures, and subsequently the high-risk lines identified were the ones that intersected the grid cells with values above the 2nd quartile .

An altitude analysis was also performed to identify areas of overlap between the average flight height of vultures and the height of the powerlines. These were done on a 0.01km^2 grid, with average height of flight above sea level calculated for each grid cell and compared with the height above sea level of high-voltage power-lines. Powerlines that were less than 50m under the average height of flight of vultures were considered high-risk for collision.

Results

High-risk power lines were identified in key locations frequently used by vultures to move from the Episkopi cliffs colony and roosting site to the interior of the island for foraging, including at Limnatis and Agios Ioannis feeding stations. The power lines identified as dangerous in these flight routes should be targeted for marking with "Fireflies" to prevent bird collisions. This especially applies for the high-voltage lines adjacent to the Paramali River SPA due to their key location intersecting the vultures' flight routes from Episkopi cliffs to the interior of the island.

Medium voltage high risk powerline identification

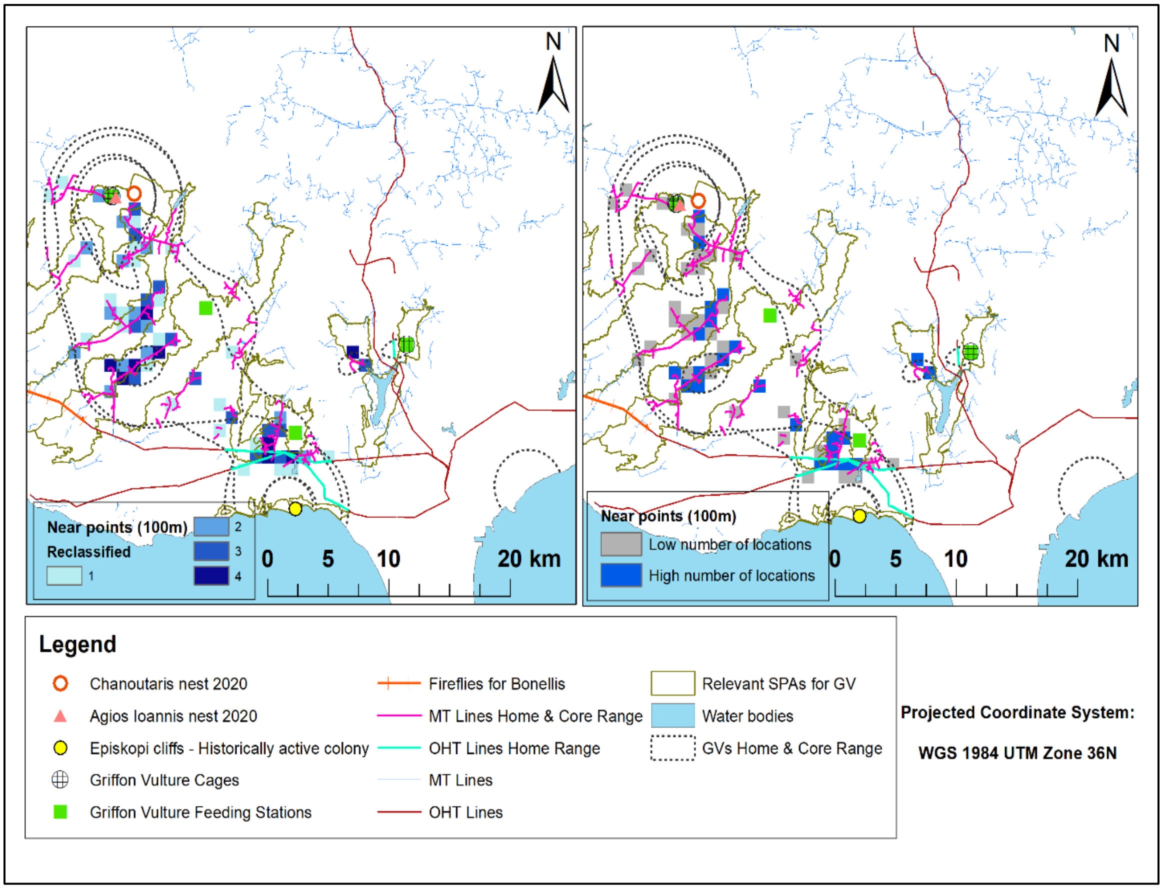

Figure 3: Map showing the reclassified values of the number of GPS point localizations found within 100m from power lines in a rasterized 1 km^2 grid cell format. The reclassified values in the four quartiles are shown on the left map, and the classification into low and high number of localizations on the right map.

Dangerous medium- voltage lines identified from the "near points" approach (Figure 3) were congruent with the findings of overlapping the GPS tracks density with power lines (Figures 4 & 5). This simplifies the selection of the most dangerous power lines to be targeted for marking with "Firefly" bird diverters.

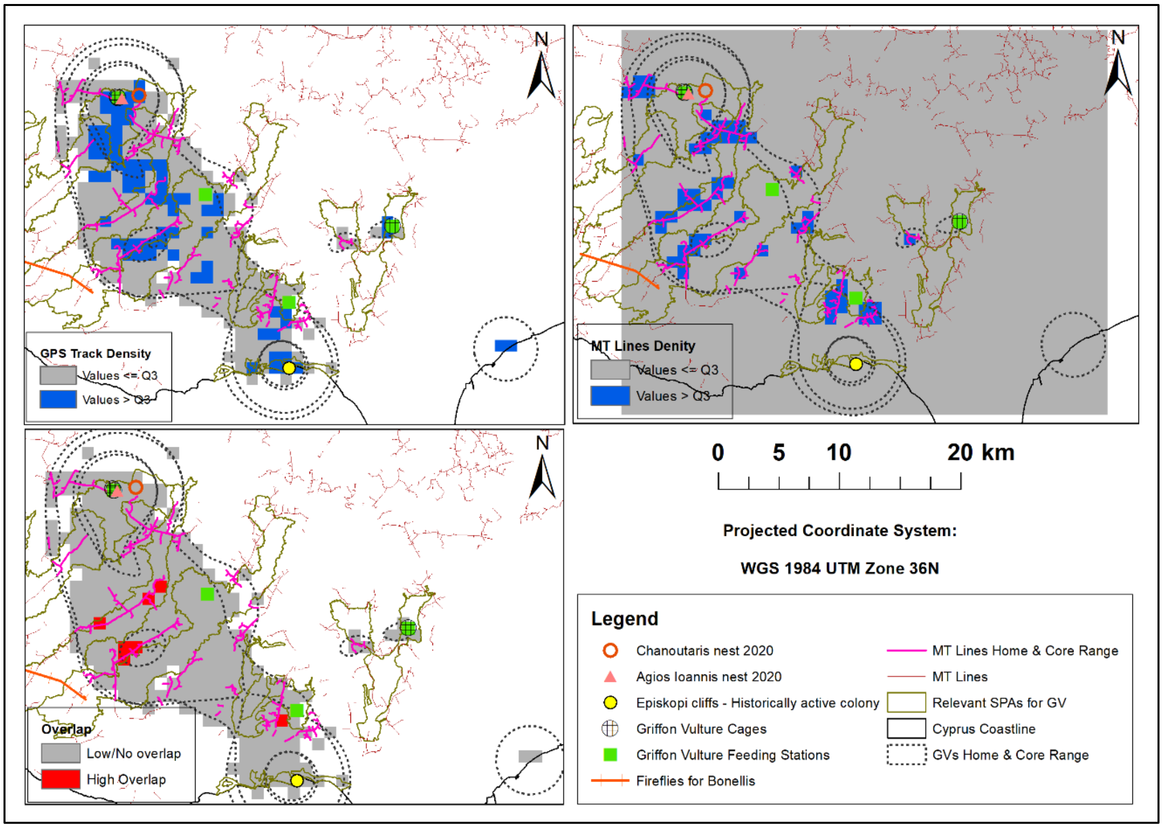

Figure 4: Map showing the GPS track density classified in low values (Values <= Q3) and high values (Values > Q3), the density of medium-voltage power lines classified in low values (Values <= Q3) and high values (Values > Q3), and the overlap between high track density grid cells (1 km^2) and the high density grid cells of medium-voltage power lines (bottom left).

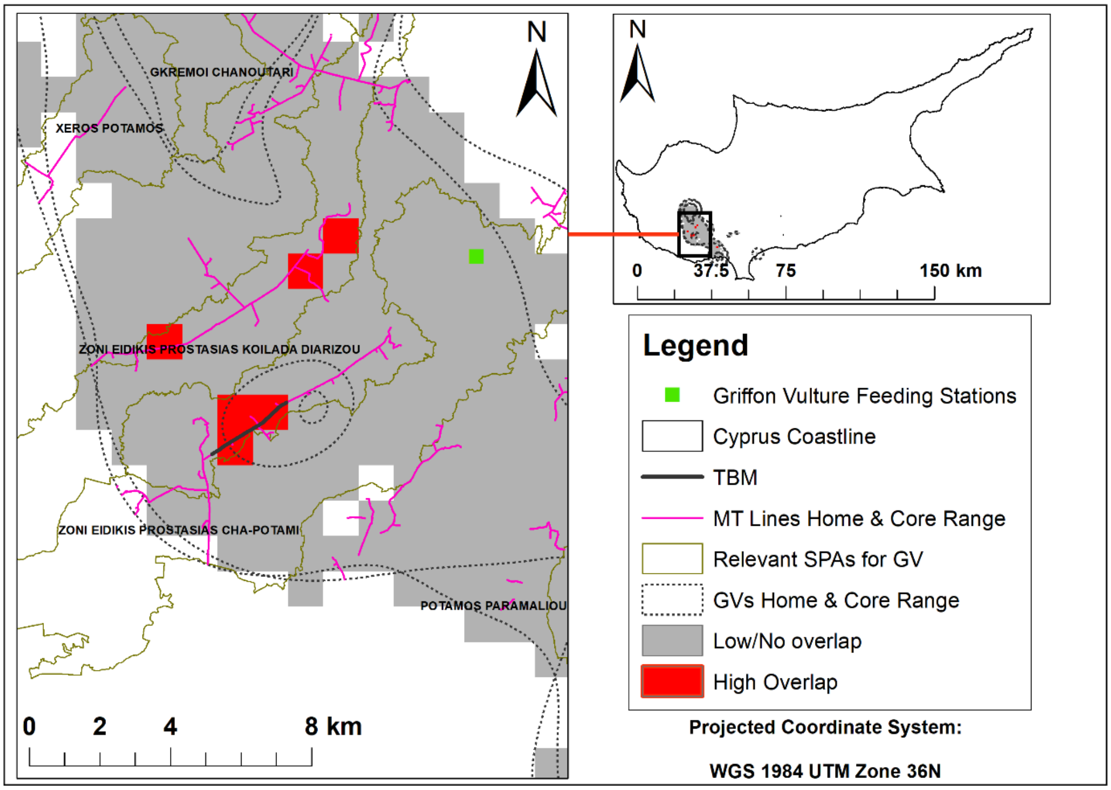

Figure 5: Detail on the identified dangerous medium-voltage power lines within the home and core range of Griffon Vultures. The power line section highlighted in black was also identified as high-risk using the "near points" method (Fig.3).

The parts of the medium-voltage power lines intersected by high overlap grid cells and hence identified as of high-risk, are scattered across the vulture range (Figures 4 & 5). Due to limited budget adjacent grid cells will most likely be selected.

Furthermore, since the highlighted part of the identified dangerous medium-voltage power line was also identified as dangerous using the "near points" method (Figure 2) it could be considered as of priority for marking with "Firelfies" (Figure 5). The approximate length of this part of the power line is **2.58 km** (Table 3).

High - voltage high risk powerline identification

The altitude analysis highlighted four powerlines of high collision risk due to overlap of average flight height and powerline height (Figures 5 & 6). These also coincided and agreed with the areas of high Griffon Vulture movement density that overlap with high-voltage powerlines. Consequently, these areas will be marked using diverters that make the lines visible to the birds, decreasing collision risk significantly. Parts of the powerlines with Line ID 132 and 109 will not be fitted with markers since the tension in the line is not suitable for marker installations.

Table 3: Identified powerlines that pose high-collsion risk to Griffon Vultures

Name of power-line	Line_ID	Length (Km)	Marking	End of line	Longitude	Latitude
Episkopi - Pissouri	132	2.3729	Unable to be marked	Western	32.8102803	34.6998161
				Eastern	32.8351307	34.7058765
Polemidia - Anatoliko	109	2.8522	Unable to be marked	Western	32.8047036	34.7064641
				Eastern	32.8358459	34.7060507
Episkopi - Pissouri	132	5.1393	To be marked	Western	32.8351634	34.7058641
				Eastern	32.8719936	34.6748057
Polemidia - Anatoliko	109	1.7184	To be marked	Western	32.8358459	34.7060507
				Eastern	32.857655	34.7014553
Trimiklini Ypsonas	152	1.0081	To be marked	Northern	32.9323608	34.7539732
				Southern	32.9370627	34.7457523
Trimiklini	166	4.0908	To be marked	Northern	32.9335247	34.7888465
				Southern	32.9403106	34.7523841
Medium-voltage line	NA	2.5825	To be marked	Western	32.6844907	34.7559886
				Eastern	32.7057094	34.7683690

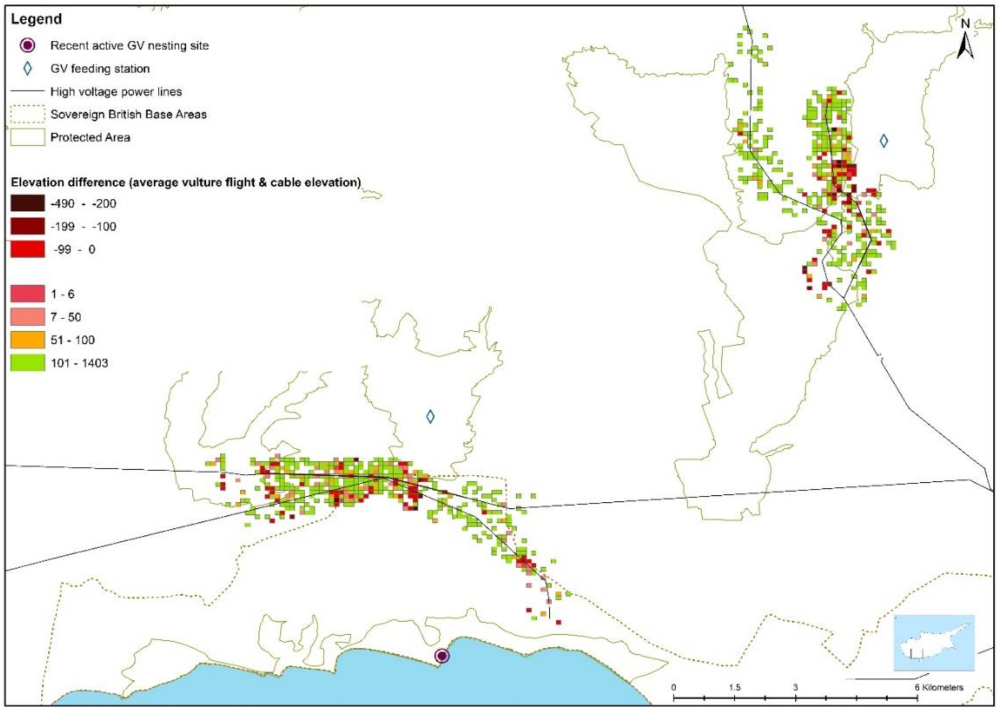

Figure 5: Altitude analysis recognized areas of high collision risk due to an overlap between the average flight height of Griffon Vultures and the height of powerlines.

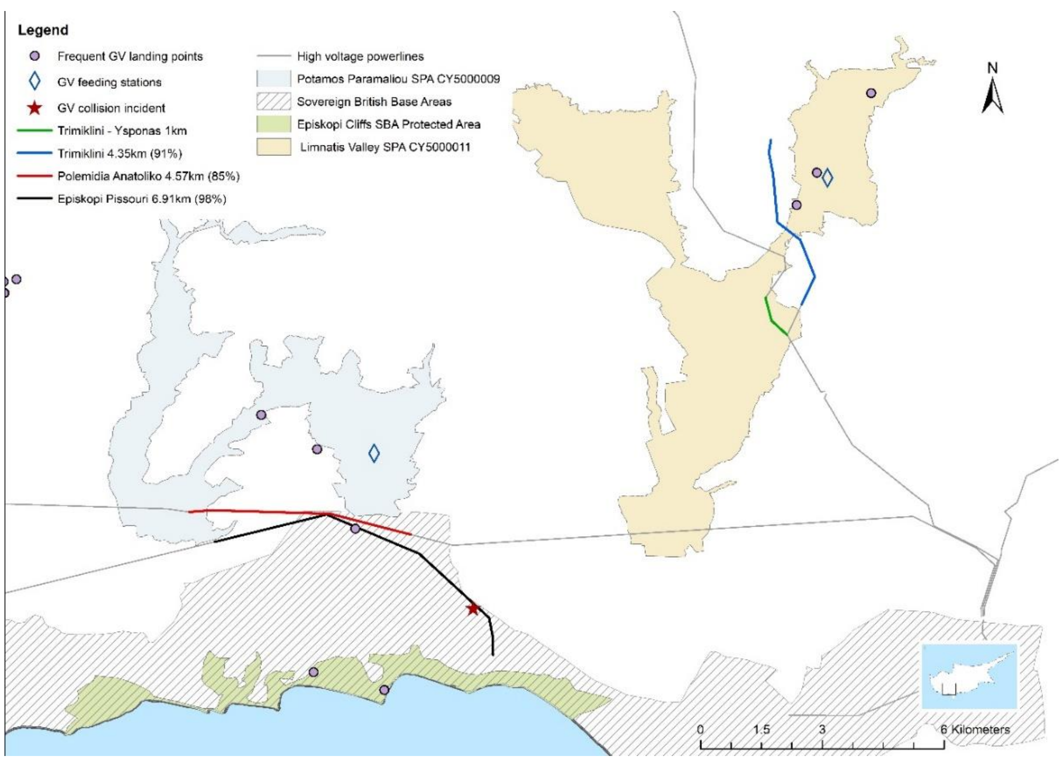

Figure 6: Identified high-risk powerlines that are to be marked with anti-collision diverters.

The parts of the five power lines identified as high-risk, four high-voltage (Polemidia-Anatolitiko, Trimiklini, Trimiklini – Ypsonas and Episkopi-Pissouri) and one medium-voltage line, are detailed in Table 3. The total length of power lines identified as dangerous for collision and electrocution is **19.76 km**.

Proposed next steps

A site visit will be carried out in order to visually assess the power-lines identified as high-risk. These will be located in the field using the coordinates in Latitude and Longitude as shown on Table 3. An on-the-ground assessment will be carried out regarding the feasibility of marking these power-lines with “Firefly” bird deterrents, as well as the feasibility of monitoring bird collisions along their length.

Since 27 out of 29 currently existing Griffon Vulture individuals have been fitted with GPS tags, frequent monitoring of the majority of the population is possible, with high probabilities of recording all potential collision incidents of vultures. Therefore, using comparative data of mortality cases before the installation of Fireflies, an assessment will be done to evaluate the effectiveness of the Fireflies that are to be installed.

References

Barrientos, R., Alonso, C.J., Ponce, C., and Palacin, C. (2011). Meta-Analysis of the Effectiveness of Marked Wire in Reducing Avian Collisions with Power Lines. *Conservation Biology* **25:** 893-903.

Boshoff, F.A., Minnie, C.J., Tambling, J.C., and Michael, D.M. (2011). The impact of power line-related mortality on the Cape Vulture *Gyps coprotheres* in a part of its range, with an emphasis on electrocution. *BirdLife International* **21**: 311-327.

Botha, A., Andevski, J., Bowden, C., Gudka, M., Safford, R., Tavares, J., and Williams, P.N. (2017). *Multi-species Action Plan to Conserve African-Eurasian Vultures*. CMS Raptors MOU Technical Publication No. 4. CMS Technical Series No. 33. Coordinating Unit of the CMS Raptors MOU, Abu Dhabi, United Arab Emirates.

Jenkins, R.A., Smallie, J.J., and Diamond M (2010). Avian collisions with power lines: a global review of causes and mitigation with a South African perspective. *BirdLife International* **20:** 263-278.

Lehman, N.R., Kennedy, L.P., and Savidge, A.J. (2007). The state of the art in raptor electrocution research: A global review.

Loss, R.S., Will, T., and Marra, P.P. (2014). Refining Estimates of Bird Collision and Electrocution Mortality at Power Lines in the United States. *PLoS One* **9**(7): e101565.