Prioritizing the Insulation of Electricity Pylons in Israel by a GIS Model Based on Hi-Res GPS loggers

Asaf Mayrose[1], Eli Haviv[1,2], Ohad Hatzofe[3], Walter Neser[3], David Troupin[1], Michal Elroy[4] & Nir Sapir[1]

[1] University of Haifa, Israel.

[2] Society for the Protection of Nature in Israel (SPNI).

[3] Israel Nature and Parks Authority (INPA).

[4] Israel Electric Corporation (IEC).

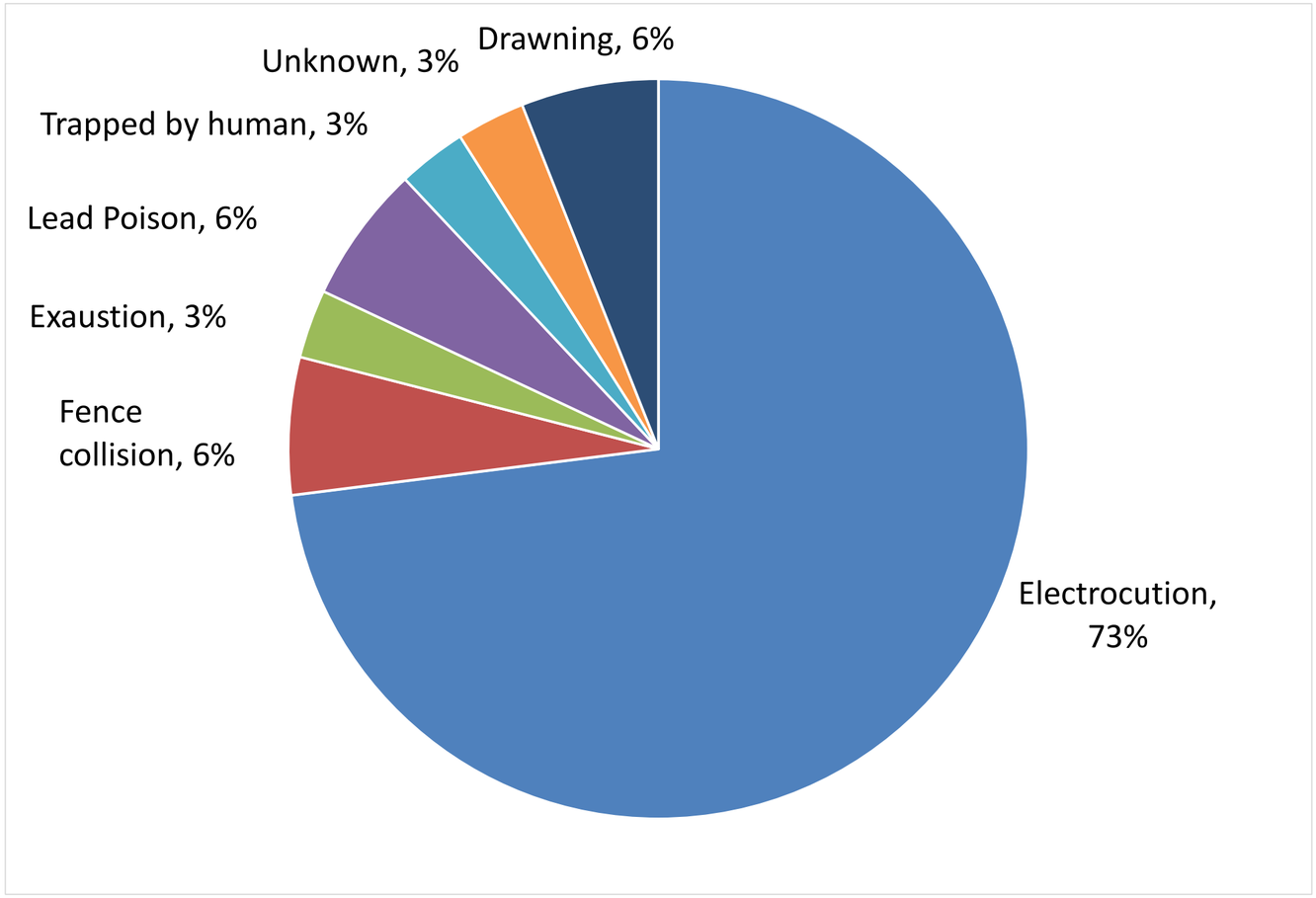
Israel Electric

רשות הטבע והגנים
Israel Nature and Parks Authority
سلطة الطبيعة والحدائق

Society for the Protection of Nature in Israel
החברה להגנת הטבע

Factors Affecting Immature Survival

Death and injury causes of Bonelli's eagles found in Israel during 2011 – 2018 (N=34).



Model aims

- To facilitate Bonelli’s eagle population recovery in Israel
- To direct the mitigation efforts towards the most dangerous power poles in the network
- To quantify the number of pylons that need to be retrofitted (in order to reduce electrocution risk by 80% or more)
- Promote a proactive approach to electrocution mitigation, rather than the reactive approach that has led mitigation efforts until now (i.e., insulating only pylons that were documented as fatal to the eagles).

Modeling approach

- The model focuses on juvenile Bonelli's eagles in their dispersal areas (low-laying areas, away from the typical habitat of the breeding territories).
- Mapping of dangerous pylons in the breeding territories of adult birds was performed through a different procedure (Hernandez-Matias *et al.* 2020).

Modeling approach

- **The challenge:** the GIS layer of the electricity grid, nor the structural elements of the pylons, were not available (confidentiality), hence we could only use a layer of pylon density in the electricity grid, set as the number of pylons in 500 m radius of each pixel.
- **MaxEnt - Maximum Entropy Modeling**, which combines true observational records, together with environmental layers (such as topography, climate, land-cover, etc.), to yield a map of the relative probability for a species' presence over a defined range.

Modeling approach

The MaxEnt model was applied in 3 stages to predict 3 different distributions. The distribution produced by the first stage was used as an explanatory variable in the second and third stages.

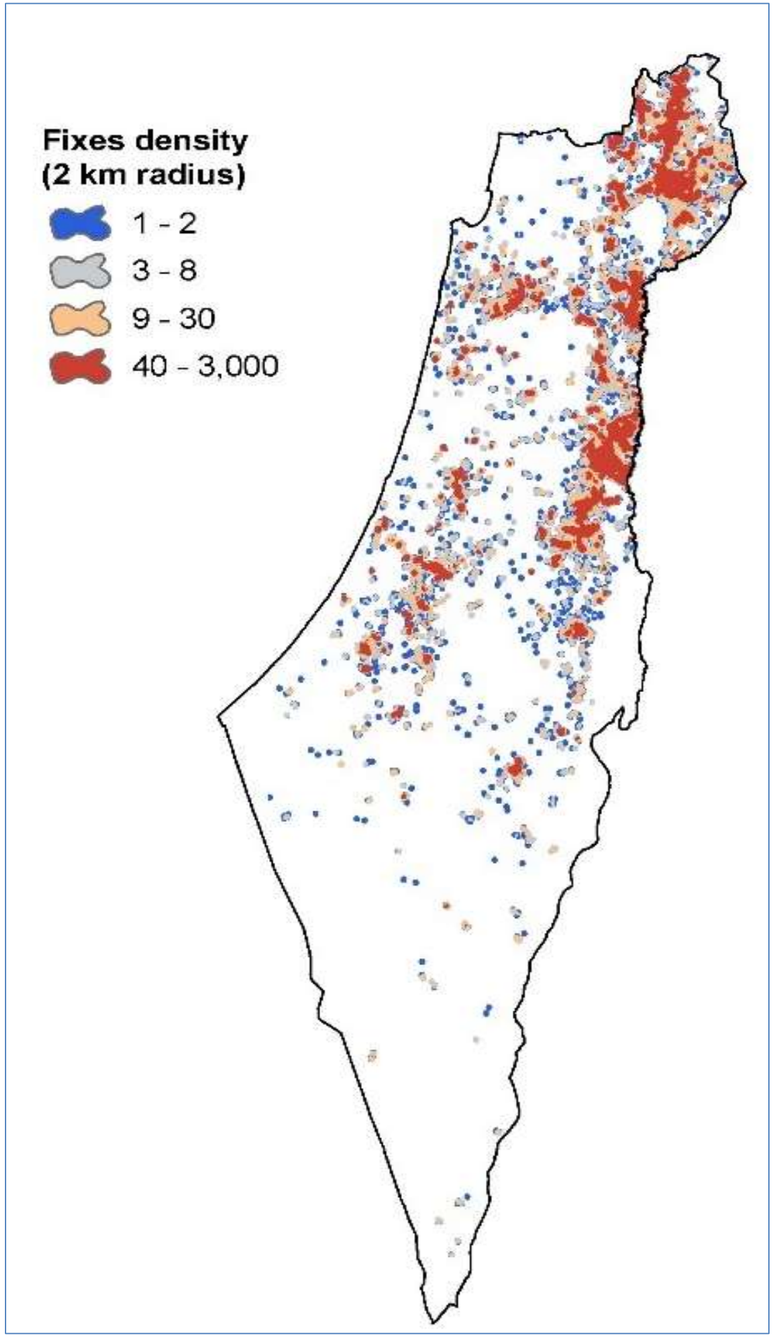
- **Stage 1: Predicting immature eagles' distribution.**
  - **Explanatory variables:** 10 environmental layers (Topography, Climate, land-use, etc.)
  - **Presence observations:** raw telemetry records
- **Stage 2: Predicting the spatial distribution of Bonelli's Eagle electrocution.**
  - **Explanatory variables:** 11 (10 environmental layers + the predicted distribution of stage #1)
  - **Presence observations:** documented Bonelli's electrocution events
- **Stage 3: Predicting the risk from existing powerlines.**
  - **Explanatory variables:** 12 (same as stage #2 + the density of existing power pylons)
  - **Presence observations:** documented Bonelli's electrocution events

Methods

Presence data

- GPS telemetry data of juvenile Bonelli's eagles (N=29 individuals), tagged in 2015 – 2019, with a total of 8,547 GPS fixes.

- 39 Bonelli's Eagle electrocution records from the years 2015 – 2021.



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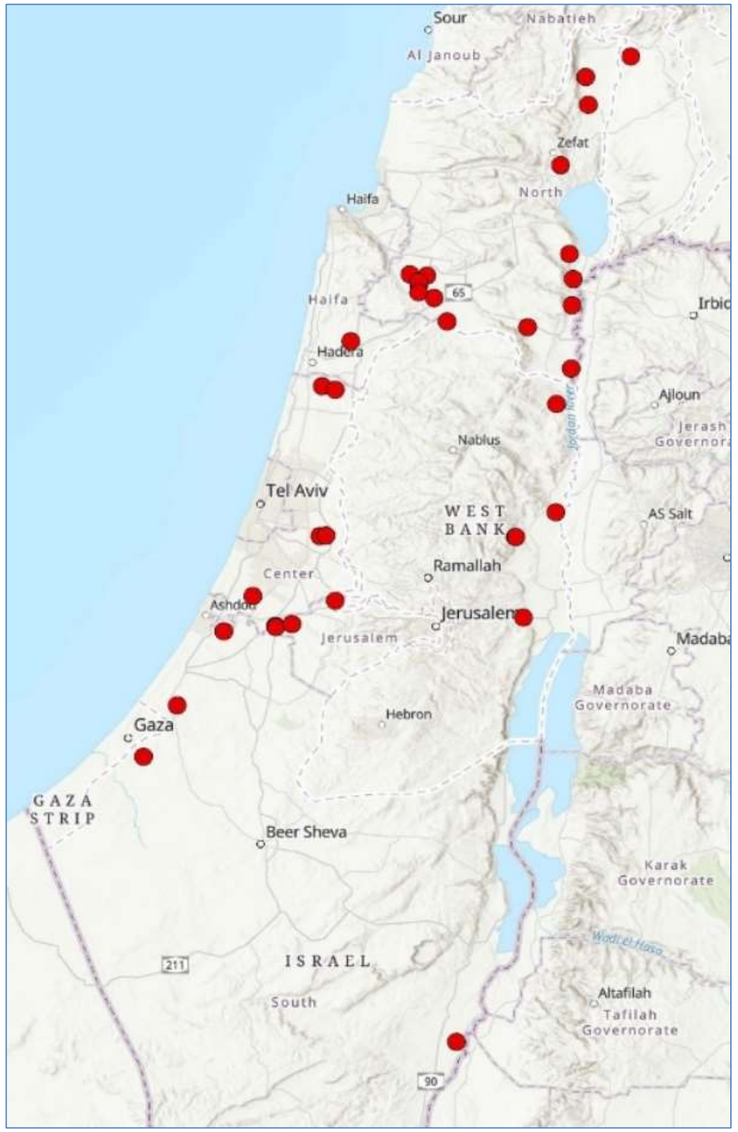


Methods

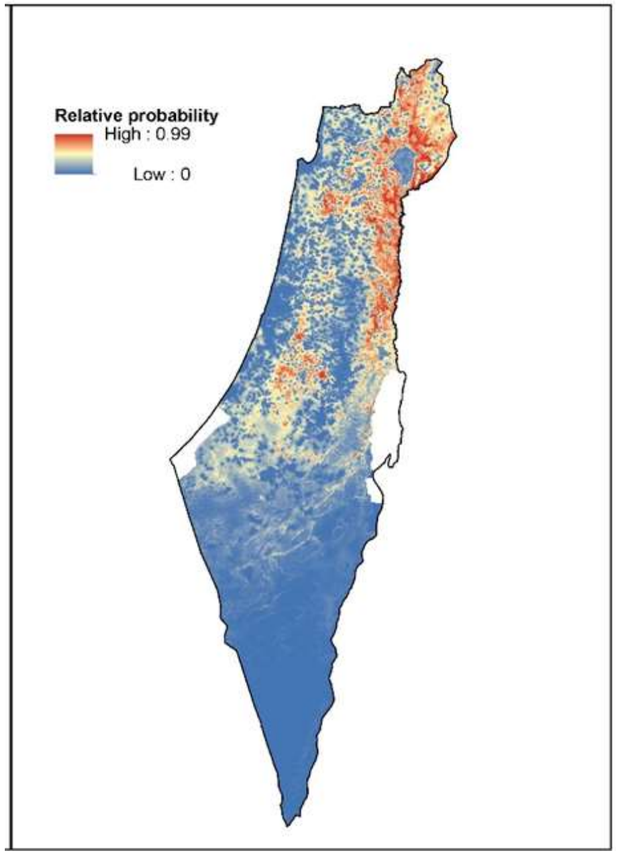
Explanatory Variables

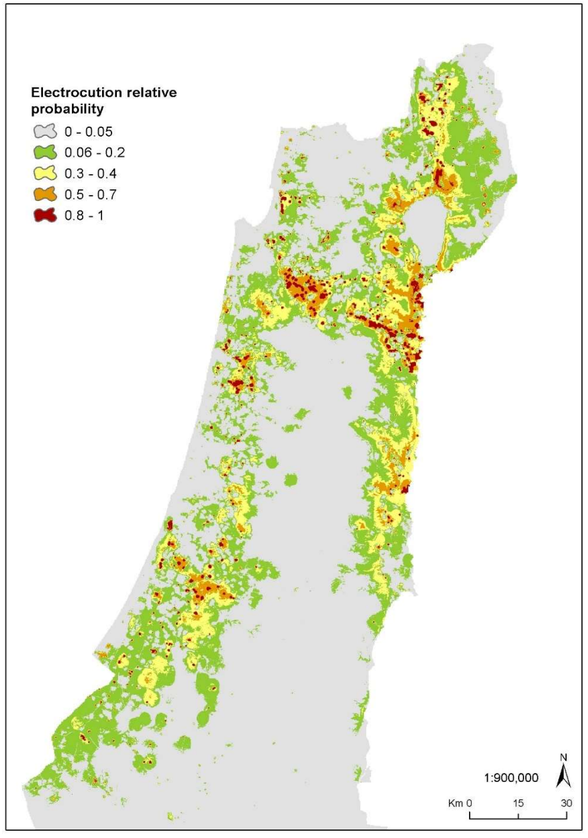
All were transformed to a resolution of 100m.

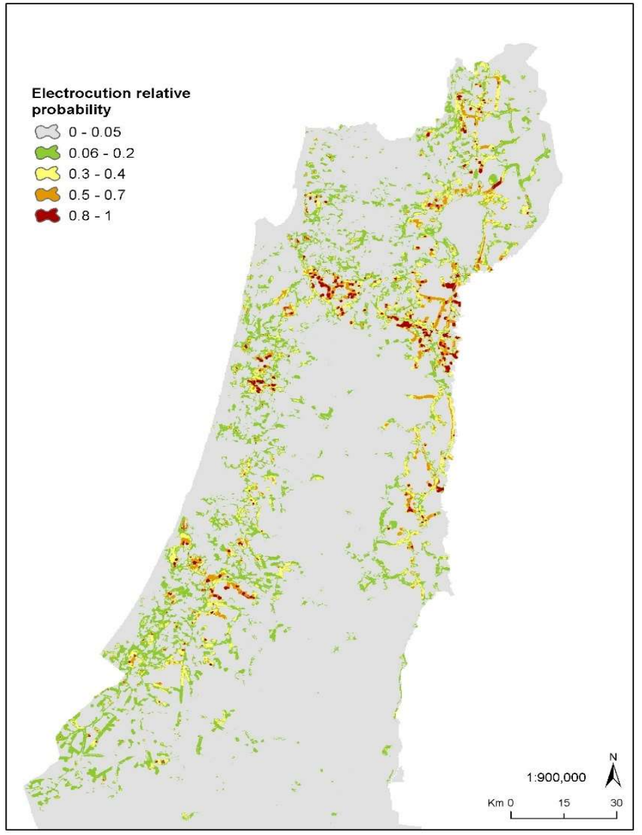
Layer Code	Description	Original res.(m)
DEM	Height a.s.l (Topography)	30
Slopes	Topographical aspect ratio	30
Precip	Annual mean precipitation	200
Maquis	Mediterranean maquis land cover	30
Forest	Natural/planted Forest cover	30
Settlement	Distance to human settlement	10
Reservoir	Distance from water reservoirs and ponds	10
Med	Distance from Mediterranean shore line	10
Lake	Distance from Sea of Galilee	10
NDVI	NDVI vegetation index	20
Explanatory Layers used for predicting sensitivity areas (Stage 2)		
PredictBon	Predicted Bonelli's dispersal distribution - Product of the 1st model	100
Explanatory Layer used for predicting sensitive power line sections (Stage 3)		
PylonDens	Number of pylons in 500 m radius of each pixel	100

1. Predicted Distribution Maps

The three stages of the model yielded different predicted distribution maps and corresponding sets of explanatory variables with their relative weights.



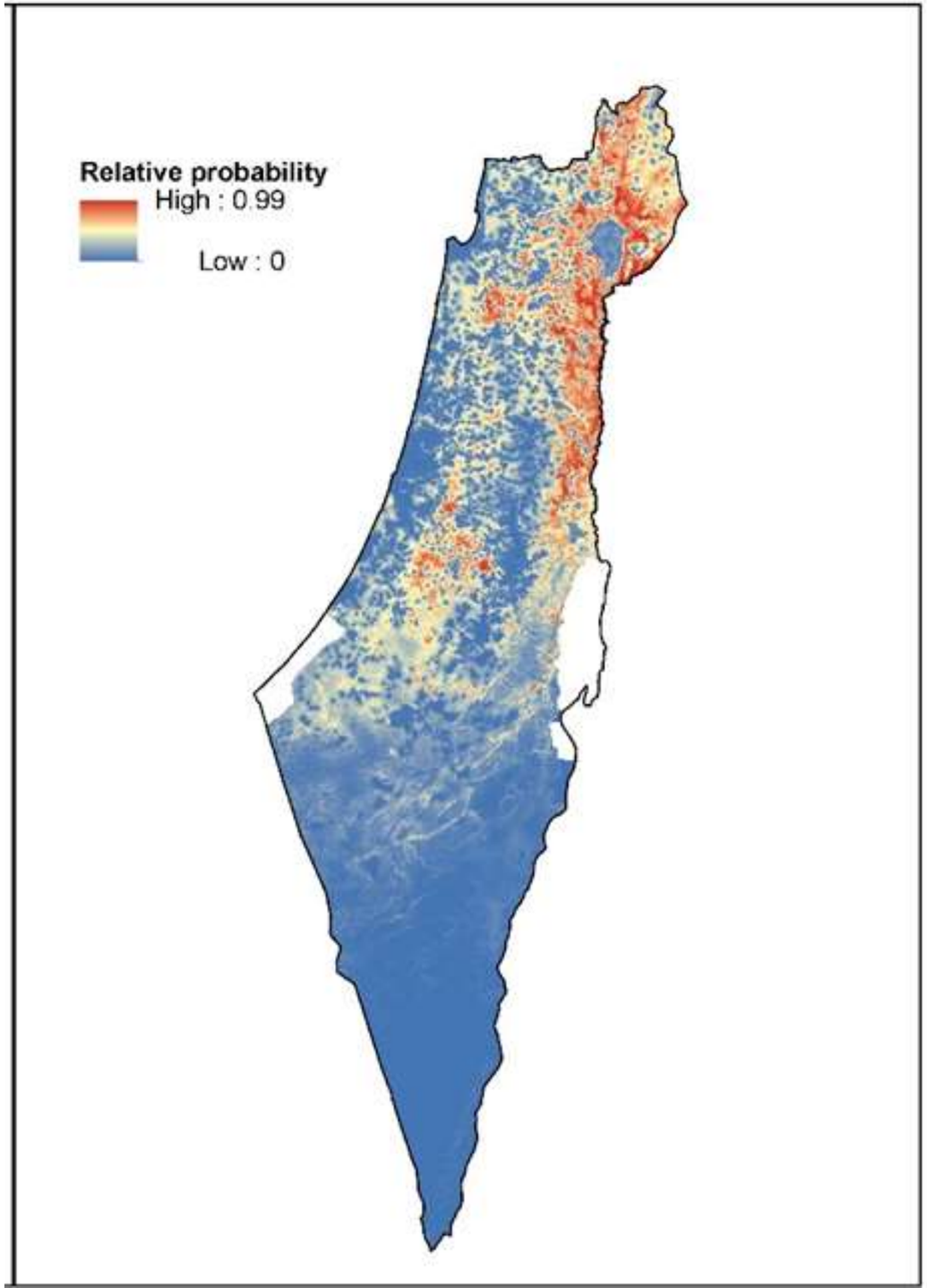




Results

Stage 1 - predicted Bonelli's Eagle dispersal distribution

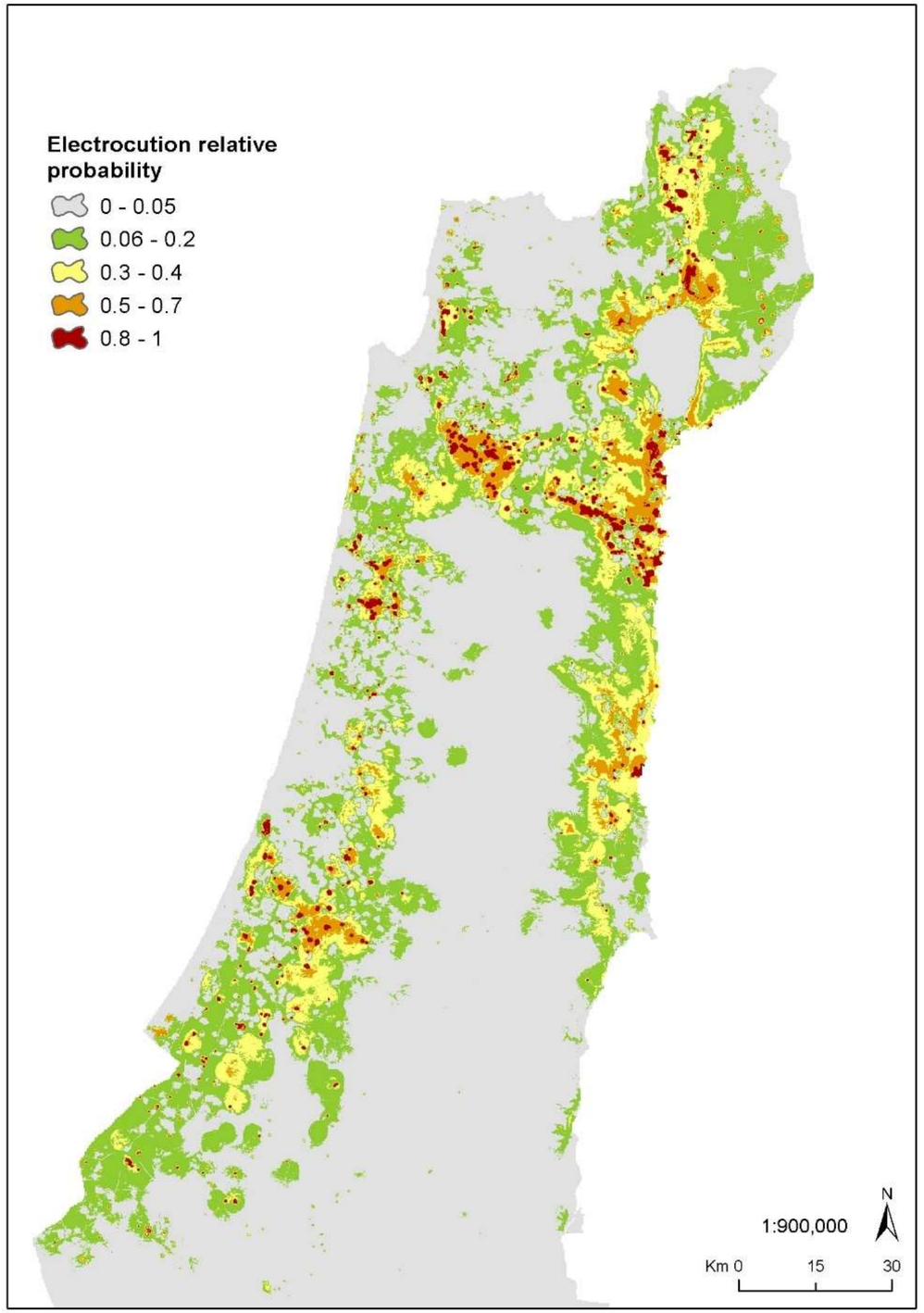
- The high probability areas covers low laying, mostly irrigated agricultural areas in Northern and Central Israel. These areas are known to be favored by the juvenile Bonelli's eagles on their dispersal.
- This map was used as one of the predictor variables of electrocution risk, in the next two stages of the model.



Results

Stage 2 - Bonelli's Eagle relative electrocution risk prediction

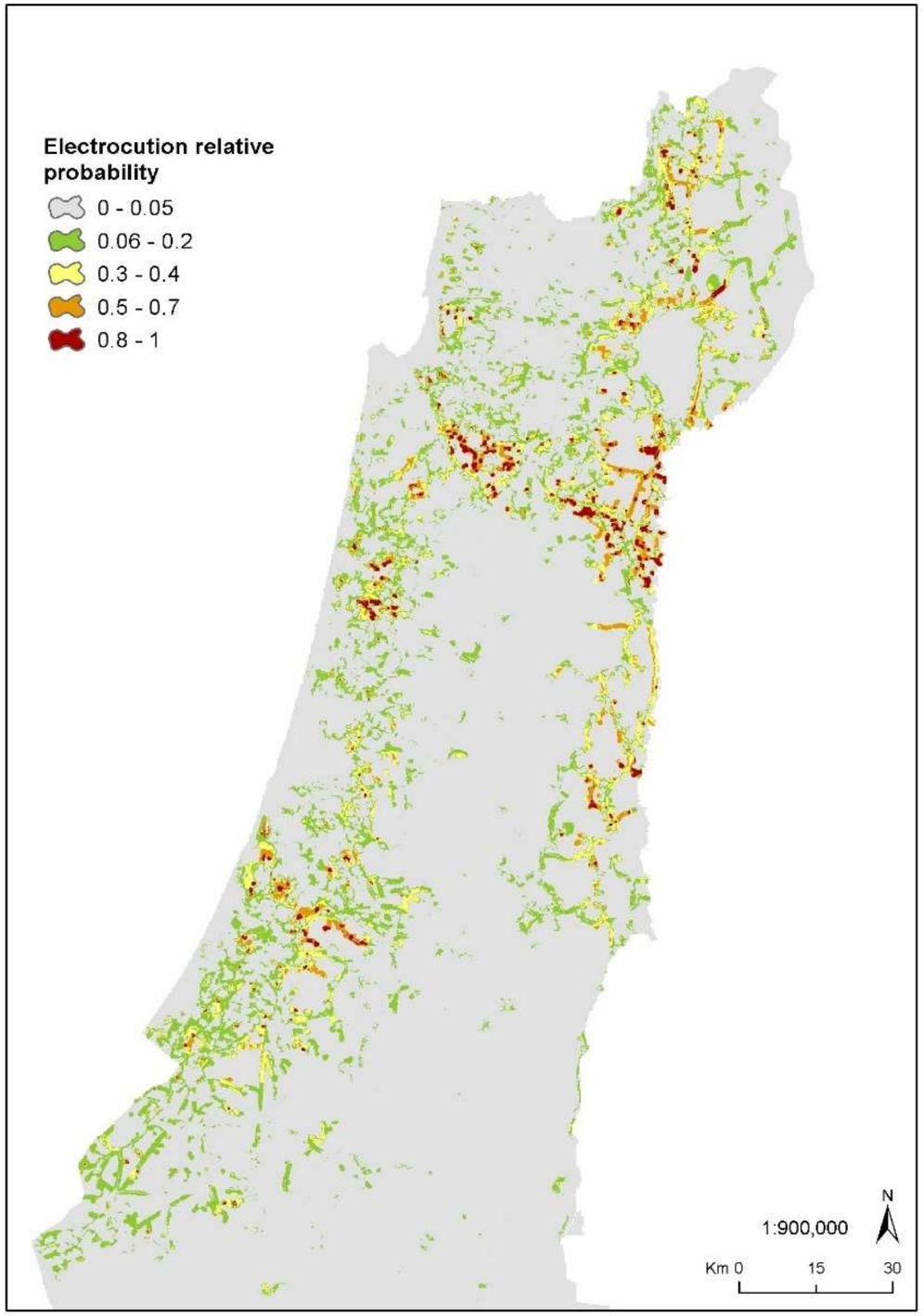
- The riskiest areas for eagle electrocution are within the higher probability dispersal areas (delineated in the previous stage)
- Within these areas it has explicitly highlighted all the water bodies and their surrounding (water reservoirs, fish ponds, etc.) producing a very selective map.
- This map can be used for the correct planning of new powerlines (taking into account their hazard to birds).



Results

Stage 3 - Relative electrocution risk of existing electricity network sections

After setting risk levels, this map was used to designate high-risk power line sections and to quantify the number of pylons that needs to be retrofitted.



Results

The relative contribution of the explanatory variables to the model

Layer Code	Description	Relative contribution to the model (%)		
		Stage 1: predicting eagle distribution	Stage 2: predicting sensitive areas	Stage 3: Sensitive power-line sections
DEM	Height a.s.l (Topography)	10.0	2.5	0.5
Slope	Topographical aspect ratio	10.0	2.1	0.7
Precip	Annual mean precipitation	32.3	0.2	0
Forest	Natural/planted Forest cover	0.8	2.0	1.7
Settlement	Distance to human settlement	25.3	0.2	1.8
Reservoir	Distance from water reservoirs and ponds	5.0	51.7	33.6
MedSea	Distance from Mediterranean shore line	10.0	2.7	2.0
Lake	Distance from Sea of Galilee	0.4	0	0
NDVI	NDVI vegetation index	5.9	0.3	0.4
Predictor Layers that were used for predicting electrocution sensitive areas (Stage 2)				
PredictBon	Product of the MaxEnt model in stage 1	NA	38.3	30.4
Predictor Layer that was used for predicting electrocution sensitive power-line sections (Stage 3)				
PylonDens	N. pylons in 500 m radius of each pixel	NA	NA	28.8

Results

The Ecological trap created by Water Reservoirs

- The much higher contribution of the water reservoir layer to the predicted electrocution distribution (51%), as compared to its marginal contribution to the predicated eagle dispersal distribution (5.0%) may indicate an exceptional high-risk potential around reservoirs.

- This is best indicated by the accumulation of true electrocution events near water reservoirs, ~ 64% of the events occur within 200 m from a reservoir.

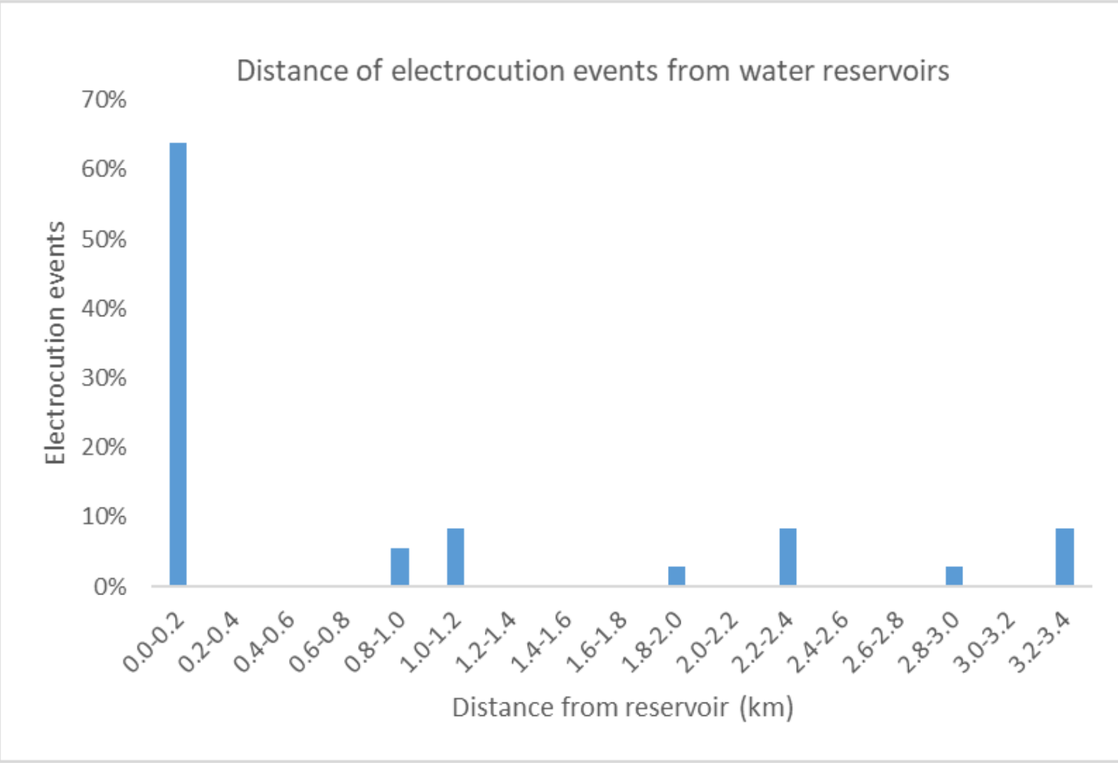
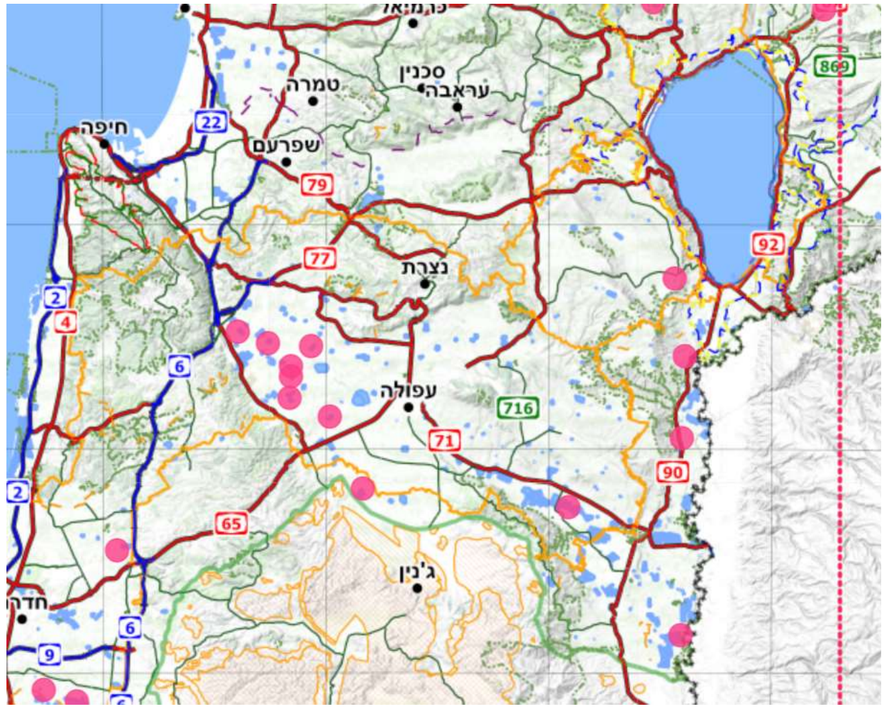


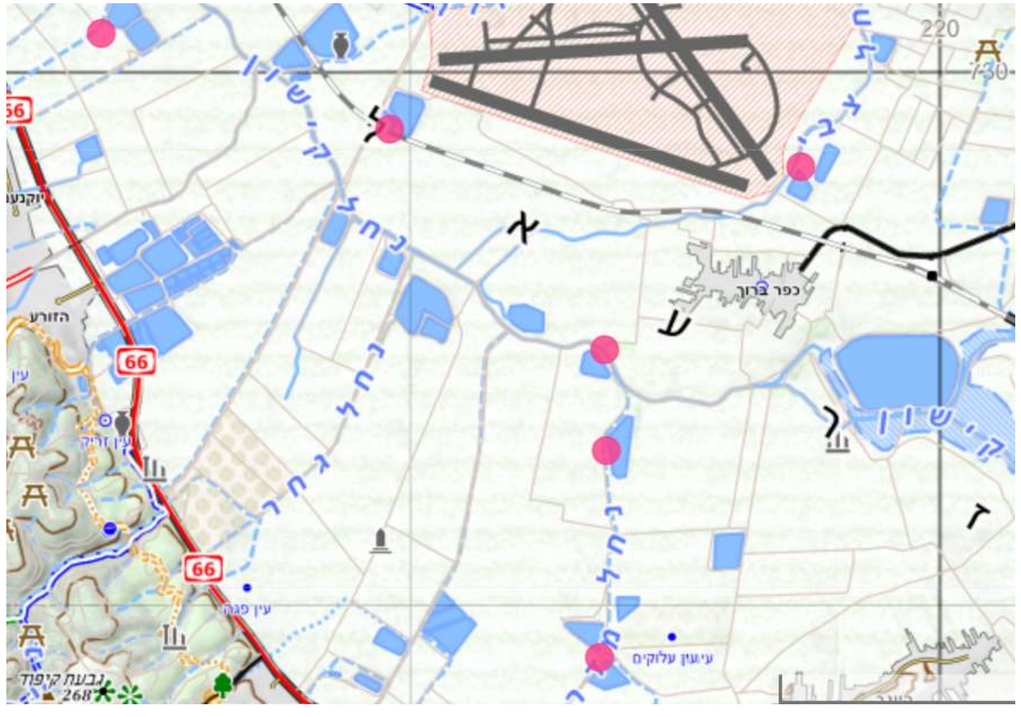
Figure: Distance of Bonelli's eagles electrocution records from water reservoirs or ponds (N=36).

Results

The Ecological trap created by Water Reservoirs

- The reservoirs are hotspots for birds and biodiversity, typically hosting waterfowl that are taken as prey by the eagles.
- To hunt in these artificial reservoirs, the eagles look for high perching observation points
- The only tall perches available for them in the vicinity of the reservoirs are the power-lines that lead to the reservoirs' control and pumping facilities, having all the trees removed when the reservoirs were initially constructed.
- This combination of environmental circumstances has apparently created a detrimental ecological trap





Results

The Ecological trap created by Water Reservoirs

Results

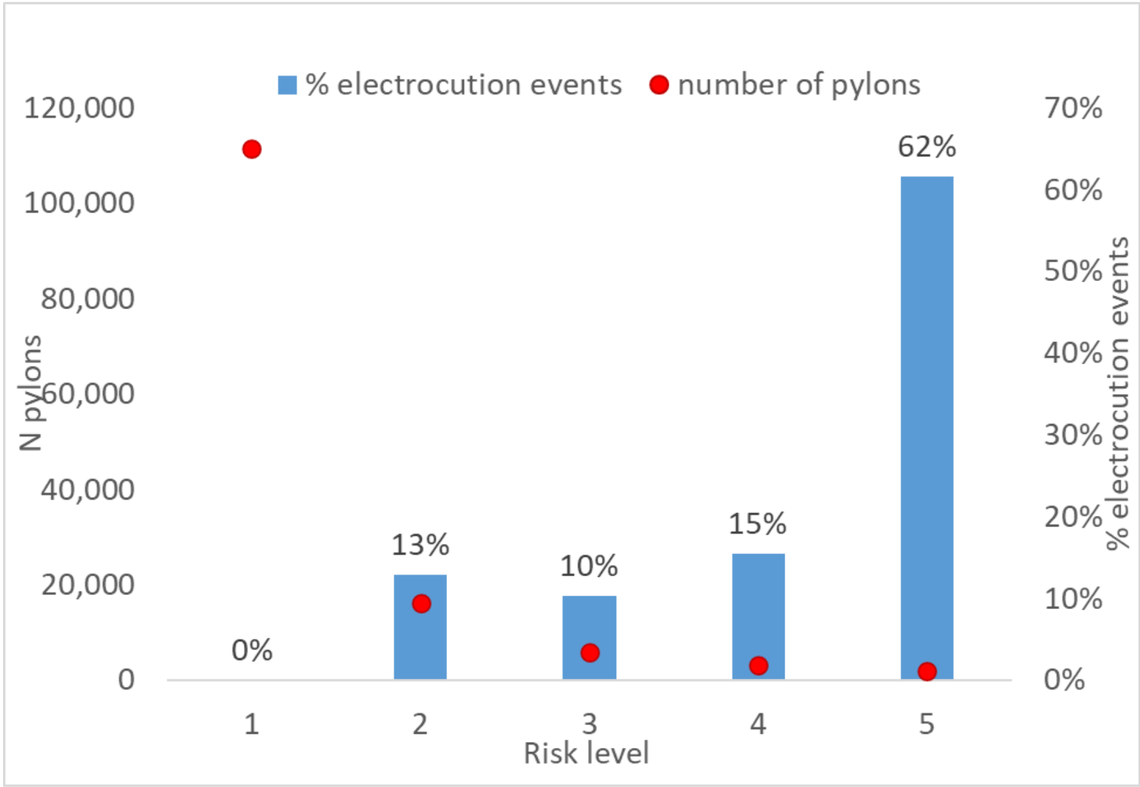
Pylons allocated for retrofitting

- 77% of the electrocution events fall within the two highest risk levels, which together represent about 3.6% of the pylons (**about 5,000 out of 150,000**).

- While working on the model, 9 more Bonelli's Eagle electrocution events were recorded (28/6/20 – 14/01/21). Of these, 8 occurred on pylons in the very high-risk category and 1 occurred on a high-risk category pylon.

Recorded Bonelli's electrocution events (N=39) in relation to the 5 risk levels of the model.

Risk level 5 = very high risk, level 1 = very low risk.



Results

The potential remediation of insulating risky pylons for other species of birds

The potential effect of retrofitting the pylons in each risk category on other species was examined by calculating the proportion of documented electrocution records of each species (N = 729 in total) in each risk category.

The species that are expected to benefit the most from the retrofitting of pylons in the highest risk levels are **Imperial eagle** (*Aquila heliaca*), **White-tailed eagle** (*Haliaeetus albicilla*), **Osprey** (*Pandion haliaetus*) and **Black stork** (*Ciconia nigra*), and to a lesser extent all the other species.

Species	% Events in each risk category					N. electrocution records
	Very High	High	Medium	Low	Very Low	
	5	4	3	2	1	
White Stork	**12%**	**16%**	24%	14%	33%	251
Black Kite	**21%**	**5%**	8%	9%	57%	219
Bonelli's Eagle	**62%**	**15%**	**10%**	**13%**	**0%**	**39**
Eagle Owl	6%	13%	10%	26%	45%	31
Short-toed Eagle	8%	13%	4%	54%	21%	24
Common Buzzard	4%	21%	8%	33%	33%	24
Black Stork	**32%**	**9%**	14%	5%	41%	22
Long-legged Buzzard	8%	15%	23%	23%	31%	13
Imperial Eagle	**70%**	**20%**	0%	10%	0%	10
Griffon Vulture	0%	0%	13%	25%	63%	8
Golden Eagle	20%	0%	20%	0%	60%	5
Egyptian Vulture	0%	0%	20%	40%	40%	5
Osprey	**40%**	**0%**	0%	0%	60%	5
White-tailed Eagle	**50%**	**0%**	50%	0%	0%	2

Concluding remarks

- The Bonelli's eagle is a critically endangered species in Israel, with electrocution posing a serious threat to the mere existence of its tiny population.
- In order for the population to become viable in the long term, it is imperative to retrofit most of the dangerous pylons in the **breeding territories**, as well as in the **dispersal areas**.

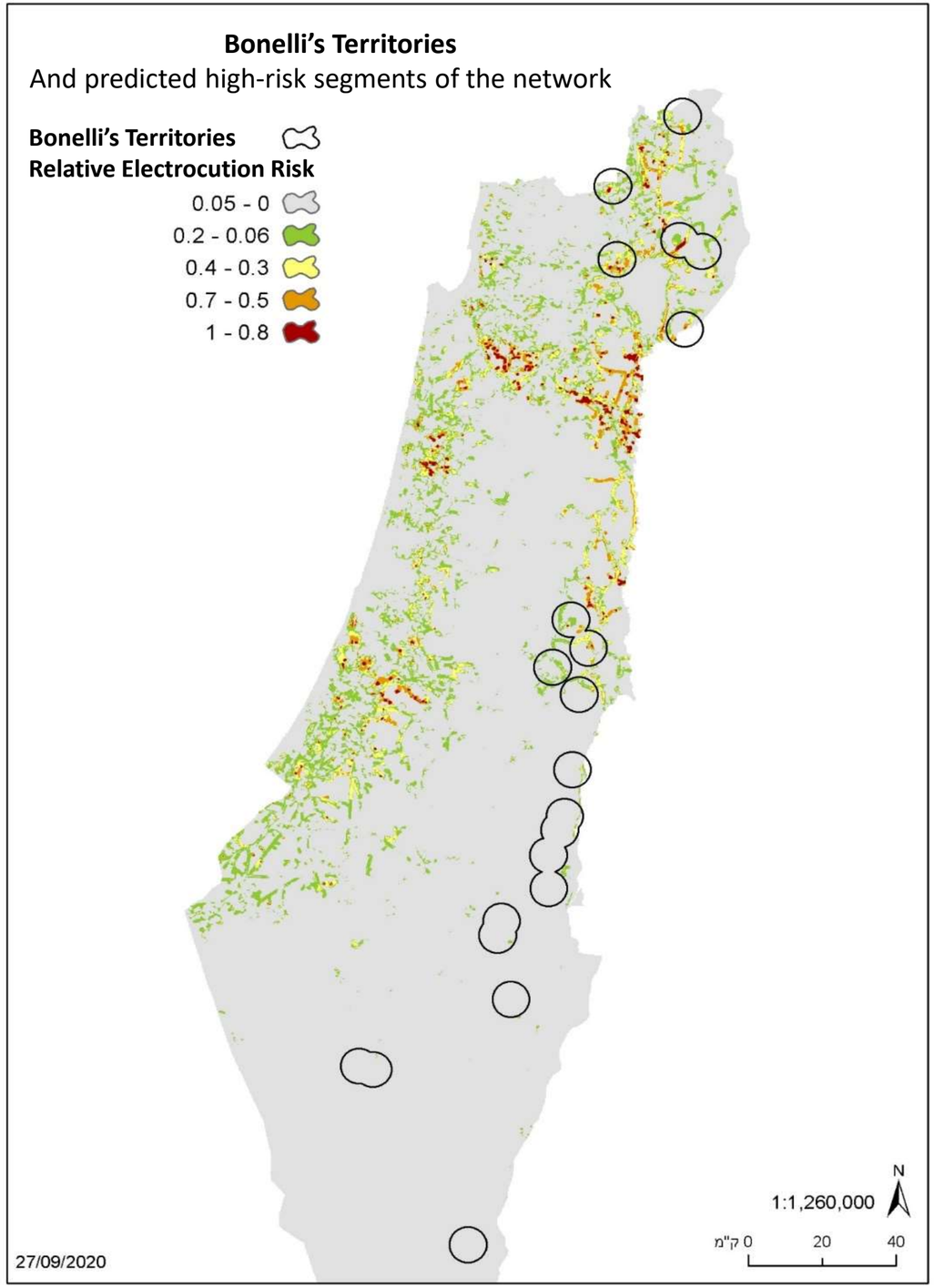
- The modeling process presented here yielded two risk maps:
  - The first map cover larger areas which do not necessarily have any electricity networks. This map is suggested for **supporting the planning of future powerlines** and choosing between alternative routes.
  - The second map is focused on areas with existing network, thus it is suitable for guiding the **modification of the existing pylons**.

Concluding remarks

- The environmental feature with the highest correlation to electrocution events is the **distance to artificial water reservoirs**, which are foraging hotspots.
- The combination of anthropogenic alterations around water reservoirs has apparently created **a detrimental ecological trap.**
- The strong attractiveness of water reservoirs for the eagles may explain the **high level of selectivity** presented by the model, suggesting that retrofitting of only about 3.6% of the pylons in the distribution network would achieve about 80% reduction in Bonelli's Eagles' electrocution probability.

Concluding remarks

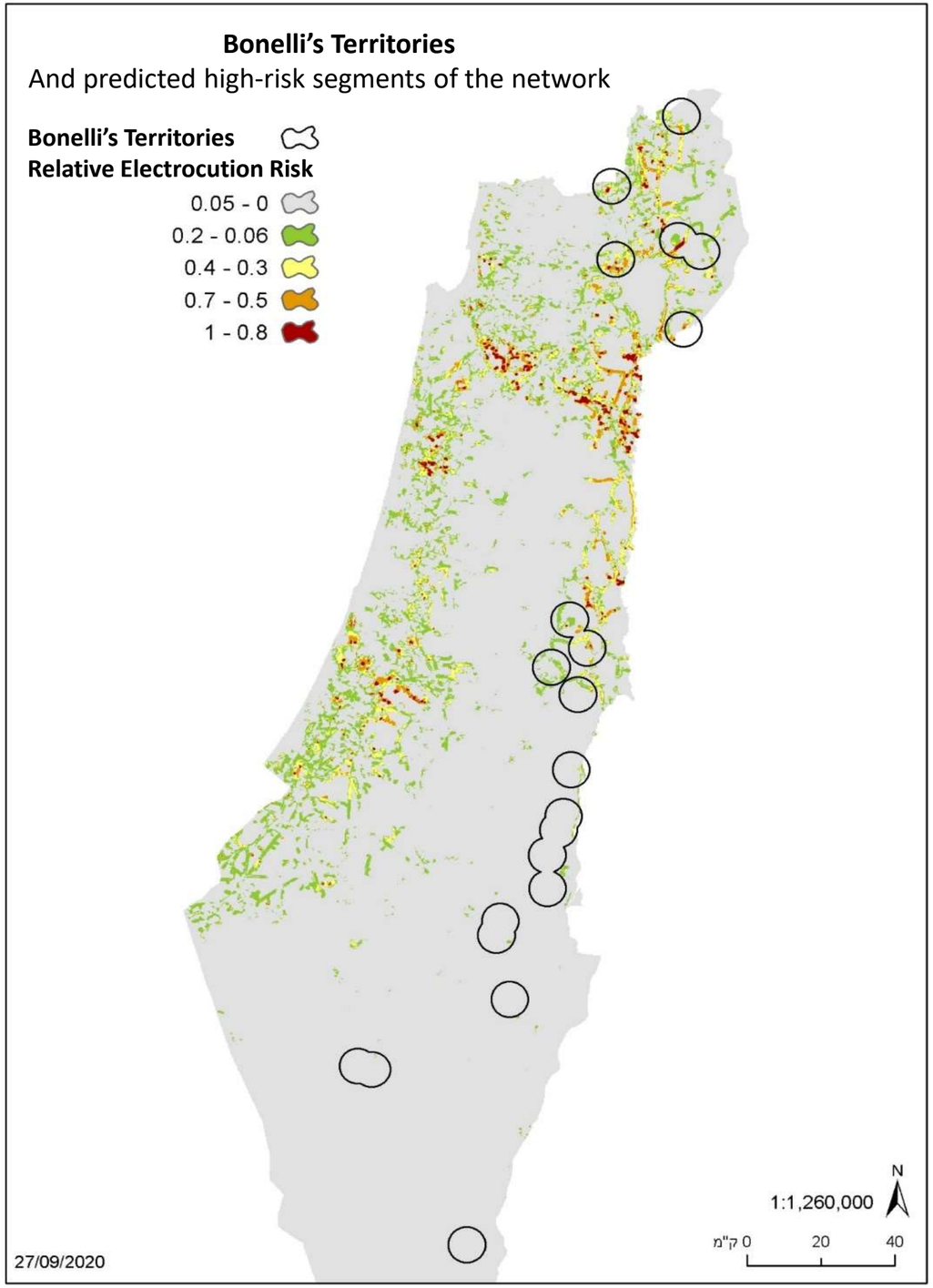
- The number of high-risk pylons in the dispersal areas is estimated at 5,000 pylons (3.6% of the pylons).
- 1,000 more pylons are nominated for correction in the breeding territories (selected through a different process)
- Retrofitting of these pylons is expected to reduce Bonelli's electrocution by about 80% (and significantly impact other species such as Imperial Eagle).



Concluding remarks

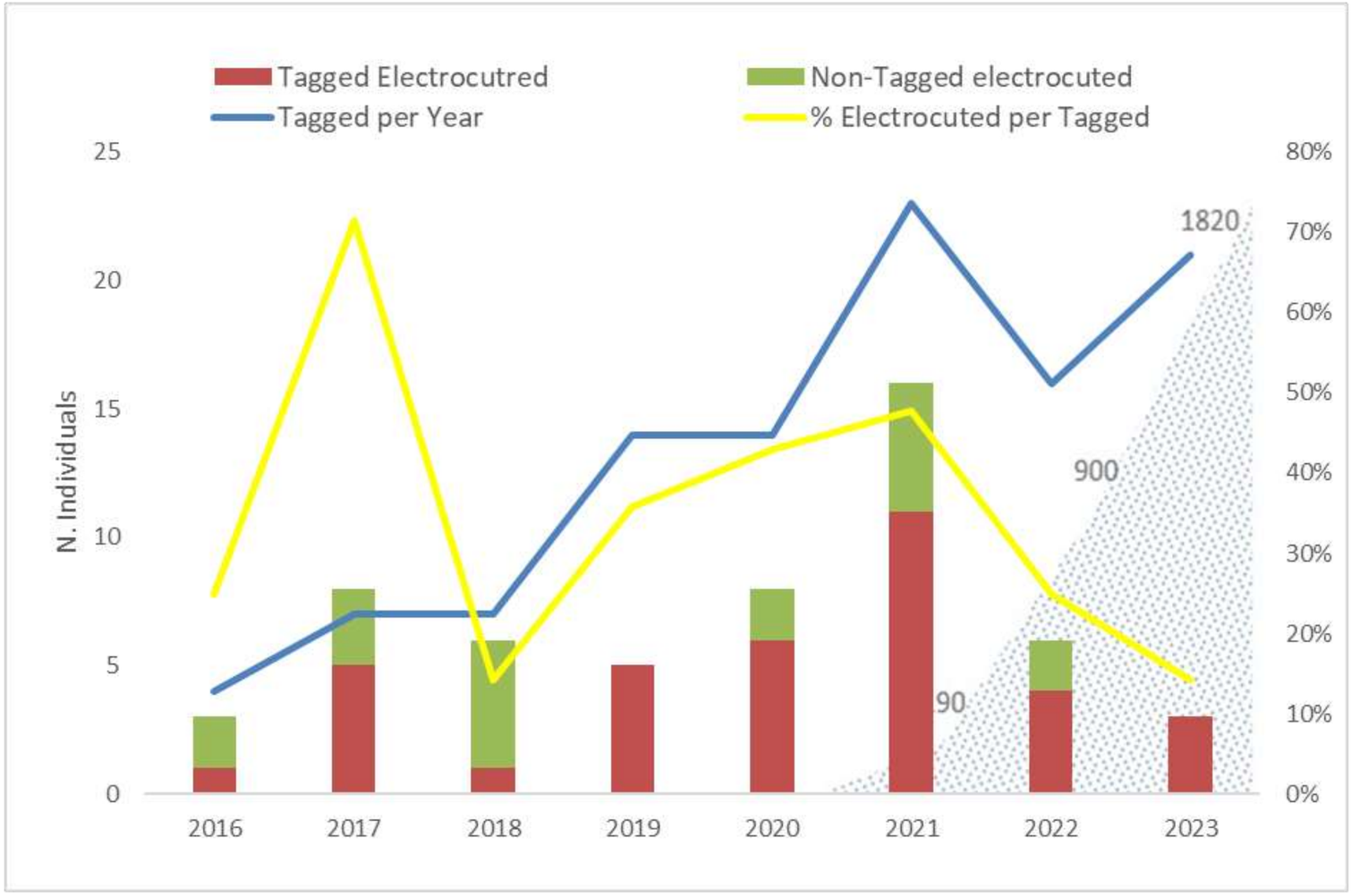
- The model was designed without taking into account the technical attributes of the pylons, while these are the ultimate correction units. Hence it should be treated as a **Master plan for mitigation**, and a more detailed planning is required before retrofitting can actually be performed.

- Yet, this master plan was found very efficient for understanding the extent of urgent insulation requirements, prioritize areas for retrofitting, estimate the budget and mobilize proactive mitigation process.



Concluding remarks

- The Israeli Electric Corporation had started mitigation according to the model
- ~ 1,600 pylons were insulated 2022-2023
- Is there a reduction in Eagle electrocution rate?



Thanks for listening!