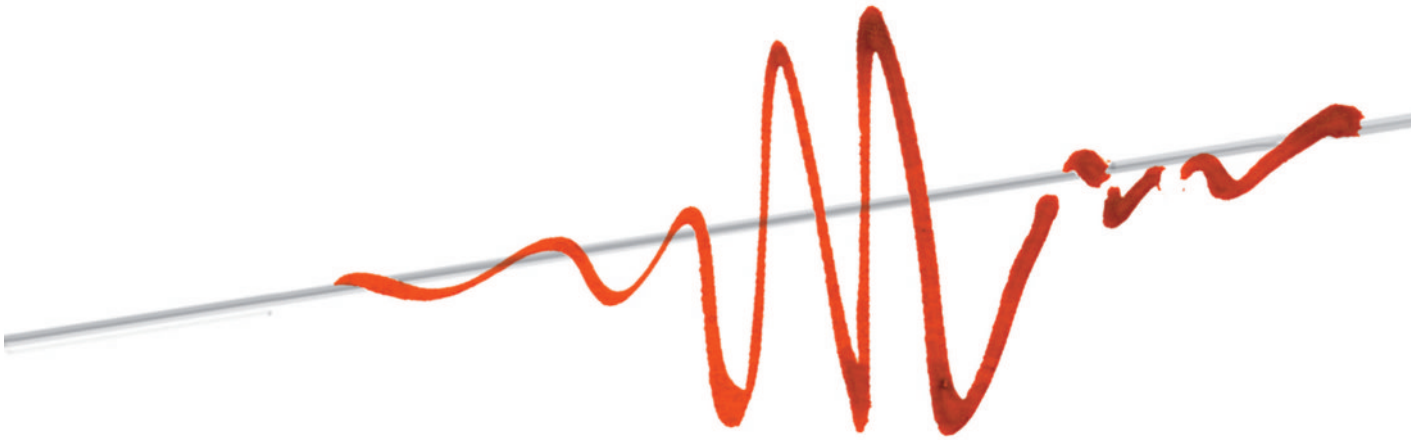
Red Eléctrica and Birdlife: 15 years of applied research



RED ELÉCTRICA DE ESPAÑA

Red Eléctrica and Birdlife:
15 years of applied research

RED ELÉCTRICA DE ESPAÑA

Our thanks go to:

All those who have participated in the research project described in this publication and who have collaborated with Red Eléctrica every day for more than 15 years in its efforts to preserve birdlife and protect the environment.

Contents

Introducción

For more than 15 years now, Red Eléctrica de España has been developing an extensive programme of activities in the field of studying the interactions between birds and electrical power transmission facilities in an attempt to mitigate the incidence of these facilities on birdlife and favour compatibility in their use.

This publication aims to make known the different applied research projects undertaken by Red Eléctrica. Many of these projects have been conducted in collaboration with public administrations and institutions of great prestige.

The projects have dealt with a great variety of topics, such as the incidence of birds colliding with electrical lines, the development of systems for marking ground wires and an evaluation of their efficacy, the installation of artificial nests for storks and artefacts for preventing birds from nesting and the use made by certain bird species of electrical lines and substations.

All these years of active, ongoing research developed in order to prevent or mitigate potential negative interactions between the electrical infrastructures and the birds are proof of the strong commitment and actions taken by Red Eléctrica to preserve and protect birdlife.

The following chapters show the progress made in research projects and the most relevant results or conclusions drawn from them.

"Preventing or mitigating negative interactions between electrical facilities and birdlife is an environmental priority for Red Eléctrica"

1. Collisions between birds and electrical lines

1.1 Study of the problems that this causes

Perhaps the best known problem with birds and electrical lines is the fact that birds often collide with the conductors or ground wires. This takes places because the birds do not see the lines in flight or are unable to detect them in time, or because they do not identify the lines as unavoidable obstacles. Collisions take place in all types of lines, both in medium to low voltage lines, or conductor distribution lines, which are not very thick (these lines have no ground wires), and in transmission lines when the collision usually occurs with the ground wire, which has a smaller diameter than the conductors and are therefore less visible.

In 1989 Red Eléctrica started to carry out research into this problem by gathering and analysing existing international bibliographical references on these accidents with electrical transmission lines involving birds and the landscape.

The conclusions drawn from the analysis gave rise, during that same year, to the first study conducted in Spain on the collision of birds with electrical lines. For this purpose, orange bird-saving spirals were installed along 4 sections of the 400- kV electrical line between Valdecaballeros and Guillena over a total distance of 28 km. Markings were installed at the point where the lines passed through the reservoirs of García Sola and Orellana and the Pela Mountains and areas of Coronada and Ahillones, in the provinces of Cáceres and Badajoz. This study showed the efficacy of the method used since a reduction of 61% was observed in the frequency of flight in the sections analysed, with a significant fall in collisions of around 60%, reaching up to 75% in efficacy with respect to protected species.

Between 1991 and 1995 Red Eléctrica took part in the ambitious project analysing the impact of electrical lines on protected nature reserves [within the Electrotechnical Research Programme (ERP)]. Through this project, in which other electrical companies also took part, and which was designed and supervised by Doñana Biological Station (Scientific Research Council), great progress was made in obtaining knowledge about the death rates of birds in electrical lines. In addition to this project, Red Eléctrica undertook many other similar studies on the same topic, which dealt with more specific issues.

• *Areas in which the collisions of birds with electrical lines were studied in the ERP project*

Between 1992 and 1993, within the framework of the ERP project, more than 30 km of electrical transmission lines were examined regularly: Valdecaballeros-Almaraz/Morata, Almaraz-Guadame, Foz de Lumbier, Cáceres-Trujillo (Llanos de Cáceres) and a distribution line in the Marshlands of Odiel (Huelva), located in different points of Andalusia, Extremadura and Navarre. The same sections were examined on seven occasions, to estimate the death rate along the sections under study and identify the species most affected, and the factors related to this. The following results were obtained:

> The global death rate among birds in collisions is quite low in proportion, and highly localised in terms of surface area. However, in the specific case of some species in danger of extinction, its repercussion on bird populations can be quite important.

> As a general rule, the species identified as being most at risk of suffering collisions are those with a heavy body weight, but a small wing span, which means that their flight is heavy and with little room for manoeuvring, such as ducks, certain land species (great bustards, little bustards, stone curlews, etc.), some long-legged birds (storks, cranes, flamingos, etc.) and vultures.

> The sociability and formation of large concentrations of birds, for either reproductive, feeding purposes or during migratory movements also increases the risk of accident due to collision. The groups that usually show this type of behaviour are marshland birds, gulls, water birds and some long-legged birds.

> Death due to collision with electrical lines is determined by the features of the surrounding landscape and the species present in nearby areas, rather than by the technical characteristics thereof.

> The reduction in visibility due to adverse weather conditions (mist or rainfall), the relief of the land or vegetation and turmoil caused by fleeing increase the probability of accidents due to colliding with electrical lines.

"The number of birds colliding with electrical lines is quite low in proportion and highly localised in terms of surface area"

1.2 Preventive identification of accidents

In relation with preventing birds from colliding with electrical lines, Red Eléctrica undertook a pioneer study on this problem. The particular ornithological relevance of the Strait of Gibraltar made Red Eléctrica aware that if the opportune measures were not taken, the negative interaction between the birds and the lines to be laid in those areas could reach alarming proportions for some

species, and for line maintenance. For this reason, a study was started, in collaboration with Doñana Biological Station (Scientific

Research Council) on birdlife in the area surrounding the future construction of the 400-kV electrical line between Pinar del Rey and Tarifa.

Between 1994 and 1995 samples were taken on the crossings of birds over what was then the future course of the line, in order to define the migration corridors used by birds along it, locate the areas of pre-migratory concentrations and identify species of particular interest in terms of sedentary, summer and winter birdlife. Based on this information, it was possible to define the sections of the future electrical line that were potentially the most conflictive for birds, and for which the adoption of preventive measures were proposed.

The results of this study are shown below:

- The best represented species in the samples were gulls (54.9% of all species observed), the griffon vulture (18.2%), the black kite (10.4%) and the white stork (9.6%).
- 54% of the birds observed corresponded to typically migratory species. These were observed in general, at greater heights above the course, meaning that they were less likely to fly over the course in situations of risk.
- Along the future line, a distinction was made between potential low, intermediate and high accident rates among birdlife, indicating that this classification was the result of a relative estimate of risk and not a hypothetical risk for the birds.

Continuing with its research activity, in 1997 Red Eléctrica cooperated with Barcelona University in analysing the risk of collision by Bonelli's eagle with electrical lines in Catalonia. To do this, the risk of collision arising from the presence of electrical power lines was evaluated, and a connection established between the death rates observed in areas in which this species nested during 1990 and 1997 and the presence of high voltage electrical transmission lines, and finally, an analysis was made of the vulnerability of the Catalan population of Bonelli's eagle compared to this type of accident and the scope of the corrective measures necessary to prevent these Accidents. The results of the study were not conclusive since only 2 collisions were detected over a period of seven years and in principle, there was no relation between the fall in the population of this species in Catalonia and deaths due to collision.

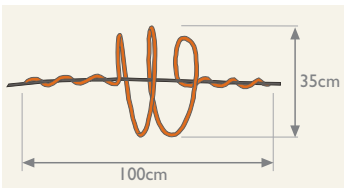
1.3 Reduction in deaths due to collision

1.3.1 Line markers

The corrective measures adopted on collision rates are based mainly on devices placed on the ground wire or on rare occasions, on the conductors (lines with no ground wires) in order to make these elements more visible for the birds.

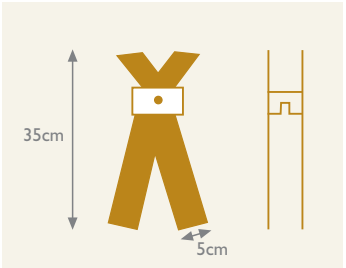
Within the framework of the ERP project mentioned above, 3 markers or signalling devices for electrical lines were studied, for the purpose of reducing collision rates. Before carrying out the marking activities, different sections of electrical lines were inspected for one year (between 1991 and 1992), and the deaths caused in these lines were studied. Subsequently 3 segments of different lines were marked along alternate sections, so that the deaths recorded on the marked sections could be compared against those of the non-marked sections and the different years of study (before and after carrying out the activities). The result of this study is shown below:

> **Bird-saving spirals.** A white PVC spiral, 1 m in length, with a maximum diameter of 30 cm. This measure had already been widely used in Spain and in other countries. 8 alternating sections were selected at the start of the 400 kV line from Valdecaballeros to Almaraz/Morata (Badajoz), in which a large number of cranes gather in the winter. The spirals were installed at staggered intervals every 10 m on both ground wires, producing a visual effect equivalent to one mark every 5 m. The fall in the number of deaths obtained through this device was 81%.



Bird-saving spirals

> **Black strips.** This consists of putting in place two black neoprene strips of 5x35 cm crossing each other, which are held in place by a polyurethane staple with luminous tapes. This device was installed at intervals of 20 m, on the 132 kV external electrical line distribution conductors between Cáceres and Trujillo, since there were no ground wires. They were placed alternately along 15 sections (7 marked sections) with a staggered lay-out, to generate a visual effect equivalent to one mark every 10 m. The area through which this line runs has an important great bustard breeding population.



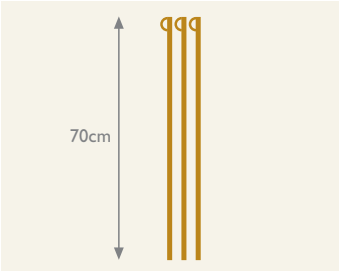
Black strips

This marker obtained a significant fall in deaths (76%), but not in the case of the great bustard, for which the death rate remains unchanged.

> **Clamps.** Black polyamide clamps measuring 70 cm long and 8 mm thick. These were installed during the central phase, in

groups of 3, at intervals of 15 m on a 13 kV electrical distribution line. 4 marked sections alternated with another 4 unmarked sections. This was the only case in which no positive results were achieved. Based on the data obtained, it was not possible to confirm the efficacy of this measure.

Although the ERP project offered conclusive data on the efficacy of bird spirals, (a measure used by Red Eléctrica), other research teams corroborated the efficacy of this measure by studying the collision rates along specific sections of the transmission grid distributed throughout very different geographic areas.



Clamps

As a result of the aforementioned study on the marking of the Pinar del Rey to Tarifa electrical line, a marking proposal for the most conflictive stretches was made, using anti-collision devices. This was finally carried out in 1997, by putting orange spirals measuring 1 m in length and 30 cm in diameter in place on most of the sections along this line (65 sections were marked, out of a total of 78). After putting the line into operation, inspections were carried out, among other activities, to determine and quantify efficacy with respect to accidents due to collision.

Line between Pinar del Rey-Tarifa
Monthly death rates (birds/km)
0.10
Frequency of flight (birds/hour)
6.2
Accident rate (% of victims)
0.004

The death rate can be considered low in relation to the lines indicated using the same methods in both areas, given the great number of times the birds fly over the lines. All the victims were located along the marked sections, whereas none were located along the unmarked sections. It therefore seems to be the case that in the study conducted in 1995 the most conflictive stretches of the lines were correctly identified.

In June 1999, Red Eléctrica tackled the project of monitoring the Valdecaballeros-Guillena line, with the principal aim of conducting an analysis into marking with orange bird-saving spirals installed in 1989 and 1994 in 4 stretches of this line, either to corroborate their validity as an anti-collision method or to make a corrective proposal. The data obtained between 1999-2000 indicated that the spirals installed in 1989 showed a very small deterioration percentage (except for the fading colour, which occurred in all the devices, and only 2.7% of the bird-saving devices, out of a total of 3,077 spirals installed were incomplete); in turn the 364 spirals installed in 1994 were all intact. The deterioration of the bird spirals did not lead to a significant change

"Studies carried out by Red Eléctrica show that marking lines with bird spirals considerably reduces the risk of the birds colliding with the electrical lines"

in the flight rate of the birds over the lines, or an increase in the accident rate along sections with deteriorated spirals, and it was thus concluded that the state of deterioration of the markers was not sufficiently important to warrant them being replaced. This suggests that the useful life of the bird spirals is over five years and that the markers continue to remain effective for at least ten years afterwards.

The table shows a comparison of the death rates for the different studies:

Line	Winter 1990-1991		Winter 1999-2000
Valdecaballeros - Guillena	Not marked	Marked	Marked
Valdecaballeros	0	0.17	0.13
Navalvillar	0.15	0.11	0.00
La Coronada	0.05	0.04	0.11
Ahillones	0.12	0	0.08
Total	**0.12**	**0.08**	**0.08**

In July 2000, Red Eléctrica started a project for marking the 400-kV electrical line between Guadame-Tajo in order to monitor the accident rate among birds due to their colliding with the ground wires when flying in the vicinity of the Natural Reserve «Laguna de Los Jarales» which is included in the "Marshlands in the South of Cordoba" ZEPA (Special Protected Bird Zone). During phase one of this study 4 sections were identified as being potentially more conflictive for birdlife, based on the flight information over these areas, and the deaths recorded. During phase two, 2 of the 4 sections were fitted with spirals. The results obtained after marking were used to compare both study phases. Currently, the marking of 2 unmarked sections has finished. Below is the death rate observed during the first and second phases of the study, and the percentage corresponding to the fall in the collision risk:

Línea Guadame -Tajo	Sin señalización (birds/km)	Marked (birds/km)	% Reduction
· All birds	19.2	7.1	62.8
· Water birds	6.8	0.8	88.2

This death rate among birds due to collisions was considered low enough to avoid endangering the conservation of any species linked to the «Laguna de Los Jarales». It was concluded that the marking was satisfactory both in terms of reducing the death rates observed along the marked sections and in terms of the changes in flying height, which affects the fall in the potential risk of collision.

1.3.2 Silhouettes of birds of prey installed on electricity pylons

Although the spirals have been shown to be effective in reducing deaths, Red Eléctrica considered it necessary to continue investigating into designing and testing new measures that would mean savings in the cost of materials, and prove easier to install in addition to being more versatile. The use of «birds of prey models» (silhouettes or 3D models) was devised as a complementary method, and also as an alternative to the bird spirals. With the silhouettes installed on the pylons, the birds would not fly too near them, thereby avoiding the associated risk of the nearby cables. Red Eléctrica conducted a study to evaluate the effect of these models on the flight of the birds, assessing their effectiveness as an anti-collision device in general, and in particular, within the vicinity of the electrical line from Pinar del Rey to Tarifa.

The construction of this line offered an ideal opportunity to test these new methods. Three different models of birds of prey were installed during the post-migration period of 1996, on different pylons, already raised along this line, without laying the cables.

It was also considered appropriate to conduct studies into the efficacy of one of the models in a different geographical area, with different types of birds, basically formed by resident species (nesting or wintering birds). For this purpose, Doñana National Park was chosen, where, between February and March 1997, another test was performed with the model giving the best results in the Strait of Gibraltar area.

Each test was comprised of between 95 and 120 hours of observation, distributed in continuous periods of between one and two hours.

During these periods, the presence of birds in the area surrounding each sample point was corded, as well as their flying height and

Oversized eagle (70 cm x 120 cm)

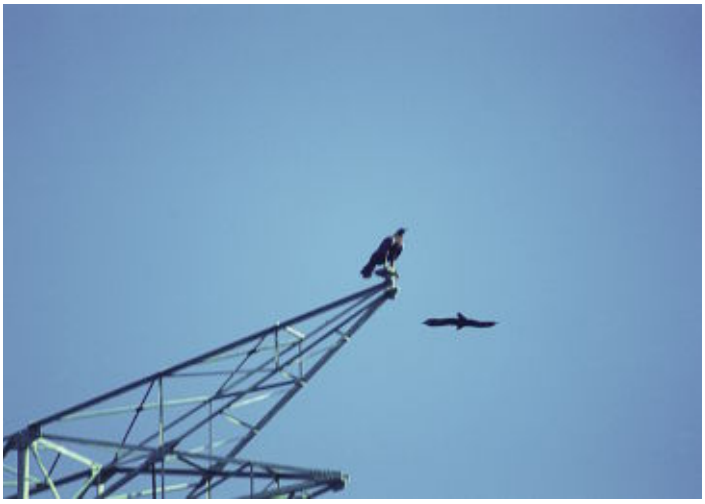
Bird in flight (105 cm x 50 cm)

Perching bird (30 cm x 40 cm)

minimum distance from the model or control point, and the type of behaviour in flight that could be attributed to the presence of the model (attacks, attempts to flee, changes in flight direction, etc.).

The tests performed were sufficiently conclusive regarding the efficacy of the models as an anti-collision method: none of them affected the behaviour of the birds in flight, to such an extent that the idea of using them to reduce the rate of accidents with electrical lines was considered. However, there was a qualitative difference between the model types tested: the most realistic model, representing an oversized eagle, caused certain reactions in some groups of birds, in particular birds of prey, but unfortunately this did not lead to a change in their behaviour in flight that might have determined less risk of collision. On the contrary, the other models tested, flat silhouettes of a bird in flight and a perching bird caused hardly any reaction among the birds, and some birds of prey even perched on the pylon itself, next to the model.

"In most tests performed, the bird silhouettes installed on the pylons were rarely effective as an anti-collision measure"



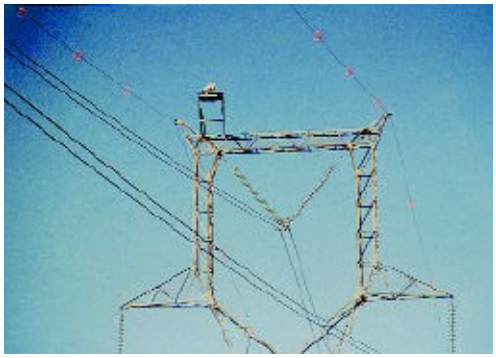
2. The effects of nesting on the transmission grid

2.1 Nesting of birds on electricity pylons

Nesting on infrastructural and construction elements is relatively common among birds. Among these infrastructures are electricity pylons on which different species of birds nest, but especially birds of prey and birds from the crow family. Birds of prey include several species, some of which are considerable in size, such as the Golden eagle (Aquila adalberti) and Bonelli's eagle (Hieraaetus fasciatus), other medium-sized birds such as the common hawk (Falco peregrinus), but the case of the white stork (Ciconia ciconia) is particular striking. This bird forms large colonies in line with the electrical lines in Spain.

There is sufficient evidence to sustain the hypothesis that electrical lines serve as a support for their nests, and therefore make a significant contribution to the widespread area in which these birds breed, mainly in areas with the appropriate characteristics for them to breed, but which lack suitable natural structures for nesting. It has been suggested that the use of the electricity pylons by these birds may offer an advantage over the use of natural supports such as cliffs or trees (they are more stable, are less easy for predators to reach, etc.).

The use of the electricity pylons by birds usually brings negative consequences for the companies owning these lines, due to their impact on electrical line maintenance. These negative affects usually materialise largely as short circuits (due to accumulations of excrements and/or materials used to make the nests), operating difficulties in the pylon during maintenance work and alterations in the distribution of the loads and the aerodynamics of the pylons (affecting their stability). The effects of nesting on the maintenance and operation of electrical lines leads to economic losses and deficient service quality and is of great concern in the case of distribution lines. As a result, the nesting of birds on electricity pylons has become a serious problem in certain areas for electrical companies, including Red Eléctrica.



2.1.1 Nesting of storks and birds from the crow family on electricity pylons

In 1995 Red Eléctrica decided to conduct a study for the purpose of analysing the problems of birds nesting in an area especially prone to problems with the electrical supply: the south-western part of the Iberian Peninsula. The results of this study were used as a basis for later studies on more specific aspects of the problem and in order to adopt an action procedure in relation to the birds' nests located on electricity pylons.

The information used as a basis for quantifying the number of nests was comprised of a series of files on nests found on pylons, following an inspection made in 1994 on the electricity transmission grid (equal to or more than 220 kV) owned by Red Eléctrica in the provinces of Badajoz, Ciudad Real, Huelva, Sevilla, Cádiz, Córdoba, Jaén, Málaga, Granada and Almería. The grid was considered to be formed, at that time, by 15 lines (including 5 not in service), with a total length of 1,800 km and some 4,000 pylons.

The presence or absence of nests was noted for each pylon examined, as well as the species responsible for building the nests and/or using them, the place on the pylon occupied by each nest and the characteristics of these nests (the nests of small birds or those of a size equal to smaller than a magpie's nest were not included in the count).

The most relevant results were the following:

> The total number of pylons affected by nests was estimated to be between 103 and 156. These figures mean that between 2.9% and 4.3% of the pylons in the grid were occupied by at least one nest of a medium-sized bird or a large bird. The total number of nests in the transmission grid was estimated to be between 132 (the minimum number recorded) and 172.

> The distribution of the nests by line was not uniform. Most lines had low percentages of nest occupation (from 0 to 0.3%), but 4 of these had considerable percentages (>5%). In particular, the 400-kV electrical line between Almaraz and Guillena, with a minimum occupation rate of 12.5% of its pylons.

> Birds belonging to the crow family were present in all electrical lines with nests, and were the only nesting species in 3 of them. Although this species is responsible for 77% of nests found in pylons (out of a total of 120 pylons), its nests represent 66% of the total. The opposite situation was seen for the white stork (nesting in 3 lines), with 17% of pylons occupied but responsible

for 26% of nests, since the existence of more than 1 nest per pylon was observed. Common kestrels (Falco tinnunculus) were recorded as nesting in of these 3 lines, but always on abandoned crows' nests and 1 Bonelli's eagle nest was also found.

> Storks and birds from the crow family were seen to have the same pylon selection model pattern: 83% of stork nests and 77% of crows' nests were found in cat head type structures. The cat-head type ones were the preferred type, whereas the double-circuit ones were usually avoided.

> It was seen that the pylon model played a very important role in the number of accidents caused by nests in the electricity service: accidents were expected in only 16% of the double-circuit pylons, even though they were slight; however, this percentage reached 97% in the case of the cat-head pylons.

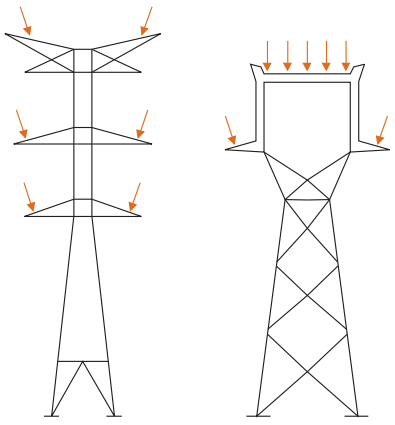
2.1.1.1 Identification of potentially affected points

In 1996 Red Eléctrica initiated a study into the factors associated with the presence of nesting birds in electricity pylons to detect common nesting habits. In particular, the main objective of the study was to prepare a methodological tool for identifying the points and pylons in the grid with the greatest likelihood of being occupied by the most common nesting species: the crow family and the white stork.

The study was carried out in the south-western part of the Pensinula, and included the Spanish provinces with the largest presence of white storks nesting in the electricity transmission grid: Huelva, Cádiz, Sevilla, Córdoba, Badajoz, Cáceres, Ciudad Real, Toledo, Madrid, Ávila, Segovia and Salamanca. The entire Red Eléctrica transmission grid was studied in those territories along 51 electrical lines, and an additional 50 electrical lines of between 66 and 220 kV owned by other companies. 239 white stork nests 68 crows' nests were observed, on 172 and 65 pylons, respectively.

Each support was analysed by measuring the value of a set of variables within its environment, and its technical attributes which, in principle, could have a bearing on the likelihood of occupation.

The variables were measured directly on site or on topographic maps and maps of farmlands and buildings. The different sets of data were analysed in order to identify the variable having the greatest importance in distinguishing between pylons with nests and pylons without nests (control pylons).



Nesting points for the white stork in double-circuit pylons (left) and cat-head pylons (right) causing problems in facility maintenance

Analysis of the factors associated with the location of groups of white storks nesting on electricity pylons

An analysis was made, to draw a distinction between 22 estimated variables in the area surrounding each occupied pylon, but only 6 were considered decisive based on the model. The variables selected were the following:

> proximity to marshland, reservoirs or rivers (having a positive influence),

> continental temperature variable: warmer monthly temperature/colder mean monthly temperature (having a negative influence),

> duration of the dry period in the summer (having a negative influence),

> proximity to asphalted roads (having a negative influence),

> presence of nearby dry croplands (having a positive influence),

> proximity to forests (having a positive influence).

In sum the areas where the white stork was found to nest on pylons were often in habitats characterised by having greater possibilities in terms of finding food (proximity to wetlands, the appropriate climatic conditions for the species), and also in open spaces where there were no other adequate supports (dry croplands).

Analysis of the factors associated with the nesting of birds belonging to the crow family on electricity pylons.

An analysis of the nesting habits of the crow family of birds was made using a set of 15 variables and it was concluded that the likelihood of occupation by crows and their like is associated to the following factors:

> proximity to asphalted roads (having a negative influence),

> proximity to other types of supports for nesting (having a negative influence),

> proximity to forests (having a positive influence),

> proximity to streams (having a negative influence).

The most important discriminative variable is the distance from the alternative support that is nearest to the nest (pylon or tree). In 70% of cases, this distance coincides with the distance from the nearest tree, which leads us to think that birds from the crow family tend to nest on pylons when there are no trees available for nesting. The «distance from the nearest road» variable tells us that selecting this option also takes into account the tranquillity of the surroundings or lack of human presence. In conclusion, the absence of the right supports and lack of human presence appear to be the factors that most influence using electricity pylons as supports for crows' nests.

Application of the results to taking preventive action with respect to nests on electricity pylons.

Based on the value of the variables estimated on topographical maps and maps of farms and croplands, the percentage of probability with respect to each point can be calculated. This value then used to evaluate the likelihood of occupation at a certain point in the grid by the white stork and birds from the crow family.

It should be said that there is an importance difference between both species studied. The white stork is a bird in full expansion in Spain, which often colonises new areas, especially when it can use the electrical lines to build its nests. However, the same is not true of crows, jays, magpies and ravens, and they are tending to disappear, for which reason the likelihood of new pylons being occupied by their nests is lower than that associated with stork nests. Consequently, at present the only useful option is to use a tool for predicting the number of nests in pylons in the case of the white stork, especially since this species has the greatest effect on the electricity transmission system.

These values were validated and applied in two different projects: in 1999 the likelihood of occupation by stork nests was calculated along 8 lines in a project conducted in the north-west area of Spain, and in 2004 the classification functions were used to identify the sections with the greatest likelihood of being occupied along a line under construction to the south of Badajoz (the 400 kV line between Balboa and the Portuguese border). Within the framework of these projects, the methodological tool developed was reviewed, and adapted with the objective of excluding from the analysis certain variables that required greater efforts to obtain.

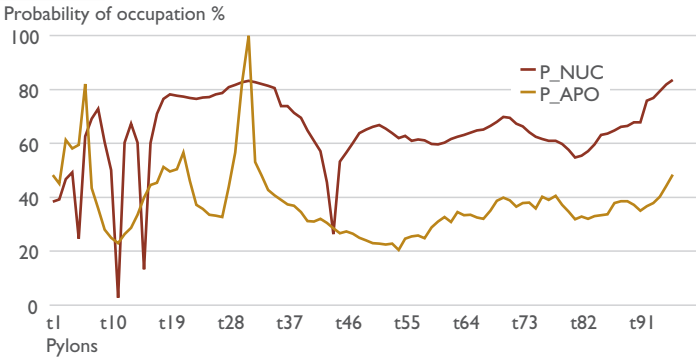
Evolution of the white stork population in Spain

Year of census	Number of couples
1948	14,513
1957	12,701
1974	7,343
1984	6,753
1990	7,901
1992	10,000
1994	16,643
2004	33,215

Information obtained from the "Atlas de las aves reproductoras de España" (Atlas of the reproductive birds of Spain) (Ministry of the Environment and the Spanish Birdwatchers Association /BirdLife), Madrid, 2003.

After making this adaptation, all the variables to be used were obtained from conventional mapping, thereby making it easier to apply the tool to a multitude of potential situations.

The table below shows the probabilities of the line between Balboa and the Portuguese border being occupied by nesting groups (P_NUC) and stork nests (P_APO) along its course.



2.1.1.2. Reduction in the numbers of nests

Artificial nesting platforms

The 400 kV electrical line between Almaraz and Guadame, with cat-head type pylons, serves as a nesting site for a colony of white storks along the stretch running through the Alcudia Valley (Ciudad Real), which was monitored by Red Eléctrica.

In 1992 the stork colony installed on that line consisted of 19 nests on 12 pylons with a maximum occupation of 3 nests on one pylon. To reduce the number of nests on the electrical lines, Red Eléctrica decided to transfer 12 of those nests to artificial platforms (one for each pylon).

These platforms are metal structures, fastened to the upper bridge, above it, and a distance from the vertical support axis, which reduces the probability of debris and excrements falling from the nest onto the insulators chain.

After placing 12 artificial platforms on the line, continuous samples were taken between 1994 and 1995 to monitor the behaviour of the storks on the pylons throughout two reproductive seasons, from the time the nests were first constructed and reconstructed to the phase when the young chicks abandoned the nests.

"The crow family and the white stork are the bird species that most often nest on electrical pylons"

The main problem identified in relation to using these platforms, in the case of the white stork, is the colonial nature of the species: in transferring the nests to the platforms, a suitable point was left free for new couples to settle, which occurred quite often in the colony under study. This behaviour is not common in other birds which nest alone and/or with a marked territorial character (as is the case of the crow family and most birds of prey).

One of the recommendations arising from this study was that of developing a system to prevent them from nesting on certain parts of the pylon. The combination of prevention methods and the installation of platforms seems to be the only way to ensure that the pylons can be used as nesting places for white storks, without causing problems in line maintenance and without losing the «ecological» function of the supports.

Anti-nesting devices
Consisting of differing numbers of rods (with a length of 60 cm, and thickness of 2 cm) and smaller rods (with a length of 1 m, and thickness of 6 mm) laid out in different directions

Anti-nesting Devices

At the end of 1995 Red Eléctrica decided to test an anti-perch device: this consisted of a series of rods supplied by Electricité de France (EDF), that had been successfully tested by the French electrical company. The test objective was to use it to prevent the birds from nesting. These rods were installed in the form of one rod or in groups of 2 or 3 at conflictive points along the

electrical line between Almaraz and Guadame. A study on the nesting habits of the white stork in the presence of these devices was conducted in 1996.

The results showed the lack of efficacy of the EDF model, as it was seen that greater protection on the upper bridge of the pylons was a more satisfactory method, since it also protected non-problematic parts of the pylons, but allowed access to other parts affecting the electrical supply (such as the anchoring points of the ground wires). However, this solution was very costly in terms of the materials used and the time needed to install the devices. On the other hand the barrier formed in this way posed an insurmountable obstacle for the maintenance operators, who found it very difficult to move along the top girder of the pylons and to gain access to certain points.

Based on the results of the above study, it was quite clear that the problem of storks nesting on the pylons required a special approach, based on the characteristics of the white stork, and also the pylons on which they were building their nests in the Peninsula. The lack of an effective solution for protecting the pylons using these devices led Red Eléctrica to take another step in studying the interactions between the storks and the electrical pylons and more specifically, in solving the problem of nesting on parts that caused problems in the electricity supply.

Consequently, an ambitious project was put in motion, which is still in progress at the present time, with the aim of finding effective, economical devices that can be installed on a great number of pylons in which there are nesting problems.

> In 1997 a catalogue of anti-nesting prototypes was prepared, that could be tested to verify their efficacy.

> In 1999 the efficacy of the anti-nesting devices was observed under real-life conditions (the ones that gave the best results in the test) installed on the pylons with nesting problems. For this purpose, monitoring was conducted on the nesting of storks on those pylons, since nothing was known about the reactions of

the birds when the nests were removed, and the devices were then installed on the pylons, limiting the available nesting points.

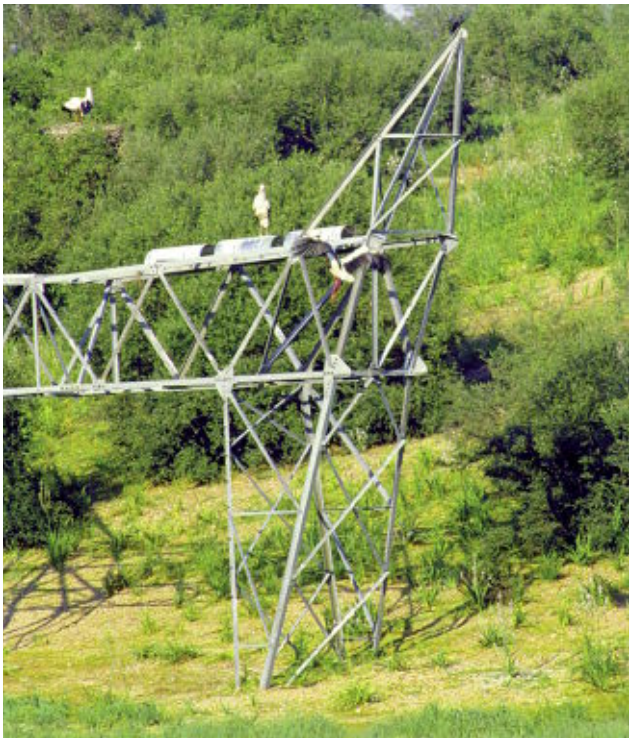
> In 2000 tests were performed, in experimental conditions, on double-circuit pylons, with new models and anti-nesting devices (based on the rods system). Furthermore, the catalogue of anti-nesting devices was enlarged and updated, and a proposal drawn up for installing them on electrical lines with existing or potential problems of nesting storks.

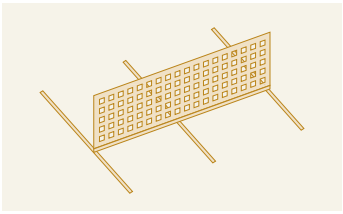
> Since 2001 monitoring has been carried out on nesting storks and anti-nesting devices installed on electrical pylons. This monitoring, which continues at present, serves not only to update the actions that need to be carried out on the pylons, but also to improve the efficiency of the devices installed (lay-out, material, etc.). The growth trend in the white stork population means that the number of nests and pylons occupied changes every year, which requires adjustments to be made in the devices installed.

The following sections describe the most significant results obtained in the above studies.

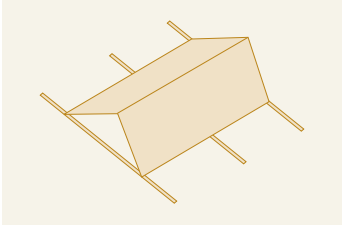
Studies performed in a «Natural laboratory»

In 1998 a test support was constructed with a cat-head design near the Almaraz-Guadame line, whose pylons have the same characteristics. In turn, two metal structures were erected, similar to the cat-head type pylons next to a breeding colony of storks in la Dehesa de Abajo (Puebla del Río, Seville); the largest colony of this species nesting in trees in the Iberian Peninsula. These structures, together with the initiation of the project, formed an enormous natural laboratory for studying the interactions between the nesting storks and the electrical lines.

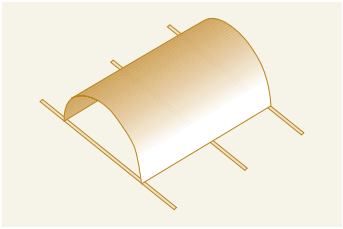




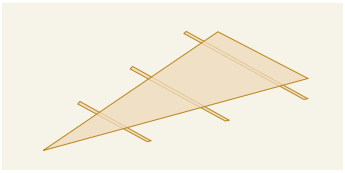
Vertical plate



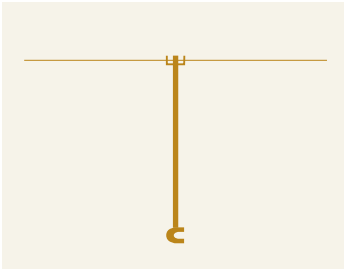
Roof



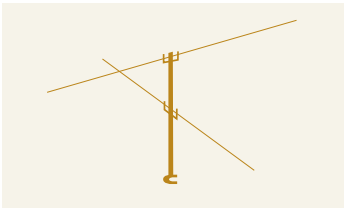
Vault



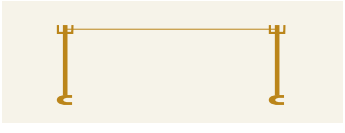
T-rods



Cross rods



Parallel rods system



Arm cover

7 different devices were selected for testing as anti-nesting devices on the cat-head type pylons, either on the bridge, crosspiece or on both structures: Vertical plate, roof, vault, arm covers, T-rods, cross rods and parallel rods system.

As a whole, the devices formed by large rods and smaller rods (T-rods, cross rods and parallel rods) were more effective than others as an anti-perch method, and consequently as an anti-nesting method. The arm cover, top and vault did not prevent the birds from perching, but performed as anti-nesting devices and in addition, protected the insulator chains against the accumulation of excrements. The vertical plate was the device with the least positive results, and therefore was the only test method that was not continued during the following studies.

One relevant observation of the study was that the efficacy of the different rods systems depending to a large extent on the correct lay-out of the device on the pylon and how well the different elements were fastened to each other and to the supporting structure. Another aspect to be considered in assessing the tested devices was their interference with line maintenance work, since all the anti-nesting devices on the bridge or crosspieces of the pylons interfered in some way or another with the work of the operators. These interferences were more important in the case of devices that completely covered the upper sides of the bridge (vault, roof) and the crosspiece (arm cover).

Based on the results obtained in the cat-head designs, the need to perform specific tests on anti-nesting devices on the double-circuit pylons arose. The ideal place for conducting this test was found on the electrical line being constructed between Peñalba and Graus, since the pylons already erected along this line had a considerable number of white stork nests and no conductors, which consequently made it possible to install different systems and devices during short test periods.

In 2000, different rod devices were installed (T-shaped, crossed and parallel rods), which all had a significant effect on the use of protected areas on the pylons by the storks. The presence of birds in the protected areas was much lower than the presence of birds in non-protected areas, or the control pylon, and the reconstruction of nests was made more difficult by the presence of the devices, although this was not prevented in all the cases.

Field tests

In 1999 the devices tested along different stretches of the Red Eléctrica lines were installed. Both cat-head type pylons and double-circuit pylons were selected.

Despite the rising trend in the number of storks nesting on transmission lines, in quantitative terms, the effect of installing anti-nesting devices, evaluated as a whole, has led to a reduction of between 34 and 39% in the number of nests estimated for 1999, on the pylons on which interventions were made. From the qualitative standpoint, the effect of this reduction was even most important, since some of the nest reconstructed on the same structures were moved several metres further away from the insulator chains. However, the reduction in nests in the cat-head pylons was set at a minimum of 44.3% (48.5% on the bridge and 36.9% on the half crosspieces), as opposed to 15.0% on the double-circuit pylons. Based on the test results in the «laboratory», the devices that offered the best results were the rods, in all their configurations (T-shaped, crossed or parallel) and the devices.

It was observed that the effect of the anti-nesting devices was greater in preventing new nests from being built than in preventing the reconstruction of nests that had been removed. This appears to be the result of the extent to which the white storks are bound to the nesting points. For this reason, to solve the existing problems caused by nesting, the actions taken to protect the pylons using anti-nesting devices will in general meet with greater success if they are preventive measures (in preventing new couples or colonies from settling) than if they were corrective measures.

Based on the latest tests, Red Eléctrica has been completing and adapting the installation on sections of line with nesting problems. Annual monitoring is being carried out on the installation of anti-

nesting devices in order to record the problems and make new proposals to correct problems arising during installation and complete it in pylons that have not yet been modified or in which new breeding points have been generated.

The sections included in this field study have 3 basic designs: the cat-head type, double-circuit type and layer type. The anti-nesting measures have varied with respect to previous years.

The areas of the pylons proposed for installing the anti-nesting devices are considered to be problematic areas in terms of the line operation and maintenance, and those in which nests have been located, as well as areas that could provide access to the storks.

There are 6 basic pylons designs, with the following parts that can be modified using anti-nesting methods (the number of areas is shown between brackets):

> Cat-head type: bridges (1), half crosspieces (2) and tower (2)

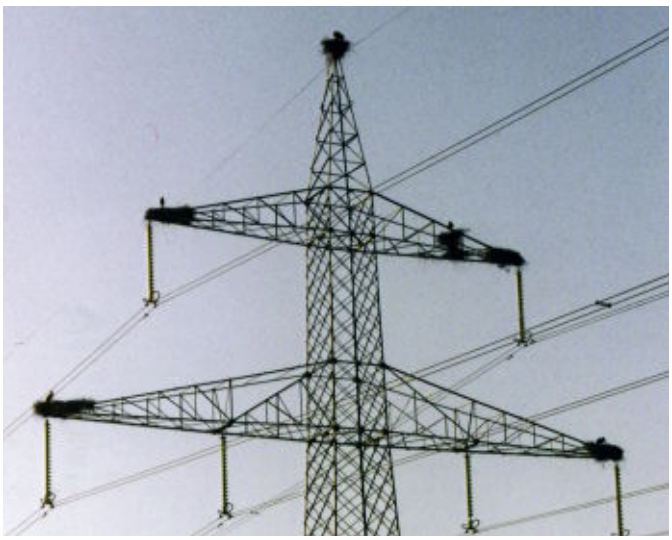
> Layer-type: bridges (1), half crosspieces (2) and tower (2)

> Double-circuit, three-crosspiece type: half cross pieces (8)

> Double-circuit type with two crosspieces and long ground wire crosspiece: short half cross pieces on the ground wire (2), short half crosspieces on the top crosspiece (2) and long half crosspieces (2)

> Double-circuit type with two crosspieces and short ground wire crosspiece: short half crosspieces (4) and long half crosspieces (2)

> Double-circuit type with two crosspieces, without ground wire crosspiece: short half crosspieces (2) and long half crosspieces (2)



The anti-nesting devices installed are formed by different configurations of T-shaped rods. The option of savings in materials is taken into account, and every effort is made to reduce the difficulties caused in the facilities by the work of the operators on the pylons.

During 2004 monitoring of the anti-nesting devices was done on more than 350 pylons corresponding to 21 electrical transmission lines, of which approximately one third are partly or completely protected by anti-nesting devices. The results obtained to date are variable. No device has managed to complete prevent the birds from building nests. In particular, in the case of already established couples, efforts to remove the nests from the protected points must be redoubled. Despite this, it is considered that the activities carried out will reduce the rate considerably, although the evaluation of the results affects a relatively small number of pylons, and in some cases the facilities are still too new to give a full idea of their efficacy.

Installing anti-nesting devices

2.1.2. Use of artificial nests made by the hawk

Electricity pylons take on a relevant ecological role in habitats with no appropriate natural structures, for birds to nest. The use of artificial nests favours the nesting of birds of prey on the pylons, enabling the electrical lines to play a positive part in interacting with birdlife.

Following the constant observation of the habits of the common hawk and its preference for electricity pylons as a nesting support in the province of Valladolid, and the breeding success of the species, this project was set up in 1997 at the proposal of the Wildlife Section of Castilla y León Government's Territorial Office of the Environment.

After analysing the areas inhabited by the common hawk in the Iberian Peninsula, the province of Valladolid was chosen for the study, since the population of this bird of prey in this region has unique characteristics through their use of a large variety of nesting supports.

The distribution of the hawk's nesting areas is governed by different factors such as the existence of suitable places in which to nest, such as river gorges and other places, trophic relations (the presence of food), types of supports in electrical lines and the presence of crows' nests.

"The installing of artificial nests on electricity pylons plays an important ecological role in habitats with no natural supports for nesting"

Study on artificial nests for use by the common hawk.

Experience in nesting and the reiterated observation of the habits of the common hawk made it advisable to test two types of artificial nests, which were installed on the half crosspieces of the electricity pylons.

> Container-nest: a standard plastic container with a capacity of 200 litres.

> Box-nest: a wooden box measuring 80 x 50 cm and between 50 and 57 cm in height.

Monitoring of the common hawk population in the province of Valladolid

During the course of the project the population of the common hawk in the province of Valladolid was monitored. This monitoring concluded that the number of common hawk nests on high voltage electricity pylons had grown in relation to traditional nests in river gorges, cliffs, abandoned quarries and buildings, leading to an increase in the population of this species in the province of Valladolid.

Box-nest occupied by a couple of hawks

Box-nest

Years of monitoring	Nests with successful breeding	Natural Cliffs	Electrical Lines
2001	17	53%	47%
2002	30	40%	60%
2003	29	36%	64%
2004	33	36%	64%

The monitoring showed that the preferred height at which the nests were built on the pylons coincided with the height of the first line conductor. It was also observed that the location of the nests on the second crosspiece may vary; it is located less often on the second crosspiece or under the lower crosspiece.

We should stress the importance of the previous intervention of birds from the crow family, which are considered excellent nest-builders, as their nests are used by hawks on both the pylons and in cliffs, even though adequate ledges exist in the latter case.

As shown in the following table, the presence of electrical lines in areas with no natural nesting supports for the common hawk leads to the successful breeding of this declining species in the province of Valladolid.

Years of monitoring	% OF SUCCESSFUL BREEDING	
	In crows' nests	In artificial nests
2001	55	66
2002	50	50
2003	58	83
2004	33	83

Hawk eggs in natural nest

Hawk chicks in natural nest

2.2 Nesting of birds in electrical substations

The constant changes in the environment lead animal species to adapt to guarantee survival. A frequent case is the use of electrical substations by birds. In Aragon and Navarre, considerable occupation of substations by the lesser kestrel (Falco naumanni) has been observed. This use is only during summer months, when large concentrations of pre-migratory birds take refuge in the porticos of the electrical substations.

During this study, it has been observed that this is not an occasional use but that the occupied substations are reused on successive years, and that birds prefer these places to others. The most important piece of information, however, is the great number of lesser kestrels that congregate there, since although some of these resting places house up to 100 of these birds, others house more than one thousand.

Given the importance of these concentrations and assuming the need to conduct a study into the relation between the lesser kestrel and electrical substations, this project was set up jointly by Doñana Biological Station and Red Eléctrica. The study aims to respond to the questions raised on the use of electrical facilities, potential death risks and preventing them, in addition to potential damage caused to the facilities and how to mitigate it.

The objectives formulated in this study, conducted between 2002 and 2004, can be summarised as follows: defining the interaction between the electrical facilities and the birds; determining the importance of the resting places in the preservation of this species at different levels, and lastly, proposing measures to mitigate the risks

Distribution of the lesser kestrel in the Iberian Peninsula

"The use of electrical substations by the lesser kestrel as resting places does not pose any risk to the species or alter the normal operation of the facilities"

for these birds in substations, if detected, and for verifying that the lesser kestrels do not alter the proper operation of the substations.

The first phase of the study consisted of locating the areas in which the lesser kestrels gather prior to migrating and searching for resting places associated to them. A visit was made to all the Red Eléctrica electrical transmission substations in the regions of Aragón and Navarre, in each case determining the presence or absence of this species, and the capacity of the facilities to house it.

To describe the capacity of the substations for housing these birds, the characteristics of the facilities themselves were analysed, and those of their surroundings. The best habitat for the lesser kestrel is formed by open spaces with traditional cereal croplands and natural woodlands, but they are also found in areas transformed into irrigated croplands. With respect to the characteristics of the facilities, those with hollow interiors or open to the exterior were considered suitable, as they enables the birds to shelter inside them. Attention was paid to human presence in the area, since it was considered that facilities outside built-up areas were easier to select.

To ascertain the origin of the lesser kestrels, two different techniques were used: reading individual plastic rings and an analysis of stable isotopes on the feathers. The origin of the birds concentrated in the resting places was considerably diverse. A total of 22 substations were visited belonging to Red Eléctrica, 5 in Navarre and 17 in Aragón. In addition, other areas in the rest of the region were visited, in which concentrations of lesser kestrels had been observed.

Initially, the presence of lesser kestrels was detected in 3 substations belonging to Red Eléctrica; Peñaflor, Magallón and La Serna, as well as Tafalla, belonging to Iberdrola. In 2004 2 new facilities were found to be occupied in Peñalba and Aragón.

Furthermore, during the summer of 2002 9 resting places were found in other supports, electricity pylons and different tree species.

Resting places	2001	2002	2003	2004
Peñaflor	-	951	489	319
Magallón	160	271	317	207
La Serna	84	217	292	108
Tafalla	843	1.452	1.349	1,018
Peñalba	-	0	0	65
Aragón	-	0	0	25
Total	**1,087**	**2,891**	**2,447**	**1,805**

Results of the simultaneous censuses for resting places of the lesser kestrel located in electrical transmission substations in Aragón and Navarre. The boxes with no data (-) in year 2001 indicate that the census was not performed.

In all the cases, the kestrels mainly used the porticos, taking refuge at night inside the lintels. In general, they occupied these places late in the evening, using other structures such as cables and lattices inside the substations or near them as perches. We should mention the use of the pylons near the substation, which housed an important number of birds both in the evening before entering the resting places and at dawn, after leaving the substations.

The observation of the flight behaviour of the kestrels in the substations was done in the evening and at dawn, in different climatic conditions. The frequencies observed with regard to the flight distance from the cables and other structures showed a low risk of collision, as occurred when analysing the way they entered the substation. Environmental factors had no influence on the collision risk.

It can be concluded that it does not seem likely that the kestrels could cause problems in the substation operations. Firstly, since they only use them as resting places before migrating, they do not use any debris, which may happen with nesting in other species. Secondly, the structures used, specifically the portico lintels, are robust and so the birds cannot damage them. The only problem is the accumulation of excrements, but this would pose no problems in the correct operation of the facilities, since the lintels are only used as supports.

3. Current lines of research

Red Eléctrica continues its research into new measures to increase birdlife protection even more. In this respect, it is working on the design and testing of a new bird-saving model that is more effective than the current one. Along this same line, research is also being done into the response of the birds to the different colours of the bird-saving devices installed to use those that are most visible to them.

Furthermore, a new line of research has been opened up, in which not only the impacts of electrical lines on birdlife will be analysed (currently, Red Eléctrica is studying their repercussions on pseudo-steppe birds with special attention paid to the great bustard) but also the feasibility of the measures in controlling the bird's habitat, and thereby reduce any impact caused.

A less innovative task, but equally important, is the monitoring of the measures installed, either to reduce collisions or to prevent birds from nesting in undesirable points on electricity pylons. This will enable us to ascertain the effectiveness of these measures and start up new studies to guarantee birdlife conservation, whilst guaranteeing the proper operation of the lines.

All the research studies referred to in this document, which are specifically aimed at studying the interactions between birds and electrical facilities, have been shown to be a valid tool in harmonising and making the presence of these facilities in natural environments compatible with preserving birdlife.

At the same time, the successive steps taken in the different studies performed mean that Red Eléctrica is now in a position to finally tackle the solution to most problems caused by its facilities to birds and vice versa. Very few aspects of this problem remain to be dealt with in the studies carried out, which in addition, have shown the important ecological role of the lines and substations as a refuge for threatened birdlife.

"Promoting the important ecological role played by electrical facilities in conserving certain endangered species of birds is one of our future lines of research"

It is precisely the line of evaluation and promotion of this ecological role of electrical facilities that offers the most opportunities for future research into the interactions of birds and the electricity transmission service. The presence of these facilities in natural environments with sufficient capacity to house certain species of birds, including birds of prey, birds from the crow family or storks, which do not have suitable places in which to nest, can be used as a valid tool in conserving those species. For this reason, for companies

such as Red Eléctrica, the designing of the right programmes to adapt these electrical lines and substations as an alternative to enable these endangered bird species to nest, is quite a challenge, after solving the maintenance problems arising from implementing these programmes.

4. Bibliographical references

1989-1992. Señalización de líneas de alta tensión para la protección de la avifauna (Marking of high voltage lines for birdlife protection): Valdecaballeros-Guillena Line. RED ELÉCTRICA /Foundation for Ecology and Wildlife Protection.

1992-1995. Análisis del impacto de líneas eléctricas sobre la avifauna de espacios naturales protegidos. (Analysis of electrical line on birdlife in protected natural areas) Sevillana de Electricidad, Iberdrola,RED ELÉCTRICA / Doñana Biological Station. (Scientific Research Council).

1994. Análisis de la eficacia de las medidas aplicadas en la línea detransporte de Almaraz-Guadame (Analysis of the efficacy of the measures applied on the Almaraz-Guadame transmission line). RED ELÉCTRICA.

1994-1995. Estudio de la señalización de la futura línea a 400 kVPinar-Estrecho (Study on marking the future 400-kV line between Pinar and Estrecho). RED ELÉCTRICA / Doñana Biological Station. (Scientific Research Council).

1995. Análisis de la eficacia de las medidas aplicadas en la línea Almaraz-Guadame para reducir los efectos de la nidificación de las cigüeñas II. Seguimiento de la nidificación en 1995 y estudio de la concentración de nidos en los apoyos (Analysis of the efficacy of the measures applied on the Almaraz-Guadame line to reduce the effects of nesting by storks II. Monitoring of nesting in 1995 and study on the concentration of nests on pylons). RED ELÉCTRICA.

1995. Estudio sobre la nidificación de aves en la red de transporte de electricidad de la Dirección Regional Sur de Red Eléctrica de España.(Study on the nesting of birds in the electrical transmission lines by Red Eléctrica de España Southern Regional Office). RED ELÉCTRICA.

*1996. Análisis de la eficacia de las medidas aplicadas en la línea de transporte Almaraz-Guadame para reducir la nidificación de cigüeñas III. (Analysis of the efficacy of the measures applied on the Almaraz-Guadame line to reduce the effects of nesting by storks).*RED ELÉCTRICA.

1996. Estudio de la nidificación de aves en la red de transporte de electricidad de Red Eléctrica de España (2ª Fase). Selección de hábitat e identificación de potenciales zonas de nidificación. (Study on nesting of birds in the Red Eléctrica de España electrical transmission grid (Phase 2). Selecting of habitats and identification of potential nesting areas). RED ELÉCTRICA.

1996. Estudio de la influencia de modelos tridimensionales sobre el comportamiento de vuelo de las aves y consideraciones sobre su aplicación en líneas eléctricas como medida anti-colisión. (Study on the influence of three-dimensional models in the flight behaviour of birds and considerations on their application in electrical lines as an anti-collision measure). RED ELÉCTRICA / Doñana Biological Station. (Scientific Research Council).

1997. Diseño de medidas disuasorias de la nidificación de cigüeñas sobre torres de líneas de transporte de electricidad.(Design of anti-nesting measures to prevent storks from nesting on electrical transmission pylons). RED ELÉCTRICA.

*1997. Control de las actuaciones con incidencia ambiental realizadas en la línea a 400 kV Pinar-Estrecho. (Control of activities having an environmental repercussion carried out on the 400-kV line from Pinar to Estrecho).*RED ELÉCTRICA.

1997. Análisis de la incidencia de la colisión con tendidos de transporte eléctrico en alta tensión en el águila perdicera. (Analysis of the incidence of collisions of Bonelli's eagle with high-voltage electrical transmisssion lines). RED ELÉCTRICA /University of Barcelona.

1997-2004. Programa de instalación de nidales artificiales para halcón peregrino en la provincia de Valladolid. (Programme for installing artificial nests for the

peregrine falcon in the province of Valladolid). RED ELÉCTRICA / Valladolid Regional Environmental Office. Government of Castilla y León.

1998. Ensayo de medidas disuasorias de la nidificación de cigüeñas sobre torres de líneas de transporte de electricidad. (Testing of anti-nesting measures for storks on electrical transmission pylons). RED ELÉCTRICA.

1999a. Seguimiento de la eficacia de medidas disuasorias de la nidificación de cigüeñas sobre apoyos de líneas de transporte de electricidad. (Monitoring on the efficacy of anti-nesting measures for storks on electrical transmission pylons). RED ELÉCTRICA

1999b. Seguimiento de la nidificación de aves en la futura línea eléctrica a 400 kV Peñalba-Graus. (Monitoring of the nesting of birds on the future 400-kV electrical line between Peñalba and Graus). RED ELÉCTRICA.

1999c. Seguimiento de la señalización de la línea eléctrica a 400 kV Valdecaballeros-Guillena.(Monitoring of the marking on the 400-kV electrical line between Valdecaballeros and Guillena). RED ELÉCTRICA.

1999d. Identificación de tramos y apoyos de futuras líneas de transporte de electricidad con elevada probabilidad de ocupación de nidos de cigüeña blanca. (Identification of sections and pylons for future electrical transmission lines with a high probability of being occupied by white stork nests). RED ELÉCTRICA.

2000a. Ensayo de nuevos prototipos de medidas disuasoras de la nidificación de cigüeñas sobre apoyos de transporte de electricidad de doble circuito. (Testing of new prototypes of anti-nesting measures to prevent storks from nesting on double-circuit electricity pylons) RED ELÉCTRICA.

2000b. Dispositivos disuasores de la nidificación de cigüeñas instalados en apoyos de líneas de transporte de electricidad. Catálogo de Dispositivos. (Anti-nesting devices to prevent storks from nesting on electrical transmission lines. Catalogue of Devices). RED ELÉCTRICA.

2000c. Seguimiento de la mortalidad de aves en la línea Guadame-Tajo a su paso por la Laguna de Los Jarales. (Monitoring of deaths in birds along the Guadame-Tagus line at Laguna de Los Jarales). RED ELÉCTRICA.

2000d. Seguimiento de la señalización de la línea eléctrica a 400 kV Valdecaballeros-Guillena en periodo invernal. (Monitoring of the marking of the 400-kV electrical line between Valdecaballeros and Guillena). RED ELÉCTRICA.

2001-2002. Seguimiento de la nidificación de cigüeñas e instalación de dispositivos disuasores en apoyos de líneas de transporte de electricidad.(Monitoring of nesting of storks and installing of anti-nesting devices on electricity transmission pylons). RED ELÉCTRICA.

*2002-2004. Uso de subestaciones de transporte de electricidad de Red Eléctrica por el cernícalo primilla (*Falco naumanni*) en Navarra y Aragón: su importancia para la conservación de la especie a nivel estatal. (The use of electrical transmission substations belonging to Red Eléctrica by the lesser kestrel (Falco naumanni) in Navarre and Aragón: the importance of this in conserving the species in Spain).* RED ELÉCTRICA / Doñana Biological Station (Scientific Research Council).

2003. Seguimiento de la nidificación de cigüeñas e instalación de dispositivos disuasores en apoyos de líneas de transporte de electricidad. (Monitoring of nesting of storks and installing of anti-nesting devices on electrical transmission lines). RED ELÉCTRICA.

2004. Tramos y apoyos de la línea de transporte de electricidad a 400 kV Balboa - Frontera portuguesa con elevada probabilidad de verse ocupados por nidos de cigüeña blanca. (Sections and pylons of the 400-kV electrical transmission line from Balboa to the Portuguese border with a high probability of being occupied by white stork nests). RED ELÉCTRICA.

Published by:
Red Eléctrica de España S.A.

Coordination:
Red Eléctrica Communication and Corporate Image Department

Technical work:
Asistencias Técnicas Clave
Red Eléctrica Environmental Department

Fotographs:
Red Eléctrica Archive

Graphic design, imaging and layout:
ZEN comunicación visual. www.zen.es

Printing:
EPES Artes Gráficas

Legal deposit:
M-48983-2005

RED ELÉCTRICA DE ESPAÑA
P.º del Conde de los Gaitanes, 177
28109 · Alcobendas · Madrid
www.ree.es

RED ELÉCTRICA
DE ESPAÑA

Pº del Conde de los Gaitanes, 177
28109 · Alcobendas · Madrid
www.ree.es