Reducing bird mortality caused by high- and very-high-voltage power lines in Belgium

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Executive summary

- High- and very-high-voltage power lines have been identified as a major human-induced source of mortality for birds. When birds fly in large groups, or in poor visibility conditions, they can collide with these structures, in some instances in sufficiently large numbers to raise concern. Several international agreements on nature conservation acknowledge this important issue. In answer to this concern, Elia, as the power transmission system operator in Belgium, intends to identify its own overhead power lines that present a serious collision risk for birds.
- The main objective of this project is to map collision-prone power lines in Belgium and to classify existing power lines according to their ñdangerousnessò in this regard. This reportôs priority classification of power lines should ultimately be seen as an answer to the following question: ñGiven present-day knowledge of bird distribution and relative sensitivity to collision mortality, what are the most dangerous power-line sections, i.e. those where the mitigation of collision risk should be focused as a priority?ò It is neither a substitute for a proper Environmental Impact Assessment nor a mitigation plan in itself.
- As a first step, a list of collision-sensitive bird species in Belgium was compiled on the basis of a review of the literature, casualty records and expert judgment. Not only ñcollision riskò itself was taken into account, but also the ñconservation valueò of each species and the probable population impact of additional mortality.
- In a second step, this list was used to define four coherent bird species groups of interest, in order to facilitate and organize the mapping work. These groups are the waterbirds (for which numerous data are available at site level), rare breeding birds (for which good data are also available in both Wallonia and Flanders), which migrate in large numbers (the mapping exercise was more difficult for them, because migration is to a considerable extent geographically spread across Belgium, with no clear migrant funnel) and widespread breeding bird species (for which relative density maps need to be built because they are not associated with specific sites or locations).
- In a third step, up-to-date knowledge of bird distribution in Belgium was used to create maps for each of the coherent bird species groups. Numerous sources of data were used: wintering waterbird counts, roost and colony counts, breeding bird atlases and observations from data-recording portals. Spatial modelling was applied to obtain high-resolution maps of widespread species and help define the best staging area for some other species.
- A ñcollision risk scoreò was defined for each of the geographical zones delimited on the maps, or based on the distance from important bird areas. The combination of the maps, with the aid of this scoring system, allows the classification of all power-line masts according to their associated collision risk for birds.
- Most of the more dangerous power lines are located in areas with major concentrations of waterbirds occur: the polders area, the wetlands in the vicinity of the Port of Antwerp and some river valleys (Yser, Meuse, Haine). About 3.4% of the network can be considered ñhigh priorityò for mitigation.
- A technical chapter describes the available mitigation tools. In the case of existing power lines, a cost-effective manner to decrease collision risk involves placing markers or ñdivertersò on the lines, in order to make them more visible to birds, even in poor visibility conditions. On the basis of current knowledge, it can be concluded that any large device (increasing the apparent size of the line to at least 20 cm), placed at least every 5-10 m along the line, preferably on the earth wire, is likely to significantly reduce collision risks.
- In view of the available budget, the placement of diverters can now be planned on Belgian power lines, focusing first on the high priority sections. Of course, other considerations, such as geographical ñgroupingò of diverters in order to reduce cost and opportunities provided by other planned work on specific power-line sections, may also influence the final planning, which is now in Eliaôs hands.

I. Introduction and objectives

Power lines and other wire infrastructures have been identified as a mortality source for birds for more than 130 years. Back in 1876, an American naturalist found more than a hundred Horned Larks *Eremophila alpestris* killed by telegraph wires in Colorado, and he drew this sad conclusion (COUES, 1876): *"Usually, a remedy has been or may be provided for any unnecessary or undesirable destruction of birds; but there seems to be none in this instance. Since we cannot conveniently abolish the telegraph, we must be content with fewer birds*ò.

There has been a huge increase in the use of wire systems around the world, with these now covering an estimated 65 million km for medium- to high-voltage lines only (JENKINS *ET AL.*, 2010). Meanwhile, there has also been a lot of progress made in the understanding and prevention of injury to birds by power lines. Several international agreements on nature conservation acknowledge this important issue. Among these, Recommendation No. 110 of the Bern Convention on the Conservation of European Wildlife and Natural Habitats states that signatories should take cost-effective measures to reduce bird mortality caused by power lines.

In answer to this recommendation and also with a general purpose of minimizing the impact of grid development on wildlife, Elia, the power transmission system operator in Belgium, intends to identify its own overhead power lines that present a serious collision risk for birds. It is very important to identify those power lines with high collision risks because although solutions do exist to prevent collision, it is necessary to prioritize their implementation in order to maintain cost-effectiveness (BEVANGER *ET AL.*, 2009).

The present project, initiated by Elia and coordinated by Aves-Natagora, in collaboration with Natuurpunt, INBO and Vogelbescherming Vlaanderen, intends to map collision-prone power lines in Belgium. This project meets recommended action II.4 of the recently published Budapest Declaration on bird protection and power lines, aiming at prioritizing power lines for mitigation ñin accordance with bird distribution data and in consultation with relevant government, industry, academic and NGO expertsò.

To achieve this goal, a conceptual framework was developed (Figure 1). As a first step, a list of bird species reported in Belgium and their sensitivity to collision to power lines has been compiled on the basis of a review of the literature and casualty records. In a second step, based on this list, four bird species groups of interest were defined in a coherent manner with available distribution data. In a third step, up-to-date knowledge of bird distribution in Belgium was used to create a map of critical areas for bird/power line collision risks, using methodologies similar to the recent sensitivity mapping exercise for wind energy in Flanders (EVERAERT *ET AL.*, 2011). Finally, a scoring system has been applied to high-voltage masts, according to their relative location on the sensitivity map. This allowed us to highlight high-risk power-line masts, in order to help Elia to define priority sectors for mitigation. Finally, technical solutions for mitigation are suggested.

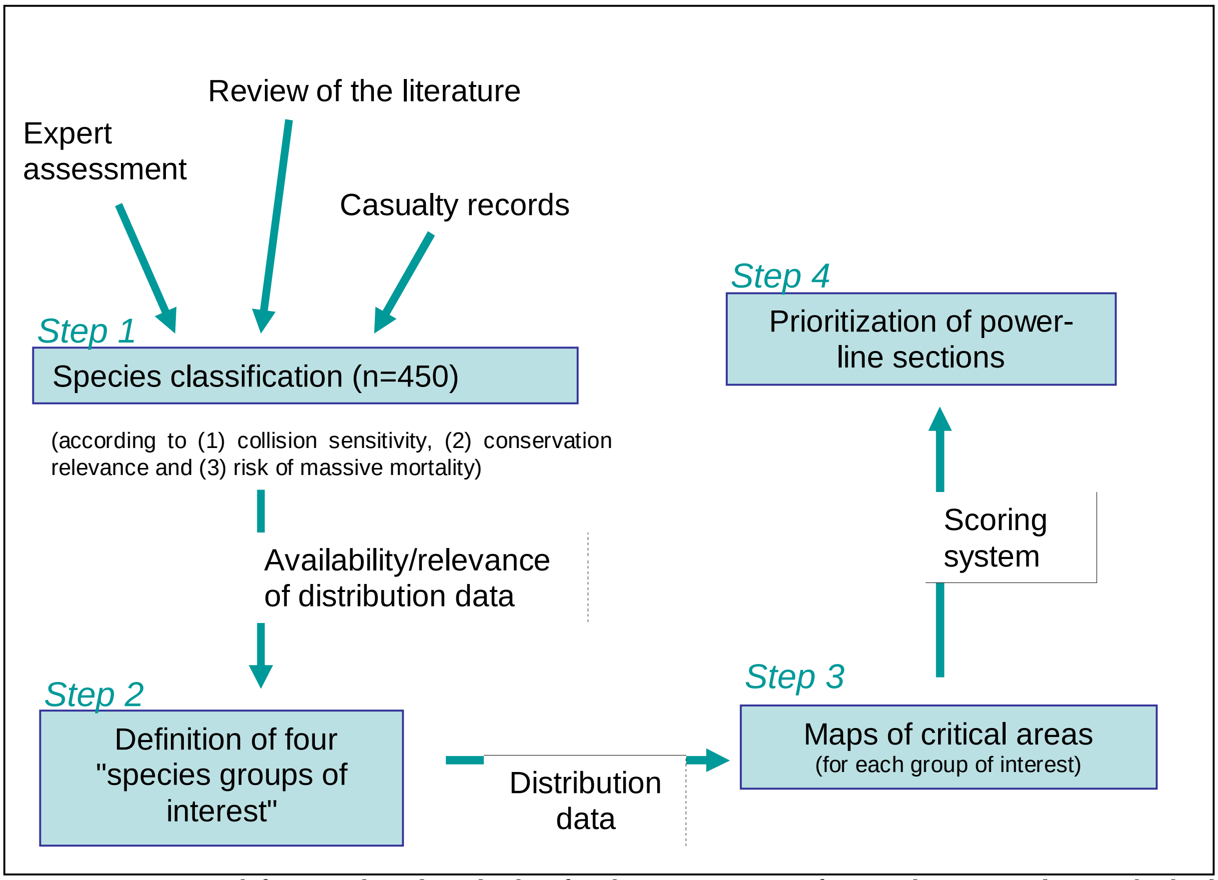

Figure 1: Conceptual framework and work plan for the prioritization of power lines according to the bird collision risk.

It is very important to note that this report does not intend to propose a mitigation plan in itself. It is merely an aid to decision-making, offering a framework to classify power-line sections according to the risk they present. The report also describes state-of-the-art mitigation techniques, but defining a proper mitigation plan for power lines in Belgium lies beyond the scope of this report.

The sensitivity map developed in the third step of this process is not only a useful decision-making aid to mitigate present-day collision risks ï it could also be used during the planning process of future grid development. Indeed, even if the power line mortality rarely directly affects population dynamics of impacted species (see below), the mere presence of industrial components, such as high-voltage power lines, in the landscape will reduce the available habitat for birds or reduce the quality of the available habitat (SOSSINKA & BALLASUS, 1997). Among the recognized examples, some meadow birds are known to avoid surroundings of the lines for breeding (ALTEMÜLLER & REICH, 1997) and wintering geese use the vicinity of power line rights of way significantly less (KREUTZER, 1997). Minimizing the development of future power lines in bird-rich areas is thus of prime importance. Where building new lines is inevitable, preventive measures in the line design (such as undergrounding lines) can be usefully implemented (JENKINS *ET AL.*, 2010). However, the mapping exercise presented in this report is not a substitute for a proper Environment Impact Assessment: the local impact of installing new power lines must be assessed using local data, and the prioritization exercise here, targeting the country level, may not be relevant in this context.

Before starting to describe the four steps of the work that have been conducted (chapter III to VI), we start with a general overview of the issue (chapter II). This short review is valuably complemented by the recent detailed review published for the AEWA and CMS by Bureau Waardenburg (PRINSEN *ET AL.*, 2011a). Finally, in Chapter VII, we enumerate the possible solutions concerning the identified ñcollision-proneò power lines in Belgium.

II. Bird mortality caused by high- and very-high-voltage power lines - an overview

II.1. Why is reducing collision mortality important?

Man-made structures create a high collision risk for wild birds all around the world. Mortality due to these collisions is a well-described phenomenon, at least in North America and Europe (BEVANGER, 1998). Despite the difficulties inherent to mortality estimations, estimated casualty numbers are very high. For example, during one year in the USA, communication masts may kill 4 to 50 million birds, collisions with power lines may kill more than 175 million birds, tens to hundreds of thousands of birds are electrocuted and wind turbines also kill thousands of birdsé (MANVILLE II, 2005). All in all, an estimated one billion birds are killed annually in the USA by anthropogenic causes, including about 58% from collisions with buildings (mostly window strikes) and about 14% with power lines (ERICKSON *ET AL.*, 2005b). In France, over 20 years 4,895 casualties (collisions and electrocutions) have been reported by naturalists, but this figure is a considerable underestimate because it is not obtained through systematic searches but rather through a compilation of reported incidents; 47% of the reported cases came from Provence ï Alpes ï Côte dôAzur (KABOUCHE *ET AL.*, 2006). The LPO claims 5 to 10 million birds are killed every year by power lines in France, which seems realistic given the 90,000 km of high- and very-high-voltage power lines in that country (see hereafter for an estimation of mortality/km/year).

However, the actual impact of these high mortality rates on bird population dynamics is not easily established (BEVANGER, 1998; BAROV, 2011). The fundamental question here is to determine if human-induced mortality is offset by better survival and reproduction rates of the survivors (compensated mortality) or if this mortality is simply adding to the ñnaturalò mortality and not offset by population dynamics (additive mortality). The second option could of course constitute a significant problem for nature protection if this concerns endangered species for example. Technically, this is not a question that is easy to answer because population dynamic parameters (mortality, fecundity, etc.) are complicated and costly to measure in the field, and even more so if these parameters need to be compared between different populations, subject to various collision-risk levels (BEVANGER, 1999).

An indication of the significance of the ñpopulation impactò of collision mortality could consist of comparing it with other mortality causes. This can also give some understanding of how power-line mortality compares with other human uses of birds, such as hunting. For example, collisions with power lines kill 2.4 times more Ptarmigan (*Lagopus sp.*) than hunting, according to a study in subalpine area of Norway (BEVANGER & BROSETH, 2004). An indirect effect of power-line mortality has also been demonstrated in a Bonelliôs Eagle *Hieraaetus fasciatus* population: eagle pairs having high-risk lines at close range of their nest showed turnover rates twice as high as pairs not in the vicinity of such lines (MAÑOSA & REAL, 2001). A comparative and very detailed study on the Eagle Owl in the Italian Alps (focusing on electrocution risks) concluded that, although interaction with resource availability is complicating the picture, there are significant effects of electrocution mortality on the population level, including population decrease in high-risk areas (SERGIO *ET AL.*, 2004). In a very recent review of transmission infrastructures and Natura 2000, some examples of population-level impact on globally endangered species relating to collision mortality are given. This concerns endangered geese species (but in that case, the actual population effect is only suspected and not quantified), the Little Bustard and Great Bustard and the raptor cases explained above (BIO INTELLIGENCE SERVICE, 2012).

For smaller birds, like passerines, a population impact is less likely, even if mortality figures are sometimes very high (SCOTT *ET AL.*, 1972), because their population dynamics depend more on a high fecundity than on long-term survival. However, even if there are no clear population effects, hence no definite impacts on nature conservation, several arguments can be made to defend a precautionary approach that intends to minimize collision risks with birds in all cases, and not only where endangered populations of emblematic species are affected:

- There is always the risk of having very dangerous power lines locally, depleting a local population and eventually creating a ñpopulation sinkò.

- There is an ethical and moral obligation to reduce human-induced mortality.
- With the anticipated necessary change to ñgreen energyò production, transmission grids are expected to constantly grow in the near future (BAROV, 2011; BIO INTELLIGENCE SERVICE, 2012). Therefore, increasing public support for such a development, e.g. by minimizing bird fatalities on existing power lines, is necessary.

In the following section, we will detail the nature of power-line collision risks for birds, emphasizing the factors determining the risk level, to explain how we compiled the sensitive species list for Belgium.

II.2. Mortality caused by power lines - the nature of the risk

II.2.1. Electrocution versus collision risks

Power lines are divided into four categories, according to their transmission voltage:

- very high voltage (225 to 400 kV);
- high voltage (50 to 225 kV);
- medium voltage (15 to 50 kV);
- low voltage (220 and 380 V)

Medium- and low-voltage lines mostly induce electrocution risks for birds. Several bird species use the pylons to perch on: as a hunting post, resting place or even for nesting. Most fatalities occur in long-winged species (storks, raptors, etc.) which can make contact with two phases simultaneously (or one phase and the earth wire). Some types of pylons, in particular metallic structures, are more dangerous than others and the electrocution risk increases when the distance between conductors decreases. Short-circuits caused by birds occasionally create bush fires in dry areas (KABOUCHE *ET AL.*, 2006).

Although high- to very-high-voltage lines are almost never insulated, the large distances between wires generally prevent electrocution risk for birds; the main risk is represented by the collision hazard. During their flight, birds simply collide with the wires and die (factors inducing this risk are explained below). Other impacts of high-voltage lines on birds, like the putative effect of strong electric and magnetic fields, have been judged insignificant (SILNY, 1997), but the possible impact on habitat availability is a growing concern, although little studied (BAROV, 2011).

In Belgium, Elia operates the high- and very-high-voltage grid system; therefore, the rest of this report will focus on collision risks.

II.2.2. Quantifying the number of killed birds

Several authors have tried to assess the mortality due to power lines by counting dead birds encountered under the wires. A large number of biases are associated with such counts (ERICKSON *ET AL.*, 2005b). Size and coloration of the carcass may induce strong variation in detectability rate between species. Dense vegetation beneath the lines may hamper research and, even more importantly, carcass disappearance or scavenger removal rates can be very high. Where these removal rates have been experimentally studied, most carcasses were eliminated in a matter of a few days (SCHICKER, 1997; ERICKSON *ET AL.*, 2005b). Therefore, mortality estimations always have to be made with caution.

In the Netherlands, with 4,600 km of high-voltage power lines, 750,000 to 1,000,000 birds are estimated to be killed by collision each year, meaning an average of 163-217 fatalities per km per year (ERICKSON *ET AL.*, 2005a). There are differences between habitats: on grassland there are 113 collisions/km/year; on agricultural land 58 collisions/km/year, and near river crossings 489 collisions/km/year. Elsewhere in Europe, there are few studies of that kind, but interestingly in Belgium Elia studied the impact of 3 km of a 70,000-V power line in Western Flanders (MORTIER, 2000). Between 5 March and 1 April 2001, 30 dead birds were found (among 25 birds identified, a quarter were gulls *Larus sp.*; other species included two Grey Herons *Ardea cinerea* and a Mute Swan *Cygnus olor*). Using adjustment techniques because of scavengers removing corpses, the author estimated that 468 birds were killed each year under these 3-km lines. This leads to an estimated

collision risk of 157 birds/km/year, a figure comparable with the studies in the Netherlands. However, the situation in Flanders and the Netherlands may be worse than average because of the abundance of waterbirds in these regions. In habitats without wetlands, death rates are probably lower, as shown in a Spanish study, averaging about 30 killed birds/km/year (ALONSO & ALONSO, 1999) and in general can vary from 0.1 to 80 casualties/km/year (JENKINS *ET AL.*, 2010).
Taking a conservative figure of 30-100 dead birds/km/year in Belgium over the total length of high-voltage grid of 5,614 km in Belgium (Elia website), we come to an extrapolated range of 170,000 to 500,000 birds killed every year nationwide.

II.2.3. Conditions increasing bird strikes with power lines

This rather high mortality figure is, however, hiding a diversity of situations: not all species of birds are similarly affected and not all power lines are equally dangerous. In order to focus actions on the most dangerous sites, it is necessary to understand the factors and conditions that create a higher collision risk. The following paragraphs first set out the morphological and behavioural characteristics of birds that are collision-prone and then review the power lines and environmental situations increasing that risk.
In short, collisions are more frequent when:

- power lines cross wetlands;
- power lines cross forests;
- power lines cross the wintering area of large flocking birds;
- power lines are multistage (two or three wires and/or an earth wire);
- weather conditions are bad (fog, rain, snow, wind, etc.);
- adults feed their young;
- fledglings are learning to fly;
- birds are migrating by night.

Bird morphology

Nearly all bird species are affected by collision (from the small Goldcrest *Regulus regulus* to big swans *Cygnus sp.*), but some are hit more than others. The sensitivity of a particular bird species depends on its morphology and its flight behaviour. Nocturnal birds, social birds and birds with aerial courtships are more sensitive to collision (BEVANGER, 1998).
It is possible to define groups of birds based on their morphology and to predict the relative sensitivity to collision of these groups (BEVANGER, 1998). ñPoor fliersò (grouses, rails, pheasants, etc.) have a high collision susceptibility (Figure **2**). These birds spend most of their life on the ground and fly only if necessary (i.e. disturbance). Their low flight agility is a problem for avoiding wires easily.
The morphological approach has been further tested using casualty records from Spain (JANSS, 2000). Four morphological parameters (length, weight, wing span and tail length) can be used to classify birds according to discriminant analyses and to predict their collision sensitivity, electrocution sensitivity or their ñmixed sensitivityò. This model, which was further backed up by Italian data (RUBOLINI *ET AL.*, 2005) shows that the main morphological determinant of risk exposure is the ñwing loading valueò: heavy birds with small wings are more prone to collision with high-voltage power lines.
Although medium-voltage lines are dangerous for raptors (BAYLE, 1999), this bird category has a high conservation value and is relatively unaffected by collisions with high- and very high-voltage power lines, probably because they have the lowest wing loading. They represent only 0.1 ï 0.4% of dead birds found under these wires in the Netherlands, Germany, France and Italy.

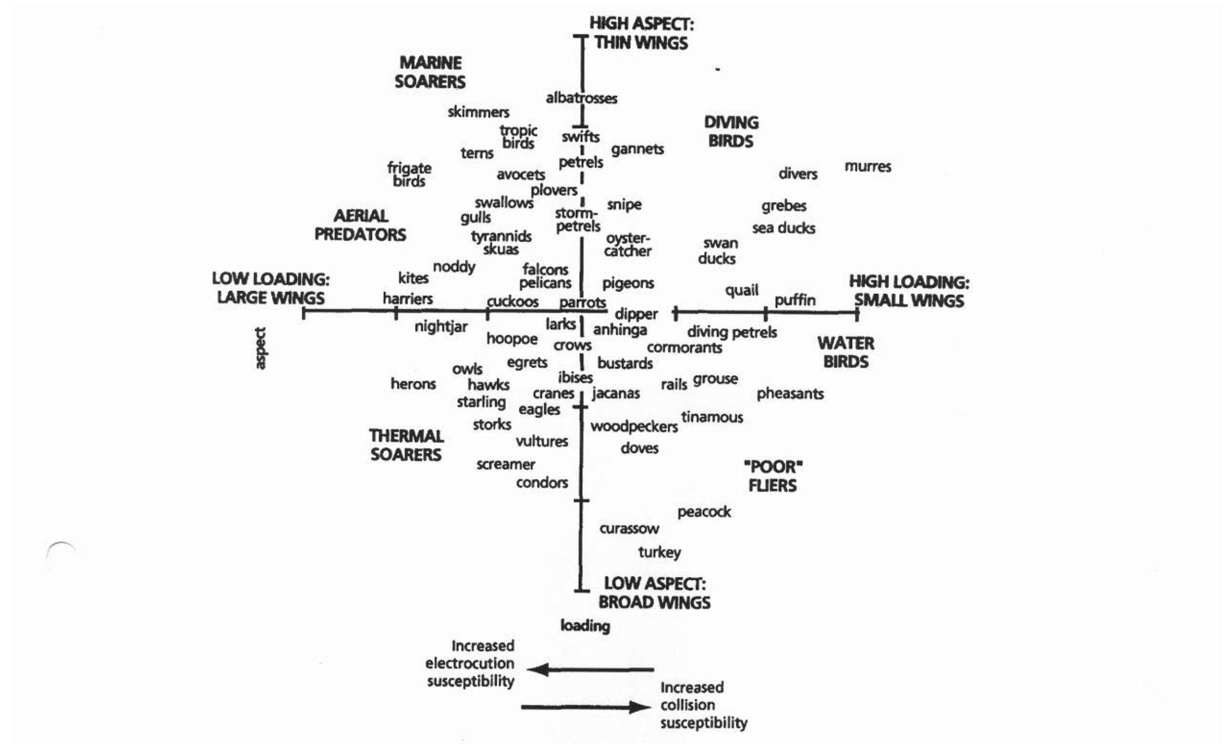

Figure 2: Morphological classification of birds and their sensitivity to power lines ***(BEVANGER, 1998)****.*

Collision also depends on the visual field of the bird. A recent study measured the visual field of the Kori Bustard *Ardeoti kori*, the Blue Crane *Anthorpoides paradisea* and the White Stork *Ciconia ciconia*, three species sensitive to collisions with power lines (MARTIN & SHAW, 2010). It appears that these birds have a narrow and vertically long binocular visual field (they grab food items with their bill using visual guidance). Blind spots above and below the binocular fields differ between these species. A bustard looking down for food when flying will have a blind spot moving its head only 25° down; for a crane this is 35°, and a stork 55°. This means that storks are more likely than bustards and cranes to detect power lines and other obstacles in front of them in flight. This study suggests that some birds are very vulnerable and that even collision mitigation with special marks might not be useful because some birds do not see the obstacle at all.

Bird behaviour

Even if some birds are ñanatomicallyò more prone to collision, as explained above, actual risk exposures also depend on the usual behaviour of the bird. For example, in Spain, cranes might suffer a higher rate of mortality than bustards, because they more commonly cross over a power line and in spite of their better flight capacity (JANSS, 2000).

The behaviour of the birds is in turn influenced by their life cycle. A Spanish report showed there were few or even no fatalities caused by power lines in the case of resident individuals, as opposed to migrant birds visiting the same areas (ALONSO & ALONSO, 1999). Migrant and over-wintering birds are probably less familiar with obstacles and are therefore more vulnerable.

During migration, especially nocturnal migration, even small passerines can be exposed to collision, as a striking example in Dungeness (a coastal site of South-East England) shows. In the vicinity of this bird observatory, two 400-kV power lines were erected, and many birds were subsequently found dead (SCOTT *ET AL.*, 1972). Between January 1964 and November 1970, 1,285 corpses of 74 species were found under the wires, especially nocturnal migrants (rails, thrushes, warblers, etc.). Diurnal migrants (swift, hirundines, larks, pipits, wagtails and finches) are apparently less sensitive, except when they have to fly low because of bad weather conditions.

In Illinois (USA), 200 to 400 individual waterfowl birds were killed each autumn by colliding with high-voltage power lines that cross a small slag pit (32 ha) of a power plant next to a 872-ha lake (ANDERSON, 1978). Several risk factors were identified that increase exposure: number of birds present (large groups increase collision risks), low visibility (waterfowl almost never collided during daylight when visibility was good), species composition or behaviour of birds, disturbance and familiarity of birds with the area.

Collision can also be related to reproductive stage. Common Terns *Sterna hirundo* seem to suffer only low rates of direct mortality through collision. However, young birds and feeding adults are more vulnerable because they fly closer to the cables more frequently. When adults raise their pulli, they tend to take the shortest way between the colony and the feeding areas, so they take more risks crossing wires or flying near the cables (HENDERSON *ET AL.*, 1996). Young and inexperienced birds are also more exposed. For example, Grey Herons *Ardea cinerea* are more likely to collide with power lines from August to December (71% of the recorded mortality are first-year birds (ROSE & BAILLIE, 1989)).

Finally, disturbance increases collision risk, as birds suddenly have to leave a roosting or feeding site. In Wallonia, an individual rare Whooper Swan *Cygnus cygnus* (the only regular wintering group in the region) was killed when colliding with a medium-voltage line after disturbance of the swan group by a careless photographer (M. Ittelet, pers. com.)

Local topography and situation of the power lines

Local topography is an important factor determining collision events. Five types of collision-prone effects are identified by KABOUCHE et al. (2006):

- Sliding effect: flying birds follow the relief and collide with a power line if it crosses their flyway perpendicularly.
- Barrier effect: birds following a valley collide with a line that crosses it perpendicularly.
- Obstacle effect: when a group of birds, flying in an open area, collide with a line when landing or when taking off.
- Springboard effect: flying birds avoiding an obstacle (relief, hedge, bridge, first power line, etc.) can collide with the wires if they are hidden by the first obstacle.
- Top effect: birds flying towards a summit collide with lines along the summit ridge.

Power lines in forests can be particularly dangerous for birds because of the open area that they create. These places can attract a lot of birds for hunting in an open area (KABOUCHE *ET AL.*, 2006). Forest fragmentation created by the rights of way can also force forest birds to cross the open stretches to reach other parts of their territory and by doing so, they are also exposed to collision. However, if the line crosses a forest with a tree height equal to or exceeding power pylon height, the collision risk is minimal for birds flying over the canopy (JENKINS *ET AL.*, 2010).

Some studies have suggested that if power lines were associated with other man-made visible structures like highways, the collision risk would decrease because birds are more cautious around these artefacts: this is apparently the case for power lines positioned alongside roads (HOERSCHELMANN *ET AL.*, 1997).

Finally, several papers logically point out that if power lines are located in habitats or sites where birds tend to gather, like wetlands, the risk is significantly increased (ALONSO & ALONSO, 1999; KABOUCHE *ET AL.*, 2006).

Type of wires / structures

Collisions occur with all kind of power lines, but mainly with the finest cables (medium and low voltage, lighting protection cables, etc.). Some kinds of cables are very difficult to see for birds: copper lines 40/10 are green with a small diameter and are very dangerous for them (KABOUCHE *ET AL.*, 2006).

The collision rate also depends on power-line design. Lines with multiple states are believed to be more dangerous for birds. In Norway, an experiment showed a significant reduction in the number of bird collisions (mainly Ptarmigans ï *Lagopus sp.*) after the removal of the earth wire (BEVANGER & BRØSETH, 2001). However, in Spain, no significant difference in the bird collision rate was observed when comparing a transmission line of 380 kV (with three cable levels and two overhead static wires), a 132-kV distribution line (one cable level and no static wire) and a 13-kV distribution line (one cable level and no static wire) (JANSS & FERRER, 1998). It must be noted that this last study also concerned three different habitats.

Of course, the presence of visual markers or other devices can prevent some of the collision events; we will come back to this particular point in the last section of the report.

Other external causes

Weather conditions influence bird flight altitude. Visibility of power lines decreases during bad weather: wind, fog, rain, snow, and so on (KABOUCHE *ET AL.*, 2006).

II.3. Future focus

To date, the impacts of high-voltage power lines on biodiversity have been studied mostly from a bird mortality (by collision) point of view, and with the purpose of avoiding those collisions. However, we know little about the actual impact of power lines at the population level (NEGRO, 1999). However, this should not hamper actions to reduce mortality in wild birds, especially if action is focused on highly sensitive sites.

Planning of future grid development with the help of a ñbird sensitivity mapò may further reduce the impact on bird habitats, although this aspect of power-line effects has been studied too little (BIO INTELLIGENCE SERVICE, 2012).

III. Step 1: Classifying birds of Belgium according to their sensitivity to collision risk

In this chapter, after briefly depicting Belgian avifauna and its relative international importance, we will explain the procedure used to classify species in relation to their supposed relevance to the issue of collision with power lines. This classification will form the basis for a power-lines sector prioritization procedure.

III.1. International significance of Belgian avifauna

Including rare and accidental species, about 450 different bird species have been reported in Belgium. Although a small and densely populated country, Belgium hosts no fewer than 94 regular breeding birds of European Conservation Concern, of which 46 have an unfavourable conservation status in Europe (HEATH & EVANS, 2000). Altogether, there are 194 breeding species in Belgium (including exotics): 183 in Flanders (VERMEERSCH *ET AL.*, 2004), 173 in Wallonia (JACOB *ET AL.*, 2010) and 103 in Brussels (WEISERBS & JACOB, 2007). In Wallonia, breeding populations of several raptor species (including the Honey Buzzard *Pernis apivorus*, a Bird Directive Annex I species) and forest species (including the Middle Spotted Woodpecker *Dendrocopos medius* and the Black Stork *Ciconia nigra*) are of special conservation importance, because their density in Wallonia is higher than the European average (PAQUET & JACOB, 2011). In Flanders, several waterbirds have a major breeding population, and in particular three species regularly exceed the threshold of 1% of the entire biogeographical population breeding in the Port of Zeebrugge (EVERAERT & STIENEN, 2007).
During the winter, waterbird populations of international importance (several species of geese and ducks) are observed in Flanders. Several sites support more than 1% of the biogeographic population of at least one species. For example, the polder complex north of Bruges is home to more than 60% of the total biogeographic population of Pink-footed Geese *Anser brachyrhynchus*. An estimated 350,000 waterbirds winter in Belgium, mostly in Flanders (HEATH & EVANS, 2000).
Due to its central position in Europe and on the southern edge of the North Sea, millions of birds also travel across Belgium during pre-nuptial and post-nuptial migrations, some of them without a stop or roosting only for a few hours/days. Counts of migrating birds from fixed observation points reached an impressive total of 5.4 million individuals in 2010 (see www.trektellen.org). Locally, migration can be very intense, such as on some of the Ardennes crests, where migration flow amounts to an average of 750 migrating individuals per watching hour (DERMIEN & PAQUAY, 2000). Species like Cranes *Grus grus* have quite narrow migration corridors and most of the Western European population of this species probably flies over Eastern Belgium during each migration trip.

III.2. Information sources and classification procedure

The species list that was used as a basis for our classification was the list of birds observed in Belgium provided by the Rarity Committees, available on their websites (http://www.la-ch.be/ for the Walloon committee and http://www.bahc.be/ for the Flemish committee). As the systematic and taxonomic sciences are currently very dynamic fields in ornithology, there are some open questions concerning the exact status of some taxa (i.e. the subspecific/specific status of the Bean Geese *Anser [fabalis] fabalis* and *Anser [fabalis] rossicus*) but this has no real relevance for the present work.

We decided not only to focus on sensitivity to collision with power lines, but also to include the concept of ñconservation relevanceò of the collision for the species. If Belgium only has a marginal population of a species, there is no point in considering it in the prioritization procedure. In contrast, a very common species with no conservation issue must not be included either in a list which intends to focus on the risk to biodiversity. However, even for very common species, high mortality numbers can be seen as detrimental from an ethical point of view. Therefore, we also included indicative ñgroup criteriaò to account for species with aggregative social behaviour that can cause the species to suffer numerous casualties.

Please note that the time period relevant for our conservation relevance and sensitivity classification is 2001 to 2011, i.e. the same as the period considered for the mapping exercise (see Chapter V). Future knowledge about bird sensitivity to collision and evolution of bird conservation status may trigger the need for an update of this classification.

The Table **1** summarizes the considered criteria and their different levels used in the classification of species, which are detailed below. We chose to use a simple ñclassification levelò (only three levels in the sensitivity to collision), because more detailed levels would have been difficult, and also mostly arbitrary, to apply to a 450-species list. As already stated, the likelihood or lack of likelihood of an impact on population level is particularly difficult to judge since there is an absence of hard evidence in most cases. The goal was simply to focus the subsequent mapping procedure on the most relevant species, and to help define the most significant ñgroup of speciesò used in the mapping exercise (step 2 and 3).

*Table **1**: Criteria and classification levels used in the listing procedure.*

Sensitivity to collision (COLS)		
	0	Null, almost never cited in mortality studies or in review
	1	Sometimes cited in studies as found injured or dead, impact on population unlikely
	2	Regularly cited in studies as found injured or dead, possible impact on population
Presence in Belgium (BEL)		
	1	Present all year round
	2	Only present during the breeding season
	3	Migrant, staging or migrating species
	4	Occasional or very rare
Conservation relevance (CONS)		
	0	Too scarce, population in Belgium not to be regarded as relevant for conservation of the species or, on the contrary, very common species with no conservation issue
	1	Relevant for conservation
	2	Highly relevant for conservation (rare or declining species, Belgium hosting an important part of the population, and/or international obligation to protect the species)
Could be present in large group (GROUP)		
	0	Low risk of high mortality due to aggregative behaviour
	1	Some risk of high mortality for large groups

III.2.1. The collision sensitivity criterion (COLS)

This criterion evaluation was mainly based on a review of the literature (see Chapter II), because systematic surveys of power line-related bird mortality in Belgium are rare. The Table **2**, from the Bern Convention document, as well as more recent review were used (PRINSEN *ET AL.*, 2011a; BIO INTELLIGENCE SERVICE, 2012).

*Table **2**: List of bird families that should tend to be focal species for environmental assessments where they are at risk as they are considered to be particularly sensitive, or potentially so, to power lines (according to the Bern Convention). Key: 0 **-** no casualties reported or likely; I **-** casualties reported, but no apparent threat to the bird population; II **-** regionally or locally high casualties; but with no significant impact on the overall species population; III **-** casualties are a major mortality factor; threatening a species with extinction, regionally or on a larger scale.*

	(a) due to electrocution	(b) due to collisions
Loons (Gaviidae) and Grebes (Podicipedidae)	0	II
Shearwaters, Petrels (Procellariidae)	0	I - II
Bobbies, Gannets (Sulidae)	0	I - II
Pelicans (Pelicanidae)	I	II - III
Cormorants (Phalacrocoracidae)	I	II
Herons, Bitterns (Ardeidae)	I	II
Storks (Ciconidae)	III	III
Ibisses (Threskiornithidae)	I	II
Flamingos (Phoenicopteridae)	0	II
Ducks, Geese, Swans, Mergansers (Anatidae)	0	II
Raptors (Accipitriformes and Falconiformes))	II ï III	I - II
Partridges, Quails, Grouses (Galliformes)	0	II - III
Rails, Gallinules, Coots (Rallidae)	0	II - III
Cranes (Gruidae)	0	II - III
Bustards (Otidae)	0	III
Shorebirds / Waders (Charadriidae + Scolopacidae)	I	II - III
Skuas (Stercorariidae) and Gulls (Laridae)	I	II
Terns (Sternidae)	0 ï I	II
Auks (Alcidae)	0	I
Sandgrouses (Pteroclididae)	0	II
Pigeons, Doves (Columbidae)	II	II
Cuckoos (Cuculidae)	0	II
Owls (Strigiformes)	I ï II	II - III
Nightjars (Caprimulgidae) and Swifts (Apodidae)	0	II
Hoopoes (Upudidae) and Kingfishers (Alcedinidae)	I	II
Bee-eaters (Meropidae)	0 ï I	II
Rollers (Coraciidae) and Parrots (Psittadidae)	I	II
Woodpeckers (Picidae)	I	II
Ravens, Crows, Jays (Corvidae)	II ï III	I - II
Medium-sized and small songbirds (Passeriformes)	I	II

Additional expert material from this project's partners was then added to the table. Particularly helpful in this regard was the list of bird victims of collision/electrocution with power lines that was provided by Vogelbescherming (Annex II). The information was collected from the Recovery Centres by Vogelbescherming between 1991 and 2010, and the Ligue Royale Belge de Protection des Oiseaux (1991-2000 period). The LRBPO does not have centralized statistics from their Centres available after 2000. The figures in Annex II only relate to birds that have been found wounded and are checked into a recovery centre, meaning birds that have been found still alive and brought in for recovery. Consequently, the overall casualty figure is a lot higher, and impossible to estimate from this data. The Annex II shows victims from ñpower linesò in general, but most of these (95%) are brought in with collision-like wounds, and very few with traces of electrocution. The top 10 species brought in for collision are common waterbirds (Grey Heron, Black-headed Gull, Herring Gull, Mallard, etc.), common raptors (Buzzard, Kestrel, Sparrowhawk) and doves (Woodpigeon and Collared Dove). More surprisingly, the Woodcock is a regularly found victim of collision. This could possibly be explained by its display behaviour ï called ñrodingò ï characterized by the male flying over the canopy or open-

areas in the forest at dusk. The sensitivity of the Woodcock to collision was also recently quoted in a proposed list of priority species for mitigation of power-line impacts (BIO INTELLIGENCE SERVICE, 2012). For the year 2010 and 2011, it was also possible to compare the collision victim numbers with the overall number of checked-in individuals from each species (Table 3). This confirms the elevated risk for waterbirds and also for the Woodcock.
In brief, species groups that are considered ñsensitiveò to collision are:

- Waterbirds (anatidae, shorebirds ï including Woodcock ï and gulls)
- Grouses, Pheasants and allies
- Great Cormorant and Grey Heron
- A few species of raptors
- Rails & Crane
- Doves
- Owls & allies
- Woodpeckers
- Swift, Kingfisher, Nightjar
- Jackdaw
- Starling

Most passerines are not judged sensitive, and seabirds are insensitive (for their living habitat is devoid of power lines!). The risk of collision mortality is judged ñmediumò for most species of raptors, a very different picture from that if electrocution risks were contemplated (PRINSEN *ET AL.*, 2011a). However, as pointed out later, we decided to take rare raptor species into consideration, as even a limited additional mortality can potentially have significant effects on population dynamics.

*Table **3**: Birds with a high (>2%) proportion of power-line victims, data from 2010 and 2011 (Vogelbescherming VL)* ***ï*** *see also Annex 2.*

Dutch name	Scientific name	Number of power-line victims	Total number of victims	Proportion involving power lines
Kleine Zwaan	*Cygnus columbianus*	1	1	100.0%
Kolgans	*Anser albifrons*	1	2	50.0%
Tafeleend	*Aythya ferina*	1	2	50.0%
Regenwulp	*Numenius phaeopus*	1	3	33.3%
Roerdomp	*Botaurus stellaris*	2	10	20.0%
Wilde Zwaan	*Cygnus cygnus*	1	8	12.5%
Houtsnip	*Scolopax rusticola*	29	241	12.0%
Rietgans	*Anser fabalis*	1	9	11.1%
Grauwe Gans	*Anser anser*	5	46	10.9%
Grote Mantelmeeuw	*Larus marinus*	2	24	8.3%
Havik	*Accipiter gentilis*	2	26	7.7%
Knobbelzwaan	*Cygnus olor*	9	153	5.9%
Koekoek	*Cuculus canorus*	1	17	5.9%
Sperwer	*Accipiter nisus*	19	412	4.6%
Brandgans	*Branta Leucopsis*	1	22	4.5%
Torenvalk	*Falco tinnunculus*	6	140	4.3%
Boomklever	*Sitta europaea*	1	27	3.7%
Slechtvalk	*Falco peregrinus*	1	27	3.7%
Blauwe Reiger	*Ardea cinerea*	14	394	3.6%
Aalscholver	*Phalacrocorax carbo*	3	90	3.3%
Witte Kwikstaart	*Motacilla alba*	1	33	3.0%
Nijlgans	*Alopochen aegyptiaca*	1	35	2.9%
Kokmeeuw	*Chroicocephalus ridibundus*	10	398	2.5%
Fuut	*Podiceps cristatus*	1	47	2.1%

III.2.2. Conservation relevance criteria (CONS)

Several existing sets of data on the conservation relevance of Belgium bird populations have been used to objectivize the CONS criteria (see Annex I). These data have been calculated at a regional level (Flanders or Wallonia), as conservation of nature is a regional competence. Instead of re-calculating these values at federal level, we decided to consider the ñregional relevanceò that is important at national level, as both regions have a responsibility to protect regional populations. If only one of the two regions hosts a significant population of a certain species, it is logical to consider this species at national level too, but probably in the subsequent mapping procedure, only the concerned region will host important sites or areas for the species.

The Red List of endangered species has been published independently in the two regions, using slightly different methodologies (DEVOS *ET AL.*, 2004; PAQUET & JACOB, 2010). All ñred listò species (excluding the near-endangered or ñrare-zeldzaamò categories) in one of the two Red Lists have been attributed a CONS level of ñ2ò.

In Flanders, several waterbird populations are reaching the threshold of 1% of the biogeographical population. These species have been given a score of 2 for the CONS criteria. In Wallonia, a few breeding birds also reached 1% of the European breeding population. If these species are also of conservation concern (i.e. if they are declining or if they are included in Annex I of the Birds Directive), their CONS level has been set to ñ2ò.

III.2.3. Group-forming criterion (GROUP)

This criterion was used to highlight species that would be irrelevant in terms of conservation of the species populations but that could suffer high losses from power-line collisions and hence may benefit from targeted actions. Logically, sensitive species for GROUP criteria again include waterbirds, and also thrushes, corvids and some granivorous passerines.

The final classification of species, including their presence type in Belgium, is presented in Annex I.

IV. Step 2: Definition of species groups used in the mapping/prioritization procedure

In the previous chapter, we have classified bird species according to their relevance to the collision risk problem in the Belgian context. In this second step, we used the classified list presented in Annex I to define a ñcoherent groupò of species, for the ultimate goal of organizing the mapping procedure.

We first focus on species that are highly sensitive to collision and highly relevant for conservation (COLS = 2 and CONS = 2); this accounts for 50 species, mostly waterbirds, some migrants (Crane, storks, etc.), some nocturnal birds and several woodpeckers. We then included a few supplementary rare bird species with a lower collision sensitivity but with a high conservation value (i.e. some raptors such as the Red Kite). The detailed distribution of these birds is generally well known in Belgium. Finally, we organized this large species set into four coherent species groups, according to their ecology, their distribution type (i.e. widespread or very localized) and geographical data availability of the listed species.

- **Group 1: Waterbirds**. This group incorporates a large number of species linked to special areas (wetlands). Some of them can also be relatively widespread, so that it is highly probable that at least some individuals can be seen anywhere on any day (i.e. Black-headed Gull north of the Meuse valley in the winter). As a rule, these species are numerous and tend to be social, meaning that they congregate on some discrete sites. Because of this, power-line collision mortality can potentially affect a large number of individuals, although, for most species, this mortality is unlikely to strongly impact population dynamics. Information on distributions and numbers are usually available as waterbirds are traditionally well surveyed by ornithologists. Common waterbirds can also be seen as an ñumbrellaò group for other, rarer species linked to wetland habitats.
- **Group 2: Rare breeding birds**. Some of the listed sensitive species are restricted to particular sites or occur in very small numbers. Collision with a power line is by definition a rare event for these species. Nevertheless, additional mortality may have a major impact on population dynamics. Rare breeding birds can also act as umbrella species for other birds linked to ñspecialò habitats. Good data on distribution, sometimes even including nest location, are also available for most rare breeding bird species.
- **Group 3: Migrants in large numbers**. These species are potentially affected while they cross the country during migration, sometimes even in large flocks. However, these flocks generally use very large corridors. Furthermore, preferential corridors and flight altitude are very much influenced by local weather conditions. Until now, no real attempt on mapping those corridors has been made on a Belgian scale. Specific migration counts are undertaken especially during autumn migration (PAQUET & DUJARDIN, 2010) but they focus more on describing numbers and phenology than location of flock corridors.
- **Group 4: Widespread species**. This group is characterized by widespread distribution without any pattern of special site occupancy or regular congregation sites. They are territorial birds either linked to a farmland or woodland habitat. Although a large number of power-line collisions are possible for these birds, data on the distribution at high resolution are sometimes not easily available. The risk pattern is, by definition, scattered (meaning low local risk over a large territory) and so it is difficult to identify the main or priority dangerous lines affecting these species.

In the following step, we will consider each of the above four groups in a mapping exercise and then check if the resulting maps can be used in the prioritization process.

V. Step 3: Compiling maps of critical areas for sensitive species

V.1. Some precautionary remarks

About the regional vs. national criteria

Elia is operating across the whole of Belgium; therefore, it is logical that the most critical bird areas at country level should be identified. However, bird monitoring and conservation is handled at regional level in Belgium because it is the responsibility of regional authorities and it is managed by associations mostly active at regional level. Furthermore, we based a great deal of the present publication on an existing similar work on sensitivity mapping for birds and wind energy in Flanders (EVERAERT *ET AL.*, 2011). To maximize coherence between the two approaches (grid and wind energy sensitivity) and for practical reasons, for Flanders we directly used the critical areas for sensitive species as defined in Everaert et al. (2011) and for Wallonia we delineated critical areas using similar approaches, based on data for that part of Belgium (including the Brussels region in some cases). We think that this is the best way of resolving the dilemma of ñnationallyò delineating important bird areas, while taking into account regional nature conservation priorities. This approach may inspire integrated work at a higher level (multi-country approaches), although additional research and testing would be necessary.

About the time reference of data used

The mapping exercise presented below is based on the most up-to-date bird distribution data available, which is from the period 2001 to 2011. This is important to keep in mind because bird ranges are in constant evolution (most species are constantly expanding or decreasing their range), and also because knowledge of these distributions as well as the techniques to record them are developing all the time. More details of the data ñtime-stampò are presented here.

The importance of waterbird sites was evaluated using data from the entire reference period (annual counts for the period 2001-2011). Colony locations and rare bird breeding sites are primarily described in the regional breeding bird atlases (Flanders: 2000-2002, Brussels: 2001-2004, Wallonia: 2001-2007) but have been updated using data from long-term monitoring schemes (VERMEERSCH & ANSELIN, 2009) or from web-based recording portals (waarnemingen.be / observations.be). Migration corridors have been delineated with knowledge gained in recent years (mostly after 2007) thanks to dedicated web-based recording tools (i.e. trektellen.nl), as well as from general knowledge from birdwatchers in Belgium. Plover stop-over sites have been modelled from observation data concerning the period 2008-2011. Common bird maps were based on regional atlas data (Flanders: 2000-2002, Brussels: 2001-2004, Wallonia: 2001-2007).

V.2. Waterbirds

Belgium, and Flanders in particular, is home to large numbers of waterbirds (see III.1). ñWaterbirdsò is a multi-family group of species sharing a strong ecological link with wetlands: it includes wildfowl, herons, rails, waders and gulls, but traditionally excludes passerines also linked to water (like the Dipper *Cinclus cinclus*). Waterbird species are often regarded as particularly sensitive to power-line collision, with this sensitivity being enhanced by their social behaviour (most species are highly social during migration and in winter, and many breed in colonies, i.e. are social during reproduction). Large groups of waterbirds can easily be disturbed by humans and disturbance often leads to a higher risk of collision, caused by panic. Colonial and communal roosting behaviour implies regular commuting trips between roosts/colonies and foraging sites. Note that some waterbirds (e.g. the Common Snipe *Gallinago gallinago*) may also sometimes use dispersed habitats (wet meadows and pastures in the Ardennes).

Waterbirds are also probably the best monitored species group in the world, with mid-winter counts organised throughout Europe for more than 40 years (GILISSEN *ET AL.*, 2002; DELANY & SCOTT,

2006). In Belgium, every winter, mid-monthly counts of waterbirds are organised in the three regions (with the help of hundreds of volunteers, coordinated by INBO for Flanders, and Aves for Wallonia and Brussels). Most breeding colonies are also well monitored (gulls, the Great Cormorant, the Grey Heron), although not annually (VERMEERSCH *ET AL.*, 2006; JACOB *ET AL.*, 2010). For some species (the Great Cormorant and gulls), results of counts at roost sites in winter are available (DEROUAUX *ET AL.*, 2010; DEVOS, 2011).
The critical areas for waterbirds have been defined using information from these three data sources: mid-winter counts (aiding identification of important wintering waterbird sites), colony censuses and roost counts.

Wintering waterbird sites

In the wind energy sensitivity map for Flanders, critical areas for waterbirds were identified using a set of numerical criteria applied to the mid-winter censuses (EVERAERT *ET AL.*, 2011). For consistency and practical reasons, we decided to stick with the original delineation of critical areas for waterbirds in Flanders. For the rest of the country, we applied similar criteria to identify critical waterbird areas, although some minor adaptations were necessary (for example, only mid-January regional counts exist for Wallonia and Brussels, as opposed to the six-monthly counts of waterbirds in Flanders).
Mid-January census data (also called ñInternational Waterfowl counts ï IWCò) from 2001 to 2010 were considered in the analysis. Two threshold criteria (2 and 15% of the regional population) were calculated for each species by estimating the total wintering population of the considered species as the average total count in mid-January during the decade from 2001 to 2010. For Flanders, instead of the mid-January counts, winter maximums were used. Table 4 shows how the criteria were applied.

*Table **4**: Criteria applied to define the importance of waterbird sites in the mapping process. In this table, **ñ**Regularly**ò** means at least 50% of the considered counts. Note that exotic species (Canada Goose) and gulls were not considered here.*

Importance for the waterbirds	**Criteria**
Fairly Important Site	Regularly 100 ï 1000 waterbirds
Important Site	Regularly more than 1000 waterbirds **or** Regularly at least 2% of the regional wintering population of at least one species
Very Important Site	Regularly at least 15% of the regional wintering population of at least one species

The resulting map of critical areas for waterbirds in Belgium is shown in Figure 3. As explained above, numerical criteria were applied on a regional basis for estimating the threshold. Nevertheless, a logical image is emerging from the analysis, with higher numbers of important waterbird sites in Flanders, especially in the polders and in the Province of Antwerp. Because of the higher numbers of waterbirds in Flanders, the number of ñvery importantò and ñimportantò sites is higher than in Wallonia and the Brussels region.
Brussels was considered together with Wallonia (as it is for the organization of the winter census); this approach was necessary because if Brussels had been considered on its own, many more sites for very small waterbirds would have been selected under the criteria of 2% of the regional population, although Brussels typically has less than 2% of all the waterbirds wintering in Belgium.
We think that taking this ñregional approachò for the criteria threshold, but a common, national, set of criteria is a valid compromise. This prevents regionally important sites being overlooked and, at the same time, suggests a clear priority for action for nationally important sites (in the case of waterbirds, most of which are located in Flanders).

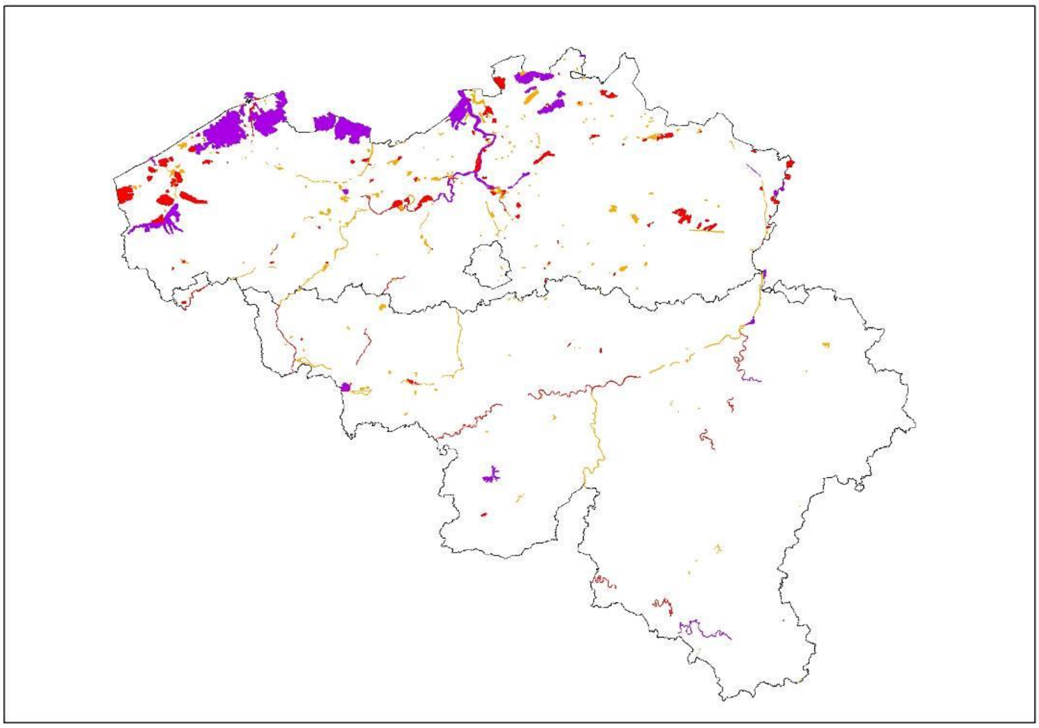

*Figure **3** : Critical areas for wintering waterbirds in Belgium (in violet **ñ**Very Important Sites**ò**, in red **ñ**Important sites**ò** and in orange **ñ**Fairly Important Sites**ò**).*

Colony locations

In the wind energy sensitivity map for Flanders, important waterbird colonies were identified using a set of numerical criteria applied to nest counts in these colonies (EVERAERT *ET AL.*, 2011). We applied the same criteria to data from Wallonia and Brussels to obtain a Belgian map of important waterbird colonies. Colony data from INBO (Flanders) or from Aves (Wallonia and Brussels) were selected from the period 2000 to 2010. Note that for some colonies, only one count is available for the period. Species taken into account were the Grey Heron, the Little Egret, the Eurasian Spoonbill, the White Stork, the Great Cormorant, the Black-headed, Mediterranean, Herring and Lesser Black-backed Gulls, and the Common, Little and Sandwich Terns. Colonies were selected according to the following criteria: ñImportant Colony Sitesò are sites where 10 to 100 breeding pairs are regularly (i.e. at least 50% of the available counts) counted, and ñVery Important Colony Sitesò are sites where more than 100 breeding pairs are regularly recorded, or at least 2% (> 10 breeding pairs) of the regional breeding population.

Figure 4 shows the locations of the identified important colony sites. Again, most sites are located in Flanders or in Northern Wallonia (lowland Belgium).

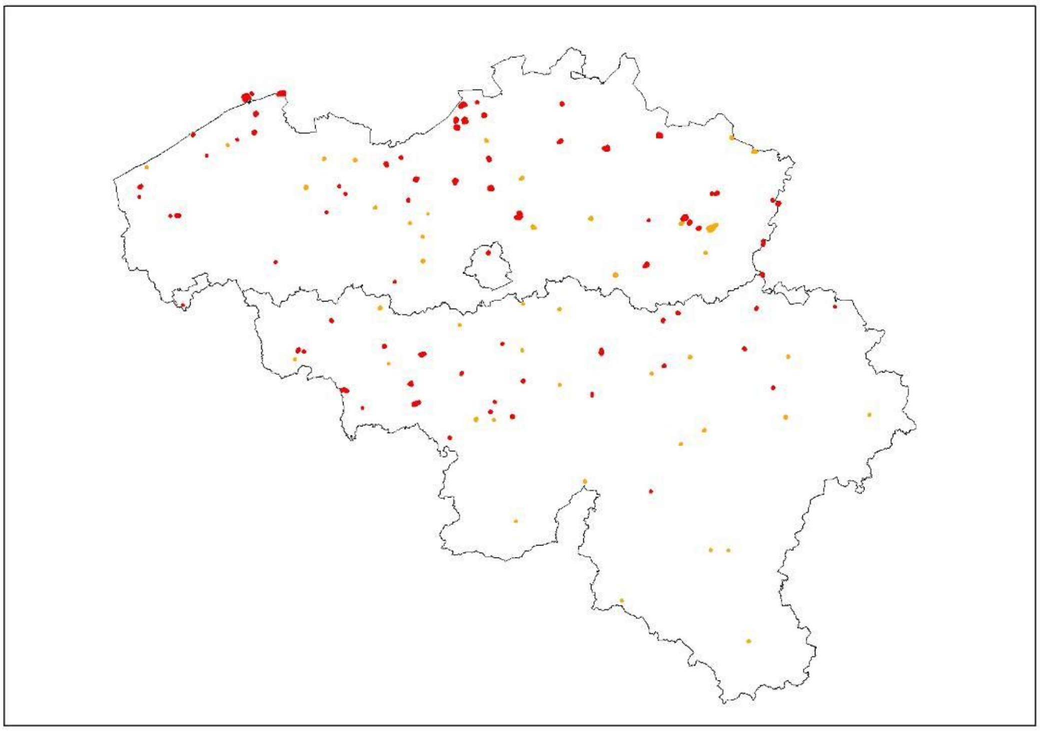

*Figure **4**: Important breeding colonies of waterbirds in Belgium (in red, **ñ**very important**ò** colonies, in orange **ñ**important**ò** colonies). Please note that the polygon outlines are larger than scale to make them easier to see.*

Roost sites

Outside the breeding season, many bird species have the habit of congregating in large numbers (up to millions of individuals for some species) at specific, traditional places to spend the night; those places are named ñcommunal night roostsò. Several ethological explanations exist for this spectacular behaviour: safety against predator attacks, temperature regulation and information exchange facilitation. As regards power-line collision risks, those roosting places are significant because they correspond to daily movements of flocks up and down the daily feeding grounds. Moreover, collision risks may also increase for roosting birds (more than for colonial breeding birds) because they are migrants that are not necessarily familiar with the local environment (PAQUET *ET AL.*, 2003).

Data used for assessing roost location importance come from:

- organized coordinated counts of the Great Cormorant and gulls (INBO and Aves data);
- other counts (e.g. roost monitoring of the Goosander in the Ardennes and the Great White Egret in some areas).

Again, for Flanders, important roosting places were identified in the wind energy sensitivity mapping exercise, and the same set of criteria was used in Wallonia. Table 5 details the criteria and thresholds used to define the relative importance of roosting places.

*Table **5**: Criteria applied to define the importance of waterbird roosting sites at the regional level. For example, the threshold of 2% was reached when a roost of more than five Great White Egrets or 80 Great Cormorants was counted.*

Importance for waterbirds	Criteria / Threshold
Fairly Important Site	Less than 100 individuals regularly counted
Important Site	Between 100 and 1000 individuals regularly counted
Very Important Site	More than 1000 individuals or at least 2% of the regional population regularly counted.

The resulting map is shown in Figure 5. Communal night roosts were located and identified for the following waterbird species: gulls (all species of *Larus sp.*), the Great Cormorant, geese (several species of *Anser sp.*), the Eurasian Curlew, the Great White Egret and the Goosander.

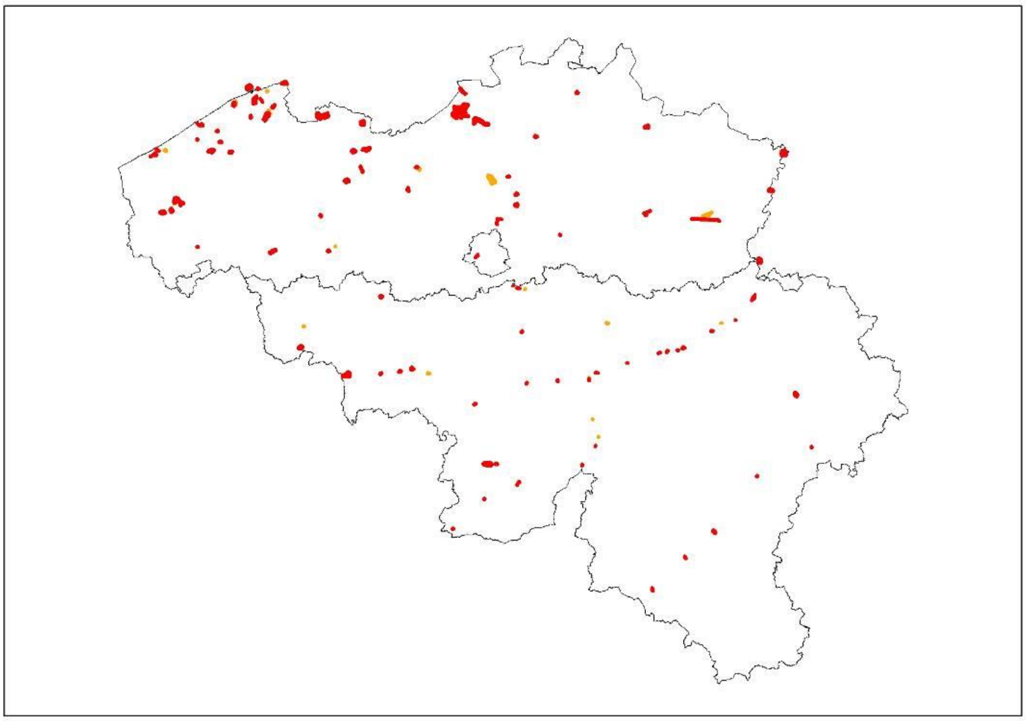

*Figure **5**: Important night-roosts of waterbirds in Belgium (in red, the **ñ**very important**ò** roost locations, in orange the **ñ**important**ò** roost locations). Please note that the polygon outlines are larger than scale to make them easier to see. **ñ**Fairly important roosts**ò** are not presented on this map.*

Local movements of waterbirds

In the Flemish wind energy risk map for birds (EVERAERT *ET AL.*, 2011), known local movements of some wintering waterbird species groups are also mapped. Originally, there were two maps. The first map shows daily local migration ï mainly of wintering ducks, geese and waders ï from resting or roosting areas to foraging areas and back. Many waterbird species like ducks rest in the daytime on open water and wetlands, and during dusk they fly to their foraging areas such as grasslands, agricultural fields and other wetlands. Additionally, waterbirds can also be forced to adopt a tidal rhythm for foraging. The second map shows daily local migration ï mainly of wintering gulls, geese, waders (mostly curlew) and cormorants ï from foraging areas to roosting areas. These movements take place around sunset.

Both maps were created using the available information, based on censuses and current knowledge of local birdwatchers. The migration routes are displayed as areas (migration corridors) where most birds can be expected to fly. In many cases the width of the corridor varies between 1000 m and 2000 m, although in certain cases a different width was used because of the combination with other nearby corridors, spatial properties of the surroundings (e.g. along canals), distance between feeding and roosting areas, etc.

The data are of course incomplete. Most of the information does not come from censuses with set criteria and it is possible that some data do not reflect the actual situation.

*Table **6**: Criteria applied to define the importance of local migration corridors of wintering ducks, geese and waders towards their foraging areas.*

Importance of local migration corridor	Criteria / Threshold
Important: to foraging place and back	Between 100 and 2000 individuals per 24 h
Important: to roosting place	Between 100 and 2000 individuals per evening
Very important: to foraging place and back	More than 2000 crossing individuals per 24 h
Very important: to roosting place	More than 2000 crossing individuals per evening

V.3. Rare breeding birds

The list of species identified as sensitive to collision with power lines includes several rare breeding bird species, of which very small populations are often concentrated at well-known sites. For some species, nest locations are even monitored from year to year. Most of these species present a particular legal status (Annex I of the Birds Directive) or are cited in the regional Red Lists of Endangered Species (see Table 7). Identifying dangerous power lines is particularly important for these species, as their populations are generally under high pressure from other factors already. However, a few of these species (Black Stork and Eagle Owl) recently increased their populations and are now quite widespread in Wallonia. It is nevertheless important to minimize collision risks as they are still vulnerable to additional mortality.

Table 7: Legal and biological status of the rare breeding species that are sensitive to collision with power lines in Belgium ***(Vermeersch & Anselin, 2009; Jacob et al., 2010)****. Species with an asterisk are considered of intermediate sensitivity to collision in Annex I but are considered in the rare breeding bird map because of their high conservation value and potential sensitivity to supplementary mortality.*

Species		Annex I	Red List (VL)	Red List (WAL)	Population estimate (VL)	Population estimate (WAL)
Hazel Grouse	*Bonasa bonasia*	X	-	Critically Endangered	-	48-140 pairs
Black Grouse	*Tetrao tetrix*	X	Extinct	Critically Endangered	0	13-27 hens
Great Bittern*	*Botaurus stellaris*	X	Critically Endangered	Critically Endangered	20 pairs	0-1 pair
Little Bittern*	*Ixobrychus minutus*	X	Critically Endangered	Critically Endangered	21 pairs	1-4 pairs
Black Stork	*Ciconia nigra*	X	-	Vulnerable	-	75-95 pairs
White Stork	*Ciconia ciconia*	X	-	-	55-60 pairs	0-1 pair
Red Kite*	*Milvus milvus*	X	Irregular	Vulnerable	-	150-180 pairs
Marsh Harrier*	*Circus aeruginosus*	X	Least Concern	Endangered	90 pairs	1-7 pairs
Hen Harrier*	*Circus cyaneus*	X	Irregular	Endangered	0-1 pairs	1-5 pairs
Montagu's Harrier*	*Circus pygargus*	X	Critically Endangered	Endangered	0-1 pairs	2-13 pairs
Peregrine Falcon*	*Falco peregrinus*	X	-	Vulnerable	27 pairs	>25 pairs
Spotted Crake	*Porzana porzana*	X	Endangered	-	5-15 pairs	irregular
Corn Crake	*Crex crex*	X	Critically Endangered	Critically Endangered	5-6 males	1-12 males
Kentish Plover	*Charadrius alexandrinus*	X	Critically Endangered	-	23-31 pairs	-
Pied Avocet	*Recurvirostra avocetta*	X	Vulnerable	Vulnerable	410-425 pairs	1-3 pairs
Eurasian Eagle Owl	*Bubo bubo*	X	-	Vulnerable	-	80-85 pairs
Tengmalm's Owl	*Aegolius funereus*	X	-	Vulnerable	-	21-100 pairs
European Nightjar	*Caprimulgus europaeus*	X	Vulnerable	Endangered	500-550 pairs	50-60 pairs
Eurasian Wryneck	*Jynx torquilla*		Critically Endangered	Endangered	Irregular breeding	45-58 pairs
Grey-headed Woodpecker	*Picus canus*	X	-	Endangered	-	33-40 pairs

The critical areas for these species have been mapped using two different approaches.

- The site-based approach is similar to the waterbird sites approach developed earlier. The mapping consists of identifying concrete sites where the breeding population, or the core breeding population, is located.

- For a few rare breeding species at risk of collision, the availability of detailed information allowed for a more accurate definition of the ñrisk-areaò than the site-based approach: accurate breeding territory locations and estimation of flight-range from the nest during the breeding season. Collision-sensitive species for which this information is available are the following: the White Stork, the Black Stork, the Eagle Owl (only present in Wallonia) and the Nightjar (in Wallonia, where it is rarer than in Flanders).

Below, we describe how these two approaches have been applied to map critical areas for these species.

Part 1: Site-based species

For Flanders, we used the ñBijzondere Broedvogelgebiedenò thematic map developed for the wind energy sensitivity mapping (EVERAERT *ET AL.*, 2011). This map has been developed according to data gathered for the ñBijzondere Broedvogels Vlaanderenò scheme developed by INBO and other data collected up to 2009. Species that were already taken into consideration in other thematic maps (colonial waterbirds) were excluded here. Only sites containing more than 2% of the estimated Flemish breeding population were retained. The species used in this thematic map are the Great Bittern (2% = 1 pair), the Little Bittern (2% = 1 pair), the Marsh Harrier (2% = 1 pair), the Hen Harrier (2% = 1 pair), the Montaguôs Harrier (2% =1 pair), the Spotted Crake (2% = 1 pair), the Pied Avocet (2% = 8 pairs), the Kentish Plover (2% = 1 pair), and the European Nightjar (2% = 10 pairs).

For Wallonia, we used the following data:

- detailed data of specific bird inventories in the Natura 2000 sites, conducted since 2006 under an agreement with the Walloon Region - DEMNA (SPW);
- detailed locations of the known breeding pairs of some rare species, as collected during the compilation of the Breeding Bird Atlas of Wallonia (during the period 2001-2007);
- detailed observation data of rare species, pooled by Centrale Ornithologique Aves; these data are mostly collected by amateur birdwatchers through observation data portals and validated by Aves;
- for some declining species (e.g. the Hazel Grouse), we used the distribution map produced for the 2001-2007 Atlas to delineate the present-day range. Natura 2000 sites that were designated for a species but are now outside the species range are excluded here.

Table **8** summarizes how the species sites were selected.

*Table **8**: Site selection criteria used for the rare breeders in Wallonia.*

Species	Site selection method
Hazel Grouse (*Bonasa bonasia*)	Natura 2000 sites designated for the species, excluding the sites falling outside the 2001-2007 range + Natura 2000 sites where recent sightings are recorded
Great Bittern (*Botaurus stellaris*)	Natura 2000 sites where breeding was recorded after 2001
Little Bittern (*Ixobrychus minutus*)	Natura 2000 sites where breeding was recorded after 2001
Marsh Harrier (*Circus aeruginosus*)	Natura 2000 sites where breeding was recorded after 2001
Hen Harrier (*Circus cyaneus*)	Hand-drawn perimeters where breeding is regularly recorded; those perimeters are used to conduct Agri-Environment Schemes favourable to this species
Montaguôs Harrier (*Circus pygargus*)	Hand-drawn perimeters where breeding is regularly recorded; those perimeters are used to conduct Agri-Environment Schemes favourable to this species
Tengmalmôs Owl (*Aegolius funereus*)	Natura 2000 sites designated for the species + Natura 2000 sites containing at least one breeding territory during the compilation of the 2001-2007 Atlas, except where its presence is known to be irregular (Western Ardennes)
Eurasian Wryneck (*Jynx torquilla*)	Natura 2000 sites where breeding has been recorded since 2001 (excluding isolated or unconfirmed cases)
Grey-headed Woodpecker (*Picus canus*)	Natura 2000 sites where observations suggest breeding after 2001 (excluding isolated or unconfirmed cases)
Black Grouse (*Tetrao tetrix*)	Natura 2000 sites where the remaining population is still observed
Corncrake (*Crex crex*)	Hand-drawn perimeters where the species is regularly recorded, limited to the Fagne-Famenne region, the stronghold of the species in Belgium

Part 2: Buffer-based species

The Black Stork *Ciconia nigra* breeds in Wallonia and is only observed as a migrant in the two other regions. Available information includes all known breeding locations and territory centroids collected during the compilation of the 2001-2007 Atlas (sources: SOLON asbl ï SPW ï Aves) and a satellite-tracking study in France indicating that breeding birds are using a range extending easily up to 20 km from the nest (VILLARUBIAS, 2003; JIGUET & VILLARUBIAS, 2004). If a 20-km radius is drawn around all known nests, the entire region south of the Sambre and Meuse valleys is included in this buffer zone. This does not adequately represent variation in the actual presence of the species, which is clearly more at risk around the main forested zones than in the agricultural landscape of the Condroz. Therefore, we decided to arbitrarily concentrate the risk-area on a 5-km radius around all known nests. An analysis with casual, occurrence data of the Black Stork shows that this 5-km buffer covers most (>50%) of all the Black-Stork occurrence data in Wallonia (from the Aves occurrence database).

The European Nightjar *Caprimulgus europaeus* breeds in both Flanders and Wallonia. For Flanders, the sites provided for the wind energy sensitivity map were used (EVERAERT *ET AL.*, 2011). For Wallonia, we selected the breeding territories recorded after 2001, excluding isolated breeding cases (source: Centrale Ornithologique Aves and the 2001-2007 Atlas). This targets the four remaining major breeding areas of the species: Lagland military camp, the Croix-Scaille forest, the Cul-des-Sarts area and the Spa-La Reid area. A 1500-m radius buffer was drawn around these territories. Although radio telemetry has shown that a foraging distance of up to 3 km can be recorded (ALEXANDER & CRESSWELL, 1990), we chose to focus the risk area on a smaller radius, closer to the usual territory size (1500 m).

The Eagle Owl *Bubo bubo* is only a regular breeder in Wallonia, and the species is well monitored. We use the known breeding location (Atlas data, IRSNB data, COA) and draw a 1500 m buffer around all these locations.

The same 1500-m buffer was used around all the known nest location of the Peregrine *Falco peregrinus* from the Flemish wind energy map (EVERAERT *ET AL.*, 2011) or from the Aves database for Wallonia and Brussels.

Critical areas for the Red Kite *Milvus milvus* were defined by Aves in an unpublished work concerning a wind energy sensitivity map for Wallonia, based on spatial modelling of the probability of the presence of nest locations.

The resulting thematic map

The general thematic map for rare breeding birds is shown in Figure **6**. Most of the critical areas for this theme are located south of the Sambre and the Meuse valley. Most of the critical areas contain only one rare species, but highly critical sites are again the Eastern polders and some high plateaus of the Ardennes (Hautes-Fagnes, Saint-Hubert, Croix-Scaille) as well as the Anlier forest.

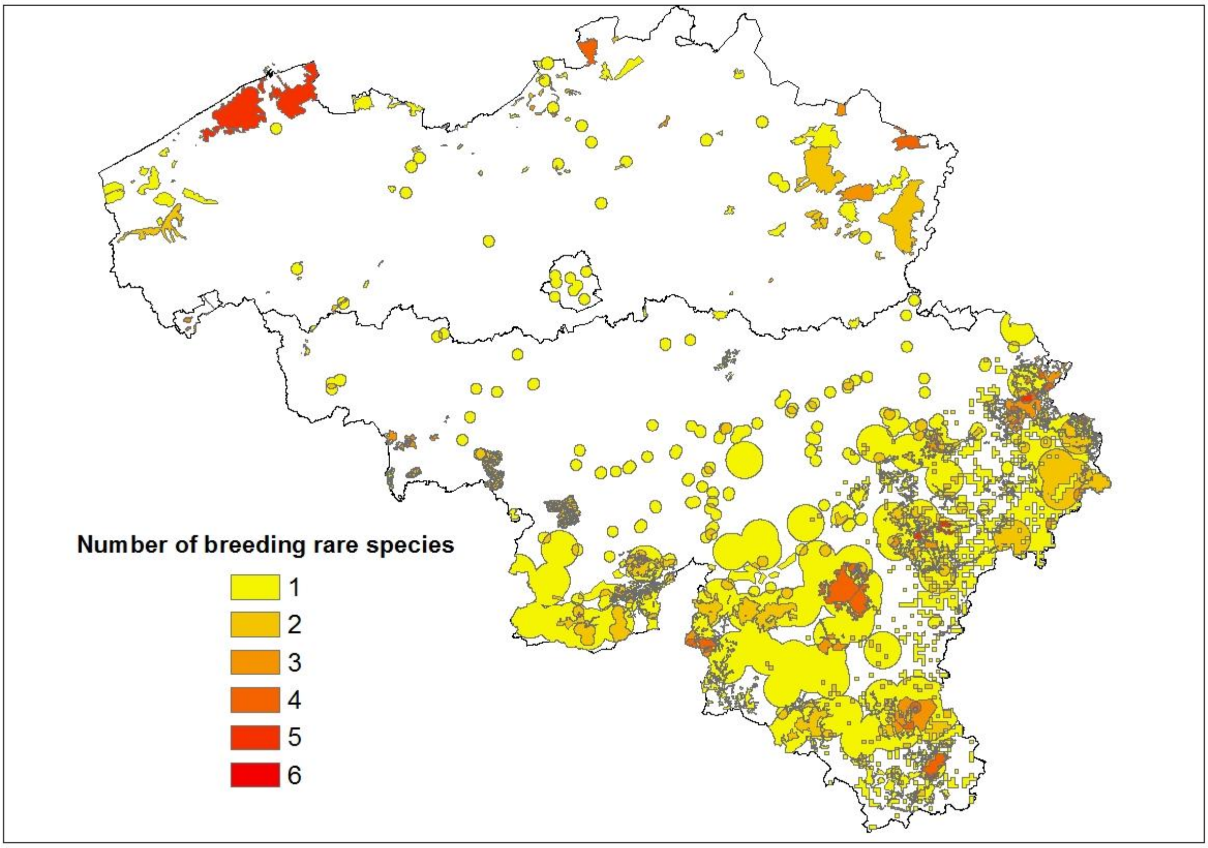

*Figure **6**: Sites with sensitive rare breeding species, with an indication of the number of rare breeding species.*

V.4. Migrants in large numbers

Mapping specific corridors for seasonal bird migration is especially difficult in a low-lying country. While in mountainous areas or regions with special coastal geography, clear migrant funnels can be observed, Belgium lacks such geographical bottlenecks. As a result, millions of migrant birds cross the country over a broad front every year. This creates a dilution of the collision risk over the whole country, even where minor concentration effects and no uniform risk exists for certain species. In the recent windmill risk atlas for the Netherlands (AARTS & BRUINZEEL, 2009) and Flanders (EVERAERT *ET AL.*, 2011), migration corridors have been tentatively defined, mainly on the basis of expert judgements, and radar data and visual counts of active migrants by amateur birdwatchers (see www.trektellen.org).

Air Force and meteorological radars allow the detection of migration flocks. This ñby-productò of radar surveillance has been widely used to study different aspects of bird migration (BERTHOLD, 2001). In Belgium, many observations are recorded by military radars but this information remains to be analysed in a systematic manner to define migration corridors (S. Sorbi ï Belgian Air Force, pers. com.). However, it is likely that this analysis will reveal varying migration intensity spread across the country, like in the Netherlands (AARTS & BRUINZEEL, 2009), rather than selective, narrow corridors.

Hundreds of birdwatchers are counting migrating or passing birds from well-defined posts every year, especially in the autumn (PAQUET & DUJARDIN, 2010). Most of these counts are collected on the dedicated www.trektellen.org website. While these data prove to be very useful in terms of describing migration intensity and phenology, on a geographical basis they are supposed to reflect much more active birdwatcher locations rather than migration funnels (although on the basis of experience, birdwatchers probably select strategic counting posts with high potentials for condensed bird migration). Using data from trektellen.org together with unstandardized records of migrating birds from the Aves bird observation database, we tentatively plotted the migration map for two collision-sensitive species in 2009 and 2010: the Woodpigeon and the Common Crane (Figure **7**).

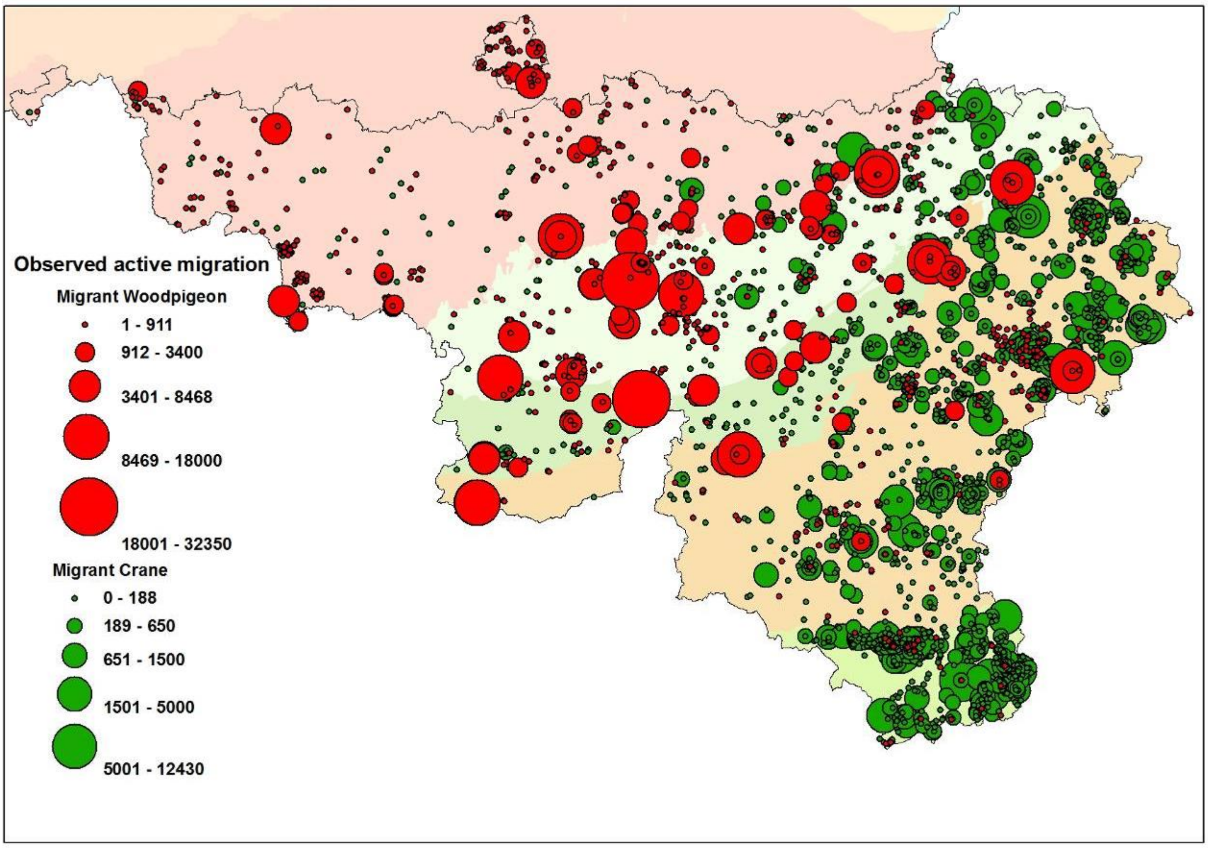

Figure 7: Map showing locations of recorded active migrants of two sensitive species ï in green, the Common Crane, in red the Woodpigeon (source: Aves database, observations.be, years 2009 and 2010). Both species can migrate over the whole country, but large groups are more likely to be observed in Eastern Belgium for the Crane and over the Condroz and Famenne ecoregion for the Woodpigeon, especially around the Meuse valley and the Northern ridge of the Ardennes region.

This map, together with expert knowledge, suggests three main migration corridors for Wallonia, as well as the ones already defined for Flanders (EVERAERT *ET AL.*, 2011): one following the Meuse valley (Woodpigeon corridor 1), another one following the Northern ridge of the Ardennes (Calestienne ï Woodpigeon corridor 2) and a third one, which is broader to take into account the major Crane corridor. In Flanders, migration corridors generally focus more on migrant waterbirds, the Eastern corridor also reflecting the greater passage of Common Crane and Woodpigeon (EVERAERT *ET AL.*, 2011). The final migration map for Belgium is presented in Figure 8.

It is important to stress the fact that these corridors are defined at macro-scale and that meso- and micro-scales (i.e. the main local migration axis through a given landscape) are not shown here.

Due to the diluted risk for migrants in terms of collision with power lines (diluted in time as migration only concerns a narrow time window and diluted in space as these corridors are over-simplifying a broad front migration pattern), we think that these migration corridors can only be considered a secondary criterion in defining the most dangerous power lines.

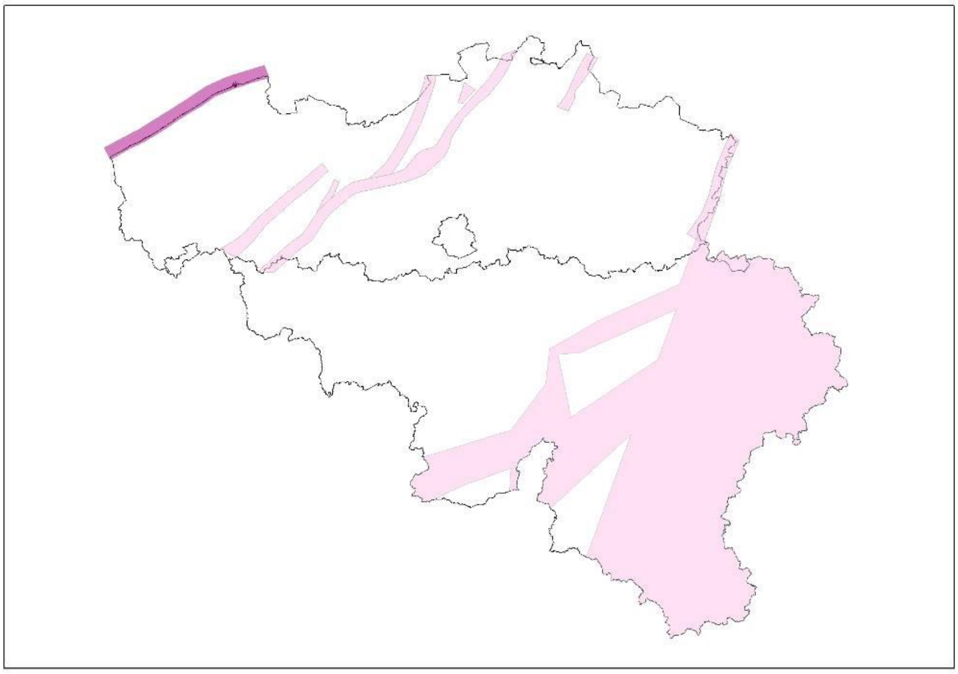

*Figure **8**: Proposed migration corridor map for Belgium. In violet, the major corridor of the migrants following the coastline and in pink, major inland migration corridors defined by Everaert* et al. *(2011) and this publication.*

V.5. Local movement of birds

V.6. Widespread breeding species

Among the targeted species for the mapping, the fourth group (widespread species) consists of species not linked to well-defined sites or areas. Their population is rather widespread in Belgium, present in variable densities in a range of habitats. This is typically the case for some forest birds (woodpeckers) or farmland birds (Grey Partridge). For these species, which are sensitive to collision, the site-based approach for the sensitivity mapping (as used for waterbirds) is not useful. It is often not possible to identify concrete sites where it would be critical for the species to address the power-line issue.

Therefore, for widespread species, we explored the use of relative density maps as a better approach to sensitivity mapping. These high-resolution maps will not only delineate the areas where the species is present or absent, they will also classify the relative density of the species over the whole country. From these maps, we will be able to select the ñhigh-densityò sectors, and consequently sensitive areas for power lines. High-resolution density mapping is generally possible through distribution modelling, using known observations of a species and statistical relationships between these data and environmental descriptors to predict the distribution (or abundance) of the species over a whole study area (FRANKLIN, 2009). It is necessary to use distribution modelling rather than ñtrue observation dataò or ñreal counted birdsò as it is generally not possible to have an indication of the abundance of every species at a very fine-grained resolution (like 1-km square) for the entire country. Distribution modelling has already been used in sensitivity mapping for windmills (PEARCE-HIGGINS *ET AL.*, 2008) and also recently applied in a multi-specific approach with bird atlas data to aid nationwide spatial planning (HERRANDO *ET AL.*, 2010).

Model-building procedure

A complete explanation of how we developed high-resolution relative density maps is available in the methodological chapter of the Breeding Bird Atlas of Wallonia (PAQUET *ET AL.*, 2010). In brief, we used the 1x1-km bird sampling from each of the three regional Atlases. This is a standardized protocol to sample birds present in squares of 1 km² (two one-hour visits during one reproductive period). The detailed methods vary slightly between the three regional atlases but as these variations mainly concern bird quantification, we simplified the data by only using presence/absence data. The grid used (although composed of 1x1-km squares) differs between the atlases (in Flanders, the grid has 1-km UTM squares while in Wallonia, the grid is based on a National Geographic Institute map). We circumvented this problem by using the appropriate grid for each region at the same time for the data, the calculated variable and the model projection. The model is thus calculated for the whole area but each variable is calculated in the correct grid. Finally, one important difference between the three sampling schemes lies in the coverage of the sampling; this coverage (meaning the proportion of sampled squares related to the total surface) is about 17% for Wallonia, 100% for Brussels (every square of this small region was sampled) and 30% for Flanders. These coverage rates are well above the minimal sampling effort necessary to obtain a high-quality spatial distribution model, which is estimated at around 4-5% (AIZPURUA *ET AL.*, 2012). In order to avoid a bias due to over-sampling in Flanders and Brussels, we randomly selected a number of sampled squares to make them equate with the coverage rate of Wallonia (17%).

To model the distribution of the species considered, we used ñpresenceò data provided by the sampling procedure on the one hand, and 20 variables concerning the environment in every square on the other hand. These variables describe the land-use (deduced from the CORINE land cover map, version 2006, published by the European Topic Centre on Land Use and Spatial Information) and bioclimatic variables calculated from the WordClim dataset (HIJMANS *ET AL.*, 2005). The modelling method is MaxEnt, a presence-only method that is now widely used in distribution work (PHILLIPS *ET AL.*, 2006) and that was successfully used in the Breeding Bird Atlas of Wallonia (PAQUET *ET AL.*, 2010). The projected result of the modelling procedure is a map estimating the probability of occurrence (ranging from 0 to 1) for every 1x1 km for that species. The probability of occurrence can be related to the ñhabitat suitabilityò of the square for the species. A bootstrap procedure, leaving out 30% of all the presence data to train the model, is used to validate the model. The final model is the average of 10 models.

When producing the map, a colour gradient is applied to symbolize the increasing probability of occurrence (or ñhabitat suitabilityò), with white representing a very high likelihood of absence of the species. This visually important threshold was determined for each species with a different cut-off analysis proposed by MaxEnt, and a ñBalance training omission, predicted area and threshold valueò was chosen.

Modelling results

Among the species identified as ñsensitive to power-line collisionò, given the available data and the prevalence of the species (the proportion of sampled data where the species were detected), the following breeding birds can be mapped using MaxEnt habitat suitability modelling: the Grey Partridge, the Northern Lapwing, the European Turtle Dove, the Green Woodpecker, the Black Woodpecker and the Middle Spotted Woodpecker. A proposed high-resolution distribution model is proposed for these species in Figure 9. Note that this is, to our knowledge, the first attempt at drawing a Belgium-wide high-resolution habitat suitability map for breeding birds. The distribution of the Barn Owl could not be modelled by this method because the available sampling data concerns only diurnal birds.

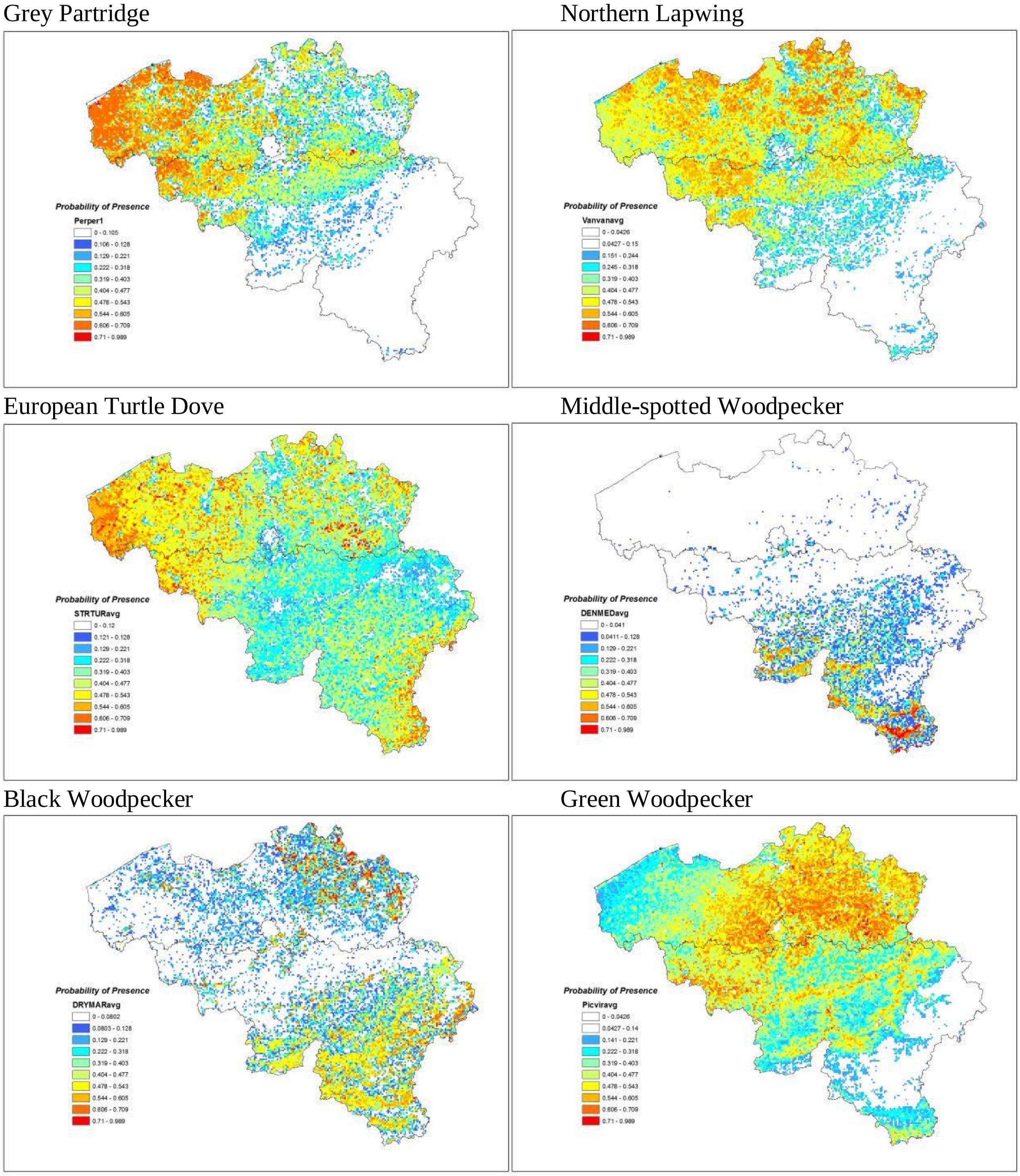

Figure ***9****: Habitat suitability maps for six rather widespread breeding species in Belgium (1-km resolution). The maps show the variation of probability of presence calculated by the MaxEnt model using sampling data from the three regional atlases. White indicates an area where the species is most probably absent. A high probability of presence is linked to habitat suitability.*

Comparing the resulting maps side by side in Figure **9** suggests that it will be difficult to use them to prioritize hazardous power lines for these sensitive species as the high-density areas for these species are quite extended, but above all because the ñbest areasò for these six species are not congruent. Even for the three woodpecker species, we see that the southern broadleaved forests are best for the Middle-Spotted Woodpecker, while the Black Woodpecker has its higher densities in coniferous woodland in the Ardennes and in the Campine, and the Green Woodpecker prefers mixed farmland areas, outside the dense woodlands. Therefore, adding the known distribution of these species to the criteria used to

prioritize power lines may result in a dilution of the priority settings. Moreover, as these birds are territorial, the risk of collision mortality is further diluted, even in territories crossed by power lines.
We therefore suggest using these distributions only to refine a prioritization exercise mainly based on waterbird congregation criteria and rare-bird areas.

V.7. Other important stop-over areas for plovers

Two Birds Directive Annex I species of ñwaterbirdsò, the Eurasian Dotterel *Charadrius morinellus* and the Golden Plover *Pluvialis apricaria* are both recognized as ñsensitive to collisionò and ñof conservation relevanceò (see Annex I), although their main staging areas are not well covered by the critical area delineation for Group 1 (waterbirds). Their habitat is more ñterrestrialò than other shorebirds. Dotterels are usually seen in very open farmland habitats during migration. Formerly thought to be a very rare bird in Belgium, it recently appeared to be a regular staging post-nuptial migrant in some farmland areas in central Belgium, sometimes in relatively large groups (ROUSSEAU-PIOT, 1995; MARIAGE & FARINELLE, 2005). This new status was linked to better knowledge and a systematic survey of this charismatic bird by birdwatchers. The Golden Plover is an abundant migrating and wintering bird in meadows and open land, mostly in the western part of the country and sometimes also on interior farmland areas. The use of intensive agricultural habitats is not anecdotal for this species, as open fields can be a very profitable staging habitat (LINDSTRÖM *ET AL.*, 2010).
In order to identify the most critical areas for these species, we used a similar spatial modelling approach as for the widespread breeding species (see page 31). Instead of atlas sampling, we used observation data of both species, extracted from the www.waarnemingen/observations.be database. From this dataset, we selected the locations of resting groups of more than 100 Golden Plovers or resting Dotterels during the period 2008-2011 (records of flying birds were excluded to focus on staging areas). For each species, only one observation per year inside a given 1x1-km square was retained (this was to avoid a long-staying group of Dotterels, recorded sometimes by dozens of different birders, creating a bias in the modelling procedure). From this data, we proceeded as explained for breeding birds in Chapter V.5. The result is a map showing the probability of occurrence (from 0 to 1) of staging Golden Plovers (Figure **10**) or Dotterels (Figure **11**).

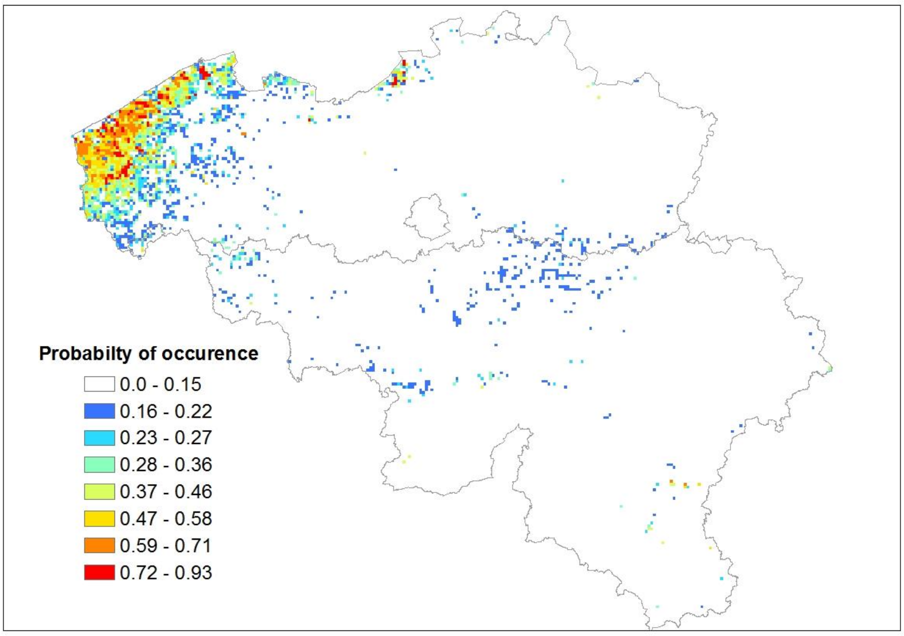

*Figure **10**: Distribution map (by probability of occurrence) of a large group (>100 individuals) of staging Golden Plovers* Pluvialis apricaria *in Belgium (2008-2011). Large groups of the Golden Plover are rare outside the Polders.*

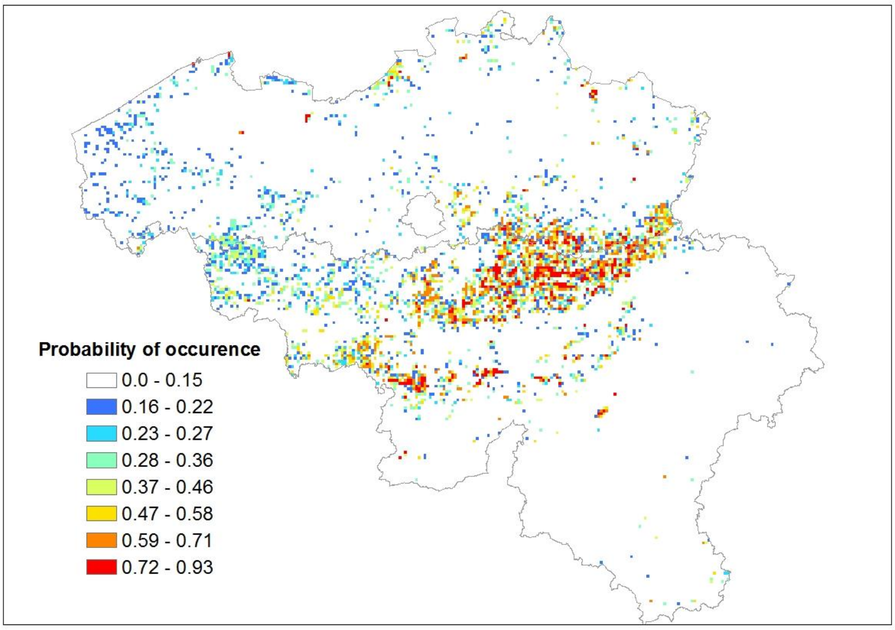

*Figure **11**: Distribution map (by probability of occurrence) of staging Dotterels* Charadrius morinellus *in Belgium (2008-2001). Very open, steppe-like agricultural areas are selected as stop-over sites by this species.*

These maps will be used in the scoring procedure as a secondary criterion, as for the widespread breeding birds. The cut-off of occurrence probability above which a square is declared to be part of the ñareasò of the species is, as for the breeding birds, the cut-off calculated as the ñBalance training omission, predicted area and threshold valueò proposed by MaxEnt.

VI. Step 4: Using the maps to prioritize power lines

In sensitivity mapping, the goal is to constitute a map of added constraints and identify high- to low-risk areas at the best possible resolution. This is a powerful planning tool when a decision has to be made at a regional scale as to where to build potentially harmful devices like windmills (BIRDLIFE EUROPE, 2011). This can also be used when considering grid development, but in the present publication the goal was slightly different: it was to identify and rank, within the existing high-voltage power grid, the line segments that present a high risk of causing additional mortality to birds, in order to take mitigating actions, like installing deterring devices (see page 39) in the most suitable order of priority. Therefore, we had to combine the different maps detailed in Chapter 5 in a way allowing us to ñscoreò the existing line pylons according to their relative collision threat.

To do this, we combined the different maps in a single ñpolygonò assembly (i.e. a large shapefile of polygonal units). Polygons can be derived from the 1x1-km grid used to model widespread species, or the waterbird areas including various buffer drawn around the site itself, or the migration corridors, and the combination of all these polygonal units. The resulting shapefile contains more than 129,000 spatial units, each of them thus containing specific information about the presence of sensitive bird species (waterbird colony, number of rare bird species, migration corridors, etc.).

The next step was to create a scoring system, mostly based on expert judgement, to characterize all these spatial units in relation to the collision risk. Table **9** shows the applied scoring system. As explained earlier, we hypothesized that the most detrimental power-line effects would be close to critical waterbird areas, especially roost sites and colonies, as they involve regular movements of large numbers of birds entering and leaving these areas. We also hypothesize that focusing on mitigation efforts for lines crossing sensitive rare-bird areas would be relevant, as it makes sense in terms of focusing on conservation efforts: regional authorities as well as nature conservation organizations are often already investing in these areas to protect a target species. Other sensitive species, like widespread breeding species and migrating birds in certain corridors, are also present around some power lines but because power lines probably represent a ñdilutedò risk for these species, we advocate handling these factors only as a secondary-priority criterion.

*Table **9**: Priority scoring system for the spatial units in the final map.*

		Distance from the critical area			
Critical area considered	Inside	Less than 1 km	Between 1 and 3 km	Between 3 and 5 km	Over 5 km
Waterbird roost	If very important =25; important=20	14	9	4	0
Waterbird colonies	If very important =25; important=20	14	9	4	0
Important waterbird site	If very important =30; important=25; fairly important=20	14	9	4	0
Daily corridor	4 if important, 6 if very important				
Rare-bird Area	10 points for area with 1 rare species, 20 for area with 2-3 rare species, 25 for area with 4-5 rare species and 30 for area with more than 5 species				
Migration corridor	8 points if power line pylon is inside, 12 for the coastal corridor				
Plover staging area	5 points for each of the 2 species, when presence cut-off is reached *				
Widespread breeding bird	4 points by species, when presence cut-off of the species is reached *				

* For scoring purposes, the cut-off value of the probability index that was used to determine the ñpresenceò of a species is the cut-off calculated by MaxEnt where the test omission rate is around 20%, meaning that the cut-off is slightly more stringent than the one used in Figure **9**.

The scoring system applied to our final spatial map allowed us to draw a kind of ñcollision risk landscapeò for Belgium, presented in Figure **12**.

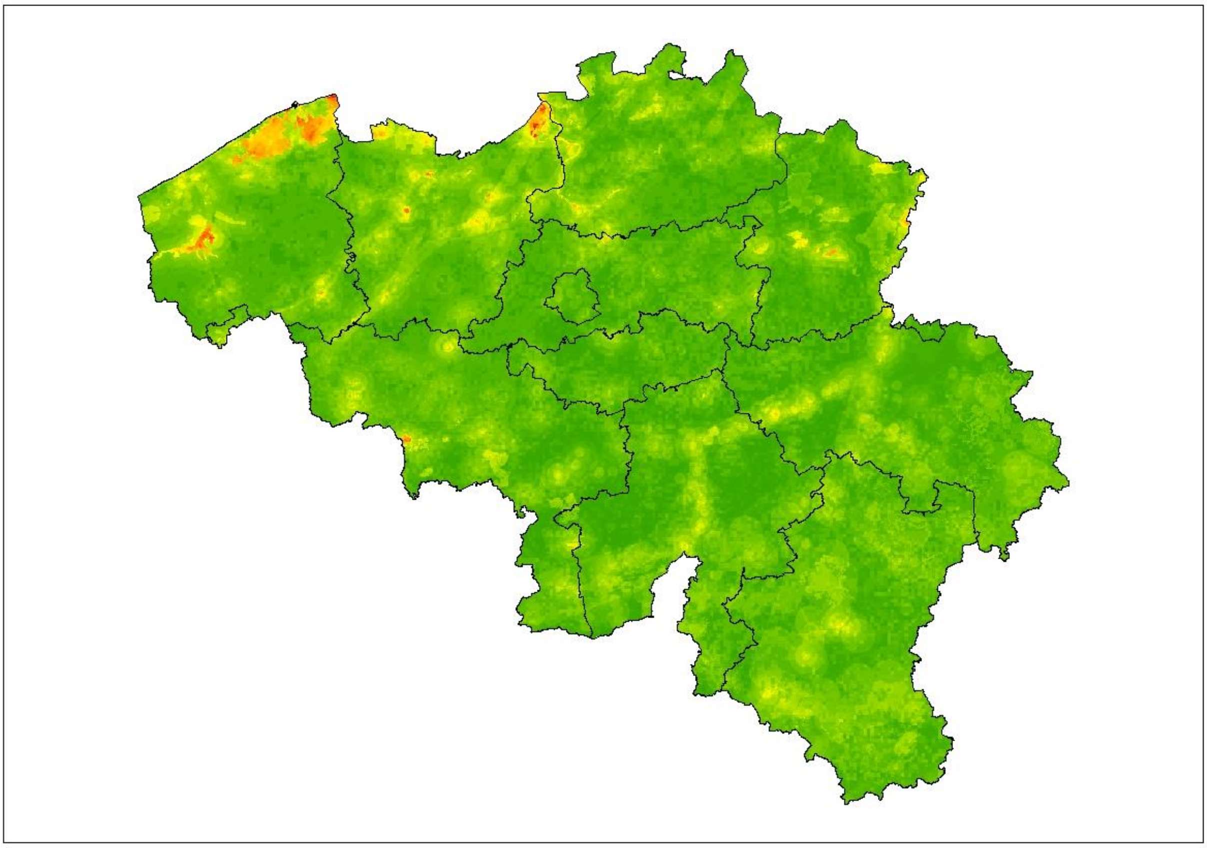

*Figure **12**: The final collision risk map for Belgium, showing on a gradient from green (low-risk areas) to red (very critical areas for bird collision risks) the status of bird collision risk with high-voltage power lines.*

The map in Figure **12** clearly emphasizes regions of high importance for waterbirds like the polders and the Port of Antwerp, or in Wallonia the Haine valley marshes or the Meuse river valley. Of course, the scoring system is based on expert judgements. However, we tried different combinations of the scoring system (like increasing the relative score for rare birds, etc.), and the risk map turned out to be rather robust.

Finally, for each of the 22,780 pylons in the Elia grid we calculated a risk score simply according to the spatial unit score where the pylon is standing. It is important to note here that we used the pylon location for practical GIS reasons, but of course the dangerous part of the grid, in terms of collision, is the line between the pylons, not the pylons themselves. So once a pylon has been identified as dangerous according to our scoring system, work should focus on the lines attached to the pylon.

This step allows us to make a classification of the entire Elia grid according to bird risks as illustrated in Table **10** and Figure **13**. About 3.4% of the pylons are considered as ñhigh priorityò (score higher than 50) and they are located mostly around important waterbird areas like coastal polders and the lower Meuse valley. The highest priority should also be given to the longest segment in critical areas, so there is no doubt that the initial efforts should focus on the Polders and Yser valley areas, then on the area around the Port of Antwerp and more sporadically the areas around some river basins in Wallonia (Meuse, Ourthe, Haine).

*Table **10**: Frequency distribution of Elia pylons according to their dangerousness for birds.*

Priority score class	Number of pylons	% of the grid
0 to 10	3015	13.2%
11 to 20	6608	29.0%
21 to 30	7066	31.0%
31 to 40	3751	16.5%
41 to 50	1567	6.9%
51 to 60	494	2.2%
more than 60	265	1.2 %

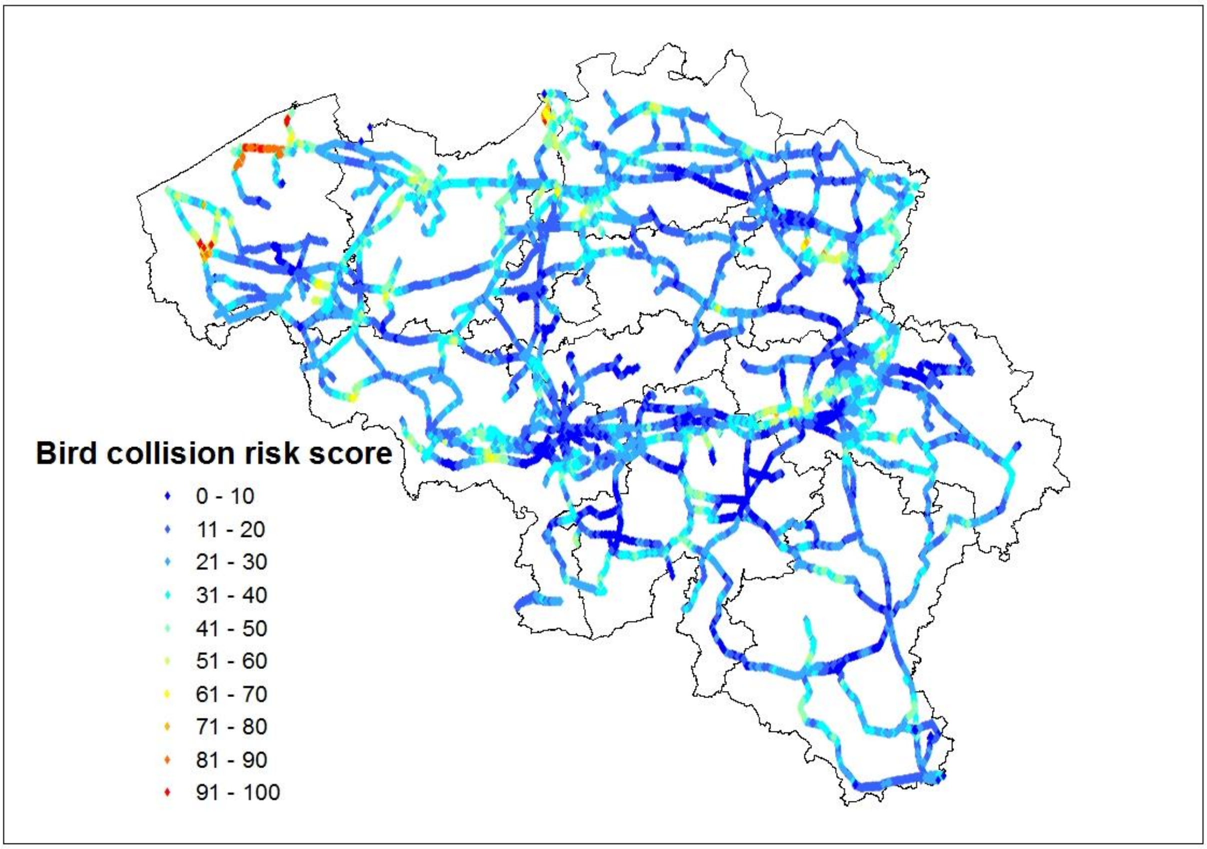

*Figure **13**: Map of the current Elia network of power lines. Pylons are coloured according to their priority scores. Most of the high-priority lines are close to waterbird sites, with a higher risk clearly existing in the Polders area and the Yser valley, and also around the Harchies marshes and the lower Meuse valley.*

It should be emphasized that this priority score probably needs to be regularly updated. Knowledge of bird distribution is developing all the time (for example, in future years we may be able to obtain detailed distribution maps for breeding Woodcocks, which we are unable to draw now). Bird ranges themselves are also always changing (for example, the Red Kite and the Peregrine are expanding their breeding range). The priority classification of ñdangerousò power lines presented here should thus be seen as an answer to the following question: ñGiven present-day knowledge of bird distribution and relative sensitivity to collision mortality, what are the most dangerous power-line sections, i.e. those where the mitigation of collision risk should be focused as a priority?ò The next chapter looks at mitigation methods.

VII. Mitigation techniques to reduce collisions between birds and power lines

This last chapter intends to review the possible technical methods for mitigating the risk once a harmful power line has been identified (according to chapter IV). Addressing all the technical issues related to the application of the described mitigation techniques (like cost of stopping power-line operation in order to install diverting devices, and cost of the risk to employees of setting up devices) is beyond our competence in the domain. Consequently, although a tentative cost/efficiency comparison is included, we focus here on comparing the efficiency of existing techniques according to the literature.

We also focus below only on existing power lines. Of course, when planning a new power line, the top priority is to avoid, wherever possible, placing it in or near a critical bird area. The approach developed in the previous chapter of this publication could also be used for grid development planning (as a ñsensitivity mappingò service (BIO INTELLIGENCE SERVICE, 2012)), but here we will not expand on the measures to be taken to decrease the collision risk at the time of planning a new line (see PRINSEN *ET AL.*, 2011a for more details).

A complete review of applied mitigation measures in Europe has recently become available (PRINSEN *ET AL.*, 2011a).

VII.1. Burying cables

The ultimate solution to avoid collision is to bury the problematic wires. This solution is very expensive (a British study estimates lifetime costs of £10.2-24.1 million/km for a buried line, as opposed to £2.2-4.2 million/km for an overhead lines (cited in BIO INTELLIGENCE SERVICE, 2012)) and difficult to implement in the case of operational high-voltage power lines. A buried high-voltage line also involves the potential risk of emitting heat and electro-magnetic fields, but this is very unlikely to have any environmental impact (BIO INTELLIGENCE SERVICE, 2012). Burying the line could however be preferable when planning a new line crossing known very critical bird areas, if a deviation of the power line is impossible.

VII.2. Removing static wire

Observations show that the static wire (ñEarth Wireò) is the most dangerous cable for birds in a transmission overhead line. When flying, even if birds can generally see bigger conductor cables, they more frequently fail to see the static wires and collide with them. This is because earth wires are generally smaller in diameter and thus less visible than conductors. In two studies where collision events were observed, collision with the earth wire accounted for 82% and 93% of all events (FAANES, 1987; SAVERENO *ET AL.*, 1996). Thus, one way to reduce collision rates would be simply to remove the static wire (JENKINS *ET AL.*, 2010): this solution would be relatively costly and might lead to power outages caused by lightning. As a result, this is unlikely to be considered as a viable solution until new anti-lightning solutions are developed (PRINSEN *ET AL.*, 2011b).

VII.3. Habitat management

Another possibility would be to take habitat management measures around existing dangerous lines. The idea here would be to keep birds away from power lines by adjusting the ñattractivenessò of the nearby habitat (PRINSEN *ET AL.*, 2011b). If a power line is located between a roost and a feeding place, a theoretical possibility would be to create a new roosting or feeding place on the same side of the line (BROWN & DREWIEN, 1995). However, no actual practical examples of such large-scale mitigation measures are currently available in the literature (PRINSEN *ET AL.*, 2011a). This is probably because this type of management would involve taking action on neighbouring land and would require a significant level of habitat modification, not to mention high environmental and financial costs (PRINSEN *ET AL.*, 2011b). Most of the time, this is not a realistic approach on a large-scale basis.

VII.4. Marking lines

Overview

The most frequently cited and realistic option for reducing the collision risk is to make power lines more visible for the birds. Different kinds of devices have been tested; they are collectively referred to as ñdivertersò. These accessories make the lines more visible for birds and also for other sky users (parachutists, paragliders, microlights, helicopters, etc.). Some studies have shown that the frequency of collisions is reduced by 25 to 95% when diverters are fitted (BROWN & DREWIEN, 1995; SAVERENO *ET AL.*, 1996; KABOUCHE *ET AL.*, 2006; YEE, 2008). Others have shown a low impact for some species (JENKINS *ET AL.*, 2010). Recently, a meta-analysis based on 21 different studies and 52 wire-marking experiments around the world showed that the mortality rate was on average 78% lower where there were marked lines (BARRIENTOS *ET AL.*, 2011): for unmarked lines, the collision rate was 0.21/1,000 bird crossings, while it was reduced to 0.05/1,000 bird crossings in the case of marked lines. Interestingly, when marked and unmarked lines are present, the decrease in collision risk in the marked sectors did not result in an increase of the risk in the nearby unmarked sectors (BARRIENTOS *ET AL.*, 2011). This is because birds avoid the power lines they notice, by flying over, rather than by passing the detected line alongside.

The review of the literature did not manage to discriminate relative effectiveness of the variety of the device available on the market. Effectiveness of visual markers may depend on the landscape and the targeted bird species. The question of the optimal density of visual markers has not yet been examined. Consequently, there is a lot of room for improvement, with in particular investigations of non-visual devices being needed (BARRIENTOS *ET AL.*, 2011).

On the basis of current knowledge, it can be concluded that any large device (increasing the apparent size of the line to at least 20 cm) placed at least every 5-10 m along the line, preferably on the earth wire, is likely to significantly reduce collision risks (JENKINS *ET AL.*, 2010; PRINSEN *ET AL.*, 2011b).

The marking colour seems to be an important factor to consider. Yellow appears to be one of the most effective colours for increasing visibility and reducing mortality in all weather conditions, but yellow dampers cause UV-sensitivity problems (BROWN & DREWIEN, 1995). Red is more visible during clear weather with blue sky and even in fog. White (or other pale colours) are more visible during the night (JANSS & FERRER, 1998). Special colours reflecting light and/or UV are also effective (BROWN & DREWIEN, 1995). Although this has not been specifically tested, we can thus recommend that when the critical line concerns for example an important gull night-roost, white is to be preferred, while for a line crossing a river valley subject to fog, red is the colour that should be chosen.

A brief review of some available diverters

Aviation balls

Aviation balls limit the collision risk but are less effective than dampers or fibreglass plates (BROWN & DREWIEN, 1995). However, it is likely that lines already equipped with aviation balls (or even ñspacersò sometimes used to keep cables away from each other) are sufficiently visible by birds, given that the balls or spacers have the characteristics mentioned above.

Spirals

When red and white spirals were used in Southern France, where they were placed at intervals of 30 m on high-voltage power lines, they reduced bird mortality by up to between 89 and 95% (KABOUCHE *ET AL.*, 2006). Their high visibility and a certain amount of noise (created by the wind blowing against the spiral) alerted the (flying) birds to danger. Spirals can be placed on the high-voltage power lines by helicopter. Red spirals are believed to be more effective in case of frequent fog, while white spirals are believed to be more effective at night.

In Spain, orange polypropylene spirals (30 x 100 cm, made by APRESA) were placed on static wires above distribution lines with a diameter of more than 2 cm. If there was only one static wire, one spiral was placed every 5-10 m along the wire; if there were two wires, spirals were fitted every 10-20 m in an alternate manner. Some spirals broke because of the effects of wind and the sun (GOBIERNO DE ARAGON, 2007). Another study in Spain showed that white spirals on distribution lines reduced

mortality of local birds (including the Common Crane, the Great Bustard, the Little Bustard, the Wildfowl, the Lapwing and Storks) by 81%: Orange spirals also seem to reduce risks of collisions but the effectiveness seems to be lower for nocturnal birds, like the Eagle Owl (JANSS & FERRER, 1998).
In Colorado (USA), yellow PVC spiral vibration dampers (1.27 cm in diameter, 112-125 cm in length) significantly reduced mortality for cranes, raptors and waterfowl colliding with distribution and transmission lines (BROWN & DREWIEN, 1995).

The ***ñ****Firefly* ***ò***

The ñFireflyò, developed by HAMMARPRODUKTER, is a rotating hard plastic disc or rectangular plate with fluorescent parts that scares birds. These devices reflect sunlight during the daylight hours and emit luminescent light at twilight and at night. Studies show that it is effective in reducing crane collision in California (YEE, 2008). HAMMARPRODUKTER specifies that this diverter is easy to fit. Because of its relatively small size and light weight, distances between individual Firefly BDFs can be small (often within the quoted 5-10 m distance).

Bird flappers

In Germany, new marking devices consisting of 50-cm-long hard plastic black and white strips fitted to an aluminium clamp are now extensively placed on transmission lines. The company RWE (see below) also developed a helicopter allowing rapid installation without impairing the power supply. These systems have proven effective (HARTMAN *ET AL.*, 2010; PRINSEN *ET AL.*, 2011b), especially in night conditions (waterfowl) and close to a large gull roost. The reduction however was negligible for some species (Coot). The German bird flappers are large and exhibit a high level of contrast and the strips move individually in the wind, resulting in a blinking effect that probably makes them clearly visible for approaching birds at twilight or even in darkness. Because of their weight, it is not possible to install a large number on a single span of an earth wire; instead, there are typically several dozen metres between individual flappers (PRINSEN *ET AL.*, 2011b).

Other types of diverters

Another kind of diverter was developed by SAPREM. They are placed with a specialized machine that runs along the cables. These are composed of two neoprene black bands hanging from the wire like a clothespin. In addition to the form, these tags have photoluminescent properties. These tags have been used in Aragon on distribution lines for wires with a diameter of less than 2 cm. Two years after installation, tags were still in good shape and had retained their colour. Only in the case of significant slopes did some tags glide along the wire (GOBIERNO DE ARAGON, 2007). A Spanish study showed that these markers reduced the mortality rate by 76% on a distribution line (JANSS & FERRER, 1998). However, this experiment concerned collision risks of Great Bustards with distribution lines, and this type of markers may be too small for transmission lines (except for the earth wire). The tags may prove to be more effective than coloured spirals but less durable (BARRIENTOS *ET AL.*, 2011).
In southern Spain, three black stripes of 70 x 0.8 cm hanging on a distribution line did not reduce the mortality of bustards, cranes and lapwings (JANSS & FERRER, 1998).

Cost Diverters - cost and practical information

Spiral: ú150/spiral, including helicopter - ú80/spiral without helicopter costs (KABOUCHE *ET AL.*, 2006). Individual spirals must be placed at an interval of 30 m on the two external wires, in an alternate manner (thus resulting in a visible spiral every 15 m). The total cost could thus amount to ú5,000 to ú8,500/km.
Spirals are available from PLP-APRESA in Spain > http://www.plp-spain.com/en/presentacion.aspx
Bird flappers: information available here > www.rwerheinruhrnetzservice.com
Neopren X-Band: information available here > http://www.saprem.com/emenu.html (this company also provides a robot system to install the device on transmission lines)
Firefly: information available here > http://www.hammarprodukter.com/659.php?itemgroup=107
From the distributor in Belgium (info@foreestgroenconsult.nl), we learned that the cost of a single Firefly is ú28.70 to ú31.30 per piece, depending on the ordered quantity. For materials only, the cost is

thus around ú3,000 to equip one wire with a Firefly every 10 m over a distance of 1 km (this does not take into account the installation cost).

The price of placing a marker will of course depend on several factors, especially the total number of diverters fitted, but apparently, a cost of as low as ú2,500/km can be obtained in some circumstances (PRINSEN *ET AL.*, 2011a). However, Elia has learned that it would cost as much as ú25,000 per line segment to adjust diverters if the line section has to be shut down during installation (J. Mortier, *pers. com.*). On the basis of the available literature, this price seems very high. An investigation is necessary and direct contact with the producer and/or potential installer of diverters by Elia would be welcome to define the exact budget. Also the fact that priority segments are scattered around the country could increase the relative price (because of the need for dispersed interventions).

If we take as ñhigh priorityò a pylon score of above 60 (from Figure **13**), this would cover 1.2% of the total Elia network, so approximately 72 km. Based on an estimated price of ú10,000/km (quite high on the basis of the available literature, but to be checked with the producers), an estimated budget of ú720,000 would be needed to fit the most dangerous power lines in Belgium with diverters.

VIII. Conclusions

We believe that we, through this publication, have provided Elia with an objective and documented basis for decision-making concerning the mitigation of bird collisions with existing power lines.

First, a Belgian list of bird species sensitive to collision was constructed, combining a review of the literature, casualty reports and local expert judgements.

In the second step, using the best available data, high-resolution distribution maps for these sensitive species were obtained. It must be stressed that some of these maps represent a breakthrough: relative density maps for common breeding bird species, using combined data from three different breeding bird atlases and state-of-the-art spatial modelling techniques, were never compiled before for Belgium. This exercise also demonstrates that bird data collected independently in the three regions of this federal country can be combined in a meaningful way to produce nationwide results. It also shows that a data portal like waarnemingen.be/observations.be can really provide a useful, and in some cases even indispensable, data source for such applications as high-resolution mapping.

Finally, these maps were combined, using a scoring system designed to emphasize areas where damage associated with power-line collisions is believed to be most significant. By doing so, power-line sections are classified according to the risk they present for birds. Most of the power lines are not to be considered ñdangerousò for birds, but in some areas the situation is critical, especially close to where major waterbird concentrations occur.

There are several effective technical measures that have been designed to prevent power line collision: diverters can be fitted directly on the line so that the power line is more visible for birds, even in poor light conditions.

Depending on the available budget, diverter placement can now be planned on Belgian power lines, focusing first on the high-priority sections. Of course, other considerations like geographical ñgroupingò of diverter placement in order to reduce cost and opportunities offered by other planned work on specific power-line sections may also influence the final planning that lies now in the hands of Elia.

Annex I. Classification of Belgian birds according to the power-line collision risk

English name	Scientific name	Sensitivity to collision	Conservation relevance
Mute Swan	*Cygnus olor*	2	0
Bewick's Swan	*Cygnus columbianus bewickii*	2	2
Whooper Swan	*Cygnus cygnus*	2	2
Taiga Bean Goose	*Anser fabalis*	2	1
Tundra Bean Goose	*Anser rossicus*	2	2
Pink-footed Goose	*Anser brachyrhynchus*	2	2
White-fronted Goose	*Anser albifrons*	2	2
Lesser White-fronted Goose	*Anser erythropus*	2	1
Greylag Goose	*Anser anser*	2	2
Lesser Snow Goose	*Anser caerulescens*	2	0
Barnacle Goose	*Branta leucopsis*	2	1
Dark-bellied Brent Goose	*Branta bernicla*	2	1
Pale-bellied Brent Goose	*Branta hrota*	2	0
Black Brant	*Branta nigricans*	2	0
Red-breasted Goose	*Branta ruficollis*	2	0
Ruddy Shelduck	*Tadorna ferruginea*	2	0
Common Shelduck	*Tadorna tadorna*	2	2
Eurasian Wigeon	*Anas penelope*	2	2
American Wigeon	*Anas americana*	2	0
Gadwall	*Anas strepera*	2	2
Baikal Teal	*Anas formosa*	2	0
Eurasian Teal	*Anas crecca*	2	2
Green-winged Teal	*Anas carolinensis*	2	0
Mallard	*Anas platyrhynchos*	2	2
Northern Pintail	*Anas acuta*	2	2
Garganey	*Anas querquedula*	2	2
Blue-winged Teal	*Anas discors*	2	0
Northern Shoveler	*Anas clypeata*	2	2
Red-crested Pochard	*Netta rufina*	2	1
Common Pochard	*Aythya ferina*	2	2
Ring-necked Duck	*Aythya collaris*	2	0
Ferruginous Duck	*Aythya nyroca*	2	1
Tufted Duck	*Aythya fuligula*	2	2
Greater Scaup	*Aythya marila*	2	1
Lesser Scaup	*Aythya affinis*	2	0
Common Eider	*Somateria mollissima*	2	0
King Eider	*Somateria spectabilis*	2	0
Long-tailed Duck	*Clangula hyemalis*	2	0
Common Scoter	*Melanitta nigra*	2	0
Surf Scoter	*Melanitta perspicillata*	2	0
Velvet Scoter	*Melanitta fusca*	2	0
Common Goldeneye	*Bucephala clangula*	2	0
Smew	*Mergus albellus*	2	2
Red-breasted Merganser	*Mergus serrator*	2	0
Goosander	*Mergus merganser*	2	2
White-headed Duck	*Oxyura leucocephala*	2	0
Hazel Grouse	*Bonasa bonasia*	2	2
Black Grouse	*Tetrao tetrix*	2	2
Western Capercaillie	*Tetrao urogallus*	2	0
Grey Partridge	*Perdix perdix*	2	2
Common Quail	*Coturnix coturnix*	2	1
Red-throated Diver	*Gavia stellata*	0	1
Black-throated Diver	*Gavia arctica*	0	1
Great Northern Diver	*Gavia immer*	0	0
White-billed Diver	*Gavia adamsii*	0	0
Little Grebe	*Tachybaptus ruficollis*	1	0
Great Crested Grebe	*Podiceps cristatus*	1	0
Red-necked Grebe	*Podiceps grisegena*	1	0
Slavonian Grebe	*Podiceps auritus*	1	0
Black-necked Grebe	*Podiceps nigricollis*	1	1
Northern Fulmar	*Fulmarus glacialis*	0	0
Cory's Shearwater	*Calonectris diomedea*	0	0
Great Shearwater	*Puffinus gravis*	0	0

Sooty Shearwater	*Puffinus griseus*	0	0
Manx Shearwater	*Puffinus puffinus*	0	0
Balearic Shearwater	*Puffinus mauretanicus*	0	0
Little Shearwater	*Puffinus assimilis*	0	0
European Storm-petrel	*Hydrobates pelagicus*	0	0
Leach's Storm-petrel	*Oceanodroma leucorhoa*	0	0
Northern Gannet	*Morus bassanus*	1	0
Great Cormorant	*Phalacrocorax carbo*	2	2
European Shag	*Phalacrocorax aristotelis*	1	0
Pygmy Cormorant	*Phalacrocorax pygmeus*	1	0
Great Bittern	*Botaurus stellaris*	1	2
Little Bittern	*Ixobrychus minutus*	1	2
Black-crowned Night Heron	*Nycticorax nycticorax*	1	1
Squacco Heron	*Ardeola ralloides*	1	0
Cattle Egret	*Bubulcus ibis*	1	1
Little Egret	*Egretta garzetta*	1	1
Great Egret	*Casmerodius albus*	1	1
Grey Heron	*Ardea cinerea*	2	0
Purple Heron	*Ardea purpurea*	1	1
Black Stork	*Ciconia nigra*	2	2
White Stork	*Ciconia ciconia*	2	2
Glossy Ibis	*Plegadis falcinellus*	1	0
Eurasian Spoonbill	*Platalea leucorodia*	1	1
European Honey-buzzard	*Pernis apivorus*	1	2
Black-winged Kite	*Elanus caeruleus*	1	0
Black Kite	*Milvus migrans*	1	2
Red Kite	*Milvus milvus*	1	2
White-tailed Eagle	*Haliaeetus albicilla*	1	0
Egyptian Vulture	*Neophron percnopterus*	1	0
Eurasian Griffon	*Gyps fulvus*	1	0
Short-toed Eagle	*Circaetus gallicus*	1	0
Marsh Harrier	*Circus aeruginosus*	1	2
Hen Harrier	*Circus cyaneus*	1	2
Pallid Harrier	*Circus macrourus*	1	1
Montagu's Harrier	*Circus pygargus*	1	2
Northern Goshawk	*Accipiter gentilis*	1	1
Eurasian Sparrowhawk	*Accipiter nisus*	2	0
Common Buzzard	*Buteo buteo*	2	1
Rough-legged Buzzard	*Buteo lagopus*	1	0
Lesser Spotted Eagle	*Aquila pomarina*	1	0
Greater Spotted Eagle	*Aquila clanga*	1	0
Steppe Eagle	*Aquila nipalensis*	1	0
Golden Eagle	*Aquila chrysaetos*	1	0
Booted Eagle	*Hieraaetus pennatus*	1	0
Bonelli's Eagle	*Hieraaetus fasciatus*	1	0
Osprey	*Pandion haliaetus*	1	1
Lesser Kestrel	*Falco naumanni*	1	0
Common Kestrel	*Falco tinnunculus*	1	1
Red-footed Falcon	*Falco vespertinus*	1	0
European Merlin	*Falco columbarius*	1	1
Eurasian Hobby	*Falco subbuteo*	1	1
Gyrfalcon	*Falco rusticolus*	1	0
Peregrine Falcon	*Falco peregrinus*	1	2
Water Rail	*Rallus aquaticus*	2	2
Spotted Crake	*Porzana porzana*	2	2
Little Crake	*Porzana parva*	2	1
Baillon's Crake	*Porzana pusilla*	2	1
Corn Crake	*Crex crex*	2	2
Common Moorhen	*Gallinula chloropus*	2	1
Common Coot	*Fulica atra atra*	2	1
Common Crane	*Grus grus*	2	2
Little Bustard	*Tetrax tetrax*	2	0
Macqueen's Bustard	*Chlamydotis macqueenii*	2	0
Great Bustard	*Otis tarda*	2	0
Eurasian Oystercatcher	*Haematopus ostralegus*	2	0
Black-winged Stilt	*Himantopus himantopus*	2	1
Pied Avocet	*Recurvirostra avosetta*	2	2
Stone-curlew	*Burhinus oedicnemus*	2	0
Cream-coloured Courser	*Cursorius cursor*	2	0
Collared Pratincole	*Glareola pratincola*	2	0
Black-winged Pratincole	*Glareola nordmanni*	2	0
Little Ringed Plover	*Charadrius dubius*	2	1
Ringed Plover	*Charadrius hiaticula*	2	1
Kentish Plover	*Charadrius alexandrinus*	2	2
Lesser Sand Plover	*Charadrius mongolus*	2	0
Greater Sand Plover	*Charadrius leschenaultii*	2	0

Eurasian Dotterel	*Eudromias morinellus*	2	2
Pacific Golden Plover	*Pluvialis fulva*	2	0
Golden Plover	*Pluvialis apricaria*	2	2
Grey Plover	*Pluvialis squatarola*	2	0
Sociable Lapwing	*Vanellus gregarius*	2	0
White-tailed Lapwing	*Vanellus leucurus*	2	0
Northern Lapwing	*Vanellus vanellus*	2	2
Red Knot	*Calidris canutus*	2	0
Sanderling	*Calidris alba*	2	0
Red-necked Stint	*Calidris ruficollis*	2	0
Little Stint	*Calidris minuta*	2	0
Temminck's Stint	*Calidris temminckii*	2	0
Least Sandpiper	*Calidris minutilla*	2	0
Bonaparte's Sandpiper	*Calidris fuscicollis*	2	0
Baird's Sandpiper	*Calidris bairdii*	2	0
Pectoral Sandpiper	*Calidris melanotos*	2	0
Sharp-tailed Sandpiper	*Calidris acuminata*	2	0
Curlew Sandpiper	*Calidris ferruginea*	2	0
Purple Sandpiper	*Calidris maritima*	2	0
Dunlin	*Calidris alpina*	2	0
Broad-billed Sandpiper	*Limicola falcinellus*	2	0
Buff-breasted Sandpiper	*Tryngites subruficollis*	2	0
Ruff	*Philomachus pugnax*	2	0
Jack Snipe	*Lymnocryptes minimus*	2	1
Common Snipe	*Gallinago gallinago*	2	2
Great Snipe	*Gallinago media*	2	0
Long-billed Dowitcher	*Limnodromus scolopaceus*	2	0
Eurasian Woodcock	*Scolopax rusticola*	2	1
Black-tailed Godwit	*Limosa limosa*	2	2
Bar-tailed Godwit	*Limosa lapponica*	2	0
Whimbrel	*Numenius phaeopus*	2	0
Slender-billed Curlew	*Numenius tenuirostris*	2	0
Eurasian Curlew	*Numenius arquata*	2	2
Spotted Redshank	*Tringa erythropus*	2	0
Common Redshank	*Tringa totanus*	2	2
Marsh Sandpiper	*Tringa stagnatilis*	2	0
Common Greenshank	*Tringa nebularia*	2	0
Greater Yellowlegs	*Tringa melanoleuca*	2	0
Lesser Yellowlegs	*Tringa flavipes*	2	0
Green Sandpiper	*Tringa ochropus*	2	0
Wood Sandpiper	*Tringa glareola*	2	0
Terek Sandpiper	*Xenus cinereus*	2	0
Common Sandpiper	*Actitis hypoleucos*	2	0
Spotted Sandpiper	*Actitis macularius*	2	0
Ruddy Turnstone	*Arenaria interpres*	2	0
Wilson's Phalarope	*Phalaropus tricolor*	2	0
Red-necked Phalarope	*Phalaropus lobatus*	2	0
Red Phalarope	*Phalaropus fulicarius*	2	0
Pomarine Skua	*Stercorarius pomarinus*	1	0
Arctic Skua	*Stercorarius parasiticus*	1	0
Long-tailed Skua	*Stercorarius longicaudus*	1	0
Great Skua	*Stercorarius skua*	1	0
Great Black-headed Gull	*Larus ichtyaetus*	2	0
Mediterranean Gull	*Larus melanocephalus*	2	2
Laughing Gull	*Larus atricilla*	2	0
Franklin's Gull	*Larus pipixcan*	2	0
Little Gull	*Larus minutus*	2	0
Sabine's Gull	*Larus sabini*	2	0
Bonaparte's Gull	*Larus philadelphia*	2	0
Black-headed Gull	*Larus ridibundus*	2	2
Ring-billed Gull	*Larus delawarensis*	2	0
Common Gull	*Larus canus*	2	2
Lesser Black-backed Gull	*Larus fuscus*	2	2
Herring Gull	*Larus argentatus*	2	2
Caspian Gull	*Larus cachinnans*	2	0
Yellow-legged Gull	*Larus michahellis*	2	0
Iceland Gull	*Larus glaucoides*	2	0
Glaucous Gull	*Larus hyperboreus*	2	0
Great Black-backed Gull	*Larus marinus*	2	0
Black-legged Kittiwake	*Rissa tridactyla*	2	0
Gull-billed Tern	*Sterna nilotica*	1	0
Caspian Tern	*Sterna caspia*	1	0
Sandwich Tern	*Sterna sandvicensis*	1	2
Roseate Tern	*Sterna dougallii*	1	0
Common Tern	*Sterna hirundo*	1	2
Arctic Tern	*Sterna paradisaea*	1	1

Forster's Tern	*Sterna forsteri*	1	0
Bridled Tern	*Sterna anaethetus*	1	0
Little Tern	*Sterna albifrons*	1	2
Whiskered Tern	*Chlidonias hybrida*	1	0
Black Tern	*Chlidonias niger*	1	1
White-winged Black Tern	*Chlidonias leucopterus*	1	0
Common Guillemot	*Uria aalge*	0	0
Brünnich's Guillemot	*Uria lomvia*	0	0
Razorbill	*Alca torda*	0	0
Black Guillemot	*Cepphus grylle*	0	0
Little Auk	*Alle alle*	0	0
Atlantic Puffin	*Fratercula arctica*	0	0
Black-bellied Sandgrouse	*Pterocles orientalis*	1	0
Pallas's sandgrouse	*Syrrhaptes paradoxus*	1	0
Stock Dove	*Columba oenas*	2	1
Common Wood Pigeon	*Columba palumbus*	2	1
Eurasian Collared Dove	*Streptopelia decaocto*	2	0
European Turtle Dove	*Streptopelia turtur*	2	2
Great Spotted Cuckoo	*Clamator glandarius*	2	0
Common Cuckoo	*Cuculus canorus*	1	2
Yellow-billed Cuckoo	*Coccyzus americanus*	2	0
Western Barn Owl	*Tyto alba*	2	2
Eurasian Scops Owl	*Otus scops*	2	0
Eurasian Eagle Owl	*Bubo bubo*	2	2
Snowy Owl	*Bubo scandiacus*	2	0
Hawk Owl	*Surnia ulula*	2	0
Eurasian Pygmy Owl	*Glaucidium passerinum*	2	0
Little Owl	*Athene noctua*	2	1
Tawny Owl	*Strix aluco*	2	1
Long-eared Owl	*Asio otus*	2	1
Short-eared Owl	*Asio flammeus*	2	1
Tengmalm's Owl	*Aegolius funereus*	2	2
European Nightjar	*Caprimulgus europaeus*	2	2
Common Swift	*Apus apus*	2	1
Pallid Swift	*Apus pallidus*	2	0
Alpine Swift	*Apus melba*	2	0
Common Kingfisher	*Alcedo atthis*	2	2
European Bee-eater	*Merops apiaster*	2	0
European Roller	*Coracias garrulus*	2	0
Eurasian Hoopoe	*Upupa epops*	2	0
Eurasian Wryneck	*Jynx torquilla*	2	2
Grey-headed Woodpecker	*Picus canus*	2	2
Green Woodpecker	*Picus viridis*	2	2
Black Woodpecker	*Dryocopus martius*	2	2
Great Spotted Woodpecker	*Dendrocopos major*	2	0
Middle Spotted Woodpecker	*Dendrocopos medius*	2	2
White-backed Woodpecker	*Dendrocopos leucotos*	2	0
Lesser Spotted Woodpecker	*Dendrocopos minor*	2	1
Calandra Lark	*Melanocorypha calandra*	1	0
Greater Short-toed Lark	*Calandrella brachydactyla*	1	0
Lesser Short-toed Lark	*Calandrella rufescens*	1	0
Crested Lark	*Galerida cristata*	1	2
Wood Lark	*Lullula arborea*	1	2
Sky Lark	*Alauda arvensis*	1	2
Horned Lark	*Eremophila alpestris*	1	0
Sand Martin	*Riparia riparia*	1	1
Eurasian Crag Martin	*Ptyonoprogne rupestris*	1	0
Barn Swallow	*Hirundo rustica*	1	0
Red-rumped Swallow	*Hirundo daurica*	1	0
House Martin	*Delichon urbicum*	1	2
Richard's Pipit	*Anthus richardi*	1	0
Blyth's Pipit	*Anthus godlewskii*	1	0
Tawny Pipit	*Anthus campestris*	1	1
Olive-backed Pipit	*Anthus hodgsoni*	1	0
Tree Pipit	*Anthus trivialis*	1	2
Meadow Pipit	*Anthus pratensis*	1	2
Red-throated Pipit	*Anthus cervinus*	1	0
Water Pipit	*Anthus spinoletta*	1	0
Rock Pipit	*Anthus petrosus*	1	0
Blue-headed Wagtail	*Motacilla flava*	1	1
Grey-headed Wagtail	*Motacilla flava thunbergi*	1	0
Black-headed Wagtail	*Motacilla flava feldegg*	1	0
British Yellow Wagtail	*Motacilla flavissima*	1	0
Citrine Wagtail	*Motacilla citreola*	1	0
Grey Wagtail	*Motacilla cinerea*	1	0
White Wagtail	*Motacilla alba*	1	0

Pied Wagtail	*Motacilla yarrellii*	1	0
Bohemian Waxwing	*Bombycilla garrulus*	1	0
Dipper	*Cinclus cinclus*	1	0
Winter Wren	*Troglodytes troglodytes*	1	0
Dunnock	*Prunella modularis*	1	0
Alpine Accentor	*Prunella collaris*	1	0
European Robin	*Erithacus rubecula*	1	0
Thrush Nightingale	*Luscinia luscinia*	1	0
Common Nightingale	*Luscinia megarhynchos*	1	2
Bluethroat	*Luscinia svecica*	1	0
Red-flanked Bluetail	*Tarsiger cyanurus*	1	0
Black Redstart	*Phoenicurus ochruros*	1	0
Common Redstart	*Phoenicurus phoenicurus*	1	2
Whinchat	*Saxicola rubetra*	1	2
Stonechat	*Saxicola torquatus*	1	0
Siberian Stonechat	*Saxicola maurus*	1	0
Isabelline Wheatear	*Oenanthe isabellina*	1	0
Northern Wheatear	*Oenanthe oenanthe*	1	2
Black-eared Wheatear	*Oenanthe hispanica*	1	0
Desert Wheatear	*Oenanthe deserti*	1	0
Rufous-tailed Rock Thrush	*Monticola saxatilis*	1	0
Blue Rock Thrush	*Monticola solitarius*	1	0
White's Thrush	*Zoothera dauma*	1	0
Siberian Thrush	*Zoothera sibirica*	1	0
Swainson's Thrush	*Catharus ustulatus*	1	0
Scandinavian Ring Ouzel	*Turdus torquatus torquatus*	1	0
Alpine Ring Ouzel	*Turdus torquatus alpestris*	1	2
Common Blackbird	*Turdus merula*	1	0
Eyebrowed Thrush	*Turdus obscurus*	1	0
Naumann's Thrush	*Turdus naumanni*	1	0
Dusky Thrush	*Turdus eunomus*	1	0
Black-throated Thrush	*Turdus atrogularis*	1	0
Fieldfare	*Turdus pilaris*	1	2
Song Thrush	*Turdus philomelos*	1	0
Redwing	*Turdus iliacus*	1	0
Mistle Thrush	*Turdus viscivorus*	1	0
American Robin	*Turdus migratorius*	1	0
Cetti's Warbler	*Cettia cetti*	1	1
Zitting Cisticola	*Cisticola juncidis*	1	1
Pallas's Grasshopper Warbler	*Locustella certhiola*	1	0
Lanceolated Warbler	*Locustella lanceolata*	1	0
Grasshopper Warbler	*Locustella naevia*	1	1
River Warbler	*Locustella fluviatilis*	1	0
Savi's Warbler	*Locustella luscinioides*	1	2
Aquatic Warbler	*Acrocephalus paludicola*	1	2
Sedge Warbler	*Acrocephalus schoenobaenus*	1	2
Eurasian Reed Warbler	*Acrocephalus scirpaceus*	1	0
Marsh Warbler	*Acrocephalus palustris*	1	0
Blyth's Reed Warbler	*Acrocephalus dumetorum*	1	0
Paddyfield Warbler	*Acrocephalus agricola*	1	0
Great Reed Warbler	*Acrocephalus arundinaceus*	1	2
Booted Warbler	*Hippolais caligata*	1	0
Icterine Warbler	*Hippolais icterina*	1	1
Melodious Warbler	*Hippolais polyglotta*	1	0
Blackcap	*Sylvia atricapilla*	1	0
Garden Warbler	*Sylvia borin*	1	0
Barred Warbler	*Sylvia nisoria*	1	0
Lesser Whitethroat	*Sylvia curruca*	1	1
Orphean Warbler	*Sylvia hortensis*	1	0
Common Whitethroat	*Sylvia communis*	1	0
Spectacled Warbler	*Sylvia conspicillata*	1	0
Dartford Warbler	*Sylvia undata*	1	0
Marmora's Warbler	*Sylvia sarda*	1	0
Subalpine Warbler	*Sylvia cantillans*	1	0
Sardinian Warbler	*Sylvia melanocephala*	1	0
Greenish Warbler	*Phylloscopus trochiloides*	1	0
Arctic Warbler	*Phylloscopus borealis*	1	0
Pallas's Warbler	*Phylloscopus proregulus*	1	0
Yellow-browed Warbler	*Phylloscopus inornatus*	1	0
Hume's Warbler	*Phylloscopus humei*	1	0
Radde's Warbler	*Phylloscopus schwarzi*	1	0
Dusky Warbler	*Phylloscopus fuscatus*	1	0
Bonelli's Warbler	*Phylloscopus bonelli*	1	0
Wood Warbler	*Phylloscopus sibilatrix*	1	0

Chiffchaff	*Phylloscopus collybita*	1	0
Iberian Chiffchaff	*Phylloscopus ibericus*	1	0
Willow Warbler	*Phylloscopus trochilus*	1	0
Goldcrest	*Regulus regulus*	1	0
Firecrest	*Regulus ignicapilla*	1	0
Spotted Flycatcher	*Muscicapa striata*	1	0
Red-breasted Flycatcher	*Ficedula parva*	1	0
Collared Flycatcher	*Ficedula albicollis*	1	0
Pied Flycatcher	*Ficedula hypoleuca*	1	0
Bearded Tit	*Panurus biarmicus*	1	1
Long-tailed Tit	*Aegithalos caudatus*	1	0
Marsh Tit	*Parus palustris*	1	0
Willow Tit	*Parus montanus*	1	2
Crested Tit	*Parus cristatus*	1	0
Coal Tit	*Parus ater*	1	0
Blue Tit	*Parus caeruleus*	1	0
Great Tit	*Parus major*	1	0
Wood Nuthatch	*Sitta europaea*	1	0
Wallcreeper	*Tichodroma muraria*	1	0
Treecreeper	*Certhia familiaris*	1	0
Short-toed Treecreeper	*Certhia brachydactyla*	1	0
Penduline Tit	*Remiz pendulinus*	1	1
Golden Oriole	*Oriolus oriolus*	1	2
Isabelline Shrike	*Lanius isabellinus*	1	0
Red-backed Shrike	*Lanius collurio*	1	2
Lesser Grey Shrike	*Lanius minor*	1	0
Great Grey Shrike	*Lanius excubitor*	1	2
Woodchat Shrike	*Lanius senator*	1	0
Eurasian Jay	*Garrulus glandarius*	1	0
Magpie	*Pica pica*	1	0
Spotted Nutcracker	*Nucifraga caryocatactes*	1	1
Jackdaw	*Corvus monedula*	2	0
Rook	*Corvus frugilegus*	1	0
Carrion Crow	*Corvus corone*	1	0
Hooded Crow	*Corvus cornix*	1	0
Common Raven	*Corvus corax*	1	2
Common Starling	*Sturnus vulgaris*	2	0
Rose-coloured Starling	*Sturnus roseus*	2	0
House Sparrow	*Passer domesticus*	1	0
Tree Sparrow	*Passer montanus*	1	1
Rock Sparrow	*Petronia petronia*	1	0
White-winged Snowfinch	*Montifringilla nivalis*	1	0
Red-eyed Vireo	*Vireo olivaceus*	1	0
Chaffinch	*Fringilla coelebs*	1	0
Brambling	*Fringilla montifringilla*	1	0
European Serin	*Serinus serinus*	1	2
Citril Finch	*Serinus citrinella*	1	0
European Greenfinch	*Carduelis chloris*	1	0
Goldfinch	*Carduelis carduelis*	1	0
Eurasian Siskin	*Carduelis spinus*	1	0
Common Linnet	*Carduelis cannabina*	1	0
Twite	*Carduelis flavirostris*	1	0
Mealy Redpoll	*Carduelis flammea*	1	0
Lesser Redpoll	*Carduelis cabaret*	1	2
Arctic Redpoll	*Carduelis hornemanni*	1	0
Two-barred Crossbill	*Loxia leucoptera*	1	0
Common Crossbill	*Loxia curvirostra*	1	0
Parrot Crossbill	*Loxia pytyopsittacus*	1	0
Common Rosefinch	*Carpodacus erythrinus*	1	0
Bullfinch	*Pyrrhula pyrrhula*	1	2
Hawfinch	*Coccothraustes coccothraustes*	1	0
Lapland Bunting	*Calcarius lapponicus*	1	0
Snow Bunting	*Plectrophenax nivalis*	1	0
Pine Bunting	*Emberiza leucocephalos*	1	0
Yellowhammer	*Emberiza citrinella*	1	2
Cirl Bunting	*Emberiza cirlus*	1	0
Rock Bunting	*Emberiza cia*	1	0
Ortolan Bunting	*Emberiza hortulana*	1	1
Yellow-browed Bunting	*Emberiza chrysophrys*	1	0
Rustic Bunting	*Emberiza rustica*	1	0
Little Bunting	*Emberiza pusilla*	1	0
Yellow-breasted Bunting	*Emberiza aureola*	1	0
Reed Bunting	*Emberiza schoeniclus*	1	2
Corn Bunting	*Emberiza calandra*	1	2

Annex II: Collision victims brought into a recovery centre

Data from Vogelbescherming (1990-2010) and the Ligue Royale Belge pour la Protection des Oiseaux (1990-2000).

Dutch Name	Scientific Name	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
Aalscholver	*Phalacrocorax carbo*	1	1	1				1				4				1		2	3		1	2	17
Bergeend	*Tadorna tadorna*															1							1
Blauwe Kiekendief	*Circus cyaneus*		1																	1			2
Blauwe Reiger	*Ardea cinerea*	9	5	9	7	5	5	4	12	3	7	5	6	2	8	12	10	6	8	12	10	4	149
Boerenzwaluw	*Hirundo rustica*																	2		1		1	4
Bokje	*Lymnocryptes minimus*	1																					1
Boomklever	*Sitta europaea*	1																				1	2
Boomvalk	*Falco subbuteo*	1	1					1		1	1							1					6
Bosuil	*Strix aluco*	1		1							1			1	1			8	2	4	6	2	27
Brandgans	*Branta Leucopsis*				1			1	1				1					1		2	1		8
Buizerd	*Buteo buteo*	4	1	5	3	6	1	3	2		5	1	4	1	4	3	2	4	2	1	4	4	60
Canadese Gans	*Branta canadensis*	1							3	1	1	2	1		4	3		1		3	4	2	26
Ekster	*Pica pica*						1				1		1	2			1			2		1	9
Fazant	*Phasianus colchicus*			1			1	1										1	1		2	2	9
Fuut	*Podiceps cristatus*			2						1		1				1	1		1	1	1		9
Gaai	*Garrulus glandarius*									1					1				1		1		4
Geoorde Fuut	*Podiceps nigricollis*								1														1
Gierzwaluw	*Apus apus*		1	3	6	1	4	7	3	3		1						3	2			1	35
Grauwe Gans	*Anser anser*	1										1					3		1			5	11
Groene Specht	*Picus viridis*						1					1	1	2	4	1				4		1	15
Groenling	*Chloris chloris*																	1					1
Grote Bonte Specht	*Dendrocopos major*																		2		2	2	6
Grote Burgemeester	*Larus hyperboreus*					1																	1
Grote Lijster	*Turdus viscivorus*			1									1										2
Grote Mantelmeeuw	*Larus marinus*	1									1		1					1			2		6
Grutto	*Limosa limosa*											1											1
Havik	*Accipiter gentilis*							1									2		1			2	6
Holenduif	*Columba oenas*					1		1	1													1	4
Houtduif	*Columba palumbus*	3	5	2	2		3	4	3	3	1	4	3	1	11	8	3	15	9	10	12	7	109
Houtsnip	*Scolopax rusticola*					2				11		3					3		1	2	26	3	51
Huismus	*Passer domesticus*															2				1	4	2	9
Huiszwaluw	*Delichon urbicon*					1												2					3
Kauw	*Corvus monedula*								1		1		3	2		2		4	3	3	2	2	23
Kerkuil	*Tyto alba*	2	3		1	2	1			2				1				6	3	1	4	1	27
Kievit	*Vanellus vanellus*	2	2		1				1	1		2	1				1					1	12
Kleine Mantelmeeuw	*Larus fuscus*	1												1					2	1	1	2	8
Kleine Zwaan	*Cygnus columbianus*	1																			1		2
Knobbelzwaan	*Cygnus olor*		1					3	4	3	1	3	1	2		2	2	2	6	3	8	1	42
Koekoek	*Cuculus canorus*																		1			1	2
Kokmeeuw	*Chroicocephalus ridibundus*	20	7	6	8	11	8	3	2	6	8	4	6	9	1	3	4	4	6	3	5	5	129
Kolgans	*Anser albifrons*																				1		1
Koolmees	*Parus major*												1						1			2	4
Kraai	*Corvus corone*	1		1			2	1	2								1	2		1	2		13
Kraanvogel	*Grus grus*									1													1
Lepelaar	*Platalea leucorodia*																		1				1
Meerkoet	*Fulica atra*															1		1					2
Merel	*Turdus merula*			1			1		1						1	3	2	5	4	1	6	7	32
Morinelplevier	*Charadrius morinellus*	1																					1
Nijlgans	*Alopochen aegyptiaca*														1	1	1	1			1		5
Oehoe	*Bubo bubo*	1		1		1	1				1												5
Ooievaar	*Ciconia ciconia*	4	1	1			1									2							9
Patrijs	*Perdix perdix*							1															1
Purperreiger	*Ardea purpurea*									1									1				2
Pijlstaart	*Anas acuta*	1																					1
Raaf	*Corvus corax*													1									1
Ransuil	*Asio otus*				1		3	1								1							6
Regenwulp	*Numenius phaeopus*							1			2	2				1					1		7
Rietgans	*Anser fabalis*																				1		1
Roek	*Corvus frugilegus*													1									1
Roerdomp	*Botaurus stellaris*												1							1	2		4
Roodborst	*Erithacus rubecula*	1																2			2		5
Scholekster	*Haematopus ostralegus*			1							1												2
Slechtvalk	*Falco peregrinus*										2		1			1				1		1	6
Smelleken	*Falco columbarius*			1																			1
Sperwer	*Accipiter nisus*		1	1		1	2		1	1	14	1		1	1	4	1	3	1	4	5	14	56
Spreeuw	*Sturnus vulgaris*			1													1	2		2	1	2	9

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