WWF Greece
Dadia Project

Technical Report
Impact of Wind Farms on Birds in Thrace, Greece.

Dadia 2005

WWF World Wide Fund for Nature

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Involved people

Carlos Ruiz. General coordination of the study, design of the methodology, analyzing of data, writing of the Technical Report, field work, import of observation in the ACCESS and in the GIS, planning and structuring of databases

Kostas Poirazidis. Design of the methodology, reviewing and supervising of the Technical Report

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Introduction

According to the European policy, wind farms are a promising alternative energy source. The wind farms can be considered as "green" energy but in some cases, especially in areas where protected species of fauna occur, some problems can arise. In the last years an increasing number of wind farms have been constructed in the Rodopi and Evros prefecture, near Dadia National Park (DNP), Greece, where the last breeding colony of the former widespread Black Vulture (*Aegypius monachus*) in the Balkans is located (Poirazidis et al. 2002)

It is believed that wind farms are less dangerous to birds than other kind of energy industrial structures, like the power lines (Nelson & Curry 1995; Osborn et al 1998). Nevertheless the number of studies is limited and each wind farm has particular situation concerning the design and the environmental conditions.

Different factors has been pointed as risk factor on the impact of the wind farms on birds, like length of the rows of turbines, space between consecutive turbines, frequencies at which soaring birds fly close to rotating blades, seasonal variations in the behavior of the birds (Barrios & Rodriguez 2004) and visibility conditions (Winkelman 1985)

A study about the impact of the wind farms on the avian community in Thrace was implemented aiming to determine the main risk factors for these wind farms, the species affected and the possible measurements to reduce those impacts.

Objective

The main aim of this study was to determine the impacts of this wind farms on the bird populations, focused in:

The death of birds through collision with the turbines
The evaluation of risky behaviour and risk factors
The changes in the habitat use and evaluation of habitat loss due to the wind farms.
Propose measurements to reduce the impacts

Study area

The area was located in the northeastern Greece, between the limit of the Rodopi and Evros prefectures. (Fig 1)

2004. Two wind farms were monitored. One of them (hereafter "Small wind farm") was located at E 663637, N 4549550 (EGSA 87) on a ridge of 750 m altitude, and consisted of a row of 13 windmills, that extent along 2200 meters and the other (hereafter "Large wind farm") was located northern from the previous one, at E 655800, N 4557615. It was constructed in three different ridges of around 950 m altitude, and consisted of 4 rows of windmills with a total amount of 60 turbines, extending over 12 kilometers along the top of these ridges (Fig 2). An additional row of 3 turbines in this wind farm was constructed during spring and summer 2004.

These wind farms were located at the West of DNP, at 6.5 km (Small wind farm) and 15 km (Large wind farm) of distance from the westernmost limit of the park.(Fig 1).

2005. Five wind farms were monitored; large and small wind farm were again monitored, while the three new wind farms were surveyed. "Sapka" located at E 662500, N 4558950, composed by 5 turbines disposed in two short rows with a common turbine (Fig 3), "Birsini", located at E 657220, N 4574130 and composed by a single row of 31 turbines and "BLS" located at E 660000, N 4557500, and composed by a row of 8 turbines.

Figure 1. General situation of the area and location of the monitored wind farms.

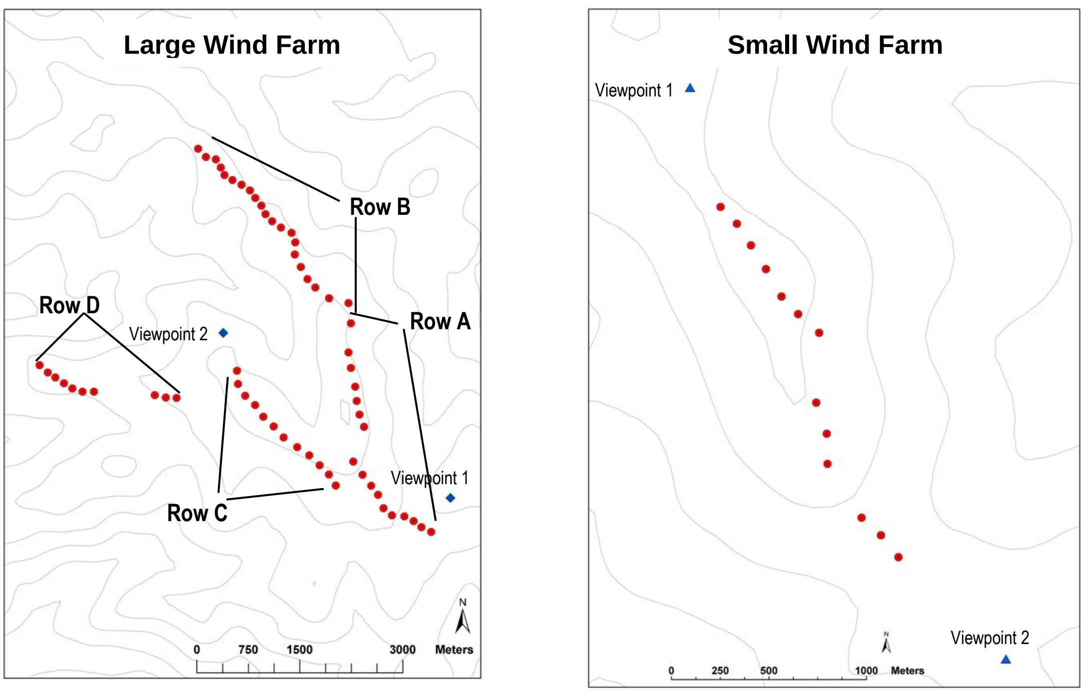

Figure 2. Distribution of the turbines in the two wind farms monitored in 2004.

Figure 3. Distribution of the turbines in Sapka wind farm, monitored in 2005.

Methodology

Three different monitoring were implemented, with the purpose of clarifying different kinds of impact:

<u>Monitoring of the collision episodes</u>

<u>Estimation of numbers and locations of the territories of the local raptor community.</u>

<u>Monitoring of the bird behavior in the risk area close to the wind farms</u>

The data presented for this report were collected between 17^{th} of March 2004 and 6^{th} of December 2005.

The study was divided in two different periods: First period hereafter **2004**, second period, hereafter **2005**.

2004 was implemented from 17^{th} of March 2004 until 16^{th} of March 2005

2005 was implemented from 16^{th} of March 2005 until 6^{th} of December 2005

Monitoring of the collision episodes

The aim of this monitoring was to determine the amount of birds that are dying because of crashing into the windmills. It aims to evaluate the species that are affected, and to uncover in which parts of the wind farms and under which meteorological conditions these episodes occur.

The monitoring was based on searching activities. The searching was developed by teams of 2, 3 or 4 persons that walk along the line of windmills, covering a band of 50 meters at each side of the row. The persons covered smaller bands, walking parallel to each other in zigzags. Thus, the entire range was covered (Fig 4). For each windmill, a total time of 30 min approximately was spent (for instance 3 persons 10 min each). During the searching, walking slowly, the observers looked for dead birds and other evidences of crashes (feathers, etc.).

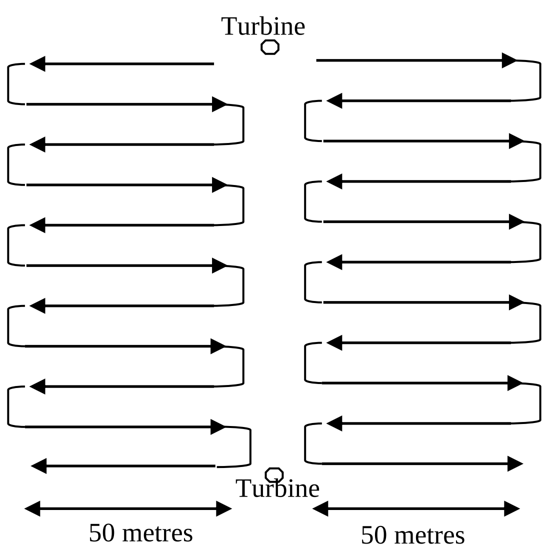

Figure 4. Zig-zag walking to search in the wind farms.

2004. A section of 8 turbines was repeatedly monitored in the Small wind farm, while a section of 9 turbines was controlled in the Large wind farm. The searching was realized only in these certain parts of the wind farms, because the other parts were full of bushes and it would have been very difficult to detect any carcass. However, collected data can then be used in a second step to roughly estimate the impact of the entire wind farm.

2005. The monitor of the collision episodes was done in 5 different wind farms. All the five wind farms of the study area were monitored during 2005. The section to search each day were selected in a conditioned random way, focused to search all wind farms and turbines but not to repeat before completing all of them.

Estimation of the numbers and positions of the territories of the local raptor community

2004. Number and position of the territories of the local raptors are evaluated applying the approach of the Systematic Raptor Monitoring in the Dadia National Park (e.g. Schindler et al. 2005). Data were collected at the same time as for the Monitoring of the behavior of the birds near the turbines (see next).

2005. No territory estimation was done during this second period.

Monitoring of the behavior of the birds near the wind farms

Low mortality but also low encounter rates were expected, complicating the evaluation of the conditions that lead to collisions of birds. Thus, it was important to obtain field data about the movements of the birds close to the turbines, which could be related with the collision events. These data provided important information about the dangerous areas, the preferences of the birds when they ought to cross the rows, and also possible positive factors detected in the design of the wind farm, which could be recommended for future actions.

The monitoring was based on observation activities from view points close to the windmills that were selected using the following criteria:

1) the point ensured the best and widest view of the controlled turbines and the neighboring hillsides in order to permit the detection (with binoculars) of all the raptors flying close to these turbines and in the neighboring area,
2) the total area surveyed from all observation points included different position of turbines in respect to their location in the row.
3) the access time to the observation point from the nearest road should be short.

The species included in the monitoring are the birds of prey (*Falconiformes*), and the Black Stork (*Ciconia nigra*). Censuses from fixed view points offer great potential for the detection of raptors in a radius of 1 - 1.5 km around the observation point. The view points in each wind farm were visited both at the same time once per week and the time spent at the view points was approximately four hours per day. During the whole sampling time the selected windmills were scanned with binoculars.

2004. In the Small wind farm all the 13 turbines were controlled, while in the Large wind farm, 45 out of the 60 turbines were controlled.

2005. All the 5 turbines from Sapka wind farm were controlled

In order to evaluate the movements of the birds close to the turbines and the risk associates with these flights, in each flight of the raptor, we identified:

1) The species.
2) The flight was drawn onto a map and
3) The observer decided if the bird is affected or could be affected by the windmills according to its distance to the windmills and to its behavior of the bird.

For birds affected by the windmills, we determined:

1) The closest turbine
2) Whether the bird crosses the row of windmills
3) The distance and height related with the turbine
4) The possible reaction with the turbine, and
5) The clouds coverage and the wind direction immediately after the observation.

Results

Searching monitoring

2004. We visited the Small wind farms during 21 days and the Large wind farm during 25 days. A total of 167 hours and 30 minutes was spent searching for carcasses between the turbines in both wind farms (Table 1).

Table 1. Duration of the searching monitoring per wind farm from *24-03-2004* until *16-03-2005*

	Large wind farm	**Small wind farm**	**SUM**
Searching time (hours : minutes)	80:08	87:22	167:30

No dead bird was found in the Small wind farm. In the Large wind farm, two birds were found dead due to collision with the turbines. One was a Hoopoe (*Upupa epops)* and the second event was a Little owl *(Athene noctua)* where only some feathers were found (6 primaries from the right wing) bitten by a mammal, probably a Fox (*Vulpes vulpes*). The most reasonable explanation is that the bird crashed against the turbines and then it was eaten by the mammal.

2005. We visited the five monitored find farms wind farm during 17 days, spending an amount of 60 hours.

Table 2. Duration of the searching monitoring from *23-03-2004* until *6-12-2005*

	The 5 wind farms
Searching time (hours : minutes)	60:35

We have detected the following events of collisions:

In Birsini wind farm one individual of Housemartin (*Delichon urbica*) was found. Also one bat of the species *Miniopterus* s*chreiberii* was found, both of them in the same day (23-8-2005) . The 2 individuals found in this wind farm were close to the turbine 6 and 17.

In Sapka wind farm four individuals of Housemartin were found between the 4-8-2005 and the 16-8-2005. Also in Sapka wind farm one individual of the bat species *Pipistrellus nathusii* was found on the 13-6-2005.

All the individuals of Housmartin were found within a period 19 days, between the 4-8-2005 and the 23-8-2005. Probably they were migrating birds. From the 5 individuals found in Sapka wind farm, 3 of them were close to the turbine number 2 while the other 2 were close to the turbine 1.

Estimation of numbers and position of the territories of the local raptor community and the Black stork

2004. During the monitoring for the estimation of the territories, 377 hours and 55 minutes were spent in the two wind farms. This time was shared nearly equally in the four view points.

Table 3. Duration of the behavior monitoring per wind farm and view point during the 2004.

	Large wind farm			**Small wind farm**			**SUM**
Sampling site	VP 1	VP 2	Total	VP 1	VP 2	Total	Both wind farms
Monitoring time (hours: minutes)	91:58	82:19	174:17	103:59	99:39	203:38	377:55

In this time 723 individuals of 16 species were observed. Territories of 7 species were located in the areas close to the wind farm. The most common species observed was the Common Buzzard, which was also the species with the highest number of territories.

Territories of four species were located in the Small wind farm, while territories of 6 species were located in the Large wind farm

Table 4. Number of territories localized in both wind farms per species.

Species	Large wind farm	Small wind farm
Black Store *(Ciconia nigra)*	**1**	**-**
Golden Eagle *(Aquila chrysaetos)*	**-**	**1**
Short Toed Eagle *(Circaetus gallicus)*	**1**	**-**
Common Buzzard *(Buteo buteo)*	**6**	**3**
Sparrowkawk *(Accipiter nisus)*	**1**	**1**
Goshawk *(Accipiter gentiles)*	**1**	**-**
Kestrel *(Falco tinnunculus)*	**1**	**2**

In the Small wind farm, two of the territories of the Common Buzzard were located in the north part of the wind farm, while the other one was in the south. The territory of the golden eagle was much bigger that in the map, the area represented is only a part of the territory of this species. (Fig 5)

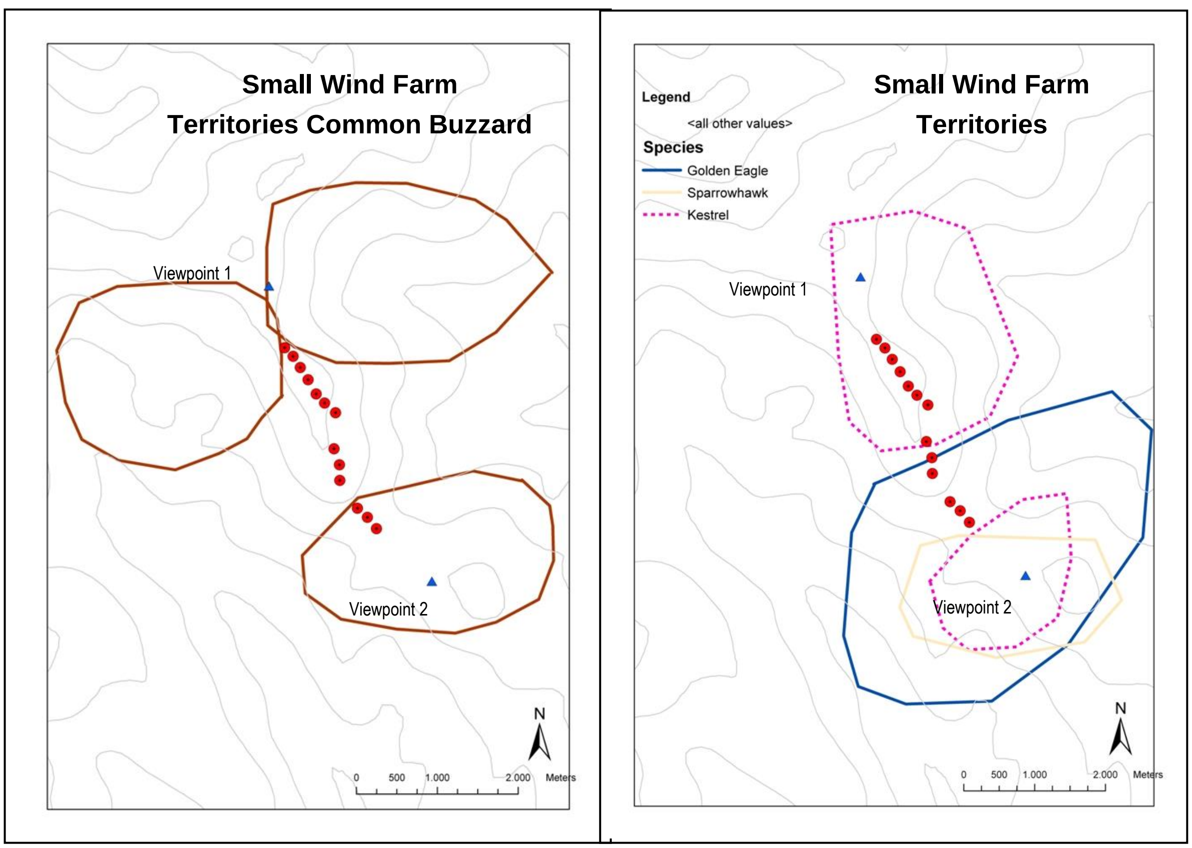

Figure 5. Location of the territories. Common Buzzard (left) and Golden Eagle, Sparrowhawk and Kestrel (right)

In the Large wind farm six territories of Common Buzzard were found. The territory of the Short Toed Eagle and of the Blak Stork were considered, even if it is a little further form the wind farm than the others. (Fig 6)

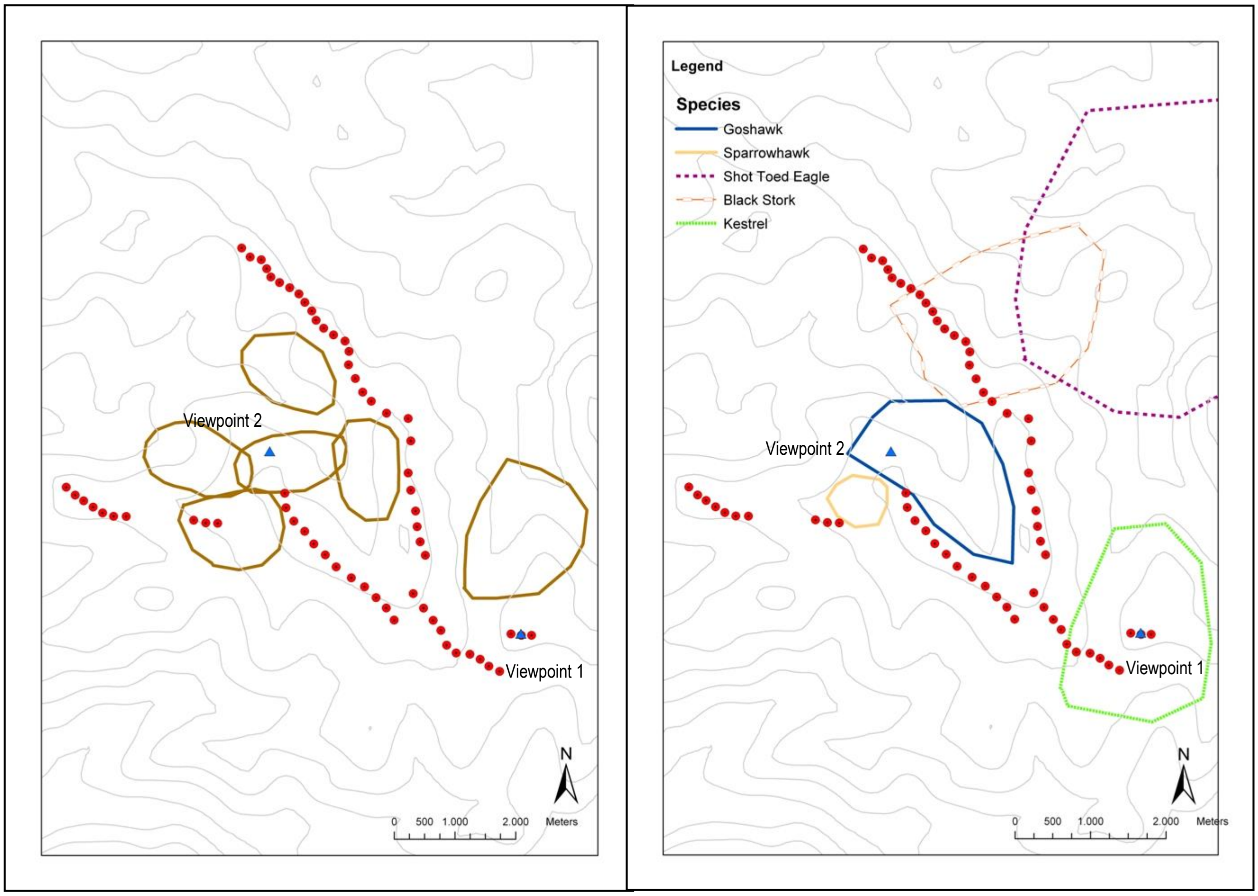

Figure 6. Location of the territories. Common Buzzard (left) and Golden Eagle, Sparrowhawk and Kestrel (right)

Apart of the species with territories in the area covered from the view points, another 9 species have been observed in the area.

This is the case of the Black Vulture, which is nesting in the DNP at a distance between 10 and 25 kilometers. Other species were observed in migratory flights, like Harriers (*Circus sp*), Egyptian Vulture (*Neophron percnopterus*), or during pre-breeding movements like the Eleonor's Falcon (*Falco eleonorae*).

Table 5. Number of observation for the species without territories in the area close to the wind farms.

Species	**N of observations**
Gyps fulvus	**61**
Aegypius monachus	**87**
Neophron percnopterus	**4**
Hieraaetus pennatus	**5**
Circus sp	**1**
Pernis apivorus	**24**
Falco subbuteo	**1**
Falco eleonorae	**1**
Falco peregrinus	**1**

Behavior monitoring

2004. During the behavior monitoring 377 h and 55 min were spent in the wind farms, shared nearly equally among the 4 viewpoints of the 2 wind farms. (Table 5).

Table 6. Duration of the behavior monitoring per wind farm and view point during the 2004.

	Large wind farm			**Small wind farm**			**SUM**
Sampling site	VP 1	VP 2	Total	VP 1	VP 2	Total	Both wind farms
Monitoring time (hours: minutes)	91:58	82:19	174:17	103:59	99:39	203:38	377:55

2005. During the behaviour monitoring 43 hours and 9 minutes were spent in Sapka wind farm

Table 7. Duration of the behavior monitoring per wind farm and view point during the 2005.

	Sapka wind farm
	VP 1
Monitoring time (hours: minutes)	43:09

During **2004**, totally 156 birds (of the species included in this monitoring) were detected in the risk area close to the windmills, 129 of them crossed the mountain ridges with the windmills. The most abundant species were the Common Buzzard, followed by the Black Vulture, the Griffon Vulture and the Black Stork. (Table 8).

Table 8. Number of birds detected in the risk area of the wind farms. 2004

Species	**Large wind farm**	**Small wind farm**	**Total**
B. buteo	37	39	76
A. monachus	23	7	30
G. fulvus	11	5	16
C. nigra	12	1	13
C. gallicus	5	0	5
N. percnopterus	3	1	4
A. nisus	1	0	1
F. tinnunculus	1	3	4
P. apivorus	3	0	3
Unidentified	0	2	2
A. chrysaetos	0	1	1
Circus. sp	0	1	1
Total	**96**	**60**	**156**

During **2005**, 18 individuals of 5 species were detected in the risk area.

Table 9. Number of birds detected in the risk area of the wind farms. 2005

Species	**Sapka wind farm**
C. gallicus	6
M .migrans	5
B. bueto	4
A. monachus	2
F. subbuteo	1
Total	**18**

Approximately every 2 hours one bird was detected in the risk area. The frequency was similar in the View Points with the exception of VP 2 of the Small wind farm, where much less birds were seen (Table 10). Although in the Small wind farm where less birds were observed than in the Large wind farm, the covered area was also smaller, and the number of controlled turbines was less.

Table 10. Frequency of birds detected in the risk area of the wind farms presented as individuals per 10 hours of behavior monitoring.

2004						2005
Large wind farm			**Small wind farm**			**Sapka wind farm**
VP 1	VP 2	Total	VP 1	VP 2	Total	VP
5.98	5.47	11.48	4.03	1.87	5.89	4.17

Crosses

Out of the total amount of birds detected in the risk area, many of them crossed the row of turbines. But not all the places were selected with the same frequency of crossing. Some gaps of the line of turbines were selected more often than others. Gaps selected by the vultures species to cross the rows of turbines were different than those selected by the rest of the monitored species. When inspecting the most commonly used gaps for vultures and for the rest of the monitored species, we see that none of them agree, showing that these two different groups chose different areas when crossing the row of turbines.

2004. Small wind farm

Table 11. Small wind farm. Density of crosses in the different gaps between two turbines expressed in birds per 100 meters and 100 hours, during 2004.

Between turbines	Crossing density (birds/100m*100 h)		
	Total	**Vultures**	**Rest of species**
1-2	4.09	0	***4.09***
2-3	2.98	0	***2.98***
3-4	2.05	0.68	1.36
4-5	2.43	***1.82***	0.61
5-6	0.79	***0.79***	0
6-7	2.71	0	***2.71***
7-8	2.46	***1.92***	0.55
8-9	1.75	0.58	1.17
9-10	0	0	0
10-11	0.30	0.30	0
11-12	0.73	0	0.73
12-13	1.36	0	***1.36***
MEAN	**1.72**	**0.65**	**1.07**

In bold, italic letters, marked the three most frequent gaps to cross for the vultures and for the rest of the species monitored.

In the next graphics these frequencies are representing in the columns, while the average for the whole row is represented as a line. According to the results, we recognize the heterogeneous use of the area and the differences between the vultures and the rest of the species monitored.

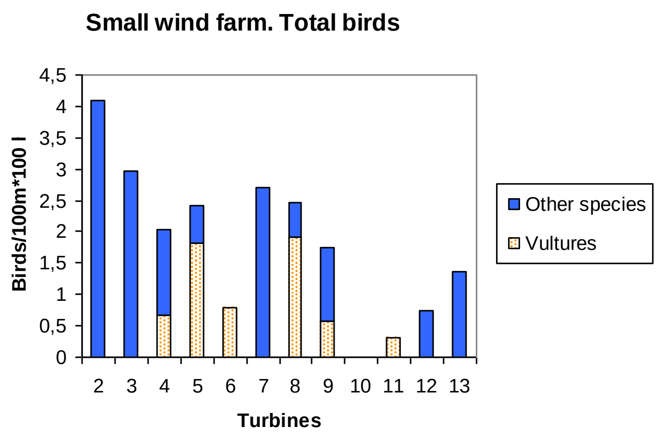

Figure 7. Small wind farm. Frequency of crossing for all the species monitored.

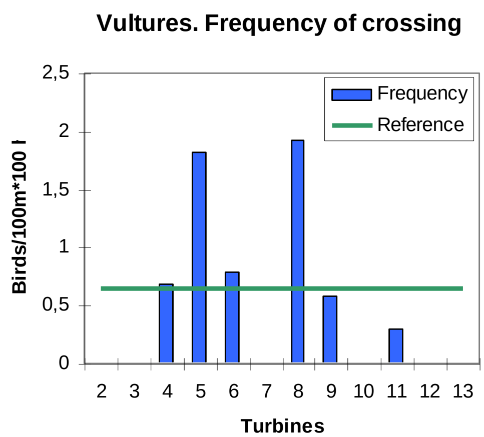

Figure 8. Small wind farm. Frequency of crossing for the vulture species.

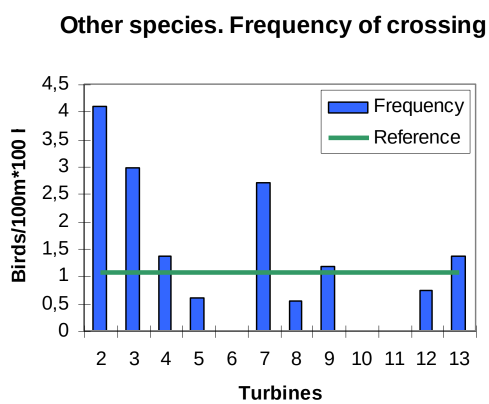

Figure 9. Small wind farm. Frequency of crossing for all the other species monitored except vultures.

In the next figure the gaps with the highest frequency of crosses for the vultures and for the rest of the monitored species are presented. None of them were the same. Thus, these two groups of birds are using the area in different ways when crossing the rows of turbines

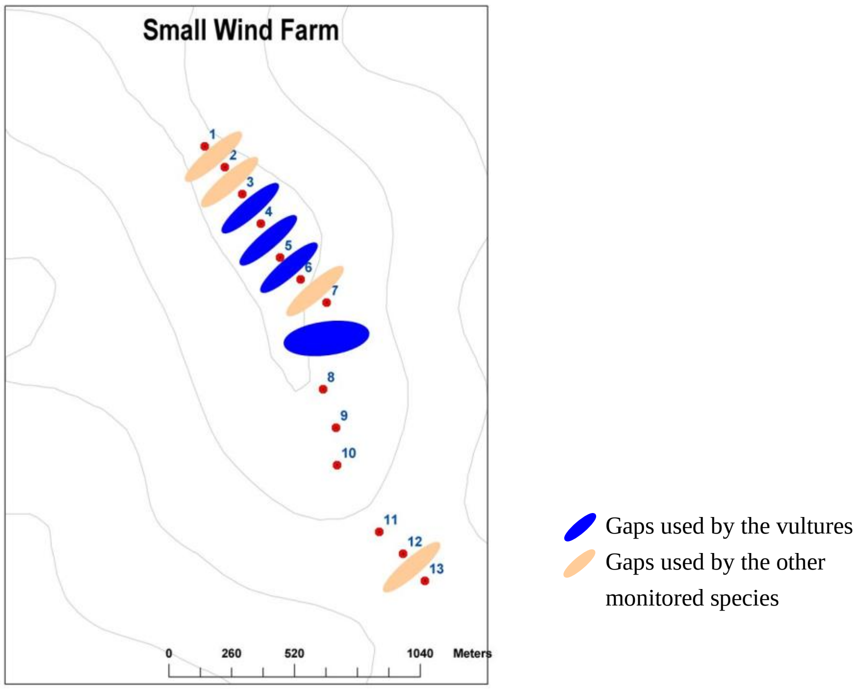

Figure 10. Small wind farm. Gaps most often used by the vultures and for the rest of the monitored species.

Apart of these flights that crossed the rows of turbine, some other birds, although they flew in the risk areas very close to the turbines, did not cross the lines. It was very obvious in the Small wind farms were 33 observations of this kind occurred.

Out of these 33 observations, 24 happened in the outermost turbines, 18 in the turbine 1 and 6 in the turbine 13. These flights were no crossing the row of turbines because they were not going between two turbines, but according to the direction of the flight and the distance from the turbines we can consider them like "outside crosses". For these flights we cannot calculate the density as we have done for the crossing observation, because it is not possible to define the length of the gap as there is only one turbine. But to have an idea about the quantity of flights that this represents from the total amount of observations, we can compare with the data of the crossing density and the total observations that originate these densities in the crossing flights

Table 12. Small wind farm. Density of crosses in the different gaps between two turbines expressed in birds per 100 meters and 100 hours. Total observations for these gaps and total observations near the extreme turbines.

Turbines	Total density Birds/100m/100 h	Total observations
Close to 1	-	***18***
1-2	4.09	5
2-3	2.98	4
3-4	2.05	3
4-5	2.43	4
5-6	0.79	1
6-7	2.71	4
7-8	2.46	9
8-9	1.75	3
9-10	0	0
10-11	0.30	1
11-12	0.73	1
12-13	1.36	2
Close to 13	-	***6***

The six observations recorded close to the turbine 13 were Common Buzzard, and 16 out of the 18 observations recorded close to the turbine 1 were also Common Buzzard while the other two were a Black Stork and a Kestrel. Except the Black Stork, all the other observations were local birds that have their territories in the area. These local birds, stayed in the area, despite the presence of the wind farm, and they learned to fly avoiding the line of the turbines, but getting closer to the extreme turbines

2004 Large wind farm

Inspecting the most commonly used gaps for vultures and for the rest of the monitored species, we saw that there was no coincidence, showing again that these two different groups chose different areas when crossing the row of turbines

We consider two different rows of turbines to analyze the crosses of the birds, the row AB and the row D (Fig 2).

Row AB

Only one of the gaps most often used agree for both groups of birds, showing again that these two different groups chose different areas when crossing the row of turbines**.**

Table 13. Large wind farm. Row AB. Density of crosses in the different gaps between two turbines expressed in birds per 100 meters and 100 hours.

Between turbines	**Crossing density** (birds/100m*100 h)		
	Total	**Vultures**	**Rest of species**
B5-B6	0.83	03	0.83
B6-B7	0.75	0	0.75
B7-B8	0	0	0
B8-B9	0	0	0
B9-B10	0	0	0
B10-B11	0	0	0
B11-B12	0.78	0	0.78
B12-B13	0	0	0
B13-B14	0	0	0
B14-B15	0	0	0
B15-B16	0	0	0
B16-B17	1.11	0	1.11
B17-B18	1.66	0	***1.66***
B18-B19	0	0	0
B19-B20	0.44	0	0.44
B20-B21	0.77	0	0.77
B21-B22	1.90	0.38	***1.52***
B22-A1	3.19	***1.60***	***1.60***
A1-A2	0.49	0.49	0
A2-A3	0.81	0.40	0.40
A3-A4	0.54	0.54	0
A4-A5	0.56	0.56	0
A5-A6	1.18	0.59	0.59

A6-A7	0.85	0.64	0.21
A7-A8	1.44	***1.44***	0
A8-A9	1.67	0.56	1.11
A9-A10	1.34	0	***1.34***
A10-A11	0.54	0	0.54
A11-A12	2.79	***2.09***	0.70
A12-A13	1.86	1.24	0.62
A13-A14	3.76	***3.76***	0
A14-A15	3.09	***2.32***	0.77
A15-A16	2.16	0.72	***1.44***
MEAN	1.19	0.59	0.60

In bold, italic letters marked the five most frequent gaps to cross for the vultures and for the rest of the species monitored

The non-homogeneous use of the area was observed as well as the differences between vultures and the rest of species (Fig 10). It is remarkable that vultures did not use at all the north part of the row AB (turbines 1B to 21B)

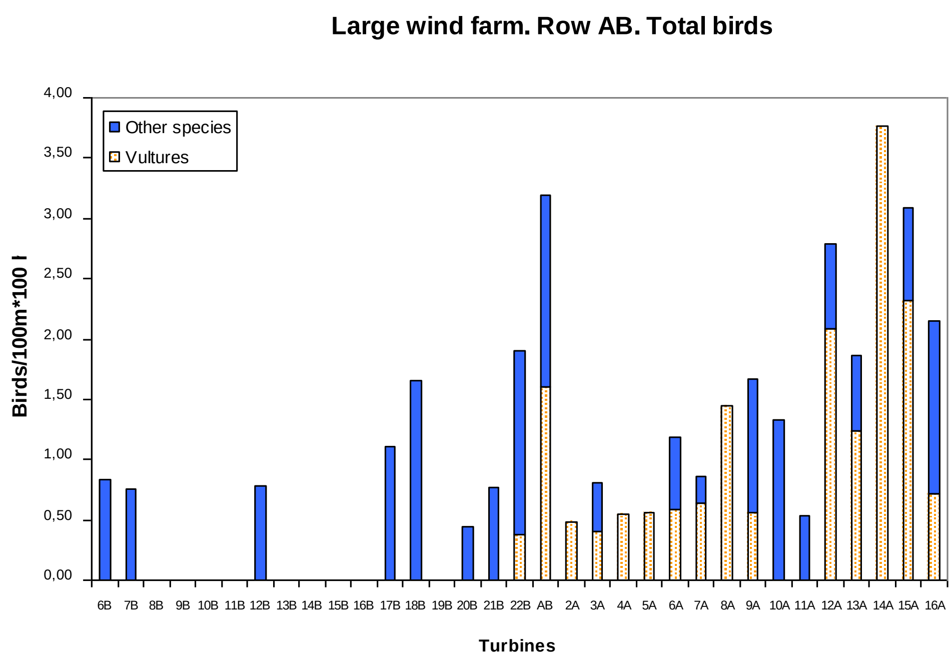

Figure 11. Large wind farm. Row AB.. Frequency of crossing for all the species monitored.

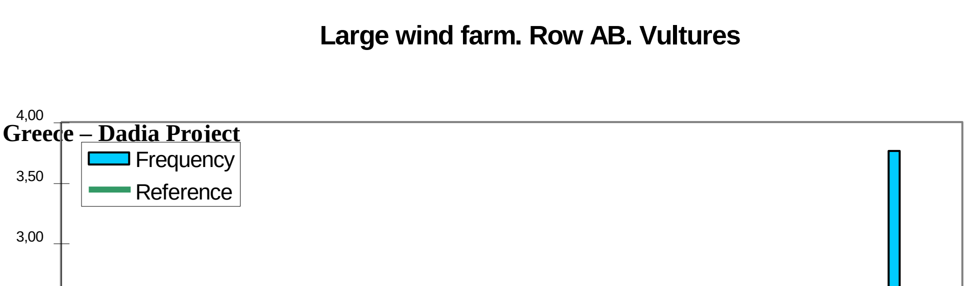

Figure 12. Large wind farm. Row AB.. Frequency of crossing for the vultures species.

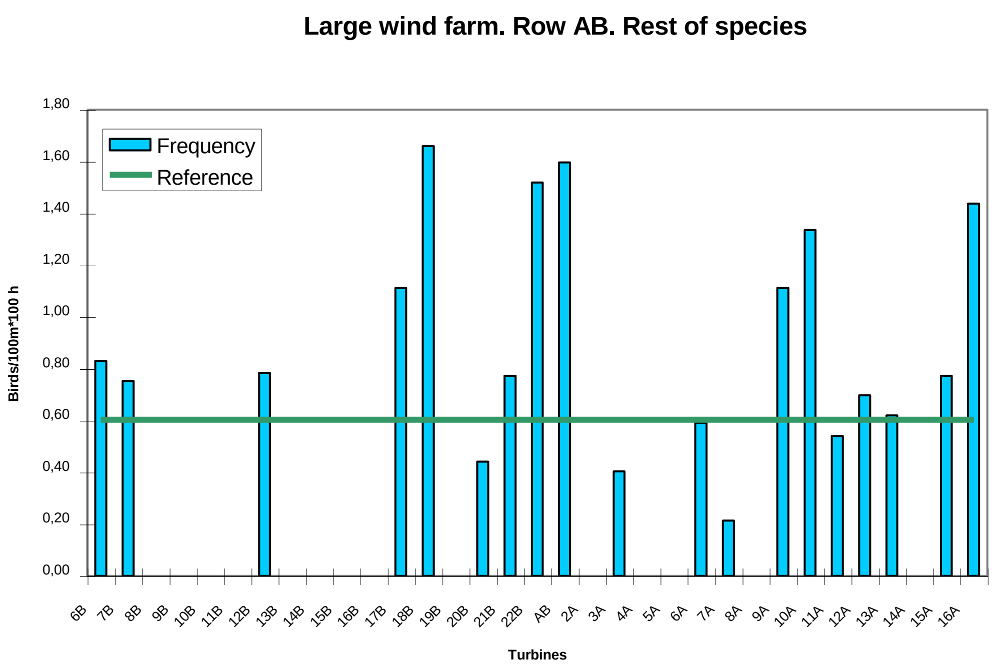

Figure 13. Large wind farm. Row AB.. Frequency of crossing for all the species monitored except vultures.

In the next figure we can see the gaps with the highest frequency of crosses for the vultures and for the rest of the monitored species. Only one gap is highly used from both groups. Also in this case we can consider that the vultures and the rest of monitored species used the area in a different way when crossing the rows of turbines

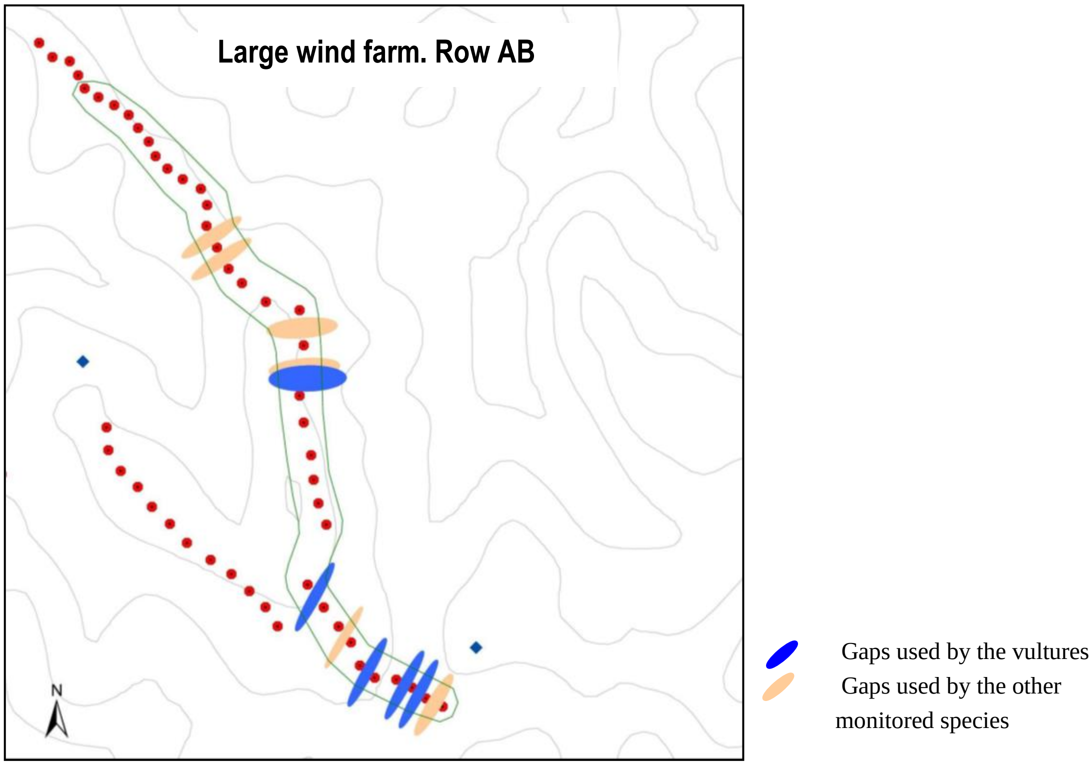

Figure 14. Large wind farm. Row AB. Gaps most often used by the vultures and for the rest of the monitored species.

Row D

Because only one vulture was seen in the risk area, we pooled the data for vultures and the rest of the monitored species. Despite of this fact, the use of the different gaps to cross the rows is again heterogeneous, with some gaps not used, and some other with a very high frequency of crosses. The only vulture observed in the risk area in this row crossed it between turbines 4D and 5D.

Table 14. Large wind farm. Row D. Density of crosses in the different gaps between two turbines expressed in birds per 100 meters and 100 hours.

Between turbines	Crossing density (birds/100m*100 h)
	Total
1D-2D	0
2D-3D	0.95
3D-4D	0.85
4D-5D	1.74
5D-6D	0.84
6D-7D	0
7D-8D	0.14
8D-9D	1.56
9D-10D	4.05
MEAN	**0.78**

In the next figure, frequency for this row was much higher between turbines 9 and 10, and there were not crosses between turbines 1 and 2

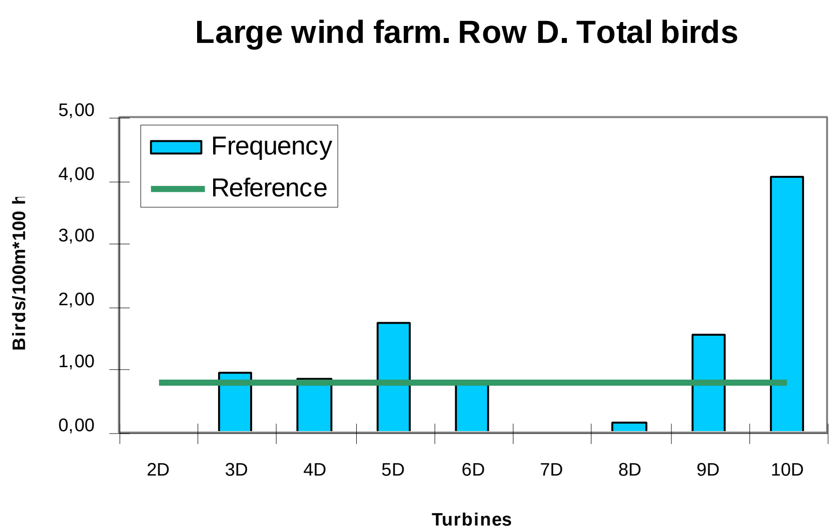

Figure 15. Large wind farm. Row AB.. Frequency of crossing for all the species monitored except vultures.

In the next map we show the three most common gaps used in this row. Two of them were located in the extreme of the row. The big gap existing in this row was almost not used by the birds.

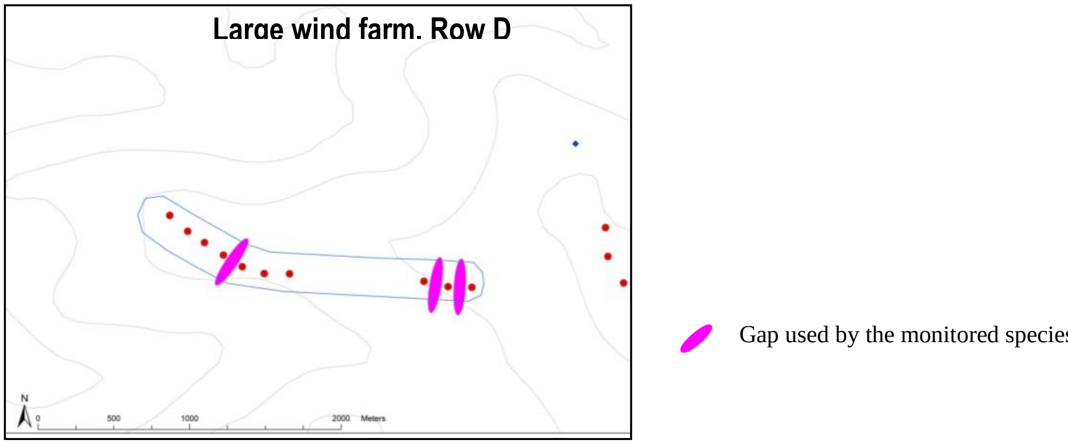

Figure 16. Large wind farm. Gaps most often used by the monitored species.

The results indicate that a difference in the behavior of vultures and the rest of species exist responding the crossing of lines of turbines. The vultures do not breed in the area in which the wind farms are located, but some kilometers further away and visit the area of the wind farms regularly. The rest of the species are local birds, with their territories around or inside the wind farms. They cover a smaller area, but concentrate most of their flights in that area. So if a territory was close to a turbine or group of turbines, the bird was observed there.

In the Large wind farm we have not observed the same behavior as in the Small wind far, in relation with the movements around the outermost turbines, despite there was an important population of Common Buzzard. This could be related with the differences of the topography, but also with the different sizes and structures of the wind farms. The Small wind farms, with only one short row of turbines, the birds are more confident with the turbines, and they get close to them. In the Large wind farm, with longer rows and more intricate structure, the local birds avoid to go so close to the turbines. In this case many of the birds observed in the risk area (crossing or not the row of turbines) were non-local birds using the area as foragers.

2005 Sapka wind farm

As the distribution of the turbines is not in a straight row, we named the gaps with letters (Fig 17)

Table 15. 2005. Sapka wind farm. Density of crosses in the different gaps between two turbines expressed in birds per 100 meters and 100 hours.

Between turbines	**Crossing density** (birds/100m*100 h)
	Total
A	0
B	0.19
C	0.13
D	0.21
MEAN	**0.15**

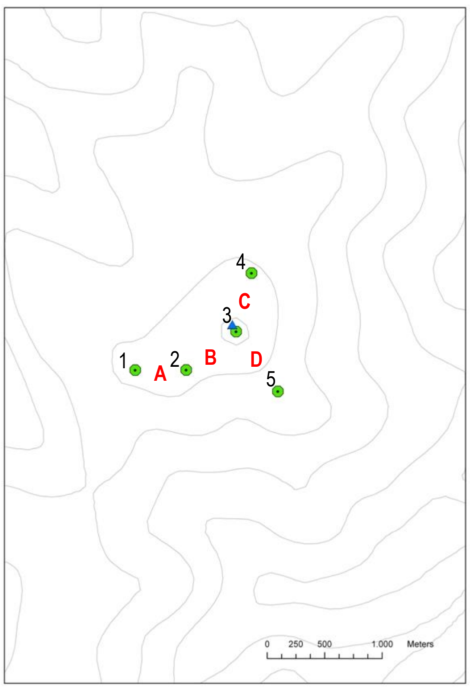

Figure 17. Number of turbines and names of the gaps.

Due to the few observations from 2005, the separated analysis between vultures and the rest of monitored species has not been done. Gaps A, B and C were used in a similar way. On the other hand gap A was not used at all (Fig 18)

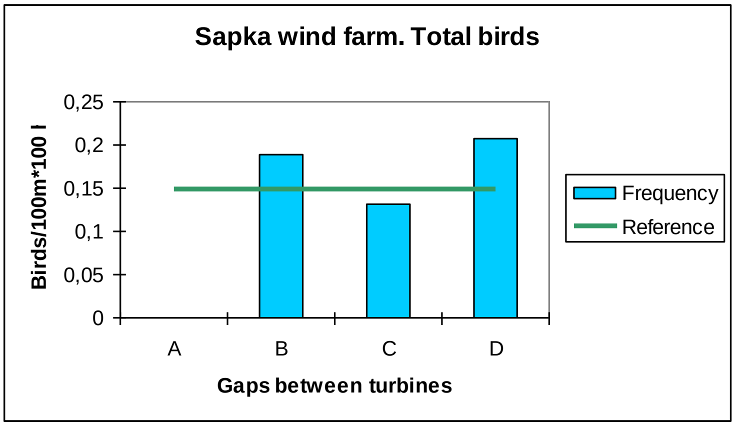

Figure 18. Sapka wind farm. Gaps most often used by the monitored species .

Proportion of risk flights

2004. From the total amount of flights observed (708 individuals), only a small proportion (156 individuals) was considered risky or in the dangerous areas. This represents a 22% of the flights. From these flights, 115 were individuals that crossed the row of turbines, which represent a 16.3% from the total flights and a 73.7% from the risky flights.

These proportions changed when separately analysing vultures and local birds. Evaluating the differences between the most common local bird, the Common Buzzard (*Buteo buteo*) and for the vultures, (Fig 19) we detected that vultures nearly always cross when being observed in the risk area. Also a bigger proportion of vultures flew close to the turbines than from the Common Buzzard.

This could mean that the Common Buzzard, which is a local species in the area close to the wind farm, present shorter movements, focused around the different territories. When they fly the risk areas, many times they do it around the turbines closest to their territories (and in the Small wind farm those turbines are the outermost turbines) and only in the half of the situations they cross the row of wind mills.

In the other hand, the vultures, which use the area of the wind farms as part of their foraging area, fly all over the wind farm. And if they get close to the turbine, it is because the turbines are in their way, so they cross the row and continue the flight.

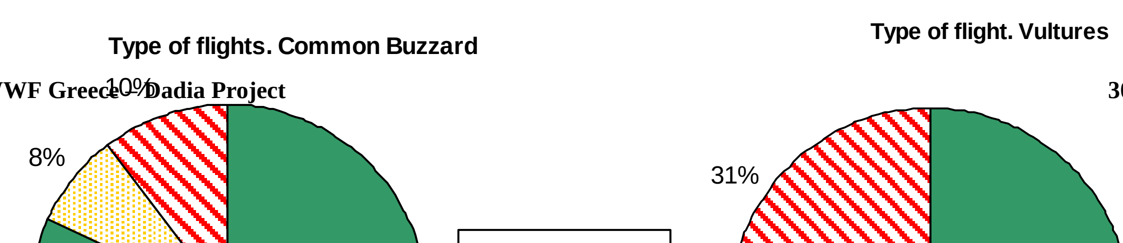

Figure 19. Proportions of different kind of flights related with the proximity to the turbines for the Common Buzzard and for the vultures during 2004.

2005. Few vultures were observed in Sapka wind farm so the analysis was done for all the species together. A big proportion of the birds observed flew into the dangerous area. From those birds, most of them crossed the line of turbines. The structure of the wind farm, without straight lines of turbines makes many of the observed flights to be in the risk area

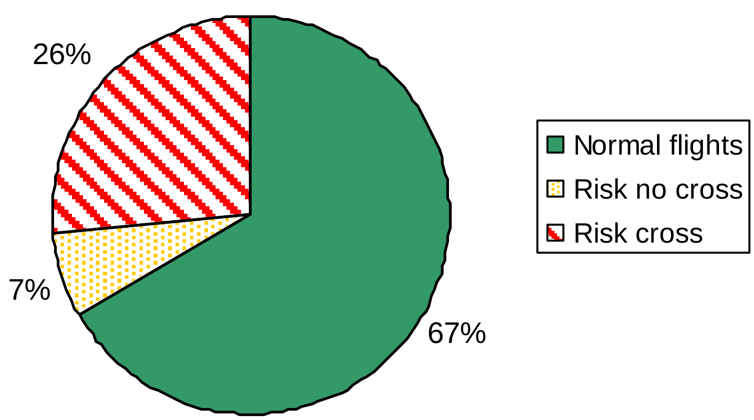

Figure 20. Proportions of different kinds of flights related with the proximity to the turbines for the Common Buzzard and for the vultures during 2005.

Wind and risk flights

2004. We compared the wind direction during the total time of observations and during the observed flights in the risk area. Some directions present a notable difference between the percentage of wind during the time spent at the observatory and the wind register in the observations.

In the Small wind farm more risk flights were registered in west wind in compare with the percentage of this kind of wind during the observation time. (Fig 21)

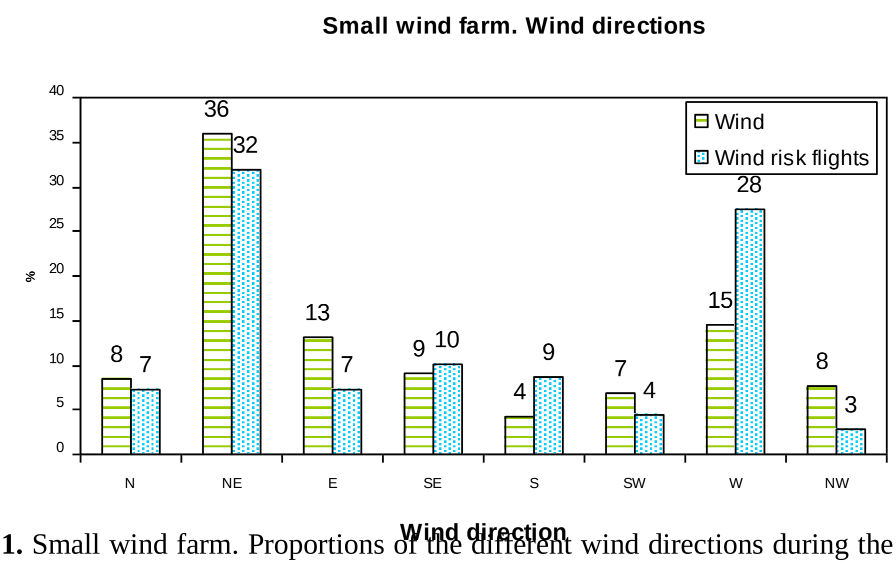

Figure 21. Small wind farm. Proportions of the different wind directions during the sample time and during the observed flights in the risk area.

In the large wind farm, the most frequent wind directions were N and SW. But while N wind was observed almost in the half of the risk flights, SW was recorded in few of the cases. (Fig 22)

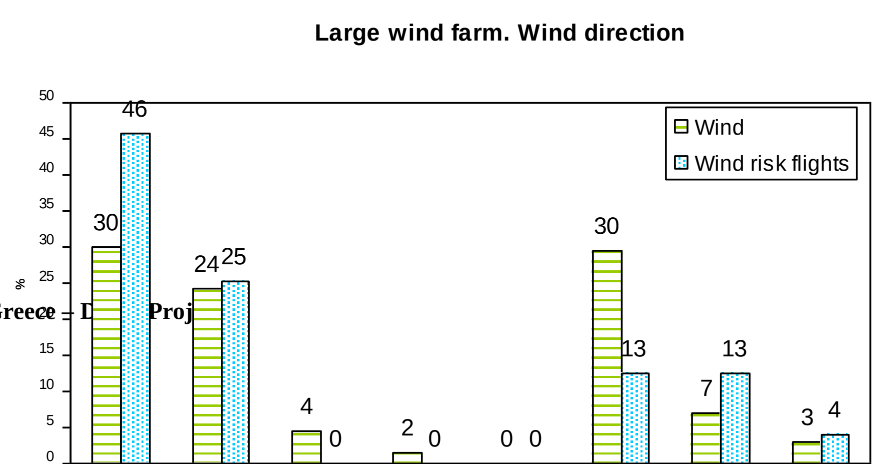

Figure 22. Large wind farm Proportions of the different wind directions during the sample time and during the observed flights in the risk area.

2005. We made the same comparison and we observed a high percentage of risky flights with NE wind. This wind was present with the same frequency as SE or N, but the greater part of the risk flights were recorded while this wind was happening. (Fig 23)

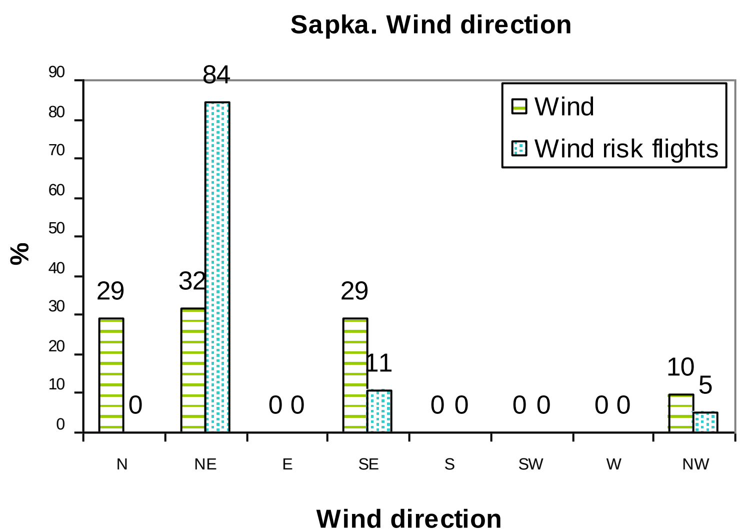

Figure 23. Proportions of the different wind directions during the sample time and during the observed flights in the risk area.

2004. Behaviour of the vultures close to the turbines

When the vultures flew close to the turbines, in the most of the cases they crossed the row and the continued the flight. But they did not always do that in a direct way. Many times these flights presented changes in their direction, or height. Some of these flights showed a common pattern in which the vulture, once it was close to the rows of turbines, change the direction of the flight and started to fly parallel to the row. After some hundred meters the bird crossed the line of windmills and it continued its flight.(Fig 24)

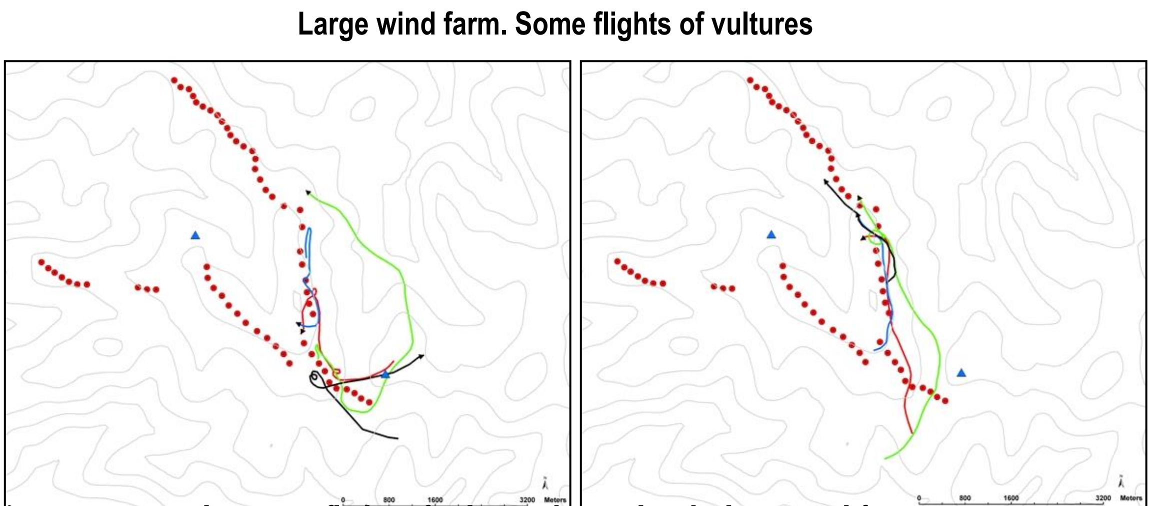

Figure 24. Some dangerous flights of vultures observed in the large wind farm.

Comparison with telemetry data

We compared the data obtained in the telemetry study (Vasilakis et al 2005) with the data obtained for the vultures in both wind farms. According to the telemetry data both wind farms are include in the foraging area for the tagged Black Vultures. The small wind farm is just in the limit of this foraging area during the breeding season, while it is inside at the non breeding season.

The large wind farm was inside the foraging area outside of the breeding season, while in the breeding season, some part of the wind farm is include in the area for forage and some part is outside that area (Fig 25). Comparing this with the data collected in the wind farm, we can appreciate a high coincidence of the turbines with the most of the crosses with the area of presence of vultures according to the telemetry, and no crosses at all in the areas that telemetry is pointing as non-use area.

Sapka find farm, monitored on 2005, is also located in the foraging area of the marked vultures in both periods.

Both monitoring are confirming their reliability with these results and the telemetry data could be used for estimation of use or non-use of the wind farm area.

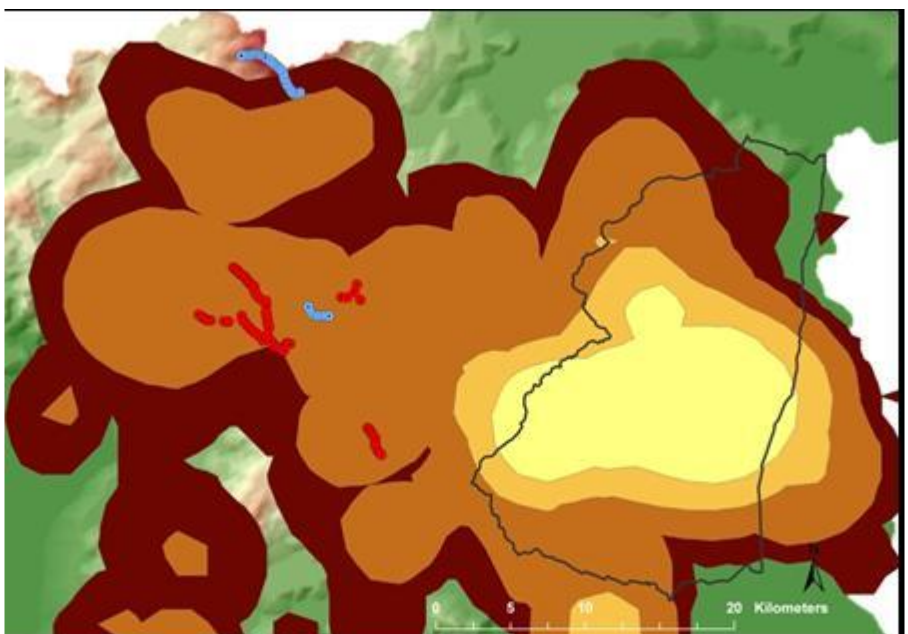

Figure 25. Foraging area for the marked vultures in the breeding season (up) and outside the breeding season (down). Location of the wind farms and limit of the DNP.

Conclusions

Few crash events and no raptor crash events show that the mortality caused by the wind farms is low. It was not possible to relate dangerous movements with mortality, due to the low number of carcasses detected. The mortality events, despite the fact that they were scarce, they were concentrated in a short period, at the beginning of the post-breeding migration. It is necessary to collect accurate data about this period.

Most of the birds detected in the risk area were local birds or vultures that visited the area regularly as a foraging area.

Local birds and vultures show different behavior when they fly in the wind farms close to the turbines: Different points to cross the row of turbines, and different proportions of flights going in the risk area and crossing the rows. Local raptors concentrate their flights in the territories. Dangerous flights occur mainly around the outermost turbines. Few of the local raptors fly in the risk areas and a low proportion of these flights cross the row of turbines
Vultures flew in the risk areas in a higher proportion. From these almost 100% cross the rows of turbines

The risky flights of local raptors happened in the turbines closest to their territories. A previous estimation of the position of the territories could predict which area will be used by them.

Many movements of the birds occur close to the outermost windmills.

Some vultures change flights searching for a cross point This kind of behavior is stronger in a larger wind farm, with longer rows of turbines

Telemetry data can predict with high precision which wind farms or which parts of the wind farms are used by the vultures

Some wind directions can increase the dangerous movements close to the turbines, mainly N in the Large wind farm W in the Small wind farm and NE in Sapka wind farm

Many factors affect the risk: Season, species, composition of the avian community, length of the rows, proximity to the center of territories, wind, etc. For this reasons, specific studies before the construction of the wind farms are needed to estimate the possible impacts

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