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Assessing the impact of nine established wind farms on birds of prey in Thrace, Greece

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CONTENTS

0. EXECUTIVE SUMMARY

1. INTRODUCTION

2. STUDY AREA

3. METHODS

- 3.1. Carcass surveys
- 3.2. Observers' detection trials
- 3.3. Scavenger removal trials
- 3.4. Mortality estimation based on carcass surveys
- 3.5. Surveys of space use by birds

4. RESULTS AND DISCUSSION

- 4.1. Carcass surveys
- 4.2. Observers' detection trials
  - 4.2.1. Observers' detection trials August 2008
  - 4.2.2. Observers' detection trials November 2008
  - 4.2.3. Observers' detection trials March 2009
  - 4.2.4. Observers' detection trials May 2009
- 4.3. Scavenger removal trials
  - 4.3.1.Scavenger removal trial August 2008
  - 4.3.2. Scavenger removal trial November 2008
  - 4.3.3. Scavenger removal trial March 2009
  - 4.3.4. Scavenger removal trial May-June 2009
- 4.4. Mortality estimation based on carcass surveys
- 4.5. Surveys of space use by birds
  - 4.5.1. Avian space use descriptors
  - 4.5.2. Crossing densities. Comparisons.
  - 4.5.3. Monthly countings. Comparisons.
  - 4.5.4. Bird use index. Graphical representation of the index in both periods

5. CONCLUSIONS AND RECOMMENDATIONS

6. STUDY TEAM AND AKNOWLEDGEMENTS

APPENDICES

0. EXECUTIVE SUMMARY

This study evaluates the impact on birds of prey of nine wind farms in Thrace, where a large scale wind farm development project of at least 960 MW is under development.

The study area is located in the prefectures of Evros and Rhodope in Thrace, northeastern Greece and it is widely known for its high ornithological value. The "Near threatened" Black Vultures reproduce a few kilometers to the southeast of the area and they use it for foraging. This is currently the only Black Vulture population left in Southeast Europe. The area is also considered as the last stronghold of the "Endangered" Egyptian Vulture in Greece, with very important premigratory concentrations while it hosts the most important Golden Eagle breeding population in Greece. Approximately 50% of the wind farm development project area is covered by Natura 2000 sites.

Carcass surveys around a selection of wind turbines in the study area were carried out by WWF Greece to estimate bird mortality. Results of the surveys were corrected for bias caused by the observers' detection ability and the scavenger removal activity. Trials to estimate the bias were performed. In addition, surveys of spatial use by birds were carried out. Indices of avian space use were then calculated and comparisons made between a previous monitoring study run by WWF Greece in 2004- 2005 and this study (hereafter also referred as "first monitoring period" and "second monitoring period" respectively).

Overall, five birds of prey were found dead (four Griffon Vultures and one Booted Eagle) during the current monitoring scheme run between 2008 and 2009 (one year). Carcasses from eleven other birds and eight bats were also discovered. Observers' detection efficiency was 66% on average, and the average time a carcass remained in the field was 23 days, although 50% of small carcasses, 22% of medium and 25% of large ones had been removed after 14 days. The estimated mortality rates were 0.152 birds of prey (including vultures)/turbine/year and 0.072 vultures/turbine/year. Griffon Vultures, Black Vultures and Common Buzzards comprised more than 50% of observations during the survey of spatial use by birds in the study area. In general, densities of birds crossing between wind turbines were positively correlated with an east exposition and steepness of the slope and the distance between turbines, while it was negatively correlated with north exposition. The use of the area was more intensive during the second monitoring period, but numbers of Common Buzzard observations drastically decreased in 2008-09.

The more frequent presence of raptors in the area may expose them to a higher risk of collision and hence higher mortality. This may be the reason underlying the higher mortality observed during the second monitoring period. In particular, the population of the Common Buzzards may have been severely affected by the operation of wind farms. The effect may have been displacement of the territorial pairs present during the first period or high mortality due to collision. Bird mortality estimates are alarming with regards to predicted collisions per year. Results are particularly alarming for Griffon Vultures not only for the breeding population in Greece but also for the population breeding in the broader area of Eastern Rhodope mountains.

Only one year of post-construction monitoring may not be adequate to properly assess the impact of wind farms on birds of prey. This applies in particular to wind farms for which pre-construction ornithological studies were of very low quality.

1. INTRODUCTION

The region of Thrace is located in north-eastern Greece, bordering with Bulgaria in the North and Turkey in the East. The prefectures of Rhodope and Evros are internationally renown for their high ornithological interest, hosting habitats of European importance mainly for large birds of prey and aquatic birds (WWF Greece 2008). Up to date, 11 wind farms with a total of 163 wind turbines have been installed in the area and are currently in operation. These investments follow the usual trend and occupy natural upland areas, normally the top of ridges where wind energy is better exploited, relatively far away from populated, industrialized or degraded areas (Madders and Whitfield 2006, Atienza 2008). The existing number of wind farms installed in the region of Thrace is expected to increase enormously in the near future, taking into account the number of applications submitted to the country's Regulatory Authority of Energy (RAE 2010) (Fig. 1).

The Black Vulture (*Aegypius monachus*)[1] is one of the most endangered bird species in Greece (IUCN, 2009). The Dadia-Lefkimi-Soufli Forest National Park hosts the only population left in the country and in the southeastern Europe, threatened with extinction due to its small size (Skartsi *et al.* 2008). However, this is a key population for the recovery of the species in the Mediterranean, with a crucial role to play in the connection between the European and Asian populations. Much effort and resources have been invested by public (e.g. regional authorities) and private organizations (e.g. WWF Greece) for the conservation of these birds. Flight characteristics and movements of the Black Vulture potentially make it one of the most vulnerable species to wind turbines. In addition to hosting the last population of the Black Vulture in SE Europe, the area is also considered as the last stronghold of the endangered Egyptian Vulture in Greece, with very important premigratory concentrations, while it also hosts the most important Golden Eagle breeding population in Greece.

With this information in mind, as well as the fact that negative impacts of wind turbines on the avifauna have been well documented in other parts of the world (see for example Barrios and Rodríguez 2004, Drewitt and Langston 2006, Tellería 2008), a big concern was raised about the probable impacts of wind farms on bird populations of the area. As a consequence, WWF Greece attempted to monitor impacts of wind farms on birds in Thrace for the first time in 2004 - 2005 (17/03/04 - 6/12/05; Ruiz *et al.* 2005), during which monitoring no raptors were found dead. The absence of findings did not allow to relate the patterns of flights in the area with mortality, but there was a clear differentiation in the flight behaviour between local birds of prey (territorial raptors, with a territory in the wind farm area) and vultures. Local raptors that entered a 250 m radius around wind turbines flew primarily around the outermost turbines, while vultures visiting the area mainly to forage tended to cross the turbines at a much higher rate. The study concluded that there was an imperative need of sound evidence-based pre-construction studies to obtain good knowledge on the factors potentially affecting bird mortality. Although ornithological studies are a legal requirement before the construction of any wind farm in Greece and thus in the area, most of them are of very poor quality and inappropriately evaluated due to the lack of expertise in the state authorites involved in the evaluation process.

[1] Scientific names in the text are given only the first time a species is mentioned. However, they have been used in tables and figures.

A second monitoring phase was implemented by WWF Greece from June 2008 to July 2009 to produce new knowledge which would be necessary for appropriate planning and management of future wind farms in the area in relation to birds. It is desirable that the implementation of this kind of monitoring activities be systematically funded by investors themselves and implemented by independent consultants in the near future, to assure the long term monitoring of the area and to prevent the expected cumulative impacts of wind farms on animal mortality, as wind farm density in Thrace increases.

This document presents the methods and findings of the second monitoring period (2008-2009). The study comprises two well differentiated parts. In the first part, bird mortality caused by wind farms in the area is assessed, based on carcasses found during systematic searching. To estimate potential bias caused by observers' efficiency and scavengers' activity, observers' detection trials and scavenger removal trials were carried out. Mortality rates were estimated taking those bias sources into account. In the second part, spatial use by birds is examined, based on data obtained during both the 2004-2005 and 2008-2009 monitoring studies. The more recent findings are presented and various indices (crossing densities, bird use index) are calculated and compared between the two study periods.

The main questions of this study were the following:

1. What was the observed raptor mortality due to collision with wind turbines?
2. In particular, what was the observed vulture mortality?
3. What is the mortality if we take into account the observers' detection efficiency and the scavengers removal rate?
4. Was there any influence of season on observers' detection efficiency and scavengers removal trials? Was there any influence of carcass size on scavenger removal trials?
5. Were there any differences in the use of the area by birds of prey between the first monitoring period (2004-2005), implemented one year after the onset of the operation of wind farms and the second monitoring period (2008-2009), carried out four years later?
6. Was there any correlation between the characteristics of the wind farms siting and the spatial use by birds?

2. STUDY AREA

The study area is located between Rhodope and Evros prefectures, in northeastern Greece. It is situated in the north west of the National Park of Dadia-Lefkimi-Soufli Forest and is included within the home range of the Black Vulture population remaining in the area (Vasilakis *et al*. 2008). A large part of these prefectures has been declared as a Wind Priority Area (WPA 1) by the Greek state. Half (50%) of the WPA 1 is covered by seven Natura 2000 sites, five of which constitute Special Protection Areas (SPAs) and two are National Parks (Fig. 1). Since 2003, 11 wind farms (WFs) with 163 wind turbines (WTs) have been installed and are currently in operation. This number is expected to increase drastically in order to fulfil the objective of 480 typical WTs (960 MW) set by the Greek state (WWF Greece 2008).

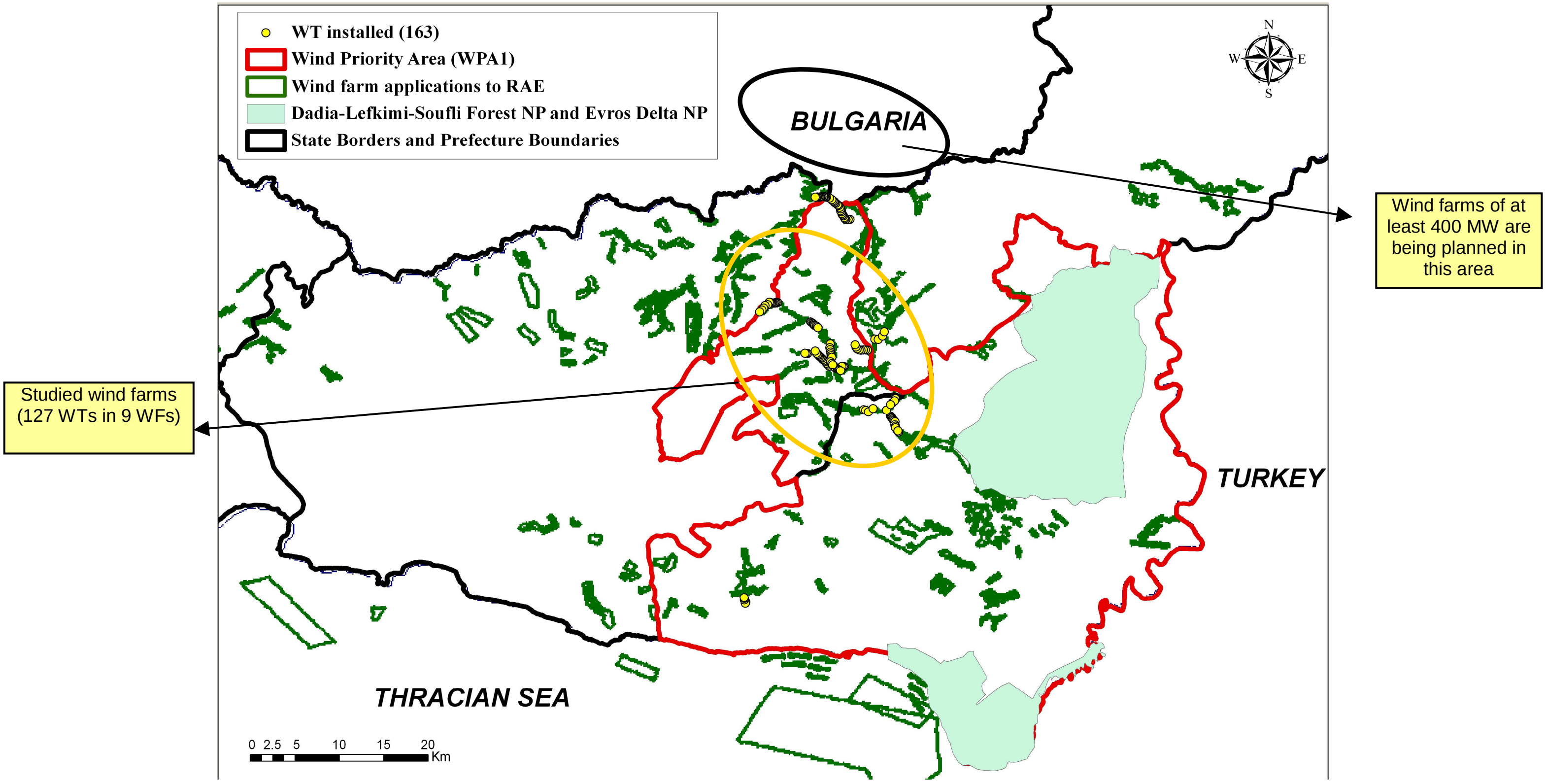


Fig. 1 Study area with operating and planned wind farms (Source: Regulatory Authority of Energy/RAE).

In total, 127 out the 163 operating WTs belonging to nine out of the 11 operating WFs were included in the monitoring scheme. Ten new WTs have been recently constructed, but their operation has not started yet

The selected WTs were distributed as follows:

1. SAPKA (X): 5 WTs, encoded X1 to X5.
2. DIDIMOS LOFOS (D): 8 WTs, encoded D1 to D8
3. GERAKI (T): 42 WTs, encoded T1 to T42
4. MATI (MA): 3 WTs, encoded MA1 to MA3
5. KERVEROS (K): 14 WTs, encoded K1 to K14
6. PELTASTIS (P): 10 WTs, encoded P1 to P10

7. MYTOULA (M): 19 WTs, encoded M1 to M19
8. SOROS (S): 13 WTs, encoded S1 to S13
9. MONASTIRI (MO): 13 WTs, encoded MO1 to MO13

The WT models present in each wind farm varied in their technical characteristics (Table 1).

Table 1. Operation characteristics of wind turbines

	Windfarm	Height (m)	Rotor diameter (m)	Rotation period	Max. Chord (m)	MW
Nec micon 52/900KW	T, S, MA, MO	44	52	22.4/14.9 rpm	2,25	0,9
Rokas Bonus 1.3MW	K, P	50	62	19/13 rpm	3	1,3
Vestas 2MW	M, D, X	60	90	16.7/19	3,5	2
N50R46 - IEC I (80)	MO	44	52	22.4/14.9 rpm	2,25	0,8

When the 2004-2005 monitoring was implemented, several currently operating windfarms were still under construction. At the time, the following wind turbines were monitored (Ruiz *et al*. 2005):

2004: 57 wind turbines were surveyed for bird behaviour (4 view points) in Soros (13), Geraki (34) and Peltastis (10) and 17 wind turbines in Soros and Geraki were searched for carcasses.

2005: 5 wind turbines in Sapka were surveyed for bird behaviour (1 view point), and all wind turbines (105) in 5 windfarms were searched for carcasses: Peltastis and Geraki named as “Large Wind Farm” or LWF and Soros named as “Small Wind Farm” or SWF in Ruiz *et al.* (2005), Sapka, Didimos Lofos and Virsini.

3. METHODS

3.1. Carcass surveys

Systematic carcass searches of all 127 wind turbines took place between 17/06/2008 and 31/07/2009, thus covering one full year of inspection. Turbines were searched two days a week. During the first months of the monitoring period visits were usually fixed on Tuesdays and Fridays, but for practical reasons, turbines were visited in a random way from February 2009 onwards. Turbines were divided in four sectors and according to the number of turbines and topographic difficulty of each sector searches were conducted by four and two people alternatively (Table 2). Each sector was searched once in the morning, the next time in the afternoon and so on. The total time needed to search all of the 127 turbines was two weeks before the next round of visits.

Table 2. Sampling design of carcass surveys.

Week	Day	Start time (summer – winter)	Wind turbines	Number of observers
A	A.1.	8:00 – 9:00	MO1-MO13, T1-T32	4
A	A.2.	12:00 – 11:00	T33-T42, MA1-MA3, D1-D8, X1-X5	2
B	B .1.	8:00 - 9:00	S1-S13, M1-M19	4
B	B.2.	12:00 – 11:00	K1-K14, P1-P10	2
C	…	…	…	…

A circular sample plot of at least 50 m radius was searched around each turbine, with the turbine as the centre of the plot. The minimum total area searched every 14 days was 99.75 ha. At each visit and turbine, observers first scanned the platform holding the wind turbine by car. They then divided the rest of the plot in two parts and each part was searched on foot, starting from the same point and following opposite directions. If general, each half circle was searched by zigzags, but the actual way of searching often varied among wind turbines depending on topography and vegetation cover. When observers encountered obstacles such as rocks, bushes, trees or other, they searched them carefully. In cases where steep slopes were found within the plot, binoculars were used. Parts of the plot not accessible to the observers due to dense vegetation or other reasons were recorded as a proportion of the plot excluded from searching.

On the plate of the turbine, carcasses of all kinds of animals that had possibly died due to an interaction with the wind turbine were a target, including passerines and bats. However, outside the plate, observers focused on birds of prey. Carcasses found during preparation of the monitoring and those randomly found during implementation were also taken into account in mortality estimates.

Searching equipment included plastic bags, plastic gloves, a GPS, measuring tape, a photo camera and binoculars. The following data were recorded prior to the onset of searching activities at every visit (Appendix I):

- Observers’ names
- Date
- Start and end time
- Wind farms

- Identification code of wind turbine
- The proportion of the wind turbine plot that was not searched.

When a carcass was found:

- Species was recorded if possible.
- GPS coordinates of the carcass position were taken (if there was more than one piece, the GPS position was taken for every piece).
- The distance and direction to the closest turbine was measured (if there was more than one piece, distance and direction to the closest turbine were measured for each piece, as well as the distance between the carcass pieces).
- Photos of the incident were taken before the carcass was touched or removed (Table 3).
- The carcass was examined for possible injuries or broken bones, and these were recorded if found.
- The carcass was checked for insects whose presence was recorded.
- The carcass was collected in a plastic bag with a data label and kept in the freezer for any further examination.
- If the carcass was a raptor or a vulture the carcass was collected and sent for x-rays and toxicological analyses to the competent institutions in the region and Thessaloniki.

Table 3. Carcass photos protocol

- ✓ Close ups of the carcass from all sides and of each carcass piece, if the carcass was cut in more than one piece.
- ✓ Photos of the wing from both sides, head, bill and other parts of the bird potentially providing information about the age of the dead animal.
- ✓ Close ups of injuries e.g. injured bill, broken wing etc.
- ✓ Close ups of insects.
- ✓ General photo of the surrounding landscape including the wind turbines.
- ✓ Photo showing the position of the bird in relation to the closest wind turbine. One person stood close to the carcass pointing at it and photos were taken both from near and from far distances, including the person, the wind turbine and the carcass. Other photos included the wind turbine, the carcass and the landscape, other wind turbines etc.

3.2. Observers' detection trials

Observers' detection bias is a quantification of the observers' ability to find dead birds, largely influenced by topography, vegetation structure and observers' experience. In the frame of the carcass surveys, observers' detection bias might heavily influence mortality estimation. One might quantify the observer's ability to find dead birds when a known number of birds are placed in the search area. We applied observers' detection trials to quantify and correct the bias of mortality estimates of vultures and raptors due to collision with wind turbines. We aimed to quantify the detection ability of every observer involved in the carcass surveys.

Three sites outside but near the windfarms were selected for trials. These were similar to the windfarm sites in terms of topography, vegetation structure, habitat types, and degree of difficulty, and they were easily accessible. Three 50 m radius sample plots were defined in each trial site. The same areas were used for the scavenger removal trials (see below).

Selected trial sites were located at a distance of 500 to 1000 m from the windfarms:

1. **Site Mytoula** (located west of the windfarm Mytoula, within a radius of 500 m around the point 659750 E, 4550781 N, taken as the trial site point of reference).
2. **Site Mati - Geraki** (located approximately 500 m south-east of the windfarm Mati within a radius of approximately 700 m from the point of reference 658640 E, 4555316 N, on either side of the road just before the Mati wind turbines).
3. **Site Peltastis** (located 500 m to 1000 m southwest of the end of windfarm Peltastis within a radius of 700 m around the point 652025 E 4557884 N, following the hillcrest, after the last wind turbine).

Each of these sites simulated a small windfarm of three wind turbines with their respective 50 m radius plots as in the surveyed wind turbines. Each hypothetical wind turbine was represented by a stick or an existing tree. At each site, the distance between hypothetical wind turbines was at least 200 m. A specific number of dead birds, bird parts (e.g. one wing) or remains (e.g. feathers) was placed at random in each plot. These carcasses and remains were from birds previously found dead in the field (e.g. in roads due to collisions with cars) that had been kept frozen. Carcasses were also provided by the Hellenic Wildlife Hospital (ΕΚΠΑΖ) from birds deceased during their rehabilitation process. The number of carcasses, carcass parts and remains, as well as their position in the plot were unknown to the observers, who were asked to survey each plot as they did in the windfarms. All necessary permissions to carry out the trials were obtained from the relevant authorities.

Observers recorded the number of findings, the description of every finding, a good description of the position of the finding in relation to the hypothetical wind turbine and the time spent searching at each plot. Observers had no contact with each other during trials. At the end of the trials all carcasses were collected from each site.

The ability of observers to detect dead birds (ε) was calculated as the ratio of the number of carcasses detected to the total number of carcasses placed:

$$\varepsilon = \text{Number of carcasses detected} / \text{Number of carcasses placed}$$

We tested for effect of season on observers' efficiency using One Way ANOVA (Brown- Forsythe) (Field 2005).

3.3. Scavenger removal trials

This trial was applied in order to quantify the bias probably affecting estimates of raptor and vulture mortality rates due to carcass removal by scavengers. Potential scavengers present in the area are mammals such as foxes, wolves, dogs and mustelids but also birds. We aimed to quantify the removal rate of raptor and vulture carcasses from

scavengers at the windfarm areas using the same study sites as in 3.2 (see above). We assumed that the same type of scavengers present at the windfarms were found in our trial study sites, since these were close to the windfarms.
Scavenger removal rate was quantified using a known number of carcasses placed at the study area and checking each carcass for a certain period of time to record its removal from the area. Carcasses and carcass parts were placed randomly at the three sites, avoiding however positions conspicuous to humans (e.g. shepherds or hunters). Carcasses were left in place for one month (if not removed earlier by a scavenger) and checked on particular dates (see section 4.3). According to the condition in which carcasses where found each time, they were assignated a category out of five possible categories, as shown in Table 4.

Table 4. Categories assigned to carcass condition during the scavenger removal trials.

A = intact / in the same position as it was left
B = it was moved, but was still visible
C = it was "eaten-scavenged", but was still present and possible to be seen
D = disappeared with a few remains
E = completely disappeared

It is worth noting two things. First, “real” raptor carcasses were used instead of poultry or other non-native species to avoid overestimating the scavenging rate, as suggested by Kerlinger and Curry (1998). Second, the carcasses were not fresh but had been frozen, and therefore were expected to be more difficult to find and be less attractive to scavengers, maybe leading to an underestimation of the scavenging rate (Smallwood 2007).

Mean carcass removal time $(\bar{t})$ was calculated as the average length of time a carcass remained at the site before it was removed :

$$\bar{t} = \frac{\sum_{i-1}^{s} t_i}{s - s_c},$$

where t_i is the removal time of the *i*th carcass, *s* is the number of carcasses used in the trials, and s_c is the number of carcasses still remaining on day 30 of the trial. This estimator is the maximum likelihood estimator assuming the removal times follow an exponential distribution and there is right-censoring of data (Erickson *et al*. 2001, 2003). We collected any trial carcasses still remaining on day 30, yielding censored observations at 30 days.

We tested for effect of season and carcass size on the removal day using Kruskal-Wallis Test (Field 2005).

Standard errors (SE) and 90% confidence intervals (CI) of both the average time a carcass remained before being removed (*t*) and the observer efficiency (ε) were calculated by bootstrapping using 5.000 bootstrap iterations.

3.4. Mortality estimation based on carcass surveys

The total number *N* of avian fatalities was estimated for all birds of prey and for vultures in particular, with their respective variances, using the number of carcasses detected during the study period corrected for scavenger removal and observers' efficiency bias, i.e. the proportion of carcasses that remained in the study area during the scavengers' removal trials and the observers' efficiency rate. The following formula was applied:

$$N\text{-estimated} = Na*Cz*Cp*Ce,$$

where *Na* is the number of collision fatalities (carcasses) detected, *Cz* is the correction factor for search area (*Cz* = 100/z, where z is the the proportion of total surface that was actually searched), *Cp* is the correction factor for scavenging (*Cp* = 100/*p*, where *p* is the proportion of birds not removed by predators during the scavenging trials), *Ce* is the correction factor for search efficiency (*Ce* = 100/e, where e is the proportion of birds found by observers) (Everaert and Stienen 2007).

3.5. Surveys of space use by birds

We surveyed the space use by birds to estimate raptor utilization rates and to record the risk movements of the bird species of interest in each of the nine monitored wind farm sites. Risk movements were flights that occured within an area of 250 m radius around each wind turbine. Parameters were estimated using data from observations at particular View Points (hereafter VPs).

<u>Selection of View Points</u>

After an initial exploration, ten VPs were selected so that all wind turbines at the nine wind farms could be observed (Tables 5 and 6, Appendix II). To select VPs, existing limitations such as the availability of time and human resources, and the relief were accounted for and some priorities were set (e.g. more observation replications and fewer VPs). Location of VPs outside the wind farms with a good view to the surrounding area, short distances between VPs and wind turbines, and with a 180º view to the turbine were preferred to reduce potential disturbance effects of observers on birds. However, this was not always possible because of the limiting factors. Some VPs had a 360º view in order to observe all the turbines of the particular study plot, defined as the area observed by each VP (see below). Selected VPs also covered the area that was covered in the previous monitoring period (2004-2005). The distance between any VP and the respective turbines observed varied from a few meters up to 2500 m.

Table 5. Area of the study plots

Wind Farm	Total area of WF (ha)	Visible area (ha)
Peltastis	1336.16	107.81
Kerveros	1414.91	250.00
Monastiri	1443.60	112.50
Geraki	3036.07	381.25
Mati	788.42	17.19
Didimos Lofos	1210.90	181.25
Sapka	1308.72	175.00
Mytoula	2168.08	265.63
Soros	1335.36	203.13

The values of visible area were estimated by a combination of field and computer work. Observers represented the actual visible surface of every study plot on its map, then digitalized the information using a GIS programme, which finally was used to generate the visible hectars.

Table 6. Description of VPs

View Point Code	Site	WT observed	GPS E	GPS N
VP1	Sapka	X1, X2, X3, X5, (X4 not with a very good view)	662618	4559361
VP2	Didimos Lofos	D1, D2, D3, D4, D5, D6, D7, D8	661611	4558668
VP3	Geraki1	T1-T17	654848	4560580
VP4	Geraki2	T19-T32	656706	4557792
VP5	Kerveros - Geraki - Mati	MA1, MA2, MA3, T33-T42, K1-K10	656417	4554932
VP6	Peltastis - Kerveros	P1-P10, K11-K14	654840	4557507
VP7	Mytoula	M1-M7	661600	4551047
VP8	Soros - Mytoula	S1-S10, M8-M19	663817	4549755
VP9	Soros	S11, S12, S13	664999	4547910
VP10	Monastiri	MO1-MO13	649805	4562921

Observations

The area observed by each VP defined an individual study plot. Each study plot comprised a specific number of wind turbines and the adjacent landscape, and was illustrated on a map (Appendix III), including the respective wind turbines to be observed. Study plots were not of equal size and their size depended on the number of wind turbines that they comprised. A second plot called “the turbine study plot” was nested within each study plot. A turbine study plot was defined as the sum of all 250 m radius circles surrounding wind turbines in the individual study plot, with each turbine as the centre of each 250 m circle.

Study plots were observed continuously for five hours and any interruption was recorded on the data sheets, indicating both the cause and the duration in minutes. The observers used 10x42 binoculars to scan circularly the wind turbines and the slopes included in the study plot. Both study plots and turbine study plots were used to collect data on the utilization rates of the area by target species including raptors, vultures, corvids, storks and other large size birds. In addition, turbine study plots were used to record data relative to the interactions of the birds with the turbines. These data were collected whenever a bird was observed flying within less than 250 m from the turbines (although this does not mean that there are no interactions when a bird flies further).

The following data were recorded by observers on each day of observation: date, code and name of VP, observers' names, start and end time of observation, as well as causes of potential interruption and duration in minutes. Observers then recorded data by entering alpha-numeric codes onto a standardized data sheet and onto the map of the corresponding plot (Appendix III) that illustrated all turbines in the plot and their identification numbers (Thelander and Rugge 1998, Lekuona 2007).

During an observation event:

- When a bird was sighted, it was tracked continuously from the time it entered the study plot until it departed or observers lost sight of it.
- The event was entered into the data sheet using an individual **numeric code**.
- The flight of the bird was drawn on the respective map, showing the direction of its trajectory and using the same code previously used in the data sheet.
- Observers recorded the following data:
  - **Start time** (the time of initial detection of the bird in the study plot, accurate to minutes).
  - **End time** (the time that the bird departed from the study plot or was lost by the sight of the observers, accurate to minutes. Consequently, the minimum time considered to be spent within the study plot was, in any case, one minute).
  - **Species** (if identification was not possible, the most detailed description or characterisation was recorded).
  - **Sex**
  - **Status** (when possible to distinguish local flights from other flights (i.e. migration flights), status was recorded)
  - **Number of individuals,** if more birds were seen flying together.
  - **Initial distance** to observers in meters (the distance between the bird and the observers at the moment that the bird was initially detected – the map helped to estimate this distance).
  - **The closest distance to observers** in meters
  - **Height above the ground** (an estimation of the flight height of the bird, which described the general impression of the observers about the overall flight in relation to the land surface).
  - **Activity type**

Data were always recorded on the first of the data sheets (Appendix IVa), whenever there was an observation event. If a bird was observed flying within the turbine study plot (i.e. at a distance 250 m or less from the wind turbines), observers collected the following second set of data (Appendix IVb) in relation to the interaction of the bird with the turbines:

- For the same event, **the same numeric code** as in the study plot page
- The **duration of the presence** of the bird in the turbine study plot in minutes (consequently, the minimum time considered was, in any case, one minute).
- The **distance of the bird to the nearest turbine** in meters.
- The **operational status** of the nearest turbine and the duration of its rotation in seconds.
- The **flight height of the bird** at its nearest distance to the turbine estimated in relation to the pylon of the turbine, e.g. flight height = 1.5 pylons.
- The **type of interaction** of the bird with the turbines. The following cases were defined:
    1. **No interaction**.
    2. The bird was **flying parallel** to the turbines or it came close to a turbine but it **did not cross** the turbines.
    3. The bird **crossed between two turbines** (or one if it was the last turbine in the plot).
    4. The bird **crossed the turbines but flied much higher** than the height of the turbines (> 2 pylons).
    5. The bird **crossed through the blades** of a turbine.
- Every time there was an interaction of the bird with the turbine, the **reaction** of the bird was recorded.
- A measurement of the **wind** was taken at the time of interaction.

Weather data were also recorded every 30 minutes on each observation day, using a manual anemometer Kestrel 3000 (Appendix IVc):

- Wind speed (average and maximum in m/sec)
- Wind direction (N, NE, E, SE, S, SW, W, NW, N)
- Temperature (ºC)
- Visibility
- Cloud cover (%)
- Fog presence (Yes/No)
- Relative humidity (%)

Observations were usually carried out twice per week: one day two observers conducted observations from two VPs and the second day three observers conducted observations from three VPs (each observer was placed on a single VP on either day). If the weather conditions allowed all VPs were visited in two weeks, completing one round of observations at all nine wind farms. Each study plot was surveyed the same number of times.

Observation times were rotated in order to cover all the daylight hours. Each study plot was visited once in the morning and the next time in the afternoon. During June, July, August, September and October 2008, and April, May and June 2009, the morning observations were carried out from 8:00 to 13:00 and the afternoon observations from 12:00 to 17:00. During the winter months (when daylight is shorter and weather conditions are different, e.g. fog in the early morning hours), observation times changed to 9:00 – 14:00 and 11:00 – 16 00, respectively.

Based on experience, the Scottish Natural Heritage (2005) recommends that a survey period of 36 hours at every VP and over each season (breeding, non-breeding, migratory) is a reasonable minimum for raptors. In our study, observers surveyed space use by birds during 205 mandays or 942 hours in total (Tables 7 and 8).

Table 7. Time spent at each of the ten VPs

View Point	Total time spent (hours:minutes)	Breeding season (Jan – Aug)	Non breeding season (Sept – Dec)
VP01	102:10	69:35	32:35
VP02	92:35	70:00	22:35
VP03	81:15	52:52	28:23
VP04	79:28	53:56	25:32
VP05	129:04	89:04	40:00
VP06	102:45	70:00	32:45
VP07	93:20	63:30	29:50
VP08	96:32	63:27	33:05
VP09	82:00	58:15	23:45
VP10	83:00	55:30	27:30
Total	**942:09**	**646:09**	**296:00**

During the monitoring of 2008-2009, more VPs were used to survey part of the area surveyed during the monitoring of 2004-05. This implies that, in absolute terms, the total time devoted to survey the common monitoring area was larger in 2008-2009 than in 2004-2005 (Table 8). However, these differences are reduced when times are seen at the scale of wind farms, and not VPs (the time spent monitoring a wind farm with two VPs is not the sum of both times, but the average of both times; as you don't see the whole wind farm from each single VP, but they complement each other).

Table 8. Comparison of the absolute times spent during 2004-2005 and 2008-2009 in areas monitored during both monitoring periods

	LWF (Peltastis and Geraki)					SWF (Soros)			Sapka
2004/05	VP 1		VP 2		Total	VP 1	VP 2	Total	VP 1
Time spent	91:58		82:19		**174:17**	103:59	99:39	**203:38**	**43:09**
2008/09	VP04	Part of VP05	Part of VP06	Part of VP03	Total	VP08	VP09	Total	VP01
Time spent	79:28	129:04	102:45	81:15	**392:32**	96:32	82:00	**178:32**	**102:10**

Two indices of avian space use were calculated: the crossing densities index and the bird use index. First, crossing densities were calculated. The crossing density reflects the density of birds crossing the space between turbines, expressed by bird individuals per 100 meters and 100 hours. Crossing densities were also calculated in the first monitoring period (Ruiz *et al*. 2005), making comparisons of the values from both periods possible. Comparisons were performed using the Mann-Whitney statistical test (Field 2005). Crossing densities were also tested against several wind farm characteristics, in order to detect potential correlations. In that case, Spearman correlation analysis was used (data were non-normally distributed) to relate geomorphological and wind turbine site variables with birds' crossing densiies. Geomorphological variables included slope (in degrees) and aspect, which is to say eastness (aspect-sine transformation, from -1 to +1) and northness (aspect-cosine transformation, from -1 to +1) (Poirazidis *et al*. 2004, Poniatowski & Fartmann 2008). The wind turbine site variable was the distance between two neighbouring wind turbines (in meters) (see Appendix IX). Aspect and slope (in degrees) were derived from 30 m DEM using a GIS programme (ArcMap 9.3). These variables were measured in the following way:

1. For every gap between any two neighbouring wind turbines, two square sampling plots were considered, to the left and the right side of the ridge where both turbines were considered, with direction from the first wind turbine to the last one. The width of each square sampling plot was the distance between the two corresponding wind turbines.
2. Inside these square plots, points at 30 m distance between them were systematically located.
3. The cell values of the raster (aspect, slope) were extracted based on the previous set of points for each square plot.
4. The average of the points' values was taken for every square plot and for every geomorphological variable to the final analysis.

Distances between two neighbouring wind turbines (in meters) were measured using ArcMap 9.3.

Second, the bird use index was calculated. Bird use index was defined as the number of hours a species was flying in the wind farm area per hours of monitoring. Three buffer zones were defined around each wind turbine: 250, 500 and 1500 m distance from the turbine. Merging the buffers around all wind turbines of every wind farm resulted in three buffers of 250, 500 and 1500 m around the wind farm respectively. Bird use indices were also calculated for the 2004-2005 study allowing comparisons between the two monitoring periods to see if there were any changes after four years.

The bird use index was calculated using ArcMap 9.3, where all flight trajectories recorded had been digitalized. To extrapolate the time every individual spent in each specific buffer zone, two basic assumptions were made: the observers recorded the flights on the map in the most accurate way and birds moved with a constant speed. As the total time of each flight and the total length and the lengths of the flight trajectories in each buffer zone were known, the time spent in each buffer zone could be calculated.

Finally, data from all VPs were aggregated to show the monthly numbers of observations and individuals, and the monthly rates of observations (number of observations/hour) and monthly rates of individuals (number of individuals/hour) recorded during both periods. Because data were not normally distributed, we used the non-parametric Kruskal–Wallis tests to analyse annual and seasonal differences in average monthly numbers of observations and individuals, as well as observation and flying rates (Sokal and Rohlf 1981, Field 2005, Farfán *et al*. 2009).

4. RESULTS AND DISCUSSION

4.1. Carcass surveys

Observers carried out carcass surveys over a total of 106 days, completing 319 hours of searches. Average searching time per day was three hours. Each wind farm was searched between 24 and 27 times in total.

Overall, 24 animal carcasses were found between June 2008 and July 2009. Two more birds found outside the systematic carcass searches were included in the list. Five carcasses belonged to the target species, while 11 of them were other birds and 8 were bats (Table 9).

Table 9. Detected carcasses: Falconiformes, other birds, and bats

Species	Description	Date	Windfarm	Nearest turbine	Distance to nearest turbine
Falconiformes					
Griffon Vulture (*Gyps fulvus*)	Cut in two pieces: wing and rest of the body	20/05/08	Kerveros	K1	Wing: 13 m Body: 34.5 m
Griffon Vulture	Cut in two pieces: Legs and tail and rest of the body	29/05/08	Geraki	T32	Legs & tail: 49.70 m Rest of body: 25 m
Booted Eagle (*Hieraaetus pennatus*)	Broken wing	04/07/08	Geraki	T36	35 m
Griffon Vulture	Injured wing, at the shoulder	30/09/08	Geraki	T1	1.6 km
Griffon Vulture	PVC ring (G05)	06/07/09	Soros	S10	18 m
Other birds					
Sand martin (*Riparia riparia*)	Intact - scavenged	14/08/08	Geraki	T35	12 m
Crested Lark (*Galerida cristata*)	Intact	30/09/08	Soros	S10	15.30 m
Chaffinch (*Fringilla coelebs*)	Portion: wings, feathers, bones	29/10/08	Mytoula	M19	43.50 m
Blackbird (*Turdus merula*)	Portion	12/11/08	Mytoula	M2	22 m
Crested Lark	Whole body	30/01/09	Sapka	X2	25.30 m
Chaffinch (*Fringilla coelebs*)	Whole body	06/02/09	Peltastis	P3	19.50 m
Ferruginous Duck (*Aythya nyroca*)	Only eyes missing	12/03/09	Monastiri	M1	19.25 m
Meadow Pipit (*Anthus pratensis*)	Intact, injured neck	13/04/09	Geraki	T33	27.55 m
Hoopoe (*Upupa epops*)	Feathers, beak	28/04/09	Geraki	T33	No data
Chukar (*Alectoris chukar*)	Whole body, intact	28/04/09	Sapka	X3	No data
Hawfinch (*Coccothraustes coccothraustes*)	Broken neck	26/06/09	Didimos Lofos	D01	10.40 m
Bats					
Whiskered Bat *(Myotis mystacinus)*	No data	08/07/08	Mytoula	M9	25 m

Bat sp.	Intact	05/09/08	Peltastis	P2	13 m
Bat sp.	Intact	5/09/08	Peltastis	P9	3 m
Bat sp.	Broken wing	16/09/08	Kerveros	K14	28.90 m
Bat sp.	Intact	25/05/09	Sapka	X2	6.10 m
Common Pipistrelle *(Pipistrellus pipistrellus)*	Intact	30/05/09	Peltastis	P1	7 m
Lesser Noctule *(Nyctalus leisleri)*	Intact	08/06/09	Peltastis	P1	10 m
Savi's Pipistrelle *(Hypsugo savii)*	No data	19/06/09	Kerveros	K11	15.6 m

The Griffon Vulture detected on 29/05/08 was found in two pieces. The first piece (head, wings and half body) was 25 m away from the turbine pylon (in an obvious position on the plate) and it was gone the next time observers scanned the area (20/06/2008, three days after the systematic search began). The second piece (half body, legs and tail) was found 49.7 m away, in a less obvious position, and it remained there for at least three and a half more months. The decision was taken of leaving the remains as they were found and not following the protocol indicated in such cases. It was considered that extra data of high interest regarding observers' detection and scavenger activity could be collected, which only a real event like this could offer.

The last two Griffon Vulture observations were made under special circumstances. The vulture found on the 30/09/08 was 1.6 km away from the nearest wind turbine, at an altitude around 200 m lower than the turbine. Toxicological tests were run and X-ray plaques obtained, and the results led to the conclusion that collision was the cause of death. On the 06/07/09 a colour plastic ring was found semi-buried in the plate under wind turbine S10, with signs of having been pressed by something heavy (such as a car) against the soil, being broken into four pieces. It was highly unlikely that a Griffon Vulture landed on the plate simply losing its ring, so the incident was considered as a result of collision with the turbine.

Three out of four Griffon Vultures individuals were adults, and only the vulture found on the 30/09/08 was immature. This is a small sample to draw clear conclusions, but it has to be taken into account that a high adult mortality may severely affect the population dynamics of a long-lived species such as the Griffon Vulture, leading to a decline in the population growth rate.

Fig. 2 Lesser Noctule found on 08/06/09

Fig. 3 Booted Eagle found on 04/07/08

4.2. Observers’ detection trials

4.2.1. Observers’ detection trials, August 2008

In the summer 2008, trials were carried out on the 23^{rd}, 24^{th} and 25^{th} of August. The first day (23/8) the trial was conducted at the site Mytoula, the second day (24/8) at Mati-Geraki and the third day (25/8) at Peltastis. In these first trials, all the observers (coded as A, B, C, D, E, Table 11) participating in the carcass searches in June, July, August and early September were tested. We used 23 carcasses, mainly parts and remains from Black Vultures (Table 10). Detection rates among observers ranged from 39.1% to 65.2% (Table 11).

Table 10. Distribution of carcasses during observers’ detection trials in the summer of 2008.

Date	Site	WT code	Record number of carcass or parts	Description of carcass/ carcass parts
23/08/08	Mytoula	M1	1	One Black Vulture wing
23/08/08	Mytoula	M2	2	One Black Vulture wing
23/08/08	Mytoula	M2	3	One Common Buzzard (*Buteo buteo)*
23/08/08	Mytoula	M3	4	Tail and legs of Black Vulture
23/08/08	Mytoula	M3	5	One Carrion Crow (*Corvus corone)*
24/08/08	Mati-Geraki	T1	1	One Black Vulture wing
24/08/08	Mati-Geraki	T1	2	Remains of a Little Owl (*Athene noctua*)
24/08/08	Mati-Geraki	T1	3	One Common Buzzard
24/08/08	Mati-Geraki	T3	4	Feathers and bones of Black Vulture
24/08/08	Mati-Geraki	T3	5	One Carrion Crow
24/08/08	Mati-Geraki	T3	6	One Black Vulture wing
24/08/08	Mati-Geraki	T3	7	Feathers, legs and bones of Black Vulture
25/08/08	Peltastis	P1	1	One Carrion Crow
25/08/08	Peltastis	P1	2	One Black Vulture wing
25/08/08	Peltastis	P1	3	One Black Vulture wing
25/08/08	Peltastis	P1	4	One Long-legged Buzzard (*Buteo rufinus)*
25/08/08	Peltastis	P1	5	Feathers of Black Vulture
25/08/08	Peltastis	P1	6	One Swallow (*Hirundo rustica*)
25/08/08	Peltastis	P2	7	One Griffon Vulture with one wing missing
25/08/08	Peltastis	P2	8	One Griffon Vulture wing
25/08/08	Peltastis	P2	9	Feathers of Black Vulture
25/08/08	Peltastis	P2	10	One Kestrel (*Falco tinnunculus)*
25/08/08	Peltastis	P2	11	One Chaffinch

Table 11. Results of observers' detection trials in summer 2008. For each site and observer, the number of carcasses found to the total number of carcasses and the time spent searching is given.

Observer	Mytoula	Mytoula time	Mati-Geraki	Mati-Geraki time	Peltastis	Peltastis time	Total detection success (%)
A	4/5	57 min.	5/7	57 min.	6/11	43 min.	**65.2**
B	2/5	No data	6/7	57 min.	5/11	47 min.	**56.5**
C	4/5	75 min.	3/7	40 min.	5/11	60 min.	**52.2**
D	3/5	60 min.	2/7	65 min.	4/11	60 min.	**39.1**
E	3/5	46 min.	5/7	52 min.	5/11	63 min.	**56.5**

4.2.2. Observers' detection trials, November 2008

The autumn 2008 trials were conducted on the 8th, 9th and 10th of November. Trials were conducted at the same three sites where the summer trials were conducted. In this trial all observers that participated in carcass searches during September, October and November were tested: A (second participation), B (second participation), C (second participation), D (second participation), F (first participation), and G (first participation). This time we used 28 carcasses (Table 12). Detection rates among observers ranged from 50.0% to 82.1% (Table 13).

Table 12. Distribution of carcasses during the autumn 2008 observers' detection trials.

Date	Site	WT code	No of carcass /c.part	Description
08/11/08	Mytoula	M1	1	One Black Vulture wing
08/11/08	Mytoula	M1	2	Feathers and bones of Black Vulture
08/11/08	Mytoula	M1	3	One Black Vulture wing
08/11/08	Mytoula	M2	4	One Griffon Vulture wing
08/11/08	Mytoula	M2	5	One Griffon Vulture with one wing missing
08/11/08	Mytoula	M2	6	Feathers, legs and bones of Black Vulture
08/11/08	Mytoula	M2	7	One Black Vulture wing
08/11/08	Mytoula	M3	8	Feathers and dry body of Little Owl
08/11/08	Mytoula	M3	9	Feathers, bones and a foot of Black Vulture
08/11/08	Mytoula	M3	10	One Black Vulture wing
09/11/08	Peltastis	P1	1	Feathers and bones of Black Vulture
09/11/08	Peltastis	P1	2	Feathers and bones of Black Vulture
09/11/08	Peltastis	P1	3	One Black Vulture wing
09/11/08	Peltastis	P1	4	One Griffon Vulture with one wing missing
09/11/08	Peltastis	P2	5	One Black Vulture wing
09/11/08	Peltastis	P2	6	One Black Vulture wing
09/11/08	Peltastis	P2	7	One Griffon Vulture wing
9/11/08	Peltastis	P2	8	One Black Vulture wing
09/11/08	Peltastis	P2	9	Feathers and bones of Black Vulture
10/11/08	Mati-Geraki	T1	1	One Black Vulture wing
10/11/08	Mati-Geraki	T1	2	Feathers, bones and a foot of Black Vulture
10/11/08	Mati-Geraki	T1	3	One Black Vulture wing
10/11/08	Mati-Geraki	T1	4	One Griffon Vulture wing
10/11/08	Mati-Geraki	T2	5	One Black Vulture wing

10/11/08	Mati-Geraki	T2	6	Feathers and bones of Black Vulture
10/11/08	Mati-Geraki	T2	7	Feathers and bones of Black Vulture
10/11/08	Mati-Geraki	T2	8	One Griffon Vulture with one wing missing
10/11/08	Mati-Geraki	T3	9	Feathers and bones of Black Vulture

Table 13. Results of the autumn 2008 observers' detection trials. For each site and observer, the number of carcasses found to the total number of carcasses and the time spent searching is given.

Observer	Mytoula	Mytoula time	Mati-Geraki	Mati-Geraki time	Peltastis	Peltastis time	Total detection success (%)
A	5/10	44 min.	8/9	53 min.	8/9	54 min.	**75.0**
B	6/10	40 min.	6/9	43 min.	4/9	41 min.	**57.1**
C	8/10	30 min.	8/9	55 min.	7/9	40 min.	**82.1**
D	5/10	41 min.	6/9	60 min.	5/9	65 min.	**57.1**
F	7/10	40 min.	4/9	33 min.	3/9	? min.	**50.0**
G	5/10	41 min.	4/9	34 min.	8/9	41 min.	**60.7**

4.2.3. Observers' detection trials, March 2009

The winter 2008-2009 trials were conducted on the 13th, 14th and15th of March 2009. This third round of trials should have been run in February 2009, but extreme weather conditions (snow and very low temperatures) impeded the normal course of the programme leading to a delay. Ttrials were conducted at the same three sites. Almost all observers participating in carcass searches in December 2008 and January, February and March 2009 were tested: C (third participation), G (second participation), H (first participation) and I (first participation). In total, we used 35 carcasses (Table 14). Detection rates among observers ranged from 65.7% to 91.4% (Table 15).

Table 14 Distribution of carcasses during the winter 2008-2009 observers' detection trials

Date	Site	WT code	No of carcass /c.part	Description
13/03/09	Mytoula	M1	1	A partially decomposed Golden Eagle (*Aquila chrysaetos*)
13/03/09	Mytoula	M1	2	One Black Vulture wing
13/03/09	Mytoula	M1	3	One Goshawk (*Accipiter gentilis*)
13/03/09	Mytoula	M1	4	Feathers, bones and a foot of Black Vulture
13/03/09	Mytoula	M2	5	One Griffon Vulture
13/03/09	Mytoula	M2	6	One Griffon Vulture wing
13/03/09	Mytoula	M2	7	One Sparrowhawk (*Accipiter nisus*)
13/03/09	Mytoula	M2	8	One Common Buzzard
13/03/09	Mytoula	M2	9	One Black Vulture wing
13/03/09	Mytoula	M3	10	One Common Buzzard
13/03/09	Mytoula	M3	11	One Black Kite (*Milvus migrans*)
13/03/09	Mytoula	M3	12	Feathers and bones of Black Vulture
13/03/09	Mytoula	M3	13	One Black Vulture wing
14/03/09	Peltastis	P1	1	Feathers and bones of Black Vulture
14/03/09	Peltastis	P1	2	One Griffon Vulture

14/03/09	Peltastis	P1	3	One Black Vulture wing
14/03/09	Peltastis	P1	4	Feathers, bones and a foot of Black Vulture
14/03/09	Peltastis	P2	5	One Black Kite
14/03/09	Peltastis	P2	6	One Common Buzzard
14/03/09	Peltastis	P2	7	Feathers and bones of Black Vulture
14/03/09	Peltastis	P3	8	One Griffon Vulture wing
14/03/09	Peltastis	P3	9	One Common Buzzard
14/03/09	Peltastis	P3	10	One Sparrowhawk
14/03/09	Peltastis	P3	11	One Black Vulture wing
14/03/09	Peltastis	P3	12	One Goshawk
15/03/09	Mati-Geraki	T1	1	One Common Buzzard
15/03/09	Mati-Geraki	T1	2	One Griffon Vulture wing
15/03/09	Mati-Geraki	T1	3	One Goshawk
15/03/09	Mati-Geraki	T2	4	One Griffon Vulture
15/03/09	Mati-Geraki	T2	5	Feathers, bones and a foot of Black Vulture
15/03/09	Mati-Geraki	T2	6	One Sparrowhawk
15/03/09	Mati-Geraki	T2	7	One Black Vulture wing
15/03/09	Mati-Geraki	T2	8	One Common Buzzard
15/03/09	Mati-Geraki	T3	9	One Black Vulture wing
15/03/09	Mati-Geraki	T3	10	One Black Kite

Table 15 Results of the winter 2008-2009 observers' detection trials. For each site and observer, the number of carcasses found to the total number of carcasses and the time spent searching is given.

Observer	Mytoula	Mytoula time	Mati-Geraki	Mati-Geraki time	Peltastis	Peltastis time	Total detection success (%)
G	8/13	42 min.	7/10	31 min.	9/12	38 min.	**68.6**
C	12/13	26 min. 30 sec	9/10	33 min. 16 sec.	11/12	30 min. 40 sec.	**91.4**
H	10/13	1 h 20 min.	9/10	54 min.	12/12	46 min.	**88.6**
I	10/13	52 min.	6/10	41 min.	7/12	34 min.	**65.7**

4.2.4. Observers' detection trials, May 2009

Spring 2009 trials were conducted on the 29th, 30th of May and 3rd of June 2009 at the same three sites. In these trials all observers participating in carcass searches in March, April and May 2009 were tested: C (fourth participation), G (third participation), H (second participation), I (second participation), J (first participation) and K (first participation). In total, we used 34 carcasses (Table 16). The detection rates among observers ranged from 63.6% to 70.8% (Table 17).

Table 16 Distribution of carcasses during the spring 2009 observers' detection trials

Date	Site	WT code	No of carcass/ c.part	Description
29/05/2009	Mytoula	M1	1	One Griffon Vulture
29/05/2009	Mytoula	M1	2	One Sparrowhawk
29/05/2009	Mytoula	M1	3	One Common Buzzard
29/05/2009	Mytoula	M2	4	Feathers and bones of Black Vulture
29/05/2009	Mytoula	M2	5	One Common Buzzard
29/05/2009	Mytoula	M2	6	One Black Kite
29/05/2009	Mytoula	M2	7	A partially decomposed Golden Eagle
29/05/2009	Mytoula	M3	8	One Common Buzzard without a wing
29/05/2009	Mytoula	M3	9	Feathers, bones and a foot of Black Vulture
29/05/2009	Mytoula	M3	10	One Black Vulture wing
30/05/2009	Peltastis	P1	1	One Griffon Vulture
30/05/2009	Peltastis	P1	2	One Common Buzzard
30/05/2009	Peltastis	P1	3	One Black Vulture wing
30/05/2009	Peltastis	P2	4	One Common Buzzard without a wing
30/05/2009	Peltastis	P2	5	Feathers, bones and a foot of Black Vulture
30/05/2009	Peltastis	P2	6	A partially decomposed Golden Eagle
30/05/2009	Peltastis	P2	7	One Black Vulture wing
30/05/2009	Peltastis	P3	8	One Common Buzzard
30/05/2009	Peltastis	P3	9	Feathers and bones of Black Vulture
30/05/2009	Peltastis	P3	10	One Sparrowhawk
30/05/2009	Peltastis	P3	11	One Black Kite
30/05/2009	Peltastis	P3	12	One Black Vulture wing
03/06/2009	Mati-Geraki	T1	1	One Common Buzzard without a wing
03/06/2009	Mati-Geraki	T1	2	One Black Vulture wing
03/06/2009	Mati-Geraki	T1	3	A partially decomposed Golden Eagle
03/06/2009	Mati-Geraki	T1	4	Feathers, bones and a foot of Black Vulture
03/06/2009	Mati-Geraki	T2	5	One Black Vulture wing
03/06/2009	Mati-Geraki	T2	6	One Griffon Vulture
03/06/2009	Mati-Geraki	T2	7	One Black Kite
03/06/2009	Mati-Geraki	T2	8	One Black Vulture wing
03/06/2009	Mati-Geraki	T3	9	Feathers and bones of Black Vulture
03/06/2009	Mati-Geraki	T3	10	One Sparrowhawk
03/06/2009	Mati-Geraki	T3	11	One Common Buzzard
03/06/2009	Mati-Geraki	T3	12	One Black Vulture wing

Table 17 Results of the spring 2009 observers' detection trials. For each site and observer, the number of carcasses found to the total number of carcasses and the time spent searching is given.

Observer	Mytoula	Mytoula time	Mati-Geraki	Mati-Geraki time	Peltastis	Peltastis time	Total detection success (%)
G	8/10	30 min	7/12	30 min	7/12	21 min	**64.7**
C	-	-	8/12	19 min 45 sec	9/12	31 min	**70.8**
H	7/10	44 min	9/12	46 min	8/12	43 min	**70.6**
I	9/10	38 min	8/12	39 min	6/12	44 min	**67.6**
J	8/10	40 min	-	-	6/12	38 min	**63.6**
K	-	-	8/12	49 min	-	-	**66.7**

Overall detection ability was then calculated for all four seasons and for every observer participating in the carcass searches (Table 18).

Table 18 Results of overall detection ability by observer. For each season and observer, the number of carcasses found to the total number of carcasses is given.

Observer	Summer 2008	Autumn 2008	Winter 2008/09	Spring 2009	Total	Total (ε)	Total (%)
A	15/23	21/28			36/51	0.71	70.6
B	13/23	16/28			29/51	0.57	56.9
C	12/23	23/28	32/35	17/24	84/110	0.76	76.4
D	9/23	16/28			25/51	0.49	49.0
E	13/23				13/23	0.57	56.5
F		14/28			14/28	0.50	50.0
G		17/28	24/35	22/34	63/97	0.65	64.9
H			31/35	24/34	55/69	0.80	79.7
I			23/35	23/34	46/69	0.67	66.7
J				14/22	14/22	0.64	63.6
K				8/12	8/12	0.67	66.7
Total	62/115	107/168	110/140	108/160	-	-	-

We placed a total of 120 carcasses for observer detection trials, distributed in four seasons. Total observer efficiency, expressed as the proportion of detected carcasses, was ε = 0.66 [SE(ε) = 0.027, CI 90%: 0.61-0.70]. No observer was able to detect more than 80% of the total of carcasses (Fig. 4). Total detection ability was also expressed by season (Table 18). Vegetation cover and structure at the trial sites changed with season and we wanted to check for an effect of these changes on the capacity of observers to detect carcasses. Athough season had a significant effect on observer efficiency (F_{BF} = 4.39, d.f.=3,17, $p < 0.05$, $\omega = 0.35$), this was not pronounced in the post hoc tests.

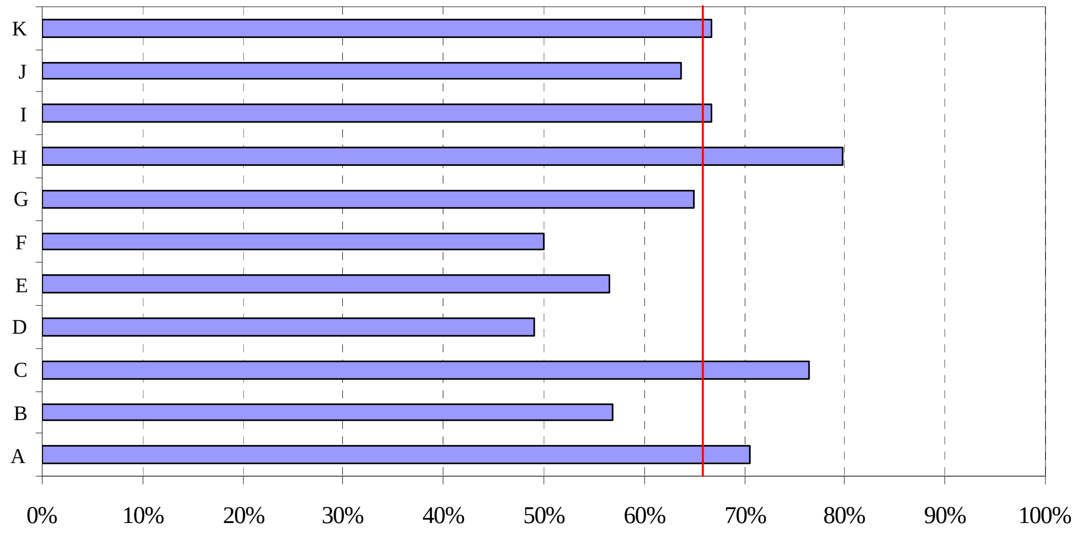


Fig. 4 Total detection ability by observer

Fig. 5 Preparing the Observers' detection trials

Fig. 6 View of the trial site at Mytoula

4.3. Scavenger removal trials

4.3.1.Scavenger removal trial, August 2008

The summer trial was conducted from the 25th of August to the 24th of September 2008. Two to three carcasses or carcass parts were placed at each of the study sites (Table 19) on 25/8/2008 (day 0). Sites were subsequently checked for remaining carcasses or carcass parts on the following dates: 26/8 (day 1), 27/8 (day 2), 28/8 (day 3), 29/8 (day 4), 1/9 (day 7), 8/9 (day 14), 14/9 (day 20), 24/9 (day 30) (Tables 20, 21 and 22).

Table 19. Distribution of carcasses or carcass parts during the summer 2008 scavenger removal trials

Site	No of carcass or carcasse piece	Description
Peltastis	1	One Long-legged Buzzard without head
Peltastis	2	One Black Vulture wing
Mati-Geraki	3	One Common Buzzard
Mati-Geraki	4	One Carrion Crow
Mati-Geraki	5	One Kestrel
Mytoula	6	One Black Vulture wing
Mytoula	7	One Common Buzzard

Table 20. Results of the summer 2008 scavenger removal trials in Peltastis

Site	Checking day	Date	Long-legged Buzzard	One Black Vulture wing
Peltastis	0	25/08/08	A	A
Peltastis	1	26/08/08	A	A
Peltastis	2	27/08/08	A	A
Peltastis	3	28/08/08	A	A
Peltastis	4	29/08/08	A	B
Peltastis	7	01/09/08	A	B
Peltastis	14	08/09/08	B	E
Peltastis	20	15/09/08	B	-
Peltastis	30	24/09/08	E	-

A = intact / in the same position as it was left
B = it was moved, but was still visible
C = it was "eaten-scavenged", but was still present and possible to be seen
D = disappeared with a few remains
E = completely disappeared

Table 21. Results of the summer 2008 scavenger removal trials in Mati-Geraki

Site	Checking day	Date	Common Buzzard	Carrion Crow	Kestrel
Mati-Geraki	0	25/08/08	A	A	A
Mati-Geraki	1	26/08/08	A	A	A
Mati-Geraki	2	27/08/08	A	A	A
Mati-Geraki	3	28/08/08	A	A	A

Mati-Geraki	4	29/08/08	A	A	A
Mati-Geraki	7	01/09/08	A	E	A
Mati-Geraki	14	08/09/08	A	-	D
Mati-Geraki	20	15/09/08	B	-	D
Mati-Geraki	30	24/09/08	B	-	D

A = intact / in the same position as it was left
B = it was moved, but was still visible
C = it was "eaten-scavenged", but was still present and possible to be seen
D = disappeared with a few remains
E = completely disappeared

Table 22. Results of the summer 2008 scavenger removal trials in Mytoula

Site	Checking day	Date	One Black Vulture wing	Common Buzzard
Mytoula	0	25/08/08	A	A
Mytoula	1	26/08/08	A	A
Mytoula	2	27/08/08	A	A
Mytoula	3	28/08/08	A	A
Mytoula	4	29/08/08	A	A
Mytoula	7	01/09/08	D	C
Mytoula	14	08/09/08	D	E
Mytoula	20	15/09/08	D	-
Mytoula	30	24/09/08	D	-

A = intact / in the same position as it was left
B = it was moved, but was still visible
C = it was "eaten-scavenged", but was still present and possible to be seen
D = disappeared with a few remains
E = completely disappeared

All carcasses were still present in their place for at least one week (Table 23).

Table 23. Overall results of the summer 2008 scavenger removal trials at the three study sites

Site	Carcass	Remaining days
Peltastis	Long-legged Buzzard	30
Peltastis	One Black Vulture wing	14
Mati Geraki	Common Buzzard	30
Mati Geraki	Carrion Crow	7
Mati Geraki	Kestrel	14
Mytoula	One Black Vulture wing	7
Mytoula	Common Buzzard	14

4.3.2. Scavenger removal trial, November 2008

The trial was conducted from the 11th of November 2008 to the 11th of December 2008. Due to lack of available carcasses, the trial was conducted at only one of the three trial sites, Peltastis. Three carcasses were placed at the study site on 11/11/2008 (day 0) and were checked on the following dates: 12/11/2008 (day 1), 13/11/2008 (day 2), 14/11/2008 (day 3), 15/11/2008 (day 4), 18/11/2008 (day 7), 25/11/2008 (day 14), 2/12/2008 (day 20) and 11/12/2008 (day 30) (Table 24).

The following carcasses were used:

1. One Long-legged Buzzard
2. One Common Buzzard
3. One Golden Eagle

Table 24. Results of the autumn 2008 scavenger removal trial in Peltastis

Site	Checking day	Date	Long-legged Buzzard	Common Buzzard	Golden Eagle
Peltastis	0	11/11/08	A	A	A
Peltastis	1	12/11/08	A	A	A
Peltastis	2	13/11/08	A	A	A
Peltastis	3	14/11/08	E	B	A
Peltastis	4	15/11/08	-	B	A
Peltastis	7	18/11/08	-	B	A
Peltastis	14	25/11/08	-	E	B
Peltastis	20	02/12/08	-	-	B
Peltastis	30	11/12/08	-	-	D

A = intact / in the same position as it was left
B = it was moved, but was still visible
C = it was "eaten-scavenged", but was still present and possible to be seen
D = disappeared with a few remains
E = completely disappeared

Carcasses at Peltastis remained between 3 and 30 days (Table 25).

Table 25 Overall **r**esults of the autumn 2008 scavenger removal trials at Peltastis

Site	Carcass	Remaining days
Peltastis	Long-legged Buzzard	3
Peltastis	Common Buzzard	14
Peltastis	Golden Eagle	30

4.3.3. Scavenger removal trial,March 2009

The trial was conducted from the 16th of March 2009 to the 15th of April 2009. As in the searcher efficiency winter trial, the winter scavenger removal trial could not be conducted in February 2009 as originally planned, because of extreme weather conditions (snow and very low temperatures) that impeded the normal course of the study.

Up to three carcasses or carcass parts were placed at each site (Table 26) on 16/3/2009 (day 0) and were checked to see if they had been removed by scavengers or not on the following dates: 17/3 (day 1), 18/3 (day 2), 19/3 (day 3), 20/3 (day 4), 23/3 (day 7), 30/3 (day 14), 5/4 (day 20), 15/4 (day 30) (Tables 27, 28 and 29).

Table 26. Distribution of the carcasses during the winter 2009 scavenger removal trials

Site	No of piece	Description
Peltastis	1	One Common Buzzard
Mati-Geraki	2	One Goshawk

Mati-Geraki	3	One Sparrohawk
Mytoula	4	One Sparrohawk
Mytoula	5	One Common Buzzard
Mytoula	6	One Sparrohawk

Table 27. Results of the winter 2009 scavenger removal trials in Peltastis

Site	Checking day	Date	Common Buzzard
Peltastis	0	16/03/09	A
Peltastis	1	17/03/09	A
Peltastis	2	18/03/09	B
Peltastis	3	19/03/09	B
Peltastis	4	20/03/09	B
Peltastis	7	23/03/09	? (no access due to snow)
Peltastis	14	30/03/09	E
Peltastis	20	05/04/09	-
Peltastis	30	15/04/09	-

A = intact / in the same position as it was left
B = it was moved, but was still visible
C = it was "eaten-scavenged", but was still present and possible to be seen
D = disappeared with a few remains
E = completely disappeared

Table 28. Results of the winter 2009 scavenger removal trials in Mati-Geraki

Site	Checking day	Date	Goshawk	Sparrowhawk
Mati-Geraki	0	16/03/09	A	A
Mati-Geraki	1	17/03/09	A	A
Mati-Geraki	2	18/03/09	A	A
Mati-Geraki	3	19/03/09	A	? (covered by snow)
Mati-Geraki	4	20/03/09	A	? (covered by snow)
Mati-Geraki	7	23/03/09	A	? (covered by snow)
Mati-Geraki	14	30/03/09	A	E
Mati-Geraki	20	05/04/09	A	-
Mati-Geraki	30	15/04/09	B-C	-

A = intact / in the same position as it was left
B = it was moved, but was still visible
C = it was "eaten-scavenged", but was still present and possible to be seen
D = disappeared with a few remains
E = completely disappeared

Table 29. Results of the winter 2009 scavenger removal trials in Mytoula

Site	Checking day	Date	Sparrowhawk1	Common Buzzard	Sparrowhawk2
Mytoula	0	16/03/09	A	A	A
Mytoula	1	17/03/09	E	C	E
Mytoula	2	18/03/09	-	E	-
Mytoula	3	19/03/09	-	-	-
Mytoula	4	20/03/09	-	-	-
Mytoula	7	23/03/09	-	-	-
Mytoula	14	30/03/09	-	-	-

Mytoula	20	05/04/09	-	-	-
Mytoula	30	15/04/09	-	-	-

A = intact / in the same position as it was left
B = it was moved, but was still visible
C = it was "eaten-scavenged", but was still present and possible to be seen
D = disappeared with a few remains
E = completely disappeared

Carcasses in Mytoula disappeared faster compared to the other sites (Table 30).

Table 30. Overall results of the winter scavenger removal trials at the three sites

Site	Carcass	Remaining days
Peltastis	One Common Buzzard	14
Mati Geraki	One Goshawk	30
Mati Geraki	One Sparrohawk	14
Mytoula	One Sparrohawk	1
Mytoula	One Common Buzzard	2
Mytoula	One Sparrohawk	1

4.3.4. Scavenger removal trial, June 2009

The trial was conducted from the 1st of June 2009 to the 2nd of July 2009. One carcass was placed at each site (Table 31). Carcasses were placed at the study areas on 01/06/2009 (day 0) and were checked on the following dates: 02/6 (day 1), 03/6 (day 2), 04/6 (day 3), 05/6 (day 4), 08/6 (day 7), 15/6 (day 14), 21/6 (day 20), 01/7 (day 30) (Tables 32, 33 and 34).

Table 31. Distribution of the carcasses during the spring 2009 scavenger removal trials

Site	No of piece	Description
Peltastis	1	One Griffon Vulture
Mati-Geraki	2	One Common Buzzard
Mytoula	3	One Common Buzzard

Table 32. Results of the spring 2009 scavenger removal trials in Peltastis

Peltastis	Checking day	Date	Griffon Vulture
Peltastis	0	01/06/2009	A
Peltastis	1	02/06/2009	A
Peltastis	2	03/06/2009	B
Peltastis	3	04/06/2009	B
Peltastis	4	05/06/2009	B
Peltastis	7	08/06/2009	B
Peltastis	14	15/06/2009	B
Peltastis	20	21/06/2009	C
Peltastis	30	01/07/2009	C

A = intact / in the same position as it was left
B = it was moved, but was still visible
C = it was "eaten-scavenged", but was still present and possible to be seen
D = disappeared with a few remains
E = completely disappeared

Table 33. Results of the spring 2009 scavenger removal trials in Mati-Geraki

Site	Checking day	Date	Common Buzzard
Mati-Geraki	0	01/06/2009	A
Mati-Geraki	1	02/06/2009	A
Mati-Geraki	2	03/06/2009	A
Mati-Geraki	3	04/06/2009	A
Mati-Geraki	4	05/06/2009	A
Mati-Geraki	7	08/06/2009	A
Mati-Geraki	14	15/06/2009	E
Mati-Geraki	20	21/06/2009	-
Mati-Geraki	30	01/07/2009	-

A = intact / in the same position as it was left
B = it was moved, but was still visible
C = it was "eaten-scavenged", but was still present and possible to be seen
D = disappeared with a few remains
E = completely disappeared

Table 34. Results of the spring 2009 scavenger removal trials in Mytoula

Site	Checking day	Date	Common Buzzard
Mytoula	0	01/06/2009	A
Mytoula	1	02/06/2009	A
Mytoula	2	03/06/2009	B
Mytoula	3	04/06/2009	B
Mytoula	4	05/06/2009	B
Mytoula	7	08/06/2009	B
Mytoula	14	15/06/2009	B
Mytoula	20	21/06/2009	C
Mytoula	30	01/07/2009	C

A = intact / in the same position as it was left
B = it was moved, but was still visible
C = it was "eaten-scavenged", but was still present and possible to be seen
D = disappeared with a few remains
E = completely disappeared

Carcasses remained at the sites for at least 14 days (Table 35).

Table 35. Overall results of the spring scavenger removal trials at the three sites

Site	Carcass	Remaining days
Peltastis	One Griffon Vulture	30
Mati Geraki	One Common Buzzard (*Buteo buteo*)	14
Mytoula	One Common Buzzard (*Buteo buteo*)	30

In total, 19 bird carcasses were used in the scavenger removal trials (Fig. 7). After 14 days 50% of small carcasses, 22% of medium and 25% of large ones had been removed (Fig. 8). Any trial carcasses still remaining at 30 days were collected.

The average length of time a carcass remained in the field before it was removed by a scavenger was t=23 days [SE(t) = 3.71 and CI 90%: 18.15-30.38]. However, both season (H=14198, d.f.=3, p<0.001) and carcass size (H=11350, d.f.=2, p<0.001) had a highly significant effect on the removal day.

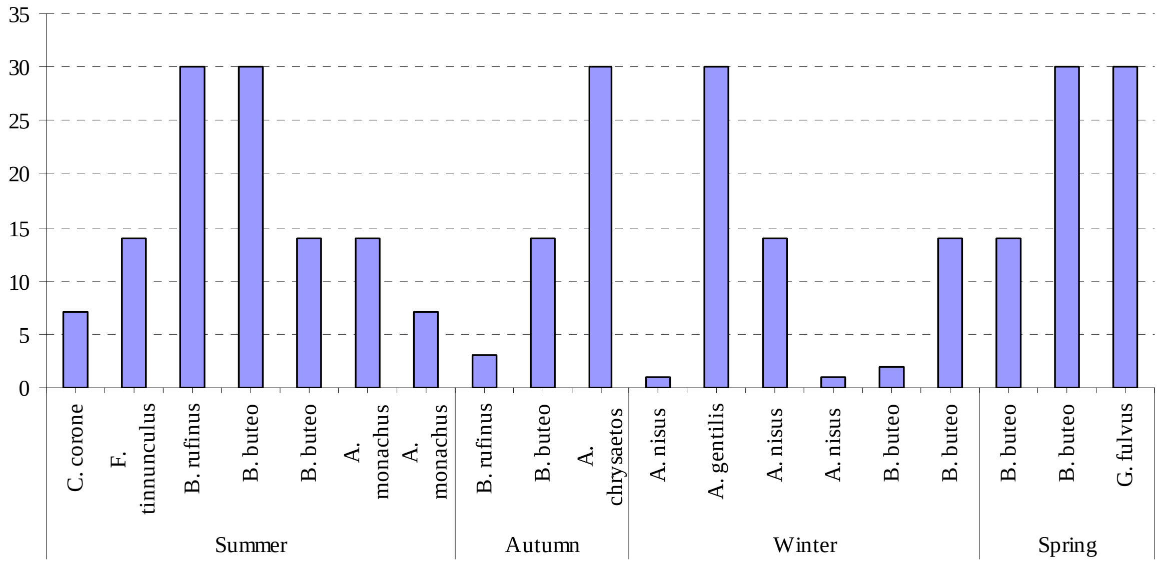


Fig. 7 Total number of carcasses per species placed in all sites per season of trial plotted against number of days they remained at site before removal

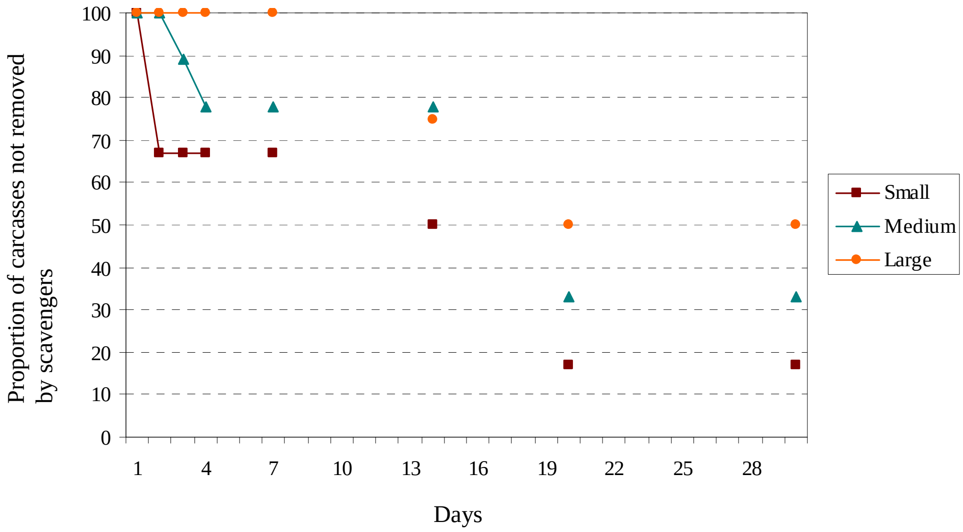


Fig. 8 Observed mean proportion of bird carcasses available for detection over a 30-day interval. Seasons were pooled to show the time carcasses remained on the trial site according to their size.

Fig. 9 View of the trial site at Mati

Fig. 10 Winter view of the trial site at Peltastis

4.4. Mortality estimation based on carcass surveys

Following Everaert and Stienen (2007), the mortality (number of avian fatalities as mentioned in the methods) for all birds of prey was *N-estimated* = 19.27 birds of prey dead for all wind turbines and the whole study period and for vultures in particular, it was *N-estimated* = 9.12 vultures dead for all wind turbines and the whole study period. Estimated mortality rate consequently was *N*=0.152 birds of prey/turbine/year and *N*=0.072 vultures/turbine/year.

Similar mortality rates have been found by Barrios and Rodríguez (2004) in Spain (Griffon Vulture mortality rates ranged from 0.03 to 0.150 birds per turbine and year). Drewitt and Langston's (2006) review of the relevant literature showed collision rates ranging from 0.01 to 23 bird collisions per year. They further note that even ostensibly low levels of additional mortality from wind turbines may be significant for long-lived species with low productivity and slow maturation rates, especially when rarer species of conservation concern are affected. They add that in such cases there could be significant effects on their populations (locally, regionally or, in the case of rare and restricted species, nationally), particularly in situations where cumulative mortality takes place as a result of multiple installation. This is highly likely the case in our study area in Thrace.

It is important to mention concerns raised by the researchers of this project about the possibility of losing carcasses due to removal by humans. These concerns are supported by evidence, such as the extremely fast disappearance (three days) of large specimens of carcasses (e.g. Griffon Vulture) that had fallen in obvious places on the wind turbines' platform. This is against findings mentioned in the relevant literature (Barrios and Rodriguez 2004) and our own results from the scavenger removal trials: smaller pieces belonging to the same carcass situated in more hidden locations remained in the area for more than four months. Active removal by humans was further supported by the finding of a Griffon Vulture ring under a windfarm.

This possibility has already been acknowledged by other researchers such as Atienza *et al* (2008) who state that it has been proved that people working at the wind farms hide carcasses, probably because they think that their job might be jeopardised if birds are killed at the wind farm, leading to an underestimation of bird mortality rates obtained from monitoring.

4.5. Surveys of space use by birds

4.5.1. Avian space use descriptors

The following tables and diagrams describe the data collected during our surveys of bird use of space in 2008 and 2009.

Table 36. Total number of observations by species and total number of birds detected by species in the total of the study area

Species	Number of observations
Aegypius monachus	149
Buteo buteo	141
Gyps fulvus	135
Buteo sp.	81
Unidentified raptors	49
Aquila chrysaetos	43
Circaetus gallicus	34
Corvus corax	32
Falco sp.	28
Ciconia nigra	22
Unidentified eagles	16
Accipiter sp.	15
Falco tinnunculus	14
Accipiter nisus	12
Hieraaetus pennatus	11
Accipiter gentilis	10
Buteo rufinus	9
Corvus corone cornix	6
Pernis apivorus	6
Aquila pomarina	3
Unidentified vultures	3
Accipiter brevipes	2
Corvus sp.	2
Unidentified gull	2
Ardea cinerea	1
Ciconia ciconia	1
Circus cyaneus	1
Columba oenas	1
Falco eleonorae	1
Falco naumanni	1
Falco peregrinus	1
Falco subbuteo	1
Falco vespertinus	1
Neophron percnopterus	1
Total	**835**

Species	Number of individuals
Gyps fulvus	215
Aegypius monachus	187
Buteo buteo	183
Buteo sp.	102
Corvus corax	56
Aquila chrysaetos	48
Circaetus gallicus	48
Unidentified raptors	48
Falco sp.	32
Ciconia nigra	31
Unidentified vultures	20
Unidentified eagle	18
Accipiter sp.	16
Accipiter nisus	15
Falco tinnunculus	13
Buteo rufinus	12
Accipiter gentilis	11
Corvus corone cornix	10
Hieraaetus pennatus	10
Pernis apivorus	10
Unidentified gull	8
Ardea cinerea	6
Aquila pomarina	3
Accipiter brevipes	2
Corvus sp.	2
Ciconia ciconia	1
Circus cyaneus	1
Columba oenas	1
Falco eleonorae	1
Falco naumanni	1
Falco peregrinus	1
Falco subbuteo	1
Falco vespertinus	1
Neophron percnopterus	1
Total	**1115**

Note that in general, the total number of observations recorded will be lower than the total number of individuals, as observations comprise at least one individual but can comprise more than one. In contrast, sometimes the same individual can be observed several times, performing different activities during the same flight (the total number of observations recorded will be higher than the total number of individuals).

Griffon Vultures (*Gyps fulvus*) were the third most common species observed following Black Vultures (*Aegypius monachus*) and Common Buzzards (*Buteo buteo*). However they presented the highest numbers of individuals recorded in the whole study area. This agrees with the observed trend of these vultures (and also of Black Vultures, but in a lower degree) to fly in groups.

Vulture individuals of both species (Griffon and Black) represented more than one third of the total bird individuals observed in the wind farm area. If Common Buzzards are added, three species represented more than half of all individual observations (Fig. 11).

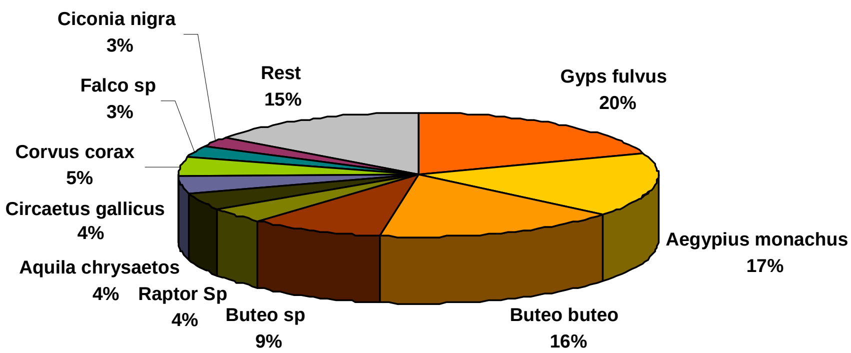


Fig. 11 The ten most abundant taxa by number of individuals in the whole study area.

The same three species (Griffon and Black Vultures, and Common Buzzard) were observed from all VPs (as well as individuals belonging to the genus *Buteo*). Two more species (Golden Eagle *Aquila chrysaetos* and Black Stork *Ciconia nigra*) were observed from nine out of ten VPs (Table 37).

Table 37. Total number of individuals by species detected per VP in the study area

Species	Number of individuals										Total
	VP1	VP2	VP3	VP4	VP5	VP6	VP7	VP8	VP9	VP10	All VPs
Gyps fulvus	18	24	20	22	11	8	20	66	16	10	215
Aegypius monachus	12	24	18	35	25	13	10	25	19	6	187
Buteo buteo	10	23	18	20	67	20	11	5	1	8	183
Buteo sp.	1	16	5	8	31	15	1	16	7	2	102
Corvus corax	5	6	2	9	27	1	2		4		56
Aquila chrysaetos	3	9	4	7	7	7	5	5		1	48
Circaetus gallicus	1	7	2		15	2	8	8	5		48
Unidentified raptors	8	5	2	4	13	3		13			48
Falco sp.		2		4	5	1	6	11	1	2	32

Ciconia nigra	8	5	5	1	3	3		1	3	2	31
Unidentified vultures	2				6			12			20
Unidentified eagles		3	1	6	3	2		1	1	1	18
Accipiter sp.		3	1		5	2	2	1		2	16
Accipiter nisus		1		4	6	3		1			15
Falco tinnunculus	0		1	4	4		1	1	1	1	13
Buteo rufinus				3	1	8					12
Accipter gentilis		5	1		2	2				1	11
Hieraaetus pennatus	1			3	3	1			2		10
Pernis apivorus				2	5	1		2			10
Corvus corone cornix	3			2	5						10
Unidentified gull		2							6		8
Ardea cinerea	6										6
Aquila pomarina					1	1	1				3
Accipiter brevipes					1					1	2
Corvus sp.	1					1					2
Ciconia ciconia			1								1
Circus cyaneus							1				1
Columba oenas										1	1
Falco eleonorae								1			1
Falco naumanni					1						1
Falco peregrinus					1						1
Falco subbuteo				1							1
Falco vespertinus				1							1
Neophron percnopterus				1							1
Total	**79**	**135**	**81**	**137**	**248**	**94**	**68**	**169**	**66**	**38**	**1115**

It is worth noting that a high proportion of total bird flights were made within the risk area of 250 m from turbines (Table 38). For example, both Griffon and Black Vulture observations in this risk zone represented almost 70% of their total flight observations. Griffon Vulture individuals were also present in their highest numbers in this zone, flying in groups, whereas Black Vultures were almost always observed flying as single individuals (Table 38).

Table 38. Total number of observations by species and total number of birds detected by species in the risk area (≤ 250 m radius around each turbine,) and proportion of flights in the risk area to the total flights observed in the whole study area.

Species	Number of observations	Proportion of risk flights (%)	Species	Number of individuals	Proportion of risk flights (%)
Gyps fulvus	94	69,6	*Gyps fulvus*	144	67,0
Buteo buteo	82	58,2	*Buteo buteo*	110	60,1
Aegypius monachus	103	69,1	*Aegypius monachus*	109	58,3
Buteo sp.	42	51,9	*Buteo* sp.	48	47,1
Corvus corax	21	65,6	*Corvus corax*	35	62,5
Unidentified raptors	32	65,3	Unidentified raptors	31	64,6
Aquila chrysaetos	28	65,1	*Aquila chrysaetos*	29	60,4
Ciconia nigra	14	63,6	*Ciconia nigra*	23	74,2
Circaetus gallicus	21	61,8	*Circaetus gallicus*	22	45,8
Falco sp.	20	71,4	*Falco* sp.	22	68,8

Unidentified eagles	13	81,3	Unidentified eagles	14	77,8
Accipiter sp.	11	73,3	*Accipiter* sp.	12	75,0
Accipiter nisus	9	75,0	*Accipiter nisus*	10	66,7
Pernis apivorus	4	66,7	*Pernis apivorus*	8	80,0
Unidentified vultures	2	66,7	Unidentified vultures	8	40,0
Falco tinnunculus	8	57,1	*Falco tinnunculus*	8	61,5
Unidentified gull	2	100,0	Unidentified gull	8	100,0
Hieraaetus pennatus	8	72,7	*Hieraaetus pennatus*	7	100,0
Ardea cinerea	1	100,0	*Ardea cinerea*	6	100,0
Corvus corone cornix	3	50,0	*Corvus corone cornix*	5	50,0
Accipiter gentilis	4	40,0	*Accipiter gentilis*	4	36,4
Aquila pomarina	3	100,0	*Aquila pomarina*	3	100,0
Buteo rufinus	2	22,2	*Buteo rufinus*	2	16,7
Circus cyaneus	1	100,0	*Circus cyaneus*	1	100,0
Falco eleonorae	1	100,0	*Falco eleonorae*	1	100,0
Ciconia ciconia	1	100,0	*Ciconia ciconia*	1	100,0
Accipiter brevipes	1	50,0	*Accipiter brevipes*	1	50,0
Columba oenas	1	100,0	*Columba oenas*	1	100,0
Corvus sp.	1	50,0	*Corvus* sp.	1	50,0
Falco vespertinus	1	100,0	*Falco vespertinus*	1	100,0
Total	**534**		**Total**	**675**	

Proportions of individuals of both species of vultures within the risk area were comparable to those detected in the broader study area, and together with Common Buzzards they were again more than half of all individual observations (Fig. 12).

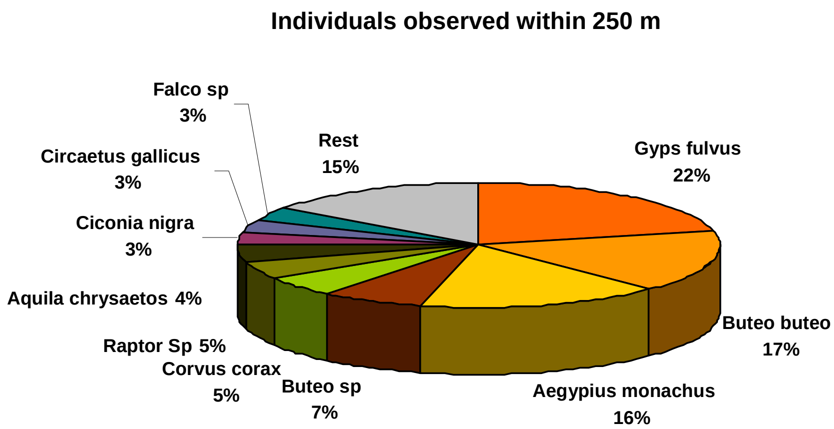


Fig. 12 The ten most abundant taxa by number of individuals in the risk area (≤ 250 m)

The same three species (*Aegypius monachus*, *Buteo buteo* and *Gyps fulvus*) were observed within the risk area from all ten View Points (as well as individuals belonging to the genus *Buteo*) (Table 39).

Table 39. Total number of birds by species detected from each View Point within the risk area :

Species	Number of individuals										Total
	VP1	VP2	VP3	VP4	VP5	VP6	VP7	VP8	VP9	VP10	All VPs
Gyps fulvus	11	6	9	17	6	6	9	57	13	10	144
Buteo buteo	6	9	16	13	32	16	8	5	1	4	110
Aegypius monachus	8	16	11	21	9	11	4	19	8	2	109
Buteo sp.	1	5	3	7	6	5	1	15	3	2	48
Corvus corax	4	4	2	7	15	1	2				35
Unidentified raptors	3	2	2	4	10	1		9			31
Aquila chrysaetos	3	4	4	6	3		4	5			29
Ciconia nigra	7	4	5	1	1			1	2	2	23
Circaetus gallicus		2	2		1	1	7	6	3		22
Falco sp.		1		4	1	1	5	8		2	22
Unidentified eagles		3	1	6	1	1		1		1	14
Accipiter sp.		1			4	2	2	1		2	12
Accipiter nisus				3	3	3		1			10
Pernis apivorus				2	4			2			8
Falco tinnunculus			1	4	1		1			1	8
Unidentified vultures	2				6						8
Unidentified gull		2							6		8
Hieraaetus pennatus	1			3	1				2		7
Ardea cinerea	6										6
Corvus corone cornix				2	3						5
Accipter gentilis		2				1				1	4
Aquila pomarina					1	1	1				3
Buteo rufinus				1		1					2
Accipiter brevipes										1	1
Ciconia ciconia			1								1
Circus cyaneus							1				1
Columba oenas										1	1
Corvus sp.	1										1
Falco eleonorae								1			1
Falco vespertinus				1							1
Falco naumanni											0
Falco peregrinus											0
Falco subbuteo											0
Neophron percnopterus											0
Total	**53**	**61**	**57**	**102**	**108**	**51**	**45**	**131**	**38**	**29**	**675**

Almost half of all individuals observed crossing the wind turbine rotors were vultures (Tables 40 and 41). Vultures also were the majority among birds crossing the wind turbines at a much bigger height than that of the wind turbines (Tables 40 and 41). The frequency of birds occurrence in the risk area (≤ 250 m) of the wind farms presented as individuals per 10 hours of behaviour monitoring, and the detailed interactions of birds pooled by observations with the wind turbines can be seen in the Appendices V and VI.

Table 40. Interactions of each bird species with wind turbines. Numbers in cells are numbers of individuals. The total number of individuals is slightly higher than before, as the same birds may have interacted more than once with the wind turbines.

	Interaction with turbines					
Species	0 / 1	2	3	4	5	Total
Gyps fulvus	81	42	72	52	9	256
Aegypius monachus	81	34	58	26	7	206
Buteo buteo	76	31	55	11	10	183
Buteo sp.	56	22	21	3	4	106
Corvus corax	28	9	19	1		57
Aquila chrysaetos	20	13	13	4		50
Unidentified raptors	22	12	15		1	50
Circaetus gallicus	27	10	7	3	1	48
Falco sp.	11	8	14	3		36
Ciconia nigra	8	11	8	4		31
Unidentified vultures	18	2				20
Unidentified eagles	4	4	7	2	1	18
Accipiter sp.	5	2	8	1		16
Accipiter nisus	7	4	4			15
Falco tinnunculus	6	4	3			13
Buteo rufinus	10	2				12
Accipiter gentilis	7	1	3			11
Hieraaetus pennatus	3	1	5	1	1	11
Corvus corone cornix	5		5			10
Pernis apivorus	2	1	2	5		10
Unidentified gull			6	2		8
Ardea cinerea				6		6
Aquila pomarina	1	1	1			3
Accipiter brevipes	1		1			2
Corvus sp.	1		1			2
Ciconia ciconia			1			1
Circus cyaneus		1				1
Columba oenas			1			1
Falco eleonorae		1				1
Falco naumanni	1					1
Falco peregrinus	1					1
Falco subbuteo	1					1
Falco vespertinus	1					1
Neophron percnopterus	1					1
Total	**485**	**216**	**330**	**124**	**34**	**1189**

0/1: The bird is flying far from the wind turbines, no interaction;
2: The bird is flying parallel to the wind turbines or it approaches a turbine without crossing them;
3: The bird is crossing between two wind turbines (or one if it is the last one);
4: The bird is crossing between wind turbines but flies much higher than the height of the wind turbines;
5: The bird is crossing and flying within the blade area of a wind turbine.

Table 41. Overall interactions of birds with wind turbines pooled by vultures and rest of species.

	Interaction with turbines					
	0 / 1	2	3	4	5	Total
Vultures	181	78	130	78	16	483
Rest of species	304	138	200	46	18	706
Total	**485**	**216**	**330**	**124**	**34**	**1189**

Figures 13 and 14 show the nearest turbines to the birds entering the risk area and the respective numbers of observations and individual birds that approached them. Turbines M7, K1, M16 and X1 concentrate the highest number of observations (≥ 15, Fig. 13). In contrast, turbine M18 concentrates the highest number of individuals (39, Fig. 14). In Appendices VII and VIII the pairs of turbines crossed by birds are shown, both in number of observations and individuals. The number of individuals crossing was used to calculate crossing densities (birds/100 m*100 h) in all gaps between wind turbines that were crossed (Tables 42 and 43).

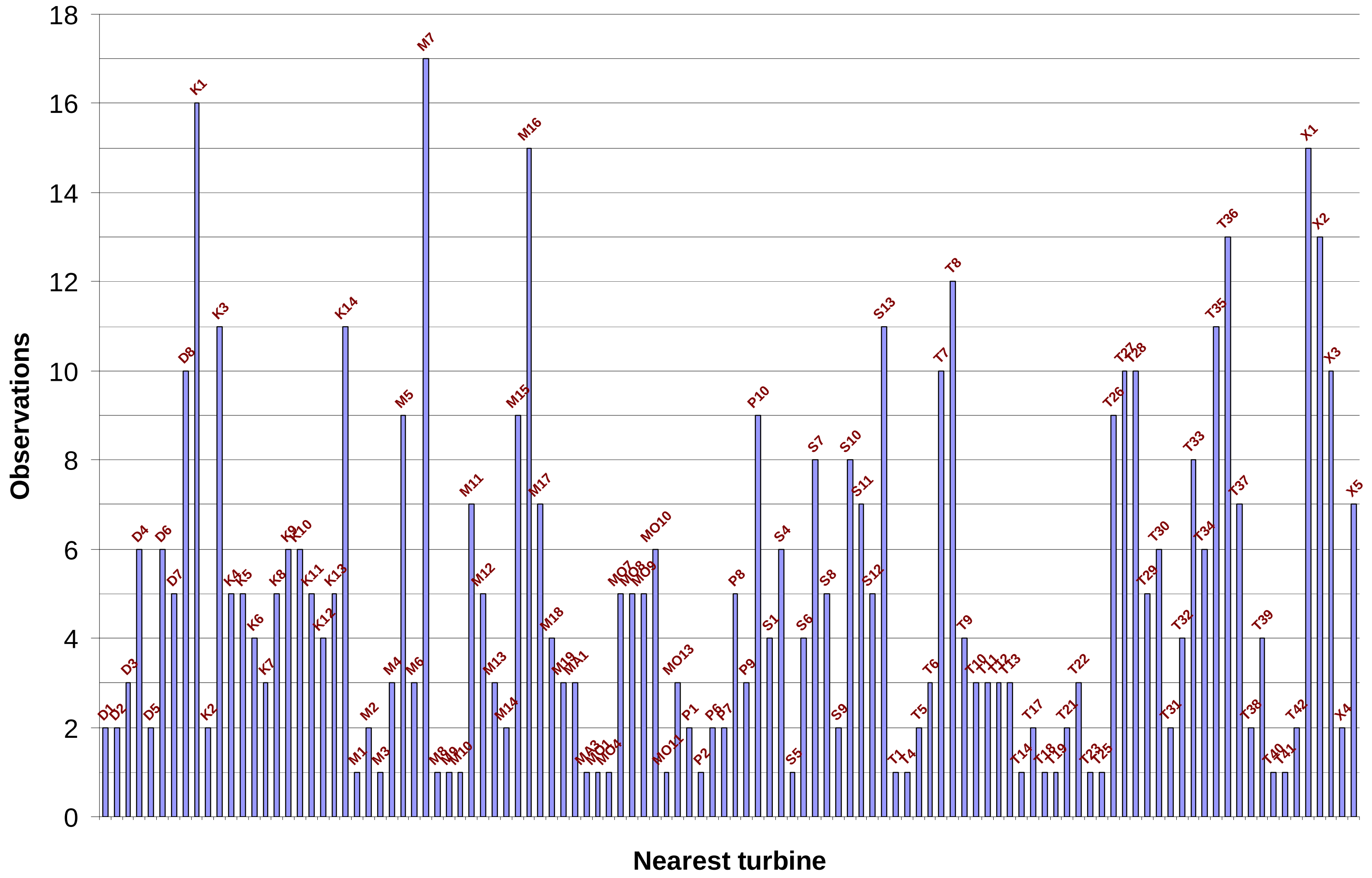


Fig. 13 Frequency of observations of birds entering the risk area of each turbine (individual turbine codes above each column).

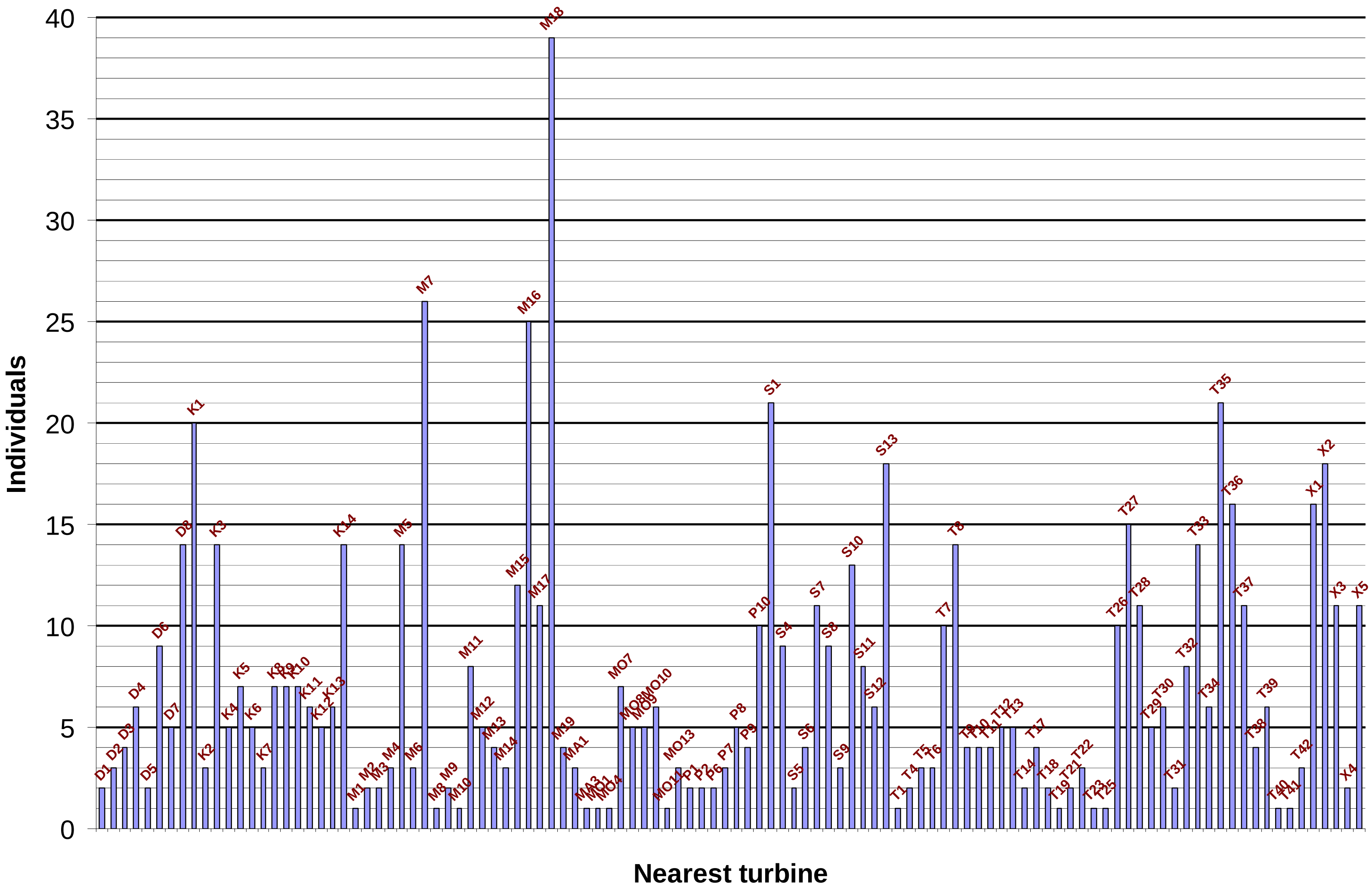


Fig. 14 Frequency of individuals of birds entering the risk area of each turbine (individual turbine codes above each column).

Table 42. Density of birds crossing between any two wind turbines expressed as individuals per 100 meters and 100 hours (see interaction types 3 and 4 in tables 41 and 42 above). Colours stress the highest values.

Crossing density (birds/100 m*100 h)

Pair of turbines	Total	Vultures	Rest
D2-D3	1.76	1.76	0.00
D3-D4	2.70	0.45	2.25
D4-D5	1.04	0.00	1.04
D5-D6	1.90	0.38	1.52
D6-D7	3.23	0.00	3.23
D7-D8	1.92	0.48	1.44
D8			
K1			
K1-K2	0.91	0.00	0.91
K2-K3	2.20	0.88	1.32
K2-T34			
K3-K4	2.50	1.50	1.00
K4-K5	1.71	0.43	1.28
K5-K6	1.54	0.51	1.03
K6-K7	2.26	0.97	1.29
K7-K8	1.52	1.52	0.00
K8-K9	0.51	0.51	0.00
K9-K10	1.75	0.88	0.88
K10-K11	3.52	2.01	1.51
K11-K12	1.34	1.34	0.00
K12-K13	0.53	0.53	0.00
K13-K14	2.81	1.76	1.05
K14			
M1			
M2-M3	0.64	0.00	0.64
M3-M4	1.30	1.30	0.00
M4-M5	2.48	0.00	2.48

Pair of turbines	Total	Vultures	Rest
M5-M6	0.29	0.00	0.29
M6-M7	0.72	0.00	0.72
M8-M9	1.60	0.00	1.60
M9-M10	0.66	0.66	0.00
M10-M11	1.23	0.62	0.62
M11-M12	0.40	0.00	0.40
M12-M13	1.67	1.12	0.56
M13-M14	0.44	0.00	0.44
M15-M16	2.25	1.33	0.93
M15-S1			
M16-M17	1.95	0.65	1.30
M17-M18	7.06	6.35	0.71
M18-M19	8.70	7.57	1.13
MA1-MA2	1.12	0.56	0.56
MA3			
MO4-MO5	0.67	0.00	0.67
MO7-MO8	1.79	0.00	1.79
MO8-MO9	1.79	0.71	1.07
MO9-MO10	0.75	0.75	0.00
MO10-MO11	0.77	0.00	0.77
MO12-MO13	0.37	0.00	0.37
MO13			
P1			
P1-P2	1.23	0.00	1.23
P6			
P6-P7	0.58	0.00	0.58
P7			

Pair of turbines	Total	Vultures	Rest
P8-P9	3.00	0.60	2.40
P9-P10	0.62	0.00	0.62
P10			
S1			
S1-S2	21.70	21.70	0.00
S3-S4	2.14	1.43	0.71
S4-S5	3.20	3.20	0.00
S6-S7	5.09	3.63	1.45
S7-S8	1.44	0.29	1.15
S8-S9	1.23	1.23	0.00
S9-S10	0.67	0.00	0.67
S10-S11	1.58	0.95	0.63
S11-S12	2.71	0.90	1.81
S12-S13	7.31	2.44	4.87
S13			
T1			
T4-T5	0.90	0.90	0.00
T6-T7	2.45	1.63	0.82
T7-T8	2.69	0.00	2.69
T8-T9	1.99	0.00	1.99
T9-T10	3.60	0.90	2.70
T10-T11	2.47	0.00	2.47
T11-T12	0.84	0.00	0.84
T12-T13	1.81	0.91	0.91
T14-T15	1.80	0.00	1.80
T16-T17	1.58	0.00	1.58
T17-T18	1.43	0.00	1.43

Pair of turbines	Total	Vultures	Rest
T21-T22	1.86	0.62	1.24
T23-T24	0.49	0.49	0.00
T25-T26	0.42	0.00	0.42
T26-T27	2.37	0.30	2.07
T27-T28	5.48	1.10	4.38
T28-T29	2.70	1.35	1.35
T29-T30	0.60	0.00	0.60
T30-T31	0.63	0.00	0.63
T32-T33	1.91	1.19	0.72
T33-T34	2.30	0.98	1.31
T34-T35	3.05	1.91	1.14
T35-T36	1.84	1.38	0.46
T36-T37	4.79	0.37	4.42
T37-T38	2.38	0.48	1.91
T38-T39	0.86	0.00	0.86
T41-T42	0.99	0.00	0.99
X1			
X1-X2	1.63	0.27	1.36
X2-X3	1.44	0.16	1.28
X3			
X3-X5	0.70	0.70	0.00
X5			

Table 43. Density of Black and Griffon Vultures crossing between adjacent turbines expressed as individuals per 100 meters and 100 hours (see interaction types 3 and 4 in tables 41 and 42 above).

Crossing density (birds/100m*100h)															
Pair of turbines	***Aegypius monachus***	***Gyps fulvus***	**Rest**	**Pair of turbines**	***Aegypius monachus***	***Gyps fulvus***	**Rest**	**Pair of turbines**	***Aegypius monachus***	***Gyps fulvus***	**Rest**	**Pair of turbines**	***Aegypius monachus***	***Gyps fulvus***	**Rest**
D2-D3	1.32	0.44	0.00	K13-K14	1.76	0.00	1.05	P10				T23-T24	0.00	0.49	0.00
D3-D4	0.45	0.00	2.25	K14				S1-S2	0.87	20.83	0.00	T26-T27	0.00	0.30	2.07
D5-D6	0.00	0.38	1.52	M3-M4	0.87	0.43	0.00	S3-S4	1.43	0.00	0.71	T27-T28	0.00	1.10	4.38
D7-D8	0.48	0.00	1.44	M9-M10	0.66	0.00	0.00	S4-S5	0.00	3.20	0.00	T28-T29	0.45	0.90	1.35
D8				M10-M11	0.00	0.62	0.62	S6-S7	0.00	3.63	1.45	T32-T33	0.95	0.24	0.72
K1				M12-M13	0.56	0.56	0.56	S7-S8	0.29	0.00	1.15	T33-T34	0.66	0.33	1.31
K2-K3	0.00	0.88	1.32	M15-M16	0.66	0.66	0.93	S8-S9	1.23	0.00	0.00	T34-T35	1.91	0.00	1.14
K3-K4	1.50	0.00	1.00	M16-M17	0.65	0.00	1.30	S10-S11	0.63	0.32	0.63	T35-T36	0.92	0.46	0.46
K4-K5	0.43	0.00	1.28	M17-M18	0.00	6.35	0.71	S11-S12	0.90	0.00	1.81	T36-T37	0.37	0.00	4.42
K5-K6	0.00	0.51	1.03	M18-M19	0.00	7.57	1.13	S12-S13	2.44	0.00	4.87	T37-T38	0.48	0.00	1.91
K6-K7	0.65	0.32	1.29	MA1-MA2	0.56	0.00	0.56	S13				X1-X2	0.00	0.27	1.36
K7-K8	1.14	0.38	0.00	MO8-MO9	0.00	0.71	1.07	T4-T5	0.90	0.00	0.00	X2-X3	0.00	0.16	1.28
K8-K9	0.51	0.00	0.00	MO9-MO10	0.75	0.00	0.00	T6-T7	1.63	0.00	0.82	X3-X4			
K9-K10	0.88	0.00	0.88	MO13				T9-T10	0.90	0.00	2.70	X3-X5	0.28	0.42	0.00
K10-K11	2.01	0.00	1.51	P1				T12-T13	0.91	0.00	0.91	X5			
K11-K12	0.67	0.67	0.00	P6				T21-T22	0.00	0.62	1.24				
K12-K13	0.00	0.53	0.00	P8-P9	0.00	0.60	2.40								

4.5.2. Comparisons of crossing densities

The crossing density index equals the number of individuals that cross the space between two adjacent turbines per 100 meters and 100 hours. The index was calculated for all birds of prey, for the rest of raptors except vultures and for each vulture species separately (Tables 44 and 45).

Table 44. Crossing density indices by wind farm (WF)

Crossing density index (birds/100 m*100 h)				
Wind farm	***Aegypius monachus***	***Gyps fulvus***	**Rest**	**Total (all birds of prey)**
Sapka	0.179	0.268	0.982	1.429
Didimos Lofos	0.380	0.127	1.710	2.217
Geraki	0.301	0.137	1.025	1.462
Kerveros	0.869	0.382	1.251	2.503
Peltastis	0.092	0.138	0.644	0.874
Mati	0.285	0.000	0.569	0.854
Mytoula	0.234	0.979	0.788	2.001
Soros	0.600	1.851	1.151	3.602
Monastiri	0.094	0.141	0.422	0.656

Table 45. Crossing density indices by WF sectors

Crossing density (birds/100 m*100 h)				
Sector	***Aegypius monachus***	***Gyps fulvus***	**Rest**	**Total (all birds of prey)**
Soros + Mytoula	0.343	1.238	0.895	2.477
Didimos Lofos	0.380	0.127	1.710	2.217
Geraki + Mati + Kerveros + Peltastis	0.374	0.180	0.951	1.505
Sapka	0.179	0.268	0.982	1.429
Monastiri	0.094	0.141	0.422	0.656

We compared the mean crossing density between the years 2004-2005 (first monitoring period) and 2008-2009 (second monitoring period). Comparisons were made first for those gaps that were monitored in both period and second for each windfarm.

Is there any difference in the crossing density index between the two monitoring periods? (Comparisons between crossing densities through the gaps that were common for both periods)

No statistically significant differences between periods for most of the crossing density indices were detected between periods, but the value of the mean rank of the above mentioned cases was always higher in the second period (2008-2009). For the Griffon

Vulture crossing density index, a statistically significant difference was detected (U = 3439, p<0.05, r=-0.15) with a higher crossing density in the second monitoring period.

Differences between monitoring periods per windfarm

Sapka: A statistically significant difference was detected for the Griffon Vulture crossing density (U = 2, p<0.05, r=-0.70), with the mean rank of the second period twice as high as the first. The large effect size (accounts for more than 25% of the variance) of this difference indicates a very concrete result.

Geraki: There was a statistically significant difference (U = 649, p<0.05, r=-0.22) in the crossing density by the rest of raptors, i.e. not including vultures, with the mean rank of the second period higher than the first. Although there wasn't a statistically significant difference for the Griffon Vulture crossing density, the mean rank of the second period was higher.

Peltastis and Soros: There were no statistically significant differences in the Griffon Vulture crossing density in either of these windfarms, but again the mean rank of the second period was higher compared to the first. In Soros, the same pattern was observed for the Black Vulture crossing density.

How do the wind farm attributes relate to the avian space use expressed as the crossing density in the first monitoring period (2004-2005)?

The crossing densities of all bird species and of those pooled together without the vultures, were positively and significantly correlated with the eastness of the slope (r=0.294, p<0.05 and; r=0.287, p<0.05 respectively), with eastness accounting for 8.64% and 8.24% of the variability respectively. They were both negatively and significantly correlated with the northness of the slope (r=-0.0341, p<0.01 and r=-0.311, p=0.01 respectively), with northness accounting for 11.63% and 9.67% of the variability of the crossing densities respectively.

All vultures' crossing densities and those of Griffon Vultures' alone were also negatively and significantly correlated with the northness of the slope (r=-0.252, p<0.05 and r=-0.257, p<0.05 respectively), with northness accounting for 6.35% and 6.60% of the variability.

When windfarms were examined separately, no correlations were found in Peltastis or Sapka. In Geraki, the crossing density of all bird species was positively and significantly correlated with the distance between turbines (r=0.313, p<0.05), with distance accounting for 9.8% of the variability. It was positively and significantly correlated with the eastness of the slope (r=0.413, p<0.05), with eastness accounting for 12.5%. It was negatively and significantly correlated with the northness of the slope (r=-0.353, p<0.05), with northness accounting for 12.46% of the variability. Also, the Griffon Vultures' crossing density was positively and significantly correlated with the eastness of the slope (r=0.33, p<0.05), with eastness accounting for 10.9%. In Soros, the Griffon Vultures' crossing density was positively and significantly correlated with the distance between wind turbines (r=0.65, p<0.05), with distance accounting for 42.25% of the variability. In other words, a positive correlation between bird crossing densities and distance between turbines means that the larger the distance the higher the probability that a bird will pass between turbines. The

Black Vultures' crossing density was negatively correlated with the northness of the slope (r=0.687, p<0.05), with northness accounting for 47.2% of the variability.

How do the wind farm attributes relate to the avian space use expressed as the crossing density in the second monitoring period (2008-2009)?

A. Correlations between WF characteristics and bird crossing densities for WTs monitored during both monitoring periods.

The crossing density of all birds was positively correlated with the eastness of the slope (r=0.272, p<0.05), with eastness accounting for 7.4% of the variability. It was negatively correlated with the northness of the slope (r=-0.285, p<0.05), with the northness accounting for 8.12% of the variability.

Both the vultures' crossing density and the Griffon Vultures' crossing density alone were positively correlated with the inclination of the slope (r=0.289, p<0.05; r=0.421, p=0.001 respectively), with inclination accounting for 8.35% and 17.72% of the variability respectively. Vultures' crossing density was also negatively correlated with the northness of the slope (r=-0.301, p<0.05), with northness accounting for 9.06% of the variability. Griffon Vultures' crossing density was positively correlated with the distance between turbines (r=0.331, p<0.01), with distance accounting for 10.96% of the variability.

Finally, the crossing density of the Black Vultures was positively correlated with the eastness of the slope (r=0.407, p=0.001) where the eastness accounted for 16.56% of the variability. It was negatively correlated with the northness of the slope (r=-0.46, p<0.001), where the northness accounted for 21.16% of the variability.

When windfarms were examined separately no correlations were found in Peltastis or Sapka, as in the period 2004-2005 (see above). In Geraki, similarly to the results for the whole study area, the crossing density of all birds was positively correlated with the eastness of the slope (r=0.345, p<0.05), where the eastness accounted for 11.9% of the variability. It was negatively correlated with the northness of the slope (r=-0.393, p<0.05), where the northness accounted for 15.44% of the variability. Vultures' crossing density was positively correlated with the distance between turbines and the eastness of the slope (r=0.331, p<0.05; r=0.33, p<0.05, respectively), where the distance and the eastness accounted for 10.96% and 10.89% of the variability respectively. Vultures' crossing density was also negatively correlated with the northness of the slope (r=-0.414, p<0.05), where the northness accounted for 17.14% of the variability. When vultures were separated, it was found that Griffon Vultures' crossing density was positively correlated with both the distance between wind turbines (r=0.556, p<0.001) and the inclination of the slope (r=0.49, p<0.01), where distance and inclination accounted for 30.91% and 24.01% of the variability respectively. Black Vultures' crossing density, on the other hand, was positively correlated with the eastness of the slope (r=0.374, p<0.05), where the eastness accounted for 13.99% of the variability, and negatively correlated with the northness of the slope (r=-0.442, p<0.01), where the northness accounted for 19.54% of the variability in the crossing density. In Soros, the only correlation found was between Black Vultures' crossing density and the inclination of the slope (r=0.645, p<0.05), where the inclination accounted for 41.6% of the variability.

B. Correlations between WF characteristics and bird crossing densities for all studied WTs

For all windfarms combined, there was a significant positive relationship between the crossing density and the distance between consecutive wind turbines. This was evident for all raptor species (r=0.196, p<0.05) that occurred in the study area except the Black Vulture. The distance between wind turbines accounts for 3.84% of the variability in the crossing density. It has to be mentioned that this correlation was even more evident for the Griffon Vulture (r=0.29, p<0.01), where distance among consecutive wind turbines accounts for 8.41% of the variation in the crossing density.

For the Griffon Vulture, the crossing density was positively correlated with the inclination of the slope (r=0.237, p=0.01). The slope accounts for 5.62% of the variability in the crossing density. That is to say that the bigger the inclination of a slope, the higher the probability for this slope to be chosen as crossing place by the raptors. This can be expressed also as a preference for steeper slopes that can potentially produce stronger updrafts.

For the Black Vulture, the crossing density was negatively correlated with the northness of a slope (r=-0.268, p<0.01). The northness of a slope accounts for 7.18 % of the variability in the crossing density.

Didimos Lofos. For the Griffon Vulture, the crossing density was positively correlated with the eastness of the slope (r=0.845, p<0.05). The eastness of the slope accounts for 71.4% of the variability in the crossing density.

Sapka. When Sapka was analyzed separately, no correlation was found between the wind farm characteristics and crossing densities.

Sapka – Didimos Lofos. However, when the data from both wind farms were pooled, there was a statistically significant correlation between the Griffon Vulture crossing densities and the distance among wind turbines (r=0.714, p<0.05). This distance accounts for 50.98% of the variability in the crossing density. That is to say that the bigger the gap between the turbines, the higher the probability for this gap to be chosen as crossing place by Griffon Vultures.

Geraki. For vultures, the crossing density was positively correlated with the distance between wind turbines (r=0.404, p<0.01). This distance accounts for 16.32% of the variability in the crossing density. This finding was even more pronounced for Griffon Vultures when examined alone (r=0.528, p<0.001). In this case, the distance of the gaps accounts for 27.88% of the variability in the crossing density.

The crossing density of Griffon Vultures was positively correlated with the inclination of the slope (r=0.498, p=0.001). The inclination accounts for 24.8% of the variability in the crossing density.

The crossing densities of all raptors pooled together, vultures but also Black Vultures alone were negatively correlated with the northness of the slope (r=-0.309, p<0.05; r=-0.352, p<0.05; r=-0.375, p<0.05, respectively). The northness accounts for 9.55%, 12.39% and 14.06% of the variability of the crossing densities respectively.

Geraki – Mati. When data for Geraki and Mati were pooled together, findings were almost the same as for Geraki alone.

Geraki – Mati – Kerveros. The crossing density of Griffon Vultures was positively correlated with the distance between wind turbines (r=0.409, p<0.01) and the inclination of the slope of the turbines (r=0.291, p<0.05; r=0.441, p=0.001 repsectively), while it was negatively correlated with the northness of the slope (r=-0.344, p<0.01). Black Vultures' crossing density but also the crossing density of all vultures and all birds pooled together were also negatively correlated with the northness of the slope (r=-0.439, p=0.001; r= -0.494, p<0.001; r=-0.353, p<0.01 respectively). Finally, the crossing densities of all vultures pooled together was also positively correlated with the distance between turbines and the inclination of the slope (r=0.33, p<0.05; r=0.266, p<0.05 respectively).

Geraki – Mati – Kerveros – Peltastis. When data belonging to all four wind farms conforming this geographical sector were pooled together, crossing densities of all birds, all vultures and Black and Griffon Vultures separately were again negatively correlated with the northness of the slope (r=-0.365, p<0.01; r=-0.517, p<0.001; r=-0.489, p<0.001; r=-0.314, p=0.01, respectievly). As in the previous case, the crossing density of Griffon Vultures was positively correlated with the distance between wind turbines (r=0.38, p<0.01) and the inclination of the slope both left and right side of the turbines (r=0.274, p<0.05; r=0.421, p<0.001 respectively).

Kerveros. No correlations were found for Kerveros alone.

Mytoula. The crossing density of birds which were not vultures was positively correlated with the distance between wind turbines (r=0.568, p<0.05), while the crossing density of both all vultures pooled together and Griffon Vultures alone were positively correlated with the northness of the slope (r=0.492, p<0.05; r=0.571, p<0.05).

Mytoula – Soros. When data of both windfarms conforming a unique geographical sector were pooled together, correlations were found only for Black Vultures. Their crossing density was positively correlated with the eastness of the slope (r=0.397, p<0.05) and negatively correlated with the northness (r=-0.423, p<0.05).

Soros. On the other hand, the only correlation found when analyzing data from Soros, was the positive correlation between Black Vultures' crossing density and the inclination of the slope (r=0.645, p<0.05).

All of the above mentioned results lead to an interesting discussion. First of all, the use of the broader area of the wind farm by raptors in general, but even more by Griffon Vultures in particular, was more intensive during the second monitoring period. When the differences between monitoring periods were analyzed by wind farms, they were significant specifically for Griffon Vultures in Sapka and for the "rest of raptors" in Geraki.

In general, there was a positive correlation of the crossing densities with the eastness of the slopes where wind turbines are located, while the opposite occurs with the northness, that was negatively correlated with the crossing densities in most cases (but see Griffon

Vultures at Mytoula above). This is to say that slopes with east exposition are selected by raptors, and specifically vultures, to cross wind farms, while slopes with north exposition are generally avoided. North exposed slopes may have less available thermal lifts due to the shorter time exposure to the sun, while east exposed slopes may have more adequate air conditions for the raptor and specially vulture flight. Such a finding might be very important regarding sensitive siting of the wind farms in the broader area.

There was also a positive correlation with the distance, especially regarding Griffon Vulture crossing densities. This is to say that the bigger the gap between the turbines, the higher the probability for this gap to be chosen as a crossing place by raptors. This can be interpreted also as avoidance of the smaller wind turbine gaps. The Black Vulture seemed to use equally smaller and bigger gaps in some cases, and this may indicate a bigger collision risk if we consider that smaller gaps might be more dangerous.

The correlation of the vulture crossing densities with the slope was also positive in many cases, i.e. vultures selected areas with steep slopes as crossing points. This may also be related to the presence of air currents. It is well known that steeper slopes produce stronger slope lifts.

4.5.3. Comparisons of monthly observation and individual numbers

Abundance of birds

During the first study period (2004-2005) 563 observations and 696 raptor individuals were recorded in the proximity of the monitored wind farms (Table 46). In the second study period (2008-2009) 589 observations and 738 raptor individuals were recorded in the same wind farms monitored in 2004-2005 (Table 46).

Table 46. Number and proportion of observations and individuals recorded in the nine study wind farms during both study periods only in the commonly monitored WTs[2]. Species that do not belong to the raptors group have been excluded, except the Black Stork.

Year	Species	No. of observations	% Observations	No. of individuals	% Individuals
2004-2005	**Raptors**	**448**	**79.574**	**553**	**79.454**
	Aquila chrysaetos	7	1.243	8	1.149
	Accipiter sp.	1	0.178	1	0.144
	Accipiter gentilis	5	0.888	5	0.718
	Accipiter nisus	10	1.776	10	1.437
	Buteo buteo	342	60.746	411	59.052
	Circaetus gallicus	18	3.197	24	3.448
	Circus sp.	1	0.178	1	0.144
	Ciconia nigra	17	3.020	19	2.730
	Falco eleonorae	1	0.178	1	0.144
	Falco peregrinus	1	0.178	1	0.144
	Falco species	3	0.533	3	0.431
	Falco subbuteo	1	0.178	1	0.144
	Falco tinnunculus	17	3.020	18	2.586
	Haliaeetus albicilla	1	0.178	1	0.144
	Hieraaetus pennatus	4	0.710	5	0.718
	Milvus migrans	3	0.533	7	1.006
	Neophron percnopterus	2	0.355	4	0.575
	Pernis apivorus	5	0.888	23	3.305
	Unidentified raptors	9	1.599	10	1.437
	Vultures	**115**	**20.426**	**143**	**20.546**
	Aegypius monachus	71	12.611	86	12.356
	Gyps fulvus	42	7.460	53	7.615
	Neophron percnopterus	2	0.355	4	0.575
Total		**563**	**100.000**	**696**	**100.000**
2008-2009***	**Raptors**	**342**	**58.065**	**416**	**56.369**
	Accipiter brevipes	1	0.170	1	0.136
	Aquila chrysaetos	25	4.244	29	3.930
	Accipiter species	5	0.849	5	0.678
	Accipitergentilis	5	0.849	5	0.678
	Accipiter nisus	11	1.868	14	1.897
	Aquila pomarina	2	0.340	2	0.271
	Buteo buteo	98	16.638	131	17.751
	Buteo rufinus	9	1.528	11	1.491
	Buteo sp.	67	11.375	82	11.111
	Ciconia ciconia	1	0.170	1	0.136
	Circaetus gallicus	20	3.396	32	4.336
	Ciconia nigra	15	2.547	16	2.168
	Unidentified eagles	12	2.037	13	1.762

[2] By “commonly monitored WTs” or “common wind farms” we mean those monitored during 2004-05 **and** 2008-09

Falco eleonorae	1	0.170	1	0.136
Falco naumanni	1	0.170	1	0.136
Falco percnopterus	1	0.170	1	0.136
Falco sp.	7	1.188	7	0.949
Falco subbuteo	1	0.170	1	0.136
Falco tinnunculus	10	1.698	10	1.355
Falco vespertinus	1	0.170	1	0.136
Hiraaetus pennatus	9	1.528	9	1.220
Pernis apivorus	6	1.019	10	1.355
Unidentified raptor	34	5.772	33	4.472
Vultures	**176**	**29.881**	**254**	**34.417**
Aegypius monachus	105	17.827	132	17.886
Gyps fulvus	68	11.545	103	13.957
Neophron percnopterus	1	0.170	1	0.136
Unidentified vultures	2	0.340	18	2.439
Total	**589**	**100.000**	**738**	**100.000**

***corresponding data to the 2004-2005 study period

Table 47. Number and proportion of observations and individuals recorded in the wind farm during the second period (all WTs). Species that do not belong to the raptors group have been excluded, except the Black Stork.

Year	**Species**	**No. of observations**	**% Observations**	**No. of individuals**	**% Individuals**
2008-2009****	**Raptors**	**502**	**63.544**	**611**	**58.807**
	Accipiter brevipes	2	0.253	2	0.192
	Aquila chrysaetos	43	5.443	49	4.716
	Accipiter sp.	15	1.899	16	1.540
	Accipiter gentiles	10	1.266	11	1.059
	Accipiter nisus	12	1.519	15	1.444
	Aquila pomarina	3	0.380	3	0.289
	Buteo buteo	141	17.848	184	17.709
	Buteo rufinus	9	1.139	12	1.155
	Buteo sp.	81	10.253	102	9.817
	Circus cyaneus	1	0.127	1	0.096
	Circaetus gallicus	34	4.304	48	4.620
	Ciconia nigra	22	2.785	31	2.984
	Unidentified eagles	16	2.025	18	1.732
	Falco eleonorae	1	0.127	1	0.096
	Falco naumanni	1	0.127	1	0.096
	Falco peregrinus	1	0.127	1	0.096
	Falco sp.	28	3.544	32	3.080
	Falco subbuteo	1	0.127	1	0.096
	Falco tinnunculus	14	1.772	14	1.347
	Falco vespertinus	1	0.127	1	0.096
	Hieraaetus pennatus	11	1.392	10	0.962
	Pernis apivorus	6	0.759	10	0.962
	Unidentified raptors	49	6.203	48	4.620
	Vultures	**288**	**36.456**	**428**	**41.193**
	Aegypius monachus	149	18.861	190	18.287
	Gyps fulvus	135	17.089	217	20.885
	Neophron percnopterus	1	0.127	1	0.096
	Unidentified vultures	3	0.380	20	1.925
Total		**790**	**100.000**	**1039**	**100.000**

****all the data for the period 2008-2009

Observations and individual composition changed between the two study periods (Table 46). In the second study period the raptor observations (no vultures included) but also the individual raptor numbers and proportions decreased (from 79.6% to 58% and from 79.5% to 56.4% respectively). In contrast, numbers and proportions of both vulture observations and individuals increased (from 20.4% to 30% and from 20.5% to 34.4% respectively).

In the first study period (2004-2005) the most abundant raptor was the Common Buzzard: about six out of every 10 observations (60.7%) and individuals were of this species (Table 46). The second most abundant subgroup was vultures, with the Black Vulture being the most abundant. During the second study period, and for the matching data with the first period (Table 46), the Common Buzzard was no longer the most abundant raptor and the proportions of observations and individuals dropped to 16.6% and 17.8% respectively. If we add the unidentified Buzzards, then these proportions increase up to 27.75% and 28.86% respectively, still lower compared to the first study period. In contrast, in the second period, the most abundant raptors were vultures with the Black Vulture still being the most abundant (17.8%). As mentioned earlier, numbers and proportions of both vulture observations and individuals increased in both species of vulture (Table 46).

In the second study period (2008-2009) and in the whole monitored area, 790 observations and 1039 individuals were recorded in the proximity of the monitored wind farms (Table 47). Vultures comprised 36.5% of the observations and 41.2% of the individuals.

Monthly observation rates for all birds of prey fluctuated between a minimum value of 0.23 observations/hour (January 2009) and a maximum value of 2.32 observations/hour (May 2009, Table 48), with a mean monthly value of 1.189 ± 0.63 (mean ± SD) observations/hour. In general, observation rates were lower in the second period compared to the first, although no statistically significant differences were found (annual: Kruskal-Wallis test, X^2= 2,430, df=1, p>0.05). The highest observation rates occurred in spring 2009, but there were no statistically significant seasonal differences (Kruskal–Wallis test, X^2= 12.933, df = 7, p>0.05).

Table 48. Monthly abundance of observations and individuals and monthly variation in observation and individual flying rates.

Year	Month	Total Number of Observations	Total Number of Individuals	Spent Observation Time	Number of Observations /hour	Number of birds /hour	Number of Raptor Obser - vations	Number of Vulture Obser- vations	Number of Individual Vultures	Number of Black Vulture Individuals	Number of Griffon Vulture Individuals	Number of Raptor Observations/hou r	Number of Vulture Individuals/h	Number of Black Vulture Individuals/h
2004	March	32	33	34.23	0.935	0.964	32	0	0	0	0	0.935	0.000	0.000
	April	38	45	30.25	1.256	1.488	30	8	11	3	8	0.992	0.364	0.099
	May	45	51	42.98	1.047	1.187	41	4	4	3	1	0.954	0.093	0.070
	June	54	59	29.96	1.802	1.969	42	13	17	10	6	1.402	0.567	0.334
	July	98	116	61.10	1.604	1.899	75	23	28	16	13	1.227	0.458	0.262
	August	54	92	31.13	1.735	2.955	32	22	29	21	5	1.028	0.932	0.675
	September	86	107	38.78	2.218	2.759	63	23	23	14	9	1.625	0.593	0.361
	October	43	52	31.78	1.353	1.636	29	14	18	10	8	0.913	0.566	0.315
	November	59	52	36.55	1.614	1.423	52	7	7	3	4	1.423	0.192	0.082
	December	29	5	25.03	1.159	0.200	26	6	14	9	5	1.039	0.559	0.360
2005	January	14	14	7.41	1.889	1.889	14	0	0	0	0	1.889	0.000	0.000
	February	0	0	0	0.000	0.000	0	0	0	0	0	0.000	0.000	0.000
2008	July	51	69	65.00	0.785	1.062	27	24	38	16	22	0.415	0.585	0.246
	August	26	28	52.96	0.491	0.529	16	10	12	10	2	0.302	0.227	0.189
	September	29	49	54.16	0.535	0.905	18	11	12	8	4	0.332	0.222	0.148
	October	23	50	57.50	0.400	0.870	13	12	37	3	16	0.226	0.643	0.052
	November	16	20	49.08	0.326	0.407	9	11	11	3	8	0.183	0.224	0.061
	December	25	59	22.75	1.099	2.593	4	7	54	25	29	0.176	2.374	1.099
2009	January	5	6	21.61	0.231	0.278	4	1	1	0	1	0.185	0.046	0.000
	February	37	47	39.83	0.929	1.180	28	9	16	3	13	0.703	0.402	0.075
	March	55	83	30.50	1.803	2.721	49	6	16	15	1	1.607	0.525	0.492
	April	64	72	51.5	1.243	1.398	51	13	7	4	3	0.990	0.136	0.078
	May	126	135	54.41	2.316	2.481	78	48	45	33	12	1.434	0.827	0.607
	June	78	85	44	1.773	1.932	54	24	26	12	14	1.227	0.591	0.273
Total		**1087**	**1329**	**912.5**			**787**	**296**	**426**	**221**	**184**			

Table 49. Monthly abundance of observations and individuals and monthly variation in observation and flying rates without Buzzards.

Year	Month	Obser vations	Indivi duals	Obs_time	Obs/h	Total birds/h	Raptor Obs	Vulture Obs	Vulture Ind	Black Vulture Ind	Griffon Vulture Ind	Raptor Obs/h	Vultures_Ind/h	Black Vulture Ind/h	Griffon Vulture Ind/h
2004	March	2	2	34.23	0.058	0.058	2	0	0	0	0	0.058	0.000	0.000	0.000
	April	15	18	30.25	0.496	0.595	7	8	11	3	8	0.231	0.364	0.099	0.264
	May	15	19	42.98	0.349	0.442	11	4	4	3	1	0.256	0.093	0.070	0.023
	June	20	24	29.96	0.668	0.801	8	13	17	10	6	0.267	0.567	0.334	0.200
	July	40	46	61.10	0.655	0.753	17	23	28	16	13	0.278	0.458	0.262	0.213
	August	33	55	31.13	1.060	1.767	11	22	29	21	5	0.353	0.932	0.675	0.161
	September	51	57	38.78	1.315	1.470	28	23	23	14	9	0.722	0.593	0.361	0.232
	October	18	23	31.78	0.566	0.724	4	14	18	10	8	0.126	0.566	0.315	0.252
	November	18	23	36.55	0.492	0.629	11	7	7	3	4	0.301	0.192	0.082	0.109
	December	4	5	25.03	0.160	0.200	1	6	14	9	5	0.040	0.559	0.360	0.200
2005	January	5	5	7.41	0.675	0.675	5	0	0	0	0	0.675	0.000	0.000	0.000
	February	0	0	0	0.000	0.000	0	0	0	0	0	0.000	0.000	0.000	0.000
2008	July	43	58	65.00	0.662	0.892	19	24	38	16	22	0.292	0.585	0.246	0.338
	August	22	24	52.96	0.415	0.453	12	10	12	10	2	0.227	0.227	0.189	0.038
	September	23	41	54.16	0.425	0.757	12	11	12	8	4	0.222	0.222	0.148	0.074
	October	22	49	57.50	0.383	0.852	12	12	37	3	16	0.209	0.643	0.052	0.278
	November	16	20	49.08	0.326	0.407	9	11	11	3	8	0.183	0.224	0.061	0.163
	December	24	57	22.75	1.055	2.505	3	7	54	25	29	0.132	2.374	1.099	1.275
2009	January	5	6	21.61	0.231	0.278	4	1	1	0	1	0.185	0.046	0.000	0.046
	February	27	35	39.83	0.678	0.879	18	9	16	3	13	0.452	0.402	0.075	0.326
	March	20	31	30.50	0.656	1.016	14	6	16	15	1	0.459	0.525	0.492	0.033
	April	32	27	51.5	0.621	0.524	19	13	7	4	3	0.369	0.136	0.078	0.058
	May	85	83	54.41	1.562	1.525	37	48	45	33	12	0.680	0.827	0.607	0.221
	June	54	62	44	1.227	1.409	30	24	26	12	14	0.682	0.591	0.273	0.318
Total		**594**	**770**				**294**	**296**	**426**	**221**	**184**				

Monthly raptor observation rates excluding vultures fluctuated between a minimum value of 0.18 raptor observations/hour (December 2008) and a maximum value of 1.89 raptor observations/hour (January 2005, Table 48), with a mean monthly value of 0.88±0.54 raptor observations/hour. Raptor observation rates were lower in the second year compared to the first, although no statistically significant differences were found (annual: Kruskal-Wallis test, X^2= 3.63, *df*=1, *p*>0.05). Within the second study period, the highest raptor observation rates occurred in spring 2009 but there were no statistically significant seasonal differences (seasonal: Kruskal–Wallis test, X^2= 12.400, *df* = 7, *p*>0.05). In the first period (2004-2005), the highest raptor observation rates occurred in autumn 2004, but there were no statistically significant seasonal differences either (seasonal: Kruskal–Wallis test, X^2= 2,077, *df* = 3, *p*>0.05).

Monthly vulture observation rates fluctuated between a minimum value of 0.046 vulture observations/hour (January 2009) and a maximum value of 0.827 vulture observations/hour (May 2009, Table 49), with a mean monthly value of 0.291±0.22 vulture observations/hour. Vulture observation rates were higher in the second period compared to the first, although no statistically significant differences were found (annual: Kruskal-Wallis test, X^2= 0.13, *df*=1, *p*>0.05). Within the second study period, the highest vulture observation rates occurred in summer - autumn 2009 but no statistically significant seasonal differences were detected (seasonal: Kruskal–Wallis test, X^2= 10.017, *df* = 7, *p*>0.05). In 2004-2005, the highest vulture observation rates occurred in summer and autumn, but there were no statistically significant seasonal differences (seasonal: Kruskal–Wallis test, X^2= 2,077, *df* = 3, *p*>0.05).

The total monthly flying rate (observed individuals) varied between 0.2 birds/hour in December 2004 and 2.9 birds/hour in August of the same year (Table 48), with a mean monthly value of 1.446 ± 0.86 birds/hour. The highest total flying rates occurred during the first period in spring, although no statistical differences were detected (annual: Kruskal–Wallis test, X^2 = 0.563, *df* = 1, *p*>0.05; seasonal: Kruskal–Wallis test, X^2= 11.907, *df* = 7, *p*>0.05).

The vulture monthly flying rate varied between 0.046 vultures/hour in January 2009 and 2.374 vultures/hour in December of the previous year (Table 48) with a mean monthly value of 0.463 ± 0.486 vultures/hour. The highest vulture flying rates occurred during the second period, although no statistical differences were detected (annual: Kruskal–Wallis test, X^2 = 0.965, *df* = 1, *p*>0.05). Summer was the season with the highest vulture flying rates, although no seasonal statistical differences were detected (seasonal: Kruskal–Wallis test, X^2= 7.413, *df* = 7, *p*>0.05). The same pattern was found for each of the Black and Griffon Vulture flying rates and their highest flying rates occurred during the second period. Regarding seasonal differences, the highest flying rates for the Black Vulture occured in the summer of the first period and the spring of the second period, but for the Griffon Vulture, the highest values occurred in the autumn of the first period and in the winter of the second period.

Due to the fact that buzzard species' observations were reduced from 60.7% in the first period to 27.75% in the second period, the buzzard data were removed from the analysis and the rest of the data were reanalyzed with the same approach.

Monthly observation rates were still not constant over the study period, fluctuating between 0.06 observations/hour in March 2004 and 1.56 observations/hour in May 2009 (Table 49), with a mean monthly value of 0.613±0.391 observations/hour. Observation rates were higher in the second period than in the first, although no statistically significant differences were found (annual: Kruskal-Wallis test, X^2= 0,480, *df*=1, *p*>0.05). The highest observation rates occurred in summer of 2004 and in spring 2009, but there were no statistically significant seasonal differences (seasonal: Kruskal–Wallis test, X^2= 9.560, *df* = 7, *p*>0.05).

Monthly raptor (without vultures) observation rates fluctuated between 0.040 raptor observations/hour in December 2004 and 0.722 raptor observations/hour in September 2004 (Table 49), with a mean monthly value of 0.308±0.207 raptor observations/hour. Observation rates were higher in the second year than in the first, although no statistically significant differences were found (annual: Kruskal-Wallis test, X^2= 0.480, *df*=1, *p*>0.05). The highest raptor observation rates occurred in spring of 2009 but there were no statistically significant seasonal differences (seasonal: Kruskal–Wallis test, X^2= 8.453, *df* = 7, *p*>0.05).

Total monthly flying rates varied between 0.058 birds/hour in March 2004 and 2.51 birds/hour in December 2008 (Table 49), with a mean monthly value of 0.817 ± 0.58 birds/hour. The highest total flying rates occurred during the second year, although no statistically significant differences were found (annual: Kruskal–Wallis test, X^2 = 1.92, *df* = 1, *p*>0.05). The highest flying rate was detected in summer 2004, although no statistical differences were detected (seasonal: Kruskal–Wallis test, X^2= 9.267, *df* = 7, *p*>0.05).

The presence of Common Buzzards in the area has most probably been highly affected by the wind farm operation. Their numbers have drastically decreased four years after the first monitoring period carried out only a year after the onset of the operation of the first wind farms. This species is highly territorial, and this reduction can be explained either by displacement of the breeding pairs (abandonment of traditional breeding territories) or by high mortality rates. Pierce-Higgins *et al.* (2009) modeled associations between wind farm infrastructure and the distribution of a range of widely distributed upland bird species across 12 wind farms in the UK. Their results showed, among others, reduced flight activity of buzzards around the turbines. They emphasized the importance of the distinction of the causes previously mentioned: “If there is high mortality of birds breeding close to the turbines associated with collision, then a wind farm may become a population sink if repeatedly colonized by naïve birds. If, however, the birds simply avoid breeding close to the turbines, then depending upon the strength of density dependence (e.g. Yalden & Pearce-Higgins 1997), displaced birds may settle elsewhere with little cost or ultimately be lost to the population.”

In this respect, it is worth mentioning that during carcass surveys conducted in the second half of 2009 and in 2010, three Common Buzzards were found dead due to collision against the revolving rotors. In addition, in 2010, one Black Vulture was found dead with injuries caused by collision with a wind turbine (Doutau *et al.* 2011).

However, there were hardly any observations of Common Buzzards in the winter of the second period (always referring to the matching wind turbines) compared to the winter of the first period. This could be explained by a more severe winter during the second period, probably pushing the buzzards to the south and to lower altitudes, but this explanation is not supported by the temperature data recorded in both periods.

When data for the Common Buzzard were excluded from analysis, observation and flying rates were higher in the second period. This was also the case for vultures, whose observation and individual rates increased in the second period. The abundance of raptors overall was therefore higher in the second period.

To conclude, a strong effect of the wind farm operation on the Common Buzzard population in the area is highly likely. However, the question remains whether this is due to displacement or higher mortality. The rest of the raptors may get used to wind farms in time, probably exposing them to a higher risk of collision and hence higher mortality.

4.5.4. Bird use index

Total bird use of all species combined and in those wind farms that were examined in both monitoring periods appears to have increased four years after the first monitoring period (Fig. 15). With the exception of Peltastis wind farm, where bird use during both periods was almost the same, the pattern of bird use in all other windfarms was similar, being generally higher during the second period compared to the first (Figures 16-19).

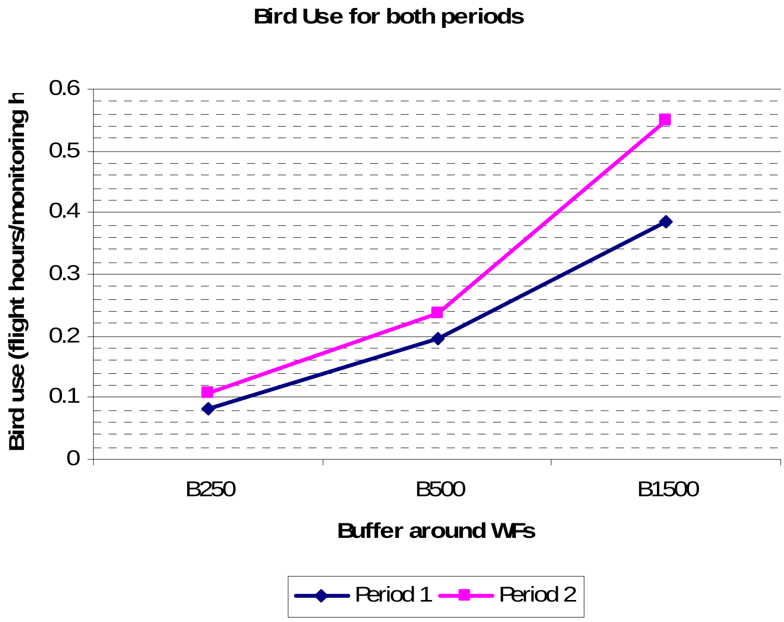


Fig. 15 Total bird use for all species combined in wind farms examined during both periods. Period 1=first monitoring period, 2004-2005, Period 2=second monitoring period, 2008-2009; B250=buffer zone 250 m, B500=buffer zone 500 m, B1500=buffer zone 1500 m (see section 3.5 for details).

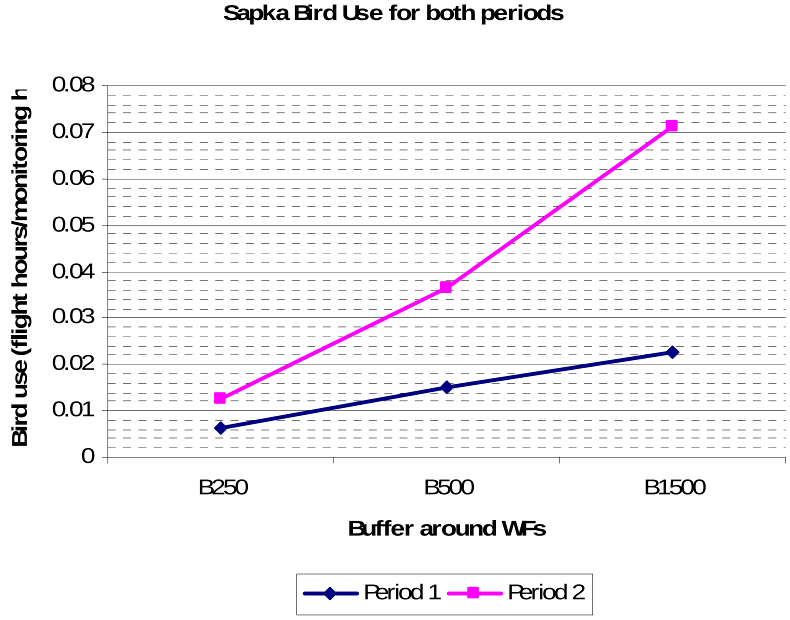


Fig. 16 Total bird use for all species combined in Sapka during both periods

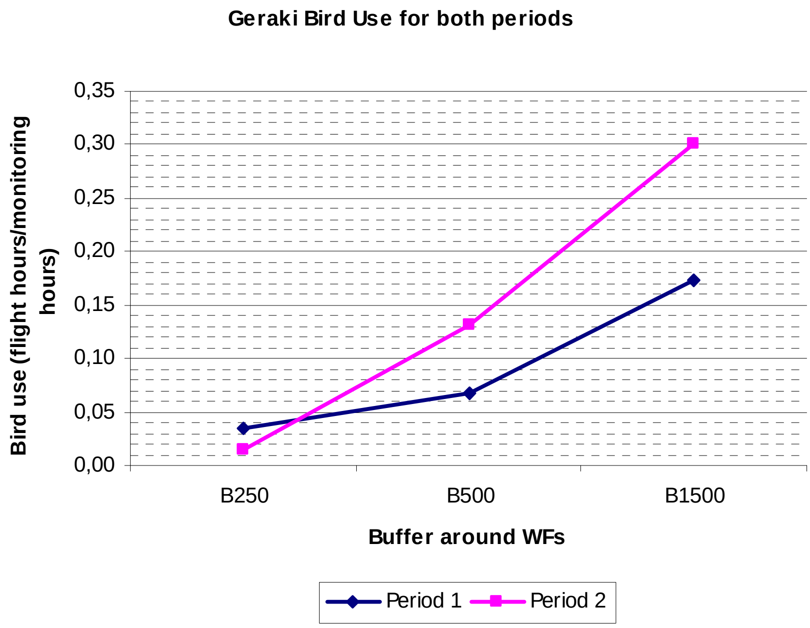


Fig. 17 Total bird use for all species in Geraki during both periods

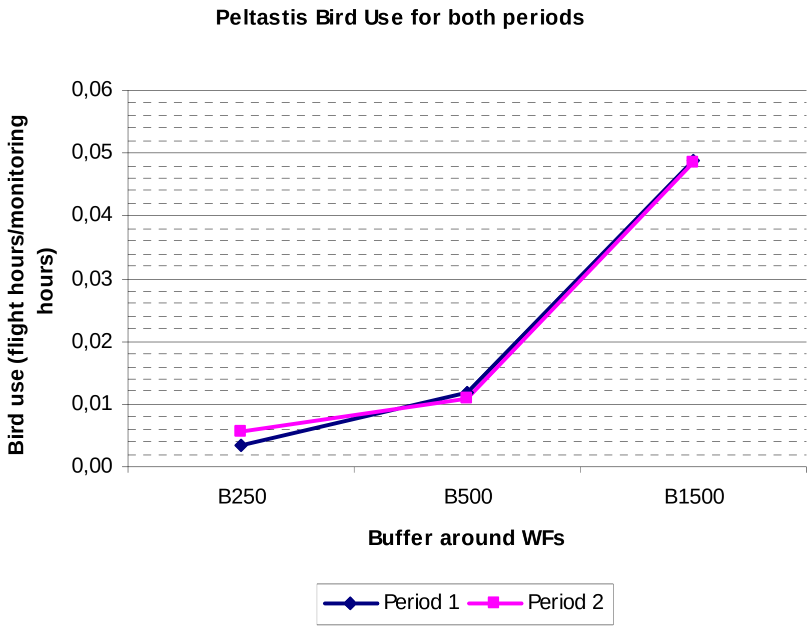


Fig. 18 Total bird use for all species in Peltastis during both periods

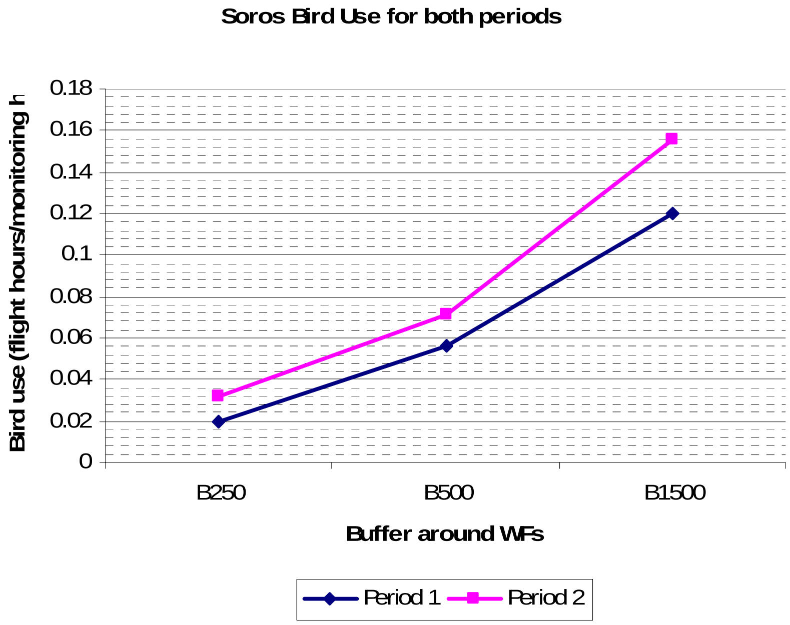


Fig. 19 Total bird use for all species in Soros during both periods

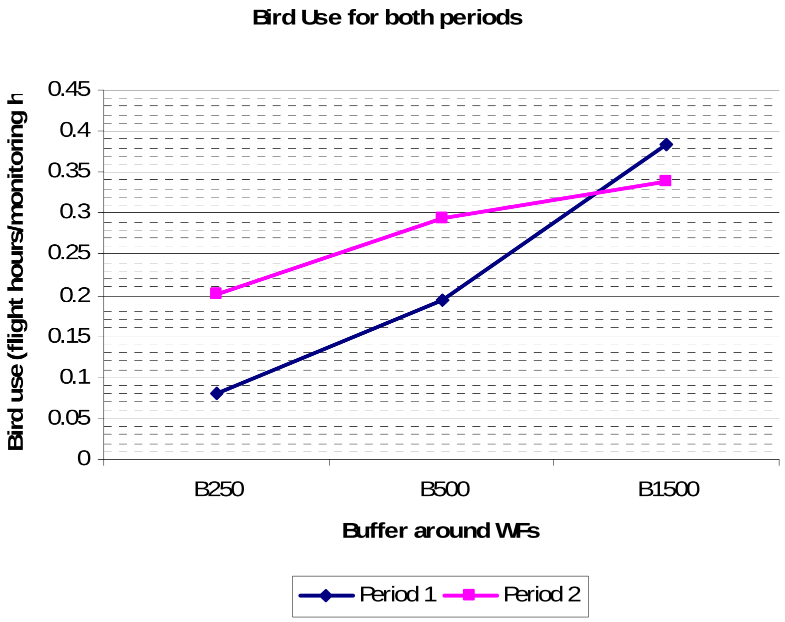


Fig. 20 Total bird use for all species in the totality of wind farms during both periods. Here wind turbines additionally examined in the second period (Period 2) are also included.

Bird use by the most relevant species in wind farms that were examined in both monitoring periods appears to have increased four years after the first monitoring period. With the striking exception of Common Buzzards, for which bird use during the first period was higher, the pattern of bird use by all other species examined was generally higher during the second period compared to the first (Figures 21-27).

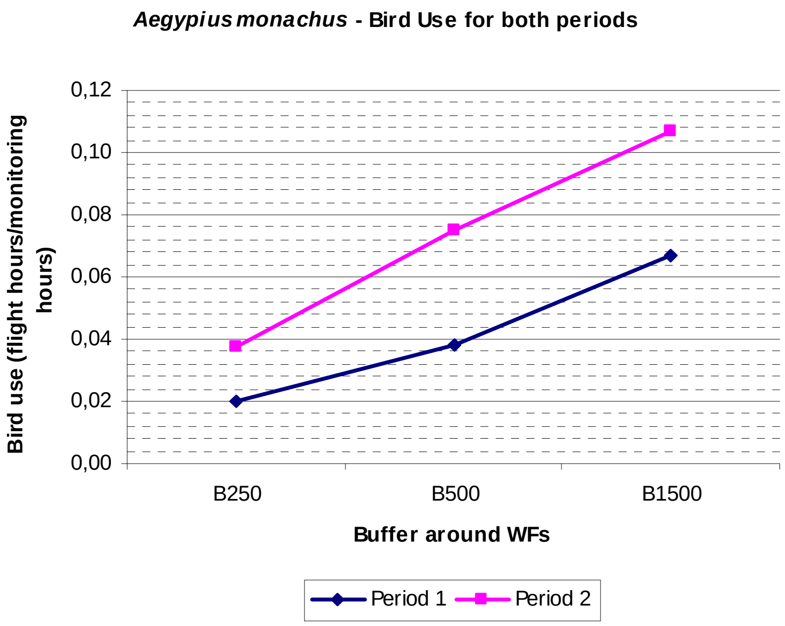


Fig. 21 Use of wind farms space by Black Vulture during both periods.

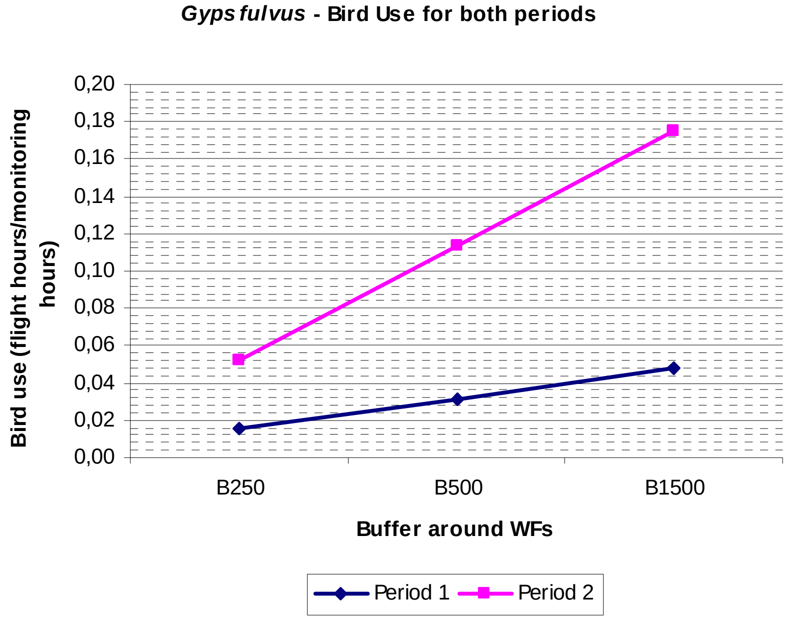


Fig. 22 Use of wind farms space by Griffon Vulture during both periods.

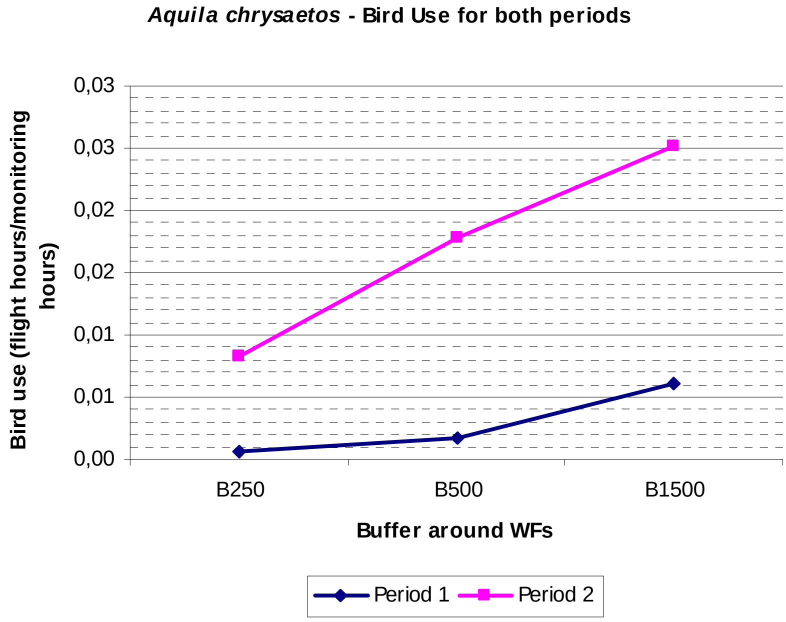


Fig. 23 Use of wind farms space by Golden Eagle during both periods.

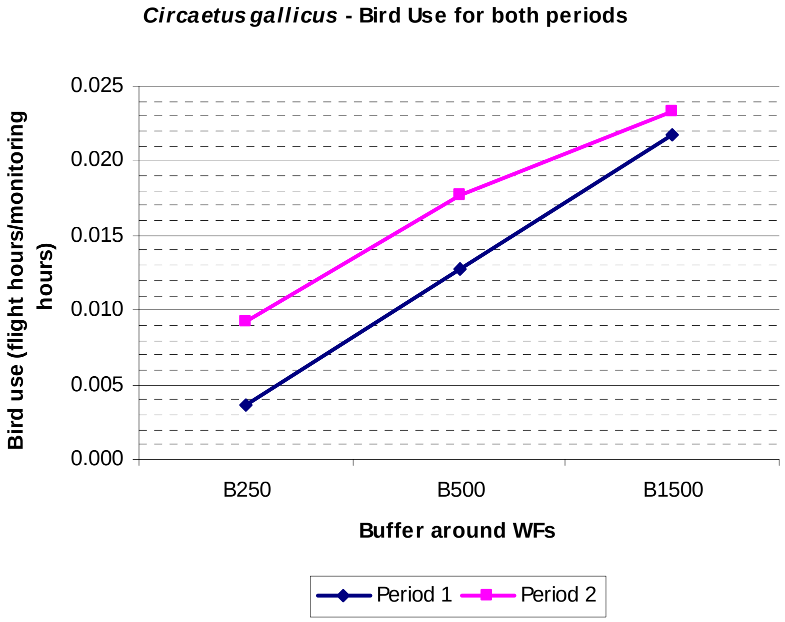


Fig. 24 Use of wind farms space by Short toed Eagle during both periods.

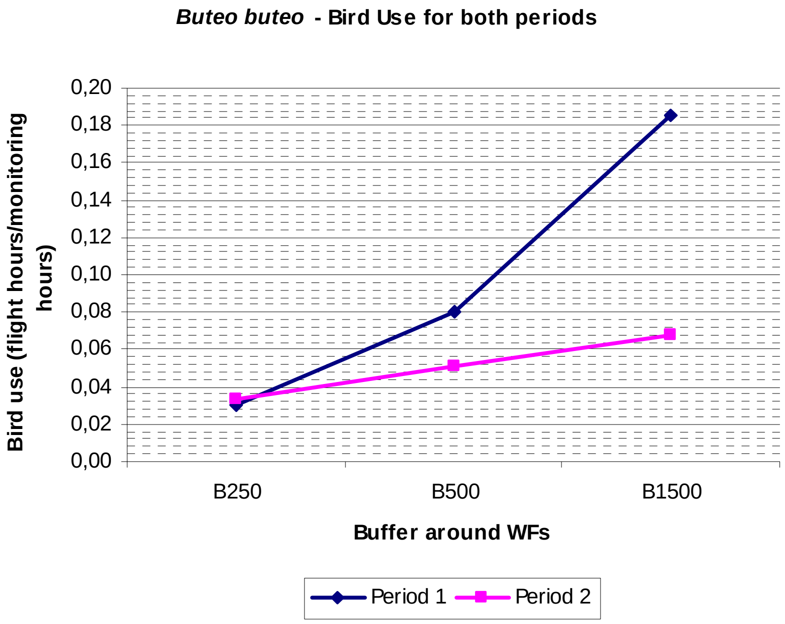


Fig. 25 Use of wind farms space by Common Buzzard during both periods.

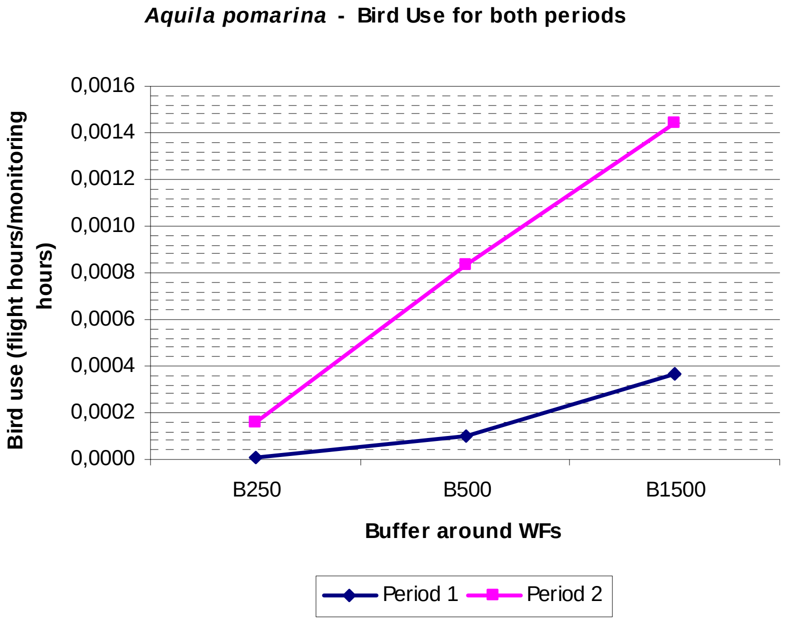


Fig. 26 Use of wind farms space by Lesser Spotted Eagle during both periods.

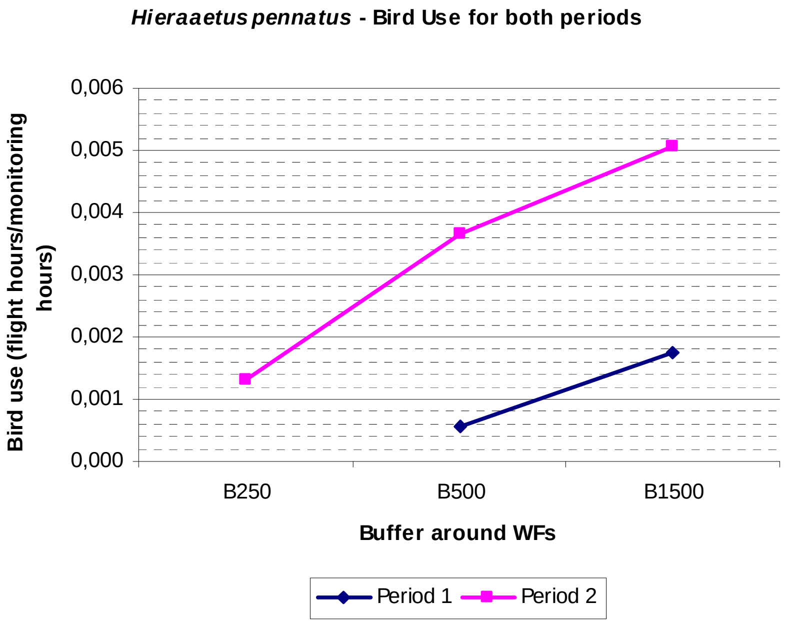


Fig. 27 Use of wind farms space by Booted Eagle during both periods.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Effect of wind farms on birds of prey

- Common and rare bird and bat species were found dead due to collision with wind turbines.
- Estimated mortality rates (birds/turbine/year) are comparable to estimations reported in the literature. Estimated vulture mortality rate was higher than the observed mortality.
- The comparison of crossing densities and individual flying rates between the two study periods (2004-2005 and 2008-2009) suggests that all raptors except the Common Buzzard used the broader wind farm area more intensively during the second period, four years after the first. This implies that raptors may have got used to the presence of the wind turbines, and this probably exposes them to a greater risk of collision. This finding was more evident for the Griffon Vulture. In fact, the higher mortality found during the second study period is in agreement with a greater exposure of birds to collision.
- The Common Buzzard population may have been affected by the operation of the wind farms probably as a result of displacement of territorial pairs present during the first period or a greater collision mortality. Even very few individuals killed could dramatically decrease the number of observations, as these are territorial pairs and their movements in the area would lead to a high number of observations.
- Three out of the four Griffon Vulture fatalities were adults. Although more data should be collected regarding the population dynamics, higher adult mortality leads to a higher risk of population decline in these long-lived animals.
- Cumulative negative impacts of operating wind farms will certainly be more serious for the long-term survival of vulture populations in the area.

5.2. Validity and effectiveness of methods used

- Carcasses or carcass parts remained in the field on average for 23 days. However, our searching interval time of 14 days may have led to an important underestimation of the real number of collision incidents and resulting fatalities, as 50%, 22% and 25 % of small, medium and large carcasses respectively had been removed within 14 days.
- Scavengers may not be the only “agents” removing carcasses from the wind farm area. Intentional removal by humans cannot be excluded and may have also led to an underestimation of mortality.

5.3. Recommendations on methods for future application

- Carcasses of various sizes should be used in scavenger removal trials in order to have more reliable estimations of removal rates.
- Both scavenger removal and observer efficiency trials should be conducted across all seasons of the year, as seasonal changes in vegetation structure may affect the results.

- The same observers should be used across all seasons, to reduce the variation originating from differences in their carcass detection ability.
- Estimated mortality has to be evaluated per species in combination with population viability analyses.
- The more intensive use by birds of the wind farm area four years after the first post construction monitoring suggests that only a single year of post-construction monitoring may not be adequate to reveal the real impact of the wind farms on birds of prey. Farfán *et al*. (2009) consider that post-construction monitoring should be conducted over a longer period, while Madders and Whitfield (2006) note that it should ideally be conducted over a period relative to the generation time of the species involved. We suggest that conducting a second post-construction monitoring after 3 to 5 years would notably improve the estimation of the impacts.
- Post-construction studies should be implemented for every wind farm by independent researchers having access to unbiased field data, following sound ornithological studies.

5.4. Conservation implications and recommendations

- Areas with steep slopes seem to be actively selected for flight by raptors and it is suggested that pre-construction ornithological studies should exclude ridges above them when evaluating suitability of locations for wind farm siting.
- Pre-construction ornithological studies should also incorporate data with regards to the relief and exposure (aspect) of the slope in their evaluation of the proposed wind farm locations: north facing slopes are avoided by most raptors, while those facing east are preferred.
- The longer the distance between turbines, the higher is the probability that raptors will attempt to cross the space between them. Therefore, the distance between adjacent wind turbines should also be accounted for in the wind farm design. Distances between turbines should be as long as possible, to prevent wind farms from becoming an insurmountable linear obstacles. This is even more important given that the density of wind farms in the area is expected to increase. Lower density of wind turbines for the Windfarm Priority Area 1 – where the specific goal of 960 MW has to be reached - can be achieved if larger and more effective machines are installed. Currently new and more productive designs of wind turbines are being produced, so that fewer turbines can produce the same amounts of energy. Having fewer clusters of lower densities, it is expected that there will be fewer sites where negative consequences may occur (WWF 2008).
- Cumulative effects of every new wind farm proposal should be evaluated before getting final authorization.
- Many new wind farms are planned to be established in the area. This means that the impact of the already established wind farms should be evaluated again, as new wind turbines occupy the space around them and change the environment in which birds fly.

6. STUDY TEAM AND AKNOWLEDGEMENTS

The following people were involved in the several phases of the preparation of the present report:

Dimitris Vasilakis: General supervision of the study, design of the methodology, data analysis, writing and review of the technical report.
Christina Zografou: General preparation and set up of the monitoring, field work, review of the technical report.
Beatriz Cárcamo: Field work, data entry onto database, data analysis, writing and review of the technical report.
Elzbieta Kret: Data analysis, writing and review of the technical report.
Marion Auffray, Stephen Beal, Ingrid Francart, Julia Gasser: Field work and data entry onto database.
Luisa Cardenete, Baptiste Doutau, Daniel Magalhaes, Emeline Pauc, Zoe Smith, Joe Wastie, Yannis Marinos, Nikos Kasimis: Field work.
Dr Panagiotis Georgiakakis identified the bats.
Dr Elena Papadatou improved the English text and made enlightening comments.
Theodora Skartsi, Project leader of WWF Greece's Evros Project and Dr Giorgos Catsadorakis, WWF Greece's Senior Scientific Advisor carried out the final scientific review of the technical report.

We are grateful to Dr Miguel Ferrer and Dr Phil Whitfield for peer-reviewing the technical report and for their many useful comments; Dr Stefan Schindler and Javier Elorriaga for their useful comments; Dr Christos Barboutis for his help with identification of passerines and the Hellenic Wildlife Hospital who kindly provided us with carcasses for the trials.

Appendix I Data sheets used in the carcass surveys.

Date	**Researchers**
Start time	**Sites**
End time	**Interruption**

Site	**Round**	**Windmills searched (e.g. T30, T31, T32…)**	**Percentage of 50 m radio surface (for windmills where you cannot search all the surface, write here (e.g. T32 (50%))**	**Comments**

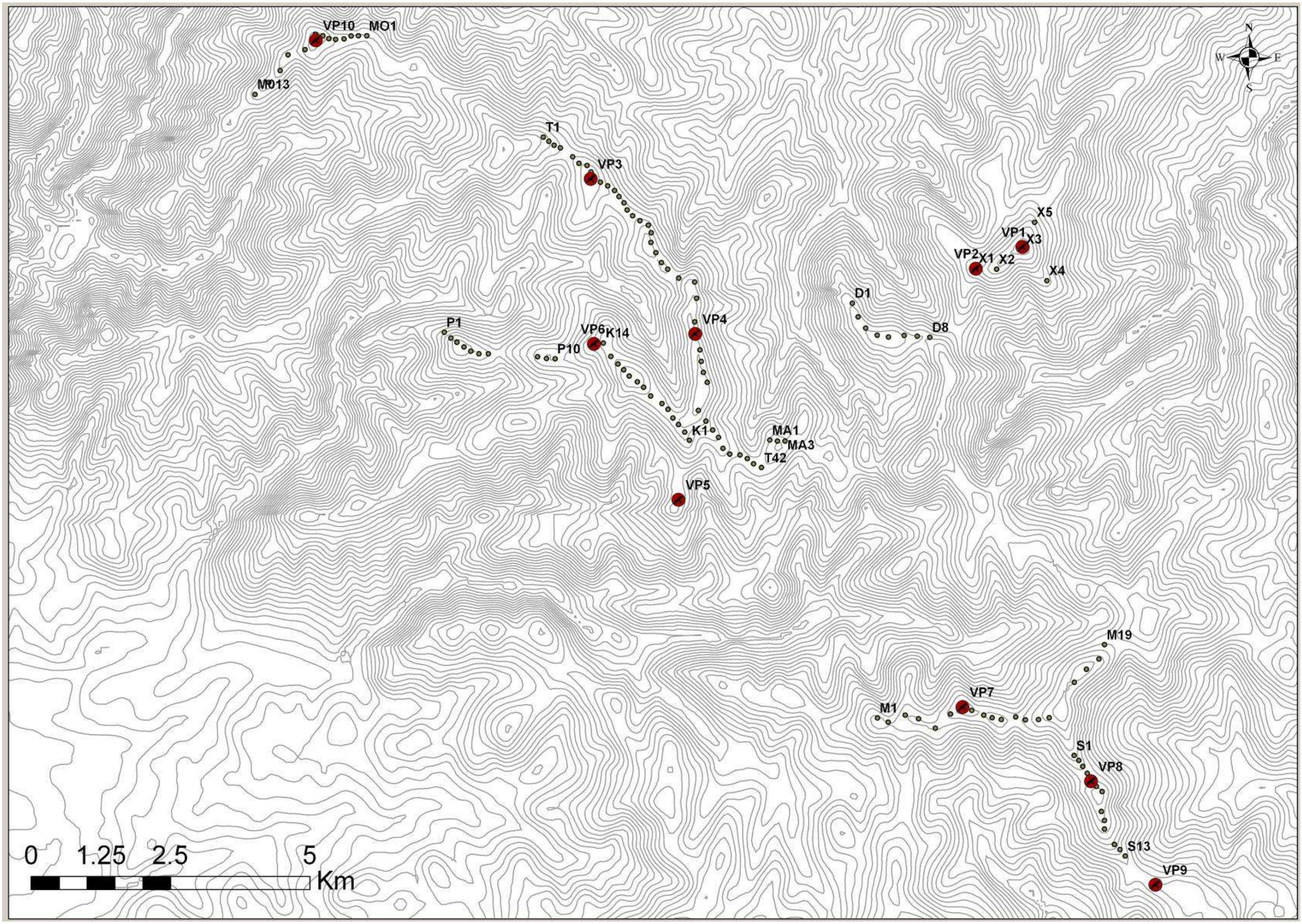
In case you find a carcass of a large raptor or a vulture, don't remove it and call the office. For the rest that you find:

ID	**Carcass condition / description**	**Species**	**Age**	**Sex**	**Site/ Turbin plot**	**GPS**	**Distance to closest turbin**	**Direction from turbine base**	**Estimated time of death**	**Estimated cause of death**	**No photo taken**	**Comments**

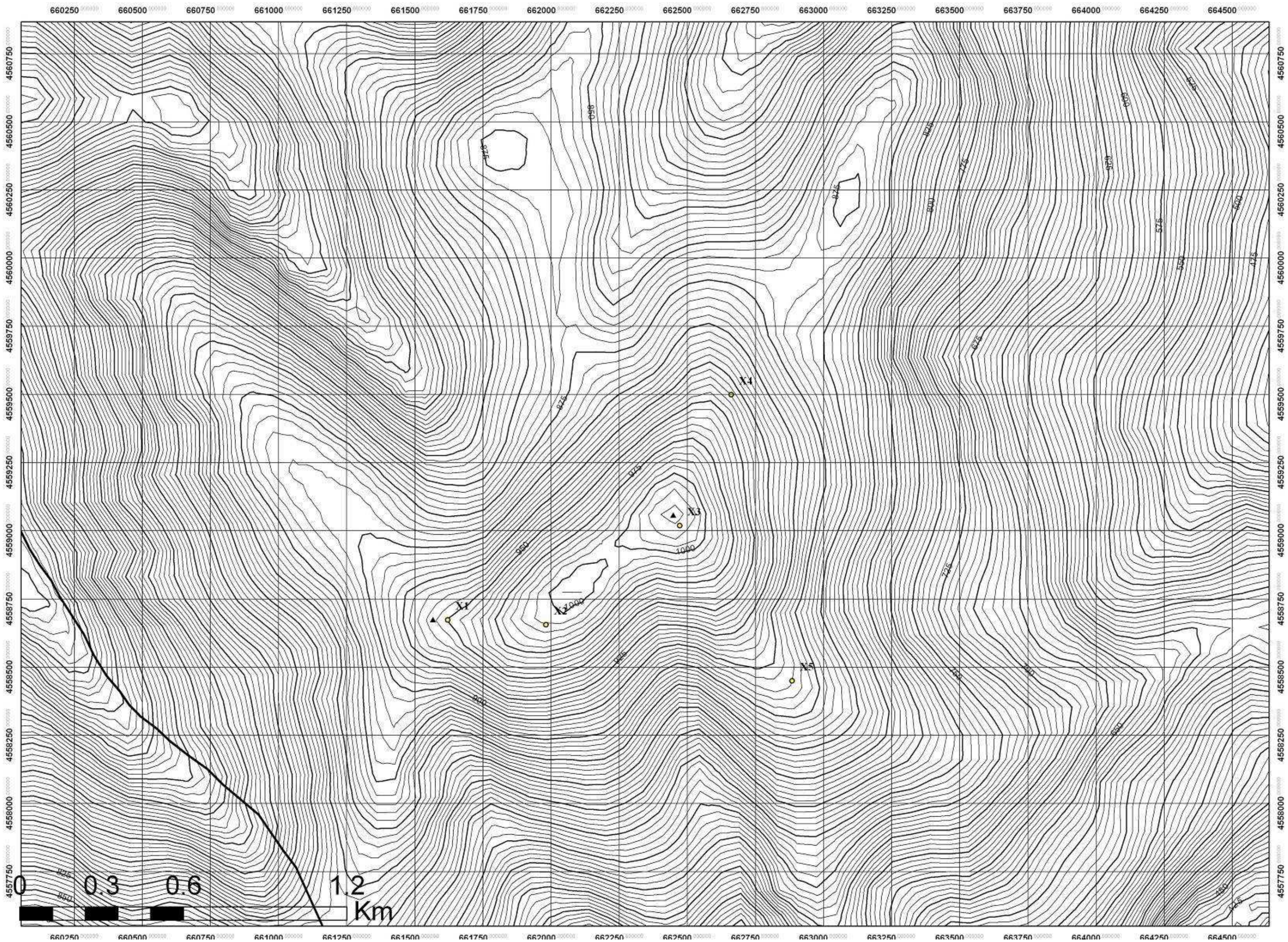
Carcass condition:

- Intact: carcass which is completely intact, not badly decomposed, no sign of been fed upon by predator or scavenger
- Scavenged: Entire carcass that shows sign of been fed upon by predator or scavenger
- Portion of a carcass
- Feathers

Appendix II Location of the ten view points used during the surveys of space use by birds.



Appendix III – Example of a space use by birds map. Map of the study plot observed from VP1.



Appendix IVa – Data sheets used in the surveys of space use by birds. Part 1

Wind Farm Monitoring 2009
Space use by birds

Date: / /2009 Researcher: Start Time: End Time: Interruption: Vantage Point:

Number (A/A)	Start Time	End Time	Species	Sex	Age	Status	Number indiv.	Initial distance to observer (m)	Closest distance to observer (m)	Height above the ground	Activity	Comments

Species: if species identification is not possible write down if it is a Vulture, Eagle, Buzzard, etc. Sex: **M** for Male, **F** for Female, **U** for Unknown
Age: Juvenile **(J)** Immature **(I)**, Adult **(A)** Unknown **(U)** **Status:** Local **(L)** (for territorial flights), Migratory **(M)**, Unknown **(U)**
Height above the ground: for the cases that the bird does not fly close to the windmills Low **(L)**, High **(H),** Very High **(VH)**, in reference to the ground, for general sense of the flight or write down at comments.
Activity: Soaring **(S)** Flying **(F)** Gliding **(G)** Display **(D)** Landing **(L)** Take off **(TOF)**, Hunting **(H)** Mobbing **(M)** Foraging **(Fo)** Perching **(P)**

Appendix IVb – Data sheets used in the surveys of space use by birds. Part 2

Wind Farm Monitoring 2009
Space use by birds

Date: / /2009 Researcher: Start Time: End Time: Interruption: Vantage Point:

Number (A/A)	Time In 250m In min	Species	Interaction with turbins	No of turbins		Operational status and sec/round	Distance to nearest tur.		Flight height	Reaction	Wind	Comments	
				No1	No2		Disatnce	No					

Time in 250m plot: the time that the bird spends in the plot of 250 m distance from turbines, in minutes.
Interaction with turbine: 1. The bird is flying far from the windmills no interaction, **2**. the bird is flying parallel to the windmills or it comes close to one but it does not cross (record a distance from the closest turbine record if it is more than one turbine also record height in relation to the pylon), **3.** the bird is crossing between 2 windmills (or one if it is the last one) we record the numbers of the turbines, the horizontal distance from the closest turbine, and the flight height (in relation with the pylons) at the moment of crossing. **4.** the bird is crossing the windmills but flies quite higher than the height of the windmills (in this case we record the flight height the time that is crossing the line of windmills and as a distance from the turbine the height from the closest turbine) **5.** the bird crosses and flies in the blade sphere of one windmill. In this case as a distance we note down if the bird passes through at 25%, 50%, 75%, 100% of the rotor length) **Operational Status:** NM not moving, MS moving slowly, MF moving fast, MVF moving very fast and record how many second it takes for a full rotation. **Reaction with the turbine:** NR no reaction, slight changes of flight direction, sudden change of flight direction, loss of balance, panic behavior and slowing down, collision.

Appendix IVc – Data sheets used in the surveys of space use by birds. Part 3

Wind Farm Monitoring 2009
Space use by birds

Date: / /2009 Researcher: Start Time: End Time: Interruption: Vantage Point:

Time											
Weather data	1	2	3	4	5	6	7	8	9	10	11
Wind Power :											
Wind Direction:											
Temperature (ST/ET):											
Visibility (ST/ET):											
Cloud cover:											
Fog presence:											
Humidity:											

Clouds: Estimation in 100%
Visibility: Excellent, good, regular, bad, very bad

Appendix V Frequency of birds detected in the risk area (≤ 250 m) of the wind farms presented as number of individuals per 10 hours of behaviour monitoring:

View Point	VP01	VP02	VP03	VP04	VP05	VP06	VP07	VP08	VP09	VP10	Total
Time spent (hours: minutes)	102:10	92:35	81:15	79:28	129:04	102:45	93:20	96:32	82:00	83:00	942:0
Number of individuals	53	61	57	102	108	51	45	131	38	29	675
Frequency	**5,19**	**6,59**	**7,02**	**12,84**	**8,37**	**4,96**	**4,82**	**13,57**	**4,63**	**3,49**	

Appendix VI Detailed interaction of observations (by species) and overall interaction of observations (Vultures – rest of species)

	Interaction with turbines					
Species	0 / 1	2	3	4	5	Total
Accipiter brevipes	1		1			2
Accipiter gentilis	6	1	3			10
Accipiter nisus	5	4	3			12
Accipiter sp.	5	2	7	1		15
Aegypius monachus	49	29	46	20	5	149
Aquila chrysaetos	16	12	11	4		43
Aquila pomarina	1	1	1			3
Ardea cinerea	0			1		1
Buteo buteo	62	25	41	6	7	141
Buteo rufinus	7	2				9
Buteo sp.	41	17	18	2	3	81
Ciconia ciconia			1			1
Ciconia nigra	8	5	8	1		22
Circaetus gallicus	14	9	7	3	1	34
Circus cyaneus		1				1
Columba oenas			1			1
Corvus corax	13	7	11	1		32
Corvus corone cornix	3		3			6
Corvus sp.	1		1			2
Unidentified eagles	3	3	7	2	1	16
Falco eleonorae		1				1
Falco naumanni	1					1
Falco peregrinus	1					1
Falco sp.	9	6	11	2		28
Falco subbuteo	1					1
Falco tinnunculus	7	4	3			14
Falco vespertinus	1					1
Unidentified gull			1	1		2
Gyps fulvus	47	27	33	22	6	135
Hieraaetus pennatus	3	1	5	1	1	11
Neophron percnopterus	1					1
Pernis apivorus	2	1	1	2		6
Unidentified raptors	22	11	15		1	49
Unidentified vultures	2	1				3
Total	**332**	**170**	**239**	**69**	**25**	**835**

	Interaction with turbines					
	0 / 1	2	3	4	5	Total
Vultures	99	57	79	42	11	288
Rest of species	233	113	160	27	14	547
Total	**332**	**170**	**239**	**69**	**25**	**835**

Appendix VII Turbines crossed during cross observations of all species (in number of observations)

Pair of turbines	Vultures observations	Rest	Pair of turbines	Vultures observations	Rest	Pair of turbines	Vultures observations	Rest	Pair of turbines	Vultures observations	Rest
-	2	1	M3-M4	2		P6	1		T12-T13	1	1
D2-D3	3		M4-M5		5	P6-P7		1	T14-T15		1
D3-D4	1	3	M5-M6		1	P7		1	T16-T17		1
D4-D5		2	M6-M7		2	P8-P9	1	4	T17-T18		1
D5-D6	1	3	M8-M9		1	P9-P10		1	T21-T22	1	2
D6-D7		4	M9-M10	1		P10	2	3	T23-T24	1	
D7-D8	1	2	M10-M11	1	1	S1		1	T25-T26		1
D8	1	4	M11-M12		1	S1-S2	3		T26-T27	1	4
K1	2	3	M12-M13	2	1	S3-S4	2	1	T27-T28	2	6
K1-K2		2	M13-M14		1	S4-S5	2		T28-T29	3	3
K2-K3	1	3	M15-M16	8	5	S6-S7	2	2	T29-T30		1
K2-T34		1	M15-S1		1	S7-S8	1	3	T30-T31		1
K3-K4	2	1	M16-M17	1	2	S8-S9	1		T32-T33	4	3
K4-K5	1	3	M17-M18	1	1	S9-S10		1	T33-T34	3	4
K5-K6	1	2	M18-M19	3	2	S10-S11	3	2	T34-T35	2	2
K6-K7	2	2	MA1-MA2	1	1	S11-S12	1	2	T35-T36	2	1
K7-K8	3		MA3		1	S12-S13	2	1	T36-T37	1	7
K8-K9	1		MO4-MO5		1	S13	2	4	T37-T38	1	2
K9-K10	2	2	MO7-MO8		1	T1		1	T38-T39		1
K10-K11	2	3	MO8-MO9	2	3	T4-T5	1		T41-T42		2
K11-K12	2		MO9-MO10	2		T6-T7	2	1	X1		3
K12-K13	1		MO10-MO11		2	T7-T8		3	X1-X2	1	5
K13-K14	4	2	MO12-MO13		1	T8-T9		2	X2-X3	1	7
K14	3	5	MO13	1		T9-T10	1	3	X3-X4	1	
M1		1	P1	1	1	T10-T11		2	X3-X5	5	
M2-M3		2	P1-P2		1	T11-T12		1	X5	2	1

Appendix VIII Turbines crossed during cross observations of all species (in number of individuals)

Pair of turbines	Vulture individuals	Rest
-	6	1
D2-D3	4	
D3-D4	1	5
D4-D5		2
D5-D6	1	4
D6-D7		7
D7-D8	1	3
D8	1	6
K1	4	3
K1-K2		2
K2-K3	2	3
K2-T34		1
K3-K4	3	2
K4-K5	1	3
K5-K6	1	2
K6-K7	3	4
K7-K8	4	
K8-K9	1	
K9-K10	2	2
K10-K11	4	3
K11-K12	2	
K12-K13	1	
K13-K14	5	3
K14	3	8
M1		1
M2-M3		2

Pair of turbines	Vulture individuals	Rest
-	6	1
D2-D3	4	
D3-D4	1	5
D4-D5		2
D5-D6	1	4
D6-D7		7
D7-D8	1	3
D8	1	6
K1	4	3
K1-K2		2
K2-K3	2	3
K2-T34		1
K3-K4	3	2
K4-K5	1	3
K5-K6	1	2
K6-K7	3	4
K7-K8	4	
K8-K9	1	
K9-K10	2	2
K10-K11	4	3
K11-K12	2	
K12-K13	1	
K13-K14	5	3
K14	3	8
M1		1
M2-M3		2

Pair of turbines	Vulture individuals	Rest
P6	1	
P6-P7		1
P7		2
P8-P9	1	4
P9-P10		1
P10	2	3
S1		1
S1-S2	25	
S3-S4	2	1
S4-S5	5	
S6-S7	5	2
S7-S8	1	4
S8-S9	2	
S9-S10		1
S10-S11	3	2
S11-S12	1	2
S12-S13	3	6
S13	2	4
T1		1
T4-T5	2	
T6-T7	2	1
T7-T8		3
T8-T9		2
T9-T10	1	3
T10-T11		3
T11-T12		1

Pair of turbines	Vulture individuals	Rest
T12-T13	1	1
T14-T15		2
T16-T17		2
T17-T18		2
T21-T22	1	2
T23-T24	1	
T25-T26		1
T26-T27	1	7
T27-T28	2	8
T28-T29	3	3
T29-T30		1
T30-T31		1
T32-T33	5	3
T33-T34	3	4
T34-T35	5	3
T35-T36	3	1
T36-T37	1	12
T37-T38	1	4
T38-T39		2
T41-T42		2
X1		3
X1-X2	1	5
X2-X3	1	8
X3-X4	1	
X3-X5	5	
X5	2	6

Appendix IX Pairs of wind turbines and distances between them

Pair of turbines	Distance (m)
D1-D2	268.28
D2-D3	245.11
D3-D4	240.25
D4-D5	208.33
D5-D6	283.93
D6-D7	234.12
D7-D8	225.51
K1-K2	170.64
K2-K3	176.42
K3-K4	155.24
K4-K5	181.42
K5-K6	150.72
K6-K7	239.94
K7-K8	203.31
K8-K9	150.48
K9-K10	177.02
K10-K11	154.26
K11-K12	145.64
K12-K13	184.89
K13-K14	276.96
M1-M2	205.28
M2-M3	333.3
M3-M4	246.65
M4-M5	346.17

Pair of turbines	Distance (m)
M5-M6	371.92
M6-M7	296.34
M7-M8	129.82
M8-M9	234.3
M9-M10	156.47
M10-M11	168.01
M11-M12	260.87
M12-M13	185.6
M13-M14	236.26
M14-M15	194.47
M15-M16	781.68
M16-M17	318.47
M17-M18	293.43
M18-M19	273.85
MA1-MA2	137.89
MA2-MA3	134.39
MO1-MO2	146.31
MO2-MO3	132.09
MO3-MO4	139.67
MO4-MO5	178.72
MO5-MO6	125.07
MO6-MO7	121.75
MO7-MO8	134.78
MO8-MO9	337.26

Pair of turbines	Distance (m)
MO9-MO10	321.12
MO10-MO11	313.34
MO11-MO12	293.77
MO12-MO13	327.97
P1-P2	158.23
P2-P3	133.67
P3-P4	150.24
P4-P5	145.93
P5-P6	151.94
P6-P7	167.06
P7-P8	889.07
P8-P9	162.41
P9-P10	157.15
S1-S2	119.36
S2-S3	132.61
S3-S4	145.21
S4-S5	161.98
S5-S6	124.47
S6-S7	142.51
S7-S8	360.9
S8-S9	168.37
S9-S10	155.53
S10-S11	327.89
S11-S12	135.06

Pair of turbines	Distance (m)
S12-S13	150.11
T1-T2	126.43
T2-T3	118.11
T3-T4	123.96
T4-T5	272.55
T5-T6	162.87
T6-T7	150.64
T7-T8	137.51
T8-T9	123.5
T9-T10	136.61
T10-T11	149.24
T11-T12	146.53
T12-T13	135.87
T13-T14	144.96
T14-T15	136.47
T15-T16	144.21
T16-T17	156.07
T17-T18	172.3
T18-T19	146.92
T19-T20	174.75
T20-T21	202.47
T21-T22	203.5
T22-T23	165.07
T23-T24	255.62

Pair of turbines	Distance (m)
T24-T25	291.04
T25-T26	297.24
T26-T27	424.8
T27-T28	229.73
T28-T29	279.99
T29-T30	209.11
T30-T31	200.97
T31-T32	191.55
T32-T33	527.84
T33-T34	236.23
T34-T35	203.1
T35-T36	168.58
T36-T37	210.26
T37-T38	162.51
T38-T39	180.14
T39-T40	150.04
T40-T41	146.91
T41-T42	156.64
X1-X2	360.84
X2-X3	610.48
X3-X5	702.89

D1-D8 Didimos Lofos
K1-K14 Kerveros

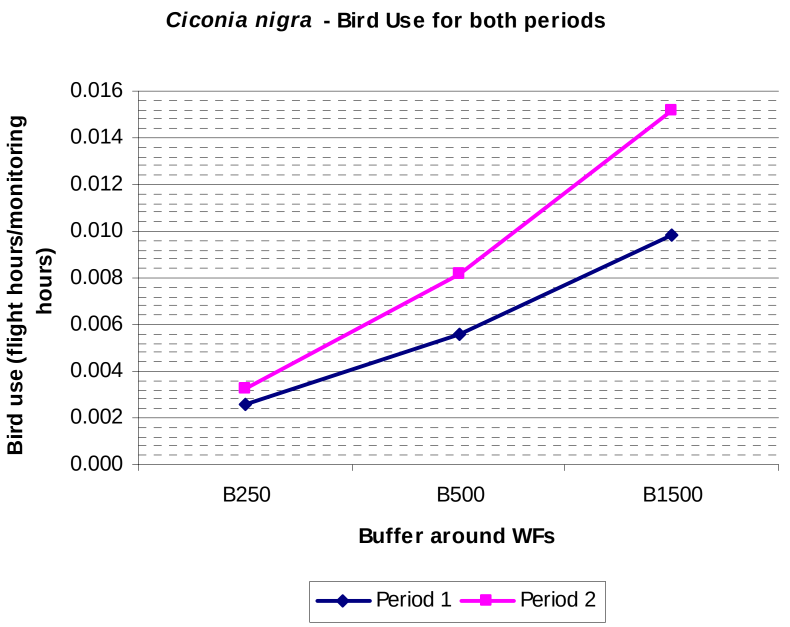
M1-M19 Mytoula
MA1-MA3 Mati

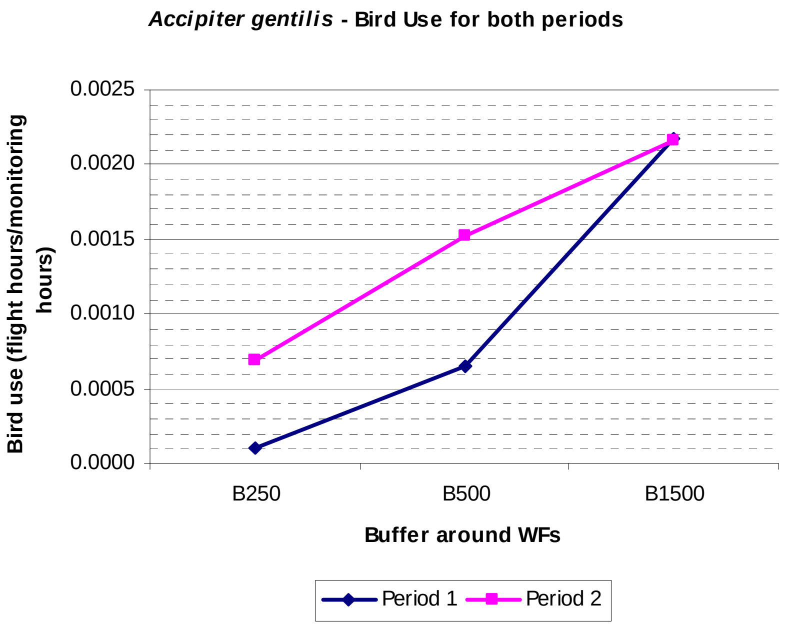
MO1-MO13 Monastiri
P1-P10 Peltastis

S1-S13 Soros
T1-T42 Geraki

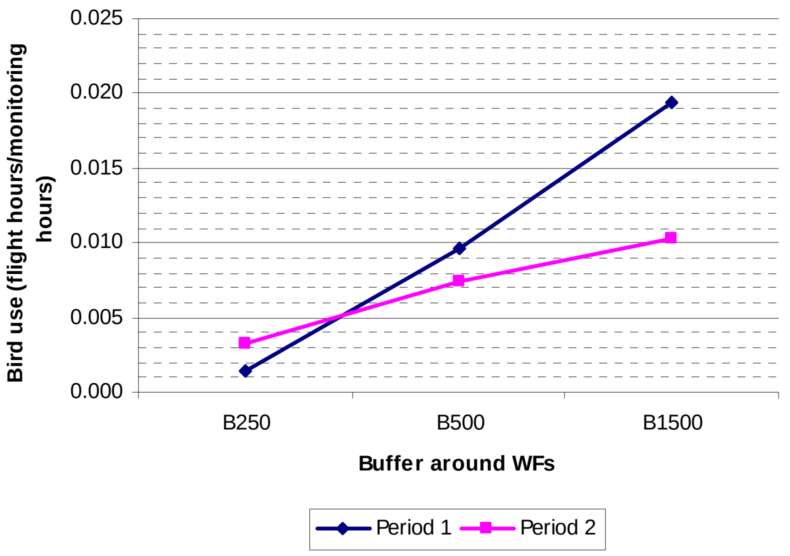
X1-X5 Sapka

Appendix X Comparison of bird use indices for Black Stork, Goshawk, Honey Buzzard, Sparrowhawk and Kestrel

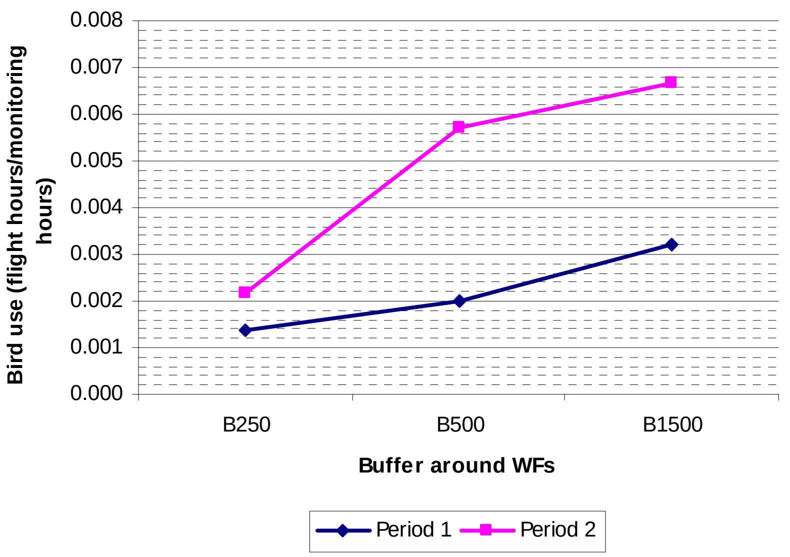


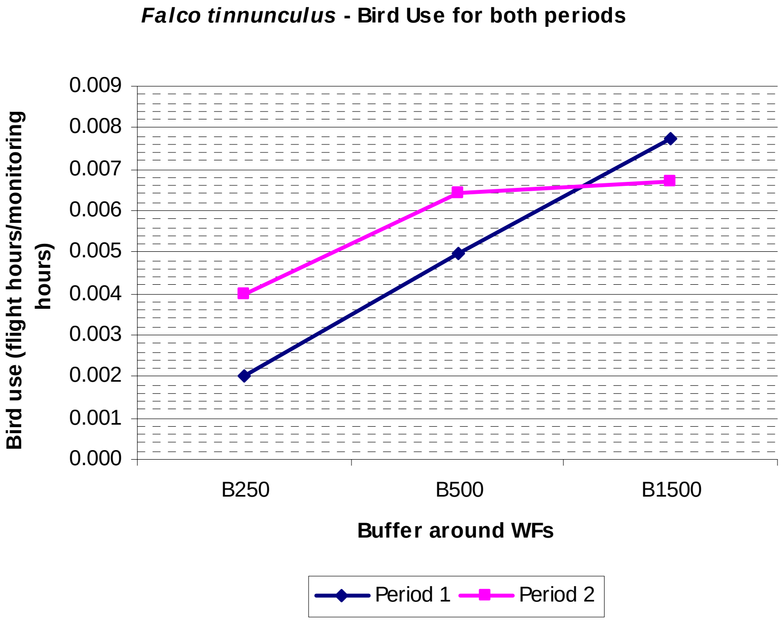


Pernis apivorus **- Bird Use for both periods**



Accipiter nisus **- Bird Use for both periods**




Falco tinnunculus **- Bird Use for both periods**
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
Bird use (flight hours/monitoring hours)
B250
B500
B1500
Buffer around WFs
Period 1
Period 2

Appendix XI Additional space use by birds data for the second monitoring period, that can be compared with those resulting from the first monitoring period (see Ruiz *et al*. 2005)

Table 50 Proportion of risk flights (all species)

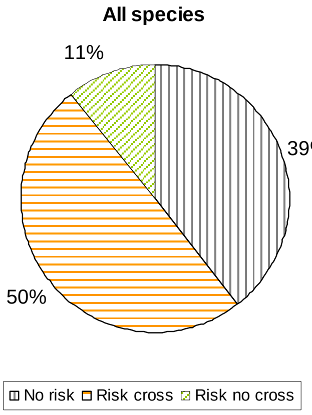
	Observations	Percentage	Individuals	Percentage
Total	835		1115	
Risk area	534	63,95%	675	60,54%
Crossed between turbines	308	36,89% of the total 57,68% of the risk flights	554	49,69% of the total 82,07% of the risk flights

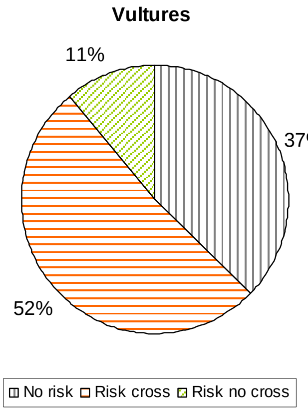
Table 51 Proportion of risk flights (vultures)

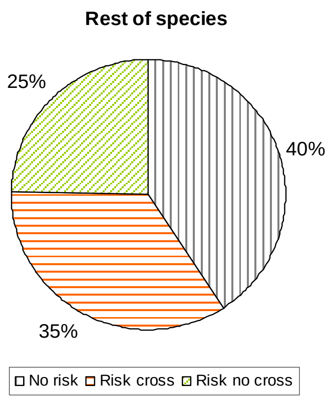
	Observations	Percentage	Individuals	Percentage
Total	285		403	
Risk	197	69,12%	253	62,78%
Crossed between turbines	121	42,46% of the total 61,42% of the risk flights	208	51,62 of the total 82,21% of the risk flights

Table 52 Proportion of risk flights (rest of species)

	Observations	Percentage	Individuals	Percentage
Total	550		712	
Risk	337	61,27	422	59,27
Cross	187	34% of the total 55,49% of the risk flights	246	34,55% of the total 58,29% of the risk flights







Appendix XII Wind data

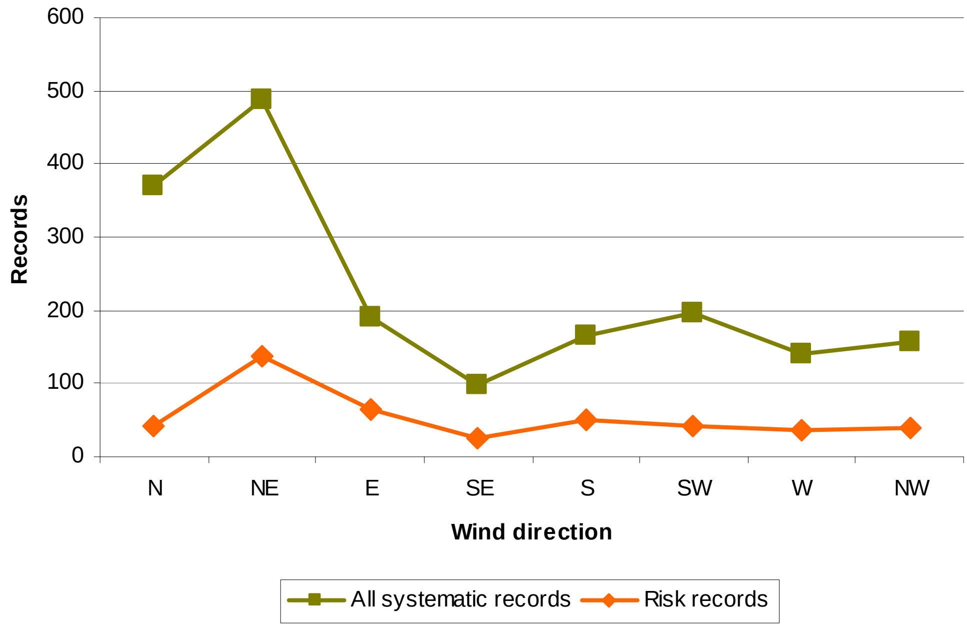


Fig. 28 Wind direction for all flights (all systematic records) and risk flights (risk records). Risk records refer to flights recorded within the risk area of wind turbines (250 m buffer zone).

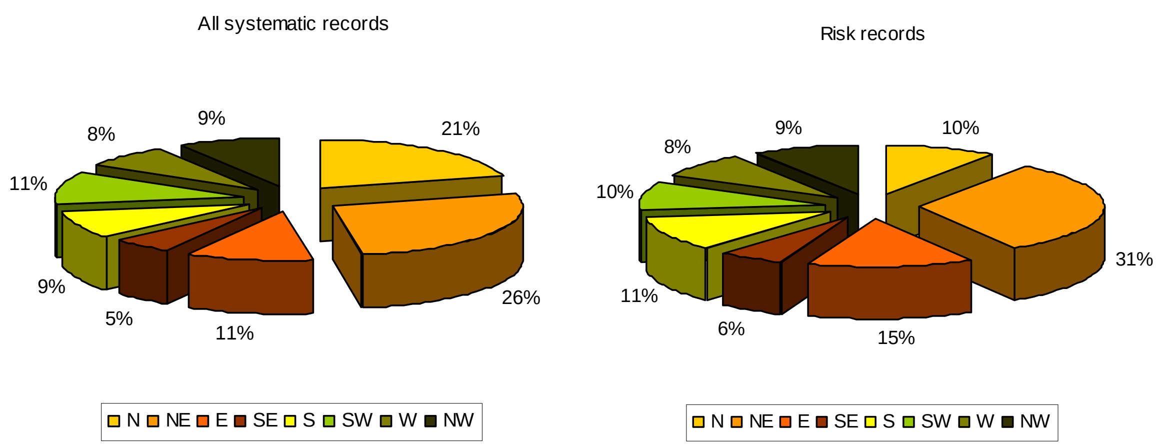


Fig. 29 Proportions of wind direction. Risk records refer to flights recorded within the risk area of wind turbines (250 m buffer zone).

Appendix XIII - Resources

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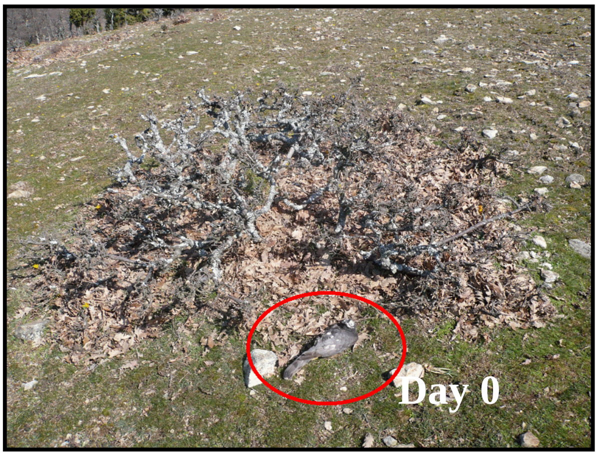
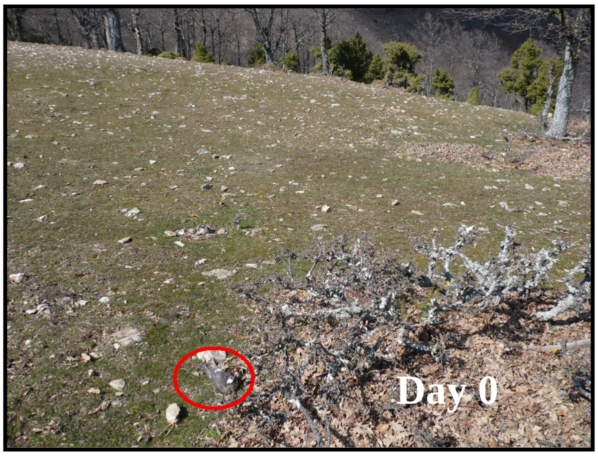
Appendix XIV – Photographs: example sequences of the scavenger removal trials

March 2009

Geraki-Mati. Sparrowhawk (*Accipiter nisus*)






Day 4


Day 7


Day 14

March 2009

Mytoula. Common Buzzard (*Buteo buteo*)