THE DADIA–LEFKIMI–SOUFLI FOREST NATIONAL PARK, GREECE: BIODIVERSITY, MANAGEMENT AND CONSERVATION

Edited by
Giorgos Catsadorakis and Hans Källander

Illustrations by
Paschalis Dougalis

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Editors:

Giorgos Catsadorakis,
P.O. Box 403,
Dadia,
GR-68 400 Soufli,
GREECE
doncats@otenet.gr
g.catsadorakis@wwf.gr

Hans Källander,
Villavägen 6,
SE-240 35 Harlösa,
SWEDEN

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Diurnal birds of prey in the Dadia–Lefkimi–Soufli Forest National Park: long-term population trends and habitat preferences

Konstantinos Poirazidis, Stefan Schindler, Eleftherios Kakalis, Carlos Ruiz, Dimitrios E. Bakaloudis, Chiara Scandolara, Chris Eastham, Hristo Hristov and Giorgos Catsadorakis

Raptors are indicators of ecosystem health and may act as conservation flagship species for conservation. Twenty-four raptor species have been found to breed in the Dadia–Lefkimi–Soufli Forest National Park (DNP), which holds one of the most diversified raptor assemblages in Europe. While only 18–20 diurnal species still breed, during five years of systematic monitoring (2001–2005) most species exhibited stable populations. The overall number of raptor territories was estimated at between 307 and 342, which corresponds to a density of 71.4 to 79.6 territories 100 km^{-2}. The Common Buzzard *Buteo buteo* represented 35–38% of the total territories in the area, while other common species were Short-toed Eagle *Circaetus gallicus*, Booted Eagle *Hieraaetus pennatus*, Lesser Spotted Eagle *Aquila pomarina*, Honey Buzzard *Pernis apivorus*, Goshawk *Accipiter gentilis* and Sparrowhawk *A. nisus*. Some other important species, such as Golden Eagle *Aquila chrysaetos*, which have shown population declines during recent decades show signs of recovery, possibly due to habitat protection and reduced persecution. Distance to foraging areas and territorial behaviour mainly determine the segregation of raptors in the DNP. Within their breeding territories raptors were selective with respect to nesting microhabitat, selecting specific forest structures and nest-tree characteristics.

Keywords: Raptors, breeding populations, systematic monitoring, conservation management, Greece

Introduction

Raptors, being at the top of the food chain, are considered biologically important and environmentally sensitive as well as being indicators of ecosystem health (Newton 1979, Sergio et al. 2005). Their unfavourable conservation status has attracted public interest (BirdLife International 2004) and they can act as a conservation flagship. The decline of most species of birds of prey has been relatively well documented in Europe (Newton 1979, Cramp and Simmons 1980, BirdLife International 2004). Greece lost large parts of its raptor populations during the last 30–50 years, but some areas still hold good numbers of these birds (Hallmann 1979, Catsadorakis 1994). The Evros region and particularly the Dadia–Lefkimi–Soufli Forest National Park (hereafter called DNP) holds one of Europe's most diverse raptor faunas including endangered species such as Black Vulture *Aegypius monachus*, Imperial Eagle *Aquila heliaca* and White-tailed Eagle *Haliaeetus albicilla.* No less than 36 species out of the 39 occurring in Europe have been observed in this area (Hallmann 1979, Dennis 1989) (Appendix 1). DNP is also one of the few places in Greece where research on the raptor populations and their habitats has been carried out for many years. The first pioneer study on the status and distribution of birds of prey in the DNP was made in 1979 by WWF International and IUCN giving accurate information for 10–13 species (Hallmann 1979). During the following years, more research was done on the status of the raptor community in DNP (Adamantopoulou and Androukaki 1989, Papageorgiou et al. 1994, Adamakopoulos et al. 1995) and on the ecology of

individual species (Vlachos 1989, Alivizatos 1996, Bakaloudis 2000, Poirazidis 2003a). Unfortunately, many of these studies were restricted to counts of the vultures and large eagles, while for the remaining species the data collected were rather poor (see also Appendix 2). Moreover, these studies did not use standardized methods to estimate numbers of pairs and, as a result, the assessment of the population trends after 20 years of protection was almost impossible.

The estimation of population status and trends of raptors poses special problems because raptors are usually dispersed, nest at low densities and their populations may fluctuate strongly (Fuller and Mosher 1987, Kirk and Hyslop 1998). Monitoring of raptor populations and the interpretation of their fluctuations require specific and long-term studies (Catsadorakis 1994). To overcome this problem, in 2000 WWF Greece formulated a systematic monitoring plan for the birds of prey (Poirazidis et al. 2002, Poirazidis et al. in press b). This monitoring should form the basis for annual relative abundance indices of the breeding territorial raptor species by using repeatable methods that would permit data comparison between years (Poirazidis et al. 2006). Relative abundance is used when it is difficult to overcome problems in estimating absolute densities. It is useful when comparing raptor populations over time, among sites or between species (Fuller and Mosher 1987) and enables the assessment of population trends. Additionally, an extensive survey of all the breeding raptors in DNP was carried out during 1999–2000 to estimate the current status of the breeding raptor species (Poirazidis 2003b) and to provide base-line information for the monitoring plan.

The main objectives of this chapter are: (1) to describe the historical changes in the populations of birds of prey in DNP, (2) to review the historical information on the breeding raptor populations during 1978–2005 with an emphasis on their population trends during the five years (2001–2005) of systematic monitoring and (3) to describe aspects of their nesting habitats.

Historical changes of raptor populations in DNP

Until 1970, twenty-four raptor species bred in the DNP (Hallmann 1979). This area constituted one of the few European regions where four vulture species could be observed together: the Black Vulture, Griffon Vulture *Gyps fulvus*, Egyptian Vulture *Neophron percnopterus* and Bearded Vulture *Gypaetus barbatus*. The Bearded Vulture nested in this region until 1969, after which only one individual was observed until it disappeared in 1994. Over the last three decades, four more species ceased to breed in DNP: White-tailed Eagle, Imperial Eagle, Bonelli's Eagle *Hieraaetus fasciatus* and Lesser Kestrel *Falco naumanni* (Adamakopoulos et al. 1995). In 1999 seventeen (17) diurnal raptor species nested within the borders of DNP, while in 2000 the number of breeding species increased to 18, when an active territory of Imperial Eagle was confirmed after the species had been absent for eight years (Poirazidis 2003b). In 2005, a new territory of the White-tailed Eagle, which had bred successfully until 1990, was possibly re-established in the area. However, in contrast to these positive changes, no breeding attempts have been recorded for Lanner Falcon *Falco biarmicus* in DNP after 2002.

From 2001 to 2005 (during the monitoring period; March to July), 19–20 species were found breeding in the area. Seventeen species were found wintering in the area, among these a considerable number of Greater Spotted Eagles *Aquila clanga* and several individuals of White-tailed Eagle, Imperial Eagle and Long-legged Buzzard *Buteo rufinus*. Other species used the area on passage, such as Osprey *Pandion haliaetus*, Bonelli's Eagle, Montagu's Harrier *Circus pygargus*, Pallid Harrier *Circus macrourus* and Red-footed Falcon *Falco vespertinus*. Finally Eleonora's Falcon *Falco eleonorae* can be met with in the area during late spring – early summer (see Appendix1 for an analytical review of the observed species).

The raptor populations during 1978–2005, with some notes on their ecology

DNP has a diverse avifauna of raptorial birds. The first estimation of the total population of all breeding species was successfully made during the integrated survey in 1999–2000. The number of territories was estimated at between 307 and 342, which corresponds to a density of 71.4 to 79.6 territories/100 km^2 (Poirazidis 2003b). Black and Griffon Vultures were excluded, because they are colonial and the survey methods were not appropriate for them.

However, during these years, 22 pairs of Black Vulture bred (and 89 individuals were seen) while 112 individuals of Griffon Vulture were observed, however without attempting to breed (see Skartsi et al., this volume).

The systematic monitoring was launched in 2001 to estimate the number of breeding territories with repeat-

able methods (Poirazidis et al. 2002, 2006, Poirazidis et al. in press b). Twenty-four points that provided a good view of the surroundings and 10 road transects were selected; from these at least 66% of the total area could be covered (Fig. 1). To a large extent most of the raptor territories in the remaining uncovered zones were also possibly recorded through detailed mapping of flight paths even at the margins of censused areas and observations of the behaviour of birds.

During the first five years of monitoring (2001–2005) the total number of territories ranged from 307 to 341 exhibiting a reasonable stability and the same was true for most of the individual species (Fig. 2). Common and Steppe buzzards *Buteo b. buteo* and *B. b. vulpinus* represented 35–38% of the total number of raptor territories in the area, while other common species were Short-toed Eagle *Circaetus gallicus*, Sparrowhawk *Accipiter nisus*, Honey Buzzard *Pernis apivorus*, Booted Eagle *Hieraaetus pennatus*, Lesser Spotted Eagle *Aquila pomarina* and Goshawk *Accipiter gentilis* (Fig. 3).

Despite the methodological problems of earlier surveys (see Appendix 2), below we shall attempt an assessment of the population trends of the different species during the last 28 years (1978–2005), with some notes on their nesting ecology.

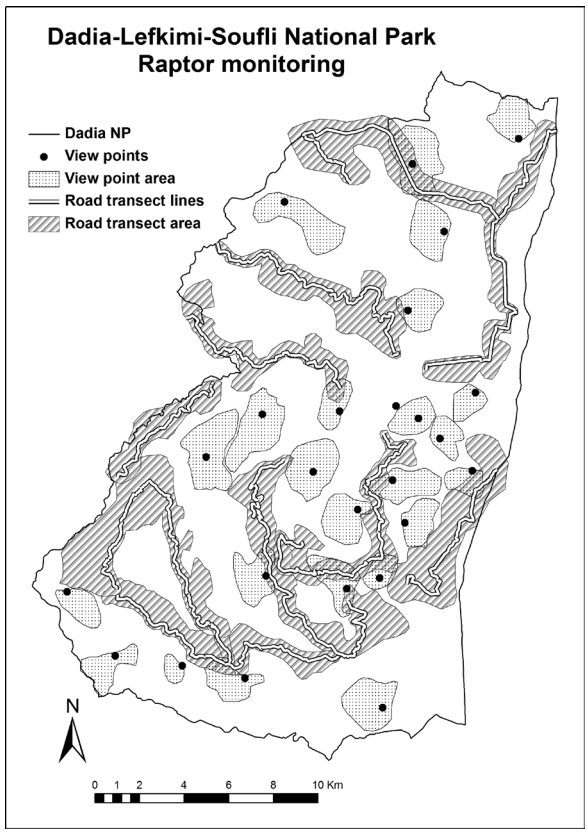

Fig. 1. Sampling areas for the raptor monitoring in DNP.

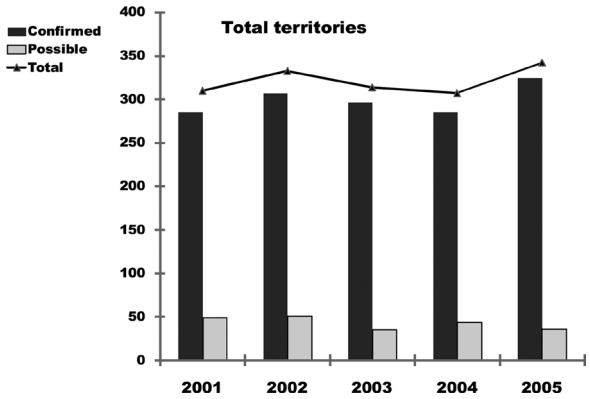

Fig. 2. Changes in the number of territories of raptor species in DNP during 2001 – 2005. Total territories = confirmed plus half of the possible ones.

Vultures

Three species of vultures breed in the area, namely Black Vulture, Griffon Vulture and Egyptian Vulture. Long-term monitoring data on their population sizes in DNP exist for the first two, while for the third species the available information is scarce (Adamakopoulos et al. 1995, Vlachos et al. 1998).

The Black Vulture is actually the only species in DNP that has shown a significant increase since 1979, due to the protection of nesting sites, supplementary feeding and the reduction of threats, such as poaching and habitat degradation. However, the population has remained stable since 1994 (Skartsi and Poirazidis 2002). The species nests in mature pine trees on steep slopes away of human presence (Poirazidis et al. 2004); a detailed

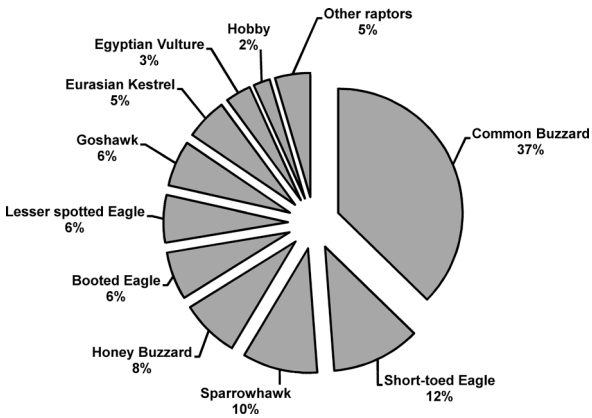

Fig. 3. Each raptor species' average percentage of all raptor territories in DNP during 2001 – 2005

analysis of its population trend and a description of its nesting habitat can be found in Skartsi et al. (chapter *Eurasian Black Vulture* in this volume).

In contrast, the Griffon Vulture is a colonial, cliff-nesting species. Its numbers increased constantly from 40 individuals in the 1990s to 75–112 at the beginning of the present century. It ceased to breed in 1995 but returned as a breeder in 2007 (for a detailed description of its population trends, see Skartsi et al. (chapter *Population trends* in this volume).

With 17 confirmed territories in 1978 (Hallmann 1979), the Egyptian Vulture, another cliff-nesting species, reached 25 territories in 1987 (Vlachos 1989), but thereafter the population declined dramatically to 10–14 pairs in the 1990s (Adamakopoulos et al. 1995). During 2001–2005 the average number of territories was 10.7 ± 1.2 with no significant variation. The estimated density was 2.5 territorries/100 km^2 and the "confirmed" territories (n = 9) were very stable during the monitoring period and constituted the main breeding population in DNP, while the number of "possible" territories varied; these were probably held by non-breeding pairs. The Egyptian Vulture's breeding area in DNP as described in the 1970s (Hallmann 1979) has not changed significantly, yet many of the old nesting sites remain unoccupied (Fig. 4). The operation of the vulture feeding station seems not to have enhanced its population (Vlachos et al. 1995). The factors affecting the breeding population are still unknown and may be associated with the conditions on the wintering grounds in Africa, but this requires further investigation (see also Skartsi et al. chapter *Population trends* in this volume).

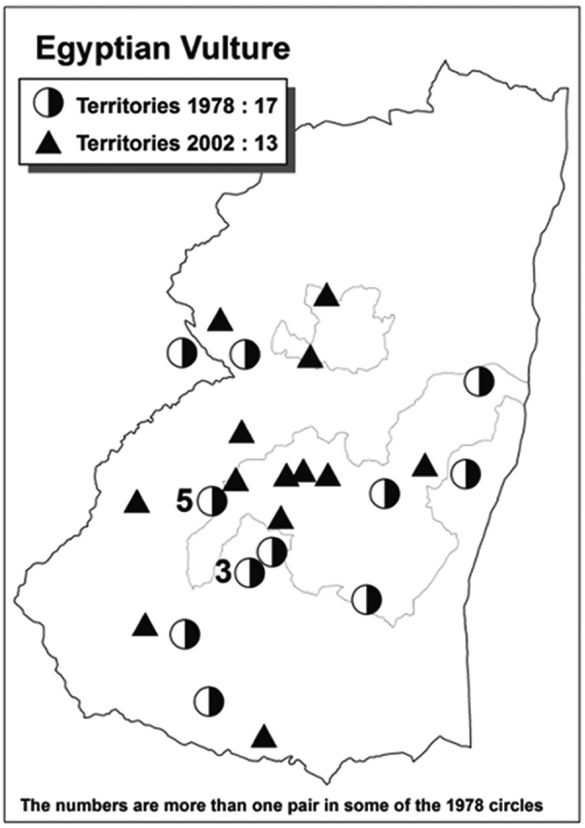

Fig. 4. The number of territories of Egyptian Vulture in 1978 and 2002.

Eagles

Six species of eagles breed (or bred formerly) in the area, namely White-tailed Eagle, Imperial Eagle, Golden Eagle *Aquila chrysaetos*, Lesser Spotted Eagle, Short-toed Eagle and Booted Eagle.

The populations of large and disturbance-sensitive raptors, such as the White-tailed Eagle and the Imperial Eagle, have declined during the last 25–28 years. For each of these species only a single territory was present at the end of the period, and they may have disappeared because conditions turned unfavourable. In the late 1970s, the Evros region held 5–7 pairs of Imperial Eagle (Hallmann 1979). In 1986 this figure had decreased to only two pairs (constituting the entire Greek breeding population), with the last confirmed nesting record in the Dadia forest in 1990 (Hallmann 1996). A marked reduction of open and semi-open habitats, which has taken place in the area since the 1950s and which is largely due to land-use changes (Triantakonstantis et al. 2006) affected these large eagles negatively. These changes have occurred for socio-economic reasons and involved land abandonment as well as the decline of free-ranging livestock (see also Liarikos et al., this volume). The Imperial Eagle preferred open areas close to the nest site where it mainly hunted European Glass Lizards *Pseudopus apodus* and Sousliks *Citellus citellus* (Adamakopoulos et al. 1995). The observed decline of this eagle in DNP, as well as that of the Long-legged Buzzard, followed the progressive disappearance of the Souslik colonies, the last colony of which survived up to 1995 (Adamakopoulos et al. 1995). As only observations of adults and immature birds and no breeding records were made, the Imperial Eagle apparently ceased breeding in the DNP after 1991. However, the recent return of this species in 2000 as a breeding species is a very hopeful message for the effectiveness of the conservation measures of the last 15 years (Fig. 5).

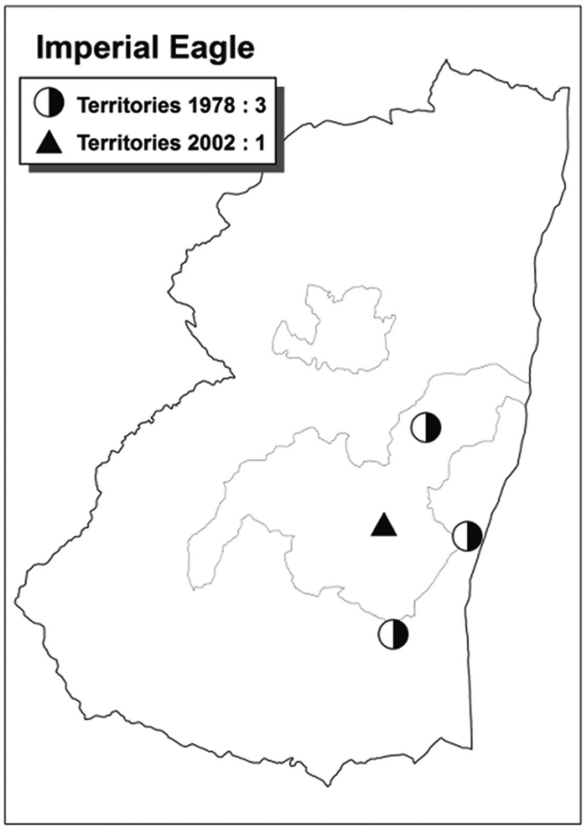

Fig. 5. The number of territories of Imperial Eagle in 1978 and 2002.

One pair of White-tailed Eagle bred until 1990 in the pine forest of the large core area. DNP must be considered as a rather dry ecosystem, at least compared with the breeding habitats normally used by White-tailed Eagles. This species usually forages over water bodies, preying mainly on fish and waterfowl but also feeds on carcasses (Watson et al. 1991). The Dadia pair usually travelled to the Evros delta (40 km away) for foraging. Since 2003 immature and adult individuals have been observed occasionally during spring and summer, and in spring 2005 a sub-adult pair was resident in the traditional breeding territory.

Compared with the number of occupied territories in 1978, in 1995 Golden Eagles had disappeared from some, in agreement with the population trend in all of Greece during that period (Adamakopoulos et al. 1995). For many years the population in the Dadia area was stable at three pairs but during the monitoring period (2001–2005) sub-adult birds were seen flying over unoccupied traditional breeding territories, indicating that new pairs were in the process of establishing themselves. The number of confirmed territories increased from four in 2001 to five in 2005, plus one probable territory. Breeding pairs are strongly territorial and hold extensive territories (mean nearest-neighbour distance (NND) for the years 2002–2005 was 8.9±1.8 km). The nests are either built on rocks or in trees. The main food of Golden Eagles in the DNP during the breeding season is tortoises (Capper 1998), which abound in the forest area (Phokas 2001), while during winter the birds feed mainly on small mammals and carcasses. Although food availability is a potentially limiting factor for this territorial eagle, it is possible that the re-occupation of past territories in recent years might have taken place due to reduced persecution as the environmental awareness of the local people has increased.

The Lesser Spotted Eagle is a priority species for conservation, for which large-scale action was drafted in a recent European Action Plan (Meyburg et al. 2001). The size of the Lesser Spotted Eagle population in DNP seems to have remained stable during the last twenty years. Nineteen pairs were recorded in 1978 (Hallmann 1979), while a population of 16–20 pairs was estimated in 1987 (Vlachos 1989), a number similar to the current population. In DNP, the Lesser Spotted Eagle uses mosaic habitats dominated by forest edges, small portions of mature forests and local streams for nesting (Poirazidis et al. 2007a). Its nesting close to main streams reflects its preference for this particular foraging habitat as indicated by the large proportion of Grass Snakes *Natrix natrix* in its diet (42.3%, Vlachos and Papageorgiou 1996). In Dadia the Lesser Spotted Eagle avoids the north-facing slopes for nesting, although such nest sites would provide protection from the high summer temperatures during its breeding season which extends into July–August. It is possible that the species optimizes its breeding success by avoiding the cold weather conditions that sometimes occur in the early breeding season (Kostrzewa and Kostrzewa 1990). A current analysis of the genetic diversity of this species in Europe found that the Balkan Peninsula acted as a refugium for this species during the last ice age, as the most common Baltic haplotype was present also in the Dadia population; northern regions were colonized after deglaciation 8000 ± 1500 years ago (Väli et al. 2004a).

Although the population seems to have been stable during the last 25 years, there was a marked change in the elevations at which the Lesser Spotted Eagles nested. While only 50% of the pairs bred below 100 m in the 1970s (Hallmann 1979), in 2000 this number had risen to 67% (Fig. 6). Habitat change has been found to affect prey availability for many raptor species negatively (Bak-

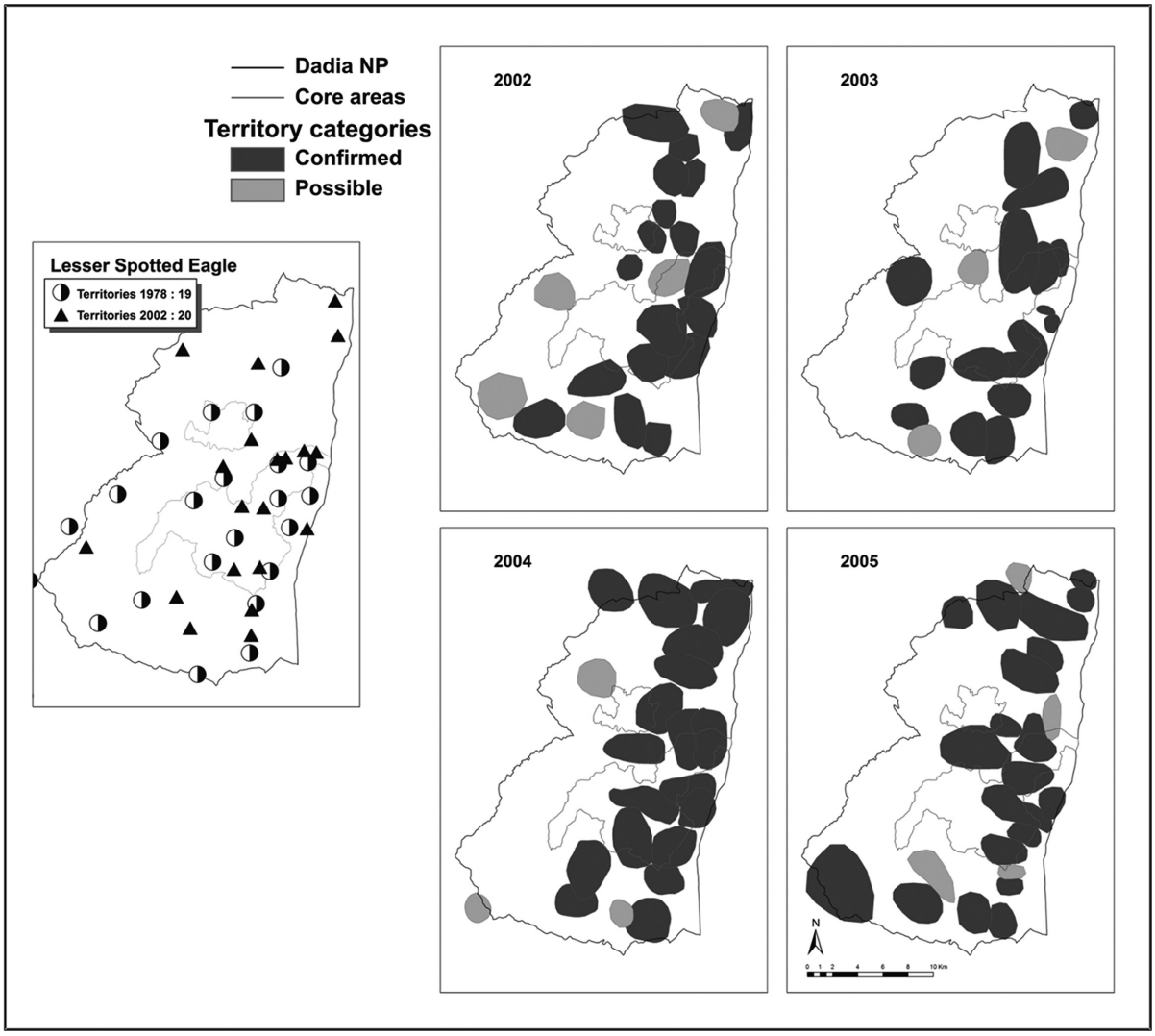

Fig. 6. The number of territories of Lesser Spotted Eagle in 1978 and 2002 and their distribution during the last four years of monitoring (2002 – 2005). Reprinted from Poirazidis et al. (2006).

er and Brooks 1981, Preston 1990) and the change in the distribution of Lesser Spotted Eagles in Dadia may be related to the reduction of open and semi-open habitats in the interior of the forests that has been recorded since the 1950s. Such reduction in forest heterogeneity has most likely resulted in a decrease in the density of reptiles and amphibians, important food for the Lesser Spotted Eagle in DNP (Vlachos and Papageorgiou 1996) thus making the population sensitive to further reduction of suitable habitat (Väli et al. 2004b). Although the species is known to be solitary and strictly territorial in other European areas (Cramp and Simmons 1980), in Dadia the concentration of many pairs in a limited area resulted in a clumped nest distribution. Clumped raptor dispersions may arise because of diminished suitability of breeding sites (Solonen 1993). In order to support the isolated (and thus more extinction sensitive) pairs of this species, five small ponds were created by WWF Greece in the core areas of DNP within the framework of a LIFE-Nature project aimed at increasing the abundance of amphibians and other prey taxa (WWF Greece 2006). This action is also expected to affect the breeding population of the Black Stork *Ciconia nigra* positively.

The Short-toed Eagle and the Booted Eagle still maintain their traditional territories within the DNP as recorded in the 1970s, with slight upward trends for

both species (Fig. 7). Bakaloudis et al. (2005) found 22 active territories of Short-toed Eagle in DNP in 1997, similar to the first population estimate (Hallmann 1979), while data from the 1999–2000 survey showed an important increase (by 83%) (Poirazidis 2003b). For the Booted Eagle Adamakopoulos et al. (1995) found 20 pairs, similar to the current population of 21–25 pairs, and this marks a considerable increase (by 153%) from the first survey in 1979.

During the monitoring period (2001–2005), the territory density of the Short-toed Eagle was 8.7 territories/100 km^2 and showed no significant changes during the five years, with an average number of territories of 36.9 ± 3.8. The maximum was 40–41 pairs in 2002 and 2005 and the minimum 31 pairs in 2001. In central Italy a lower density (2.05 pairs/100 km^2) was estimated for Short-toed Eagles (Petretti 1988) than the 5.92 pairs/100 km^2 for DNP reported by Bakaloudis et al. (2005) and the 8.7 pairs/100 km^2 found during the monitoring period. Short-toed Eagles select mature pine stands on south-facing slopes, near clearings and in areas with little disturbance (Bakaloudis et al. 2001). They prey exclusively on reptiles, mainly snakes, and seek prey mostly in open habitats where prey availability is higher (Bakaloudis et al. 1998). DNP is characterized by a high diversity of habitats (Schindler et al. 2008) offering this species an optimal landscape for both nesting and foraging.

Similarly the Booted Eagle population appeared to be stable during the five years of census (density 4.7 territories/100 km^2). The mean number of territories was 20 ± 1.2, with no significant trend. Although raptor numbers may have been seriously under-estimated in 1979, the increase recorded during the last decade is probably real and is due to improved forest conditions in the DNP created by a more conservation-friendly management. An increase of Booted Eagles has been recorded in Western Europe during the last few decades, which may be attributed to the species' adaptability to changing environments (Carlon 1996). In Doñana National Park (south-western Spain), the Booted Eagle population increased from six pairs in the early 1980s to 150 in 2000 (Suarez et al. 2000).

The Booted Eagle is a generalist raptor (Veiga 1986, Sanchez-Zapata and Calvo 1999) nesting in a variety of areas independently of geomorphology, distance to possible sources of disturbance as well as distance from forest clearings and main streams (Poirazidis 2003a). It also occupies territories in fragmented forests with a high proportion of clearings. Territorial behaviour (average NND 3425 m ± 1230) seems to be one of the main factors determining the location of its nest sites,

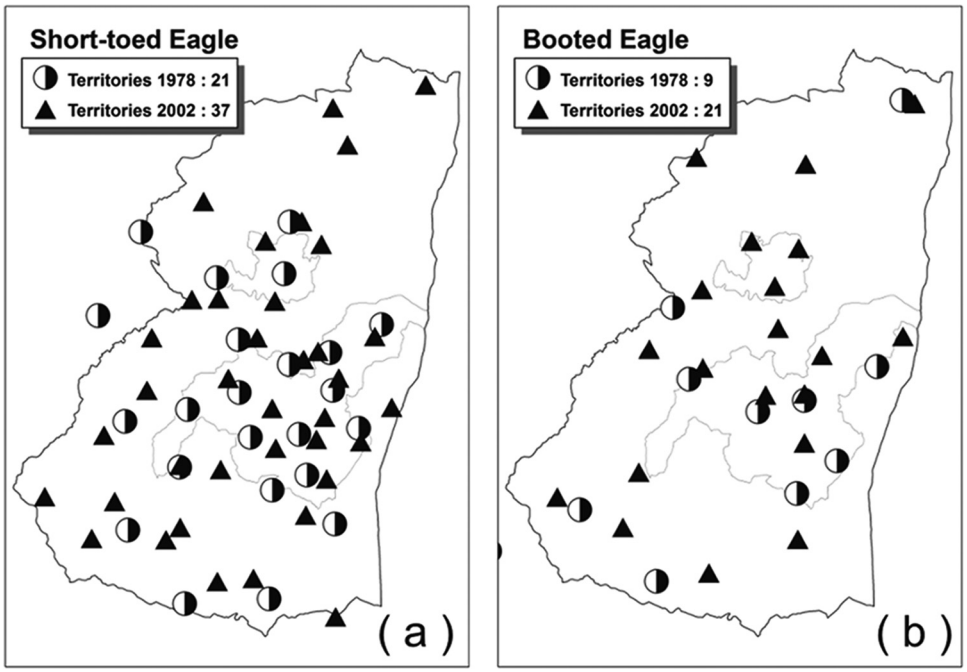

Fig. 7. The number of territories of Short-toed Eagle (a) and Booted Eagle (b) in 1978 and 2002.

many of which are located in the mountain zone (Fig. 7b). On the other hand, on the micro-scale level this species is very selective with respect to stand structure characteristics, preferring trees of large DBH reflecting the birds' need for mature trees to support their big nest (Cramp and Simmons 1980). In addition, the presence of mature forest around nests was the most important vegetation characteristic, probably because this enables the birds to construct nests in different trees in different years, as also found in Italy by Sergio et al. (2002). Similar findings were made in DNP also for other raptors, such as the Goshawk and the Common/Steppe Buzzard (Poirazidis et al. 2007a). These "forest" raptors preferred to establish nest sites in open forest with high canopy.

Medium-sized raptors

Five species belonging to this category breed in DNP, namely Long-legged Buzzard, Common/Steppe Buzzard, Honey Buzzard *Pernis apivorus*, Black Kite *Milvus migrans* and Marsh Harrier *Circus aeruginosus*.

The Long-legged Buzzard population in Dadia decreased from seven pairs in 1978 (Hallmann 1979) to five in 1990 (Alivizatos 1996) and a stable population of 3–4 pairs presently, which gives a density of 0.9 territories/100 km^2. It has disappeared from most of its traditional forest territories in the highlands, and nowadays nests in the lowlands where a mosaic of habitats exists as a result of human agro-pastoral activities (Fig. 8a). Colonies of European Sousliks occurred in 10 of the 16 territories of Long-legged Buzzard found in the Evros region in 1993 (Alivizatos and Goutner 1997). The observed decline of the Long-legged Buzzard in DNP followed the progressive disappearance of the Souslik colonies, the last of which disappeared in 1995 (Adamakopoulos et al. 1995). Considering the large contribution of this small mammal to the diet of the Long-legged Buzzard, it is probable that the decrease in Souslik numbers has affected the distribution of Long-legged Buzzards (Alivizatos and Goutner 1997).

The Common/Steppe Buzzard is a generalist occurring in almost all available habitats in DNP (Fig. 8b) and is very common. Unfortunately, there is no information on its densities in the 1970s or later, so it is impossible to assess its population trend. In DNP, the Common/Steppe Buzzard has a density of 28–30 territories/100 km^2 with a mean NND between the very regularly dispersed nest sites of 1.45 km. This NND is similar to the values found in a study in the UK, where they ranged from 1.53 km to 1.95 km (Dare and Barry 1990). Sergio et al. (2002) found an identical density to that in the DNP in the Italian Pre-Alps (28–31 pairs/100 km^2), but in central Italy populations were less dense with 19.8 pairs/100 km^2 (Cerasoli and Penteriani 1996) and 8.3 pairs/100 km^2 (Penteriani and Faivre 1997b), with a mean distance of 2.5 km between nest sites in the latter study. In DNP, the Common Buzzard population varied during the five years of monitoring between a maximum of 122–128 pairs and a minimum of 110–112 pairs. In

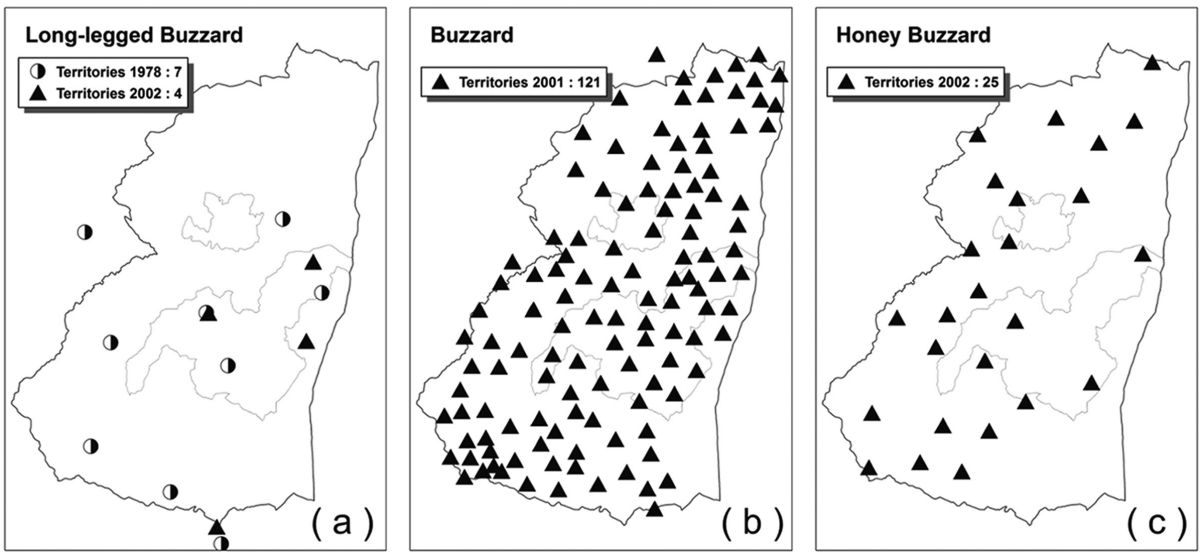

Fig. 8. The number of territories of Long-legged Buzzard (a) in 1978 and 2002, the distribution of the territories of Common/Steppe Buzzard in 2001 (b) and the distribution of Honey Buzzard territories in 2002 (c).

the Italian Alps Common Buzzards shifted nesting sites due to disturbance (Sergio et al. 2002). In DNP they are opportunists regarding their nesting microhabitat and nests regardless of the proximity to human habitations (Poirazidis 2003a), a situation resembling that of the Red-tailed Hawk *Buteo jamaicensis*, a New World species that can nest near human settlements if there is not too much human activity (Bednarz and Dinsmore 1982, Speicer and Bosakowski 1988).

The Honey Buzzard has increased during the last twenty years from 2–4 pairs in 1987 (Vlachos 1989) to 10–12 pairs in 1994 (Adamakopoulos et al. 1994), although this trend is likely to be an effect of underestimates during the early survey years. During the monitoring period (2001–2005), the estimated population averaged 24.3 ± 3.9 pairs, corresponding to a density of 5.7 territories/100 km^2, covering most of the forested area (Fig. 8c). The population peaked at 28 pairs in 2001, thereafter declining to only 18 pairs in 2004. In 2005 the population increased again reaching 24 pairs. The density in DNP is low to medium compared with that in other parts of Europe: 11.7 pairs/100 km^2 in southern Finland (Solonen 1993), about 4 pairs/100 km^2 in the German state of Hessen (Schindler 1997) and ranging from 5.0 pairs/100 km^2 to 22.1 pairs/100 km^2 in Austria (Gamauf and Winkler 1991, Gamauf and Herb 1993). Throughout Europe the abundance of Honey Buzzards is highest in broad-leaved and mixed forests on rich soils and in areas with plenty of water bodies. The optimal environments for this raptor seem to occur in areas with higher spring and summer precipitation than DNP.

Black Kites and Marsh Harriers breed in areas adjacent to DNP and use the park temporarily for foraging. The Black Kite has a good breeding population along the riparian forest of the Evros River and in 2003 one pair may have nested in a pine forest close to Dadia village but this was not confirmed. The Marsh Harrier breeds in an extensive reed bed very close to the south-eastern border of the National Park. During 2002–2003, one or two females may have bred inside the south-eastern border of DNP, but this was also not proved.

Hawks

Three species of hawks breed in DNP, Goshawk, Sparrowhawk *Accipiter nisus* and Levant Sparrowhawk *A. brevipes*.

During the last 28 years the overall population of Goshawk has not changed significantly nor has the spatial distribution of its territories varied (Fig. 9a, Appendix 2). During the five census years, the Goshawk population was very stable, with 18 to 22 pairs and a mean density of 4.5 territories/100 km^2. The nest spacing was very regular (NND 3061 m ± 1088) indicating a strong territorial behaviour (Poirazidis et al. 2007a). The observed density is similar to that found for other European populations, such as in Italy, estimated at 5.03 pairs/100 km^2 (Penteriani and Faivre 1997a) and Finland, estimated at 4–6.6 pairs/100 km^2 (Solonen 1993).

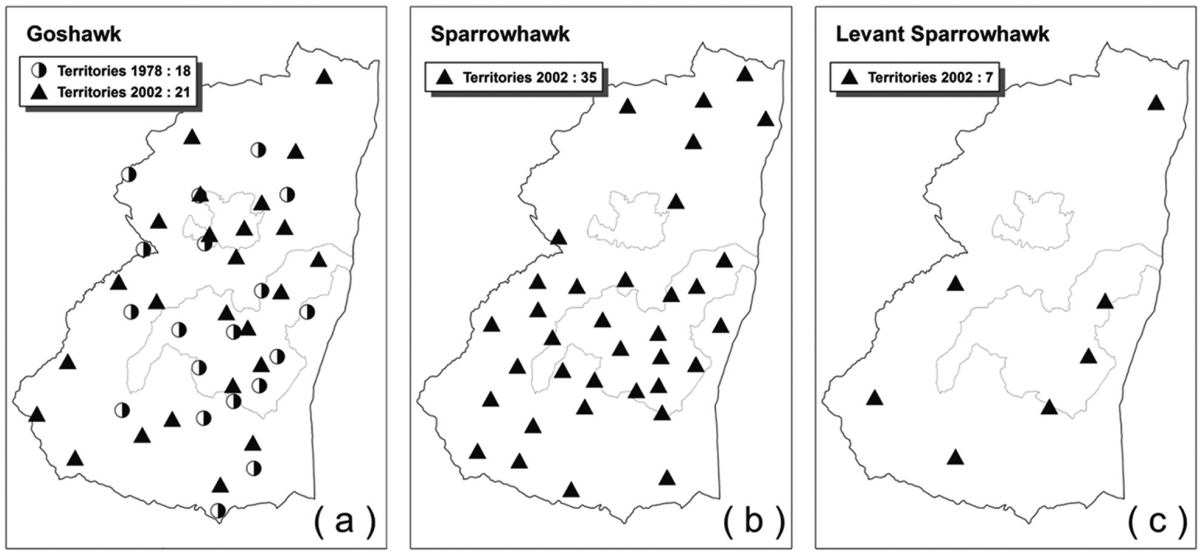

Fig. 9. The number of territories of Goshawk in 1978 and 2002 (a) and territories of Sparrowhawk (b) and Levant Sparrowhawk (c) in 2002.

The Goshawks' choice of low-elevation sites for nesting (54% of nests below 130 m) – similar to that of the Lesser Spotted Eagle – is probably also related to higher densities of prey in the lowlands (Poirazidis et al. 2006). This results in nests being closer to human habitations than found in other studies (Speiser and Bosakowski 1987, Penteriani and Faivre 1997a). An association between breeding density and main prey distribution has also been reported in Italy, where a higher nest density of Goshawks was found at lower elevations than in the mountain zone (Penteriani and Faivre 1997a), and in Sweden, where food was the main factor determining Goshawks' habitat use (Kenward and Widén 1989).

For Goshawk, an open stand structure is important for pairing and for fledgling activities near the nest before the young birds disperse (Kenward et al. 1993, Penteriani et al. 2001). Nesting in mature forests with an open structure and at great height facilitates the pair's access to the nest, provides good visibility of the surroundings as a protection against predators and facilitates hunting in areas adjacent to the nest (Titus and Mosher 1981, Speicer and Bosakowski 1987, Moorman and Chapman 1996).

The importance of mature forest as a vital parameter in raptors' nesting habitat is suggested by the fact that the variable "number of trees in diameter class 36–80 cm" had the highest loading in a multivariate analysis of four sympatric raptor species in DNP (Poirazidis et al. 2007a). The Goshawk showed the strongest association with this habitat variable among the raptor species in DNP (Poirazidis et al. 1997, Bakaloudis et al. 2001), thus the availability of suitable nesting microhabitats is likely of primary importance for this species, as also found in other studies in Europe and North America (e.g. Reynolds et al. 1982, Crocker-Bedford and Chaney 1988, Lilieholm et al. 1994, Kenward 1996, Penteriani et al. 2001).

The Sparrowhawk population was very stable during the monitoring period with an average number of pairs of 31.2 ± 3.3 at a density of 7.3 territories/100 km^2. These figures are probably underestimates of the population breeding in DNP since this species is secretive and difficult to find with the methods applied and several nest sites no doubt remained undiscovered (Fig. 9b). In Scotland nest numbers fluctuated by no more than 15% around the mean level of 34 pairs over a 17-year period, with no overall trend (Newton 1991).

The Levant Sparrowhawk's main breeding area is along the Evros River, the border to Turkey, where its population is very high (K. Poirazidis pers. obs.). Only a few pairs breed inside the National Park, where a maximum population of seven pairs was observed in 2000 and 2002 (Fig. 9c).

Falcons

The DNP is not a suitable area for falcons. Four species of falcon breed in DNP, namely Peregrine *Falco peregrinus*, Lanner *F. biarmicus*, Hobby *F. subbuteo* and Common Kestrel *F. tinnunculus*, but their populations are small. One more falcon, the Lesser Kestrel *F. naumanni*, bred formerly, but no evidence for breeding exists from recent years.

For the last 20 years only one pair of Peregrine has been considered breeding in the study area. However, in 2001 a new territory was verified in the DNP, and in 2003 three pairs were located (Fig. 10a). Unfortunately, this increase of the Peregrine Falcon population was followed by the disappearance of the single pair of Lanner Falcon that had bred in the area for more than 20 years (Fig. 10b). The observed changes in the status of the big falcons (Peregrine and Lanner) are very difficult to explain, but since both species use similar nesting and foraging habitats, it is possible that inter-specific competition caused the disappearance of the Lanner. It has been observed in similar-sized and powerful raptor species that pairs of one species have sometimes been driven off their former territory by the other (Kostrzewa 1991).

The Hobby holds a very stable population in DNP with a maximum number of 12 territories (2.8 territories/100 km^2) estimated during 2002, a density which is much lower than in other areas. For instance, in northern Italy, Bogliani et al. (1994) estimated a density of 29 nests/100 km^2 in poplar plantations on the Po river plain. During the monitoring period the average number of pairs of this species was 6.9 ± 2.2 with a mean density of 1.6 territories/100 km^2 (Fig. 10c). In general, the census methods used are not optimal for the detection of falcon territories. For this reason, the counts may not reflect the true size of the Hobby population and the observed variation may be larger than the true one. In the Evros area the Hobby is a species that mainly nests in poplar plantations along the Evros River (K. Poirazidis pers. obs.) where its densities may be higher than in DNP and comparable to those reported by Bogliani et al. (1994).

With 15 territories in 2001 and 22 in 2005 the Kestrel is probably the only raptor species whose population increased during the five year of systematic raptor monitoring. The average number of territories was 17.4 ± 3.5 (4.1 territories/100 km^2) during 2001–2005 (Fig. 10d). The Kestrel is easier to detect than other species

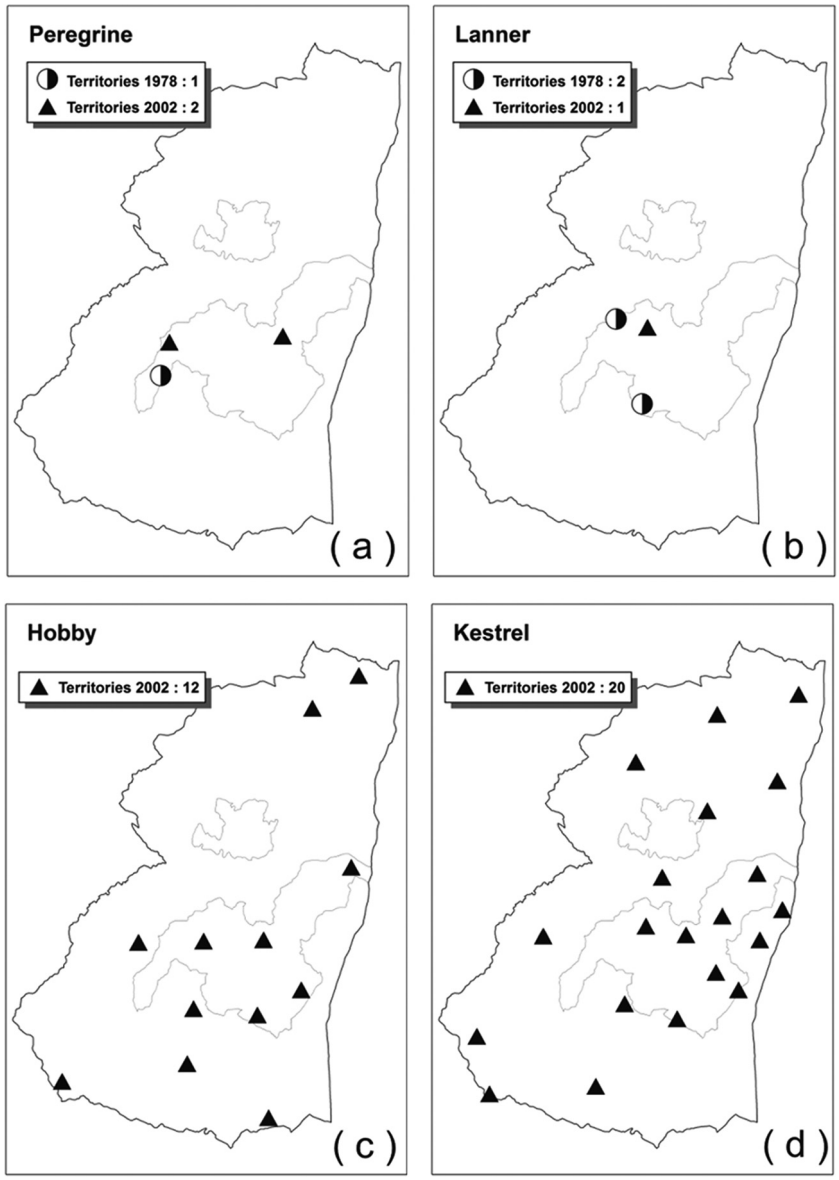

Fig. 10. The number of territories of Peregrine Falcon (a) and Lanner Falcon (b) in 1978 and 2002 and territories of Hobby (c) and Kestrel (d) in 2002.

of falcon, because it is more active over open ground, which likely results in relatively accurate estimates of its population size.

Conclusions

The assemblage of birds of prey in DNP remains almost as diverse as described 30 years ago and many populations have remained stable since the 1970s. Moreover, some important species that showed population declines during recent decades now show signs of having started to recover. The re-establishment of some old territories of Golden Eagle, the return of the Imperial Eagle and possible return of the White-tailed Eagle, are some of the positive results of the protection and conservation measures implemented in the area during the last 15 years.

Raptor monitoring is a time-intensive and difficult task. In order to estimate raptor population trends, long series and a large amount of data are needed. A system-

atic monitoring based on GIS methodology could be an efficient tool to deal with data of this kind. The methodology used in DNP is an integrated GIS-based method for the collection and analysis of this huge amount of observations and has provided rather accurate information on which population sizes of typical territorial species, such as most of the eagles, buzzards, hawks and falcons, were estimated. However, a larger amount of data is needed to increase the precision of the population estimates for species that nest at high densities, such as the Common Buzzard. For less territorial species, such as the Short-toed Eagle and the Egyptian Vulture, some difficulties arise. The home-ranges of neighbouring pairs overlap greatly in these species, making the delineation of the different territories difficult. Some other species are very secretive. The key issue for all species, whose population sizes are difficult to estimate, was to obtain more good-quality data (like territorial observations, landings, etc.).

Our findings show that all species have shown more or less stable populations during the five years of intensive monitoring, exhibiting very slight fluctuations, as is the rule for raptor populations (Newton 1979, 1991). However, in order to distinguish natural short-term fluctuations from population trends a long-term monitoring programme (of >20 years' duration) must be implemented. In the revised monitoring plan for the DNP, a five-year period between surveys is anticipated instead of annual surveys, in order to minimise costs and to safeguard the surveys' continuity in the future (Poirazidis et al. 2007b). Hopefully, the recently established Management Agency of the National Park will incorporate this monitoring in its future activities.

The investigation of the various raptor species' habitat selection has proceeded in a stepwise fashion, where the various criteria of selection are hierarchically ordered (Penteriani et al. 2001). Geomorphology and distance to foraging areas seem to be the first criteria determining territory segregation in DNP, affected also by the species' territorial behaviour (Poirazidis 2003a). High habitat diversity resulted in short distances between nest sites. Within their breeding territories the birds were selective with respect to microhabitat, choosing forest structures and nest-tree characteristics that probably maximize breeding success.

A multi-layered plan to preserve the remarkable diversity of raptors in DNP must be implemented and certain management measures should be enforced:

(1) In the forest area subjected to management, small groups of mature trees forming open stands must be preserved. Instead of selective loggings where isolated mature trees are kept at a large scale, a management encouraging the formation of even-aged small forest stands should be followed; this would be the most favourable management for raptors.

(2) Small forest clearings must be retained and/or created in areas of dense forest because such clearings are vital to many bird species occurring in the DNP.

(3) The creation of small wetlands within the forested area would benefit species such as the Lesser Spotted Eagle.

(4) Forests become suitable for nesting to most raptorial birds after 50–60 years. Thus, at any stage of forest management, tree groups of at least this age, in various positions and at least 300–500 m apart must be preserved within the managed stands.

(5) Isolated trees more than 80 years old must be preserved in all stands, especially when occurring in dense forest, because it is the specific features of such trees that are selected by the raptors.

(6) As all of the area is important for the species studied, measures to protect nest-sites should be applied all over the elevation spectrum of the area both in the core zones and in the intensively managed zones.

The DNP is still one of the most important European forests for birds of prey and the integrated monitoring of their populations combined with conservation-oriented management will contribute to safeguarding their future (Poirazidis et al in press a).

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Appendix 1. Birds of prey observed in the DNP. B: Breeding; M: Migrating; R: Resident; W: Wintering; S: Summer visitor; BF: Bred formerly.

	Species		Present status
1	Honey Buzzard	*Pernis apivorus*	B, M
2	Black Kite	*Milvus migrans*	M
3	Red Kite	*Milvus milvus*	M
4	White-tailed Eagle	*Haliaeetus albicilla*	BF
5	Bearded Vulture	*Gypaetus barbatus*	BF
6	Egyptian Vulture	*Neophron percnopterus*	B, M
7	Griffon Vulture	*Gyps fulvus*	R, M
8	Black Vulture	*Aegypius monachus*	R
9	Short-toed Eagle	*Circaetus gallicus*	B, M
10	Marsh Harrier	*Circus aeruginosus*	M, W
11	Hen Harrier	*Circus cyaneus*	M, W
12	Pallid Harrier	*Circus macrourus*	M
13	Montagu's Harrier	*Circus pygargus*	M
14	Goshawk	*Accipiter gentilis*	R, M, W
15	Sparrowhawk	*Accipiter nisus*	R, M, W
16	Levant Sparrowhawk	*Accipiter brevipes*	B, M
17	Common and Steppe Buzzard	*Buteo b. buteo, B. b. vulpinus*	B, M, W
18	Rough-legged Buzzard	*Buteo lagopus*	W
19	Long-legged Buzzard	*Buteo rufinus*	B, M, W
20	Steppe Eagle	*Aquila nipalensis*	M, W
21	Lesser Spotted Eagle	*Aquila pomarina*	B, M
22	Greater Spotted Eagle	*Aquila clanga*	W
23	Imperial Eagle	*Aquila heliaca*	R, W
24	Golden Eagle	*Aquila chrysaetos*	R
25	Booted Eagle	*Hieraaetus pennatus*	B, M
26	Bonelli's Eagle	*Hieraaetus fasciatus*	FB, M
27	Osprey	*Pandion haliaetus*	M
28	Lesser Kestrel	*Falco naumanni*	B, M
29	Common Kestrel	*Falco tinnunculus*	B, M, W
30	Red-footed Falcon	*Falco vespertinus*	M
31	Merlin	*Falco columbarius*	W
32	Hobby	*Falco subbuteo*	B, M
33	Eleonora's Falcon	*Falco eleonorae*	S
34	Lanner Falcon	*Falco biarmicus*	R
35	Saker Falcon	*Falco cherrug*	W
36	Peregrine Falcon	*Falco peregrinus*	B, M, W

Appendix 2. Historical data on number of territories of birds of prey in the DNP.

Estimation year	1979 Hallman (1979)	1987 Vlachos (1989)	1993–1994 Adamakopoulos et al. (1995)	1999–2000 Poirazidis (2003)
Vultures				
Gypaetus barbatus	No data	1 ind.	1 ind.	0
Aegypius monachus	5	12–15	20	20
Gyps fulvus	0	8–10	8–12	0
Neophron percopterus	17	20–25	10–14	13–14
Eagles				
Haliaeetus albicilla	1	1	0	0
Aquila chrysaetos	5	4–5	3–4	4
Aquila heliaca	3	1	0	1
Aquila pomarina	19	16–20	14–17	20
Circaetus gallicus	21	13–16	20–23	37–40
Hieraaetus pennatus	9	8–10	20	21–25
Medium-sized raptors				
Buteo buteo	No data	15–20	16–20	120–130
Buteo rufinus	7	5–10	7–9	4
Pernis apivorus	No data	2–4	10–12	25–30
Hawks				
Accipiter gentilis	18	10–15	10–12	21
Accipiter nisus	No data	5–10	8–10	35
Accipiter brevipes	No data	No data	8–12	7
Falcons				
Falco tinnunculus	No data	No data	5–10	12
Falco subbuteo	No data	?	3–5	12
Falco peregrinus	1	No data	1	2–3
Falco biarmicus	2	1	1	1–2