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

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A regional-historical approach to the high raptor diversity of the Dadia–Lefkimi–Soufli Forest National Park

Giorgos Catsadorakis

Potential reasons underlying the high diversity and abundance of raptorial birds in DNP are explored with emphasis on larger temporal and spatial scales. In terms of food resources for these birds, the DNP and the surrounding area support high reptile densities and offer a regular supply of livestock carcasses. Its proximity to the River Evros floodplain and delta ecosystems and its location in a transition zone between wooded hill country and low-lying, flat and treeless plains and croplands, are all favourable factors. In terms of nesting habitats, the presence of an extensive mature pine forest, a network of rocky outcrops, some large cliffs and a fine-grained landscape make the region unique. Of importance to soaring birds are favourable, energy saving orographic winds. A landscape mosaic gives raptors short flying distances between nesting and feeding patches. An extremely low human population density, attributed to the area's geographic location and topographic particularities, explains both the low level of disturbance and why the mature forest stands have been preserved.

Keywords: Dadia, Greece, raptor diversity, raptor assemblage, regional-historical approach, birds of prey

Introduction

At present, the Dadia – Lefkimi – Soufli Forest National Park (DNP) is one of the best studied forested areas in Greece, with respect to forestry, biodiversity, landscape and ornithology (Adamakopoulos et al. 1995, Kati 2001, Bakaloudis 2000, Poirazidis et al. 2004, Kati et al. 2004, Kazantzidis 2007, Poirazidis et al. 2007, Schindler et al. 2008 and this volume). A number of past and recent studies have highlighted the area's high biodiversity. Initially it was designated a Nature Reserve (in 1980) mainly because of its great variety of raptorial birds, including the Black Vulture *Aegypius monachus* which held an outstanding position amongst them. Since the late 1970s, 36 out of the 38 European diurnal raptor species have been observed; 24 of these have bred and 16–20 still do so.

Although many studies have taken place in DNP, the underlying reasons for this high diversity and abundance of raptorial birds have hardly been addressed. Even in the few cases where they have been touched upon (e.g. Adamakopoulos et al. 1995, Xirouchakis 1999, Poirazidis et al. 2006, Schindler et al. 2008), it was implicitly assumed that the most important ecological processes affecting animal species richness and abundance operated at local spatial scales. They were considered to be local resource availability, vegetation structure, landscape mosaic and the size of habitat patches, while potential influences operating at larger temporal or spatial scales (Ricklefs 1987, 2006) were ignored. This is contrary to the fact that many of the large raptors (especially vultures and large eagles) utilise a much larger area than that of the park's (Vasilakis et al. 2008). In addition, no serious attempt has been made to examine any historical processes that may have contributed to the area's present species richness of birds of prey. However, unless populations and habitats, and the processes that affect them, are simultaneously examined at local, regional and historical scales, it will prove impossible to draw conclusions concerning the true role of local habitat and landscape heterogeneity (Ricklefs 1987, 2006). Because ecological processes operate across a range of spatio-temporal scales, it is important to match the scale of the research approach with that of the scale of the process (Ricklefs 1987, Dunning et al. 1992, Greenwood 1992, Whittaker et al. 2001, Suárez-Seoane and Baudry 2002). The conservation of Mediterranean raptors also requires a regional approach (Sánchez-Zapata and Calvo 1999), because in the semi-natural areas of the Mediterranean, influenced by man for more than 10,000 years (Covas and Blondel 1999, Blondel and Aronson 1999), the raptor assemblages have been affected by various natural and anthropogenic factors acting at different spatio-temporal scales.

Nesting habitat and food supply (Newton 1979, 1991) are not the only factors limiting present day raptor populations (Janes 1985, Newton 1991). Consequently, on their own they are insufficient for explaining the high densities of raptor species in the DNP. Other limiting factors may include the distribution of feeding areas (throughout the year) as well as nesting sites (Janes 1985, Bernstein et al. 1991, Selås 1997). Additional limiting factors are those influencing a bird's ability to detect and capture prey, competitors, human persecution, disturbance, toxic chemicals, floater : breeder ratio, immigration and emigration rates, thermal environment, as well as energy costs for flying between nesting and foraging sites (Houston 1979, Bernstein et al. 1991). Various kinds of neighbourhood effects may also play vital roles, such as the existence of source and sink populations, and landscape complementation and supplementation (sensu Whittaker et al. 2001). One might expect animals to be attracted to places combining different favourable conditions. The aforementioned issues lead necessarily to an examination of the whole system on a larger scale by encompassing the area outside the park and the historical role of human influence.

Methodological framework and limitations

Although the local assemblage of birds of prey is treated as a whole, it is necessary to differentiate between the carrion eaters and the predators. Within the latter group, the differences between species are numerous regarding phenology, movements, diet and prey preferences, hunting strategies, nesting habitat and nest site choice, tolerance to disturbance and territoriality, etc. All this variation must of course be taken into consideration, but in this article I have tried to use the widest possible grouping, as the scale of analysis is rather large. Thus, some variation is unavoidably masked by the scale of the approach.

The basic rationale behind this hierarchically structured analysis of interdependent factors and processes is schematically shown in Fig. 1. The analysis will alternate

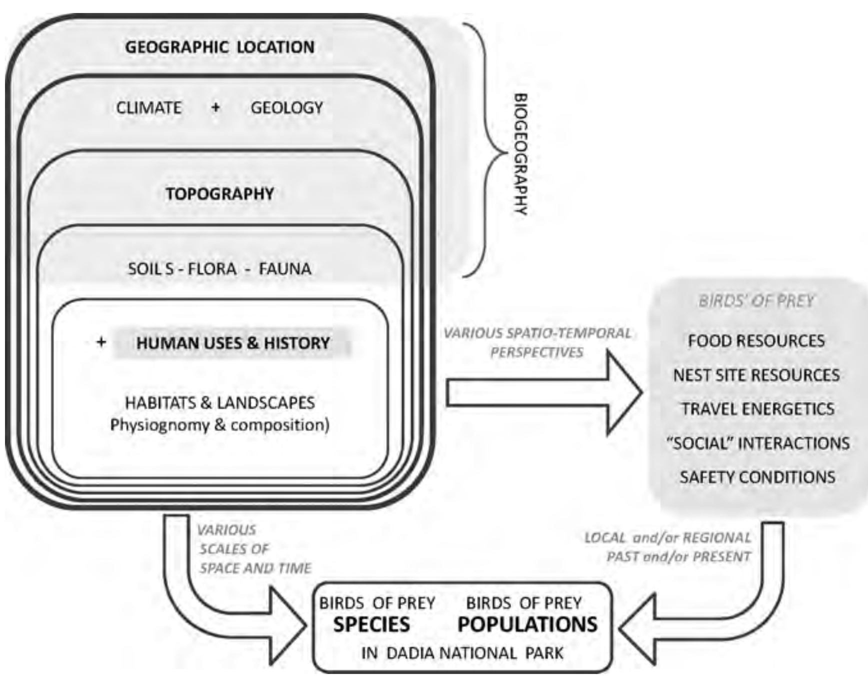

Fig. 1. Schematic diagram depicting the hierarchical approach applied in this paper regarding the main factors affecting the species and populations of birds of prey in the DNP.

between local (DNP) and larger spatial scales (Turkish Thrace, Greek and Bulgarian Thrace and the Rhodope massif (see Fig.1, p. 18 in the Introduction to this volume) and between the present, recent and more distant historical times.

Is DNP indeed an area of "exceptional" raptor diversity?

To answer this question I asked experienced ornithologists, specialists on birds of prey who work in the best areas for birds of prey in Greece, to provide data on species richness (Table 1). The exercise showed that in absolute numbers, DNP hosts more breeding raptor species than does any other area in Greece. With respect to the density of individual species, DNP is only surpassed by two much smaller mountain areas. However, when only the core zones of DNP are considered, the total species density is by far the highest in Greece. Furthermore, what readily distinguishes DNP is that for many species densities are very high. An average of 380–390 pairs nest within the area of ca. 145 km^2 censused by Poirazidis et al. and Skartsi et al. (this volume), giving a combined density of almost 2.7 pairs km^{-2}. DNP is the last stronghold of the Black Vulture in SE Europe and holds the entire Greek population of this species with an average of 20 breeding pairs and a total population of c.100 individuals (Skartsi et al. 2003, Skartsi et al., this volume). It also holds 15–30% of the Griffon Vultures *Gyps fulvus* nesting in mainland Greece (R. Tsiakiris, pers. comm.); 25–30% of the Greek population of Lesser Spotted Eagle *Aquila pomarina*; 20–50% of the Booted Eagles *Hieraaetus pennatus*; and 8–10% of the Short-toed Eagles *Circaetus gallicus* (Hellenic Ornithological Society database).

It is difficult to find comparable data on entire raptor communities for other parts of Europe. However, Poirazidis et al. (this volume), compared individual species densities with those elsewhere in Europe, and showed that DNP's position varies according to species, but as a whole its numbers and diversity of species are impressive. It seems that only a few places in Europe, mostly in the Iberian Peninsula, may equal it. In fact, DNP seems to be second only to the Monfragüe National Park, which is recognised as the best area for raptors and vultures in the Iberian peninsula by supporting c.1170 pairs of 16 breeding species in an area of 184 km^2, i.e. a density of c. 6.35 pairs km^{-2} (http://reddeparquesnacionales.mma.es/en/parques/monfrague/novedades/pdf/monf_almena_06.pdf).

The biogeographical aspect of local raptor species richness

The distributional patterns of species are not random but follow geographic patterns that reflect their recent ecology and phylogeographic history, i.e. "history of place" and "history of lineage" (Kryštufek and Griffiths

Table 1. Recent (5–10 years) data from the best studied sites for raptor species diversity in Greece according to Greek ornithologists with good local knowledge. Intensity of observation differs between areas and this may represent a cause of variation. Data provided by 1= S. Xirouchakis, 2 = S. Zogaris, 3 = Personal data, 4 = Sidiropoulos et al. 2006, 5 = M. Panagiotopoulou, 6 = K. Poirazidis and Th. Skartsi.

Locality	Total area (km^2)	Breeding species of birds of prey	Number of species 100 km^{-2}
White Mountains (Crete island)[1]	540	12	2.2
Mount Idi (Crete island)[1]	490	10	2.0
Mount Asterousia (Crete island)[1]	160	10–11	6.8
Mount Dikte (Crete island)[1]	350	10–12	3.4
Mount Ochi (Euvoia island)[2]	400	7	1.7
Amvrakikos Wetlands (Region of Epirus)[2]	450	10	2.2
Cape Sounion and surrounding area (Attica)[2]	300	5	1.7
Prespa National Park (Region of Western Macedonia)[3]	325	9	2.7
Almopia Mountain Arc (Region of Western Macedonia)[4]	~2000	16	0.8
Kompsatos Valley (Region of Thrace)[5]	165	14	8.4
Dadia National Park (Region of Thrace)[6]	420	16–19	4.5
Dadia National Park (absolute protection zone)[6]	78	16–19	24.3

2002). With respect to lineage there is nothing exceptional about the DNP raptor community when compared with that of other areas in south-eastern Europe. There are no endemic species or subspecies present and none of the species is outside, or even close to the margins of its main geographic range (Cramp and Simmons 1980). All species breeding in the area are widely distributed across the Western Palearctic (Cramp and Simmons 1980, www.birdlife.org 2008). So, from the aspect of species composition there is nothing noteworthy, beyond the fact that the area lies within the latitudinal band in which most 'hotspots' for higher animal and plant taxa occur (Gaston and David 1994 for several taxa; Gasc et al. 1997 for reptiles).

Ten of the 20 raptor species that breed in the area are present throughout the year, whilst three species are winter residents. Two of them breed occasionally (White-tailed Eagle *Haliaeetus albicilla* and Imperial Eagle *Aquila heliaca*) while one is only a winter visitor (Great Spotted Eagle *Aquila clanga*). The only species with a mainly easterly distribution, which are not present in the central and western Mediterranean but occur in other parts of Greece, are the Lesser Spotted Eagle, the Long-legged Buzzard *Buteo rufinus* and the Levant Sparrowhawk *Accipiter brevipes*.

Food resources

Predator food resources

A number of published and unpublished data show that tortoises, snakes and lizards especially constitute a large and more constant proportion of the diets of many raptors in DNP than do other animals, such as mammals, amphibians and birds; for example, reptiles form a large part of the diet of Short-toed Eagle, Lesser Spotted Eagle Booted Eagle *Hieraeetus pennatus*, Golden Eagle *Aquila chrysaetos*, White-tailed Eagle, Imperial Eagle, Egyptian Vulture *Neophron percnopterus*, Common Buzzard *Buteo buteo*, Long-legged Buzzard and Common Kestrel *Falco tinnunculus*, ranging from 3–100% (e.g. Vlachos 1989, Adamakopoulos et al. 1995, Vlachos and Papageorgiou 1996, Alivizatos and Goutner 1997, Bakaloudis et al. 1998, Bakaloudis, this volume). The first three of these species rely most of all on reptilian food and it is these that have populations denser than anywhere else in Greece.

In the mid-1980s, a study of the herpetofauna of the Evros area (Helmer and Scholte 1985, Strijbosch et al. 1989) demonstrated that this area (DNP included) supported 39 species of reptiles and amphibians ("more than any other place in Europe"), which were present in "...population densities higher in many cases than it was known hitherto to literature" (Helmer and Scholte 1985). This high number must be attributed to the biogeography, geology, habitat diversity and history of the area, as is generally the case in the Mediterranean (Blondel and Aronson 1999). Temperature, humidity and precipitation (mild winters, moderately dry and hot summers) allow for a higher productivity and a longer growth period in these upper Meso-Mediterranean zones and, in combination with the above factors, support higher species richness and densities than do the drier, purely Mediterranean places. There are no directly comparable studies to show whether these densities are still maintained 25 years later, but indications exist that, although reptile densities may have declined because of forest expansion and reduction of grazing pressure, they still remain high.

In addition, in contrast to the permeable limestone which dominates most of Greece, the impermeable igneous and flysch substrates of the DNP result in freely available surface water (even though it decreases drastically in summer), which may partly explain the flourishing amphibian and wet-habitat reptile populations. Whereas an exceptional abundance of reptiles is indeed present, there is no evidence for similar high densities in other animal groups. However, it seems likely that the area's habitat diversity, its horizontal and vertical heterogeneity, and ecosystem productivity have also permitted other animals, such as rodents, bats and birds, to thrive (e.g. Adamakopoulos et al. 1995, Kati and Kakalis, this volume, Papadatou, this volume).

Scavenger food resources

Paleontological and historical data show that, prior to human domination, the area was inhabited by Red Deer *Cervus elaphus*, Roe Deer *Capreolus capreolus*, Fallow Deer *Dama dama* and other wild ungulates. There were also predators, such as lions *Panthera leo*, Wolves *Canis lupus*, Lynx *Lynx lynx*, Golden Jackals *Canis aureus*, Red Foxes *Vulpes vulpes* and Wild Cats *Felis sylvestris* (Herodotus, http://www.parstimes.com/history/herodotus/persian_wars/polymnia.html, Spassov and Iliev 1994, Spassov and Markov 2004). The expansion of human activities gradually eliminated or drastically diminished these wild animals and replaced them with numerous free-ranging livestock; livestock carcasses presumably have been the primary food resource for vultures for centuries. The DNP and Eastern Rhodope have always been characterized by a network of small settlements of subsistence farmers, who relied heavily on free-grazing stock for their living. This indicates that there has always been food available for scavengers, but apparently not more so than in most other areas of Greece or the Balkans. However, a closer look at a wider spatial and temporal scale may lead to another conclusion. In fact, DNP lies in the centre of an area where livestock rearing has been very important for centuries. At the end of the 19th century, the vilayet of Adrianople in the Ottoman Empire, i.e. an area of c. 37,000 km^2 to which the DNP belonged, was inhabited by c.1 million people and was stocked with 2.5 million sheep, 750,000 goats, 250,000 cattle, 50,000–60,000 pigs, 70,000–90,000 horses, mules and donkeys, and 5,000 camels (Chotzidis 2007), numbers that remained at similar levels at least up to World War I (Brunnbauer 2000). The nomadic Sarakatsan livestock keepers alone held 600,000 sheep and goats, and despite the existence of national borders between Turkish Thrace, southern Bulgaria and Greece, they moved their herds in a SE – NW direction to mountain pastures in the Rhodope mountain range each spring until the 1930s (Chotzidis 2007). One of the main transhumance routes was along the Erythropotamos and Ardas river valleys, 37 and 55 km as the crow flies from the centre of DNP (Fig. 2). This proximity to a major transhumance route may have played a very important role in the establishment of vulture colo-

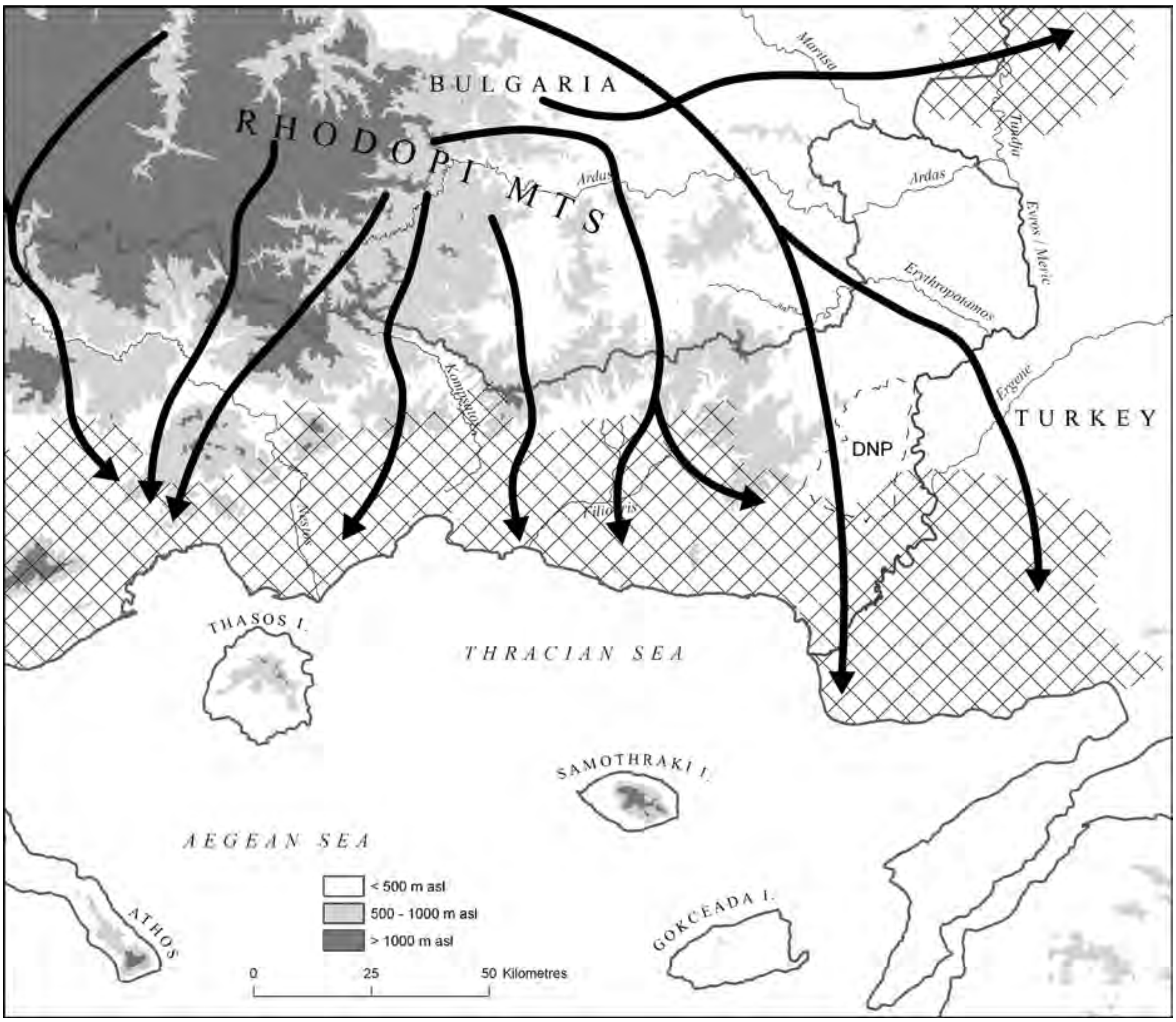

Fig. 2. Main sheep and goat transhumance routes in north-eastern Greece, southern Bulgaria and European Turkey at the beginning of the 20th century. State boundaries are as of 1913–1918. Cross-hatched areas denote the lowlands used in winter. Modified after Beuermann (1967).

nies in this part of Thrace, as it is widely recognized that historically, in Europe, large concentrations of vultures occurred in areas with high livestock densities or close to large transhumance routes (Marinkovic and Karadzic 1999, Olea and Mateo-Tomas 2009).

Nesting sites and habitats

Among locally nesting raptors some are mainly or exclusively cliff-nesting (e.g. Griffon Vulture, Egyptian Vulture, Peregrine Falcon *Falco peregrinus* and Lanner Falcon *F. biarmicus*, Golden Eagle, Eagle Owl *Bubo bubo* and Long-legged Buzzard). Most others nest mainly or exclusively in trees (Black Vulture, Booted Eagle, Lesser Spotted Eagle, Short-toed Eagle, Goshawk *Accipiter gentilis*, Sparrowhawk *A. nisus*, Levant Sparrowhawk, Common Buzzard and Honey Buzzard *Pernis apivorus*). The question to be posed with respect to the availability of nesting habitats is the following: Is there an unusual diversity of potential nesting sites for raptors in DNP?

Cliff and rock nesting sites for both territorial and colonial species

Because of its ophiolithic and volcanic substrates, especially in the central and southern half of DNP (see Fig. 4 in Skias, this volume) numerous small to medium sized rock outcrops are scattered all over the area, principally at hill summits, which provide ideal sites for rock-nesting, territorial raptors. This landscape feature is very rare in Greece. Three very large cliffs suitable for large, colonial cliff nesters, such as the Griffon Vulture, provide many additional breeding sites (Fig. 3). The significance of these outcrops and cliffs is greatly enhanced by the fact that this habitat is absent within a very wide radius around the DNP.

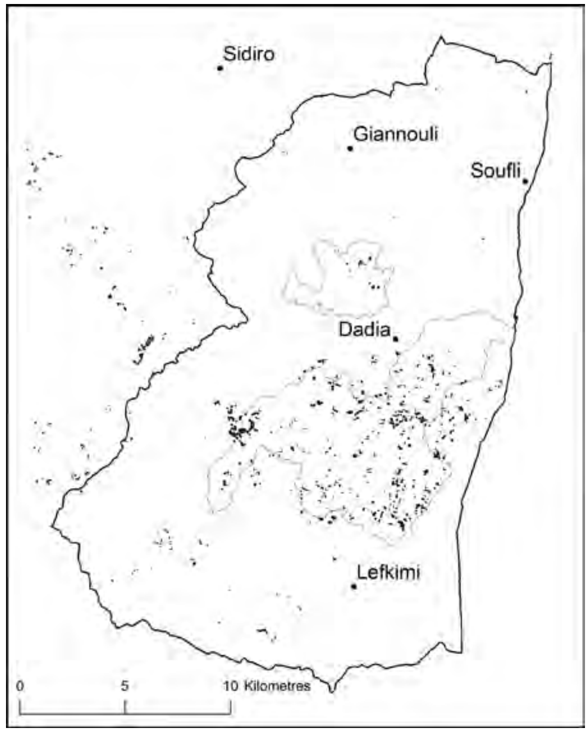

Fig. 3. Map of DNP and its immediate vicinity showing areas with rocky outcrops.

Unique and isolated mature woodland for tree-nesting species

Many studies have investigated the requirements of tree-nesting raptors by focusing on features of their nesting trees and the surrounding habitat. Examples are the work of Vlachos (1989) on the Lesser Spotted Eagle and that of Bakaloudis (2000) on the Short-toed Eagle. Adamakopoulos et al. (1995) and Poirazidis et al. (1996, 2007) identified a number of important attributes of the forest stands preferred by several species of tree-nesting raptors:

(1). Pines are preferred to oaks and other broad-leaved trees, and Black Pine *Pinus nigra* is used proportionately much more frequently than is Turkish Pine *Pinus halepensis brutia*.

(2). Mature stands and mature trees are strongly preferred by most medium to large sized species. Large species, such as Black Vulture, Golden Eagle and White-tailed Eagle, use trees with a DBH larger than 50 cm.

(3). Different species prefer nesting trees that are situated in different elevation zones and in different positions along hill gradients. The Black Vulture and the large eagles prefer to nest in the upper half of a slope, which facilitates take-off and landing (Cramp and Simmons 1980, Selås 1997, Fargallo et al. 1998).

At regional scales, the proportion of unfragmented forest cover is a good predictor of the abundance of tree-nesting raptor species (Bosakowski and Smith 1997, Sánchez-Zapata and Calvo 1999). Also, at the local scale of the DNP Poirazidis et al. (2007) showed that for four species overall habitat suitability increased with increasing percentage of mature forest, increasing percentage of oak forest and increasing percentage of other broad-leaved trees.

The ophiolithic and volcanic substrates of the central and southern DNP (see Fig. 4 in Skias, this volume) are also biogeographically and ecologically responsible for the presence of the isolated Black and Turkish pine woodland which is a unique and distinctive feature in the region. Because of their growth patterns, these pines offer suitable nest sites for various raptors, including large, tree-nesting species (Adamakopoulos et al. 1995, Poirazidis et al. 1996, 2007). The pine forests in Dadia, where the highest concentrations of nests of birds of prey are found, cover ca 61% of the core zones (Portolou 1996). Not only is the importance of these pine woodlands increased because they form the largest island of pines in Thrace, but also because they constitute the only area in the region where old, thick-stemmed, mature pines have survived (Fig. 4).

Whilst the occurrence of Black Pines is associated with magnesium-rich soils it is not known which abiotic factors are responsible for the presence of the isolated area of Turkish Pine (Skordilis and Thanos 1995, Fady et al. 2003), but the persistence of quite extensive mature stands with many trees of large DBH can be attributed both to the rugged topography, which has made logging difficult, and to their limited suitability as firewood and construction timber.

Unique fine-grain geomorphology may favour high territory densities

Topography greatly affects animals and ignoring its potential effects may lead to a misunderstanding of the ecology and territorial behaviour of animals living in mountainous terrain (Reid and Weatherhead 1988, Powell and Mitchell 1998). In rough terms, a NE-SW line divides the DNP geologically into two major zones (see Fig.4 in Skias, this volume): the northern half consists of molasse and the southern mainly of Paleogene volcanic and sedimentary rocks (Pe-piper and Piper 2002). The molasse zone has suffered intense erosion and is characterized by deep soils, gentle slopes and almost no rocky outcrops (Fig. 5). In contrast, the volcanic zone in the centre and south exhibits a rugged

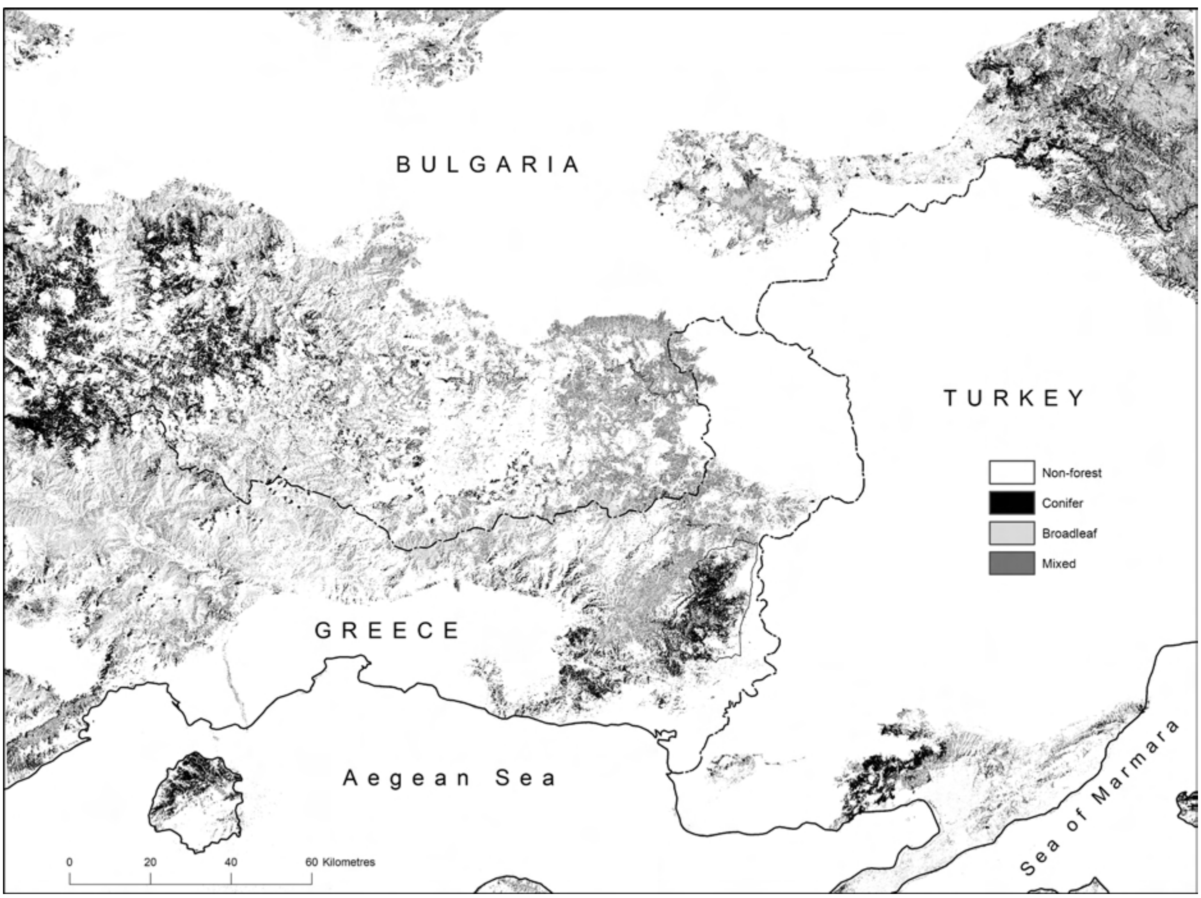

Fig.4. Map showing forest cover across Thrace in Bulgaria, Greece and Turkey. Small forests have been excluded. The isolated occurrence of conifer woodland in the area of the DNP is clearly shown.

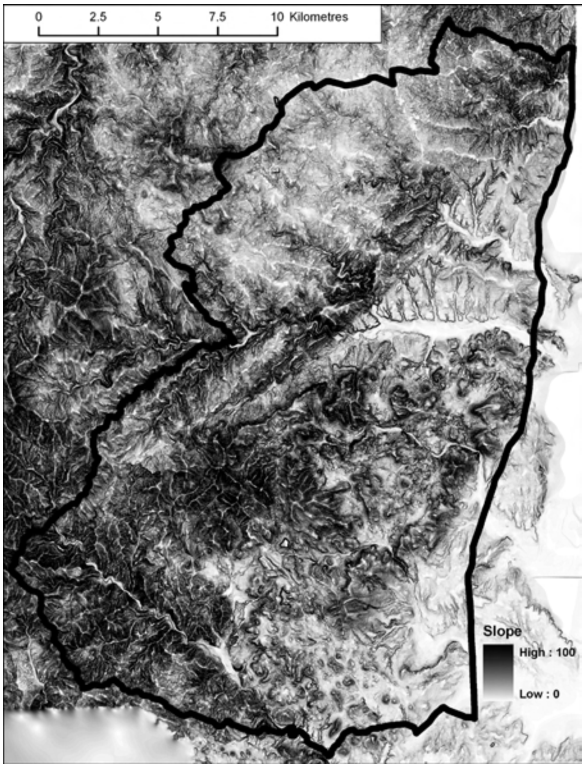

Fig. 5. The distribution of slopes of different steepness in the DNP.

topography of numerous, discrete, low hills separated by a dense network of valleys and temporary streams. This particular topographic feature becomes even more apparent when compared with other mountain areas in Greece, most of which consist of limestone and show a very rugged relief (high cliffs, gorges, deep valleys). In contrast, the DNP relief is softer, with shallower valleys and much gentler slopes. However, as one proceeds to a smaller scale, one finds a repeated landscape of small hills and valleys, which is unique in Greece.

The grain size of this fine-grained landscape of DNP coincides with the territory size of several raptor species. This dense network of similar, yet structurally and compositionally diverse and rather self-contained "landscape and habitat units" (i.e. a wooded hill, a large clearing and a stream valley), enables territorial species with similar requirements to establish territories close to each other, with mutual access to nesting and feeding sites, water and safety, while at the same time keeping interspecific competition low. In this way it may greatly increase the carrying capacity of the area, as a fine-grained spatial segregation of habitats is suggested to allow more species to co-occur (Berg 1997). More importantly, DNP's attractiveness to raptors is enhanced because a similar fine-grained structure is not found in an extensive area around it, either in Greece, Bulgaria or Turkey. No attention has so far been paid to this landscape feature, even though it is evident in high resolution satellite pictures[1].

The spatial interplay of feeding and nesting habitats and resources

Proximity to the Evros River and Delta as wintering and feeding grounds

For more than 30 km the park's eastern boundaries extend along the narrow fluvial zone of the River Evros at a distance of 1–3 km from the river. The DNP constitutes the nearest woodland with suitable nesting habitats for many raptorial birds including vultures (Bakaloudis et al. 1998), which search the fluvial areas along the river and its tributaries for food. The centre of DNP is only c.30 km from the Evros Delta (Fig. 1 in the Introduction to this volume), an area of great significance for breeding, migrating and wintering birds that offers prey for raptors throughout the year but especially during winter when tens of thousands of migrants, including Coots *Fulica atra* and ducks gather there (Handrinos 1989, Hellenic Ornithological Society database). The proximity of good wintering and post-breeding dispersal grounds (the plains of Thrace, the wetlands of the Evros delta) is also advantageous for those species that undertake seasonal short-distance movements between nesting and wintering areas, as is the case elsewhere (Janes 1985, Selås 1997).

The importance of the forested-hill – treeless-plain ecotone

The main geomorphologic feature of Greek Thrace is the abrupt division into two, almost equally wide zones running from west to east. North of the division are the slopes of the Rhodope massif, while the southern zone consists of low alluvial plains sloping gently towards the sea. The division between these zones is clear-cut and coincides roughly with the 200 m contour (Fig. 6). The DNP is situated at the easternmost edge of the large, forested Rhodope mountain range, surrounded by a

[1]Unfortunately, we do not have at our disposal digital terrain models of the wider area with resolution high enough to manifest this difference.

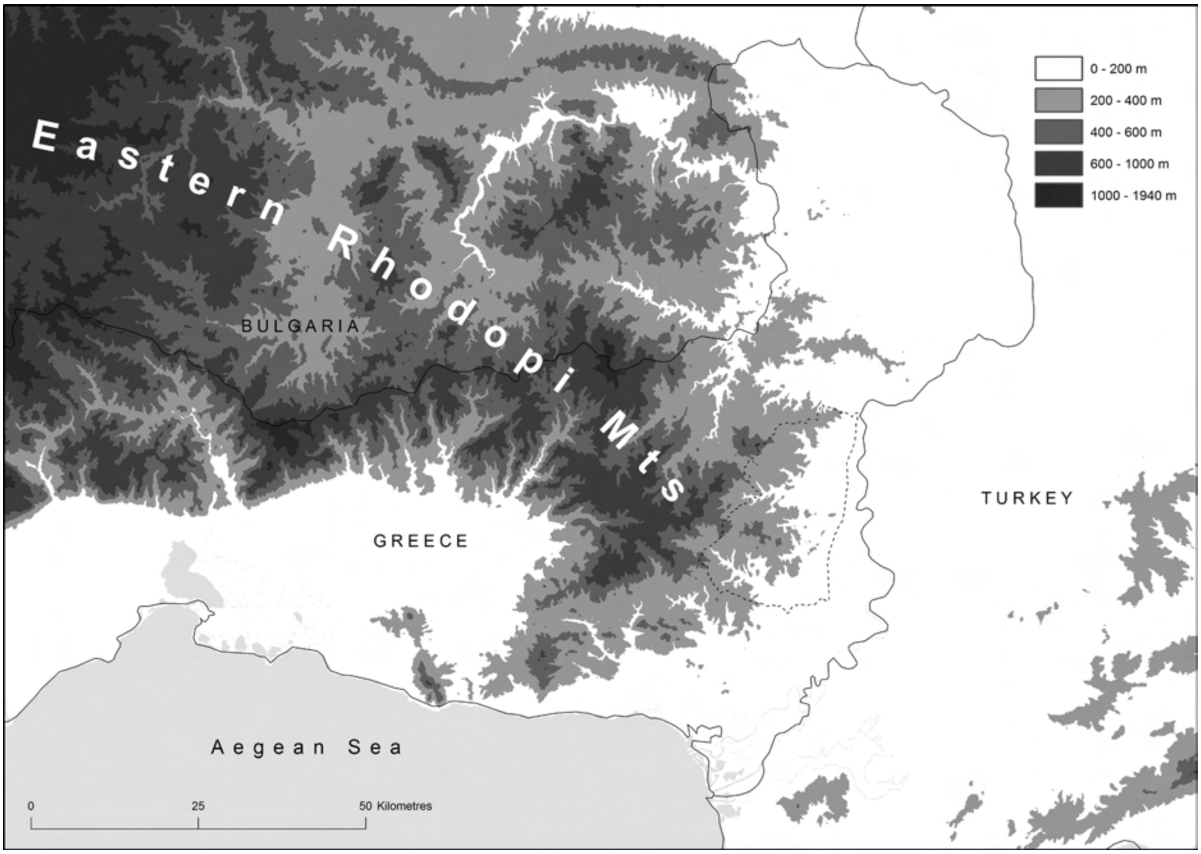

Fig. 6. Topographic map of Greek Thrace and the eastern Rhodopi Mts. The 200 m contour separates the area into a zone of hills and mountains and a plains zone.

wide zone of steppe, treeless grazing land and cereal fields, which reach the alluvial plains of the River Evros. To the east, across all of Turkish Thrace right up to the Bosporus there are no major forested areas for hundreds of kilometres (Fig. 4). Thus, DNP is the last suitable nesting habitat at the edge of a huge area devoid of such habitat, which alone may have created a kind of 'hot-spot' for nesting raptors and contributed to its high concentrations of nesters. The area may attract many non-breeding birds, prospectors and floaters of immature, sub-adult or adult status from the Rhodope interior. These individuals may become familiar with the Evros region thus increasing the chances that they will stay, establish a territory and eventually breed (Newton 1979).

Seen at a larger scale, DNP as a whole lies within a c.10 km wide edge zone, an ecotone between a hilly, forested area and a flat, tree-less lowland. It is long known (Pianka 1983) that ecotones and edges possess high biodiversity because they contain species from both ends of the habitat gradient and, in addition, particular ecotone species. Also for those raptors that nest in woodland and forage in open areas, ecotones are considered to be optimal habitats.

Proximity to the agro-sylvo-pastoral mosaic of the Eastern Rhodope hinterland

In the forested areas of the Eastern Rhodope, the intricate mosaic of vegetated and open habitats provide a network of feeding habitats close to suitable nesting sites, a fact very important for Mediterranean raptors (Sánchez-Zapata and Calvo 1999, Xirouchakis 1999). This applies to both local and regional scales, because the Eastern Rhodope as well as large parts of the central Rhodope range has, for hundreds of years, contained small settlements of loggers, subsistence farmers and livestock breeders. The last graze their herds of sheep and goats, and to a lesser extent cattle, in the forest and still employ traditional, extensive management of the grazing land and forest. The landscapes thus created consist of open woodland, pastures and small farmland with dispersed mature trees – excellent raptor habitats for nesting and especially for hunting. DNP is contiguous with the easternmost part of this area, which extends for several hundred kilometres towards the north-northwest in Greece and Bulgaria (Stoychev et al. 2004).

Topography, orographic conditions and raptor energetics

At certain spatial scales, local topography is an important wind creator and modifier of the wind dynamics of an area. Generally, prevailing winds in the DNP are of medium speed, mainly from N and NE becoming stronger along the ridges and hilltops. This is why the overall area's wind potential, as measured by the National Centre for Renewable Resources, is very high compared with all adjacent areas in the region (Fig. 7). It is actually one of the best in the country in this respect and constitutes a Priority Area for Wind Power (PAWP 1). The numerous slopes with their different exposures to the sun, in combination with rock outcrops and a varied vegetation cover, create thermals, orographic winds, valley breezes,

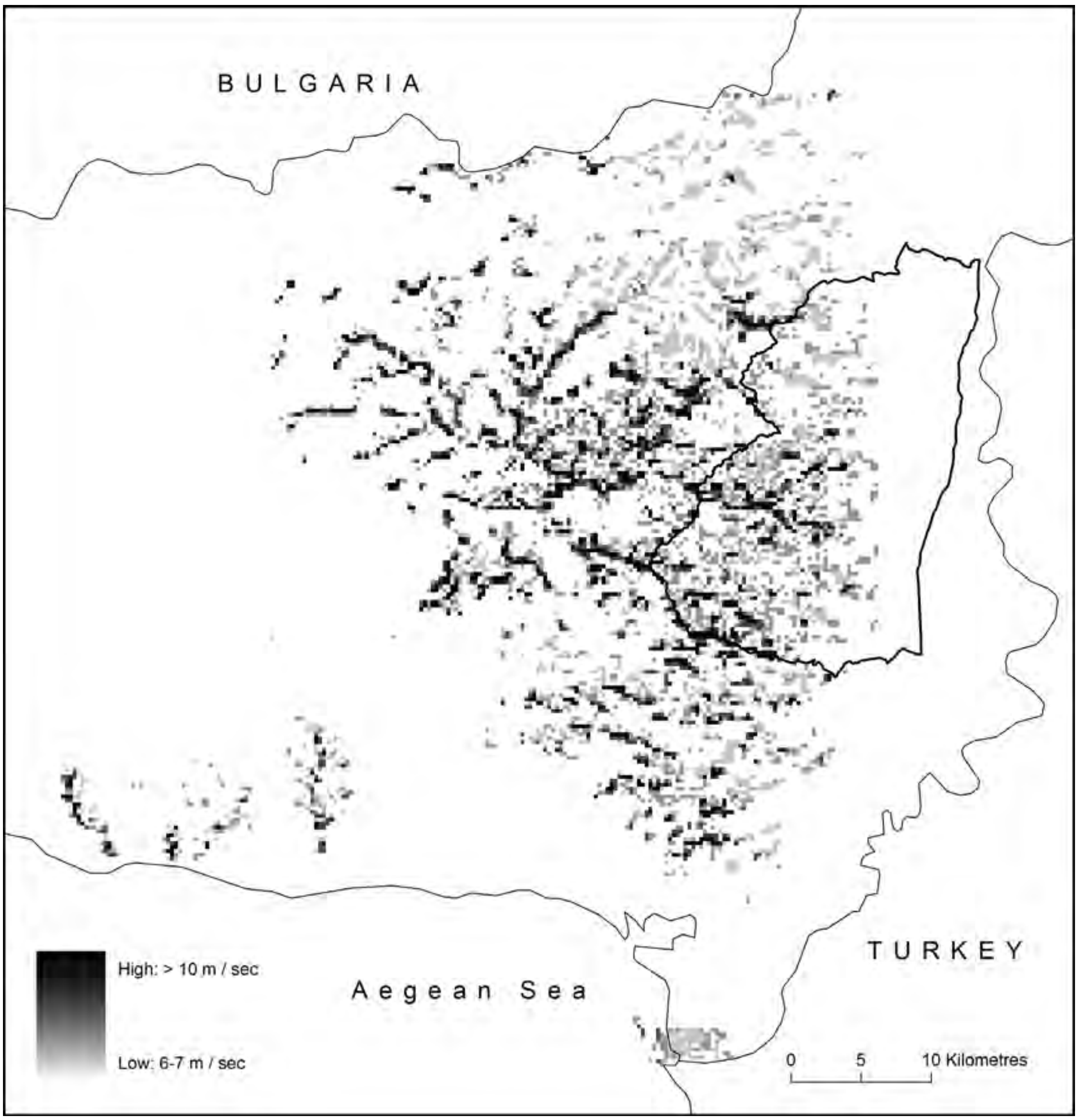

Fig. 7. Areas of exploitable wind potential in the eastern part of Greek Thrace (Evros and Rhodopi prefectures). Only areas with prevailing winds over 6 m s^{-1} are shown. (Modified from Centre of Renewable Energy Sources, http://www.cres.gr/kape/datainfo/maps.htm)

anabatic winds and slope lift (Pikros 1993), all of which facilitate raptor movements (Cone 1962, Pennycuick 1972).This is of great importance especially for large soaring birds, such as vultures and large eagles, which need to reduce flight energy costs in their search for food over huge areas (Kanellis 1973, Houston 1979, Leshem and Yom-Tov 1996). It is evident from the topography of the DNP, and from the measurements of its wind potential, that unusually favourable wind conditions for large soaring birds prevail over much of the park. Such conditions also minimize flight energy expenditure (see also Selås 1997); positive effects of slope lift on the search time for vultures have also been documented (Hiraldo and Donázar 1990). But even for smaller birds, e.g. medium-sized eagles, which hunt within the mosaic of the DNP, flying is greatly facilitated by the topography and the resulting wind conditions, which in general seem to have been underestimated as an added value to habitat quality for the local raptor assemblage.

Furthermore, areas with favourable flight conditions extend towards the north-west into the extensively managed agro-pastoral landscapes outside the park and into similar areas in the Eastern Rhodopes of southern Bulgaria. This is the area most intensively, in fact almost exclusively, used by vultures in their search for food (Vasilakis et al. 2008). Monitoring of radio-tagged vultures has shown that Black Vultures search an area of c.10,000 km^2 and may travel as far as 105 km from the Dadia colonies (Vasilakis et al. 2008). In contrast, vultures rarely fly eastwards over the plains of Turkish Thrace (Vasilakis et al. 2008), presumably because food resources are scarce but certainly also because flight conditions are less favourable there.

Humans and landscapes as influenced by location and topography

It is widely accepted that low or medium anthropogenic disturbance increases species diversity (Blondel and Aronson 1999), whereas heavy disturbance can severely disrupt biological processes. The most important historical feature of the modern Mediterranean biota is the strong anthropogenic influence on their structure (Covas and Blondel 1999). The low disturbance regimes to which the habitats of DNP and surrounding areas have been exposed to for centuries by the small human population through livestock grazing, cultivation, logging, coppicing and fires, created the landscape mosaic we see today (as elsewhere in Europe, Herrando et al. 2003). The human role in creating and maintaining this landscape type and the reasons why this extensive woodland mosaic has been preserved to date – in contrast to other parts of Greece where similar areas have been replaced by other land uses – must be considered. After all, an area's geographic location and topography not only influence animal assemblages directly but also human societies and their activities which in turn affect animal abundance and distributions.

It is noteworthy that the Dadia forest complex is unique in Greece in so far as there is no other area within a similarly low elevation spectrum (10–650 m asl) and of relatively low relief that is covered to c.75% with forest and yet is devoid of built-up areas, settlements, scattered buildings, roads, dams, etc. In contrast, and particularly during the last 30 years, lowland forests in Greece have badly deteriorated because of fires and their consequences: soils lost through erosion, grounds bulldozed and turned into fields or subjected to overgrazing, conversion to scrub, or illegal building. In the Dadia forest such threats have been absent, because the local people have had a keen interest in preserving it. Given the unsuitability of the terrain for cultivation, the forest has been their primary source of income. Topography and geographic location have partly, but crucially, shaped the patterns and intensity of human use of the area: only a few flat areas of limited extent are suitable for cultivation, slopes are rocky, soils are shallow and poor in nutrients, and the close proximity to the fertile lands of Evros have not made terrace-building a wise investment.

The relief thus generally discourages land use other than forest exploitation and sheep and goat husbandry (even the raising of cattle is difficult in rugged terrain). For centuries local people were loggers, who provided wood fuel for the nearby towns, charcoal-burners, providers of resinous-torches (dadiá in Greek, hence the name of the village) and livestock keepers. However, in some places the rugged terrain makes even timber exploitation difficult and less rewarding. It also presents difficulties for transport and communication and in general it is an obstacle to many human activities. All these factors have contributed to the overall low human population density and discouraged all but few people from visiting the least accessible places.

Many sources show that these wooded hills have been thinly inhabited since antiquity and today the population index is the lowest in all of Greece for similar elevation zones. An almost circular 2000 km^2 area centred on the Chapka peak and encompassing the DNP (Fig. 8), has a population index of c.1 ind. km^{-2}, while the mean population density in Greece is 83 inds km^{-2}, and other thinly populated areas in Greece, such as Prespa and Za-

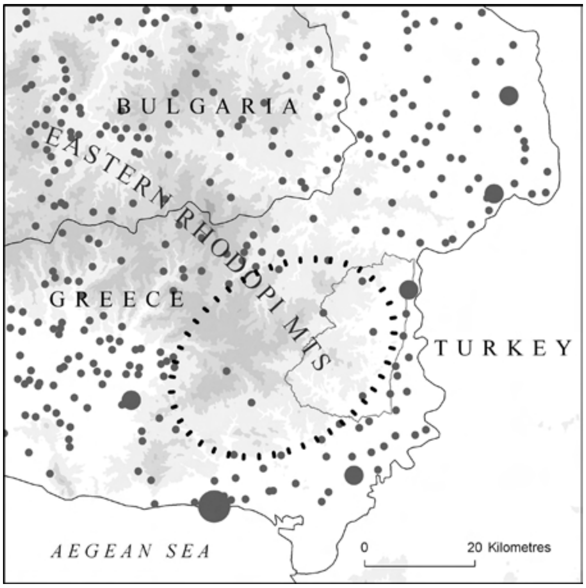

Fig. 8. Map showing the huge area with extremely low human population density, including the DNP and an area to its west. Dots signify extant settlements.

gori, reach 7 and 4.5 inds km^{-2}, respectively. It should be remembered that the average elevation of this area is less than 400 m asl (range 20–1100 m) and that its southernmost point is less than 15 km from the sea! The few settlements that were established were close to patches of fertile, flat land, and because these are few and small, the villages were also small. Most only survived until the first half of the 20th century, so even the limited environmental impact they had, ceased more than 90 years ago. At the end of the 19th century, there were 17 villages within the area of the park, but today only seven remain, and three of these are situated at the periphery of the focal area on the main road along the Evros river plain (Kornofolia, Provatonas, Soufli; see Fig. 2 in the Introduction to this volume).

Historical factors may also explain why the area was never densely populated. It has always been a border area, which would have made any large investment risky. Neither should one underestimate the role that military expediencies might have played in keeping the exploitation of the hilly Eastern Rhodope region low. On the other hand, it is untrue that the forest has not suffered from fires. There have been numerous small-scale fires at least during the last 30 years that we know of in detail (Dasiopoulou 2000). Historical evidence also shows that the forest has burnt extensively in the past. For example, during the Greek Civil war (1946–1949) a large part of the forest was set on fire by various warfare actions (Kassapis 1999). For centuries, as everywhere in the Mediterranean, livestock keepers have started small fires in the forest to create grazing land. These have been favourable for biodiversity, because they have maintained a mosaic of forest clearings and uneven-aged forest and scrub. Furthermore, despite the small fires and heavy grazing, there has never been extensive soil erosion (see also Maris and Vasileiou, this volume). This is attributed to the mechanical and physico-chemical properties of the soils and the physical features of the stream catchments (rocky substrates and stream beds, low-sloping drainage basins and stream beds, and the high interception of precipitation by the forest cover). In conclusion, the inhabitants cared for their main resource, the forest, did not cut it, did not allow the fires to destroy it, which in combination with the ruggedness of the terrain, preserved the large pines.

References

Adamakopoulos, T., Gatzoyannis, S. and Poirazidis, K. (eds). 1995. Specific Environmental Study of the Dadia Forest. Volumes A, B and C. – WWF Greece, Athens. (In Greek.)

Alivizatos, H. and Goutner, V. 1997. Feeding habits of the Long-legged Buzzard (*Buteo rufinus*) during breeding in Northeastern Greece. – Isr. J. Zoology 43: 257–266.

Bakaloudis D. E., Vlachos, C. G. and Holloway, G. J. 1998. Habitat use by short-toed eagles (*Circaetus gallicus*) and their reptilian prey during the breeding season in Dadia Forest (north-eastern Greece). – J. Appl. Ecol. 35: 821–828.

Bakaloudis, D.E. 2000. The ecology of Short-toed Eagle (*Circaetus gallicus*, Gm.) in Dadia – Lefkimi – Soufli Forest complex, Thrace, Greece. – PhD diss., Reading University, UK.

Berg, Å. 1997. Diversity and abundance of birds in relation to forest fragmentation, habitat quality and heterogeneity. – Bird Study 44: 355–366.

Bernstein, C., Krebs, J. R. and Kacelnik, A. 1991. Distribution of birds amongst habitats: theory and relevance to conservation. – In: Perrins, C. M., Lebreton, J.-D. and Hirons, G. J. M. (eds). Bird Population Studies. Relevance to conservation and management. Oxford Ornithology Series. Oxford University Press, pp. 317–345.

Beuermann, A. 1967. Fernweidewirtschaft in Südosteuropa. Ein Beitrag zur Kulturgeographie des östlichen Mittelmeergebietes. – Westermann, Braunschweig.

Blondel, J. 1999. Landscape patterns and biodiversity at different scales of space and time in the Mediterranean Region. – Contr. Zoogeogr. Ecol. East. Medit. Region 1: 1–19.

Blondel, J. and Aronson, J. 1999. Biology and wildlife of the Mediterranean Region. – Oxford University Press, Oxford.

Bosakowski, T. and Smith, D. G. 1997. Distribution and species richness of a forest raptor community in relation to urbanization. – J. Raptor Res. 31: 26–33.

Brunnbauer, U. 2000. Social adaptation to a mountain environment: Pomaks and Bulgarians in Central Rhodope, 1830–1930. – In: Nitsiakos, V. and Kassimis, Ch. (eds). The mountainous areas of the Balkan Peninsula. Structure and transformation. Plethron and Konitsa Municipality, pp. 53–78. (In Greek.)

Chotzidis, A. A. 2007. Agricultural economy in the vilayet of Adrianople (1878–1912): Re-assessing efforts to intensify production. – Peri Thrakis 5: 109–160. (In Greek.)

Cone, C. D. Jr. 1962. Thermal soaring in birds. – Am. Sci. 50: 180–209.

Covas, R. and Blondel, J. 1998. Biogeography and history of the Mediterranean bird fauna. – Ibis 140: 395–407.

Cramp, S. and Simmons, K. E. L. 1980 . Handbook of the birds of Europe , the Middle East and North Africa. The Birds of the Western Palearctic. Vol. II: Hawks to Bustards. – Oxford.

Dasiopoulou, G. 2000. A proposal for a fire fighting scheme in the Dadia – Lefkimi – Soufli Nature Reserve. – WWF Greece, Athens. (In Greek.)

Dunning, J. B., Danielson, B. J. and Pulliam, H. R. 1992. Ecological processes that affect populations in complex landscapes. – Oikos 65: 169–175

Fady, B., Semerci, H. and Vendramin, G. G. 2003. EUFORGEN Technical Guidelines for genetic conservation and use for Aleppo pine (*Pinus halepensis*) and Brutia pine (*Pinus brutia*). – International Plant Genetic Resources Institute, Rome, Italy.

Fargallo, J. A., Blanco, G. and Soto-Largo, E. 1998. Forest management effects on nesting habitat selected by Eurasian Black Vultures (*Aegypius monachus*) in Central Spain. – J. Raptor Res. 32: 202–207.

Gasc, J.-P., Cabela, A., Crnobrjna-Isailovic, J., Dolmen, D., Grossenbacher, K., Haffner, P., Lescure, J., Martens, H., Martínez Rica, J. P., Maurin, H., Oliveira, M. E., Sofianidou, T. S., Veith, M. and Zuiderwijk, A., 1997. Atlas of Amphibians and Reptiles in Europe. – Societas Europaea Herpetologica. Muséum National d' Histoire Naturelle, Paris.

Greenwood, J. 1992. Understanding bird distributions. – Trends Ecol. Evol. 7: 252–253.

Helmer, W. and Scholte, P. 1985. Herpetological research in Evros, Greece: Proposal for a biogenetic reserve. – Societas Europaea Herpetologica & Council of Europe. Report by the Research Institute for Nature Management, Arnhem & Department of Animal Ecology, Catholic University, Nijmegen.

Hiraldo, F. and Donázar, J. A. 1990. Foraging time in the Cinereous Vulture *Aegypius monachus*: seasonal and local variations and influence of weather. – Bird Study 37: 128–132.

Houston, D. C. 1979. The adaptations of scavengers. – In: Sinclair, A. R. E. and Norton-Griffiths, M. (eds). Serengeti: dynamics of an ecosystem. Chigago Univeristy Press, Chicago, pp. 263–286.

Janes, S. W. 1985. Habitat selection in raptorial birds. – In: Cody, M. L. (ed.). Habitat Selection in Birds. Academic Press, pp. 159–190.

Kanellis, A. 1973. Die Geier. – Griechisen Alpenvereins. Mitteilungen der Sektion Athen 85: 2–9.

Kassapis, V. 1999. The Civil war at Evros (1946–1949). – Private edition, Alexandroupolis. (In Greek.)

Kati, V. 2001. Methodological Approach on Assessing and Optimizing the Conservation of Biodiversity : a case study in Dadia Reserve (Greece). – PhD diss., Université Catholique de Louvain, Faculté des Sciences, Unité d' Ecologie et de Biogéographie, Belgium.

Kati, V. and Sekercioglou, C. H. 2006. Diversity, ecological structure, and conservation of the landbird community of Dadia reserve, Greece. – Divers. Distrib. 12: 620–629.

Kati, V., Devillers, P., Dufrêne, M. Legakis, A., Vokou, D. and Lebrun, Ph. 2004. Testing the value of six taxonomic groups as biodiversity indicators at local scale. – Conserv. Biol. 18: 667–675.

Kazantzidis, S. 2007. Trends in current ornithology in Greece. – J. Biol. Res.-Thessalon. 8: 139–149.

Kryštufek, B. and Griffiths, H. I. 2002. Species richness and rarity in European rodents. – Ecography 25: 120–128.

Leshem, Y. and Yom-Tov, Y. 1996. The use of thermals by soaring migrants. – Ibis 138: 667–674.

Marinkovic, S. and Karadzic, B. 1999. The role of nomadic farming in the distribution of the Griffon Vulture *Gyps fulvus* in the Balkan Peninsula. – Contr. Zoogeogr. Ecol. East. Medit. Region 1: 141–152.

Newton 1979. Population ecology of raptors. – T & A D Poyser.

Newton, I. 1991. Population limitation in birds of prey: a comparative approach. – In: Perrins, C. M., Lebreton, J. D. and Hirons, G. J. M. (eds). Bird Population Studies: relevance to conservation and management. Oxford University Press, Oxford, pp. 3–21.

Olea, P. P. and Mateo-Tomas, P. 2009. The role of traditional farming practices in ecosystem conservation: the case of transhumance and vultures. – Biol. Conserv. 142: 1844–1853.

Papadatou, E. 2006. Ecology and conservation of the long-fingered bat *Myotis capaccinii* in the National Park of Dadia – Lefkimi – Soufli, Greece. – PhD diss. University of Leeds, Institute of Integrative and Comparative Biology.

Pennycuick, C. J. 1972. Animal flight. – Arnold, London.

Pe-Piper, G. and Piper, D. J. W. 2002. The igneous rocks of Greece. The anatomy of an orogen. – Gebrüder Borntraeger, Berlin, Stuttgart.

Pianka, E. R. 1983. Evolutionary Ecology. – Harper & Row, New York.

Pikros, K. 1993. Aero-nautical meteorology. – Pikros Editons, Edessa, Greece. (In Greek.)

Poirazidis K., Goutner, V., Tsachalidis, E. and Kati, V. 2007. Comparison of nest-site selection patterns of different sympatric raptor species as a tool for their conservation. – Anim. Biodivers. Conserv. 30:131–145.

Poirazidis, K., Papageorgiou, A. and Kasimiadis, D. 2006. Mapping the animal biodiversity in the Dadia National Park using multi-criteria evaluation tools and GIS. – In: Manolas, E. (ed.). International Conference on Sustainable Management and Development of Mountainous and Island Areas, 29–30 September 2006, Naxos. Vol. 2. Democritus University of Thrace, pp. 299–304.

Poirazidis, K., Skartsi, Th., Pistolas, K. and Babakas, P. 1996. Nesting habitat of raptors in Dadia reserve, NE Greece. – In: Muntaner, J. and Mayol, J. (eds) VI Congress on Biology and Conservation of Mediterranean Raptors; Monografias, No 4, SEO, Madrid, pp. 327–333.

Poirazidis, K., Goutner, V. Skartsi, Th. and Stamou, G. 2004. Nesting habitat modelling as a conservation tool for the Eurasian Black Vulture (*Aegypius monachus*) in Dadia Nature Reserve, northeastern Greece. – Biol. Conserv. 118: 235–248.

Portolou, D. 1996. Dadia Forest, Greece: Structure, Regeneration and the Potential for Mixed Stands. – MSc diss., University College London.

Powell, R. A. and Mitchell, M. S. 1998. Topographical constraints and home range quality. – Ecography 21: 337–341.

Ricklefs, R. E. 1987. Community diversity: relative roles of local and regional processes. – Science 235: 167–171.

Ricklefs, R. E. 2006. Evolutionary diversification and the origin of the diversity-environment relationship. – Ecology 87: S3–S13.

Sánchez-Zapata, J. A. and Calvo, J. F. 1999. Raptor distribution in relation to landscape composition in semi-arid Mediterranean habitats. – J. Appl. Ecol. 36: 254–262.

Schindler, S., Poirazidis, K. and Wrbka, T. 2008. Towards a core set of landscape metrics for biodiversity assessments: A case of study from Dadia National Park, Greece. – Ecol. Indic. 8: 502–514.

Selås, V. 1997. Nest-site selection by four sympatric forest raptors in southern Norway. – J. Raptor Res. 31: 16–25.

Sidiropoulos, L., Tsiakiris, R., Konstantinou, P. and Azmanis, P. 2006. The significance of the Almopia mountain arc for the conservation of raptors in the Balkans. – In: Coles. S., Dimopoulos, P. and Kehagias, G. (eds). Proceedings of the 3rd Congress of the Hellenic Ecological Society and the Hellenic Zoological Society, Ioannina, Greece, 16–19 November 2006, pp. 309–314. (In Greek.)

Skartsi, T., Vasilakis, D. and Elorriaga, N. J. 2003. Black Vulture and Griffon Vulture monitoring in the National Park of Dadia–Lefkimi–Soufli Forest. Annual Technical Report. – WWF Greece, Athens.

Skordilis, A. and Thanos, C. A. 1995. Seed stratification and germination strategy in the Mediterranean pines *Pinus brutia* and *P. halepensis*. – Seed Sci. Res. 5: 151–160.

Spassov, N. and Iliev, N. 1994. Animal remains from the submerged late Neolithic – Early Bronze Age settlement near Sozopol (the south Black Sea coast of Bulgaria). – Thracia Pontica 6: 1–30.

Spassov, N. and Markov, G. 2004. Biodiversity of large mammals (Macromammalia) in the Eastern Rhodopes (Bulgaria). – In: Beron, P. and Popov, A. (eds). Biodiversity of Bulgaria, 2. Biodiversity of Eastern Rhodopes (Bulgaria and Greece). Pensoft & Natl. Mus. Nat. Hist., Sofia, pp. 929–939.

Stoychev, S., Hristov, H., Iankov, P. and Demerzhiev, D. 2004. Birds in the Bulgarian part of the Eastern Rhodopes. – In: Beron, P. and Popov, A. (eds). Biodiversity of Bulgaria, 2. Biodiversity of Eastern Rhodopes (Bulgaria and Greece). Pensoft and Natl. Mus. of Nat. Hist., Sofia, pp. 881–894.

Strijbosch, H., Helmer, W. and Scholte, P. 1989. Distribution and ecology of lizards in the Greek province of Evros. – Amphibia-Reptilia 10: 151–174.

Suárez-Seoane, S. and Baudry, J. 2002. Scale dependence of spatial patterns and cartography on the detection of landscape change: relationships with species' perception. – Ecography 25: 499–511.

Vasilakis, D., Poirazidis, K. and Elorriaga, J. N. 2008. Range use of a Eurasian Black Vulture (*Aegypius monachus*) population in the Dadia National Park and the adjacent areas, Thrace, NE Greece. – J. Nat. Hist. 42: 355–373.

Vlachos, C. and Papageorgiou, N. 1996. Breeding biology and feeding of the lesser-spotted eagle (*Aquila pomarina*) in Dadia Forest, north-eastern Greece. – In: Meyburg, B.-U. and Chancellor, R. D.(eds). Eagle Studies. World Working Group of Birds of Prey, Berlin, pp. 337–347.

Vlachos, Ch. 1989. The ecology of Lesser-spotted Eagle *Aquilla pomarina* in the Dadia Forest, Evros Prefecture. – PhD diss., Aristotle University of Thessaloniki, School of Geotechnical Sciences, Department of Forestry and Natural Environment. (In Greek.)

Whittaker, R. J., Willis, K. J. and Field, R. 2001. Scale and species richness: towards a general, hierarchical theory of species diversity. – J. Biogeogr. 28: 453–470.

Xirouchakis, S. M. 1999. Habitat selection of diurnal raptors during the breeding season in the Dadia Reserve, Evros. – Contr. Zoogeogr. Ecol. East. Medit. Region 1: 161–169.