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

Edited by
Giorgos Catsadorakis and Hans Källander

Illustrations by
Paschalis Dougalis

WWF Greece
Athens 2010

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

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

Suggested citation:

Author's name. 2010. Title of paper. – In: Catsadorakis, G. and Källander, H. (eds). The Dadia–Lefkimi–Soufli Forest National Park, Greece: Biodiversity, Management and Conservation. WWF Greece, Athens, pp. 000–000.

Published by:
WWF Greece,
26 Filellinon str.,
GR-105 58 Athens, Greece
Tel:+30 2103314893, fax: +302103247578
e-mail: support@wwf.gr
http://www.wwf.gr

ISBN 978-960-7506-10-8

Typeset by ZooBo Tech, Torna Hällestad, Sweden
Printed by Schema + Chroma, GR-574 00 Sindos, Thessaloniki, http://www.kethea-print.gr
Illustrations by Paschalis Dougalis
Maps on pages 18–28, 36, 42, 86, 89, 217 and 231–243 prepared by Nikolaos Kasimis, those on pages 23, 27 and 232 by Konstantinos Poirazidis.
The book was printed on130 g FSC-certified Sappi Era Silk paper.
Cover photo: Giorgos Catsadorakis.

Landscape and biodiversity in Dadia–Lefkimi–Soufli Forest National Park

Konstantinos Poirazidis, Vassiliki Kati, Stefan Schindler, Dimitrios Triantakonstantis, Dionissios Kalivas and Stylianos Gatzogiannis

The relationships between heterogeneous landscapes and biodiversity have been well investigated and in many cases human activities have played a significant role in the creation of landscape patterns. In the Dadia–Lefkimi–Soufli Forest National Park (DNP), natural and anthropogenic disturbances during the last century, such as forest fires, uncontrolled logging and extensive livestock grazing created a mosaic of different land-cover categories. However, nowadays natural succession and forest management have altered the mosaic of habitats towards a more homogeneous forest area. More than 70% of the land is now covered with oak and pine forests in either pure or in mixed stands negatively affecting some fauna species depending on heterogeneity and semi-open habitats negatively. Despite this alteration, habitat diversity is one of the main gradients characterizing the landscape structure in Dadia. Although an optimal level of heterogeneity can hardly be determined as it depends on the taxa under consideration, diversity and spatial configuration of landscapes were found to be important drivers of local biodiversity in DNP and must be considered in the management and conservation of the park.

Keywords: Heterogeneity, landscape structure, land use change, diversity of habitats, local biodiversity

Biodiversity and heterogeneity – a questionable relationship

Nowadays, there is much discussion about the human impacts on landscapes and biological diversity worldwide. Most landscapes have been influenced by human land use, and the resulting landscape mosaic is a mixture of natural and human-managed patches that vary in size, shape, and arrangement (e.g., Forman and Godron 1986, Krummel et al. 1987). The intrinsic value of biodiversity is widely recognized as is its ecological, social, economic, cultural and aesthetic value (Pimm et al. 1995, Mittermeier et al. 1999), but human-induced loss of biodiversity has currently reached alarming rates at the levels of genes, species and ecosystems (Barbault and Sastrapradja 1995, Brooks et al. 2002). Nevertheless, human impact has not always impoverished local or regional diversity; in some cases human activity has had positive effects by increasing biological diversity through the creation of heterogeneous landscapes (Blondel and Aronson 1999, Brotons et al. 2004, Kati et al. 2004b, Saïd and Servanty 2005).

The relationships between landscape and biodiversity have been investigated intensively during the last two decades (e.g. Wiens et al. 1993, With and Christ 1995, Miller et al. 1997, Pino et al. 2000, Poudevigne and Baudry 2003, Betts et al. 2005, Quevedo et al. 2006). It is believed that anthropogenic disturbances enhanced landscape heterogeneity and that the "mosaic effect" of landscape patchiness therefore had a beneficial, rather than impoverishing impact on species diversity (Le Houerou 1981, Blondel and Aronson 1999, Ernoult et al. 2003). In fact, mosaics play an important role for many animal groups, such as insects (e.g. Chust et al. 2004, Saarinen and Jantunen 2005), birds (e.g. Sanchez-Zapata and Calvo 1999, Brotons et al. 2004) and mammals (e.g. Jepsen et al. 2005, Saïd and Servanty 2005), and a positive relationship between landscape heterogeneity and biodiversity has been demonstrated (e.g. Forman 1995, Bignal and McCracken 1996).

When human disturbance exceeds a certain threshold, however, it can have a disastrous impact on biodiversity. In such cases we refer to landscape fragmentation, loss and degradation, which are widely considered to be the most important threats to biodiversity on a global scale (e.g. Soulé 1987, Fahrig and Meriam 1994, Tilman et al. 1994, Fahrig 2001). In Mediterranean ecosystems human-induced disturbances, such as fires, clear-cutting, grazing and logging, are believed to have had a direct or sustained impact for thousands of years (Naveh and Dan 1973). On the other hand, this long-lasting exploitation of natural resources in the Mediterranean resulted in the extinction of several plant and animal species and in a severe reduction in the area of primary forest vegetation (Quézel 1976, Myers et al. 2000, Guo 2003). Human activities also led to a wide array of adaptations of vegetation structure and of individual species (Blondel and Aronson 1999).

The landscape of the Dadia–Lefkimi–Soufli Forest National Park (hereafter DNP) is covered mostly by woodland. However, during recent centuries this area was never a “virgin” forest without any human impact on the succession history of its ecosystems. Natural or anthropogenic forest fires, uncontrolled logging and extensive livestock grazing created a fine mosaic of open land-cover categories. Many of the factors that created clearings inside the forest have nowadays been diminished (e.g. livestock grazing, uncontrolled natural fires), resulting in a significant decrease of forest clearings and natural grasslands. This has had a significant effect on landscape composition and configuration.

The current paper aims to summarize the research carried out in DNP on landscape features and their effects on species diversity. Its objectives are: (1) to describe different aspects of the landscape of DNP, particularly regarding geomorphology, land-cover types and landscape structure; (2) to review land-use changes during the last century and thereby explain current patterns of landscape heterogeneity; and (3) to review the influence of current landscape heterogeneity on local biodiversity.

Heterogeneity in the DNP

Geomorphology

The DNP is characterized by an undulating landscape with low hills and hundreds of gullies. The distribution

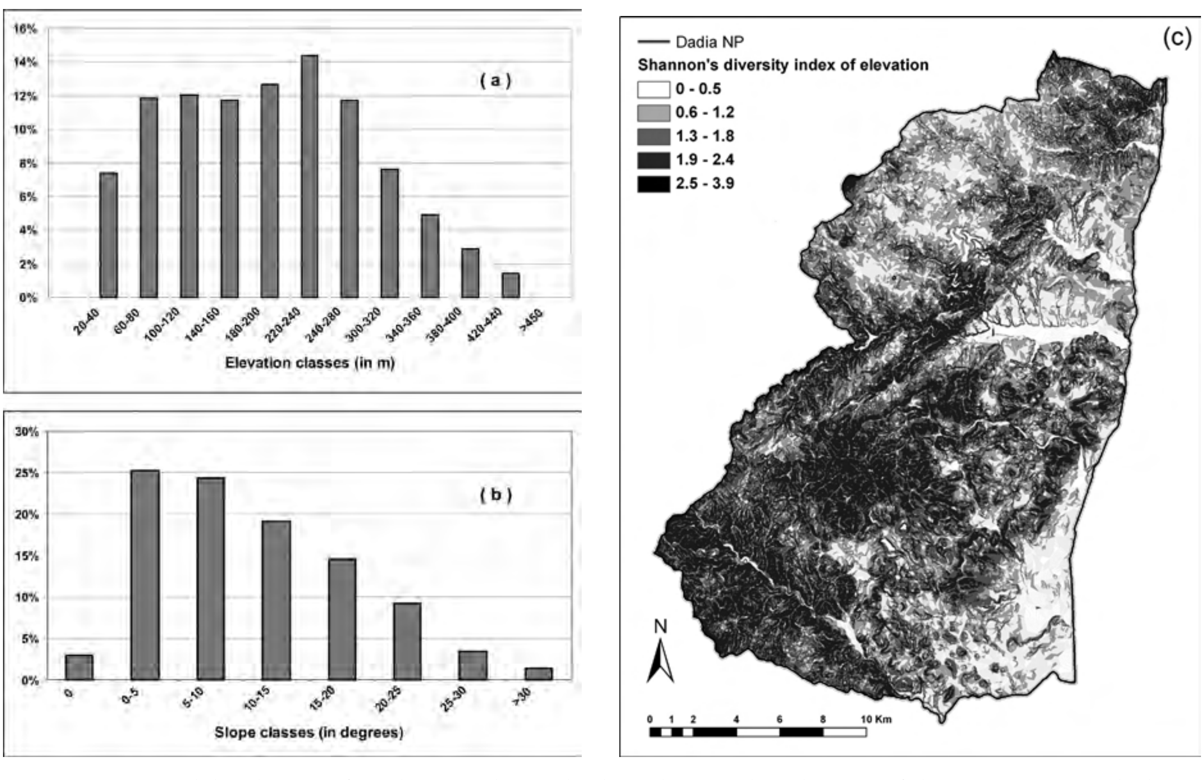

Fig. 1. Proportional distribution of (a) elevation classes, (b) slope classes and (c) diversity of elevations in DNP (the latter as measured by Shannon’s diversity index).

of the geomorphologic parameters is irregular. Although the altitude ranges from 20 to 640 m above sea level, 90% of the area lies below 320 m and has gentle or moderate slopes, while steeper slopes are found mainly in the central and southwestern part of the area and are associated with the highest altitudes of the park (Fig. 1a & b). This difference is also reflected in the diversity of the park's geomorphology. Half of the area – mainly the lowlands and the northwest – is characterized by a gently rolling relief, with low elevational diversity. In contrast, the highlands as well as the southwest have a highly diverse geomorphology (Fig. 1c).

Land cover – types of vegetation

DNP is dominated by woodland. More than 70% of the area is covered by oak and pine forests in either pure or mixed stands. Most of the oak forest is present in the northern and the south-western parts of the area, while pine forests are concentrated in the central and eastern parts. Mixed forests cover the intermediate zones and the broad-leaved forest (mainly *Arbutus andrachne* and *Phillyrea media*) the south-west (Poirazidis 2003). Fourteen different land-cover types have been recognized (details presented in Fig. 5 of the introduction chapter to this volume). Intensive reforestation has taken place in the area during the last 50 years (Triantakonstantis et al. 2006) which has resulted in a more homogeneous forest area with less forest edge but with a high diversity of habitat types still present. More than 55% of the forest belongs to mixed vegetation types in different proportions and variable patterns of composition and configuration (for an example, see Fig. 2).

Landscape structure

Landscape structure quantifies composition and configuration of a landscape and is characterized by measures such as patch size, edge density, patch shape, isolation, texture, connectivity, diversity, edge contrast, etc. (Turner et al. 2001). Gradients of landscape structure in DNP can be expressed optimally by variables such

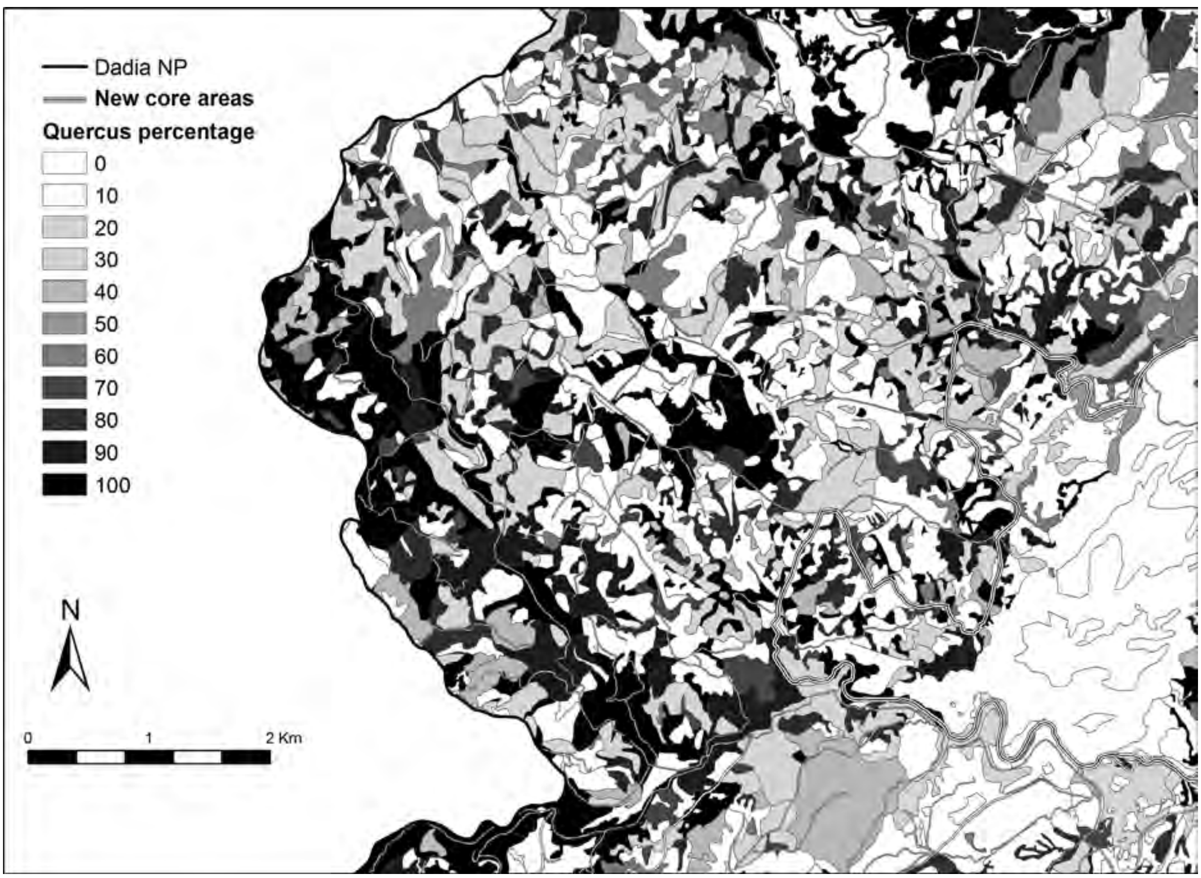

Fig. 2. An example of the pattern of mixed forest in DNP (% of oak tree cover in the north-western section).

as landscape diversity, edge contrast (which is related to habitat fragmentation) and patch shape (Schindler et al. 2008). The gradient of landscape diversity is especially pronounced and reaches from areas with very few and dominating habitats, towards ones with a high variety and interspersion of habitats. Diverse landscapes occur in several parts of the park but the highest values of landscape diversity are reached around the borders of the strictly protected areas where different forest types are mixed with clearings and fields. Low diversity is found in the eastern agricultural areas and in the oak forests at the northern and south-western borders of the park (Fig. 3).

Edge contrast was the second most important gradient of landscape structure in DNP (Schindler et al. 2008). It quantifies the contrast among different habitat patches, and high values are often related to anthropogenic fragmentation. The pattern of this gradient is clustered with the highest values occurring in the eastern part of the study area, which consists of agricultural land with many small patches of highly fragmented forest (Fig. 4). Two clusters of very low edge contrast coincide with the two strictly protected areas, which remain unfragmented due to the absence of forest roads and agricultural land. Another measure of landscape structure, "patch shape irregularity," was the dominant characteristic of the third main gradient that resulted from our research (Schindler et al. 2008). Most irregularly shaped patches occurred in the two core areas of DNP.

The three gradients of landscape structure provide a good overview of the effects of management on habitat heterogeneity and landscape characteristics (Table 1). The strictly protected areas of the DNP are covered by

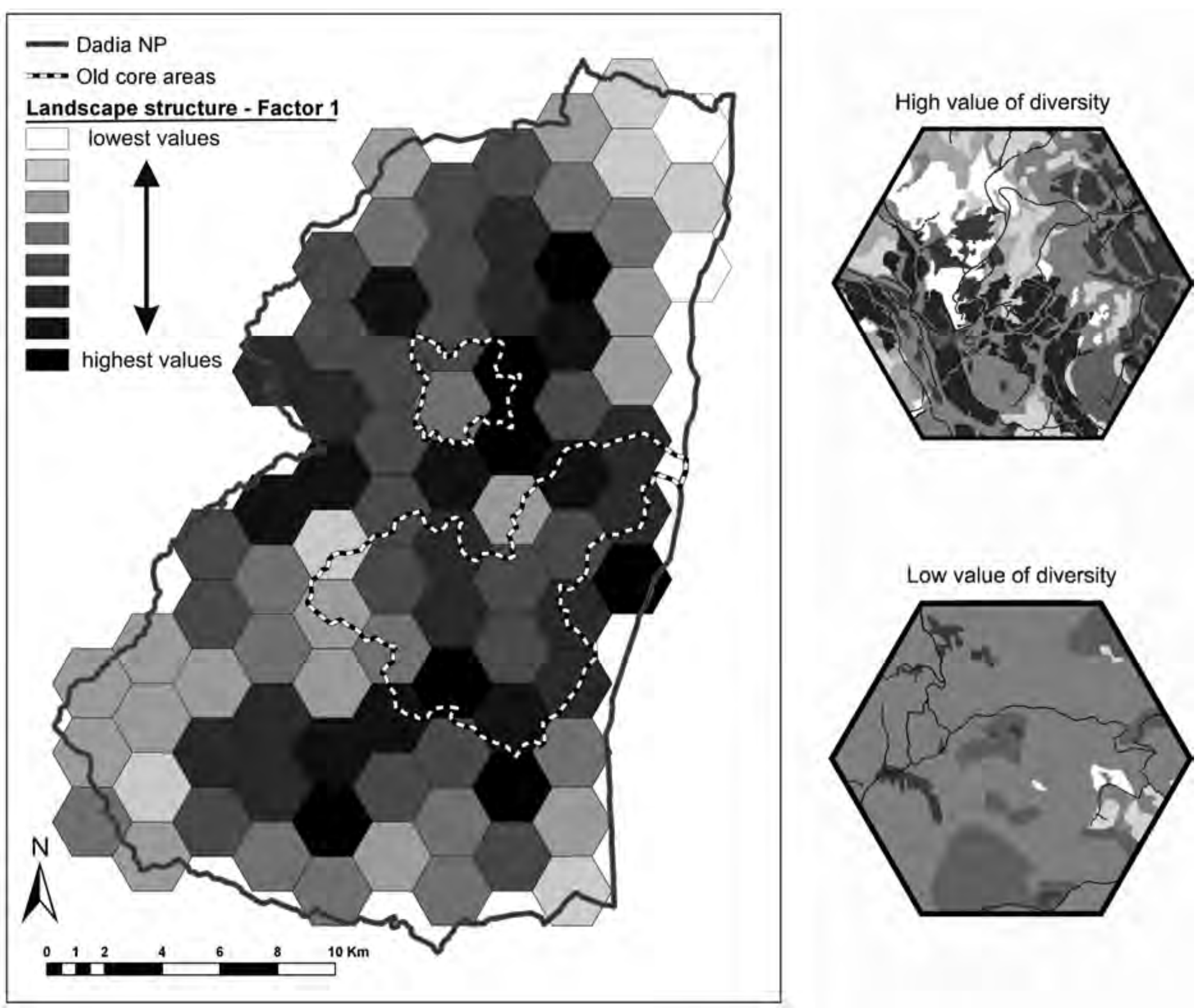

Fig. 3. Pattern of landscape diversity in DNP and examples of areas with particularly high and low values.

unfragmented forests. The parts surrounding the core areas are characterized by a great diversity of habitat types and a low to medium level of fragmentation.

Land-cover changes in DNP

As mentioned in the previous chapters, woodland covers most of the landscape of DNP. However, in recent centuries DNP was not a "virgin" forest without any human impact on the succession history of its ecosystems. Especially during the past 60 years, many stochastic events played a leading role in creating what we now wish to conserve. In the past there was a higher percentage of open areas in the park, as can be seen from older aerial photos (Triantakonstantis et al. 2006). Natural or anthropogenic forest fires (e.g. during the Second World War and the civil war that followed), uncontrolled logging and extensive livestock grazing created a fine mosaic of open land-cover categories such as agricultural land, grassland, scrubland, rocky areas and degraded oak forest.

After the 1960s, many of the above-mentioned activities declined and a management plan for the forests was implemented. In 1980, a Nature Reserve was established with two areas under strict protection and with an adjoining buffer zone (for details, see the introduction chapter to this volume). Together with other very important changes, this has resulted in many factors that in the past created open habitat nowadays having decreased in importance (e.g. livestock grazing, uncontrolled semi-natural fires). This has led to a significant decrease in the number of forest clearings and the amount of semi-natural grassland. Environmental heterogeneity is one of the main factors generating biological diversity (Huston 1994) and it is obvious that many changes influencing habitat heterogeneity took place in the ecosystem of

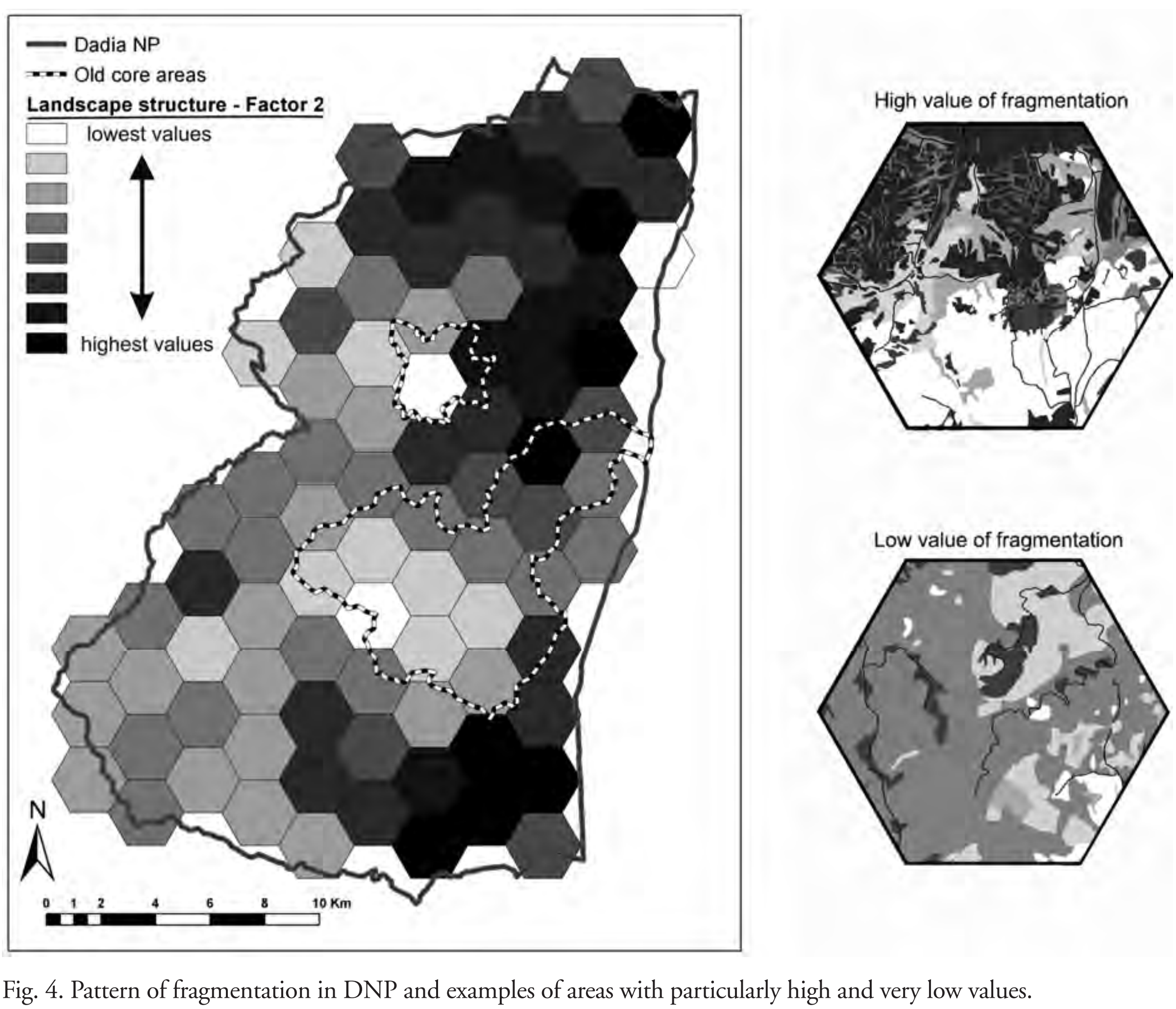

Fig. 4. Pattern of fragmentation in DNP and examples of areas with particularly high and very low values.

Table 1. Local differences in landscape structure in the DNP.

Region	Habitat diversity	Fragmentation	Patch shape irregularity
Core areas	medium	low	high
Agricultural areas	low	high	low–medium
Unmanaged forest pastures	high	medium–high	medium
Managed forest	medium	medium	varying (low–high)

DNP. Although the detailed analysis of the changes in landscape structure is still on-going, it seems that a high level of habitat heterogeneity characterized the area in 1945, while in the following years natural forest expansion created more continuous and homogeneous forest habitats. According to recent research (Triantakonstantis et al. 2006), only 46% of the DNP was covered by forest in 1945, reaching 54% in 1973 and 72% in 2001. On the other hand, the proportion of clearings decreased from 35% in 1945 to 25% in 1973 and 9% in 2001. The extent of agricultural land was quite stable during this period, with 18, 20 and 16%, respectively (Fig. 5, Table 2).

Forest expansion rates were high during the whole study period but were more evident after 1973 when the prescribed management of the forest was launched and the first protection status was implemented in the area. More than 60% of the forest expansion took place within a 200 m zone in the vicinity of the old existing forest patches resulting in more homogeneous forest ecosystems (Fig. 6). It is interesting, however, that forest expansion in what later became the strictly protected areas of the reserve was slower than in the managed forest. There are no scientific data that would explain the reasons for this difference, but it is possible that the forest policy in the managed area supported the re-establishment of forest in the clearings. Together with a decline in free-ranging livestock in many parts of the managed forests of the buffer zone, this may have acted towards a quicker natural regrowth. In contrast, these two factors never operated in the core areas.

Both natural succession and anthropogenic management have acted in different ways during the last 50 years creating an increasingly homogenous and forested landscape in DNP. But how have these changes in landscape heterogeneity affected local biodiversity? How much forest or opening is optimal to support the highest biodiversity? To answer these questions, data from all past periods are necessary, but unfortunately this information is not available. Thus, present biodiversity in areas of different heterogeneity must be used to approach the correct answers.

Table 2. Trends in land use changes in the buffer zone and the core areas of DNP from 1945 to 2001.

Change	1945–1973	1973–2001	1945–1973	1973–2001
	Buffer zone (%)		Core areas (%)	
Forest → Forest	74	91	83	91
Forest → Clearings	23	4	15	7
Forest → Agricultural land	3	2	2	1
Clearings → Forest	50	69	55	65
Clearings → Clearings	40	19	43	31
Clearings → Agricultural land	10	10	3	3
Agricultural land → Forest	8	27	20	63
Agricultural land → Clearings	3	5	14	4
Agricultural land → Agricultural land	89	63	66	30

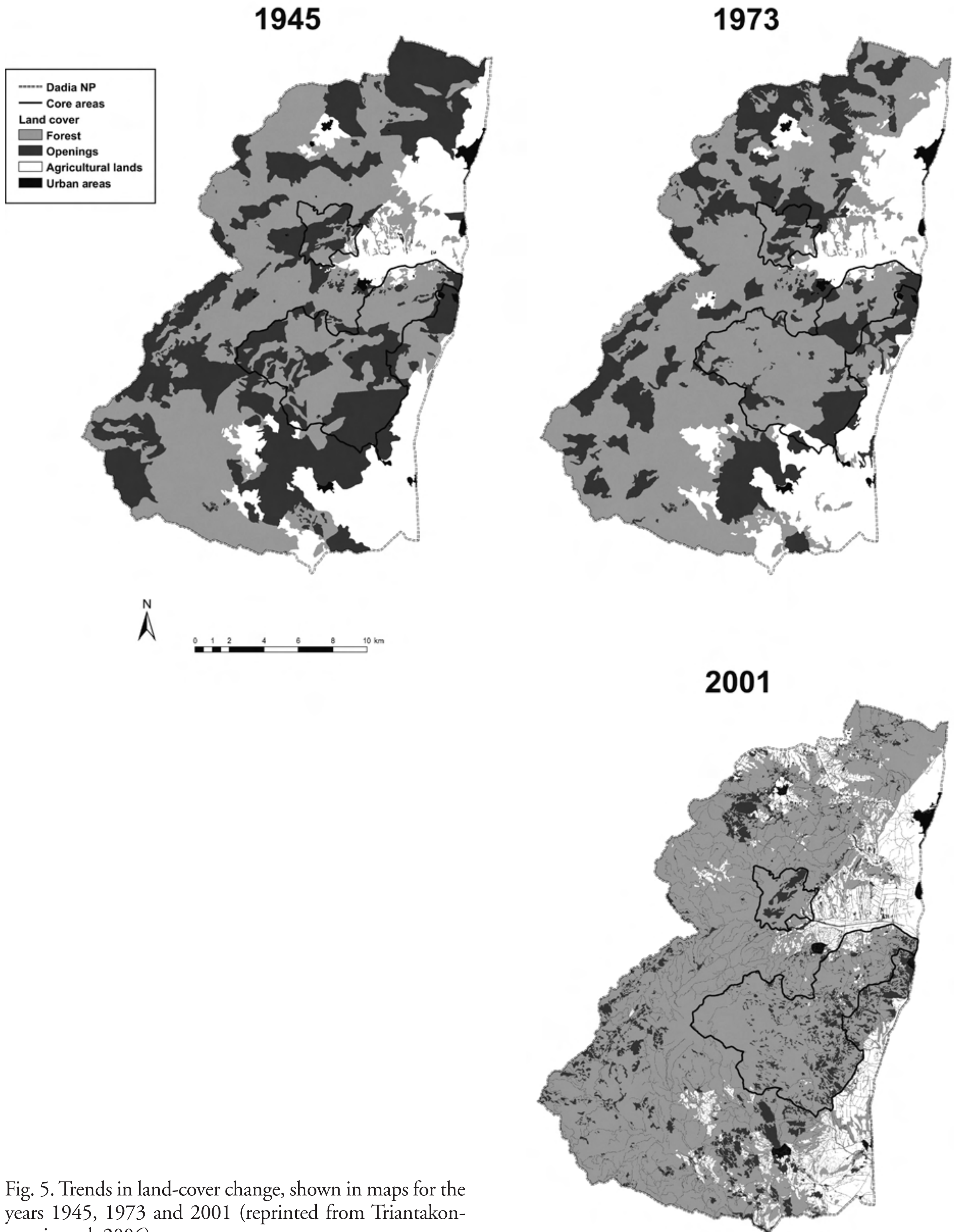

Fig. 5. Trends in land-cover change, shown in maps for the years 1945, 1973 and 2001 (reprinted from Triantakonstantis et al. 2006).

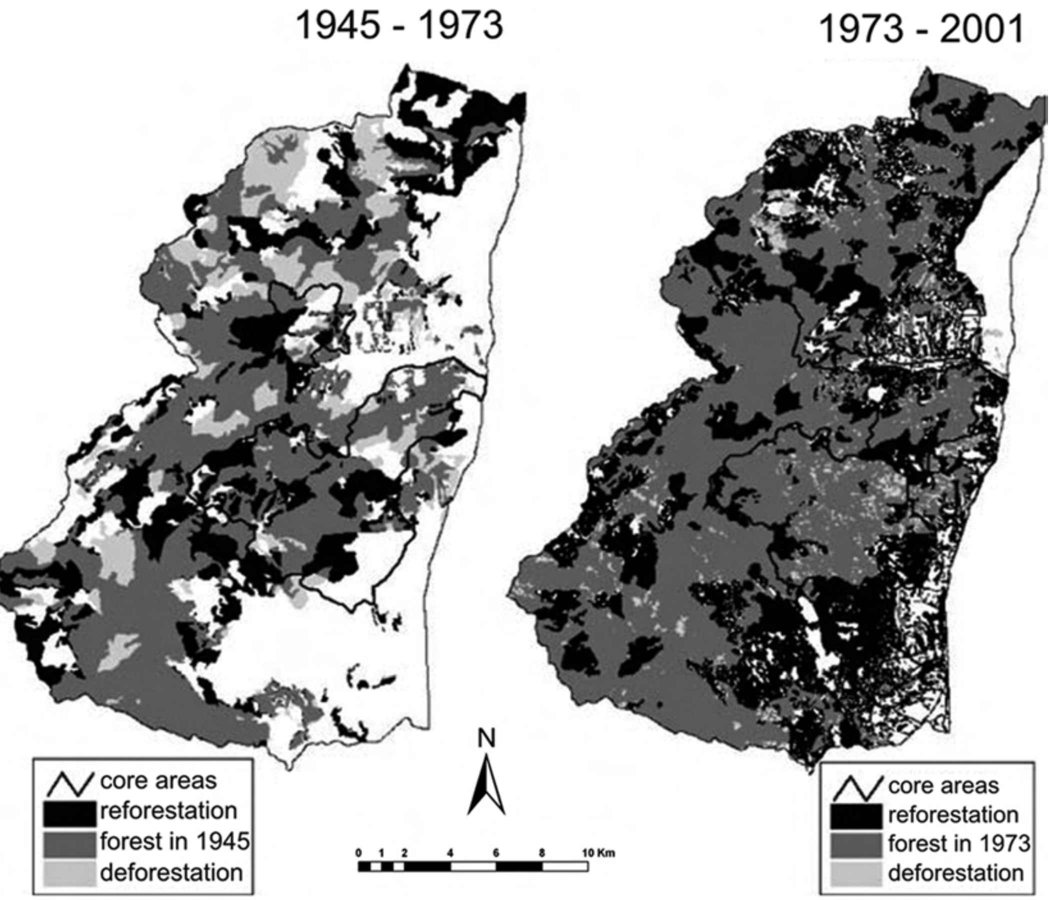

Fig. 6. Maps of regeneration and deforestation during 1945–1973 and 1973–2001 (reprinted from Triantakonstantis et al. 2006).

Landscape heterogeneity and local biodiversity in DNP

DNP is known for its high biodiversity, including unique and rare species of flora and fauna (e.g. Helmer and Scholte 1985, Adamakopoulos et al. 1995, Kati et al. 2000, Grill and Cleary 2003, Kati et al. 2004a, Korakis et al. 2006). The area is of great importance for diurnal raptorial birds because of the particularly high number of breeding species (17–18, of which 12 are tree-nesting), and also because of the sizable populations of some of these species (Hallmann 1979, Poirazidis et al. 1996, Poirazidis et al., this volume). A considerable breeding population of Black Stork *Ciconia nigra* also occurs in the area (Tsachalidis and Poirazidis 2006).

Heterogeneous landscapes provide a variety of breeding and foraging areas in close proximity and can maintain a high diversity and abundance of raptorial birds (Sanchez-Zapata and Calvo 1999, Anderson 2001). A definite reduction in the availability of open and semi-open habitats, as recorded for the mountain zone of DNP since the 1950s, affected the distribution of many raptor species, such as the Lesser Spotted Eagle *Aquila pomarina*, Long-legged Buzzard *Buteo rufinus* and Egyptian Vulture *Neophron percnopterus*. These species lost several of their traditional territories in the mountain zone (Poirazidis 2003); they now mainly occupy the lowlands, reflecting their preference for nesting in mosaic habitats dominated by forest edges and small portions of mature forests (Alivizatos 1996, Väli et al. 2004, Poirazidis et al. 2007). Non-intensive cultivated fields and pastures inside the forest are mainly used for foraging and are vital elements for raptor conservation in DNP (Bakaloudis et al. 1998, Xirouchakis 1999). On the other hand, raptor species adapted to the forest interior, such as Goshawk *Accipiter gentilis*, Booted Eagle *Hieraaetus pennatus* and Honey Buzzard *Pernis apivorus*, showed stable or increasing populations (Poirazidis 2003). It is possible that the changes towards a more forest-friendly management, could have improved the nesting habitat of these species and consequently their population sizes (Poirazidis et al. 2007).

Landscape heterogeneity has a positive influence on the community of smaller birds (passerines and woodpeckers) in DNP (Moskát and Fuisz 2002, Kati and Sekercioglu 2006). The highest diversity of these birds was detected at sites of a mosaic character that combined different kinds of vegetation patches within a limited area, such as grassy openings, hedges and forest plots. These sites were situated either in the agricultural zone of DNP, or were clearings in the pine forest. Several other studies have shown that horizontal heterogeneity (but also vertical heterogeneity) affects the distribution of small terrestrial birds positively (e.g. Blondel et al. 1973, Böhning-Gaese 1997, Farina 1997, Grand and Cushman 2003).

Spatial heterogeneity has a positive influence on the species richness of woody plants (Bascompte and Rodriguez 2001), and irregular shapes of patches have been shown to contain a higher diversity of vascular plants and bryophytes than regular ones (Moser et al. 2002). In accordance with these studies, we found that sites of a mosaic character in our study area were also the richest in species of woody plants (Kati 2001).

Landscape diversity is also known to be one of the important factors for pond-breeding amphibians (Brodman et al. 2003). In our study area, the most important sites for the semi-aquatic herpetofauna (amphibians and freshwater terrapins) were the ones that combined a diversity of wet microhabitats, such as brooks, inundated land, puddles and ditches (Kati et al. 2007). Anthropogenic impact can be favourable for the semi-aquatic herpetofauna, making habitats more diversified by the creation of artificial aquatic microhabitats (puddles, ditches). Such new microhabitats can improve water availability during the arid season and thus favour the semi-aquatic herpetofauna, although they are far poorer in species richness than natural ones (Kati et al. 2007).

Semi-open or open habitats of a thermophilous character, such as oak woods and heaths, with a well developed shrub layer were found to be the most important sites for lizards and terrestrial tortoises (Kati et al. 2007). High densities of reptiles were also found in forests, mainly in mixed forest and oak forest, but they were dominated by just two to three species (Bakaloudis et al. 1998). Although no strong evidence for links between habitat heterogeneity and reptile diversity was found in some studies of the herpetofauna in DNP (Helmer and Scholte 1985, Kati et al. 2007), when considering larger spatial scales, an increasing effect of landscape heterogeneity on reptile species richness was detected (Schindler et al. 2009, Schindler et al. in press).

Considering six different taxonomic groups together to represent local biodiversity (woody plants, orchids, Orthoptera, semi-aquatic herpetofauna, terrestrial herpetofauna and birds), we found that landscape heterogeneity has significant positive effects on species richness (Kati and Poirazidis 2005, Schindler et al. 2009, Schindler et al. in press).

According to existing knowledge, landscape heterogeneity could have significant positive effects on many taxa (Kati and Poirazidis 2005, Schindler et al. 2009, Schindler et al. in press), but the extent of the studied area plays an important role for the detection of these relationships. For example, woody plants, Orthoptera and birds were related to landscape heterogeneity at smaller scales, while reptile diversity was predicted better at larger scales (Schindler et al. 2009, Schindler et al. in press). An optimal level of heterogeneity can hardly be determined as it depends on the taxa of interest, but diversity and spatial configuration of landscapes are important drivers of biodiversity and must be considered in the conservation of managed forests (Radford and Bennett 2004, McDonald et al. 2005, Quevedo et al. 2006). However, special attention should be paid to the thresholds above which the effects of heterogeneity become negative.

Continuous research on the pattern of relations between landscape heterogeneity and species richness will be useful to understand the impact of heterogeneity on biodiversity, and to improve management decisions in DNP and other Mediterranean forest landscapes (Poirazidis et al. in press). A systematic monitoring of land use and land-cover changes and their effects on indicator species would improve management decisions in DNP.

References

Adamakopoulos, T., Gatzogiannis, S. and Poirazidis, K. 1995. Specific Environmental Study of the Dadia Forest Special Protection Area. Parts A+B, C. – WWF-Greece, Ministry of Environment, Ministry of Agriculture, ACNAT. WWF-Greece, Athens. (In Greek.)

Alivizatos, H. 1996. The ecology of the Long-legged buzzard (*Buteo rufinus*) in the Evros Prefecture. – PhD Dissertation, Agriculture University of Athens, Athens. (In Greek.)

Anderson, D. L. 2001. Landscape heterogeneity and diurnal raptor diversity in Honduras: The role of indigenous shifting cultivation. – Biotropica 33: 511–519.

Bakaloudis, D., Vlachos, C. and Holloway, G. J. 1998. Habitat use by Short-toed Eagle *Circaetus gallicus* and their reptilian prey during the breeding season in Dadia forest. – J. Appl. Ecol. 38: 821–828.
Barbault, R. and Sastrapradja, S. 1995. Generation, maintenance and loss of biodiversity. – In: Heywood, V. H. and Watson, R. T. (eds). Global Biodiversity Assessment. UNEP, Cambridge University Press, Cambridge, pp. 193–275.
Bascompte, J. and Rodriguez, M. 2001. Habitat patchiness and plant species richness. – Ecology Letters 4: 417–420.
Betts, M. G., Diamond, A. W., Forbes, G. J., Villard, M. A. and Gunn, J. S. 2005. The importance of spatial autocorrelation, extent and resolution in predicting forest bird occurrence. – Ecol. Model. 191: 197–224.
Blondel, J., Ferry, C. and Frochot, B. 1973. Avifaune et végétation – essai d'analyse de la diversité. – Alauda 16: 63–84.
Blondel, J. and Aronson, J. 1999. Biology and Wildlife of the Mediterranean Region. – Oxford University Press, Oxford.
Böhning-Gaese, K. 1997. Determinants of avian species richness at different spatial scales. – J. Biogeogr. 24: 49–60.
Bignal, E. M. and McCracken, D. I. 1996. Low-intensity farming systems in the conservation of the countryside. – J. Appl. Ecol. 33: 413–424.
Brodman, R., Ogger, J., Bogard, T., Long, A. J., Pulver, R. A., Mancuso, K. and Falk, D. 2003. Multivariate analyses of the influences of water chemistry and habitat parameters on the abundances of pond-breeding amphibians. – J. Freshw. Ecol. 18: 425–436.
Brooks, T. M., Mittermeier, R. A., Mittermeier, C. G., Da Fonseca, G. A. B., Rylands, A. B., Konstant, W. R., Flick, P., Pilgrim, J., Oldfield, S., Magin, G. and Hilton-Taylor, C. 2002. Habitat loss and extinction in the hotspots of biodiversity. – Conserv. Biol. 16: 909–923.
Brotons, L., Herrando, S. and Martín, J.-L. 2004. Bird assemblage in forest fragments within Mediterranean mosaics created by wild fires. – Landsc. Ecol. 19: 663–675.
Chust, G., Pretus, J. LL., Ducrot, D. and Ventura, D. 2004. Scale dependency of insect assemblages in response to landscape pattern. – Landsc. Ecol. 19: 41–57.
Ernoult, A., Bureau, F. and Poudevigne, I. 2003. Patterns of organization in changing landscapes: implications for the management of biodiversity. – Landsc. Ecol. 18: 239–251.
Fahrig, L. 2001. How much habitat is enough? – Biol. Conserv. 100: 65–74.
Fahrig, L. and Meriam, G. 1994. Conservation of fragmented populations. – Conserv. Biol. 8: 50–59.
Farina, A. 1997. Landscape structure and breeding bird distribution in a sub-Mediterranean agro-ecosystem. – Landsc. Ecol. 12: 365–378.
Forman, R. T. T. 1995. Land Mosaics: The Ecology of Landscapes and Regions. – Cambridge University Press, Cambridge.
Forman, R. T. T. and Godron, M. 1986. Landscape Ecology. – John Wiley and Sons, New York.
Grand, J. and Cushman, S. A. 2003. A multi-scale analysis of species-environment relationships: breeding birds in a pitch pine-scrub oak (*Pinus rigida–Quercus ilicifolia*) community. – Biol. Conserv. 112: 307–317.
Grill, A. and Cleary, D. 2003. Diversity patterns in butterfly communities of the Greek nature reserve Dadia. – Biol. Conserv. 114: 427–436.
Guo, Q. F. 2003. Disturbance, life history, and optimal management for biodiversity. – AMBIO 6: 428–430.
Hallmann, B. 1979. Guidelines for the conservation of birds of prey in Evros. – IUCN/ WWF.
Helmer, W. and Scholte, P. 1985. Herpetological research in Evros, Greece: Proposal for a biogenetic reserve. – Research Institute for Nature Management, Arnhem and Department of Animal Ecology, Catholic University, Nijmegen.
Huston, M. A. 1994. Biological Diversity. The coexistence of species in changing landscapes. – Cambridge University Press, Cambridge.
Jepsen, J. U., Madsen, A. B., Karlsson, M. and Groth, D. 2005. Predicting distribution and density of European badger (*Meles meles*) setts in Denmark. – Biodivers. Conserv. 14: 3235–3253.
Kati, V. 2001. Methodological approach on assessing and optimizing the conservation of biodiversity: a case study in Dadia reserve (Greece). – PhD thesis, Université Catholique de Louvain, Louvain, Belgium.
Kati, V., Lebrun, P., Devillers, P. and Papaioannou, H. 2000. Les orchidées de la réserve de Dadia (Grèce), leurs habitats et leur conservation. – Les Naturalistes Belges 81: 269–282.
Kati, V., Dufrêne, M., Legakis, A., Grill, A. and Lebrun, P. 2004a. Conservation management for Orthoptera in the Dadia reserve, Greece. – Biol. Conserv. 115: 33–44.
Kati, V., Devillers, P., Dufrêne, M., Legakis, A., Vokou, D. and Lebrun, P. 2004b. Testing the value of six taxonomic groups as biodiversity indicators at a local scale. – Conserv. Biol. 18: 667–675.
Kati, V. and Poirazidis, K. 2005. Local biodiversity hotspots in a Mediterranean reserve: where and why species concentrate? – Book of Abstracts, 1st DIVERSITAS Open Science Conference: Integrating biodiversity science for human well-being, 9–12 Nov. Oaxaca, Mexico.
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., Foufopoulos, J., Ioannidis, Y., Lebrun, P., Papaioannou, H. and Poirazidis, K. 2007. Diversity, ecological structure and conservation of herpetofauna in

a Mediterranean area (Dadia National Park, Greece). – Amphibia-Reptilia 28: 517–529.

Korakis, G., Gerasimidis, A., Poirazidis, K. and Kati, V. 2006. Floristic records from Dadia–Lefkimi–Soufli National Park, NE Greece. – Flora Mediterranea 16: 11–32.

Krummel, J. R., Gardner, R. H., Sugihara, G., O'Neill, R. V. and Coleman, P. R. 1987. Landscape patterns in a disturbed invironment. – Oikos: 321–324.

Le Houerou, H. N. 1981. Impact of man and his animals on Mediterranean vegetation. – In: di Castri, F. and Goodall, D. W. (eds). Ecosystems of the World. Elsevier, Amsterdam, pp. 479–521.

McDonald, M. A., Apiolaza, L. A. and Grove, S. 2005. The birds of retained vegetation corridors: A pre- and post-logging comparison in dry sclerophyll forest in Tasmania. – For. Ecol. Manage. 218: 277–290.

Miller, J. N., Brooks, R. B. and Croonquist, M. J. 1997. Effects of landscape pattern on biotic communities. – Landsc. Ecol. 12: 137–152.

Mittermeier, R. A., Myers, N., Gil, P. R. and Mittermeier, C. G. 1999. Hotspots: Earth's biodiversity richest and most threatened ecosystems. – CEMEX, Mexico, D.F.

Moser, D., Zechmeister, H., Plutzar, C., Sauberer, N., Wrbka, T. and Grabherr, G. 2002. Landscape patch shape complexity as an effective measure for plant species richness in rural landscapes. – Landsc. Ecol. 17: 657–669.

Moskát, C. and Fuisz, T. 2002. Habitat segregation among the Woodchat Shrike, *Lanius senator*, the Red-backed Shrike *Lanius collurio,* and the Masked Shrike *Lanius nubicus*, in NE Greece. – Folia Zool. 51: 103–111.

Myers, N., Mittermeier, R. A., Mittermeier, C. G., da Fonseca, G. A. B. and Kent, J. 2000. Biodiversity hotspots for conservation priorities. – Nature 403: 853–858.

Naveh, Z. and Dan, J. 1973. The human degradation of Mediterranean landscapes in Israel. – In: di Castri, F. and Mooney, H. A. (eds). Mediterranean-type ecosystems: origins and structure. Springer-Verlag, Berlin, pp. 373–390.

Pimm, S. L., Russel, G. J., Gittleman H. L. and Brooks, T. M. 1995. The future of biodiversity. – Science 269: 347–350.

Pino, J., Rodà, F., Ribas, J. and Pons, X. 2000. Landscape structure and bird species richness: implications for conservation in rural areas between natural parks. – Landsc. Urban Plan. 49: 35–48.

Poirazidis, K. 2003. Breeding habitat selection by co-existing raptor species in the National Park of Dadia–Leukimi–Soufli. – PhD dissertation, Aristotle University of Thessaloniki. (In Greek.)

Poirazidis, K., Skartsi, T., Pistolas, K. and Babakas, P. 1996. Nesting habitat of raptors in Dadia reserve, NE Greece. – In: Muntaner, J. and Mayol, J. (eds). Biologia y Conservacion de las Rapaces Mediterraneas, 1994. Monografias, vol. 4. SEO, Madrid, pp. 325–333.

Poirazidis, K., Goutner, V., Tsachalidis, E. and Kati, V. 2007. Nesting habitat differentiation among four sympatric forest raptors in the Dadia National Park, Greece. – Anim. Biodiv. Conserv. 30: 131–145.

Poirazidis, K., Schindler, S., Kati, V., Martinis, A., Kalivas, D., Kasimiadis, D., Wrbka, T. and Papageorgiou, A. C. In press. Conservation and biodiversity in managed forests: developing an adaptive decsion support system. – In: Li, C., Lafortezza, R. and Chen, J. (eds). Landscape ecology and forest management: challenges and solutions on a changing globe. Higher Education Press-Springer.

Poudevigne, I. and Baudry, J. 2003. The implication of past and present landscape pattern for biodiversity research: introduction and overview. – Landsc. Ecol. 18: 223–225.

Quevedo, M., Bañuelos, M. J. and Obeso, J. R. 2006. The decline of Cantabrian capercaillie: How much does habitat configuration matter? – Biol. Conserv. 127: 190–200.

Quézel, P. 1976. Le dynamisme de la végétation en région méditerranéenne. – Collana Verde 39: 375–391.

Radford, J. Q. and Bennett, A. F. 2004. Thresholds in landscape parameters: occurrence of the white-browed treecreeper *Climacteris affinis* in Victoria, Australia. – Biol. Conserv. 117: 375–391.

Saarinen, K. and Jantunen, J. 2005. Grassland butterfly fauna under traditional animal husbandry: contrasts in diversity in mown meadows and grazed pastures. – Biodivers. Conserv. 14: 3201–3213.

Saïd, S. and Servanty, S. 2005. The influence of landscape structure on female roe-deer home-range size. – Landsc. Ecol. 20: 1003–1012.

Sanchez-Zapata, J. A. and Calvo, J. F. 1999. Raptor distribution in relation to landscape composition in semi-arid Mediterranean habitats. – J. Appl. Ecol. 199: 254–262.

Schindler, S., Kati, V., von Wehrden, H., Wrbka, T. and Poirazidis, K. 2009. Landscape metrics as biodiversity indicators for plants, insects and vertebrates at multiple scales. – In: Breuste, J., Kozovà, M. and Fink, M. (eds). European Landscapes in Transformation: Challenges for Landscape Ecology and Management. European IALE Conference 2009, 12 – 16 July 2009, Salzburg, Austria and Bratislava, Slovakia, pp. 228–231.

Schindler, S., Poirazidis, K., Papageorgiou, A. C., Kalivas, D., von Wehrden, H. and Kati, V. In press. Landscape approaches and GIS for biodiversity management. – In: Andel, J., Bicik, I., Dostal, P., Lipsky, Z. and Shaneshin, S. G. (eds). Landscape modelling: geographical space, transformation and future scenarios. Urban and Landscape Perspective Series, Vol. 8, Springer Verlag, pp. 207–220.

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

Soulé, M. E. 1987. Viable Populations for Conservation. – Cambridge University Press, Cambridge.

Tilman, D., May, R. M., Lehman, C. L. and Novak, M. A. 1994. Habitat destruction and the extinction debt. – Nature 371: 65–66.

Triantakonstantis, D., Kollias, V. and Kalivas, D. 2006. Forest re-growth since 1945 in the Dadia forest nature reserve in northern Greece. – New For. 32: 51–69.

Tsachalidis, E. and Poirazidis, K. 2006. Nesting habitat selection of the Black Stork *Ciconia nigra* in Dadia National Park, northeastern Greece. – In: Manolas, E. (ed.). International Conference on Sustainable Management and Development of Mountainous and Island Areas, Democritus University of Thrace, Naxos, pp. 147–153.

Turner, M. G., Gardner, R. H. and O'Neill, R. V. 2001. Landscape ecology in theory and practice. – Springer-Verlag, New York.

Väli, Ü., Treinys, R. and Poirazidis, K. 2004. Genetic structure of Greater *Aquila clanga* and Lesser Spotted Eagle *A pomarina* populations: implications for phylogeography and conservation. – In: Chancellor, R. D., Meyburg, B.U. (eds). Raptors Worldwide. World Working Group on Birds of Prey & BirdLife Hungary, Budapest, pp. 473–482.

Wiens, J. A., Stenseth, N. C., Van Horne, B. and Ims, R. A. 1993. Ecological mechanisms and landscape ecology. – Oikos 66: 369–380.

With, K. A. and Christ, T. O. 1995. Critical thresholds in species responses to landscape structure. – Ecology 76: 2446–2459.

Xirouchakis, S. 1999. Habitat selection of diurnal raptors during the breeding season in the Dadia reserve, Evros. – Contrib. Zoogeogr. Ecol. Eastern Mediterr. Region 1: 161–169.