Relationship between the Productivity of the Lesser Spotted Eagle *Aquila pomarina* and Forest Characteristics at the Macrohabitat Level

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Abstract

Until now, forest characteristics of Lesser Spotted Eagle macrohabitat have received very little attention. Productivity relationships with macrohabitat forest characteristics are also undiscovered despite the fact that forests cover a considerable part of the Lesser Spotted Eagle macrohabitats. We investigated forest age and tree species composition in Lesser Spotted Eagle macrohabitats and their relationships with productivity of the species. The species at the macrohabitat level significantly avoided coniferous, pine and middle-aged forests and preferred deciduous, black alder and mature forests. We found no evidence that forest age and tree species composition in Lesser Spotted Eagle macrohabitats were related to the productivity of the species. We suggest that the population of the species can be adversely affected by unbalanced forestry not only at the nest-site, but also at the landscape level.

Key words: *Aquila pomarina*, preference, productivity, forest, macrohabitat

Introduction

The current widespread deforestation of old growth forests may negatively affect species that use such forests (Hakkarainen et al. 2008). A large number of forest raptors prefer old growth forests at the home-range, nest-site and nest-tree level (Jedrzejewski et al. 1988, Moen and Gutiérrez 1997, Ripple et al. 1997, Boal and Mannan 1998, Meyer et al. 1998, Suarez et al. 2000, Lõhmus 2006). Forest characteristics in terms of age and tree species composition at the home-range and nest-site level are thought to be related to the survival and reproductive performance of raptor individuals (Korpimäki 1988, Thome et al. 1999, Penteriani et al. 2002, Laaksonen et al. 2004, Hakkarainen et al. 2008).

Lesser Spotted Eagle, *Aquila pomarina*, is a medium-sized tree nesting raptor, with 95% of its distribution range concentrated in eastern and central Europe, where its population is considered to be declining (Burfield and Van Bommel 2004). The majority of previous studies on habitats of Lesser Spotted Eagle focused mainly on forest characteristics at the nest-site level: the species breeds in old diverse forest patches, but avoids pine stands (Drobelis 1994, Skuja and Budrys 1999, Bergmanis 2004, Langgemach et al. 2001, Väli 2003), except in the southern part of the distribution range (Vlachos and Papageorgiou 1996). Despite the fact that forests cover about 40 – 60% of the Lesser Spotted Eagle macrohabitat (in the Baltic states, Väli et al. 2004), avoidances and preferences by the species for forest characteristics in terms of forest age and tree species composition have not been studied at the macrohabitat level so far. Langgemach et al. (2001) studied tree species composition at the macrohabitat level in the western part of the distribution range and found that the share of deciduous forests in the Lesser Spotted Eagle sites is three time larger than in the landscape. Forestry operations are reported to have a negative impact on the habitats of large forest-dwelling bird species, changing the structure of breeding territories, destroying nest-sites and structural elements necessary for breeding (Duncan 1997, Ewins 1997, Saurola 1997, Sulkava and Huhtala 1997, Widén 1997, Lõhmus 2003, Treinys and Mozgeris 2006). Forestry-related habitat alterations are regarded as a critical threat to the Lesser Spotted Eagle population in Europe (Meyburg et al. 2001), therefore the knowledge of Lesser Spotted Eagle avoidances and

preferences for forest characteristics at the macrohabitat level can help to evaluate new aspects related to forestry and the protection of the species.

Lesser Spotted Eagle spends a considerable amount of its hunting time (86%) in the extensively used open landscape (Bergmanis 1999). Nevertheless, the importance of forests for foraging to particular pairs can be rather great (up to 38% of the total hunting time, Scheller et al. 2001). The productivity of Lesser Spotted Eagle is usually related to the density of rodents, whereas the forest is considered to be the source of alternative prey for raptors when the abundance of the main prey species decreases in open areas (Lõhmus and Väli 2004). The forest is also very important as a hunting area for early-morning foraging or when weather conditions are unfavourable (Meyburg et al. 2004). However, the relationships between forest characteristics at the macrohabitat level and the productivity of Lesser Spotted Eagle have not been analysed yet.

In the present study, we aimed to investigate: 1) which forest characteristics in terms of age and tree species composition are preferred or avoided by Lesser Spotted Eagle at the macrohabitat level and 2) the relationships between forest characteristics at the macrohabitat level and the productivity of the species.

Materials and methods

A total of 79 Lesser Spotted Eagle nests were observed in northeastern and western parts of Lithuania (Figure 1).

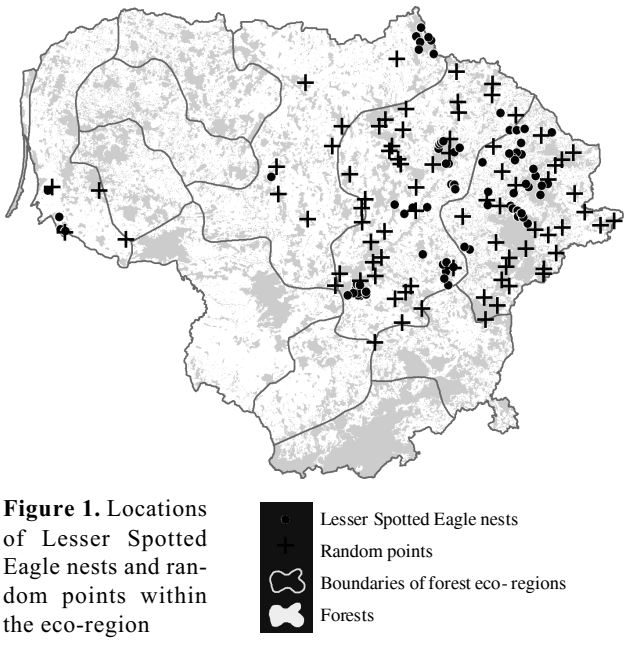

Figure 1. Locations of Lesser Spotted Eagle nests and random points within the eco-region

For analysis only one nest of eagle pair was included. The same number of random points was generated in the forests within the same eco-region (Anonymous 2002) using GIS techniques. Only the southern part of the western eco-region (close to the Nemunas delta) was used to search for random point locations. A 2 km radius buffer was created around both nests and random points to represent each area of 1256 ha. Same approach was used in the previous Lesser Spotted Eagle habitat studies at the macrohabitat level (macrohabitat ~ breeding territory, an area occupied by a pair of mated birds over successive years; Steenhof 1987) (Lõhmus and Väli 2004, Väli et al. 2004). The information available from the stand-wise forest inventories stored in the database of the State Forest Cadastre (boundaries of forest compartments and their attributes), forest growth models and forestry operation records were obtained from local forest enterprises to correspond the date of field observations. Buffer zones around nests (random points) were overlaid with forest compartments to get forest characteristics within macrohabitats. The shares of the main Lithuanian tree species were calculated taking into account the actual species composition of the main story buffered forest compartments: spruce, pine, birch, black alder, aspen, and oak and ash (the latter two species were combined into one variable due to the small area they cover in the landscape). Other tree species were used only to determine the total forest area in the macrohabitat. Four forest age groups were used based on technical tree maturity age (pine, ash ≥101, spruce ≥71, oak ≥121, birch, black alder ≥61, aspen ≥41 years, Deltuvas 2008) : 1) forest compartments younger than 10 years and recently felled areas were considered as clear cuts, 2) from 11 years to half of technical maturity age – young growth forests, 3) forests from half of technical maturity age to technical maturity age – middle-aged, and 4) older than the age of technical maturity – mature forests. All this resulted in the following forest variable types: 1) tree species (pine, spruce, oak-ash, birch, black alder, aspen), 2) clear cuts, 3) young growth, 4) middle-aged and 5) mature forests share, as well as the shares of 6) coniferous and 7) deciduous trees in the total forest area within the macrohabitat. To reveal preferences for forest characteristics of the Lesser Spotted Eagle, were compared macrohabitats and the random plots using a t-test or a Mann-Whitney U test (Kolmogorov-Smirnov test was used check the normality of distribution of the variable).

Mean productivity data for 48 pairs were collected during the period 2004 - 2006. The investigation period included one full phase of the productivity cycle, namely low, average and good year (Treinys unpubl.). The average number of fledglings per three years per macrohabitat was considered here as the mean productivity. The correlation coefficient was

determined between the mean productivity of the pair and the area covered by coniferous, deciduous, pine, spruce, birch, black alder, aspen, oak and ash forests, as well as by clear cuts, and young growth, middle-aged and mature forests in the macrohabitat. The pairs (i.e. their macrohabitats) were classified according to productivity as 1) high productivity if 3 or 4 nestlings were raised in the period 2004-2006 (n = 20) and 2) common productivity if the number of nestlings was 2 or less (n = 28). Forest variables on different productivity macrohabitat were compared using a Mann–Whitney U test.

Results

Data on the forest characteristics in the macrohabitats of Lesser Spotted Eagles and random plots are provided in Table 1. Lesser Spotted Eagle at the macrohabitat level preferred deciduous and avoided coniferous forests. Lesser Spotted Eagle significantly preferred black alder and avoided pine, whereas spruce, aspen, birch and oak-ash were used according to their availability in the landscape. Lesser Spotted Eagle used clear cuts and young growth forests at the macrohabitat level according to their availability, preferred mature and avoided middle-aged forests. Detailed results of statistical comparisons are presented in Table 2.

Table 1. Means, standard deviations and range limits of the shares (%) of variables within the macrohabitats of Lesser Spotted Eagle (AQ) and random plots (RP)

Variable		Mean	Standard deviation	Range limits
Pine	RP	32	27	0-89
	AQ	20	23	0-78
Spruce	RP	18	12	0-61
	AQ	20	11	0-43
Oak and Ash	RP	4	6	0-24
	AQ	7	8	0-37
Birch	RP	24	11	6-49
	AQ	26	9	10-58
Black alder	RP	7	6	0-28
	AQ	10	7	0-30
Aspen	RP	5	6	0-21
	AQ	7	7	0-30
Coniferous	RP	50	24	3-92
	AQ	41	22	1-88
Deciduous	RP	41	21	8-80
	AQ	49	17	12-85
Clear cut	RP	6	6	0-34
	AQ	7	5	1-25
Young growth forest	RP	19	10	2-51
	AQ	17	7	6-40
Middle-aged forest	RP	46	12	16-68
	AQ	40	12	15-69
Mature forest	RP	20	11	1-46
	AQ	26	11	2-47

No significant correlation was found between the mean productivity and forest characteristics of macrohabitat (Table. 2). Forest characteristics did not differ significantly in common and high productivity macrohabitats of Lesser Spotted Eagle either (Table. 2).

Table 2. Results of statistical tests and correlation analysis

Variable	Macrohabitat and random plots		Mean productivity of eagles and forest characteristics		High and common productivity macrohabitats	
	t or U statistic	p-level	Correlation coefficient	p-level	U statistic	p-level
Coniferous	2.86	0.01	-0.05	0.73	219	0.20
Deciduous	-2.63	0.01	0.08	0.59	240	0.40
Pine	-2.97	0.003	-0.02	0.90	247	0.49
Spruce	-1.23	0.22	-0.11	0.46	277	0.95
Oak-ash	2626	0.09	0.07	0.64	259	0.66
Birch	-1.05	0.30	0.03	0.86	238	0.38
Black alder	-2.46	0.02	0.08	0.61	279	0.98
Aspen	-1.74	0.09	0.05	0.76	274	0.90
Clear cut	2557	0.05	0.03	0.84	270	0.83
Young growth forest	1.75	0.08	0.14	0.34	201	0.10
Middle-aged forest	2.99	0.003	-0.04	0.81	205	0.12
Mature forest	3.57	0.001	-0.08	0.58	250	0.60

Discussion and conclusions

Our findings were that Lesser Spotted Eagle at the macrohabitat level significantly avoided coniferous, pine and middle-aged forests and preferred deciduous, black alder and mature forests. The preference for moist deciduous mixed forests and avoidance of pine dominated forests was reported for a large part of the Lesser Spotted Eagle range: in Belarus (Ivanovski and Bashkirov 2002), Estonia (Väli 2003), Latvia (Bergmanis 2004), except Greece (Vlachos and Papageorgiou 1996). In Lithuania, the share of deciduous and pine forests in the eagle's macrohabitats was similar to that recorded in Germany (Brandenburg) (cf. appendix, Langgemach et al. 2001). Besides, the share of the above mentioned variables in Lesser Spotted Eagle macrohabitats differed significantly from their availabilities in the landscapes of both countries, though differences were less in Lithuania.

A strong preference for deciduous trees and the avoidance of pine may be related to 1) nest-site requirements and/or 2) foraging traits. First, the share of deciduous forests in nest-sites, at least in Lithuania, is not significantly larger comparing to their availability in macrohabitats (55% ± 22% (SD) vs. 49% ± 17% (SD), t = 1.64, df = 156, p = 0.1), whereas use of deciduous as nest-trees is close to availability in the nest-sites and macrohabitats (52%, n = 108, Mischenko et al. in press). Thus, the preference for deciduous trees cannot be explained only by nest-site, nest-tree requirements. Second, Lesser Spotted Eagle spends about ¼ of its hunting time in the forest (Scheller et al. 2001), most often foraging in moist areas (Meyburg et al. 2004). Moreover, eagles forage in forests

throughout the breeding season, under bad weather conditions and during early-morning hours, therefore such biotopes are thought to be a permanent source of the main prey (Meyburg et al. 2004). Intermediate swamps (dominated by *Betula* sp., *Alnus glutinosa* etc.) support one of the highest average abundance of small mammals and, moreover, the fluctuation in the abundance of small mammals in this habitat type tends to be minimal (Mažeikytė 2002). The significance of the forest as a source of alternative prey for Lesser Spotted Eagle was confirmed by Balčiauskienė et al. (2007) – *Clethrionomys glareolu*s made up 11% (n = 38) of vole species found in pellets. Pine dominated forests were not avoided only in the southern part of the Lesser Spotted Eagle distribution range, however in that part of the range reptile species are dominant prey (Vlachos and Papageorghiou 1996).

We found no evidence that the age and tree species composition of forests in macrohabitats were related to the productivity of the eagles. Besides, we detected no differences in forest characteristics within the macrohabitats used by pairs with successful and failed breeding attempts per three year period. We see 4 reasons why we lack evidence that preferred forest variables are not related to productivity.

1. Preferences in terms of breeding success of animal could be adaptive (preferred habitats are better), non-adaptive (preferred habitats are worse) or correspond to neutral choice (preferred habitats are neither better nor worse). Later could be retained through "tradition", a delayed response to environment changes, or serve as a part of adaptive strategy to "buffer" individuals against unpredictable conditions (Lõhmus 2004). In our study, the data obtained support the neutral choice pattern. The same pattern was found previously: in the major part of the distribution range Lesser Spotted Eagle preferred grasslands (Väli et al. 2004), but the productivity of the species was not significantly related to their share in the macrohabitat (Lõhmus and Väli 2004). Arlt (2007) also found a mismatch between habitat characteristics linked to preference and those linked to individual fitness.

2. A landscape with a certain forest structure could be only the indicator of the suitability of the habitat for settling. Lõhmus and Sellis (2003) found the aggregation of potential nest-trees in Black Stork territories as compared to the random landscape. Thus, forest age could be an important cue to occupy a certain habitat patch for many years, but could lack the indicative value as predictor for habitat quality in terms of breeding success.

3. Habitat choice may depend on habitat characteristics, but productivity can be determined by predation, which is not predictable (Kristan III et al. 2007, Sergio et al. 2003). The main natural predator of Lesser Spotted Eagle in the Baltic forests is the widespread pine marten, but the importance of threat for breeding success has not been determined yet (Väli 2003). In Latvia, however, pine marten is the main predator affecting breeding success of the Black Stork (86% of nest predation cases, n=43; M. Strazds, pers. comm.)

4. The importance of the open landscape for Lesser Spotted Eagle foraging and thus for breeding success can outweigh the importance of forests. The preference for old growth forests and the share of such forests in the home-range were positively related to the breeding output of the forest-dwelling owl *Aegolius funereus*, suggesting through better survival and feeding possibilities (Laaksonen et al. 2004). Lesser Spotted Eagle, in spite of foraging in the forest, spends most of its time hunting in the extensively used open landscape containing a rather high density of prey, indicated by small home-range size and the prevailing hunting method in Baltic States (Bergmanis 1999). Bergmanis et al. (2006) found that breeding success was positively related to the total number of small mammals in meadow habitats. The productivity of Lesser Spotted Eagle was related to landscape heterogeneity (Lõhmus and Väli 2004), whereas heterogeneous landscapes support a diverse community of small mammals (Mažeikytė 2002). Beside, hunting skills of raptor male are age-dependent (Rutz et al. 2006), thus even the similar macrohabitats could have different benefits for individuals and their fitness.

We would like to draw the attention to the fact that intensive timber harvesting can adversely affect the population of Lesser Spotted Eagle not only at the nest-site (Treinys and Mozgeris 2006), but also at the landscape level by decreasing the quality of habitats. The significance of forest age and tree species composition at the macrohabitat level hasn't been properly recognized yet, though they can serve as important cues for the species in long-term territories selection. We suppose that protection measures, at least in Special Protected Areas under the Bird Directive, should ensure a proper forest structure both at the macrohabitat and nest-site level.

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ЗАВИСИМОСТЬ МЕЖДУ ПРОДУКТИВНОСТЬЮ МАЛОГО ПОДОРЛИКА *AQUILA POMARINA* И ХАРАКТЕРИСТИКАМИ ЛЕСА НА УРОВНЕ ТЕРРИТОРИИ

Римгаудас Трейнис и Гинтаутас Мозгерис

Резюме

Характеристики леса на уровне территорий малого подорлика пока не имеют надлежащего внимания со стороны исследователей. Зависимости между продуктивностью и лесными характеристиками территорий тоже исследованы недостаточно, несмотря на то, что лес покрывает значительную часть территорий малого подорлика. Наши исследования концентрировались на возраст и породный состав леса на территориях малого подорлика и их связь с продуктивностью вида. Малый подорлик на уровне своей территории достоверно избегал хвойной, сосновый и средневозрастной лес, и предпочитал лиственный, черноольховый и спелый лес. Мы не нашли доказательств, что возраст и породный состав леса на территориях малого подорлика был бы связан с продуктивностью вида. Мы предполагаем, что несбалансированное лесное хозяйство может иметь негативное влияние на популяцию вида не только на уровне гнездовых мест, но и территорий.

Ключевые слова: *Aquila pomarina,* предпочтение, продуктивность, лес, территория