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Nesting preferences of common buzzard *Buteo buteo* and goshawk *Accipiter gentilis* in forest stands of different structure (Niepolomice Forest, Southern Poland)

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Abstract: Studies on nesting preferences of common buzzard and goshawk were carried out in two distinctly different parts of the Niepolomice Forest (S Poland): deciduous (oak-hornbeam wood) and coniferous. Characteristics of nest sites were determined on three spatial scales, separately for: (1) nest tree; (2) nest tree area (0.07 ha circle centred at nest tree) and (3) nest stand (15 ha circle centred at nest tree). Nesting preferences discovered for the nest tree and its surroundings, included height and diameter of trees, age of the forest stand, distance to the nearest open area or forest road and occurrence of open areas in the vicinity of the nest. In the diverse habitat of oak-hornbeam wood, more similar to natural woods, nest site selection operated on several levels, possibly starting at the most extensive end of the scale before narrowing to the selection of a particular nest tree. In the more homogeneous habitat of commercially exploited coniferous forest, the surrounding of the nest were found to be insignificant, and the nesting decisions were likely to be based principally on individual characteristics of a tree i.e. its shape and size, being suitable for nesting.

Key words: *Buteo buteo*, *Accipiter gentilis*, habitat selection, habitat heterogeneity, nest site preferences, silviculture.

Introduction

The questions, which habitat factors are preferred by a given species or, conversely, whether the nesting decision is randomly made within a habitat, have repeatedly been considered in various publications on birds of prey (Jędrzejewski et al., 1988; Hubert, 1993; Selas, 1997; Penteriani & Faivre, 1997b; Penteriani et al., 2001; Penteriani, 2002) and are of prime significance to their protection. When analysing the preferences of birds, it is essential to determine whether the selection of suitable features of a nest site is possible within a habitat which is internally diversified, or whether the choice is made only between habitats when they are internally homogeneous. In the latter case, one can expect a random mode of nesting within a habitat or that the choice of site would depend on specific individual perception, and intra- or inter-specific competition for sites. Therefore the nest site selection does not result from habitat characteristics but only from the density and spacing of individuals (Fretwell & Lucas, 1970).

As raptors are long-lived, territorial species, usually occupying the same site for more than one season, it can be presumed that the nest site selection process is especially important for them. For this reason, raptors invest more effort in nest site selection than short-lived species (Krüger, 2002). Owing to their mobility, raptors have the opportunity to penetrate many different patches of a habitat and assess the habitat's relative quality, which can influence the reproductive success they achieve (Selas, 1997). The selection of a nest site should be a balanced trade-off between hiding the nest, and the possibility of escape from it in case of danger. Apart from nest location the effectiveness of its active protection against predators also depends on flying abilities, body size and other features of a particular species (Selas, 1997; Penteriani, 2002). The structure and certain characteristics of a site (sites defined as "the areas occupied exclusively by individuals or mated pairs"; Rodenhouse et al., 1997) often serve as direct signals helping to quickly identify the quality of a habitat (Hilden, 1965). According to Penteriani et al. (2001), an example of such a signal can be "stand structure, which can guide the raptor species in the selection of nesting habitat". The same authors (Penteriani & Faivre, 1997a; Penteriani et al., 2001) suggested that "the species choose nest stands on the basis of their overall structural features and then focus on a particular nest tree, a landmark in the forest", which is consistent with the hypothesis that proximate features work hierarchically (Lack, 1937).

Another issue taken up during the consideration of habitat preferences in raptors is what differences occur between nesting habitats occupied by distinct species and where these differences stem from (KRÜGER, 2002). These preferences may result from differences in body size and flight ability, but also may derive from inter-specific differences in nest predation risk, microclimatic conditions required during the breeding season, hunting behaviour, or intra-specific competition for nest sites and territories. In large and medium-size raptors, which experience rather low levels of nest predation, the selection of a nest site may depend chiefly on the protection of the nest against extreme thermal conditions, or on the local diversity of food availability (NEWTON, 1979; SELAS, 1997).

Apart from theoretical considerations on rules of nest site selection, detailed analyses of habitat requirements for forest raptors such as common buzzard *Buteo buteo* L., 1758 and goshawk *Accipiter gentilis* L., 1758 and the manner of their response to anthropogenic alterations in forests is also important because of the practical implications. Above all, such analyses can provide valuable data for sustainable management, and help to minimize the conflicts between timber production and wildlife conservation (PENTERIANI & FAIVRE, 2001). The two species in question are among the raptors most intensively studied with respect to habitat selection. Despite rather stable or even increasing populations of the common buzzard and goshawk in Europe and in Poland (BIJLSMA, 1997; BIJLSMA & SULKAVA, 1997; SNOW & PERRINS, 1998; TOMIAŁOJĆ & STAWARCZYK, 2003), alterations in forest landscapes, especially shrinking of old forest stands and fragmentation of forests in general, can adversely affect the nesting of these raptors (WIDÉN, 1997; PENTERIANI & FAIVRE, 2001). The current intensive commercial exploitation of many forest areas (RYKOWSKI, 1996) often forces forest birds of prey to nest in very homogeneous habitats such as even-aged monocultures. Development of methods to study habitat preferences in common species and definition of the rules governing these processes could become a valuable contribution to the protection of rare species.

The main aim of this study was to analyse the nesting requirements of common buzzard and goshawk in the Niepolomice Forest, in order to determine which features of nest trees and their surroundings act as signals for nest site selection by these two species. Influence of habitat heterogeneity on the pattern of site and nest selection was also checked.

Study area

The studies were carried out in the Niepolomice Forest (S Poland, 50°07′ N, 20°23′ E; later abbreviated to NF), a major forest complex extending 10–30 km east of Krakow. The forest consists of two parts: deciduous (northern) and coniferous (southern). The 2000–2003 studies covered the whole NF, except for a small Kolo forest complex in the deciduous part (2.2 km^2; Fig. 1). The entire study area extends over 106 km^2 and is 98% covered by forest. For the sake of simplicity, the two forest complexes in the northern NF were jointly referred to as oak-hornbeam wood (abbreviated to Oh-wood; area of 17.6 km^2), and the southern part as coniferous forest (abbreviated to Con-forest, area of 88.7 km^2). Con-forest is a single patch of pine stands, covered mostly by *Pino-Quercetum* mixed coniferous forest, with small enclaves of deciduous woods: alder riverine carrs, oak woods and birch woods. From the beginning of the 19th century, clear cutting and artificial regeneration with Scots pine *Pinus sylvestris,* has been the sole practice applied there. As a result, compact even-aged and single-storey pine stands now predominate in Con-forest (ĆWIKOWA et al., 1984; ROKOSZ, 1984). Oh-wood in NF consists of two forest complexes (the third complex was excluded from this study), where oak-hornbeam wood *Tilio-Carpinetum* predominates. Riverine carrs, forest glades and out-river beds of the Vistula River are also characteristic features of this part of NF (ĆWIKOWA et al., 1984). In comparison with Con-forest, Oh-wood is more similar to natural woods and is also more heterogeneous in terms of age and size of trees.

In the entire study area, stands in the 51–100 years age-class predominate (47%), whilst younger stands aged 21-50 years cover 23%, and stands older than 101 years account for 15% of the area. The average age of pine stands is 66 years, and oak stands 82 years (database from the Regional Directorate of State Forests, Krakow 2002). The tree species predominating in Oh-wood stands are sessil- and common oaks *Quercus petraea* and *Q. robur* respectively*,* with a combined cover of ca. 74% of the area. Other species cover the following proportions of the area: alder *Alnus glutinosa* – 8%, ash *Fraxinus excelsior* – 5%, hornbeam *Carpinus betulus* and Scots pine – 2% each, and lime *Tilia cordata* – 1%. The remaining species include mainly larch *Larix decidua*, poplars *Populus* sp. and birches *Betula* sp. The stands of Con-forest are composed principally of one species, Scots pine, accounting for ca. 79% of the forest complex area. Common alder constitutes ca. 11% of the area and birch, 2%. Other species in Con-forest are beech *Fagus silvatica* and larch (database from the Regional Directorate of State Forests, Krakow 2002).

The forest stands of NF are mostly single-storey. Only in some oak woods and on the fringes of coniferous forests there is a sparse lower storey of hornbeam and lime. Of the undergrowth species in Con-forest, alder buckthorn *Frangula alnus* is particularly common, whereas in Oh-wood, predominating undergrowth species are European spindletree *Euonymus europea*, red dogwood *Cornus sanguinea* and several species of hawthorn *Crategus* sp. and *Sambucus* sp. (ĆWIKOWA et al., 1984).

Methods

Data collection

The study area was controlled in the breeding and non-breeding seasons in 2000 and 2001 in order to identify territories of common buzzard and goshawk, and then to find occupied nests. The remaining field measurements connected with analysed variables were continued into the year 2003. Field observations were plotted on a 1 : 20 000 forest stand map. The number of pairs was estimated according to the territory-mapping method, on the basis of the total number of certainly and probably occupied breeding territories (KRÓL, 1985).

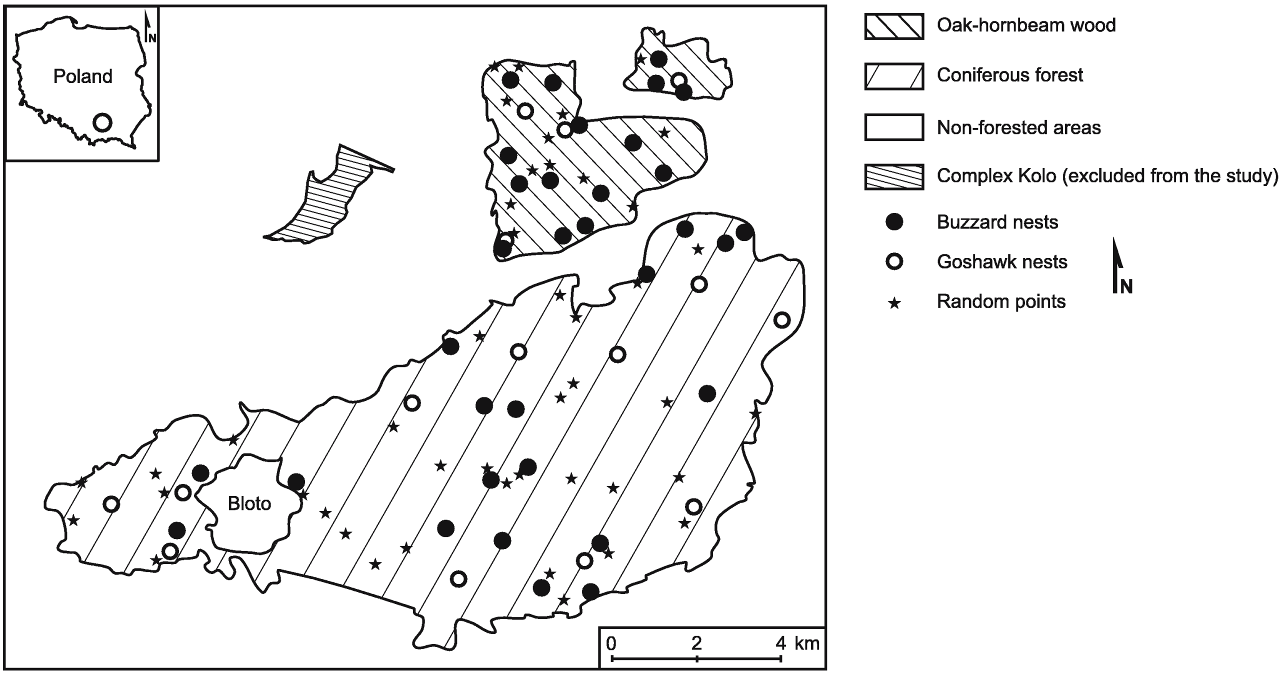

Fig. 1. A schematic map of the Niepolomice Forest (S Poland). The locations of common buzzard and goshawk nests occupied in 2000–2001, as well as random points, are marked in the map.

For each nest tree, the following variables were collected: species, height, diameter at breast height (dbh), height of lowest branches of the crown, height of the nest on a tree, and location of the nest, distinguished as: the fork of the main trunk (1), the lateral branches near (2), or farther from the trunk (3), the deformed, horizontally crooked tops of tree crowns (4). All height measurements were taken with a PM-5/1520 P SUUNTO height gauge. Dbh was measured 130 cm above the ground with a calliper.

In order to analyse nest site preferences, nest tree characteristics were compared with characteristics of random trees. Random points were generated on the digital layer of the study area, with the use of randomisation function of ArcView GIS 3.0 software. The procedure was carried out only in the area of stands equal or older than 50 years of age, since nests of neither of the two studied species were found in younger stands. The total number of analysed random points roughly corresponded to the number of located nests pooled for both analysed species. After the geographical coordinates of randomly drawn points had been entered into a handheld GPS receiver, these points were identified in the field. The first tree found on the position indicated by the GPS receiver was regarded as the random tree. This method generated some bias in choosing random tree, resulting from irregular distribution of trees, and thus uneven probability of tree selection. However, this bias should be rather negligible in comparison to the differences between characteristics of nest trees in relation to corresponding random trees. For random trees, the same set of measurements was taken as for real nest trees, except for nest height and location.

Data analysis

The nesting preferences were analysed by means of ArcView 3.0 software at three spatial scales: nest tree, nest tree area defined as a circle of 15 m radius (0.07 ha) around the nest tree, and nest stand, defined as a circle of 218 m radius (15 ha) around the nest tree. Size of nest tree area reflected conditions in the immediate neighbourhood of the nest [cf. nest-tree area (SQUIRES & RUGGIERO, 1996), nest site (SELAS, 1997), micro habitat (KRÜGER, 2002)]. Area of the nest stand was determined to reflect conditions at a larger spatial scale (cf. goshawk's nest area; REYNOLDS et al., 1992), and at the same time to generate enough variation between the nests; analyses on a larger scale would yield only a little difference between sites due to the heterogeneous character of the NF.

Analyses at the nest tree (and random tree) level were done on the basis of all data collected in the field (see Data collection). Additionally, for each nest, the distances to the nearest nest of the same species, the nearest open area, forest edge and forest road were calculated by means of GIS software. Data for analyses at the nest tree area and nest stand levels, and corresponding areas delimited around random trees, were obtained from a vector database with relevant biological/forest data, prepared for the whole NF. The variables studied at the nest tree area level included: predominating tree species (determined according to the area covered), average dbh and height of trees, age of the stand, and tree density (number of trees per hectare) in the forest sections with a nest. The same variables were studied at the nest stand level, except for the tree density and age of the stand, but with an additional estimate of the proportion of open space in the area.

Open areas taken into account in the GIS analyses included non-forest areas around the studied complexes, forests younger than 5 years, and non-forest areas greater than 0.25 ha within forest complexes. Boundaries of the largest non-forest area within Con-forest, the Bloto fen (ca. 6 km^2, Fig. 1), were regarded as forest edge. The distances from nests to the nearest roads were measured with respect

Table 1. Characteristics of area surrounding common buzzard and goshawk nests in two different parts of the Niepolomice Forest (oak-hornbeam wood and coniferous forest) in 2000–2001.

Variables	Oak-hornbeam wood			Coniferous forest					
	Buzzard (B) ($n = 15$)	Random (R) ($n = 13$)	P (B/R)	Buzzard (B) ($n = 18$)	Goshawk (G) ($n = 11$)	Random (R) ($n = 32$)	P (B/R)	P (G/R)	P (B/G)
Nest tree area									
Tree species	Oak (93%)	Oak (84%)	0.583	Pine (89%)	Pine (100%)	Pine (81%)	0.693	0.312	0.512
Average tree height (m)	27.4 ± 3.3 (20.0–33.0)	25.0 ± 3.6 (18.4–33.0)	0.044*	22.2 ± 2.9 (14.0–26.0)	21.5 ± 1.8 (19.0–25.0)	22.4 ± 2.5 (15.9–27.0)	0.976	0.124	0.122
Average tree dbh (cm)	55.1 ± 17.5 (29.0–83.0)	42.3 ± 17.6 (19.4–81.0)	0.065	33.0 ± 6.5 (23.0–46.0)	29.7 ± 5.3 (21.0–36.0)	32.0 ± 7.7 (17.9–51.0)	0.610	0.433	0.220
Density of trees ha^{-1}	123.2 ± 114.9 (21–460)	157.2 ± 143.0 (17–397)	0.721	340.2 ± 179.2 (50–770)	441.4 ± 228.7 (196–224)	342.1 ± 167.8 (57–701)	0.924	0.257	0.309
Average age of stands (years)	119.5 ± 34.3 (60–170)	94.4 ± 33.1 (53–170)	0.045*	86.7 ± 17.1 (50–115)	77.5 ± 15.1 (50–105)	84.8 ± 23.9 (50–135)	0.447	0.466	0.134
Nest stand									
Tree species	Oak (100%)	Oak (92%)	0.464	Pine (89%)	Pine (91%)	Pine (84%)	1.000	1.000	1.000
Average tree height (m)	21.9 ± 4.8 (12.9–29.0)	19.7 ± 4.9 (12.5–29.2)	0.201	19.4 ± 3.1 (11.5–23.6)	20.1 ± 1.9 (16.9–23.2)	18.5 ± 4.1 (9.1–24.4)	0.610	0.199	0.492
Average tree dbh (cm)	41.4 ± 12.3 (21.3–65.6)	33.2 ± 12.5 (16.9–67.1)	0.032*	27.8 ± 5.6 (16.1–40.1)	28.6 ± 5.4 (19.1–39.4)	25.8 ± 6.9 (10.5–42.1)	0.256	0.171	0.611
Percentage of open areas	11.2 ± 13.7 (0–40)	15.5 ± 17.5 (0–51)	0.751	5.3 ± 5.9 (0–20)	1.0 ± 1.8 (0–5)	8.9 ± 12.3 (0–45)	0.772	0.023*	0.019*

Explanations: Means ± SD and ranges (in brackets) are presented. P – values describe differences in nest tree characteristics between common buzzard (B), goshawk (G) and random points (R). Mann-Whitney U test was applied for analyses of all variables, excluding "tree species", for which Fisher exact test was used (in oak-hornbeam wood: oaks vs. other tree species; in coniferous forest: pine vs. other tree species). * $P < 0.05$. For "tree species", the dominant tree species and its share in nest surroundings are given.

to public and forest roads, without taking into account lines delimiting forest subsections.

The nesting preference analysis was carried out separately in Oh-wood and Con-forest, because of essential differences in the types of habitats. Since the number of goshawk nests in Oh-wood was low ($n = 4$), nesting preferences in this species were only studied in Con-forest. For the same reason, comparison of nesting of common buzzard and goshawk was carried out for Con-forest only. Mann-Whitney U test was applied for analyses of all variables, excluding the case of "tree species", for which Fisher exact test was used.

Results

The average population number of common buzzard in NF in the period 2000–2001 was estimated at 52 pairs/year, which makes this species the most numerous among all raptors nesting in the area. Goshawk was the second most numerous species, estimated at 20 breeding pairs/year. The population density of common buzzard was 4.9 pairs/10 km^2 of the total area (105.9 km^2) and 5.0 pairs/10 km^2 of the forested area (103.4 km^2). Goshawk occurred with densities of 1.9 pairs/10 km^2 calculated both for the total area and the forested area. As a result of the inspection of all occupied territories, a total of 33 nests of common buzzard (15 in Oh-wood and 18 in Con-forest) and 15 nests of goshawk (4 in Oh-wood and 11 in Con-forest; Fig. 1), occupied in the 2000 or 2001 breeding seasons, were located within the study area.

The results of analysed characteristics on the level of nest tree area and nest stand are presented in Table 1. The nest sites of both raptors did not differ from random sites with respect to the predominating tree species in the nest tree area and nest stand. In Oh-wood, the tree height and the age of stand in the nest tree area of common buzzard were significantly higher than those determined for random tree areas. In Oh-wood and in Con-forest alike, nests of both species were not situated in stands younger than 50 years. In Oh-wood, the dbh in the nest stand of common buzzard was significantly greater than in random stands. The proportion of open areas in the nest stand of goshawk was significantly lower in Con-forest than in the random or common buzzard nest stands. The tree density in the forest sections with the nests of common buzzard and goshawk did not differ from random in either part of NF.

Characteristics describing a nest tree are presented in Table 2. The nests were situated on trees of the most available species in a given part of NF. In Oh-wood, 73% of nests of common buzzard were placed on oaks, whereas single nests were found on pine, alder, birch and lime. In Con-forest, 89% of common buzzard nests and 82% of goshawk nests were situated on pines; there were also a pair of common buzzard and two pairs of goshawk nesting on birch and one pair of common buzzard on alder. The frequency of nests placed on oaks in Oh-wood and on pines in Con-forest didn't differ from the share of these species in stands of the two studied parts of NF.

In Oh-wood, the nest trees of common buzzard were taller and thicker than the random trees. Crowns of the nest trees were also higher above the ground –

Table 2. Characteristics of common buzzard and goshawk nest trees in two different parts of the Niepolomice Forest (oak-hornbeam wood and coniferous forest) in 2000-2001.

Variables	Oak-hornbeam wood			Coniferous forest					
	Buzzard (B) (n = 15)	Random (R) (n = 13)	P (B/R)	Buzzard (B) (n = 18)	Goshawk (G) (n = 11)	Random (R) (n = 32)	P (B/R)	P (G/R)	P (B/G)
Tree species	Oak (73%)	Oak (62%)	0.689	Pine (89%)	Pine (82%)	Pine (62.5%)	0.056	0.291	0.622
Tree height (m)	30.3 ± 2.7 (24.0–33.0)	26.3 ± 3.7 (18.5–31.0)	0.003*	23.5 ± 4.0 (18.5–34.0)	24.0 ± 4.0 (17.5–31.0)	23.1 ± 3.7 (13.5–28.0)	0.515	0.773	0.611
Nest height (m)	20.2 ± 3.6 (15.0–25.5)	–	–	18.3 ± 2.4 (14.5–22.5)	17.7 ± 2.7 (14.0–23.5)	–	–	–	0.550
Height of lowest crown branches (m)	14.8 ± 4.0 (7.0–21.0)	11.5 ± 4.0 (6.0–18.0)	0.047*	16.1 ± 2.8 (10.0–21.0)	15.0 ± 2.7 (10.5–18.5)	13.1 ± 3.9 (2.5–18.5)	0.017*	0.189	0.390
Dbh of the tree (cm)	68.6 ± 17.5 (40.0–98.0)	45.3 ± 22.8 (17.5–89.0)	0.006*	39.2 ± 8.2 (26.2–66.0)	35.3 ± 9.4 (25.0–55.0)	35.8 ± 8.6 (18.0–56.0)	0.156	0.483	0.049*
Distance to forest edge (m)	407.2 ± 338.5 (21–1338)	511.9 ± 448.6 (9–1376)	0.751	1107.3 ± 1057 (123–3421)	781.4 ± 365.7 (252–1374)	1082.6 ± 996.7 (27–3280)	0.960	0.967	0.982
Distance to open area (m)	208.1 ± 160.6 (21–548)	254.1 ± 284.7 (9–996)	0.892	258.1 ± 194.1 (0–663)	372.9 ± 138.9 (154–606)	242.5 ± 225.4 (27–1028)	0.440	0.019*	0.039*
Distance to forest road (m)	396.1 ± 346.6 (67–1127)	314.2 ± 296.9 (46–879)	0.316	266.9 ± 175.5 (21–564)	316.8 ± 166.4 (116–714)	201.5 ± 146.4 (29–553)	0.194	0.028*	0.438
Distance to nearest conspecific nest (m)	817.3 ± 260.3 (550–1460)	–	–	1433.8 ± 795.7 (460–3850)	2257.3 ± 572.5 (1400–2990)	–	–	–	0.002*

For explanations see Table 1. For "tree species", the dominant tree species and its share in the whole set of nest tree species chosen for by the studied raptors are given.

both in Oh-wood and in Con-forest. In Con-forest, common buzzard nests were situated on trees thicker than those that contained goshawk nests.

The majority of common buzzard nests in Oh-wood (87%, n = 15) were situated in the fork of the main trunk, and only some nests were placed on lateral branches more than 1 m from the trunk (13%, n = 15). In Con-forest, a significant proportion of common buzzard nests, apart from these situated in the fork (39%, n = 18), were located on a lateral branch, both near the main trunk (17%, n = 18) and at a distance of more than 1 m from the trunk (22%, n = 18), whereas other nests were found on the deformed, horizontally crooked tops of tree crowns (22%, n = 18). Only one nest of goshawk in Con-forest (9%, n = 11) was situated on lateral branches near the trunk, and all the remaining nests were placed in a fork of the main trunk (91%, n = 11). In Con-forest, 7 nests of common buzzard (39%, n = 18) and 5 of goshawk (45%, n = 11) were placed on trees with a distorted trunk or crown structure. The heights of nest positions in these two species did not differ.

The two studied raptor species nested both near the edge of the forests and deep inside the forest complexes. However, nests of goshawk in Con-forest were located at significantly greater distances from any open areas when compared to nests of common buzzard and random trees. Goshawk nests were also more distant from any public or forest roads than were the random trees. The nearest neighbour distance for common buzzard nests was significantly shorter in Oh-wood than in Con-forest. The nearest neighbour distance for goshawk nests in Con-forest was markedly longer than for common buzzard nests in this part of NF.

Discussion

Comparison of characteristics of real nest trees, nest tree areas and nest stands with corresponding trees and areas selected at random revealed that common buzzards nested on relatively high and thick trees, with other high and thick trees also in the immediate neighbourhood, as well as in older stands. Goshawks most frequently placed their nests in a fork of the main trunk, on trees with low shares of non-forest areas in the neighbourhood (nest stand). Goshawk nests were also located at a considerable distance from roads and large open areas. Results of the analysis of nest preference of common buzzard and goshawk indicate that the decision on nest location in NF is not random but based on preferences towards certain features of the nest tree and its surroundings. Significant influence of the analysed characteristics was found only in Oh-wood of NF. This result can be attributed to the considerable heterogeneity of Oh-wood, generating a higher diversity of breeding site quality. In comparison with Con-forest, Oh-wood is more heterogeneous in terms of species composition, as well as age and size of trees. The stands of Con-forest are fairly homogeneous as a result of long-lasting and intensive forest management, involving introduction of pine monocultures over vast areas. Thus, the variation between breeding sites is relatively small in Con-forest, and the stand surrounding a nest is not likely to be a direct factor indicating the quality of a nest site (Penteriani et al., 2001). In such circumstances, the primary nest site selection discriminates between the younger pine stands, which probably could not provide the minimum level of suitability, and relatively older ones, which are internally homogeneous due to the intensive silviculture, with sites within them to be of sufficient but equal suitability. It can be expected that in a habitat as homogeneous as Con-forest, the key factor which influences nesting by common buzzard and goshawk, is finding a specifically shaped nest tree. From the standpoint of silviculture, however, the essential objective for the purpose of producing timber is to obtain trees of straight boles, with high and rather narrow crowns (Matthews, 2001). Such trees rarely provide suitable conditions for nest building. Large trees with wide or deformed crowns suitable for nests might not be very common in commercial forest stands, particularly in coniferous ones (Bielański, 2004).

Taking into account the lack of differences of the studied variables between the nest and random trees in Con-forest, one may turn to another hypothesis; namely that the nests are being placed on trees in a random fashion. However, if the structure and size of a tree influence the fitness of an individual, it can be expected that birds will actively seek trees which are more suitable rather than choose trees at random. Each individual following such a pattern will have a selective advantage over birds nesting in random trees. In some nest trees in Con-forest, trunks or crowns were deformed, which facilitated nest building (Bielański, 2004). The presence of tree distortions may provide some differences in the suitability of trees and support their preemption (meaning that "individuals always choose the best unoccupied breeding site from sites differing in terms of expected reproductive success"; Pulliam & Danielson, 1991).

In Oh-wood the trees were higher, thicker and older in the nest tree area and nest stand of buzzard, which indicates that selectivity in a habitat is not targeted on a nest tree alone, but also extends to its surroundings. However, the question remains whether a bird first selects a patch and then a single tree suitable for nesting (Penteriani et al., 2001), or whether the structure of the stand is only a consequence of the earlier selection of a nest tree (Selas, 1997). The suggestion that the stand structure is a direct signal which could guide further selection by a bird, even prior to the location of a tree suitable for nesting, seems fairly obvious (Penteriani et al., 2001). An older stand is by definition more diversified than a younger one, and thus the probability of finding a suitable nesting site is greater in these areas. The fact that many of the characteristics reported in the nest stands of Goshawk are the same within various areas studied in Europe and North America (Penteriani et al., 2001; Penteriani, 2002), may support the presumption that the stand structure acts as a proximate factor in the selection of the nest tree.

As the sites within Oh-wood are diversified, the occurrence of pre-emption, should be expected, deciding about the sequence of occupying sites from the most suitable to the poorest. The breeding density of common buzzard in Oh-wood was higher then in Con-forest. This result can be presumably attributed to the greater abundance and availability of the buzzard's most important prey (i.e., small rodents and forest birds; Jędrzejewski et al., 1994) in diversified deciduous wood habitat (Cieślak, 1984; Zbigniewska, in Jędrzejewski et al., 1994; Jokimäki & Huhta, 1996; Pugacewicz, 1996; Wesołowski et al., 2002). In large forest areas these types of prey are often hunted in the forest interior (Tomiałojć et al., 1984; Pugacewicz, 1996). The second rationale could be the smaller size of Oh-wood complexes and hence the greater proximity of buzzard nests to forest edge and surrounding open areas, again creating better foraging conditions. The suitability of the deciduous wood habitat both for nesting and foraging should be higher than that of the coniferous forest (Jędrzejewski et al., 1988; Pugacewicz, 1996). However, according to the model of ideal dominance distribution (Fretwell & Lucas, 1970) and territorial behaviour of raptors, the suitability of a habitat decreases with the increase in density of breeding pairs. New settlers are supposedly forced to move to the alternative poorer habitat (in this example – Con-forest) with lower competition from already-settled individuals.

In conclusion, in different habitats of Oh-wood and Con-forest, different patterns of choosing nest sites and nest trees were observed. It is hard to consider habitat selection with respect to such altered forests. The use of unsuitable nesting habitat, as managed forests often offer, is probably inevitable for raptors. Because of area reduction of natural forest stands and intensification of commercial utilisation of forests, one may expect that the mechanisms used by raptors in selecting nest sites will also evolve. It is also likely that other direct factors will be perceived as key signals influencing the decision to nest at a given site. Nevertheless, bearing in mind the results of this study, the following recommendations aimed at an increase in forest suitability for raptors should be considered essential: (i) leaving patches of old forest within managed forest complexes, (ii) recovery of stand complexity, in terms of tree species, age, multilayered structure and heterogeneity of tree sizes and shapes, (iii) renouncing the creation of even-aged coniferous monocultures in favour of introduction of mixed uneven-aged forests. Although such recommendations could be treated as catchwords, undoubtedly it is still necessary to stress their importance.

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References

Bielański, W. 2004. Impact of common silvicultural treatments on nest tree accessibility for Common Buzzard *Buteo buteo* and Goshawk *Accipiter gentilis*. Ornis Fenn. **81:** 180–185.

Bijlsma, R.G. 1997. The Buzzard *Buteo buteo*, pp. 160–161. In: Hagemeijer, E.J.M. & Blair, M.J. (eds) The EBCC atlas of European breeding birds: Their distribution and abundance, T & A D Poyser, London.

Bijlsma, R.G. & Sulkava, S. 1997. The Goshawk *Accipiter gentiles*, pp. 154–155. In: Hagemeijer, E.J.M. & Blair, M.J. (eds) The EBCC atlas of European breeding birds: Their distribution and abundance, T & A D Poyser, London.

Cieślak, M. 1984. Wyniki ilościowych badań ptaków lęgowych w Nadleśnictwie Sobibór [The results of quantitative studies of breeding birds in the Sobibór forest administrative unit]. Notatki Ornitologiczne **25:** 25–30.

Ćwikowa, A., Grabowski, A., Lesiński, A.J. & Myczkowski, S. 1984. Flora and vegetation of the Niepołomice Forest, pp. 2–11. In: Grodziński, W., Weiner, J. & Maycock, P.F. (eds) Forest ecosystems in industrial regions: Studies of cycling of energy nutrients and pollutants in the Niepołomice Forest Southern Poland, Ecological Studies 49, Springer Verlag.

Fretwell, S.D. & Lucas, H.L. 1970. On territorial behaviour and other factors influencing habitat distribution in birds. Acta Biotheoretica **19:** 16–36.

Hildén, O. 1965. Habitat selection in birds: a review. Ann. Zool. Fenn. **2:** 53–75.

Hubert, C. 1993. Nest-site habitat selected by common buzzard (*Buteo buteo)* in southwestern France. J. Raptor Res. **27:** 102–105.

Jędrzejewski, W., Jędrzejowska, B. & Keller, M. 1988. Nest site selection by the Buzzard *Buteo buteo* L. in the extensive forests of Eastern Poland. Biol. Conserv. **43:** 145–158.

Jędrzejewski, W., Szymura, A. & Jędrzejowska, B. 1994. Reproduction and food of the Buzzard *Buteo buteo* in relation to the abundance of rodents and birds in Białowieża National Park, Poland. Ethology Ecology & Evolution **6:** 179–190.

Jokimaki, J. & Huhta, E. 1996. Effects of landscape matrix and habitat structure on a bird community in northern Finland: a multi-scale approach. Ornis Fenn. **73:** 97–113.

Król, W. 1985. Breeding density of diurnal raptors in the neighbourhood of Susz (Iława Lakeland) in the years 1977–79. Acta Ornithol. **21:** 95–114.

Krüger, O. 2002. Analysis of nest occupancy and nest reproduction in two sympatric raptors: common buzzard *Buteo buteo* and goshawk *Accipiter gentilis*. Ecography **25:** 523–532.

Lack, D. 1937. The psychological factor in bird distribution. Brit. Birds **31:** 130–136.

Matthews, J.D. 2001. Silvicultural systems. Clarendon Press, Oxford, 284 pp.

Newton, I. 1979. Population ecology of raptors. T & A D Poyser, Berkhamsted, 400 pp.

Penteriani, V. 2002. Goshawk nesting habitat in Europe and North America: a review. Ornis Fenn. **79:** 149–163.

Penteriani, V. & Faivre, B. 1997a. Breeding density and nest site selection in a Goshawk *Accipiter gentilis* population of the Central Apennines (Abruzzo, Italy). Bird Study **44:** 136–145.

Penteriani, V. & Faivre, B. 1997b. Breeding density and landscape-level habitat selection of common buzzards (*Buteo buteo*) in a mountain area (Abruzzo Apennines, Italy). J. Raptor Res. **31:** 208–212.

Penteriani, V. & Faivre, B. 2001. Effects of harvesting timber stands on Goshawk nesting in two European areas. Biol. Conserv. **101:** 211–216.

Penteriani, V., Faivre, B. & Frochot, B. 2001. An approach to identify factors and levels of nesting habitat selection: a cross-scale analysis of Goshawk preferences. Ornis Fenn. **78:** 159–167.

Pugacewicz, E. 1996. Lęgowe ptaki drapieżne polskiej części Puszczy Białowieskiej [Birds of pray breeding in the Polish part of the Białowieża Primeval Forest]. Notatki Ornitologiczne **37:** 173–224.

Pulliam, H.R. & Danielson, B.J. 1991. Sources, sinks, and habitat selection: a landscape perspective on population dynamics. Am. Nat. **137,** Suppl.: S50–S66.

Reynolds, R.T., Graham, R.T., Rieser, H.M., Bassett, R.L., Kennedy, P.L., Boyce, D.A. Jr., Goodwin, G., Smith, R. & Fisher, E.L. 1992. Management recommendations for the Northern Goshawk in the Southwestern United States. USDA For. Serv. Gen. Tech. Rep. RM-217, Fort Collins, 90 pp.

Rodenhouse, N.L., Sherry, T.W. & Holmes, R.T. 1997. Site-dependent regulation of population size: a new synthesis. Ecology **78:** 2025–2042.

Rokosz, M. 1984. History of the Niepołomice Forest, pp. 24–27. In: Grodziński, W., Weiner, J. & Maycock, P.F. (eds) Forest ecosystems in industrial regions: Studies of cycling of energy nutrients and pollutants in the Niepołomice Forest Southern Poland, Ecological Studies 49, Springer Verlag.

Rykowski, K. 1996. Ochrona różnorodności biologicznej w lasach [Protection of forest biological diversity], pp. 169–184. In: Łonkiewicz, B. (ed.) Ochrona i zrównoważone użytkowanie lasów w Polsce [Conservation and sustainable use of Forests in Poland], Foundation IUCN Poland, Warszawa.

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

Snow, D.W. & Perrins, C.M. 1998. The birds of the Western Palearctic. Concise Edition. Vol. 1. Non-Passerines. Oxford University Press, Oxford/New York, 1008 pp.

Squires, J.R. & Ruggiero, L.F. 1996. Nest site preference of Northern Goshawks in south-central Wyoming. J. Wildl. Manage. **60:** 170–177.

Tomiałojć, L. & Stawarczyk, T. 2003. Awifauna Polski. Rozmieszczenie, liczebność i zmiany [The avifauna of Poland. Distribution, numbers and trends]. Polskie Towarzystwo Przyjaciół Przyrody "pro Natura", Wrocław, 870 pp.

Tomiałojć, L., Wesołowski, T. & Walankiewicz, W. 1984. Breeding bird community of a primeval temperate forest (Białowieża National Park, Poland). Acta Ornithol. **20:** 241–310.

Wesołowski, T., Tomiałojć, L., Mitrus, C., Rowiński, P. & Czeszczewik, D. 2002. The breeding bird community of a primeval temperate forest (Białowieża National Park, Poland) at the end of the 20th century. Acta Ornithol. **37:** 27–45.

Widén, P. 1997. How, and why, is the Goshawk (*Accipiter gentilis*) affected by modern forest management in Fennoscandia? J. Raptor Res. **31:** 107–113.

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