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Characteristics of nesting trees of the white-tailed eagle in central Poland

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Abstract: The white-tailed eagle *Haliaeetus albicilla* is a large bird of prey that has increased its numbers in Poland and range rapidly in recent decades. It builds large nests on big branches of trees and has high requirements in terms of nest trees. The availability of suitable nesting trees may be a limiting factor for this bird species. In Poland, at the beginning of the 21st century, the Scots pine *Pinus sylvestris* has been the most common choice for the white-tailed eagle, accounting for 70% of nest trees. The aim was to assess the nest preferences of the white-tailed eagle colonising new areas in the fragmented forest complexes of part of the central European lowlands. We analyzed the white-tailed eagle's nest trees in a newly colonised area of central Poland in the Mazovia Province. In 2023–2024, we collected data on about 90% of known eagle nest trees in Mazovia. It is an area of low forest cover and relatively young forest stand age. Measurements of nest trees and the immediate surroundings were taken. Of the 78 known trees, white-tailed eagles built 45% on the black alders *Alnus glutinosa*, 40% on the Scots pines and 15% on poplars *Populus* sp. Poplars and alders were selected much more frequently than would be expected based on their availability in the study area. The average age of the nest trees differed markedly between tree species. Pines were the oldest with an average age of 116, followed by alders at 84, and poplars about 70 years. The height of eagle nest placement was strongly correlated with tree height and age, while it was not related to the thickness of the tree. The poplars chosen by the white-tailed eagle was the youngest but thickest trees, providing a good support for the nest. Scots pine allowed the highest nest placement among species, and poplar the lowest. The main reason for nesting on poplars and alders is the limited availability of old, large Scots pines in Mazovian Lowland. The marked change in preference for nest tree species indicates the strong ecological plasticity of the white-tailed eagle.

Keywords: *Haliaeetus albicilla*, nesting tree, *Pinus sylvestris*, *Alnus glutinosa*, *Populus alba*

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Introduction

A suitable nesting site is one of the key elements of a bird's breeding habitat. The possibility of building a nest is an essential condition for birds to begin breeding (Mainwaring et al., 2014; Zawadzki et al., 2020). In particular, this concerns individual species birds of prey with specific high nest-site requirements. Limited availability of breeding sites may be an important reason for the reduction of raptor populations (Tapia & Zuberogoitia, 2018). Individual raptor species have specific requirements regarding location, height above ground, orientation, and way of hiding the nest site (Anderwald et al., 2014). The nest-site selections include the crown of trees, cliffs, and on the ground (Tapia et al., 2007). Nests of birds of prey are recognised as a critical habitat component for these group of species in Europe (Tucker & Heath, 1994). The problem of finding suitable trees for building a nest is often faced by birds of prey with large body sizes associated with old, mature forests. This is described as a result of forest management and too low an age of felling of trees (Löhmus, 2003; Löhmus & Sellis, 2003; Rosenvald & Löhmus, 2003). In managed forest, nests may be subject to competition among forest-dwelling species of birds of prey and the black stork *Ciconia nigra*. Such situations suggest limited availability of suitable nesting trees in the forest habitats (Skuja & Budrys, 1999; Treinys et al., 2009). The black stork and white-tailed eagle *Haliaeetus albicilla* (thereafter WTE) need large old trees for the nesting, which are usually considerably older than the felling age of managed stands. For instance, in NE Poland, the mean age of nest trees (only the Scots pine *Pinus sylvestris*) of the WTE was 157 years (from 103 to 200), and of the black stork (mainly the pedunculate oak *Quercus robur*) was 164 years (from 101 to 220). In the mentioned study area, the age of final cutting of the Scots pine was 120 years, and of the pedunculate oak – 140 years (Zawadzki et al., 2020). The above data indicate that large-sized birds such as the WTE may have difficulty selecting a suitable nest tree in younger managed stands.

The WTE is the biggest European forest-dwelling raptor with a body mass of 4–6 kg and a wingspan of 2.2–2.5 m (Cramp & Simmons, 1980; Fisher, 1984; Mizera, 1999). It builds large nests from branches, placed on the upper part of the crown of big, old trees. The new nest has a diameter of about 100 cm and a height of about 70 cm. Old, long-term used nests have a diameter of 170–250 cm and a height of about 150 cm, up to 600 cm. Its weight reaches about 600 kg, but occasionally it can weigh over 1 tonne (Hordowski, 2019; Mizera, 1999).

At the beginning of the 20th century, as a result of long-term severe persecution by humans, the European and Polish populations of the WTE came to the

brink of extinction. The population recovery began in the mid-20th century. Before World War II, the WTE range in Poland covered only north-western and locally western parts of the country. In the 1980s and 1990s, the WTE expanded its range and numbers to the north-eastern and eastern, then central, parts of the country. During the last 25 years, the WTE has extended its range southwards, strongly increasing its density (Mizera, 1999; Tomiałojć & Stawarczyk, 2003; Anderwald, 2014). One of the newly colonised areas is the Mazovian Lowland (Olszewski et al., 2020; Mirowski & Górski, 2023). The national population number was assessed at 40–50 breeding pairs in the 1930s, 180–200 pairs in the 1980s, and 450–500 pairs at the end of the 1990s (Adamski et al., 1999; Tomiałojć & Stawarczyk, 2003). The population increased to 767 pairs in 2008, and 1500–1600 in 2023 (Zawadzka et al., 2009; Cenian, 2024). The WTE population grew so strongly that it began to exert pressure on other bird species (Zawadzki et al., 2022). At the same time, when the WTE increased in range and number, its habitat requirements changed. Whereas in the past this raptor used to nest only in old-growth forests near natural bodies of water, recently it has begun to colonise even small forest complexes near rivers and fishponds, where it preys on birds and fish (Anderwald, 2014).

In central Europe, the WTE nest exclusively on large, old trees, usually in the crown top (Fisher, 1984; Mizera, 1999; Lontkowski & Stawarczyk, 2003; Zawadzka et al., 2006; Anderwald, 2014; Hordowski, 2019). The available data show that the average diameter of white-tailed eagle nesting trees is 60 cm (45–87 cm) for Scots pine trees (Zawadzki et al., 2020), or 49 cm (at least 40 cm) (Anderwald, 2014), black alder *Alnus glutinosa* 51 cm (at least 35 cm) and beech *Fagus sylvatica* 64 cm (at least 45 cm) (Anderwald, 2014).

The Scots pine is the most common choice of nest trees by the WTE in Poland. Nevertheless, the raptor also, but less frequently used the beech *Fagus sylvatica*, oaks *Quercus* sp., black alders *Alnus glutinosa*, birches *Betula* sp., poplars *Populus* sp., and, exceptionally, also Douglas fir *Pseudotsuga menziesii*, Norway spruce *Picea abies*, Weymouth pine *Pinus strobus*, European larch *Larix decidua*, lime *Tilia cordata*, and European ash *Fraxinus excelsior* for building nests (Mizera, 1999).

Nationwide data by the Eagle Conservation Committee based on almost 1500 nest trees showed the presence of WTE nests in 15 tree species in Poland, with Scots pine accounting for 70.3%, followed by beech 8.5%, black alder 7.1%, and oak 6.4%. Raptor studied sporadically built nests on poplars, the fir *Abies alba*, willow *Salix* sp., aspen *Populus tremula*, and Weymouth pine (Zawadzka et al., 2009). In the Augustów Forest (NE Poland), WTE nested almost exclusively on the Scots pines (Zawadzka et al., 2006;

Zawadzki et al., 2020). Data from the Silesian region (SW Poland) indicated a dominance of nests on the Scots pine – 46.6%, followed by nests located on the black alder – 19.6%, and on the oak – 15.4%. In the Silesian the WTE used total eight tree species for nesting (Lontkowski & Stawarczyk, 2003).

In Central Europe, the Scots pine is the most commonly chosen nesting tree for the WTE, followed by beech, which is preferred in Germany (Fisher, 1984; Looft & Neumann, 1990; Mizera, 1990). The preference for pine trees is due to the specific shape of old trees of this species: thick, spreading branches capable of supporting a large nest, and at the same time providing good inflow thanks to the loose crown (Zawadzki et al., 2020; Zawadzka & Zawadzki, 2024). Similar features are also described for beech trees (Fisher, 1984; Looft & Neumann, 1990). However, the WTE is also able to nest on other tree species. This study aimed to characterise nest preference of the WTE young population colonising new areas in the fragmented forest complexes of central European lowlands – the Mazovian Lowland. Birds find good feeding conditions there preying mainly on fish ponds and big rivers, but poorer nesting sites due to the younger age of the tree stands in managed forests. In these studies, the hypothesis that Scots pines aged around 100 years would not be the preferred nesting tree, as WTE find good nesting conditions in pines older than 120 years was tested. It was assumed that WTE would be forced to use other tree species, looking for sufficiently sturdy branches and unobstructed flight paths to their nests. It was expected that, as in previous studies, the WTE in Mazovia would prefer the old Scots pine trees as nesting sites, but may show greater flexibility in this regard, depending on local habitat conditions of forests.

Study area

The study was carried out in the Mazovian Province, located in central Poland, which covers around 11% of the country's area. The area has low forest cover (23%) and high human population density (155 people/km²) (Łukawska et al., 2025). The Mazovia Province is situated in the Central European lowland, a flat area cut by the valleys of several large rivers – the Vistula, the largest in Poland, and its main tributaries – the Bug, the Narew, the Pilica, the Wkra, and the Bzura as well as smaller rivers. The study area is characterised by a few natural water bodies (only 144 lakes and 12 artificial reservoirs in the entire voivodeship). There are 90 fish pond complexes with an area of at least 10 hectares within the province. The distribution of water is uneven. Lakes and reservoirs are mainly located in the northern and western parts of the area, ponds in the east

and south, and river valleys with branches and oxbow lakes in the central part. The forests of Mazovia cover a total area of 815,000 hectares, 45% of which are privately owned, with the remainder managed by the State Forests (Łukawska et al., 2025). Administratively, forest management is divided into 35 forest districts and the Kampinoski National Park. The mean age of forest stands is about 60 years, the main forest-forming species are the Scots pine (75%), the oaks (10%), and the silver birch *Betula verrucosa* (6%). Alder forest in swampy areas cover 6% and are mostly dominated by the black alder. The Mazovian Province is characterised by a high fragmentation of forests (the average area of a private plot is about 1 ha), and there are few large (over 10,000 ha) forest complexes. In the valleys of main rivers, the wooded areas in floodplains are often composed of the white poplar *Populus alba* and the black poplar *Populus nigra* and hybrids of these species. The study area lies outside the range of the beech tree (Kondracki, 1994; Chmielewski et al., 2023).

Methods

Field data collection

Data on WTE nesting sites were collected between 2018 and 2023. In places of frequent observations of WTE in potential convenient nesting areas, a search was undertaken for bird-studied nests in forest areas. During this period, 85 WTE nests were located in the Mazovian Province. Measurements were done between 2023 and 2024.

WTE nesting trees and their nearest surroundings were measured during the non-breeding season (autumn and winter) to avoid scaring the birds. The diameter of the trunk at a height of 1.3 m was measured using a clup, and the height of the tree, the height of the nest location and the height of the crown setting – the height of the first branch above the ground – was measured using the MeasureHeight application (Bijak & Sarzyński, 2015). Tree species were identified basing at buds, leaves and bark of trees. An assessment of the immediate surroundings within a 20 m radius around the nest tree was also made. The breast diameter and height of all trees thicker than 10 cm in this plot and their distance from the nest tree were measured. Crown closure were visual assessed on a percentage scale, according to the State Forest instruction (2024) (see Table 1). Data were also obtained on the number of neighbouring trees in the 0.125 ha circle area around the nest (radius = 20 m). Data on the age of the trees in the stand were obtained from the Forest Data Bank (BDL 2024, <https://www.bdl.lasy.gov.pl/portal/mapy-en>). During the database creation, the distance

Table 1. The analyzed habitat parameters

Parameters	Description
DBH [centimeters]	Diameter at breast height (1.3 m above the ground level)
Tree height [metres]	Height of the tree
Nest height [metres]	Height of the base of the nest
First branch height [metres]	Height of the first bigger branch above the ground, at least 5 cm diameter near trunk
Crown height [metres]	Distance from the tree top to the base of the crown
Distance to the tree top [metres]	Distance from the base of the nest to the tree top
Tree age [years]	Age of the nesting tree species in the stand
Stand age [years]	Age of the stand surrounding the nesting tree
Canopy closure [%]	Level of the trees' crown closures
DBH of neighbouring trees [centimeters]	Average value of the DBH of all trees growing within a radius of 20 m around the nesting tree
Height of neighbouring trees [meters]	The average height of all trees growing within a radius of 20 m around the nesting tree
Distance to the neighbouring trees [meters]	Average distance to all trees growing within a radius of 20 m around the nesting tree
N of trees around the nest tree	Number of trees with DBH bigger than 14cm growing within a radius of 20 m around the nesting tree

of the nest from the top of the tree and the height of the tree crown were calculated. Eight nesting trees (10% of known nests) could not be reached due to their location in areas permanently cut off by water, such as Vistula islands or beaver lodges.

Statistical analyses

Ivlev's electivity index D (Jacobs, 1974) was used to assess the WTE preference for nest tree species:

$$D = (r - p) / (r + p) - 2p,$$

where r is a percent of a given tree species in a total number of nesting trees, and p is a percent of the tree species in the forest stands on the study area. D varies from -1 (complete avoidance) to 1 (maximum positive selection).

The comparison between WTE nest trees belonging to different species (pine, alder, poplars) were carried out. Due to deviations from data normality, the Kruskal-Wallis test was used, with Dunn's test as a post-hoc test to compare the parameters of the nesting trees. Differences between nesting tree DBH and tree height, and the average values of trees in their surroundings within 20 m circle, were compared using the Wilcoxon test. Spearman correlation was used to test the relationship between basic tree parameters (height, DBH) and nest height. Finally, a GLM analysing nest height relative to collected tree measures and data on trees growing within $r=20$ m from the nest was constructed to check which parameters are crucial for nesting height. All calculations were performed in R, with the R-Studio overlay. The ggpubr library (Kassambra, 2020) and ggplot2 were used for plotting (Wickham, 2016).

Results

78 WTE nest trees were measured in Mazovia Province, representing approximately 90% of known nests in the study area. The nests were located on three species of trees. The most frequently used nest tree species in the area of Mazovia Province was the black alder, which accounted for 35 (44.9%) of the measured nest trees, followed by the Scots pine – 31 trees (39.7%) (Fig. 1). The remaining 12 nests (15.4%) were built on poplars, 10 on the white poplar, two on the white and black poplar hybrids (Fig. 1). The Ivlev's selectivity index for Scots pine ($D = 0.31$) showed low preference of this tree species by WTE, while the score for deciduous species

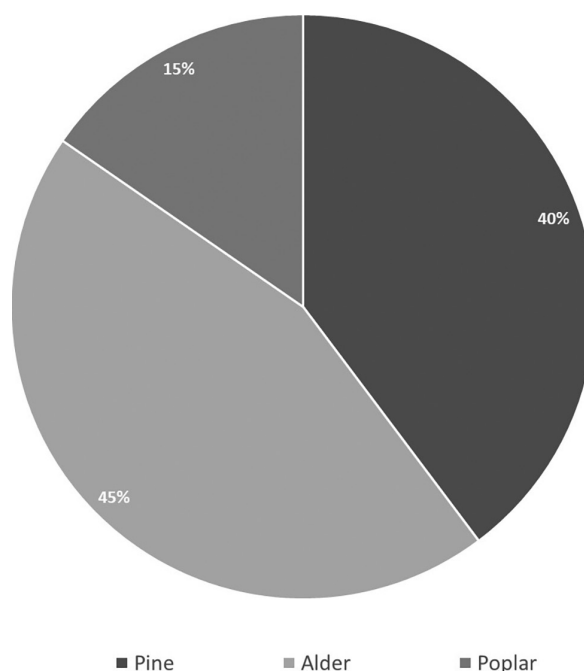


Fig. 1. Tree species used by the white-tailed eagle for nesting in the Mazovia Province

indicated them as preferred by the WTE – for the black alder 0.76 and for poplar 0.87. Alders and poplars were chosen more often in relation than its availability in the whole study area. Nests on the Scots pine were located most often within forest complexes, nests on the black alder – in small wet alder forests, and on poplars – along river valleys (Fig. 2).

The difference among tree species

Using the Kruskal-Wallis test, the parameters of nest trees and their surroundings were compared for the different tree species studied. Poplars were significantly thicker than pines and alders (Fig. 3A), despite having the lowest age. The average age of

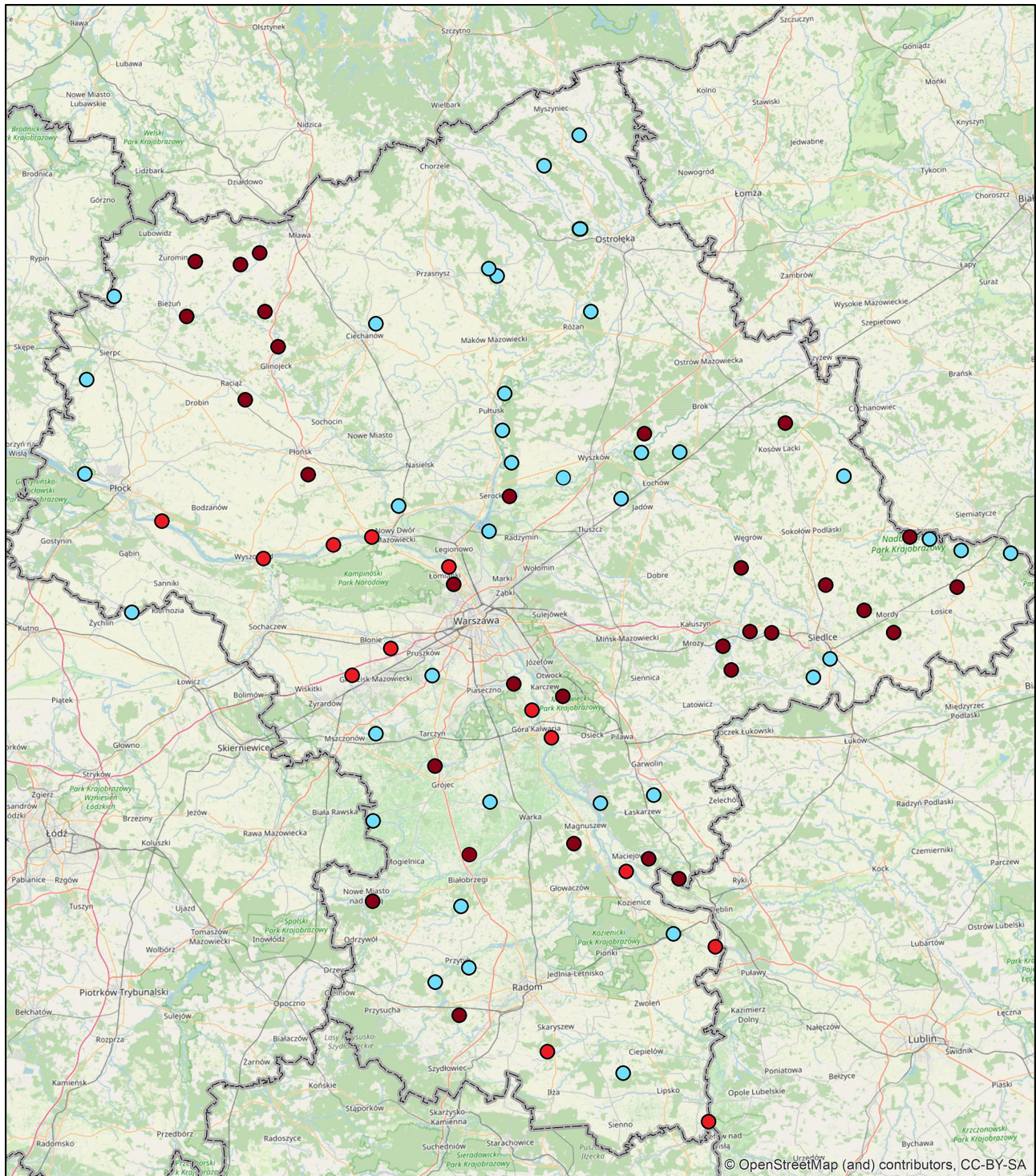


Fig. 2. Distribution of surveyed white-tailed eagle nest trees in Mazovian Voivodeship

the nest trees differed markedly between tree species. Pines were the oldest with an average age of 116 years, followed by alders at 84, and the youngest were poplars at 73.6 years (Fig. 3B, Table 2). Pine trees were the oldest among species studied, but the stand surrounding the nest site did not differ significantly between nest tree species.

Nests on the Scots pines were located higher than on deciduous trees. The nests on Scots pine trees were located on average 12.1 metres below the top, on black alder trees 15.7 metres, and on poplar trees 18.5 metres below the top (Table 2). Some nests were built in retention of old-growth forests and even on single Scots pines growing in clear-cuts and young plantations, which lowered the average stand age. Differences due to tree biology and habit were evident – crown parameters and the distance of the nest from the tree top. There were no significant differences between the key parameters, such as nest tree height (Table 2).

The surrounding environment of nest trees of different species varied. The poplars had the fewest neighbours, but at the same time, they were the thickest trees, often other massive poplars. At the same time, the trees around poplars were lower than those growing around pines or alders (Table 2).

WTE nest trees were significantly thicker than mean trees growing in the neighbourhood (62.4 cm vs 43.8 cm, $V=2365$, $p < 0.0001$) and taller than their average neighbours (27.8 m vs 23.8 m, $V = 2246.5$, $p < 0.0001$). The WTE chose the tallest trees within a radius of 20 m in 64% of locations, while the nesting tree was the thickest in only 32% of sites. The height of the nesting tree did not differ significantly from the tallest trees in the 20 m radius ($W = 585$, $p = 0.46$), while its thickness was less than the maximum achieved by trees within a 20 m radius ($W = 568$, $p = 0.001$).

We tested the relationships between the WTE nest placement height and the three basic parameters of the nest tree, presented at Figure 4. The results

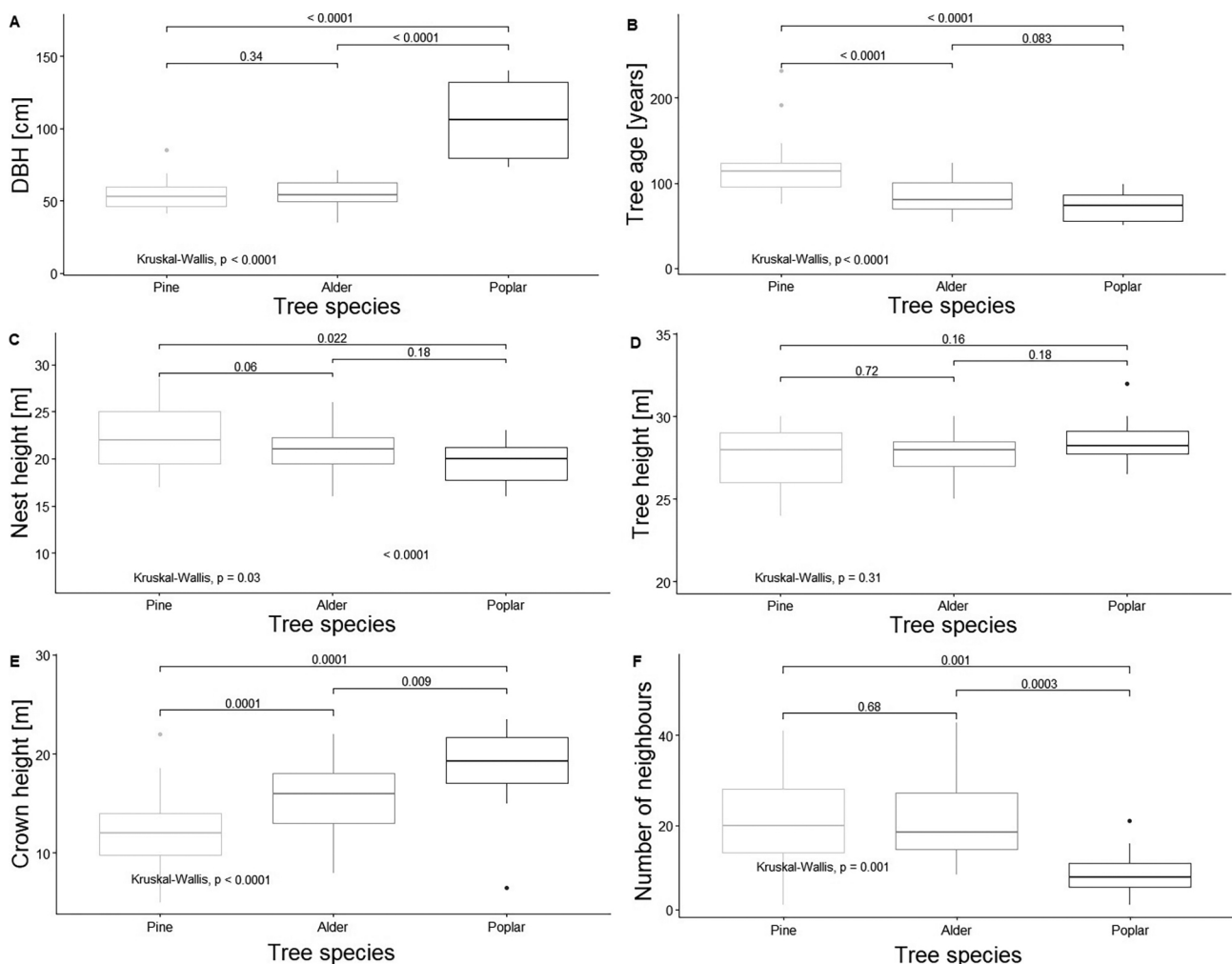


Fig. 3. Comparison of key parameters among nesting tree species by the Kruskal-Wallis test (Dunn's post-hoc test). Horizontal line – median, box – interquartile range, vertical line – values within 1.5 times the interquartile range, dots – values between 1.5 and 3 times the interquartile range

indicate that the height of WTE nest placement is strongly correlated with tree height and age, while it is not related to the thickness of the tree chosen by the birds (Fig. 4).

A GLM model considers parameters that can affect the choice the height the nest is placed (Table 3). The model indicated the significant importance of two parameters – tree species and nesting

Table 2. Comparison of characteristics of the white-tailed eagle nesting tree species by using the Kruskal-Wallis test

Parameter	Scots pine			Black alder			Poplars			KW results
	$\bar{X} \pm SD$	Min–Max	SE; 95% CI	$\bar{X} \pm SD$	Min–Max	SE; 95% CI	$\bar{X} \pm SD$	Min–Max	SE; 95% CI	
DBH [cm]	53.6 $\pm$ 9.83	41–85	1.77; 3.61	55.1 $\pm$ 9.30	35–71	1.57; 3.20	106.4 $\pm$ 26.6	73–140	7.68; 16.9	$p < 0.0001$
Tree height [m]	27.5 $\pm$ 1.83	24–30	0.33; 0.67	27.8 $\pm$ 1.31	25–30	0.22; 0.44	28.5 $\pm$ 1.51	26.5–32	0.44; 0.96	$p = 0.31$
Nest height [m]	22.4 $\pm$ 3.52	17–28.5	0.63; 1.29	20.8 $\pm$ 2.35	16–26	0.40; 0.81	19.5 $\pm$ 2.48	16–23	0.72; 1.58	$p = 0.03$
First branch height [m]	15.1 $\pm$ 3.51	7–21	0.63; 1.29	12 $\pm$ 3.28	6–20	0.56; 1.13	10 $\pm$ 4.67	5–21	1.35; 2.97	$p = 0.0001$
Crown height [m]	5.3 $\pm$ 3.05	3–15	0.55; 1.12	6.9 $\pm$ 1.90	2–9.5	0.32; 0.65	8.3 $\pm$ 2.43	5–12	0.70; 1.54	$p < 0.0001$
Distance to the tree top [m]	12.1 $\pm$ 3.71	5–22	0.67; 1.36	15.7 $\pm$ 3.33	8–22	0.56; 1.14	18.5 $\pm$ 4.58	6.5–23.5	1.32; 2.91	$p = 0.002$
Tree age [years]	116.5 $\pm$ 30.4	76–232	5.46; 11.2	84 $\pm$ 17.7	55–124	2.99; 6.09	73.6 $\pm$ 17.6	51–100	5.09; 11.2	$p < 0.0001$
Stand age [years]	86.8 $\pm$ 56.9	6–232	10.2; 20.9	84 $\pm$ 17.7	55–124	2.99; 6.09	73.6 $\pm$ 17.6	51–100	5.09; 11.2	$p = 0.19$
Canopy closure [%]	39 $\pm$ 20.1	0–80	3.60; 7.36	49.1 $\pm$ 13.4	30–80	2.26; 4.59	31.7 $\pm$ 23.7	0–90	6.83; 15.0	$p = 0.04$
DBH of neighbouring trees [cm]	43 $\pm$ 6.67	31–58	1.26; 2.59	44.4 $\pm$ 5.32	33–59	0.94; 1.92	65.4 $\pm$ 37.6	24–160	11.9; 26.9	$p = 0.018$
Height of neighbouring trees [m]	24.5 $\pm$ 1.99	20–28	0.39; 0.80	24.1 $\pm$ 2.24	18–27	0.89; 1.81	21.1 $\pm$ 5.62	11–30	1.78; 4.02	$p = 0.079$
Distance to the neighbouring trees [m]	13.4 $\pm$ 1.66	8–17	0.32; 0.66	12.9 $\pm$ 1.51	9–17	0.27; 0.55	11.6 $\pm$ 2.70	5–15	0.85; 1.93	$p = 0.054$
N of trees around the nest tree	22.1 $\pm$ 10.81	1–41	2.01; 4.11	21.4 $\pm$ 2.09	9–44	1.67; 3.40	9.4 $\pm$ 5.85	1–21	1.85; 4.19	$p = 0.001$

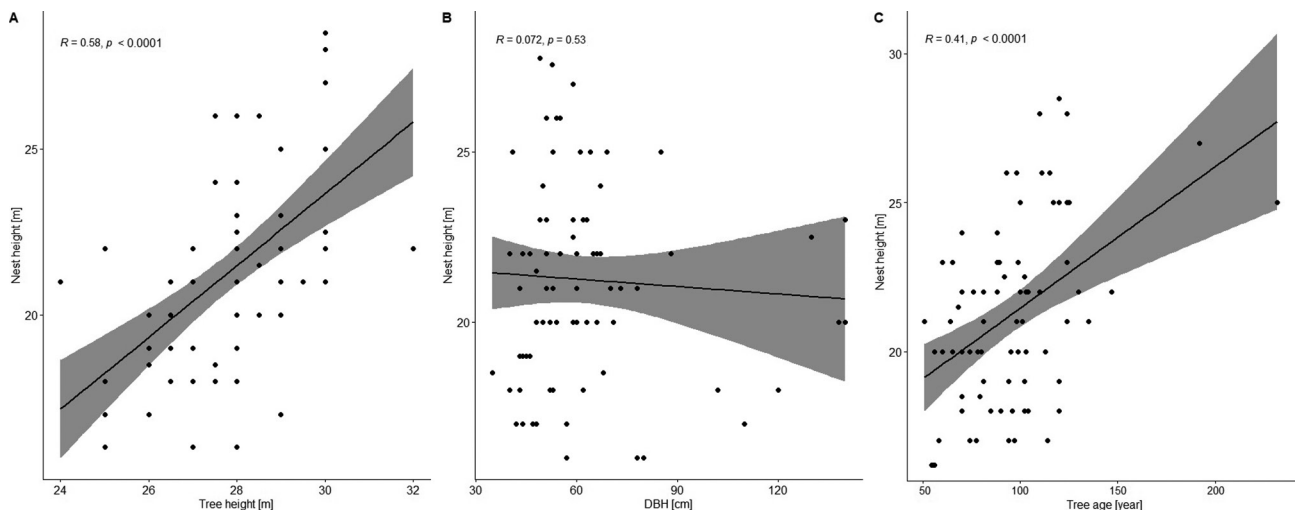


Fig. 4. Spearman correlation results between nest height and (A) tree height, (B) diameter, (C) tree age

Table 3. GLM results for parameters impacting the nest height of the WTE (Gamma error distributed with log link)

Fixed effect parameter	Estimate	Std. error	t-value	P
Intercept (Pine)	12.74	1.08	11.75	< 0.001
Alder	−0.04	0.02	2.39	0.020
Poplar	−0.12	0.04	3.07	0.003
Tree age	−0.0005	0.0003	0.22	0.829
Tree height	0.027	0.004	6.55	< 0.001
Crown height	0.003	0.002	1.59	0.118
DBH	0.0008	0.0005	1.42	0.161
Canopy closure	0.0001	0.0004	0.32	0.752
N of neighbours (20 m radius)	−0.0003	0.0007	0.42	0.673

tree height. On taller trees, nests were placed higher; Scots pine allowed the highest nest placement among tree species, and poplar the lowest. The other analysed parameters appeared to have no significant effect on WTE nest height (Table 3).

Discussion

There is surprisingly little information in the scientific literature on WTE regarding selectivity towards nesting places. In northern Europe, the birds often nest on cliffs or dwarf trees (Cramp & Simmons, 1980). In central Europe, the WTE built nests exclusively on big trees (Fisher, 1984; Mizera, 1999; Hordowski, 2019). Across Poland, the most common nesting tree is the Scots pine, on which approximately 70% of nests are found (Mizera, 1999; Zawadzka et al., 2009; Anderwald, 2014), although the species structure of nesting trees varies regionally (e. g. Stawarczyk & Lontkowski, 2003; Zawadzka et al., 2006; Przybyliński, 2017; Olszewski et al., 2020).

WTEs living in Mazovia chose the black alder, Scots pine and poplar trees for their nesting sites. The same tree species were used by WTE in located in Mazovia the Kampinos National Park, not included in present study (Olszewski et al., 2020). This study has shown that in Mazovia Province, the WTEs built the most nests on the black alders and strongly preferred this species as a nest tree. In turn, the number of nests on poplars was much smaller, but simultaneously, the raptors studied showed the strongest preference for this tree species. The frequent use of the black alder trees for nesting was also described in the Łódź region in central Poland, most often in small forests (Anderwald & Przybyliński, 2011; Przybyliński, 2017). Although the number of nests built on the Scots pines was high in Mazovia, the species was weakly selected as a nest tree. There were fewer nests on the Scots pine trees than would be suggested by the availability of pine in the forests covered the study area. Thus, the study confirms the hypothesis that WTE do not prefer Scots pine in newly colonised areas, but indicates that WTE are

very flexible in their choice of nesting trees, while maintaining high requirements regarding tree size.

The dominance of Scots pine among WTE nesting trees in Poland results from its loose, umbrella-shaped crown and sturdy, thick branches, capable of maintaining the enormous nest. In all studies, the WTE strongly selected the oldest stands. The ages of the nest stands in the Silesia region were, respectively, for pines 100–140 years, for beech 130–150 years, for oak 120–150 years (Lontkowski & Stawarczyk, 2003). The suitability of the Scots pine for the WTE significantly increases with age above 120 years, whereas the corresponding age for the black alder is 80–100 years (Anderwald, 2014). In the Augustów Forest, the average age of WTE nest trees was 157 years (Zawadzki et al., 2020). In turn, in the Kampinos National Park, the WTEs built nests on trees aged from 50 to 189, mean 144 years (Olszewski et al., 2020). Old Scots pines, oldest than 120 years, have properly shaped loose crowns and thick branches. In central Poland, the age of Scots pine stands rarely exceeds 90–100 years old. Such stands are also often too dense for flying by WTE. Limited availability of old Scots pine stands forcing raptors to look for alternative nesting sites. However, the age of alders in Mazovia Province is similar to age of WTE nest trees indicated by Anderwald (2014) coming from across the country.

All nest tree species in present study have comparable parameters. The black alder and poplars are not inferior in thickness to Scots pine, despite their much lower age. A study by Anderwald (2014) suggests a suitable DBH for nesting trees of 35–50 cm and an optimal DBH above 50 cm. In turn, the thickness of nest trees in the Augustów Forest amounted to above 60 cm (Zawadzki et al., 2020). Surveys done in the Mazovia Province showed that the thickness of nest trees slightly exceeded 50 cm for pines and alders, while poplars were twice as thick as them. The height of nests above ground on the Scots pine was somewhat higher. The observed differences in nest height above ground are due to the structure of particular tree species – on the Scots pine the nest is more often built on top of the crown, because Scots

pine has a wide strong crown high up, deciduous trees have lower thick branches and the nest is further away from the top. The nest trees in Mazovia Province were taller and thicker than average values for the height and DBH of trees growing within a 20 m radius, but these were not always the thickest and tallest. This result may be due to the selection of trees with crowns providing a solid base and shaped appropriately for the placement of a nest (often distorted), which are not always the tallest and thickest. Another important factor affecting the choice of a nesting tree is the possibility of a good flyway to the nest. This parameter is not directly related to the nesting tree sizes, but to the distribution of the trees growing in its vicinity. The results of earlier studies from Poland (Anderwald, 2014; Zawadzki et al., 2020), Germany (Looft & Neumann, 1990), and Japan (Shiraki, 1994) were partly different, because WTE selected mainly the tallest and the thickest tree as place of nesting. Furthermore, placing nests in trees that are taller and thicker than those growing in the surrounding area has been demonstrated in Hokkaido (Japan). The nesting trees were 7.9 m taller than those growing in the surrounding area, and also thicker. In those studies, the WTE used 13 tree species for building a nest, with a clear preference for two of them (Shiraki, 1994). In turn, in Schleswig-Holstein the WTE selected the oldest beech as a nest trees (Looft & Neumann, 1990).

The frequent selection of the black alder by the WTE in Mazovian Province is a natural reaction to the specific structure and age of dominated stands in central Poland. Relatively often, the black alders forms small groups in hard-to-reach, flooded areas. This makes it easier to find a suitably shaped crown of alder than of a pine for a WTE nest in the landscape of central Poland. In turn, the huge poplar trees in the riverine forests on the banks of the Vistula, where the thickness of the lateral branches is as thick as the DBH of some Scots pines or black alders, allow the nest to be stably positioned. Furthermore, nesting in alders or poplars is often due to their proximity to feeding sites such as fish ponds or rivers.

On the other hand, the black alder and poplars force the nest to be placed lower, as they do not have such strong branches at the top of the crown as the Scots pines. It is not uncommon for the horizontal branches at the top of the crown to provide space for stable nest placement, allowing the WTE to fly in. The question of flying may be another important topic for the birds – a lot of nests on Scots pine trees were located in small retention patches within clearcuts and even on single trees.

Nesting on poplars is further evidence of a search for loose-standing trees – the crown density is much lower than around Scots pines and half that around

black alders. The frequent choice of alder and poplar trees for nesting in Mazovia demonstrates the great adaptability of the WTE population, which helps explain the rapid colonisation of central Poland by this raptor.

Conclusions

Building huge nests from branches, the WTE has high requirements in terms of nest tree selection. In Mazovia Province, the WTE nested most often on alder trees, followed by Scots pine, and relatively often on poplars. The species structure of nesting trees in our study differed from previous data from Poland. The main reason is the limited availability of old Scots pine trees with a convenient flight path. The marked change in preference for nest tree species indicates the strong ecological plasticity of the WTE. At the same time, it could explain the rapid colonisation process of central Poland by the WTE, which spread relatively quickly in an area with low forest cover and limited availability of old and vast stands, exploiting available feeding grounds.

Conflict of interest

The authors declare no conflict of interest.

References

- Adamski A, Lontkowski J, Maciorowski G, Mizera T, Rodziewicz M, Stawarczyk T & Waclawek K (1999) Rozmieszczenie i liczebność rzadszych gatunków ptaków drapieżnych w Polsce w końcu 20. wieku. *Notatki Ornitologiczne* 40: 1–22.
- Anderwald D (2014) Drzewa gniazdowe bielika *Haliaeetus albicilla* przykładem drzew biocenotycznych. *Studia i Materiały CEPL* 16: 131–150.
- Anderwald D & Przybyliński T (2011) Porównanie populacji lęgowej bielika *Haliaeetus albicilla* w Pradolinie Warszawsko-Berlińskiej PLB100001 i na Wielkim Sandrze Brdy PLB220001. *Studia i Materiały CEPL* 13: 105–113.
- Anderwald D, Przybyliński T & Zawadzka D (2014) Podręcznik najlepszych praktyk ochrony ptaków szponiastych. Centrum Koordynacji Projektów Środowiskowych, Warszawa.
- Bijak S & Sarzyński J (2015) Accuracy of smartphone applications in the field measurements of tree height. *Folia Forestalia Polonica Series A* 57: 240–244. doi:10.1515/ffp-2015-0025.
- Cenian Z (2024) *Biuletyn* 22. Komitet Ochrony Orłów, Olsztyn.

- Chmielewski S, Dombrowski A, Tabor J, Górski A & Łukaszewicz M (2023) Ptaki Niziny Mazowieckiej. Monografia Faunistyczna. Mazowiecko-Świętokrzyskie Towarzystwo Ornitologiczne, Pionki-Poznań.
- Cramp S & Simmons KLE (1980) Handbook of the birds of Europe, the Middle East and North Africa. The Birds of the Western Palearctic V. 1. Oxford University Press, Oxford.
- Fisher W (1984) Die Seeadler. Die Neue Brehm-Bucherei. A Ziemsen Verlag, Wittenberg-Lutherstadt.
- Hordowski J (2019) Gniazda i legi ptaków Polski. Ptaki szponiaste i sokoły. Nakładem autora.
- Instrukcja Urządzania Lasu (2024) Dyrekcja Generalna Lasów Państwowych, Warszawa
- Jacobs J (1974) Quantitative measurements of food selection; a modification of the forage ratio and Ivlev's electivity index. *Oecologia* 14: 413–417. doi:10.1007/BF00384581.
- Kassambra A (2020) Ggpubr: 'ggplot2' Based Publication Ready Plots. R package version 0.4.0. <https://CRAN.R-project.org/package=ggpubr>.
- Kondracki J (1994) Geografia Polski. Mezoregiony fizyczno-geograficzne. PWN, Warszawa.
- Looft V & Neumann T (1990) Seeadler *Haliaeetus albicilla*: Vogelwelt Schleswig-Holsteins 2 (ed. by V Looft V & Busche G) Wachholtz-Verlag, Neumünster.
- Lõhmus A (2003) Do Ural owls (*Strix uralensis*) suffer from the lack of nest sites in managed forest? *Biological Conservation* 110: 1–9. doi:10.1016/S0006-3207(02)00167-2.
- Lõhmus A & Sellis U (2003) Nest trees – a limiting factor for the Black Stork (*Ciconia nigra*) population in Estonia. *Aves* 40: 84–91.
- Łukawska I, Borowski S, Mandziuk A & Radomska J (2025) Supervision of private forests in the Mazowieckie Province. *Sylvan* 169: 94–107. doi:10.26202/sylvan.2025009.
- Mainwaring MC, Hartley IR, Lambrechts MM & Deeming DC (2014) The design and function of birds' nests. *Ecology and Evolution* 20: 3909–3938. doi:10.1002/ece3.1054.
- Mizera T (1999) Bielik. Monografie przyrodnicze 4. Wyd. Lubuskiego Klubu Przyrodników, Świebodzin.
- Mirowski I & Górski A (2023) Bielik *Haliaeetus albicilla* (Linnaeus, 1758): Ptaki Niziny Mazowieckiej. Monografia Faunistyczna (ed. by S Chmielewski, A Dombrowski, J Tabor, A Górski & M Łukaszewicz M) Mazowiecko-Świętokrzyskie Towarzystwo Ornitologiczne, Pionki-Poznań, pp. 361–374.
- Olszewski A, Matusiak J & Olech B (2020) Biologia i ekologia bielika *Haliaeetus albicilla* w okresie lęgowym w Kampinoskim Parku Narodowym. *Kulon* 25: 69–91.
- Przybyliński T (2017) Stan populacji lęgowej bielika *Haliaeetus albicilla* na Ziemi Łódzkiej w drugiej dekadzie XXI wieku. *Studia i Materiały CEPL* 19: 42–55.
- R Core Team (2024) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. <https://www.R-project.org/>.
- Rosenvald R & Lõhmus A (2003) Nesting of the black stork (*Ciconia nigra*) and white-tailed eagle (*Haliaeetus albicilla*) in relation to forest management. *Forest Ecology and Management* 185: 217–223. doi:10.1016/S0378-1127(03)00216-0.
- Shiraki S (1994) Characteristics of white-tailed sea eagle nest sites in Hokkaido, Japan. *The Condor* 96: 1003–1008. doi:10.2307/1369109.
- Skuja S & Budrys RR (1999) Nesting sites of black stork, lesser spotted eagle and common buzzard and their nest exchange in the forest of north, north-east and Central Lithuania. *Baltic Forestry* 5: 67–74.
- Treiny R, Skuja S, Augutis D & Stončius D (2009) Nest-site use by black stork and lesser spotted eagle in relation to fragmented forest cover: case study from Lithuania. *Ekologija* 55: 182–188. doi:10.2478/v10055-009-0022-8.
- Tucker GM & Heath MF (1994) Birds in Europe: their conservation status. BirdLife Conservation Series no. 3. BirdLife International, Cambridge, UK.
- Tapia L, Kennedy P & Mannan B (2007) Habitat sampling: Raptor research and management techniques manual. Raptor research foundation (ed. by D Bird & Bildstein) Hancock House Publishers, Surrey, Canada, pp. 153–169.
- Tapia L & Zuberogaitia I (2018) Breeding and nesting biology in raptors: Birds of prey, biology and conservation in the XXI century (ed. by JH Sarasola, JM Grande & JJ Negro) Springer International Publishing AG, pp. 63–94. doi:10.1007/978-3-319-73745-4_3.
- Tomiałojć L & Stawarczyk T (2003) Awifauna Polski. Rozmieszczenie, liczebność i zmiany. PTPP pro Natura, Wrocław.
- Wickham H (2016) ggplot2: Elegant Graphics for Data Analysis. Springer-Verlag New York. <https://ggplot2.tidyverse.org>.
- Zawadzka D, Zawadzki J & Sudnik W (2006) Rozwój populacji, wymagania środowiskowe i ekologia żerowania bielika *Haliaeetus albicilla* w Puszczy Augustowskiej. *Notatki Ornitologiczne* 47: 217–229.
- Zawadzka D, Mizera T & Cenian Z (2009) Dynamika liczebności bielika *Haliaeetus albicilla* w Polsce. *Studia i Materiały CEPL* 11: 22–31.

- Zawadzka D & Zawadzki G (2024) The importance of the Scots pine for the diversity of forest avifauna: The Augustów Forest as a case study. *Forests* 15: 1317. doi:10.3390/f15081317.
- Zawadzki G, Zawadzka D, Sołtys A & Drozdowski S (2020) Nest sites selection by the white-tailed eagle and black stork – implications for conservation practice. *Forest Ecosystems* 7: 59. doi:10.1186/s40663-020-00271-y.
- Zawadzki G, Zawadzki J, Drozdowski S & Zawadzka D (2022) The avoidance of living in the vicinity of a top predator: the coexistence of the black stork and the white-tailed eagle in NE Poland. *The European Zoological Journal* 89: 1223–1237. doi:10.1080/24750263.2022.2134478.