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Logging affects the white-backed woodpecker *Dendrocopos leucotos* distribution in the Białowieża Forest

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The white-backed woodpecker (WbW) is a critically endangered species in Europe. The Białowieża Forest (BF) is of major importance for its conservation. Distribution of WbW in deciduous stands of the BF was studied in relation to habitat resources. In March–April 2005 we replicated a 1991 study where the WbW population was estimated using playback drumming techniques. Woodpeckers were recorded in only one-third of its former distribution area. A logistic regression model revealed that one variable (volume of dead wood) correctly classified 69.2% of habitat patches as occupied by the WbW, and 93.8% as missing the WbW. Plots with woodpeckers had six times more dead wood (54.2 m^3 ha^{-1}) than plots where WbWs were absent (8.9 m^3 ha^{-1}). Our results demonstrate that reduction in the WbW population is causally linked to ongoing logging and consequent removal of dead wood. The only way to prevent further WbW population decline is to protect the entire BF as a national park.

Introduction

The white-backed woodpecker (WbW) is one of the rarest woodpeckers in Europe. Its breeding is limited to deciduous-rich forests with a considerable amount of dead wood (Aulén 1988, Wesołowski 1995a, 1995b, Carlson 2000). In some countries this species has gone extinct due to habitat loss. During the last few decades, the WbW has declined regionally, mostly due to intensive silvicultural practices degrading habitat quality (Glutz von Blotzheim & Bauer 1980, Cramp 1985, Virkkala *et al*. 1993). It has been suggested that in the past the WbW bred in the whole of western Europe (Tomiałojć 2000).

In Poland this species is listed as endangered, with an estimated population size of about 400–600 pairs (Wesołowski 2001, Burfield & Bommel 2004). The Białowieża Forest (hereafter BF) population of the WbW is one of the largest in Europe, and is the largest in Poland — at the beginning of the 1990s Wesołowski (1995b) recorded ca. 115–130 pairs there.

This specialized species is associated with forests containing a high amount of dead wood and where large deciduous trees are present (Angelstam *et al*. 2002, Gjerde *et al*. 2005). The main food of this woodpecker — wood- and bark-living insects, mainly Coleoptera and Cerambycidae — commonly occur in dead or dying

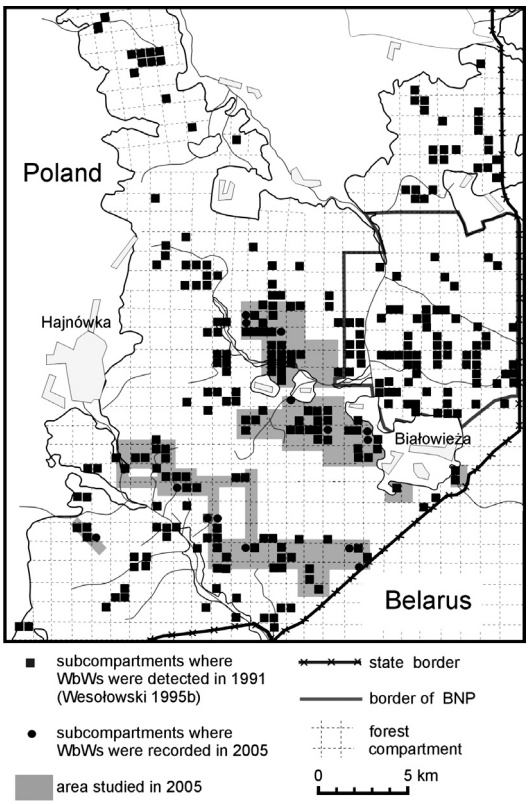

Fig. 1. Study area.

wood (Aulén 1988).

In this paper, we examine how 14 years of management of the BF affected the distribution of WbW territories by comparing their present distribution with population estimates before intense logging started (Wesołowski 1995b). We then assess habitat components necessary for its survival in managed stands by comparing local vegetation structure between stands where the woodpecker is still present and stands where the species is now missing.

In order to quantify the extent of habitat degradation we compare a number of potentially relevant parameters of stands to those forest patches where WbWs are still present with the stands where they were not recorded recently. We predict that, as a result of recently accepted plans of logging (150 000 m^3 $year^{-1}$) the old-growth stands in the managed part of the BF will disappear until 2011 (Wesołowski 2005).

Study area

We conducted our study in the BF, NE Poland (52°30´–53°N and 23°30´–24°15´E). This forest is characterized by a large amount of primeval tree stands which are multi-storey, mixed-species, and uneven-aged (Faliński 1986). However, only the central fragment of its Polish part was adequately protected since 1921 as the Białowieża National Park (hereafter BNP). The majority of tree stands (ca. 83%) in the Polish range of the BF is under management. Even nature reserves, which were created there, do not protect tree stands effectively enough — dead and dying trees are still removed according to legal practices. A large part of the BF is covered by deciduous stands of several forest types:

- Hornbeam–lime–oak stands *Tilio–Carpinetum* (with dominant hornbeam *Carpinus betulus*, small-leaved lime *Tilia cordata*, pedunculate oak *Quercus robur* and Norway spruce *Picea abies*).
- Swampy deciduous stands *Circaeo–Alnetum*, *Carici elongate–Alnetum* (composed mostly of alder *Alnus glutinosa*, ash *Fraxinus excelsior* and spruce). These stands contain the largest amount of downed logs.
- In coniferous stands (*Querco–Piceetum*, *Pineto–Quercetum*, *Peucedano–Pinetum*) the canopy is composed of spruce and Scotch pine *Pinus sylvestris*.

We restricted our study to the managed part of the BF.

Methods

During our study we focused on deciduous forest subcompartments because they represent a subset of the study plots surveyed by Wesołowski (1995b). In early spring 2005, we chose a sample of 75 square plots within the study area (each plot was a quarter of a forest compartment ca. 28.4 ha) where in 1991 WbWs were recorded by Wesołowski (1995b; Fig. 1). Because a territory of one pair is larger than one square kilometer (Wesołowski 1995a), we also included neighboring subcompartments if they

were covered by deciduous stands. Between 23 March and 4 April, we played back drumming of the WbW in these subcompartments, as was done in 1991: observers walked along division lines, stopped every 533 m and played back drumming for up to five minutes. The use of the tape recording increased the detection rate five times (Wesołowski 1995b). Consequently, we recorded the presence (or absence) of all heard or seen WbWs. This method was described in detail by Wesołowski (1995b).

In July 2005 we measured habitat within 13 of the subcompartments where WbWs were detected, and in 16 where they were absent. We selected 50 × 50 m samples within these subcompartments (one sample per one subcompartment). Firstly, they were randomly selected on the map, then found in tree stands. Next, within those samples we described all trees, with DBH ≥ 4 cm (DBH = diameter at breast height). This DBH limit was set accordingly with our observations of the foraging WbW — the thinnest tree used by WbW as foraging tree had 4 cm of DBH (own unpubl. data). The following parameters were recorded: tree species, tree condition (alive, standing dead, downed log), and DBH of all standing trees. We described snags in greater detail with the following: height and percentage of bark was estimated.

Because many downed logs are broken into several pieces, we took the following measurements of each piece: two diameters if they were > 10 cm, length, percentage of bark cover, and decay classes (1–4 scale, based on Maser *et al.* 1979):

1. hard wood with intact bark cover,
2. hard wood with some parts without bark,
3. medium-soft wood, almost without bark,
4. soft wood with a friable texture, without bark.

The second diameter of snags was extrapolated from the data on fallen logs. Next, we calculated the volume of dead wood using the formula for the volume of a cut away cone:

$$V = 1/3\pi h(R^2 + Rr + r^2)$$

where h = height or length of a tree, R and r = two radiuses calculated from the tree diameters. Then, we compared characteristics of subcompartments with and without the recorded presence of white-backed woodpeckers in 2005 using the following parameters: density of alive and dead trees, deciduous trees, proportion of tree species, density of spruces and alders, volume of dead trees, average DBH of trees, percentage of bark on the snags and decay class of downed logs. Dead spruces were considered special because they are a very important foraging substrate of the WbW in the BNP (own unpubl. data).

Differences in dead tree species frequency distribution were compared with the *G*-test (Sokal & Rohlf 1981). For other statistical comparisons the Mann-Whitney test was used. The importance of habitat parameters was analysed with logistic regression. This method is distribution free and can thus include both discrete as well as contribution variables. The best logistic regression model, with the highest overall percentage of correctly classified observations was determined using stepwise procedure. All these calculations were performed with Statistica 7.0 (StatSoft Inc. 2005).

Results

We recorded the WbW only in 25 forest subcompartments (Fig. 1). Subcompartments where the WbW was not detected contained significantly less dead wood (Table 1). The number of thick snags (> 20 cm DBH) was over three times lower in the areas where woodpeckers were absent as compared with those where they were recorded (5.0 and 17.2 h^{-1} respectively, $z = 2.78$, $P < 0.01$; Fig. 2). The volume of downed logs in subcompartments without woodpeckers was around one-sixth of that in the compartments where WbWs were recorded (3.5 and 23.0 $m^3\ h^{-1}$ respectively, $z = 3.46$, $P < 0.001$). Similarly, the volume of snags was one-fifth (5.4 and 27.4 $m^3\ h^{-1}$ respectively, $z = 2.46$, $P = 0.014$, Fig. 3).

Alder was the most common dead tree within subcompatments where WbWs were recorded (on average 40%). Differences between the share of dead trees within woodpecker and non-woodpecker samples were significant ($G = 13.90$, df = 6, $P < 0.05$; Fig. 4). Other characteristics (number of alive trees, number of all snags,

Table 1. A comparison of stand characteristics where the white-backed woodpeckers were present (WbW) with those where they were not recorded (No WbW).

Variable	Avg. ± SD WbW	Avg. ± SD No WbW	Median WbW	Median No WbW	Range WbW	Range No WbW	Z	*P*
Downed logs volume (m^3 ha^{-1})	23.0 ± 26.42	3.5 ± 3.92	14.9	2.4	1.8–101.5	0–13.1	3.46	0.001
Snags volume (m^3 ha^{-1})	27.4 ± 45.42	5.4 ± 4.27	9.4	4.8	0.2–137.8	0.05–17.4	2.46	0.014
Total dead wood volume (m^3 ha^{-1})	50.4 ± 62.59	8.9 ± 6.67	30.6	8.3	2.0–221.2	0.3–25.7	3.20	0.001
Number of all snags ha^{-1}	112.3 ± 88.31	82.3 ± 77.51	84.0	52.0	16–328	8–252	1.27	0.204
Number of snags (> 20 cm DBH) ha^{-1}	17.2 ± 21.06	5.0 ± 4.95	12.0	4.0	0–84	0–16	2.78	0.005
Number of deciduous snags (> 20 cm DBH) ha^{-1}	14.8 ± 20.55	4.3 ± 3.99	8.0	4.0	0–80	0–12	2.46	0.014
Number of spruce snags (> 20 cm DBH) ha^{-1}	2.5 ± 2.60	0.8 ± 2.18	4.0	0.0	0–8	0–8	2.19	0.029
Number of alder snags (> 20 cm DBH) ha^{-1}	14.8 ± 19.76	7.0 ± 17.62	12.0	0.0	0–72	0–68	2.00	0.460
Number of alive trees (> 20 cm) ha^{-1}	249.2 ± 67.50	290.5 ± 62.57	268.0	292.0	96–340	168–388	1.53	0.125
Number of alive alders ha^{-1}	176.6 ± 201.88	69.8 ± 184.7	12.0	0.0	0–624	0–668	2.04	0.041
DBH of snags	12.8 ± 3.95	10.7 ± 4.29	11.9	9.3	6.8–19.2	6.0–24.0	1.80	0.072
DBH of alive trees	17.1 ± 4.24	16.5 ± 3.97	17.5	15.6	10.9–27.4	10.9–24.2	0.31	0.759
Bark on snags (%)	77.5 ± 16.57	72.5 ± 16.22	81.2	71.9	37.8–94.7	42.0–97.0	0.92	0.357
Decay class of logs	2.6 ± 0.49	2.5 ± 0.48	2.6	2.5	1.2–3.1	1.5–3.5	1.15	0.250

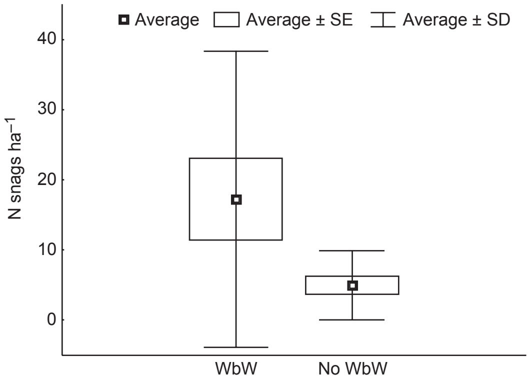

Fig. 2. Average number of snags (> 20 cm DBH) on studied samples.

average DBH of trees, percentage of bark on the snags and decay class of downed logs) did not differ significantly between woodpecker and non-woodpecker samples (Table 1).

The logistic regression model including eight parameters (log volume, snag volume, total dead wood volume, density of alive alders, density of all snags > 20 cm DBH, deciduous snags, alder snags and spruce snags) showed significant differences between woodpecker and non-woodpecker plots. The complete set of parameters correctly classified 76.9% of plots occupied by the WbW and 93.8% where this species was not recorded (χ^2 = 19.77, df = 7, P = 0.011). When using only one variable (in the optimal model) — total dead wood volume — the model correctly classified 69.2% and 93.8% of plots, respectively (χ^2 = 15.47, df = 1, P < 0.001).

Discussion

The alder was the most common tree species among dead wood in subcompartments where the WbW was present. This results from the fact that the WbW was found, as previously recorded by Wesołowski (1995b), mostly in ash–alder stands. It is accepted that this species prefers swampy stands (e.g. Aulén 1988). However, in the strictly protected part of the BNP, the WbW is almost as common in lime–hornbeam as in ash–alder stands (Wesołowski 1995a). The differences in distribution of the WbW in those two forest types are enhanced in the managed part of the BF by sylvicultural practices (Wesołowski *et*

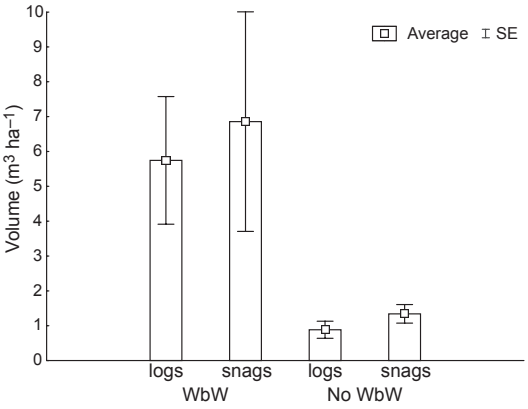

Fig. 3. Average volume of downed logs on studied samples.

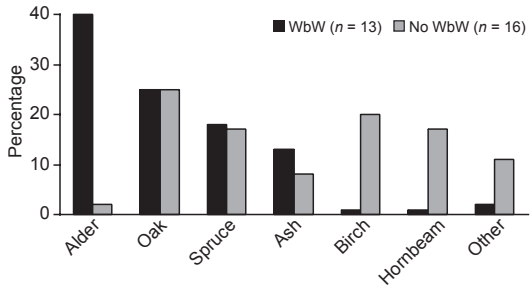

Fig. 4. Share of dead wood on studied plots according to tree species.

al. 2003). Swampy places are usually the least intensively managed and left to be thinned or cut last because access is limited to the period when the ground is frozen (Wesołowski 1995b).

Between 1991 and 2005 the number of forest subcompartments where the WbW was present fell by two thirds. In 1991 in the whole Polish part of the BF 115–130 pairs of WbW bred including ca. 30 pairs in the BNP (Wesołowski 1995b). The number of WbWs breeding in primeval stands of the BNP seems to be stable (Wesołowski *et al*. 2003) but our woodpecker survey from the managed part of the BF indicates a dramatic decrease in the population size of this woodpecker. Moreover, our results suggest that this decline is linked to heavy logging and removal of dead wood from this part of the BF.

The WbW occupied the stands where the amount of dead wood was large. However, patches rich in dead wood quickly disappear from the managed BF. There still exists some patches of old-growth in the managed BF where density of thick snags is only slightly lower than in the primeval deciduous stands of the BNP. However, the volume of logs in the BNP is much higher (at least 3–5 times; own unpubl. data) than in the managed stands where we recorded the WbW. It appears that the primeval conditions of the BNP are optimal for this species as the number of breeding pairs remained stable between 1991 and 2001 (Wesołowski *et al*. 2003).

Carlson (1998) found that the WbW condition depends on the density of dead deciduous logs. Among all European woodpeckers, the WbW most frequently forages on downed logs (Matsuoka 1979, Aulén 1988, own unpubl. data). Recently, Gjerde *et al*. (2005) demonstrated a strong positive relationship between the occurrence of this species and the amount of snags. In the strictly protected part of the BNP nearly half of the volume of dead wood is composed of spruce, and on this species the WbW very often forages (own unpubl. data). In the other part of the BNP logged till 1996, many infested spruces and many aspens (*Populus tremula*) are still being removed (Walankiewicz & Czeszczewik 2005, Wesołowski *et al*. 2005). In the managed stands of the BF, foresters quickly remove all infested or dying spruces. In this way, the state forestry impoverishes feeding conditions of the endangered WbW.

Conservation implications

Because the WbW strongly depends on dead wood, the best way to keep its BF population in good condition would be to stop logging in patches of old-growth stands. It seems that the Polish part of the BF including that in the BNP is the core area of the WbW population. In the Belarussian part of the BF, according to a rough estimate, only 20–50 pairs of the WbW bred in 1991 (Wesołowski 1995b). Logging of that part of the forest started a few years ago.

We recommend that in deciduous stands a minimum density of snags (> 20 cm DBH) should be 17 ha^{-1}, and the volume of the downed logs (> 10 cm diameter) at the level of 23 m^3 ha^{-1}. These are average values found in stands studied by us in the BF where the WbW recently

occurred. This is in accordance with the results of our earlier work (Walankiewicz *et al*. 2002), in which we recommended to leave the same number of snags to maintain density of all woodpeckers as in primeval stands of strict reserve of the BNP. Such thicker snags (especially deciduous species) are also useful for the WbW as nesting trees — the minimum DBH of a nesting tree in the BNP was 26 cm (Wesołowski 1995a), therefore it is important to leave also older dead and dying trees in stands.

We found the WbW only in one-third of the subcompartments where they occurred in 1991 (Wesołowski 1995b). Our study plot covered only about 38% of subcompartments outside the BNP where the WbW were recorded 14 years before. It is necessary to do another inventory of this species within the whole BF. It seems that after 10 to 15 years of logging, the number of WbW in the managed BF decreased considerably — perhaps one third of the previous population has survived. This shows that intensive exploitation of the BF led to the shrinkage of the habitats suitable for the endangered WbW. As with other species, the WbW needs a certain minimum population to survive. If the rate of logging in the BF continues at its current rate, we expect that within the next 10–20 years all suitable stands within the managed part will be logged.

The new management plans accepted in 2003 (to be enforced until 2011, Regionalna Dyrekcja Lasów Państwowych 2003) increased logging quotas to about 150 000 m^3 $year^{-1}$. The full execution of these plans will result in an almost complete disappearance of the old-growth remnants in the BF (Wesołowski 2005). The 30 pair breeding population in the BNP is not big enough for survival of this bird in the entire BF — this has been shown in Sweden and Finland where the situation of this species is also critical (Aulén & Carlson 1990, Tiainen 1990, Virkkala *et al*. 1993). The area of the BNP (105 km^2) is too small to support a viable population of the WbW. What is worse, in a half of the BNP dying or dead spruces and aspens are still removed. The existing nature reserves are not excluded from cutting ("sanitary" or "management").

Moreover, forests in northeastern Poland and in western Belarus, as well as most other Polish forests, provide very little habitat for the species due to "normal" management (Angelstam *et al*. 2002, Sikora & Rys 2004). Safeguarding the few remaining patches of the unlogged forest in the BF must be a top priority as these are of vital importance for the WbW's survival. The best way to achieve this is enlargement of the BNP on the whole Polish BF (Wesołowski 2005).

The Polish government does not recognize the importance and urgency of the matter and has done nothing to stop logging. This inaction is not due to a lack of knowledge. Every Polish government in the last 15 years was informed about the problem by the most authoritative conservation bodies in Poland. Inaction is also not due to a lack of money — refraining from logging is not an economic loss. Discontinuation of logging in natural forests would diminish the volume of timber produced by Polish forestry by < 0.3%. Actually, abandoning forestry operations would be economically beneficial (Wesołowski 2005).

The conservation prospects of the WbW in managed stands of the BF are bleak in the light of its foraging habits on insects living in dead wood (Matsuoka 1979, Aulén 1988), which will soon disappear due to intense management. Sadly, the European Union is also turning a blind eye to its vanishing primeval forests and its old-growth specialist the white-backed woodpecker (Wesołowski 2005).

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