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Effects of forest management on Three-toed Woodpecker *Picoides tridactylus* distribution in the Białowieża Forest (NE Poland): conservation implications

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Abstract. Distribution of Three-toed Woodpeckers and that of dead wood were mapped in two fragments of the Białowieża National Park (BNP) differing in their management history — primeval (old-growth stands of natural origin, no human intervention) and logged (as the former but subject to 80 years of commercial forestry). Data were collected during the breeding seasons 1999–2001. In the end of April 2000, the whole BNP was systematically searched; playbacks of drumming were used to enhance detection of birds. Presence/absence of Three-toed Woodpeckers and of dead wood (standing and downed Norway spruces and snags of other trees) were recorded within each forest sub-compartments (ca. 28 ha). Data from censuses done in smaller plots in 1975–1999 showed that in the primeval forest the woodpeckers bred twice more frequently in swampy and coniferous forests than in the oak-hornbeam habitat. These preferred habitat types covered larger areas in the logged fragment than in the primeval part (66% vs. 41%). Yet despite this, Three-toed Woodpeckers were recorded there over twice less frequently (14% of 176 sub-compartments) than in the primeval (36% of 164 sub-compartments) part. These differences followed sharp contrasts in the dead wood availability; all but one sub-compartments in the primeval fragment contained some form of dead wood, whereas dead spruces were missing in almost 30% of sub-compartments in the logged part. This was the effect of continuous "sanitary" logging, purposeful removal of dying and dead spruces from the Forest. To restore Three-toed Woodpecker habitats it is necessary to ban removal of dead spruces in the managed part of BNP. However, the BNP area is too small, to assure the long-term survival of the Białowieża Forest population. To achieve this, it is necessary to resign from removal of dying and dead spruces in the whole Polish part of the Białowieża Forest (600 km^2). This would create breeding habitat for a maximum 260–320 pairs.

Key words: Three-toed Woodpecker, *Picoides tridactylus*, conservation of endangered species, primeval forest, dead wood, snags

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INTRODUCTION

Three-toed Woodpecker is widespread in the boreal and alpine coniferous forests of the Palaearctic zone, especially in forests dominated by spruce *Picea* spp. It requires dead coniferous trees both for foraging and for excavating holes (reviews in Glutz von Blotzheim & Bauer 1980, Cramp 1985, Ruge 1997). In Poland it is a scarce breeder (ca. 200 pairs) restricted to large forests containing substantial amount of Norway Spruce *Picea abies* in the Carpathian Mts. (*P. t. alpinus*) and in the NE part of the country (*P. t. tridactylus*). The Białowieża Forest constitutes the Polish stronghold of the boreal subspecies (Tomiałojć & Stawarczyk 2003, Wesołowski 2005).

The dependence on dead wood brings Three-toed Woodpeckers in direct conflict with the interests of forest managers, for whom dying and dead — especially spruce — trees constitute largely a threat to timber production interests. Therefore, managers are keen to remove dying spruces as

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soon as they appear, so as to minimise amount of dead spruce wood in the forest. These widespread practices have resulted in a serious deficit of dead wood in most European forests dominated by spruce (Scherzinger 1995, Siitonen 2001, Gutowski et al. 2004, Hanski & Walsh 2004). Local extinctions of Three-toed Woodpeckers observed in several places of Europe (reviews in Glutz von Blotzheim & Bauer 1980, Cramp 1985, Ruge 1997, Tomiałojć & Stawarczyk 2003) were usually explained by habitat destruction due to these intensive "sanitary loggings". However, except of Amcoff & Eriksson's (1996) field study, these were mostly post-hoc explanations not based on direct observations.

Here we present results of a study carried out in the Białowieża Forest (NE Poland), where patches of primeval lowland temperate forest, untouched by forestry operations have survived (Tomiałojć et al. 1984, Faliński 1986). Large scale timber extraction begun in the Forest less than a hundred years ago, and the currently managed fragments did not initially differ from the retained parts in terms of climate, soils, history or plant and animal communities (Faliński 1986, Bobiec et al. 2000, Tomiałojć & Wesołowski 2004). This offers a — unique in the temperate zone — opportunity to observe differences between the "control" (no direct human intervention) and "experimental" (managed) areas and allows one to assess impact of man-made changes on biological phenomena.

To assess effects of forestry on Three-toed Woodpecker and its habitats we gathered systematic data on distribution of woodpeckers and availability of dead wood in the two neighbouring parts of the Białowieża National Park differing in history of their management: 1) the primeval fragment (strictly protected since 80 years, reference area) and 2) the logged fragment — formerly commercially managed area, included into the Park only few years before the study period. We use results of these comparisons to propose measures necessary for assurance of the long-term survival of Three-toed Woodpecker in the Białowieża Forest.

STUDY AREA

The Białowieża Forest complex is situated at the Polish-Belarusian border (52°41'N, 23°52'E). Its western part (613 km^2, ca. 41% of the area) belongs to Poland. The Forest represents a relic remnant of the vast lowland forests that once covered great parts of temperate Europe. Its present unique features result from its considerable size, great compactness and exceptionally good state of conservation (Tomiałojć et al. 1984, Faliński 1986, Tomiałojć & Wesołowski 1990, 2004). Though traces of human presence from as early as the Neolithic period are known, intensive timber-cutting did not start there before the beginning of this century. The majority of tree stands in the Polish part are now under management, but a 47.5 km^2 block of best preserved primeval stands has been since 1921 strictly protected within the Białowieża National Park (hereafter referred to as BNP).

The stands preserved in BNP are distinguished from those in other temperate forests by the following features: they are multi-storey, mixed-species, uneven-aged, composed of trees reaching unusual heights (the tallest Norway Spruces reach 55 m, several other species 42–45 m) and contain large amount of dead and uprooted trees. Detailed descriptions of the primeval habitats, as well as their photos, are given in Tomiałojć et al. (1984), Faliński (1986) and Tomiałojć & Wesołowski (1990) thus only a brief review of the most important features of the main habitats present is given below.

Oak-hornbeam stands (*Tilio-Carpinetum*) are most structurally diversified ones. They are composed of a dozen or so species of trees (Hornbeam *Carpinus betulus*, Lime *Tilia cordata*, Pedunculate Oak *Quercus robur*, Norway Spruce, Continental Maple *Acer platanoides*), being extremely diverse regarding the age and size of trees. Several stands as a whole are over 200 years old, with many trees 250–400 years old. Volume of dead wood amounts to 100–150 m^3/ha (Bobiec 2002).

Swampy deciduous stands (*Circaeo-Alnetum*, *Carici elongate-Alnetum*) are less stratified, canopy composed mostly of Alder *Alnus glutinosa*, Ash *Fraxinus excelsior* and Spruce. The highest number of fallen logs is characteristic of this habitat type. Volume of dead wood is similar to the previous habitat.

In coniferous stands (*Querco-Piceetum*, *Pineto-Quercetum*, *Peucedano-Pinetum*) canopy is composed of Spruce and Scotch Pine *Pinus sylvestris* with an admixture of birches *Betula* spp. and some oaks. Amount of dead spruce wood (mainly snags or logs) is highest of all habitats (Walankiewicz 2002).

The Park was enlarged in 1996 by inclusion of 57.5 km^2 of formerly commercially exploited

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stands (Fig. 1). The newly included part contains the same forest types as the primeval one and the mature old-growth stands are still similar to the primeval ones. They are mostly of primeval origin (self-sown) and have remained multi-species and uneven-aged. However, snags and fallen trees have been continuously removed from them. The main difference stems from the presence of clearings and young tree plantations in the logged fragment, that are absent in the primeval part. Tree stands younger than 60 years cover about 23% of the newly included fragment.

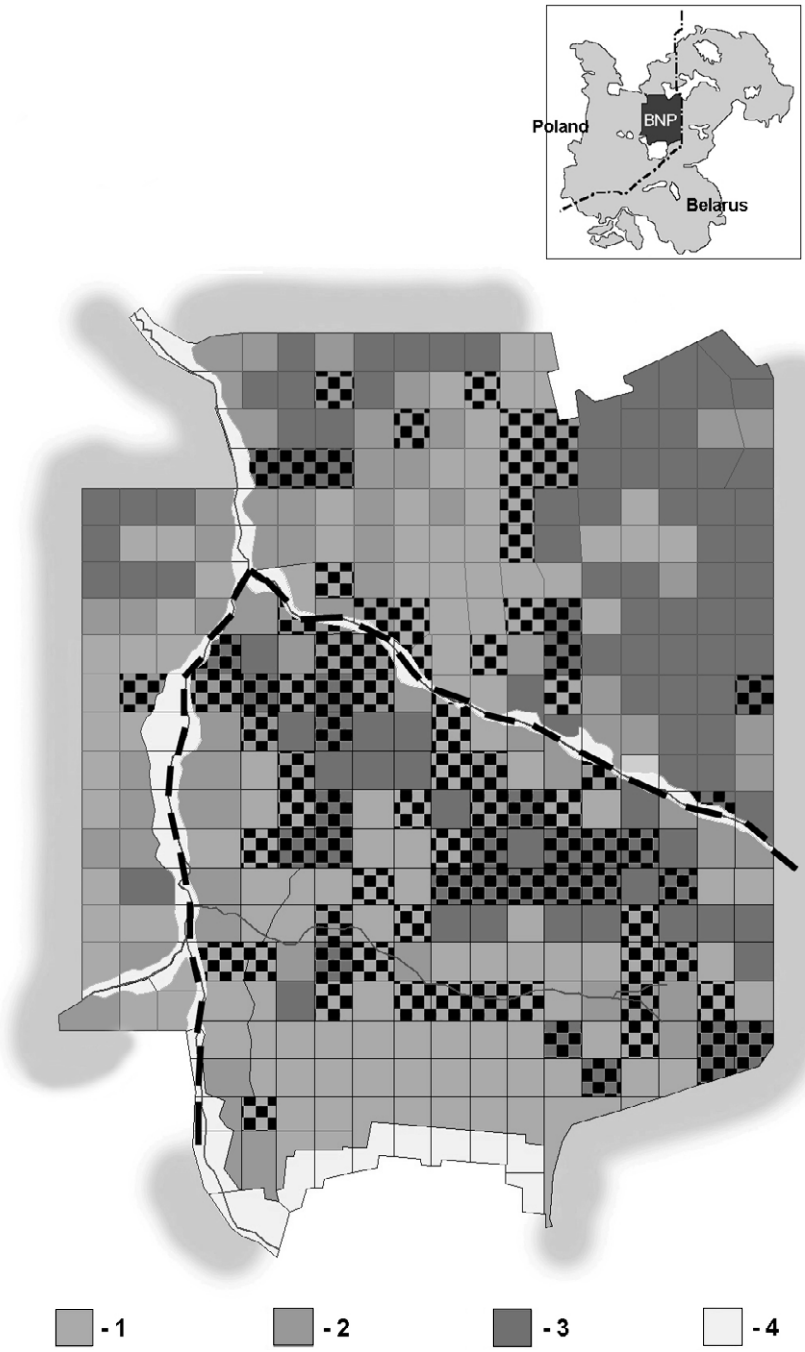


Fig. 1. Localization of the Białowieża National Park within the Białowieża Forest (inset) and distribution of *Picoides tridactylus* (dotted) within the Park in relation to habitat and type of management. For every sub-compartment (typically 533 x 533 m) the prevailing vegetation type is shown: 1 — deciduous, mostly oak -hornbeam forest, 2 — coniferous forest, 3 — wet deciduous forest, 4 — meadows. Thick broken line separates the strictly protected part (SE fragment) from the logged areas (N and W fragments).

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MATERIALS AND METHODS

For management purposes, Białowieża Forest is divided into 1066 (one verst) x 1066 m compartments which, as a rule, are further divided into four parts. This results in a regular network of ca 533 x 533 m squares (sub-compartments). The partition lines between them are shown both on forestry maps and they are marked in the field. We took advantage of this system, and used the sub-compartments (typically 28.4 ha) as sampling units. There were 164 of them in the primeval and 176 in the logged part of BNP. For each of these units we attempted to gather data on the presence of Three-toed Woodpeckers and presence of dead wood.

Data on woodpeckers

Presence of Three-toed Woodpeckers was recorded in the field during a general faunistic inventory of BNP in 1999–2001 (Wesołowski et al. 2003), but 83.6% of 122 observations origin from 2000 when special efforts were made to map distribution of this species in BNP. The whole area of BNP was systematically covered on April 15–29, 2000. This corresponded to the late pre-breeding period of this species (Wesołowski & Tomiałojć 1986). The sub-compartment partition lines constituted the base of transects to be covered by observers. The transects were designed so that the two neighbouring lines ran half-compartment (533 m) apart. This produced a good coverage of the whole area, neither spot in BNP was further than 300 m away from the transect route. While walking along the transect, an observer followed the division line, stopping at each crossing of sub-compartment lines (every 533 m) to play-back there records of Three-toed Woodpecker. After "drumming" for up to 5 min the observer walked to the next point. Whenever Three-toed Woodpecker was heard or seen, independent if along transect or from the play-back point, the observer put its localization on a field map. As a rule observations started early in the morning and were continued till midday.

In the analysis all breeding season (= April 15–June 15, Wesołowski & Tomiałojć 1986) records were pooled. All sub-compartments in which the birds were recorded within this period were classified as used by Three-toed Woodpeckers.

Habitat data

Information on presence/absence of dead wood in the forest was gathered during a leafless period of 2000 in the logged part and in 2002 in the primeval fragment. The observers walked the same transects used for Three-toed Woodpecker survey (see above) and recorded — within the visibility distance — presence/absence of three forms of dead wood:

– dead spruce: tree with the DBH > 15 cm; in various stages of decay from freshly dead ones, still with brown needles, to barkless trunks without branches,

– uprooted tree: upwards protruding rootpad of a fallen tree, diameter of disc > 1 m; such large rootpads belonged mostly to fallen spruces,

– snag: standing trunk of other tree species, no branches, DBH > 15 cm, height > 2 m.

In the logged part, data on dead wood were recorded separately for each management unit (> 1 ha) identified within a subcompartment on the forestry maps. If some form of dead wood was recorded in any such unit within a subcompartment it was classified as the one containing the respective form of dead wood. In the primeval part, where borders between management units were often blurred, not easily detectable in the field, the data were recorded only at the subcompartment level.

Data on forest types were extracted from official inventory and management plans of local forestry authorities Browsk, Białowieża (logged part) and those of BNP (primeval fragment) (Anonymous 1995 and unpubl.). Three classes of forest habitats were distinguished. All stands dominated by coniferous trees (described as BMśw, BMw, BMb, Bw, Bśw, Bb on the forestry maps) were classified as "coniferous". Stands dominated by deciduous trees were classified either as "oak-hornbeam" (categories Lśw, LMśw, LMw, Lmb) or "swampy" (Ol, OlJ, Lw).

Statistical procedures followed the formulas given in STATISTICA package (Anonymous 1996). All probabilities presented in the text are two-tailed χ^2.

RESULTS

Three-toed Woodpeckers were recorded over twice more frequently in the primeval (36% of 164) than in the logged part (14% of 176 sub-compartments, $\chi^2 = 21.6$, $p < 0.0001$, Fig. 1). In the primeval part woodpeckers used the

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oak-hornbeam patches for breeding twice less frequently, than the coniferous or swampy ones (Table 1, $\chi^2 = 33.1$, df = 2, $p < 0.0001$). As the area covered by various habitats differed substantially between the two fragments (Table 2), this could bias the contrast. Therefore, to get a more valid comparison, we calculated the expected number of records in the logged fragment, assuming that individual habitats were occupied by woodpeckers with the same frequency as in the primeval fragment (Table 1), and taking into account different proportion of habitat types in the logged part (Table 2). So calculated theoretical value amounted to 72, i.e. 41% of occupied subcompartments, about 2.9 times more than the actually observed value of 14% ($\chi^2 = 31.4$, $p < 0.0001$). In other words, we found Three-toed Woodpeckers in hardly a third of subcompartment predicted to contain them in the logged fragment, if there had been no management.

Table 1. Frequency of *Picoides tridactylus* breeding in different habitats in the primeval part of BNP. Summed data from all permanent study plots (25–33 ha each) within a habitat, for all years in the period 1975–1999. Results from individual seasons within each plot were taken as data points — extracted from Tomiałojć et al. (1984), Tomiałojć & Wesołowski (1994, 1996) and Wesołowski et al. (2002).

Habitat type	No of observations	Breeding of *P. tridactylus*	
		N	%
Oak-hornbeam	85	26	30.6
Swampy	52	37	71.2
Coniferous	53	39	73.6

Table 2. Share of different forest habitats in the primeval and logged fragments of BNP (from the Forest Management and Inventory Plans — Anonymous 1995 and unpubl.).

Habitat type	Primeval		Logged		Logged/ primeval ratio
	Area (ha)	%	Area (ha)	%	
Oak-hornbeam	2657	58.3	1586	33.8	0.6
Swampy	873	19.2	1480	31.6	1.7
Coniferous	1028	22.6	1625	34.6	1.6

Dead, standing or fallen spruces were recorded in over 90% of subcompartments in the primeval part (Table 3), and all but one subcompartment contained at least one form of dead wood. Dead wood was observed significantly less frequently in the logged fragment, in almost 30% of sub-compartments no dead spruces or uprooted trees were found (Table 3).

A more fine-grained approach, analysis of presence of deadwood at the level of management units in the logged part, showed that dead spruces were present in only 34–42% of them (Table 4), and that every form of dead wood was least frequently found in the coniferous habitat. The difference was significant in the case of snags ($\chi^2 = 55.1$, df = 2, $p < 0.0001$) and of uprooted trees ($\chi^2 = 110.5$, df = 2, $p < 0.0001$, Table 4).

Table 3. Frequency (%) of subcompartments with different forms of dead wood in the primeval and logged fragments of BNP.

Attribute	Primeval (N = 143)	Logged (N = 168)	χ^2	p
Dead spruce	93.7	72.0	24.6	< 0.00001
Uprooted tree	96.5	73.2	13.2	0.0006
Snag	97.9	83.9	36.1	< 0.00001

Table 4. Frequency of management units containing different forms of dead wood in relation to habitat in the logged part of BNP.

Habitat type	N	Percentage of units containing:		
		Dead spruce	Snag	Uprooted tree
Oak-hornbeam	223	42.1	68.2	63.1
Swampy	214	41.7	50.2	38.1
Coniferous	264	34.1	34.1	16.3

DISCUSSION

We used very crude, low resolution methods to collect data. A single record of drumming Three-toed Woodpecker was sufficient to classify a whole sub-compartment (ce. 30 ha) as occupied. Similarly, presence of even one dead spruce was enough to rank a subcompartment as one containing dead wood. Such qualitative, presence/absence methods, based on short-term observations tend to produce "noisy" results and are quite conservative. Using them it is very difficult to detect any but the largest scale disparities. On the other hand, if a difference is found, it most probably reflects the existence of the real biological dissimilarities.

Dead spruces, standing and downed were much less common in the logged fragment than in the primeval part. This deficit was especially pronounced in the preferred by woodpeckers coniferous habitat. This shortage was presumably much more severe than indicated by our qualitative

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comparisons, probably of magnitude found in other studies done in the Białowieża Forest. Walankiewicz et al. (2002) observed that standing dead trees (> 20 cm DBH) were five times less numerous in the managed forest outside the National Park, and Bobiec (2002) found that dead wood constituted 18–31% of wood biomass in the primeval oak-hornbeam and swampy forest but only 1–2% in the commercially exploited patches of the same habitats. The deficit of dead spruce wood was partially due to replacement of old-growth stands by young tree plantations, but as tree stands aged below 60 years covered about 23% of the logged fragment, this could not account for all the deficit. To large extent the shortage of dead spruces was caused by their selective removal in so called "sanitary cuttings" aimed at controlling bark beetle *Ips typographus* numbers.

Three-toed Woodpeckers were much scarcer in the logged fragment (14% of subcompartments) than in the primeval part. Accounting for differences in proportion of habitats between the forest parts, the woodpeckers were almost three times less widespread in the logged fragment, than they would have to be there, if the forest stands retained the primeval features. In other words two thirds of potentially utilisable area remained uninhabited by the birds. As the two fragments of BNP do not differ in any other important respect (see Introduction) except for different management history, we conclude that the deficit of Three-toed Woodpeckers in the logged part is due to habitat destruction by forestry operations.

Conservation implications

Three-toed Woodpecker's restricted distribution in the logged fragment of BNP is due to shortage of dead spruces; hence the only way for the improvement of their status is via restoration of dead wood stock. There is no problem on the supply side; action of several mortality agents (strong winds, insects, fungi) constantly provides substantial quantities of new dead spruce (review in Gutowski et al. 2004). There is, however, no possibility for this wood to accumulate in the forest, as it is immediately removed as a "threat to the forest health". To improve situation these practices must be immediately stopped, the more so that destroying Three-toed Woodpecker habitats is forbidden by law (Polish bill on nature protection, Bern Convention, EU's Bird Directive, Wesołowski 2005).

Refraining from "sanitary" logging of dying spruces in the BNP constitutes a necessary first step, but it would not be sufficient to ensure the long-term survival of Three-toed Woodpecker in the Białowieża Forest. This specialised species requires large areas for living. In Sweden Three-toed Woodpeckers need 100–400 ha/pair (Amcoff & Eriksson 1996), in Switzerland their home ranges approach 200 ha (Bütler & Schlaepfer 2001) and in Germany a breeding pair needs ca. 90 ha in optimal habitat (Pechacek 2004).

It seems, thus, reasonable to assume that also in the Białowieża Forest, at least a 90 ha patch of the locally optimal habitat (coniferous and swampy forest) is required to accommodate a Three-toed Woodpecker pair and larger area in the oak-hornbeam habitat. This denotes, that even the full restoration of dead would supply within the currently logged fragment of BNP, would provide room for only ca. 35 breeding pairs. Thus, even under the most optimistic scenario, the whole area of BNP would provide living space for only ca. 50-60 Three-toed Woodpecker pairs. This figure is too small to assure the long-term survival of the Białowieża Forest population (review in Soulé 1987). To achieve this, it is necessary, to resign from removal of dying and dead spruces in the whole Polish part of the Białowieża Forest (600 km^2). Restoration of dead wood within this area would provide breeding habitat for 260–320 Three-toed Woodpecker pairs, what could offer a reasonable chance for this species persistence in the Białowieża Forest.

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STRESZCZENIE

[Wpływ gospodarki leśnej na rozmieszczenie dzięcioła trójpalczastego w Puszczy Białowieskiej: konsekwencje dla ochrony gatunku]

W latach 1999–2001 badano rozmieszczenie dzięcioła trójpalczastego i występowanie martwych świerków w Białowieskim Parku Narodowym. Obserwacje prowadzono w okresie przedlęgowym i lęgowym, w kwietniu 2000 wykonano specjalną kontrolę na całym terenie BPN z użyciem stymulacji magnetofonowej. Gatunek ten spotykany był ponad dwukrotnie częściej na ściśle chronionym obszarze (36% ze 164 ćwierć oddziałów) niż w zagospodarowanej części BPN (14% ze 176, Fig. 1). W borach i lasach podmokłych dzięcioły trójpalczaste gniazdowały wyraźnie częściej niż w grądach (Tab. 1). Uwzględniając różne udziały poszczególnych typów lasów w obu częściach BPN (Tab. 2) obliczono, że w części zagospodarowanej powinno być około 3 razy więcej dzięciołów niż obserwowano. Przyczyną takich różnic jest silna dysproporcja w ilości martwych świerków pomiędzy dwoma częściami BPN (Tab. 3). Szczególnie rzadko spotykano wszystkie trzy formy martwych drzew (obumierające, martwe stojące lub przewrócone) w zagospodarowanych borach (Tab. 4), gdzie prowadzone są najbardziej intensywne cięcia sanitarne, polegające na usuwaniu martwych drzew.

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Ograniczenie rozmieszczenia dzięcioła trójpalczastego w części zagospodarowanej wynika z braku martwych i obumierających świerków, dlatego najważniejszą metodą ochrony tego gatunku jest odnowienie tych zasobów. Aby zmienić tę sytuację, należy wstrzymać praktyki "poprawiania zdrowotności lasu" poprzez eliminację martwych drzew, gdyż prowadzą one do niszczenia siedlisk chronionego przez prawo gatunku — dzięcioła trójpalczastego. Samo wstrzymanie usuwania martwych świerków na terenie BPN nie zapewni jednak przetrwania tego dzięcioła, wymaga on bowiem bardzo rozległych terenów. Nawet w najlepszych warunkach jedna para potrzebuje w okresie lęgowym ok. 90 ha lasu. Zakładając, że w Puszczy Białowieskiej w borach i lasach podmokłych jedna para dzięciołów trójpalczastych wymaga takiego obszaru (i większego obszaru w grądach), w zagospodarowanej części BPN mogłoby występować tylko ok. 35 par tego gatunku. Nawet według najbardziej optymistycznego scenariusza, w całym BPN wystarczyłoby miejsca dla około 50–60 par lęgowych. Aby mówić o stabilnej populacji niezbędne jest stworzenie warunków dla ok. 260–320 par na całym obszarze Puszczy. Oznacza to, że aby gatunek ten mógł przetrwać, należy bezzwłocznie zaprzestać usuwania martwych świerków na terenie całej Puszczy Białowieskiej.



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