

The White-backed Woodpecker *Dendrocopos leucotos* in Hungary: results of a two-year nationwide survey

Márton MOLNÁR^{1*}, Gerard GORMAN² & András SCHMIDT³



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Abstract This paper summarizes a two-year (2021 and 2022) survey which sought to determine the breeding population of White-backed Woodpecker (*Dendrocopos leucotos*) in Hungary. The survey was initiated by the Hungarian Woodpecker Group of MME/BirdLife Hungary and was the first to be conducted nationwide on this species. All hill ranges where the species was historically known to occur were visited. A total of 31 observers were involved, and 102 UTM squares in which White-backed Woodpeckers were known to breed, or potentially breed, were visited. The results suggest that the Hungarian breeding population of this endangered species ranges between 480 and 800 pairs.

Keywords: White-backed Woodpecker, *Dendrocopos leucotos*, population size, umbrella species, intensive forest management

Összefoglalás A fehérhátú fakopáncs (*Dendrocopos leucotos*) magyarországi állomány nagyságának megállapítását célzó két éves (2021–2022) országos felmérés eredményeit összegezzük. A felmérést a Magyar Madártani és Természetvédelmi Egyesület Harkályvédelmi Szakosztálya szervezte. Ez volt a fehérhátú fakopáncs vizsgálatára irányuló első országos léptékű kutatás. Minden olyan régióban zajlott a felmérés, ahol ismert vagy feltételezett volt a faj jelenléte. Összesen 31 önkéntes felmérő vett részt a munkában, amely során 102, 2,5×2,5 km-es UTM négyzetet mértünk fel. Az eredmények alapján e veszélyeztetett faj magyarországi állományát 480–800 költő párba becsüljük.

Kulcsszavak: fehérhátú fakopáncs, *Dendrocopos leucotos*, populáció méret, esernyőfaj, intenzív erdőgazdálkodás

¹ Coordinator of the White-backed Woodpecker Working Group, Hungarian Woodpecker Group, BirdLife Hungary 1121, Budapest, Költő utca 21., Hungary

² Independent Picid Researcher, Hungarian Woodpecker Group, BirdLife Hungary 1121, Budapest, Költő utca 21., Hungary

³ Head of Natura 2000 Unit, Department for Nature Conservation, Ministry of Agriculture, 1055 Budapest, Kossuth Lajos tér 11., Hungary

* corresponding author; e-mail: marcipalkata@gmail.com

Introduction

The White-backed Woodpecker *Dendrocopos leucotos* is distributed entirely within the Palearctic region. Its range covers three eco-climatic regions: the temperate, Mediterranean and boreal. It occurs from northern Spain and southern France (the Pyrenees) in the west, central Italy (the Abruzzi) and the Balkans in the south, Scandinavia in the north and eastwards through Russia and Asia to Japan (Gorman 2014). The species is polytypic with twelve subspecies recognised (Gill *et al.* 2023). The nominate *D. l. leucotos* occurs in

Hungary. This species has been studied in several countries (although mostly in Europe) and pertinent data from these studies are included in this paper.

The species inhabits a variety of forested habitats across its range, mostly deciduous (Wesołowski 1995, Grangé *et al.* 2002), but also mixed deciduous-coniferous (Fernández & Azkona 1996). In parts of Russia, forests dominated by conifers are sometimes inhabited (Dementiev & Gladkov 1966), but in general, stands of pure conifer, such as plantations of Norway spruce *Picea abies*, are avoided (Hämäläinen *et al.* 2020). White-backed Woodpeckers are strongly associated with stands of mature deciduous trees and deadwood. Numerous studies from different countries have shown that large areas of unmanaged old-growth forest with a high proportion of deadwood, standing and fallen, are typically required for both foraging and breeding (Håland & Ugelvik 1990, Costantini & Melletti 1992, Grangé 1993, Virkkala *et al.* 1993, Hogstad & Stenberg 1994, Bernoni 1995, Mikusiński & Angelstam 1998a, 1998b, Frank 2002, Håpnes 2003, Melletti & Penteriani 2003, Pavelka 2003, Garmendia *et al.* 2006, Czeszczewik 2009, Gerdzhikov *et al.* 2018, Schwaiger & Lauterbach 2019, Urkijo-Letona *et al.* 2020, Bühler 2021). In Hungary, this woodpecker is only found in hill forests (Gorman 2021, Gorman *et al.* 2021), typically where there are native deciduous tree species older than 60–70 years and a minimum volume of 20 m³/ha of deadwood (Szmorad *et al.* 2018). However, White-backed Woodpeckers also occur in less optimal managed forests in Hungary where there is a close to natural regeneration, with sufficient rotting timber. This is also the case, for example, in Scandinavian forests where management is nominal (Aulén 1988, Aulén & Carlson 1990).

The global population of the White-backed Woodpecker is not precisely known but is considered to be large with most of the population occurring in the eastern part of its range. European populations occupy around 35% of the global range, with a breeding population of 232,000–586,000 pairs estimated (BirdLife International 2023). A preliminary estimate of the total world population size has been made of 1,320,000–3,350,000 adult birds, although validation of this estimate is needed (BirdLife International 2023). The European range is fragmented, particularly in the west of the continent where the species is often very localised and overall trends have often been unclear. Despite some local increases, populations were reported to be declining in several European countries in recent decades, for example in Poland (Wesołowski & Tomiałojć 1986), Sweden (Aulén 1988), Germany (Scherzinger 1990), Norway (Håland & Ugelvik 1990), Finland (Virkkala *et al.* 1993, Martikainen *et al.* 1998), Spain (Fernández & Azkona 1996) and Latvia (Krams 1998). Yet, the overall European trend is now considered to be stable (Lanz *et al.* 2020). The main reasons for the local declines of the species are the loss of old-growth deciduous forests and inappropriate forestry management (Carlson 2000, Håpnes 2003, Sabatini *et al.* 2018). The Red List of the International Union for Conservation of Nature (IUCN) categorises White-backed Woodpecker as *Least Concern* (BirdLife International 2023). Owing to the forest habitat types in which it thrives, the White-backed Woodpecker can be considered an umbrella species, as its occurrence is linked to the presence of many other species (flora, fauna and fungi) of high conservation concern (Roberge *et al.* 2008).

White-backed Woodpecker is the most range-restricted member of the Picidae in Hungary, the only species from the nine that occur to be assigned ‘Strictly Protected Species’ status

(Gorman *et al.* 2021). In Hungary, as elsewhere, intensive forest management, which often involves the introduction of non-native tree species, clear-cutting, fragmentation, felling of mature trees and the removal of deadwood, is a widespread problem (Szmorad *et al.* 2018). For example, in a study of 25 nesting cavities in Hungary, carried out in the Aggtelek, Bükk and Zemplén hills, Gorman (2021) found that all cavities were in dead deciduous trees (snags) or in decaying sections of living trees.

Logging in protected areas, even in the spring during the breeding season, has resulted in a reduction in the number of woodpeckers. Before the survey documented here was conducted, the size of the Hungarian breeding population was estimated to be between 260–670 pairs (Gorman *et al.* 2021).

The survey had two main aims. First, to determine, as precisely as practical, the size of the Hungarian breeding population based on samples from all known subpopulations. Second, to determine the presence or absence of the White-backed Woodpecker in all of the regions where the species was said in the literature to have occurred in recent years, including those places from which it may have later disappeared.

Materials and Methods

Study area

Kőszeg hills

This is the westernmost area of White-backed Woodpecker distribution in Hungary, with an approximate size of 4,400 ha. The nearest population in the country to here is found some 90 km to the east in the Bakony range, hence, within Hungary, Kőszeg can be considered geographically isolated. A large part of the hills is covered by suitable forest, especially beech (*Fagus sylvatica*) stands (Bölöni *et al.* 2011), and a substantial area (4,200 ha) is protected (Kőszegi Tájvédelmi Körzet/Kőszegi Landscape Protection Area).

Bakony hills

The Bakony range is the largest in area of the Transdanubia ranges, covering some 400,000 ha. Thus, we believed that this area had the potential to hold a relatively high population of the species. Although the total area of potential habitat is large, the Bakony is quite isolated owing to the surrounding landscape being mostly open and flat farmland. The climate of these hills is favourable for deciduous tree species, especially beech (*Fagus sylvatica*), therefore many suitable White-backed Woodpecker habitats are present (Bölöni *et al.* 2011). A substantial part (8,753 ha) of the area is protected (Magas-Bakonyi Tájvédelmi Körzet/Bakony Landscape Protection Area), and thus, it is also favourable for White-backed Woodpeckers as forest management is not overly intensive.

Vértes hills

The Vértes is located to the east of the Bakony hills. We considered the habitats of this area to be suboptimal for White-backed Woodpeckers as there are no large continuous areas of

suitable habitat. Although the Vértes is around 31,000 ha in size, stands of mature deciduous trees, particularly beech, only exist in small patches (Bölöni *et al.* 2011). Historically, White-backed Woodpeckers have probably never been common in the area and only a few anecdotal observations have been made in recent decades (Riezing & Gorman 2023). For these reasons, we presumed that the forests here could only support an exceedingly small population, or perhaps no pairs at all. Furthermore, this notion is supported by the fact that the surrounding open habitats mean that the Vértes hills are isolated.

Gerecse hills

The Gerecse is located to the north-east of the Vértes. It can be considered quite isolated as it is mainly surrounded by open habitats except to the south-west where the Vértes hills are located only a few kilometres away. Although the Gerecse is around 85,000 ha in size, favourable forests are found only in isolated patches compared to that of the other regions where stable populations exist (Bölöni *et al.* 2011).

Pilis and Visegrád hills

These hills cover approximately 30,000 ha and include large tracts of suitable beech forests (Bölöni *et al.* 2011). Besides having large suitable habitats, a sizeable proportion of the area is protected (Duna-Ipoly National Park). All in all, the area has the capacity to sustain a remarkable population of White-backed Woodpecker.

Börzsöny hills

The Börzsöny is the westernmost range of Hungary's Northern Hills and covers approximately 60,000 ha. Suitable deciduous forest habitats, particularly with mature beech, are common (Bölöni *et al.* 2011) and a sizeable proportion of the area is protected (Duna-Ipoly National Park).

Karancs-Medves hills

This region is a small, approximately 6,700 ha, area in northern Hungary by the Slovakian border. It is rich in mature beech forests, thus, the capacity to hold a significant population of White-backed Woodpecker exists. A sizeable part of the area is protected (Karancs-Medves Tájvédelmi Körzet/Karancs-Medves Landscape Protection Area). It is also favourable for White-backed Woodpeckers, because forest management is not overly intensive in its protected areas. Furthermore, the population of the species here is not isolated, as there are similar protected habitats close by on the other side of the Hungarian-Slovakian border in a protected area (CHKO Cerová Vrchovina).

Mátra hills

This range of around 90,000 ha is located in the centre of the Northern Hills. Suitable deciduous forest habitats, particularly with mature beech, are widespread and much of the area is protected (Mátrai Tájvédelmi Körzet/Mátra Landscape Protection Area). In addition, the Mátra is favourable for White-backed Woodpeckers, because forest management is not overly intensive in its protected areas. Furthermore, the forests here are not isolated as they are bordered to the north, west and east by other well-forested areas.

Heves-Borsod, Uppony and Putnok hills

In this paper, we discuss these hilly regions together because they are quite similar in their habitats and are adjacent to one another. They are located in the northeast of Hungary and have a combined area of approximately 90,000 ha. They are typified by low average altitudes (300–400 meters) which means that only a few isolated patches of suitable habitat for White-backed Woodpecker exist, usually on northern slopes where there are stands of beech. These hills are surrounded on all sides by other well-forested areas.

Bükk hills

The Bükk is located in the centre of the Northern Hills. Besides being large in size (approximately 100,000 ha), this range also has the largest average altitude in Hungary, with fifty peaks rising above 900 meters. This has resulted in extensive areas of beech forest and hence many suitable habitats for White-backed Woodpecker (Bölöni *et al.* 2011). Thus, one of the largest populations in the country was expected. This expectation was verified by the data in the Hungarian Bird Atlas database. A large area of the range is protected as the Bükki National Park and is connected to other large forest habitats to the north and west.

Aggtelek karst

Aggtelek is located to the north of the Bükk hills and lies on the Slovakian border. It is quite large, approximately 120,000 ha, with many suitable deciduous forest habitats, particularly of mature beech. A sizeable proportion (19,890 ha) of this area is protected by the Aggtelek National Park where forest management is relatively non intensive, and thus, favourable for White-backed Woodpeckers. Aggtelek adjoins the forests of the Slovak Karst protected area, in Slovakia, where extensive suitable habitats for the species also exist.

Zemplén hills

This range is located in the very northeast of Hungary and covers approximately 100,000 ha. Suitable deciduous forest habitats, particularly with mature beech, are widespread (Bölöni *et al.* 2011). The presence of White-backed Woodpeckers in this range is well-known anecdotally, however, no detailed data on the population of the species has ever been published. Nevertheless, on the basis of field observations, a large population was presumed in the Zemplén's forests. The area also adjoins extensive suitable habitats in neighbouring Slovakia. Much of the centre and north of the range is protected as the Zempléni Tájvédelmi Körzet/Zemplén Landscape Protection Area.

Outline of the survey

The methodology used was based on the survey protocol used in the project “Strategic studies to underpin the protection of biological diversity, natural and landscape features” (KEHOP 4.3.0-VEKOP-15-2016-00001) as described in the Bird Atlas of Hungary (Szép *et al.* 2021), with slight adjustments made in order to consider the characteristics of the target species. Sample units were 2.5×2.5 km UTM squares. The UTM squares where White-backed Woodpecker was known to have occurred in recent years were collected for each

subpopulation, and surveyors selected the squares to be actually visited. Random selection of squares was not possible as all surveyors were volunteers and the accessibility of squares also had to be considered.

Ideally, a minimum of two surveys were conducted in each selected square, one between 1 March and 20 April, and another between 21 April and 5 June, in the morning hours from dawn to noon. In twenty-six squares, only the first survey was conducted due to a lack of human capacity, and because experience had shown that the first survey period was much more significant in terms of finding the species. During each survey, all parcels of the square (each 2.5×2.5 km UTM square is divided into 25, 500 x 500 m parcels) that potentially held White-backed Woodpecker habitat (parcels covered at least partially by mature, approximately at least 50-year-old deciduous forest based on visual observation and/or Google Maps satellite photos) had to be visited by the surveyor (excluding inaccessible areas, such as fenced areas, restricted access areas, etc.). The two surveys were to be conducted along differing routes, wherever it was possible, and at least one week apart. The aim was to find as many individuals of White-backed Woodpecker as possible and try to establish the number of occupied territories (that is, at least one specimen seen) within the square. The use of playback (of calls and drumming) was allowed as a possibility to increase detection rates, but surveyors' attention was drawn to take care to avoid unnecessary disturbance. The use of playback was not standardised as to instrument or call type used or to spatial distribution of playback use, as the goal was not comparison of detection rate with other surveys, but to achieve as high detection rate as possible while avoiding unnecessary disturbance. All observations (both acoustic and visual) of the species were to be recorded with the following data: date, coordinates and breeding evidence code (the four main categories of which are unlikely, possible, probable and certain) of the Bird Atlas of Hungary project (Szép *et al.* 2021).

After the completion of their surveys, the surveyors were obliged to submit the observation data of the target species, and also an estimate for the minimum number of occupied territories within the square. In some cases, surveyors gave a range for the estimated number of territories (for example, 3–5 territories), in which case the minimum number was used for the calculation of the national population. Surveyors were also asked to upload their data to the online database of the Bird Atlas of Hungary project.

In those regions where the main goal of the survey was to simply determine the presence or absence of the White-backed Woodpecker (such as the Pilis, Visegrád, Gerecse and Vértes hill ranges) the full-scale survey according to the protocol was not obligatory in order to optimise the use of capacities. Rather, the remaining habitats in those areas that were considered to have the highest potential to still hold White-backed Woodpeckers, were to be covered as thoroughly as possible in the breeding season. Nevertheless, eleven squares in these regions were surveyed according to the full protocol.

Methodology for the estimation of the national population and pair densities

Minimum estimation of breeding pairs

The number of occupied territories found within the framework of the survey + the number of further UTM squares in which the species had been seen since 2010 based on the Hungarian

Bird Atlas, assuming that a minimum of one pair still occurred in each of those squares. At the beginning of the survey, it was decided to collect data from the last 10 years because forest management planning works in 10-year cycles in Hungary.

Maximum estimation of breeding pairs

The arithmetic mean of occupied territories within the surveyed UTM squares of each region was multiplied by the number of UTM squares in the given region in which White-backed Woodpecker had been observed since 2010, taking into account habitat suitability of each square in the following way: UTM squares in which more than 75% of the area was considered to be suitable habitat were counted in their entirety (with the arithmetic mean of the observed territories of the surveyed UTM squares). UTM squares in which 25–75% of the area was considered to be suitable habitat were given a factor of 0.5, and UTM squares in which 10–25% of the area was considered to be suitable habitat were counted as holding only one pair.

Habitat unsuitability in the UTMs was estimated from the percentage of open habitats, villages, and other areas based on the map of the Hungarian Bird Atlas. In addition, forest tree species communities were checked from the National Forest Map database (www.erdoterkep.nebih.hu). From this the percentages of unsuitable and suitable habitats were estimated, considering Turkey oak (*Quercus cerris*) woodlands, coniferous stands and black locust (*Robinia pseudoacacia*) plantations as unsuitable habitats for the White-backed Woodpecker. Large clearcuts visible on the satellite map were also omitted from the calculation as unsuitable areas. Area calculations were based on the forest parcel areas provided in the National Forest Map database and using the area gauge function of the database.

Estimation of pair densities and extent of occupied habitats

According to the number of estimated breeding pairs found and the number of surveyed UTM squares, we calculated the average number of breeding pairs in a single UTM in each region. Subsequently, we changed this to a breeding pairs/100 ha of occupied/potential habitat value in order to avoid pitfalls such as multiplying the estimated density with the total area of a region. Using only occupied/potential habitat areas to estimate densities also allowed us to compare densities between the different regions and also with data from other European populations.

In addition, we calculated minimum and maximum densities in each region and the lowest and highest numbers of breeding pairs found in each UTM and changed this to breeding pairs/100 ha of occupied/potential habitat value.

We also estimated the approximate extent of the occupied habitats for White-backed Woodpecker in each region. All squares in which White-backed Woodpecker have been observed since 2010 were considered as occupied.

Finally, the correlation between average density and the approximate extent of occupied habitats was investigated using Microsoft Excel 2013 programme.

Results

According to the Hungarian Bird Atlas database and our survey undertaken in 2021–2022, we found 308 UTM squares in Hungary in which White-backed Woodpecker had been present since 2010 (*Figure 1*). Breeding evidence is probable in all of these squares except three from the Vértes where we determined that the species is now extirpated (if it ever bred there at all). This decision seemed to be verified by the lack of observations during our survey. In conclusion, we identified 305 UTM squares in Hungary in which White-backed Woodpeckers likely breed.

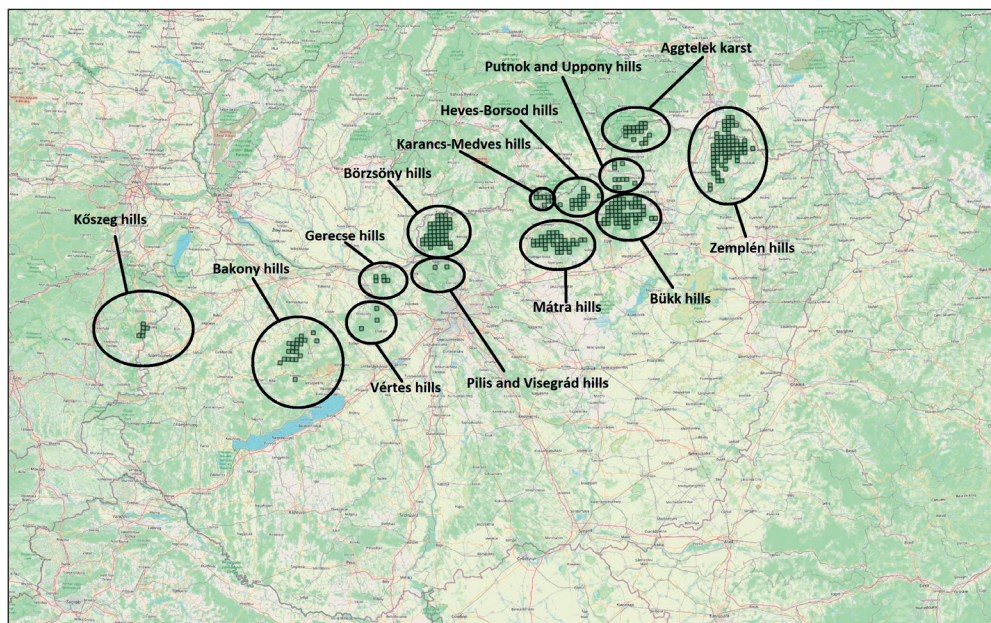


Figure 1. UTM squares by region in which White-backed Woodpecker has been observed since 2010
 1. ábra UTM négyzetek régióknként, amelyekben a fehérhátú fakopáncs előfordulása ismert 2010 óta

During the survey, we investigated a total of 85 UTM squares from the 306 in which White-backed Woodpecker certainly breeds (*Figure 2*). These UTM squares are located in all the regions of Hungary inhabited by the species. We found a total of 267 territories in these squares. A further 17 UTM squares were surveyed in regions from which we had no, or very few, historical observations such as the Vértes, Pilis and Cserhát Hills.

The results of the estimation of the Hungarian White-backed Woodpecker population suggest a breeding size of 480–800 pairs (*Table 1*). The average density of White-backed Woodpecker in Hungary was estimated at 0.49 breeding pairs/100 ha with a minimum of 0.16 and a maximum of 1.44 breeding pairs/100 ha (*Table 2*). We found a correlation between the extent of occupied habitat and average breeding pair density (*Figure 3*). Below we discuss the results from each forested region separately.

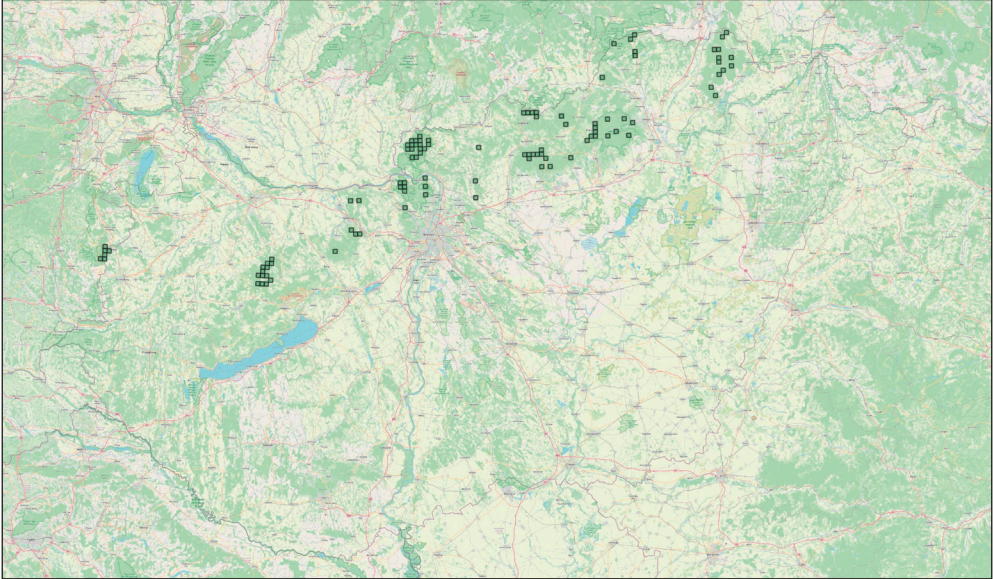


Figure 2. Surveyed UTM squares
2. ábra Felmért UTM négyzetek

Table 1. Estimations of the number of White-backed Woodpecker breeding pairs across Hungary
1. táblázat A magyarországi fehérhátú fakopáncs fészkelő állományok becslése

Region surveyed	Minimum number of breeding pairs	Maximum number of breeding pairs
Kőszeg hills	16	16
Bakony hills	36	38
Vértes hills	0	0
Gerecse hills	0	5
Pilis and Visegrád hills	0	5
Börzsöny hills	87	129
Karancs-Medves hills	14	16
Mátra hills	69	110
Heves-Borsod, Uppony and Putnok hills	33	47
Bükk hills	85	158
Aggtelek karst	30	47
Zemplén hills	110	229
Total:	480	800

Table 2. Extent of suitable White-backed Woodpecker habitats and breeding pair densities in the surveyed areas in Hungary

2. táblázat A fehérhátú fakopáncsok számára alkalmas élőhelyek és a felmért területek nagysága régióként, a költőpárok denzitásával

Region	Suitable habitat (ha)	Surveyed area (ha)	Minimum density (pairs/100 ha)	Maximum density (pairs/100 ha)	Average density (pairs/100 ha)
Kőszeg hills	3,750	3,750	0.32	0.8	0.43
Bakony hills	13,750	8,125	0.16	0.8	0.33
Vértess hills	–	2,500	–	–	–
Gerecse hills	–	1,250	–	–	–
Pilis and Visegrád hills	–	5,625	–	–	–
Börzsöny hills	30,000	10,625	0.16	1.28	0.54
Karancs-Medves hills	5,625	3,125	0.32	0.32	0.32
Mátra hills	24,375	6,875	0.16	1.28	0.6
Heves-Borsod, Uppony and Putnok hills	16,875	1,875	0.16	0.8	0.48
Bükk hills	35,000	7,00	0.16	1.44	0.53
Aggtelek karst	11,875	3,125	0.16	0.8	0.51
Zemplén hills	45,000	7,500	0.16	1.12	0.67

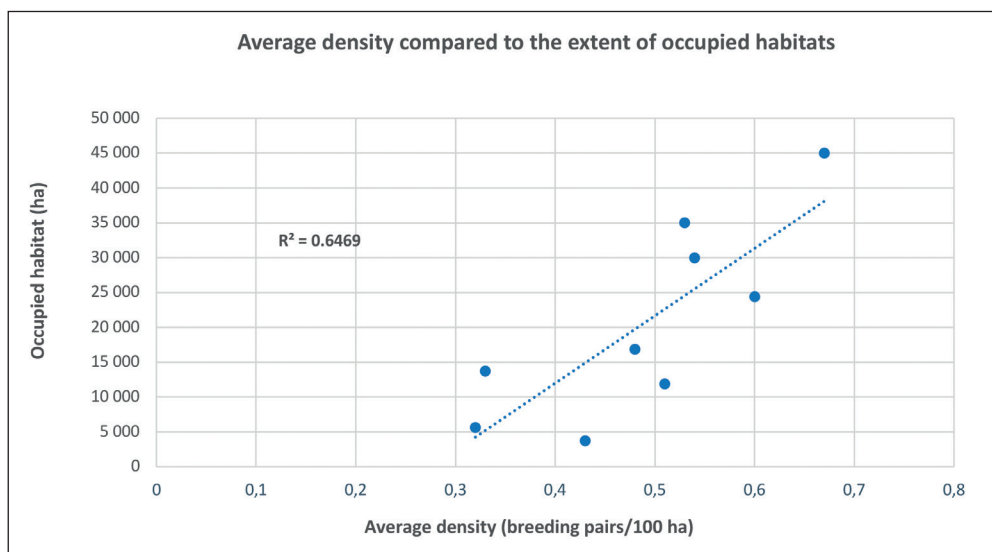


Figure 3. Comparison of the density of White-backed Woodpecker breeding pairs and the extent of occupied habitats in each region

3. ábra A fehérhátú fakopáncs költőpárok denzitásának összefüggése az alkalmas élőhelyek kiterjedésével régióként

Kőszeg hills

We found 6 UTM squares where the species was likely to breed. All 6 squares were visited, and 16 territories found. Thus, a total of 16 breeding pairs were estimated to reside in this area. Indeed, Kőszeg was the only area where we were able to survey 100% of the potential habitats, and thus, it is likely that the most precise local data of all was from this population. Average density was estimated at 0.43 breeding pairs/100 ha with a minimum of 0.32 and a maximum of 0.8 breeding pairs/100 ha. The extent of occupied habitats was 3,750 ha.

Bakony hills

We identified a total of 22 UTM squares where the species had been seen since 2010. A total of 13 squares were visited and 27 territories found. Taking this data into account, we estimated the average number of pairs in a UTM here to be 2.08. Most of the UTM squares held just 1 or 2 pairs as they were often partly covered by unsuitable habitats. UTM squares at the tops of hills tended to have larger areas of suitable deciduous habitat, mainly beech forests, and hence the highest number of territories (5) was found here.

On the basis of the survey, we estimated a minimum of 36 and a maximum of 38 breeding pairs in this region. Density was estimated at 0.33 breeding pairs/100 ha with a minimum of 0.16 and a maximum of 0.8 breeding pairs/100 ha. 13,750 ha of occupied habitat was determined.

Vértes hills

We found 4 UTM squares where the species had been observed since 2010. A total of 4 UTM squares were visited but no White-backed Woodpeckers were found. We were not able to calculate density and occupied habitat size, owing to the lack of observations.

Gerecse hills

A total of 5 UTM squares were found where the species had been observed since 2010. During the survey, two of these were visited but no White-backed Woodpeckers were found. We were not able to calculate density and occupied habitat size owing to the lack of observations.

Pilis and Visegrád hills

A total of 2 UTM squares were found where the species had been observed since 2010. A total of 9 UTM squares were surveyed, and one adult male White-backed Woodpecker found. We were not able to calculate density and occupied habitat size owing to the low number of observations.

Börzsöny hills

In this region, 47 UTM squares in which the species had been seen since 2010 were identified. A total of 17 UTM squares were surveyed, and 57 White-backed Woodpecker territories were found. The highest number in a single UTM square was 8, which was not surprising owing to the many stands of deciduous forest habitats, particularly with mature

beech. The average number of pairs in a UTM was 3.35. Thanks to the high number of participants, the survey in these hills covered a sizeable proportion of the potential White-backed Woodpecker habitat. We estimated a minimum of 87 and a maximum of 129 breeding pairs. Density was estimated at 0.54 breeding pairs/100 ha with a minimum of 0.16 and a maximum of 1.28 breeding pairs/100 ha. 30,000 ha of occupied habitat was determined.

Karancs-Medves hills

In this region, we found 9 UTM squares in which the species had been observed since 2010. During the survey, we visited 5 UTM squares in which 10 White-backed Woodpecker territories were found. The results were the same in all UTM squares surveyed, with 2 territories discovered in each square. Hence, the average number of pairs in a UTM was 2. In this region, we estimated a minimum of 14 and a maximum of 16 breeding pairs. Density was estimated at 0.32 breeding pairs/100 ha. The minimum and the maximum values were the same, and 5,625 ha of occupied habitat was determined.

Mátra hills

A total of 39 UTM squares were found in which the species had been observed since 2010. 11 UTM squares were surveyed, and 41 White-backed Woodpecker territories found. The highest number in a single square was 8. This was most likely due to the extensive mature forest stands in the core area. At the edges of suitable habitat, squares with just 1 or 2 territories were found. The average number of pairs in a UTM was 3.73. According to the results, we estimated a minimum of 69 and a maximum of 110 breeding pairs. Density was estimated at 0.60 breeding pairs/100 ha with a minimum of 0.16 and a maximum of 1.28 breeding pairs/100 ha. 24,375 ha of occupied habitat was determined.

Heves-Borsod, Uppony and Putnok hills

A total of 27 UTM squares were found in which the species had been observed since 2010. During the survey, 3 UTM squares were surveyed and 9 White-backed Woodpecker territories found. The highest number in a single square was 5. One of the squares held a single territory. The average number of pairs in a UTM was 3. In these hills we estimated a minimum of 33 and a maximum of 47 breeding pairs. Density was estimated at 0.48 breeding pairs/100 ha with a minimum of 0.16 and a maximum of 0.8 breeding pairs/100 ha. 16,875 ha of occupied habitat was determined.

Bükk hills

A total of 57 UTM squares were found in the Bükk in which the species had been observed since 2010. 12 UTM squares were surveyed, and 40 territories found. The highest number of territories in a single square was 9. Squares with just 1 or 2 territories were found mainly in forests at the edges of the area. The average number of pairs in a UTM was 3.3. We estimated a minimum of 85 and a maximum of 158 breeding pairs in this heavily forested range. Density was estimated at 0.53 breeding pairs/100 ha with a minimum of 0.16 and a maximum of 1.44 breeding pairs/100 ha. 35,000 ha of occupied habitat was determined.

Aggtelek karst

A total of 19 UTM squares where the species had been seen since 2010 were identified. 5 UTM squares were surveyed, and 16 territories found. The highest number of territories in a single square was 6. Squares with just 1 or 2 territories were also found. The average number of pairs in a UTM was 3.2. In this region, we estimated a minimum of 30 and a maximum of 47 breeding pairs. Density was estimated at 0.51 breeding pairs/100 ha with a minimum of 0.16 and a maximum of 0.8 breeding pairs/100 ha. 11,875 ha of occupied habitat was determined.

Zemplén hills

A total of 72 UTM squares in which the species had been seen since 2010 were identified. This is the highest number of all of the regions surveyed in Hungary. 12 UTM squares were visited, and 50 territories of White-backed Woodpecker found. The highest number in a single square was 7. Squares with only 1 or 2 territories were also found. The average number of pairs in a UTM was 4.16. A minimum of 110 and a maximum of 229 breeding pairs were estimated. Density was estimated at 0.67 breeding pairs/100 ha with a minimum of 0.16 and a maximum of 1.12 breeding pairs/100 ha. 45,000 ha of occupied habitat was determined.

Discussion

Kőszeg hills

The estimations for this area are the most precise from all of the regions surveyed as all potential habitats were visited. However, this is a small and isolated subpopulation with probably no connections to any others in Hungary (the nearest population in the country to here is found some 90 km to the east in the Bakony range) and therefore, can be considered vulnerable. Pair density was found to be lower than the national average in this region, and thus, the population is particularly at risk.

Bakony hills

These estimations are higher than earlier estimations for the area, which were determined during the establishment of the Northern Bakony Natura 2000 site (I1) and suggested 20–30 pairs. This earlier estimation was lower owing to an absence of thorough monitoring. Nevertheless, this subpopulation is small and isolated and therefore can be considered vulnerable. This is also confirmed by the fact that pair density in these hills is significantly lower than the national average, however the extent of occupied habitats is fairly large.

Vértes hills

The results of the survey (no birds found) led us to conclude that the White-backed Woodpecker is extirpated from the Vértes range. Indeed, evidence for this species having ever bred in this area is lacking. Nevertheless, it is possible that wandering individuals may, very occasionally, appear in the region (Riezing & Gorman 2023). To support the chance,

albeit slim, of the “return” of this woodpecker to the Vértes as a breeding species, the overall forest management policy would need to be reevaluated.

Gerecse hills

White-backed Woodpeckers are not known to have ever been common in the Gerecse and additionally very few observations have been reported in recent years. These facts suggested that at best the Gerecse could only sustain a small population of the species, however its total area, approximately 85,000 ha, is large. Being surrounded mainly by open land also means that the area is isolated.

Although no White-backed Woodpeckers were found in this range during surveys, recent observations suggest that a small population may persist. According to the Hungarian Bird Atlas database, breeding was confirmed in 2013 and 2015, and individuals were seen in the breeding season until 2020. In conclusion, we estimated 0–5 breeding pairs in the Gerecse, although further research is needed to clarify the situation.

Pilis and Visegrád hills

Knowledge of the White-backed Woodpecker here is historically scant. Only a few verified observations exist and there are no documented breeding records. Nevertheless, we believed that the paucity of observations did not rule out that a small population of the species could exist, owing to the suitable habitats that are available, and the fact that a fairly large population of 87–158 pairs resides just 10 km away in the Börzsöny range, albeit across the River Danube.

According to the results of the survey, the status of the White-backed Woodpecker in these hills is still unclear. Several areas of suitable habitat were extensively surveyed but no positive results obtained. This suggests that a sizeable population is not present. Indeed, only one individual, an adult male in the Visegrád hills, was found during the survey (Gorman *pers. obs.*). This leads to two scenarios: first, that an exceedingly small breeding population exists; second, that the species does not breed but remnant or vagrant birds occur. In conclusion, we estimated 0–5 breeding pairs for these areas combined, although further research is needed to clarify the situation. In the meantime, to support any potentially remaining small population, the prevailing forest management should be reviewed. Mature forest stands should be preserved, and less intensive practises implemented. Moreover, in those areas of forest where the species was most recently observed, forest management should cease or at least be minimized. Improving the condition of the forests of the Pilis and Visegrád hills is also worthwhile as an important population exists in the nearby Börzsöny range. Although this species is typically sedentary, dispersing individuals could potentially arrive from that area and if that were to occur, may remain if suitable forest habitats are present.

Börzsöny hills

Compared to most of the other ranges surveyed, the Börzsöny hills are well-researched ornithologically. White-backed Woodpecker has been studied here for decades and a fairly large population is known to exist (Schmidt 2000, Selmeczi 2010, Szekeres 2010, 2012).

Our estimation for this area is slightly higher than the earlier official one of 100 pairs, determined during the establishment of the Börzsöny and Visegrád hills Natura 2000 site (I2). The higher number reached probably reflects the more intensive surveying rather than an actual increase in numbers. The significant population size in these hills is complimented by the large extent of occupied habitats and high density of breeding pairs – the third highest of all regions. Therefore, we consider the Börzsöny population to be stable.

The low-intensity forest management practised in protected areas is also favourable for White-backed Woodpeckers. In addition, the forested habitats of the Börzsöny are not totally isolated as they are geographically close to those of the Cserhát, Pilis and Visegrád hills and also to the southernmost forests of central Slovakia.

Karancs-Medves hills

The presence of breeding White-backed Woodpecker in this small region has been known for some time (Drexler 1995, Rozgonyi 2000). Our estimation is slightly higher than the earlier official one which stated 6–12 pairs (Kiss *et al.* 2007). This higher number most probably does not reflect an actual increase in the population, but rather the more intensive surveying conducted. The lowest pair density of all regions was found here and there can be several reasons for this. One is the structure of the landscape: there are large open habitats within the forest. Second, forest management is highly unsuitable. In addition, as the whole area is small, suitable habitat patches are also small, and thus, are prone to being degraded or even totally destroyed. In conclusion, this small population and the small-sized habitats occupied are vulnerable as they are extremely sensitive to human activities. Nevertheless, geographical isolation is not necessarily a serious threat to this population as White-backed Woodpeckers also occur in the forests of neighbouring Slovakia (Kiss *et al.* 2007).

Mátra hills

According to the Hungarian Bird Atlas database and other publications, we presumed that this area would hold one of the largest populations of White-backed Woodpecker in Hungary (Czajlik & Harnos 2000). On the basis of this region's habitat characteristics, it was suspected that this population would be quite large. Our estimation is much higher than the earlier official one of 40–50 breeding pairs, determined during the establishment of the Mátra Natura 2000 site (I3). This considerable difference is a result of the lack of large scale research in the past. The significant population size is combined with a high pair density, the second highest of all regions, and large extent of occupied habitats. In conclusion, this range holds one of the largest populations in Hungary.

Heves-Borsodi, Uppony and Putnok hills

Although the overall combined area is quite large, the territories found are isolated, and thus, the population is vulnerable and threatened. The surveying activity here was the lowest of all areas which resulted in a major difference between the minimum and maximum population estimations. The forested habitat in these hills is very fragmented, and thus, conducting surveys is complex, hence further research is needed to clarify the estimate. The

population density in this region is almost the same as the national average, but nevertheless, is very fragmented and vulnerable. This is strengthened by the fact that the size of occupied habitats is also small.

Bükk hills

Surveying activity was low, with only a small proportion of the area covered. This resulted in a significant difference between the minimum and maximum population estimations and further research is therefore needed. Despite this, we found that the size of the White-backed Woodpecker population in the Bükk was slightly larger than the earlier estimation of 80–90 breeding pairs which was determined during the establishment of the Bükk hills Natura 2000 site (I4). The density is close to the national average. Favourable White-backed Woodpecker habitats exist here mainly because of the relatively low intensity of forest management practised in protected areas. In conclusion, this area has much occupied habitat (the second largest in the country) and a significant population of the species which can remain stable over the long term if the appropriate forest management is maintained.

Aggtelek karst

The presence of White-backed Woodpeckers in this hilly area was confirmed several decades ago (Bankovics 1987), but until recently, the population size of the species was still unclear. In 1999, only 3–6 pairs were estimated for the whole area (Horváth *et al.* 1999).

The estimation here is slightly higher than the official estimation of 30 pairs, determined during the establishment of the Aggtelek karst Natura 2000 site (I5). Such a survey of this species had previously never been done in this area which may explain the significant difference between the two estimations. The forest habitats at Aggtelek are connected to adjacent extensive forests in Slovakia and consequently the White-backed Woodpecker population here is not isolated. Thus, this population can probably persist and remain stable in the long term if its habitats are maintained. This is supported by the fact that the population density is a little higher than the national average.

Zemplén hills

Our survey supports the belief that this region holds the largest population of White-backed Woodpecker in Hungary. The figures estimated are significantly higher than the recent official estimation of 51–100 pairs, determined during the establishment of the Zemplén hills, Szerencs hills and Hernád-valley Natura 2000 site (I6). As in other regions, this difference can be explained by the lack of earlier large-scale surveys. The stark contrast between the minimum and maximum numbers is owing to the widespread distribution of White-backed Woodpeckers in this region and by the fact that due to the Zemplén's large size the coverage of our survey was relatively low. Further research is needed in order to enhance the estimation. As this local population is the largest in Hungary, its importance cannot be overstated. Population density and the extent of occupied habitats were both found to be the highest in this region and consequently can most likely remain stable in the long term.

The results of the first nationwide survey of the Hungarian White-backed Woodpecker population suggest an estimated population breeding size of 480–800 pairs. The survey

revealed that there are several, most likely stable, populations in the northern ranges of Börzsöny, Aggtelek, Mátra, Bükk and Zemplén. These populations form the bulk of Hungary's total population of this species. Smaller populations also inhabit the adjacent, less extensive and lower Karancs-Medves, Heves-Borsod, Uppony and Putnok hills. In addition, several geographically isolated populations exist in Transdanubia (Visegrád, Gerecse, Bakony and Kőszeg hills). All of Hungary's White-backed Woodpecker populations are vulnerable to changes in their habitats owing to the prevailing and widespread intensive forestry management methods. However, those in Transdanubia are particularly at risk as they are small in size and isolated (Schmidt 2009), which means that immigration into the gene pool is problematic (del Hoyo *et al.* 2020). Such isolated populations are susceptible to decline, as examples from elsewhere in Europe have shown (Aulén & Carlson 1990, Virkkala *et al.* 1993, Carlson 2000, Håpnes 2003). Consequently, decisive conservation action is needed in those areas. General forestry management methods should be reconsidered. Ideally, this would mean ceasing intensive forestry management entirely in areas where White-backed Woodpeckers occur. If this is not possible, then detrimental forestry practise should at least be reduced. For example, mature deciduous stands, especially beech dominated forests older than one hundred years, should not be logged but preserved and deadwood always left in place (Garmendia *et al.* 2006, Roberge *et al.* 2008, Frank 2018). Furthermore, in areas where White-backed Woodpeckers have become scarce, with only a few recent observations of individual birds, such as the Gerecse and Visegrád hills, forest management should be revised and, ideally, ended.

The overall population density of White-backed Woodpecker in Hungary turned out to be low (0.32–0.67) when compared to most other regions in Europe. A study from neighbouring Austria found 1.0–1.28 and 1.5–1.87 pairs/100 ha densities in two different regions of the Northern Limestone Alps (Weißmar & Pühringer 2015). Here the White-backed Woodpecker occurs in deciduous and mixed forests at altitudes between 400 and 1400 m, mainly between 600 and 1200 m. In the old beech forests of the Central Balkan Range, breeding density is estimated to 1.2 pairs/100 ha (Gerdzikov 2022). In Slovenia, at Gluha loza SPA, 0.6–0.9 pairs/100 ha density was estimated (Denac & Mihelič 2015). The results led us to two possible explanations. One is that the Hungarian population is an isolated population as the Great Hungarian Plain and connected open habitats are huge barriers for the species (Schmidt 2009). The suitable habitats (mainly beech or mixed forests) do not cover as large, continuous areas as those in higher elevation or northern regions. Such a peripheral population, with smaller suitable habitat sizes, can support pairs only at low densities. The second explanation is that forestry management is too intensive in Hungarian forests which results in suboptimal habitat conditions and subsequently lower densities. Ultimately, it is likely that the low densities of breeding pairs in Hungary is resultant from these two combined factors. Nevertheless, low density values are known from other countries, too. For example, in two areas in Slovenia 0.1–0.2 and 0.4 breeding pairs/100 ha were estimated (Denac & Mihelič 2015). In these cases, the low densities were probably also due to the edge-effect and unsuitable forest management, as in Hungary. In the Spanish Pyrenees a density of 0.38 breeding pairs/100 ha was reported (Fernandez & Azkona 2010).

In our study, we found that there is a correlation between the extent of occupied habitats and pair density. Quite simply, smaller population patches hold White-backed Woodpecker pairs at lower densities. This fact reveals that some subpopulations are particularly at risk. Geographic isolation is apparent in all subpopulations of the Transdanubian region, as well as in some of the northern subpopulations, as these hills are surrounded by open habitats, lowlands or intensively managed forests. This isolation renders them highly vulnerable (Ellegren *et al.* 1999), and as the White-backed Woodpecker is an extremely sedentary species (Schmidt 2009, Kirwan *et al.* 2022), immigration is unlikely. In addition, the small size of inhabited areas and low density of breeding pairs make these populations even more threatened.

In conclusion, the Transdanubian subpopulations and those in the Karancs-Medves, Heves-Borsod, Uppony and Putnok hills, face multiple threats. Thus, significant changes in forest management methods are urgent in these regions.

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