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Nest site characteristics of the Great-spotted Woodpecker in a bottomland riparian forest in the presence of invasive tree species

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Abstract This study was carried out in Hungary, in an old unmanaged riparian poplar-willow forest during the breeding seasons of 2014 and 2015. The occurrence of two invasive tree species, the green ash and boxelder, is significant in the study area, which influences negatively the populations of native riparian tree species in Central Europe. We studied Great-spotted Woodpecker nest sites in the presence of these invasive species. Throughout the study period, eight and twelve nesting cavity trees were mapped. Trees were recorded in 20-20 circular plots of 0.05 ha both for each mapped nest trees and random plots as well. Species, diameter at breast height and condition were recorded for each tree. Composition and diversity of nest site and random plots were compared. Distributions and preferences were calculated for nest tree use. Most of the recorded trees were invasive. Nest site plots had more native trees compared to random plots. Nest site showed higher diversity in terms of all three variables. Decayed and dead willow and white poplar hybrid trees were preferred for nesting. Diameter at breast height of nest trees was between 30–90 cm. Studies about cavity excavators in transformed habitats have high importance for nature conservation of riparian forests.

Keywords: Picidae, breeding, alluvial forest, green ash, boxelder maple

Összefoglalás A vizsgálatot 2014–2015-ben, egy kezeletlen folyó-menti fűz-nyár ártéri erdőben végeztük. A területen két invázios fafaj fordul elő, az amerikai kőris és a zöld juhar. A két faj Közép-Európa szerte negatívan befolyásolja az ártéri erdőkben őshonos fafajok állományait. A nagy fakopáncs költőterületét vizsgáltuk az említett invázios fafajok jelenlétében. A vizsgálati periódusban 8, illetve 12 költőodút térképeztünk fel. A fás vegetációt 0,05 hektáros, kör alakú mintaterületeken mértük fel 20 költőhelyen, illetve 20 random mintaterületen. Rögzítettük a fák faját, mellmagassági átmérőjét, kondícióját. A költő- és random mintaterületek összetételét és diverzitását hasonlítottuk össze. Mind a költőhelyeken, mind a random mintaterületeken a legnagyobb arányban a két invázios faj volt jelen, ám a költőterületeken gyakoribbak voltak az őshonos, és ritkábbak az invázios fajok a random mintaterületekhez képest. A költőhelyeken az idősebb, korhadt, illetve holt fák nagyobb elegyarányban voltak jelen. A költőhelyek diverzitása mindhárom vegetációs változó esetében nagyobb volt. A vizsgált faj egyedei költőodúk készítésére a korhadó, valamint holt fűz és szürke nyárfákat részesítették előnyben. Ezek mellmagassági törzsátmérője 30–90 cm-es között változott. Az odúkészítő fajokról szóló vizsgálatok az átalakult ártéri élőhelyeken nagy jelentőségűek a megfelelő természetvédelmi kezelések kidolgozásához.

Kulcsszavak: Picidae, költés, ártéri erdők, amerikai kőris, zöld juhar

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Introduction

Riparian forests maintain high natural and conservational value. These forests provide source-rich habitats for a high diversity of species. Alluvial forests also serve as green corridors for forest associated species to maintain their opportunities for dispersing. These habitats are highly threatened by river control management and inter alia invasive plant species. Numerous European rivers were regulated for economic reasons and their river beds were transformed to more straight statuses. In lowland Central Europe, riparian forests have two main distinguished types: the willow-poplar forests (softwood gallery forests), situated closer to the river bed; and further away, the oak-ash-elm forests (hardwood gallery forests). Distribution of hardwood gallery forests has drastically decreased as a result of river control, dam management or forest clearing for agricultural land use. Most softwood gallery forests of Hungary are composed of poplar and willow species with dominant native species like white poplar *(Populus alba)*, black poplar *(Populus nigra)*, white willow *(Salix alba)* and crack willow *(Salix fragilis)*. Because of their high genetic similarity, the Hungarian distribution of aspen *(Populus tremula)* and white poplar overlap; thus, hybrids with high variability and introgressive populations of poplars are present in the riparian forests. Due to the extensive distribution of planted hybrid poplar *(P. × euramericana)*, nowadays the majority of trees that resemble black poplar in these forests are most likely hybrids of black poplar and the planted Euamerican poplars (Haraszthy 2001, Gencsi & Vancsura 2002).

Floodplain forests are especially at risk of alien plant invasion because of the permanent propagulum supply and the presence of moist, nutrient-rich disturbed habitats which are very suitable for new establishment. Among the invasive tree species the green ash *(Fraxinus pennsylvanica)* and boxelder *(Acer negundo)* are the most notable mainly in the under- and midstorey level. Due to their abundant and effective dispersed fruits, rapid growth and good regenerative capacities, they have a strong transformative effect on the species composition of floodplain forests by hindering the renewal of native species, of which very few seedlings and saplings can be found in such forests. They influence the chemical traits of the soil and also develop a second canopy layer under the canopy of native trees and thus increasingly shade the ground preventing the saplings of the autochtonous trees from growing properly (Csiszár & Bartha 2008, Udvardy 2008, Erfmeier *et al.* 2011).

In North America, the green ash and the boxelder maple are considered to be mid-successional species as they live in an intermedier lane between the early-successional willow-poplar and the late-successional ash-elm riparian forests. Our focal species are present in the midstorey and the lower canopy layer of the two above-mentioned habitats. They tolerate the higher ground water levels and floods less and the droughts more than the willow and poplar species (Rumble & Gobeille 1998). In addition to the above-mentioned habitat preferences of the two species, the river control managements happened to be beneficial for the green ash and the boxelder maple as the floods are scarcer and the level of ground water is deeper. These species survive more successfully in the shade and grow better at the clearings of the source-rich European riparian forests, than the European willow and poplar species (Saccone *et al.* 2010, Porté *et al.* 2011). These species also produce allelopathic chemicals that can prevent the saplings of native species from developing properly (Csiszár 2009, Csiszár *et al.* 2013). As a result, there

are very few saplings of the native species in the study area, making these habitats more homogenous than one and a half century ago. Nowadays, aging poplar and willow trees and various generations of these two invasive species can be found simultaneously in these forests. This is a widespread environmental problem in the bottomland riparian forests of Central Europe (Mihály & Botta-Dukát 2004, Erfmeier *et al.* 2011).

Picid birds (Picidae) can be considered as keystone species playing key role in forest ecosystems (Gorman 2011). A total of 277 species are known worldwide, while only 11 species are native to Europe (9 of them are breeding in Hungary) (Lammertink 2014). These species live in woody habitats and feed mainly on arthropods. Cavity-excavator species can only breed in habitats where trees are old and thick enough to allow for the production of cavities within them (Gorman 2004). A high number of animal species depend on tree cavities. Among others, cavity-excavators can provide nesting opportunities for other cavity-dwelling species. Cavity-nester birds include ducks (Anatidae), owls (Strigidae), doves (Columbidae), flycatchers (Muscicapidae) and tits (Paridae) etc., while the most frequent mammalian cavity-dweller species are rodents (Rodentia) and bats (Chiroptera) (Bai *et al.* 2005, Politi *et al.* 2010). Apart from vertebrates, we can also find several examples for secondary cavity-dwelling invertebrates including wasps (Hymenoptera) or butterflies (Lepidoptera).To maintain the diversity of cavity-dwellers, it is essential to protect the cavity-excavators as well. Woodpeckers can be considered as umbrella species since through their protection it is possible to protect other species. Each woodpecker species has distinct habitat preferences in terms of both foraging and nesting. Habitat utilization studies of cavity excavator species can support the conservation of their secondary cavity-dweller species as well (Ross *et al.* 1997, Mazgajski 1998, Martin & Eadie 1999, Adkins Giese & Cuthbert 2003, Melletti & Penteriani 2003, Kosiński & Winiecki 2004, Martin *et al.* 2004, Kosiński *et al.* 2006, Pasinelli 2007, Roberge *et al.* 2008a, 2008b, Vaillancourt *et al.* 2008, Wan *et al.* 2008, Hebda 2009, Kozma 2009, Edman *et al.* 2011, Gorman 2011, Cooke & Hannon 2012).

Numerous works have examined the nest site use of certain woodpecker species (Mazgajski 1998, Kosiński & Winiecki 2004, Pasinelli 2007, Hebda 2009, Kozma 2009). Nevertheless, one can barely find any such studies that took place in habitats highly transformed by invasive plant species. There is an increasing need for such studies, as there are altered habitats worldwide with actual range expansion. According to climate change scenarios, habitat transformations will spread around the globe (Starzomski 2013).

There is a huge lack of knowledge about the mentioned, altered riparian habitats, though this environmental problem is considered to be widespread in Central Europe. Beyond the changes in vegetation characteristics, the fauna and so the cavity-nesting communities happened to be affected by this problem. The Great-spotted Woodpecker *(Dendrocopos major)* is the most common woodpecker species in Europe, being present with high densities in most woody habitats, thus making the most cavities. As a generalist species could have a crucial role in such altered communities as the main cavity-excavating species. For further understanding, it is important to study the habitat use of this species in such transformed habitats (Ónodi & Csörgő 2013, 2014).

The questions of our study were the following: Are there any compositional differences between the characteristics of nest site and random plots? What detailed characteristics do nest trees have?

Material and methods

Our study area was a 60–70-year old unmanaged riparian poplar-willow forest (cc. 35 ha) (N 47°04' E 20°11' – N 47°02' E 20°11') situated in the Central-Tisza Landscape Protection Area, which belongs to the Hortobágy National Park, in the floodplain area of the river Tisza *(Figure 1)*. The following native tree species were recorded: white poplar, black poplar, white willow, crack willow. Among the overstorey species, there are some introduced tree species in the area: green ash, boxelder maple, white mulberry *(Morus alba)* and common hackberry *(Celtis occidentalis)*. Among them, the green ash and the boxelder maple are known to be invasive plants as well. The midstorey consisted mainly of the saplings of the above mentioned invasive species. The other scrub layer species are European dewberry *(Rubus caesius)* and, at the edges, the North-American bastard indigobush *(Amorpha fruticosa)*.

Apart from the study species, the Great-spotted Woodpecker, three other woodpecker species are breeding in lower densities in the area: the Lesser-spotted Woodpecker *(Dryobates minor)*, the Green and the Black Woodpecker (*Picus viridis* and *Dryocopus martius*).

Bird census

Great-spotted Woodpecker nest trees were mapped in the breeding seasons of 2014 and 2015, as we followed the chirping begging calls of the nestlings (Kosiński & Winiecki 2004, Kosiński *et al.* 2006, Pasinelli 2007). 8 and 12 cavity trees were mapped, respectively. None of the nest trees of the latter year were reused from the former year.

Figure 1. Map of the study area (N47°04'; E 20°11' – N47°02'; E20°11')
1. ábra　A vizsgált terület térképe (N47°04'; E 20°11' – N47°02'; E20°11')

Vegetation survey

Characteristics of habitat were measured in 12.62 m radius circular plots (0.05 ha) centred on 20 active woodpecker nest trees and on 20 points, randomly selected from 32 semi-random plots on a 100 m by 100 m grid. Tree species, DBH (diameter at breast height) and condition of each tree were recorded in every plot. Only trees with DBH greater than 3 cm were recorded, because this value is supposed to be the minimum diameter of trees that support prey species for the Great-spotted Woodpecker (Gorman 2004).

Tree species were recorded according to the following categories: willow species (W.), black poplar and its hybrids (Pb.), white poplar and its hybrids (Pw.), green ash (A.), box-elder maple (M.), white mulberry (Mb.) and common hackberry (H.). In parallel with the current study, we have been gathering data on foraging microhabitat use of the studied species all year round. So that, both willow species were listed in one single category due to the very similar architecture and bark structure which makes difficult to identify the exact species when the branches are covered with snow.

Vegetation parameters were recorded after earlier studies on woodpecker nest site utilization (Hogstad 1971, Pettersson 1983, Török & Csorba 1986, Morrison & With 1987, Török 1990, Aulén & Lundberg 1991, Suhonen & Kuitonen 1991, Engstrom & Sanders 1997, Osiejuk 1998, Imbeau & Desrochers 2002, Pechacek 2006, Hogstad 2009, Czeszczewik 2010). Diameter at breast height was recorded in 10 cm intervals. The category for the thickest trees was ">100 cm". Condition of trees was assigned in three categories: living trees (less than half of their branches are decayed), decaying trees (more than half of their branches are decayed, but still have living branches) and dead trees (the whole tree and all of the branches are dead). The thickness of the utilized part of tree was assigned to one of the following six categories: <10.1 cm, 10.1–20 cm, 20.1–30 cm, 30.1–40 cm, 40.1–50 cm, 50 cm<. We estimated the thickness of the branch relative to the biometric measures of the study species (length 21–23 cm, wingspan 34–39 cm) (Cramp 1985). We gathered data on the condition of the used substrate in three categories: "Living", "Decaying" and "Dead".

Data analyses

Chi-square test was used to compare the distributions in species, DBH and condition between nest site and random plots.

Shannon diversity index was calculated for tree species, DBH and condition in the case of each plot. Diversity indices of nest site and random plots were compared through Hutcheson's diversity t-test (Hutcheson 1970, Poole 1974).

The ratio of the number of native trees to the pooled number of native and invasive trees was calculated for each plot. Values of nest site and random plots were compared with two-sample t-test with Welch correction.

According to the availability of each category of the three dimensions measured at random plots, frequency distributions and Jacobs' selectivity indices were calculated to examine which type of trees were used and preferred for nesting cavity excavation. This index can result in values from −1 to +1, where negative values are referring to avoidance

Tree species	Nest site (680)	Random (566)
Willow	17.79%	9.01%
White poplar hybrid	13.09%	10.78%
Black poplar hybrid	9.85%	3.89%
Green ash	24.71%	29.86%
Boxelder maple	28.68%	41.87%
White mulberry	5.29%	3.89%
Common hackberry	0.59%	0.71%

Table 1. Frequency distributions of tree species in the nest site and random plots

1. táblázat Az egyes fafajok gyakoriság-eloszlásai a költőhelyen, illetve random plotokban. Fafajok fentről lefelé: fűz, fehér nyár hibridek, fekete nyár hibridek, amerikai kőris, zöld juhar, fehér eper, nyugati ostorfa

Tree diameter at breast height	Nest site (680)	Random (566)
3.1–10 cm	32.35%	45.41%
10.1–20 cm	23.82%	21.73%
20.1–30 cm	14.26%	13.78%
30.1–40 cm	8.97%	5.48%
40.1–50 cm	6.91%	4.95%
50.1–60 cm	3.97%	2.65%
60.1–70 cm	3.38%	1.59%
70.1–80 cm	2.06%	2.30%
80.1–90 cm	1.47%	0.88%
90.1–100 cm	1.32%	0.53%
100 cm<	1.47%	0.71%

Table 2. Frequency distributions of tree diameter at breast height in the nest site and random plots

2. táblázat Az egyes mellmagasságban mért törzsátmérő kategóriák gyakoriság-eloszlásai a költőhelyen, illetve random plotokban

and positive values are referring to preference. For these measures, we only worked with trees of a DBH greater than 10 cm.

Analyses were carried out with PAST 2.17c (Hammer *et al.* 2001). Tables were managed with Microsoft Office Excel 2007 software.

Tree condition	Nest site (680)	Random (566)
Living	30.88%	39.93%
Decaying	58.24%	53.71%
Dead	10.88%	6.36%

Table 3. Frequency distributions of tree condition in the nest site and random plots

3. táblázat Az egyes fakondíció kategóriák gyakoriság eloszlásai a költőhelyen, illetve random plotokban (kondíció kategóriák fentről lefelé: élő, korhadó, holt)

Results

The most frequent tree species were the invasive species, among them the most abundant is the boxelder maple, while native tree species were less abundant. At the random plots, white poplar hybrids were the most abundant native trees, while willow trees were the most frequent in the nest site plots. White mulberry and common hackberry trees happened to be sporadic species. Nest site plots had less invasive trees and more native trees than random plots *(Table 1)*. Chi² test showed significant difference between the two distributions (X^2=53.955, df=6, P<0.0001).

Both plot types had gradually less trees in the greater DBH categories, although thinner, younger trees were represented in lower proportions in the nest sites *(Table 2)*. Chi² test showed significant difference between the two distributions (X^2=29.885, df=9, P<0.0001).

Decaying trees were represented the most and dead trees the least at both types of plots, although nest site plots had more decaying and dead trees and less living trees *(Table 3)*.

Plot	Nest site (680)	Random (566)
1	1.18	1.16
2	1.46	1.18
3	1.54	0.91
4	0.88	0.44
5	1.09	1.10
6	1.59	1.29
7	1.03	1.08
8	1.45	1.41
9	1.36	1.04
10	1.20	1.44
11	1.34	1.15
12	1.11	1.17
13	1.22	1.15
14	1.26	1.47
15	1.37	1.42
16	0.85	1.24
17	1.16	1.45
18	1.43	1.08
19	1.24	1.03
20	1.45	1.23
Mean	1.26	1.17
SD	0.20	0.23

Plot	Nest site (680)	Random (566)
1	27.98	81.87
2	138.30	108.73
3	76.79	50.75
4	55.51	122.25
5	38.55	135.69
6	95.09	36.75
7	139.54	58.83
8	38.85	72.58
9	89.55	26.32
10	18.30	59.42
11	25.98	2.77
12	65.28	41.87
13	84.82	41.82
14	96.59	8.32
15	37.20	24.46
16	78.66	88.60
17	67.85	82.99
18	49.14	52.85
19	68.93	49.99
20	26.86	41.39
Mean	65.99	59.41
SD	34.93	35.60

Table 4. Tree species diversity (Shannon) in the nest site and random plots
4. táblázat Shannon diverzitási értékek a fafajok esetében a költőhelyen, illetve random plotokban

Table 5. Shannon diversity indices in the case of tree diameter at breast height in the nest site and random plots
5. táblázat Shannon diverzitási értékek mellmagasságban mért törzsátmérő esetében a költőhelyen, illetve random plotokban

Chi^2 test showed significant difference between the two distributions (X^2=15.505, df=2, P<0.0001).

Nest site plots showed higher diversity values in the case of tree species *(Table 4)*, diameter at breast height *(Table 5)* and tree condition *(Table 6)*. Diversity t-test showed significant differences between nest site and random plots in terms of Shannon diversity indices of tree species (t=5.607, df=953.43, P<0.0001) and diameter at breast height (t=4.8318, df=1116, P<0.0001). The t-test did not show significant differences for tree condition (t=1.4687, df=1223.7, P=0.14218).

According to the two-sample t-test with Welch correction, nest site plots had significantly higher values for ratio of the number of native trees to the pooled number of native and invasive trees, compared to the random plots *(Table 7)* t(Welch)=3.5591, p(Welch t)=0.0014).

Plot	Nest site (680)	Random (566)
1	41.28	97.72
2	179.59	123.18
3	121.67	56.42
4	85.11	150.93
5	63.16	164.61
6	118.83	38.03
7	165.95	82.90
8	54.21	96.39
9	123.48	36.95
10	33.34	72.58
11	48.04	6.59
12	103.83	56.37
13	97.02	63.93
14	137.23	26.38
15	53.58	30.26
16	115.89	119.46
17	95.07	115.84
18	85.11	52.51
19	93.81	81.82
20	44.40	61.30
Mean	93.03	76.71
SD	41.39	42.40

Plot	Nest site (680)	Random (566)
1	0.65	0.39
2	0.38	0.21
3	0.46	0.08
4	0.56	0.16
5	0.92	0.18
6	0.39	0.18
7	0.12	0.35
8	0.27	0.30
9	0.42	0.20
10	0.15	0.19
11	0.33	0.29
12	0.38	0.38
13	0.27	0.32
14	0.53	0.38
15	0.39	0.21
16	0.92	0.24
17	0.37	0.35
18	0.45	0.13
19	0.33	0.36
20	0.35	0.14
Mean	0.43	0.25
SD	0.21	0.10

Table 6. Shannon diversity indices in the case of tree condition in the nest site and random plots

6. táblázat Shannon diverzitási értékek a fakondíció esetében a költőhelyen, illetve random plotokban

Table 7. Ratio values for the number of native trees to the sum of the number of native and invasive trees in the nest site and random plots

7. táblázat Őshonos fák aránya az őshonos és invázós fák összegéhez képest a költőhelyen, illetve random plotokban

12 nests out of 20 were made in willow trees, 7 nests were made in white poplar hybrids and one nest was made in a boxelder maple tree, which means 60%, 35% and 5%, respectively. According to Jacobs' selectivity indices, birds showed preference for willows and white poplar hybrids. The highest preference value was observed for willow trees. All other trees were avoided by the studied species, but boxelder maple showed slightly lower avoidance *(Table 8)*.

For cavity excavation, a wide range of DBH was utilized from trees between 10.1 and 20 cm to trees of maximum 90 cm thickness. Most of the nest trees were between 30.1 and 50 cm thick. According to their availability, the preferred trees were ranged from 30.1 to 70 cm, but 80.1–90 cm DBH trees were also preferred. Other categories were avoided *(Table 9)*.

Tree species	Utilization frequencies	Jacobs' selectivity indices
Willow	60%	0.77
White poplar hybrid	35%	0.38
Black poplar hybrid	0%	-1.00
Green ash	0%	-1.00
Boxelder maple	5%	-0.81
White mulberry	0%	-1.00
Common hackberry	0%	-1.00

Table 8. Utilization frequencies and Jacobs' selectivity indices for species of nest trees

8. táblázat Az egyes fafajok gyakoriság-eloszlásai és ezek Jacobs szelektivitási index értékei a költőfák esetében. Fafajok fentről lefelé: fűz, fehér nyár hibridek, fekete nyár hibridek, amerikai kőris, zöld juhar, fehér eper, nyugati ostorfa

Tree condition	Utilization frequencies	Jacobs' selectivity indices
Living	10%	-0.55
Decaying	75%	0.28
Dead	15%	0.24

Table 10. Utilization frequencies and Jacobs' selectivity indices for condition of nest trees

10. táblázat Az egyes fakondíció kategóriák gyakoriság-eloszlásai és ezek Jacobs szelektivitási index értékei a költőfák esetében (kondíció kategóriák fentről lefelé: élő, korhadó, holt)

Substrate condition	Utilization frequencies
Living	10%
Decaying	75%
Dead	15%

Table 12. Frequency distributions of substrate condition at nesting cavities

12. táblázat Az egyes fakondíció kategóriák gyakoriság-eloszlásai a költőodúknál (kondíció kategóriák fentről lefelé: élő, korhadó, holt)

Tree diameter at breast height	Utilization frequencies	Jacobs' selectivity indices
10.1–20 cm	0%	-1.00
20.1–30 cm	10%	-0.50
30.1–40 cm	35%	0.66
40.1–50 cm	25%	0.54
50.1–60 cm	10%	0.37
60.1–70 cm	15%	0.71
70.1–80 cm	0%	-1.00
80.1–90 cm	5%	0.52
90.1–100 cm	0%	-1.00
100 cm<	0%	-1.00

Table 9. Utilization frequencies and Jacobs' selectivity indices for diameter at breast height of nest trees

9. táblázat Az egyes mellmagasságban mért törzsvastagság kategóriák gyakoriság-eloszlásai és ezek Jacobs szelektivitási index értékei a költőfák esetében

Diameter at nest height	Utilization frequencies
0–10 cm	0%
10.1–20 cm	5%
20.1–30 cm	60%
30.1–40 cm	25%
40.1–50 cm	5%
50 cm<	5%

Table 11. Frequency distributions of tree diameter at nest height

11. táblázat Az egyes költőodúknál becsült törzsvastagság kategóriák gyakoriság-eloszlásai

75% of nest trees were in "decaying" condition. 15% of the utilized trees were dead and 10% were living. The preferred condition stages were the "decaying" and the "dead", where decaying trees were more preferred. Living trees were avoided *(Table 10)*.

60% of nesting cavities were excavated in parts of trees with the diameter at nest height of 20.1–30 cm. Other categories were represented less and less *(Table 11)*. 75% of nesting cavities were excavated in decaying substrates *(Table 12)*.

Discussion

Within the literature one can rarely find studies on nest site use of the Great-spotted Woodpecker in riparian forests. These studies were carried out mostly in oak-ash-elm forests *(Fraxino-Ulmetum)* (Kosiński & Winiecki 2004, Kosiński *et al.* 2006), while none of them took place in willow-poplar alluvial forests *(Populo-Salicetum)*. Besides, we could not find any example of woodpecker nest site studies in habitats transformed by invasive tree species. There is a huge lack of knowledge on these topics so far.

Among native trees, nest site plots had more trees from all of the available three species, but the difference was proportionately bigger in terms of willow and black poplar hybrid trees, than white poplar hybrids. In one of our earlier studies made in the same study area, through weekly standard, year-round foraging observations, we found, that invasive tree species were avoided (Ónodi & Csörgő 2014). In spite of that, among other tree species, the rough barked native willow and black poplar hybrids were the most preferred trees for foraging (Ónodi & Csörgő 2014). The green ash and boxelder maple were scarcely used for foraging by the study species (Ónodi & Csörgő 2014). This could be due to that these tree species have very few prey items in them. Both non-native species have anti-herbivore secondary metabolic products in their tissues, in the leaves and in the living wood as well (Csiszár & Bartha 2008, Udvardy 2008, Csiszár 2009). Among the few insect species that can inhabit the wood of green ash, the most common is the Ash Bark Beetle (*Leperisinus fraxini*, Scolytidae) that lives in the bark of the trees (Udvardy 2008). According to the literature, there is not any documented wood boring insect species, which could inhabit the wood of boxelder in Europe (Csiszár & Bartha 2008).

Foraging woodpeckers preferred bigger, older native trees, which could be the reason why nest site plots had more abundant thicker, older trees and less young trees than random plots. This phenomenon is similar to the results of Kosinski and Winiecki (2004). They found in *Quercus-Fraxinus-Ulmus* and *Quercus-Carpinus* stands in Poland, that Great-spotted Woodpeckers used nest sites with proportionately bigger and older trees of higher total basal area.

Most trees were decaying at both nest site and random plots. Nest site plots had more decaying and dead trees and less living trees. Although living trees were preferred by the foraging birds, nest site plots had proportionately less living trees than random plots. This could be from the fact that most of the living trees in the study area are invasive and thus avoided by the foraging birds for both foraging and nesting (Ónodi & Csörgő 2014).

According to our results, nest site plots had higher diversity in terms of all three studied variables, as birds chose nest sites with more thick, decaying or dead native trees, while the

overall characteristics of this transformed habitat are less diverse, due to the high frequencies of young, living invasive trees.

As there are so few studies on the nest site utilizations of the Great-spotted Woodpecker and we could not find any studies held in poplar-willow riparian forests so far, it is hard to compare their nest tree utilizations as well. In other studies, willow trees were not among the preferred nest trees, although these trees were sporadically present in those study sites (Kosiński & Winiecki 2004, Kosiński *et al.* 2006). Willow trees were only mentioned by Kosiński *et al.* (2006) as highly preferred nest tree species for the Middle-spotted Woodpeckers. In our study area, these tree species provide the most suitable, 20–30 cm thick substrates with the proper volume of soft decaying wood. As white poplar hybrid trees are hybrids of white poplar and aspen trees, our studied woodpeckers used these trees similarly to Aspens that were used in other studies as well. Aspens were preferred by Great-spotted Woodpeckers for example in Bialowieza National Park in Poland (Wesolowski & Tomialojc 1986), in Norway (Hagvar *et al.* 1990) and in Sweden (Hansson 1992). The used aspen cavity trees were described as dead and decaying trees in case of Bialowieza, but were considered to be living trees in both the Norwegian and Swedish studies. Such high preference could be related to its soft wood, which can mean less effort for excavation (Kosiński & Kempa 2007). The other preferred trait of this species is its smooth bark. The latter trait could lower the success of scansorial nest predators such as Pine Marten *(Martes martes)* and Stone Marten *(M. foina)* (Glue & Boswell 1994, Walankiewicz & Czeszczewik 2005).

Great-spotted Woodpecker chose dead and decaying trees for nesting in other studies as well (Glue & Boswell 1994, Smith 1995, Smith 1997, Kosiński & Winiecki 2004, Smith 2007), although, among other European woodpecker species, the Great-spotted Woodpecker use living trees the most. In some studies the species used near exclusively living trees for nesting (Kosiński & Kempa 2007). Compared to other *Dendrocopos* species, like the dead wood specialist White-backed Woodpecker *(D. leucotos)* which has a slightly greater body size and considerably greater bill length (Gorman 2004), the Great-spotted Woodpecker's shorter and deeper bill occurred to be more efficient for excavating nesting cavities in hard, living trees (Aulén & Lundberg 1991). According to the condition of such transforming riparian habitats, high proportion of native trees suitable for nesting are in decaying or dead condition as well. Older willow and white poplar hybrid trees are mostly decaying under these soil water conditions. In contrary to other studies in which cavities were found in old, larger trees with 50–60 cm diameter at breast height (Kosiński & Winiecki 2004), our study birds mainly excavated their nesting cavities in medium diameter trees of 30–40 cm. These trees represented 10% of the available stems applicable for cavity excavation by Great-spotted Woodpecker. Equivocally with other studies, our studied species made cavities in substrates between 20 and 30 cm diameter at nest height (Glue & Boswell 1994).

In their native habitats, in particularly in green ash woodlands, green ash and boxelder maple support a high diversity of forest bird species, including cavity-nesting species (Rumble & Gobeille 2008). According to our results, we predict that the population decrease of native, alluvial tree species could lead to a suboptimal habitat for numerous members of riparian forest communities (Magura *et al.* 2008). In that case, the density of woodpecker

species could decrease. As the main cavity excavator, the Great-spotted Woodpecker plays a key role in riparian forest ecosystems. Its decrease in density caused by habitat alteration would supposedly have a considerable influence on the cavity-dwelling community. Among the secondary cavity-nesters of this species we can find tits (Paridae), nuthatches (Sittidae), sparrows (Passeridae), starlings (Sturnidae) and flycathcers (Muscicapidae) (Kotaka & Matsuoka 2002), even though the Great-spotted Woodpecker is one of the most important nest predators for cavity-nesting species, for example in the Bialowieza National Park, where certain species even avoid nesting in woodpecker cavities (Wesolowski 2007). Decaying processes of natural cavities could be initiated by the foraging excavations of woodpeckers, as they can inoculate wood-decaying fungi. Such holes, within decades can become nesting cavities. The wood of the invasive tree species is much harder, so these trees can produce hollows slower than willow and poplar trees; thereby, the importance of nesting and foraging cavities made by the generalist Great-spotted Woodpecker will undoubtedly rise (Jackson & Jackson 2004).

Through their above mentioned processes, green ash and boxelder maple are considered to be such transforming species. In the making of conservation management plans, it is adequate to use the "novel ecosystem" approach. Certain transforming species can change fairly entire ecosystems in irreversible ways. The restoration of such habitats could be impossible or so resource intensive, that it could even cause great harm to the processes of the ecosystem. In our case, these invasive tree species support the essential midstorey and secondary canopy layer as important microhabitats for various forest-dwelling species. Managers should secure the current processes of such altered ecosystems while taking efforts to conserve the indigenous habitat as much as possible (Milton 2003, Hobbs *et al.* 2006, Lindenmayer *et al.* 2008, Hobbs *et al.* 2013).

As the green ash and boxelder maple are considered to be mid-successional species in their North-American, native alluvial habitats (Iverson *et al.* 2008, 2009), through river control managements the more straight, deeper riverbeds of Central Europe happened to be more optimal for these species, than the native riparian tree species. The conditions of native riparian woodland ecosystems could be mitigated by the restoration of natural, meandering and flooding processes of such riverbeds (Scott *et al.* 1997, van Turnhout *et al.* 2010), though this consideration is yet to be an utopistic approach due to inter alia economic reasons.

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