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# SONGBIRD COMMUNITIES IN RIPARIAN FOREST AND POPLAR PLANTATIONS IN THE SPECIAL NATURE RESERVE UPPER DANUBE

## *Struktura zajednica ptica pjevica ritskih šuma i plantaža topole u specijalnom rezervatu prirode Gornje Podunavlje*


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**ABSTRACT**

The research was conducted on 36 points in the northern area of the Special Nature Reserve Upper Danube. The survey of forest songbird communities was carried out using the point transect method, in parallel with the survey of vegetation characteristic on the same points, using the circular plot method. In total, 50 bird species were recorded, 24 of which (forest songbirds) underwent qualitative analysis. Investigated points were grouped in three forest types: riparian forest and young and mature hybrid poplar *Populus* x *euroamericana* plantations. The average estimated population densities of forest songbirds were 693 pairs per km$^2$. The most abundant species in riparian forests and mature poplar plantations were the Chaffinch *Fringilla coelebs* and the Great Tit *Parus major*, while in young poplar plantations, the most abundant species were the Great Tit, the Blackcap *Sylvia atricapilla*, and the Greenfinch *Chloris chloris*. The greatest density and the highest number of species were recorded in the riparian forest, while mature poplar plantations had the greatest diversity and evenness of birds.



**Keywords**: bird population density, forest types, ecological groups, vegetation characteristics, diversity, Upper Danube


## INTRODUCTION

Birds are good indicators of habitat quality, since they select it on the grounds of its characteristics, and can quickly move to another area (Gregory *et al*. 2005),


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especially migratory birds that have to determine their habitat every year (Cody 1985). Changes in the abundance and distribution of common birds indicate changes to the environment and can be used for decision-making regarding their habitat management (Temple & Wiens 1989). The natural forests, in comparison with the managed ones, usually show a higher value of bird diversity and density (Saniga 1995).

The area covered with hybrid poplar plantations in the world is increasing, with hybrid poplar plantations representing nearly 4% of global forests (Pawson *et al.* 2013). Poplar plantations have multiple impacts on the surrounding forests; in some areas, they have been shown to decrease bird communities in the surrounding agricultural lands and floodplains, such as riparian forests (Pont 1987, Godreau 1999); they should be avoided in areas of high conservation value (Archaux & Martin 2009). In some cases, poplar plantations show no impact on the present fauna (Urlich *et al.* 2004). Multiple papers have shown hybrid poplar plantations having lower bird population densities than natural and semi-natural forest (Pont 1987, Hanowski *et al.* 1997, Godreau 1998, Twedt *et al.* 1999), with extensively managed plantations being preferred by breeding birds to intensively managed plantations (Pont 1987, Godreau 1998). The number of bird species has been shown to increase with the size of plantations (Godreau 1998), which are proved to be useful to common species (Britt *et al.* 2007), but also can also provide suitable habitats for the threatened species (Delarze & Ciardo 2002). The diversity of bird species can change rapidly through forest management, such as timber harvesting (Vanderwel *et al.* 2007, Chizinski *et al.* 2011) or mechanical and chemical site preparations (Lane *et al.* 2011). Some research suggests avoiding or completely stopping the removal of undergrowth and low branches, in order to create better foraging and nesting niches for birds (Goreau 1998, Archaux & Martin 2009). According to Pawson *et al.* (2013), climate changes have a powerful impact on plantations due to adaptations of forest management (such as shortening the rotation time, thinning and pruning plantations, biofuel extraction, and large-scale afforestation, forestation and potential deforestation), which are being introduced to reduce the effect of climate change on plantation production capacity.

The objective of this paper is to:

– determine certain forest songbird densities, determine species evenness and the diversity of communities in the types of forests studied, and determine what vegetation factors affect the habitat selection in certain species;
– compare bird communities between the types of forests studied, and determine the importance of those forests for different bird communities;
– collect more detailed bird distribution data in the researched area that can be used for future research.

## METHODS

### Study area

The study was conducted in riparian forests and hybrid poplar plantations (*Populus x euroamericana*) in the Special Nature Reserve Upper Danube (Gornje Podunavlje), Serbia, which are under the management of the public company "Vojvodinašume" (Figure 1). For this study, 36 points were chosen randomly; 12 points in riparian forests (36.4 ha) and 24 in hybrid poplar plantations, with 12 points laid out in each of mature (33.4 ha) and young plantation forest types (13.8 ha); the total area was 83.6 ha. The study was conducted in coordinates between 45.78°-45.82°N and 18.86°-18.92°E, and between 45.76°-45.78°N and 18.93°-18.96°E. Riparian forests in the Special Nature Reserve are composed of White Poplar *Populus alba* (Stojanović *et al.* 2014); with Sessile Oak *Quercus robur*, Black Poplar *Populus nigra*, Narrow-Leafed Ash *Fraxinus angustifolia* and European White Elm *Ulmus laevis*, they make riparian forest within the order *Populetalia albae* Br.-Bl. 1931 (Trinajstić 2008).

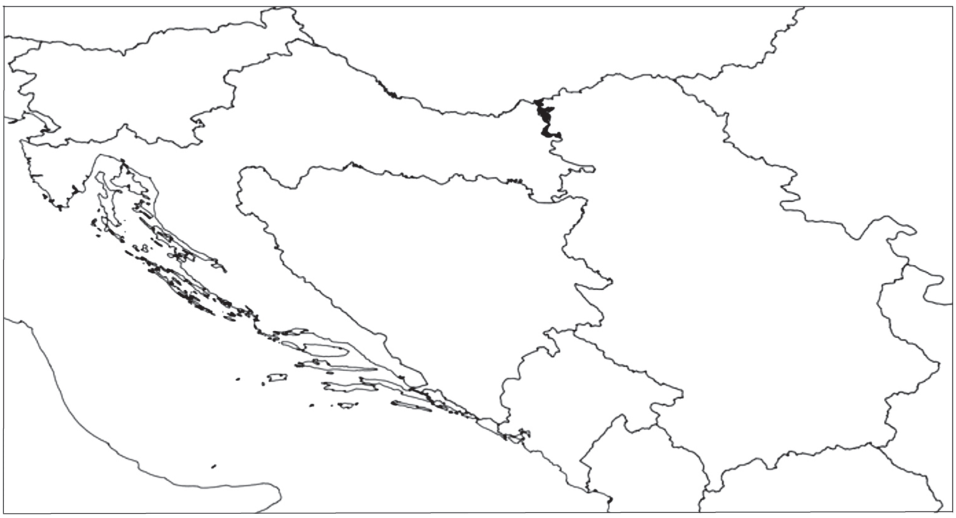

**Figure 1.** Location of the Special Nature Reserve Upper Danube (filled black) on the map.
***Slika 1.*** *Položaj Specijalnog rezervata prirode Gornje Podunavlje na karti (ispunjeno crno).*

### Bird surveys

The survey was conducted in the spring of 2016, following the point count method described in Bibby *et al.* 1992 and Gregory *et al.* 2004. Three counts were completed for each point in all types of forests during the breeding season (April-June), and the highest number of individuals recorded at each point was used for analysis. The survey was conducted between sunrise and 10:00 am on days with no wind and no precipitation. Points were at least 270 meters apart, in order to avoid double counts of loud species (Gregory *et al.* 2004), and at least 100 meters from the edge of the forest in order to avoid the edge effect. During bird surveys, all birds singing or seen in three counting bands were noted: within 50 meters of each point, between 50 and 100 meters, and further than 100 meters; only the first two were used in further analysis. Bird locations, movements, and behaviour (singing males, aggression, woodpeckers drumming) were noted. Six minutes were spent on each point, but birds were counted during the last 5 minutes only.

**Vegetation surveys**

The survey was conducted using the circular plot technique described in James & Shugart (1970) and Cyr & Oelke (1976). Vegetation survey was conducted at each point where bird survey was conducted. Five plots per point were surveyed, each 11.28 meters in diameter (0.04 ha). For every tree inside the plot, the species was determined and basal area ($m^2$) calculated. Furthermore, on each circular plot canopy height, shrub density, ground vegetation (categorized with the dominant type of vegetation), percentage of bare ground cover and canopy cover were noted. Plantations were split into young (3-10 years old) and mature stands (18 or more years old). Tree diameters were estimated using a Biltmore scale, and categorized in one of 8 categories: A: 7.5-15 cm, B: 15-23 cm, C: 23-38 cm, D: 38-53 cm, E: 53-68 cm, F: 68-84 cm, G: 84-101 cm and H: >101 cm (James & Shugart 1970). Basal area was calculated as described in James & Shugart (1970). Basal areas of all eight categories were summed to determine basal area per surveyed point; in the case of dead trees, their basal areas were added to living trees, but also calculated separately. Categories A and B were grouped as "small trees", C, D, and E as "medium size trees", whereas F, G, and H were categorized as "large trees". Dead trees were also noted. The percentage of canopy cover and ground cover was surveyed 20 times per plot, from random points within the plot, three steps apart. To calculate the percentage of canopy and ground cover, and to estimate canopy height ocular tube, a cardboard cylinder with cross threads taped to the end was used. Shrubs were counted in two crossed plot radii of the outstretched arm length across the circular plot.

**Analysis**

Songbird densities were estimated as in Kralj (2000), Kralj & Radović (2005), Kirin *et al.* (2011) and Martinović (2016), using inner 50-meter radius, where for birds with lower detectability and low number of registered individuals, 50-100 meter band was used as well (Bibby *et al.* 1992). As the applied method is appropriate for songbirds, only songbird data from the survey were used for quantitative analysis. Data for other taxa were used for the qualitative list of species only, due to the low number of registered individuals and delimitations of the method applied. Densities were calculated for each forest type, whereas for all forests, the overall density was calculated. Furthermore, songbirds were divided into their ecological groups, based on the dominant position of the nest (canopy, shrubs, holes, ground), and by dominant vegetation layer used for foraging (canopy, shrubs, trunk, ground, air), according to Kirin *et al.* (2011) and Martinović (2016). Shannon diversity index was used to calculate the diversity of communities, while Simpson's index was used to calculate the evenness of the species (Krebs 1992). Sørensen's index was used for the comparison of similarity in structural characteristics of forests and bird communities for all types of forests (Odum 1971). The Shapiro-Willks W test showed that variables were not normally distributed; therefore, the non-parametric test Spearman Rank R was applied. Vegetation variables were used for primary component analysis (PCA), to identify principal sources of variation in habitat structure. All statistical analyses were performed using Statistica v.7.0 (StatSoft 2004) and Microsoft Excel 2016 software.

## RESULTS

In the survey conducted, 50 bird species were recorded, including 26 songbird species (Table 1). Most species were recorded in the riparian forest (37 species), followed by mature poplar stands (36) and young poplar stands (29). Average total density was estimated to 69.3 pairs/10 ha. Densities of songbirds were the highest in the riparian forest. Most abundant bird species were the Great Tit *Parus major* and the Common Chaffinch *Fringilla coelebs* in both riparian forests and mature stands. Young stands also had the Great Tit as one of the most abundant bird, alongside the European Greenfinch *Chloris chloris*. Only five species were recorded in all forest types: the Great Tit, the Common Chaffinch, the Blackcap *Sylvia atricapilla*, the Blue Tit *Cyanistes caeruleus* and the Golden Oriole *Oriolus oriolus*, whereas some species occurred only in one type of forest (i.e. Red-backed Shrike *Lanius collurio* in young stands), as shown in Table 1.

During riparian forest vegetation surveys, 16 tree species were recorded. Forest consisted mostly of Black and White poplar, but also Sessile Oak, European White Elm, Field Elm *Ulmus minor* and Narrow-leafed Ash were relatively abundant (Figure 2). Mature plantation stands were exclusively monocultures, while in young stands hybrid poplar trees represented 93.2% of total basal areas in plantations (Table 2). Recorded tree species – besides hybrid poplar – in the surveyed young poplar stands were Sessile Oak and White Willow *Salix alba*. Dominant ground vegetation type in all the surveyed plots were broad-leaved herbaceous plants, except in young poplar stands, where cane and reeds with blackberry *Rubus sp.* undergrowth were dominant.

The most abundant species in nesting niches are hole-nesters, followed closely by species nesting in the canopy. Looking at the foraging sites, species foraging

**Table 1.** Ecological groups of forest songbirds with nesting (h – hole-nesting species, c –canopy species nesting, s – species nesting in a layer of shrub, g – ground species nesting) and foraging niche (b – bark gleaning species, c – canopy feeding species, s – species foraging in a layer of shrub, g – ground feeding species, a – areal feeders), and population densities in different types of forest, as well as the overall density given. The number of survey points per forest type is indicated.

***Tablica 1.*** *Ekološke skupine šumskih pjevica prema nišama gniježđenja (h – dupljašice, c – krošnja, s – grmlje, g – tlo) i traženja hrane (c – krošnja, b – deblo, s – grmlje, g – tlo, a – zrak) te gustoće populacija u različitim tipovima šuma, te prosječne gustoće kroz sve tipove šuma. Broj točaka na kojima je izvršeno istraživanje naveden je u zagradama za svaki tip šume.*

| | | **Ecological groups** | | **Population density (pairs/km²)** | | | |
|---|---|---|---|---|---|---|---|
| | | nesting | foraging | average (36) | riparian (12) | mature (12) | young (12) |
| *Fringilla coelebs* | Common Chaffinch | c | g | 127.3 | 212.2 | 127.3 | 42.4 |
| *Parus major* | Great Tit | h | c | 102.6 | 159.2 | 95.5 | 53.1 |
| *Sylvia atricapilla* | Eurasian Blackcap | s | s | 63.7 | 106.1 | 42.4 | 42.4 |
| *Ficedula albicollis* | Collared Flycatcher | h | a | 46.0 | 106.1 | 31.8 | 0.0 |
| *Cyanistes caeruleus* | Blue Tit | h | c | 42.4 | 95.5 | 21.2 | 10.6 |
| *Erithacus rubecula* | Eurasian Robin | g | g | 38.9 | 84.9 | 31.8 | 0.0 |
| *Emberiza citrinella* | Yellowhammer | g | g | 31.8 | 0.0 | 63.7 | 31.8 |
| *Oriolus oriolus* | Golden Oriole | c | c | 26.9 | 8.8 | 36.0 | 36.0 |
| *Muscicapa striata* | Spotted Flycatcher | c | a | 24.8 | 42.4 | 31.8 | 0.0 |
| *Poecile palustris* | Marsh Tit | h | c | 21.2 | 31.8 | 31.8 | 0.0 |
| *Turdus merula* | Common Blackbird | s | g | 21.2 | 42.4 | 21.2 | 0.0 |
| *Chloris chloris* | European Greenfinch | c | c | 17.7 | 0.0 | 0.0 | 53.1 |
| *Troglodytes troglodytes* | Eurasian Wren | g | g | 17.7 | 31.8 | 21.2 | 0.0 |
| *Coccothraustes coccothraustes* | Hawfinch | c | c | 17.7 | 21.2 | 31.8 | 0.0 |
| *Carduelis carduelis* | European Goldfinch | s | g | 14.1 | 0.0 | 21.2 | 21.2 |
| *Turdus philomelos* | Song Thrush | s | g | 14.1 | 31.8 | 10.6 | 0.0 |
| *Hippolais icterina* | Icterine Warbler | s | c | 10.6 | 0.0 | 31.8 | 0.0 |
| *Saxicola rubicola* | European Stonechat | g | g | 10.6 | 0.0 | 0.0 | 31.8 |
| *Certhia familiaris* | Common Treecreeper | h | b | 10.6 | 10.6 | 21.2 | 0.0 |
| *Phylloscopus collybita* | Chiffchaff | g | c | 7.1 | 10.6 | 10.6 | 0.0 |
| *Sitta europaea* | Eurasian Nuthatch | h | b | 7.1 | 21.2 | 0.0 | 0.0 |
| *Aegithalos caudatus* | Long-tailed Tit | s | c | 7.1 | 0.0 | 21.2 | 0.0 |
| *Certhia brachydactyla* | Short-toed Treecreeper | h | b | 3.5 | 10.6 | 0.0 | 0.0 |
| *Turdus viscivorus* | Mistle Thrush | c | g | 3.5 | 10.6 | 0.0 | 0.0 |
| *Locustella fluviatillis* | River Warbler | s | s | 3.5 | 0.0 | 0.0 | 10.6 |
| *Lanius collurio* | Red-backed Shrike | s | s | 1.0 | 0.0 | 0.0 | 2.9 |
| **TOTAL DENSITY** | | | | **692.8** | **1038** | **704.5** | **336** |

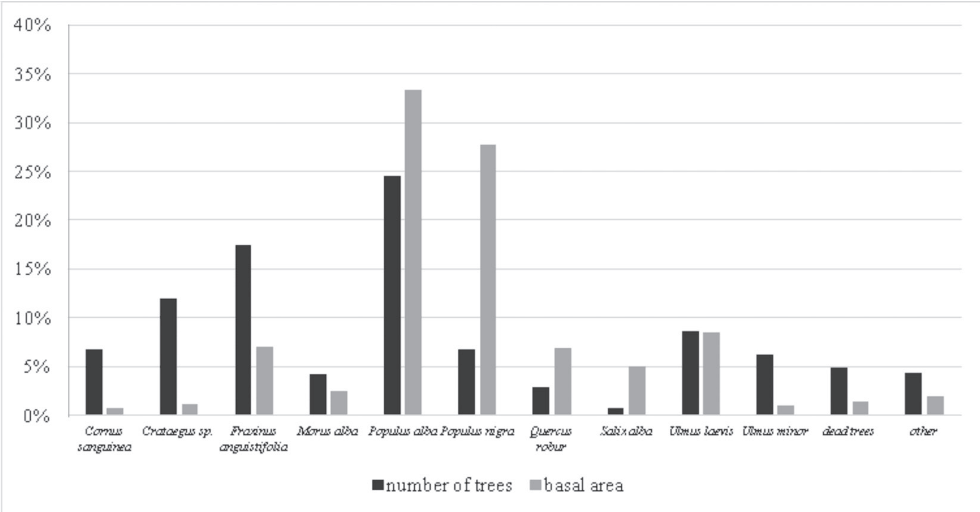


**Figure 2.** Tree species composition and corresponding basal areas in riparian forest of the study area.

***Slika 2.*** *Drvenaste vrste zabilježene u istraživanju vegetacije ritskih šuma izraženo u postotnim udjelima stabala i temeljnica.*

**Table 2**. Tree species represented in different types of forest in the surveyed area, along with ground vegetation and canopy cover, and shrub density (%S – tree abundance, %B – basal area).

***Tablica 2.*** *Vrste drveća u različitim tipovima šume na istraživanom području, sa postotkom pokrivenosti tla vegetacijom i pokrovnosti krošnje te gustoća grmlja (%S – postotni udio drveća, %B – udio temeljnice).*

| | **mature plantations** | | **young plantations** | | **riparian forest** |
|---|---|---|---|---|---|
| | %S | %B | %S | %B | Figure 2 |
| *Populus x euroamericana* | 100.0% | 100.0% | 97.4% | 93.2% | |
| *Quercus robur* | 0.0% | 0.0% | 2.2% | 5.8% | |
| *Salix alba* | 0.0% | 0.0% | 0.4% | 1.0% | |
| | | | | | |
| ground cover | 100.0% | | | | 96.0% |
| canopy cover | 36.0% | | 92.0% | | 79.6% |
| shrub density (per hectare) | 0 | | | | 571 |

on the ground and canopy are the most abundant. The percentages of birds by ecological groups in riparian forests are shown in Table 3.

**Table 3.** Percentage of ecological groups of birds between different types of forest in the surveyed area.

***Tablica 3.*** *Postotni udjeli po ekološkim grupama ptica između različitih tipova šume na istraživanom području.*

| | nesting | | | | foraging | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **canopy** | **hole** | **shrub** | **ground** | **air** | **canopy** | **bark** | **shrub** | **ground** |
| **average** | 31.5% | 33.7% | 19.5% | 15.3% | 10.2% | 36.6% | 3.1% | 9.8% | 40.3% |
| **Riparian forests** | 28.4% | 41.9% | 17.4% | 12.3% | 14.3% | 31.5% | 4.1% | 10.2% | 39.9% |
| **Mature stands** | 32.2% | 28.6% | 21.1% | 18.1% | 9.0% | 39.7% | 3.0% | 6.0% | 42.2% |
| **Young stands** | 39.1% | 19.0% | 22.9% | 18.9% | 0.0% | 45.5% | 0.0% | 16.6% | 37.9% |

Mature poplar stands have shown to have the highest diversity and highest species evenness, followed by riparian forests and lastly young stands, as shown in Table 4. Sørensen's index shows that riparian forests and mature poplar stands have the highest similarity (84%), while similarities between young poplar stands and both riparian forests and mature poplar stands were lower (68%).

In the primary component analysis, 5 axes were produced (Appendix 1). The PC1 axis inversely describes the naturalness of the forests. It is negatively correlated with the number and basal area of old trees, the number of trees, shrubs, canopy and ground cover, the height and most of the native tree species; it is however positively correlated with the number and basal area of hybrid poplars. The PC2 and the PC3 describe the age of the forest, whereby the PC2 is negatively correlated with the number of middle-aged trees and the tree height, and positively with the number of young trees, while the PC3 is only positively correlated with the tree height, canopy cover and the number of middle-aged trees. The PC4 describes the tree species diversity, being positively correlated with the number of Black Poplar and European White Elm, and negatively with the number of Narrow-leaved Ash. The PC5 describes the share of Sessile Oak in the forest, be-

**Table 4.** Values of Shannon diversity index and Simpson's index.

***Tablica 4.*** *Vrijednosti Shannonovog indeksa raznolikosti i Simpsonovog indeksa.*

| | **Shannon diversity index** | **Simpson's index** |
|---|---|---|
| **Riparian forest** | 2.44 | 0.11 |
| **Mature stands** | 2.65 | 0.09 |
| **Young stands** | 2.08 | 0.14 |

ing only negatively correlated with the number of oak trees and basal area (Appendix I). Songbird abundances were correlated with the PC scores (Appendix II). The number of bird species, the number of individual birds, as well as the majority of species and ecological groups were negatively correlated with PC1, showing preference to more natural forests. The number of individuals, canopy nesters (esp. the Chaffinch) and ground feeders showed preference to older forest stands.

## DISCUSSION

The total number of recorded species and the number of recorded songbirds is higher than found in different mountains and hills of Croatia (Kirin 2009, Kirin *et al*. 2011, Martinović 2016). Riparian forests have a higher population density than continental Sessile Oak forests (Kralj & Radović 2005), forests in the area of Petrova gora (Martinović 2016), Medvednica and Žumberačko gorje (Kirin *et al*. 2011), whereas similar densities were recorded in the National Park Białowieża in Poland (Wesołowski *et al*. 2006). Riparian forests in Hungary, Slovenia and Slovakia also have similar densities to the ones surveyed in this research (Waliczky 1992, Božič 2002, Mošanský 2009). Mature plantation stands have similar population densities to the similarly aged stands in Poland (Kartanas 2010), but greater than the similarly aged stands in France (Archaux & Martin 2009). Young stands have lower densities than the similarly aged plantations in both papers. Furthermore, mature poplar stands show a different ecological group structure from beech forests (Martinović 2016), but similar density, whereas Turkey Oak *Quercus cerris* forest in Žumberačko gorje and Sessile Oak forests in Medvednica show higher densities, also with a different ecological group structure.

Bird abundance has shown an increase in more natural stands (Appendix II). Fluvial forests in this area are better connected and less fragmented compared to other studied stands; this can contribute to a high diversity and abundance of birds. Ecologic niche composition in mature poplar stands is similar to riparian forest, and many species show an affinity towards more nature forests. The Special Nature Reserve has plantations of different tree species; thus, more research needs to be carried out in order to gain a better insight into the bird fauna in this area. The bird survey technique used in this paper is more appropriate for the forest bird survey, since it is more likely to detect more cryptic and quiet species; it is also more practical for habitats where greater densities and diversities are expected.

Native riparian forests have a higher number of species and population densities compared to plantations, as in Martín-García *et al*. (2013). However, mature plantations stands have a higher diversity and evenness of species, not only in comparison with young stands, which confirms previous research (Hanowski *et* *al*. 1997), but also compared to riparian forest. This may be so mainly because of considerable habitat fragmentation, especially in plantations, where the positive edge effect may cause the increase in diversity and density (Odum 1971, Kirin *et al.* 2011). Higher diversity in mature stands may also be attributed to trees being old enough for creating new niches, like holes for nesting (Villard & Taylor 1994). Additionally, Martín-García *et al.* (2013) suggests that birds may use plantations as corridors to spread to different areas, yet on the other hand, landscape matrix with open areas may limit bird movements outside of plantations as a result of a "gap-crossing" decision (Desrochers & Fortin 2000; Bélisle & Desrochers 2002).

Young plantation stands in the Special Nature Reserve border open areas as grasslands and meadows, which can explain increased densities of species that prefer these habitats, such as the European Stonechat *Saxicola rubicola*, the River Warbler *Locustella fluviatilis* and the Red-backed Shrike, as young and very young stands provide suitable habitats for these species (Godreau *et al.* 1999, Archaux & Martin 2009). Since forests in this area are intensively managed (by removing sprouts and shrubs, trimming low branches), some species, like the Blackcap and the River Warbler, might forage in tall herbaceous plants that are abundant in plantation stands instead in the shrubs (Kartanas 2010). The Icterine Warbler *Hippolais icterina* was recorded only in mature poplar stands, which seems to be this species' preferred habitat type in the Danube area (Waliczky 1992).

The Collared Flycatcher *Ficedula albicollis*, a Natura 2000 species (Official Journal of the European Union 2010), was among the most abundant species in riparian forests and mature poplar stands. Its preference for older trees was previously researched (BWPi 2006, Kralj *et al*. 2009, Martinović 2016; Appendix II), and it is not selective regarding forest types (Tomiałojć 2000). As a migratory hole-nesting species, it returns to breeding grounds when the Great Tits, with whom it competes for nesting sites, are already nesting (Löhrl 1976, Wesołowski 2007). Its relatively high density in mature stands (Table 1) may be explained by a higher availability of nesting sites and reduced competition in old natural forests. The usage of young poplar stands by hole-nesting species may be explained in two ways: 1) hole-nesters use only young stands for foraging and were not actually nesting there; and 2) old Sessile Oak, Black and White Poplar, and White Willow trees are not cut down during deforestation and site preparation. This allows for hole-excavating species to create nest cavities used by secondary hole-nesting species. Bark-foraging species were only recorded in riparian forests, with preferences to poplar and elm trees, with the Common Treecreeper *Certhia familiaris* as an exception, since this species has been registered in mature poplar stands as well. The Common Treecreeper was previously recorded breeding in the Special Nature Reserve (Obradović 1990), and in the neighbouring Baranya, in hybrid poplar stands, there was the only treecreeper species, as well as in Sessile Oak forests, with significantly fewer observations than the Short-toed Treecreeper *Certhia brachydactyla* (Rucner & Rucner 1972). The higher density of the Common Treecreeper in mature stands compared to riparian forests may be due to the absence of the more aggressive Short-toed Treecreeper (BWPi 2006). Species recorded in poplar stands, such as the Red-backed Shrike, the River Warbler, the Yellowhammer *Emberiza citrinella* and the European Stonechat are specialists (Devictor *et al*. 2007) that prefer open habitats and forest edges (BWPi 2006, Svendsen *et al*. 2015). In some studies, the Golden Oriole has been labelled as the species specific to poplar stands (Berthelot *et al*. 2005; Dănilă *et al*. 2015), with some surveys recording its nesting exclusively in mature poplar stands (Dagley 1994). In this survey, the Golden Oriole had a four times higher density in poplar plantations than in riparian forests, whereby previous findings were confirmed.

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SAŽETAK

Na području Specijalnog rezervata prirode Gornje Podunavlje je na 36 točaka provedeno istraživanje šumskih zajednica ptica metodom točkastog transekta te vegetacijskih značajki metodom kružnih ploha. Zabilježeno je ukupno 50 vrsta ptica, od čega je 24 uključeno u kvantitativnu analizu. Šume su podijeljene u ritske šume te mlade i stare plantaže hibridne topole *Populus x euroamericana*. Prosječna procijenjena gustoća ptica u svim tipovima šuma je 665 parova/km$^2$. Najbrojnije vrste ptica u ritskim šumama i starim plantažama su zeba *Fringilla coelebs* i velika sjenica *Parus major*, dok su u mladim plantažama najbrojnije vrste velika sjenica, crnokapa grmuša *Sylvia atricapilla* i zelendur *Chloris chloris*. Najveću brojnost vrsta i populacija imale su ritske šume, dok su stare plantaže topole imale najveću raznolikost i ujednačenost zajednica.

**Appendix I** Factor loadings of 20 vegetation variables for 5 PC-axis with added inherent values. percentages of variations and description of each component. Factor loadings bigger than [0.7] are bolded, while loadings between [0.5] and [0.7] are underlined.

**Dodatak I** Opterećenja 20 vegetacijskih varijabli za 5 PC-osi s dodanim svojstvenim vrijednostima. postotcima varijacije i opisom svake komponente. Masno su otisnuta faktorska opterećenja veća od [0,7], a podcrtana su opterećenja između [0,5] i [0,7].

| Variable | Factor loadings | | | | |
|---|---|---|---|---|---|
| | PC1 | PC2 | PC3 | PC4 | PC5 |
| Number of young trees | -0.526 | **0.741** | -0.345 | 0.050 | 0.096 |
| Number of middle aged trees | -0.280 | -0.532 | **0.755** | 0.142 | -0.036 |
| Number of old trees | **-0.779** | -0.370 | -0.385 | 0.046 | 0.169 |
| Young trees basal area | -0.247 | **0.749** | -0.458 | 0.073 | 0.132 |
| Middle aged trees basal area | -0.641 | -0.335 | 0.643 | 0.051 | -0.070 |
| Old trees basal area | **-0.792** | -0.399 | -0.397 | -0.052 | 0.080 |
| Number of trees | **-0.894** | 0.229 | 0.171 | 0.169 | 0.101 |
| Basal area summary | **-0.914** | -0.371 | -0.079 | -0.007 | 0.053 |
| Shrubs | **-0.711** | -0.072 | -0.155 | -0.385 | -0.353 |
| Ground cover | **0.751** | -0.333 | -0.202 | -0.123 | 0.222 |
| Canopy cover | -0.565 | -0.487 | 0.582 | 0.115 | -0.085 |
| Tree height | -0.564 | -0.561 | 0.514 | 0.209 | -0.057 |
| Number of White Poplar | -0.626 | 0.492 | 0.462 | -0.174 | 0.092 |
| Number of Black Poplar | -0.583 | -0.108 | -0.304 | 0.619 | 0.094 |
| Number of poplar trees | **-0.793** | 0.425 | 0.329 | 0.052 | 0.119 |
| Number of Sessile Oak | -0.396 | -0.069 | -0.372 | -0.142 | -0.620 |
| Number of dead trees | -0.619 | 0.312 | 0.201 | -0.075 | -0.417 |
| Number of hybrid poplar trees | **0.950** | -0.106 | 0.050 | 0.040 | 0.133 |
| Number of Field Elm | -0.638 | 0.529 | 0.392 | 0.057 | 0.080 |
| Number of European White Elm | -0.651 | -0.213 | -0.009 | -0.527 | 0.314 |
| Number of elm trees | **-0.783** | 0.108 | 0.187 | -0.351 | 0.265 |
| Number of Narrow-leaved Ash | -0.567 | -0.083 | -0.251 | **0.708** | 0.063 |
| Number of tree species | **-0.946** | 0.094 | -0.032 | -0.050 | -0.100 |
| White Poplar basal areas | **-0.722** | 0.200 | 0.298 | -0.322 | 0.133 |
| Black Poplar basal area | -0.684 | -0.217 | -0.371 | 0.504 | -0.024 |
| Poplar trees basal area | **-0.947** | -0.019 | -0.062 | 0.138 | 0.071 |
| Sessile Oak basal area | -0.589 | -0.307 | -0.385 | -0.223 | -0.501 |
| Dead trees basal area | -0.533 | -0.061 | -0.030 | -0.177 | -0.482 |
| Hybrid poplar trees basal area | 0.661 | -0.464 | 0.477 | 0.147 | 0.063 |
| Field Elm basal area | -0.606 | 0.543 | 0.374 | 0.129 | 0.143 |
| European White Elm basal area | -0.540 | -0.479 | -0.341 | -0.412 | 0.384 |
| Elm trees basal area | -0.592 | -0.431 | -0.307 | -0.400 | 0.396 |
| Narrow-leaved Ash basal area | -0.605 | -0.234 | -0.299 | 0.459 | 0.120 |
| **inherent value** | **15.197** | **4.727** | **4.216** | **2.673** | **1.913** |
| **% explained variations** | **46.1%** | **14.3%** | **12.8%** | **8.1%** | **5.8%** |

**Appendix II** Relation between ornithological variables and primar components (Spearman Rank corelation). Statistically significan corelations ($p<0.05$) are bolded. (abrevations: ns – nesting niche, fd – foraging niche)

**Dodatak II** Odnosi između ornitoloških varijabli i primarnih komponenti (Spearman Rank korelacija). Podebljane brojke predstavljaju statistički značajnije korelacije ($p<0,05$). (kratice: ns – niša gniježđenja, fd – niša hranjenja)

| | **PC1** | **PC2** | **PC3** | **PC4** | **PC5** |
|---|---|---|---|---|---|
| *Parus major* | **-0.506** | -0.016 | 0.142 | -0.010 | 0.042 |
| *Erithacus rubecula* | **-0.520** | 0.090 | 0.293 | -0.102 | -0.160 |
| *Fringilla coelebs* | **-0.646** | -0.168 | **0.414** | -0.098 | -0.065 |
| *Turdus merula* | -0.287 | -0.179 | -0.007 | -0.029 | -0.022 |
| *Turdus philomelos* | -0.110 | 0.113 | -0.121 | -0.216 | **0.385** |
| *Turdus viscivorus* | -0.138 | -0.041 | -0.008 | 0.252 | -0.252 |
| *Sylvia atricapilla* | **-0.436** | 0.037 | -0.049 | -0.282 | 0.268 |
| *Cyanistes caeruleus* | **-0.593** | 0.069 | 0.118 | -0.167 | -0.037 |
| *Ficedula albicollis* | **-0.411** | -0.166 | 0.108 | -0.284 | 0.132 |
| *Poecile palustirs* | -0.172 | -0.309 | 0.057 | 0.072 | -0.007 |
| *Muscicapa striata* | -0.179 | -0.118 | 0.159 | 0.186 | -0.084 |
| *Emberiza citrinella* | 0.253 | 0.029 | -0.056 | 0.100 | 0.002 |
| *Chloris chloris* | 0.320 | 0.199 | -0.264 | -0.206 | -0.008 |
| *Phyloscopus collybita* | 0.029 | -0.098 | -0.100 | 0.034 | -0.294 |
| *Certhia brachydactyla* | **-0.397** | 0.000 | -0.047 | 0.058 | 0.000 |
| *Troglodytes troglodytes* | -0.133 | 0.062 | 0.309 | -0.240 | 0.142 |
| *Certhia familiaris* | **-0.365** | -0.128 | 0.100 | 0.175 | -0.056 |
| *Sitta europaea* | -0.245 | 0.187 | 0.245 | -0.280 | 0.327 |
| *Hippolais icterina* | -0.073 | -0.285 | 0.295 | 0.295 | -0.073 |
| | | | | | |
| bird species | **-0.184** | 0.108 | 0.065 | -0.218 | -0.183 |
| individuals | **-0.712** | -0.187 | **0.342** | -0.087 | -0.013 |
| species <50 m | **-0.756** | -0.177 | 0.234 | -0.106 | 0.036 |
| species 50–100 m | -0.263 | 0.151 | **0.331** | -0.080 | -0.063 |
| | | | | | |
| ns canopy | **-0.500** | -0.245 | **0.359** | 0.118 | -0.056 |
| fd canopy | **-0.472** | -0.202 | 0.156 | -0.070 | -0.110 |
| ns holes | **-0.684** | -0.213 | 0.137 | -0.137 | 0.034 |
| fd bark | **-0.462** | 0.011 | 0.226 | -0.027 | 0.153 |
| ns shrubs | **-0.415** | -0.133 | 0.125 | -0.074 | 0.179 |
| fd shrubs | -0.317 | 0.078 | -0.094 | -0.303 | 0.299 |
| ns ground | -0.124 | 0.132 | 0.126 | -0.086 | -0.221 |
| fd ground | **-0.595** | -0.287 | **0.410** | -0.059 | -0.092 |
| fd air | **-0.376** | -0.180 | 0.138 | 0.006 | 0.083 |