Breeding densities of woodpeckers (Picinae) in the inner and outer zones of a Central European city

Hnízdní hustoty „datlů“ (Picinae) ve vnitřní a vnější zóně středoevropského města

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Kopij G. 2017: Breeding densities of woodpeckers (Picinae) in the inner and outer zones of a Central European city. *Sylvia* 53: 41–57.

During the years 2003–2010, woodpecker territories were mapped within the administrative boundaries of the Wroclaw city, SW Poland. The total area of the city is 293 km², including 32 km² of wooded areas dominated by old oaks (13 forests, 44 parks and many alleys and other scattered tree vegetation). In the present study, two zones of the city were distinguished – the inner (more than 50% of built-up areas; ca. 1/3 of the whole study area) and the outer zone (mostly open and forested areas; ca. 2/3 of the whole study area). Seven woodpecker species were recorded with the following ecological densities (pairs per 1,000 ha of wooded areas): *Dendrocopos major* – 62.5, *Picus viridis* – 13.8, *Dendrocoptes medius* – 12.5, *Dryobates minor* – 11.6, *Dryocopus martius* – 6.6, *Picus canus* – 4.4, and *Dendrocopos syriacus* – 0.6. Population densities of the typical forest woodpeckers, i.e. *Dryocopus martius, Dendrocopos major,* and *Dendrocoptes medius*, were higher in the outer than in the inner zone of the city, while population densities of the forest-steppe species, i.e. *Picus canus* and *Picus viridis*, were higher in the inner than in the outer zone. Overall population densities of all woodpecker species were considerably higher in wooded areas in the outer than in the inner zone of the city, namely 114.7 versus 103.6 pairs per 1,000 ha of wooded areas.

V letech 2003–2010 jsem mapoval teritoria „datlů“ v katastru města Vratislavi, jz. Polsko. Celková rozloha studované oblasti je 293 km², včetně 32 km² porostů dřevin s převažujícími starými duby (13 lesů, 44 parků a mnoho alejí a dalších prvků rozptýlené zeleně). Město bylo rozděleno na vnitřní (více než 50 % zastavěných ploch; cca 1/3 celkové studijní plochy) a vnější zónu (převažující otevřené a zalesněné plochy; cca 2/3 celkové studijní plochy). Bylo zaznamenáno sedm druhů „datlů“ s následujícími ekologickými populačními hustotami (páry na 1 000 ha porostů dřevin): Dendrocopos major – *62,5,* Picus viridis – *13,8,* Dendrocoptes medius – *12,5,* Dryobates minor – *11,6,* Dryocopus martius – *6,6,* Picus canus – *4,4 a* Dendrocopos syriacus – *0,6. Populační hustoty typických lesních druhů (*Dryocopus martius, Dendrocopos major, Dendrocoptes medius*) byly vyšší ve vnější zóně města, zatímco populační hustoty lesostepních druhů (*Picus canus, Picus viridis*) byly vyšší ve vnitřní zóně města. Celkové populační hustoty všech druhů dohromady byly vyšší ve vnější zóně města, konkrétně 114,7 oproti 103,6 párům na 1 000 ha porostů dřevin.*

Keywords: communal forest, park, territory mapping, urban ecology, Wrocław.

INTRODUCTION

Woodpeckers (subfamily Picinae) are regarded as good indicators of environmental quality (Morrison & Chapman 2005, Myczko et al. 2014). Most species belonging to this group are associated with old tree stands of deciduous or mixed forests. In Central Europe, such habitats have been greatly reduced and fragmented. The Birds Directive (79/409/EEC) adopted by the E.U. Member States therefore ensures the protection of most woodpecker species. It is the case of the Black Woodpecker (*Dryocopus martius*), Grey-headed Woodpecker (*Picus canus*), Middle Spotted Woodpecker (*Dendrocoptes medius*), White-backed Woodpecker (*Dendrocopos leucotos*), and Syrian Woodpecker (*Dendrocopos syriacus*). However, due to the conservation of woodland reserves, increasing the level of forest coverage, and possibly also due to climate change (milder winters), populations of woodpecker species have grown in many European countries in recent decades (Mikusiński 1995, Tomiałojć & Stawarczyk 2003, del Hoyo et al. 2014, IUCN 2017).

However, stands of old trees have survived also in cities, either in the form of parks in centres or as communal forests on the peripheries. In general, parks and communal forests have been regarded as suboptimal, or even marginal habitas for most woodpecker species, because their vegetation structure is usually simplified and the patch sizes may be too small to enable the birds to establish territories (Salvati et al. 2001, Myczko et al. 2014). However, some observations undertaken in recent few decades suggest that such habitats may play an important role as refuges for species associated with old trees (Kopij 2010, 2014a, Kopij & Hołga 2008). Numerous urban bird atlases (Fraissinet & Dinetti 2007, Dunn & Weston 2008, Luniak 2017) have recorded most of the woodpecker species in urban parks and forests (even in the city centres). The Great Spotted Woodpecker (*Dendrocopos major*), Lesser Spotted Woodpecker (*Dryobates minor*), and Green Woodpecker (*Picus viridis*) are usually considered common, while the remaining species are rare and inhabit rather wooded areas in the outer city zones (Yankov 1992, Fuller et al. 1994, Luniak et al. 2001, Fuchs et al. 2002, Hewlett 2002, Otto & Witt 2002, Kalyakin & Volzit 2006, Nowakowski et al. 2006, Fraissinet & Dinetti 2007, Weiserbs & Jacob 2007, Vránová et al. 2007, Czyż 2008, Janiszewski et al. 2009, Schlemmer et al. 2013). A few of these atlases have also attempted to estimate population densities over the whole city. Among larger Central European cities (with human population of more than 500,000), such estimates are available only for Warsaw (Luniak et al. 2001), Łódź (Janiszewski et al. 2009), Berlin (Otto & Witt 2002), and Hamburg (Mitschke & Baumung 2001).

Although a considerable body of literature exists on the woodpecker habitat selection and population densities in forests and urban parks (e.g., Glutz von Blotzheim & Bauer 1994, Bauer & Berthold 1997), most of these studies were carried out in habitat plots smaller than 30 ha, appropriate to estimate densities of only some very common passerine species. Such plots are not adequate for the estimation of woodpecker density, as most of them hold territories larger than those study plots (Glutz von Blotzheim & Bauer 1994, Kosiński & Kempa 2007). Population studies on woodpeckers on larger plots (100–1,000 ha) are much less common (e.g., Kosiński & Kempa 2007, Kopij & Hołga 2008), and there are only few such studies conducted on very large plots (>10,000 ha; e.g., Tjernberg et al.

1993, Kopij 2011). There is a negative relationship between population densities and the size of the study area (Gaston et al. 1999). Small study plots reveal higher densities, while much lower densities are characteristic for large areas (cf. Glutz von Blotzheim & Bauer 1994). This is partly because population densities are often overestimated in small study areas, while the lower densities in larger areas may partly be a result of underestimation, as it may be more difficult to detect birds in large areas.

The aim of this study was to estimate breeding densities of woodpecker species in urban area, where old trees are relatively well-preserved in parks and urban woods. For each species, population densities were estimated separately for the inner and outer zones of the city. Unlike in most other studies on woodpeckers' population density, the presented density estimates were derived from a large area.

METHODS

Study area

The city of Wrocław (SW Poland) is situated in the large Oder valley, where four other smaller rivers (Oława, Ślęża, Bystrzyca and Widawa) join the Oder river. The climate of Wrocław is temperate, slightly warmer than that of the neighbouring areas. The mean annual temperature is 9.7˚C. Mean annual precipitation is 548 mm. The snow cover lasts on average 35 days per year (Smolnicki & Szykasiuk 2002, Bryś & Bryś 2010).

The city within its administrative boundaries has an area of 293 km^2 and the human population of 637,075 as of 2016. Arable land comprises 44.8% of the total area, whereas 5.6% is covered by forests and other wooded areas, 3.4% by water, 9.8% by roads, 18.7% by built-up areas, 3.7% by gardens, 6.1% by sport fields, and 1.3% by wastelands. Marshlands and meadows comprise altogether 6.6% (Smolnicki & Szykasiuk 2002).

Forests in this study are areas used mainly for wood production and almost entirely covered by trees. Tree stands are composed of indigenous species and the undergrowth is relatively well-developed. Most of the 13 forests in Wrocław (all of them were surveyed) are dominated by *Tilio-Carpinetum* stands. They range in size from 10 to 680 ha (median = 175.8 ha) and their total area is 2,286 ha. Only two forests (Mokrzański, Rędziński) are dominated by pines (*Pinus sylvestris*). In most forests, the age of the canopy trees ranges between 50 and 100 years. Only in the Leśnicki and Kosmonautów forests, most trees are younger than 40 years. Only two smaller forests (Kuźnicki – 9.4 ha, and Rakowiecki – 22.4 ha) were situated in the inner zone, while all the other forests were in the outer zone (see below for zone definition).

Parks are semi-open areas composed of timbered and open places with mown grass, playgrounds, sparse buildings and other man-made structures (e.g., picnic tables, fountains, monuments, water bodies). In comparison with forests, parks also have a much reduced undergrowth. Tree stands, as well as undergrowth, are often mixed with exotic species. Parks are set aside mainly for recreation, being situated in a close proximity to human settlements. Human pressure is, therefore, much higher here than in the forests. In Wrocław, there are 44 parks ranging in size from 2 to 120 ha (median = 17.8 ha), and their total area is 781 ha. Like forests, most parks in Wrocław are also dominated by *Tilio-Carpinetum* stands. In a few parks (Tysiąclecia, Grabiszyński, and Skowroni/Andersa), the stands of mixed broadleaved and coniferous trees

predominate. In all parks, old (age >100 years) trees make up more than 50% of the tree stand. Only in the Tysiąclecia park, the trees are 10–20 years old. Four small (>10 ha) and two larger parks (Lesicki – 21 ha, Złotnicki – 20 ha) are located in the outer zone, while all the others are in the inner zone of the city.

Other small wooded areas, such as tree clumps, avenues and hedgerows, are scattered all over the city, but are especially common in the south-eastern part. The total area of these habitats is 133 ha.

Two zones were distinguished in the city: inner and outer (Fig. 1). These zones differ in the proportion of densely built-up, open and wooded areas. In the inner zone (ca. 1/3 of the total study area), more than 50% of the area is occupied by densely built-up areas, while in the outer zone (ca. 2/3 of the study area) mostly by open and wooded areas. In the outer zone, wooded areas (forests, parks and other wooded areas) cover altogether 2,380 ha, in the inner part 820 ha.

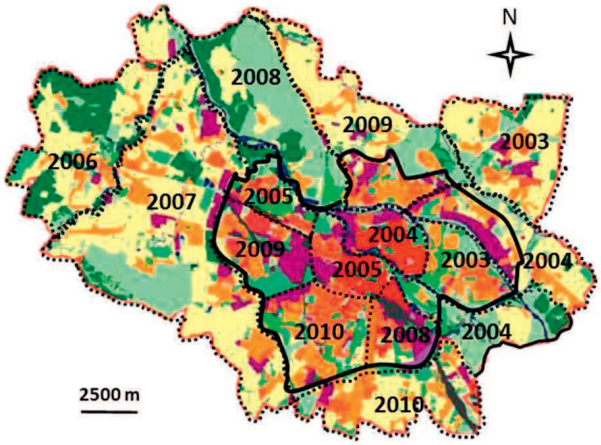

Fig. 1. The study area in the city of Wroclaw. Black solid line – a border between the inner and outer zones of the city; black dashed line – borders of the particular study plots (a year of survey is given). Colour filling: black – railways; purple – industry areas; red – densely built-up areas (city centre); orange – sparsely built-up areas; dark green – forests; light green – parks; bluish green – grasslands; yellow – arable grounds.
Obr. 1. *Studovaná oblast ve městě Vratislavi. Černá souvislá čára – hranice mezi vnitřní a vnější zónou města; černá přerušovaná čára – hranice dílčích studijních ploch (uveden rok studia). Barevná výplň: černá – železnice; nachová – průmyslové oblasti; červená – hustě zastavěné oblasti (centrum města); oranžová – řídce zastavěné oblasti; tmavě zelená – lesy; světle zelená – parky; modrozelená – trávníky; žlutá – orná půda.*

Territory mapping

A simplified version of the territory mapping method (Bibby et al. 2012) was used. I mapped territories of woodpeckers associated with forests, parks and other wooded areas as their breeding and feeding habitats. All such habitats within the administrative boundaries of Wrocław were surveyed four times during the breeding season. The first survey was carried out in April, second in May, third in June and fourth in July. The July survey was focused mainly on the Syrian Woodpecker, which starts to breed later in the breeding season than the other woodpecker species (Glutz von Blotzheim & Bauer 1994). Different parts of the city (2,000–5,000 ha) were surveyed in different years (Fig. 1). Some of them (200–2,000 ha) were covered by Kopij (2004, 2005, 2007, 2008, 2010, 2014a,b,c, 2016a) and Kopij & Hołga (2008). All parts of the city, and all wooded habitats were covered within the period from 2003 to 2010.

Each visually or acoustically recorded woodpecker individual was plotted on the map 1 : 10,000. Special attention was paid to simultaneously calling and drumming birds and those performing other territorial and/or breeding behaviour. Sex was determined if possible. At least two records of such birds at the same site (within ca. 1 km for larger and 0.5 km for smaller species) during two different surveys, and all found nesting sites were assumed as representing an occupied

territory. For a territory exceeding the boundary of the study area, only ½ of it should be taken into account while calculating population density (Bibby et al. 2012). However, due to the large size of the study area, and a clear confinement of most woodpecker species to wooded areas, which were not dissected by the city (i.e., study area) boundaries, there were no such cases in this study.

To compare differences in the population density of woodpeckers in the outer and inner zones, ecological density (pairs per 1,000 ha of wooded areas) of each woodpecker species was calculated for all wooded areas (forests, parks and

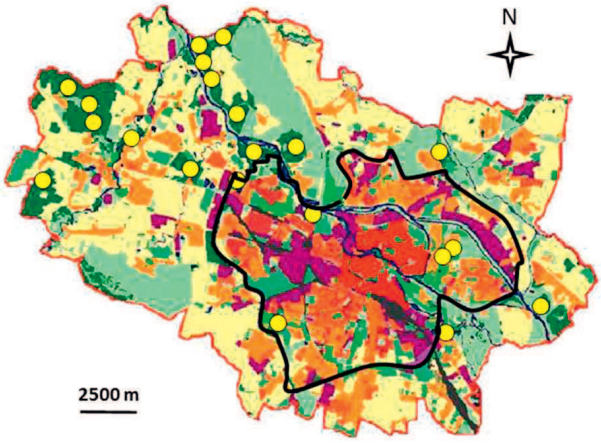

Fig. 2. Distribution of Black Woodpecker (*Dryocopus martius*) territories in the city of Wrocław during the years 2003–2010. For map explanations see Fig. 1.
Obr. 2. *Rozmístění teritorií datla černého (*Dryocopus martius*) ve Vratislavi v období 2003–2010. Vysvětlivky k mapě viz obr. 1.*

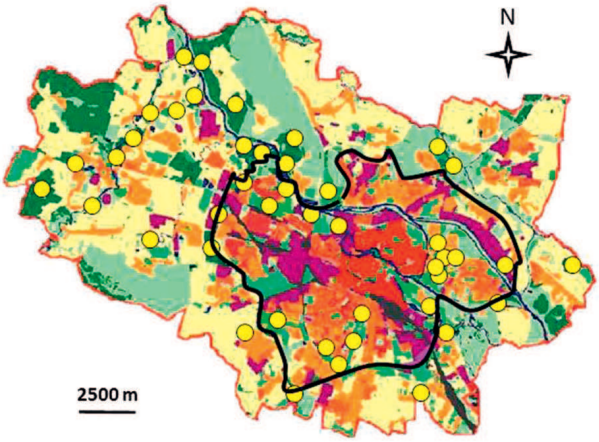

Fig. 4. Distribution of Green Woodpecker (*Picus viridis*) territories in the city of Wrocław during the years 2003–2010. For map explanations see Fig. 1.
Obr. 4. *Rozmístění teritorií žluny zelené (*Picus viridis*) ve Vratislavi v období 2003–2010. Vysvětlivky k mapě viz obr. 1.*

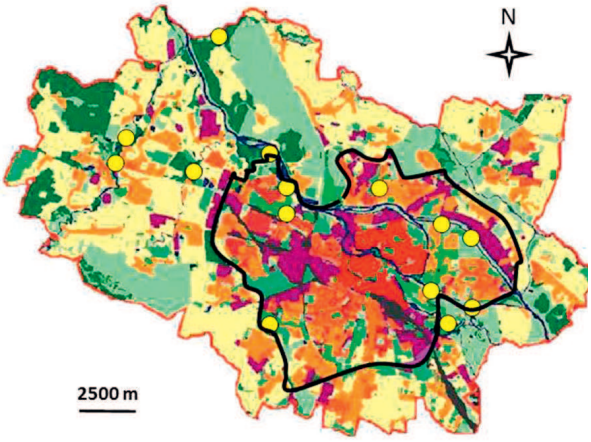

Fig. 3. Distribution of Grey-headed Woodpecker (*Picus canus*) territories in the city of Wrocław during the years 2003–2010. For map explanations see Fig. 1.
Obr. 3. *Rozmístění teritorií žluny šedé (*Picus canus*) ve Vratislavi v období 2003–2010. Vysvětlivky k mapě viz obr. 1.*

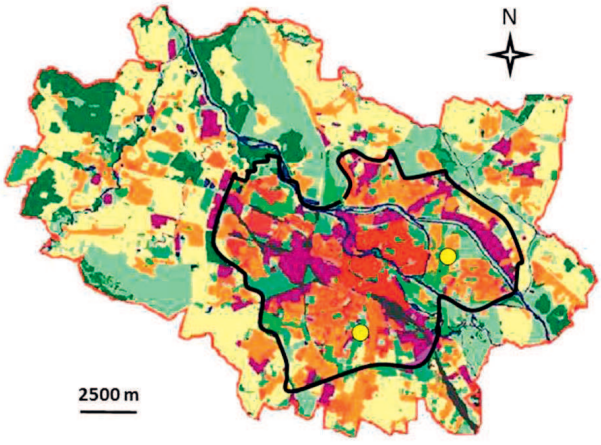

Fig. 5. Distribution of Syrian Woodpecker (*Dendrocopos syriacus*) territories in the city of Wrocław during the years 2003–2010. For map explanations see Fig. 1.
Obr. 5. *Rozmístění teritorií strakapouda jižního (*Dendrocopos syriacus*) ve Vratislavi v období 2003–2010. Vysvětlivky k mapě viz obr. 1.*

all other wooded areas). For each woodpecker species, the crude density was also calculated (pairs per 1,000 ha of the whole study area).

Maps were generated to show the distribution of breeding pairs of all woodpecker species (Fig. 2–8). The distribution is shown on the background of habitats in the city of Wrocław.

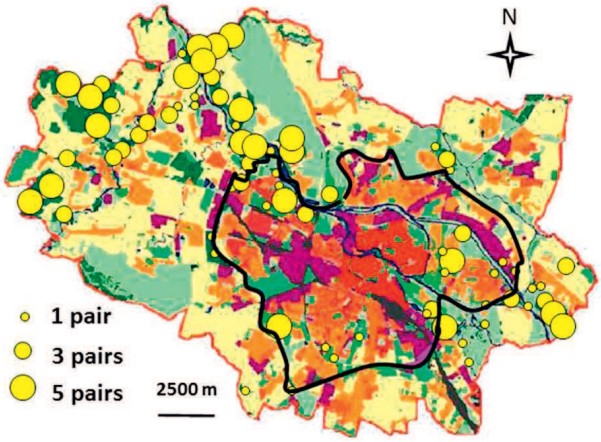

Fig. 6. Distribution of Great Spotted Woodpecker (*Dendrocopos major*) territories in the city of Wrocław during the years 2003–2010. For map explanations see Fig. 1.
Obr. 6. *Rozmístění teritorií strakapouda velkého (*Dendrocopos major*) ve Vratislavi v období 2003–2010. Vysvětlivky k mapě viz obr. 1.*

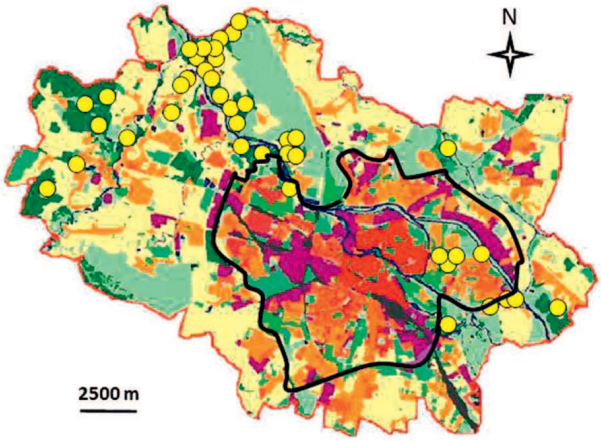

Fig. 7. Distribution of Middle Spotted Woodpecker (*Dendrocoptes medius*) territories in the city of Wrocław during the years 2003–2010. For map explanations see Fig. 1.
Obr. 7. *Rozmístění teritorií strakapouda prostředního (*Dendrocoptes medius*) ve Vratislavi v období 2003–2010. Vysvětlivky k mapě viz obr. 1.*

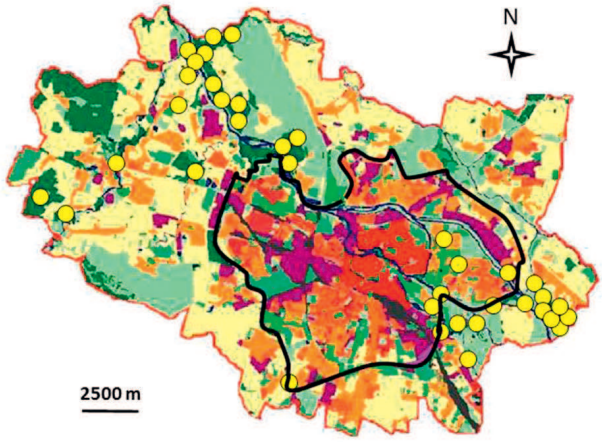

Fig. 8. Distribution of Lesser Spotted Woodpecker (*Dryobates minor*) territories in the city of Wrocław during the years 2003–2010. For map explanations see Fig. 1.
Obr. 8. *Rozmístění teritorií strakapouda malého (*Dryobates minor*) ve Vratislavi v období 2003–2010. Vysvětlivky k mapě viz obr. 1.*

RESULTS

In total, seven woodpecker species were recorded as breeding in the city of Wrocław during the years 2003–2010 (Table 1). Most Black Woodpecker territories were located in the north-western part of the city, where there are the largest forests (Fig. 2). The Grey-headed Woodpecker occurred along rivers (Fig. 3), while the Green Woodpecker was quite evenly distributed all over the city (Fig. 4). The Syrian Woodpecker was rare as only two probably breeding pairs were recorded (Fig. 5). Most breeding territories of the Great and Middle Spotted Woodpeckers occurred in the north-western part of the city, where there are the largest forests (Fig. 6 and 7), while the Lesser Spotted Woodpecker was equally common in the north-western and eastern parts of the city (Fig. 8), where larger wetland areas occur.

The Great Spotted Woodpecker was by far the most abundant species, making up more than a half of all woodpecker breeding pairs. The Middle Spotted and Lesser Spotted Woodpeckers were

Table 1. Population densities of woodpecker species in the outer and inner zones of the city of Wrocław in 2003–2010. N – number of breeding pairs, D_c – crude density (pairs per 1,000 ha of the whole area), D_e – ecological density (pairs per 1,000 ha of wooded areas).
Tab. 1. *Populační hustota „datlů" ve vnější a vnitřní zóně města Vratislavi. N – počet hnízdících párů, D_c – hrubá populační hustota (páry na 1 000 ha celkové rozlohy), D_e – ekologická populační hustota (páry na 1 000 ha porostů dřevin).*

species / *druh*	outer zone / *vnější zóna* (19,300 ha, 2,380 ha of woods / *porostů dřevin*)			inner zone / *vnitřní zóna* (10,000 ha, 820 ha of woods / *porostů dřevin*)			total / *celkem* (29,300 ha, 3,200 ha of woods / *porostů dřevin*)		
	N	D_c	D_e	N	D_c	D_e	N	D_c	D_e
Black Woodpecker *Dryocopus martius*	17	0.9	7.1	4	0.4	4.9	21	0.7	6.6
Grey-headed Woodpecker *Picus canus*	8	0.4	3.4	6	0.6	7.3	14	0.5	4.4
Green Woodpecker *Picus viridis*	25	1.3	10.5	19	1.9	23.2	44	1.5	13.8
Syrian Woodpecker *Dendrocopos syriacus*	0	0	0	2	0.2	2.4	2	0.1	0.6
Great Spotted Woodpecker *Dendrocopos major*	158	8.2	66.4	42	4.2	51.2	200	6.8	62.5
Middle Spotted Woodpecker *Dendrocoptes medius*	34	1.8	14.3	6	0.6	7.3	40	1.4	12.5
Lesser Spotted Woodpecker *Dryobates minor*	31	1.6	13.0	6	0.6	7.3	37	1.3	11.6
total / *celkem*	273	14.2	114.7	85	8.5	103.6	358	12.2	111.9

also relatively numerous. Both nested in a similar density of 11–12 pairs per 1,000 ha of wooded areas. The proportion of abundance among these three woodpecker species was: Great Spotted Woodpecker 0.72 : Middle Spotted Woodpecker 0.14 : Lesser Spotted Woodpecker 0.14 (N = 277 pairs of all three species). Both the Grey-headed Woodpecker and the Green Woodpecker were relatively common in Wrocław. The former was, however, three times less numerous than the later one. Also, the Black Woodpecker was found to be relatively numerous (Table 1).

The overall population densities of all woodpecker species were considerably higher in wooded areas in the outer than in the inner zone of the city, namely 114.7 versus 103.6 pairs per 1,000 ha of wooded areas. In the typical forest species such as the Black, Great, and Middle Spotted Woodpecker, the ecological densities in the inner zone reached 51–77% of densities in the outer zone, while in the species associated with semi-open woodlands (Grey-headed and Green Woodpecker), the ecological densities in the inner zone reached 215–221% of the densities in the outer zone.

In the forest-steppe woodpecker species, i.e. the Grey-headed and Green Woodpecker, the ecological density could not be precisely calculated, as it was difficult to estimate the size of the available potential habitat of these species (a mosaic of small wooded areas and wood edges together with riv-

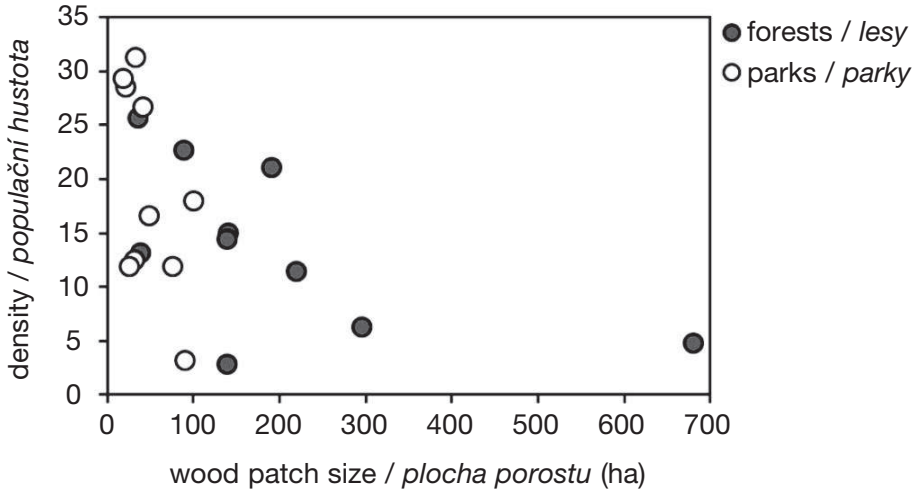

Fig. 9. Relationship between the overall woodpecker population density (pairs per 100 ha of wooded habitats) and the wood patch size in the city of Wrocław. Data for 10 forests and 10 parks listed in Appendix 1.
Obr. 9. *Vztah mezi celkovou populační hustotou „datlů" (páry na 100 ha porostů dřevin) a rozlohou studijní plochy ve Vratislavi. Data pro 10 lesů a 10 parků uvedených v příloze 1.*

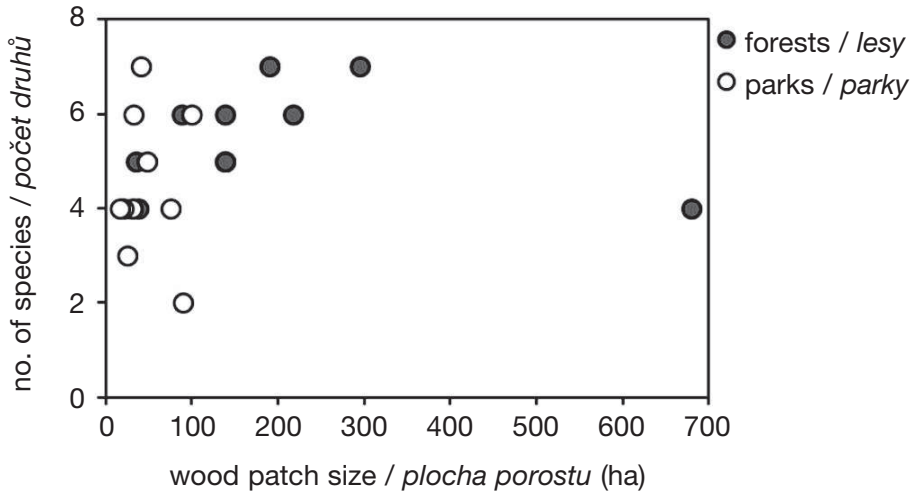

Fig. 10. Relationship between the number of woodpecker species and the wood patch size in the city of Wrocław. Data for 10 forests and 10 parks listed in Appendix 1.
Obr. 10*. Vztah mezi počtem druhů „datlů" a rozlohou studijní plochy ve Vratislavi. Data pro 10 lesů a 10 parků uvedených v příloze 1.*

ers, meadows, fields and other open habitats). If the crude density is taken into account, the population density of the Grey-headed Woodpecker was only slightly higher in the inner than in the outer zone (0.6 vs. 0.4 pairs per 1,000 ha). This difference in the crude density was, however, quite high in the case of the Green Woodpecker (1.9 vs. 1.3 pairs per 1,000 ha; Table 1). However, for all forest woodpecker species pooled, the crude density in the outer zone more than doubled that in the inner zone (Table 1).

The density of woodpeckers declined with the increase in the size of the study plot (Fig. 9), while the number of woodpecker species increased with wood patch size (Fig. 10).

DISCUSSION

Population density and species diversity

Noticeable differences were recorded in population densities of woodpeckers breeding in the outer and inner zones of the city of Wrocław. Typical forest species (Black, Great Spotted, Middle Spotted Woodpecker) nested in higher densities in the outer than in the inner zone. It should be pointed out, however, that woods are less fragmented in the outer than in the inner zone, and fragmentation is known to negatively affect woodpecker densities (Kosiński & Kempa 2007, Myczko et al. 2014). In the case of forest-steppe woodpecker species, population density of both the Grey-headed and Green Woodpecker was higher in the inner than in the outer zone, which may suggest an increase along the urbanization gradient.

It has been documented that most woodpeckers respond negatively to increasing urbanization (Chace & Walsh 2006). The following factors may play a role: the size of wooded areas, tree species composition, structure and age of tree stands, presence of dead trees, competition with other species, and presence of predators. In urban environments, especially in the inner zone, the wooded areas are usually of a relatively small size, and this may be the main factor selecting against most woodpecker species. However, the species of the genus *Picus* are less dependent on forest size. They are typically inhabitants of the forest-steppe zone and may benefit from urbanization, as it fragments continuous forests, resulting in greater heterogeneity of the land cover (Chamberlain et al. 2009). Species is considered urbanized when it increases its abundance along the urban gradient (from rural areas to the city centre). In addition, urbanizing species may extend their breeding season (usually breeding earlier than in the non-urban habitats), reduce migratory ability and increase breeding success (Chamberlain et al. 2009).

The data on woodpecker abundance collected in Wrocław suggest that at least three woodpecker species, namely the Black, Grey-headed and Green Woodpecker, have increased in numbers in the last few decades (cf. Szarski 1955, Lontkowski et al. 1988, Dyrcz et al. 1991). However, due to a lack of comparative quantitative studies from the past, it is impossible to determine any trends in population densities of any of the woodpecker species separately for the inner and outer zone of the city. Myczko et al. (2014) have shown a decrease in the woodpecker species richness and their abundance with the decrease of the distance from the Poznań city centre. They pointed out that larger wood patch size may mitigate this negative effect, especially in the case when woods are multi-layered and comprise a larger proportion of deciduous trees.

Seven woodpecker species recorded in the city of Wrocław is a similar number to that recorded in other big cities in Poland, such as Warsaw (Luniak et al. 2001), Łódź (Janiszewski et al. 2009) and Poznań (Myczko et al. 2014), and in other cities in Central European countries (Mitschke & Baumung 2001, Otto & Witt 2002, Wichmann & Frank 2005). However, either the Green Woodpecker or Grey-headed Woodpecker was recorded in all these cities, while both species occur and are relatively common breeding residents only in Wrocław. The Grey-headed Woodpecker occurs in cities situated only in southern Poland (Tomiałojć & Stawarczyk 2003). The Syrian Woodpecker is a newcomer to the Polish avifauna. It started to breed in the country in the late 1970s (Michalczuk

2014). In Silesia (SW Poland) it is known to breed only in a few isolated sites. Its breeding in Wrocław had not been documented before. However, in some cities situated in the Vistula valley (Kraków and Warsaw) and eastwards from this river (Lublin, Zamość, Przemyśl), it is a well-established breeding resident, with 20–40 pairs recorded in each of these cities (Luniak et al. 2001, Biaduń 2001, Tomiałojć & Stawarczyk 2003, Fröhlich & Ciach 2013, Michalczuk 2014).

Other investigations conducted using the simplified territory mapping method in all wooded areas in Warsaw (Luniak et al. 2001) and Łódź (Janiszewski 2009) have shown that the Black, Green and Middle Spotted Woodpeckers nested in the same densities in Wrocław and Łódź, but in much lower densities in Warsaw (Table 2; no distinction was made by the authors between the inner and outer zones in these cities). It should be stressed, however, that the results obtained by the simplified version of the mapping method are not accurate enough to make a proper comparison (see the separate chapter below). They may, however, indicate general tendencies. The differences in population densities of woodpeckers in the selected biggest Polish cities cannot be linked to different geographical locations, as Warsaw and Łódź are situated much closer to each other than to Wrocław. Also, the structure and age of woods is similar in Łódź and Warsaw. However, quantitative studies on woodpeckers were conducted in Warsaw during the years 1986–1990, therefore about 15–20 years earlier than in Łódź and Wrocław. It may be concluded that the differences were due to a real increase in numbers of the Black, Green and Middle Spotted Woodpeckers over the last 15–20 years in Poland (Tomiałojć & Stawarczyk 2003). Such increase over the last few decades has been evidenced in Wrocław in all these three species and also in the Grey-headed Woodpecker (cf. Szarski 1955, Dyrcz et al. 1991, Kopij 2010,

Table 2. Population densities of woodpeckers (breeding pairs per 1,000 ha of wooded areas) in selected Polish cities.
Tab. 2. *Populační hustoty „datlů" (hnízdící páry na 1 000 ha porostů dřevin) ve vybraných městech v Polsku.*

city / *město*	Warsaw	Łódź	Wrocław
whole area / *celková rozloha*	494 km²	293 km²	293 km²
wooded areas / *plocha porostů dřevin*	143.3 km²	28.4 km²	32 km²
study period / *období*	1986–1990	2001–2008	2002–2010
Black Woodpecker / *datel černý*	1.0	5.3	5.9
Grey-headed Woodpecker / *žluna šedá*	0.0	0.0	3.9
Green Woodpecker / *žluna zelená*	2.8–4.2	15.1–15.8	12.3
Syrian Woodpecker / *strakapoud jižní*	1.4–2.8	0.4	0.6
Great Spotted Woodpecker / *strakapoud velký*	20.9–34.9	105.6–140.8*	55.9
Middle Spotted Woodpecker / *strakapoud prostřední*	2.1–3.5	12.0–14.1	11.2
Lesser Spotted Woodpecker / *strakapoud malý*	5.6–10.5	39.8–45.8*	10.3
source / *zdroj*	Luniak et al. (2001)	Janiszewski et al. (2009)	this study / *tato práce*

* values most probably overestimated / *hodnoty nejspíše nadhodnocené*

2014a,b,c, 2016a). It does not mean that this increase in population density occurred also in the wooded areas in the inner zone. Nevertheless, it may indicate an urbanization process in some woodpecker species taking place in Poland in the few recent decades. This urbanization process is especially pertinent to the Green Woodpecker, which was recorded as nesting even in the city centres in Warsaw (Luniak et al. 2001), Łódź (Janiszewski et al. 2009), Wrocław (this study), and also in Berlin (Otto & Witt 2002) and Hamburg (Mitschke & Baumung 2001). However, there is a lack of comparative analyses of population densities of woodpeckers in the inner and outer zones in those cities. It is, therefore, difficult to determine whether the woodpeckers really infiltrate into the cities and whether they undergo the urbanization process.

It has been shown convincingly that the ecological population density of woodpeckers (per wooded area) in large woodlands and in farmlands with highly fragmented forests is the same (Tjernberg et al. 1993), although this could be species-specific. In most cases, the ecological population densities of woodpeckers recorded in Wrocław are higher than those recorded in forest

Table 3. Ecological population densities of woodpeckers (breeding pairs per 1,000 ha of wooded areas) in the Wrocław city and outside the cities in selected regions in SW Poland during the years 2001–2010. Explanations: DM – Black Woodpecker, PC – Grey-headed Woodpecker, PV – Green Woodpecker, DE – Middle Spotted Woodpecker, DI – Lesser Spotted Woodpecker. The Great Spotted Woodpecker was excluded in the studies outside the city of Wrocław.
Tab. 3. *Ekologické populační hustoty „datlů" (hnízdící páry na 1 000 ha porostů dřevin) ve Vratislavi a mimo města v různých regionech jz. Polska v letech 2001–2010. Vysvětlivky: DM – datel černý, PC – žluna šedá, PV – žluna zelená, DE – strakapoud prostřední, DI – strakapoud malý. Strakapoud velký nebyl ve studiích mimo Vratislav zahrnut.*

region / *oblast*	whole area / *celková rozloha* (km²)	forests / *porosty dřevin* (km²)	forest type / *typ porostu*	DM	PC	PV	DE	DI	source / *zdroj*
Wrocław, outer zone / *vnější zóna*	200	23.8	oak, pine / *dub, borovice*	7.1	3.4	10.5	14.3	13.0	this study / *tato práce*
Wroclaw, inner zone / *vnitřní zóna*	93	8.2	oak / *dub*	4.9	7.3	23.2	7.3	7.3	this study / *tato práce*
Grądy Odrzańskie	35	15	oak, mixed / *dub, smíšený*	2.7	6.0	6.0	3.3	10.0	Kopij 2015
Niemodlin Land	300	120	pine, spruce / *borovice, smrk*	2.8	0.4	0.1	0.7	0.4	Kopij 2016b
Niemodlin Forest	200	195	pine / *borovice*	2.6	0.2	0.0	0.1	0.1	Kopij 2016c
Nysa Land	720	15	mixed / *smíšený*	8.7	3.3	6.0	8.7	8.7	Kopij 2012
Grodków Land	584	70	oak, mixed / *dub, smíšený*	1.7	1.0	0.6	–	0.7	Kopij 2006

fragments in farmland, as well as in less fragmented forests (Table 3). The reason for this could be that there are probably larger proportions of old oaks in most wooded areas in Wrocław than in the neighbouring areas. Milder winter weather conditions in Wrocław than outside the city (Smolnicki & Szykasiuk 2002) may also play a role in that regard.

Methodical considerations

There are many sources of bias and lack of precision regarding the population estimation of woodpeckers, such as the selection of the counting method or size of the study area. The simplified version of the mapping method could provide a source of bias as clusters of records are important while interpreting the data. In the present study, four repeated counts could not produce enough records for an accurate interpretation of the clusters.

There is a certain misconception regarding the counting method in woodpeckers. Nest finding combined with territory mapping (Tomiałojć 1980) is certainly the most accurate method. However, it is too time-consuming and, therefore, practically not applicable in large study plots. The playback technique may be more appropriate in such situation. Using this method, one survey conducted in March/April may be often sufficient to estimate population densities of most woodpecker species (Kosiński & Winiecki 2005, Kosiński & Kempa 2007). Most of them are highly territorial and as such very vocal in the pre-laying period during the phase of territory establishment in early spring (March/April in Central Europe). However, under sunny and windless conditions, it is easy to detect woodpeckers and estimate their population density in that peak period of their vocal activity, even without playback (e.g., Kopij & Hołga 2008, Walankiewicz et al. 2011).

There is a possibility that densities of woodpecker species with large territories (e.g., Black Woodpecker) have been overestimated in this study. In some neighbouring wood patches, the same pair could have been counted twice. It is well known that drumming in some woodpecker species and territorial calls in others are performed by both male and female. Considering this, special attention was paid to avoid double counts in this study, especially in the Black Woodpeckers, Grey-headed Woodpeckers and Green Woodpeckers. In the cases when calling birds were recorded close to each other (closer than 1 km apart), or called simultaneously (two birds heard at the same time), an attempt was made to determine whether these were calls uttered by a male and female of the same pair or by two separate males. Nevertheless, the birds may sometimes fly over a distance longer than 1 km and could be counted as separate pairs.

In the present study, the densities of woodpeckers declined with the increase in the size of the study area, whilst a positive relationship was found between the number of woodpecker species and wood patch size. These correlations were only slightly different in the inner (parks) and outer zone (forests). The correlation between woodpecker population density and wood patch size has been also evidenced by Gaston et al. (1999), Kosiński & Winiecki (2005) and Kosiński & Kempa (2007). The reason for such correlation is probably a strong tendency among researchers to choose plots of the most optimal habitats for population estimates of the selected species, while suboptimal and marginal habitats are neglected by those researchers. In large study plots, both optimal and suboptimal habitats are more likely to be represented, and the results obtained from such areas are therefore more reliable, even if less ac-

curate. To overcome this notorious bias of selecting attractive plots for population studies, it is recommended that, at least for species with large territories and with low population densities, only large study plots should be designed for population density estimations. On the other hand, it is more difficult to precisely estimate population densities of selected species on larger areas and the probability of underestimation is higher in larger than in smaller plots.

Finally, there are marked year-to-year fluctuations in the population densities of some woodpecker species, caused mainly by winter weather conditions (snowfall and snow cover; e.g. Wesołowski & Tomiałojć 1986, Christen 1994). Given that the present study was conducted over the period 2003–2010, the distribution of territories may be heterogeneous among years/plots. However, the mild climate in the study area is not expected to cause substantial fluctuations in woodpecker densities.

SOUHRN

V období 2003–2010 jsem mapoval teritoria „datlů“ na 293 km² území města Vratislavi (jz. Polsko). Území zahrnovalo 32 km² ploch s porosty dřevin: 13 příměstských lesů, 44 parků a řadu menších ploch s rozptýlenou zelení. Příměstské lesy jsou využívány k produkci dřeva a tvoří je zapojené porosty původních dřevin s vyvinutým keřovým patrem (většinou společenstvo Tilio-Carpinetum*). Stáří porostů se většinou pohybuje mezi 50 a 100 lety. Rozloha lesů se pohybuje od 10 do 680 ha (medián = 175,8 ha) a jejich celková plocha je 2 286 ha. Parky jsou částečně otevřené plochy s porosty dřevin, sečenými trávníky, hřišti, řídce rozptýlenými budovami atp. Podobně jako lesy, většina parků náleží ke společenstvu* Tilio-Carpinetum*. Oproti lesům mají výrazně redukovaný keřový podrost a zahrnují i exotické druhy dřevin. Zastoupení více než stoletých stromů zde přesahuje 50 %. Rozloha parků se pohybuje od 2 do 120 ha (medián = 17,8 ha) a jejich celková plocha je 781 ha. Ostatní porosty dřevin, jako skupiny stromů, aleje, živé ploty atp., jsou rozptýleny po celém území, ale nejčastější jsou v jihovýchodní části města. Jejich celková plocha je 133 ha.*

Studijní plocha města byla rozdělena na vnitřní (cca 1/3 celkové rozlohy; více než 50 % zastavěné plochy; porosty dřevin 820 ha) a vnější zónu města (méně než 50 % zastavěné plochy, porosty dřevin 2 380 ha; obr. 1). Většina parků se nachází ve vnitřní zóně města, zatímco většina lesů ve vnější zóně. Byla použita zjednodušená metoda mapování hnízdních okrsků. Všechny porosty dřevin v katastru města byly navštíveny čtyřikrát v hnízdní sezóně. Po jednom snímku bylo provedeno v dubnu, květnu, červnu a červenci. Různé části města byly zkoumány v různých letech (každá plocha vždy jen v jednom roce; obr. 1).

*Bylo zaznamenáno sedm druhů „datlů“ (tab. 1, obr. 2–8) s následujícími ekologickými populačními hustotami (páry na 1 000 ha porostů dřevin): strakapoud velký (*Dendrocopos major*) – 62,5, žluna zelená (*Picus viridis*) – 13,8, strakapoud prostřední (*Dendrocoptes medius*) – 12,5, strakapoud malý (*Dryobates minor*) – 11,6, datel černý (*Dryocopus martius*) – 6,6, žluna šedá (*Picus canus*) – 4,4 a strakapoud jižní (*Dendrocopos syriacus*) – 0,6. Souhrnná ekologická populační hustota všech druhů „datlů“ byla vyšší ve vnější oproti vnitřní zóně města – 114,7 oproti 103,6 párům na 1 000 ha porostů dřevin. Ekologické populační hustoty typických lesních druhů „datlů“ (datel černý, strakapoud velký, strakapoud prostřední) ve vnitřní zóně města dosahovaly 51–77 % hustot zaznamenaných ve vnější zóně, zatímco*

hustoty lesostepních druhů (žluna zelená a šedá) ve vnitřní zóně města dosahovaly 215–221 % hustot zaznamenaných ve vnější zóně. V případě lesostepních druhů, jako je žluna šedá a zelená, nemohla být ekologická hustota přesně odhadnuta, protože u rozptýlené zeleně je obtížné stanovit plochu obývaného biotopu. Proto byla spočítána i hrubá populační hustota (páry na 1 000 ha celkové rozlohy studované oblasti). Hrubé populační hustoty žluny šedé ve vnitřní zóně města byly mírně vyšší než ve vnější zóně (0,6 vs. 0,4 párů na 1 000 ha). V případě žluny zelené byly hrubé populační hustoty výrazněji vyšší ve vnitřní zóně města (1,9 vs. 1,3 párů na 1 000 ha). U všech lesních druhů „datlů" byly hrubé populační hustoty ve vnější zóně přibližně dvojnásobné oproti hustotám ve vnitřní zóně (tab. 1).

Populační hustoty zaznamenané ve Vratislavi byly podobné jako v dalších větších městech v Polsku (vnější a vnitřní zóna města nebyla v těchto studiích rozlišována; tab. 2), ovšem ve většině případů byly ekologické populační hustoty vyšší ve Vratislavi než v krajině mimo město či méně fragmentovaných lesích (tab. 3). Vysvětlením může být vyšší zastoupení starých dubů ve velké části porostů dřevin ve Vratislavi. Mírnější zimy ve Vratislavi oproti krajině mimo město (Smolnicki & Szykasiuk 2002) mohly také sehrát svou roli.

Populační hustoty „datlů" klesaly se vzrůstající rozlohou studijní plochy (obr. 9), zatímco počet druhů „datlů" s plochou rostl (obr. 10, viz také příloha 1). Negativní korelace mezi populační hustotou „datlů" a velikostí vzorkované plochy je obecně známým faktem (Gaston et al. 1999, Kosiński & Winiecki 2005, Kosiński & Kempa 2007). Důvodem je zřejmě tendence výzkumníků upřednostňovat při studiu malých území plochy s optimálním biotopem, zatímco méně kvalitní biotopy jsou opomíjeny. Při studiu velkých území jsou zahrnuty všechny přítomné biotopy a výsledky jsou tedy reprezentativnější. Na druhou stranu zde hrozí podhodnocení velikosti populace, protože velké plochy je obtížné pečlivě prozkoumat.

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Došlo 2. prosince 2016, přijato 16. srpna 2017.

Received 2 December 2016, accepted 16 August 2017.

Appendix 1. Numbers of breeding pairs of woodpeckers in larger forests and parks in the city of Wrocław. Explanations: DM – Black Woodpecker, PC – Grey-headed Woodpecker, PV – Green Woodpecker, DA – Great Spotted Woodpecker, DE – Middle Spotted Woodpecker, DI – Lesser Spotted Woodpecker. Syrian Woodpecker: single probably breeding pairs recorded in the Szczytnicki and Skowroni/Andersa parks.

Příloha 1. *Počet hnízdících párů „datlů" ve větších lesích a parcích ve městě Vratislavi. Vysvětlivky: DM – datel černý, PC – žluna šedá, PV – žluna zelená, DA – strakapoud velký, DE – strakapoud prostřední, DI – strakapoud malý. Strakapoud jižní: po jednom pravděpodobně hnízdícím páru zaznamenáno v parcích Szczytnicki a Skowroni/Andersa.*

locality / *lokalita*	forest type / *typ porostu*	area (ha) / *rozloha*	DM	PC	PV	DA	DE	DI	total / *celkem*
forests / *lesy* (outer zone / *vnější zóna)**									
Mokrzański	conifers / *jehličnany*	680	3			21	3		27
Ratyński	conifers / *jehličnany*	295	1	1	1	13	1	2	19
Rędziński	oak / *dub*	218	2		1	12	6	4	25
Lesnicki	oak / *dub*	190	3	1	1	23	8	4	40
Strachociński	oak / *dub*	139	1			13	6	1	21
Osobowicki	oak / *dub*	138	1		2	10	4	3	20
Kosmonautów	mixed / *smíšený*	138	1	1	1			1	4
Pilczycki	oak / *dub*	88	1	1	2	14	2		20
Lesicki	pine / *borovice*	38			1	3	1		5
Bystrzycki	oak / *dub*	35		1	1	6	1		9
total / *celkem*		1,959	13	5	10	115	32	15	190
parks / *parky* (inner zone / *vnitřní zóna)**									
Szczytnicki	oak / *dub*	100	2		4	7	3	2	18
Tysiąclecia	mixed / *smíšený*	90			1	2			3
Zachodni	oak / *dub*	75		1	1	7			9
Grabinszyńki	mixed / *smíšený*	48	1	1	1	5			8
Wschodni	oak / *dub*	41	1	1	1	5	1	2	11
Sołtysowicki	oak / *dub*	32	1	2	1	5	1		10
Skowroni/ Andersa	mixed / *smíšený*	31	1		2	1			4
Poludniowy	oak / *dub*	25			1	2			3
Pilczycki	oak / *dub*	21	1		1	4			6
Popowicki	oak / *dub*	17	1		1	3			5
total / *celkem*		480	8	5	14	41	5	4	77

*Only two smaller forests (Kuźnicki – 9.4 ha, and Rakowiecki – 22.4 ha) were situated in the inner zone, and four small parks (>10 ha) and two (c. 20 ha) were in the outer zone (not included in this table).