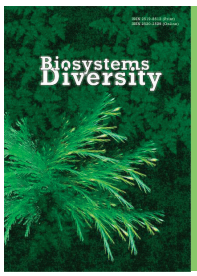

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# Diversity and structure of avian communities in extensive lowland pine forests in relation to the distance from the forest edge

G. Kopij

*Wrocław University of Environmental & Life Sciences, Wrocław, Poland*
*University of Namibia, Ogongo Campus, Namibia*

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*Wrocław University of Environmental & Life Sciences, Kożuchowska st., 5b, Wrocław, 50-651, Poland.*

*University of Namibia, Ogongo Campus, Namibia.*
*E-mail: gkopij@unam.na*

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Most studies on edge effect are related to the forest-field edge, i.e. to the ecotone. However, there is a lack of studies attempting to investigate the effect of the distance from the forest/field edge on the avian communities in large continuous forests. The purpose of this study was to investigate this issue. The study area comprised a continuous coniferous forest, the so called Niemodlin Forest, situated in Opole Silesia, SW Poland. The line transect method has been employed in this study. In total, 54 breeding bird species were recorded. On particular 0.5 km section, the numbers varied from 34 to 48. Both the number of species and number of breeding pairs only slightly decreased with the distance from the forest/field edge. Overall, the differences between the mean densities of breeding species on 10 sections were not statistically significant. The Chaffinch *Fringilla coelebs* was by far the most numerous bird species, recorded as eudominant in 164 out of 165 sections. The Chiffchaff *Phylloscopus collybita*, Willow Warbler *Phyloscopus trochilus* and Blackap *Sylvia atricapilla* were dominants in all 10 sections, while the Blackbird *Turdus merula* dominated in nine (90%) and the Robin *Erithacus rubecula* in eight (80%) sections. The communal dominance slightly increased, but the number of dominant species and Pielou's Evenness Index remained stable with the increase of the distance from the forest/field edge. While Shannon's Diversity Index remained constant, Simpson's Diversity Index decreased markedly with the increase in distance from the forest/field edge. The proportion of long-distance migrants slightly decreased, while that of short-distance migrants and residents remained constant with the increase in the distance from the forest/field edge. Strikingly, no such changes in the proportion of all feeding guilds were shown. More than half of all breeding bird species show a negative correlation between population density and the distance from the forest/field edge. The dominance of some species decreased with the increase of the distance from the forest/field edge: Hawfinch *Coccothraustes coccothraustes*, Starling *Sturnus vulgaris*, Blue Tit *Parusa caeruleus*, Raven *Corvus corax*, Wren *Troglodytes troglodytes*, Wood Pigeon *Columba palumbus*, and Wood Lark *Lullula arborea*. With the exception of the Yellowhammer *Emberiza citrinella*, the clearcuts in this study, not only failed to increase, but most probably caused a decrease in the number of both species and individuals. It is because clearing not only creates edges, but also causes loss of forest habitat and often results in forest fragmentation. Edge and area effect may in fact interact, in such way that the edge effect may drive out the area effect, causing the increase.

*Keywords*: community ecology; edge effect; population density

## Introduction

Understanding the ecology of habitat edge is crucial in landscape eology, habitat conservation, and forest management (Ries et al., 2004). The edge can be defined as a boundary between two distinct habitat patches. The habitat patch may refer to different levels of habitat organization. In this study, it refers to different age classes of the pine stand, as the vegetation composition (pine dominanted forest) is uniform throughout. The edge effect refers to the effect of a transition between two habitats on the species composition, diversity and dominance of an assemblage in the marginal (edge) habitat.

A considerable body of literature exists on so called edge effect in avian communities (Hansson, 1983; Kroodsma, 1984; Villard, 1998; Ries et al., 2004; Ries & Sisk, 2004, 2010; Borbaro et al., 2012; Kopij, 2013). However, most of these studies on edge effect are related to the forest-field edge, i.e. to the ecotone. The preference of ecotones by some forest species has been well-documented (Borbaro et al., 2012; Kopij, 2013). However, there is a scarcity of studies attempting to investigate the effect of the distance from the forest/field edge on the avian communities in large extensive forests (Tomiałojć et al., 1984).

Extensive pine forests are quite homogenous in regard to composition and structure of tree species. They, however, can be regarded as a mosaic of plots of different age tree stands of various areas, the sizes ranging from a few ha to several hundred ha. Small patches of forest clear-cuttings, young tree plantations and mature stands create the amount of forest edge, without fragmenting the landscape.

The purpose of this study was to investigate the structure of avian communities across such a mosaic and in relation to a distance from the forest/field edge. Specifically, two parameters, the density and dominance, were related to the distance from the forest/field edge, in order to distinguish typical forest species and those which prefer ecotones. I hypothesize that the diversity of birds and number of dominant species declines with the increase from the forest/field edge, while density of domiant species inceases along this gradient.

## Materials and methods

The study area comprised a continuous coniferous forest, the so called Niemodlin Forest, situated in Opole Silesia, SW Poland (Fig. 1). Most of the research was conducted in Prószków Forest Inspectorate (transects III–VIII), with only two transects (transects I–II) designed in Tułowice Forest Inspectorate (Kopij, 2016a, 2016b).

Prószków Forest Inspectorate with an afforested surface area of 180 km$^2$ comprises mainly Fresh Mixed Coniferous Forest (63.8% of all afforested surface), and Fresh Mixed Deciduous Forest (26.8%). Alder comprises only 0.6%. Scotch Pine *Pinus sylvestris* constitutes

82.2% of the total afforested surface area, while the English Oak *Quercus robur* and Beech *Fagus sylvatica* together 8.2%. Other tree species include *Picea abies*, *Larix decidua*, *Betula verrucosa*, *Acer platanoides*, *A. pseudoplatanus*, *Fraxinus excelsior*, *Tilia cordata*, *Ulmus glabra*, *Carpinus betulus*, *Robinia pseudoaccacia*. About 79,000 $m^3$ of the wood is harvested annually, and 173 ha is reforested. Most tree stands are 41–60 (III class) and 81–100 (V class) years old (25.0% and 17.2% respectively). Old tree stands (VI class: age 101–120 years, and older) comprise 13.5%.

Tułowice Forest Inspectorate, with an afforested surface area of 173.6 $km^2$ comprises mainly so called Fresh Mixed Coniferous Forest (47.9%), Fresh Mixed Deciduous Forest (46.8% of all afforested surface), and Alder (5.3%). The Scotch Pine, English Oak and Common Birch are the most common tree species (62.4%, 17.4% and 6.9% respectively of the total afforested surface area). Most tree stands are 41–80 years old (42.6%), with 14.0% older than 100 years. About 68,000 $m^3$ of the wood is harvested annually.

The line transect method (Bibby et al., 1992) was employed to estimate population densities and dominance of all breeding bird species. Birds were censused on eight transects, which run on the border lines between particular forest plots. All transects run through fresh pine forests. Following the forest ducts, each transect was divided into sections, each one about 0.4 km long in transects I–VI and 0.6 km long in transects VII–VIII, in relation to the distance from the forest edge. An average length of sections was 0.47 km (SD = 0.09; n = 165).

Birds were counted separately on each section. Transect length ranged from 8.0 to 14.7 km. Birds were counted on each transect within a belt c. 100 m width (50 m on each side of the transect). Therefore, a 1 km long transect was an equivalent to 10 ha. Each transect was surveyed three times in the breeding season, once in each month: April, May and June. In total, the transects had 165 sections and were 77.7 km in total length. Each section was placed in one of ten categories in relation to its mean distance from the forest edge: 1) 0.0–0.5 km from the forest edge; 2) 0.5–1.0 km from the edge; 3) 1.0–1.5 km from the edge and so on.

Counts were conducted in the morning under sunny and windless weather conditions. Transects I–IV were surveyed in 2002, while transects VII–VIII were surveyed in 2004. As recommended in the line transect method (Bibby et al., 1992), a breeding pair, not an individual, was a census unit.

The number of breeding pairs and dominance were estimated for each section on each transect. The maximum number of breeding pairs on whatever survey in each section was assumed as the real number of breeding pairs. The total number of breeding pairs of each species on a particular transect was calculated as totals of maximum numbers recorded on each section within the transect.

The following guilds were distinguished:

– foraging: G – granivores; I – insectivores (Lg – ground-feeders, Lb – bark-feeders, Lf – foliage-feeders); O – all others;

– nesting: G – on the ground; V – in herbaceous vegetation; T – in trees or shrubs; H – in tree holes;

– migration: L – long-distance migrant (wintering mostly in Africa south of Sahara); S – short-distance migrant (wintering mainly in the southern Palearctic region); R – resident (wintering within the breeding range).

The following indices were used to characterize the diversity and evenness of the communities (Odum & Barrett, 2005):

Shannon's diversity index: $H' = -\sum p_i \log p_i$, where $p_i$ is the proportion of breeding pairs belonging to the ith species.

Simpson's diversity index: $D = ((\sum n(n-1))/N(N-1)$, where $n$ – total number of breeding pairs belonging to a given species, $N$ – total number of breeding pairs of all species.

Pielou's evenness index: $J' = (-\sum p_i \log p_i)/\log S$, where $p_i$ is the proportion of breeding pairs belonging to the $i$th species; $S$ – total number of species. J' varies between 0 and 1. The less variation in between species in a community, the higher J' is.

Dominance was calculated as the percentage of breeding pairs of a given species in relation to all breeding pairs of all species. A dominant species comprises 5–9.99 % of all breeding pairs recorded, eudominant – 10% and more, while subdominant – 2–4.99%.

The differences between the mean densities of breeding species on 10 sections were tested by ANOVA. The variation in densities and other parameters in all transects pooled were tested with $\chi^2$-test.

## Results

In total, 54 breeding bird species were recorded (Table 1, 4). On particular 0.5 km sections, the numbers varied from 34 to 48 (x = 39.0; SD = 4.37). Both the number of species and number of breeding pairs only slightly decreased with the distance from the forest/field edge (Fig. 1). Overall, the differences between the mean densities of breeding species on 10 sections were not statistically significant ($F_{9,530} = 0.551$, $P = 0.837$).

**Table 1**
Population parameters on all transects pooled together

| Species | xN | SD | Min | Max | F | %D | Min | Max |
|---|---|---|---|---|---|---|---|---|
| *Fringilla coelebs* | 38.8 | 0.40 | 3.2 | 4.4 | 10 | 13.4 | 8.6 | 16.4 |
| *Phylloscopus collybita* | 26.1 | 0.58 | 2.0 | 3.8 | 10 | 9.0 | 7.7 | 10.8 |
| *Phylloscopus trochilus* | 21.2 | 0.34 | 1.8 | 2.8 | 10 | 7.3 | 5.9 | 9.8 |
| *Turdus merula* | 18.1 | 0.27 | 1.4 | 2.3 | 10 | 6.3 | 4.6 | 9.2 |
| *Sylvia atricapilla* | 16.9 | 0.35 | 1.0 | 2.2 | 10 | 5.9 | 3.9 | 7.1 |
| *Erithacus rubecula* | 16.4 | 0.45 | 1.0 | 2.4 | 10 | 5.7 | 3.9 | 7.1 |
| *Emberiza citrinella* | 13.7 | 0.51 | 0.6 | 2.6 | 10 | 4.7 | 2.5 | 6.6 |
| *Parus ater* | 13.1 | 0.32 | 0.8 | 1.8 | 10 | 4.5 | 3.0 | 7.6 |
| *Anthus trivialis* | 12.1 | 0.24 | 0.8 | 1.6 | 10 | 4.2 | 2.8 | 5.2 |
| *Turdus philomelos* | 10.3 | 0.20 | 0.7 | 1.4 | 10 | 3.6 | 2.5 | 4.5 |
| *Dendrocopos major* | 9.9 | 0.34 | 0.6 | 1.8 | 10 | 3.4 | 2.4 | 5.2 |
| *Parus major* | 8.4 | 0.31 | 0.3 | 1.3 | 10 | 2.9 | 1.3 | 4.3 |
| *Regulus regulus* | 7.1 | 0.17 | 0.5 | 1.0 | 10 | 2.5 | 2.0 | 3.9 |
| *Troglodytes troglodytes* | 6.6 | 0.30 | 0.3 | 1.4 | 10 | 2.3 | 1.3 | 3.6 |
| *Streptopelia turtur* | 5.8 | 0.27 | 0.2 | 1.0 | 10 | 2.0 | 0.7 | 3.6 |
| *Phylloscopus sibilatirx* | 5.5 | 0.23 | 0.2 | 1.0 | 10 | 1.9 | 0.7 | 3.2 |
| *Garrulus glandarius* | 5.2 | 0.15 | 0.3 | 0.8 | 10 | 1.8 | 1.3 | 3.0 |
| *Parus cristatus* | 5.1 | 0.17 | 0.2 | 0.8 | 10 | 1.8 | 0.5 | 2.8 |
| *Cuculus canorus* | 4.9 | 0.32 | 0.1 | 1.2 | 10 | 1.7 | 0.4 | 4.6 |
| *Prunella modularis* | 4.2 | 0.20 | 0.2 | 0.8 | 10 | 1.5 | 0.6 | 3.0 |
| *Sitta europaea* | 3.7 | 0.21 | 0.1 | 0.8 | 10 | 1.3 | 0.4 | 2.0 |
| *Columba palumbus* | 2.7 | 0.21 | 0.0 | 0.8 | 9 | 0.9 | 0.0 | 2.0 |
| *Dryocopus martius* | 2.5 | 0.12 | 0.1 | 0.5 | 10 | 0.9 | 0.4 | 1.7 |
| *Columba oenas* | 2.3 | 0.14 | 0.1 | 0.5 | 10 | 0.8 | 0.2 | 2.0 |
| *Oriolus oriolus* | 2.3 | 0.09 | 0.1 | 0.4 | 10 | 0.8 | 0.4 | 1.4 |
| *Sturnus vulgaris* | 2.3 | 0.24 | 0.0 | 0.8 | 8 | 0.8 | 0.0 | 2.0 |
| *Corvus corax* | 2.2 | 0.09 | 0.1 | 0.4 | 10 | 0.8 | 0.4 | 1.0 |
| *Coccothraustes coccothraustes* | 2.0 | 0.22 | 0.0 | 0.6 | 6 | 0.7 | 0.0 | 1.9 |
| *Phoenicurus phoenicurus* | 1.9 | 0.21 | 0.0 | 0.7 | 8 | 0.7 | 0.0 | 2.6 |
| *Parus caeruleus* | 1.8 | 0.18 | 0.0 | 0.6 | 8 | 0.6 | 0.0 | 1.5 |
| *Sylvia curruca* | 1.8 | 0.11 | 0.0 | 0.4 | 9 | 0.6 | 0.0 | 1.5 |
| *Sylvia communis* | 1.6 | 0.07 | 0.1 | 0.3 | 10 | 0.6 | 0.2 | 1.3 |
| *Regulus ignicapillus* | 1.5 | 0.17 | 0.0 | 0.6 | 8 | 0.5 | 0.0 | 1.0 |
| *Certhia brachydactyla* | 1.5 | 0.12 | 0.0 | 0.4 | 8 | 0.5 | 0.0 | 1.5 |
| *Muscicapa striata* | 1.4 | 0.12 | 0.0 | 0.4 | 8 | 0.5 | 0.0 | 1.0 |
| *Certhia familiaris* | 1.2 | 0.09 | 0.0 | 0.3 | 8 | 0.4 | 0.0 | 1.3 |
| *Lullula arborea* | 1.0 | 0.13 | 0.0 | 0.4 | 5 | 0.3 | 0.0 | 1.0 |
| *Parus montanus* | 0.8 | 0.08 | 0.0 | 0.2 | 6 | 0.3 | 0.0 | 0.5 |
| *Apus apus* | 0.7 | 0.11 | 0.0 | 0.3 | 4 | 0.2 | 0.0 | 1.1 |
| *Aegithalos caudatus* | 0.5 | 0.07 | 0.0 | 0.2 | 4 | 0.2 | 0.0 | 0.6 |
| *Anas platyrhynchos* | 0.4 | 0.05 | 0.0 | 0.1 | 4 | 0.1 | 0.0 | 0.3 |
| *Buteo buteo* | 0.4 | 0.05 | 0.0 | 0.1 | 4 | 0.1 | 0.0 | 0.3 |
| *Picus canus* | 0.4 | 0.07 | 0.0 | 0.2 | 3 | 0.1 | 0.0 | 0.5 |
| *Lanius collurio* | 0.3 | 0.07 | 0.0 | 0.2 | 2 | 0.1 | 0.0 | 0.5 |
| *Pyrrhula pyrrhula* | 0.3 | 0.05 | 0.0 | 0.1 | 3 | 0.1 | 0.0 | 0.4 |
| *Turdus viscivorus* | 0.3 | 0.07 | 0.0 | 0.2 | 2 | 0.1 | 0.0 | 0.7 |
| *Accipiter gentilis* | 0.2 | 0.04 | 0.0 | 0.1 | 2 | 0.1 | 0.0 | 0.2 |
| *Carduelis spinus* | 0.2 | 0.04 | 0.0 | 0.1 | 2 | 0.1 | 0.0 | 0.3 |
| *Ficedula hypoleuca* | 0.2 | 0.04 | 0.0 | 0.1 | 2 | 0.1 | 0.0 | 0.2 |
| *Grus grus* | 0.2 | 0.04 | 0.0 | 0.1 | 2 | 0.1 | 0.0 | 0.4 |
| *Jynx torquilla* | 0.2 | 0.04 | 0.0 | 0.1 | 2 | 0.1 | 0.0 | 0.2 |
| *Motacilla alba* | 0.2 | 0.06 | 0.0 | 0.2 | 1 | 0.1 | 0.0 | 0.7 |
| *Parus palustris* | 0.2 | 0.04 | 0.0 | 0.1 | 2 | 0.1 | 0.0 | 0.4 |
| *Accipiter nisus* | 0.1 | 0.03 | 0.0 | 0.1 | 1 | 0.0 | 0.0 | 0.2 |

*Note*: xN – the sum of average numbers of breeding pairs on 10 sections (each 0.5 km long), SD – standard deviation; Min. – minimal number of pairs on section; Max. – maximal number of pairs on section; Mean – Mean dominance; F – frequency of occurrence on 10 sections; %D – average domination on 10 sections; Min. – minimal dominance on section; Max. – maximal dominance on section.

The Chaffinch *Fringilla coelebs* was by far the most numerous bird species, recorded as eudominant in 164 out of 165 sections (Table 1). The Chiffchaff *Phylloscopus collybita*, Willow Warbler *Phyloscopus trochilus* and Blackcap *Sylvia atricapilla* were dominants in all 10 section categories, while Blackbird *Turdus merula* dominated in nine (90%) and Robin *Erithacus rubecula* in eight (80%) section categories. In all section categories, the dominant species comprised 47.6% of all breeding pairs recorded. The subdominant group comprised another 30.1% and was composed of Yellowhammer *Emberiza citrinella*, Coal Tit *Parus ater*, Tree Pipit *Anthus trivialis*, and Great Spotted Woodpecker *Dendrocopos major* (on some sections, these were even dominant species), and Great Tit *Parus major*, Goldcrest *Regulus regulus*, Wren *Troglodytes troglodytes* and Turtle Dove *Streptopelia turtur* (Table 1, 4).

The cumulative dominance slightly increased, but the number of dominant species and the Pielou's Evenness Index remained stable with the increase of the distance from the forest/field edge (Table 2). While Shannon's Diversity Index remained constant, Simpson's Diversity Index decreased markedly with the distance increase from the forest/field edge. The proportion of long-distance migrants slightly decreased, while that of short-distance migrants and residents remained constant with the increase of the distance from the forest/field edge. Strikingly, no such changes in the proportion of all feeding guilds were shown (Table 2).

**Table 2**
Population parameters and indices
in relation to the distance from the forest edge

| Distance from edge, km | 0.0–0.5 | 0.6–1.0 | 1.0–1.5 | 1.5–2.0 | 2.1–2.5 | 2.6–3.0 | 3.1–3.5 | 3.6–4.0 | 4.1–4.5 | 4.5–5.0 |
|---|---|---|---|---|---|---|---|---|---|---|
| Dominance | | | | | | | | | | |
| Cumulative dominance | 43.7 | 48.6 | 54.8 | 46.8 | 54.1 | 55.4 | 49.0 | 55.6 | 56.7 | 49.6 |
| No. of dominant species | 6 | 7 | 7 | 6 | 7 | 8 | 6 | 7 | 7 | 6 |
| Indices | | | | | | | | | | |
| Shannon's Diversity | 1.42 | 1.29 | 1.36 | 1.40 | 1.34 | 1.42 | 1.38 | 1.36 | 1.29 | 1.36 |
| Simpson's Diversity | 33.22 | 16.16 | 27.01 | 17.68 | 22.42 | 15.08 | 11.58 | 18.57 | 16.17 | 12.67 |
| Pielou's Evenness | 0.91 | 0.85 | 0.85 | 0.87 | 0.87 | 0.85 | 0.87 | 0.85 | 0.84 | 0.88 |
| Migration guilds | | | | | | | | | | |
| Long-distance | 15.76 | 17.99 | 13.77 | 15.71 | 14.88 | 16.19 | 19.3 | 14.53 | 16.38 | 21.73 |
| Resident | 29.46 | 25.92 | 25.95 | 27.10 | 29.41 | 28.08 | 23.54 | 27.63 | 23.10 | 27.90 |
| Short-distance | 54.81 | 56.13 | 60.25 | 57.17 | 55.76 | 55.78 | 57.15 | 57.81 | 60.49 | 50.40 |
| Feeding guilds | | | | | | | | | | |
| Granivores | 12.19 | 9.00 | 6.73 | 8.36 | 7.78 | 7.56 | 8.87 | 8.36 | 5.04 | 9.31 |
| Insectivores (bark) | 9.15 | 5.04 | 5.77 | 6.69 | 6.77 | 7.56 | 4.63 | 5.45 | 5.04 | 9.30 |
| Insectivores (leaves) | 52.80 | 60.80 | 59.59 | 56.83 | 59.47 | 57.21 | 59.46 | 60.71 | 65.53 | 57.39 |
| Insectivores (ground) | 23.35 | 21.60 | 24.36 | 25.42 | 23.32 | 23.04 | 23.55 | 22.18 | 22.68 | 22.09 |
| Others | 2.54 | 3.60 | 3.52 | 2.68 | 2.71 | 4.68 | 3.48 | 3.27 | 1.68 | 1.94 |
| Nesting guilds | | | | | | | | | | |
| Ground | 4.57 | 5.40 | 5.45 | 4.01 | 3.38 | 6.48 | 5.80 | 3.27 | 4.62 | 5.43 |
| Hole | 22.36 | 16.92 | 17.94 | 22.40 | 20.63 | 20.52 | 15.83 | 20.71 | 19.32 | 21.70 |
| Trees/shrubs | 44.17 | 51.10 | 47.74 | 46.15 | 46.64 | 48.59 | 49.40 | 47.63 | 46.63 | 48.86 |
| Vegetation (herbaceous) | 28.93 | 26.62 | 28.84 | 27.42 | 29.40 | 24.46 | 28.96 | 28.36 | 29.40 | 24.04 |

More than half of all breeding bird species showed a negative correlation ($R^2 > 0.30$) between population density and distance from the forest/field edge (Fig. 1, Table 3). The most negatively affected species ($R^2 > 0.50$) were (in descending order): Hawfinch *Coccothraustes coccothraustes*, Starling *Sturnus vulgaris*, Raven *Corvus corax*, Blackcap, Blue Tit *Parus caeruleus*, Great Tit, and Chiffchaff (Fig. 1). The Blackbird, Short-toed Treeceeper *Certhia brachydactyla*, Coal Tit, and Wood Pigeon *Columba palumbus* were slightly positively affected (Fig. 1).

The dominance of some species decreased with the increase of the distance from the forest/field edge. The most affected species in that regard were Hawfinch, Starling, Blue Tit, Raven, Wren, Wood Pigeon, Wood Lark *Lullula arborea* (Table 5). Not affected were Tree Pipit, Spotted Flycatcher *Muscicapa striata*, Song Thrush *Turdus philomelos*, Dunnock *Prunella modularis*, Lesser Whitethroat *Sylvia curruca*, Short-toed Tree-creeper, Golden Oriole *Oriolus oriolus*, Blackcap, Chiffchaff, and Coal Tit. There was also a number of species, the dominance of which increased with the distance from the forest/field edge: Blackbird, Redstart *Phoenicurus phoenicurus*, Chaffinch, Crested Tit, Goldcrest, Whitethroat *Sylvia communis*, Willow Warbler (Table 5).

The dominance of the Jay *Garullus glandarius*, and Wood Warbler *Phylloscopus sibilatrix* initially increased and then decreased; while the reverse situation was noted for the Great Spotted Woodpecker, Stock Dove *Columba oenas*, and Cuckoo *Cuculus canorus*.

**Table 3**
The equation and R-square value for population parameters and indices in relation to the distance from the forest edge

| Distance from edge, km | Equation | $R^2$ value |
|---|---|---|
| Dominance | | |
| Cumulative dominance | 0.7376x + 47.373 | 0.2523 |
| No. of dominant species | 0.0061x + 6.667 | 0.0007 |
| Indices | | |
| Shannon's Diversity | –0.0032x + 1.379 | 0.0423 |
| Simpson's Diversity | –1.5316x + 27.480 | 0.4761 |
| Pielou's Evenness | –0.0022x + 0.876 | 0.1023 |
| Migration guilds | | |
| Long-distance | 0.3536x + 14.679 | 0.1965 |
| Resident | –0.2266x + 28.055 | 0.0978 |
| Short-distance | –0.1298x + 57.289 | 0.0188 |
| Feeding guilds | | |
| Granivores | –0.2678x + 9.793 | 0.1915 |
| Insectivores (bark) | –0.0342x + 6.728 | 0.0038 |
| Insectivores (leaves) | 0.5191x + 56.124 | 0.2256 |
| Insectivores (ground) | –0.1247x + 23.845 | 0.1111 |
| Others | –0.0953x + 3.534 | 0.1067 |
| Nesting guilds | | |
| Ground | –0.0009x + 4.846 | 0.0001 |
| Hole | 0.0296x + 19.670 | 0.0016 |
| Trees/shrubs | 0.1338x + 46.955 | 0.0438 |
| Vegetation (herbaceous) | –0.1653x + 28.552 | 0.0631 |

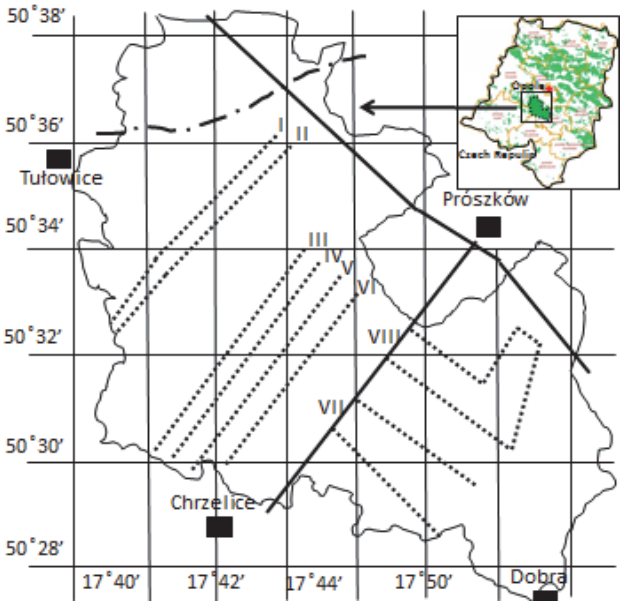


**Fig. 1.** The Niemodlin Forest with location of transects (dotted lines) designed for bird counts

## Discussion

Considering the degree of preference to the forest edge or interior, four groups of birds can be distinguished (Villard, 1998): forest-interior specialists (e.g. Wood Warbler), interior-edge generalists (e.g. Chiffchaff), edge specialists (e.g. Yellowhammer), and field-edge specialists (e.g. Ortolan Bunting *Emberiza hortulana*).

Clear-cutting is regarded as the major factor contributing to the forest mosaic (Hansson, 1982). In comparison with pure habitats, ecotones have usually higher number of both species and individuals due to the greater structural complexity of the edge and microclimate resulting from lower temperature and higher humidity than neighbouring habitats; spill-over effect; and complementary resource distribution, i.e. a concentration of resources near the edge, as two bordering patches may contain different resources, and they are most readily abailable near the edges (Ries & Sisk, 2004). For example, in coniferous forests in Sweden, species most numerous in deep forests were the Chaffinch, Robin, and Goldcrest, on clearcut: Tree Pipit, Yellowhammer and Great Tit. Most species were, however, most common on the forest edge, except for the Blackbird and Willow Tit *Parus montanus*.

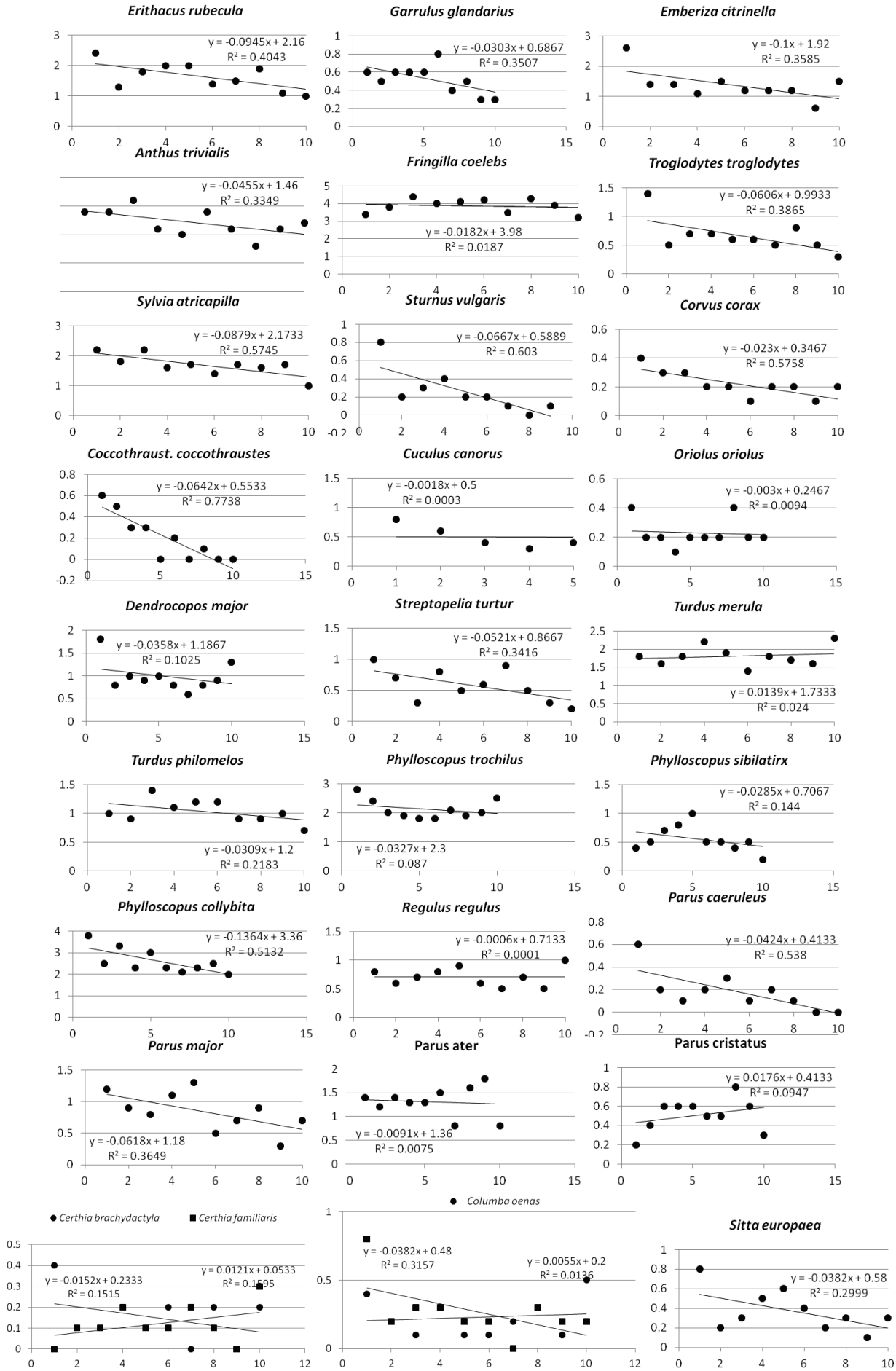


**Fig. 2.** Population densities (pairs per 0.5 km of transect; vertical axis) in relation to the distance from the forest edge: 1 = 0.5 km; horizontal axis

**Table 4**
Average number of breeding pairs per 0.5 km transect in relation to the distance from the forest edge (x – the average, SD – standard deviation)

| Distance from edge, km | 0–0.5 | | 0.6–1.0 | | 1.0–1.5 | | 1.5–2.0 | | 2.1–2.5 | | 2.6–3.0 | | 3.1–3.5 | | 3.6–4.0 | | 4.1–4.5 | | 4.5–5.0 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | x | SD | x | SD | x | SD | x | SD | x | SD | x | SD | x | SD | x | SD | x | SD | x | SD |
| *Accipiter gentilis* | 0.0 | 0.0 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 |
| *Accipiter nisus* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0 | 0.0 | 0.0 | 0.0 |
| *Aegithalos caudatus* | 0.0 | 0.0 | 0.1 | 0.2 | 0.1 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.4 | 0.2 | 0.6 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 |
| *Anas platyrhynchos* | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0.1 | 0.3 | 0.1 | 0.2 | 0 | 0.0 | 0.0 | 0.0 |
| *Anthus trivialis* | 1.4 | 3.6 | 1.4 | 5.2 | 1.6 | 5.1 | 1.1 | 3.6 | 1.0 | 3.5 | 1.4 | 4.9 | 1.1 | 4.2 | 0.8 | 2.8 | 1.1 | 4.6 | 1.2 | 4.6 |
| *Apus apus* | 0.0 | 0.0 | 0.1 | 0.2 | 0.0 | 0.0 | 0.2 | 0.5 | 0.0 | 0.1 | 0.3 | 1.1 | 0.0 | 0.0 | 0.1 | 0.4 | 0 | 0.0 | 0.0 | 0.0 |
| *Buteo buteo* | 0.0 | 0.0 | 0.1 | 0.2 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.1 | 0.3 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 |
| *Carduelis spinus* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.1 | 0.3 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 |
| *Certhia brachydactyla* | 0.4 | 1.0 | 0.1 | 0.4 | 0.1 | 0.3 | 0.2 | 0.7 | 0.1 | 0.4 | 0.2 | 0.9 | 0.0 | 0.0 | 0.2 | 0.6 | 0 | 0.0 | 0.2 | 0.7 |
| *Certhia familiaris* | 0.0 | 0.0 | 0.1 | 0.4 | 0.1 | 0.3 | 0.2 | 0.5 | 0.1 | 0.4 | 0.1 | 0.4 | 0.2 | 0.6 | 0.1 | 0.2 | 0 | 0.0 | 0.3 | 1.3 |
| *Coccothraustes coccothraustes* | 0.6 | 1.5 | 0.5 | 1.9 | 0.3 | 1.0 | 0.3 | 1.1 | 0.0 | 0.1 | 0.2 | 0.6 | 0.0 | 0.0 | 0.1 | 0.4 | 0 | 0.0 | 0.0 | 0.0 |
| *Columba oenas* | 0.4 | 1.0 | 0.2 | 0.8 | 0.1 | 0.3 | 0.3 | 0.8 | 0.1 | 0.3 | 0.1 | 0.2 | 0.2 | 0.6 | 0.3 | 1.0 | 0.1 | 0.4 | 0.5 | 2.0 |
| *Columba palumbus* | 0.8 | 2.0 | 0.2 | 0.8 | 0.3 | 0.9 | 0.3 | 1.2 | 0.2 | 0.5 | 0.2 | 0.6 | 0.0 | 0.0 | 0.3 | 1.0 | 0.2 | 0.8 | 0.2 | 0.7 |
| *Corvus corax* | 0.4 | 1.0 | 0.3 | 1.0 | 0.3 | 1.0 | 0.2 | 0.5 | 0.2 | 0.7 | 0.1 | 0.4 | 0.2 | 0.9 | 0.2 | 0.6 | 0.1 | 0.4 | 0.2 | 0.7 |
| *Cuculus canorus* | 0.8 | 2.0 | 0.6 | 2.1 | 0.4 | 1.2 | 0.3 | 0.8 | 0.4 | 1.3 | 0.4 | 1.3 | 0.5 | 2.1 | 0.2 | 0.8 | 0.1 | 0.4 | 1.2 | 4.6 |
| *Dendrocopos major* | 1.8 | 4.6 | 0.8 | 3.1 | 1.0 | 3.2 | 0.9 | 3.1 | 1.0 | 3.3 | 0.8 | 3.0 | 0.6 | 2.4 | 0.8 | 2.8 | 0.9 | 3.8 | 1.3 | 5.2 |
| *Dryocopus martius* | 0.4 | 1.0 | 0.2 | 0.6 | 0.2 | 0.5 | 0.2 | 0.5 | 0.2 | 0.8 | 0.5 | 1.7 | 0.2 | 0.6 | 0.1 | 0.4 | 0.2 | 0.8 | 0.3 | 1.3 |
| *Emberiza citrinella* | 2.6 | 6.6 | 1.4 | 5.0 | 1.4 | 4.6 | 1.1 | 3.6 | 1.5 | 5.1 | 1.2 | 4.3 | 1.2 | 4.5 | 1.2 | 4.5 | 0.6 | 2.5 | 1.5 | 5.9 |
| *Erithacus rubecula* | 2.4 | 6.1 | 1.3 | 4.8 | 1.8 | 6.0 | 2.0 | 6.9 | 2.0 | 6.8 | 1.4 | 4.9 | 1.5 | 5.7 | 1.9 | 7.1 | 1.1 | 4.6 | 1.0 | 3.9 |
| *Ficedula hypoleuca* | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0 | 0.0 | 0.0 | 0.0 |
| *Fringilla coelebs* | 3.4 | 8.6 | 3.8 | 13.8 | 4.4 | 14.3 | 4.0 | 13.7 | 4.1 | 13.7 | 4.2 | 15.4 | 3.5 | 13.6 | 4.3 | 15.6 | 3.9 | 16.4 | 3.2 | 12.4 |
| *Garrulus glandarius* | 0.6 | 1.5 | 0.5 | 1.7 | 0.6 | 1.9 | 0.6 | 1.9 | 0.6 | 2.1 | 0.8 | 3.0 | 0.4 | 1.5 | 0.5 | 1.8 | 0.3 | 1.3 | 0.3 | 1.3 |
| *Grus grus* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.4 | 0.1 | 0.3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Jynx torquilla* | 0.0 | 0.0 | 0.1 | 0.2 | 0.0 | 0.0 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Lanius collurio* | 0.2 | 0.5 | 0.1 | 0.4 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Lullula arborea* | 0.4 | 1.0 | 0.1 | 0.4 | 0.0 | 0.0 | 0.1 | 0.3 | 0.0 | 0.1 | 0.2 | 0.9 | 0.2 | 0.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Motacilla alba* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.7 |
| *Muscicapa striata* | 0.4 | 1.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0.1 | 0.3 | 0.2 | 0.7 | 0.1 | 0.2 | 0.0 | 0.0 | 0.2 | 0.8 | 0.1 | 0.4 | 0.2 | 0.7 |
| *Oriolus oriolus* | 0.4 | 1.0 | 0.2 | 0.6 | 0.2 | 0.5 | 0.1 | 0.4 | 0.2 | 0.8 | 0.2 | 0.9 | 0.2 | 0.9 | 0.4 | 1.4 | 0.2 | 0.8 | 0.2 | 0.7 |
| *Parus ater* | 1.4 | 3.6 | 1.2 | 4.4 | 1.4 | 4.6 | 1.3 | 4.2 | 1.3 | 4.3 | 1.5 | 5.6 | 0.8 | 3.0 | 1.6 | 5.9 | 1.8 | 7.6 | 0.8 | 3.3 |
| *Parus caeruleus* | 0.6 | 1.5 | 0.2 | 0.6 | 0.1 | 0.3 | 0.2 | 0.7 | 0.3 | 0.9 | 0.1 | 0.2 | 0.2 | 0.6 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Parus cristatus* | 0.2 | 0.5 | 0.4 | 1.5 | 0.6 | 1.9 | 0.6 | 1.9 | 0.6 | 1.9 | 0.5 | 1.9 | 0.5 | 2.1 | 0.8 | 2.8 | 0.6 | 2.5 | 0.3 | 1.3 |
| *Parus major* | 1.2 | 3.0 | 0.9 | 3.3 | 0.8 | 2.7 | 1.1 | 3.7 | 1.3 | 4.3 | 0.5 | 1.9 | 0.7 | 2.7 | 0.9 | 3.4 | 0.3 | 1.3 | 0.7 | 2.6 |
| *Parus montanus* | 0.2 | 0.5 | 0.0 | 0.0 | 0.2 | 0.5 | 0.1 | 0.2 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.3 | 0.1 | 0.4 | 0.1 | 0.4 | 0.0 | 0.0 |
| *Parus palustris* | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0.0 | 0.0 | 0.1 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Phoenicurus phoenicurus* | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0.2 | 0.7 | 0.1 | 0.3 | 0.1 | 0.2 | 0.3 | 1.2 | 0.1 | 0.2 | 0.3 | 1.3 | 0.7 | 2.6 |
| *Phylloscopus collybita* | 3.8 | 9.6 | 2.5 | 9.0 | 3.3 | 10.8 | 2.3 | 7.7 | 3.0 | 10.1 | 2.3 | 8.4 | 2.1 | 8.1 | 2.3 | 8.5 | 2.5 | 10.5 | 2.0 | 7.8 |
| *Phylloscopus sibilatirx* | 0.4 | 1.0 | 0.5 | 1.9 | 0.7 | 2.2 | 0.8 | 2.8 | 1.0 | 3.2 | 0.5 | 1.9 | 0.5 | 1.8 | 0.4 | 1.6 | 0.5 | 2.1 | 0.2 | 0.7 |
| *Phylloscopus trochilus* | 2.8 | 7.1 | 2.4 | 8.7 | 2.0 | 6.5 | 1.9 | 6.6 | 1.8 | 5.9 | 1.8 | 6.4 | 2.1 | 8.1 | 1.9 | 7.1 | 2.0 | 8.4 | 2.5 | 9.8 |
| *Picus canus* | 0.2 | 0.5 | 0.0 | 0.0 | 0.1 | 0.2 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Prunella modularis* | 0.6 | 1.5 | 0.2 | 0.8 | 0.5 | 1.7 | 0.5 | 1.6 | 0.3 | 0.9 | 0.2 | 0.6 | 0.8 | 3.0 | 0.5 | 1.8 | 0.4 | 1.7 | 0.2 | 0.7 |
| *Pyrrhula pyrrhula* | 0.0 | 0.0 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.4 | 0.0 | 0.0 |
| *Regulus ignicapillus* | 0.6 | 1.5 | 0.1 | 0.4 | 0.0 | 0.0 | 0.1 | 0.4 | 0.2 | 0.5 | 0.1 | 0.4 | 0.1 | 0.3 | 0.2 | 0.6 | 0.1 | 0.4 | 0.0 | 0.0 |
| *Regulus regulus* | 0.8 | 2.0 | 0.6 | 2.3 | 0.7 | 2.4 | 0.8 | 2.9 | 0.9 | 3.1 | 0.6 | 2.1 | 0.5 | 2.1 | 0.7 | 2.4 | 0.5 | 2.1 | 1.0 | 3.9 |
| *Sitta europaea* | 0.8 | 2.0 | 0.2 | 0.8 | 0.3 | 1.0 | 0.5 | 1.6 | 0.6 | 1.9 | 0.4 | 1.3 | 0.2 | 0.9 | 0.3 | 1.2 | 0.1 | 0.4 | 0.3 | 1.3 |
| *Streptopelia turtur* | 1.0 | 2.5 | 0.7 | 2.7 | 0.3 | 1.0 | 0.8 | 2.5 | 0.5 | 1.7 | 0.6 | 2.1 | 0.9 | 3.6 | 0.5 | 1.8 | 0.3 | 1.3 | 0.2 | 0.7 |
| *Sturnus vulgaris* | 0.8 | 2.0 | 0.2 | 0.6 | 0.3 | 1.0 | 0.4 | 1.3 | 0.2 | 0.7 | 0.2 | 0.9 | 0.1 | 0.3 | 0.0 | 0.0 | 0.1 | 0.4 | 0.0 | 0.0 |
| *Sylvia atricapilla* | 2.2 | 5.6 | 1.8 | 6.5 | 2.2 | 7.0 | 1.6 | 5.5 | 1.7 | 5.7 | 1.4 | 5.1 | 1.7 | 6.6 | 1.6 | 5.7 | 1.7 | 7.1 | 1.0 | 3.9 |
| *Sylvia communis* | 0.2 | 0.5 | 0.1 | 0.2 | 0.2 | 0.5 | 0.1 | 0.4 | 0.1 | 0.4 | 0.2 | 0.9 | 0.1 | 0.3 | 0.1 | 0.4 | 0.3 | 1.3 | 0.2 | 0.7 |
| *Sylvia curruca* | 0.0 | 0.0 | 0.3 | 1.2 | 0.2 | 0.5 | 0.2 | 0.5 | 0.1 | 0.4 | 0.2 | 0.6 | 0.4 | 1.5 | 0.1 | 0.4 | 0.1 | 0.4 | 0.2 | 0.7 |
| *Troglodytes troglodytes* | 1.4 | 3.6 | 0.5 | 1.9 | 0.7 | 2.2 | 0.7 | 2.2 | 0.6 | 2.0 | 0.6 | 2.4 | 0.5 | 2.1 | 0.8 | 3.0 | 0.5 | 2.1 | 0.3 | 1.3 |
| *Turdus merula* | 1.8 | 4.6 | 1.6 | 5.8 | 1.8 | 6.0 | 2.2 | 7.3 | 1.9 | 6.3 | 1.4 | 4.9 | 1.8 | 7.2 | 1.7 | 6.3 | 1.6 | 6.7 | 2.3 | 9.2 |
| *Turdus philomelos* | 1.0 | 2.5 | 0.9 | 3.3 | 1.4 | 4.4 | 1.1 | 3.6 | 1.2 | 4.0 | 1.2 | 4.5 | 0.9 | 3.6 | 0.9 | 3.4 | 1.0 | 4.2 | 0.7 | 2.6 |
| *Turdus viscivorus* | 0.0 | 0.0 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.7 |
| Number of sections surveyed | 5 | | 19 | | 19 | | 32 | | 25 | | 17 | | 13 | | 18 | | 10 | | 6 | |
| Total no. of species recorded | 37 | | 43 | | 40 | | 41 | | 35 | | 48 | | 39 | | 39 | | 34 | | 34 | |
| Mean no. of pairs recorded | 39.4 | | 27.8 | | 31.2 | | 29.9 | | 29.6 | | 27.8 | | 25.9 | | 27.5 | | 23.8 | | 25.8 | |
| Total number of pairs recorded | 197 | | 520 | | 587 | | 945 | | 750 | | 467 | | 332 | | 494 | | 238 | | 153 | |

A similar situation was recorded in this study. In Tilio-Caprinetum hornbeam forest is Silesia, SW Poland, species such as the Starling, Nuthatch *Sitta europea*, Robin, Firecrest *Regulus ignicapilla*, Blackcap, Blue Tit and Greater Spotted Woodpecker were more numerous in the interior than on the forest edge; while species such as the Yellowhammer, Chiffchaff, Chaffinch and Goldfinch *Caduelis carduelis* were more numerous on the edge than in the forest interior (Kopij, 2013). Habitat specialists (forest specialists in this study) usually avoid edges, while shrub-nesting species often show higher densities on the edges (Ries & Sisk, 2010).

With the exception of the Yellowhammer, in this study the clearcuts caused most probably a decrease in the number of both species and individuals. It is because clearcuts not only create edges, but also cause forest fragmentation and even loss of forest habitat (Hannson, 1982, Kroodsma, 1984). Edge and area effect may in fact interact, in such way that the edge effect may drive out the area effect, causing the increase. In any case, this increase can be caused by the following factors: 1) lower territorial defense and interspecific competition on the edge than in deep forest, as resources from both habitats can be accessed in one territory; 2) higher primary productivity on the edge than in deep forest, as the light intensity increases towards the edge; 3) richer insect fauna on the edge than in deep forest, as a result of higher primary productivity on the edge; 4) ambush predation from deep forest and lower predation pressure on the edge (Burgess & Sharpe, 1981; Kroodsma, 1984; Lahti, 2001; Banks-Leite et al., 2010). In the hornbeam forests in the Białowieża National Park, the overall breeding density of birds slightly

decreased with the increase of distance from the forest edge (Tomiałojć et al., 1984). This decrease was mainly due to the presence of species from the forest margins, such as the Yellowhammer, Savi's Warbler *Locustella luscinioides*, Common Rosefinch *Caprodacus erythrinus*; and those species which strongly prefer forest margins: Starling, Greenfinch *Caruelis chloris* or Turtle Dove; or prefer margins on forest interior, like Tree Pipit and Chiffchaff (Tomiałojć et al., 1984). However, the overall density of forest-interior species did not decrease. Although species such as the Song Thrush, Robin and Chaffinch are regarded in Western Europe as forest-edge species, in the primeval forests of the Białowieża National Park they are typical forest-interior species. Also species which are usually regarded as preferring forest edge, the Common Buzzard *Buteo buteo*, Song Thrush, Blackbird and Wood Pigeon *Columba palumbus*, were in Białowieża NP more common in the interior than on the edge (Tomiałojć et al., 1984).

**Table 5**
Dominance in relation to the distance from the forest edge

| Species | Guilds | | | 0.0–0.5 | 0.6–1.0 | 1.0–1.5 | 1.5–2.0 | 2.1–2.5 | 2.6–3.0 | 3.1–3.5 | 3.6–4.0 | 4.1–4.5 | 4.5–5.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Fringilla coelebs* | S | Ic | T | 8.63 | 13.67 | 14.10 | 13.38 | 13.85 | 15.11 | 13.51 | 15.64 | 16.39 | 12.40 |
| *Phylloscopus collybita* | S | Ic | V | 9.64 | 8.99 | 10.58 | 7.69 | 10.14 | 8.27 | 8.11 | 8.36 | 10.50 | 7.75 |
| *Phylloscopus trochilus* | L | Ic | V | 7.11 | 8.63 | 6.41 | 6.35 | 6.08 | 6.47 | 8.11 | 6.91 | 8.40 | 9.69 |
| *Turdus merula* | S | Ig | T | 4.57 | 5.76 | 5.77 | 7.36 | 6.42 | 5.04 | 6.95 | 6.18 | 6.72 | 8.91 |
| *Sylvia atricapilla* | S | Ic | T | 5.58 | 6.47 | 7.05 | 5.35 | 5.74 | 5.04 | 6.56 | 5.82 | 7.14 | 3.88 |
| *Erithacus rubecula* | S | Ig | V | 6.09 | 4.68 | 5.77 | 6.69 | 6.76 | 5.04 | 5.79 | 6.91 | 4.62 | 3.88 |
| *Emberiza citrinella* | R | G | T | 6.60 | 5.04 | 4.49 | 3.68 | 5.07 | 4.32 | 4.63 | 4.36 | 2.52 | 5.81 |
| *Parus ater* | R | Ic | H | 3.55 | 4.32 | 4.49 | 4.35 | 4.39 | 5.40 | 3.09 | 5.82 | 7.56 | 3.10 |
| *Anthus trivialis* | S | Ig | G | 3.55 | 5.04 | 5.13 | 3.68 | 3.38 | 5.04 | 4.25 | 2.91 | 4.62 | 4.65 |
| *Turdus philomelos* | S | Ig | T | 2.54 | 3.24 | 4.49 | 3.68 | 4.05 | 4.32 | 3.47 | 3.27 | 4.20 | 2.71 |
| *Dendrocopos major* | R | Ib | H | 4.57 | 2.88 | 3.21 | 3.01 | 3.38 | 2.88 | 2.32 | 2.91 | 3.78 | 5.04 |
| *Parus major* | R | Ic | H | 3.05 | 3.24 | 2.56 | 3.68 | 4.39 | 1.80 | 2.70 | 3.27 | 1.26 | 2.71 |
| *Regulus regulus* | R | Ic | T | 2.03 | 2.16 | 2.24 | 2.68 | 3.04 | 2.16 | 1.93 | 2.55 | 2.10 | 3.88 |
| *Troglodytes troglodytes* | S | Ig | V | 3.55 | 1.80 | 2.24 | 2.34 | 2.03 | 2.16 | 1.93 | 2.91 | 2.10 | 1.16 |
| *Streptopelia turtur* | L | G | T | 2.54 | 2.52 | 0.96 | 2.68 | 1.69 | 2.16 | 3.47 | 1.82 | 1.26 | 0.78 |
| *Phylloscopus sibilatirx* | L | Ic | V | 1.02 | 1.80 | 2.24 | 2.68 | 3.38 | 1.80 | 1.93 | 1.45 | 2.10 | 0.78 |
| *Parus cristatus* | R | Ic | H | 0.51 | 1.44 | 1.92 | 2.01 | 2.03 | 1.80 | 1.93 | 2.91 | 2.52 | 1.16 |
| *Garrulus glandarius* | R | O | T | 1.52 | 1.80 | 1.92 | 2.01 | 2.03 | 2.88 | 1.54 | 1.82 | 1.26 | 1.16 |
| *Cuculus canorus* | L | Ic | T | 2.03 | 2.16 | 1.28 | 1.00 | 1.35 | 1.44 | 1.93 | 0.73 | 0.42 | 4.65 |
| *Prunella modularis* | S | Ic | V | 1.52 | 0.72 | 1.60 | 1.67 | 1.01 | 0.72 | 3.09 | 1.82 | 1.68 | 0.78 |
| *Sitta europaea* | R | Ib | H | 2.03 | 0.72 | 0.96 | 1.67 | 2.03 | 1.44 | 0.77 | 1.09 | 0.42 | 1.16 |
| *Columba palumbus* | S | G | T | 2.03 | 0.72 | 0.96 | 1.00 | 0.68 | 0.72 | 0.00 | 1.09 | 0.84 | 0.78 |
| *Dryocopus martius* | R | Ib | H | 1.02 | 0.72 | 0.64 | 0.67 | 0.68 | 1.80 | 0.77 | 0.36 | 0.84 | 1.16 |
| *Columba oenas* | S | G | H | 1.02 | 0.72 | 0.32 | 1.00 | 0.34 | 0.36 | 0.77 | 1.09 | 0.42 | 1.94 |
| *Oriolus oriolus* | L | Ic | T | 1.02 | 0.72 | 0.64 | 0.33 | 0.68 | 0.72 | 0.77 | 1.45 | 0.84 | 0.78 |
| *Corvus corax* | R | O | T | 1.02 | 1.08 | 0.96 | 0.67 | 0.68 | 0.36 | 0.77 | 0.73 | 0.42 | 0.78 |
| *Sturnus vulgaris* | S | Ig | H | 2.03 | 0.72 | 0.96 | 1.34 | 0.68 | 0.72 | 0.39 | 0.00 | 0.42 | 0.00 |
| *Phoenicurus phoenicurus* | L | Ic | H | 0.00 | 0.00 | 0.32 | 0.67 | 0.34 | 0.36 | 1.16 | 0.36 | 1.26 | 2.71 |
| *Sylvia curruca* | L | Ic | T | 0.00 | 1.08 | 0.64 | 0.67 | 0.34 | 0.72 | 1.54 | 0.36 | 0.42 | 0.78 |
| *Coccothraustes coccothraustes* | S | Ic | T | 1.52 | 1.80 | 0.96 | 1.00 | 0.00 | 0.72 | 0.00 | 0.36 | 0.00 | 0.00 |
| *Parus caeruleus* | R | Ic | H | 1.52 | 0.72 | 0.32 | 0.67 | 1.01 | 0.36 | 0.77 | 0.36 | 0.00 | 0.00 |
| *Sylvia communis* | L | Ic | T | 0.51 | 0.36 | 0.64 | 0.33 | 0.34 | 0.72 | 0.39 | 0.36 | 1.26 | 0.78 |
| *Certhia brachydactyla* | R | Ib | H | 1.02 | 0.36 | 0.32 | 0.67 | 0.34 | 0.72 | 0.00 | 0.73 | 0.00 | 0.78 |
| *Regulus ignicapillus* | S | Ic | T | 1.52 | 0.36 | 0.00 | 0.33 | 0.68 | 0.36 | 0.39 | 0.73 | 0.42 | 0.00 |
| *Muscicapa striata* | L | Ic | H | 1.02 | 0.00 | 0.32 | 0.33 | 0.68 | 0.36 | 0.00 | 0.73 | 0.42 | 0.78 |
| *Certhia familiaris* | R | Ib | H | 0.00 | 0.36 | 0.32 | 0.67 | 0.34 | 0.36 | 0.77 | 0.36 | 0.00 | 1.16 |
| *Lullula arborea* | S | Ig | G | 1.02 | 0.36 | 0.00 | 0.33 | 0.00 | 0.72 | 0.77 | 0.00 | 0.00 | 0.00 |
| *Parus montanus* | R | Ic | H | 0.51 | 0.00 | 0.64 | 0.33 | 0.00 | 0.00 | 0.39 | 0.36 | 0.42 | 0.00 |
| *Apus apus* | L | Ic | H | 0.00 | 0.36 | 0.00 | 0.67 | 0.00 | 1.08 | 0.00 | 0.36 | 0.00 | 0.00 |
| *Aegithalos caudatus* | R | Ic | T | 0.00 | 0.36 | 0.32 | 0.00 | 0.00 | 0.36 | 0.77 | 0.00 | 0.00 | 0.00 |
| *Buteo buteo* | R | O | T | 0.00 | 0.36 | 0.32 | 0.00 | 0.00 | 0.36 | 0.39 | 0.00 | 0.00 | 0.00 |
| *Anas platyrhynchos* | S | O | G | 0.00 | 0.00 | 0.32 | 0.00 | 0.00 | 0.36 | 0.39 | 0.36 | 0.00 | 0.00 |
| *Picus canus* | R | Ib | H | 0.51 | 0.00 | 0.32 | 0.00 | 0.00 | 0.36 | 0.00 | 0.00 | 0.00 | 0.00 |
| *Turdus viscivorus* | S | Ic | T | 0.00 | 0.36 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.78 |
| *Pyrrhula pyrrhula* | S | Ic | T | 0.00 | 0.36 | 0.00 | 0.00 | 0.00 | 0.36 | 0.00 | 0.00 | 0.42 | 0.00 |
| *Lanius collurio* | L | Ic | T | 0.51 | 0.36 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| *Motacilla alba* | S | Ig | G | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.78 |
| *Carduelis spinus* | S | O | G | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.36 | 0.39 | 0.00 | 0.00 | 0.00 |
| *Grus grus* | S | Ic | T | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.36 | 0.39 | 0.00 | 0.00 | 0.00 |
| *Accipiter gentilis* | R | O | T | 0.00 | 0.36 | 0.00 | 0.00 | 0.00 | 0.36 | 0.00 | 0.00 | 0.00 | 0.00 |
| *Jynx torquilla* | R | Ic | H | 0.00 | 0.36 | 0.00 | 0.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| *Parus palustris* | S | Ic | H | 0.00 | 0.00 | 0.00 | 0.33 | 0.00 | 0.36 | 0.00 | 0.00 | 0.00 | 0.00 |
| *Ficedula hypoleuca* | L | Ic | H | 0.00 | 0.00 | 0.32 | 0.00 | 0.00 | 0.36 | 0.00 | 0.00 | 0.00 | 0.00 |
| *Accipiter nisus* | S | O | T | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.36 | 0.00 | 0.00 |
| Mean number of pairs | | | | 39.4 | 27.8 | 31.2 | 29.9 | 29.6 | 27.8 | 25.9 | 27.5 | 23.8 | 25.8 |

Ground-feeding species, such as the Song Thrush and Robin, do not show any pronounced changes in density in relation to the distance from the forest edge, as they are much more affected by the ground layer and undergrowth than the age of tree stands. Some bird species may use the clearcuts to a greater extent in summer and autumn than in spring, but this premise should be examined further.

Contrary to expectation, in this study Shannon's Diversity Index did not change in relation to the distance from the forest/field edge, but Simpson's Diversity Index clearly declined along this gradient, as expected. This may indicate that Simpson's Diversity Index is more sensitive in calculating diversity indices along ecological grandients. Also contrary to expectation, the number of dominant species in relation to the distance from the forest/field edge, remained stable, as were also proportions of feeding guilds. These indicate that avian communities in extensive pine forests (with a mosaic of old and young tree stands and clearcuts) are only slightly affected by the distance from the forest/field

edge. Only densities and dominance of some typical wood and edge species appear to be affected in this regard.

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