sciendo

DOI: 10.2478/pesd-2019-0035 PESD, VOL. 13, no. 2, 2019

ASSESSMENT OF THE ECOLOGICAL CONDITIONS OFFERED BY DECIDOUS STANDS FROM THE NORTHERN ROMANIA FOR THE AVIAN POPULATIONS

Măciucă Anca[1], Dănilă Alin[2]

Key words: forest biodiversity, avian populations, sustainable management

Abstract. Bird populations are fundamental elements of forest biodiversity and play a very important role in maintaining the ecological balance and normal functions of forest ecosystems, so that they are an indicator of sustainable management taken into account at European level. Consequently, the existence or setting up by management measures of the most favourable conditions for diverse assemblages of birds is one of the objectives of sustainable forest management. For this purpose the paper aims to assess the ecological conditions offered by broadleaved stands from the northern Romania for the avian populations. The parameters considered were the stands layers, the composition and spatial distribution of forest shrubs, the stand density, the biological potential of forest species, stand age and stand ecological dynamic, landscape parameters. Using these parameters as partial favourability indices, a simple method for assessing the ecological conditions offered to bird populations based on a Total Favourability Index (TFI) is proposed for practical forest management purposes. According to this index, in the case study of the northern broadleaved managed stands, the ecological favourability for birds is medium.

1. Introduction

Forest ecosystems play a major role at regional, national and global scale. The loss of biodiversity in temperate forests is a serious threat to the stability and functioning of these ecosystems compromising the provisioning of their multiple services. Avian populations are an important component of forest biodiversity; they are high up in the food chain, so they are good indicators species of the general state of ecosystems and environment. Birds play multiple roles: control of insect pests, vegetal species seed dissemination, transport of larvae, eggs, insects,

[1] Forestry Faculty, Ștefan cel Mare University, Suceava, ancam@usv.ro
[2] Direcția Silvică Botoșani, andrei_alin_94@yahoo.com

collembola, and microorganisms contributing to the restoration of soil underground fauna communities of disturbed forests, part of the ecosystem matter circuit. Recent studies (Inger et al., 2014) revealed that while the populations of rare birds recover after benefiting from protection measures (Bird Directive, Natura 2000 network) many common bird populations continue to decline. So, the conservation measures applied outside the protected areas, in the managed forests became more and more important; also, the assessment of bird populations is a European indicator of sustainable forest management. In this context our study propose an easy to apply tool for assessing the ecological conditions offered by stands to ornithofauna and the possibility to identify the factors that must be improved and management measures to do it.

2. Material and methods

Research was conducted in the north of the Moldavian Plateau, in the deciduous hill forests situated in the Jijia river basin, in U.P VII Suharău, O.S Dorohoi.

Five factors have been adopted: the number of stands vegetal layers, the composition and spatial distribution of shrubs, the stands density, the composition and the biological potential of the woody plant species, along with the stands age. For each of these factors a partial index of favourability of the ecological conditions was determined and based on them a total ecological favourability index.

The total favourability index (ITF) was determined by a graphical method, reporting the surface of the optimal polygon (S_o), whose sides are all equal to 5 if all partial indices have the maximum value, at the surface of the polygon whose sides have different lengths (equal to or less than 5) depending on the actual situation of the partial indices, therefore depending on the real ecological conditions in the studied area (S_r):

$$I_{tf} = \frac{S_o}{S_r}$$

In order to analyze the ecological potential of tree and shrub species to meet the food and shelter needs of avian fauna, the results of studies conducted in Belgium and France were used (Table 1). (Branquart, Dufrene, 2005)

Tab.1. Ecological potential of forest tree and shrub species for birds

Ecological potential for birds			
very high	high	medium	low
birch, oak sp., beech, cherry, willow sp. blackthorn	maple, sycamore, alder, ash, poplar sp., scots pine, mountain ash, whitebeam, dogwood, elderberry	elm, lime, wild apple, hawthorn	hornbeam, hazelnut

(source: Branquart, Dufrene, 2005)

The following age stages of forest dynamic significant for avian diversity have been taken into account for assessing the environmental potential (Table 2).

The bird species identification was performed in seven stands with different ecological factors, selected from the analyzed forest area and which are presented in Table 3. The field data were gathered between April 21 and May 19, 2018, every two weeks, in clear days, early in the morning (generally between 5 and 7 a.m).

Tab. 2. Significant age stages for ornithofauna

Age stages	I	II	III	IV	V	VI	VII
Age (yrs)	1-3	4-7	9-12	13-20	40-80	81-125	125-200

(source: Ferry, Frochot, 1970)

The method used to identify bird species was the one of presence - absence; the diagonal of the selected stands was walked on a steady pace, during which time the sounds of the different species were recorded; the species identification was based on the attached audio guide of Atlas of Community Interest Birds Species from Romania, (CNDD, 2015), and Bird Songs of Romania CD (Zsoldos, 2007).

Tab. 3. Bird species assessment sites

Stand	Ecological conditions			
	Composition	Age	Density	Shrubs
36A	4ST 2FA 3CA 1DT	110	0.8	-
37B	6ST 2SC 2PA	70	0.7	elderberry
38 C	6FA 1GO 1CA	130	0.8	-
39	7FA 1GO 1CA 1DT	120	0.8	elderberry
44 A	7FA 1GO 2DT	140	0.6	elderberry
44 C	3ST 2CI 2TE 2PA 1DT	30	0.8	-
44 D	7ST 2PA 1CI	15	0.5	-

The study was carried out for 1465 ha area, covered by mixed forests with main species beech, hornbeam and oaks, situated between 200-400 m altitude; climatic conditions: mean annual precipitations 563,3 mm, mean annual temperature 8,6ºC .

3. Results and discussions

Results. The main factors determining the presence and distribution of bird species during the breeding period that have been analyzed are the habitat structure (I), the temporal dynamics of the forest (II) and the landscape scale parameters (III).

I. The analyse of **habitat structure** focuses on stands layers, the composition and spatial distribution of forest shrubs, the stand density, and the biological potential of forest species.

Regarding the stand layers, 75% of the studied area is covered by even aged stands, mostly beech and hornbeam mixed forests, with two layer, trees and herbaceous layer. Tree stands where, besides the tree and grassy or seedlings layer, shrubs layer also appear, occupies 14% of the area. The stands in which vertical vegetation is organized in four layers occupy only 11% of the area (figure 1).

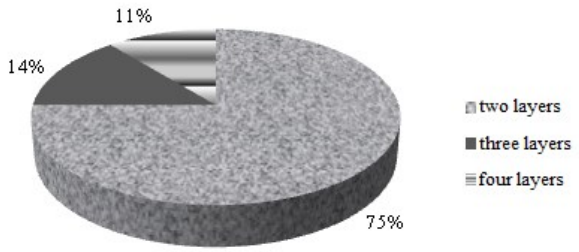

Fig.1. Stands distribution according to layers number

Depending on the number of layers, a score is given to the stands, which represents their potential to provide favourable conditions for the installation of bird species and a partial index (I_{layer}) related to this characteristic of the habitat is calculated (table 4).

The value of the partial index (I_{layer}) calculated using the weighted average is 2.3; according to this value, the potential related to stands layers of the analysed area is low to medium. Regarding the composition and distribution of shrubs, the

analyse has revealed that shrubs cover only 20% of the forested area and the predominant species are elderberry (*Sambucus nigra*) 87% of the area, followed by dogwood (*Cornus sanguine*) 8% and hazelnut (*Corylus avellana*) 5%.

Tab. 4 Ecological potential according to the number of layers of stands

Potential	low	low-medium	medium	medium-high	high
Rank	1	2	3	4	5
Layers	one layer	two layers	three layers	four layers	> four layers
Area (ha)	0	1069,6	200,5	158,2	0
I_{layer} score					**2,30**

Depending on the percentage of the studied area on which are shrubs, a score is given and a second partial index, I_{shrub} is determined (Table 5).

Tab. 5. Ecological potential according to the area occupied by shrubs

Potential	low	low-medium	medium	medium-high	high
Rank	1	2	3	4	5
Shrub area %	0-20	21-40	41-60	61-80	81-100
% from total area covered by shrubs in the studied zone	20	0	0	0	0
I_{shrub} score					**1.00**

The partial index (I_{shrub}) related to the presence of the shrubs has a value of 1.0 and the ecological potential is low from this point of view.

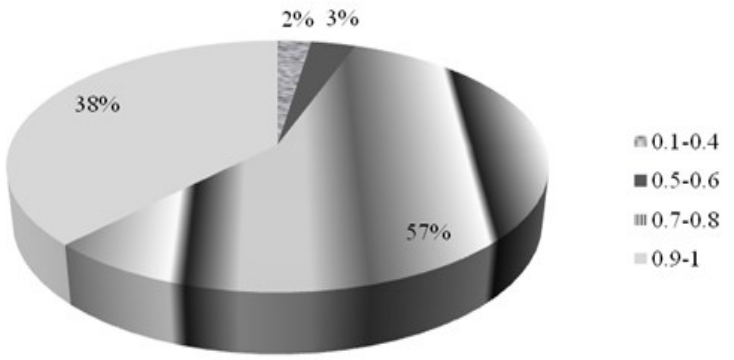

Fig. 2. Stands distribution according to density

For bird assemblages, the optimal conditions are ensured by understocked, less dense stands. In the studied area, 57% of the total is covered by stands with best ecological conditions related to stand density (figure 2).

By assigning a score to different categories of density, it was determined how favourable the conditions offered by the stands are for birds from this point of view by calculating a partially related index of density (I_{dens}) using the weighted average; the index score is 4, 003 (Table 6).

Tab. 6 Ecological potential according to stands density

Potential	low	low-medium	medium	medium-high	high
Rank	1	2	3	4	5
Density	0,1-0,2	0,3-0,4	0,9-1	0,5-0,6	0,7-0,8
Area (ha)	0,4	33,1	535,1	44,4	803,6
I_{dens} score					**4, 003**

The fourth parameter that influences the selection of the place for nesting and breeding is the stands composition (Figure 4) because the different tree species have different possibilities to meet the different survival needs of bird species.

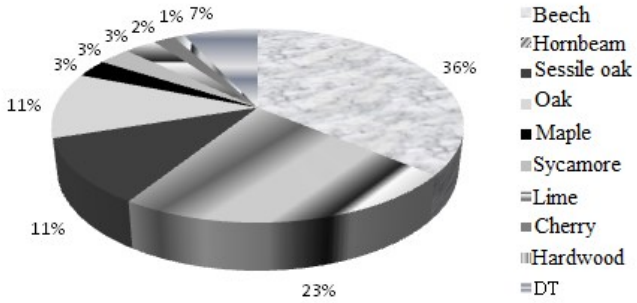

Fig. 4. Tree species area distribution

The main species is beech (*Fagus sylvatica* L.), which covers 36% of the total area, and is a species with very high ecological potential, followed by hornbeam (*Carpinus betulus* L.) with 23%, then sessile oak (*Qurcus petraea* Matt. Liebl.) - 11%), oak (*Quercus robur* L.) - 11%, maple (*Acer platanoides* L.) and sycamore (*Acer pseudoplatanus* L.) 3% each, cherry (*Prunus avium* L.) - 2%, and various hardwoods (1%). Taking into account the capacity of woody species to meet the needs of the avifauna in the studied area to a higher or lower degree, a rank and a partial index (I_{sp}) related to this ecological potential of the plant species is calculated (Table 7).

Species with high and very high ecological potential hold the highest percentage so that the result of calculating the weighted average for the partial index I_{sp} is 4.11; this value signifies a high potential for the whole production unit.

Tab. 7. Ecological potential for ornithofauna depending on the stands woody plant species

Potential	low	low-medium	medium	medium-high	high
Rank	1	2	3	4	5
Species	alien	hornbeam, hazelnut	lime, wild apple	whitebeam, maple, sycamore, ash, poplar, dogwood, elderberry	beech, birch, oak, cherry, willow sp.
Area (ha)	0	332,9	57,1	238,5	893,0
I_{sp} score					**4,11**

II. The **forest dynamics** analysis considered only the forest development phases because no other information on the ecological succession was available.

The age stages distribution for the studied area reveal the presence of all age stages, but the area for each of them is uneven. The 1-20 years stage covers 136.9 ha, the 21-80 years covers 588.5 ha, the 81-125 years – 568.9 ha and forests older than 125 years cover 108.9 ha. The succession of age stages in the age dynamics of forest ecosystems determines the change of bird assemblages, therefore, a score was assigned to each age stage, based on which the partial index I_{age} was determined equal to 4.00 (medium high).

Table 8 Ecological potential according to age dynamics of stands

Potential	low	low-medium	medium	medium-high	high
Rank	1	2	3	4	5
Age stages structure	Predominantly age stage V	Predominantly age stages I-IV	Predominantly age stage VI - VII	All age stages but unbalanced	All age stages balanced
I_{age} score					**4,00**

Using the five partial indices determined (I_{layers} = 2,30, I_{shrubs}= 1, I_{dens}= 4,003, I_{sp} = 4, I_{age}=4) a diagram was made by representing two polygons: one for the ideal situation in which all the indices would have maximum values (the polygon with the black sides) and one obtained by representing the values of the partial indices as they were determined according to the actual situation in the analyzed area (polygon with the grey sides) (Figure 6).

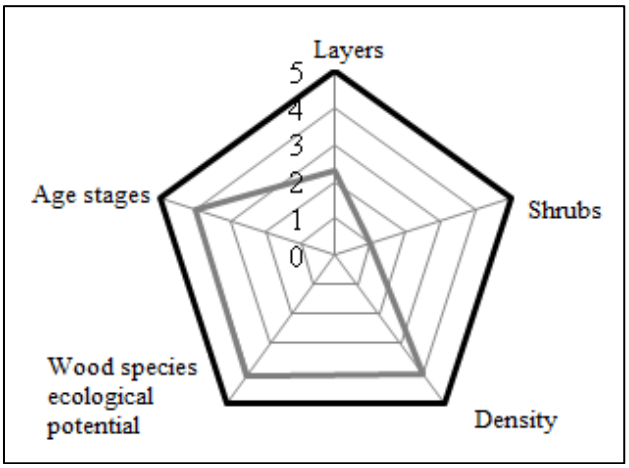

Fig. 6. Graphical determination of the Total Favourability Index

Reporting the surface of the optimal polygon to the surface of the actual polygon the value of the total index was 2.66. According to the total index value scale, the favourability of ecological conditions for bird populations falls into the medium category (Table 9).

Tab. 9 Total Favorability Index value scale

IFT value	IFT= 1	1 < IFT ≤ 2	2 < IFT≤3	3 < IFT≤6	IFT > 6
Ecological favourability for avian fauna	very high	high	medium	low	very low

III. The ecological conditions analyse at **landscape scale** was more rough, as only information on fragmentation, anthropical disturbances and forest edges were available.

For the studied field, the area is continuous, homogeneous; it is only one category of land use - forest, so there is no question of fragmentation or connectivity of the fragments. In the category of anthropic disturbances were included the harvesting works, namely the definitive regenerating cuts, as it turns out from the management plan. The calculated percentage of the areas covered by felling cuts in the total area of the study unit was 20.3%.

For the forest edges, two aspects were considered: the exterior edge where the forest meet the agricultural lands and the inner edges of the production unit, formed at the contact of the mature forest with the newly harvested stands. The length of

the edges with the agricultural land is 16.72 km and the total length of the exterior edge is 17.21 km, so the percentage of the edge with the agricultural land represents 97.32%. The length of the edge between young and old stands is 47.93 km, and the total edge between all stands is 289.1 km which means a percentage of 16.5% of edges between old stands and newly harvested ones.

All the recorded bird species in the field (in habitats with different structure characteristics like age, density, composition, understorey from 36A, 37B, 38C, 39, 44A, 44C, 44D management units) are shown in the Table 10 with their systematic classification.

Tab. 10. Bird species identified in stands with different ecological conditions

Nr. crt.	Ordinul	Familia	Specia
1	Columbiformes	Columbidae	*Columba oenas*
2			*Streptopelia turtur*
3	Piciformes	Picidae	*Dendrocopos leucotos*
4	Passeriformes	Muscicapidae	*Ficedula parva*
5		Sylviidae	*Sylvia atricapilla*
6			*Sylvia communis*
7			*Phlloscopus collybita*
8			*Phylloscopus sibilatrix*
9		Acrocephalidae	*Hypolais icterina*
10		Sturnidae	*Sturnus vulgaris*
11		Passeridae	*Passer montanus*
12		Motacillidae	*Anthus trivialis*
13		Turdidae	*Turdus philomelos*
14			*Turdus viscivorus*
15			*Turdus vulgaris*
16		Paridae	*Parus major*
17			*Parus caeruleus*
18		Certhiidae	*Certhia familiaris*
19		Prunellidae	*Prunella modularis*
20		Oriolidae	*Oriolus oriolus*
21		Fringilidae	*Carduelis carduelis*
22			*Fringilla coelebs*
23		Cinclidae	*Turdus merula*
24	Cuculiformes	Cuculidae	*Cucuclus canorus*

A number of 24 bird species belonging to 4 orders and 16 families were identified. Only insectivorous and omnivorous species have been identified, no day

and night raptors have been targeted. Thus, the species identified represent 80% of the total of 30 species characteristic of the Columbidae ornithological zone.

Different studies carried out in temperate European forests highlight that a proper analyse concerning the forest ornithocenosis must integrate both the parameters related to the stands structure and those of the landscape level (Bas, 2009; Hewson, 2011; Begner, 2015; Conor, et al., 2014; Terraube, 2016).

In order to determine how favourable the ecological conditions for ornithofauna in the studied area are, the basic factors that determine the presence of varied and well represented populations of avifauna species have been identified. These factors have been determined and chosen after analyzing the most significant Romanian and abroad scientific studies (Simon, 1978; Rang, 1990; Szakacs, 1988; Branquart, Dufrene, 2005; Dugravot, 2009; Hewson, 2011, Bergner, 2015).

Regarding habitat structure, stands layers are a decisive factor for the occurrence of highly diverse bird assemblages because each layer offers different food and nesting conditions (Dugravot, 2009; Doupuey, 2010). So different bird species show preference for certain stand layers: the lower layer, the soil and the herbaceous strata is preferred by species such as *Turdus merula* and *Erithacus rubecula*, the bushes layer by the Parus, Silvia and Turdus sp., the area of the trunks by Dendrocopos and Parus sp., the lower part of the canopy by Regulus, Certhia, and Parus sp., and the upper part of the canopy by *Streptopelia turtur* and Columba sp. The predominance of two layers stands in the analyzed area (75%), shows that this forests does not offer optimal conditions for a high bird diversity, as proved by the partial I_{layer} of 2.3 which is characteristic for a medium ecological favourability.

Shrubs, both by cover and height, are another decisive factor for bird communities (Diaz, 2006; Wilson et al., 2006, Dugravot, 2009). Shrubs are increasing the habitat heterogeneity offering various nesting and refuge sites and food availability through fruits, seeds and associated arthropod species; for granivorous species (like those from Fringillidae family – *Fringilla coelebs*, Emberiza sp., Carduelis sp.) but for sedentary insectivorous birds in winter season too. Those last ones have a higher ecological efficiency because they keep under control insect populations a longer period throughout the year. The understorey is preferred for nesting especially by *Troglodytes troglodytes* and Turdus, Parus, Silvia sp. Because in the study area the shrubs cover is only 20%, and the value of partial index I_{shrub} is 1,00 the ecological potential is low from this perspective.

The third determinant structural element is the stand density, that closely correlates with the number of bird species (Dugravot, 2009). The studies revealed that increasing density is correlated with increasing number of birds in understoked stands, until the density reaches the 0,7-0.8 value; then, after the stands becomes fully stocked and starts to be overstocked, the bird number decreases again because

of the close environment. The analysed unit have 57% stands with optimum density for birds, the remaining area being covered with young stands and close oak stands, so the partial index I_{dens} score is 4.003 that mean a medium to high ecological potential.

Another parameter is the diversity of woody species; a number of researches (Dugravot, 2009; Graham 2014; Domokos, 2016) highlight that in general, the number of avian species increases with increasing vegetation diversity even if this factor is not as important as the vertical structure of the stands. But, in the situation of a given composition, different vegetal species have a different ecological potential to support species of fauna in general and birds in particular. In our study case, beech, a major species (covering 36% of studied area), belongs to the category of species with very high ecological potential. As species with high or very high ecological potential covers the largest areas (893.0 ha – 61% and 293.5 ha – 20%), the partial index I_{sp} has a value of 4.11 and the potential of the studied forests is high.

A fifth element relevant for bird populations is the age dynamics of the stands, because different stages of forest growth offer different conditions for the ornithofauna (in terms of food, microhabitats, dead wood, light and microclimat conditions, etc); so, in the early age stages and in the old growth forest the bird richness is high but represented by different species for each of this two stages and the diversity is lower in young to mature forest (Ferry, Frochot, 1970; Muller, 1985; Wilson et al., 2006, Dugravot, 2009). The forested areas where all the age stages are represented and balanced, shelter the most diverse bird assemblages. In the case of our study, all the significant age stages are present but are unbalanced and the score of the partial index I_{age} - 4.00, indicates a medium-high ecological potential.

All the partial indices considered above have been integrated in the Total Favorability Index IFT. The 2.66 score calculated for the index indicates that the level of ecological conditions offered by the studies forests for bird populations is medium.

This situation is improved by the fact that the length of the exterior forests edges with the surrounding agricultural land represents 97% of the total edges length, and the interior edges 17%. In the edge zone the various microclimate and vegetation conditions lead to a habitat heterogeneity increase and more bird species can fulfill their food and breeding needs (Deconchat, 2014; Terraube, 2016). The edges have a positive influence on pest control too: the omnivorous birds became more insectivorous (the percent of insects in their diet increase), because more light gets on the edge of the forest and they better see the insects and can catch them more easily.

The main anthropic disturbances that affect avian population are the harvesting works, tree felling and extraction causing the diminishing of food sources, nesting and breeding places and the presence of workers and harvesting equipments disturbs the ornithofauna. Considering that the calculated percentage of the area planned for felling operations in the total area of the study unit was 20.3%, the impact of the disturbances is temporary and reversible.

In order to improve the ecological conditions offered to ornithofauna by the studied forest stands, a number of management measures can be applied; such measures have been promoted by our specialists and researchers even before the emergence of sustainable management and biodiversity conservation concepts (Simon, 1978, Szakacs, 1988).

Measures that promote the shrub species diversity and the development of cover and height of under storey (Diaz, 2006), the vertical and horizontal spatial heterogeneity of stands (even and uneven-aged), the tree species biodiversity, the maintaining of 1-5 standing dead or old trees per ha for food (associated with xylophages insects) and cavity nesting (Rang, 1990) are recomended. Along with them, measures for prohibit grazing, avoid game overpopulation, avoid pesticide use, controlling the regeneration of acacia with invasive tendencies in some of the young stands, carving multilayer exterior and interior edges, eventually in young stands that did not offer enough nesting places, artificial nests and feeder installation to improve the bird efficiency (Simon, 1978,) and set aside a percent of forest (10%) to conserve microhabitats (Augustynczik et al., 2018).

Conclusions

We conclude that some of the forest habitat parameters in the studied area are favourable for diverse and stable bird communities, and that others can be improved; therefore, the stand density, the woody vegetation composition of the stands and the age structure are optimal for bird populations, while the understorey structure and the stands layers need to be improved. At landscape level, the external edges predominate compared to the internal ones but overall ecotones are well represented and have beneficial effects on birds. Based on the chosen structural parameters because of their influence on bird communities and based on ranking grids for every parameter, a simple graphic tool to use in practice was proposed for assess the capacity of the forest habitat to provide suitable conditions for avian population. This tool permit to practitioners to elaborate and apply management measures to enhance bird population abundance and diversity with positive effects for pest control and forest ecosystems stability.

References:

Augustynczik, A., et al., (2018), *Diversification of forest management regimes secures tree microhabitats and bird abundance under climate change*, Science of The Total Environment 650(2):2717–2730

Barbercheck, M., (2011), *Biological Control of Insect Pests*, organic Agriculture, 25 aprilie 2011, http://articles.extension.org/pages/18931/biological-control-of-insect-pests

Bas, Y., (2009), *Décomposition des effets des changements des paysages et des pratiques d'exploitation sur la biodiversité des milieux agricoles et forestiers*, These de doctorat de l'Universite Pierre et Marie Curie, Paris, 155 p.

Bergner, A., et al., (2015), *Influences of forest type and habitat structure on bird assemblages of oak (Quercus spp.) and pine (Pinus spp.) stands in southwestern Turkey*, Forest Ecology and Management, (336), 137-147,

Begehold, H., et al., (2015), *Forest development phases as an integrating tool to describe habitat preferences of breeding birds in lowland beech forests*, Journal of Ornithology 156:19-29, DOI 10.1007/s10336-014-1095-z

De Bont, A., (1986), *The geographic spread of nesting places inside the reproduction area as an indication of degradation of the ecosystem rather than of well-being of the species*, Abstracts of I.O.C. Ottawa, Canada

Branquart E., Dufrene M., (2005), *Normes de gestion pour favoriser la biodiversité dans les bois soumis au régime forestier - Complément à la circulaire n°2619*, Ministère de la région Wallonne, 84 p.

Conor, T., et al., (2014), *Factors affecting the bird diversity of planted and semi-natural oak forests in Ireland*, Bird Study, 61, 309–320

CNDD, (2015), Atlas al păsărilor de interes comunitar din România, Ed. Fundației Centrul național pentru dezvoltare Durabilă, 608p.

Deconchat, M., et al., (2014), *BILISSE : La biodiversité des lisières forestières Synthèse du rapport final*,
http://docs.gip-ecofor.org/public/bgf/BGF_BILISSE_RapportFinal.pdf

Diaz, Leticia, (2006), *Influences of forest type and forest structure on bird communities in oak and pine woodlands in Spain*, Forest ecology and Management, 223, p.54-65

Domokos, T., et al., (2016), *Bird communities of different woody vegetation types from the Niraj Valley, Romania*, Turkish Journal of Zoology, no. 40, p. 734-742,
http://journals.tubitak.gov.tr/zoology/issues/zoo-16-40-5/zoo-40-5-11-1510-64.pdf

Dugravot, S., (2009), *Facteurs structurant les communautés d'oiseaux et sélection de l'habitat*,
https://perso.univ-rennes1.fr/sebastien.dugravot/CM%20L3pro%202009.pdf

Dupouey, J.L., (2010), *Projet Corylus: influences de la composition et de la structure des masses forestières sur la biodiversité. Rapport final de la Convention GIP Ecofor-MEEDM n°0000192*,
http://cemadoc.irstea.fr/oa/PUB00029007-projet-corylus-influences-composition-structure-de.html

Ferry, C., Frochot, B., 1970, *L'avifaune nidificatrice d'une foret de chenes pedoncules en Bourgogne: Etude de deux successions ecologiques*, Revue d'ecologie, La terre et la vie, no. 2, http://hdl.handle.net/2042/58740

Hewson C. M., et al., (2011) *Species specific responses of woodland birds to stand-level habitat characteristics: the dual importance of forest structure and floristics*. For. Ecol. Manage. 261:1224–1240

Inger, R., et al., 2015, *Common European birds are declining rapidly while less abundant species' numbers are rising,* Ecology Letters, no. 18, p. 28–36,
http://onlinelibrary.wiley.com/doi/10.1111/ele.12387/abstract

Muller, Z., 1985, L'avifaune forestière nicheuse des Vosges du Nord. Sa place dans le context médio-européen, Thèse Doct. en Sciences, Université de Dijon, 318 p.

Rang, C., 1990, *Factori stresanți de origine antropică cu rol în diminuarea populațiilor de păsări din arborete*, Revista Pădurilor, nr. 3-4, p.166-168

Richard, D. G., et al., 2007, Population trends of widespread woodland birds in Europe, Ibis (2007), 149 (Suppl. 2), 78–97

Simon, D., (1978), *Contribuții la evaluarea eficacității păsărilor insectivore*, Revista Pădurilor, nr. 5, p.241-243

Svensson, S., (1977), *Land use planning and bird censuswork with particular reference toapplication of the point sampling method*, Polish Ecological Studies, no.34, p. 99-117

Szakacs, C., (1988), *O metodă preliminară de stabilire a eficienței ecologice naturale la ornitocenozele insectivore, proprii unor arborete din jurul municipiului Brașov*, Revista Pădurilor, nr. 3, p. 126-131

Terraube, J., et al., (2016), *Forest edges have high conservation value for bird communities in mosaic landscapes*. Ecology and Evolution, no. 6, p. 5178–5189, doi:10.1002/ece3.2273

Zsoldos A., (2007), *Cântece de păsări din România*, CD realizat în cadrul programului „Monitorizarea păsărilor comune din România"

Wilson, M., et al., (2006), *Effects of growth stage and tree species composition on breeding bird assemblages of plantation forests*, Bird Study, 53:3, 225-236, https://doi.org/10.1080/00063650609461437