University of Sopron
Faculty of Forestry

Effects of conservation-oriented forest management on the composition of forest bird communities in mid-mountain oak forests

Theses of doctoral (PhD) dissertation

Mariann Komlós

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Doctoral School: Roth Gyula Doctoral School of Forestry and Wildlife Management Sciences

Leader: Prof. Dr. Sándor Faragó

Program: Ecology and Diversity of Forest Ecosystems **(**E1)

Leader: Prof. Dr. Csaba Mátyás

Supervisors: Prof. Dr. Dániel Winkler

Dr. Gábor Ónodi

1. Introduction

The importance of forests for birds cannot be overstated - around 75% of all known bird species live in forests, and forests are the primary habitat for most of them. Forest birds have a complex relationship with many features of their environment, and this relationship is highly sensitive and plastic. There is a long history and literature on the use of birds as environmental indicators due to their ease of observation and high mobility. Their responses to environmental changes are expressed in changes at the level of both the whole bird community and individual groups. However, the majority of studies analysing the relationship between bird communities and forest population-level characteristics have been carried out in the hemiboreal zone, largely in the Americas or focusing on the Atlantic and Scandinavian regions of Europe. With a few exceptions, studies of this kind on oak forests are still rare in the Central European region or focus on primary forests. In particular, studies exploring a wide range of background variables of tree stand structure, focusing on the analysis of interactions, are lacking.

Also in North America, research is more prevalent on the effects of structural interventions involving deadwood production on the ecosystem – mainly in conifer stands, and specifically on the habitat selection and foraging behaviour of woodpecker species.

While more and more studies are coming out in Europe, studies on woodpecker foraging marks in artificially created dead wood and thus the foraging preferences of birds is still rare. In our country, there has been no similar experimental study on the effects of complex conservation forest management, which makes my work unique.

2. Aims of the study

My study was part of a larger research project, LIFE4OakForests. The project aims to develop and test conservation-oriented forest management practices in native mixed oak forests. Within this framework, my aim was to contribute to a deeper understanding of the relationships between forest bird communities and forest structure and composition, and to be the first in Hungary to investigate the effects of conservation-oriented management and dead wood creation on bark-foraging bird species. I investigated the different foraging preferences of bark-foraging birds and the effects of different artificially created deadwood types on the foraging activity of this particular species group.

My research sought to answer the following questions:

1. Which forest structural and compositional characteristics affect the overall abundance of birds and the abundance of different guilds and individual bird species?
2. Beyond forest structure variables, what is the impact of tree species composition?
3. What preferences of bark-foraging bird species can be detected for the species, diameter and height of the studied trees?
4. What was the distribution of foraging marks found on the recorded trees during the baseline survey, separately for the trunk and branches of the trees?

5. Following conservation management, what is the distribution of foraging marks found on trees? How are these related to the type of treatment, diameter at breast height and tree species?
6. How are the foraging marks found in each depth category after conservation management distributed between treatment types, tree species and breast height diameter values? Are there significant differences between depth categories?

3. Material and methods

3.1 Effect of forest structure variation on the composition of breeding bird communities (I. survey)

Census methods

Our sampling areas were located the Bükk, the Duna-Ipoly and the Balaton Uplands National Park Directorates. The bird communities of five national Natura 2000 oak habitats were surveyed, these habitats are: pannonian Turkey oak forests, pannonian hornbeam oak forests, pannonian downy oak forests, Euro-Siberian oak forest steppe. In total, 11 sampling areas were surveyed: Bükkzsérc, Cserépfalu, Kerecsenden in the Bükk, Garáb and Mátraszőlős in the Eastern Cserhát, Mátraszentimre in the Mátra, Diósjenő and Nagyoroszi in the Börzsöny, Esztergom in the Pilis, Fót in the Gödöllő Hills and Balatonfüred-Koloska in the Balaton uplands. To assess the background variables of tree stand structure, a 40 m equilateral triangular grid survey was used, with stratified circular sampling of tree stand characteristics as part of the pre-intervention baseline survey in 2019. We recorded the following variables within a 20 m circle: tree species, health, social status, perimeter and DBH. At each tree stand point, we recorded the height of 2-3 live dominant trees and the height of all standing dead trees. We recorded the shrub level and lying dead wood were estimated using the line intersect method. The microhabitats were recorded: exposed heartwood, stump and trunk cavities (wet and dry), bark pockets, exposed sapwood, stumps.

The ornithological data were recorded every 240 m on the triangular grid. At a given point, the number of singing bird species seen or heard and their numbers were recorded for ten minutes after 3 minutes of rest. We recorded which birds were observed from the inner 50 m radius circle and which from the surrounding 50-100 m ring. Three surveys were carried out from the second half of March to the end of June.

Data analysis

The data were processed by counting the maximum number of individuals of a given species per point among the replicates in a given area. The 45 bird species recorded during the study were grouped into guilds according to three criteria: feeding, breeding and migration. The groups are exclusive for each attribute, i.e. a species can only be assigned to one group. For each bird point, the average data from four forest survey points were used to generate the background variable data. I determined species richness, total abundance, and abundance of each guild and species. For each species analysis, I used the abundance of forest-dwelling and foraging species present in at least

10% of all bird points. I used a decision-tree modelling approach to explore relationships between predictors and bird species abundance in the R 4.1.2 environment using the "*ctree*" function of the *party* package.

3.2. Survey of the effects of conservation management actions on the occurrence of foraging marks of bark-feeding bird species (II. survey)

Census methods

We surveyed the effects of two important types of conservation forest management actions, deadwood-creation and opening of gaps, on tree stand structure and the distribution of foraging marks of bark-feeding bird species in 80x80 m experimental plots at 12 sites. The actions in the experimental quadrats were as follows:

- creation of standing deadwood by girdling - this will slowly kill the tree
- creation of lying deadwood: downing trees with low or high stumps,
- in addition, treatments independent of the gaps, such as bark wounding or the creation of standing or lying dead trees, were carried out.

Three small and one large gap per experimental square were opened. The survey was similar to the grid sampling survey, but here, in addition to that, each tree was marked with precise gps coordinates and plotted on a tree map, and data was recorded for each tree, resulting in a much more detailed database. After conservation actions, we recorded treatment methods, the health and decay status of the trees. We also recorded the number of trees that may have been spontaneously damaged or felled.

The recording of foraging marks of woodpeckers and other bark-associated bird species was carried out once during the winter season on snow-free days. The type of treatment, tree species, degree of decay and feeding traces were recorded on standing and lying dead trees, stumps, and an equal number of untreated trees (which formed the control trees) produced by the treatments. The coverage of foraging marks on trees was estimated on a percentage basis, separately assessed on the trunk and branches of trees. The marks were recorded in 4 depth categories: 1) 'Marks on the bark' means that birds had searched for prey by only superficial pecking. 'Bark scaling' means that birds had peeled off sections of bark and foraged beneath it. We also identified deeper excavation marks: ones that penetrated only into the sapwood and others that entered deeper into the heartwood. Trace data were cumulatively estimated, i.e., subsequent surveys recorded traces observed on previous occasions. The surveyed foraging marks are not diagnostic of the species of birds that leave them, so our study did not include species identification. The survey detailed above was carried out on 2 occasions: before the treatments (baseline survey) in the winter of 2019-2020 and 1 year after the treatments in the winter of 2021-2022.

Data analyses

We examined the frequency and distribution of woodpecker foraging marks in the context of tree species, diameter at breast height categories (10-20; 20.1-40 and over 40 cm) and tree height categories (0.5-15; 15.1-25 and over 25 m). Jacobs' preference indices were calculated for the distribution of woodpecker foraging marks in relation to tree species and height.

In addition, we used mixed-effects models (GLMM) with a zero-inflated beta distribution and logit link function. Due to the limited occurrence of secondary species, only pedunculate oak (*Quercus robur*), sessile oak (*Quercus petraea*) and Turkey oak (*Quercus cerris*) were included in the model. Our analyses were performed in the statistical environment of R, using the packages *glmmTMB, emmeans, multcomp* and *effects*.

I also examined the frequency and distribution of woodpecker foraging marks after treatment using generalised linear mixed-effects models. Due to the limited occurrence of secondary tree species, I created tree species groups in this case. My analyses were performed in the statistical environment R using the *glmmTMB, emmeans, multcomp* and *multcompView* packages.

4. Summary of scientific results, theses

The questions I asked in my objectives were answered as follows:

1. The most important factor for bird communities in the hill oak forests was the density of trees with a diameter at breast height greater than 30 cm, which positively influenced the total abundance of the studied birds, the foliage gleaners, the primary and secondary cavity nesters, and the resident birds. In addition, the abundance of the middle spotted woodpecker (*Leiopicus medius*), the wood warbler (*Phylloscopus sibilatrix*), the collared flycatcher (*Ficedula albicollis*), the blue tits (*Cyanistes caeruleus*) and the marsh tit (*Poecile palustris*) was positively affected the high density of thick trees. The highest tree height at the survey point positively influenced the abundance of common chaffinch (*Fringilla coelebs*) and Eurasian nuthatch (*Sitta europaea*).

2. The density of trees thicker than 10 cm, had a negative effect on the abundance of shrub nesters. The density of the shrub layer positively influenced the total abundance of birds, the foliage gleaners, secondary canopy nesters and resident species.

3. The study of secondary tree species showed that the presence of linden (*Tilia* sp.), beech (*Fagus sylvatica*) and hornbeam (*Carpinus betulus*) species positively influenced the abundance of particular species. Linden had a positive effect on Eurasian treecreeper (*Certhia familiaris*), hornbeam had a positive effect on marsh tit (*Poecile palustris*) and beech and hornbeam also had on wood warbler.

4. By examining the foraging marks of bird species that feed on tree bark (woodpeckers and Eurasian nuthatch), the most preferred tree species, both on the trunk and on the branches, was pedunculate oak (*Quercus robur*). When looking only at the foraging marks on the trunk, the most preferred species was Turkey oak (*Q, cerris*). Regarding the use of branches, the most preferred species was downy oak (*Q. pubescens*). Birds avoided hornbeam and field maple (*Acer campestre*).

5. When examining the foraging marks along trunk diameter, the percentage cover was highest on trees in the diameter category of 20.1-40.0 cm. In that category, the preference for trunks was the strongest,

and for trees above 40 cm diameter, the preference for branches was the strongest. Jacobs preferences indicated that birds avoided the middle height category (15.1-25.0 m) and preferred the tallest (>25 m) trees for both trunks and branches.

6. Tree species identity significantly influenced the occurrence of foraging marks on tree trunks. Similarly, the interaction of diameter at breast height and height was a significant factor in the probability of occurrence of the marks. For branches, all three variables, namely tree species, diameter and height, were also found to be significant factors. The correlation was stronger for branches than for trunks.
7. After the management actions, the type of treatment had the strongest significant effect on the distribution of foraging marks found on trees , but both species and diameter at breast height had a significant effect on the proportion of marks. Among the tree species groups, the highest cover of foraging marks was found on pedunculate, sessile and downy oaks (other oak category besides Turkey oak). The next proportion of foraging marks was recorded on Turkey oak and the lowest on other broadleaved tree species (hornbeam, field maple, beech etc.).

7/a Among the marks found in the group of other oaks, the highest change was detected in girdled trees, followed by the proportion of trees managed as high stump (high stump + lying deadwood), then low stump (stump + lying deadwood), and finally the proportion of foraging marks found on control trees, which was far below the proportion of all treatment types.

7/b On the exchange, the highest proportion of foraging marks was found on trees treated with high stumps, followed by almost equal proportions on with girdled trees and low stumps. On control trees the proportion of marks was far below that of the treated trees.

7/c For other broadleaved tree species, I also found the most marks on trees treated with high stump, followed by downed with low stump and then the control trees. The fewest marks were found on the girdled trees.

8. For foraging marks on the bark surface, treatment type and species group identity had a significant effect on the distribution of marks, whereas diameter had no significant effect. The highest proportion of marks was detected in the other category of oak species. The proportion of marks found was highest on girdled trees, followed by trees with high stump and then low stumps. The proportion of marks was lowest on control trees. The girdled trees had the highest cover of foraging marks on the bark, followed by the high-stumped trees, and finally, in almost equal proportions, the low-stumped and control trees. Marks on other broadleaved tree species were found only on low-stumped and control trees.

9. The greatest cover of surface bark scaling was found in the high-stumped trees and their lying pairs, followed by girdled trees, then low-stumped trees and finally the distribution of marks on the control trees. No correlations were found for foraging marks reaching the sapwood. For the marks reaching the heartwood, treatment type and tree diameter showed a significant correlation with the distribution of marks. Marks in that particular depth category were found in two treatment types in total, trees with high stumps and ringed trees.

4. Scientific publications

Proofread journal articles

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- Dvorak M., Komlós M. (2024): Blutspecht *Dendrocopos syriacus* (Linnaeus, 1758). In: Dvorak, M., Grüll, A., Ranner, A., Laber, J., Berg H.M., Pellinger,

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