University of West Hungary

Theses of doctoral (Ph.D.) dissertation

Ecological succession of breeding bird communities in the Sopron Mountains

Daniel Winkler

Sopron

2005

Doctoral School: Roth Gyula Forestry and Wildlife Management Doctoral School

Program: Ecology and diversity of forest ecosystems

Advisor: Prof. Dr. Varga Ferenc

1. Introduction and aims of the research

The Sopron Mountains is one of the areas in Hungary where extensive coniferous stands can be found. Starting at the end of 1980's most of the spruce forests in the Sopron Mountains were damaged because of a heavy bark beetle gradation. Large-scale sanitation cuttings of bark beetle-affected stands were carried out, which remarkably changed the age class structure of the forests in the Sopron Mountains. These environmental changes have a great effect on the avifauna.

Through the above-mentioned reasons the area of clear-cuts and young afforestations had been extended. The author conducted breeding bird surveys in young plantations as well as in other different-aged stages of deciduous and coniferous forest types most characteristic for the Sopron-Mountains.

Avian assemblages are determined, to a degree, by vegetation and forest structure. The consecutive phases of a forest succession might provide habitats of different structure and often different plant species composition. These progressional changes can cause significant changes in the associated bird communities.

The 5-year study (1998-2002) in the Sopron Mountains gave the opportunity to investigate bird community succession in two different ways:

- conducting bird censi in different successional stages simultaneously and comparing the breeding bird communities recorded,
- continuous monitoring (straightforward method) of the breeding bird communities of individual plots to follow the real successional changes.

The aims of the research were to

- describe the species composition of breeding bird communities ordered to the different-aged stands (secondary successional stages)
- determine bird species diversity, density- and dominance structures in the bird communities of different stages
- describe the successional changes in bird communities
- measure habitat amplitude of the bird species recorded
- analyze the habitat overlap between the bird species
- prove the effect of secondary forest succession on European Nightjar's (*Caprimulgus europaeus* L.) nesting
- investigate the relationship between habitat structure and bird species diversity, density based on the recorded data.

2. Matherial and methods

Census methods

Bird censi were carried out three times during the breeding season using the "treble-visit fixed-radius (r=75 m) point count technique" which is a modified version of the French IPA point count method. At each survey station singing males and observed pairs were recorded during the 20 min. count period. The method used was suitable for recording pigeon- (*Columbiformes*), nightjar- (*Caprimulgiformes*), woodpecker- (*Piciformes*) and passerine bird (*Passeriformes*) species only.

Study area

The study is based on the breeding bird data of two series of different aged managed deciduous and managed coniferous forests in the Sopron Mountains. Five different phases of secondary forest succession have been investigated for both forest types.

Stages in deciduous forest

A1: 1-2 year old afforestation after clear-cut. The area is planted with young trees of up to 60 cm height. The cover of herb layer is 80-95%, including species e.g. *Calamagrostis epigeios, Rubus fruticosus, Solidago gigantea, Epilobium montanum, Chamaenerion angustifolium, Hypericum perforatum, Erigeron annuus.*

B1: 5-6 year old afforestation – medium-dense shrub stage. Apart from the young trees, additional shrubs could also be found. Height of the young trees is up to 1,5 m. The cover of small trees and shrubs is 65-75%. Species in the herbaceous vegetation are the same as the ones in the previous stage, furthermore a few species characteristic for older forest stands can also be found, e.g. *Mycelis muralis, Galium sylvaticum, Lapsana communis, Fallopia dumetorum.*

C1: 9-10 year old, dense stands – the cover of young trees is 80-85%. Height of the young trees 2-5 m. The cover of herb layer is variable, compared with the species composition of the previous stage, but most of the species typical for the open habitats are missing.

D1: Low pole stage – height of the trees 12-12 m. Canopy is closed, the cover is 80-90%. The ground vegetation includes species e.g. *Melica uniflora, Poa nemoralis, Milium effusum, Galium sylvaticum, Carex pilosa, Galium odoratum.*

E1: "climax" forest – old deciduous stands, height: 20-34 m. Cover is about 75-85%. Species in the herbaceous vegetation are e.g. *Melica uniflora, Poa nemoralis, Milium effusum, Galium sylvaticum, Carex pilosa, Hedera helix, Galium odoratum, Dentaria bulbifera, Dryopteris filix-mas.*

The main tree species of the deciduous forest stands studied: *Quercus petraea, Fagus sylvatica, Carpinus betulus.*

Stages in coniferous forest

A2: 1-2 year old afforestation after clear-cut. Height of the young plantation is up to 70 cm. The cover of herbaceous layer is 75-90%, including species e.g. *Calamagrostis epigeios, Rubus fruticosus, Solidago gigantea, Epilobium montanum, Chamaenerion angustifolium, Centaurium erythraea, Holcus lanatus, Hypericum perforatum, Erigeron annuus.*

B2: 5-6 year old afforestation – medium-dense shrub stage. Additional shrubs (*Rubus fruticosus, Rosa canina*) can also be found. Height: up to 1,8 m. Tree and shrub coverage is 65-70%. Apart from the species present in the previous stage, a few additional forest species can also be found, e.g. *Galium sylvaticum, Lapsana communis, Fallopia dumetorum.*

C2: 9-10-year-old, dense stands – the cover of young trees is 85-95%. Height: 3-6 m. The Ground vegetation cover is not significant, appearing rather only at edges.

D2: Low pole stands – height of the trees 11-12 m. Canopy is closed, cover is 90-95%. Shrub layer is completely missing, herbaceous vegetation is not significant.

E2: "climax" forest – old coniferous stands. The cover is 75-85%, height: 24-32 m. Shrubs like *Rubus fruticosus* are also present. Species in the herbaceous vegetation are e.g. *Hieracium lachenalii, Luzula albida, Melica uniflora, Poa nemoralis, Milium effusum, Galium sylvaticum, Carex pilosa, Galium odoratum, Dentaria bulbifera, Dryopteris filix-mas.*

The main tree species of the coniferous forest stands studied: *Picea abies, Pinus sylvestris, Larix decidua.*

Vegetation surveys

At each bird survey station the following vegetation characteristics were estimated for each layer: mixture proportion (%), cover (%), tree height (m).

Data analysis

Breeding bird communities connected to the different stages were yearly analyzed. For each community the dominant, subdominant, accessorial and rarus species were determined. The following characteristics of the bird communities studied were used:

- number of bird species (S), expected number of species calculated by the rarefation method ($E(S_n)$)
- density of breeding pairs (D_e), mass density (D_t)
- individual and mass dominance structures (Do_e and Do_t)
- Shannon diversity (H'), diversity with Järvinen-Väisänen's correction factor (H_{cor})
- evenness (J)
- community dominance index according to number of individuals (KDI_e) and to mass (KDI_t)

Breeding bird communities were also analyzed in relation to the faunal units, nesting site, and migratory habits.

For comparison of diversities of bird communities connected to different stages the Hutcheson-test was used.

Similarity measures (Jaccard's species similarity index, Sørensen's similarity index) were used to determine the differences between the stages. Hierarchical cluster analysis was also carried out using the Sørensen and Czekanowski indexes.

The turnover rate (TR) of succession in forest bird communities was calculated by dividing a measure of dissimilarity of communities at two consecutive stages by the time interval separating them. For the analysis the complement of Jaccard-index was used.

The stability of breeding bird communities was measured by the yearly variation in species richness, diversity, density and evenness (CV-indices), and by a more complex index, the average individual turnover (IT).

Habitat-amplitude for each bird species was measured using the Simpson index. The habitat overlap between the recorded species was measured using Renkonen's index of percentage similarity.

To determine the relationship between habitat structure and breeding bird communities correlation analysis and principal component analysis followed by multiple linear regression analysis were carried out.

For the investigations connected to the characteristic species of early successional stages, the European Nightjar (*Caprimulgus europaeus* L.), bioacoustic methods were used. Time- and frequency-based variables (pulse rate in the major and minor phrases, mean pulse length of the major and minor phrases) of the recorded song of nightjar males were measured. These variables were subjected to canonical discriminant function analysis for individual recognition and for long-term tracking the nightjar territories.

3. Summary of scientific results

A total of 49 breeding bird species (*Columbiformes, Caprimulgiformes, Piciformes*, *Passeriformes*) were encountered during the five-year period of the study.

Theses

1. Based on censi of birds in different successional stages simultaneously and comparison of the bird communities recorded, the author revealed the following trends:
- Species richness, expected number of species calculated by the rarefaction method, density of breeding pairs, mass density and diversity showed similar, increasing trend. Their numerical values were the lowest in the clear-cut areas with young (1-2 year old) plantations, and the highest in the mature stands. After a starting, significant increase (5-6 year old stands) there is a slight decline in the 9-10 year old plantations (dense stands). Further decrease can be observed in the low pole stands. Concerning bird species richness, density- and diversity, their values were about the same in the first three stages of the deciduous and coniferous stands studied. Nevertheless, considerable differences can be found between the low pole and

mature stages of the two forest types: the numerical values of the mentioned bird community characteristics were lower in the coniferous stands.
- Evenness values (Pielou's equitability index) haven't shown any particular trend.
- The values of the community dominance indexes were the highest in the early stage (1-2 year old plantations). A drastic decrease can be observed in the shrub stage, followed by a progressive increase in the closed, dense young stands (9-10 year old plantations) and low pole stands. Bird communities in the mature stands were characterized by low community dominance-values.

2. The comparison of bird community diversities (Hutcheson's test) of different stages yielded differences significant at 1% level (18 cases), significant at 5% level (5 cases) and significant at 10% level (7 cases). There was a significant difference at 1% level between diversity values of bird communities recorded in the first two stages (for both deciduous and coniferous forests). The comparison of diversities of the shrub stage (5-6 year old plantations) and the dense thicket stage (9-10 year old plantations) yielded difference only for the deciduous series (significant at 10% level). For what concern the corresponding stages in deciduous and coniferous forests, significant difference (at 10% level) can be observed only comparing diversity values of low pole stands (while there are no remarkable differences between diversity values of other corresponding stages).

3. Analysing the breeding bird communities of different stages, the author proved the following specific trends:
- The classification according to the faunal units was applied for all stages. Bird communities of the early stage (1-2 year old plantations) consisted mainly of Palearctic species. In all other stages the European species were dominating (culminating in the low pole stage). The Euro-Turkestanean species were characteristic mostly for the open habitats, early successional stages.
- The result of classifying bird species in relation to the nesting site showed that breeding bird communities of the early stage consisted mostly ground-nesting species, with a few additional foliage nesters. Bird communities in the medium dense stage (5-6 year old afforestations) included predominantly shrub-nesting species, but also appearing were some canopy-nester and even hole-nester ones. Towards to the mature stages the proportion of canopy-nesting and cavity-nesting species shows a gradual increase, while a simultaneous decrease can be observed in the proportion of ground-nesting ones.
- The analysis of bird communities according to the migratory habits of birds showed an interesting trend. The ratio of sedentary species (including partial migrants) increased towards the mature stages while that of the migratory species (short-distance and tropical migrants together) showed the opposite trend. The tropical migrants predominated in the early successional stages. The observed trend is true for both the species number and density.

4. Similarity measures and hierarchical cluster analysis based on Sørensen- and Czekanowski indexes clearly showed the separation of bird communities ordered to the very early stage of afforestation (1-2 year plantations). The clustering pattern indicated similarity between bird

communities of the shrub stage (5-6 year old plantations) and dense thickets (9-10 year old plantations), as well as between the communities of the low pole stands and mature stands.

5. The turnover rate (TR) showed the same trend both for the deciduous and coniferous secondary successional series. After a rapid start observed between the communities of the first two stages the turnover rate decreased monotonously with the time.

6. The author estimated the habitat-amplitude for each bird species using the Simpson index, and measured the habitat overlap between the recorded species. Most of the observed species appeared in more than one successional stage. Species with the highest habitat-amplitude can be regarded as habitat generalists, appearing with high densities in all, or at least four stages. These species are *Phylloscopus collybita, Fringilla coelebs, Turdus merula, Erithacus rubecula, Sylvia atricapilla*. Species having relatively small habitat amplitude can be considered as habitat specialists. Part of these species (e.g. *Caprimulgus europaeus, Locustella naevia*) are characteristic for the early successional habitats, while others (mostly the cavity-nesting ones) are connected the mature stage. The hierarchical cluster analysis based on Renkonen's index of percentage similarity exhibited the highest habitat overlap between the members of three passerine families (*Turdidae*, *Sylvidae* and *Paridae*).

7. Based on the continuous monitoring (straightforward method) of bird communities in the different stages the following changes has been described by the author:
- The greatest structural change during the 5-year study period occurred in bird communities of the initial stage. Species richness, density of breeding pairs, mass density and diversity increased monotonously. The increase in diversity was considerable (Hutcheson't t-test yielded significant differences in several cases between certain years's diversities). Changes in the mentioned community characteristics was just the opposite (decreasing) regarding the bird communities of the shrub stage. The rate of decrease in diversity was moderate. Bird community characteristics ordered to the other stages (dense thickets, low-pole stands, mature stands) showed slight fluctuation only.
- The results of quantifying bird community compositional stability (CV, IT indices) proved that the initial stage supports the less stable communities. From the shrub stage towards to the mature stands a gradual increase can be observed in bird community stability.

8. The author revealed (using bioacoustic methods) that secondary forest succession has a great effect on nesting of the nightjar (*Caprimulgus europaeus* L.). Applying discriminant function analysis to the four time- and frequency-based variables of the nightjar's song it was possible to distinguish to a high degree of accuracy the nightjar males/pairs breeding in the Sopron Mountains. Thus, the author was able to map the individual territories and follow their yearly changes. It was proved in two cases, that microhabitat-change with secondary forest succession prevented the nightjar pairs from using the same nesting habitats again. Moving to a different optimal habitat was inevitable for these pairs.

9. Investigations on relationships between bird communities and habitat structure variables resulted in the followings:

- Foliage height diversity (FHD) and diversity in bird communities showed a strong correlation both for deciduous and coniferous forests (Pearson coefficients are R_L=0,904 and R_F=0,968 - significant at 0,01 level). A similar strong correlation can be found between FHD and bird density (R_L=0,922 and R_F=0,943 - significant at 0,01 level).
- The cumulative cover of all vegetation layers (COVSUM4) both for deciduous and coniferous forests was strongly correlated with bird species diversity (R_L=0,847 and R_F=0,923 - significant at 0,01 level). Strong correlation could be observed also in relation to bird density (R_L=0,890 ill. R_F=0,867 - significant at 0,01 level).
- The cumulative cover of ligneous layers (COVSUM3) showed weaker correlation with bird species diversity in deciduous forests (R_L=0,789 at 0,05 level) and non-significant correlation in coniferous forests. Concerning the relationship between COVSUM3 and bird density, significant correlation (R_L=0,813 at 0,05 level) could be observed only in the case of deciduous forests.
- For further investigations mean values of eight habitat-variables were calculated for each stage. In the first step, principal component analysis (PCA) was used to summarize the vegetation data into a few independent factors (PC). Following PCA, multiple linear regression analysis was carried out to examine the relationship between bird species diversity/density and the habitat components (PC). The regression model showed that apart from the principal component most highly correlated with shrub characteristics (physiognomical character) also principal component determined mostly by floristic composition variables (number of tree species, tree species richness) had considerable effect on bird species diversity and density.

Bibliography of personal publications

Publications in revised journals

Winkler, D. (1999): Madárközösségek szukcessziójának vizsgálata a Soproni-hegységben. Soproni Egyetem Tudományos Közleményei 42-45: 107-117.

Winkler, D. (2005): Ecological succession of breeding bird communities in deciduous and coniferous forests in the Sopron Mountains, Hungary. Acta silvatica & Lignaria Hungarica 1: 49-58.

Book chapter

Winkler, D. (2000): A madárközösségek, mint bioindikátorok alkalmazási lehetősége. *In* Frank, T. *szerk.* Természet – Erdő – Gazdálkodás. Magyar Madártani és Természetvédelmi Egyesület & Pro Silva Hungaria Egyesület, Eger. 163-167.

Summaries published for conferences

Winkler, D. (2000): Adatok a lappantyú (*Caprimulgus europaeus* L.) habitat-választásához és költésbiológiájához. Az Erdőmérnöki Kar tudományos konferenciájának előadásai. NYME, Sopron. 53-58.

Faragó, S. – Dittrich, G. – Winkler, D. (2003): Arthropodous food availability for adult wildfowl species in the Lajta-Project. Managing partridges and other game in the agricultural landscape. Provincia di Udine, Assessorato caccia e pesca. Abstracts. 48-49.

Presentations at conferences

Winkler, D. (1998): Vágásterületek és erdőfelújítások madártani vizsgálata a Soproni-hegységben. – „A Magyar Tudomány Napja" – Haracsi Lajos emlékülés. 1998. december 2. Soproni Egyetem.

Winkler, D. (2000): Vágásterületek és erdőfelújítások madárközösségeinek vizsgálata a Soproni-hegységben. A Tallós Pál Akadémiai Kör „Természetvédelem és erdőgazdálkodás" konferenciája. 2000. március 2-3. Fertő-Hanság Nemzeti Park, Sarród.

Winkler, D. (2000): A lappanytú (*Caprimulgus europaeus* L.) habitat-választása és költésbiológiája. – Tudományos Konferencia. 2000. december 15. Nyugat-Magyarországi Egyetem, Sopron.

Faragó, S. - Dittrich, G. - Winkler, D. (2003): Arthropodous Food Availability for Adult Wildfowl Species in the Lajta Project, Hungary (Poster). Udine, Italy. 2003. október 21-25.

Faragó, S. – Dittrich, G. – Winkler, D. (2004): Animal food availability for Great Bustards in the Lajta Project, Hungary (Poster). First Meeting of the Signatory States of the Memorandum of Understanding on the Conservation and Management of the Middle-European Population of the Great Bustard. Illmitz, Austria. 2004. szeptember 17-18.

Dissertations, research reports

Winkler, D. (1996): A madárvilág szukcessziójának vizsgálata a Soproni-hegység tarvágásos területein. Diplomamunka. Erdészeti és Faipari Egyetem, Sopron. 71 pp.

Winkler, D. (2001): A Soproni Tájvédelmi Körzet faunája. *In.* Koloszár, J. *szerk.*: Soproni Tájvédelmi Körzet kezelési terve. NYME – Fertő-Hanság Nemzeti Park. 36-63.

Lecture notes

Traser, Gy. – Winkler, D. (2000): Állatrendszertan. Környezetmérnöki Tagozat. Kézirat. NYME, Sopron. 154 pp.

Other publications

Gál, J. – Kolics, L. – Winkler, D. – Marosán, M. (2003): Nappali ragadozó madarak betegségei. A Vadgazda 12: 28-29.