Bird communities in European taiga forest: A comparison between a large forest block in Archangelsk, Russia, and some small-grained old-growth fragments in central Norway

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The large intact areas of old-growth forest of the Archangelsk oblast represent today a possibility of studying taiga ecology in ecosystems that we do not find in Fennoscandia. They are to be regarded as the sources for the taiga-elements in our own coniferous forests. This study of bird communities was done in the core of one of the old remaining, intact forests of Archangelsk, alongside the Yula river in Pinega and Vinogradovsky rayons («regions»). Bird communities in mature spruce and pine dominated forests were studied in spring 2005. These communities from the core area of the taiga are compared with coniferous forest in the rural municipality of Lierne in eastern central Norway, studied in 2004. This latter area should be representative for the westernmost parts of the taiga. Due to extensive forestry exploitation and natural heterogeneity it is heavily fragmented, leaving behind only smaller fragments of more or less coherent old-growth stands.

Findings in our comparison:

• Species dependent on sufficient amount of dead wood, e.g. woodpeckers, comprise far less of the bird communities within the small-grained old-growth fragments in Lierne compared with the situation in the virgin taiga at Yula.
• The abundance of all hole-nesters (including those using snags and cracks in the trunks) is considerably diluted in the bird community within the old-growth forest in Lierne compared with those found in the coniferous forests at Yula.
• The assemblage forming the old-growth bird guild (predominately passerines) is still almost as abundant in the remaining fragments in Lierne as in the large block of taiga at Yula.

As high abundance of hole-nesters might reflect the occurrence of several other vulnerable forest species among insects, vascular plants, bryophytes and lichens, our findings from the bird survey should also indicate a more general high conservation value of this large block of taiga at Yula.

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INTRODUCTION

Clear-felling was introduced in the Fennoscandian boreal coniferous forest in late 1950s and early 1960s, and has thereafter become the leading felling practice. Simultaneously, extensive construction of forest roads allowed the exploitation of new areas and the use of heavy trucks for transport. This increased exploitation resulted in a rising rate of fragmentation and degeneration of old-growth forest habitats, thus reducing the natural biodiversity in a substantial part of this biome (Esseen *et al*. 1992, Edenius & Elmberg 1996, Andrén 1997); e.g. many well-documented negative impacts for avian fauna have been reported (Sandström 1991, Angelstam 1992, Andrén 1994, Edenius & Elmberg 1996, McCollin 1998, Chalfoun *et al*. 2002, Laiolo *et al*. 2004). In substantially fragmented landscapes some bird species may have requirements that are greater than the mean size of the remaining patches (Andrén 1997). Therefore the spatial habitat configurations (e.g. the graininess of the fragmented old-growth patches) of a forest landscape become most important for its suitability as a breeding area for these species. From Finland it is reported that some «taiga-species» can only can maintain their «natural» population densities within continuous «virgin» forest landscapes of significant magnitude, e.g. in the order of 1000 km^2 (Virkkala 1991).

In Russia the clear-felling practice started somewhat earlier (probably as early as in the 1930s). The forested areas were then mainly intact, natural old forests covering enormous areas. Felling started near to old settlements and vast clear-cuttings were made into these old forests at a broad scale as roads and railways were built successively into the wilderness. Today some large units of old growth forests still exist in Archangelsk oblast («county»), beyond the existing infrastructure, representing the last large bodies of old taiga-ecosystems in the north-western part of Europe (Yaroshenko *et al*. 2001, Aksenov *et al*. 2002).

Within areas with moderate logging activities in Fennoscandia, there have been created more heterogeneous forest landscapes than under the original natural situation, alternating between quite open, newly logged sections, intermingled with dense young, planted tree stands, and smaller blocks with remaining «virgin» forest. This forest landscape might still represent suitable habitats for a large variety of the bird species associated with the taiga, but many species associated with the old-growth coniferous forest seem to be less satisfied with these types of «disturbed» taiga forest, such as those we can find in central Norway (Thingstad *et al*. 2003). However, to what extent these taiga-associated bird species suffer due to the ongoing fragmentation of the western taiga is still insufficiently investigated. To look for an answer we have to go far into the middle part the Archangelsk oblast, to a taiga area still lacking roads and other infrastructures for timber transport; the only alternative for transportation of timber is by floating. Further, according to the Russian constitution, forests edging the greater rivers are protected from greater interference in a one km broad zone up from the rivers banks. As a result any intensive forest exploitation in these undeveloped upper parts of the Archangelsk oblast becomes quite unprofitable. During the period 24-28 May 2005 we visited the upper parts of Yula River, an area still representing «undisturbed» continuous taiga, though along rivers some trace of anthropogenic activity is inevitable. Some of the aims of our visit were to collect preliminary data of the bird assemblages in these pristine taiga forest habitats, and compare the species composition in these assemblages with those that have been disclosed from more heavily exploited taiga habitats in central Norway. The vital question becomes: is the species composition of the bird communities in the remaining patches of old-growth taiga forest in Fennoscandia significantly affected by the ongoing fragmentation of this landscape?

STUDY AREAS

One of our study areas is situated in the rural municipality of Lierne in eastern central Norway

(64°25´N, 13°55´E). The coniferous forest located here represents some of the westernmost situated taiga in the Palearctic region, where the spruce *Picea abies* probably invaded as late as approximately 2500 years ago. This landscape is now dominated by spruce forest mixed with birch *Betula pubescens* and some pine *Pinus sylvestris*, rowan *Sorbus aucuparia*, goat willow *Salix caprea*, alder *Alnus incana* and aspen *Populus tremula*, thus being a characteristic forest for the northern boreal vegetation zone in Norway (Moen 1999). As also typical for many Fennoscandian boreal forest landscapes, particularly in Norway with vast topographical variations, this forest area in Lierne was quite fragmented in its «pristine» condition, due to many bogs, watercourses and low alpine habitats in the landscape. Due to clear-felling since the 1950s, significant parts of the originally wooded areas (with 72 % forest coverage) now consist of open, or partially open, clear-felled areas interspersed with young, productive woodland (the fastest growing phase of the re-growth), leaving less than 35 % of the area covered by old growth. The tree line (woodland limit) here varies between 500 and 650 m a.s.l. The mean size of the core areas (more than 100 meters from any edge effects from surrounding «hostile» habitats) of the remaining old-growth forest stands in the actual study area is in the present situation approximately 8 ha. However, many of the surveys were conducted in Storbekken protected area, which has an extension of 65 ha. This last area is still less than 1 ‰ of 1000 km^2, which might be the area requirement for maintenance of «natural» population densities of some «taiga-species» (Virkkala 1991).

In contrast, the other study area at the Yula river basin in Archangelsk oblast, Russia, consists of a still continuous chiefly «virgin» taiga forest (Fig. 1). The area is today one of the last, large remaining natural old-growth forests west of the Ural Mountains and thereby of unique importance as a reference area for taiga ecosystems of the north-western taiga, and non-governmental organizations (NGOs) have wanted its protec-

Figure 1. The pine forest (A, p.48) and the spruce dominated mixed forest (included pine and deciduous trees) in the Yula area (B, p.48), the spruce forest in the Ura area (C, above) and the tree and bush vegetation (predominately consisting of bird cherry and birch) along the banks of Ura river (D, above). Photos: Per Gustav Thingstad.

tion (Yaroshenko *et al*. 2001). To better illustrate the actual forests in the Archangelsk oblast three drawings, which follow the terminology used by Huse (1965), of different spruce forests are added. Figure 2a presents the structure and composition of an old spruce forest influenced by flooding in a meandering part of the river, and Figure 2b the same in a spruce forest on dryer habitat above the level of floods. Figure 2c shows the later phase of a post-fire succession (burnt more than 100 years ago), with younger spruce mixed with some pine, birch and aspen. The first two forest types were quite similar in general appearance, with a multilayered complex forest with abundance of dead, standing and fallen trees. This was also the impression of the youngest forest, but trees were smaller and the dead trees were mainly deciduous trees of smaller dimensions.

Except for some traces of anthropogenic activities near to river banks, due to old use of the river as transportation path for fishing and hunting, the impression of the forests was that natural processes had been in progress for centuries; resulting in a forest with tracks of several fires, fire refugees, parasitic fungi weakening the spruce, wind-felling, and more recently bark beetle attacks, creating a very complex forest matrix.

Yula River is a tributary from the south into The Pinega River just east of Karpogory town in Pinega rayon («region»). Ura River is one of the

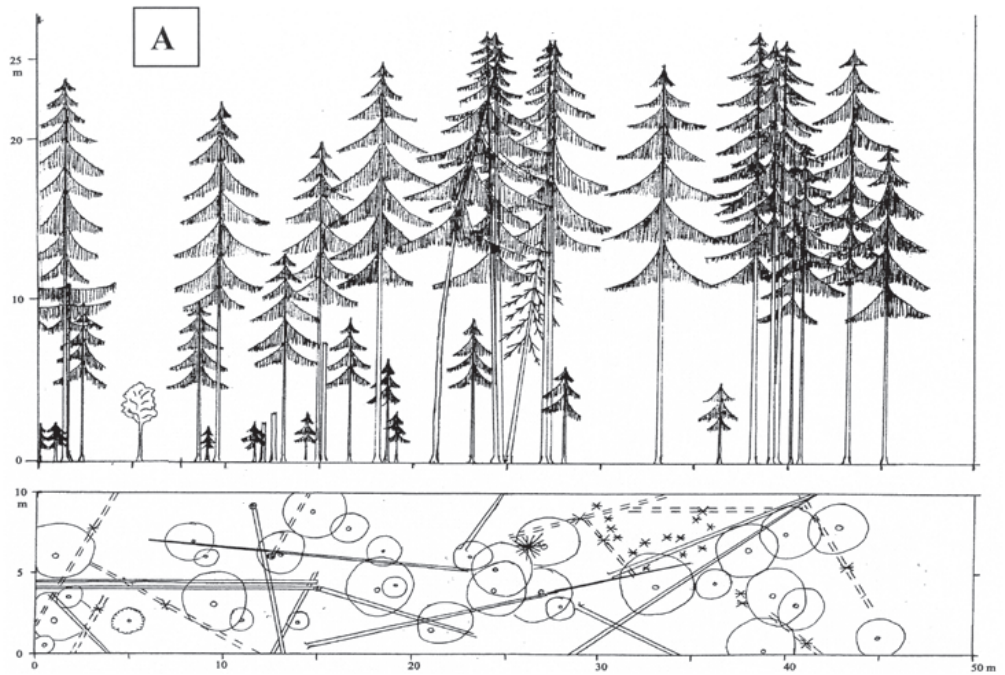
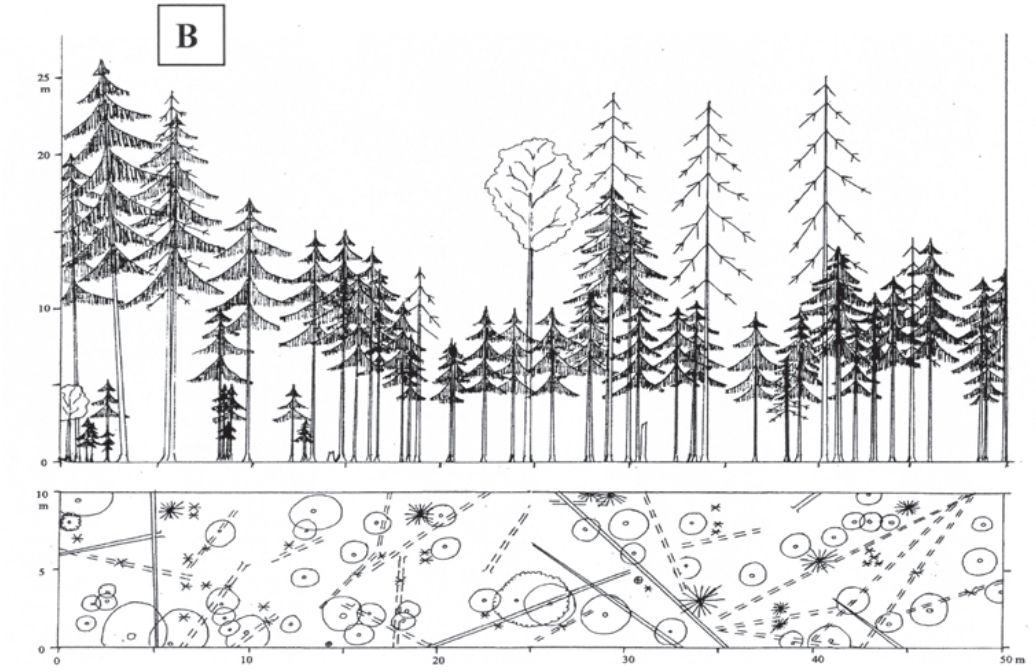


*Figure 2. Vertical and horizontal segment s (10 x 50 m) of spruce dominated forests. The symbols on the vertical projections represent trees; spruces (alive and dead) and birches. In addition, on the horizontal projections the dead lying logs (trunks) are shown in different decomposing phases (from recently felled, shown by unbroken lines, to completely decayed logs with forest rejuvenation so-called "carcass regeneration", shown by broken lines). All young trees are symbolised by *, and snags of varying heights by o. (From Bjelkåsen & Ivantsov in litt.).*
(A, above) A forested floodplain with lots of fallen logs close to the river Yula.
(B, right) A section with 250-300 old forest close to the river Ura, presently being under a bark beetle attack.
(C, right) A section from the same area as B, but being burnt more than 100 years ago.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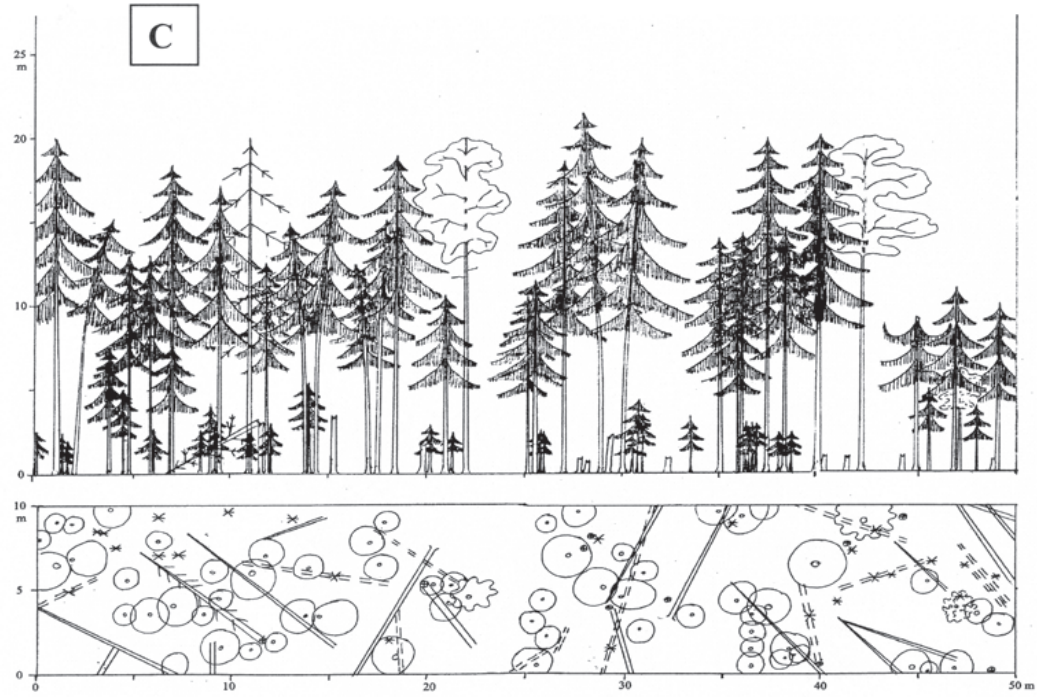
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braided streams and sources to Yula in its upper basin. Our study area (63°10´ N, 44°20´ E) was approximately 80 km south of Karpogory in Pinega and Vinogradovsky rayons. The forest landscape is quite flat without any steep gradients, and between 150 – 250 m a.s.l., which is among the highest elevations in Archangelsk oblast. The river has typically eroded some 5 – 25 m into the ground where no cliffs are to be seen.

Spruce dominated the forests, and the forest was typically multilayered with lots of dead, standing and fallen trunks. The spruce forest was now in a stage with heavy gap-dynamic processes. The gaps are formed by wind-felling, creating areas of 1 – 2 ha size, by an outburst of beetle attack on standing trees, and by attack of the saprophytic fungi *Fomitopsis pinicola* on spruces that still seem to be quite viable. Traces of old wind-felling and following re-growth of spruce were commonly seen together with newer wind-felling that often follow the edges of the older ones.

Some parts of our bird study area at Ura passed sections that showed traces of forest fires. These parts were now in a deteriorating condition, indicating that fires went through this area for 100 years or more ago, and were more mixed with birch and aspen than the surroundings. In particular the surveyed pine-dominated forest found on the sandy ridge of Yula had traces of many fires, but the pine trees had mainly survived.

River edges were mostly covered by forests. Up to approximately 5 m above normal water level of the rivers, regular spring flooding had created a humid and swampy type of forest. The shore and edge of the Yula and Ura rivers were often (mainly on the inner curves of meanders) dominated by more fertile soils due to deposits from spring flooding, but also eroded by ice during flooding. This quite widespread habitat created a corridor-like, but patchy habitat structure over the landscape. It was typically dominated by grass and herbs – with clusters of bird-cherry *Prunus padus* trees and thickets of *Salix* sp scrubs. Among the herbs *Veratrum album* was a common and partly dominant species.

MATERIAL AND METHODS

The point method was selected for collection of the field data. This is a method commonly used for studying extensive areas, and a cost-effective method for providing representative data of the bird community (Bibby *et al*. 1992). The data used in this study were collected from one morning census at each point (census time: 5 minutes) during late May 2004 (Lierne) and late May 2005 (Yula and Ura). A 100 metre fixed radius was used, but areas at the edges that might hold other habitats were omitted. All registrations were taken down from points that were spaced with a distance of 250 metre; their locations were in advanced selected by use of GPS-positions.

In Lierne only a spruce dominated habitat type was surveyed, while four types of forest were surveyed in Yula. Due to shortage of available time this resulted in fewer surveyed points per forest type in the latter area (Table 1). Among other factors the weather conditions varied during these surveys, and this might have influenced the number of observed birds per point. The conditions were quite optimal during the survey period in Russia. However, no group (or guild, cf. below) of birds should have been particularly affected by this or other methodological errors. Accordingly, the revealed differences in the relative occurrences of total individuals in the compared groups should reflect real differences in the composition of the bird communities.

Some of the registered bird species have been assigned as belonging to a guild (cf. Table 1). Guild one consists of hole- and snag-nesting species, while guild two consists of the remaining species associated to old-growth coniferous forest (cf. Thingstad *et al*. 2003).

RESULTS

The frequencies of the individual bird species, as well as the total number of observed birds, vary quite considerably between the study areas

Table 1. The numbers of birds from the performed point surveys in old-growth fragments in Lierne, central Norway, and the four different types of taiga forest in the vicinity of the rivers Yula and Ura, in Archangelsk. See text for explanation of the guild concept.

Species	Guild	Lierne	Yula-pine	Yula-mix	Ura-spruce	Ura-edge	Total
Fringilla montifringilla	2	41	27	6	27	1	102
Phoenicurus phoenicurus	1	12	11	3	17	7	50
Turdus philomelos	2	32	3	1	1	0	37
Regulus regulus	2	26	1	3	7	0	37
Erithacus rubecula	0	29	1	2	2	0	34
Carduelis spinus	0	16	8	2	5	3	34
Fringilla coelebs	0	2	5	3	17	7	34
Phylloscopus trochilus	0	18	0	1	2	5	26
Anthus trivialis	0	1	12	2	4	1	20
Phylloscopus collybita	0	0	1	3	14	2	20
Troglodytes troglodytes	0	10	0	1	6	1	18
Prunella modularis	0	13	0	0	3	1	17
Loxia curvirostra	2	4	2	1	9	0	16
Turdus iliacus	0	6	2	1	0	6	15
Dryocopus martius	1	1	10	1	3	0	15
Acrocephalus schoenobaenus	0	0	0	1	0	13	14
Turdus pilaris	0	11	0	0	0	2	13
Parus montanus	1	6	0	2	3	0	11
Dendrocopos major	1	0	5	0	5	1	11
Parus ater	1	4	0	2	4	0	10
Sylvia atricapilla	0	0	2	0	0	8	10
Muscicapa striata	1	0	6	1	3	0	10
Cuculus canorus	0	0	6	0	2	1	9
Pyrrhyla pyrrhula	0	3	0	0	5	0	8
Parus major	1	8	0	0	0	0	8
Phylloscopus borealis	0	0	0	0	1	6	7
Corvus cornix	0	2	0	0	0	5	7
Bonasa bonasia	2	1	0	1	4	0	6
Tringa ochropus	2	0	2	0	2	2	6
Ficedula hypoleuca	1	0	2	2	2	0	6
Perisoreus infaustus	2	5	0	0	0	0	5
Carpodacus erythrinus	0	0	0	0	1	4	5
Cerhia familiaris	1	4	0	0	0	0	4
Turdus viscivorus	2	0	0	0	3	0	3
Scolopax rusticola	0	3	0	0	0	0	3
Strix uralensis	1	0	2	0	1	0	3
Tetrao urogallus	2	2	0	0	0	0	2
Tetrao tetrix	0	0	1	1	0	0	2
Accipiter gentilis	2	2	0	0	0	0	2
Carduelis flammea	0	1	0	0	0	0	1
Motacilla flava	0	1	0	0	0	0	1
Picoides tridactylus	1	1	0	0	0	0	1
Lagopus lagopus	0	1	0	0	0	0	1
Falco tinnunculus	0	1	0	0	0	0	1
Buteo lagopus	0	1	0	0	0	0	1
Emberiza rustica	2	0	0	1	0	0	1
Pinicola enucleator	2	0	0	0	1	0	1
Sum/N survey points		**268/57**	**109/19**	**41/11**	**154/25**	**76/7**	**648**

in question (Table 1). For visualisation of the differences in the species composition of the revealed bird communities in the five surveyed type of taiga forest, a hierarchical cluster analysis was carried out (Fig. 3). The forest edging the Ura river is a highly productive deciduous tree and bush habitat, a young succession stage quite different from the other four surveyed forests dominated by different types of coniferous trees. Ura-edge might therefore be regarded as an «outgroup» in this analysis. The obtained dendrogram discloses the close relation between Yula-mix (the surveyed edges at Yula, dominated by spruce, but also containing pine and some deciduous trees) and the spruce forest in the Ura area. The bird community in the relatively homogeneous pine forest in the Yula area is also quite closely related to those communities that were disclosed in the two above-mentioned forest areas. Simultaneously the bird community in the spruce-dominated old-growth forest in Lierne shows up to be somewhat distant from all the three Russian coniferous habitats. The geographic distance between Lierne and Yula will trigger some differences in the bird species composition in itself, and as already mentioned some of the variation might also be caused by different weather conditions during the survey periods in Lierne (in May 2004) and Yula (in May 2005). However, to some extent the numbers of observed bird individuals per point in the different habitats also reflect the varying productivity in the studied forests; e.g. 4.7 individuals per point in Lierne and 6.2 in the spruce forest at Ura. However, due to the small amount of data from some of the surveyed forests, we will not give more attention to these differences, but rather focus on the relative differences in occurrence of some vital bird groups in the revealed communities.

The group of birds being most dependent on plentiful access of dead wood is the woodpeckers. This requirement is highly fulfilled in the old-growth taiga at Yula. However, the dimension of the trunks might be a constraint factor according to the size requirement of the nest cavities for these species, and accordingly the forest consisting of big pines at Yula is the preferred habitat. The woodpeckers constitute 13.8 % of the surveyed individuals in this forest, while they only count for less than 1 % in the bird community in the old-growth fragments in Lierne. The spruce forest at Ura might be most comparable to the forest in Lierne, but also here the woodpeckers are sevenfold as abundant (Fig. 4). The deviation between the numbers of registered woodpeckers in the five study units and those numbers that should be expected if they were evenly distributed in the communities becomes statistically significant ($\chi^2 = 38.93$, df = 4, $p < 0.01$).

Some additional bird species are also dependent on holes or other types of cavities in trunks or snags for their nests. These species are mentioned

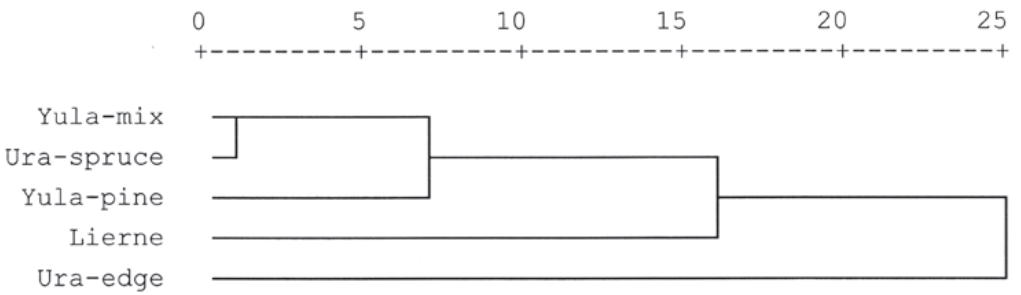

Figure 3. Dendrogram showing the result from the hierarchical cluster analysis using the within-group linkage method with squared Euclidean distance as measure interval (SPSS 13.0). Log transformed values (x + 1) of the relative abundances of the involved species were used in the analysis.

under guild one in Table 1. In the pine forest at Yula this guild contributes 1/3 of the total bird community and approximately 1/4 in the two spruce-dominated Russian forests. By way of comparison, in the old-growth fragments in Lierne this guild forms only 13 % of the bird community; only the edge deciduous forest at Ura has a smaller share (Fig. 5). Also the deviation between the numbers of registered individuals in guild one and those numbers that should be expected if they were evenly distributed becomes statistically significant ($\chi^2 = 20.87$, df = 4, $p < 0.01$).

If we in these comparisons further add the rest of the species that were found to be associated with old-growth coniferous forest in Lierne, the differences between the four surveyed plots with coniferous taiga (omitting the edge habitat of the Ura) become insignificant. In all the coniferous forest in question this last assemblage constitutes more than 55 % of the total bird community; the pine forest at Yula as much as 65 %, e.g. 9.5 % more than its contribution in Lierne. Moreover, the «out-group», the edge habitat at river Ura now clearly shows its divergence from the other habitats (Fig. 6).

DISCUSSION

The bird assemblage in the Palearctic boreal coniferous forest (the taiga) is well studied, and many of the species concerned are quite restrictive in their habitat requirements (Virkkala 1991, Elmberg & Edenius 1999). Any known species composition of a bird community can consequently give us good information about the habitat quality of the surveyed area in question. Some of the disclosed variations in the species contributions in our five study units must be reflecting some of these differences in habitat quality between the study plots; e.g. the great contribution of woodpeckers in our Russian bird communities is made possible by the huge amount of dead wood of adequate size in these areas (Angelstam & Mikusinski 1994, Stenberg & Hogstad 1995). At one of the count points in the pine forest at Yula we could hear simultaneously four different individuals of *Dryocopus martius* and in addition two *Dendrocopos major,* although most of these were outside our 100 metre survey radius. In addition to all the available dead wood, the great continuity of this virgin taiga block is undoubtedly the key factor for supporting such a high density of woodpeckers.

Dead wood as a minimum factor for biodiversity in most of the Fennoscandian taiga areas, and the abundance of hole-nesters might indicate the occurrence of several other vulnerable forest species among insects, vascular plants, bryophytes and lichens (Nilsson & Ericson 1992, Virkkala *et al*. 1994). A great number of hole- and snag-nesting bird species (guild 1) might therefore be a useful indicator for the more general conservation value of the forest. The great abundance of bird species belonging to guild one in the actual surveyed coniferous forests at Yula is therefore a definite indication of the great overall conservation importance of this forest block.

The guild two in Table 1 consists of species being associated to old-growth taiga forest in Norway (cf. Thingstad *et al*. 2003). A corresponding analysis from Yula would most probably have picked out some other species constellation as being more typical for the core taiga region, and such a guild could have disclosed even greater differences between Lierne and the three old-growth blocks from the Yula area than those shown in Figure 5. However, as long as a forest landscape contains a sufficiently high proportion of suitable habitats, the loss of suitable habitat *per se* is the main cause of declining population sizes of old-growth associated species (Helle & Järvinen 1986, Andrén & Delin 1994). For mammals and birds being attached to the virgin taiga this seems to hold true as long as the landscape has more than 30 % of suitable habitats. At further losses real fragmentation problems might arise, due to insufficient patch sizes, isolation and predation factors (Haila 1990). In our study area in Lierne this critical limit seems now to be

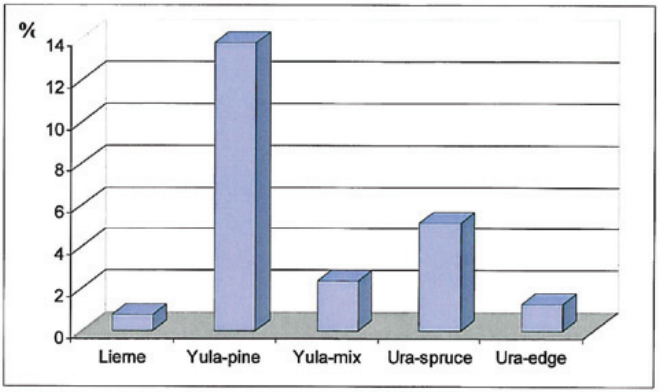

Figure 4. The portion of woodpeckers in the surveyed bird communities (cf. text to Table 1)

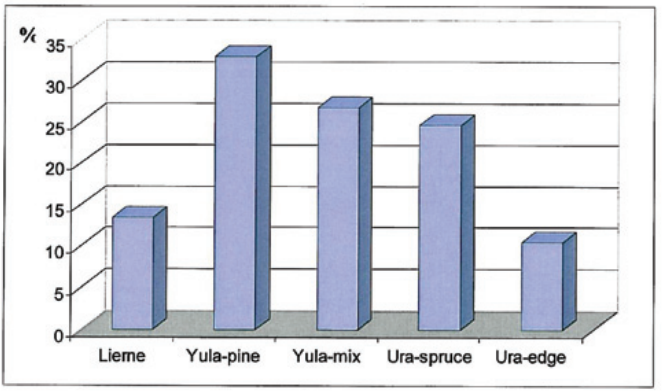

Figure 5. The portion of hole- and snag-nesting bird species (reported as guild one in Table 1) in the surveyed bird communities.

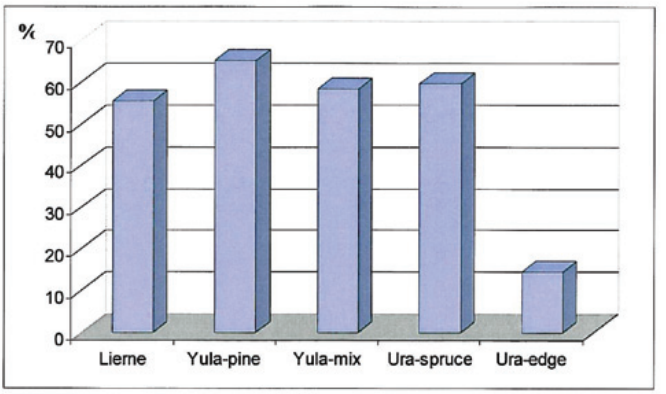

Figure 6. The portion of old-growth forest associated bird species (given as the sum of guild one and guild two in Table 1) in the surveyed bird communities.

close, as less than 35 % of the landscape is currently covered with old-growth forest, the mean size of the core areas of remaining old-growth forest stands is only 8 ha, and logging activities in the old-growth leftovers is still going on (Thingstad *et al*. 2003). However, for most of the species in guild two the amount of suitable habitat in Lierne seems still to be adequate for maintenance of vital populations. At the same time, for many area-demanding taiga specialists, such as *Accipiter gentilis, Tetrao urogallus, Picoides tridactylus* and *Perisoreus infaustus*, the patch size of the old-growth stands has already become a constraining factor, implying that their population sizes are declining or depleted in the Fennoscandian taiga landscape (BirdLife International 2004). The existing material is, however, far too restricted for further evaluation of these infrequently occurring species.

Although our study is not extensive, it still illustrates the importance of preserving some of the remaining larger blocks of natural taiga as refuges for maintenance of the biodiversity connected to this biome, and as reference areas for scientific studies. Furthermore, such areas might also be suitable for development of future eco-tourism projects and other environmentally friendly activities where the intact forests are used as a resource for rural development. Therefore some of the inner parts of the Yula river basin in southern Archangelsk oblast could be a candidate as a Natural World Heritage Area in a network of old growth forest reserves in the western taiga region. However, to achieve such a goal international cooperation and involvement are necessary.

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SAMMENDRAG

Fuglesamfunn i europeisk taiga: En sammenligning mellom et stort urørt skogområde i Arkhangelsk og noen små fragmenter med gammelskog i Midt-Norge

Skogene langs Yula elva i Karpogory skogdistrikt i Arkhangelsk oblast representerer noen av de siste store sammenhengende områdene med relativt uberørt taiga i Europa. I løpet av noen dager sist i mai 2005 fikk vi foretatt en del punkttakseringer i dette området. Disse ble sammenlignet med tilsvarende takseringer fra våren 2004 fra mindre restbestander med gammel barskog i Lierne, Nord-Trøndelag. Spesielt fuglearter som er avhengig av rikelig tilgang på død ved, som hakkespettene, utgjorde en betydelig større andel av fuglesamfunnet i taigaskogen ved Yula enn det vi fant innen våre norske restbestander med gammel barskog. Denne rike forekomsten av hullrugere (inklusive de som benytter avbrekte høgstubber og sprekker i trærne) avspeiler et miljø som burde være egnet for mange andre sårbare arter innen insekter, høyerestående planter, sopp og lav. Våre fugletakseringer gir derfor klare indikasjoner på en generell høg bevaringsverdi av dette store sammenhengende taigaområdet ved Yula.

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