SONGBIRD DIVERSITY AND CAVITY-NESTING BIRD HABITAT IN THE PROPHET TERRITORY OF NORTHEASTERN BRITISH COLUMBIA, 1998

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ABSTRACT

In May and June 1998, a songbird inventory and survey of nest cavities was conducted to provide baseline data on the abundance and diversity of birds in the Prophet River area of northeastern British Columbia. We compared the relative abundance, species richness, species diversity and community structure of birds among five habitat types: open black spruce (*Picea mariana*) bog (OSbBog), mature white spruce (*P. glauca*; MatSw), mature mixed (Matmx), mature aspen (*Populus tremuloides*; MatAt) and immature aspen (ImmAt).

In each habitat, we sampled approximately 28 point count stations spaced at 200 m intervals along linear transects. Up to four different stands were surveyed per habitat type in order to minimize pseudo-replication. Stations were visited on three occasions from 23 May to 30 June. Comparison of songbird diversity among habitat types suggested higher values in the three mature habitats (MatSw, Matmx, and MatAt) and lower values in the OSbBog and ImmAt habitats. The higher songbird diversity found in mature habitats was attributed to the greater complexity of vegetation structure (e.g., multiple canopy layers, canopy gaps, higher shrub, herb and tree canopy cover) found in those habitats. Comparison of songbird community structure among habitats indicated that mature habitat types were similar in terms of their relative abundance and bird species composition and richness. Bird community structure in the OSbBog and ImmAt differed from each other and from the mature forest habitats, mainly because of a number of bird species unique to those habitat types.

Four red- and two blue-listed species were found in relatively low abundance in the study area: the Cape May Warbler (*Dendrocia tigrina*; common in mature white and black spruce stands), the Bay-breasted Warbler (*D. castenea*; rare in mature white spruce and mixed stands), the Connecticut Warbler (*Oporornis agilis*; rare in immature aspen), the Black-throated Green Warbler (*D. virens*; rare in mature aspen and mixed stands), the Canada Warbler (*Wilsonia canadensis*; rare in mature aspen stands) and the Philadelphia Vireo (*Vireo philadelphicus*; rare in mature mixed stands).

A total of 53 cavities, representing six species of primary cavity excavators, were found in the study area. Characterization of active (90%) and old (10%) cavities suggested that defective or dead aspen of medium to large size were important nest tree characteristics. The results also indicated that the most common cavity nester in the area (Yellow-bellied Sapsucker; *Sphyrapicus varius*) selected its nesting habitat based mainly on the presence of trees with heart rot.

Based on the results, we recommend that mature and old-seral forests in the Prophet River area be managed for because: 1) they have the highest diversity of songbirds and cavity nesters, 2) they have the highest number of red- and blue-listed species, and 3) they represent a rare component of the landscape. A combination of conservation and management measures is recommended, including the establishment of protected areas, forest ecosystem networks, wildlife habitat areas and wildlife tree reserves.

TABLE OF CONTENTS

ABSTRACT ii
TABLE OF CONTENTS iii
TABLE OF FIGURES iv
TABLE OF TABLES iv
INTRODUCTION 1
STUDY AREA 1
METHODS 3
Habitat Description 3
Songbird Sampling 4
Nest Cavity Sampling 4
Data Analysis 4
RESULTS 5
Habitat Description 5
Relative Abundance 5
Species Richness 7
Species Diversity 10
Songbird Community Structure 10
Red- and Blue-listed Species 11
DISCUSSION 15
Species Diversity 15
Songbird Community Structure 16
Cavity-nesting Species 16
Red- and Blue-listed Species 17
Cape May Warbler 17
Bay-breasted Warbler 17
Connecticut Warbler 18
Black-throated Green Warbler 18
Canada Warbler 19
Philadelphia Vireo 19
MANAGEMENT RECOMMENDATIONS 20
ACKNOWLEDGEMENTS 21
LITERATURE CITED 22
APPENDIX 1. Bird species list of the Prophet River area, 1998 26
APPENDIX 2. List of dominant and co-dominant shrub and herb species in five habitat types surveyed in the Prophet River area, 1998. 29
APPENDIX 3. Selected photographs of habitats, Prophet River area, 1998. 30

TABLE OF FIGURES

Figure 1. Location of point count stations in the Prophet River area, 1998. Habitat codes: OSbBog: open black spruce bog; MatSw: mature white spruce; Matmx: mature mixed forest; MatAt: mature aspen; ImmAt: immature aspen. 2
Figure 2. Comparison of the mean (± SD) number of individuals per point count or richness among five habitat types in the Prophet River study area, 1998. Differences among groups were tested using non-parametric Kruskal-Wallis tests followed by Dunn's method for multiple comparisons. Similar letters indicate that no significant differences were detected. 7
Figure 3. Comparison of the mean (± SD) number of bird species per point count station among five habitat types in the Prophet River study area, 1998. Differences among groups were tested using non-parametric Kruskal-Wallis tests followed by Dunn's method for multiple comparisons. Similar letters indicate that no significant differences were detected. 9
Figure 4. Cluster tree showing similarity in songbird community among habitat types in the Prophet River study area, 1998. 10
Figure 5. Locations of red- and blue-listed species and cavity nests in the Prophet River study area, 1998. 12

TABLE OF TABLES

Table 1. Summary of vegetation variables assessed in five habitat types of the Prophet River study area, BC, 1998. 6
Table 2. Mean relative abundance of bird species in five habitat types of the Prophet River study area, 1998. Species are listed from the least to most abundant within migration categories (*n* = no. stations sampled). 8
Table 3. Bird species diversity, evenness and total number of species of five habitat types in the Prophet River study area, 1998. 9
Table 4. Red- and blue-listed species sightings in the Prophet River study area, 1998. 11
Table 5. Summary of cavity characteristics for 53 active and old cavities in the Prophet River study area, 1998. 14
Table 6. Characteristics of nest tree with cavities found in the Prophet River study area, 1998. 14
Table 7. Habitat variables selected as indicators of Yellow-bellied Sapsucker (YBSA) nesting habitat in the Prophet River study area, 1998. 15

INTRODUCTION

Industrial activities such as oil and gas development and logging are increasing in the Prophet River area of northeastern British Columbia (Webster 1997; Canfor 5-year development plan, May 1997). The potential impacts of these activities on wildlife are of concern to the First Nations people of the region (B. Wolf, Prophet River Indian Band, pers. comm.). Historically, wildlife populations have provided First Nations and other users with an important source of food and economic opportunity through hunting, outfitting and trapping. At the request of the Prophet River Indian Band, a comprehensive multi-species wildlife inventory study was initiated in 1997 to address the limited quantitative data available on wildlife abundance and distribution in the region.

Large-scale declines in some North American songbird populations have raised concerns regarding the long-term viability of these populations (Askins et al. 1990, Finch 1991, Hagan and Johnston 1992, Finch and Stangel 1993). Habitat loss and fragmentation of both breeding and wintering ranges are considered principal causes of these declines (Ambuel and Temble 1983, Finch 1991, Hagan and Johnston 1992, Robinson et al. 1995). Although few studies have explicitly addressed bird communities of the boreal forest, logging and gas exploration in northern Canada have the potential to negatively affect many songbird species (Kuhnke 1992, Schmiegelow et al. 1997). As studies conducted in agricultural landscapes demonstrate, fragmentation of large tracts of boreal forest may negatively impact forest interior species by increasing nest predation (Wilcove 1985, Robinson et al. 1995) and increasing competition with generalist species (Askins and Philbrick 1987). Forest harvesting may also decrease the frequency of natural disturbances such as insect outbreaks, which are correlated with an increase in songbird abundance in some years (Morse 1978, Welsh 1987, Rotenbery et al. 1993). Some authors have also pointed out that resident species of the boreal forests, such as cavity nesters, could be similarly affected by large scale forest harvesting because of their relatively large home ranges and their dependence on dead or diseased trees and coarse woody debris (Conner et al. 1975, Virkkala and Liehu 1990, Schmiegelow et al. 1997).

During May and June 1998, we conducted songbird surveys in accessible portions of the southeast Prophet Territory to provide data on songbird diversity for various habitat types. Our main objective was to compare the diversity and community structure of songbirds among five major habitat types representative of the study area. These habitats were delineated primarily on the basis of stand age and tree species composition as well as their importance with respect to potential logging activities. Our second objective was to make management recommendations concerning six red- and blue-listed species that were found in the study area. Our final objective was to conduct a preliminary survey of tree cavities used by local cavity nesters in order to characterize the nesting and roosting habitat of resident species.

STUDY AREA

The southeastern portion of the Prophet River Indian Band Territory lies within the Taiga Plains ecoprovince and the Muskwa Plateau and Fort Nelson Lowlands ecosections of northeastern B.C. (Fig. 1). The area is within the Boreal White and Black Spruce (BWSB) biogeoclimatic zone, primarily the BWSBmw2 (moist warm) subzone/variant. Winters are long and cold, and the growing season is relatively short. Mean July and January temperatures for

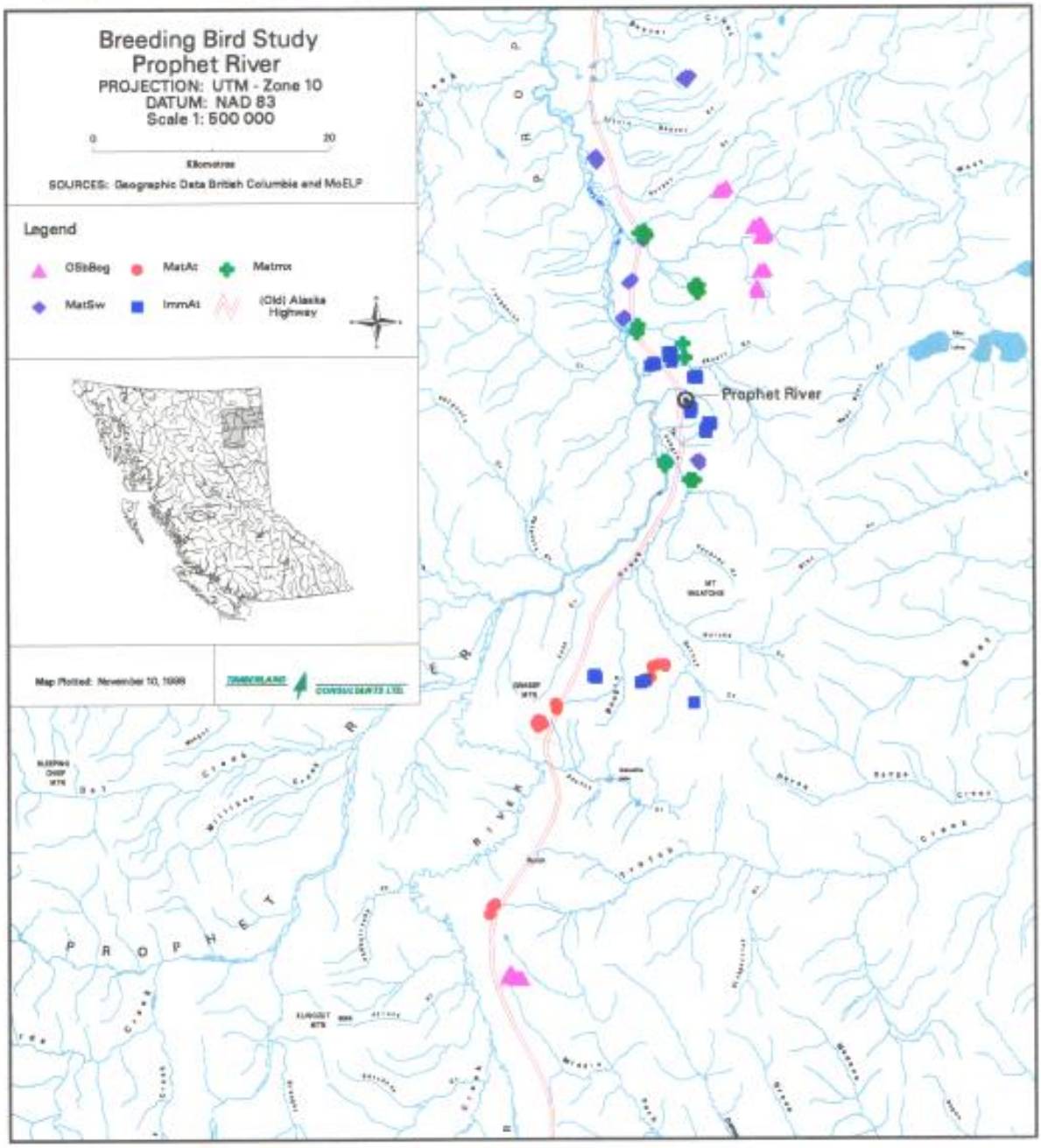

Figure 1. Location of point count stations in the Prophet River area, 1998. Habitat codes: OSbBog: open black spruce bog; MatSw: mature white spruce; Matmx: mature mixed forest; MatAt: mature aspen; ImmAt: immature aspen.

Fort Nelson (80 km north of the Prophet River Reserve) are 16.7 and –22.0 C, respectively. Average annual precipitation is 449 mm, 191 mm of which falls as snow (Environment Canada climate normals, unpubl. data). Drainage is poor, with numerous creeks, rivers, and bogs scattered throughout the region. The topography is varied, with many plateaus extending above the surrounding terrain and elevation ranges from 610 to 1275 m.

Frequent fires have resulted in a mosaic of successional coniferous (primarily lodgepole pine *Pinus contorta*) and deciduous (primarily trembling aspen *Populus tremuloides*) forests (MacKinnon et al. 1992). Black (*Picea mariana*) and white spruce (*P. glauca*) stands are found throughout the region, along with scattered subalpine fir (*Abies lasiocarpa*). Willow (*Salix* spp.) and red alder (*Alnus* spp.) often cover open areas.

METHODS

Habitat Description

Habitat stratification was conducted using forest cover maps as a base. A GIS map was produced showing immature (age classes 2-4), mature (5-7) and old forest (8-9) stands of the following 8 forest types: stands of >80% black spruce; >80% white spruce; >80% lodgepole pine; >80% black and white spruce; >80% lodgepole pine, black spruce and white spruce; >80% deciduous; mixed deciduous and coniferous stands (no component >80%); and open habitats containing primarily non-commercial brush, not sufficiently restocked, old cutblocks, etc. The non-productive forest or non-forest descriptor classes (including non-productive brush and swamp, which often indicated shrub meadows or recently burned areas) were combined to reflect non-commercial forest habitats. There were essentially no early seral forests (age class 1; <20 years) delineated on the forest cover maps.

Songbirds were sampled using the point count technique (Ralph et al. 1985) with 100 m fixed radius plots established in five habitat types: (1) open black spruce bog (OSbBog); (2) mature aspen (MatAt); (3) mature white spruce (MatSw); (4) mature mixed forest (Matmx); and (5) immature aspen (ImmAt). Habitat types were prioritized for sampling according to four criteria: (1) contrast in vegetation structural attributes; (2) proportional representation in the area; (3) relative importance for local resource management activities (i.e., logging and gas exploration); and (4) accessibility by road or trail.

Because forest cover data does not always reflect reality in the field, a number of habitat variables were measured at each point count station, including presence of multiple canopy layers, two leading tree species, tree canopy, shrub layer and herb layer cover, tree diameter at breast height (dbh) classes and height, 2-3 leading shrub species and height, 2-3 leading herb species, number of snags in a 5.6-m radius, and if possible, site series (DeLong et al. 1990). The location of each point count station was determined using a global positioning system (GPS) to facilitate analyses, mapping, and identification of biogeoclimatic subzones, biophysical features and broad ecosystem units from the digital data base. Regardless of forest cover classification, the habitat variables obtained from each point count station were used to examine relationships and trends among habitat variables.

Songbird Sampling

We compared songbird diversity using Resource Inventory Committee (1996) standards. For each habitat type, an average of 28 point count stations were distributed among at least four stands (Fig. 1). Within each stand, three to eight points were distributed on linear transects at 200 m intervals. To minimize potential edge effects, stations were situated at least 100 m from any edge. At each point count station, one observer recorded all bird species seen or heard during a 5-minute period. Counts were conducted between 0500 and 0930 h on three occasions from 23 May to 30 June. To minimize time of day effects, the single observer varied the order in which stations were surveyed. Surveys were not conducted on rainy days or days when wind speeds exceeded 30 km/hr.

Nest Cavity Sampling

Surveys of old and new nest cavities were conducted along point count transects and within good candidate stands in May and June of 1998. Cavities were checked for occupancy by knocking on trees between 0500 and 1500 h. Active cavities were detected by following adults to their nests and by listening for nestling begging calls. For the cavity survey, we only considered occupied cavities or those for which the species of primary excavator could be determined based on the shape and size of the cavity.

For each cavity, we described nest tree characteristics by measuring tree species, height and decay class, cavity height and orientation, as well as tree defects. Considering that the Yellow-bellied Sapsucker (YBSA; see Appendix 1 for Latin names of all bird species) was the most common primary excavator in the study area, a comparison of YBSA nest site characteristics and randomly chosen sites was undertaken in order to determine which characteristics best predicted nest site selection for this species. Random sites were located by choosing a random bearing and distance (maximum of 300 m) from a nest tree using a random number table. In nest and random plots, we assessed all trees >7.5 cm dbh for the following variables in 5.6 m radius circular plots: tree species, diameter (dbh) and decay class, percent of trees with fungal conks, percent canopy cover and number of canopy layers.

Data Analysis

Non-passerines (e.g., corvids, raptors and woodpeckers with the exception of the YBSA), non-breeding species (e.g., Pine Siskin, Pine Grosbeak and White-winged Crossbill), birds flying over stations and birds sampled outside of 100-m radius stations were excluded from analyses of point count data. Cavity-nesting species generally have low densities and large territories and are therefore more difficult to survey by the point count technique. However, because of their high probability of detection, we included the YBSA and Red-breasted Nuthatch (RBNU) in our analyses.

We calculated relative abundance (i.e., the number of individuals of a given species divided by the total number of individuals recorded in a given habitat type) only for species having a minimum of three detections. For the analysis, we considered the total number of species sampled over three visits. We also made comparisons of the number of individuals and the number of species (i.e., species richness) per point count station among habitat types using Kruskal-Wallis tests followed by Dunn's method for multiple comparisons (Zar 1984). All comparisons were tested with $\alpha = 0.05$. We compared bird diversity (a measure that

incorporates both the number of species and the abundance of individuals of each species within a given habitat type) among habitats using the Shannon-Wiener diversity index (Krebs 1989), which in contrast to other diversity indices, is sensitive to changes in rare species. We also used the Shannon-Wiener evenness measure 'J', which compares how evenly the relative abundances of different species are distributed in a given habitat type.

Because diversity indices do not consider the species composition (i.e., the association among species in a given habitat type), similarity indices combining the species, abundance and composition can provide a global comparison of bird communities. We calculated a similarity index for each habitat type based on the Euclidean distance technique (Krebs 1989). We then used a clustering technique to group habitat types with similar bird communities by using the average linkage clustering technique (Krebs 1989).

We used descriptive statistics to describe nest cavity and tree characteristics because of the low number of cavities found during the survey period. We applied logistic regression analysis (PROC logistic; SAS Institute Inc. 1988) to compare 37 YBSA nest sites and 37 randomly-surveyed sites to determine which habitat variables best predicted nest site selection by this species. This model rejected habitat variables with $\alpha > 0.20$; this α level was used because of the large number of variables being tested.

RESULTS

Habitat Description

Vegetation description for the five habitat types indicated that the three mature habitats had a higher overall structural complexity (i.e., higher canopy shrub and herb cover, higher canopy height, greater number of snags, greater proportion of trees in higher dbh classes, and presence of multiple layers; Table 1). Tree species composition was similar for the OSbBog and the MatSw where coniferous species were dominant, and for the ImmAt, MatAt and Matmx where deciduous species dominated.

Relative Abundance

Comparison of the number of individuals among habitats showed that the three mature forest habitats did not differ significantly (Kruskal-Wallis, H = 50.4, df = 4, $P < 0.0001$; Fig. 2). The mean number of individuals per point count station was significantly lower in the OSbBog and in the ImmAt habitats as compared to the mature habitat types. Differences between the latter two habitats also were not significant. Bird communities in each habitat type were dominated by a few abundant species (generally five species comprising >8% of the total relative abundance in each habitat; see Table 2). Pooling habitats, the Yellow-rumped Warbler (YRWA) was the most common species [mean = 12.6 ± 4.4 (SD) %; Table 2] followed by the Tennessee Warbler (TEWA) (mean = 12.0 ± 5.9%; Table 2).

In the OSbBog habitat, YRWA, Dark-eyed Junco (DEJU), Chipping Sparrow (CHSP), Palm Warbler (PAWA) and Hermit Thrush (HETH) were the most common species encountered, accounting for 74.8% of the total relative abundance (Table 2). This habitat type also had the

Table 1. Summary of vegetation variables assessed in five habitat types of the Prophet River study area, BC, 1998.

Variables	OSbBog	MatSw	Matmx	MatAt	ImmAt
Site series [a]	06	01, 01-$, 07	01, 01-$	01-$	N/A
Multiple canopy layer	no	yes	yes	yes	no
Dominant tree sp. [b]	Sb	Sw	Sw, At	At	At
Dominant shrub sp. [b]	Late	Gral, Prro	Gral,Prro, Hicr	Gral	Gral, Wlsp
Dominant herb sp. [b]	Carex, Bube	Bube, Meho	Bube	Carex, Bube	Bube
Tree height (m) range	6-12	24-30	24-30	24-30	18-24m
Mean shrub height (m)	0.6	1.7	1.6	1.7	1.8m
Tree dbh (cm) range	0-15	31-45	31-45	31-45	15-30cm
Mean no. snags	0	2.5	3.4	3.8	0.5
Median tree canopy closure (%)	15	58	53	35	75
Median shrub cover (%)	65	46	58	70	60
Median herb cover (%)	15	38	70	75	50

[a] All habitat types surveyed are within the BWSB biogeoclimatic zone and the BWSBmw2 subzone/variant (DeLong et al. 1990).
[b] Common and Latin names and species code corresponding to all tree, shrub and herb species are listed in Appendix 1.

highest abundance of short-distance migrants, but the lowest abundance of resident species, accounting for 47% and 1% of detections, respectively.

The MatSw was characterized mainly by a high abundance of TEWA, CHSP, YRWA, RBNU and Golden-crowned Kinglet (GCKI)(Table 2). TEWA reached its highest abundance in this habitat type, along with Cape May Warbler (CMWA), a red-listed species which ranked sixth in this habitat. Relative abundance of resident species was highest in this habitat, accounting for 9% of detections.

In the Matmx, TEWA, YRWA, GCKI, Swainson Thrush (SWTH) and Western Tanager (WETA) were the most abundant species. GCKI and WETA reached their highest abundance (8.1 and 7.3%, respectively, in this habitat; Table 2).

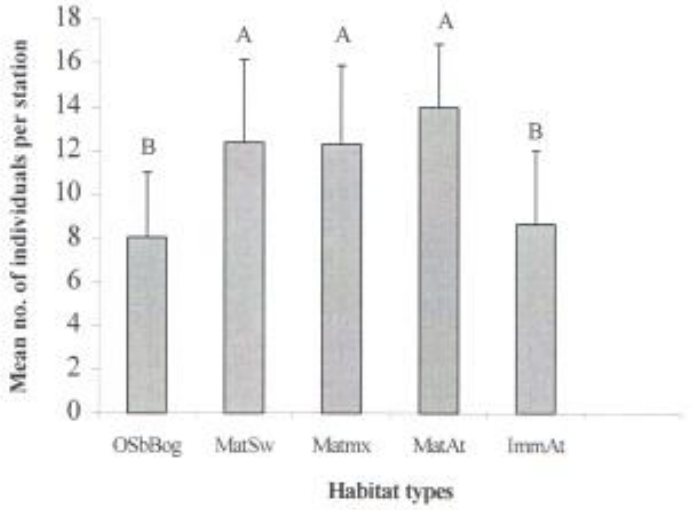

Figure 2. Comparison of the mean (± SD) number of individuals per point count among five habitat types in the Prophet River study area, 1998. Differences among groups were tested using non-parametric Kruskal-Wallis tests followed by Dunn's method for multiple comparisons. Similar letters indicate that no significant differences were detected.

In the MatAt habitat TEWA, YRWA, CHSP, SWTH, White-throated Sparrow (WTSP) and Warbling Vireo (WAVI) were the most abundant species. The latter three species reached their highest abundance in this habitat (8.9, 8.6 and 8.3 % respectively; Table 2).

Community structure of the ImmAt differed from other habitats due to the dominance of the Ovenbird (OVEN) and the Red-eyed Vireo (REVI). These two species were found almost exclusively in the ImmAt and accounted for 38.9% of total abundance. Co-dominant species for this habitat were YRWA, SWTH and TEWA and relative abundance of resident species ranked second lowest at 3.5% (Table 2).

Species Richness

The total number of species recorded per habitat type was higher and similar in the MatAt, Matmx, MatSw and ImmAt habitat types (Table 3). OSbBog had the lowest number of species out of all habitats (Table 3). Comparison of richness (i.e., number of species per point count stations) indicated a significant difference among habitats (Kruskal-Wallis, $H = 57.0$, $df = 4$, $P < 0.0001$; Fig. 3). The OSbBog and the ImmAt values were similar but both differed significantly from the habitat types characterized by a mature or old seral stage (i.e., MatSw, Matmx and MatAt; Fig. 3). Richness values did not differ significantly among mature habitats (Fig. 3).

Table 2. Mean relative abundance of bird species in five habitat types of the Prophet River study area, 1998. Species are listed from the least to most abundant within migration categories (*n* = no. stations sampled).

Species[a]	OSbBog (*n*=30)	MatSw (*n*=28)	Matmx (*n*=26)	MatAt (*n*=26)	ImmAt (*n*=30)
Neotripical migrants					
MOWA	0.00	0.00	0.00	0.30	0.00
FOSP	0.83	0.00	0.00	0.00	0.00
OCWA	0.00	0.00	0.00	0.59	0.38
COWA	0.00	0.00	0.00	0.00	1.15
BTNW	0.00	0.00	0.54	1.48	0.00
BWWA	0.00	0.81	0.27	0.59	1.15
LEFL	0.00	0.00	0.00	0.89	2.31
LISP	3.31	0.00	0.00	0.00	0.00
VATH	0.00	2.15	0.00	1.48	0.00
ALFL	0.83	0.27	0.00	2.67	0.00
BBWA	0.00	1.34	3.25	0.00	0.00
RBGR	0.00	0.81	1.90	0.89	1.54
AMRE	0.00	0.00	0.27	7.42	1.15
MAWA	2.07	1.34	1.90	1.48	2.31
CMWA	0.00	7.26	2.44	0.00	0.00
SOVI	0.00	4.84	4.61	1.19	0.77
PAWA	11.98	0.00	0.00	0.00	0.00
RCKI	9.92	0.27	0.27	0.89	1.92
WETA	0.00	7.26	7.32	0.00	0.00
REVI	0.00	0.00	1.08	0.59	13.85
WAVI	0.00	1.34	2.17	8.31	5.38
GCKI	0.00	7.80	8.13	4.75	1.15
SWTH	1.24	6.18	7.59	8.90	9.62
OVEN	0.00	3.49	6.78	2.08	25.00
CHSP	14.88	11.29	5.69	9.20	2.69
TEWA	3.72	16.67	15.72	16.02	7.69
Short-distance migrants					
WIRE	0.00	1.88	1.08	1.48	0.00
AMRO	0.41	0.00	1.63	0.89	1.54
YSBA	0.00	1.88	4.88	2.97	1.92
WTSP	0.41	0.81	1.08	8.61	1.15
HETH	11.57	0.00	0.00	0.00	1.54
DEJU	16.12	1.08	0.54	0.89	0.77
YRWA	20.25	11.02	12.20	9.20	10.38
Residents					
BCCH	0.00	0.00	0.00	0.59	1.15
BRCR	0.00	0.81	1.36	0.30	0.00
BOCH	0.41	1.08	0.81	0.00	0.77
RBNU	0.41	8.06	6.23	4.75	2.31

[a] Common and Latin names and corresponding codes for all species are listed in Appendix 2. Species in **bold** are classified as red-or blue-listed by the B.C. Conservation Data Centre (1998).

Table 3. Bird species diversity, evenness and total number of species of five habitat types in the Prophet River study area, 1998.

Habitat types	Diversity	Evenness	Total no. of species
MatAt	4.06	0.84	29
Matmx	4.03	0.86	27
MatSw	3.89	0.85	25
ImmAt	3.75	0.70	26
OSbBog	3.16	0.78	17

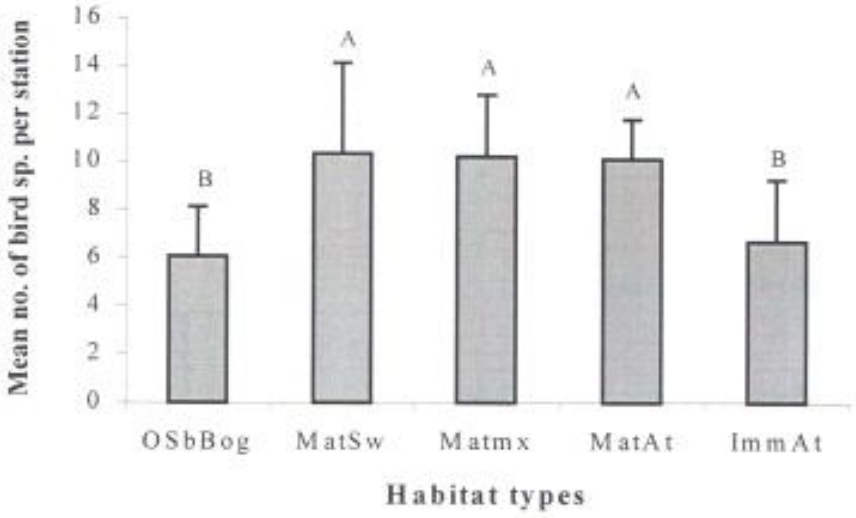

Figure 3. Comparison of the mean (± SD) number of bird species per point count station (richness) among five habitat types in the Prophet River study area, 1998. Differences among groups were tested using non-parametric Kruskal-Wallis tests followed by Dunn's method for multiple comparisons. Similar letters indicate that no significant differences were detected.

Species Diversity

The Shannon-Wiener measure of diversity for each habitat indicated that songbird diversity was highest in the MatAt and Matmx habitats and lowest in the OSbBog habitat (Table 3). The evenness index 'J' followed the same trend, with similar and higher values in mature habitat types and lower values in ImmAt and OSbBog habitats.

Songbird Community Structure

Songbird community structure was similar for MatSw, Matmx and MatAt habitats (Fig. 4). Similar composition and abundance of long and short distance migrants as well as resident species likely accounted for their comparable similarity indices.

The OSbBog habitat, which had both a simple horizontal and vertical structure, differed from all the other habitat types. This low similarity with other habitats was due to an absence of resident species and a high abundance of specialist species unique to this habitat (i.e., PAWA, HETH, RCKI and Lincoln Sparrow (LISP); Table 2).

Bird community structure of the ImmAt habitat was more similar to the mature habitat types (MatSw, MatAt and Matmx) than the OSbBog (Fig. 4). The latter result was due to the high abundance of OVEN and REVI in the ImmAt.

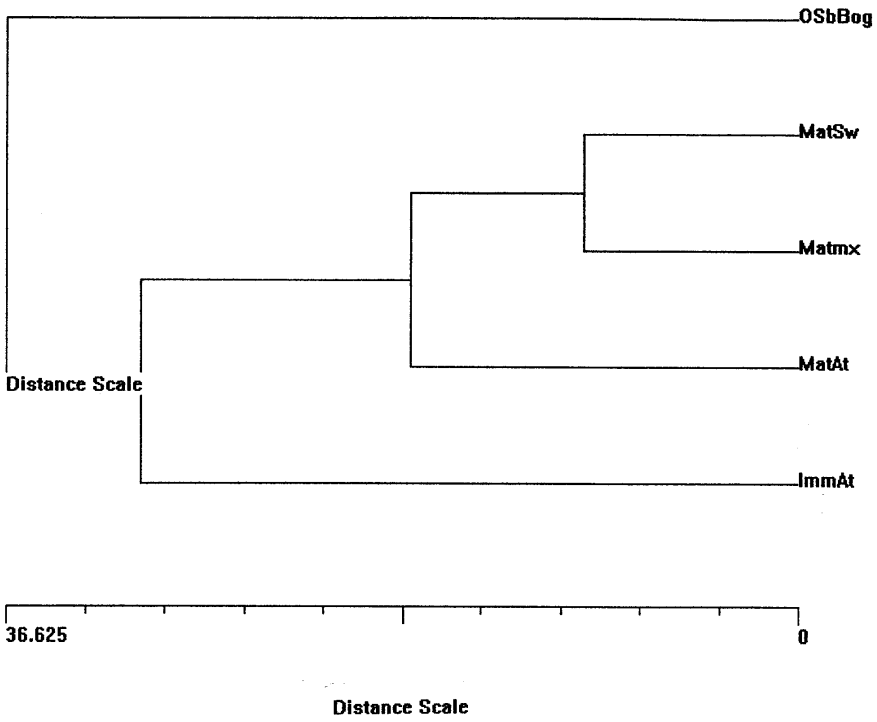

Figure 4. Cluster tree showing similarity in songbird community among habitat types in the Prophet River study area, 1998.

Red- and Blue-listed Species

We detected four red- and two blue-listed species during point count surveys (Table 4 and Fig. 5), most of which were found in mature and old forest habitat (Table 4). The CMWA was the most common of these species and reached its maximum abundance in the MatSw habitat type. Some birds were also located in mature black-spruce stands outside of the sampling period (see Table 4).

The Bay-breasted Warbler (BBWA), the second most abundant species of this group, was located mainly in Matmx and MatSw stands (Table 4). Unlike the CMWA, the BBWA seemed to be more abundant in the mature mixed habitat type. Six sightings of the Connecticut Warbler (COWA) were made and these were concentrated close to the Prophet River Indian Reserve in ImmAt habitat. The Black-throated Green Warbler (BTNW) was a rare breeding songbird species in the study area, and was located only in two mature habitats (Matmx and MatAt) (Table 4).

The Philadelphia Vireo (PHVI) and the Canada Warbler (CAWA) were the rarest breeding songbird species in the study area with four and two sightings, respectively (Table 4). The PHVI was found mostly in the Matmx and MatAt habitat types, whereas the CAWA was detected in open MatAt habitat.

Table 4. Red- and blue-listed species sightings in the Prophet River study area, 1998.

Species	Status	No. (%) of sightings within the sampling period[a]	No. of sightings outside the sampling period	Total no. of sightings	Habitat type
Cape-May Warbler	red	36 (2.9)	12	48	MatSw/ Matmx
Bay-breasted Warbler	red	17 (1.4)	2	19	MatSw/ Matmx
Black-throated green Warbler	red	7 (0.6)	0	7	Matmx/ MatAt
Connecticut Warbler	red	3 (0.2)	3	6	ImmAt
Philadelphia Vireo	blue	2 (0.2)	2	4	Matmx/ MatAt
Canada Warbler	blue	1 (0.1)	1	2	MatAt

[a] A total of 1231 bird sightings were made during the point count session.

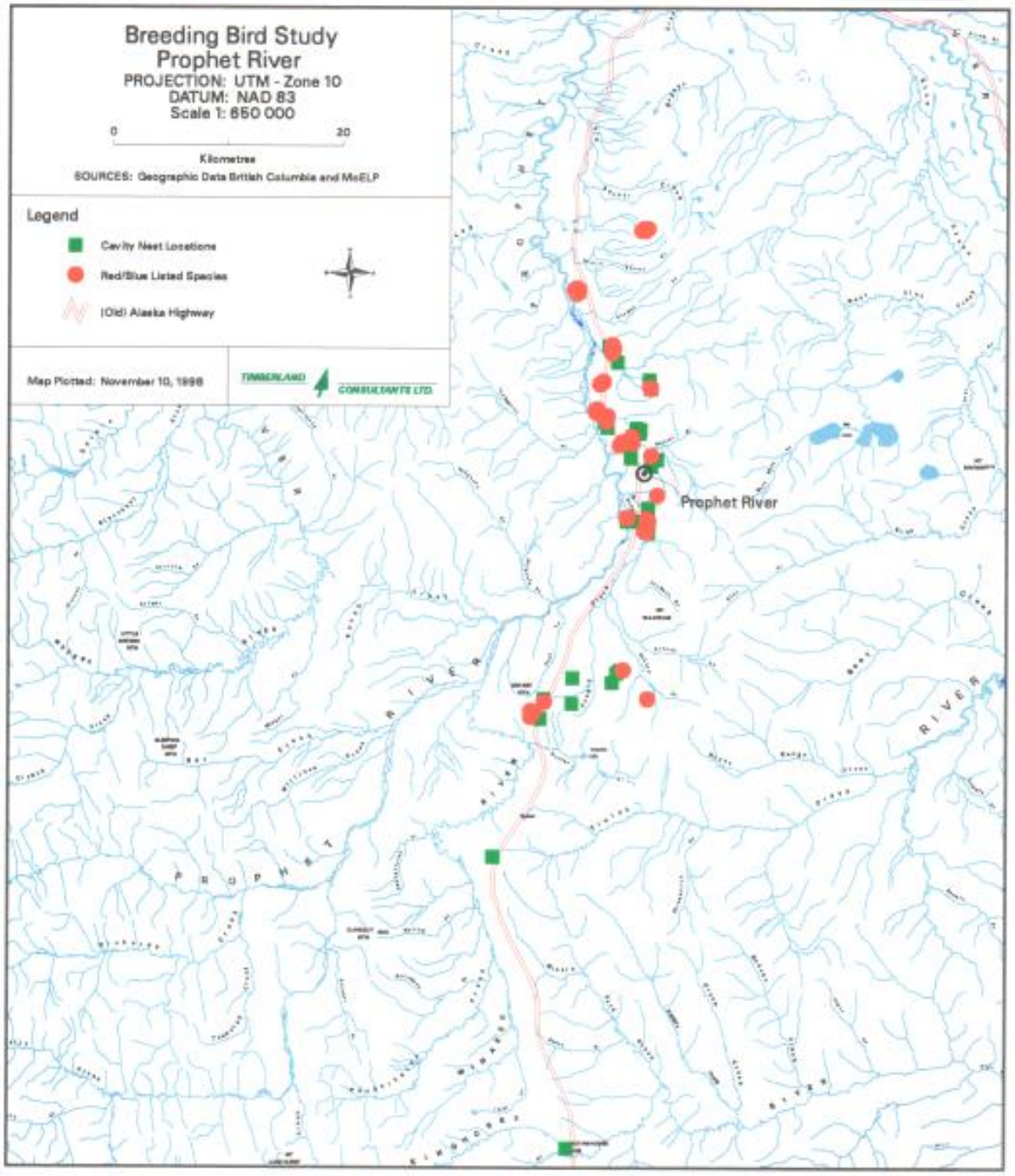

Figure 5. Locations of red- and blue-listed species and cavity nests in the Prophet River study area, 1998.

Characterization of Nest Cavities

A total of 53 cavities of six species were found during the survey period (Fig. 5). Most of these (90%) were active nests and the remainder were old (i.e., > 3 yrs. old) nest cavities. During the nest cavity survey, only a few cavities were detected by looking at potential trees on transects or in selected stands. In contrast, 89% of the cavities were detected by listening to the begging calls of nestlings during the feeding period.

Assessment of trees with cavities indicated that all cavity-nesting species used dying or dead aspen of medium to large size with heart rot (Table 5). More than 50% of all cavities were in mature mixed habitat types which were represented by the subzone/variant and site series SwSbmw01 and 01-$. The majority of trees found with cavities were still standing and cavities were usually located in the middle section of trees. Twenty percent of all trees found with cavities had more than one cavity, which suggested multiple use by the same or different species over several years.

Although RBNU was the most common cavity-nesting species in the study area (i.e., it was detected on 49% of all point count stations), only two active nests were found. In contrast, we found 35 active and two old nests of YBSA, the second most common primary excavator species in the Prophet River study area (i.e., detected on 26% of all the point count stations). Of the YBSA nests found, 70, 22 and 8% were in the Matmx, MatAt and ImmAt habitat types, respectively. The Three-toed Woodpecker (TTWO) ranked second highest in terms of nest detection during the survey with six active nests (11% of all nests found). This species was only found in the mature white and black spruce. Pileated Woodpecker (PIWO), Northern Flicker (NOFL) and Hairy Woodpecker (HAWO) cavities combined comprised 15% of all cavities detected during the survey.

Descriptive comparisons of trees with cavities showed that YBSA were nesting mainly in deciduous trees in mature mixed or deciduous stands (Table 6). In contrast, TTWO cavities were mainly in coniferous trees in mature coniferous stands. Cavities of YBSA appeared to be located higher and were found in taller trees compared with those of TTWO. Compared with TTWO, YBSA also seemed to choose larger trees with a greater occurrence of heart rot. Both species chose dying (i.e., decay class 2) or dead (i.e. decay >2) trees. NOFL cavities were found primarily in unforested areas (e.g., clear-cut) where some large trees were present. Like YBSA, NOFL cavities were in large deciduous trees with heart rot. Nest tree characteristics for less common bird species are given in Table 6.

Comparison of YBSA nest sites and randomly selected plots for various characteristics indicated selection for nest sites with a high incidence of heart rot ($\chi^2 = 4.17$, $P = 0.04$, Table 7), based on visual assessment of conks. No other variables assessed were significant at the $\alpha = 0.20$ level.

Table 5. Summary of cavity characteristics for 53 active and old cavities in the Prophet River study area, 1998.

Habitat type (%)	Tree sp. (%)	Tree dbh (cm) mean ± SD.	Tree ht (m) mean ± SD.	Cavity ht (m) mean ± SD.	Dead or dying trees used (%)	Broken top (%)	Conks (%)	Trees with ≥ 2 cavities (%)
Matmx (60)	At (89)	33 ± 7.7	21 ± 7.0	9 ± 3.6	class 2 (81)	11.3	83	20
Matcon[a] (13)	Conifer(11)				class 3 (19)			
MatAt (27)								

[a] Matcon: mature conifer.

Table 6. Characteristics of nest tree with cavities found in the Prophet River study area, 1998.

Bird Species	No. cavities	Habitat type (%)	Tree species	Tree dbh (cm ± SD)	Tree ht. (m ± SD)	Cavity ht. (m ± SD)	Broken top (%)	Trees with conks (%)	Dead or dying trees (%)
YBSA	37	Matmx (68)	At (100)	32 ± 6.4	22 ± 5.3	9 ± 3.4	2	95	100
TTWO	6	Matcon (100)	Con. (87.5)	26 ± 4.1	17 ± 8.1	5.8 ± 4.1	33	50	100
NOFL	4	Unforested (50)	Dec. (100)	37 ± 11.5	14 ± 8.4	5.9 ± 4.4	25	75	100
		Matmx (50)							
RBNU	2	Matmx (100)	At (100)	38 ± 5.6	10 ± 4.2	8.4 ± 2.8	100	50	100
HAWO	1	Matmx (100)	At (100)	33	25	8	0	0	100
PIWO	2	Matmx (100)	At (100)	33 ± 1.4	9 ± 4.1	50 ± 4.2	0	100	100

Table 7. Habitat variables selected as indicators of Yellow-bellied Sapsucker (YBSA) nesting habitat in the Prophet River study area, 1998.

Variable	Parameter estimate	χ^2	*P*
Intercept	2.7	1.90	0.16
% of At	-0.3	0.88	0.34
Dbh class	-0.1	0.07	0.79
Decay class 1	-0.4	0.70	0.40
% of trees with conks	-0.04	4.17	0.04
% canopy cover	0.0	0.00	0.99
Presence of multiple canopy layers	-0.1	0.03	0.85

DISCUSSION

Species Diversity

Mature and old growth stands in the Prophet River area had the highest diversity of songbirds of all the habitat types surveyed. Other studies in boreal forests have demonstrated the same pattern (Telfer 1993, Lance and Phinney 1994, Lance et al. 1995, Bennett and Enns 1996). This pattern is generally attributed to the more complex habitat structure and greater niche diversity of older forests. Our results also support a pattern of higher songbird diversity with increasing habitat complexity. In our study, the MatAt habitat type with a well-developed multi-layered tree canopy and a high shrub and herb cover had the highest songbird diversity of all habitats sampled. The two other mature habitats sampled (Matmx and MatSw) also had relatively high songbird diversities, which we attribute to greater canopy cover and complexityand to the presence of natural disturbances in these habitats. In contrast, the OSbBog and the ImmAt habitat types had a less complex vegetation structure and relatively low songbird diversity.

Frequent gaps in the canopy created by disturbances such as windthrow and insect infestation were probably responsible for the high heterogeneity of mature forest habitats. Such small-scale disturbances are known to enhance bird diversity as more niches are created (Lavorel et al. 1994). The TEWA, for example, was very abundant in openings created in the closed canopy of mature stands but rare in sites with few or no openings.

The old seral stage forests in the study area also had a higher abundance of resident species. This result is in agreement with the results of Schieck and Nietfeld (1995) and Schmiegelow et al. (1997), which indicate a preference for older forests by these species. In the Prophet River area, resident species were represented mainly by the cavity-nesting guild. This guild requires large live, dying and dead trees for nesting, roosting and foraging activities during summer and winter (Goggans et al. 1988, Harestad and Keisker 1989, Machmer and Steeger

1995, Steeger et al. 1996, Bull et al. 1997). The general absence of cavity nesters from the OSbBog and ImmAt habitats, which were less complex in their vegetation structure and lacked large trees and snags, is consistent with the requirements of these species.

Songbird Community Structure

Our results suggest that similar complexities in the structural features among habitats were responsible for the similarity in the songbird community structure. The MatSw and Matmx habitat types were the most similar in terms of both songbird community structure (i.e., the majority of cavity-nesting species and closed canopy specialists were common to both of these habitats) and structural habitat complexity.

The unique songbird community found in the OSbBog relative to all other habitats can be explained by a number of factors. The cavity-nesting guild was absent from this habitat, presumably due to the lack of large trees and snags required by this guild. The OSbBog also had a very high abundance of short-distance migrants (represented mainly by sparrows) using the abundant open areas suitable for nesting and foraging. A few very abundant long-distance migrants (e.g., PAWA, LISP, RCKI) were unique to the OSbBog. Overall, the low number of species present in the OSbBog compared to other habitats was an important factor decreasing similarity with other habitat types.

The REVI, OVEN and LEFL were the only very abundant long distance migrants specific to the ImmAt habitat. This lack of long distance migrants probably accounted for the fact that this habitat ranked the second most different in terms of songbird community structure.

Cavity-nesting Species

Our survey of cavity-nesting species in the Prophet River area suggested that only the RBNU and YBSA were abundant. These two species seemed to reach their maximum abundance in mature and old-seral stands with a high snag density and a high, relatively closed canopy. Although the OSbBog habitat was at a late seral stage, it lacked large snags and a high closed canopy associated with these species. The TTWO, which requires mature and old forest coniferous stands that have a high density of trees affected by bark beetles (Goggans et al. 1988, Steeger et al. 1998), was the second most common species of woodpecker in the study area. PIWO and HAWO, two species that require and are probably limited by the scarcity of mature or old forest deciduous stands, were uncommon in the Prophet River area.

Cavity-nesting species breeding in the Prophet River area generally used defective, dying or dead large size trees for nesting and roosting. Natural disturbance agents such as diseases, insects and fire create such trees. These disturbances are more likely to occur in mature and old forest stands where older trees susceptible to these agents are more abundant. Our results are in agreement with other studies that demonstrate preference by cavity nesters for stands that have a high density of large trees and snags (Mannan and Meslow 1984, Renken and Wiggers 1989, Machmer and Korol 1998).

Aspen plays an extremely important role in the breeding ecology of cavity nesters of the Prophet River area, as exemplified by the YBSA, which was very common but localized in deciduous stands. The tendency of aspen to develop fungal heart rots which facilitate cavity excavation (Conner et al. 1976) as well as aspen abundance and turnover are likely responsible for observed nest tree preference of this species in the Prophet River area. Strong nest tree

selection for aspen has been reported for many other regions of B.C. (Harestad and Keisker 1989, Steeger and Machmer 1995, Steeger et al. 1996, Walters 1996, Machmer and Korol 1998) and is usually attributed to woodpecker dependence on trees softened by fungal heart rots.

Red- and Blue-listed Species

Four red- and two blue-listed species were found in the Prophet River area. Their presence in the study area corresponds to the western edge of their distributions in Canada (Enns and Siddle 1996). The general status and habitat associations of each species in the study area are described in the following sections.

Cape May Warbler

The CMWA is a relatively abundant neotropical migrant of the boreal forest across Canada (Godfrey 1986). However, in B.C. its distribution is limited to the Boreal and Taiga plains ecoprovinces of the Peace region (mainly Fort St. John and the Fort Nelson area), where populations are considered scarce (Bennett and Enns 1996, Enns and Siddle 1996, Cooper et al. 1997a, Bennett 1998). This species is insectivorous and its populations are known to increase during spruce budworm outbreaks (Crawford et al. 1983, Welsh 1987).

The CMWA is associated with fairly tall and dense (i.e., closed canopy) stands of white-spruce on relatively flat ground (Cooper et al. 1997a). In the Prophet River area, the CMWA was most abundant in mature and old forest white-spruce habitat type (site series: 01, 01$ and 07). Some birds were also located in mature black-spruce stands outside of the sampling period and in dense conifer patches located within mature mixed habitat. A high closed canopy with little or no openings and a low shrub layer appeared to be important habitat variables in the habitat use of this species. Along the Liard River, higher densities of CMWA were found in upslope mixed and coniferous forest habitats; the species was absent in deciduous and riparian stands (Bennett and Enns 1996).

In northeastern B.C., habitat availability for the CMWA is known to be moderately abundant but patchily distributed (Cooper et al. 1997a). In our study area, CMWA habitat was also patchily distributed and found mainly in riparian zones of the Prophet River and its tributaries where no clear-cut logging had occurred recently.

Because of increased logging activity in the Prophet River area and habitat specificity of the CMWA, this species may be affected by habitat loss. Habitat fragmentation and creation of canopy gaps associated with forest harvesting or seismic activities likely decreases habitat suitability and may allow generalist species to colonize the interior forest and increase interspecific competition Cooper et al. (1997a). However, according to our observations the creation of seismic lines in CMWA habitat did not seem to affect the birds' presence (i.e., most of our sightings were <200 m from old or newly created lines). Further study would be required to address potential impacts of seismic lines on the interspecific competition of CMWA with more generalist species.

Bay-breasted Warbler

The BBWA is a rare forest interior, long-distance, neotropical migrant that breeds in mixed and coniferous forests found all across Canada and the northern United States (Godfrey 1986, Enns and Siddle 1996). In B.C., its distribution corresponds to the Peace region (i.e., Fort

St. John and Fort Nelson areas). Like the CMWA, the BBWA seems to reach maximum abundance during spruce budworm outbreaks (Cooper et al. 1997b).

In the Prophet River study area, the species was found mainly in mature and old forest mixed and white spruce stands (site series: 01, 01$ and 07). Unlike the CMWA, the BBWA seemed to be more abundant in the mature mixed habitat type, although it was also associated with habitats characterized by a high closed canopy with little or no openings. Along the Liard River, higher densities of BBWA were found in mixed and coniferous riparian habitats but the species was not found in stands where aspen and balsam poplar comprised >25-30% of the canopy cover (Bennett and Enns 1996).

Analogous to the CMWA, BBWA habitat may be negatively impacted by logging activities (which focus primarily on mature and old forest stands) or creation of seismic lines. Again, most of our sightings were <200 m from old or newly created lines. Impacts of these lines on reproductive success of BBWA and on their interactions with generalist species would require more in-depth study.

Connecticut Warbler

The COWA is a rare neotropical migrant distributed from western Québec to the extreme northeastern part of B.C. (Godfrey 1986, Enns and Siddle 1996). General habitat characteristics for the COWA include mature deciduous stands with closed, relatively high canopies and a well-developed shrub layer (Cooper et al. 1997c). The species was found in the Prophet River area at a very low density in ImmAt (i.e., 40-60 yrs), in stands with closed canopy cover with a high density of stems and a well-developed shrub layer.

This study is among the few studies conducted in the Fort Nelson area that has documented the presence of the COWA. Other songbird surveys along the Smith, Dunedin and Liard Rivers have not recorded the latter species (Bennett and Enns 1996, Bennett 1998), although it was found in the Tuchodi-Gathto region (MacNaughton 1995). The very low abundance of this species in the study area might be linked to the scarce and patchy distribution of high quality habitat. Four of the six territorial males were located in homogenous stands >100 ha, suggesting that populations of this species might need large tracts of suitable habitat.

Given that most sightings were close to the Prophet River Reserve, housing development and/or agriculture may also affect suitable habitat. However, the availability of suitable COWA habitat in the Prophet River area is expected to increase as immature aspen stands mature. Due to the scarcity of immature aspen stands in the landscape, logging activities will probably have minor effects on the COWA habitat in undeveloped areas. As suggested by Cooper et al. (1997c), the COWA should remain red-listed because of its restricted and isolated distribution.

Black-throated Green Warbler

The BTNW is an uncommon, forest interior, neotropical migrant songbird. In B.C., it is restricted to the Boreal and Taiga Plains ecoprovinces (Cooper et al. 1997d). It uses primarily mature and old forest mixed-woods in riparian zones and is red-listed because of its restricted distribution, small populations and severe threats to its habitat in the Peace Lowlands (Cooper et al. 1997d).

In the Prophet River area, the BTNW is a rare breeding songbird, which was located only in two stands. The species was recorded in a mature mixed stand with relatively high canopy cover (i.e., 65%) and in a mature aspen stand that had a relatively open canopy (i.e., 35%), a multiple layers and a prominent shrub layer (site series: 01, 01$). Although this species inhabits a wider range of habitats (i.e., coniferous and deciduous forests) than other red- and blue-listed species of the Prophet River area, it is more likely to use older seral stands in riparian habitats (Cooper et al. 1997d).

Songbird surveys along the Smith, Dunedin and Liard Rivers have not recorded the BTNW (Bennett and Enns 1996, Bennett 1998), although the species was found in the Tuchodi-Gathto region (MacNaughton 1995). The rarity of the BTNW in the Prophet River area is likely related to the low proportion of suitable habitat. Isolated populations might be particularly susceptible to stochastic events, such as forest fire, which occur frequently in the study area.

Canada Warbler

The CAWA breeds from the northeastern B.C., across Canada east to Nova Scotia and in the eastern USA (Godfrey 1986, Enns and Siddle 1996). In B.C. the species is restricted to the Boreal and Taiga Plains ecoprovinces.

In the Prophet River area, the CAWA was one of the rarest birds sampled with only one singing male in an open mature aspen stand and one inside the Reserve near a house (probably a non-breeder). Habitat of this species is characterized by a late successional stage of aspen, with a well-developed and complex shrub layer and an open uneven canopy layer (Cooper et al. 1997e). Bennett and Enns (1996) describe CAWA habitat along the Liard River as mature and old-growth stands dominated by aspen with a shrub layer > 2m, on low to middle slopes. Cooper et al. (1997e) also suggest that the species might be more common on steep slopes where open forests occur more frequently.

As in our study, Bennett (1998) documented a low abundance of CAWA in the Smith and Dunedin drainages, 150 km northwest of Fort Nelson. In the Liard River area (450 km northwest of the Prophet River study area), the species seems to be more abundant (Bennett and Enns 1996). A difference in the availability of suitable habitat in the landscape likely explains the differences in the relative abundance of this species among study areas. Although potential habitats (i.e., moderate and steep slopes) for this species were not systematically surveyed during this study, populations of the Prophet River area are likely isolated and susceptible to stochastic events.

Philadelphia Vireo

The PHVI is an uncommon neotropical migrant that breeds from the northeastern B.C. to southwest Newfoundland (Godfrey 1986, Enns and Siddle 1996). It is an edge specialist in second-growth deciduous forests and riparian zones (Cooper et al. 1997f). The species will also use old forest stands with frequent openings and a dense sapling understory.

In the Prophet River area, the PHVI was one of the rarest birds sampled with only four sightings. Nevertheless our observations of three males at the edge of old forest forests and old clear-cuts are consistent with existing habitat use descriptions (site series: 01, 01$; Cooper et al.

1997f). The very low density of PHVI in Prophet River is in accordance with findings of other studies along the Liard, Smith and Dunedin rivers, where the species was not recorded during extensive surveys (Bennett and Enns 1996, Bennett 1998).

MANAGEMENT RECOMMENDATIONS

1. Land managers should ensure that some mature and old forest stands (e.g. >80% Sw, >80% At and >80% mixed) should be protected in the Prophet River area because: (1) they have the highest diversity of songbirds and cavity-nesters; (2) they have the highest number (i.e., five species) of red- and blue-listed species; and (3) they represent a relatively rare component of the landscape in the Prophet River area.

2. Forests of the areas should be managed to promote a diversity of seral stages, ranging from young to mature and old forest.

3. Considering that the retention of wildlife tree patches and single tree retention (Province of B.C. 1995) are not likely to maintain closed-canopy specialist species at current population levels (Crawford et al. 1981), we recommend that protected areas or reserves be designated in order to maintain diversity and species composition in the Prophet River area. These areas must be well planned to maximize connectivity and minimize habitat fragmentation. Forest ecosystem networks (FENs) which incorporate mature forests with forest interior habitat conditions would be helpful in achieving these goals. Suitable FENs should be delineated and incorporated into 5-year development plans. Where opportunities for old-seral FENs are lacking, immature and mature forest reserves should be delineated for future recruitment with connectivity objectives in mind. Because most old seral stage stands are situated along the Prophet River, creation of protected riparian FENs should be considered to maintain songbird diversity and community structure of old forests.

4. Although the OSbBog and ImmAt habitat types generally had lower bird species diversity, they had a unique bird community (i.e., high abundance of some specialist species such as PAWA and OVEN) and representative amounts of these habitats should be retained in the landscape.

5. Considering the number of red- and blue-listed species found in many of the habitats surveyed, wildlife habitat areas (WHA's) should be designated, incorporating sites with high habitat quality and demonstrated use by selected red- and blue-listed species.

Cooper et al. (1997a-f) provide a series of recommendations and management options, many of which would pertain to the listed species found in the Prophet River area. Many of these recommendations may also be used to maintain the overall songbird diversity and include the following:

a) Manage the forest at a landscape level using land-use trends;

b) Allow natural disturbances such as fire, insect outbreaks, blowdown and diseases to occur;

c) Manage for multiple species, except when single species deserve special concern;

d) Monitor populations to keep current on effects of silvicultural practices;

e) Create and maximize sizes of forest reserves, while minimizing edge and isolation effects;

f) Promote microhabitat diversity by providing uneven-aged forests;

g) Preserve as much old forest as possible; and

h) Promote public awareness of migratory songbird declines.

6. Because of increased logging activities in the Prophet River area, primarily clear-cutting in mature and old forest stands, it is likely that old seral stage structural components such as live defective, diseased and dead trees will be a limiting factor for cavity-nesters. We therefore recommend that logging plans incorporate wildlife tree patches (WTPs) containing a mixture of large healthy, live defective and dead trees of various species and decay classes representative of the original stand. WTPs should incorporate trees with active nest cavities and veteran trees whenever possible.

7. Aspen stands (especially mature aspen) are extremely important for primary and secondary cavity nesters in the Prophet River area. These stands should be considered a priority for retention in local logging plans, considering the recent use of aspen for pulpwood industries in northeastern B.C. (Comeau et al. 1996). Long-term monitoring of cavity nester populations should be considered in intensively managed forests of the area.

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APPENDIX 1. Bird species list of the Prophet River area, 1998

Common name	Latin name	Bird species code
1 Alder Flycatcher	*Empidonax alnorum*	ALFL
2 American Redstart	*Setophaga ruticilla*	AMRE
3 American Robin	*Turdus migratorius*	AMRO
4 Barn Swallow	*Hirundo rustica*	BASW
5 Bay-breasted Warbler	*Dendroica castenea*	BBWA
6 Black-capped Chickadee	*Parus atricapillus*	BCCH
7 Solitary Vireo	*Vireo solitarus*	SOVI
8 Blackpoll Warbler	*Dendroica striata*	BLWA
9 Boreal Chickadee	*Parus hudsonicus*	BOCH
10 Bohemian Waxwing	*Bombycilla garrulus*	BOWA
11 Brown Creeper	*Certhia americana*	BRCR
12 Black-throated green Warbler	*Dendroica virens*	BTNW
13 Black and White Warbler	*Mniotilta varia*	BAWW
14 Canada Goose	*Brenta canadensis*	CAGO
15 Canada Warbler	*Wilsonia canadensis*	CAWA
16 Clay-colored Sparrow	*Spizella pallida*	CCSP
17 Cedar Waxwing	*Bombycilla cedrorum*	CEWA
18 Chipping Sparrow	*Spizella paaserina*	CHSP
19 Cape May Warbler	*Dendroica tigrina*	CMWA
20 Common Raven	*Corvus corax*	CORA
21 Common Snipe	*Gallinago gallinago*	COSN
22 Connecticut Warbler	*Oporornis agilis*	COWA
23 Common Yellowthroat	*Geothlypis trichas*	COYE
24 Dark-eyed Junco	*Junco hyemalis*	DEJU
25 Eastern Phoebe	*Sayornis phoebe*	EAPH
26 Evening Grosbeak	*Coccothraustes vespertinus*	EVGR
27 Fox Sparrow	*Passrella iliaca*	FOSP
28 Golden-crown Kinglet	*Rgulus satrapa*	GCKI
29 Great-grey Howl	*Strix nebulosa*	GGHO
30 Gray Jay	*Perisoreus canadensis*	GRJA
31 Greater Yellowlegs	*Tringa melanoleuca*	GRYL
32 Green-winged Teal	*Anas crecca*	GWTE
33 Hammond Flycatcher	*Emphidonax hammondii*	HAFL
34 Hairy Woodpecker	*Picoides villosus*	HAWO
35 Hermit Thrush	*Catharus guttatus*	HETH
36 House Sparrow	*Passer domesticus*	HOSP
37 Kildeer	*Charadrius vociferus*	KILDEER
38 Least Flycatcher	*Empidonax minimus*	LEFL
39 Le Conte's Sparrow	*Ammodramus leconteii*	LESP
40 Lincoln's Sparrow	*Melospiza lincolnii*	LISP
41 Mallard	*Anas platyrhynchos*	MALL

42 Magnolia Warbler	*Dendroica magnolia*	MAWA

Bird species list of the Prophet River area, 1998.

Common name	Latin name	Code
44 Morning Dove	*Zenaidura macroura*	MODO
45 Morning Warbler	*Oporosnis philadelphia*	MOWA
46 Northern Flicker	*Colaptes auratus*	NOFL
47 Northern Goshawk	*Circus cyaneus*	NOGO
48 Northern Harrier	*Accipiter gentilis*	NOHA
49 Northern Waterthrush	*Seiurus noveboracensis*	NOWA
50 Orange-crown Warbler	*Vermivora celata*	OCWA
51 Olive- sided Flycatcher	*Contopus borealis*	OSFL
52 Ovenbird	*Seiurus aurocapillus*	OVEN
53 Palm Warbler	*Dendroica palmarum*	PAWA
54 Philadelphia Vireo	*Vireo philadelphicus*	PHVI
55 Pine grosbeak	*Pinicola enucleator*	PIGR
56 Pigmy Howl	*Glaucidium gnoma*	PIHO
57 Pine Siskins	*Carduelis pinus*	PISI
58 Pileated Woodpecker	*Dryocopus pileatus*	PIWO
59 Rose-breasted Grosbeak	*Pheucticus ludovicianus*	RBGR
60 Red-breasted Nuthatch	*Sitta canadensis*	RBNU
61 Ruby-crown Kinglet	*Regulus calenda*	RCKI
62 Red-eyed Vireo	*Vireo olivaceus*	REVI
63 Ringed-neck Duck	*Aythya collaris*	RNDU
64 Red-tailed Hawk	*Buteo jamaicensis*	RTHA
65 Red-winged Blackbird	*Agelaius phoeniceus*	RWBL
66 Sandhill Crane	*Grus canadensis*	SACR
67 Savanna Sparrow	*Passerculus sandwichensis*	SASP
68 Sora	*Porzana carolina*	SORA
69 Solitary Sandpiper	*Tringa solitaria*	SOSA
70 Spruce Grouse	*Dendragapus canadensis*	SPGR
71 Swainson's Thrush	*Catharus ustulatus*	SWTH
72 Tennessee Warbler	*Vermivora peregrina*	TEWA
73 Tree Swallow	*Tachycineta bicolor*	TRSW
74 Three-toed Woodpecker	*Picoides tridactylus*	TTWO
75 Varied Thrush	*Ixoreus naevius*	VATH
76 Warbling Vireo	*Vireo gilvus*	WAVI
77 Western Tanager	*Piranga ludoviciana*	WETA
78 Winter Wren	*Troglodytes troglodytes*	WIWR
79 White-throated Sparrow	*Zonotrichia albicollis*	WTSP
80 White-winged Crossbill	*Loxia leucoptera*	WWCR
81 Yellow-bellied Flycatcher	*Emphidonax flaviventris*	YBFL
82 Yellow-bellied Sapsucker	*Sphyrapicus varius*	YBSA
83 Yellow Warbler	*Dendroica petechia*	YEWA
84 Yellow-rumped Warbler	*Dendroica coronata*	YRWA

APPENDIX 2. List of dominant and co-dominant shrub and herb species in five habitat types surveyed in the Prophet River area, 1998.

Common name	Latin name	Code
Shrubs		
Labrador tea	*Ledum groenlandicum*	LATE
Prickly rose	*Rosa acicuralis*	PRRO
Highbrush cranberry	*Viburnum edule*	HICR
Green alder	*Alnus viridis*	GRAL
Herbs		
Meadow horsetail	*Equisetum pratense*	MEHO
Bunchberry	*Cornus canadensis*	BUBE
Yellow bog sedge	*Carex dioica*	CAREX

APPENDIX 3. Selected photographs of habitats, Prophet River area, 1998.

Matmx: mature mixed

ImmAt: immature aspen

OSbBog: Open black spruce bog

MatSw: Mature white spruce