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Avian Response to Stand and Landscape Structure in the Boreal Mixedwood Forest in Alberta

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Avian Response to Stand and Landscape Structure in the Boreal Mixedwood Forest in Alberta

SFM Network Project: The Landscape Structure and Biodiversity Project (LSBP): avian response

by

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ABSTRACT

One goal of the Landscape Structure and Biodiversity Project is to determine whether species' abundance patterns across a landscape are primarily explained by stand-level or landscape-level composition and configuration. In this report I outline results of research on 4 projects conducted by me and my graduate students. First I present data on 14 passerine species collected at 2 sites: a logged area (Owl River), and a burned area (Goodwin Burn). Birds were sampled on large-scale grids and then data analysed to determine whether fine-scale vegetation at the sampling point, or larger scale (100m to 1000m) landscape composition variables best explained their presence or absence at a point. Species varied in terms of which scale best explained their presence at points. Half of the species were more likely to be found in the harvested landscape, but this could be due to the fact that less forest was disturbed in the harvested vs the burned landscape. Harvesting had a negative impact on one species and a positive impact on 4; burning had a negative impact on one species and a positive impact on one species. Scales from 100-500 m were most important in explaining presence/absence of species.

The second project, by PhD student Samantha Song, examined songbird responses to harvesting at a finer scale: at forest/clearcut edges compared to natural edges (aspen vs white-spruce) and aspen forest interior. She found some crowding of birds at clearcut edges immediately post-harvest, but no differences in abundance or species richness 2 years post-harvest. Predation on artificial nests at aspen-clearcut edges was not higher than levels at natural edges or in forest interior. Changes in vegetation in the forest at recently harvested edges had not yet occurred and are not expected to be very different several years post-harvest due to the rapid regeneration of cutblocks, which prevent high levels of sunlight or wind from penetrating the forest edge. Species abundances were related to forest structure, particularly stand age, canopy cover, understory density and amount of conifer, and not by "treatment".

The third study, by MSc student Ben Olsen, studied barred owl (*Strix varia*) habitat associations in the boreal mixedwood at several spatial scales. Using radio telemetry he located nest sites, plotted home ranges and followed pre-dispersal movements of juveniles. Barred owls selected different habitat characteristics at different scales: home ranges contained more old (100+ yr) forest than the overall landscape, but within a home range birds used old forest less than expected for foraging. Owl nesting and roosting cavities were found in old aspen and balsam poplar snags within small stands of old forest. Stands with cavities were older than randomly selected stands on the landscape.

The fourth study studied the habitat relationships of 2 species of woodpeckers, Black-backed (*Picoides arcticus*) and Three-toed (*P. tridactylus*), that we suspected might be burn-dependent. This study, done by MSc student Jeff Hoyt, examined presence/absence of these woodpeckers in conifer stands (jack pine, spruce) that had been recently burned, were mature, or were old. In addition he collected data on nest and foraging sites for woodpecker pairs. He found that neither species was present in mature forest, both were found at highest abundances in recently burned forest (up to 8 years post-fire) and that three toed woodpeckers were also found at moderate abundances in old growth forests. Analyses on nest and foraging sites is ongoing.

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INTRODUCTION

The boreal forest is a mosaic of terrestrial and aquatic habitats created by topographic differences and historical disturbance patterns. The boreal forest is quickly becoming a leading frontier for forest operations in Canada. During the past five years within Alberta, the majority of the boreal forest (>220 000 km2) has been committed to various forest companies. A short harvest rotation period (70-90 yr depending on dominant species) and current two-pass forest harvesting will impose a narrow range of cutblock sizes, shapes and rotations, reducing the spatial and temporal heterogeneity created by natural disturbances. Ecological studies in the Pacific Northwest, in eastern temperate forests of North America and in boreal forests in Fenno-Scandia have raised concerns about the ecological sustainability of traditional forestry operations. Linked to this, future global markets for Canadian forest products may be influenced by the degree to which our forests are managed in a sustainable way. The maintenance of biodiversity and ecological processes must join with fibre production as goals for forest management.

Several forestry companies in Alberta have embraced the concept of ecologically sustainable forestry (or ecosystem management) which emphasises the retention of ecological processes and biodiversity in the forest in combination with fibre removal. One approach to ecologically sustainable forestry is to attempt to emulate the patterns and structure of natural disturbance such as fire (e.g. Hunter 1993). Despite this attempt at coarse filter management for biodiversity, there will be species that are fire dependent or old growth dependent that may "slip through the cracks" and may require some fine-filter management. These species may be useful as indicators of forest ecosystem change under forest management.

Most forest management decisions are made at a small scale and variation in logging techniques is often done at the stand-scale. Few companies are concerned about effects of harvesting at a landscape scale or conversely the influence of the structure and composition of the landscape on processes that may occur on the stand scale. Recent studies indicate that, for some organisms, processes and patterns occurring at the landscape scale may influence their presence, abundance and ecological relationships (e.g. Pearson et al. 1993). Thus, research directed at understanding population dynamics of wildlife in the industrial forest landscape must include studies at both the stand and landscape scales. The goal of the Landscape Structure and Biodiversity Project (LSBP) of NCE/SFM is to help the forestry industry to understand what range of variability is important in maintaining biodiversity at the landscape scale and whether differences between natural disturbance patterns and those created by logging are critical to the maintenance of biodiversity.

In this report I present the results of 4 studies conducted by me and graduate students in my lab as part of the LSBP group. One study (core LSBP bird project) examines the relative contributions of stand level and landscape level structure and composition to the distribution of birds on the landscape in burned and logged landscapes. The second study looks in more detail at songbird responses (settlement patterns, abundance, species richness, productivity) to recent clearcut edges compared with natural edges and forest interiors. This study will help us to explain the patterns found in project 1. The last 2 studies focussed on some species that we felt might be sensitive to landscape change produced by forest management. The Barred Owl *(Strix varia*) apparently requires large continuous blocks of old aspen or mixedwood forest for foraging and old poplar snags for nesting (Mazur et al. 1998). Hence, fragmentation of the forest and short-rotation lengths may remove habitat for this species. Black-backed (*Picoides arcticus*) and Three-toed (*P. tridactylus*) woodpeckers are residents of the boreal forest and inhabit old growth coniferous forests, burns, and other areas of standing dead trees or "snags. The Black-backed woodpecker in particular has been described as a fire dependent species, requiring early post-fire conditions (0-6 yrs), which create snags suitable for nesting and foraging (Hutto 1995). In addition, both the Three-toed and Black-backed woodpecker are known to require large diameter coniferous trees for nesting which are found primarily in structurally diverse old growth forests, and may not be present within mature forests (<100 yrs) (Bull 1983, Stelfox 1995). Little is known about the habitat preferences of these species in the boreal mixedwood forest in Alberta, but information from elsewhere suggests that they might decrease in abundance through habitat loss under the proposed harvesting regimes in Alberta.

METHODS AND DATA ANALYSIS

Study Areas, Sampling and Data Analysis

Core LSBP bird study

We sampled three landscapes of boreal mixedwood forest in northwestern Alberta (between latitude 54^{o}55'N and 55 ^{o}25'N; longitude 111 ^{o} 55'W): one had been logged in the winter of 1993-1994 (Owl River) and one had burned in the summer of 1990 (Goodwin Burn) and one was unburned and unlogged (Reference). Prior to disturbance all landscapes were of similar origin (most stands had burned between 1920 and 1940) and forest composition. At Owl River and Reference we set up a large grid of approximately 7 X 11 km with 58 points regularly placed at 1000m intervals. Lakes and inaccessible wetlands were avoided so that the grid had missing points in places, usually along the edges. At Goodwin, due to poor access, we could not place out such a large grid and instead laid out 29 points a minimum of 1000 m apart along access routes.

Birds were sampled over a 100m radius around grid points using 10 min point counts, 3 times between the last week May and the first week July 1997. Vegetation was sampled within a100m radius of the point count station on 3 20X10m plots: one centrally located and the other 2 between 50 and 100 m radius. We used a relevé technique for shrub and ground cover (abundance classified by cover classes) per species. Trees and snags were tallied by species and dbh class within each plot. Structural characteristics were also measured: % cover and height of ground cover, shrub layer, subcanopy, and canopy.

Forest cover classifications were determined using Alberta Vegetation Inventory data in a GIS format (ArcView). We reclassified forest cover into 10 classes for Owl River and Reference and added 3 burn classes for Goodwin (Table 1). Each grid point was given 4 buffers: radii 100m, 250m, 500m and 1000m. Forest cover for each class was calculated for each buffer area using FRAGSTATS.

For the local detailed vegetation data, we reduced the number of variables by running a PCA analysis and retaining the smallest set of components that accounted for at least 90% of the variation in the data set. Instead of using the components in the analysis, we used 1-3 variables that were most highly correlated to that component. Since the distribution of the birds across the grid was binomial (present or absent at a point) we used stepwise logistic regressions with location (burned or logged landscape) as a categorical value. First we ran a model at each scale (local, 100m, 250m, 500m and 1000m) and noted which model was the best fit (i.e. had the lowest P-value and best predicted the presence and absence of the species). We then ran the model on significant local scale variables and landscape variables at all scales, if they were found to be significant at one scale, to determine a final model. To date, data are only analysed for Owl River and Goodwin sites.

Table 1. Cover types (% of area) used in analysis for influence of landscape composition on forest bird presence/absence

Cover type	**Reference**	**Owl River (logged)**	**Goodwin burn**
Open (cutblock and anthropogenic openings)	2.58	11.02	3.03
Burn	0	0	52.0
Deciduous	41.0	42.6	12
Marsh/nontreed lowland	9.12	8.74	7.03
Mixed deciduous pine	2.85	1.89	0.44
Mixed deciduous spruce	1.26	1.42	1.27
Pine	18.03	7.52	2.13
Black spruce or larch	21.7	20.9	9.8
White spruce	1.88	1.66	0.74
Water	1.54	4.15	11.57

Songbird responses to edge

Data were collected in aspen-dominated boreal mixedwood forest in the Calling Lake region of Alberta. A description of the study area can be found in Schmiegelow et al. (1997) and Song (1998). Full details of methods and analysis are found in Song (1998). Briefly, we enumerated bird species, food supply (insect biomass) and vegetation structure in old (100+yr) and mature (~80yr) aspen forest along recent clearcut edges (1 and 2 years post-harvest), at aspen/white spruce edges and in aspen forest interiors. We also conducted an artificial nest experiment to look at predation rates along these edges. Forest structure and composition were measured.

Habitat selection at different scales by Barred Owls

Data were collected in the Calling Lake study area (as above). A description of the area, methods, and analyses is found in Olsen (1999). Briefly, Olsen conducted playbacks of owl calls to locate owl territories, he captured and radio-tagged the birds and monitored their movements. This enabled him to find nest/roost sites, to plot home ranges and to locate foraging areas. Vegetation structure and composition were measured at all nest/roost sites. All locations were entered into a GIS platform and digital vegetation inventory was used to characterize stand/landscape characteristics of owl habitat vs the entire study area to determine owl habitat selection.

Habitat selection by woodpeckers

During April 1997 and 1998 habitat association surveys were conducted in 20-25 sites in burned, old growth and mature; white spruce, black spruce and jack pine habitats in the Mariana Lake region of Alberta. Surveys were conducted between 8- 23 April by playing taped recordings of woodpecker calling and drumming. In April 1998, surveys were conducted in 2 replicates of different aged burns (3-4yr, 8 yr and 16-17 yr post fire) to determine at what age post-burn forests become unsuitable habitat for Black-backed and Three-toed woodpeckers. Within each burn 20-25 sampling sites were surveyed using call playbacks between 3-24 April. Woodpecker numbers in forests of different age were compared using G-tests.

Vegetation data were collected at each site surveyed during 1997 and 1998 habitat association surveys and 1998 post-burn suitability surveys. We then compared woodpecker presence/absence data with vegetation data at each site surveyed to determine which vegetation variables are the best predictors of woodpecker presence/absence. Nests were located during other sampling.

During May of 1998, foraging observations were conducted on Black-backed woodpeckers foraging in a 3 year-post-burn forest. Males and females were observed foraging on a total of 17 different territories. Foraging observations were made every 30 seconds. The observational period ended when the bird could no longer be found or a total of 20-25 trees used for foraging were located. For each tree used for foraging 2 random trees were selected. Therefore, a total of 20-25 trees for each male and female and 40-50 random trees for each male and female were collected at each territory. The DBH, species, burn class and whether the tree was standing or down, was recorded for each tree.

Insect sampling was conducted within one burn of the 3 age classes. A total of 32 trees (16 black spruce trees and 16 jack pine trees) were sampled within each of the 3 burns. Trees sampled ranged in dbh from 110mm to 200mm. From each tree, sections measuring 30cm in length were cut from the base, middle and upper portion of the tree. A total of 288, 30cm sections were collected. Ten, 1 inch thick slices were cut from each log section all of the insect galleries were probed with tweezers for adults and larvae. As well the bark was removed from each slice to look for bark beetles. The number of galleries per slice was recorded and an average number for each log section was calculated.

RESULTS

Core LSBP Bird Study

The scale at which the models best explained the presence/absence of a species varied with species (Table 2). Connecticut Warbler and Western Wood Pewee, for example, had best fit models at the scale of 100m, whereas the distribution of Yellow-bellied Sapsucker and White-throated Sparrows was best explained using forest cover data at the 1000m scale. Half of the species were more likely to be found in the logged landscape as opposed to the burned landscape (Table 2) but this may be due to the overall amount of forest cover being higher in the logged landscape and not an effect of disturbance type *per se*. The presence of clearcuts negatively affected the presence of Hermit Thrushes and positively influenced the presence of Connecticut Warbler, Lincoln's Sparrow, Mourning Warbler and Rose-breasted Grosbeak. Fire negatively influenced Yellow-bellied Sapsucker but positively influenced Western Wood Pewee. White-throated Sparrow and Least Flycatcher appeared to be positively affected by either burn or logging (total open space). Interestingly, a combined "openess" variable (burn and open combined) did not enter final models for the majority of species, whereas burn and open separately did, suggesting that birds perceive cutblocks and burns differently. At the local scale, Ovenbirds were more prevalent at points with closed canopy cover (they are not found in cutblocks, Hannon unpub data) and Wood Pewees were negatively associated with canopy cover (they are common in areas of dead, burned standing trees, Hannon unpub data) (Table 2). Most variables entering at scales 250m and above were related to forest composition (i.e. whether it was deciduous, mixedwood or pine) suggesting that species may use landscape level species composition as a cue for settling in an area. Finally, water did not enter any of the final models, suggesting that water bodies (even though prevalent in the area) are not acting as barriers for movement into areas. No species had best fit models using only the local vegetation variables. Models will be rerun using General Linear models with Poisson errors for those species that were more abundant. This will allow more precise estimates of habitat associations than those just involving presence/absence at a point.

Table 2. Results of stepwise logistic regressions that entered local vegetation variables and landscape forest cover variables for 5 species of birds in boreal forest of Alberta. +,- indicate a positive or negative relationship, numbers in brackets indicate scale that variable entered and L=logged, B=burned

Species	Local variables	Scale of best model	Full model	Landscape effect?*
Chipping Sparrow	black spruce +	100m 250m	grid (L) Black spruce (100) + Decid (100) - water (500) + 80/58**	100m (L)
Connecticut Warbler	herb cover + leaf litter cover-	100m	leaf litter - herb cover + cut (100) + dec (250) + 89/61	100m (L) 1000m (L)
Hermit Thrush	Corylus cornutata cover-	500m	Corylus cover - cut (100) - Black spruce (500) + 83/52	
Least Flycatcher	none	1000m	marsh (250) + total open (250) + marsh (1000) + 90/41	
Lincoln Sparrow	aspen - Alnus cover -	500m	aspen - dec (100) - dec/spruce (100) + cut (100)+ water (250) + dec/pine (500) - black spruce (1000) + 93/67	500 (L)
Mourning warbler	none	100-500m	water (100) + white spruce (100) + open (250) + 94/35	
Ovenbird	Arctostaphylus cover - canopy cov + dbh1 - herb cov + shrub cov -	250m	Arctostaphylus cover - dbh1 - Dec (250) + (97/96)	100m (L)
Rose-breasted grosbeak	herb cover + total snags -	500-1000m	total snags - Open (500) + Dec (1000) + Marsh (1000) + (96/59)	100m (L) 250m
Red-eyed Vireo	Arctostaphylus cover - dbh 1 - white spruce + balsam poplar + aspen +	250m	dbh1 - aspen + Dec (250) + 82/86	
Tennessee Warbler	none	no models at any scale???	--	

Table 2. Continued.

White-throated Sparrow	black spruce - Corylus cover - jack pine -	1000m	total open (250) + 0/100	500m (L) 1000m (L)
Western wood peewee	canopy cov -	100m	burn (100) + pine (100)+ marsh (100)+ (95/55)	
Yellow bellied sapsucker	total Larch trees +	1000m	total Larch trees + burn (100m)- mix dec/spruce (100) + (98/20)	500m (L)
Yellow-rumped warbler	herb cover -	1000m	herb cov - mix dec/pine (250)+ pine (500) + water (500) + (77/67)	

* L=higher in logged, B=higher in burned.
** numbers in brackets indicate % correctly predicted by the model for absence and presence respectively.

Songbird Responses to Edge

Details of statistical analyses and results are given in Song (1998). Briefly the results are as follows. We documented an increase in abundance of birds at forest/clearcut edges one year post-harvest, likely due to crowding in of birds displaced by harvesting. This effect disappeared by 2-yr post-harvest. There was no difference in bird density, species composition or richness between forest/clearcut edges and forest/white spruce edges and forest interior and although there were some differences in insect abundance with edge type, bird density did not vary with insect biomass. We found no evidence for species being attracted to or avoiding edges, but the clearcut edge was a clear habitat boundary for some species, whereas the white spruce edge was not. Predation of artificial nests also did not vary with edge type. Vegetation structure measured at the stand level, particularly stand age, canopy cover, understorey density and amount of conifer, was more important for predicting density and composition of songbird communities in aspen stands than edge type.

Habitat Selection at Different Scales by Barred Owls

Details of statistical analyses and results are given in Olsen (1999). Briefly he found, based on telemetry locations during the breeding season for 9 owls, that the habitat composition of barred owl home ranges was quite variable but when compared to the landscape at large, contained a higher proportion of old forest (mixedwood, deciduous and coniferous). Within the home range, foraging locations were also highly variable between owls, but occurred in mature forest more than expected based on availability and less in old mixedwood than expected. Cavity trees used by owls were compared to randomly selected trees on the territory. Cavity trees were primarily in old aspen or balsam poplar of 33.5-77 cm dbh, and were larger than random trees. Cavities were found in patches of old trees (25.6 old snags/ha in nest patches compared with 9.6/ha for random points). Snag (>34cm dbh) availability was greatest around the nest, less on the home range, and even less in the landscape as a whole.

Habitat Selection by Woodpeckers

Three-toed woodpeckers were not detected in any of the mature forest habitats and they occupied burned and old growth habitats in similar abundance (G= 4.45, p=0.516) (Fig. 1). Black-backed woodpeckers were only detected in burned forest types and their numbers did not differ significantly between these burned habitats (G= $8.29x10^{-2}$, p=0.961) (Fig. 1). Black-backed woodpeckers were not detected in old growth coniferous forest in the Mariana Lake region, but they were detected in old growth coniferous forests surveyed at a distance of 250 km from any burns greater than 200 ha.

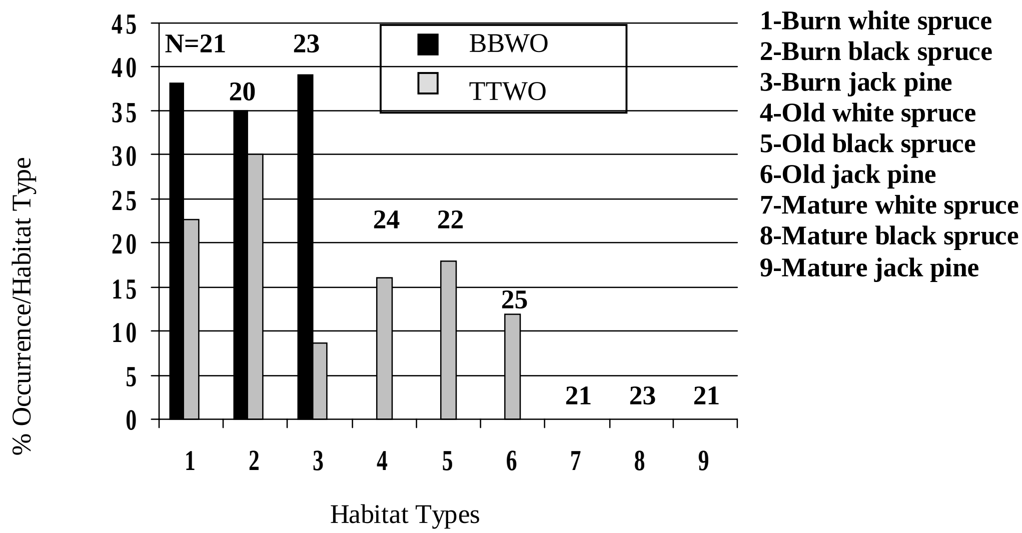

Figure 1. % Occurrence of Black-backed and Three-toed Woodpeckers/Habitat Type in 1997 and 1998.

Black-backed woodpeckers were present in similar numbers in both the 3 and 8yr post-fire categories (G=7.06, p=0.572). However, there was a significant decrease in Black-backed woodpecker numbers between 8 and 16 years post-fire (G=35.1, p=$2.3x10^{-6}$). Three-toed woodpecker numbers decreased significantly between 3 and 8 years post-fire (G=4.57, p=$3.89x10^{-2}$) (Fig. 2). Information from elsewhere suggests that there is a foraging niche partitioning between these two species. Three-toed woodpeckers feed primarily on Scolytid larvae (bark beetles), which are present for only a short period post-fire. Black-backed woodpeckers feed primarily on Cerambycid larvae (wood-boring beetles) which remain in the standing dead trees for a longer period post-burn. The Three-toed woodpeckers are unable to feed on the wood-boring larvae due to the shorter length of their bill and are restricted to insects under the bark (Murphy and Lehnhausen 1998). We are currently analysing data on insects collected from trees in the burns of different age. This information will allow us to compare the relative abundance of insects in the three different height locations of the tree (bottom, middle, top). These data will be used to explain woodpecker foraging height. The information obtained for each of the different aged burns will allow us to interpret and quantify the woodpecker numbers observed in burns of different ages.

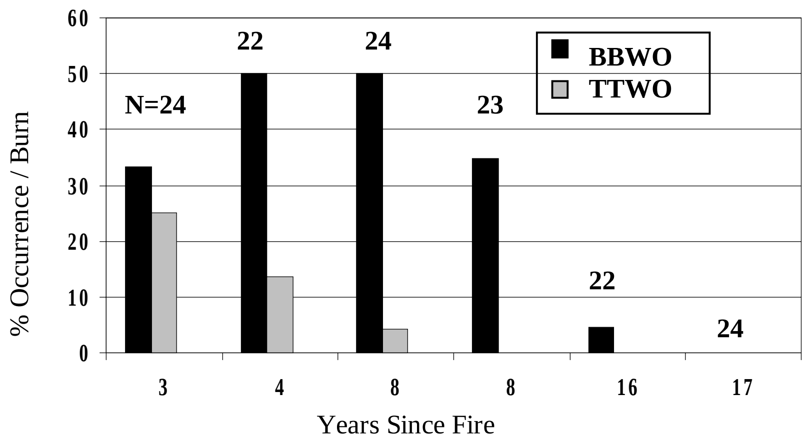

Figure 2. % Occurrence of Black-backed and Three-toed Woodpeckers in Post-Burn Forests.

Woodpecker presence/absence from sampling points will also be analysed in more detail using the vegetation data sampled at each point. This will allow more precise prediction of the habitat types preferred by these woodpecker species. Also, these data will hopefully provide threshold values that forest managers can use when assessing the suitability of different forest types to Black-backed and Three-toed woodpeckers. For example, in non-burned forests, a minimum number of recently standing dead trees/ha for Three-toed woodpeckers could be obtained. Furthermore, data from different aged burns will provide information about whether the vegetation variables that best predict woodpecker presence/absence change between different burn ages. This information will indicate whether the birds are using different parts of the burns at different times post-burn.

During 1997 and 1998, a total of 25 Black-backed woodpecker nests were located in the 3 and 8 year post-burn forest. The mean diameter at breast height (DBH) was 230 mm (min= 155 mm; max=387mm). Black-backed woodpeckers were using a number of different species for nesting, including, white spruce, black spruce, aspen, jack pine and poplar. Jack pine was used slightly more often than its availability, although not significantly more. Trees that were 100% burned with 80-100 % bark retention were used significantly more than other burn classes, although this may be a product of the availability of this burn class. Analyses have not yet been conducted to determine if the woodpeckers are selecting significantly larger trees or trees of a certain species or burn class, than would be expected by random.

Jack pine, black spruce and white spruce represented over 85% of the total tree species that were used and available for foraging. Burned trees represented over 95% of used and available trees. Foraging data are currently being analysed.

MANAGEMENT APPLICATIONS

Landscape Effects on Songbirds

Although results are preliminary, clearly landscape variables are important in predicting the presence and absence of the species analysed to date. Disturbance type influenced distribution of most species: some were more prevalent in logged and others in burned landscapes, although this may be due to difference in the amount of total mature forest cover between the two sites (there was more burned than logged). Anthropogenic openings at the larger scales did not appear to be negative for any species, perhaps not surprising given the low percentage of the landscape cleared to date (Table 1). So far, the results suggest that forest managers can use AVI data at the landscape scale to make predictions about species presence/absence, however more precise predictions of species' abundances may require more detailed vegetation data at the stand level- analyses are ongoing on this aspect. We also need to sample more landscapes that have a higher percentage harvested to evaluate the influence of harvesting at the landscape scale. I am currently (summer 1999) sampling an agricultural landscape that has only 23% forest cover in an attempt to identify species sensitive to landscape-level forest loss.

Songbird Responses to Habitat Edges

1. Creation of edge through clearcutting of aspen did not have an immediate (up to 2 yr post-harvest) negative effect on songbird abundance or species composition at the levels of harvest after the first pass. Hence, creation of edge does not appear to increase habitat loss beyond direct loss through harvesting, however, older edges (>15yr) should be sampled.
2. Emphasis should be placed on evaluation of effects of habitat loss on old growth species, especially after the second pass of harvesting.
3. Rare species are often not adequately sampled at the spatial scales used on our work. More attention should be paid to evaluating habitat loss on rare species. We are currently doing an analysis of rare species across the boreal mizedwood.
4. The natural range of vertical and horizontal stand vegetation structure and composition should be maintained over the landscape in order to retain all members of the bird community. Conifer in the mixed wood appears to be very important for some bird species and hence the mixedwood should not be "unmixed" through silvicultural methods. In addition, the structural variability of old aspen/mixedwood stands should be maintained through longer rotation lengths or protected areas.

Barred Owls:

1. Large old aspen or poplar trees (min 33.5 cm dbh up to 77 cm dbh) and snags should be left in groups in clearcuts. Since these could be susceptible to blowdown, groups of younger aspen trees should be also left to "recruit" as old trees and snags as the cutblock regenerates.
2. Some stands should be allowed to grow past rotation age to at least 100 yr in order to develop old growth characteristics.

Research is needed on the threshold amount of old growth required on a landscape to keep barred owls in an area. More information is needed on snag formation, and on how large patches for nest building should be.

Woodpeckers:

1. Rotation aged stands of conifer are not suitable habitat for either woodpecker species. Hence some portions of the landscape must be allowed to grow beyond rotation age to attain old growth characteristics and some areas must be allowed to burn. Significant portions of the landscape should be in the post-burn age classes 1-8 yr.

Research is required on reproductive output of birds in burns and old growth. Burns may be important source habitats for these species. More information is needed on how large fires need to be to attract woodpeckers, what the optimal spatial and temporal distribution of fires should be across the landscape, and how far woodpeckers can disperse to find new burn habitat. More information is needed on how salvage logging of burns may affect woodpecker habitat. More information is needed about the size requirements and the spatial distribution of old growth stands on the landscape.

CONCLUSIONS

Although conclusions are tentative at this point, pending further data analysis, there are some consistent conclusions that appear to be emerging from the research. First, at the stand, forest and landscape level, old growth forest must be maintained on the landscape to provide nesting and foraging habitat with sufficient structural and compositional heterogeneity to maintain boreal songbirds on the landscape. In addition, some areas of burned forest are required for burn-dependent species, such as the Black-backed Woodpecker. For up to 10 years post-disturbance, burned and logged forests differ significantly in vegetation structure and compositon and in bird community composition (Hobson and Schieck in press). Both our NCE research and other research that we have done in the boreal mixedwood has indicated that negative edge effects are not occurring in the logged landscapes, at least not up to 5yr post-harvest (Song 1998, Song and Hannon in press, Cotterill and Hannon 1999 unpubl. report, Song and Hannon 1999 unpubl. report , Hannon and Villard 1999 unpubl. report). Hence, creation of edges by logging will not increase loss of usable habitat beyond that of the area logged. Finally, understanding of species' responses to habitat change must be undertaken at both the stand and the landscape levels.

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