

NEOTROPICAL MIGRANT PASSERINE ABUNDANCE
AND DISTRIBUTION IN BOREAL FOREST

S. Rangen
Dept. of Biology
University of Saskatchewan
Saskatoon, SK
S7N 0W0

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Abstract

Variation in vegetative structure and composition, and predator communities, of 25 and 76-100 year old mixedwood boreal forest were used to evaluate factors affecting abundance, distribution, community structure, and productivity of songbirds. Point counts and spot-mapping were used to determine relative abundance and bird densities, respectively. Behavioral censuses were conducted to document reproductive behavior. White-throated sparrows and yellow-rumped warblers had a high abundance in old growth forest. Differences in bird species composition and abundance were not as marked as expected in the age classes of forest examined. One species was unique to young forest while two species were found only in old forest. Wicker nests containing plasticine and quail eggs were distributed to evaluate predation on ground and off-ground nests. Survival times for artificial ground nests were 1.3-fold higher than off-ground nests, though concealment was a confounding factor. Successful ground nests had a high amount of grass cover; unsuccessful off-ground nests had poor concealment. Mice, birds, and red squirrels accounted for most of the predation events. Alterations in predator abundance or searching strategies may be responsible for greater mortality of off-ground nests.

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Introduction

The North American Breeding Bird Survey (Robbins *et al.* 1989) indicates absolute declines over the past 10 years for several neotropical migrant birds (see also Askins *et al.* 1990). However, passerine population patterns of abundance and density and basic life history traits have not been well documented in boreal forest communities (Welsh 1987, Westworth and Telfer 1993). Young and old age class forests are important habitats in which to assess these patterns because of the forest industry's impetus to decrease rotation age and, subsequently, the creation of a younger and less complex forest mosaic that may reduce the number of species and productivity of birds that rely on climax forests (Welsh 1987, Farr 1992).

Several factors affect the breeding success of songbirds including habitat characteristics, predation, food, competition, and weather. Vegetation patterns are one primary component that influence microhabitat selection of nesting and foraging sites and, subsequently, survivorship and breeding productivity. Predation may further influence the quality and abundance of available resources in habitats. An understanding of predator-prey dynamics and physical attributes of boreal forest is necessary to manage stand structure and timber harvesting for the conservation of songbirds.

Assumptions inherent in wildlife management techniques are that density or abundance of a species is a good indicator of the suitability of a given habitat for that species and that density is positively correlated with survival and reproduction of individuals (Van Horne 1983, 1986). However, areas of high abundance may not necessarily be highly suitable habitat; in fact, they may represent population "sinks" rather than "sources" (Pulliam 1988).

Productivity of birds in different habitats or microsites within a single habitat may be affected by predation. Partitioning of nest sites by height may allow co-existence of species while minimizing cumulative density effects. Martin (1988a) found that predation rates were higher when simulated nests of a single species at one height were used rather than nests of multiple species distributed over 3 heights. A heterogeneous distribution of nests may provide a more realistic orientation of nests in space but also simulate a wider range of co-existing species. Other parameters being equal (e.g., concealment) this type of distribution should further increase the searching effort of predators.

This study investigated 1) whether abundance/density was a reliable predictor of habitat that was associated with a high reproductive success in young and old mixedwood forest and 2) whether predators responded differently to varying spatial distributions of artificial songbird nests in young mixedwood forest. Identification of habitat characteristics chosen by birds to enhance reproductive success will facilitate the development of more reliable sustainable land use practices and so facilitate ecosystem management for the FMF. Evaluating clutch survival in relation to variation in nest density and spacing patterns enables me to test whether predation drives avian community composition, independently of vegetation characteristics.

Methodology

Mixedwood (Populus tremuloides and P. balsamifera dominated) forest stands of two age classes were selected to encompass a 9 ha spot-mapping grid with a minimum 20 m buffer zone of the same vegetation type and 4 point count stations (described below). Six young (25 year old) stands were situated in compartment 8 of Marlboro working circle, which consisted of naturally regenerating or planted conifers. Six old stands (76-100 years old) were located in compartments 13 of Marlboro and McLeod working circles. In both habitat types, deciduous trees comprised 60-80% of the tree volume.

Relative bird abundance was sampled using the variable-radius point count method (Reynolds *et al.* 1980) and recording birds within or beyond a 50 m radius. Each of 6 sites containing 4 stations were visited twice in June. Each of the four stations were visited at either 05:00, 05:30, 08:00, or 08:30 hours. Ten minutes was spent at each count station with stations separated by at least 250 m (between plot centers). Both auditory and visual observations were recorded. Bird encounters that are clearly beyond the edge of the study site were excluded from final abundance estimates. Individuals heard from more than one point were included in the point to which they were the closest. The maximum number of individuals per species of the two visits was analyzed. Analysis of the maximum value had greater biological meaning than the average of the two visits assuming new birds arrived or others were missed. Differences in bird species abundance between habitats were tested by a Mann-Whitney U-test (SAS 1989).

To address the relationship between species abundance and productivity, 6 young and old mixedwood sites were sampled. Grids 300 m x 300 m (subdivided into 25 m x 25 m quadrats) were established. Twelve visits were conducted between 1 June and 31 July, during territory establishment, nest building, incubation, brooding, and fledging periods. Territories were spot mapped (International Bird Census Committee 1970) on grids for each site 7-8 times in June to obtain absolute densities. Within each of 7-8 visits, the 12 grids were randomly assigned to 1 of 4 observers to control observer bias. With 4 observers, all 12 grids were visited once over a 3-day period to complete a rotation of a single visit. Two young and 2 old habitat types were visited daily between 05:00 and 09:00 hours. Territories were delineated by one observer using transparent acetates to reduce analyst bias. Nest locations found during spot-mapping and behavioral censuses were mapped. Daily survival probability (Mayfield 1975) of nests in each habitat type was tested using a Mann-Whitney U-test. Canopy closure was measured at 10-20 randomly selected grid intersection points 3-4 times from May-Sept. using a spherical densiometer.

To augment density estimates provided by spot mapping, and to ameliorate the disruptive nature of nest monitoring, a reproductive index was employed. During regular transect walks through the 12 grids from 09:00 to 13:00 hours, reproductive behavior was monitored. For each visit bird species, sex, distance from the ground, type of vocalization (song, call, non-vocal), age (adult or fledgling), activity, nest location, grid cell location, perch substrate, and height of perch substrate were recorded. When a bird was encountered, its activity at the initial

point of contact was recorded following an instantaneous sampling regime. Activities were comprised of 3 major categories: reproductive, resting, and foraging. Reproductive behavior included presence of apparently mated pairs, transportation of nest material, food, or fecal sacs, bird calls indicative of nesting or brood rearing (Dale 1993), distraction displays, and observations of nests, nestlings, and fledglings (Martin and Geupel 1993). Utility of a reproductive index is based on the ability of recorded behaviors to represent different stages of the breeding cycle; thus, attempts were made to verify the index by nest searches.

Effects of vertical distribution on artificial nest depredation was examined using 11 plots (100 m x 100 m) located in regenerating mixedwood cutblocks (25 years old). These sites were comparable in age and tree composition to spot-mapped plots. All sites were located in Marlboro 8. Plot sizes (1 ha) were comparable to nest predation studies that used transects 500 m long with nests distributed up to 10 m on either side of the line. Plots were placed at least 800 m from neighboring nest predation and spot-mapped sites. Six and 5 sites were randomly assigned to plots with heterogeneously or homogeneously distributed nests, respectively, in terms of artificial nest placement. The homogeneous treatment had nests placed on the ground only, while the heterogeneous treatment had nests placed at various height classes ranging from the ground to 5 m above ground. Twenty-five wicker nests were distributed at random on a horizontal and vertical axis within each height class.

Nests containing 1 Japanese quail (*Coturnix japonica*) and 1 painted plasticine egg, were set out during the incubation period of nesting songbirds. Nests were checked every 3-4 days over a 12-day period. A predation event was noted if at least one egg was marked, penetrated, or missing. Presence of real eggs provided predators with a form of positive reinforcement while artificial eggs provided a means of identifying predators from tooth and beak marks. Rubber gloves and boots were worn to avoid tainting nests and eggs with human scent.

At artificial nest sites, a modified point-quarter sampling (Krebs 1989) was employed to obtain tree and shrub measurements. The nest tree or ground nest served as the center point. In each quarter, the distance to the nearest tree from center was measured. Species and height were recorded for each tree. Species and height of the nest tree were also recorded. Measured trees were >3 m tall and were ≤ 25 m from point center. This procedure was also used for green alder (*Alnus crispa*) and willow (*Salix* spp.) that were ≥ 1 m tall. Tree density was calculated according to Krebs (1989). Deciduous and coniferous saplings and seedlings were counted in a 3 m radius around the nest. Percent cover of herbs, lichen, moss, water, bare ground and rock, woody debris, shrubs (<1 m), and grass/sedge were estimated in a 2 m radius surrounding the nest. Horizontal and vertical concealment of the nest were visually estimated 1 m from the nest in 4 cardinal directions and above and below the nest. These estimates were averaged to obtain a single value of percentage of the nest obscured by foliage.

Kaplan-Meier survival curves were constructed for homogeneously and heterogeneously distributed nests over the 12-day exposure period. Curves were compared using a Breslow statistic (SPSS 1993). Vegetative variables at failed versus surviving nests and at nests

depredated by different predators were compared by Mann-Whitney U and Kruskal-Wallis tests, respectively.

Results

Data analyses are ongoing. Sample sizes and sampling effort are summarized. Preliminary analyses of bird abundance, daily survival of real nests, and artificial nest predation data are given.

Spot-mapping and Behavioral Censuses

Spot-mapping visits (7-8) from 1 June to 7 July comprised 28 hours per grid, with a total of 168 hours for each young and old mixedwood forest. Behavioral censuses during 8 visits from 1 June to 28 July yielded sampling times of 180 hours for old mixedwood forest and 192 hours for young mixedwood forest. Time allotted to young stands was lower than old stands because one grid was abandoned after five visits due to the repeated presence of a black bear (Ursus americanus).

Survival of Natural Nests

Nests of all species (including ground and lower canopy nesters) were pooled within each age class of habitat. Daily survival probability for natural nests in young stands was 0.81 ± 0.07 (± 1 SE) ($n = 18$) and 0.69 ± 0.11 ($n = 16$) for old stands ($Z = 0.7632$; $P = 0.7632$).

Bird Species Richness and Abundance

Bird species richness was 29 and 30 in young and old mixedwood forest, respectively. Several species were present at only one point count station (i.e., Connecticut warbler (Oporornis agilis), common yellowthroat (Geothlypis trichas), red-eyed vireo (Vireo olivaceus) whereas white-throated sparrows (Zonotrichia leucophrys) were present at 83% of stations (Table 1). There was significantly higher relative abundance of white-throated sparrows and yellow-rumped warblers (Dendroica coronata) in old than young mixedwood forest. If birds species detected at fewer than three point count stations were deleted, a total of 19 and 15 species were detected in young and old sites, respectively. Species that were consistently present primarily in young sites included Lincoln sparrows (Melospiza lincolni), hermit thrushes (Hylocichla guttata), Tennessee warblers (Vermivora peregrina), and ruffed grouse (Bonasa umbellus). American redstarts (Setophaga ruticilla) and red-breasted nuthatches (Sitta canadensis) were unique to old mixedwood forest while alder flycatchers (Empidonax alnorum) were only detected in young forest. Common ravens (Corvus corax) and American crows (Corvus branchyrhynchos) that were only detected flying over sites and were unknown to reside on sites were not included in the predator group. Red squirrels (Tamiasciurus hudsonicus) detected during point counts were included in Table 1 due to their importance as predators (Seitz and Zegers 1993). Relative abundance of gray jays (Perisoreus canadensis) and red squirrels did not differ between young and old forest.

Table 1. Abundance of each bird species (mean±SE) individuals detected during point counts in young and old mixedwood boreal forest near Hinton, Alberta (June 1995). Results of a Mann-Whitney U-test for significant differences are shown by the P value.

Species	Seral Stage				P
	Young	n	Old	n	
<u>Migrants</u>					
Corvids					
American Crow	0		5	1	
Flycatchers					
Alder Flycatcher	1±0	3	0		
Least Flycatcher	1.6±0.40	5	2.17±0.48	6	
Grosbeaks, Sparrows and Finches					
Rose-breasted Grosbeak	2.0	2	1.67±.33	3	1
Dark-eyed Junco	1.75±.18	12	1.54±.022	13	0.33
Chipping Sparrow	2±.35	11	2.16±.34	12	0.67
Lincoln's Sparrow	1.78±.28	9	1	1	0.45
Song Sparrow	2	1	0		
White-throated Sparrow	1.71±.23	21	2.58±.21	19	0.001*
Pine Siskin	3.6±2.11	5	2.14±0.7	7	0.73
Purple Finch	0		1	1	
Kinglets					
Ruby-crowned Kinglet	1	1	1	1	
Phalaropes					
Common Snipe	1	2	0		
Thrushes					
Hermit Thrush	1.92±.26	12	2±0.58	4	0.94
Swainson's Thrush	1.98±.26	9	1.36±0.17	14	0.08
Varied Thrush	0		3	1	
American Robin	2.29±0.24	7	1.83±0.23	5	0.67
Vireos					
Warbling Vireo	1.69±0.24	13	1.83±0.23	18	0.79
Red-eyed Vireo	0		1	1	
Solitary Vireo	2	1	0		

* indicates significant differences

Table 1 (continued). Abundance of each bird species (mean±SE) individuals detected during point counts in young and old mixedwood boreal forest near Hinton, Alberta (June 1995). Results of a Mann-Whitney U-test for significant differences are shown by the P value.

Species	Serai Stage				P
	Young	n	Old	n	
<u>Migrants</u>					
Warblers					
Yellow-rumped Warbler	1.69±0.17	13	2.76±0.28	21	0.007*
Connecticut Warbler	0		1	1	
Common Yellowthroat	1	1	0		
Mourning Warbler	1	1	3	3	
Ovenbird	1.25±0.25	4	1.86±0.23	14	0.18
American Redstart	0		1.5±0.5	2	
Orange-crowned Warbler	1.64±0.31	11	1±0	6	0.12
Tennessee Warbler	1.54±0.16	11	4	1	0.11
Waxwings					
Cedar Waxwing	1.5	2	2	2	1
Woodpeckers					
Yellow-bellied Sapsucker	2	1	0		
<u>Residents</u>					
Corvids					
Common Raven	1	2	1	1	1
Grouse					
Ruffed Grouse	1.17±0.17	6	0		
Nuthatches					
Red-breasted Nuthatch	0		1±0	6	
Woodpeckers					
Hairy Woodpecker	0		1	1	
Northern Flicker	1	1	0		
Unknown Woodpecker	1.33±	3	2	2	0.75
<u>Predators and Nest Parasitism</u>					
Brown-headed Cowbird	0		2	1	
Gray Jay	1.5±0.19	8	1.57±0.3	7	1
Red Squirrel	1.0±0	7	1.6±0.4	5	0.1

* indicates significant differences

Survival of Artificial Nest Contents

Of 276 artificial nests, 9 nests were removed from the analysis because eggs were incorrectly classified as depredated during the experiment or not removed after the 12-day exposure period. Of the remaining nests, 50.6% were depredated. Nests distributed at ground level suffered 33.3% failure, while nests distributed throughout the canopy to 5 m experienced 71.7% depredation. Survival time for ground nests was greater than off-ground nests ($X^2 = 28.9$, $P \leq 0.0001$) (Fig. 1). Respective mean (± 1 SE) survival times for homogeneously and heterogeneously distributed nests were 11.1 days (± 0.26) and 8.59 days (± 0.30).

Vegetative Characteristics of Artificial Nest Sites

For nests located on the ground, unsuccessful nests were associated with a greater tree height in the vicinity of the nest than successful nests (Table 2). Grass cover at nest sites was 1.6-fold higher for nest contents that survived than those that were depredated. A reverse trend was evident for shrub (<1m) cover with failed nests experiencing a higher cover value. Successful nests distributed from 0-5 m had a greater tree height in the area surrounding the nest, a pattern similar to that of homogeneously distributed nests. Depredated nests were situated in trees that were taller than successful nests. Nests that failed had a high amount of bare ground and rock composing ground cover. These nests were also poorly concealed compared to successful nests.

Density of shrubs at nests depredated by mice was significantly greater than those depredated by squirrels and birds (Table 3). Height of the tree at which a nest was located was significantly shorter for mice than other predators. Predators destroyed nests at different height class intervals. Mice visited nests that were a minimum of 5-times lower in height than other predator groups. Percent nest concealment was significantly lower for birds compared to mice. Amount of bare ground and rock differed between nests depredated by mice and birds. Amount of water near the nest was 2.5-times lower for birds than mammals.

Predators of Artificial Nest Contents

Of the 135 nests depredated, 65.9% of the predation events were attributed to a specific predator. Mice were responsible for the largest proportion of failed nests (62.4%) followed by birds (24.7%) and squirrels (12.9%). The group of predators termed mice might have included predation events by deer mice (Peromyscus maniculatus), boreal red-backed vole (Clethrionomys gapperi), and shrews (Sorex spp.).

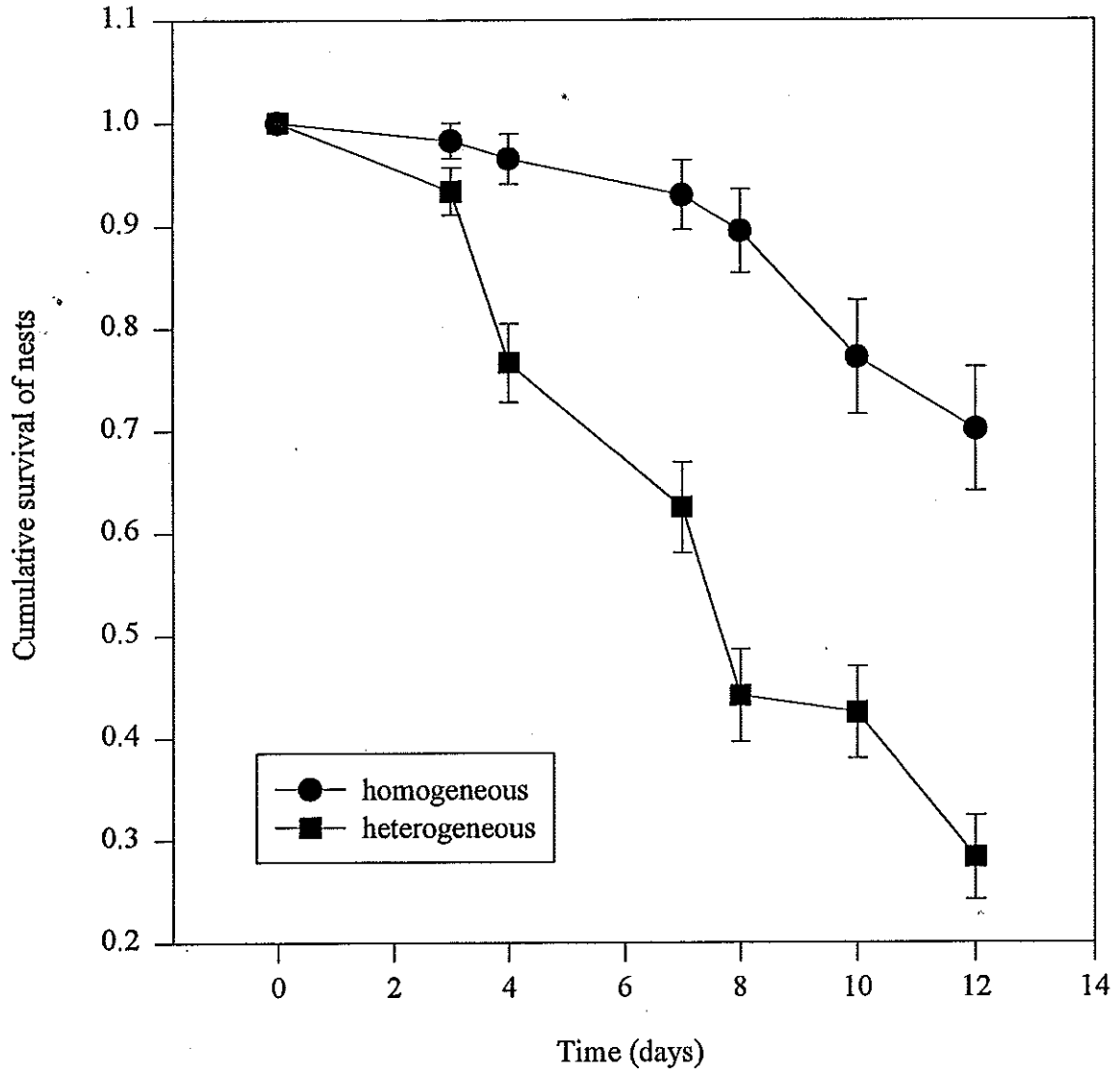


Figure 1. Survival of homogeneously and heterogeneously spaced nests in young mixedwood boreal forest near Hinton, Alberta (June 1995).

Table 2. Vegetative parameters and nest concealment (mean \pm 1 SE) for successful and unsuccessful nests distributed homogeneously and heterogeneously in young mixedwood boreal forest near Hinton, Alberta (June 1995). Results of a Mann-Whitney U-test for significant differences are shown by the P value.

Vegetative Parameters	Homogeneous			Heterogeneous		
	Successful n=98	Unsuccessful n=49	P	Successful n=34	Unsuccessful n=86	P
Canopy Closure (%)	33.71 \pm 2.54	31.76 \pm 3.52	0.6014	41.32 \pm 4.84	42.95 \pm 3.17	0.8339
Trees and Shrubs						
<u>Density (ha)</u>						
trees	244.50 \pm 15.97	260.66 \pm 17.26	0.1435	293.57 \pm 25.40	245.06 \pm 15.10	0.0940
shrubs	5347.14 \pm 106.90	5529.24 \pm 156.76	0.3531	1911.43 \pm 127.0	1731.74 \pm 96.74	0.2032
<u>Height (m)</u>						
nest tree				3.05 \pm 0.51	6.71 \pm 0.39	0.0001*
trees	6.32 \pm 0.22	6.71 \pm 0.22	0.0227*	5.81 \pm 0.25	6.48 \pm 0.17	0.0353*
shrubs	2.36 \pm 0.08	2.41 \pm 0.13	0.8084	2.19 \pm 0.09	2.15 \pm 0.06	0.4809
<u>saplings (no.)</u>						
deciduous	5.55 \pm 0.68	4.29 \pm 0.67	0.4013	2.26 \pm 0.48	4.61 \pm 0.83	
coniferous	6.78 \pm 0.79	6.82 \pm 1.04	0.9514	3.88 \pm 1.07	3.87 \pm 0.41	0.4164
Ground Cover (%)						
grass	9.22 \pm 0.97	5.81 \pm 0.93	0.0442*	5.49 \pm 0.95	6.54 \pm 0.64	0.3967
herb	65.31 \pm 1.83	63.41 \pm 2.94	0.8100	52.19 \pm 3.32	58.94 \pm 1.96	0.0580
litter	0.63 \pm 0.08	0.68 \pm 0.13	0.8514	0.46 \pm 0.12	0.59 \pm 0.09	0.3360
shrubs (<1 m)	1.87 \pm 0.29	2.37 \pm 0.34	0.0289*	2.24 \pm 0.46	2.44 \pm 0.30	0.7633
moss	25.13 \pm 0.95	22.21 \pm 1.03	0.0631	25.51 \pm 0.99	24.84 \pm 0.99	0.5321
lichen	29.00 \pm 1.54	32.18 \pm 1.87	0.0809	32.99 \pm 1.93	29.18 \pm 1.34	0.1917

* indicates significant differences

Table 2 (continued). Vegetative parameters and nest concealment (mean \pm 1 SE) for successful and unsuccessful nests distributed homogeneously and heterogeneously in young mixedwood boreal forest near Hinton, Alberta (June 1995). Results of a Mann-Whitney U-test for significant differences are shown by the P value.

Vegetative Parameters	Homogeneous			Heterogeneous		
	Successful n=98	Unsuccessful n=49	P	Successful n=34	Unsuccessful n=86	P
woody debris	21.48 \pm 1.17	23.52 \pm 1.39	0.3921	21.21 \pm 1.76	17.83 \pm 1.27	0.1531
bare ground/rock	8.99 \pm 0.80	9.41 \pm 1.09	0.6250	10.26 \pm 1.25	16.44 \pm 1.39	0.0101*
water	3.21 \pm 0.38	3.28 \pm 0.62	0.5844	1.79 \pm 0.31	2.15 \pm 0.26	0.6577
Nest Concealment (%)	72.35\pm1.29	72.79\pm1.85	0.8565	58.35\pm3.40	49.20\pm3.17	0.0206*

* indicates significant differences

Table 3. Vegetative parameters, nest concealment, and nest height class (mean \pm 1 SE) for nests depredated by mice, squirrels, and birds in young mixedwood boreal forest near Hinton, Alberta (June 1995). Results of a Kruskal-Wallis test for significant differences are shown by the P value.

Vegetative Parameters	Predator			P
	Mice n=53	Squirrel n=11	Bird n=21	
Canopy Closure (%)	38.15 \pm 3.57	34.27 \pm 8.77	29.38 \pm 5.24	0.2709
Trees and Shrubs				
<u>Density</u> (ha)				
trees	277.59 \pm 19.47	197.39 \pm 25.27	197.20 \pm 21.16	0.0375*
shrubs	4506.61 \pm 250.39	2989.09 \pm 581.85	2108.63 \pm 307.64	0.0001*
<u>Height</u> (m)				
nest tree	1.12 \pm 0.39	5.00 \pm 1.33	6.59 \pm 0.82	0.0001*
trees	6.65 \pm 0.23	7.08 \pm 0.53	6.32 \pm 0.38	0.3173
shrubs	2.48 \pm 0.12	2.25 \pm 0.24	2.02 \pm 0.08	0.1034
<u>Saplings</u> (no.)				
deciduous	5.38 \pm 1.08	7.09 \pm 3.41	2.62 \pm 0.74	0.1155
coniferous	5.67 \pm 0.82	3.36 \pm 1.34	4.81 \pm 1.02	0.3988
Ground Cover (%)				
grass	5.54 \pm 0.81	5.18 \pm 0.94	6.90 \pm 1.38	0.3362
herb	60.09 \pm 2.71	61.85 \pm 6.28	68.39 \pm 2.85	0.3244
litter	0.72 \pm 0.12	1.00 \pm 0.29	0.43 \pm 0.12	0.1787
shrubs (<1 m)	2.14 \pm 0.30	3.09 \pm 1.11	2.43 \pm 0.44	0.6568
moss	23.37 \pm 1.04	25.64 \pm 2.33	25.83 \pm 1.95	0.5437
lichen	31.77 \pm 1.89	24.23 \pm 3.74	27.31 \pm 2.67	0.2366

* indicates significant differences

Table 3 (continued). Vegetative parameters, nest concealment, and nest height class (mean \pm 1 SE) for nests depredated by mice, squirrels, and birds in young mixedwood boreal forest near Hinton, Alberta (June 1995). Results of a Kruskal-Wallis test for significant differences are shown by the P value.

Vegetative Parameters	Predator			P
	Mice n=53	Squirrel n=11	Bird n=21	
woody debris	22.33 \pm 1.54	20.86 \pm 3.23	16.43 \pm 2.49	0.1337
bare ground/rock	10.32 \pm 1.54	16.73 \pm 4.33	19.36 \pm 2.10	0.0003*
water	3.31 \pm 0.49	3.27 \pm 1.74	1.31 \pm 0.34	0.0478*
Nest Concealment (%)	67.34 \pm 2.41	54.12 \pm 6.37	50.64 \pm 4.47	0.0042*
Nest Height Class (m)	0.47 \pm 0.16	2.41 \pm 0.63	2.57 \pm 0.38	0.0001*

* indicates significant differences

Discussion

Bird Species Richness and Abundance

Changes in age structure of forest may contribute to long-term alterations of boreal forest bird species richness and composition (Helle and Jarvinen 1986, Farr 1992, Westworth and Telfer 1993, Schieck *et al.* 1995). Bird abundance and distribution in different successional stages often result from wide variation in vegetation parameters (Schieck and Nietfeld 1995). Older forests are dominated by trees with a large diameter at breast height (dbh), snags, and down woody debris. Structural heterogeneity is typically greater than young forest as gaps in the canopy allow lower strata in the subcanopy, shrub, and ground layer to flourish (Huenneke 1983).

As a result of the increased vertical and horizontal structural diversity associated with old stands, several studies have reported increased species richness and relative abundance in these forest communities. Telfer (1992) found 25% and 67% more species in mature (51-150 years) than young (0-25 years) and than old (≥ 150 years) mixedwood forest, respectively, in the prairie provinces. Patterns of species richness were slightly different in northern Alberta mixedwood forest with old forest (≥ 120 years) exceeding that of young (23-26 years) and mature (51-63 years) by 20% and 33%, respectively. In contrast, species richness was essentially identical in young and old forest in my study.

The absence of large differences in species richness and relative abundance in my study may be related to the age difference between treatments of about 50 years. In essence, the contrast of young and old forest may in fact be more representative of young and mature forest and, therefore, differences in habitat characteristics were not as distinct. Characterization of vegetation of sites in 1996 will aid in understanding the similarity in bird species composition and abundance between habitat types. Vertical heterogeneity in some of my old mixedwood sites may be limited by an underdeveloped subcanopy of conifers and shrub layer. Other factors such as annual variation or sampling error may have also contributed to a poor distinction in bird abundance between habitat types. In contrast, the observed abundance may be real such that all bird species are present in each forest type, but that they partition foraging and nesting sites differently. Furthermore, some species may cue on microsite characteristics that may be present in either seral stage rather than vegetation patterns that were unique to the various successional phases of forested habitats. Further comparisons of FMF bird abundance and species richness with that from other studies conducted in boreal mixedwood forest may help generate additional hypotheses as to why little difference existed between forest types.

Survival of Artificial Nest Contents

Some studies reported that ground nesting species are more susceptible to predation than off-ground nesters and clutch size tends to decrease with increased nest predation (Ricklefs 1969, Slagsvold 1982, Collias and Collias 1984). These species have, therefore, evolved with a cryptic and monomorphic coloration to combat the increased risk of predation (Martin 1988b).

However, Martín (1988b, 1993) reported a reverse trend with nest predation losses greater and clutch sizes smaller for off-ground than ground nests. Our findings were similar, with predation higher on nests distributed above ground. This emphasizes the effects of types of predators and co-existing bird species on the degree of nest predation (Martín 1988a,c). Moreover, Martín (1988a) found that when nests of three different species were situated at 0, 1, and 3 m above ground, predation rates were lower due to partitioning of nest sites in different areas. My results suggest that partitioning of nest resources by coexisting species in the vertical dimension will not lower predation pressure, but further work is required to adequately test Martín's hypothesis.

Vegetative Characteristics at Artificial Nest Sites

Taller nest tree heights for failed nests suggested that predators may be approaching nests from the top of the canopy than from below the nests or that concealment was poorer for nests in taller trees. Differences in nest tree heights of surviving and failed nests may also be related to nest substrate with successful nests located in shrubs and unsuccessful nests in trees.

Some parameters appeared to be linked to treatment rather than predator effects. Mouse depredation of nests occurred where there was a high shrub density. However, high shrub density was associated with homogeneous sites; thus, the observed difference was likely a treatment effect that had little biological significance for the identified predators. Concealment appeared to differ across treatments, which may make it difficult to attribute the observed effects to the spatial distribution of nests. Because nest visibility likely confounded results, it should be controlled in future experiments.

Habitat heterogeneity in the vertical dimension provides additional nesting and foraging sites and typically results in greater densities and species richness of breeding songbirds. If structural heterogeneity conferred by specific forest types appears to lower susceptibility of nests to losses by predators and, thereby, affecting species abundance and population recruitment, this particular habitat feature should possibly be enhanced. For example, the conversion of natural mixedwood forest to coniferous monocultures or tending regenerating stands may decrease structural heterogeneity needed for coexistence of species. In turn, cumulative nest density may be maximized as might susceptibility of nest losses to predators.

Predators of Artificial Nest Contents

A large proportion of predation events was attributed to mice. A bias toward mice may occur if a considerable number of eggs that went missing were due to another predator. It may be more plausible that red squirrels and gray jays removed eggs completely from the nest whether the eggs were consumed, cached, or merely carried a distance before being dropped. Mean height class of nests visited by unknown predators were in the 2-3 m range similar to squirrels and birds. This suggested that the identification of predators was skewed toward mice, particularly when the unknown portion of depredated nests contributed an additional 32% of egg losses. Small mammal trapping or predator removal experiments could help clarify this issue.

Future Research

To characterize spot-mapping sites, vegetative attributes will be recorded in summer 1996. Ten grid intersection points on birding sites will be randomly selected for habitat analysis with the condition that sampling points are a minimum of 50 m apart. T-squared sampling (Krebs 1989) will be used to obtain tree measurements. This technique will enable me to calculate unbiased estimates of tree density and dispersion. Deciduous and coniferous seedlings and saplings (≤ 3 m high) will be tallied in a 3 m radius around the sampling point. For shrub and ground cover characteristics, a 11.3 m (0.04 ha) radius circle will be used at the center of each grid cell intersection (Bessie 1995).

An inadequate number of natural bird nests was located to obtain a site-specific estimate of nesting success. Consequently, a relative reproductive index can not be verified by actual nesting information. Furthermore, of those observations collected during behavioral censuses, very few were 1) highly indicative of reproductive success and 2) representative of migrating songbirds. Overall, the pursuit of relative reproductive indices in mixedwood areas of the FMF appears unfeasible, but I will provide a complete assessment of this situation in the next progress report.

Due to the difficulty in assessing density/productivity relationships, the pilot study conducted to evaluate predation of artificial songbird nest contents will become the focus of research in 1996. For example, tests will be conducted to determine whether concealment was a factor in the results of 1995 using modified and unmodified wicker nests. A new proposal will be completed in April 1996 that will address some of these new hypotheses and corresponding experiments in detail.

Conclusions

Relative reproductive indices for songbirds in FMF do not appear to provide managers with a new alternative for assessing the viability of populations. For continued research in this domain, other forest types with higher bird densities would need to be sampled or an extraordinary amount of time would need to be allocated to censuses.

A similar bird species composition and abundance in young and old mixedwood forest may be related, in part, to vegetative characteristics and/or annual variation. To adequately determine whether short rotation logging will have detrimental effects on songbird species presence and abundance another age class of mixedwood forest could be examined or the current old age class of 76-100 years could be subdivided to encompass components of both mature and old forests. Future research will resolve further whether bird abundance, bird species richness, and simulated nest predation in 1 young and old mixedwood forest are related to habitat heterogeneity and stand structure of managed forests.

A heterogeneous distribution of artificial nests may provide a more realistic orientation of

nests in space but also simulate a wider range of co-existing species. However, heterogeneously distributed nests or off-ground nesters suffered greater losses to predation than homogeneously distributed nests or ground nesters. Consequently, the effects of nest dispersion on predation requires further investigation.

Both aspects of my study - (1) habitat use and productivity of songbirds and (2) habitat heterogeneity and artificial nest predation - can contribute new valuable information to enable managers to develop and implement conservation strategies that promote neotropical migrant bird diversity and critical habitat conservation in managed ecosystems. Data arising from this program expands the information available on forest ecosystem health and are available to decision-makers that can modify policy to better reflect the multiple values of FMF.

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