Fundy Model Forest

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PROJECT UPDATE REPORT

Habitat Requirements of Forest Birds in the Fundy Model Forest

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Abstract

The primary goal of this project is to develop scientifically-based habitat associations for birds that are DNRE vertebrate indicator species. All of this information will serve as a sound scientific basis for current and future Crown land. This project has three major objectives: (1) Determine aspatial (i.e. stand structure, stand composition) habitat relationships for avian indicator species. (2) Determine spatial (e.g. patch size) habitat requirements of avian indicator species. (3) Examine aspatial and spatial habitat requirements for a range of other bird species to determine if they might serve as better indicator species in upcoming forest management planning exercises. In this study we have adopted a range of bird monitoring techniques that enable us to determine the relative density and reproductive activity for forest birds in sampled forest stands. Data from intensively sampled vegetation plots and a Geographic Information System (GIS) has been used to develop detailed habitat association models for forest bird species. These models allow for prediction of the incidence of bird species across southeastern N.B. Initial results indicate that local stand variables explain a large proportion of the variability in forest bird community composition. Local vegetation variables may be even more important as predictors of reproductive activity than as predictors of density of males. Out of eleven species for which we found significant stand-level (GIS) relationships, three (Ovenbird, Blackburnian Warbler, Black-throated Blue Warbler) are correlated with mature or overmature forest conditions. Data on these species will be used in the next phase of this project – the determination of the spatial requirements for mature forest birds. For this, we have adopted a "species centered approach" to delineating patches and landscapes.

1.0 Introduction and Background

In the development of the 2002 management planning objectives for Crown land, the Fish and Wildlife branch of the Department of Natural Resources and Energy (DNRE) has made extensive use of the 'indicator species' approach. Crown land licensees will be required to retain certain types and sizes of forest that meet the needs of indicator species. The Fish and Wildlife branch was forced to rely on incomplete data and research literature from other areas of the continent. This is problematic due to recent scientific findings which reveal that the habitat requirements of species can significantly vary from region to region (Rosenburg et al. 1999). This uncertainty is of concern for two major reasons: (1) If the species-habitat and species-area relationships are incorrect or have been underestimated, it is possible that target species *will not be effectively protected* in 2002 Crown land forest management plans. (2) If species-area relationships are overestimated, it is possible that *annual allowable cuts for Crown land are being restricted more than is necessary.*

The primary goal of this project is to develop scientifically-based habitat associations for birds that are DNRE vertebrate indicator species. All of this information will serve as a sound scientific basis for current and future Crown land management policy and will heighten policy credibility not only with licensees, but with the New Brunswick public as a whole. Since 2000 we have been working closely on an ongoing basis with DNRE to ensure that our research will be useful in future planning processes.

2.0 Objectives

This project has three major objectives:

(1) Determine aspatial (stand structure, stand composition) habitat relationships for avian indicator species. This includes such stand attributes as vegetative species composition and the size and physical distribution of species within the stand.

(2) Determine spatial (patch size) habitat requirements of avian indicator species.

(3) Examine aspatial and spatial habitat requirements for a range of other bird species to determine if they might serve as better indicator species in upcoming forest management planning exercises.

In 2000-2001, research was focused primarily on the first of these objectives. This report summarizes our preliminary results that address the aspatial (stand level) habitat requirements of forest birds.

3.0 Methods

3.1 Study Area

This study is being conducted in the Greater Fundy Ecosystem (GFE) and Fundy Model Forest (FMF), which are located in the southeastern part of New Brunswick. (Fig. 1). This portion of the Acadian Forest Region (Rowe 1959) falls within the Southern New Brunswick Uplands and the Fundy Coast Ecoregions. The area is characterized by 89% forest cover, a maritime climate, and rolling topography (Woodley et al. 1998). Current study sites exist in the Fundy Plateau Ecodistrict. The forest cover in this area is primarily made up of tolerant hardwoods (sugar maple [*Acer saccharum*], yellow birch [*Betula allegheniensis*], American beech [*Fagus grandifolia*]), and mixedwood communities (red spruce [*Picea rubens*], balsam fir [*Abies balsamea*], yellow birch, sugar maple, American beech). Intensive forestry activities are common in all areas of the GFE except for Fundy National Park. As a result, in recent decades many of the tolerant hardwood and mixedwood stands of the region have been converted to plantations. Land ownership is divided among private woodlot owners, the Government of New Brunswick, industrial freehold (J.D. Irving Ltd.), and the Federal Government (Fundy National Park).

Fig. 1 Location of the Greater Fundy Ecosystem Intensive Study Area (ISA).

3.2 Bird Census Techniques

We use two techniques to determine the density and relative reproductive activity of New Brunswick forest birds:

1. *Point count method*. Auditory detection of male singing are used to determine the presence of bird species across sample landscapes. Point counts are carried out 3 times during the breeding season at sampling points at least 250m apart and arranged in a systematic random sample (see 3.5 Sampling Design, below). Species are recorded using standard fixed radius (50m, 100m) point count methodology (Ralph et al. 1995).

2. *Playback method*. Gunn et al. (2000) developed a method that uses a taped playback of Black-capped Chickadee mobbing calls to provide a rapid means to determine reproductive score for up to 50 species (0=species not detected or singing male detected, 1 = pair observed together at a sample point, 2 = individual carrying nest material detected at a sample point, 3 = food carrying or other evidence of successful hatching at a sample point, 4 = fledglings detected at a sample point). The playback method is conducted from 5:30 am until 1:30 pm (no significant difference could be detected due to time of day in the 2000 field season). Playback rounds are carried out four times throughout the field season (June 5 – July 15) to maximize the number of reproductive observations.

3.3 Vegetation Sampling

Using a 20 m x 10 m fixed area plot, a range of local vegetation variables were sampled at each bird survey point (Appendix A). Methods are based on those used by Bowman et al. (2001). However additional variables that are likely to constitute key stand-level habitat for species have been added.

3.4 Geographic Information System Data

Data on the age, cover type, dominant species, canopy closure, and vertical structure is available from the New Brunswick Forest Inventory for all sampled stands. We created a coarser variable titled ‘Habitat’ that summarized stand composition into six broader categories that reflect DNRE habitat classes. These were: tolerant hardwood, intolerant hardwood, tolerant mixedwood, tolerant mixedwood, pine, and softwood. These data were gleaned from a Geographic Information System (GIS) and summarized by sample point. With a combination of intensively measured vegetation (20 x 10 m plots) and stand-level GIS information, it was possible to analyze habitat associations using two independent data sets at two scales: the ‘fine-scale’ vegetation plot, and the ‘local-scale’ stand type.

3.5 Sampling Design

The 2001 field season was primarily concerned with developing sound stand-level habitat association models. These stand-level associations allow wildlife biologists and forest managers to predict the geographical distributions of a range of species. The full range of stand ages and cover types were sampled in broad categories. Structural and compositional characteristics of sample stands are described in Tables 1 and 2. The sampling scheme for the 2001 field season is outlined in Table 3.

Table 1. Structural characteristics of sample stands

	Regenerating/ Sapling	Young	Immature	Mature/ Overmature
Height	2-5m	5-7m	7-12m	12+
Max DBH	6cm	10cm	30cm	None
Age[1]	10-30	30-45	45-70	70+

Table 2. Stand composition characteristics of sample stands

Habitat Type	Composition
Hardwood	>75% hardwood
Softwood	>75% softwood
Mixedwood	<75% hardwood and <75% softwood

Table 3. Distribution of sample points within stand type treatments[2]

	Regenerating/ sapling	Plantation (20-30 yrs)	Young	Immature	Mature/ Overmature	Total
Hardwood	10	NA	30	20	20	100
Mixedwood	30	NA	30	20	20	100
Softwood[3]	20	35	30	20	20	135
Total						335

To eliminate pseudoreplication only one point was placed in each stand unless stands were very large (> 20 ha). In total, 335 points were established in 250 stands. For the purposes of stand level analysis, in cases where more than one point existed per stand, these 'duplicates' were randomly excluded from analysis.

All sample points were randomly placed at least 50 m from stand edges in forest patches of comparable size (>10 ha) (to limit the confounding effect of area). Regenerating/ sapling, and young stands with a history of 'highgrading' and other types of selection cutting were avoided. This was avoid the confounding effect of residual old

[1] Does not apply to Mature or Overmature stands that are uneven aged.

[2] Sample size is reduced in Immature and Mature stands because of the intensive sampling effort in these age classes in 2000. 50% of 2001 Immature and Mature sample points were placed in the same location as in 2000 so that it is possible to assess between year variability in bird communities. Smaller sample size of sapling hardwood and softwood stands reflects the rarity of these stand types.

tree stems or snags within a younger stand. All regenerating/sapling and young stands were of clearcut origin.

3.6 Statistical Analysis

In exploratory stand-level analysis we used direct gradient analysis (Canonical Correspondence Analysis [CCA]) (ter Braak 1996) that simultaneously employs ordination and multiple regression to statistically test the significance of each stand-level variable in determining bird community composition. Monte Carlo permutation tests will be used to determine the significance of ordination results ($p<0.05$). Forward selection was used to determine the stand-level variables that contributed the most to explaining variability in community structure.

To develop stand-level associations for individual species, multiple logistic regression (from the family Generalized Linear Models [GLMs]) was used to build optimal models relating abundance and reproductive success of birds to the complete set of local vegetation characteristics. When categorical GIS data were used as predictors they were treated as 'factors' in multiple logistic regression analysis. Optimal models are those explaining the most variance in response variables while still remaining the most parsimonious (according to the AIC). All regression modeling was preformed in SPLUS (MathSoft Inc. 2000).

3.7 Species-Centered Approach

In addition to addressing Objective 1 (stand level habitat relationships), logistic regression models allow for the prediction of the distribution of a species across a landscape. This provides the unique opportunity to develop a "species-centered approach" to delineating patches for subsequent landscape-scale sampling. One of the potential challenges with the patch-matrix concept in a forest matrix is the difficulty in delineating 'patches'. Because species have different habitat requirements, each will respond to different patch boundaries. This problem is reduced when a patch is adjacent to recently clearcut matrix. However in a forest mosaic of many age-classes and cover types, defining a 'patch' is often an arbitrary process based on assumptions about potential habitat and non-habitat. Several landscape studies have suggested this problem as an explanation for not detecting a significant influence of patch size and other configuration metrics on bird species distribution (McGarigal and McComb 1995, Drapeau et al. 2000).

The species-centered approach is a three step process:

(1) With the use of stand-level habitat models, Resource Selection Functions (RSFs) (Boyce and McDonald 1999) were developed for all common (>10 observations) territorial forest bird species. RSFs use logistic regression models to determine 'probability of occurrence' for species based a suite of measured habitat variables or existing data layers in a Geographic Information System (GIS).

(2) Probability of occurrence (0 – 1.0) or reproductive success for a range of forest bird species was implemented spatially using GIS.
(3) Sample sites for landscape configuration study are being established in areas with a high probability of occurrence ($p>0.8$) for each species, that are surrounded by a matrix with low probability of occurrence ($p<0.1$).

Stand-level Resource Selection Functions (RSFs) were developed using log-linear modeling (logistic regression). Optimal models will be those explaining the most deviance in the response variable. Only significant variables ($p<0.05$) will be used in RSFs. Resource Selection Function were used for all stand-level models (eq.1).

$$P\ (1/X) = e(\exists_0 + \exists_1 x_1 + \exists_2 x_2 + \ldots \exists_k x_k) /\ 1 + \ e(\exists_0 + \exists_1 x_1 + \exists_2 x_2 + \ldots \exists_k x_k)$$ **eq. 1**

Where ∃ are the regression coefficients, and $x_1 \ldots x_i$ are the predictor variables in a logistic regression equation.

4.0 Preliminary Results

4.1 Exploratory Multivariate Analysis

It is important to note that the results listed below are preliminary and certainly not intended to be comprehensive. Analysis to date has been exploratory with the primary purpose of informing the design of the 2002 field season.

Exploratory CCA helped us to determine the most important stand level variables for the whole community of sampled forest birds. As expected, local vegetation explained substantial variation in the forest bird community as a whole (75.9 %) (Fig. 2).

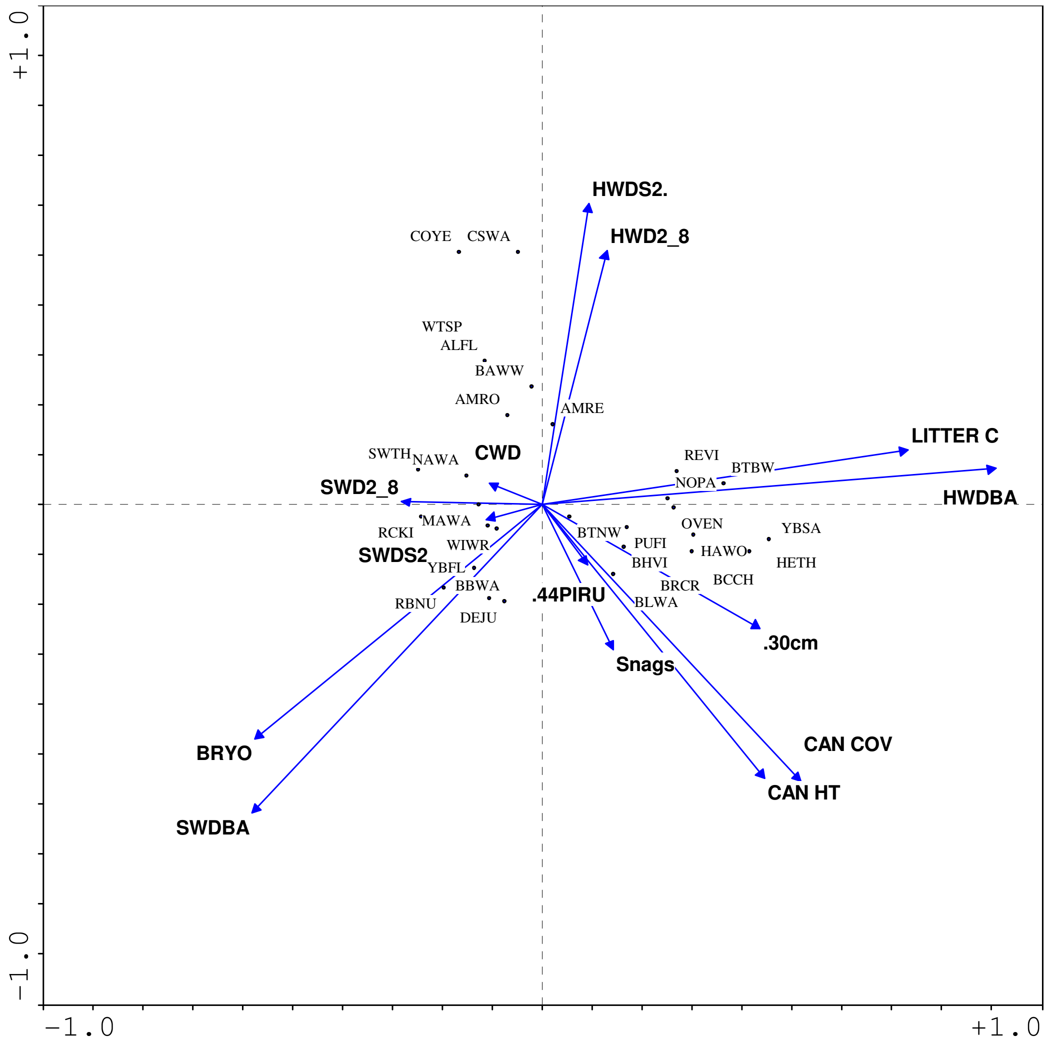

Fig. 2 CCA biplot depicting multivariate relationship among bird species and structural attributes of sampled stands in 2001 (75.9 % of species-environment relation explained, Monte Carlo test $p<0.0005$). Most significant stand-level variables for this community are represented by long axes (HWDBA=hardwood basal area, CANCOV=canopy cover, CANHT=Canopy Height, .44 PIRU= density of spruce >44cm dbh, LITTER C=Litter layer, SNAGS=dead trees, CWD=coarse woody debris, SWDBA=softwood basal area, BRYO=proportion of bryophytes, .44CM=density of trees>44cm dbh, .30cm = density of trees>30cm dbh, SWD2_8=density of SWD trees 2-8cm dbh, HWD2_8=density of HWD trees 2-8cm dbh, SWDS2 = softwood shrub layer, HWDS2= hardwood shrub layer. Birds are correlated with stand-level variables if their centroid (point) falls in close proximity to stand-level axes. Bird Codes: RBNU=Red-breasted Nuthatch, BLWA=Blackburnian Warbler, WIWR=Winter Wren, PISI=Pine Siskin, NOPA=Northern Parula, RCKI=Ruby-crowned Kinglet, BBWA=Bay-breasted warbler, BTNW=Black-throated Green Warbler, HETH=Hermit Thrush, WBNU=White-breasted Nuthatch, PIWO=Pileated Woodpecker, BRCR=Brown Creeper, REVI=Red-eyed Vireo, BTBW=Black-throated Blue Warbler, BCCH=Black-capped Chickadee, OVEN=Ovenbird. CMWA=Cape May Warbler, CSWA=Chestnut-sided Warbler, WTSP=White-throated Sparrow, ALFL=Alder Flycatcher, BAWW=Black-and-white Warbler, AMRO=American Robin, MAWA=Magnolia Warbler, SWTH=Swainson's Thrush, NOPA=Northern Parula, YBSA=Yellow-bellied Sapsucker, HAWO=Hairy Woodpecker, RCKI=Ruby-crowned Kinglet, YBFL-Yellow-Bellied Flycatcher, RBNU=Red-breasted Nuthatch, DEJU=Dark-eyed Junco.

4.2 Fine-scale Habitat Associations

Due to our emphasis on developing RSFs for design of the 2002 field season, very little emphasis was placed on determining fine-scale habitat relations based on 2001 data. However, analysis of the 2000 data revealed that fine-scale stand structures are important for predicting the presence/absence and reproductive activity of individual bird species (Table 4). Reproductive activity appears to be more sensitive to variation in stand-level variables than abundance. In the upcoming year, this analysis will be used for all species of forest birds present in 2001 data.

Table 4. Results of generalized linear models relating stand-level variables to abundance and reproductive success[a]

Species[b]	Abundance		Reproductive Activity	
	Variable	Deviance (%)	Variable	Deviance (%)
Ovenbird	Hardwood basal area Canopy closure	6.5^{***} (+) 2^{***}(+)	Hardwood basal area	10.7^{***}(+)
Blackburnian Warbler	Large spruce (>8 cm dbh)	14^{***}(+)	Large spruce (>8cm dbh) Softwood basal area Tree density (>44cm dbh)	13^{***}(+) 2^{*}(-) 2^{*}(+)
Red-eyed Vireo	Canopy cover	3.6^{**}(+)	Hardwood basal area Canopy cover Tree density (>10cm dbh)	8.5^{***}(+) 8.5^{***}(+) 2^{*}(+)
White-breasted Nuthatch		NS	Hardwood basal area Tree density (>44cm dbh) Tree density (>10cm dbh)	30^{***}(+) 10^{***}(+) 5.7^{*}(+)
Yellow-bellied Sapsucker		NS	Hardwood basal area	20.5^{***}(+)

[a] Variables are listed in order of entry. Relationships are significant at: $p<0.001^{***}$; $p<0.01^{**}$; or $p<0.05^{*}$. Positive and negative relationships are noted by (+) or (-) respectively.

[b] A reduced number of species are reported here representing neotropical migrants (Ovenbird, Blackburnian warbler, Red-eyed Vireo) short-distance migrants (Yellow-bellied sapsucker) and resident species (White-breasted nuthatch).

4.3 Stand-Scale (GIS) Habitat Associations

Stand-scale GIS attributes were reasonably good predictors of presence/absence of a number of species. Stand age and cover type were frequently the most powerful predictors (Table 5). In several instances the combination of these variables resulted in the best statistical models. Of all 11 species examined, three were significantly positively correlated with mature or overmature forest: Ovenbird, Blackburnian Warbler, and Black-Throated Blue Warbler (Figs. 3, 4, 5). We developed Resource Selection Functions for these species and mapped the predicted distribution of each across the Fundy Model Forest land base (Fig. 6). Because Ovenbird and Black-throated Blue Warblers inhabit similar habitats (according to these models), only Ovenbird distribution was mapped.

Table 5. Results of logistic regression models relating stand-level GIS variables to presence/absence of forest bird species. 'Stand variable' refers to the GIS variable used in analysis. 'Level' indicates the categorical variable(s) where the species was found to be most abundant.

Species	**Stand Variable**	**Level**	**Pseudo r^2**	**Significance (p)**
Ovenbird	Habitat + Age	Hardwood Mature	0.44	<0.0001
Blackburnian Warbler	Habitat + Age	Mixedwood, Hardwood Mature - Overmature	0.27	<0.0001
Red-eyed Vireo	Habitat	Hardwood	0.35	<0.0005
Yellow-bellied Sapsucker	Habitat	Hardwood	0.13	<0.0001
Black-throated Green Warbler	Habitat + Age	Hardwood Young - Mature	0.09	<0.02
Swainson's Thrush	Habitat + Age + Vertical strata	Softwood Sapling-Young, overmature Canopy Layers 2 +	0.14	<0.0001
Golden-Crowned Kinglet	Habitat	Softwood	0.24	<0.0001
Ruby-Crowned Kinglet	Habitat + Age	Softwood Regerating – Sapling	0.35	<0.0001
Winter Wren	Habitat	Softwood, Mixedwood	0.15	<0.001
Black-throated Blue Warbler	Habitat + Age	Hardwood Mature	0.26	<0.0001
American Redstart	Age	Regenerating, sapling, overmature	0.17	<0.0005

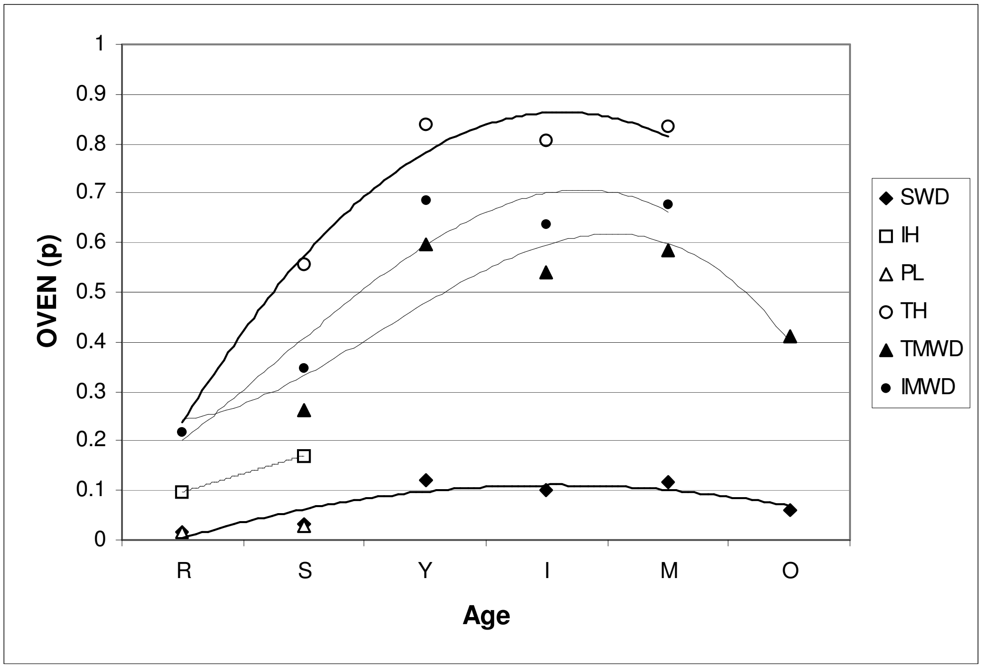

Fig. 3 Results of logistic regression analyses with the GIS category 'L1DS' (AGE) and Habitat Type as predictor variables and probability of presence/absence of singing male Ovenbirds as a response variable (pseudo - r2 = 0.47, p<0.0001). (SWD=Softwood, IH=Intolerant Hardwood, PL=Plantation, TH=Tolerant Hardwood, TMWD=Tolerant Mixedwood, IMWD=Intolerant Mixedwood, R=Regenerating, S=Sapling, Y=Young, I=Immature, M=Mature, O=Overmature).

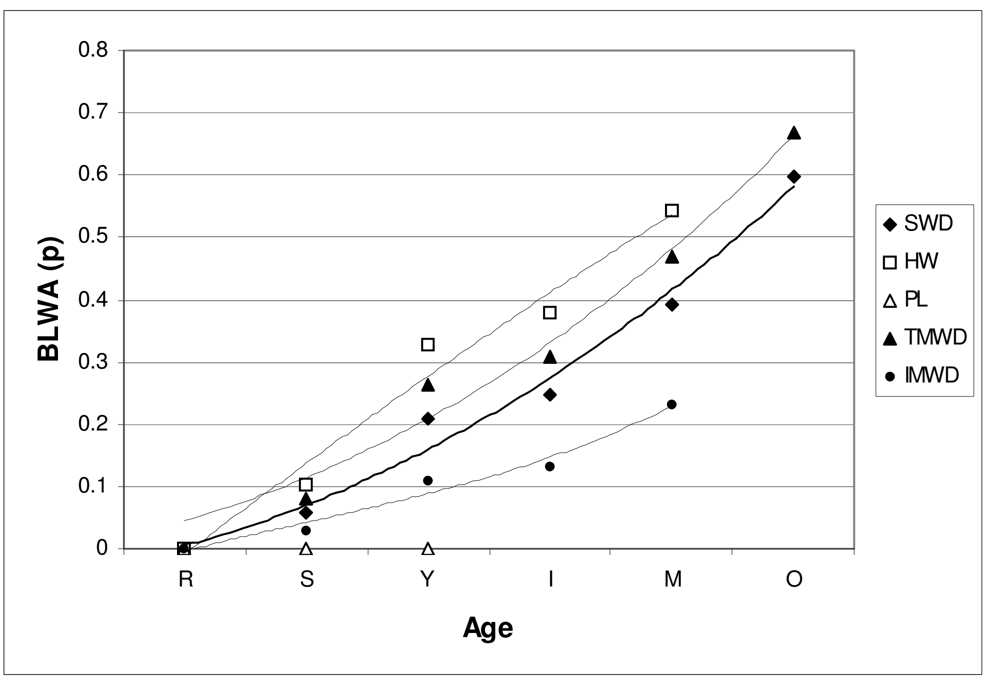

Fig. 4 Results of logistic regression analyses with the GIS category 'L1DS' (AGE) and Habitat Type as predictor variables and probability of presence/absence of singing male Blackburnian Warblers as a response variable (pseudo - r2 = 0.27, p<0.0001). Codes as in Fig. 3.

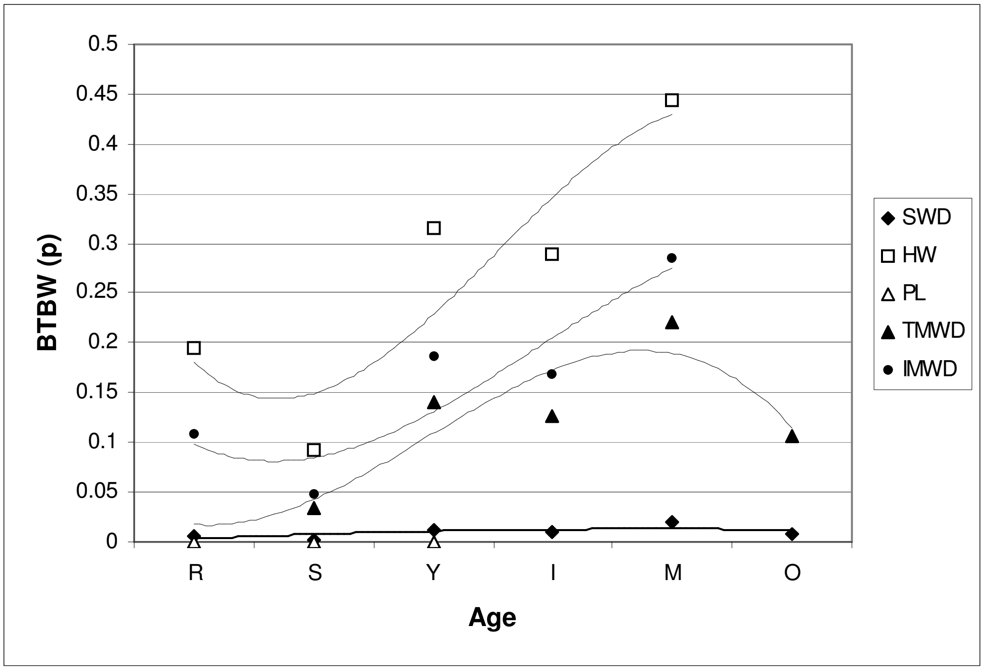

Fig. 5 Results of logistic regression analyses with the GIS category 'L1DS' (AGE) and Habitat Type as predictor variables and probability of presence/absence of singing male Black-throated Blue Warblers as a response variable (pseudo - r2 = 0.26, p<0.0001). Codes as in Fig. 3.

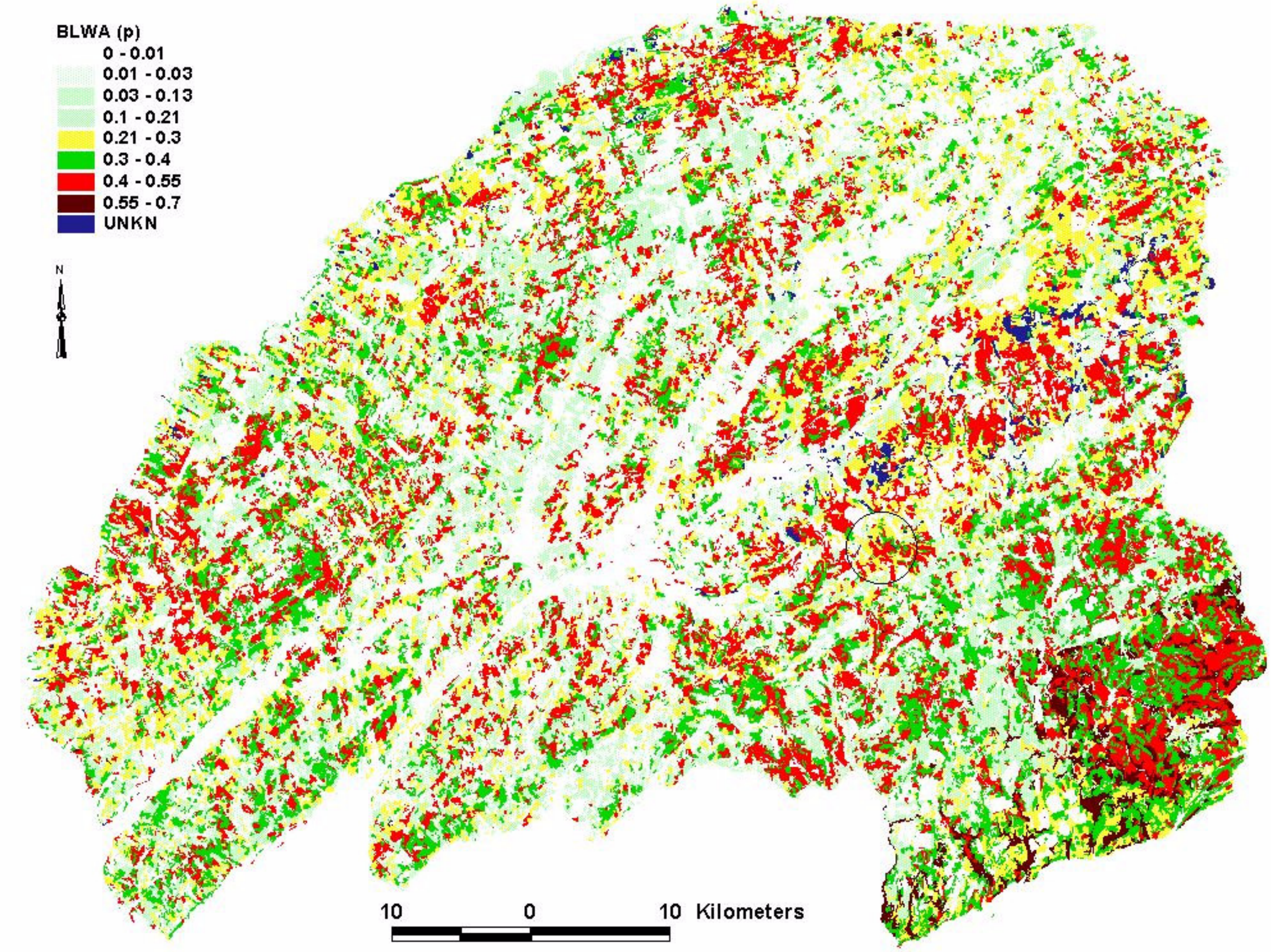

Fig. 6 Predicted distribution of Blackburnian Warbler in the Fundy Model Forest.

5.0 Discussion

The preliminary information presented in this report indicates that it will be possible for us to develop detailed information that allows forest managers to predict forest bird-habitat relationships at both the fine scale (stand structures e.g. snags, CWD, basal area) and the stand-level scale (patch type, age class etc.). Further, GIS is an effective predictor of the presence and absence of habitat for several bird species. However, some time is still required to (a) develop fine-scale habitat associations using 2001 data, (b) examine potential interactions between fine-scale and stand-level variables, (c) test the predictive power of models at both scales.

A great advantage to the development of resource selection functions is that they allow for prediction of species distributions across broader landscapes. The results of the models summarized above are being used in the design of the second phase of this project: the assessment of spatial components of habitat associations for forest birds (Objectives 2 and 3). Areas of high probability of species occurrence will be considered a ‘patch’. Our 2002 experimental design is based on sampling a wide range of patch sizes and landscape compositions to determine if thresholds exist that relate to either of these variables. This will provide critical information for forest managers who wish to manage for adequate amounts and configurations habitat. Success in our application to FMF in 2002 will enable us to sample as broad a range of these landscape characteristics as possible. Large sample size should allow for the adequate testing of hypotheses that relate to spatial scale.

6.0 2001 Funding

Table 6 summarized the funding acquired by the Forest Bird Research Project in 2001.

Expected funding sources for 2002 are summarized in our 2002 FMF proposal.

Table 6 Funding for forest bird research in 2001.

Project Title	Amount	Funding Agency
Habitat requirements of N.B. Department of Natural Resources’ avian indicator species	$8,000	Fundy National Park
	$25,000	Environmental Trust Fund
	$11,500	Fundy Model Forest
	$3,000	New Brunswick Summer Student Employment Program
	$3,000	GFERG
	$6,000	ACWERN
Total	$56,500	

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Appendix A: Vegetation data collected at each sample point

Data Title	Abbreviation	Codes
Observer	OBS	Initials
Even/Uneven aged	UN/EVEN	1 = EVEN 2 = UNEVEN
Tree age (dominant)	DOMAGE	
Tree age (co-dom)	COAGE	
Sight distance	SIGHT	
Disturbance history	DIST	1 = CC recent 2 = CC old 3 = Thin 4 = Group selection 5 = Highgrade 6 = Burn 8 = Budworm 9 = None
Community Type	COMM	IMWD = immature mixedwood MMWD = mature mixedwood ITH = immature tol hwd MTH = mature tol hwd IIH = immature intolerant hardwood MIH = mature intolerant hardwood SWD = softwood Y = young (use as prefix) S = sapling R = regenerating
Nearest stand boundary	BOUND	Smallest distance (not ranges)
Mature spruce	SPRUCE8	1 = 0 2 = <5 3 = 5-10 4 = >10 5 = 50-75 6 = 75 –100 7 = 100 +
Canopy	CANHT	
Subcanopy 1	SUBHT	
Shrub	SHHT	
Ground cover	GRHT	
Canopy cover	CANCOV	
Subcanopy cover	SUBCOV	
Shrub cover	SHCOV	
Ground cover	GRCOV	
Shrub species	SHSP	
Shrub cover	SHRCOV	S1 = <0.5m S2 = 0.5-1m S3 = 1-1.5m S4 =1.5-2m
Herbaceous species	HERBSP	See species codes
Herbaceous cover	HERBCOV	See abundance codes
Tree species	TREESP	See species codes
DBH	DBH	
Snags species	SNAGSP	See species codes
Snag DBH	SDBH	
Snag decay class	SDECAY	See decay codes
Tree size classes	V44CM	Tress >44cm
	V10TOTAL	Trees>10cm
Shrub classes	SWDS2	Softwood shrub stems >0.5m
	HWDS2	Hardwood shrub stems >0.5m
Litter layer	LITTER	Litter coverage (%)
Litter depth	LITTER_D	Litter depth at four corners of sample plot