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"The Fundy Model Forest (FMF) is a partnership of 38 organizations that are promoting sustainable forest management practices in the Acadian Forest region."

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Assessing Forest Bird Habitat at Stand and Landscape Scales in the Fundy Model Forest:

Preliminary Results

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April 17, 2001

Introduction

The persistence of animal populations is dependent upon the existence of adequate suitable habitat at a wide range of scales. It is becoming increasingly clear that the pattern and composition of landscapes are critical habitat features for a variety of species. Landscape pattern can affect predation rates (Robinson et al. 1995), genetic diversity (Husband and Barrett 1996), movement (Machtans et al. 1996), pairing and nest success (Hagan et al. 1996, Roberts and Norment 1999) and food availability (Burke and Nol 1998). Landscape composition (i.e. extent and type of cover) also affects species persistence; some species require large tracts of suitable habitat (Donovan et al. 1995, Hargis and Bissonette 1997).

Forest management affects the structure, pattern and extent of forest stands and landscapes. If forest species are to be maintained, it is critical that we understand habitat requirements at both of these scales. The purpose of this study is to define quantitative relationships between forest structure and composition and the abundance and reproductive success of forest birds. Birds have been widely used as indicators of sustainable forest management.

Project Objectives

1. Determine aspatial (stand structure, stand composition) habitat relationships for forest birds in the Greater Fundy Ecosystem (GFE) and Fundy Model Forest (FMF). This includes determining the influence of such stand attributes as plant species composition and the size and physical distribution of tree and shrub species within the stand.

2. Determine spatial habitat requirements on presence and reproductive success of forest birds in the GFE and FMF; including pattern (e.g. patch size, connectivity, edge) and composition (extent of different cover types).

Study Area

The Greater Fundy Ecosystem (GFE) and Fundy Model Forest (FMF 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). The forest cover in this area is made up primarily 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 balamea], 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, many tolerant hardwood and mixedwood stands have been converted to softwood plantations.

Methods

Study sites were established in two 25 km2 landscapes that represent extremes of forest fragmentation (16% and 80% mature forest). Systematic sampling grids (with points 300m apart, n=216) were established to ensure adequate representation of each major mature stand type (immature and mature mixedwood and hardwood) and patch size (1 180 ha)(Fig. 2, Fig. 4). Vegetation, snags and coarse woody debris were sampled at each point. Bird species presence and reproductive success were determined for each sample point using 'point count' (Ralph et al. 1995) and 'playback' (Gunn et al. 2000) methods . Playback provides an index of reproductive success derived from direct observations of productivity (pairs, food carrying, nest material carrying, fledglings). A reduced set of variables relating to landscape structure (% mature forest) and pattern (edge density) was measured at multiple scales for each sample point (radius = 150 m, 500 m, 1000 m, 2000 m) with the use of GIS (Geographic Information System).

Statistical Analyses

In exploratory stand-level analysis we used direct gradient analysis (Canonical Correspondence Analysis) (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 were 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 test for stand-level associations for individual species, we used poisson regressions to build optimal models relating abundance and reproductive success of birds to a complete set of local vegetation characteristics. Optimal models were those explaining the most deviance in the response variable. Residuals from these regressions were saved and used as new variables representing bird abundance and reproductive success independent of the effects of local vegetation. This new set of data was regressed (using poisson regression) against a set of landscape metrics (landscape cover and edge density at 150 m 2000 m scales) to measure the independent effects of landscape composition and pattern on forest bird abundance and reproductive success.

Results

76% of the variation in community structure in both landscapes combined could be explained by stand-level variables ($p<0.05$) in Direct Gradient Analysis. The most significant stand-level variables were hardwood basal area (HWDBA), softwood basal area (SWDBA), and canopy cover (CC) (Fig. 4).

Significant stand-level models were developed for most forest bird species (Table 1). Consistent with the Direct Gradient Analysis, the most common significant variables were hardwood and softwood basal area (Fig. 5). For some species, variables that contributed to stand-level reproductive success models did not contribute to stand-level abundance models.

With the effects of stand-level vegetation removed, the reproductive success and abundance of most species were not significantly correlated with landscape composition (Table 2). Swainson's Thrush abundance (Fig. 7), Ovenbird reproductive success (Fig. 9), and White-breasted Nuthatch reproductive success were correlated with landscape pattern or composition at larger scales .

Discussion

Our results indicate that despite the relative homogeneity of sample stands, the forest birds examined exhibit resource specialization. Explained deviance is low for all species due to the lack of variability in sample stands. Only a few species such as Black-capped Chickadees and Blue-headed Vireo were not significantly correlated stand-level features. No stand-level variables were correlated with Black-throated Blue Warbler abundance or reproductive success ($p>0.1$) which is surprising in light of evidence from New England revealing tight correlations between this species and hardwood forest and shrub cover (Steele 1992). Not surprisingly, in both direct gradient analysis and poisson regressions, significant stand-level bird habitat appeared to reflect either the nesting or foraging requirements of bird species (Ehrlich et al. 1988). The importance of different stand-level variables to explaining reproductive success versus abundance could indicate the presence of a gradient in local habitat quality. Productivity is highest in stands with particular stand-level features (for example density of > 44 cm dbh trees for Blackburnian Warbler). Reproductive success is lower in stands without these features, but this does not preclude the presence of unpaired males (abundance).

These preliminary results indicate that for most species, the local scale (<150 m radius) is the most important determinant of habitat quality. However, for some species, landscape composition and pattern are important. Our finding that Ovenbird reproductive success declines in landscapes with high edge density reflects previous work from agricultural landscapes which indicated that nest predation is higher and food availability is lower in edge zones for this species (Burke and Nol 1998). In the case of Ovenbird, reproductive success is significantly influenced by landscape pattern and composition but abundance is influenced only weakly by these variables (Fig.8). Our sample of Swainson's Thrush reproductive success observations (in the playback method) and for White-breasted Nuthatch abundance were both very small, so it is possible that both reproductive success and abundance are affected by landscape composition in these species. However, the decoupling of reproductive success and abundance for some species at both the stand and landscape scales indicates that abundance is not always an effective indicator of reproductive success (Van Horne 1983).

Forest Management Implications

While these results are only preliminary, more finely-tuned species-habitat models may be used by forest managers in developing both stand and landscape-level prescriptions in the Fundy Model Forest. For several species it may be important to maintain a higher percentage of mature forest within landscapes and to reduce edge created by roads and timber harvest. Further sampling will allow us to develop threshold levels of critical habitat features for a range of species. Resource Selection Functions (Boyce and McDonald 1999) may be developed for species at a wide range of scales. This will enable us to predict areas within the FMF and GFE that contain the highest abundances and/or reproductive success of forest bird species.

Acknowdedgments

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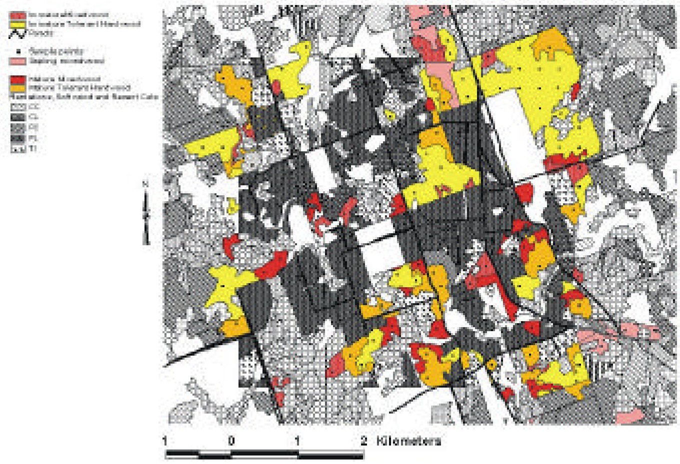
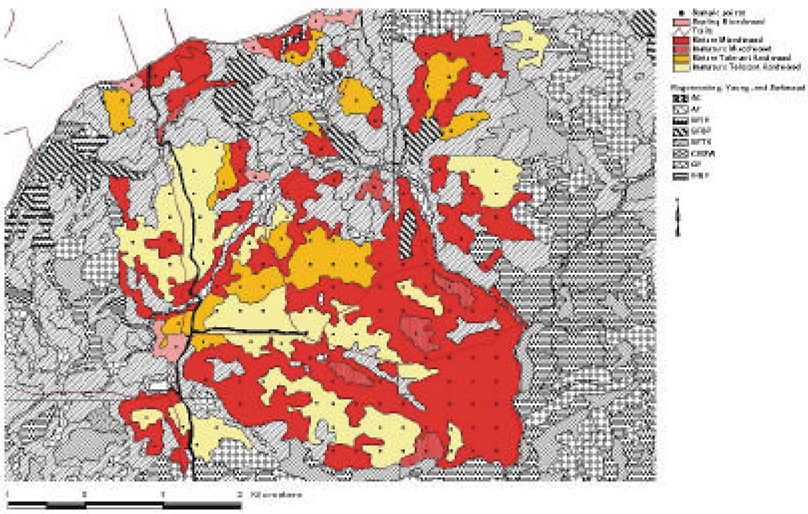
Fig. 1. Location of GFE Intensive Study Area (ISA) and Fundy Model Forest

Figs. 2 and 3. Forest bird sample areas in (a) Managed landscape, and (b) Unmanaged landscape.

(a)





(b)

Fig. 4 Canonical Correspondence Analysis Biplot for Fundy mature forest bird community. Most significant stand-level variables for this community are represented by long axes (HWDBA=hardwood basal area, CC=canopy cover, LL2=Litter layer, ML=mid-layer, DD=snag trees, WD=coarse woody debris, SWDBA=softwood basal area, Trees44=density of trees>44cm dbh, TB=density of trees >10cm dbh, SL=shrub layer. Bird are correlated with stand-level variables 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. Due to space limitations, all bird species included in this ordination were not included on this biplot.

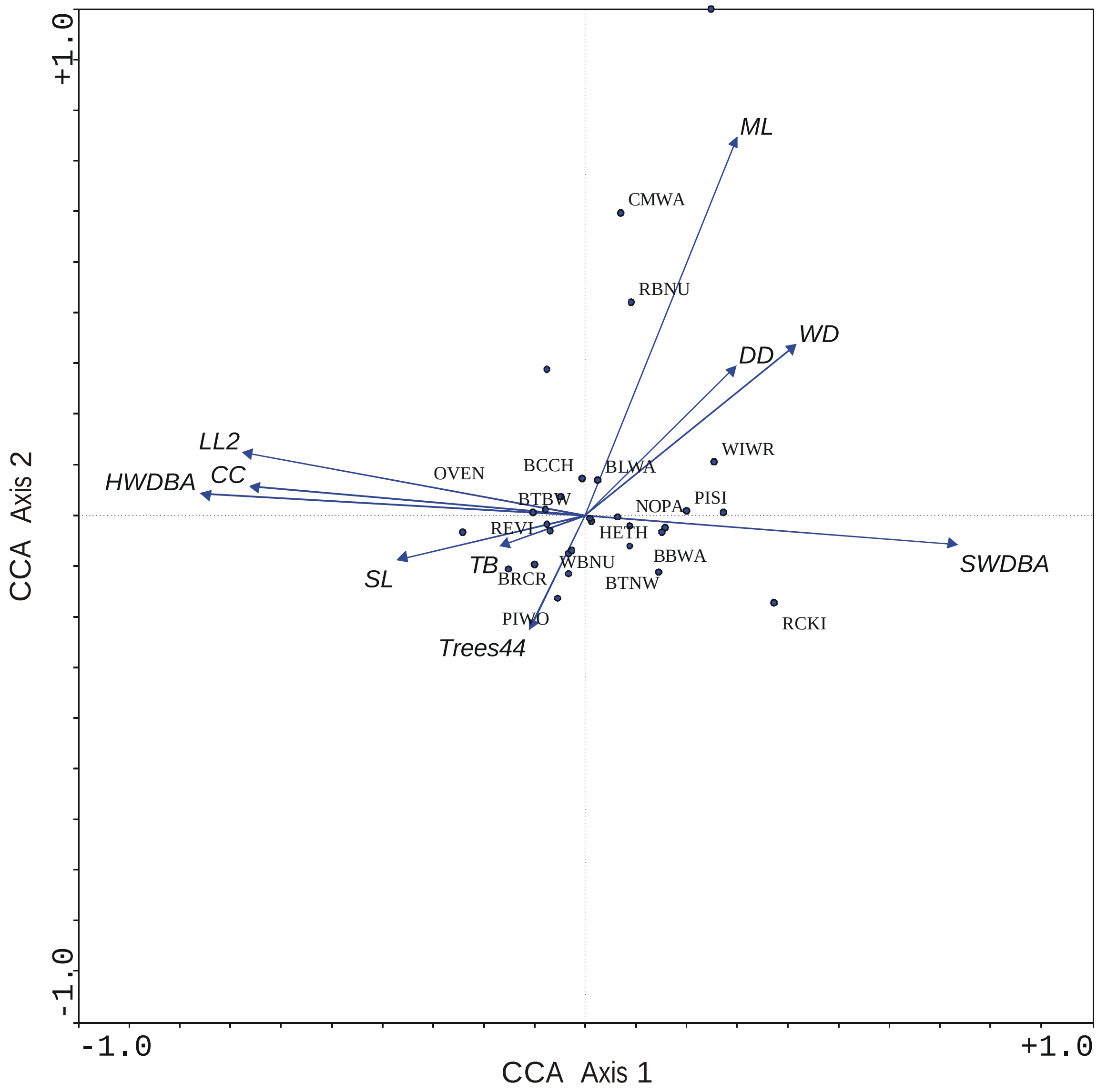


Table 1. Results of generalized linear models relating stand-level variables to abundance and reproductive success[a]

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

[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).

Table 2. Results of generalized linear models relating landscape composition (% mature forest) to abundance and reproductive success[a]

Species[b]	Abundance		Reproductive Success	
	Variable	Deviance (%)	Variable	Deviance (%
Ovenbird		NS	% mature forest within 500m Edge density within 1000m[c]	6.4*(+) 5.9*(-)
Blackburnian Warbler		NS		NS
Red-eyed Vireo		NS		NS
Yellow-bellied Sapsucker		NS		NS
Swainson's Thrush	% mature forest within 500m	30.9***(+)		NS

[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) .
[c]Note that these two spatial variables were highly correlated. Both variables were not significant (p<0.05) when modeled simultaneously.

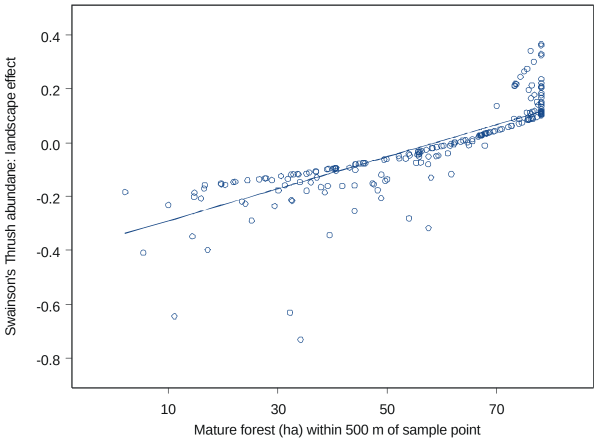


Fig. 7 Effect of landscape composition on Swainson's Thrush abundance. Landscape effect is an indicator ofabundance once the effect of stand-level habitat has been statistically removed ($P < 0.05$).

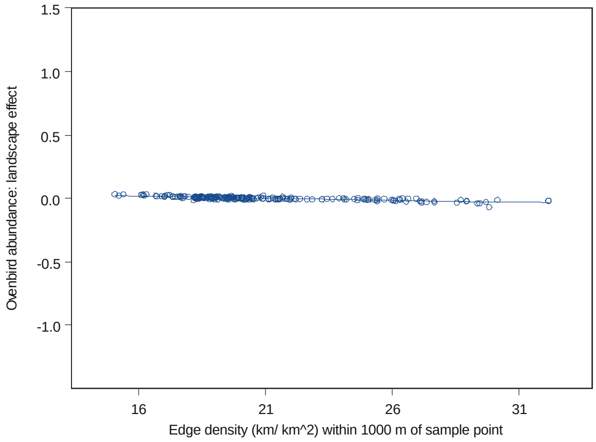


Fig. 8 Effect of landscape pattern (edge effect) on Ovenbird abundance. Landscape effect is an indicator ofabundance once the effect of stand-level habitat has been statistically removed. This relationship is not significant ($p > 0.1$).

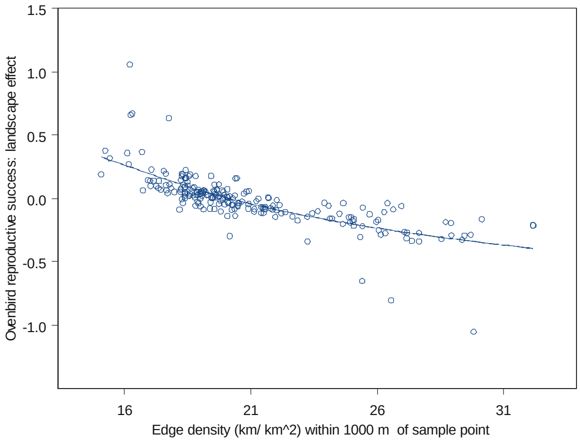


Fig. 9 Effect of landscape pattern (edge effect) on Ovenbird reproductive success. Landscape effect is an indicator ofabundance once the effect of stand-level habitat has been statistically removed ($p < 0.05$).