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Land use intensity and forest cover change: effects on the community composition of birds in the boreal forest

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SFM Network Final Project Report

Land use intensity and forest cover change: effects on the community composition of birds in the boreal forest

SFM Network Project: Land use intensity and forest cover change: effects on the community composition of birds in the boreal forest.

by

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RESEARCH QUESTIONS AND OBJECTIVES

Background:

This proposal arises from my previous NCE/SFM research as part of the Landscape Structure and Biodiversity Project (LSBP; see Hannon in press for a review of this project). In that project we worked in landscapes disturbed by logging and fire and developed models that predicted bird species' presence/absence and abundance related to local vegetation structure and composition and to amount, composition and configuration of forest cover in areas of up to 1 km radius around sampling points (Hannon 1999). Two main results emerged: 1) each species responded differently to local *vs* landscape structure and 2) we realized that our sampling areas may not have had sufficient forest cover removed to show significant effects on species distribution and abundance. In addition, our sites did not encompass a full range of possible land use activities that will occur in the boreal forest in the future.

My previous work on fragmentation effects on birds in the boreal forest lead me to consider the importance of landscape context of forest fragments, since effects in forest fragments differed between landscapes logged and those disturbed by agriculture (Hannon & Cotterill 1998; Cotterill & Hannon, 1999) and we found that some species could compensate for forest loss by moving into other habitat types (Norton, Hannon & Schmiegelow, 2000). Hence studies on all landscape elements, not just the forest fragments, are essential to assess the effects of forest removal and land use activities on biodiversity. In addition, theoretical models have shown that there may be thresholds of forest cover above which the effects of habitat fragmentation are minimal (e.g. Pearson et al 1996) and hence an analysis of a gradient of forest cover and land use activities is essential to identify these thresholds (e.g. Blair 1996; McIntyre & Hobbs 1999). A search for common structural or functional elements of different land use activities will enable easier application of landscape metrics for monitoring landscape change and its effects on biodiversity. Finally, knowledge of changes in community composition of organisms as land use activity increases and/or forest cover decreases will be essential for monitoring responses in biodiversity to land use change. I used birds as biodiversity indicators as they are easy to census and they operate on scales appropriate to the scale of change produced by logging, agriculture and oil and gas activity

Global Objective:

- to understand the relationship between land use intensity/land cover change and biodiversity changes in the boreal forest and to develop indicators of these for biodiversity monitoring.

Specific Objectives:

1. To determine how to measure land use intensity.
2. To determine how well we can predict species presence/abundances from remotely sensed information.
3. To determine how bird community composition changes with changing land use intensity and overall forest cover change.
4. To use this information in landscape planning in a regional context to conserve intact bird communities and conserve species at risk of declining due to landscape change.

PROGRESS, KEY FINDINGS AND CONTRIBUTIONS

Objectives 1 & 2: To determine how to measure land use intensity. To determine how well we can predict species presence/abundances from remotely sensed information.

This project was done in collaboration with A. Sanchez (Earth and Atmospheric Sciences) under the LUCC umbrella group. We used a set of land use categories devised by Sanchez for his work in Costa Rica, modified for use in Alberta landscapes. This consisted of cover type classifications (e.g. aspen forest) modified by descriptors such as age and use (e.g. cattle grazing, clearcut). We spatially referenced and took pictures of all habitat types to help classify a Landsat image and measured detailed vegetation around sampling points (using protocols developed for LSBP). Land use classification done by Sanchez lab (see his report). All field sampling has been completed, however, data analysis is not complete because the image classification was not adequate to delineate in enough detail the habitats used by birds. In order to be useful to predict bird species presences, we need to know forest age, tree species composition within stands and be able to differentiate land uses such as pasture vs crop. IKONOS images were purchased for part of the study area to try and remedy this, but no progress has been made to finish this classification. The only dataset analysed is the one for owls (see below).

Since our site at Athabasca did not have AVI data, we have to rely on remotely sensed data. However, for our sites used in the LSBP study, we had both AVI and a Landsat image classified by the Sanchez lab. In Table 1 are the results of a comparison between classifications

Table 1. Comparison of land cover types in three landscapes in north central Alberta using AVI and Landsat imagery.

	reference	reference	owlriver (cut)	owlriver (cut)	goodwin (burn)	goodwin (burn)
	Landsat	avi	Landsat	avi	Landsat	avi
%A_OPEN	2.53	1.26	1.83	2.48	4.86	0.74
%CUT	3.37	1.75	7.32	9.97	1.98	2.29
%BURN	0.00	0.00	0.00	0.00	34.98	52.01
%SbLt	0.88	21.72	0.72	20.97	0.00	9.77
%Pj	9.87	17.85	10.41	7.48	0.00	2.13
%Sw	8.38	1.88	5.59	1.57	0.00	0.75
%DEC	24.42	40.86	28.32	41.50	14.63	12.00
% MARSH	8.27	9.10	10.25	8.70	12.36	7.03
%WATER	3.08	1.54	5.43	4.15	10.54	11.57
% M_DP	na	2.80	na	1.89	na	0.44
% M_DS	na	1.24	na	1.29	na	1.27
%undiff con	15.22	na	12.86	na	10.23	na
%con mix	7.80	na	5.69	na	0.00	na
% dec mix	13.62	na	9.48	na	0.00	na
%undiff mix	2.55	na	2.10	na	10.41	na

using the two systems. First, note the discrepancies between some of the land cover classes using each system. Second, note the fairly high proportion of undifferentiated stands produced by the Landsat classification (i.e. these could not be classified by tree species). Clearly at this point, more work has to be done on classifications of Landsat images for them to be useful for wildlife biologists.

Objective 3. To determine how bird community composition changes with changing land use intensity and overall forest cover change.

To address this objective I initiated 3 main field projects as outlined below.

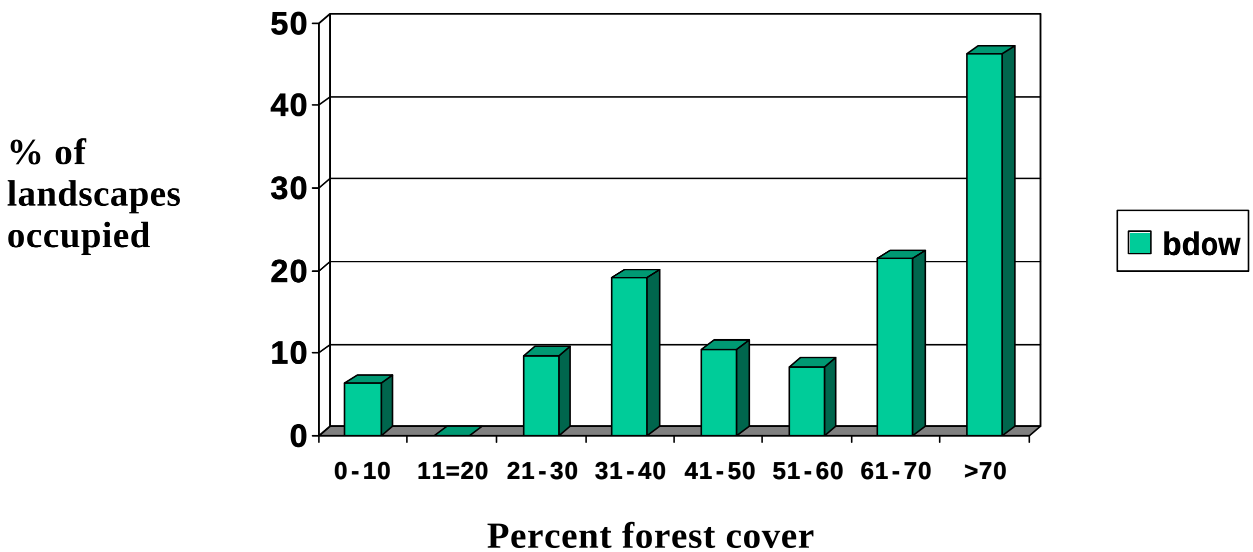
Project 1: Land use intensity and bird community composition near Athabasca, AB.

In this project we sampled the bird communities across a range of land use types in a primarily agricultural landscape. I chose this landscape as a "worst case scenario". In other words, we could determine how flexible bird species were to a range of disturbances and I could compare our results to data we have collected in forestry landscapes to see which species have dropped out. We sampled 143 points over a range of forest cover types and ages/land use activities. Migratory passerine birds were sampled using 3 rounds of point counts in spring, waterfowl/shorebirds were sampled in a survey of dugouts/wetlands, resident species (woodpeckers, chickadees, nuthatches, grouse) were sampled using playbacks in early April, and owls were sampled using playbacks in Feb. We spatially referenced and took pictures of all habitat types to help classify the image and measured detailed vegetation around sampling points (using protocols developed for LSBP). Land use classification was done by Sanchez lab (see his report). All field sampling has been completed, however, data analysis is not complete because the image classification was not adequate to delineate in enough detail the habitats used by birds. IKONOS images were purchased for part of the study area to try and remedy this, but no progress has been made to finish this classification. The only dataset to be analysed is the one for owls (see Project 2 below).

Project 2: Effects of forest cover and configuration on presence of resident owl species

This project was completed by my MSc graduate student Stephanie Grossman (Grossman 2003). The study was conducted in 3 study areas: Beaverhills area, Meanook (near Athabasca) and Lac la Biche. These varied in amount of regional forest cover and primary land use (agriculture vs forestry). Owls were sampled using standard playback techniques in Feb-April in 45-50 3X5 km landscapes within each study area. Because owls have larger home ranges than passerines and woodpeckers, the reclassified Landsat images prepared by Young (2003) (Sanchez lab) could be used in the analysis of forest cover levels and configuration. Three owl species were abundant enough to analyse: Barred Owls (*Strix varia*), Great-horned owls (*Bubo virginianus*) and Northern Saw-whet owls (*Aegolius acadicus*). Great-horned owls were most abundant in the Ministik region where forest cover was lowest (25% forest cover/62% anthropogenic/agricultural matrix); Saw-whets were least abundant at Lac la Biche (55% forest cover/13% anthropogenic/forestry matrix) and found at similar frequencies at Ministik and Meanook, and Barred Owls were found most frequently at Meanook, where forest cover was intermediate (45% forest cover/36% anthropogenic/agricultural matrix). Overall, Great-horned owls were most likely to be detected in areas with moderate levels of forest cover and moderate levels of fragmentation (measured by patch size, amount of edge, connectedness of patches) and their numbers dropped in landscapes with very high or low values of these variables. Saw whets also responded positively to increases in forest cover, but were most abundant in landscapes with moderate to high forest cover that were patchy. Barred owls appear to prefer landscapes with moderate forest cover, but with some large patches. Evidence for threshold effects, analysed using break point regressions, was not strong for any species and there appeared to be a lot of variation across sites and regions. However, the barred owl appeared to be most sensitive to reductions in overall forest cover (Fig. 1).

Fig 1. Percentage of landscapes occupied by barred owls over a range of forest cover conditions. N varies between 12-31 for each forest cover category (Grossman 2003).



Project 3: Effects of forest cover and configuration on presence and mating success of resident grouse, woodpeckers and passserines in an agricultural landscape

This project is being conducted by my PhD student, Trisha Swift. She has completed 2 field seasons and will be doing her third field season next spring/summer. The objectives and rationale of this project are:

1) To determine the shape of the relationship between bird presence/abundance or reproductive success and the amount of forest cover in the landscape. Do "critical thresholds" exist? The effect of a given amount of forest loss on a population may depend on how much remains to begin with; rather than declining linearly with habitat loss, models predict that abundance or persistence may drop suddenly below some critical threshold in habitat cover (Fahrig 2001).
2) To compare the relative effect of forest amount versus configuration on the presence/abundance and reproductive success of resident birds. Fragmentation *per se* results in changes in the configuration of habitat (e.g. the shape, size, number, and distribution of remaining habitat patches) rather than in less total habitat (Fahrig 1997). However, it remains unclear what the relative impacts of habitat loss versus fragmentation are on the ability of populations to persist (Villard et al. 1999).
3) To examine how the resolution (grain) of the image affect the fit of the models (1 and 2 above). This should reflect the appropriate resolution at which to measure landscape indices for resident birds; the scale at which organisms operate on the landscape likely

varies among taxa (Major et al. 2003).

4) To test the predictions of the above models in a new study region, near Athabasca, AB. Testing ecological models is vital in assessing their generality.

The first two seasons were conducted in an agricultural region just east of Edmonton, Alberta. Resident passerines, woodpeckers and grouse were sampled in a series of 100 ha landscapes that ranged in forest cover from 0.6% to 90%. Landscapes were chosen so as to vary forest configuration as much as possible. Playbacks were broadcast at nine stations within each landscape to increase detection rates of resident birds. Birds were recorded by species, and by sex and age (adult or fledgling) where possible. The two latter were used to derive reproductive indices (pairing success and fledgling abundance).

Analyses to date have addressed the first objective. The relationship between each species' presence/ abundance /reproductive indices and forest amount were investigated by comparing the fit of a series of possible models: one linear model and several critical threshold models (with thresholds defined at 10, 20, 30, 40, 50, or 60% forest cover) using AIC. In 2002 the "best" models suggested critical threshold responses (between 10-50% forest cover) for eight of eleven species. Threshold values were consistent for four of these species in 2003: presence of white-breasted nuthatch (10-20% forest cover; Fig. 2), hairy woodpecker (10%), and black-billed magpie (10%); and abundance of black-capped chickadee (20-30%). AIC weights were very high (0.97 or higher for the one or combined two best models) for the first three and 0.47-0.64 for the last. There were sufficient reproductive data to analyse for four species. Chickadee fledglings had a 20-30% threshold in 2002 and 10% in 2003; white-breasted nuthatch, hairy woodpecker and downy woodpecker pairing success had no strong best model(s), though a 30-60% threshold or linear model was suggested for the first two. In 2003, the apparently "single" white-breasted nuthatches and hairies were followed to get more accurate pair data. With these new data a 10-40% threshold was suggested for white-breasted nuthatch pairs (Fig. 2), and a 10-20% threshold for pairs of hairy woodpeckers.

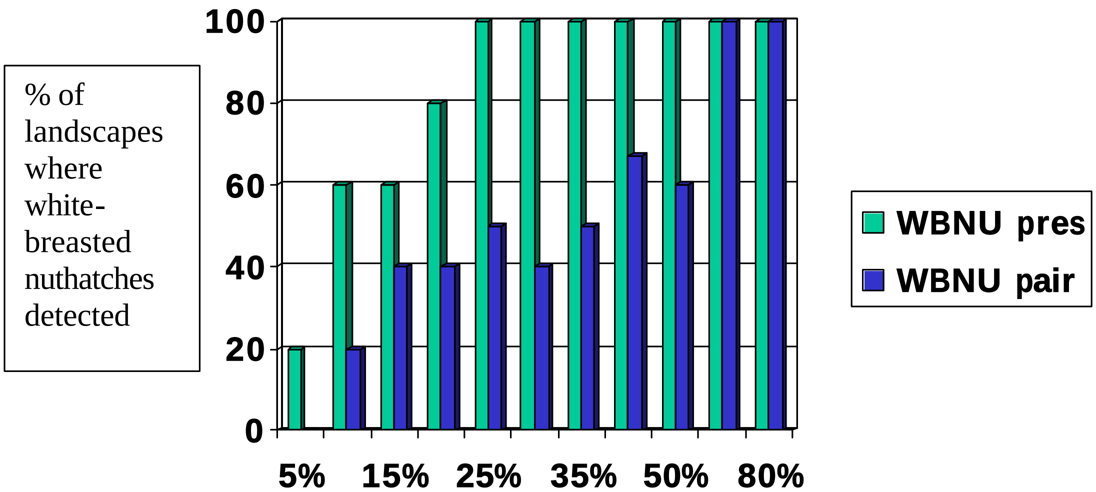


Fig. 2. Presence of white-breasted nuthatch and presence of white-breasted nuthatch pairs in landscapes with different levels of forest cover.

The results for the first objective indicated that threshold responses to changing forest cover were common among resident birds, and imply a sensitivity to moderate or severe levels of forest loss. If threshold responses are common among wildlife in general, this has implications for wildlife monitoring. A population that has remained stable despite progressive habitat loss may decline suddenly below some unknown threshold, thus precluding effective conservation measures.

To this point forest metrics have been measured from a Landsat satellite image with a resolution of 30m. However, this resolution does not pick up small wood lots or fence rows, which may be important habitat or movement corridors for birds (Johnson and Adkisson 1985). Hence, an IRS satellite image with a resolution of 5m will be hand digitised, and new forest amount and configuration variables calculated. The fit of the models (from the first two objectives) generated using the coarse versus fine resolution forest indices will then be compared. The resolution that yields models with the best fit should reflect the grain at which resident birds operate on the landscape, and thus the grain at which landscapes should be managed for these birds.

In 2004 bird surveys will be conducted near Athabasca, Alberta, using the same techniques and design used in 2002-2003. These data will be used to test the predictions of the models described in objectives 1-3. The new study region is also an agricultural area in which forest cover is aspen dominated. Hence, if the responses of resident birds are similar in this region to those predicted from 2002/2003 models, this will suggest that these relationships can be generally applied to aspen/agricultural systems. They can then be used in predicting the consequences of habitat change in such systems or in conservation planning.

Objective 4: To use this information in landscape planning in a regional context to conserve intact bird communities and conserve species at risk of declining due to landscape change.

My research on this objective is ongoing and has 3 main components.

1) **Species most sensitive to reductions in forest cover**

From field data collected by me and my students, we are in the process of identifying species that appear to be most sensitive to changes in overall forest cover (i.e. they are the first species to decline, be absent or have reduced pairing success as forest cover is reduced). From Grossman's work, we know that Barred Owls appear to be the most sensitive owl species to reductions in forest cover and Swift's preliminary analysis indicates that it is the white-breasted nuthatch. In a cross-Canada analysis of migratory species we (SFMN researchers Pierre Drapeau, Marc-Andre Villard and me) examined passerine species in Alberta, Quebec and New Brunswick and assessed their sensitivity to loss of forest cover at both the stand (within 100m of the sampling station) and landscape (within 1km of sampling station) scales. Twenty-two species of the 56 forest species analysed showed lower abundances or absences in stands and/or landscapes with reduced forest cover. Of these, 8 are considered to be older forest specialists (Schmiegelow and Monkkonen 2002) and 3 are rare in commercial forest types in Alberta (Hannon et al. 2003) (Table 2).

2) Rare species of concern for managers of boreal mixedwood stands.

We have compiled a list of rare species found in commercial aspen-mixedwood stands and conducted an analysis of which species should be targetted by managers for special management

(Hannon et al. 2003). These rare species are Bay-breasted Warbler, Canada Warbler, Cape May Warbler, Brown Creeper, Golden-crowned Kinglet, Boreal Chickadee, Black-and-white Warbler, Warbling Vireo, Western Wood-Pewee and Philadelphia Vireo.

Table 2. Species that were negatively affected by loss of forest cover in at least one of the 3 locations at both scales or at either the stand or landscape scale. Species with # are old forest specialists, those with @ are considered rare species in commercial forest types in Alberta (Hannon et al. 2003), and those with & were species that increased in abundance with increasing basal area in partial cuts (Tittler et al. 2001). Resident species are bolded.

Species	Responded negatively at the stand scale	Responded negatively at the landscape scale
Brown creeper[#@]	*	*
Blackburnian warbler	*	*
Bay-breasted warbler[#@]	*	*
Black throated blue warbler	*	*
Golden crowned kinglet[#@]	*	*
Red breasted nuthatch[#]	*	*
Yellow-rumped warbler[&]	*	
Veery	*	
Black-throated green warbler[#]	*	
Ovenbird	*	
Red-eyed vireo	*	
Ruby crowned kinglet	*	
Rose-breasted grosbeak		*
Swainson's thrush[#&]		*
Black-capped chickadee		*
Boreal chickadee[#]		*
Yellow-bellied sapsucker		*
Purple finch		*
Northern waterthrush		*
Northern Parula warbler		*
Connecticut warbler		*
Magnolia warbler[#]		*

3) Temporal and spatial variation in population dynamics of forest birds: issues for monitoring biodiversity.

This project is being conducted by my MSc graduate student Judith Toms. Analysis is almost complete and Judith will defend her thesis by Dec 2003. Using data sets collected on breeding passerine birds in relatively undisturbed locations at the Calling Lake and Meanook study sites, Judith is examining the population dynamics of songbirds and their implications for monitoring programs and experimental design. By comparing two survey techniques (point counts and territory mapping), she has affirmed that point counts are an adequate index of the number of territorial individuals for 12 study species. She then developed a way to determine the appropriate spatial scale for studies of population dynamics: a clustering technique/ randomization test followed by estimating the scale of spatial autocorrelation. Fifteen of 25 species examined at the Calling Lake site were significantly autocorrelated to distances greater than or equal to 10km, and results from the Meanook site were consistent with those from Calling Lake. She is currently investigating plausible mechanisms of the observed autocorrelation by examining several factors known to operate at large spatial scales: breeding and wintering season weather, white spruce cone crops, phenology of flowering trees and shrubs, and abundance of Lepidopteran caterpillars. Results to date suggest that monitoring programs require grids of point count stations, and that grids should be separated by some tens of kilometers in order to be independent. Further work will examine the implications of temporal variability for monitoring programs.

MANAGEMENT IMPLICATIONS

1. Research should be funded to increase the resolution and detail of classified Landsat imagery. This will be highly useful to forest managers and wildlife ecologists both for monitoring of habitat supply for wildlife and for building predictive models of sensitive wildlife.
2. The approach of looking for species which are sensitive to reductions in forest cover has been fruitful as it will allow us to narrow down which species should be monitored as indicators for forest ecosystem change. Not all species show thresholds responses to reductions in forest cover, but some do.
3. Presence/absence data may not be sufficient to detect possible changes in the persistence of birds in forested landscapes under management. Some species showed a higher threshold when reproductive indices were measured, than when presence alone was measured. This suggests that we must develop indicators of population persistence or reproductive output for sensitive species.
4. Abundances of birds are highly variable across space and time. Analyses of spatial autocorrelation and variability in population dynamics across space are required to plan appropriate monitoring programs.

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