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Fiona K.A. Schmiegelow and Steven G. Cumming

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Project name: Directed Sampling of Avian Indicators of Forest Change: Refining Models and Sampling Methods, and Identifying Species at Risk

THE REMOTE AREAS PROJECT - A RETROSPECTIVE STUDY OF AVIAN INDICATORS OF FOREST CHANGE

Fiona K.A. Schmiegelow[1] and Steven G. Cumming[2]
[1]Department of Renewable Resources, University of Alberta
[2]Boreal Ecosystems Research Limited, Edmonton, Alberta

Department of Renewable Resources (GSB 751)
University of Alberta,
Edmonton, AB, Canada. T6G 2H1
780-492-0552 fiona.schmiegelow@ualberta.ca

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Background: The boreal forest is the largest terrestrial biome on earth. Canada contains a significant proportion of the world's boreal forests, and the greatest area of intact forest (i.e. free from industrial and other human developments). Mixedwood forests are the most productive of boreal forest types, from both an ecological and economic perspective. The province of Alberta contains most of the mixedwood forest found in western Canada, and much of this has been allocated for various forms of resource extraction. There is thus an urgent need for reliable information on which to base sustainable management practices and long-term conservation planning in these forests.

Resource use in Alberta's forested regions by various industrial sectors, primarily forestry and energy, has the potential to drastically alter the composition and structure of these forests and related biota. In recognition of the complexity of managing for single species, many forest companies are adopting a landscape approach to biodiversity management. Such a coarse-filter approach assumes that maintenance of suitable habitats and landscape structure, within some range of (natural) variability will result in conservation of biological diversity. However, it is necessary in forest landscape management to identify and monitor measurable parameters (indicators) to check whether biodiversity objectives are being realised. Birds are often used as an indicator group for biodiversity due to their abundance, ease of census, and use of a diversity of habitat types. In addition, they have known sensitivities to to a variety of forest changes induced by development activities, such as in the age, composition and spatial strtruture of forests. Alberta's boreal forests support particularly high bird diversity, in part due to their productivity, and also because they intersect the eastern limits of species with western ranges, and the western limit of species with more eastern ranges.

Effective wildlife conservation in forested landscapes managed for multiple objectives increasingly relies on models to predict the outcome of alternative management scenarios on the distribution and abundance of focal species or groups. Habitat models based on remotely sensed data such as forest inventories are inexpensive to develop compared to models based on detailed vegetation surveys, and facilitate rapid assessment over large areas. Further, there is little practical point in modeling species abundance in terms of independent variables that can neither be measured nor estimated from available, broad-scale data. In contrast, once developed and validated, models based on vegetation inventory attributes can be linked to landscape simulation models to evaluate the consequences of alternative management activities and policies over large spatial and temporal scales, and for comprehensive conservation planning.

Objectives: The Remote Areas Project was a multi-year, retrospective study, designed to:

1. Better describe distributions, relative abundances, and habitat associations of breeding bird species, in boreal mixedwood forests of central and northern Alberta.

2. Establish relationships between these attributes and patterns of land-use related to forestry and energy sector activities.

3. Help define ecological benchmarks, contribute to the identification of resource development thresholds, and develop meaningful indices of avian biodiversity.

4. Develop and validate multi-scale predictive bird-habitat models suitable for application in GIS-based and other spatial frameworks used for resource management and conservation planning.

Study Design: The first stage in designing this research project was to construct an impact hypothesis diagram (Figure 1), that described potential mechanistic linkages between various disturbance agents and the abundance of the indicator group.

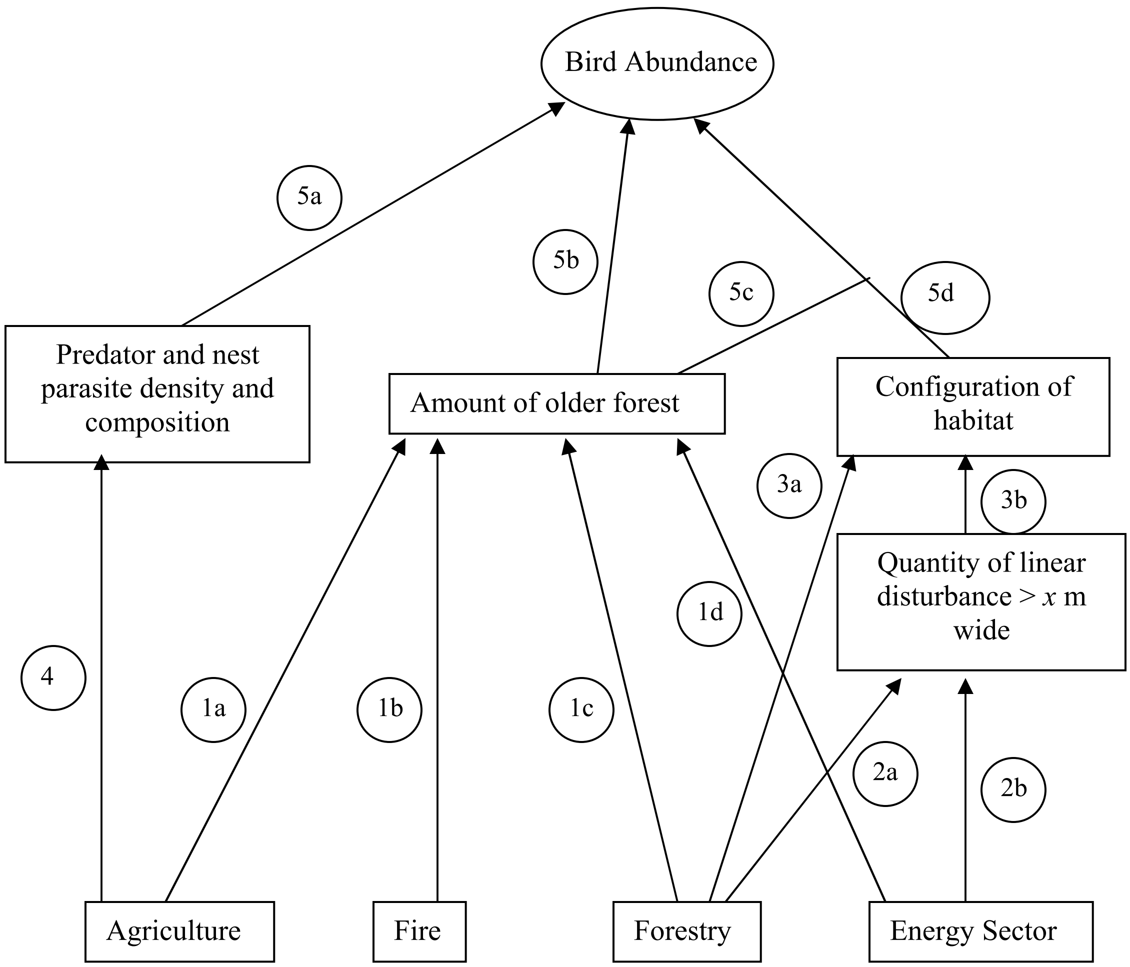

Figure 1. Impact hypothesis diagram for forest birds in northeastern Alberta.

We decided to focus our research efforts on the effects of forestry and energy activities on the amount and configuration of older forests, as these were the factors contributing the most uncertainty with respect to our ability to predict management outcomes. The rationale underlying the Remote Areas Project was that the existing contrast in landscape attributes could be used to quantify and predict relationships (i.e. a retrospective approach). Sampling units were 100 km^2 landscapes, equivalent to townships. A multivariate approach was used to characterize the habitat composition and structure, and human footprint (forestry and energy sector related activities), of all potential sites, based on GIS information obtained from vegetation inventory maps, supplemented by additional coverages of energy sector activity. Selection of sampling sites was model-based, using a form of optimal sample design. The goal was to sample landscapes that were likely to provide the most information about landscape-scale attributes of theoretical and management interest, namely the abundance and distribution of habitat types of perceived importance to forest birds (such as older, merchantable forest), and the amount of recent disturbances (both natural and anthropogenic). The widest possible range (e.g., low to high) of each landscape attribute was covered by the initial stage of sampling, in order to address threshold issues. For example, our samples included sites with very little energy sector activity (minimal density of seismic lines and no well sites), as well as those with high activity levels (~84 well sites with associated infrastructure). See Schmiegelow et al. (2004) for further details on study design.

Field sampling was initiated in May of 2001 in northeastern Alberta (study area bounded on the south by 54”30”, on the west by 117’30”, on the north by 58’, and on the east by the Saskatchewan border (110’); Figure 2a). The study area included Alberta Pacific Forest Industry’s and Weyerhaeuser Slave Lake’s Forest Management Areas, where a total of 43 townships were surveyed (Figure 2b). Using the data gathered from the 2001 summer field season, predictive models were generated, which allowed identification of covariates with highly uncertain effects, and of landscapes where sampling would be expected to reduce this uncertainty and improve the statistical models. This information was used to direct sampling in the 2002 field season. A total of 53 townships were surveyed from May to July of 2002, selected from an expanded study region that included Slave Lake Pulp’s Forest Management Area (Figure 2b).

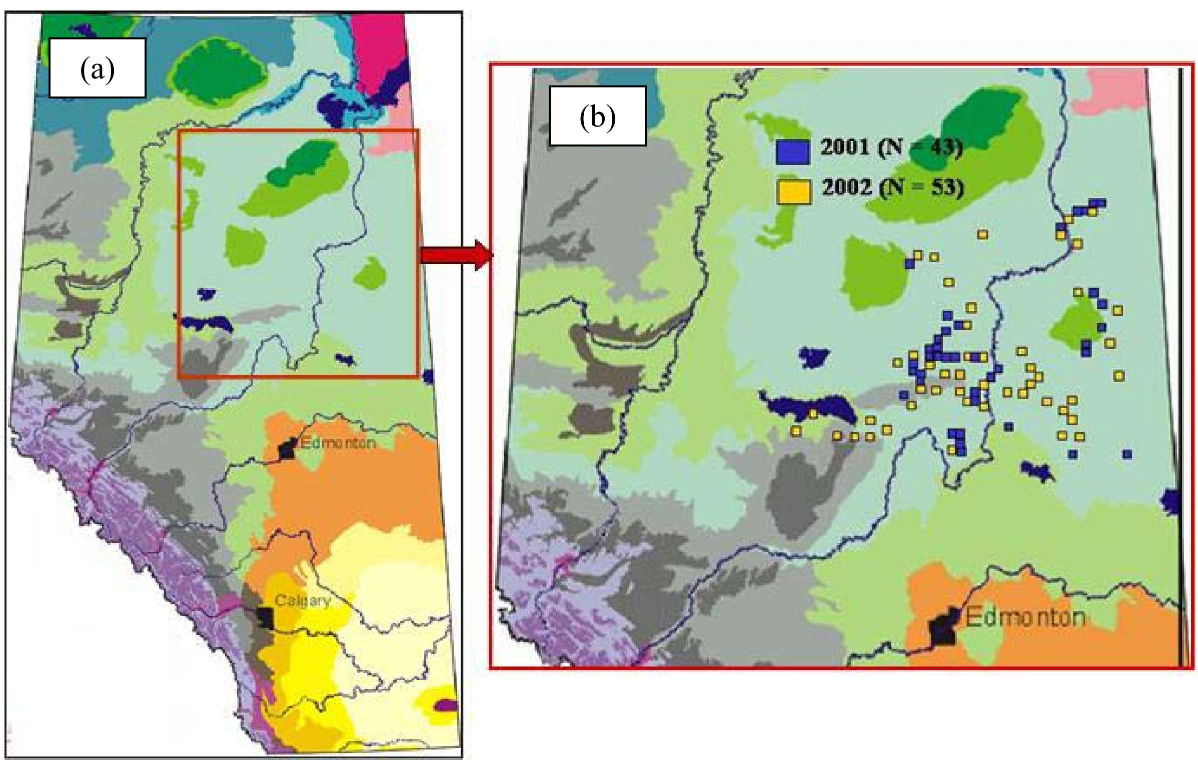

Figure 2. Location of the study area in Alberta (a), and location of sampling sites (10x10 km landscapes) in 2001 and 2002 (b).

Bird Sampling - Within each landscape, several survey methodologies were used during the breeding season (May-July; Figure 3). The location of sampling areas within landscapes was based on reclassified forest inventory data, which we reduced to twelve major habitat classes. Triangular line transects were established to sample forested habitat types roughly in proportion to their abundances, adapting a protocol widely used for wildlife surveys in Finland and Sweden. Point count surveys were conducted in one or more large patches of older commercial forests. In 2001, we focused on patches of older deciduous or deciduous dominated forest. In 2002, a modified protocol and increased sampling effort placed equal emphasis on patches of older coniferous-dominated forest, in order to better capture species associated with this habitat type. Point counts were augmented by playback methods to increase detections of breeding activity. Each landscape was visited once during the breeding season, in the year of sampling. Winter surveys for resident bird communities were also conducted in many of the sample landscapes.

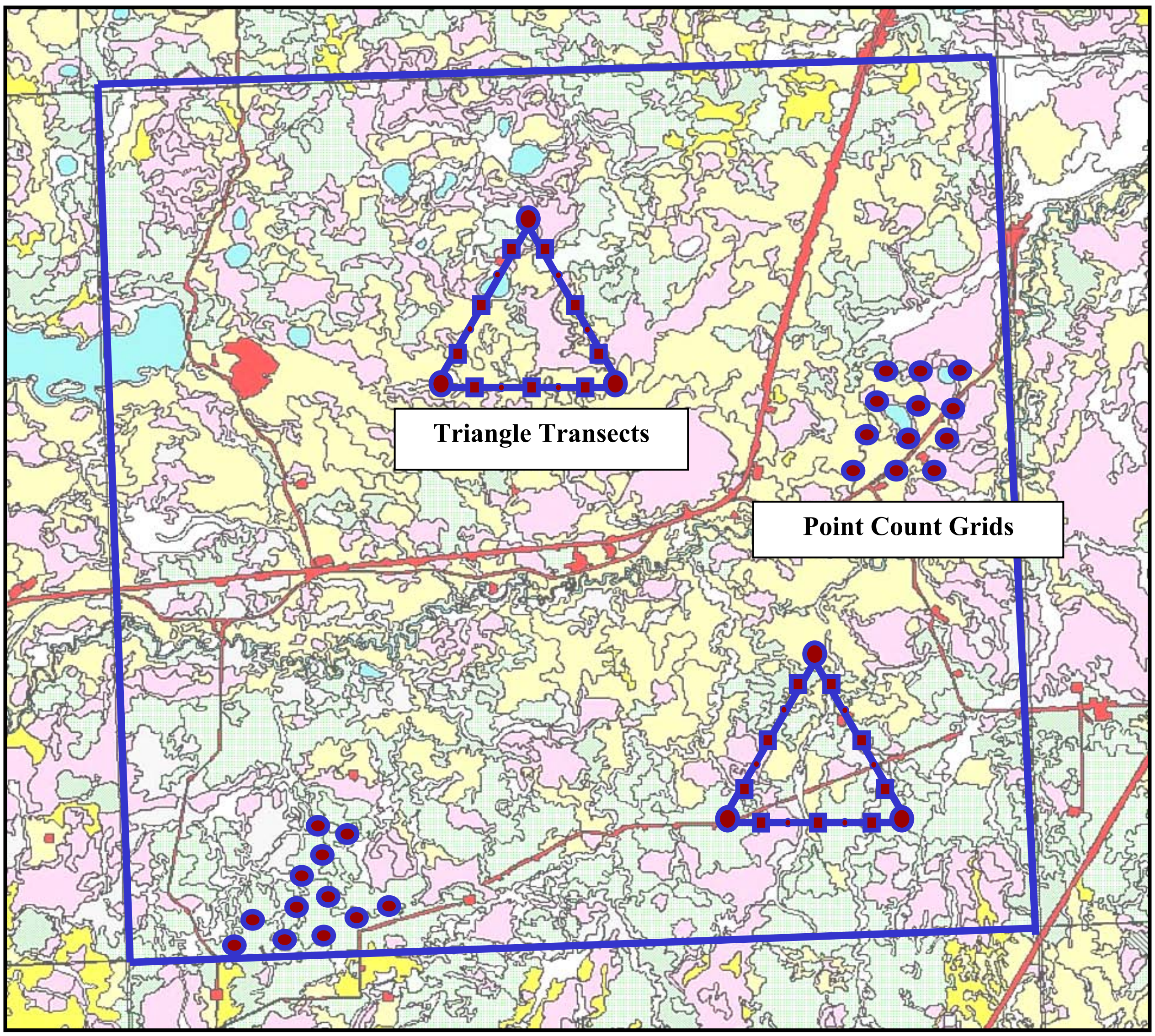

Figure 3. Sample design for forest bird surveys within 10x10 km landscapes.

Results to Date: In the 2001 and 2002 field seasons, we sampled a total of 96 landscapes, and collected more than 30,000 bird records. Most detections were of singing males. The five species most commonly encountered (Tennessee Warbler, Yellow-rumped Warbler, Swainson's Thrush, Ovenbird and White-throated Sparrow) accounted for 30% of all observations. The Black-throated Green Warbler was the 4^{th} or 5^{th} most abundant species of neotropical migrant in patches of old mixedwood forest. The species was uncommon in the first Breeding Bird Atlas surveys for northeastern Alberta, ranking 29^{th} out of 37 species of NTM. It is also very uncommon in Breeding Bird Survey data from this region. Results below provide some clues as to the reasons for this discrepancy.

Preliminary modelling of the first two years of point count data revealed that the patch-level abundance of many old-forest songbirds is significantly related to both the amount and spatial distribution of older forest in the surrounding landscape. The total amount of habitat is important, but so are the size, shape and spatial arrangement of habitat patches across the landscape. The abundances of some species are also very sensitive to the amount of industrial development on the landscape, or the size of "the industrial footprint," measured by the densities of linear disturbances such as roads and pipelines. As the density of roads and pipelines within a landscape goes up, the abundance of species such the Black-throated Green Warbler goes down, even in patches of their favoured habitat (Figure 4). Other species are also negatively affected by the amount of forest recently harvested. The mechanisms are not clear, but some species may be considered "forest-interior" species that require large tracts of contiguous forest. The Breeding Bird Survey employs roadside counts that may bias detection of such species.

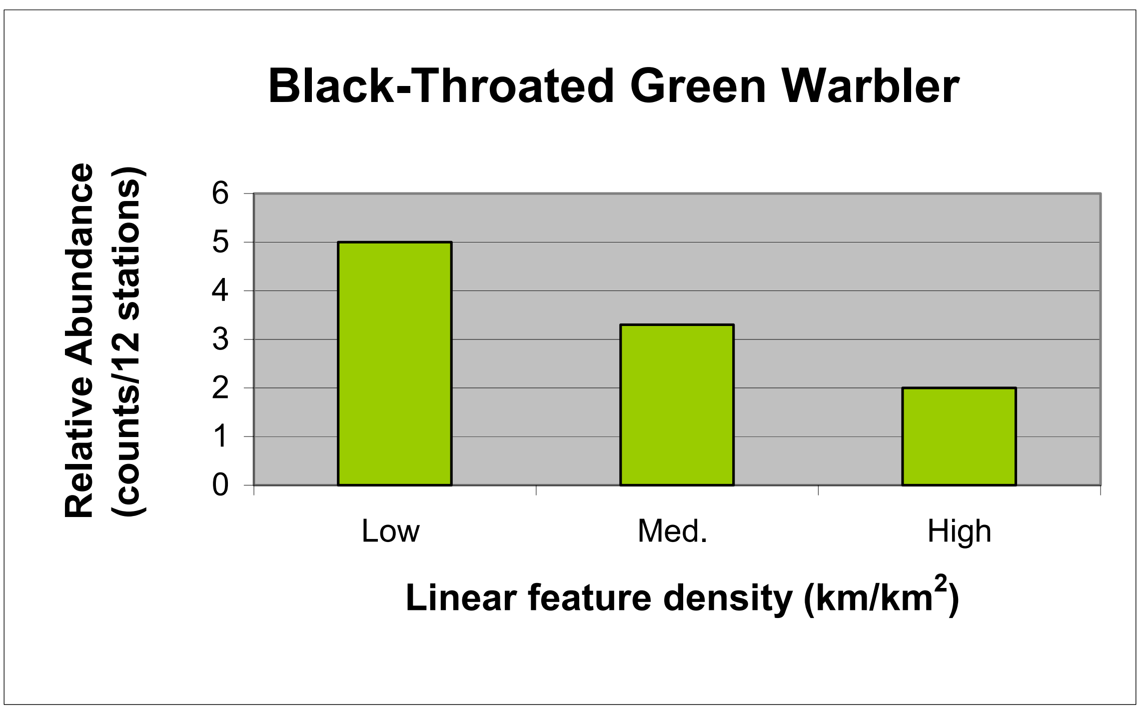

Figure 4. Mean detections of Black-throated Green Warblers on grids of 12 point-count stations in landscapes with low, medium and high densities of large linear disturbances (primarily roads and pipelines).

It is also clear that there are strong geographic gradients in the abundance of many species, likely due to range limits. For example, the best Black-throated Green Warbler (BGNW) model included both westing and northing as explanatory variables, and also the sampling date:

$$\text{BGNW abundance} = \underset{-}{\text{North}} + \underset{+}{\text{West}} + \underset{+}{\text{jd}} + \underset{+}{\text{Cv}} + \underset{-}{\text{Cf}} + \underset{-}{\text{W}} + \underset{-}{\text{P1}}$$

where North = degrees north, West = degrees west, jd = julian date, Cv = amount of older forest, CF = configuration of older forest, W = density of well sites, and P1 = "excess" road and pipeline density, given well density. Symbols below the variables in the equation (+/-) indicate the direction of the relationship. Note that all variables associated with increased industrial activity (CF, W, P1) enter negatively, whereas Cv enters positively. Overall, the influence of sampling date was strongest for neotropical migrant species (Figure 5). This is not surprising, as these long-distance migrants face the most constrained breeding season, with first arrivals late in May.

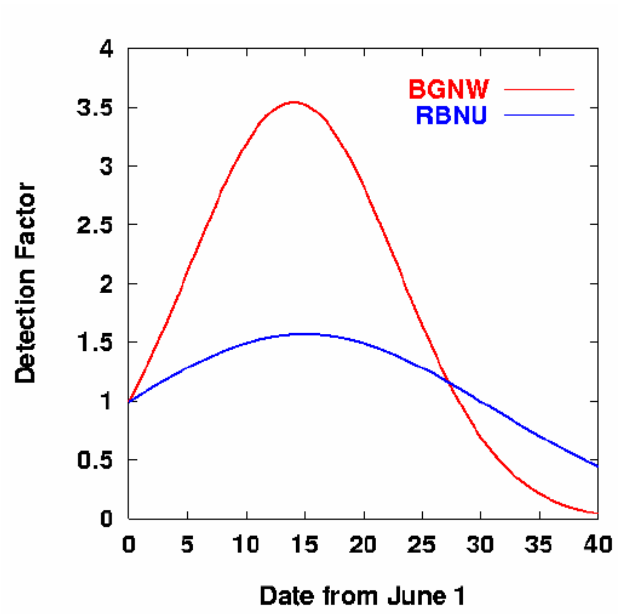

Figure 5. The influence of sampling date within the breeding season on the detected abundance of Black-throated Green Warbler (BGNW), a neotropical migrant species, and Red-breasted Nuthatch (RBNU), a resident, at a location in the approximate center of the study region

Our modified within-site sample design in 2002 achieved the goal of better capturing species associated with older coniferous forests, and revealed marked variation in the community composition of old deciduous and old coniferous forests (Table 1). Our initial habitat stratification for the purposes of quantifying amount and configuration of older forest did not distinguish these two stand types. While abundances of both habitat types are predicted to decline with increased harvesting, older coniferous forests face the greatest pressures. Thus, species restricted to this habitat type may be considered most at risk in the near-term.

Table 1. Ranked frequency of the 15 most commonly detected species in older coniferous and older deciduous forests in northeastern Alberta. Species whose names appear in italics are unique within the top ranks.

Older Coniferous Forest		**Older Deciduous Forest**	
Species	**Frequency**	**Species**	**Frequency**
Tennessee Warbler	0.14	Tennessee Warbler	0.15
Yellow-rumped Warbler	0.13	Yellow-rumped Warbler	0.12
Swainson's Thrush	0.09	Ovenbird	0.09
Red-breasted Nuthatch	0.05	White-throated Sparrow	0.08
Winter Wren	0.05	Swainson's Thrush	0.08
Pine Siskin	0.05	Red-breasted Nuthatch	0.04
Ovenbird	0.05	*Red-eyed Vireo*	0.03
White-throated Sparrow	0.04	*Black-throated Green Warbler*	0.03
Golden-crowned Kinglet	0.03	Pine Siskin	0.03
Western Tanager	0.03	Solitary Vireo	0.02
Chipping Sparrow	0.03	Chipping Sparrow	0.02
Bay-breasted Warbler	0.02	Yellow-breasted Sapsucker	0.02
Solitary Vireo	0.02	Western Tanager	0.02
Ruby-crowned Kinglet	0.02	*Mourning Warbler*	0.02
Cape May Warbler	0.02	*Least Flycatcher*	0.02

Next Steps: Given the strong influence of both space and time on species distribution and abundance, it is important to account for these variables in the statistical models describing response to resource development activities. All analyses to date have been conducted at the scale of our sample landscapes (100 km^2). We now plan to conduct finer-scale analyses of the spatially-referenced data to account for local variation (e.g., patch size and matrix effects). Finally, we are reconsidering our initial choice of focal habitat (old mesic forest), given species-specific responses to cover type variation within this broad habitat class (e.g. differing songbird communities in old coniferous-dominated and deciduous-dominated mesic forest). Nevertheless, based on the analyses to date, we conclude that energy sector and forest harvesting activities have already resulted in significant declines in populations of some species.

While our sample design strived to encompass the full range of attribute values available, we were constrained by access considerations, which resulted in us failing to sample any truly pristine areas (i.e. those more than ~ 20 km from the nearest road or seismic exploration line). Such areas tend to occur in the north/northeast of our study region, and along the Athabasca River Valley. Given the striking effects of industrial development seen in the first two years of data, we feel it is imperative to sample landscapes at the lower end of the existing range of industrial development, to provide an anchor for relationships. Further, the large tracts of older, riparian forest that exist in the Athabasca River Valley are identified as key components of protected areas designs for the area, but there exists no avian data for these sites. To determine potential bird abundances in undeveloped mixedwood forests, we plan to survey truly remote, "pristine" areas in northeastern Alberta in 2004. Pristine areas have been defined as landscapes with at least 20% of old upland deciduous or mixedwood forest where the energy sector has never entered (based on well-site densities as of 1999) or where there has been no oil and gas activity since 1980. Some potential sites have been identified in the Athabasca and Clearwater River valleys, the slopes of the Birch Mountains, and south of Muskwa Lake. Access to these sites is possible only by helicopter, floatplane or watercraft. Within sites, survey techniques will be similar to those used in 2001 and 2002.

Benefits of This Research: The statistical models of bird-habitat relations resulting from this study are predictive models of species distributions and abundances. The entire study was designed specifically so that these models could be directly linked to spatial simulation engines (including GIS applications) and used for conservation or management planning and cumulative impacts assessment. These applications can be used as a decision-support tool when evaluating land-use strategies for multiple values, including the identification of high conservation forests within forest certification processes, and the design of protected area networks.

Our work also has important implication for biodiversity monitoring programs. To be a useful management tool, a monitoring program must employ appropriate indicators, with established causal relationships to anticipated changes, and be statistically credible. We believe the methods presented here provide the rigour necessary to establish indicators, sampling and analytical techniques for boreal bird communities, as one component in the design of a robust biodiversity monitoring program.

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