

BOREAL AVIAN MODELLING PROJECT

(formerly known as: National Boreal Bird-Habitat Modelling Project)

Project Report 2007-08

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PROJECT DESCRIPTION:

The Boreal Avian Modelling Project (formerly the National Boreal Bird-Habitat Modelling Project) was initiated to help address the lack of basic information on boreal birds and their habitats across boreal forests in Canada. The rapid pace and rate of ecological change resulting from industrial development and climate change in the boreal forest has spurred the need to effectively manage species and their habitats. Although baseline data is lacking for much of the boreal, through the collective efforts of researchers and agencies across Canada, there is a critical mass of studies from which data can be collated and models of bird abundance, distribution and associations with climate and land cover can be developed. These models will be made broadly accessible to organisations interested in boreal conservation planning and migratory bird management. Models will be regularly updated with monitoring data or new research results as they become available.

The overall project objectives are as follows:

- a)** Assemble existing data sets on all boreal forest birds and their habitats through cooperative efforts with boreal bird researchers and associated agencies.
- b)** Develop spatially-explicit, habitat-based predictive models of bird species distribution and abundance in the boreal forests of Canada. These models must be capable of producing credible and testable predictions of future distribution and abundance patterns under a complex range of management, land use and climate change scenarios that will create forest conditions that have little or no current analogue.
- c)** Build support for development and application of these models to management of boreal forests in Canada through links with our partners. Expand efforts to engage end-users of project products to ensure relevance and applicability.

The relevance and application of the resulting information from this project are multifold to agencies concerned with conservation of boreal birds and forests:

1. As a foundation for conservation planning, including establishment of conservation objectives and priorities. The work will contribute to Bird Conservation Region Plans throughout boreal Canada, and also to proposed approaches to address the issue of 'incidental take' under the Migratory Birds Convention Act;
2. Information on habitat associations and use by boreal birds to inform strategic planning for migratory bird programs;
3. For the identification of priority habitats for protection, including evaluation of existing protected areas, and recommendations for new protected areas in boreal forests;
4. Information for the assessment of environmental impacts of development;
5. An education tool for scientists, planners, land managers, decision-makers, partners, and the broader public;
6. Support for monitoring of boreal birds in Canada, both to inform monitoring needs and sampling design, and as an analytical tool for resultant monitoring data.

Within the 2007-08 fiscal year, we achieved the following overarching results:

- (i) Launch of a publicly-accessible website presenting rigorously-developed models of distribution and abundance of boreal birds in western Canada as predicted by climate and habitat variables,
- (ii) Assembly of a comprehensive database populated with data on boreal birds from across Canada,
- (iii) Development of prototype national models based on remotely-sensed habitat & climate variables, and,
- (iv) Initiation of prototype regional bird-habitat models based on forest resource inventory data within forest management areas in the Boreal Plains.

REPORT ON RESEARCH PROGRESS:

Update on bird data assembly

(i) Workshop to foster relationships in Eastern Canada – Quebec, April 2007.

In order to foster data partnerships with researchers and agencies in Eastern Canada, we sponsored a workshop in Québec on April 22-23, 2007. The meeting was hosted by Cumming and technical committee member André Desrochers at Université Laval's research station in Forêt Montmorency. There were 14 scientists in attendance representing key avian ecology research groups from Québec and Atlantic Canada, including Environment Canada (EC) and Ducks Unlimited Canada (DUC). After a review of the project and results to date given by Steering Committee representatives, we heard a number of presentations on major modelling initiatives in Eastern Canada, notably regional predictive models developed by EC researchers and waterfowl distribution and abundance models developed by DUC. The DUC models were noteworthy in that they demonstrated the feasibility of expanding our modelling efforts to include bird groups beyond forest songbirds. The main results of the meeting were a renewed commitment to timely provision of data by members of the Technical Committee and the emergence of a formal data sharing agreement between the project and EC Québec Region. An indirect result of the meeting was an agreement with Hydro Québec who have provided very extensive datasets from otherwise unsampled regions.

(ii) Eastern Canada contacts

After the eastern Canada workshop described above, we initiated an intensive effort to contact data holders across eastern Canada. This consisted of initial contact, follow-up by steering committee members and provision of staff support to assist data management, negotiate individual data-sharing agreements and facilitate data transfer. Currently in the East we have incorporated 10 new projects, including over 50,000 stations from the Ontario Breeding Bird Atlas (of which over 15,000 are in boreal forest) and over 2,000 stations from Quebec, Newfoundland & Labrador, and New Brunswick. New data partners in the east include Ducks Unlimited Canada (Quebec), Hydro Quebec, OMNR Terrestrial Assessment Program, EC's Forest Bird Monitoring Program in Ontario and EC Atlantic Region, researchers from Acadia University, Université Laval, Université du Québec à Montréal and University of New Brunswick. We anticipate data from Newfoundland and Labrador Hydro in the near future and negotiations continue for the participation of EC Québec Region. [Update July 2008: data from EC Québec Region has been received.]

(iii) Updates to western datasets

Partnerships in western Canada continued to provide new data, from ongoing projects with new station locations. We incorporated 15 new project locations and data for 2250 more stations into the Western Dataset. These updates provided information from areas of boreal forest previously identified as data gaps, including portions of the Mackenzie Basin in NWT, eastern SK and the boreal shield of MB and SK.

(iv) Summary of bird data set

As of March 2008, the dataset contained 552,200 data points from 33,806 point count stations (Figure 1). Contributions have been provided from 39 data partners on 71 projects to date. Key gaps will be pursued through known data holders, particularly in Québec. Significant gaps will persist because there are large areas of the boreal forest, especially in the Boreal and Taiga Shield and Taiga Cordillera, where no surveys have ever been conducted. This highlights the need for targeted data collection programs, such as a long-term, national boreal-bird monitoring program.

We continue to store the raw data, project metadata, spatial covariates and derivative products at the University of Alberta, Department of Renewable Resources. These data products are also shared among Steering Committee members working on the analysis at the U of A Department of Biological Sciences and Université Laval Département des sciences du bois et de la forêt. Further sharing of the data is restricted by a data-sharing protocol currently under development and by the data-sharing agreements covering individual datasets. A number of options are being explored for long term archiving of the observational data and of the spatial covariates used to model them. However, one authoritative version will be housed and maintained in a spatial data warehouse being established at Cumming's lab at Université Laval. We expect that mirrors will be maintained at other agencies including Environment Canada. The best guarantee of long-term integrity and safety of the data is to replicate it amongst several responsible institutions with dedicated long-term funding for database maintenance.

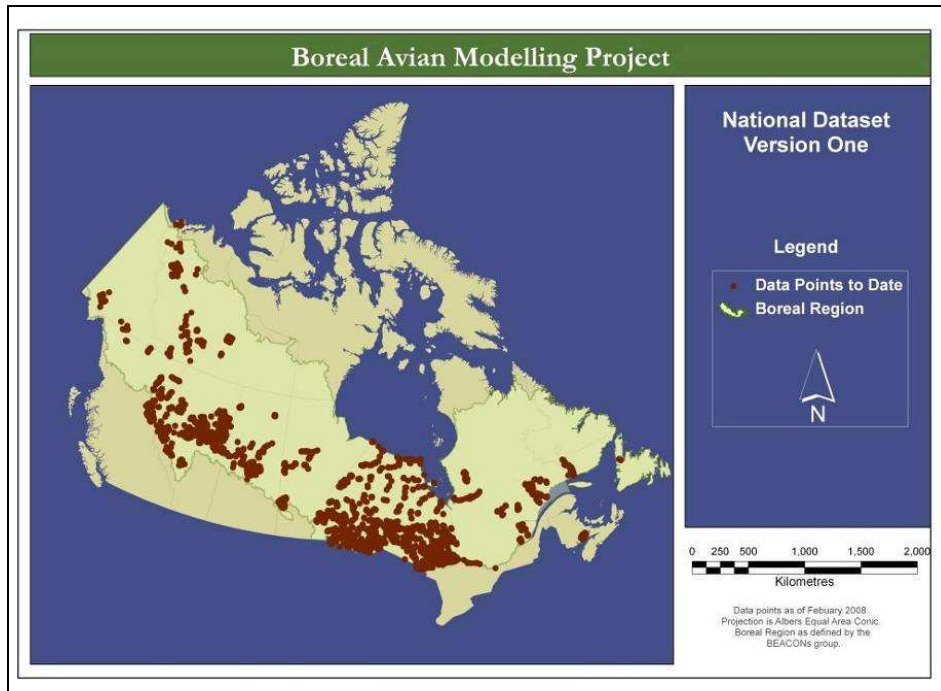


Figure 1: Locations of all data points collated into the project database to March 2008

Update on biophysical data assembly & analysis

(i) Updates on national coverages

We continue to build on our extensive library of spatial covariates that includes national cartographic data (e.g. streams, rivers and lakes, land use), spatially interpolated climate data, comprehensive fire history and fire regime data, and remotely-sensed measures of productivity and land or vegetation cover classes. We continue to research new products and updates to the current suite of biophysical data already in our database. With support from Natural Resources Canada, we have created a continuous national layer of Earth Observation for Sustainable Development of Forests (EOSD) data compiled by UTM zone, a grid-based coordinate system for specifying locations on the surface of the Earth; this LANDSAT-based data set has 30m resolution. We are also exploring a 250m resolution option, MODIS-based 2005 Landcover for Canada. This is an intermediate alternative to the 1-km resolution North American Land Cover (NALC) and 30-m EOSD products. Our CART models rely on habitat definitions provided by the NALC. This dataset provides a very coarse level of habitat resolution but is a consistent dataset covering the entire country. The CART models accurately identify the climatic envelope within which species can exist. In areas where the CART has low model reliability we believe that the poor resolution of the NALC dataset is a key limitation. The EOSD data overcomes this limitation but is very large and cumbersome to work with. Analysis using EOSD data for regional models has resulted in greater predictive accuracy that reflects the more precise definition of forest type and greater spatial resolution of EOSD. The intermediate resolution MODIS data is attractive because it is approximately consistent with habitat patch structure typical of boreal forests. Relative to other products, it may be able to support more reliable estimates of species richness and avian density at the level of habitat classes. An initiative to assemble a sub-national coverage of digital forest inventory data is described below. A systematic evaluation of the relative utility of these four extensive habitat layers is planned for next year.

Update on Model development and validation

(i) Development of the method for reliability assessment

Model reliability determines the quality of model predictions and thus, it must be assessed for all models. Previously, the reliability of classification and regression tree (CART) models could be assessed only when the targeted attributes (*i.e.* dependent variables of CART models) had binomial distributions. Our project aims to predict densities of boreal songbirds, so the dependent variables in our CART models are assumed to have Poisson distributions. However, as there is no standard method for assessing the reliability of models with such distributions, we developed a novel way to do so (Fang et al. 2008, in section on Project communications). We also developed a new assessment method based on the large number theorem and simulation. The case study showed that our method based on Poisson distributions underestimated the reliability of models, while the large number/simulation provided a more reasonable assessment. We applied the latter method to reliability assessment of our CART models.

(ii) Statistical approaches to address variability in sampling methods

Approaches to data correction in GLM occupancy

When estimating habitat associations of forest songbirds, one option is to simply use binary, presence/ absence data. For 85% of species, the mean count is nearly identical to the mean proportion of sites where a species is detected. Binary data are the easiest to collect and have fewer field-based assumptions than counts, so we would like to model data this way where possible. Using presence/ absence data, it is possible to estimate “occupancy rate” relative to specific habitat types. The simplest way to measure occupancy rate is to document the proportion of sites where a species is detected. In other words, observers visit n sites, determine the proportion of sites where the species was detected, and use this proportion as an estimate of occupancy rate. However, estimators of occupancy based on raw proportions are underestimates of true occupancy rate because rare species often go undetected in a sampling unit even when present. This is known as detection error, which has long been ignored in the scientific literature because biologists have assumed that it does not influence relative suitability of habitat. While that is often true, not accounting for detection error leads to underestimates of absolute occupancy rate because detection rate is usually < 1 . Thus, underestimating occupancy rate by ignoring detection error means that estimates of population size tend to be biased low. Two approaches to account for detection error that correct occupancy rate are the multiple visit method of Mackenzie et al. (2002, *Ecology* 83: 2248-2255), and a new analytical method that we developed in collaboration with Dr. Subhash Lele. In general, we have found that the method of Mackenzie et al. tends to overestimate occupancy rate because the assumption of closed capture is violated for many species. Lele’s method provides an intermediate estimation of occupancy rate for most birds (*i.e.* estimates higher than naïve estimators and lower than Mackenzie) that adjusts for nuisance factors such as time of day or date. The additional benefit of the Lele method is that it only requires a single visit to a sampling station to calculate how nuisance factors influence detection error. With Lele, we are working on user-friendly software to implement this method of analysis.

Offset correction for application in modelling

An important achievement of this project was the creation of a national database of boreal forest songbird abundances. Application of this dataset in modelling posed a serious statistical challenge due to the large variation among data from a diversity of contributors. The original studies from which data were collated had a wide range of purposes, and although we included only those using point count surveys, there was still considerable variation in sampling design. Point count surveys differed in terms of numbers of visits to a

site (total and annual), duration of surveys, and sampling distance (radius). We accounted for this variation in sampling schemes by employing “offsets”, or corrections, in our modelling approach. The standard offset for bird count data is based on the number of visits to a sampling site, used widely in avian ecology. However, corrections for differences in sampling duration and radius have rarely been attempted. To address this problem, we developed a unique correction factor for this project that incorporated differences in all three variables (visits, duration, and radius) into our models. We estimated the correction factor based on expected bird counts for a standard sampling duration of 10 minutes and radius of 100 metres. Our results indicated that expected bird counts were not correlated with either sampling period or radius. We plan to further explore these relationships to optimize our correction factors for future modelling efforts.

(iii) Progress on CART models of Western Canada data (Phase I)

As our first approach to building predictive models of bird species distribution and abundance, we chose classification and regression trees (CART models). This method is appropriate because our dataset includes such a large suite of biophysical explanatory variables, including numerous landcover, climate, productivity, and elevation characteristics for all sampling sites. We did not know in advance which of these variables would be important, which poses a challenge for model selection. CART is a flexible technique suitable for this situation. Regression trees are built by splitting data into smaller, more similar groups with respect to the response variable (in this case, the effort-weighted numbers of individuals recorded at each bird sampling location); the result is a tree that groups survey locations with approximately the same mean bird abundance, defined by some combination of the explanatory variables.

Initial CART models for Western Canada were built in 2006-07. This year, we created substantially revised models using updated data sets and new refinements to the analytical methods to better account for differences in protocol among data contributors. With the addition of data-sharing partners, the updated Western dataset increased notably in size and provided a better spatial representation of more areas in the Western boreal forest (Figure 1 – MB to YK). Thus, we computed new spatial weights to account for the changed patterns of spatial heterogeneity (clumping) in the dataset, using the Regular Grid method (Isaaks, EH and Srivastava, RM. 1989. *An Introduction to Applied Geostatistics*, Oxford University Press, New York), which can reduce CART model bias. We also developed a new method to address sampling differences within our database (see section (ii) above, “Offset correction”). A correction factor was estimated for each species and specific sampling scheme.

Songbird species were selected for modelling according to two criteria, adapted from our earlier analyses. First, we developed initial abundance models for 56 candidate species, selecting those from our dataset with a *prevalence* of greater than 1% (i.e. where unweighted presences were detected in at least 1% of sites in the updated Western dataset). Full CART models were built for each species with the statistical software R. The CART modeling settings used were: distribution (method) = Poisson, weight = spatial weights, and minimal class size (minbucket) = 200. We calculated explained deviance for each model, a measure of explanatory power analogous to the R^2 statistic in linear regression models, and selected those with an explained deviance of 30% or better for detailed study and presentation. (The two criteria were overruled in close cases to ensure inclusion of all species from the 2006-7 results). We estimated model reliability with bootstrap simulations (1000 runs, with 80% of data drawn for each run), using the method developed in this project for Poisson distribution data (details in Section (i), “Development of the method for reliability assessment”, and in Fang et al. (2008) - see section on Project communications).

The most informative model was for the Nashville Warbler (NAWA); almost 80% of the variation in its distribution was explained (Table 1). The lowest amount of deviance explained was ~30%, for the Blue Jay (BLJA). The variation of climate features between April and October was the most important predictor of bird distributions. Among the biological covariates, the relative amount of land covered by differed vegetation types was a key factor. Leaf Area Index (LAI), an indicator of productivity, was also important in the CART model of several species, such as Magnolia Warbler (MAWA) and Yellow-bellied Flycatcher (YBFL). The overall reliability of all CART models was quite high, and group-level predicted mean densities and estimated reliabilities were uncorrelated. This indicates that the reliability metric correctly measures uncertainty in the estimation of the mean rather than merely sampling or process error. Our model prediction errors include two components: the error in prediction of the Poisson mean, and the process error associated with sampling from a Poisson distribution with the predicted mean. Because the variance of Poisson data is equal to the mean, a high correlation between the mean and the reliability metric would indicate that process error was dominant and that the metric was in fact uninformative (we know the process error component *a priori*).

Table 1. The overall quality of CART models for 31 boreal forest songbird species.

Species	Exp. Dev. *	Species	Exp. Dev. *	Species	Exp. Dev. *
NAWA	0.780	MAWA	0.462	BHCO	0.350
TOWA	0.707	AMGO	0.441	YBFL	0.347
CSWA	0.704	PISI	0.429	WAVI	0.343
VEER	0.694	BLPW	0.427	WETA	0.335
WCSP	0.694	BTNW	0.424	YWAR	0.334
EVGR	0.626	DEJU	0.417	YRWA	0.318
WIWA	0.609	SWTH	0.414	REVI	0.317
MGWA	0.604	OCWA	0.396	CAWA	0.313
VATH	0.574	OVEN	0.392	BLJA	0.312
BLBW	0.540	CMWA	0.385	~	~
BBWA	0.479	MODO	0.372	~	~

*Exp. Dev. = explained deviance (%).

By way of example, we include here the CART model for the Ovenbird (Figure 2). Ovenbirds are a widespread boreal species, but are of conservation concern in parts of their range. Ovenbirds tend to prefer mature deciduous-dominated or mixed stands. A number of studies have focused on this species, thus there is a good data foundation here. Data for these species are also likely to be highly reliable: their loud and ubiquitous songs are highly recognisable in bird surveys.

Shown also are the resulting predictive maps of their distribution and relative abundance, and the predicted reliability of the models (Figure 3). These maps represent the first time we have had data-driven predictions of landbird distribution across the extent of the boreal forest.

These models are a work in progress. Estimated 'reliability maps' generated from the models provide guidance on where data collection efforts should focus over short to medium term, and help to characterize the structure of geographic ranges. An important contribution of the CART modelling exercise has been to identify a small set of meaningful climatic variables for use in future modelling. It has also demonstrated some of the shortcomings of using remote-sensed habitat covariates initially selected for inclusion in the models.

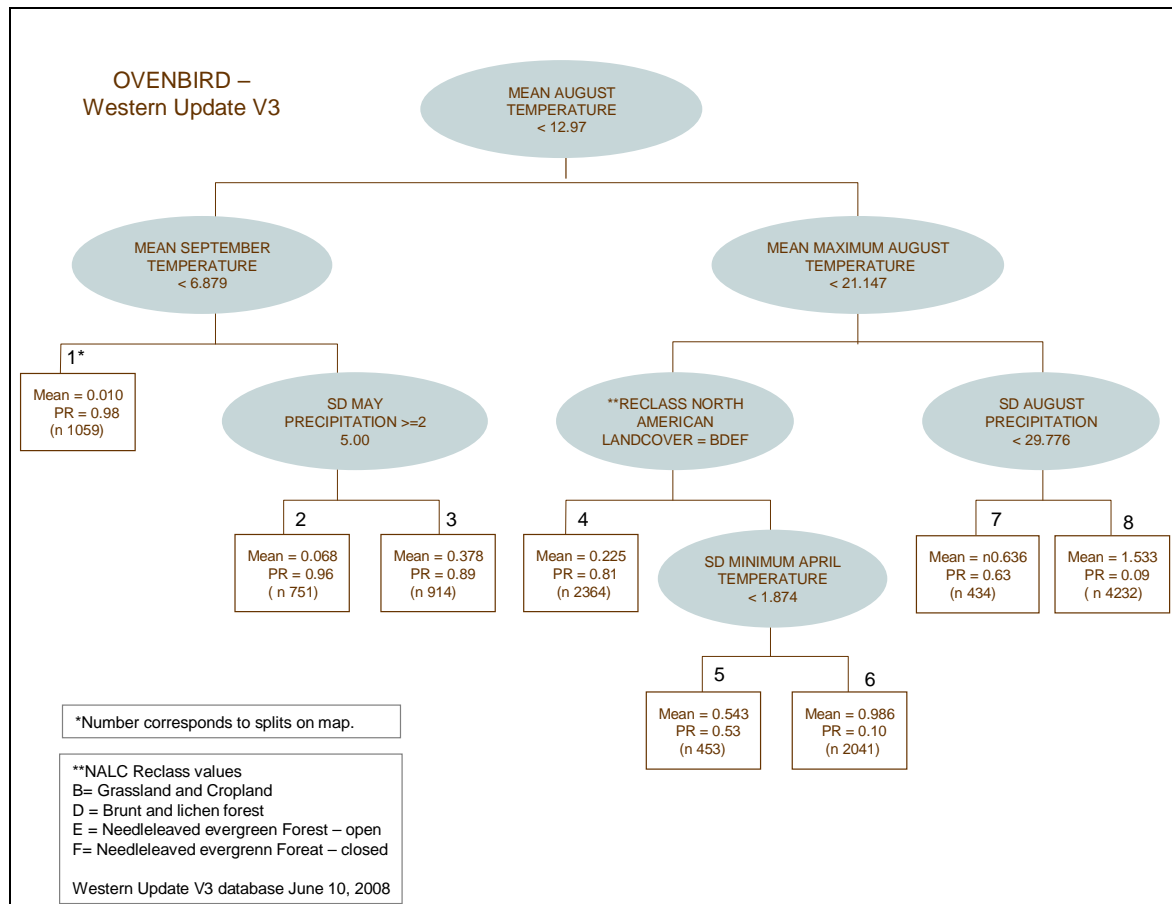


Figure 2: CART model for Ovenbird in the western boreal forest (MB-YK).

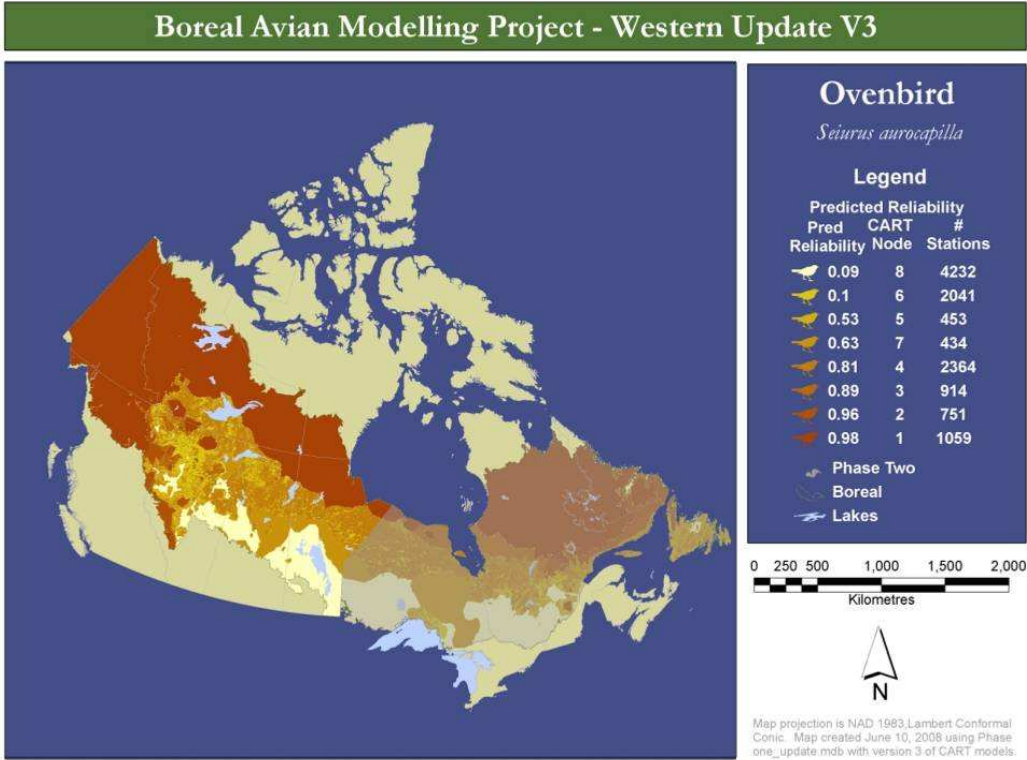
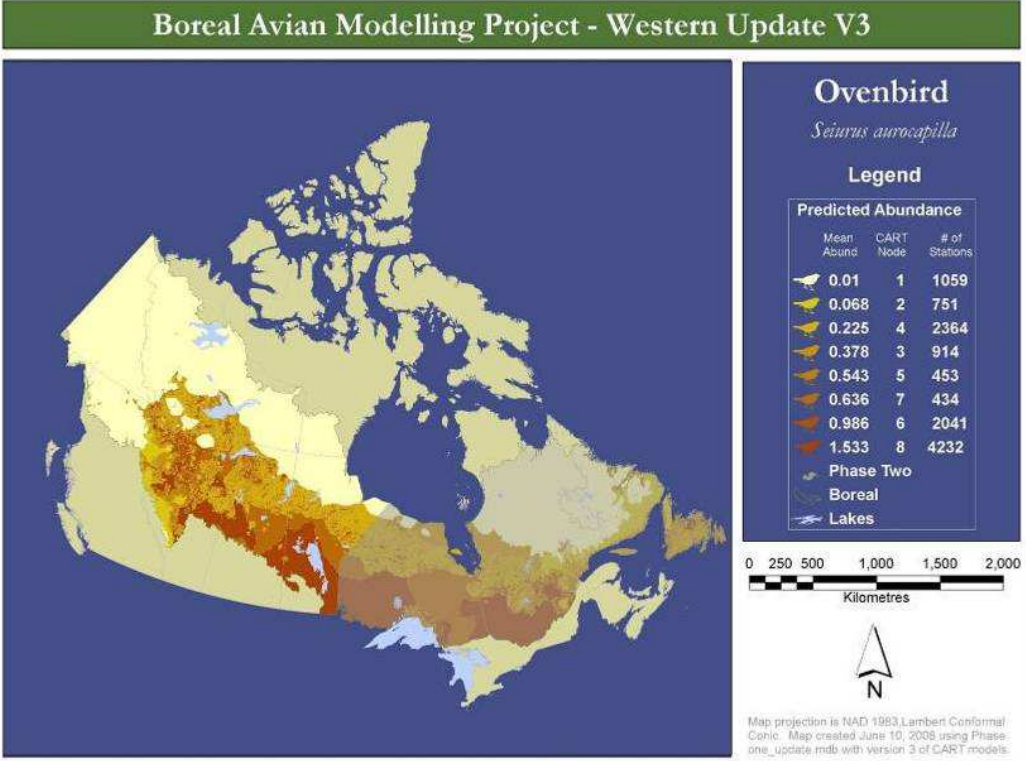


Figure 3: Predicted abundance and reliability maps for Ovenbird in the western boreal forest.

(iv) Progress on national models

With the successful collation over the past year of sufficient datasets, we are now applying the CART modeling approach at a national scale, to encompass the full extent of Canada's boreal forest. Again, we present the Ovenbird to illustrate the potential of these national models.

The methods used for spatial weight computation, offset estimation, bootstrap simulation, and reliability assessment are the same as those we used to build CART models for Western Canada. The model for OVEN (Figure 4) explained 32% of the variation in its distribution and relative abundance (Figure 5a). Climate variables figured prominently in this model.

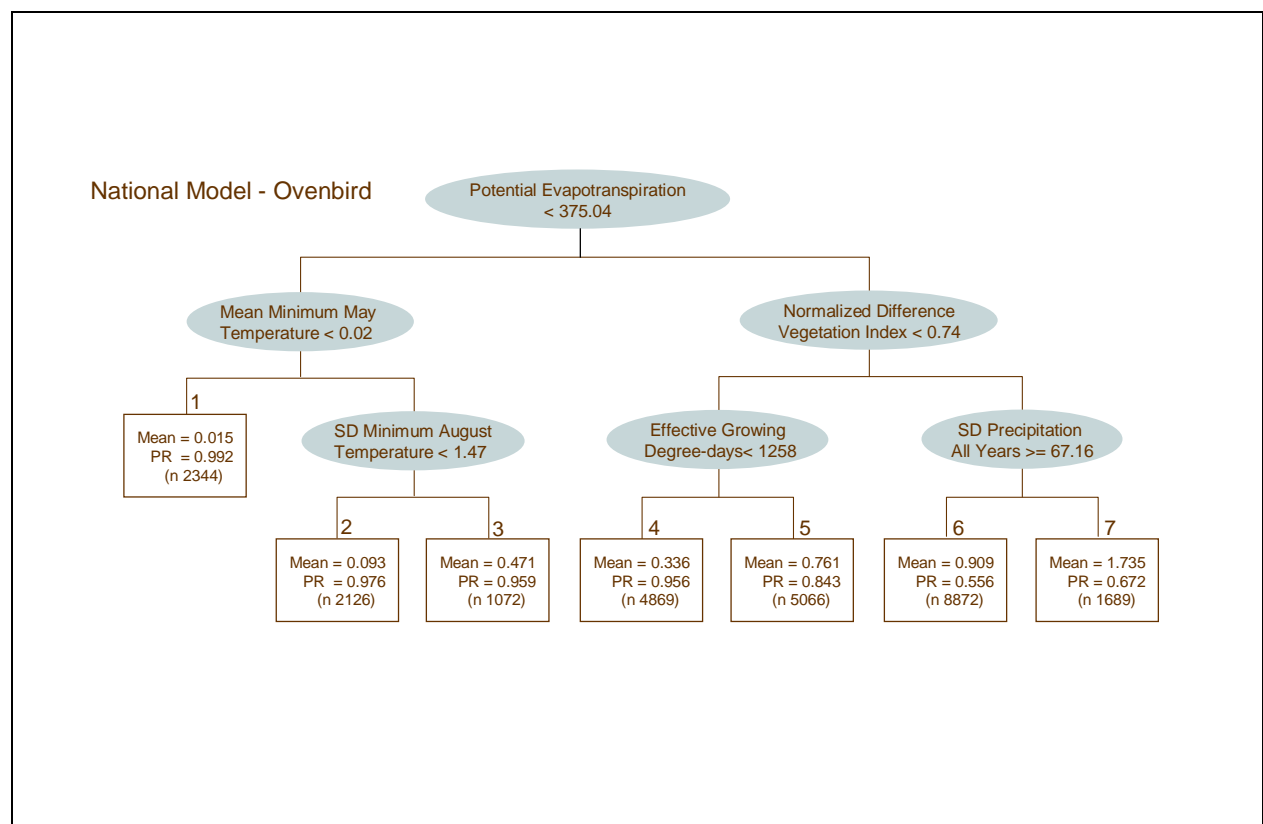


Figure 4: CART model for Ovenbird across Canada's boreal forest.

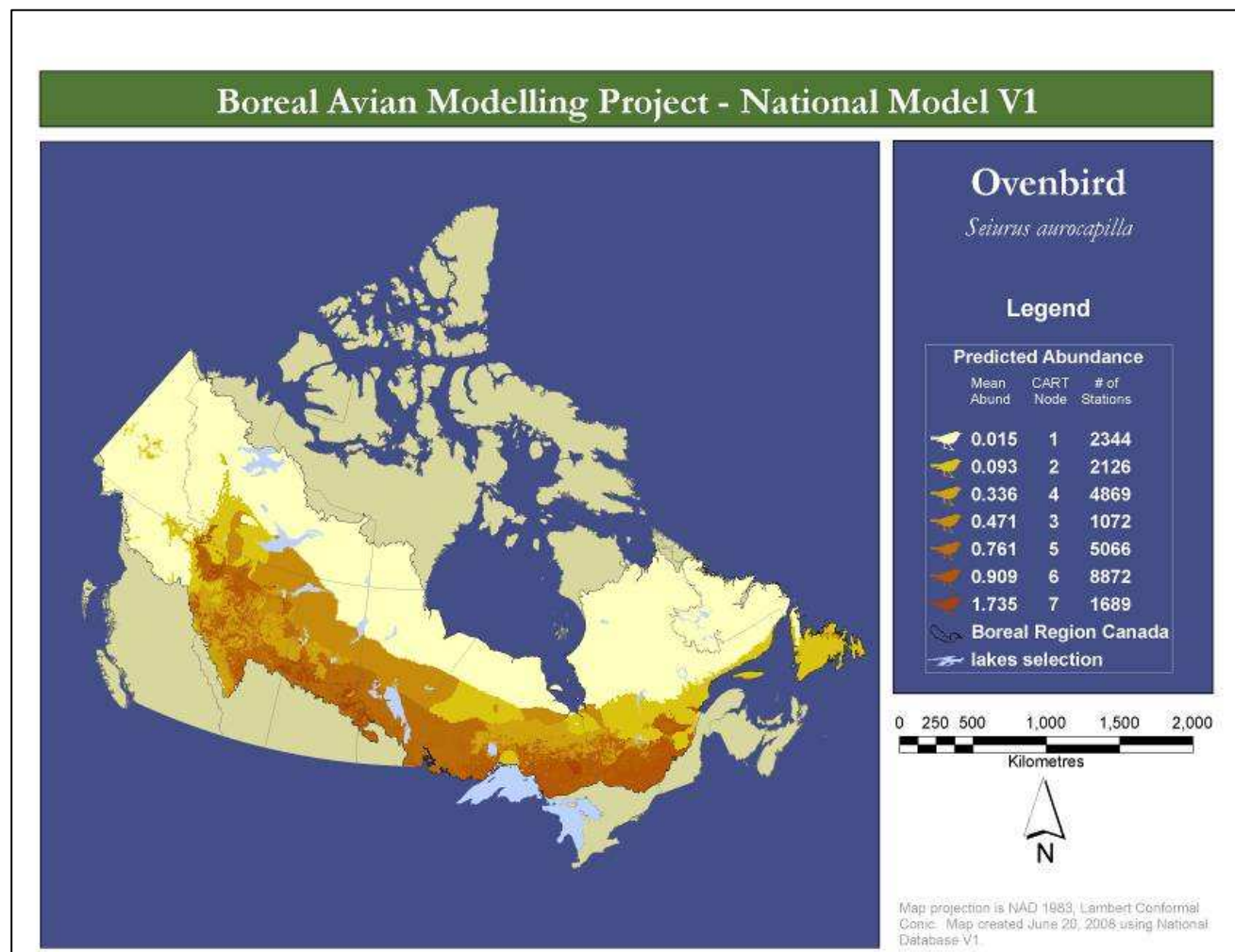


Figure 5a: Predicted abundance for Ovenbird across Canada's boreal forest.

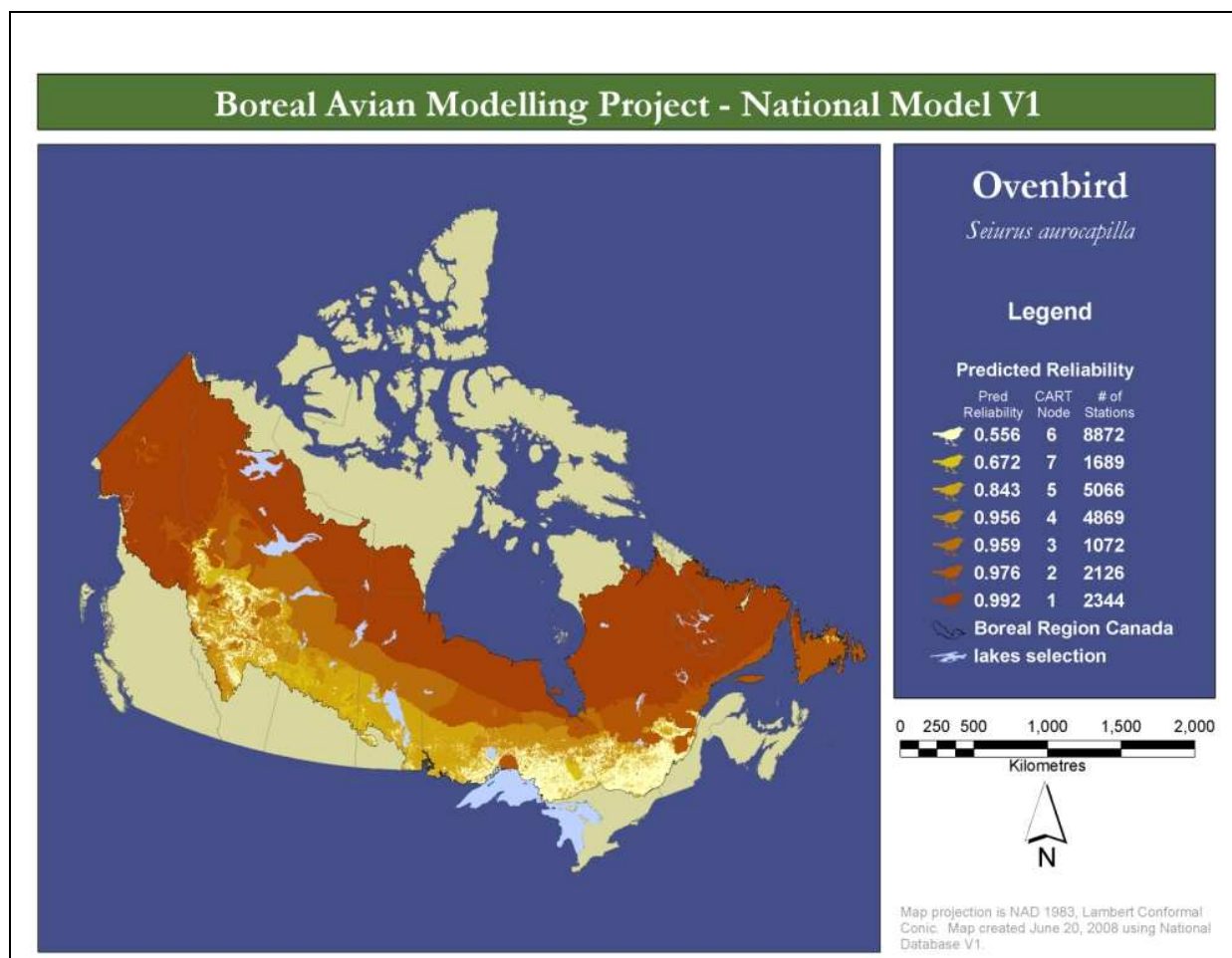


Figure 5b: Predicted reliability maps for Ovenbird across Canada's boreal forest.

The next stages of modeling will become more challenging due to the very complex structure of the database. So far, we have restricted analysis to data collected by relatively standard point-count surveys. Other significant data sets were collected under widely different sampling protocols (e.g. belt transects). Further, within individual studies, the data are spatially stratified in project-specific ways, and the database comprises surveys collected in almost 20 years. However, almost all individual studies were short term, so the data are also temporally structured. We know that important year effects exist (e.g. extreme spring weather, outbreaks of insect prey), but we have only a few scattered long-term studies with which to model these processes. We also know that patch level abundances of at least some species are affected by larger scale patterns in habitat distribution, and may exhibit responses to landscape-scale changes lagged over 10 years or more. Finally, there is reason to believe that species responses (to habitat, for example) are not constant across the boreal forest. We look forward to tackling these analytical challenges, knowing that our national bird-habitat models will provide much-needed information to support the conservation of migratory songbirds in North America. Our models will facilitate the identification of factors driving bird species distributions and abundances across the boreal, and predictions under future scenarios, knowledge that is a crucial component for effective management of this forest ecosystem and the birds that depend upon the habitat it provides.

Species diversity

A much needed step in boreal forest avian conservation is identifying areas of high biodiversity value within the biome's Canadian extent boreal. Many efforts are underway to manage areas of the boreal forest under a conservation mandate. However, whether the areas being selected will provide the level of avian protection desired by Canadians remains unknown. Part of the project will be working to identify regions of the boreal forest with unique boreal species, areas of high avian biodiversity, and where species select unique and rare habitats. Preliminary findings on diversity trends in five ecoregions of the country to date suggest that substantial variation exist. For example, the leading species in each ecoregion based on rank-abundance curves were: 1) **CORDILLERA** = Swainson's Thrush, Yellow-rumped Warbler, Dark-eyed Junco, Pine Siskin, and Chipping Sparrow; 2) **BOREAL PLAINS** = Ovenbird, Tennessee Warbler, White-throated Sparrow, Yellow-rumped Warbler, and Chipping Sparrow; 3) **BOREAL SHIELD** = White-throated Sparrow, Nashville Warbler, Red-eyed Vireo, Ovenbird, and Swainson's Thrush; 4) **HUDSON PLAINS** = White-throated Sparrow, Savannah Sparrow, Ruby-crowned Kinglet, Dark-eyed Junco, and Swainson's Thrush; and 5) **TAIGA** = White-winged Crossbill, Swainson's Thrush, Yellow-rumped Warbler, Tennessee Warbler, and Chipping Sparrow. Most boreal birds are found in all five ecozones modelled so far. All of the species found in only one ecozone are rarities simply because they are typically found outside the boreal forest.

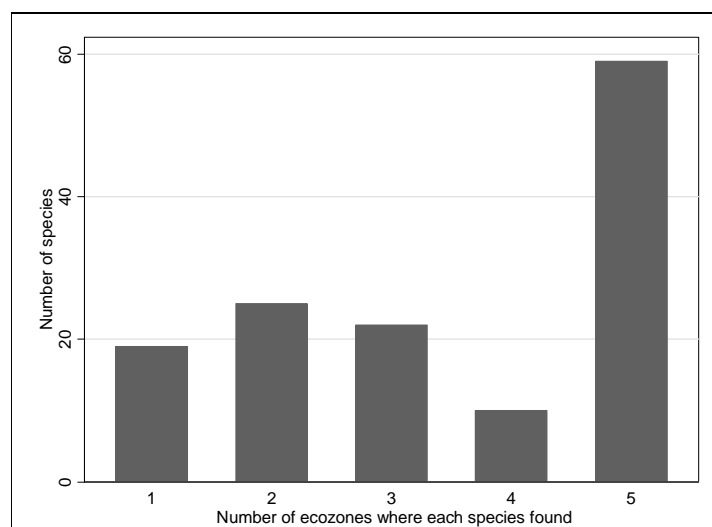


Figure 6: Bar chart showing number of species that are uniquely found in one or more ecozones. Note the vast majority of the species in the boreal are found in all five ecozones.

(v) Progress on regional-scale models

Assembly of Forest Resource Inventory data

To build national models of avian distribution and abundance, we have used only biophysical variables that are available for the entire boreal region. In particular, we used landcover variables derived from satellite-based sensors such as LANDSAT and MODIS. Such data are inadequate for assessing or predicting the impact of forest management practices on forest birds, for two main reasons. Firstly, they have very limited thematic precision. Many bird species are sensitive to variation in canopy tree species composition, height and age, yet no satellite-based products can measure these basic vegetation attributes. Secondly, they cannot be connected to forest management planning tools, which depend fundamentally on projecting harvestable volumes of target tree species through time. Satellite-based landcover maps not only lack the required thematic detail, but they can not be projected through time under processes such as stand growth, succession or regeneration. Thus, avian habitat models derived from satellite landcover data cannot be used to link forest management actions to the desired biotic indicators at the scale of forest tenure areas.

The preferred source of spatial landcover information for regional forest management applications is digital forest inventory data. It is straightforward to develop regional or management-unit specific models using covariates derived from these sources. Digital forest inventory exists for most of the actual or potentially commercial forests in the Canadian boreal forest, so models developed through this project could in principle be applied very widely. Unfortunately, there have been significant difficulties in doing so systematically and consistently in order to make model predictions comparable between regions. These difficulties involve dispersed data ownership, technical GIS issues in linking songbird and inventory data over large areas, and variable data formats and standards between among inventories. We have recently embarked on a far-reaching collaborative project to resolve these difficulties and pave the way for the broadest possible application of our statistical analyses to forest management planning across the Canadian boreal.

In collaboration with Environment Canada, the Canadian BEACONS project, two research groups in the Sustainable Forest Management Network, and Cumming's lab at Laval, we are assembling the most complete possible suite of present and past inventory datasets from across Canada. We have secured data from YK, BC, AB, SK, MB and ON, and expect to conclude agreements with all remaining jurisdictions by Summer 2008. Cumming's lab is pursuing a general solution to the technical GIS challenges as part of a broader program funded through his Chair. The main commitment of BAM over the reporting period has been to design and finance a solution to the third problem, that of variation in data format and attributes among inventories. Beginning with a team meeting in November 2007, we developed a Common Attribute Schema to consistently represent attributes (e.g. canopy species, height, age and density) that are recorded in all or most Canadian inventories, without loss of precision. We have engaged Timberline Natural Resource Group Ltd, a corporation with almost 40 years of experience in forest inventory production and management, to verify and expand the initial specifications to include other attributes of ecological interest such as disturbance histories, ecosite, moisture regime and a consistent representation of non-forested cover types such as categories of wetlands. All existing inventories are organized as a (semi-) regular grid of "mapsheets" of approximately 100km² in area. The underlying grid system varies between jurisdictions (e.g. 1:20,000 NTS grid in Québec, the township grid in Alberta). We have specified metadata standards for the provenance and characteristics of the underlying mapsheets, including the grid system, original geographic projection, data ownership, inventory standards, and details of the original aerial photography. The protocol includes the design and implementation of automated processing scripts to convert all existing inventories into a standardized format,

essentially a text-based representation of a normalized relational database. A full description of the Common Attribute Schema and metadata will be presented in a report scheduled for Fall 2008 and a subsequent manuscript. The database management and software systems will be completed by technical staff in Cumming's lab over the next 18 months.

Population estimates from western boreal region

Data collated from five ecoregions in the western boreal forest were used to generate population estimates (abundance and density) for individual landbirds and all landbird species for which we had sufficient data. Habitat covariates were generated from EOSD landcover and additional covariates based on characteristics of the sampling protocol (survey duration, sampling distance, time of day, date, number of visits). The effect of eight different statistical approaches on estimation of density was also tested. No one method is correct because assumptions are violated by point count methodology to some degree. The most robust estimate of density is likely to emerge through a detectability correction that combines occupancy estimates for species who typically only have one individual detected per station and distance estimation for those species where more than one individual exists per station. Next steps in this analysis will compare results against density estimates derived from regional spot-mapping studies. These density estimates could be used in future to estimate population size, if combined with results of a GIS exercise to evaluate the amount of habitat existing in each ecoregion.

Age-composition models piloted on regional forest management areas

A good opportunity to influence landscape planning and migratory bird management in the boreal forest exists through regional management units such as forest tenures licensed to forest companies and model forests. Finer-scale regional models than we have worked with thus far are necessary, and as noted above, digital forest inventory data is an appropriate source of habitat data. We examined candidate areas across western Canada, where datasets were most robust, and selected four initial sites (Duck Mountains MB, Prince Albert Model Forest SK, Alberta Pacific Forest Industries FMA AB, CanFor TFL areas in northeast BC). Inconsistencies in the available forest inventory data have limited our initial effort to the AIPac FMA.

Figures 7 and 8 show examples of the relationship between forest age and probability of occurrence. The predictive accuracy of these models improves dramatically relative to those using remotely-sensed habitat data, such as EOSD or NALC data, for many species as forest age is an important predictor of bird abundance, underscoring the value of using forest inventory data. Obtaining a Canada-wide dataset that allows us to identify the leading conifer species and forest age is a leading priority for the next phase of the project.

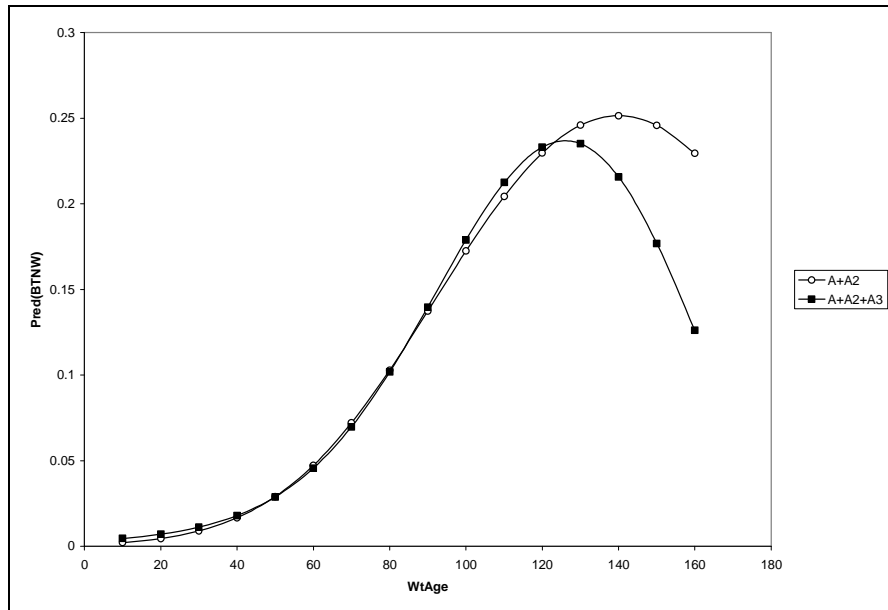


Figure 7: Example of how probability of occurrence of Black-throated Green Warbler changes with forest age in NE Alberta with two assumptions on the functional form of the age/ occurrence relationship.

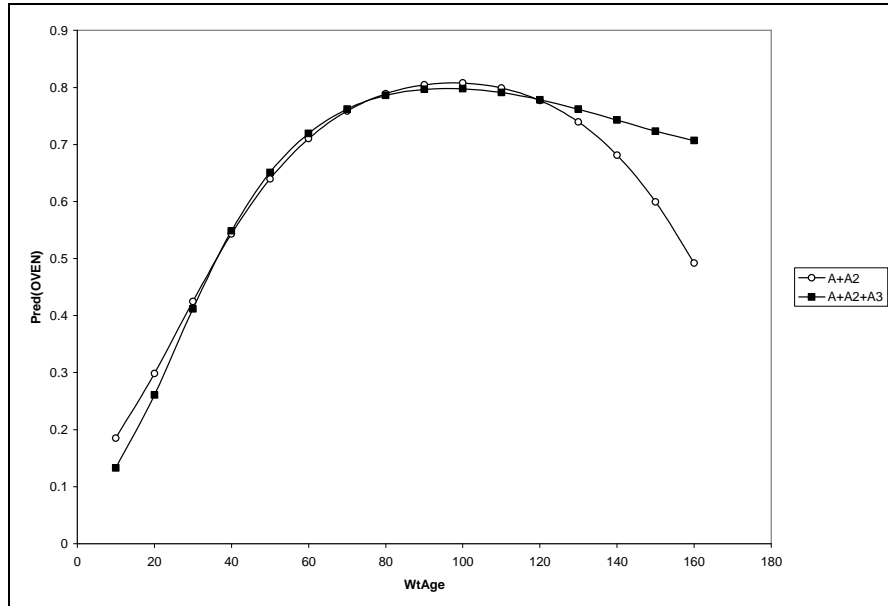


Figure 8: Example of how probability of occurrence of Ovenbird changes with forest age in NE Alberta with two assumptions on the functional form of the age/ occurrence relationship.

Value-added applications

(i) Product generation for EC's Incidental Take File

Providing results that will assist in migratory bird planning and management in Canada's boreal forest is a priority for this project. To that end, some initial steps were made in March 2007 (excluded from reporting last year) to demonstrate the applicability of modelling results to Bird Conservation Region planning needs for habitat objectives. Using results generated for individual species, composite maps for species associated with each deciduous, coniferous (Figure 9) and bog habitats (based on expert opinion and published literature) were generated. These maps show the potential for assisting with selection of conservation objectives for those developing BCR plans.

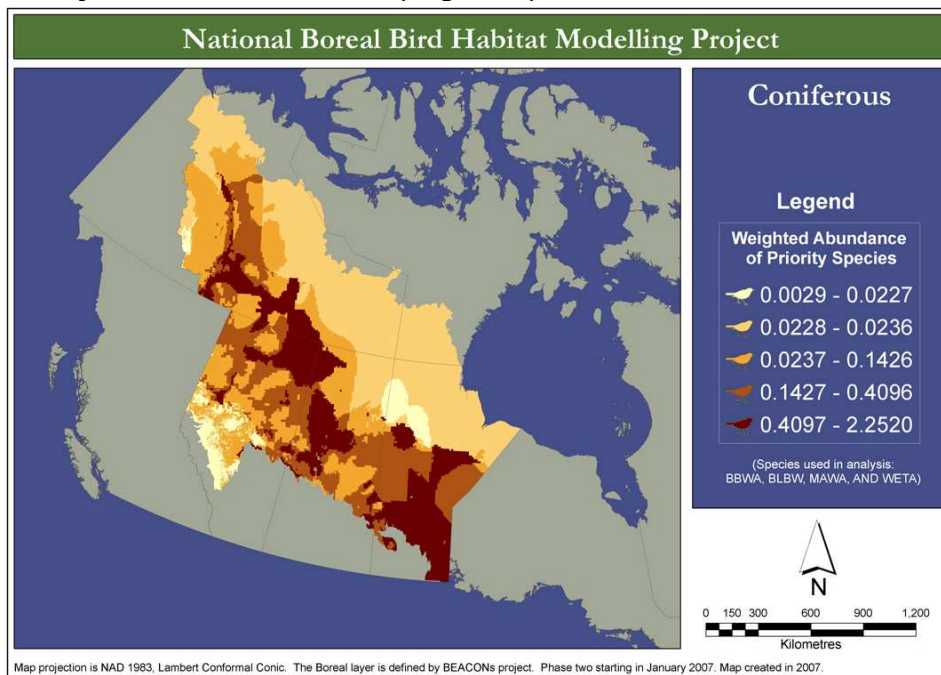


Figure 9: Abundance estimates for conifer-associated species, Bay-breasted Warbler, Blackburnian Warbler, Magnolia Warbler and Western Tanager, in the western boreal forest and based on an overlay of individual abundance estimates generated from CART models.

(ii) COSEWIC status reporting

By request, the project contributed models of Canada Warbler to a new COSEWIC status report on this species. Models were based on our western datasets, and were used to inform estimates of distribution and abundance of this species across Canada.

(iii) Third-party reporting on the assessment of human activity on boreal forests

Datasets assembled for this project were provided to a member of the steering committee, Erin Bayne, as a contribution to the analysis and writing of a joint report with the Canadian Boreal Initiative. The report assessed the conservation implications of a business-as-usual development scenario vs. a conservation framework in a forest tenure in the Boreal Plains and in the southern Mackenzie watershed over the next 50 years. The report gives some insight into the potential of these data for application such as scenario analyses, land use planning exercises, forest certification, and environmental assessments. The models described in Appendix 3 are examples of what was used in this report. The full report was released in January 2008 and can be viewed at:

http://www.borealcanada.org/documents/report-MkSA0108_FINAL.pdf

(iv) Data rescue

An unforeseen benefit of our data acquisition process has been to secure and permanently archive data from disparate studies that were in danger of becoming permanently lost. Much of our data was collected by tax-payer funded academic research typically based on graduate student research projects. As students graduate, computers age or fail, and faculty age or retire, the underlying data are often inevitably and irretrievably lost. Several data contributors report that such losses have been narrowly averted solely due to this project. In other cases, we have prompted the georeferencing of older data sets collected before the recent advent and widespread use of GPS systems. Again, recovering the spatial coordinates of sample locations can become impossible within a very few years of study conclusion. Thus, we have contributed to the security and future use of a significant amount of very expensive data.

Project management

Several changes in the management of the project resulted with the departure of our project coordinator, Dr. Dan Mazerolle, in the summer of 2007. We took the opportunity created by staffing changes to re-structure our project management. The three core positions are now project biostatistician (Dr. Shoufan Fang), project ecologist (Dr. Kara Lefevre) and data manager/administrator (Trish Fontaine). These positions report directly to the Steering Committee, who have collectively assumed the role of project coordination. This new, "flatter" reporting structure has involved in greater involvement by the Steering Committee in program delivery and better exchange of information and cohesion of the team generally. Kevin Hannah (Environment Canada) provides additional technical support and expertise in avian life history.

Kara Lefevre joined as our project ecologist in November. Lefevre was working part time until her Ph.D. defence early this March. As of April 2008, she is dedicated fulltime to the project and based at Université Laval in Steve Cumming's lab. Lefevre brings with her a strong background in avian and forest ecology, conservation biology and environmental policy. Other changes to the team included the expansion of the role of Trish Fontaine to include data management and program administration. The project Steering Committee was expanded with the addition of Dr. Erin Bayne. Erin has been a great source of ideas and energy for the entire team. The Steering Committee now consists of Erin Bayne, Steve Cumming, Fiona Schmiegelow and Samantha Song.

Technical Committee

With our expansion in eastern Canada, we increased representation on the Technical Committee with two eastern researchers: Dr. Phil Taylor, Acadia University (currently on sabbatical at Bird Studies Canada) and Dr. Jean-Luc DesGranges, Environment Canada. No face-to-face meeting of the Technical Committee was held this fiscal year because the team was focused on delivering results discussed at the previous meeting, held in December 2007. A meeting is anticipated in late 2008 where we will present results and discuss the path forward.

The Technical Committee includes the following membership:

- Peter Blancher, Environment Canada
- Marcel Darveau, DUC/Université Laval
- André Desrochers, Université Laval
- Jean-Luc DesGranges, Environment Canada
- Andrew DeVries, Forest Products Assoc. of Canada
- Pierre Drapeau, Université du Québec à Montréal
- Charles Francis, Environment Canada

- Keith Hobson, Environment Canada
- Craig Machtans, Environment Canada
- Julienne Morissette, Ducks Unlimited Canada
- Rob Rempel, Ontario Ministry of Natural Resources
- Phil Taylor, Acadia University (currently on sabbatical at Bird Studies Canada)
- Stuart Slattery, Ducks Unlimited Canada
- Steve Van Wilgenburg, Environment Canada
- Lisa Venier, Canadian Forest Service
- Pierre Vernier, University of British Columbia
- Marc-André Villard, Université de Moncton

Updates on funding partners

BAM successfully competed for funding from the USGS Fish & Wildlife Service under the US Neotropical Migratory Bird Conservation Act. In 2007-08, we were also grateful for financial assistance from Environment Canada, Forest Products Association of Canada, Canada Research Chairs program, Ducks Unlimited Canada, Natural Sciences and Engineering Research Council of Canada, Université Laval, and University of Alberta. The Canadian BEACONS project provided further in-kind support.

SUMMARY OF PROJECT COMMUNICATIONS:

The project website is now accessible at www.borealbirds.ualberta.ca in English and French. The main content to date was a summary of the Classification and Regression Tree (CART) models of data assembled from Western Canada (as of summer 2006), including national maps of predicted relative abundances and prediction errors. We are now working to update the look and functionality of the website, with an improved architecture that will facilitate the addition of new results (anticipated Fall 2008). We have also re-run the western CART models following the addition of new data, and will be re-posting those results on the new site.

In December 2007, we initiated an informal update series provided to data partners and technical committee members. The updates describe recent results, major findings and project developments. Our intent is to continue to distribute these information updates on a quarterly basis.

The project was presented in a number of forums throughout the 2007-08 fiscal year:

Schmiegelow, FKA & SJ Song. 8 May 2007. The National Boreal Bird-Habitat Modelling Project. Presentation to Environment Canada's Migratory Birds Outcome Project Planning meeting. Gatineau, QC.

Cumming SG, S Fang, FKA Schmiegelow, and SJ Song, 21 Sept 2007. "National avian habitat models from remote sensed data". Carrefour de la recherche forestière, Québec, QC.

Cumming SG. Regional dynamic models of forest management, fire and wildlife. L'école d'été FORAC (De la Forêt au Client), 21 June 2007. Université Laval, Québec QC.

Carlson M, EM Bayne, and B Stelfox. Jan. 2008. Finding a balance: Assessing the future impacts of conservation and development in the Mackenzie watershed. Canadian Boreal Initiative. Presented at University of Alberta, Seminars on Environmental Research and Issues

Bayne EM, J Ball, L Habib, C Machtans, L Mahon, and FKA Schmiegelow. Feb. 2008. Sustainability of boreal forest bird populations in the face of rapid energy sector development, Invited presentation at International Partners in Flight Conference. McAllen, Texas.

Bayne, EM. March 2007: "Integrating Cumulative Effects Research Into ALCES", Invited presentation at NWT-ALCES Working Group Forum. Hay River, NWT.

The project was also discussed as part of broader presentations on the Western Boreal Conservation Initiative to EC's Ecosystem Sustainability Board in December 2007 and February 2008.

Publications:

Fang S, SG Cumming, FKA Schmiegelow, SJ Song and EM Bayne (submitted) Prediction reliability measures for Classification and Regression Tree (CART) models of Poisson data. *Computational Statistics & Data Analysis*.

We have made initial contact with the editor of *Frontiers in Ecology and the Environment* and have confirmed their interest in a review paper on the need for effective decision-making and management tools for conservation of boreal forests, the role bird-habitat models can play and the contribution of this projects effort. We anticipate further development and submission of this manuscript by Winter 2008.