Boreal Avian Modelling Project

Predictive tools for the monitoring and assessment of boreal birds in Canada, 2009-2012

2010-2011 Annual Report to Environment Canada

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EXECUTIVE SUMMARY FOR 2010 – 2011

The purpose of the Boreal Avian Modelling (BAM) Project is to better understand how environmental factors, including human activities, determine the abundance and distribution of boreal bird species. The intended areas of application of this collaborative project include conservation planning, monitoring, assessment of population status, environmental assessment, and protected areas management. Our goal is to develop and disseminate reliable, quantitative tools to support these applications. We are achieving this goal by integrating and modelling observational data from a large and growing number of past studies conducted by scientists in government, industry and academia. Increasingly, we are also incorporating data from ongoing monitoring programs such as Breeding Bird Surveys and provincial Breeding Bird Atlases. This interim report describes work undertaken or completed during 2010-11, the second year of a three-year contribution from Environment Canada.

The BAM Project has continued to pioneer new methods of assembling, standardising, and analysing avian data to 1) describe the present distributions of boreal bird species and 2) explain these distributions by identifying the important habitat features associated with areas of high abundance for given species. Highlights of our progress and accomplishments in 2010-11 include:

- The geographic scope of the project was expanded to a continental scale by including the boreal and hemi-boreal regions of Canada and USA, based on the definition of the boreal presented by Brandt (2009);
- The BBS route data were integrated into the BAM database;

- Statistical methods were developed to account for incomplete detectability of birds by point count survey, including the effects of survey date and distance. As a result, now we may estimate more reliably true densities from detected counts. We created a database of species' density estimates by habitat class for several commonly used spatial stratifications (e.g. BCRs, provinces) and are in the process of developing a means to deliver this to project partners and resource managers.
- Recommendations for standardised protocols were developed to improve the value of future point-count surveys, including those associated with Breeding Bird Atlas programmes;
- Scientific input was provided to land-use modelling and planning efforts including: identification of priority areas in Bird Conservation Region 6 (Boreal & Taiga Plains) by Environment Canada, land-use scenario modelling for the Alberta Land Use Framework (Lower Athabasca Regional Plan including the oilsands), and, trend estimation for boreal bird populations in Western Canada by the Canadian Wildlife Federation;
- Several new collaborative research initiatives were explored with members of the BAM Technical Committee to better utilise the potential of the new datasets created or assembled by BAM. These initiatives include comparisons of regional modelling products and a systematic effort to compare avian habitat used in different regions of Canada. New modelling studies were initiated to estimate the impact of global climate change on future boreal bird populations at regional levels using downscaled climate projections;
- Information about BAM project results was communicated to partners, collaborators and end users to inform bird conservation and management efforts. This includes scientific publications, technical reports, increased interactions with Technical Committee members (both in person and through Webinars), and ongoing updates to the project website.

In 2011-12, we expect significant new developments in avian distribution modelling, including extensions of the MARXAN-models presented below. We also expect new results on species range delineation based on hierarchical models that include the improved detection models developed over the past year. We will prioritise work on community level analysis, to map avian diversity and characterise the large scale factors that influence geographic patterns in diversity. We will also be contributing to a number of national initiatives to project the effects of land use change and conservation planning on avian distributions. Finally, we look forward to closer collaboration with the Canadian Atlas community, including the application of model-based design methodologies to select optimal locations for future atlas and point-count sampling efforts in remote parts of the boreal.

The continued success of the Boreal Avian Modelling Project relies on strong partnerships with organisations and individuals providing funding, data and collaboration. We extend our gratitude to our data partners and members of the Technical Committee for their vital support and involvement. With our increased technical capacity, and the foundation of large datasets and strong analytical techniques, we look forward to ongoing opportunities for collaboration, and for more detailed explorations of the questions surrounding conservation and management of boreal birds in North America.

TABLE OF CONTENTS

HIGHLIGHTS OF ACCOMPLISHMENTS IN 2010 – 2011

We achieved the following **key results** during the 2010-2011 fiscal year:

1) Augmented the project capacity through the addition of a quantitative ecologist, a project coordinator, and a doctoral student;
2) Published an essay in the peer-reviewed journal Avian Conservation and Ecology that described the BAM Project goals, argued for monitoring and conservation of boreal birds, and presented an overview of the BAM database and some preliminary modelling results;
3) Completed two manuscript drafts describing approaches to correction methods to account for differences in point count data collection methods related to survey time and distance intervals;
4) Developed preliminary, quantitatively-derived recommendations for an international standard for point count survey methods in boreal forests, and secured preliminary acceptance of the importance of stratifying observations by at least two time and distance classes;
5) Hosted a Technical Committee meeting in Edmonton to outline project progress, determine how the BAM database and project could best advise conservation efforts (such as monitoring program design), and develop new collaborative projects using the database;
6) Developed bird-habitat association models in association with the Alberta Biodiversity Monitoring Institute for the boreal portion of Alberta for use by the Alberta Land Use Secretariat, and for application in the Lower Athabasca Region Plan (oilsands regions);
7) Extended the BAM project internationally, by establishing partnerships to acquire bird data from boreal portions of the U.S, including Alaska, the upper Mid-west, and New England, and through the addition of a new Technical Committee Member;
8) Completed the addition and correction of Breeding Bird Survey locations and survey counts for all parts of the country except BC to the BAM dataset;
9) Finalised statistical methods to address detection error and variation in survey methods, including creation of computer programs to facilitate rapid calculation of density estimates when new data are incorporated and to model community richness and similarity;
10) Initiated a collaborative project to determine whether and how habitat selection differs regionally for boreal birds;
11) Developed new tools to estimate local (alpha), landscape-level (beta), and regional (gamma) diversity from our dataset, and conducted preliminary analysis of geographic variation in bird communities across Canada;
12) Initiated a collaborative project to compare and validate two different modelling approaches used in Canada to predict avian distribution (BAM and IRMA: Inférences régionales par modélisation aviaire, a modelling approached developed in Environment Canada by J-L Desgranges, Science and Technology, Wildlife and Landscape Science Directorate (S&T, WLSD);
13) Completed downscaling of continental climate change projections for use in modelling to determine the impacts of climate change on boreal bird populations and distributions; and,
14) Drafted a manuscript summarising the results of the national CART models (reported in 2009) and presenting new methods for drawing ecological conclusions from large suites of CART models.

PROJECT DESCRIPTION AND OBJECTIVES

Across Canada's boreal forest, management efforts are hampered by a lack of information on birds and their habitats. The boreal region is a key breeding area for the major share of North America's migratory landbirds, but is also under increasing pressure from industrial development and climate change. We have little coherent knowledge about the density, distribution, and habitat needs of species and communities, and little ability to effectively predict the effect of threats to populations or the efficacy of management actions directed at mitigating negative impacts. The Boreal Avian Modelling Project (BAM) was initiated to address these knowledge gaps using a model-based approach, building on the assembly of existing datasets from avian researchers across Canada. Our overall goal is to support proactive conservation of bird populations and habitats in this immense and globally significant area.

The **project's objectives** are to:

- Assemble and maintain the most complete and current repository of spatially referenced data for boreal birds and their habitats.
- Apply and refine state-of-the art analytical methods to:
  - Provide reliable information on boreal bird habitat associations
  - Describe species distributions
  - Refine and forecast population status and trends
  - Generate testable hypotheses about key mechanisms driving these patterns (e.g., climate, land use, latitude).
- Improve the standardisation and rigour of avian data collection by providing standards for bird sampling protocols and database structure.
- Provide a broader conservation legacy for avian data collected in North America's boreal forest.
- Build support from academia, industry, governments, non-governmental organisations, and other interested parties for further development and testing of boreal bird population models and other decision-support tools, and their proactive application to the management of boreal forests and biodiversity conversation.
- Encourage public awareness and support education by providing ready access to current information on the status of boreal bird populations.

RELATIONSHIP BETWEEN BAM PROJECT AND CWS

Environment Canada's Canadian Wildlife Service (CWS) is responsible for the conservation and protection of migratory bird populations as mandated by the Migratory Birds Convention Act. The agency is further responsible for recovery of Species at Risk under the Species at Risk Act. The BAM Project supports related activities in the following areas:

- Bird Conservation Region (BCR) planning and management of incidental take of migratory birds

  BCR plans are foundational to the conservation framework described in the regulatory approach proposed to address the issue of 'incidental take' under the

Migratory Birds Convention Act; completion of these plans is a priority for Environment Canada (EC). The BAM Project assists BCR plan completion and implementation through improved techniques for the completion of plan elements (e.g., habitat associations, population objectives, conservation objectives, priority actions and areas) and through provision of results that can be used directly by BCR planners working in boreal/hemi-boreal BCRs (4, 6, 7, 8, 12, 14).

Under proposed changes to the Migratory Birds Regulations, CWS is working to identify risks and consequences of incidental take to migratory bird populations and to evaluate best management practices for avoidance of incidental take. Analyses from BAM are relevant to estimates of take, risk characterisation, and impact on boreal landbird populations.

- Migratory bird monitoring:

  Long-term, comprehensive monitoring of bird populations is an ongoing priority for CWS with a focus on boreal populations as a priority. BAM assists monitoring design by providing analytical products relevant to developing survey standards, protocols and analyses to deal with variation between species and habitats, site selection and prioritisation and other related issues, as well as information to identify gaps in existing efforts. Insights with respect to which species are likely to respond to natural and anthropogenic changes, and where, will assist with prioritizing future monitoring investments. BAM is developing some basic tools to assist with monitoring, including: maps of distribution, occupancy and abundance, and data locations; and databases of habitat suitability by jurisdiction and BCR. These tools will be invaluable in designing a stratified monitoring program that is both effective and cost-efficient.

- Species-at-Risk assessment:

  BAM datasets and analyses are relevant for recovery planning for listed forest-bird species. Information on population density estimates, distributions, habitat associations, and response to anthropogenic disturbance (land use change, climate change) by boreal birds as well as techniques to derive these estimates can assist with critical habitat identification, setting of targets, and recommendations for best practices to assist with species recovery. Risk characterisation for populations can help identify species that should be considered for formal status assessment.

- Environmental assessment, identification and evaluation of protected areas, and decision support:

  Essential information on boreal bird populations (density, distribution, habitat associations and response to disturbance) derived by BAM can inform (1) the impact assessment of large-scale environmental projects by proponents and regulatory authorities, (2) the development of guidance by EC for best practices on Environmental Assessment statements (e.g. data sources, analytical approaches, monitoring techniques), (3) the identification of existing and new protected areas and their potential to contribute to conservation of populations, and (4) assessment of the conservation value of land-use planning efforts for boreal birds. Reporting below demonstrates developing decision support tools with application to (1) estimation of environmental impact of development (individual and cumulative effects), and (2) land-use planning for management of boreal birds (as a dedicated value or one of many values).

Progress in 2010 – 2011 on proposed major activities for 2009-12

1. Data compilation

(i) Updates to national avian dataset

We have expanded our database to include surveys from 97 projects, which has doubled the number of bird records to over 1 million and increased the number of point count locations to 77,000. In 2010 we added over 1,000 new point count sampling locations to the database, as well as updated 300 sites with additional years of data, for a total of over 30,000 sampling events added.

(ii) New datasets

We are acquiring several large datasets that will substantially increase the sample size and spatial coverage of survey locations. Our project scope will expand internationally to encompass the entire North American boreal zone as defined by Brandt (2009).

Our efforts to secure new data during the fiscal year included 1) completing the acquisition of avian count data and the correction of stop locations from surveys conducted as part of the North American Breeding Bird Survey (BBS) across Canada (see 1.iii below for detailed accomplishments); 2) initiating acquisition of acquire avian count data from approximately 15,000 point count locations from boreal regions of Alaska; 3) expanding our geographic coverage to include the hemiboreal region of southern Canada and the northern U.S.; and 4) working with the National Breeding Bird Atlas committee to acquire existing Atlas point count datasets for the Maritimes, Manitoba and British Columbia to be incorporated into the BAM database.

Our data acquisition from the U.S. boreal has been streamlined by establishing new collaborations with existing regional programs in Alaska, the upper-midwest, and New England, regions that are already compiling avian point count data. Thus, we anticipate that we will be able to acquire most of the avian data from the U.S. boreal by the end of 2011.

We continue to incorporate data from regional studies (new and ongoing). We have received data from the Teslin area of Yukon Territory which will be added to the database as well as 3 additional years of data from Calling Lake, AB, which represents the longest continuous, standardised study of boreal songbirds in Canada. Efforts are underway with Dr. Pierre Drapeau, Université du Québec à Montréal, to acquire data from studies conducted in the northern boreal region in Quebec.

We anticipate that these new data will greatly improve our ability to address our program objectives for delivering information to help conserve boreal bird populations. The new data from the BBS and Alaska are filling substantial gaps in our survey coverage of geographic locations, habitats, and climate spaces. This has greatly improved our estimates of avian suitability by habitat type for the Alberta Land-use Framework (http://landuse.alberta.ca/) and our estimates of bird distributions across the boreal forest region of North America Sections 2 i and 4 iii). The data from Alaska additionally fill an important geographic gap in survey coverage north and west of the Canadian Rockies, a region where the boreal avifauna shifts abruptly from eastern to western species (Erskine 1977, Handel et al. 2009). Addressing this gap increases the relevancy of BAM products for land-use planning and conservation efforts in northwestern Canada and interior Alaska, an area actively undergoing development for energy extraction and transportation.

(iii) Incorporation of Breeding Bird Survey (BBS) data

We also began assembling BBS route data targeted at filling key gaps in BAM's coverage not filled by off-road point-count data (e.g., Yukon Territory, eastern Québec). We worked closely with the national BBS office to generate or correct geo-referenced locations for BBS stops. This task has proven to be much larger than originally thought. To date we have incorporated all GPS route information available from observers that we have in hand. We have also incorporated coordinates from the Patuxent BBS website, and for routes with no observer collected coordinates we have added coordinates to the routes. Data entry from individual locations along survey stops in each route (50 stops/route) is complete (except for British Columbia) and has been sent to the BBS office to be verified against in-house maps and records. We will then assist with incorporating any identified changes. We are incorporating BBS data from the years 1996 through 2009, based on availability at the 50 stop level for the bird survey data, resulting in inclusion of over 37,000 individual stop locations over a 13-year period and over 260,000 sampling events. The distribution of point count and BBS survey locations as of March 2011 is shown in Figure 1.

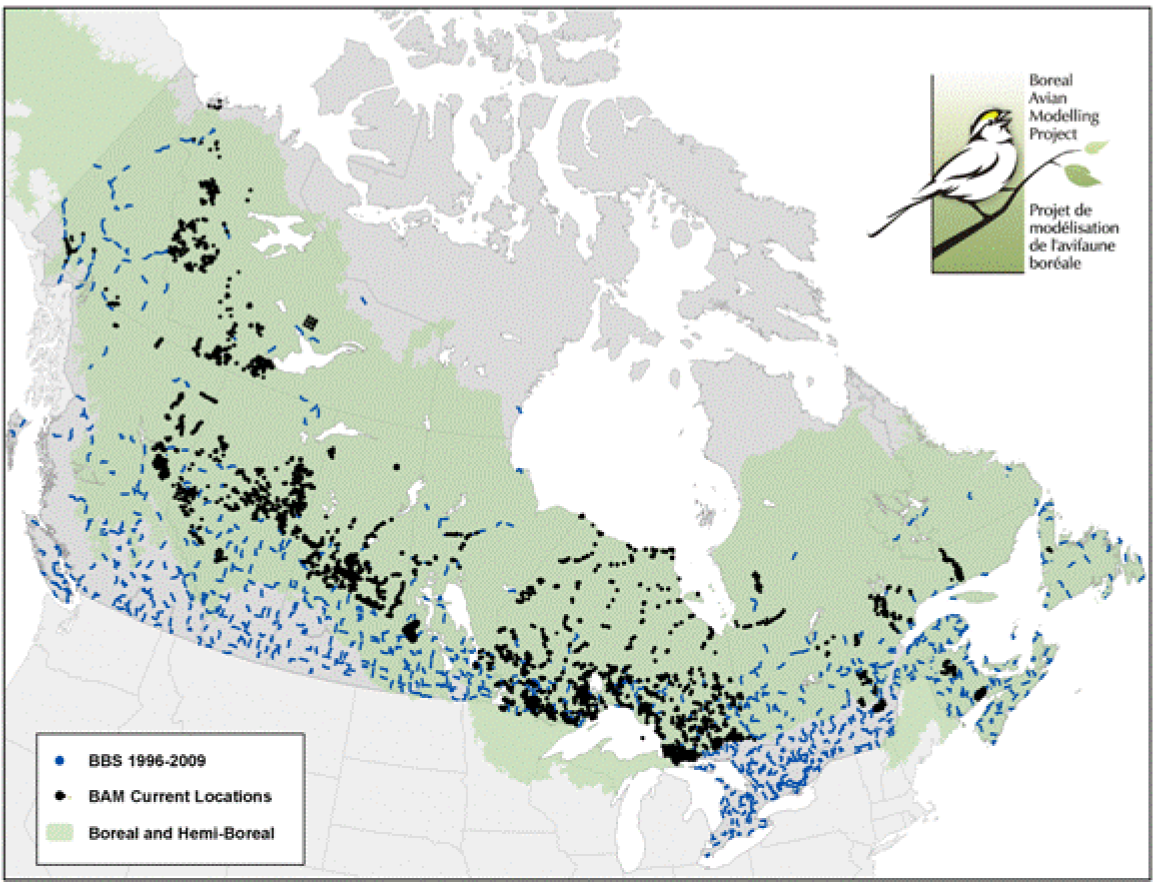


Figure 1: Distribution of point count and BBS data locations included in the BAM Dataset, March 2011.

(iv) Updated GIS data layers

Investigations to identify discover various additional GIS datalayers that can be used to inform our modelling efforts are ongoing. Although we have used the newer MODIS landcover dataset from the CEC, which has been collapsed into 19 landcover classes, we found that for some analyses, the new class descriptions do not always provide sufficient detail compared to the previous product with 39 classes. Therefore, we have reverted to using the 39-class product, subsequently collapsed for our purposes into 17 classes (based on ecological criteria).

We have been using the Geobase National Road Network data for both BBS digitizing and for some analysis of road density issues and available habitat. We are also exploring applications of the Global Forest Watch Canada Access database, used to identify disturbed areas within boreal forests. This database has also been augmented through temporal sequencing to evaluate anthropogenic change in many areas of the boreal forest. Enhanced anthropogenic disturbance data have also been generated for a significant portion of the boreal region in Canada as part of the Environment Canada scientific assessment of critical habitat for boreal caribou. These data are not currently available, but we will be exploring their concordance with our data coverage for future applications.

In the coming fiscal year, we will be revisiting the data layers we are currently using for annual updates and looking for previously unavailable products. Collaboration with the BEACONs group, and their complementary efforts to assemble geophysical data for conservation planning in boreal regions, will facilitate this effort.

2. Species assessment and monitoring

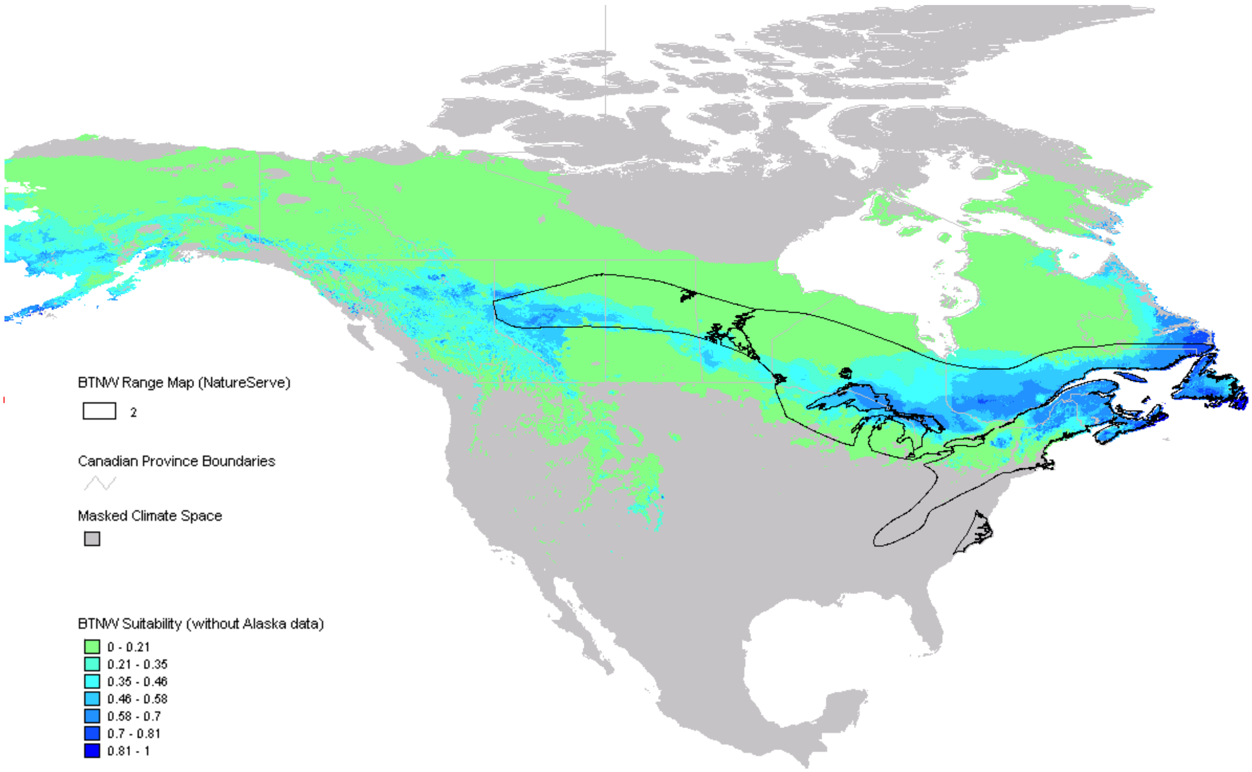
(i) Species' distribution mapping

We have applied the Maxent distribution modelling software (Phillips and Dudik 2008) to the most recent version of the BAM database, allowing us to produce detailed preliminary predictions of species' distributions within the boreal forest region. Our goal is to produce the best possible distribution maps for conservation, monitoring, and management purposes.

Maxent is a robust and user-friendly machine-learning algorithm and modelling tool based on maximum-entropy principles. It was developed for use with presence-only occurrence data, but it can take advantage of absence information to constrain the model-building climate space and fit models similar to generalised linear models, but with more automated options for model complexity.

We have begun exploratory analyses using 4-km grid-cell resolution climate data representing monthly temperature and precipitation normals for the 1961-1990 period (supplied by Andreas Hamann, University of Alberta, as part of a collaborative research project). Additional derived bioclimatic variables and remotely-sensed vegetation variables will eventually be added to improve model fit and spatial predictions. Using a subset of 12 relatively uncorrelated climate variables, and aggregating bird presence information to the same 4-km grid cell resolution (i.e., data from individual point-count locations were used to determine whether a species was present in a given grid cell), we first developed distribution maps using the BAM point-count dataset. Examples for two species (Black-throated Green Warbler and Connecticut Warbler) are shown in Figure 2. Climate space not represented by the survey data (as identified by Maxent) is "masked" in grey.

To explicitly evaluate the contribution of new avian datasets, we developed a second set of models that included point-count data from the Alaska Gap Project (Alaska Natural Heritage Program 2011). For most species, these data improved the models substantially (see examples in Figure 3). However, given that the models were based solely on climate space,



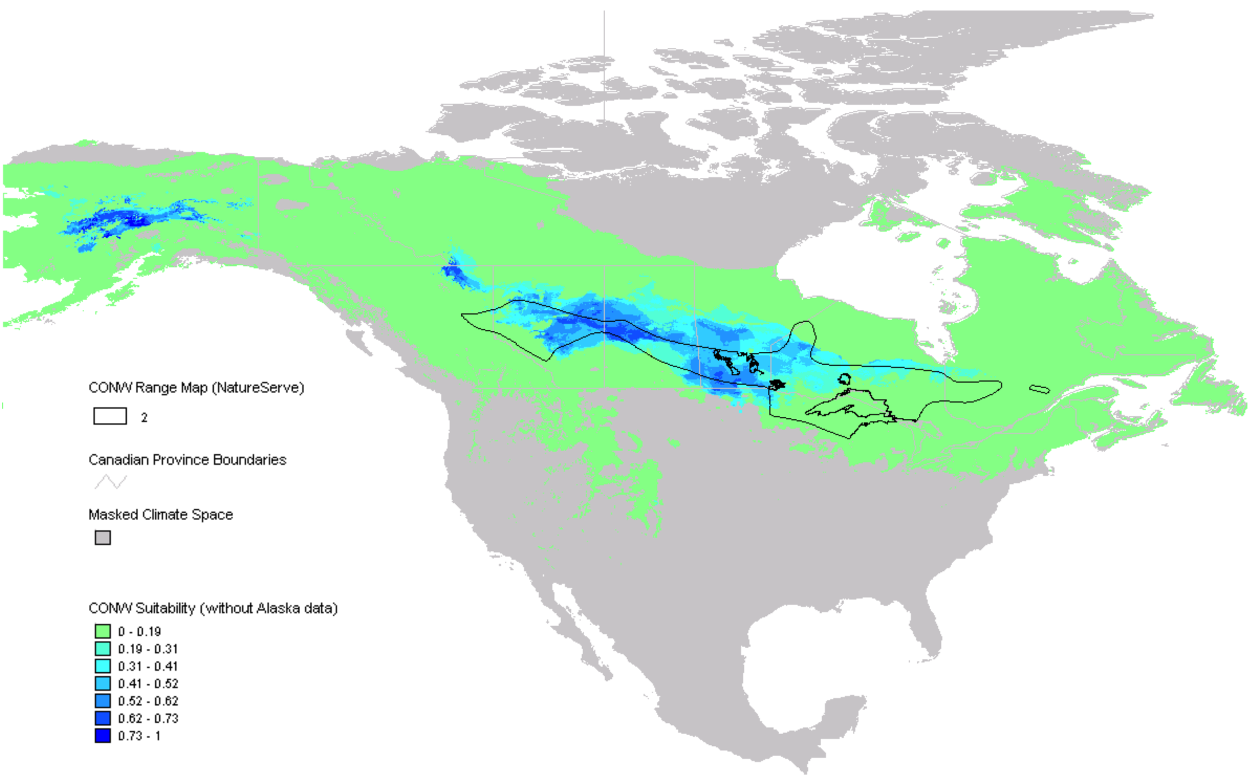
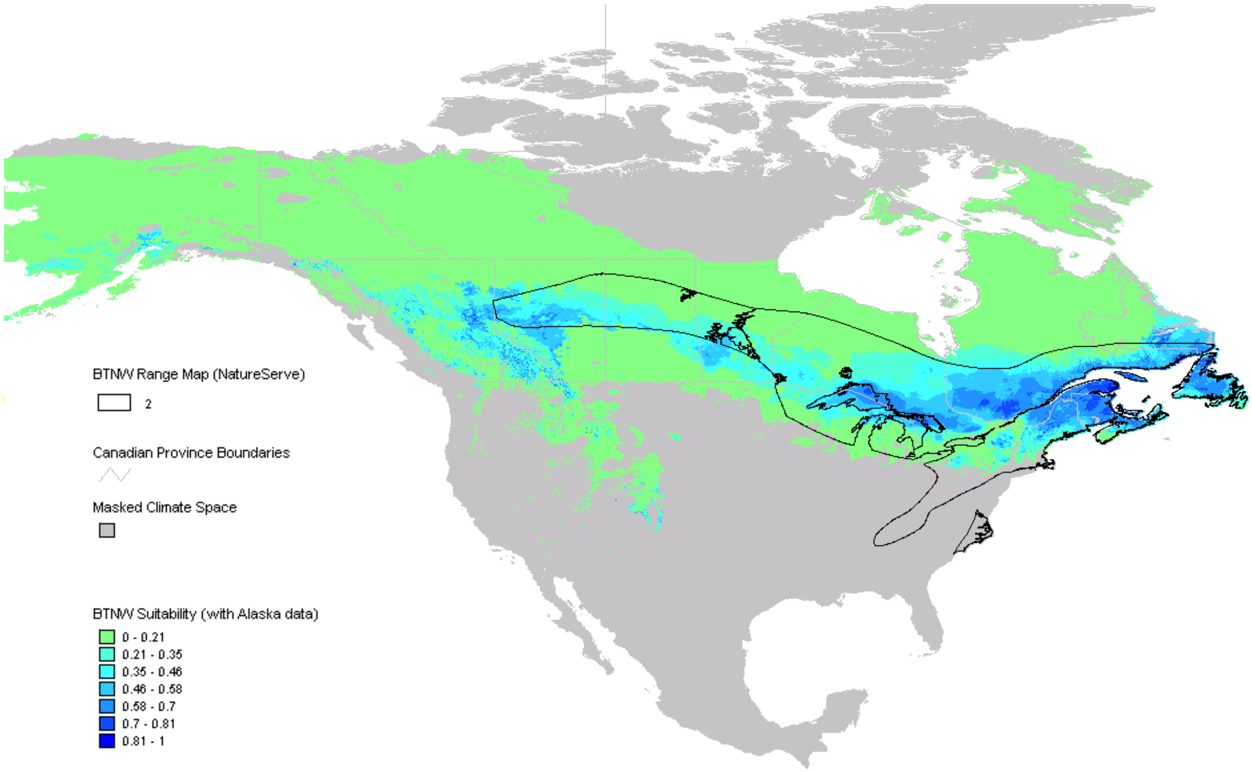


Figure 2. Predicted range distributions of Black-throated Green Warbler (BTNW) and Connecticut Warbler (CONW) using BAM dataset and 4-km grid-cell resolution climate variables. Range distributions predicted using NatureServe data (black outline) are presented for comparison. Climate space not represented by the survey data (as identified by Maxent) is “masked” in grey.



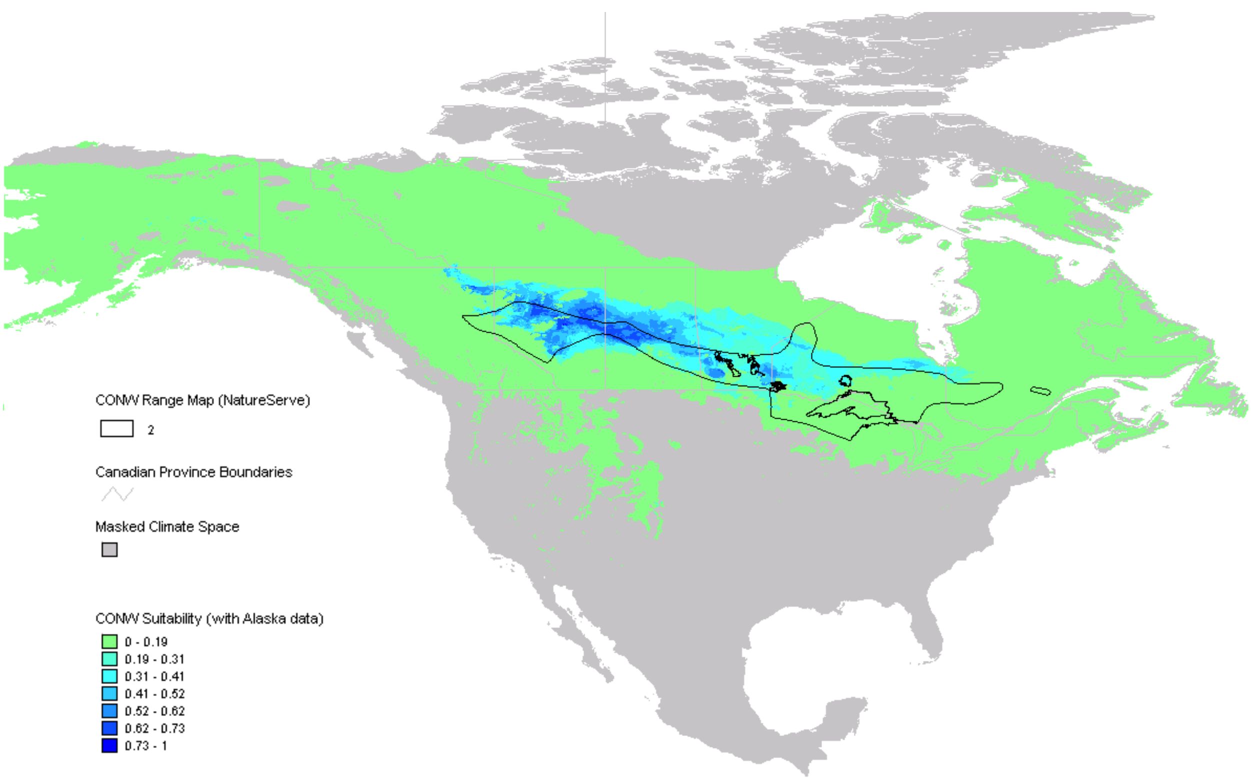
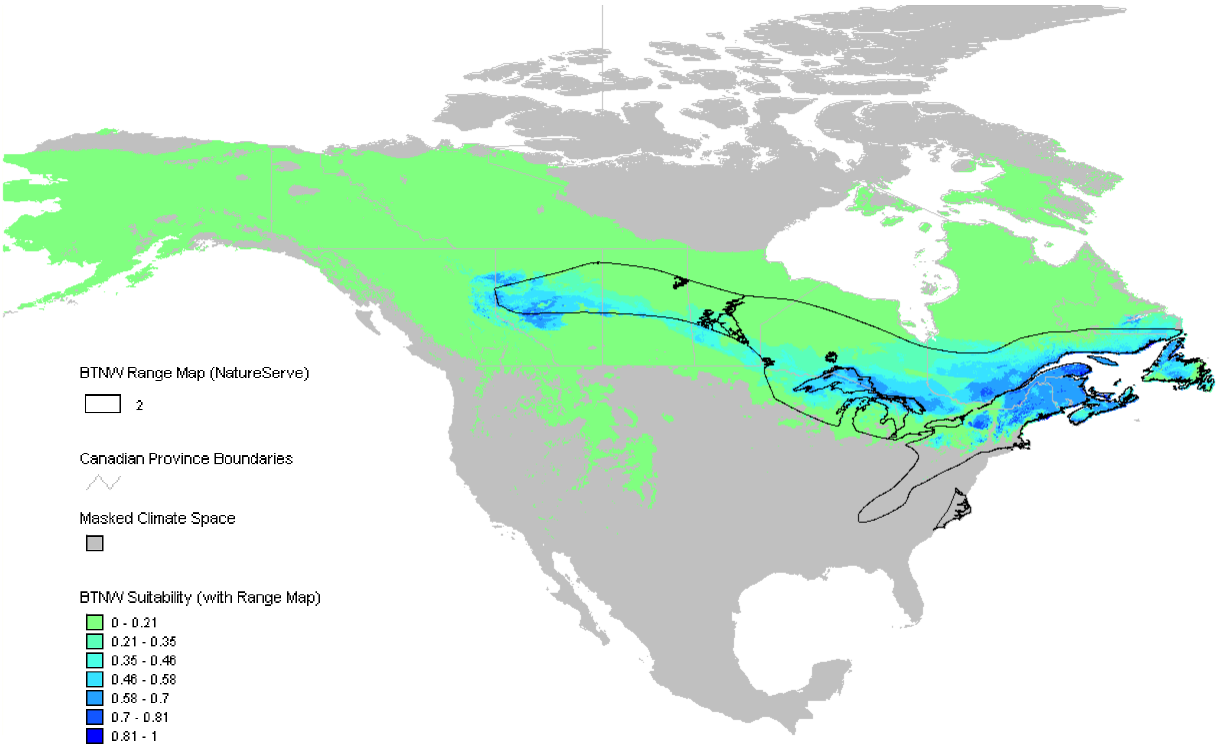


Figure 3. Predicted distributions of Black-throated Green Warbler (BTNW) and Connecticut Warbler (CONW) using core BAM dataset + Alaska Gap data and 4-km grid-cell resolution climate variables.

the predictions still represent "potential" distributions that may not be occupied due to historical biogeographic factors, such as the separation of Alaskan boreal forests from Canadian boreal forests by several mountain ranges.

To constrain distribution maps to areas known to be within the general vicinity of a species' range (without excluding everything outside of published range maps), we experimented with adding distance-to-range edge (negative values within range, positive values outside the range edge) as a covariate in the models (based on NatureServe range maps, http://www.natureserve.org/getData/birdMaps.jsp). This accomplished the goal of constraining modelled distributions, while providing a useful comparison between potential and actual species distributions (Figure 4). We will continue to explore this approach as a potential way to develop more realistic species distribution maps.

As data from new geographic regions are added to the BAM dataset, we can continue to improve the spatial accuracy of predictive distribution maps, and explicitly evaluate the contribution of specific regions and the climate space that they represent. Climate-based models (unconstrained by range maps) will also enable us to evaluate the accuracy of NatureServe range maps and to suggest modifications. We plan to automate the generation of Maxent distribution models and spatial predictions, such that up-to-date maps and GIS data can be made broadly available.



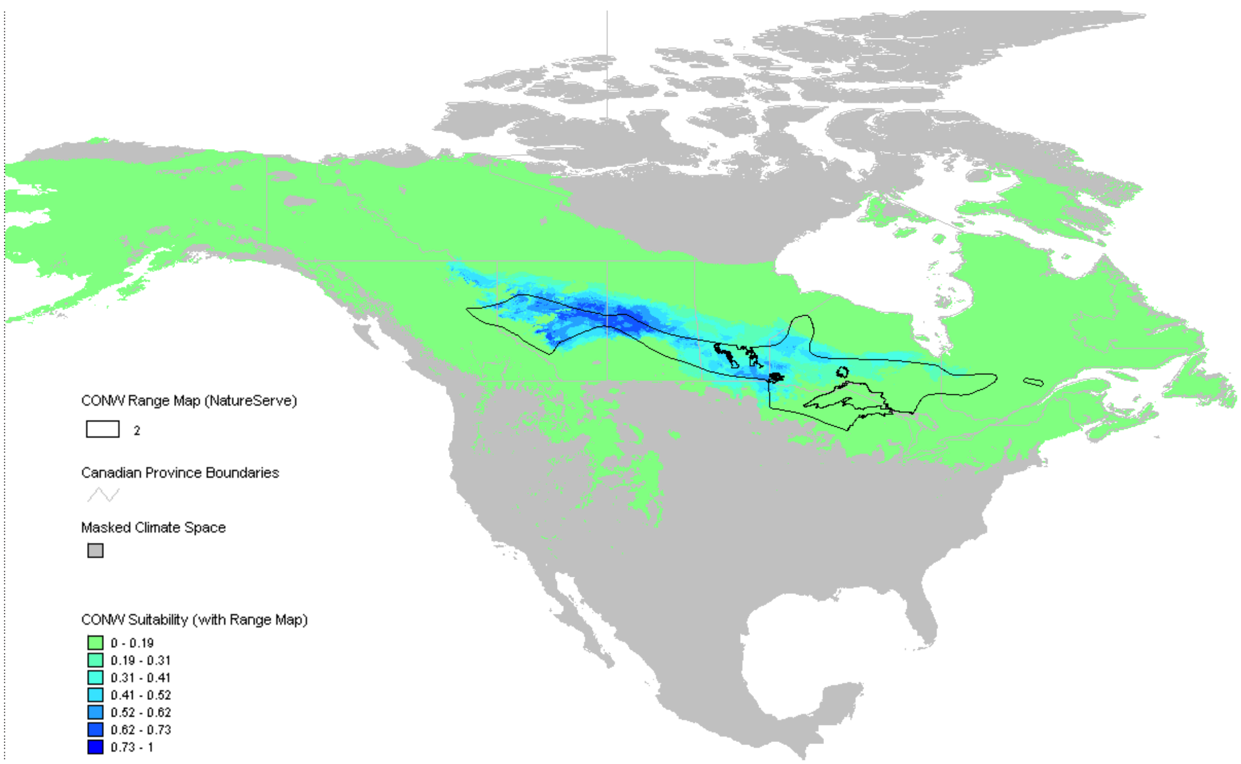


Figure 4. Predicted distributions of Black-throated Green Warbler (BTNW) and Connecticut Warbler (CONW) using models as in Figure 3 but with NatureServe range maps as additional model inputs.

(ii) Density estimation

When BAM data are used to estimate avian densities, two forms of observational bias must be adequately addressed: bias due to the detection process used; and bias due to the variation in survey efforts. Once these biases are accounted for in the density estimates, valid inferences about the ecological processes influencing avian densities may be made.

The first form of observational bias is due to the *detection process* since not all birds present are detected during surveys. Adjusting for avian detectability is complicated both by the different forms of detection bias and the many methods for accounting for them, each with its own inherent strengths and limitations (Efford and Dawson 2009, Nichols et al. 2009, Simons et al. 2009).

The second form of observational bias arises from *variation in survey effort* among our data contributors both in terms of the *duration* of the point counts (e.g., 3, 5, 10 min) and the *maximum distance* from the observer to which birds are counted (e.g., 100-m versus unlimited distance). Furthermore, these two forms of bias may interact, thus further complicating how to effectively account for the observation bias inherent in the data.

To our knowledge, these two forms of observational bias have not been dealt with simultaneously in the avian literature. Thus no simple prescribed approach exists to address this complex issue with the BAM data. For this reason, the BAM team has spent considerable time addressing observational bias with the BAM data. We view this as a fundamental, necessary step that must be completed before we can confidently address more complex ecological questions such as simulating avian responses to both land use and climate change or identifying important areas and habitats for conserving populations of key species or communities of birds, particularly over the extensive and variable regions included in the continental scope of our project.

This year, we made significant progress in assessing methods for accounting for observation bias which are summarised in four sections below. Until quite recently we had be dealing with the different components of observation bias in separate analyses which we then applied to the data to adjust the counts (Sections iii-v).

The team has now developed a cutting edge analytical approach for simultaneously dealing with all of the forms of observational bias that were previously accounted for in separate analyses of the off-road data (i.e., the majority of point count data in the database). This completes our methodological development of density estimators for the survey data that were collected off-road (Section vi).

Our future work on observational bias will focus on reconciling differences in avian counts collected at roadside versus off-road locations. This work will then form the basis for incorporating the BBS survey (i.e., roadside) counts into our models of avian densities.

(iii) Detection bias: Evaluation of occupancy and abundance (N-mixture) models

Occupancy and abundance (N-mixture) models are widely used methods for correcting survey data for detection error. They are assumed to provide unbiased estimates of the proportion of sites used (which are useful in improving models of habitat selection) and abundance (which can be useful in estimating densities and population sizes), (MacKenzie et al. 2006). These methods have fewer assumptions and require data collection that is easier to conduct in the field than other abundance estimators such as distance sampling. The BAM team therefore examined occupancy and N-mixture models for their potential to estimate avian densities based on point-count data. Specifically, we examined whether these models meet their chief assumption that birds do not move into or out of the sampling area over the time period when multiple visits are made to point count stations (i.e., that the population is "closed"). We also examined whether these models could be improved by relaxing the requirement for multiple visits to sites. Finally, we evaluated these models to determine how they account for different forms of detection bias.

Closure assumption.— We found that probability of detection using both occupancy and abundance (N-mixture) models was negatively related to the mass (g) of the species. As territory size is proportional to body size (mass), this suggests that the probability of detection for species with large territories is low due to within territory movements. This result indicates that the basic assumption of closure may often be violated and that the severity of this violation increases with territory size (Figure 5). We consider this a severe limitation to these models (Bayne et al. in revision).

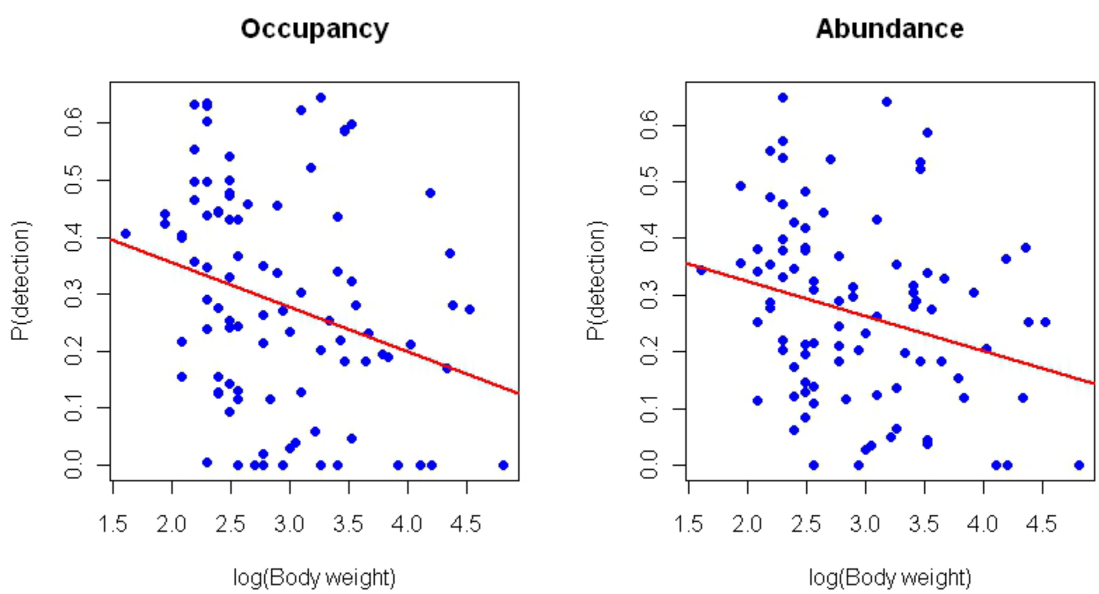


Figure 5. Relationship between probability of detection (estimated by multiple-visit surveys and occupancy and N-mixture models) and body size. Each dot represents a species, 2–8 repeated visits were used from BAM database.

Number of visits.— Occupancy and abundance (N-mixture) models require multiple visits to sites which increase survey costs while decreasing the number of sites that can be visited. This limitation is particularly problematic in the boreal where remote locations are often quite difficult and expensive to access.

As an alternative to the multiple visit approach, we therefore investigated whether occupancy and abundance (N-mixture) can be estimated from surveys with a single visit. Contrary to MacKenzie et al. (2006), we demonstrated that under certain conditions, we can separate out occupancy and abundance from detection error with a single visit to survey sites (Lele et al. under revision, Sólymos et al. In review). The required condition is that at least one continuous covariate in the model must influence either the avian counts or detection rates. A literature survey conducted as part of preparing the manuscript of Lele et al. (under revision) indicates this condition is almost always met. As part of this effort we developed a software package in program R to fit occupancy and abundance models with single visit data. This package will be freely available once the methodology is published.

Decomposing detection.— A drawback of using occupancy or abundance (N-mixture) approaches (including the single visit extensions) is that the detectability side of the models uses a Bernoulli distribution, which treats the detection process as homogeneous. However, the detection process is actually the product of two Bernoulli processes. The first detection process is the probability that a bird gives a cue, such as a song, and is thereby available for sampling (P_{avail}). The second is the probability of detecting a bird given that it is available for detection (e.g., singing is detected by the observer, P_{detect}). This multiplicative nature of the detection process ($P_{avail} \cdot P_{detect}$) is now becoming widely acknowledged (Nichols et al. 2009), yet statistical approaches to address this issue have not been widely developed or used. Ignoring this issue can lead to biased estimates of detectability and we view this as a further limitation to occupancy and N-mixture models.

Heterogeneity in detection with distances of birds from points.— Finally, distance sampling is the only abundance estimator that accounts for heterogeneity in detectability due to the distance of birds from observers, which is perhaps the most ubiquitous source of detection bias in animal surveys. In the face of such heterogeneity, all other density estimators, including N-mixture models do not perform well (Efford and Dawson 2009). However, distance sampling is not without its limitations, some of which we address below (Section iv).

Conclusions.—We feel that our development of the single-visit approach to occupancy and N-mixture models will help extend these analytical approaches to a much wider variety of survey situations than are currently allowed by the standard multiple-visit approach. However, both single- and multiple-visit models are currently limited for estimating avian densities because the different components of the detection process cannot be separated and the effective area of the surveys cannot be estimated. We feel that these issues are better addressed using a combination of distance sampling to address P_{detect} and time-of-removal models to address P_{avail} (Farnsworth et al. 2005, Handel et al. 2009). We applied such models to the BAM data and describe these below (Sections iv and vi).

(iv) Relationships between detection rates and survey effort: how robust is the Effective Distance Radius (EDR) approach to variation in count duration and maximum distance of counts?

Distance sampling is probably the most widely used method in wildlife ecology for adjusting raw survey counts for detectability to estimate animal abundance (Buckland et al. 2001). These models address the detectability of those birds available for sampling (P_{detect}). The estimate of P_{detect} for point count surveys is often expressed as the effective detection distance radius (EDR) of the survey, which is used to define the area effectively sampled during the survey. Since birds vary in how loudly they sing, EDR can vary quite substantially among species (Figure 6). The application of distance sampling to avian point counts has recently come under heavy scrutiny due to the findings of large errors in estimating distances to singing birds, particularly those birds 65–86 m from observers (Alldredge et al. 2006). A practical solution to this problem is to limit the number of distance intervals and thereby minimise errors in estimating distances to singing birds. The simplest distance sampling model is a binomial model with two distance intervals divided by a single distance cut point. This model was developed in the 1980s to simplify data collection and was found to be quite robust in simulations (Buckland 1987). However, the binomial model has seen little use in North America despite the wide availability of data to be analyzed (Ralph et al. 1992).

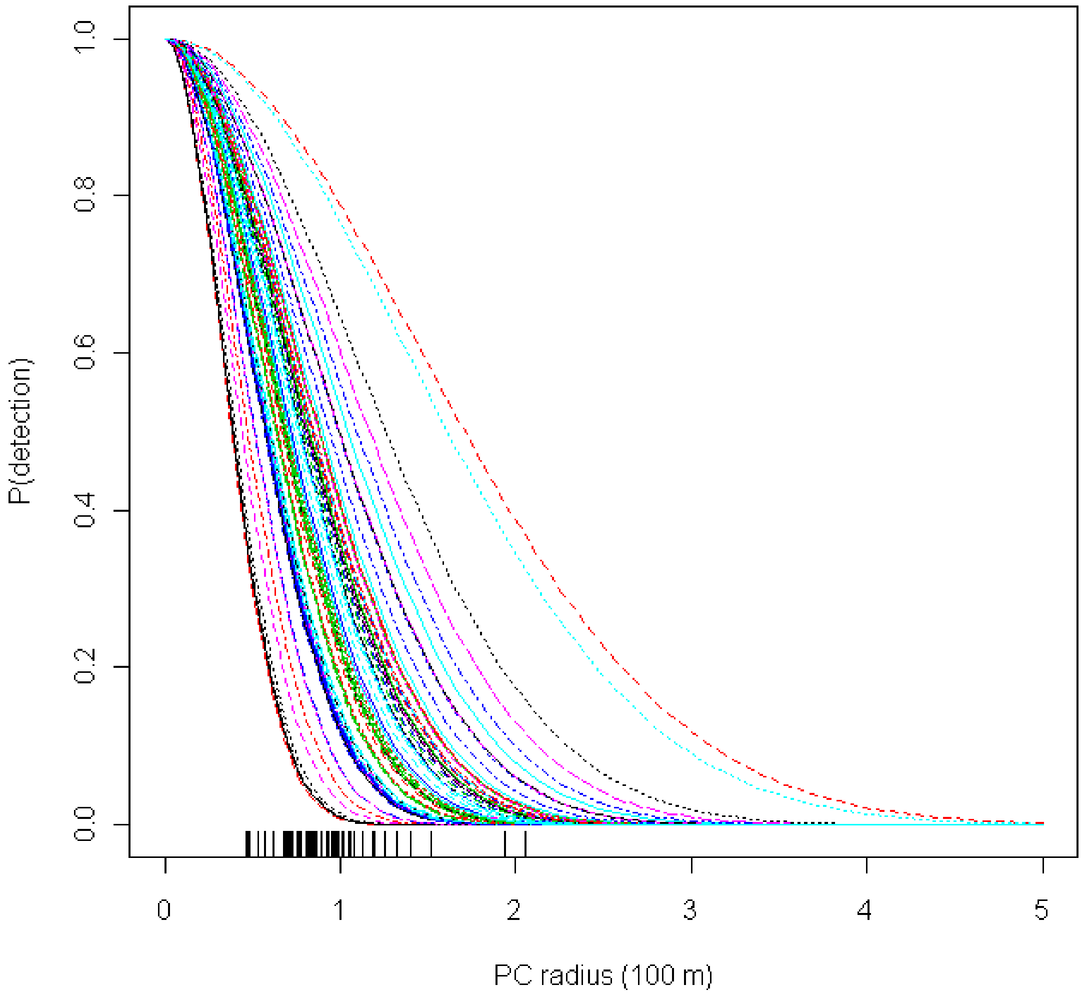


Figure 6. Detection probabilities for 71 species in relationship to the distance of birds from sampling points. The effective detection radius (EDR) of each species is denoted above the x-axis.

The BAM dataset includes a substantial number of surveys where the counts of birds were tallied relative to at least a distance cut-point of 50 m (0–50 m, >50 m) from the observer. Thus, binomial distance sampling was used to estimate EDR and thereby adjust the raw BAM survey counts for the effective area sampled (see BAM website http://www.borealbirds.ca/index.php/bam_edr). However, several issues with the binomial model have not been resolved in relation to goodness-of-fit and how robust the estimates of EDR and breeding density are to variation in survey duration and maximum distance to which birds are surveyed. Furthermore, EDR may vary with habitat and the total number of birds at a survey point and accounting for these covariate effects will improve estimates of avian density (Marques et al. 2007). We addressed these issues over the past year and are finalizing a manuscript which we will submit to the Auk in 2011 (Matsuoka et al. in preparation).

Goodness-of-fit.— We estimated EDR using binomial and multinomial distance data and found these models result in similar estimates of EDR for 98% of 97 species. Thus, for the majority of species, the binomial models were reliable estimates of breeding density with reasonable goodness-of-fit. The two clear exceptions were American Crow (*Corvus brachyrhynchos*) and Common Raven (*Corvus corvus*), for which binomial models tended to overestimate EDR and therefore underestimate breeding density.

Effects of maximum count distance.— We found that the estimates of EDR were not robust to pooling of data (pooling robust) with different maximum count distances and instead were on average 12% lower for data collected out to a maximum distance of 100 m compared to data collected to an unlimited distance. The magnitude of this disparity increased with increasing values of EDR. However, when we applied EDR to the counts we found that the resulting estimates of breeding density were equivalent between data collected to 100 m versus an unlimited distance. Thus, EDR must be calculated separately for surveys with different maximum detection distance but the resulting estimates of breeding density are comparable. We suggest that surveys, when possible, should count birds out to unlimited distances as this will typically increase the number of detections for analysis and thereby increase precision in estimates of EDR and breeding density.

Effects of count duration.— Estimates of EDR were equivalent relative to counts of 3, 5, or 10 min in duration and thus pooling the values is robust. However, the raw counts increased with count duration such that estimates of breeding density increased on average by 20% from 3- to 5-min counts and 29% from 5- to 10-min counts. This indicates that studies using different count durations cannot directly compare estimates of abundance derived from distance sampling; this likely holds true for other abundance estimators as well (Section v). If increases in density with count duration are due in part to bird movements, then breeding densities from the longer counts are overestimated due to violations of the closure assumption (Buckland 2006). This positive bias arises because observers are more likely to count birds moving towards than away from the point due both to heterogeneity in detectability with distance and the larger area of distance bands farther from the point. This argues for a short count period (3 or 5 min) when estimating breeding densities to minimise positive bias (Buckland 2006). However, the longer counts might be particularly useful for increasing detections of rare species (subsection a).

Covariate effects.—Our preliminary results indicate that EDR varies among general habitats categories for 40% of species, with EDR generally increasing along a gradient from closed forest through open forest to non-forested areas (Figure 7). We also found that estimates of EDR varied with the total number of birds detected at the point for 60% of species, with 3-times more species showing increases rather than decreases in EDR with increases in total avian detections. By accounting for these covariate effects on EDR, we will be able to minimise bias when we compare avian densities between geographic and habitat strata (Marques et al. 2007). Finally, we also found that EDR is negatively correlated with maximum song frequency of species. This confirms the value of using the EDR approach since high frequency sounds travel shorter distances than low frequency sounds. This pattern was so strong that we were able to build a regression which allowed us to estimate EDR for any songbird with a known song frequency.

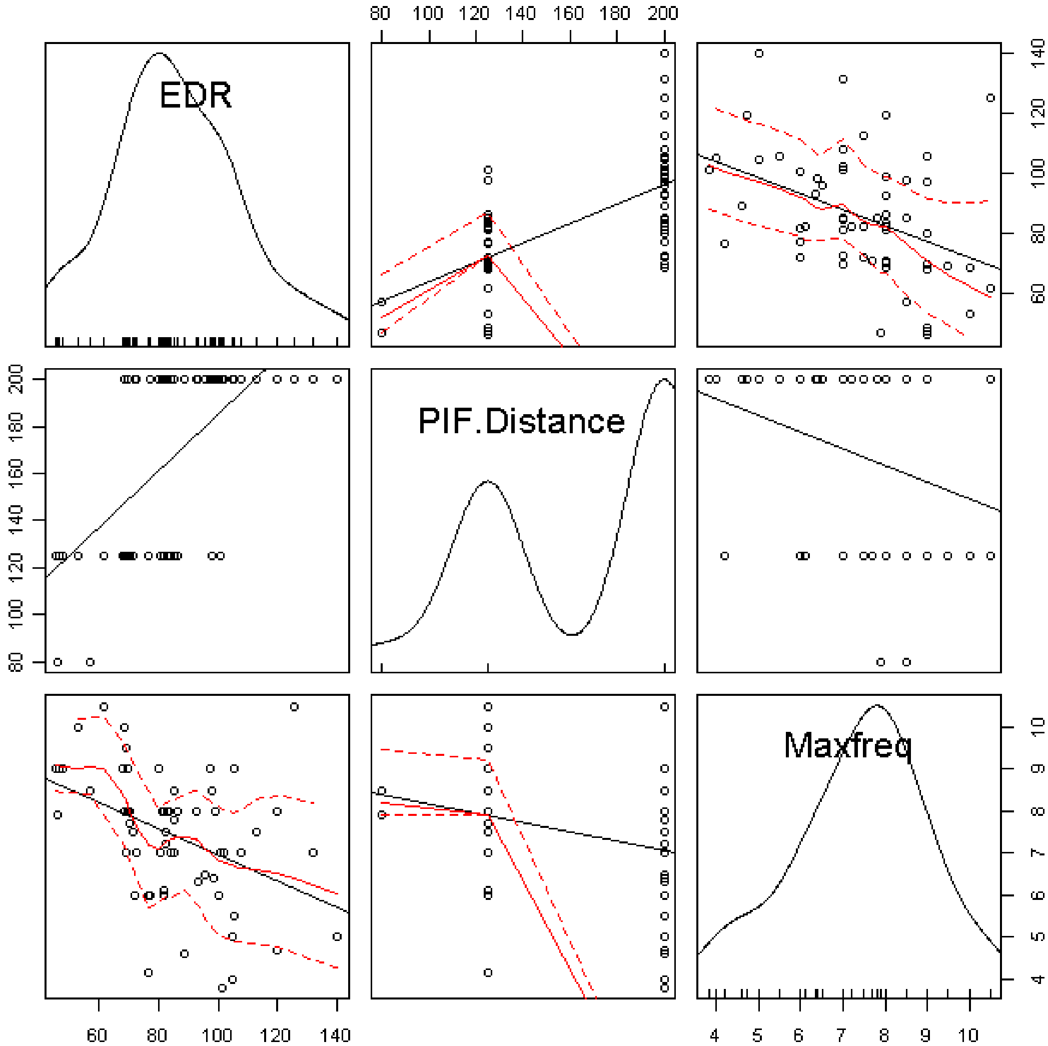


Figure 7. Scatter graphs of pairwise relationships among the effective detection radius of surveys (EDR, m), Partners in Flight maximum detection distances (PIF. Distance, m), and maximum song frequency from the Birds of North America accounts (Max freq, MHz). For example, the upper right box represents the relationship between EDR (y-axis) and Maxfreq (x-axis).

Conclusions.—Binomial distance sampling models appear to be equivalent to multinomial distance models in estimating EDR and therefore produce robust estimates of density for that portion of the breeding population that is giving cues and is thereby available for detection. Including covariate effects of habitat and total avian abundance will improve estimates of EDR and breeding density. However, estimates of EDR and breeding density were sensitive to maximum distance of the survey and count duration, respectively. These relationships between detection rate and survey effort need to be take into account when estimating breeding density for the entire BAM dataset. Also, for species that do not sing often during our survey period (mid-May through June), it will be necessary to account for

P_{avail} to provide unbiased estimates of density (Handel et al. 2009). We address this component of detectability below (subsection b).

(a) Bias in survey effort: approaches for correcting point counts of different durations to a common standard

Despite pleas for a standardised approach to collecting point count data (Verner 1988, Ralph et al. 1993), a wide degree of variation persists in the duration of time over which birds are recorded at individual survey locations during point count surveys. Therefore, direct quantitative comparisons of avian counts from different studies using different count durations are not currently possible. A clear need exists for point count standards that will allow for robust comparisons of studies conducted in different areas and years. Regardless, when dealing with existing datasets, the question remains as to what can be done to make data derived from different methodologies as comparable as possible? This important question must be resolved for the BAM dataset which includes a range of different count durations in the off-road data (3, 5, 10 min) but only 3-min counts for the roadside surveys from the BBS.

To address these issues we examined how avian counts accumulate over time in the BAM dataset (3, 5, 10 min) and whether such knowledge could be used to adjust counts of variable durations to a common duration standard. Our prediction was that the counts should increase with count duration in a consistent but nonlinear manner across species. We tested our prediction using generalised linear models (GLM) and generalised estimating equations (GEE) and with count duration treated either as a fixed effect or an exposure term. We controlled for autocorrelation of counts in time and space as well as the covariate effects of habitat, time (day, season, year), and whether counts were conducted roadside or off-road. We are currently preparing a manuscript on this topic which we will submit for publication in 2011 (Bayne et al. in preparation).

Fixed effects and roadside bias.—We were quite surprised to find that only 65% of 75 species showed the expected pattern of counts increasing with count duration modelled as a fixed effect. The species that did not follow this pattern were found to have their highest predicted mean count during a 3-min roadside survey (35% of 75 species). However, all roadside surveys were 3-min in duration, so our findings in part reflect a confounding interaction (on/off-road x count duration) which could be removed if we had roadside surveys of 5 and 10 min durations. However, our results indicate that roadside surveys may be inherently different from off-road surveys, possibly because 1) birds can be heard for greater distances along roadside or 2) BBS methods sample a different population of birds that are attracted to habitats along roads.

Correction factors.—When we looked only at the off-road counts, however, we found over a 10-min survey that on average 60% of individuals were detected from 0–3 min, and 75% from 0–5 min. Thus it is feasible that corrections could be developed to account for variation in count duration. However, the accumulation of counts over time varied among species such that a relatively higher proportion of individuals of common species are counted during the early count intervals (0–3, 3–5 min). Our analyses of audio recordings at point counts indicated that this pattern was not due to observer bias in selectively counting the common species first and the rare species second. Instead, populations of birds may be heterogeneous relative to detectability with some individuals easily detected while others much more difficult to detect (Farnsworth et al. 2002). If so, then commonly-counted species may have a relatively large proportion of their population that is easy to detect, possibly due to a propensity to counter sing, such as has been found for Ovenbirds (*Seiurus* *autocapilla*; Van Horn and Donovan 1994). Thus species-specific correction factors for count duration are needed.

Conclusions.—Developing species-specific corrections for the effects of survey duration on avian counts is both feasible and strongly advised for the off-road BAM survey data. Our results do indicate inherent differences in either detectability or the populations sampled by roadside versus off-road counts. Thus challenges remain on how best to account for survey duration when combining the off-road BAM data with data from the 3-min roadside BBS counts.

(b) A cutting-edge tool for simultaneously addressing bias in detection and survey effort

The BAM team developed a new method that simultaneously adjusts the survey counts for (1) incomplete detectability of birds both in terms of P_{avail} and P_{detect} and (2) variation in survey effort in terms of count duration (e.g., 3, 5, 10 min) and maximum distance to which birds are counted (e.g., 100 m versus unlimited distance). The estimation of P_{avail} is entirely new in our analyses and uses a time-of-removal model to estimate the proportion of birds in the sampled population that are giving cues and thus are available for detection. This removal model operates on the premise that singing follows a Poisson distribution with the mean determined by singing rate and count duration. Birds that sing more often have higher P_{avail} which we estimate from counts with multiple time intervals (i.e., 0–3 min, 3–5 min, 5–10 min; Farnsworth et al. 2002). Our models of P_{avail} with time-of-day and time-of-year effects (Figure 8) were better supported than models with no effects which is consistent with diurnal and seasonal singing behavior as it related to avian counts (Rosenberg and Blancher 2005, Thogmartin et al. 2006). Our estimates of average singing rate were also positively correlated with singing rates from the literature (Figure 9), which further validates our approach.

We used distance sampling to estimate P_{detect}, expressed as EDR, from counts with multiple distance intervals. We modelled EDR relative to habitat as we previously found this to influence detectability. We then used the resulting models of P_{avail} and P_{detect} to estimate per hectare bird densities. Thus, the resulting density estimates were simultaneously adjusted for detectability and survey effort. A preliminary assessment showed that the ranked abundance of 17 of 56 species changed by more than 10 places when ranks were based on densities versus raw counts. For example, Golden-crowned Kinglet (*Regulus satrapa*) was the 32th most abundant species based on unadjusted counts but was the 8th most abundant species after accounting for detectability (Table 1). This emphasises the importance of accounting for detectability when determine the structure of breeding bird communities. We will soon be making the density estimates available in a database which can be queried relative to geographic strata and landcover. We anticipate that this will have a variety of applications such as assessing the impacts of proposed developments on boreal birds and defining habitat targets for achieving population goals in BCRs and for species of concern.

In addition, we programmed these analyses and the organisation of the results using high performance parallel processing and sparse matrix representations. This now allows us to easily apply the new density estimator to ecological questions related to habitat use and responses to land use or climate change. We can also now quickly update our density estimates as more data become available. This will be particularly important as we integrate the large datasets from Alaska, the hemiboreal region, and the BBS.

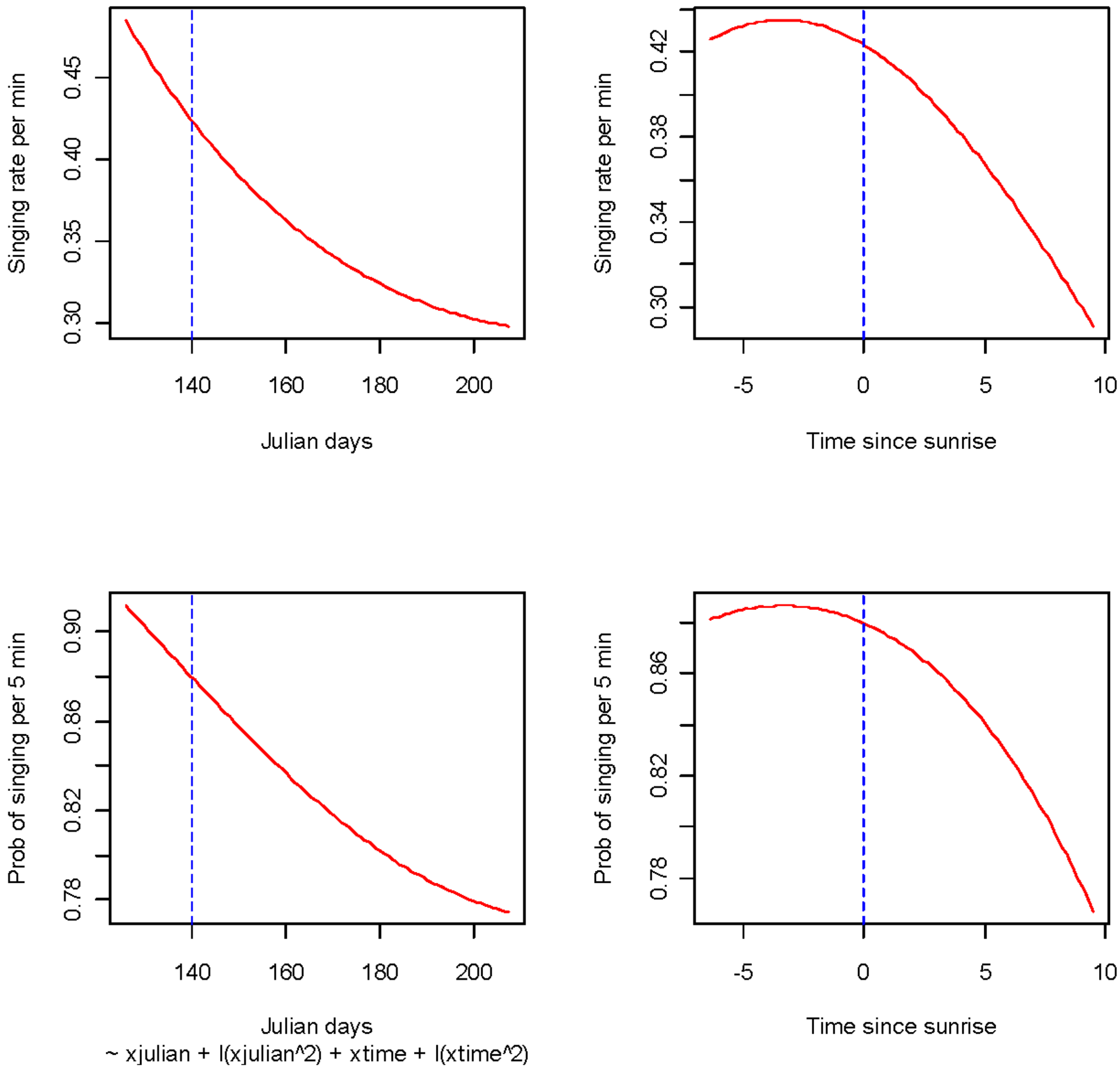


Figure 8. Time of day and date effects on singing rate and probability of singing per 5 minutes for Ovenbird.

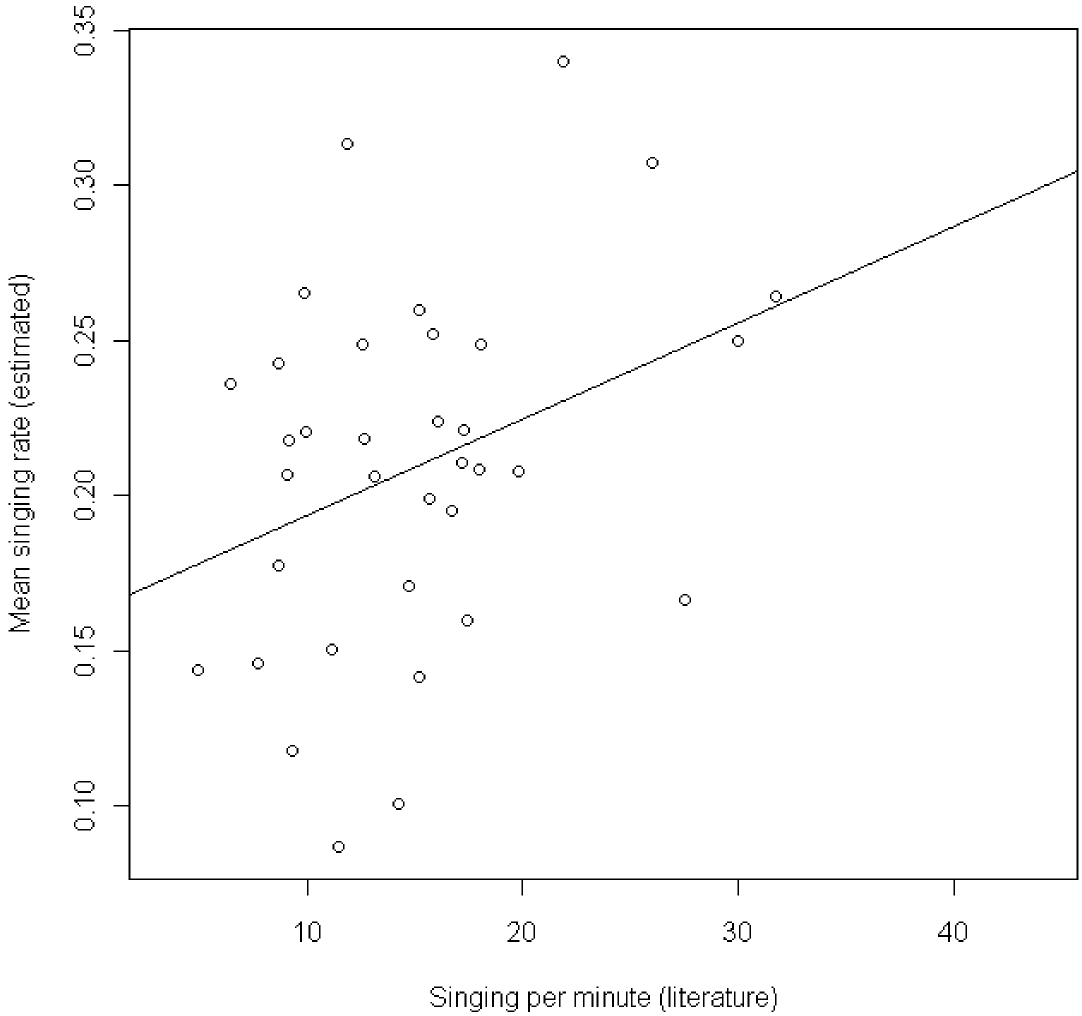


Figure 9. Relationship between estimated mean singing rate and singing rate from the literature.

Table 1. Ranked abundance of 56 species based on counts corrected for detection probability (density, birds / ha) and raw uncorrected counts (birds / point). The difference in the ranks (difference) indicates the degree that the uncorrected counts under (-) or overestimate (+) the ranked abundance among species.

	Corrected counts		Uncorrected counts		
Species	Density	Rank	Birds / point	Rank	Difference
YRWA	0.356	1	0.310	4	-3
TEWA	0.202	2	0.236	7	-5
REVI	0.190	3	0.433	3	0
WTSP	0.183	4	0.498	1	3
OVEN	0.182	5	0.459	2	3
AMRO	0.172	6	0.299	5	1
CHSP	0.168	7	0.214	8	-1
GCKI	0.167	8	0.058	32	-24
MAWA	0.136	9	0.154	12	-3
AMRE	0.120	10	0.123	17	-7
BCCH	0.117	11	0.114	19	-8
SOSP	0.113	12	0.201	9	3
YWAR	0.109	13	0.111	21	-8
SWTH	0.109	14	0.238	6	8
RBNU	0.097	15	0.093	26	-11
NAWA	0.095	16	0.152	13	3
BTNW	0.089	17	0.145	14	3
CEDW	0.089	18	0.062	30	-12
DEJU	0.088	19	0.079	28	-9
LEFL	0.085	20	0.112	20	0
RCKI	0.084	21	0.122	18	3
BLBW	0.075	22	0.050	35	-13
BBWA	0.074	23	0.036	43	-20
BOCH	0.074	24	0.016	50	-26
COYE	0.073	25	0.127	16	9
CSWA	0.069	26	0.104	22	4
BAWW	0.067	27	0.071	29	-2
MOWA	0.062	28	0.098	24	4
GRAJ	0.055	29	0.040	41	-12
WIWR	0.052	30	0.159	11	19
PISI	0.048	31	0.024	47	-16
RBGR	0.046	32	0.099	23	9
BHVI	0.044	33	0.051	34	-1
ALFL	0.044	34	0.090	27	7
HETH	0.043	35	0.136	15	20
VEER	0.043	36	0.097	25	11
BRCR	0.043	37	0.030	44	-7
LISP	0.042	38	0.058	31	7
YBFL	0.039	39	0.047	37	2
BLPW	0.037	40	0.010	56	-16
PUFI	0.037	41	0.017	49	-8
AMCR	0.034	42	0.198	10	32
CMWA	0.033	43	0.011	54	-11
TRES	0.032	44	0.049	36	8
SWSP	0.030	45	0.045	38	7
NOWA	0.027	46	0.040	40	6
CAWA	0.026	47	0.030	45	2
PHVI	0.023	48	0.025	46	2
PAWA	0.018	49	0.020	48	1
WIWA	0.015	50	0.012	51	-1
EAWP	0.015	51	0.040	39	12
OCWA	0.015	52	0.012	52	0
CONW	0.014	53	0.038	42	11
CORA	0.010	54	0.053	33	21
NOPA	0.008	55	0.010	55	0
OSFL	0.003	56	0.012	53	3

3. Selecting and developing avian habitat data layers

(i) Update on Forest Resource Inventory (FRI)/Common Attribute Schema (CAS) assembly

Different jurisdictions across Canada, including both government organisations and private industry, hold Forest Resource Inventory (FRI) data that contain detailed spatial information about forest age, structure, and composition that provides valuable information concerning habitat conditions. Over the last three years we have:

1. Assembled all digital Forest Resource Inventory data that exists for the BAM study region as defined in 2008;
2. Developed a standardised representation of these inventories called the Common Attribute Schema (CAS); and
3. Completed an initial translation of all the assembled inventories to this standardised format.

In 2010 – 2011, we developed an automated scripting system to:

1. Export each source data set from its native GIS format as a shapefile and an attribute table;
2. Translate the attribute tables into the CAS format; and,
3. Upload the shapefiles and tables into the open source PostGIS.

The system is essentially a set of python and perl scripts with links to GIS applications. The translation stage assigns a unique ID to each polygon, and merges external information as necessary. The development of this scripting tool was essential to ensure that the process is repeatable and to provide the minimal framework for effective updates. In the course of this work, we discovered and corrected numerous minor bugs in the original translation code. We also uncovered and resolved some ambiguities and oversights in the initial CAS specification. The revised specifications will be posted on the next update to the BAM website. We have also created a prototype of a systematic verification system to validate all the translation rules. However, executing this stage requires at least six months FTE staffing plus additional support from the contractors who developed the CAS. In partnership with BEACONs, we will be seeking additional resources to complete this work.

The CAS dataset has already been used to generate data tables for national models of other wildlife species, and for a model comparison study restricted to parts of Ontario and Québec (conducted by Cumming's lab as part of an agreement with Environment Canada, Science and Technology, Wildlife and Landscape Science Directorate (EC, S&T, WLSD) described in Section 5 below). The CAS dataset is now available for applications to regional and national analysis of the BAM dataset projected for 2011 and beyond.

A background document outlining the CAS approach was posted on the BAM website in 2010. The report detailing the CAS approach to standardising forest resource inventory information across Canada was completed by Timberline Natural Resource Group in February 2011 and is available from the BAM Project Coordinator.

(ii) National wetlands mapping product

Standardised high-resolution wetlands maps have not been available at national extents. Pursuant to a meeting in Edmonton between Cumming's lab and Ducks Unlimited Canada (DUC) scientific and technical staff in July 2010, we were introduced to the prototype Hybrid Wetland Layer (HWL) that DUC had developed for Western Canada. The HWL integrates two main data sources: 1) the LANDSAT-based EOSD product, which includes water and wetland classes in its legend; and 2) the vectorial CanVec maps digitised from 1:50,000 NTS map sheets, which includes five or six distinct wetland classes. The integration of these two products yields a high-spatial resolution raster product that is the most complete representation of open water and wetlands. The DUC western boreal office agreed to produce a national version of the HWL, covering the entire boreal region of Canada. A first version was compiled in October 2010. The current revised version of the national product was released to BAM in January 2011.

(iii) Status of S4H collaboration evaluating landcover products

In 2008-9, we initiated a collaborative project with the Canadian Forest Service (CFS) and Space for Habitat (S4H) to evaluate the alternate landcover products available for habitat modelling, including MODIS LCC05, NALC 2000, Landsat based EOSD, and FRI data. The BAM contributions to analyses were completed and the preliminary conclusion was that the MODIS-based 250-m resolution landcover data were the most appropriate for habitat modelling throughout the boreal region. S4H assumed responsibility for preparing a manuscript summarizing the results for submission to the Canadian Journal of Remote Sensing.

4. Habitat associations, impact assessment and risk characterisation

(i) Update on CARTs

In 2010 – 2011, we conducted a comprehensive analysis of CART (Classification and Regression Trees) models previously generated for 97 songbird species (described in the 2009 – 2010 BAM report). We quantified the frequency of selection and explanatory power of each of 131 explanatory variables available to the fitting process, and variation in these values by migratory group. In general, a small proportion of the available covariates are sufficient to explain more of the explainable variance in each group. We also developed some novel but simple tests on the structures of regression trees that tested some prior hypothesis, for example on the relative importance of climatic and land-cover covariates. One exciting new finding is that landcover covariates tend to occur on the right-hand side of a regression tree (on the CART output). This positioning on the model structure may be interpreted to mean that habitat specialists select for preferred forest habitat types within climatically-suitable regions. A draft of a manuscript presenting the complete analysis was completed in March 2011 and will be submitted following team review to the journal *Global Ecology and Biogeography* by June 2011.

(ii) Update on assistance to Environment Canada Marxan Analysis

C. Lisa Mahon, BAM team affiliate on staff at EC, is nearing completion of a project designed to determine priority areas for boreal birds using avian and habitat data derived partially from the BAM datasets. This is a prime example of how the BAM dataset and products (in this case, standardised density models) can be used by resource managers to further boreal bird conservation efforts.

Mahon is currently working to identify priority areas for a subset of boreal forest landbirds within Bird Conservation Region (BCR) 6, the Boreal Taiga Plains, using the decision support tool Marxan. She is conducting two multi-species co-location analyses using different types of conservation feature data: species breeding range and habitat suitability models. It is expected that priority areas determined based on suitable habitat within a species breeding range should provide a finer level of detail because habitat suitability models are used to model the distribution of species based on specified habitat ratings. Marxan will attempt to include only suitable habitats for all species within the priority area network. Habitat suitability (HS) models used in this analysis include: BAM standardised density models for n=28 boreal songbirds and Wildlife Habitat Rating Standard (WHRS) models for n=5 boreal landbirds (raptors, woodpeckers, nightjar). She implemented all habitat models using the BAM-Land Cover 2005 habitat layer (17 habitat types) and calculated effective habitat using a Habitat Evaluation Procedure (HEP) where habitat units (or effective habitat)=habitat quality (HS value) x habitat amount (area of available habitat for each habitat type).

Mahon has completed pre-processing of GIS data for use as Marxan input data including calculating the amount of breeding range (analysis 1) and suitable habitat (analysis 2) for each species within the study area and each planning unit. For each analysis, she is currently in the process of developing parameters for the Marxan model, completing a series of 100 runs, and interpreting spatial (map) and tabular output. After completion of the Marxan analyses, projected for mid-2011, she will write a manuscript with BAM team members comparing priority area networks developed using both simple (species breeding range) and complex (habitat suitability models) conservation feature data.

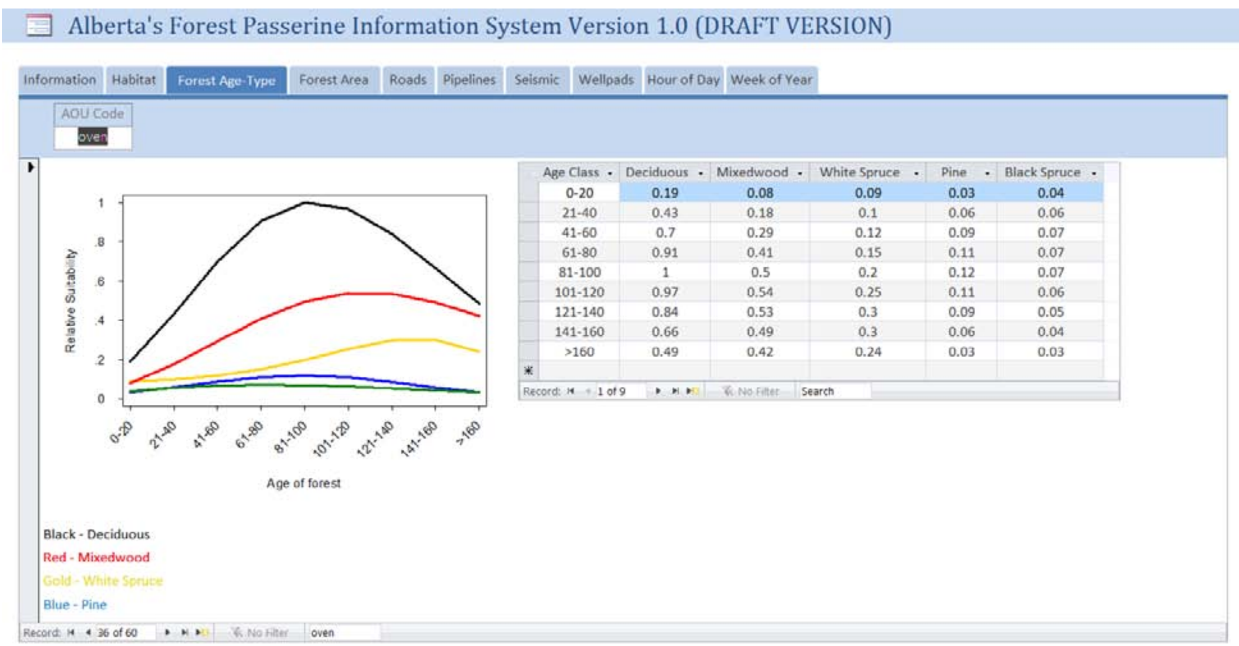
The Marxan analysis results will provide useful guidance for efforts to implement the BCR 6 plan. They will also provide an example for future direction for other boreal BCRs.

(iii) Scenario evaluation

We have begun to apply BAM data to scenario models for portions of the Canadian boreal forest. First, as described in the 2009 – 2010 BAM report to EC, we used the TARDIS approach (Cumming and Armstrong 2004) and simulated the trade-offs between the economic returns of timber harvests and the population sizes of five species of forest-dependent songbirds (including Canada Warblers, Threatened, Schedule 1, SARA) under different scenarios of timber management across a 5.6 million ha boreal region (Hauer et al. 2010).

Second, TARDIS has been substantially re-engineered since 2009 to *i*) incorporate footprints from the oil and gas industry (Hauer et al. 2010), *ii*) to project how climate change will influence forest age, structure, and composition by modifying future fire regimes (Krawchuk and Cumming 2010), and *iii*) to incorporate our standardised FRI data and interpolated maps of climate and annual meteorological data. Thus, in the coming year, we anticipate being able to use both FRI and climate data to predict avian responses to future landscape changes.

Third, we used BAM data and estimated avian densities in relation to forest type and age in the NE part of Alberta. These data now comprise the Alberta Forest Passerine Information System. This database was a partnership with the Alberta Biodiversity Monitoring Institute (ABMI) that allowed us to use consistent vegetation and human disturbance layers as well as coordinated bird data to create the largest ever modelling effort in Alberta (52,000 point counts were used to derive response variables). These results are being used as scientific inputs into the Alberta Land-use Framework, a new provincial government initiative that uses land-use scenario modelling to develop regional management plans that balance sustained economic growth against other social and environmental goals (http://landuse.alberta.ca/). The database is a summary of BAM results and sub-projects of BAM team members and presents the state of knowledge about passerine response to various habitat types and land-uses. An example of database content is captured in the screen shot below. Analyses from this database will be presented on the BAM website in 2011 – 2012 as part of the ongoing web updates, and we anticipate making a downloadable version of the database available.



Age Class	Deciduous	Mixedwood	White Spruce	Pine	Black Spruce
0-20	0.19	0.08	0.09	0.03	0.04
21-40	0.43	0.18	0.1	0.06	0.06
41-60	0.7	0.29	0.12	0.09	0.07
61-80	0.91	0.41	0.15	0.11	0.07
81-100	1	0.5	0.2	0.12	0.07
101-120	0.97	0.54	0.25	0.11	0.06
121-140	0.84	0.53	0.3	0.09	0.05
141-160	0.66	0.49	0.3	0.06	0.04
>160	0.49	0.42	0.24	0.03	0.03

Fourth, in a similar vein, we initiated a collaborative project with Matt Carlson of the ALCES group and the Canadian Wildlife Federation (CWF). BAM is developing avian habitat suitability models for a western boreal cumulative impact assessment that will model the future of boreal bird populations in the region shown in Figure 10 below. The ALCES group with collaboration from BAM is currently working to develop realistic measure of land-use scenarios in various parts of the region and obtaining the GIS data to fully parameterise the model. The objectives of the project are to: 1) demonstrate the long-term consequences of emerging land use trajectories to western boreal ecological goods and services; and 2) assess the relative benefits and liabilities of potential strategies for balancing development and conservation in the region. The analysis will inform public outreach efforts by the Canadian Wildlife Federation, and the primary audiences are the general public and decision makers. The unique aspect of this particular project compared to past exercises will be the integration of results with ALCES Mapper which will provide a spatial representation of inter-relationships among land-use and natural disturbance and their environmental and socioeconomic consequences.

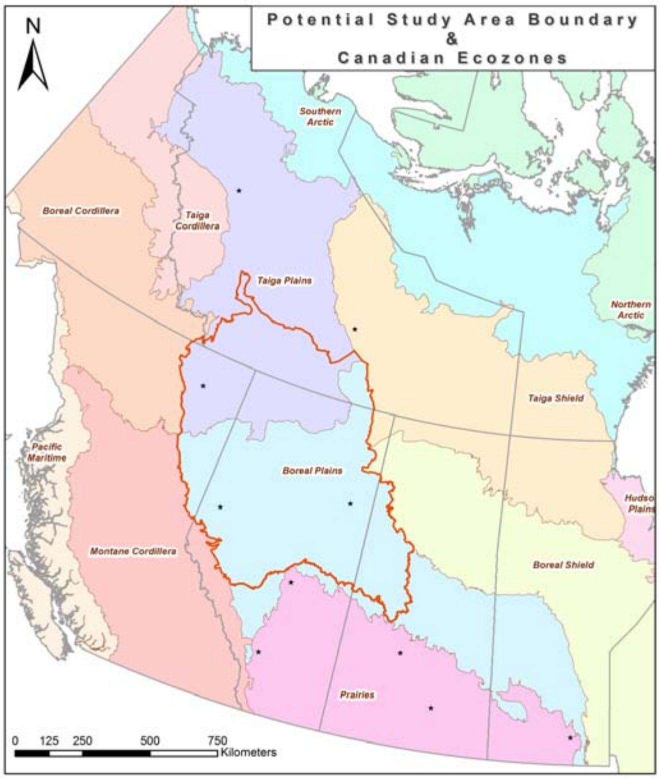


Figure 10: Study area for BAM/CWF/ALCES collaborative project to evaluate future boreal bird populations

These collaborative projects with the ABMI and CWF illustrate how the BAM project is uniquely positioned to make valuable contributions to various conservation initiatives throughout the country.

(iv) Climate change

Diana Stralberg, a PhD student supervised by Erin Bayne and Fiona Schmiegelow, joined the BAM team in Fall 2010, supported by funding from the Alberta Ingenuity Fund (4 years) and the Isaac Walter Killam scholarship (2 years). She initiated a collaborative project with Andreas Hamann in the Department of Renewable Resources to model climate change impacts on vegetation and boreal bird species using bioclimatic niche models.

To support this modelling work, we helped develop downscaled climate change projections based on the Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report (AR4) (IPCC 2007). Downscaling is the process of constructing regional or subregional climate scenarios using global climate model outputs and additional information. General circulation model (GCM) projections were obtained from the World Climate Research Programme's Coupled Model Intercomparison Project phase 3 (WCRP CMIP) multi-model dataset [http://www-pcmdi.llnl.gov/ipcc/info_for_analysts.php]. Historical projections were taken from the 20th century simulation, which were generally initiated between 1850 and 1880 and run through 1999 or 2000. Future projections were taken from three emission scenarios (IPCC 2000)—SRESA2 (high), SRESA1B (intermediate), and SRESB2 (low)—run from 2000 or 2001 through at least 2099 or 2100. Monthly temperature and total precipitation projections were averaged across multiple model runs (if available) for the following thirty year periods: 1961-1990 (baseline), 2011-2040, 2041-2070, and 2071-2100. A total of 24 GCM simulations were used, 17 of which were run for all three future scenarios. Future climate normals (30-year averages) were compared with GCM-projected baseline normals to generate anomalies (temperature differences and precipitation percentage change) for each future time period and emissions scenario, which were then downscaled to a 0.5-degree resolution using a thin-plate spline interpolation. Downscaled anomalies were added to high-resolution baseline climate data (1961-1990) for North America (1-km in western Canada and U.S., 4-km elsewhere) to create future monthly climate projections and derived bioclimatic indices such as climate moisture index and growing degree days.

These fine-scale climate projections (downscaled from the global climate models to regional scales) will be used as inputs to BAM avian habitat models to assess potential impacts of future climate change scenarios on boreal bird distributions and avian communities. They will also be used to model and project future vegetation characteristics, which will also be used as inputs to bird models. At the regional or province level, climate change scenarios can be combined with future land use scenarios to evaluate the combined impacts and compare their relative importance for avian communities.

5. Model Comparison and Validation

In 2010, BAM began work on a collaborative project of model comparison and validation proposed by Technical Committee member Dr. Jean-Luc DesGranges (EC S&T, WLSD). This project is part of the BAM efforts to broaden the application of its data and methods for avian conservation.

Over the last decade, DesGranges has developed a family of neural network models known as IRMA (Inférences Régionales par Modélisation Aviaire, DesGranges et al. 2000) that predicts species abundances or occurrence probabilities for over 179 avian species. The training data were assembled from disparate sources in eastern North America. DesGranges has recently assembled validation data at several hundred locations in boreal Québec and along the St. Lawrence River designed for external validation of the IRMA models. BAM has also developed avian abundance models for the boreal region of Canada for roughly 100 species of forest songbirds; these are the Classification and Regression Tree (CART) models described in previous reports. The BAM models have not been validated against independent data. Noting that the prediction regions for the CART and IRMA models overlap substantially, DesGranges proposed a systematic comparison of the two suites of models against each other on their respective training sites and against the validation data. It was agreed that this work would be conducted in Cumming's lab at Laval, financed by a separate Contribution Agreement between Environment Canada and Université Laval. The work began in autumn of 2010 and a summary report for this collaboration will be available in 2011.

6. Community Characterisation

The compiled dataset represents a rich resource that can be used to describe and model patterns of songbird diversity across the Canadian boreal forest. A quantitative understanding of boreal bird communities, not just single species, will guide our understanding of the inter-relationships between species, facilitate prediction of future impacts, and support effective conservation of avian biodiversity. We seek to:

1. Quantify species richness and other community metrics across boreal regions of Canada and identify geographical areas of particular importance, using richness as an indicator;
2. Analyse the environmental drivers of these patterns, including relative contributions of climate and vegetation factors;
3. Determine the degree to which species assemblages are unique, using uniqueness as an additional indicator of conservation value.

The first step to develop these metrics requires a method to automate data analysis. We recently completed computer code that allows us to estimate local (alpha) diversity at various spatial scales and habitat definitions. Estimation of alpha diversity conducted using rarefaction will allow standardization of sampling effort in different regions and creation of a common diversity metric to use for spatial and habitat comparisons. Landscape (beta) diversity is a measure of how much communities change from one location to another. Our computer coding allows us to rapidly change the spatial and habitat definitions used when computing these diversity metrics. With completion and incorporation of the BBS dataset, we can run these models at relatively small spatial units which will allow us to develop explicit hypotheses about the factors influencing avian diversity in the boreal forest.

Our hypothesis is that climate has a more important influence on bird diversity than vegetation type at large spatial scales (e.g. national, BCR), because species richness is generally associated with productivity (Huston & Wolverton 2009) and vegetation is not highly variant at large scales across the boreal forest. However, the effect of climate gradient is likely to be confounded by variations in land-use intensity. Areas of higher human density experience more vegetation change and they tend to be concentrated in the southern boreal (Hobson & Bayne 2000), which has a relatively milder climate and greater productivity than more northerly regions.

Preliminary analyses reveal interesting patterns of alpha and beta diversity. Figure 11 shows the pattern of alpha diversity (here indicated by richness) along a longitudinal gradient. On average, the most westerly sites (i.e. Alberta, Yukon and NWT) show the lowest alpha diversity, with richness peaking in central areas (Manitoba and Ontario), and then declining again near the Atlantic Ocean (Newfoundland). While only preliminary, this result is consistent with a hypothesis in community ecology called the mid-domain effect, that predicts areas adjacent to range edges (i.e. Rocky Mountains & Atlantic Ocean) will have lower diversity than areas further away.

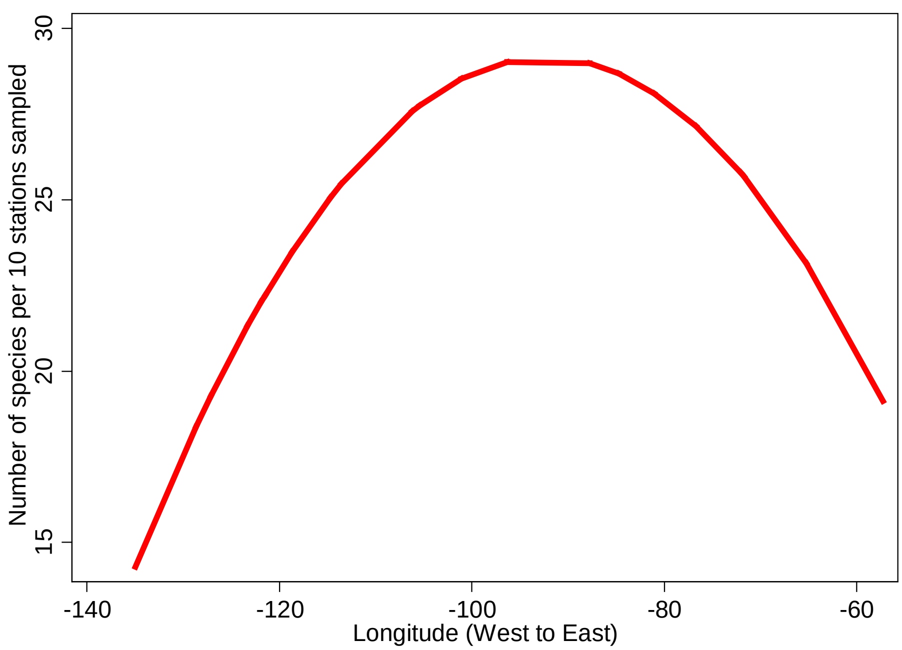


Figure 11 – Number of passerine bird species detected per 10 point count stations sampled using rarefaction. Example shows curve for coniferous forest. The left side of figure represents western sites (i.e. NWT, BC) while the far right represents eastern sites (NL).

Beta diversity also reveals striking patterns that indicate that communities change fairly consistently with increasing distance. Beta diversity is represented by the Renkonen index, which is a measure of the percent change in community similarity (i.e., how similar is the abundance and composition of bird species?) with increasing distance between any two points. Figure 12 shows the amount of turnover in community similarity in coniferous forest between degree blocks in boreal Canada. Between the most extreme locations in boreal

Canada we find that communities change by 30%. These results provide the basic building blocks for future analyses that will allow us to fulfill commitments for 2011 – 2012 to:

- Map patterns of avian community diversity, using a range of diversity metrics and community definitions (e.g. guilds);
- Identify areas of ecological uniqueness (priority areas) across the boreal forest using several criteria; and,
- Identify of guilds or indicator species as foci for management and monitoring.

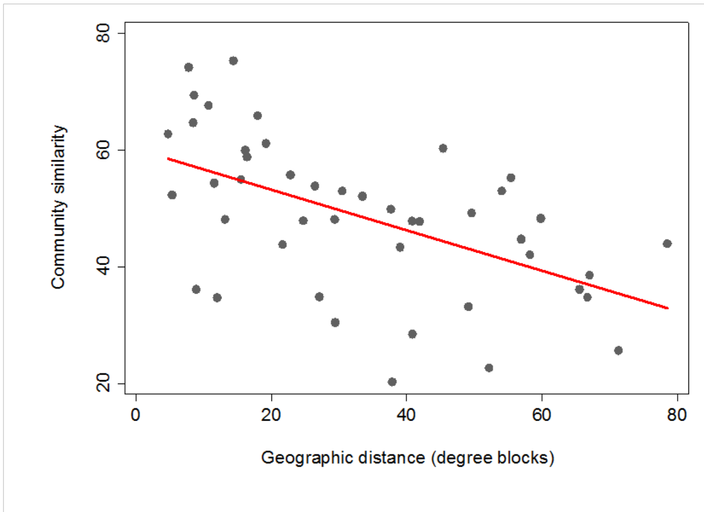


Figure 12: The amount of turnover in community similarity in coniferous forest between degree blocks in boreal Canada.

Community characterisation and analysis depends on the development of spatial abundance models at a higher spatial resolution than that used by the CART models (~1 km pixels), necessitating the use of alternate models. With the progress made in the past year, and the addition of new members to the project team, BAM is well positioned to focus more efforts in the coming year on the community characterisation component of the project.

7. Expansion to other bird groups: Waterfowl

One of the original objectives of the BAM work was to determine the feasibility of expanding the BAM dataset and area of study to include other bird groups such as waterfowl. Unquestionably, parallels exist between the taxa, in terms of how data are collected, maintained, and analysed, and how the results are applied in conservation and management situations. While it does not seem necessary or feasible to augment the existing BAM boreal landbird dataset with waterfowl data at this time, opportunities exist to apply some of the lessons learned from the BAM project to other taxa, and to share common resources such as biophysical datasets. Examples of how this has been done in the past year include: ongoing collaborations (including graduate student projects) between BAM team members and Ducks Unlimited; the participation by Ducks Unlimited staff on the BAM Technical Committee; and the publication of the project overview in ACE-ECO describing the nature and function of the BAM project.

APPLICATIONS OF BAM RESULTS IN 2010 - 2011

Over the past year, BAM project results had direct application to boreal bird and land conservation and management initiatives at a variety of scales, and through a variety of users, including industry, government, and non-governmental organisations.

- Environmental Assessment in Oilsands Region of Alberta: Decision-support tools posted on the BAM website were used in the environmental assessment of a proposed oilsands mine for Total E&P Joslyn Ltd., Joslyn North Creek Mine to estimate local and regional impacts. Similarly, the government submissions related to this project made use of BAM results (http://www.ceaa.gc.ca/050/detailseng.cfm?evaluation=37519&nav=3). Planned refinements to online decision-support tools will increase relevance to environmental impact assessment in the oilsands region and other areas of the boreal forest targeted for industrial development, and will inform guidance provided by federal government on impacts to migratory birds.

- Land Use Framework in Lower Athabasca Region: The avian data contained in the BAM dataset were combined with vegetation and human disturbance layers from the Alberta Biodiversity Monitoring Institute to develop estimates of relative habitat suitability for birds in relation to forest type and age in Alberta, under a Memorandum of Understanding signed for this purpose. These results serve as scientifically-based inputs to the Government of Alberta's Land Use Framework that employs land-use scenario modelling to develop sustainable regional management plans. See Section 4 iii for further details.

- Assistance for completion of BCR plans: Information on habitat associations provided by BAM was used by Environment Canada to prepare BCR plans, in particular to complete Element 2: Habitat Associations of Priority Species for boreal-based plans in BCR 6 (Boreal Taiga Plains), BCR 7 (Taiga Shield & Hudson Plains), and BCR 8 (Boreal Softwood Shield). Habitat associations were easily derived by species from our web-based tool.

- Refinement of BCR plans and implementation: Environment Canada has identified completion of priority areas assessment as the next step for BCR plans (original Element 7). BAM is collaborating with EC on a pilot effort on boreal landbirds within BCR 6 (Boreal Taiga Plains) using a community approach. BAM estimates of avian densities relative to habitat are being used to define targets for population sizes for a number of bird species across the BCR. This information is used in the computer program Marxan (http://www.uq.edu.au/marxan/) to select a network of conservation areas that meet population goals for all constituent species in the analysis and thereby optimize community diversity across the network. See section 4 ii for further details.

- Estimation of impact of incidental take: EC has been actively working to reform Migratory Birds Regulations and develop guidance and best management practices for the management of incidental take. Determining the contribution of various industry sectors (and other types of human activity) is central to determining the net impact of take and thus where conservation efforts should be directed. BAM has produced population estimates for forest birds that contribute to the estimates of take for forestry, oil and gas, mining and wind energy.

- PIF status assessments: EC has used BAM results as a source of information to guide discussion on population estimation and development of PIF population estimates, and in the review and revision of regional assessment of relative density scores for boreal BCRs.

- Assistance to National Breeding Bird Survey program: In the process of incorporating Breeding Bird Survey (BBS) data into the BAM dataset, BAM has provided the CWS BBS national office with assistance which has resulted in a number of benefits to the BBS related to georeferenced routes and standardised data.

- Assistance for National Breeding Bird Atlas Efforts: BAM is providing assistance in the design of survey protocols and survey design for Atlas monitoring efforts currently underway across Canada, working in collaboration with the Canadian Atlas Committee. As a result of discussion and a webinar hosted by BAM on the topic of the Atlas program needs, BAM is identifying the geographic areas and habitat types that are under-represented by the current survey efforts (Atlas, BBS, BAM), and where the addition of Atlas point count data would be most effective. The Atlas committee was receptive to the idea of altering its point count protocol to provide additional time and distance information on some of its routes. This would provide BAM with additional data for calculating correction factors based on different data collection methodologies. See Communications, Webinar #6 for further details.

PROJECT COMMUNICATIONS IN 2010 – 2011

BAM continued to pursue a variety of outreach approaches tailored to different audiences.

1. Webinars

In 2010 – 2011, we continued with a Webinar series started in 2009 – 2010 to support enhanced communications with our Technical Committee. This continues to provide an efficient and effective means of providing updates on our progress, facilitating meaningful discussion of our methods and results, and discussing opportunities for collaboration. The webinars to date have had excellent participation from the Technical Committee, and based on direct and indirect feedback, have been very well received. The topics covered are described below, with supporting materials provided in Appendix 1.

(i) Webinar #4: Beyond CARTS: Synthesis and New Directions (Oct. 15, 2010)
The first three Webinars focused on the avian dataset and the biophysical variables BAM has assembled and standardised, and on methods for estimating nuisance parameters and for deriving densities from counts.

This fourth webinar focused on the results of the national CART analyses, reviewing the data and models used, and providing a synthesis and preliminary interpretation of variable selection. CART models were developed for 97 species, using Version 1 of the national avian dataset. Of 131 climate, landcover and productivity covariates available, a relatively small number were consistently selected and contributed most of explained deviance among the models. The national CARTs did show an improvement over previous versions using only data from western Canada. Notably, the BAM Land Cover Classification (BAM LCC) was the most frequently selected covariate. In previous analyses, lower resolution land covariates were rarely selected. The new landcover data evidently represent the vegetation-related aspects of habitat better than did previous classification systems. A subset (13 covariates) describes more than 50% of the explainable variance for 97 species. Smaller subsets were identified at the level of migratory groups. Some examples of ecological conclusions based on the frequencies of variable selection and the structure of the CART trees were introduced as forming the scientific content of the forthcoming manuscript on this work.

As a dimension-reduction exercise driven by the avian data, the CART process has worked well. This concludes our use of CART-like models for species-level data. The work presented identifies key bioclimatic variables for inclusion in the next generation of GLM and GLMM models. Input from the TC was solicited as to further analysis of the CART structure useful for this purpose, and for the paper in progress.

(ii) Webinar #5: Regional Variations in Habitat Selection (Feb. 4, 2011)

Following from discussions at the November 2010 Technical Committee meeting, this webinar was designed to stimulate discussion and outline collaboration opportunities around the issue of evaluating regional differences in bird habitat selection. Erin Bayne made a brief presentation titled “Determining whether habitat selection differs in eastern and western Canada for boreal birds”. Discussion addressed how best to quantify the concept of variations in habitat associations, what areas or regions to consider, and which boreal bird species should be studied. An initial group of collaborators was identified. Bayne has prepared a short summary of the concepts discussed and is currently circulating it among the Technical Committee. The computer code to assess different combinations of habitat and spatial comparisons of selection has been developed. After discussions with the various participants of the Technical Committee, a publication will be prepared in 2011.

(iii) Webinar #6: BAM, BBS and the Atlases: Effective collaboration by design (Mar. 6, 2011)

In January 2011, BAM was approached by EC staff on behalf of the Canadian Breeding Bird Atlas committee, to enquire if BAM could assist in sample design in remote areas. BAM responded by hosting a webinar dedicated to sample design and survey protocol issues, emphasising commonalities and differences among the main data sources: point-count data assembled by BAM, Breeding Bird Atlas data, and Breeding Bird Survey (BBS) data.

The outcomes of the webinar included the following:

1) BAM will provide maps and quantitative measures of sampling distribution in the boreal and local representativeness with respect to various digital landcover products;
2) Several atlas projects (Maritimes, BC, and Manitoba) have collected significant point-count data that is not currently included the BAM databases, and provisions were made for BAM to acquire these data; the Ontario Atlas data are already included in the BAM dataset;
3) BAM presented evidence of the value of stratifying point count observations into two distance classes (e.g. less than 50m and greater than 50m) and two temporal classes (e.g. 0-3 minutes and 3-5 minutes). It was agreed that this additional precision could be provided by Atlas project’s hired staff conducting point-count surveys in remote locations;
4) BAM explained quantitative methods for both balanced and model-based design, introduced systems developed for this purpose by Cumming and Schmiegelow, and proposed their application in sample years 2012 and beyond. This will be further explored by the parties.

2. Technical Committee Meeting, Edmonton, November 29-30, 2010

The BAM team and 11 members of the Technical Committee attended a face–to-face meeting on November 29-30, 2010. The goal of the meeting was to engage the Technical Committee members in discussions about BAM goals and priorities, to identify areas where BAM results could aid in conservation and planning efforts, and to evaluate opportunities for collaboration with the BAM team using the dataset and developed methodologies.

Each session was led by a BAM team or TC member outlining current work, with the majority of the session spent in discussion. Key points of agreement and action were summarised in the meeting minutes, and were incorporated into the team work plan, and are summarised below in Table 2. Several specific topics for collaboration between the BAM team and the TC members were identified, including providing input to sampling designs, the use of microphone arrays, and conducting habitat modelling at regional scales.

Table 2: Summary of Technical Committee Meeting Topics and Outcomes

Session Topic	**Description**	**Outcome**
Avian and Biophysical Datasets	Update on status of avian and biophysical datasets and plans for project expansion into hemiboreal and Alaska	Information item. Endorsement of BAM as repository for point count data and support for expansion and inclusion of spot-mapping data, as well as the geographic expansion.
Population Estimation	Update on methodologies for population estimation including detectability, comparison of roadside (BBS) vs off-road surveys, use of spot-mapping for estimate validation.	Endorsement to create range of estimates to demonstrate effect of approach. Manuscript on effective detection radius work to be distributed in early 2011. Endorsement to use spot mapping data to validate. Sub-group formed to explore microphone arrays to test distance measurements.
Species Range and Distribution	Next generation of models for estimation of species range and distribution	Description of GLM approach as next effort. Exploration of incorporating evolutionary ecology as predictor, of presence/absence maps to assess priority species, reliability of monitoring programs, inputs for conservation planning. Request for information to inform provincial atlas efforts. Prospectus of potential models to predict range to be developed & circulated by Cumming & Solymos.
Conservation Planning	Update on existing collaborations and application of BAM data in conservation planning in AB Land Use Framework, ecological benchmark analyses (BEACONs), and Canadian Boreal Forest Agreement, and identification of future applications.	Value of BAM to regional planning efforts recognised and agreement on strong BAM role in application to modelling current distribution and future scenario models. No specific additional opportunities identified at this time.

Session Topic	Description	Outcome
Avian Monitoring	Review of status of boreal landbird monitoring in Canada, potential contribution of BAM to survey protocols and design of monitoring programs.	BAM to provide data on potential sites for re-visiting to calculate trend at national scale. BAM to generate information on survey protocols, undersampled sites to direct future monitoring efforts. Explicit list of needs to be provided to BAM in early 2011.
Regional Models and Validation	Discussion of regional scale modelling to identify variation in habitat associations and other aspects of avian ecology, and efforts for model validation through comparison of regional efforts.	Interest by TC members in collaboration to develop regional comparisons of habitat selection, effects of regional variation in natural disturbance. Proposal to be developed by Pierre Drapeau and BAM webinar to follow. Update on cross-validation efforts by Jean-Luc Desgranges with his models developed in Quebec and recognition of significant difference in purpose, application, scale, status of BAM results.
Land Use Change	Discussion of modelling platforms (Alces-aspatial, Tardis-spatial) and other regional models for evaluating land use scenarios and discussion of retrospective analyses.	Follow-up webinar to finalise modelling approaches; generation of prospectus on sources of land use change data e.g. Global Forest Watch
Climate Change	Update on BAM project to assess impact of climate change on boreal bird populations	Ph.D. thesis (Diana Stralberg) will predict shifts in species' ranges in response to climate change and land-use at regional & continental scales. Research proposal circulated in early 2011.
Natural Disturbance	Proposal from NRCan for collaboration to identify signal of past spruce budworm outbreaks.	Proposal from NRCan for submission to BAM
Management Toolbox	Identification of potential conservation tools and products from BAM for provision via web, databases, etc.	Delineation by TC of core products & tools desired for maps, databases, data layers, etc. for incorporation into next version of website. Affirmation of positioning of BAM products as neutral provider of credible information.
Waterfowl Monitoring	Exploration of potential for expansion to waterfowl and identification of synergies with efforts to develop habitat layers.	Update on efforts by DUC and Cumming to model CWS waterfowl breeding population data and potential use of BAM habitat layers.

3. Website Upgrades

Work is underway to keep the website current and a vital source of information about boreal birds for end-users such as federal, provincial and territorial governments, environmental non-governmental organisations, academia, industry and other parties interested in boreal bird conservation including the general public. Technical Committee members have provided direction into products and tools that would assist them in their conservation and management activities. The following upgrades are at the planning stages or in progress, with completion scheduled for 2011 – 2012:

1. Update the description of avian database to reflect additional data, inclusion of the BBS data, expansion to include Alaska and the hemi-boreal region;
2. Provide an overview of the dataset, its extent, parameters, and capabilities, and link this to the Autodocumentation of the dataset already posted on the website;
3. Document the biophysical dataset, and describe the creation of the Common Attribute Schema (CAS) which is a national summary of forest resource inventory data;
4. Add a series of tools and products, including maps and queriable databases for website users to access information derived by the BAM team from the BAM dataset, (e.g., habitat suitabilities, density estimates, maps of distribution or abundance);
5. Add a section of protocols and primers to assist with monitoring and survey design, environmental assessment and other applications of BAM data.
6. Build in community-level results (in addition to species-level results)
7. Expand the library component to include technical reports generated by the project; and,
8. Reconfigure the home page to better indicate what information is available on our web site, and how best to access it.

4. Presentations, Reports and Manuscripts

(i) Presentations

BAM was represented in a number of venues during the 2010 - 2011 fiscal year.

Bayne E, SG Cumming, SJ Song, and FKA Schmiegelow. 2010. Evaluating the current and future status of boreal forest songbirds through a national data collection, analysis, and reporting system. Joint Meeting: 24th International Congress for Conservation Biology (ICCB 2010) and Society for Conservation Biology. Edmonton, Alberta. 3-7 July 2010. Abstract at: http://birenheide.com/scb/schedule/singlesession.php?sessno=21&order=863#863

Bayne E. and BAM, ABMI, and ILM teams. 2010. Adaptive planning for boreal birds: Why research and monitoring can't be separate. Presentation to the CWS Seminar Series. 26 January 2010. Edmonton, AB.

Cumming SG, KL Lefevre, E Bayne, S Fang, T Fontaine, FKA Schmiegelow, and SJ Song. 2010. Climate vs. Landcover in modelling boreal songbird distributions. Canadian Society for Ecology and Evolution, 11 May 2010, Québec City, QC.

Song SJ and BAM team. 2010. Boreal Avian Modelling Project: Update to the Landbird Technical Committee. Environment Canada Landbird Technical Committee Meeting. 20-21 October 2011. Saskatoon, SK.

(ii) Reports (not published in literature; posted on Technical Reports page of our website)

BAM Project Team. 2010. Appendices to the 2009-2010 Annual Report of the Boreal Avian Modelling Project. http://www.borealbirds.ca/files/BAM_2009_10_Project_Report_Appendices_Sept_2010.pdf (~17 MB)

Cumming, S.G., F.K.A. Schmiegelow, E.M. Bayne, and S.J. Song. 2010. Canada's Forest Resource Inventories: Compiling a tool for boreal ecosystems analysis and modelling-a background document. Version 1.0 7 January 2010. http://www.borealbirds.ca/files/technical_reports/CAS_Backgrounder_v1.0.pdf

Cumming, S.G., K. Lefevre, and M. Leblanc. 2010. The Boreal Avian Modelling Project Avian Dataset: Structure and Descriptive Statistics. http://www.borealbirds.ca/files/technical_reports/BAM_ADD_part1_version1.zip (~23.4 Mb)

Cumming, S.G., and M. Leblanc. 2010a. The Boreal Avian Modelling Project Biophysical Dataset. Part 1: Catalogue and Descriptive Statistics. http://www.borealbirds.ca/files/technical_reports/BAM_ADD_part2_version1.zip (~8.9 Mb)

Cumming, S.G., and M. Leblanc. 2010b. The Boreal Avian Modelling Project Biophysical Dataset. Part 2: Population and Sample Distributions. http://www.borealbirds.ca/files/technical_reports/BAM_ADD_part3_version1.zip (~30.3 Mb)

(iii) Publications (published)

Cumming SG, KL Lefevre, E Bayne, T Fontaine, FKA Schmiegelow, and SJ Song. 2010. *Toward Conservation of Canada's Boreal Forest Avifauna: Design and Application of Ecological Models at Continental Extents*. Avian Conservation and Ecology 5(2):8 URL: http://www.ace-eco.org/vol5/iss2/art8/

Sólymos P and SR Lele. 2011. *Global pattern and local variation in species-area relationships.* Global Ecology and Biogeography. http://onlinelibrary.wiley.com/doi/10.1111/j.1466-8238.2011.00655.x/abstract

Song S. Contribution to "Section 4: Expand our knowldege base for conservation" in Berlanga H et al. 2010*. Saving our Shared Birds: Paterners in Flight Tri-National Vision for Landbird Conservation.* Cornell Lab of Ornithology: Ithaca NY.

Song S, E Bayne, S Cumming, T Fontaine, C Rostron, F Schmiegelow. 2010. *Boreal Avian Modelling Project: An integrated, national-scale project for management and conservation of North America's boreal birds.* The All-Bird Bulletin. Spring 2010. Page 10-11. http://www.nabci-us.org/aboutnabci/bulletinspring10.pdf

Song S, E Bayne, S Cumming, F Schmiegelow, T Fontaine, C Rostron. 2010. *Boreal Avian Modelling Project: An Integrated Project for Managing and Conserving North America's Boreal Birds.* Bird Watch Canada. Fall 2010, No. 53. http://www.bsc-eoc.org/download/BWCfa10.pdf

(iv) Scientific Publications (in press)

Bayne EM, S Lele, P Solymos. 2010. Bias in the estimation of bird density and relative abundance when the closure assumption of multiple survey approaches is violated: a simulation study. Submitted to Auk March 2010. (In Revision)

Lele SR, M. Moreno, EM Bayne. 2010. Dealing with detection error in site occupancy surveys: what can we do with a single survey? Submitted to Environmetrics 2010. (In revision)

Sólymos P, S Lele, and E Bayne. 2011. Abundance estimation in the presence of zero inflation and detection error using single visit data. Submitted to Environmetrics. (In review)

(v) Scientific Publications (in preparation, not yet submitted)

Bayne EM et al. 2011. In prep. Approaches to correcting point counts of different duration to a common standard: an example using boreal birds.

Cumming SM, EM Bayne, Fang, T Fontaine, K Lefevre, D Mazerolle, F Schmiegelow, P Solymos, S Song, S Stralberg. 2011. In prep. The relative roles of climate and vegetation in explaining boreal songbird distributions. To be submitted to Global Ecology and Biogeography

Matsuoka SM, EM Bayne. 2011. In prep. Using binomial distance sampling to estimate detectability of boreal forest birds: comparisons to Partners in Flight detection distances. To be sumbmitted to the Auk.

Solymos, Bayne, Matsuoka, BAM Team. 2011. In prep. Calibrating indices of avian point count density.

(vi) Consultant Reports Prepared for BAM (available from Project Coordinator)

Timberline Natural Resource Group. 2011. Common Attribute Schema (CAS) for Forest Inventories across Canada. Prepared by JA Cosco, Chief Inventory Forester, for the BAM and Canadian BEACONs Projects. Feb. 2011.

PROJECT MANAGEMENT

Steering Committee, Project Staff and Affiliates
The project Steering Committee consists of Drs. Fiona Schmiegelow, Erin Bayne, Steve Cumming, and Samantha Song. This group is collectively responsible for project coordination, including staff management, liaison with project partners and the Technical Committee, and overall leadership of the project.

This fiscal year saw a significant increase in the capacity of the BAM team, with the addition of project staff, an affiliate and a PhD student.

Core staff positions this year included:

- Database Manager (Trish Fontaine)
- Quantitative Ecologist (Steve Matsuoka, on secondment from the US Fish and Wildlife Service, Alaska Office from August 2010)
- Project Coordinator (Catherine Rostron 0.5 FTE from May 2010)
- Statistical Ecologist (Dr. Peter Sólymos 0.5 FTE).

BAM was also pleased to welcome Dr. C. Lisa Mahon, Environment Canada, as a Project Affliliate and Diana Stralberg, PhD candidate with Drs. Bayne and Schmiegelow, to the project team. Lisa Mahon is applying bird-habitat models to land use and conservation planning tools to inform avian conservation planning. Diana Stralberg's PhD thesis will evaluate potential climate and land-use change impacts on boreal breeding bird distributions.

Technical Committee

Our Technical Committee (TC) continues to provide independent scientific advice on project direction and results. In 2010 – 2011 we welcomed the addition of Dr. Colleen Handel, Research Wildlife Biologist with the USGS Alaska Science Center to the Technical Committee, and look forward to the expansion of the BAM dataset and geographic extent to include Alaska. We would like to thank Andrew de Vries, Forest Products Association of Canada, who resigned from the Technical Committee for his past involvement.

Technical Committee members:

Peter Blancher, Environment Canada
Marcel Darveau, Ducks Unlimited / Université Laval
Jean-Luc Desgranges, Environment Canada
André Desrochers, Université Laval
Pierre Drapeau, Université du Québec à Montréal
Charles Francis, Environment Canada
Colleen Handel, United States Geological Survey, Alaska Science Center
Keith Hobson, Environment Canada
Craig Machtans, Environment Canada
Julienne Morissette, Ducks Unlimited Canada
Rob Rempel, Ontario Ministry of Natural Resources / Lakehead University
Stuart Slattery, Ducks Unlimited Canada
Phil Taylor, Acadia University
Steve Van Wilgenburg, Environment Canada
Lisa Venier, Natural Resources Canada
Pierre Vernier, University of British Columbia
Marc-André Villard, Université de Moncton

Contact with the TC was maintained this year through a 2-day, in-person committee meeting in Edmonton in November, 2010, as well as webinars and other targeted communications, and individual communications with the project team to address technical questions, as necessary. The webinar format will continue to be used into 2011-12 to encourage discussion on key scientific questions, to solicit advice and facilitate collaboration, and to inform the TC on BAM progress.

Support Team
Many additional people provide time and expertise to BAM project activities. In particular, we would like to recognise the contributions of the following individuals:

Connie Downes (Environment Canada): BBS data
Mélina Houle (Université Laval): spatial data analyst
Marie-Anne Hudson (Environment Canada): BBS data
Bénédicte Kenmei (Université Laval): computer programming
Mélanie-Louise Leblanc (Université Laval): programming of statistical summaries
Paul Morrill (Web Services): website design & programming
Sheila Potter (Blue Chair Designs): graphic design and website design and development
Pierre Racine (Université Laval): GIS programming

PARTNERSHIPS

To achieve its objectives, BAM continues to rely on partnerships on many levels, including our data contributors, our Technical Committee and its members, our funders, and our study collaborators. The following partnerships were initiated in 2010 – 2011:

- International Partnership with Alaska Government Agency for Avian Conservation and Management: The additions of Steve Matsuoka and Colleen Handel to the project team and Technical Committee respectively have extended our partnerships beyond Canadian borders to include the boreal region of Alaska. Their experience with boreal bird conservation, and their access to avian as well as biophysical data will allow BAM to undertake a continental approach to boreal bird conservation and management.

- National-scale Conservation Planning Partnership with Industry: BAM is positioned to provide technical information to support the efforts of the Canadian Boreal Forest Agreement. The CBFA is a new initiative of Canadian forest companies and environmental organisations designed to realise a stronger, more competitive forestry industry while ensuring a better-protected, more sustainably managed boreal forest. Early interest has been indicated by CBFA in BAM products and their application to regional-scale studies under this initiative.

- Regional-scale Conservation Planning Partnership with an ENGO: A collaborative project initiated with the Canadian Wildlife Federation early in 2011 will see BAM developing avian habitat suitability models that will inform models predicting the future of boreal bird populations in western Canada.

- National-scale Partnership with Technical Committee: Technical committee member Lisa Venier (Canadian Forest Service, Sault Ste. Marie) proposed a new collaboration between her team and BAM to identify the effects of insect outbreaks on boreal birds. Venier will identify the status of various initiatives to assemble a national time-series of insect outbreak maps and make a specific data request to BAM.

The BAM project would not exist without the generous contributions of its funding and data partners.

Funding partners

We are grateful to the following organisations that have provided funding to the BAM Project since its initiation:

Founding organisations and funders

Environment Canada
University of Alberta

Additional financial supporters

United States Fish and Wildlife Service, Neotropical Migratory Bird Conservation Act Grants Program
Alberta Research Council (ARC)
Alberta Ingenuity Grant
Alberta Innovates (previously ARC above)
Alberta Landuse Framework
Alberta Pacific Forest Industries Inc.
Canada Foundation for Innovation
Canada Research Chairs program
Canadian Boreal Initiative
Ducks Unlimited Canada
Environmental Studies Research Fund
Fonds québécois de la recherche sur la nature et les technologies
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Ministère des Ressources naturelles et de la Faune (provincial government):MRNF
Natural Sciences and Engineering Research Council of Canada
Sustainable Forest Management Network
Université Laval

Data partners

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Institutions

Acadia University, Alberta Biodiversity Monitoring Institute, Alberta Pacific Forest Industries Inc., AMEC Earth & Environmental, AREVA Resources Canada Inc., AXYS Environmental Consulting Ltd., Bighorn Wildlife Technologies Ltd., Bird Studies Canada, Canadian Natural Resources Ltd., Canfor Corporation, Daishowa Marubeni International Ltd, Canada Centre for Remote Sensing and Canadian Forest Service, Natural Resources Canada, Canadian Wildlife Service and Science & Technology Branch, Environment Canada, Global Land Cover Facility, Golder Associates Ltd., Government of British Columbia, Government of Yukon, Hinton Wood Products, Hydro-Québec Équipement, Kluane Ecosystem Monitoring Project, Komex International Ltd., Louisiana Pacific Canada Ltd., Manitoba Hydro, Manitoba Model Forest Inc., Manning Diversified Forest Products Ltd., Matrix Solutions Inc. Environment & Engineering, MEG Energy Corp., Mirkwood Ecological Consultants Ltd., US National Park Service, Numerical Terradynamic Simulation Group, Ontario Ministry of Natural Resources, OPTI Canada Inc., PanCanadian Petroleum Limited, Parks Canada, Petro Canada, Principal Wildlife

Resource Consulting, Regroupement Québec, Rio Alto Resources International Inc., Saskatchewan Environment, Shell Canada Limited, Suncor Energy Inc., Tembec Industries Inc., Tolko Industries Ltd., US Fish and Wildlife Service, Université de Moncton, Université du Québec à Montréal, Université du Québec en Abitibi-Témiscamingue, Université Laval, University of Alberta, University of British Columbia, University of Guelph, University of New Brunswick, University of Northern British Columbia, URSUS Ecosystem Management Ltd., West Fraser Timber Co. Ltd., Weyerhaeuser Company Ltd., Wildlife Resource Consulting Services MB Inc.

Individuals

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BOREAL AVIAN MODELLING PROJECT
Predictive tools for the monitoring and assessment of boreal birds in Canada, 2009-2012
2010 – 2011 Annual Report to Environment Canada

APPENDIX 1

Appendix 1: Presentations

Webinar 4: Beyond CARTS: Synthesis and New Directions, Oct. 2010
Webinar 5: Determining whether habitat selection differs in eastern and western Canada for boreal birds, Feb. 2011
Webinar 6: BAM, BBS, Atlases: Effective Collaboration by Design, Mar. 2011

BAM National CARTS

1. Data Review
2. CART models
3. Synthesis: variable selection

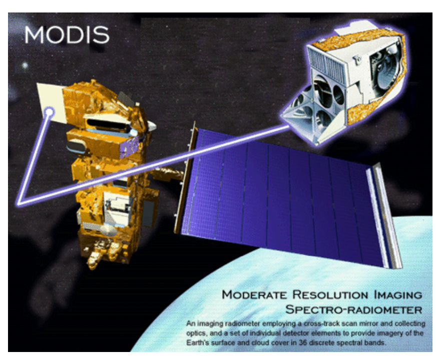
Technical Committee Webinar IV

Friday October 15th 2010

Boreal Avian Modelling Project

Projet de modélisation de l'avifaune boréale

Biophysical Data: Sources



MODIS LCC-05

250m resolution, 39 classes

Reclassed to 17

CFS Laurentian Centre

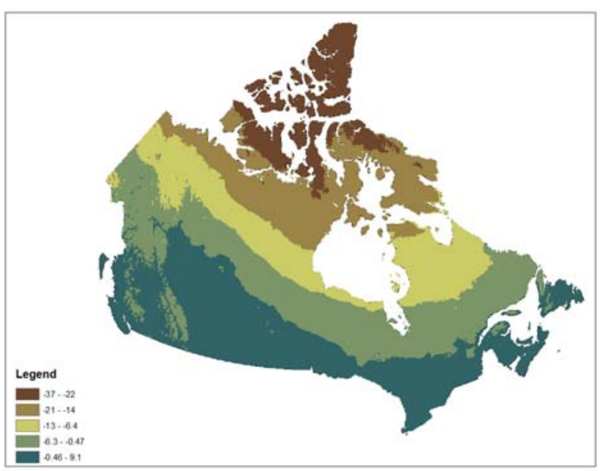
Other remote-sensed variables

- Monthly Leaf Area Index
- Monthly NDVI
- GPP and NPP (8 yr means)
- Continuous Vegetation Fields
  - Compositions on Trees, Shrubs and Bare ground.

Climate Data

- **Given:** Annual grids of Monthly Means/Totals of
  - – Daily Minimum Temperature
  - – Daily Maximum Temperature
  - – Daily Mean Temperature ($0.6 \cdot T_{min} + 0.4 \cdot T_{max}$)
  - – Daily Precipitation
- **Calculated:** 30 Year Normals 1971-2000
  - – Means of Monthly Data (n=48)
  - – *Standard Deviations of Monthly Data (n=48)*

April Mean Temperature



Other climatic variables (n≈ 12)

- Annual mean T and P
- Coldest Temperature
- PET and CMI
- Growing season start, end and length
- Heat sums of summer
- Seasonality

CART models
Developed for ***97 species***

1. Response variables: counts at rounds
2. Offset: empirical factors for sampling
   distance, duration, date and time.
3. Geographic weighting to compensate for spatial autocorrelation.
4. **Covariates: *many* (131 = 106+25)**
5. Bootstraped estimates of prediction reliability and node cutoff values.

National Dataset -- Base de données nationale

Nashville Warbler
Paruline à joues grises

Vermivora ruficapilla

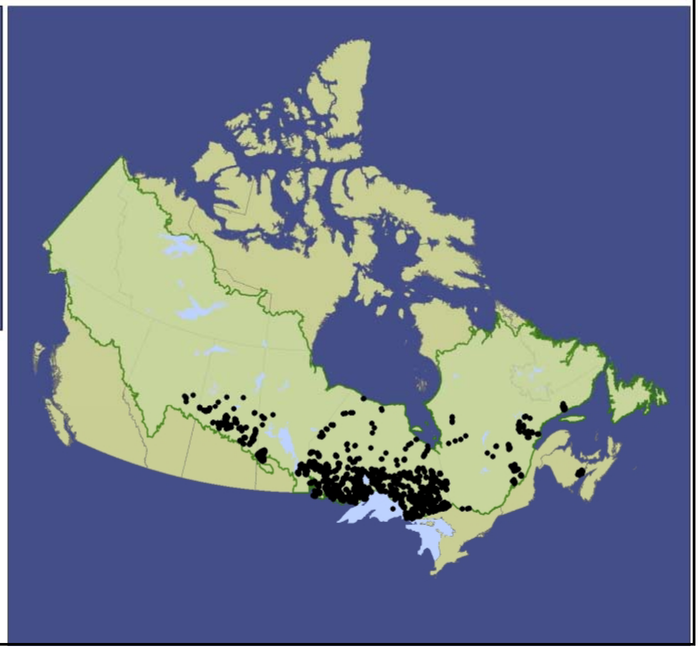
Data Locations
Localisations des données
Lakes
Lacs
Boreal Region
Région boréale

Boreal Avian Modelling Project
Projet de modélisation aviaire boréal

Kilometres -- Kilomètres
0 250 500 1,000 1,500 2,000

February 25, 2009

Lambert Conformal Conic
Conique conforme de Lambert



National CART Trees

Nashville Warbler

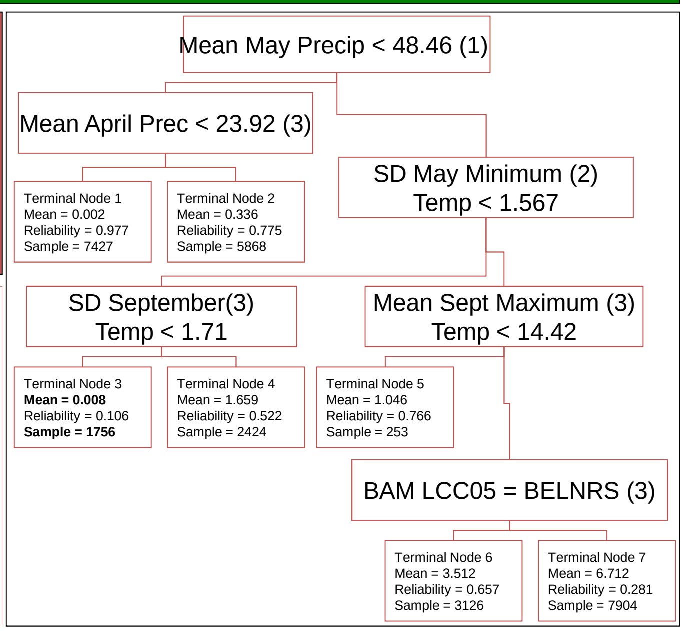
Paruline à joues grises

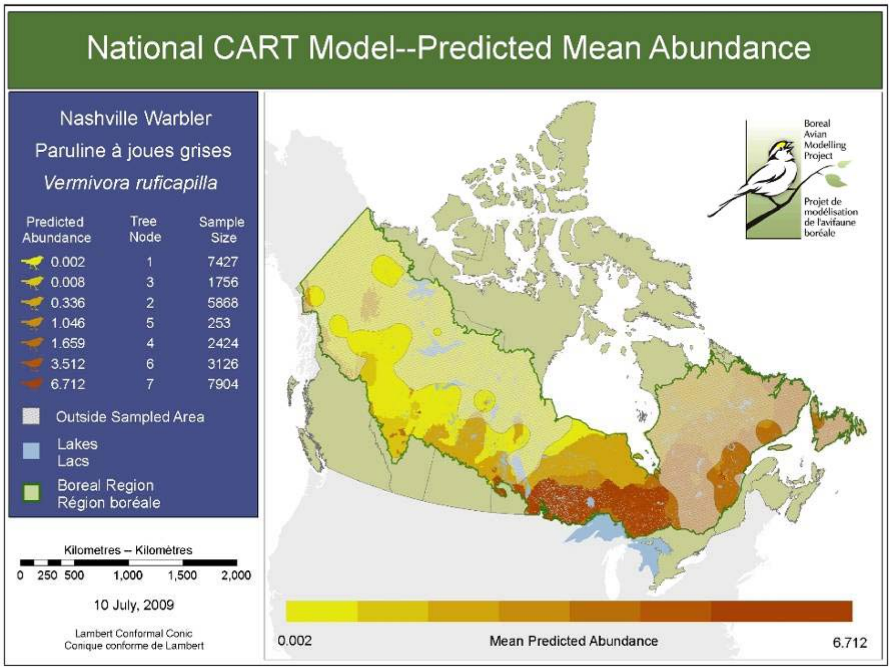
Vermivora ruficapilla

Boreal Avian Modelling Project
Projet de modélisation de l'avifaune boréale

Version: 10 August 2009

www.borealbirds.ca





Most frequently selected covariates, by migratory class with mean %deviance explained.

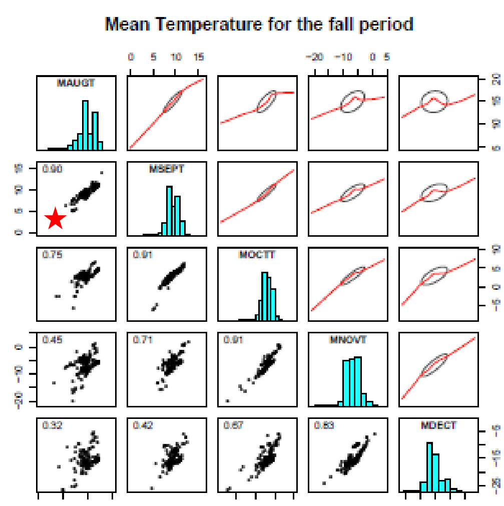
Resident Species			Short Distance Migrants			Long Distance Migrants		
BAMLCC	0.400	0.0882	BAMLCC	0.439	0.127	BAMLCC	0.317	0.088
SDFEBMAX	0.200	0.1759	MJULMINT	0.171	0.105	SDMAYMIN	0.171	0.029
LAIAPR	0.200	0.2384	SDOCTMAX	0.146	0.053	SDMAYMAX	0.171	0.047
GDDBSETHR	0.200	0.0727	PET	0.146	0.162	SEPNDVI	0.146	0.103
SEASON	0.133	0.0318	LAIAPR	0.146	0.244	SDJUNMIN	0.146	0.064
SDMARMIN	0.133	0.0216	SDAUGMAX	0.122	0.111	MSEPT	0.146	0.306
SDJUNMIN	0.133	0.0214	LAIMAY	0.122	0.028	SDMAYT	0.122	0.032
SDJULT	0.133	0.0391	SDSEPMAX	0.098	0.099	SDAUGMIN	0.122	0.113
SDDECT	0.133	0.0399	SDMARMAX	0.098	0.164	MSEPPRC	0.122	0.182
SDAUGT	0.133	0.0135	SDAPRPRC	0.098	0.122	MMAYPRC	0.122	0.169
NUDAYSGS	0.133	0.0622	MMAYT	0.098	0.029	MMAYMINT	0.122	0.263
MSEPT	0.133	0.3387	MMARMINT	0.098	0.308	LAIAPR	0.122	0.227
MFEBMINT	0.133	0.1832	MAPRMINT	0.098	0.081	SDSEPMAX	0.098	0.100
MAUGMAXT	0.133	0.1820	LAIOCT	0.098	0.054	SDMAYPRC	0.098	0.056
LAIJAN	0.133	0.1625	APRNDVI	0.098	0.038	SDJULT	0.098	0.049

11/04/2011 12

p(Total Deviance Explained) over all models, by Migratory Group.

Resident Species		Short Distance Migrants		Long Distance Migrants		All Species	
LAIAPR	0.118	BAMLCC	0.114	MSEPT	0.089	BAMLCC	0.085
MSEPT	0.229	LAIAPR	0.186	MMAYMINT	0.153	LAIAPR	0.155
BAMLCC	0.316	MAPRT	0.257	BAMLCC	0.208	**MSEPT**	**0.218**
SDFEBMAX	0.403	MMARMINT	0.318	LAIAPR	0.264	MAPRT	0.258
MFEBMINT	0.464	MAUGT	0.369	MSEPPRC	0.308	**MAUGT**	**0.293**
MAUGMAXT	0.524 (6)	PET	0.417	MINCOLD	0.351	MMAYMINT	0.325
LAIJAN	0.577	MJULMINT	0.454	MMAYPRC	0.392	PET	0.354
SDJANMIN	0.624	SDMARMAX	0.486	SEPNDVI	0.422	MSEPPRC	0.382
SDNOVT	0.668	SDAUGMAX	0.514 (9)	MAUGT	0.451	MJULMINT	0.409
MAUGMINT	0.709	SDJUNMIN	0.539	SDJUNPRC	0.480	MMARMINT	0.436
GDDBSETHR	0.745	SDAPRPRC	0.563	SDAPRMAX	0.509 (11)	MAUGMAXT	0.462
MMAYMINT	0.773	JULDAYST	0.587	MAPRRPRC	0.537	SDJUNMIN	0.482
NUDAYSGS	0.794	SDMAYT	0.610	SDAUGMIN	0.564	MMAYPRC	0.502 (13)

Further dimension reduction is possible:



TBL_STEVE_ORIGINAL_VALUES

STEVEID	NODE	PARENT	LEFT	RIGHT	ISINT	OP	TREEVAL	ISLEAF	PRUNED
AMRE1	1	0	2	3	-1	<	40.29	0	0
AMRE10	10	5	0	0	0		0.4492	-1	0
AMRE11	11	5	0	0	0		3.7122	-1	0
AMRE12	12	6	0	0	0		0.0050	-1	0
AMRE13	13	6	0	0	0		1.4664	-1	0
AMRE14	14	7	0	0	0		0.0222	-1	0
AMRE15	15	7	16	17	-1	>=	28.94	0	-1
AMRE16	16	15	0	0	0		1.9336	-1	-1
AMRE17	17	15	0	0	0		4.5830	-1	-1
AMRE2	2	1	4	5	-1	<	0.6704	0	0
AMRE3	3	1	6	7	-1	<	0.9967	0	0
AMRE4	4	2	8	9	-1	<	7.695	0	0
AMRE5	5	2	10	11	-1	>=	26.11	0	0
AMRE6	6	3	12	13	-1	>=	28.93	0	0
AMRE7	7	3	14	15	-1	=	abcdfg hikopq	0	0
AMRE8	8	4	0	0	0		0.00158	-1	0
AMRE9	9	4	0	0	0		0.09520	-1	0

TBL_COVARIATE_NODES

SPCODE	STEVEID	COV	ESTMEANCUT	ESTMEANEFF
AMRE	AMRE1	SDJUNPRC	40.334	0.253535
AMRE	AMRE15	sdsepprc		
AMRE	AMRE2	SEPNDVI	0.670	0.080926
AMRE	AMRE3	SDJUNMIN	0.996	0.05326
AMRE	AMRE4	MJULMINT	7.703	0.021655
AMRE	AMRE5	SDJUNPRC	26.256	0.022474
AMRE	AMRE6	SDSEPPRC	28.870	0.055476
AMRE	AMRE7	BAMLCC	ABCDFHIJLRST	0.145834

TBL_TERM_NODE_BOOT_STRAP

UNQ_ID	SPCODE	TNODE	\hat(p)	\hat(r)	\hat(N)	Node_ID
1AMRE	AMRE	1	0.001517	0.987654	979	AMRE8
2AMRE	AMRE	2	0.094364	0.859442	13818	AMRE9
3AMRE	AMRE	3	0.445262	0.034494	10380	AMRE10
4AMRE	AMRE	4	3.490351	0.078364	264	AMRE11
5AMRE	AMRE	5	0.060962	0.124609	1252	AMRE12
6AMRE	AMRE	6	1.362435	0.309154	441	AMRE13
7AMRE	AMRE	7	0.032882	0.539526	886	AMRE14
8AMRE	AMRE	8	2.062867	0.175277	637	

Reclass of variables into n types

Classification of nodes in tree as Root, internal, and terminal (1,2 and 3)

Look at weighted frequency of occurences by location within variable type.

group	level1	level2	level3
SummerTemp	15	8.94	9.81
SpringTemp	12	5.27	4.88
LAI	10	8.13	7.78
FallTemp	8	4.94	4.80
BAMLCC	7	8.33	7.67
WinterTempSD	7	3.66	4.20
FallPrecip	5	1.60	1.22
SummerTempSD	4	14.49	14.06
FallTempSD	4	5.21	5.53
GDD	4	2.62	2.78
NDVI	3	7.68	6.88
SummerPrecipSD	3	2.69	2.73
WinterTemp	3	2.08	2.28
Moisture	3	1.59	1.53
SpringTempSD	2	8.53	7.96
SpringPrecipSD	2	2.90	3.35
SpringPrecip	2	1.93	1.91
MINCOLD	2	0.00	0.46
SummerPrecip	1	1.47	0.96
WinterPrecipSD	1	0.69	0.58
SEASON	0	1.44	1.35
FallPrecipSD	0	1.07	1.08
PP	0	0.92	0.67
ANNPRC	0	0.67	0.59
WinterPrecip	0	0.25	0.25

11/04/2011 17

Conclusions:

1. The CART modelling excercise has succeeded to identify a relatively small number of variables that are consistently important across many species….as we hoped.
2. Many of these variables have intriguing potential interpretations (e.g. variances in winter or breeding season temperatures).
3. We now have some bases to formulate more hypotheses and to specify novel climate covariates

Boreal Avian Modelling Project

Projet de modélisation de l'avifaune boréale

Webinar 5: Determining whether habitat selection differs in eastern and western Canada for boreal birds, Feb. 2011

Determining whether habitat selection differs in eastern & western Canada for boreal birds

BAM Group

Boreal Avian Modelling Project

Projet de modélisation de l'avifaune boréale

1

Assumptions

- 1) East was everything east of Manitoba/Ontario border
- 2) Habitat was the LCC – MODIS national classification modified by BAM into 18 classes
- 3) Only used unlimited distance point counts
- 4) NO CORRECTIONS FOR DURATION

Boreal Avian Modelling Project

Projet de modélisation de l'avifaune boréale

2

Steps

- 1) Calculate mean count per species per habitat class in east & west separately
- 2) Compute relative percentage of each bird species found in each habitat class per region
- 3) Calculated percentage similarity index (PS) of habitat selection between regions

$$PS = \sum \min(p1i, p2i)$$

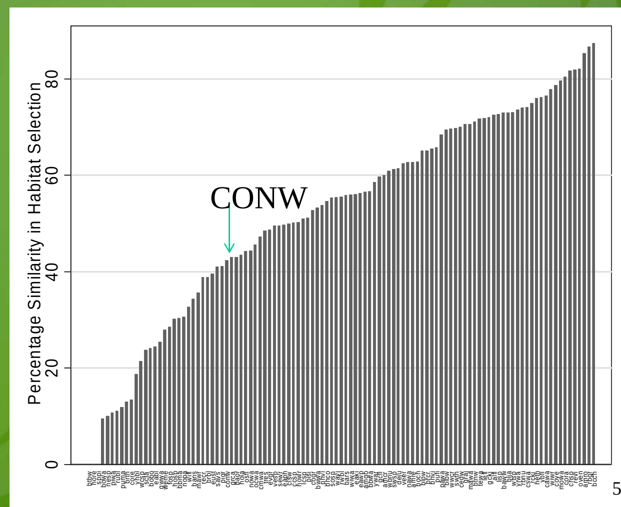
3

Alder Flycatcher

	Mean Count ALFL		Proportion ALFL			
Habitat Class	West	East	West	East	West (n)	East (n)
Closed Conifer	0.0619	0.0854	2.6%	3.2%	1,648	2,763
Closed Deciduous	0.0763	0.1014	3.2%	3.8%	498	3,263
Closed Mature Mixedwood	0.0817	0.1269	3.4%	4.8%	3,502	5,163
Closed Young Mixedwood	0.1111	0.1451	4.7%	5.5%	1,458	1,881
Closed Deciduous Mixedwood	0.0609	0.1117	2.6%	4.2%	2,002	9,025
Open Conifer	0.0771	0.1253	3.2%	4.7%	4,062	4,079
Sparse Conifer	0.1310	0.2144	5.5%	8.1%	542	611
Sparse Conifer Shield	0.0538	0.1503	2.3%	5.7%	390	459
Poorly Drained	0.1107	0.1578	4.6%	5.9%	488	1,001
Open Mature Deciduous	0.1053	0.2229	4.4%	8.4%	2,877	7,599
Open Young Deciduous	0.3184	0.1537	13.4%	5.8%	917	6,088
Open Mixedwood	0.0558	0.1503	2.3%	5.7%	448	985
Open Young Mixedwood	0.2328	0.2146	9.8%	8.1%	958	1,319
Open Herb/Grass	0.1391	0.0668	5.8%	2.5%	2,351	6,095
Open Northern	0.1873	0.0468	7.9%	1.8%	299	1,046
Mixed Forest/ Crop	0.2504	0.0453	10.5%	1.7%	2,955	8,610
Burns	0.3278	0.5344	13.8%	20.1%	790	131
TOTAL	2.3815	2.6531	100%	100%	26,185	60,118

4

PS in habitat selection between east and west

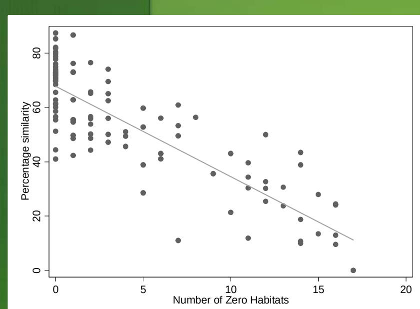


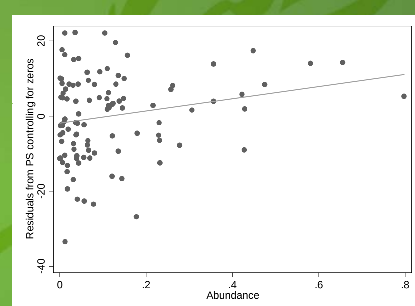
Boreal Avian Modelling Project
Projet de modélisation de l'avifaune boréale

5

What influences PS?

	numzer~s	abunda~e
numzerohab~s	1.0000	
abundance	-0.4345	1.0000





. regress percentagesim numzerohabitats abundance

Source	SS	df	MS
Model	37307.7801	2	18653.8901
Residual	12804.716	104	123.122269
Total	50112.4961	106	472.759398

Number of obs	=	107
F(2, 104)	=	151.51
Prob > F	=	0.0000
R-squared	=	0.7445
Adj R-squared	=	0.7396
Root MSE	=	11.096

percentage~m	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
numzerohab~s	-3.098705	.214467	-14.45	0.000	-3.524002	-2.673409
abundance	20.02793	8.122331	2.47	0.015	3.921038	36.13481
_cons	64.44412	1.958604	32.90	0.000	60.56014	68.3281

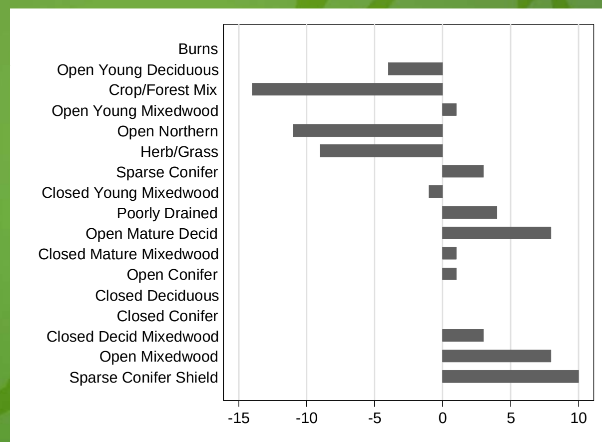
Boreal Avian Modelling Project
Projet de modélisation de l'avifaune boréale

6

Rank Order Habitat Selection - ALFL

Best western habitat

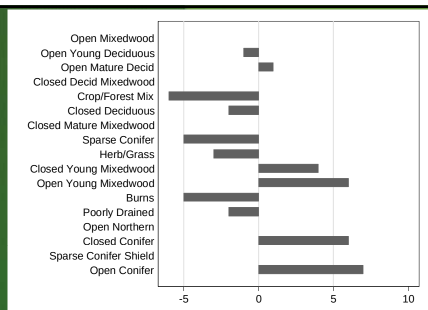
Worst western habitat

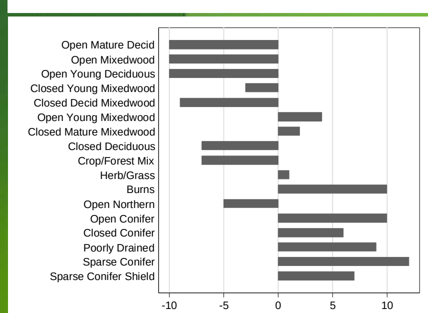


Less preferred in east

Equally preferred

More preferred In east

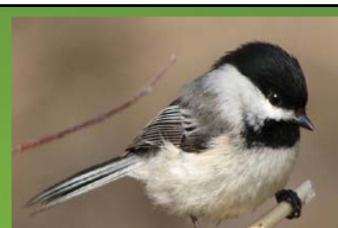




Less preferred in east

Equally preferred

More preferred In east



BCCH
Avg. change in rank = 2.82
PS= 87.3%

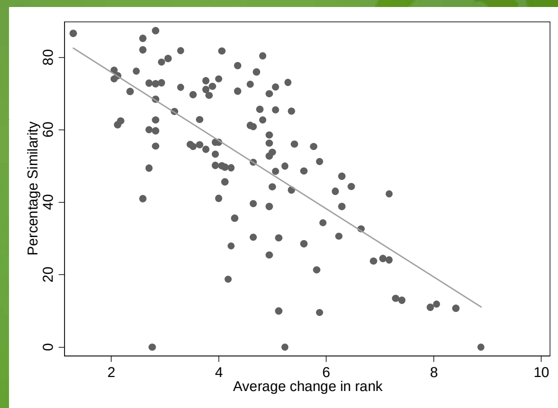
CONW
Avg. change in rank = 7.29
PS = 42.3%

8

Relationship between PS & Rank change index

```
Number of obs =       107
Spearman's rho =     -0.6474

Test of Ho: avgrnkcng and percentagesim are independent
    Prob > |t| =       0.0000
```



Source	SS	df	MS
Model	22609.1871	1	22609.1871
Residual	27503.309	105	261.936276
Total	50112.4961	106	472.759398

Number of obs =	107
F(1, 105) =	86.32
Prob > F =	0.0000
R-squared =	0.4512
Adj R-squared =	0.4459
Root MSE =	16.184

percentage~m	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
avgrnkcng	-9.414527	1.013337	-9.29	0.000	-11.42379	-7.405267
_cons	94.70635	4.825449	19.63	0.000	85.13838	104.2743

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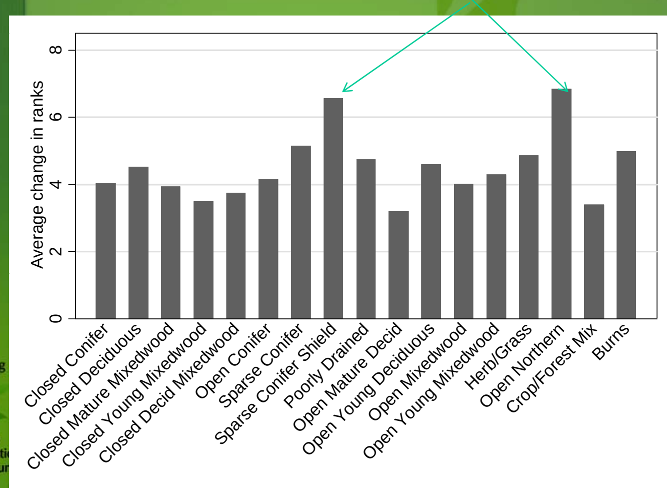
9

Do some habitats show > change in rank suitability between regions?

Are these the same habitat?



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10

Things to consider

- Habitats with zeros could be altered by transformation & standardization which are “common recommendations” for PS
- Duration is on average, lower in the east (Driven by Ontario Atlas)
- There is a lot more data to come & some of it is limited distance counts

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11

Issues

- What do we mean by habitat?
  - Is composition really that important?
- Are habitats the same thing across regions?
  - Is the remote sensing the problem NOT the birds
- How do we split the country logically?
  - Should it be species specific?

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12

Should we look at forest age/ height?

- From forestry perspective, a key issue is when do some of the “old growth” birds enter & is this the same everywhere
- I would argue this is predicated under belief that if species use younger forest somewhere maybe it will be flexible in my region!

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13

BAM Approach to modelling forest age

- To date we have only done this for boreal Alberta. Thus, we have a relatively common AVI (Alberta Vegetation Inventory) standard

Age Class	Deciduous	Pine	W. Spruce	B. Spruce	Mixedwood
0 - 20	603	140	144	47	515
21 - 40	1,355	201	151	154	1,175
41 - 60	1,050	241	60	153	674
61 - 80	2,706	328	27	861	1,670
81 - 100	4,945	485	93	1,077	2,727
101 - 120	5,139	441	248	612	2,513
121 - 140	4,870	221	409	314	2,447
141 - 160	680	67	141	115	807
> 160	28	31	90	40	126

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14

Habitat definitions

Modelling age

- We model age as a non-linear curve for each of the leading tree species in boreal Alberta
- Use fractional polynomials:
  - Treat age class as a continuous variable
  - Make a fractional polynomial model for each leading tree species
  - Merge fractional polynomial terms for each leading species into a single model to predict average counts or densities

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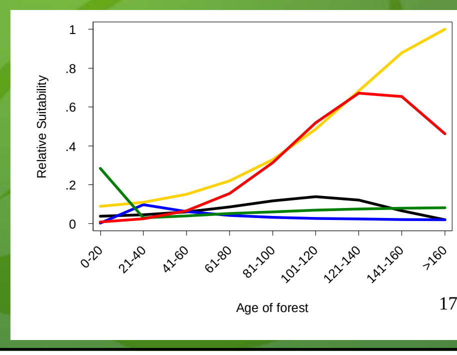
What is a fractional polynomial?

- A quadratic term – X & X^2 is one example of a power function. Other power functions like X & X^{-3} or X^{-2} & X^2 allow for a wide array of non-linear parametric shapes



17

How would we compare?

- Do we have a different shape of curve (i.e. fracpoly terms) among regions
- Does peak abundance differ by *x* years among regions?
- Does a different tree species have higher count among regions controlling for age?

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18

Key questions

- What spatial scale are we going to use and why? (In AB, used 150 & 200 metre buffers)
- Is tree species the right categories or should we use “tree form”
  - I.E. Quebec B. Spruce is same as Alberta W. Spruce and we use genus as the leading category
  - Or do we include moisture regime and a tree type as coniferous, mixedwood, and deciduous

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19

CAS (Common Attribute Schema) Issues

- Age, height, density are NOT calculated the same way in the CAS for each inventory
  - In other words, the CAS does not say tree height is 16 metres everywhere
- Instead it is ordinal data that keeps the lower and upper bound of the interval reported by the vegetation inventory
  - I.E. AB – 16m, 17m, 18m etc
  - I.E. SK – 0 to 5m, 5 to 10m, 15 to 20m. Etc

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20

Composition & Density (Leading Species)

- % cover of each tree species also varies among inventories
  - I.E. Alberta – 10% increments
  - I.E. Saskatchewan – 25% increments
- Tree density is typically in 4 classes BUT the cutoffs of these classes vary
  - I.E. What is open stand may have different densities in each region.

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21

Errors in variable approach?

- Errors-in-variables models or measurement errors models are regression models that account for measurement errors in the independent variables.
- Standard regression models assume regressors have been measured exactly, or observed without error; as such, those models account only for errors in the dependent variables
- When some regressors have been measured with errors, estimation based on the standard assumption leads to inconsistent estimates, meaning that the parameter estimates do not tend to the true values even in very large samples.

http://en.wikipedia.org/wiki/Errors-in-variables_models

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22

Other ideas

- Do this comparison where
  - A) Have lots of data
  - B) Inventories are the most similar
  - C) Full sampling continuum of either age within a leading species OR:
  - D) an age class across leading species

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23

BAM, BBS and the Atlases:

Effective collaboration by design?

BAM Webinar on Sample Design

Tuesday March 8 2011

1230-1430 MST

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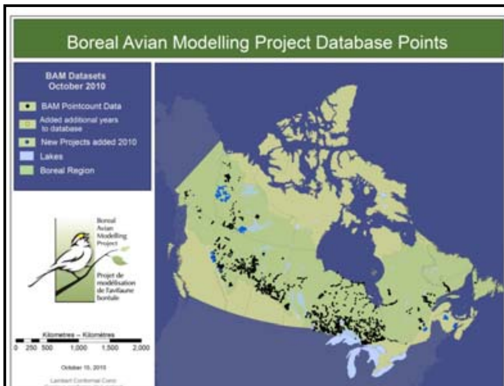
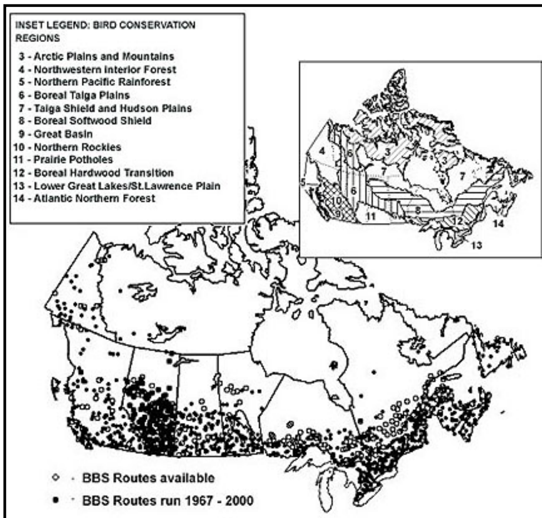
1



The BAM collection

- Point count data;
- From managed forests or frontier forests under threats.
- Locations as remote and off-road as we could find/afford.
- Overall design: haphazard
- Mostly single visits.

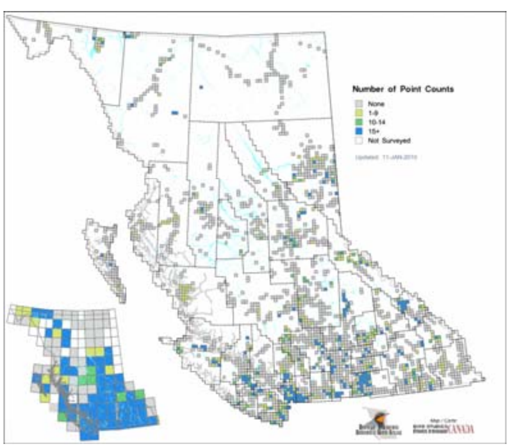
2



BBS Routes

- Point counts
- Roadside, 3 minutes
- Most not in boreal
- Design determined by road network.
- Repeated measures!

3



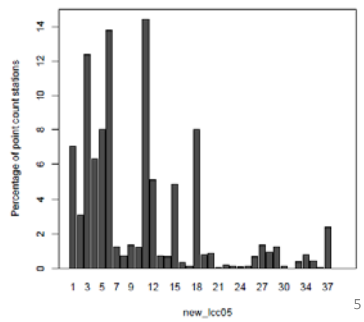
Breeding Bird Atlases

- Landscape units surveyed mysteriously
- With some point counts
- Design *constrained* by road access;
- Some capacity and wish to go offroad .
- Multi-year projects, repeated at 10yrs or so.

4

Limited access and biased site selection are common problems:
Many vegetation types are poorly sampled, nationally and within regions.

BAM can help with this *now* … Steven Matsuoko will explain how.



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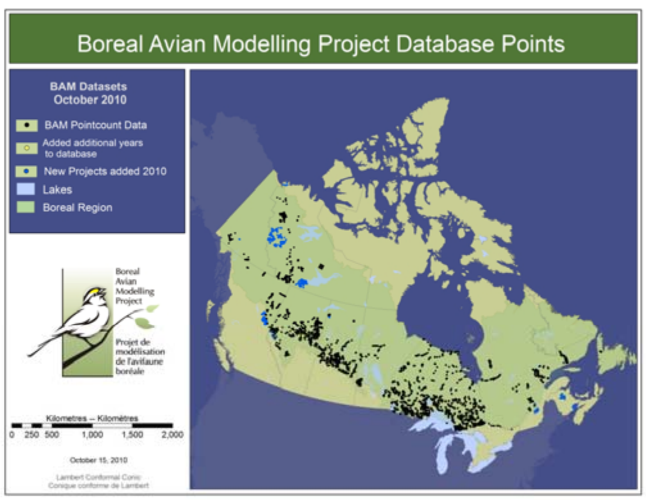
Poor sample design leads too…



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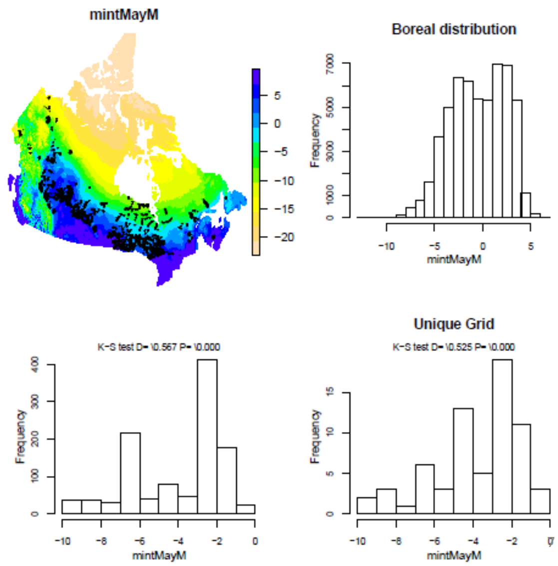
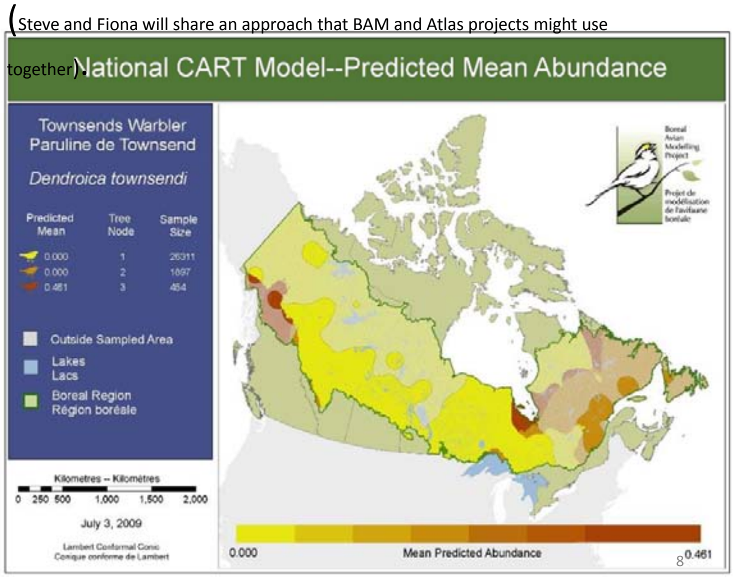
Unbalanced samples of covariates; poor contrast



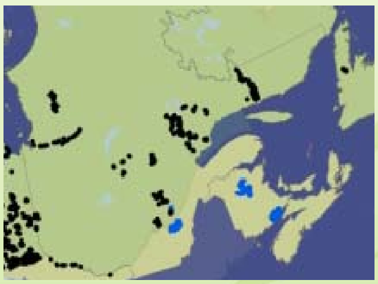
…faulty inference and unreliable prediction.

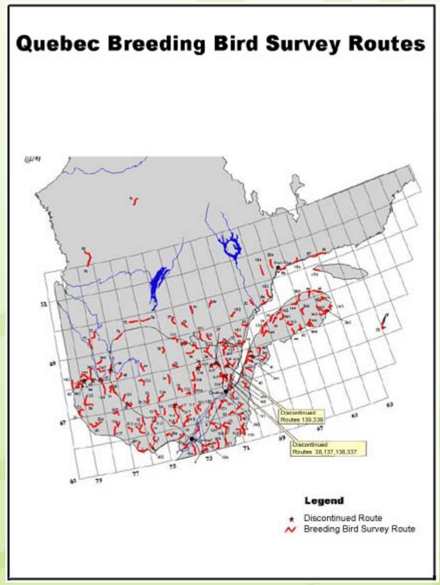
(Steve and Fiona will share an approach that BAM and Atlas projects might use together).



BAM + BBS: very tempting, but it won't work yet.

Erin will explain the problem, and how Atlas projects could help us solve it





Charles Francis said:

"The Canadian Breeding Bird Atlas Committee [was] wondering whether BAM might be able to assist with advice or protocols for selecting priority squares in boreal areas, particularly from the perspective of identifying areas where new data would be of greatest value for improving modelled estimates of distributions?"

Charles will kick off with the view from EC;

Mike will speak of objectives, scope and timelines for current Atlas projects.

How Canadian Breeding Bird atlases should distribute point counts in the boreal

Preliminary meeting

Mar. 8, 2011

Mike Cadman

11

Need from BAM

- How to select survey (and point count) locations to help atlases meet their goals
- How atlassing can best contribute to long-term monitoring in the boreal

12

Current atlas situation

- Manitoba, Quebec both in 2nd year of 5-6 year project (2010-2015)
- BC in 5th year of 5-6 year project
- SK, NF potential next projects (?)
- Ontario start 3rd atlas 2018(?)
- Much data in remote areas collected by paid crews

13

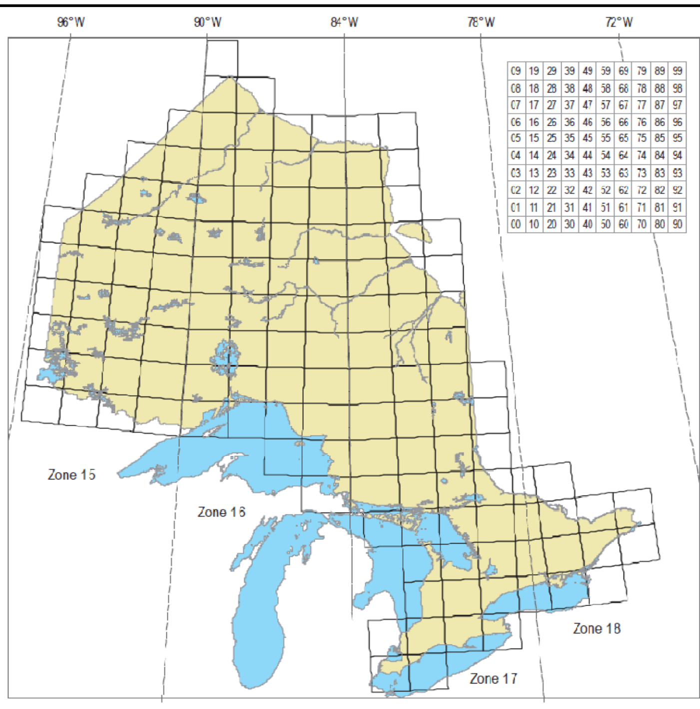
Atlas goals

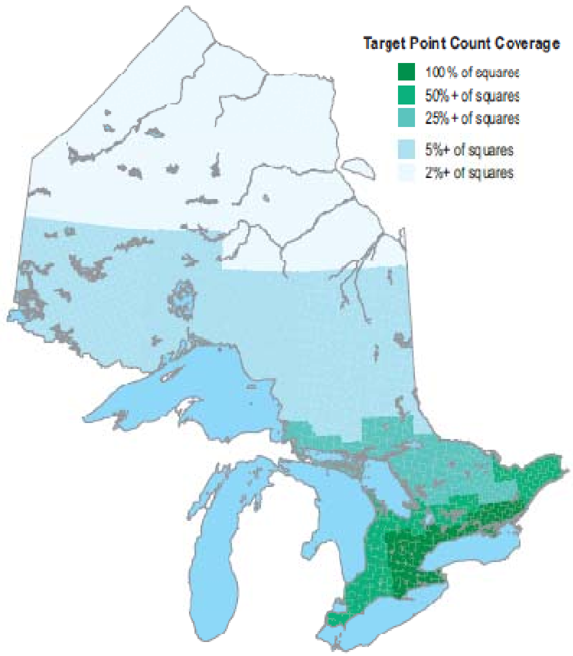
- Detailed maps of each species' distribution by breeding record occurrence
- Map relative abundance
- Compare to past and future atlases

14

EC priorities for atlas point counts

1. Provide a baseline for comparison of bird populations over time for areas and species not well covered by other surveys. (Then for priority species, then all species, for the whole province.)
2. Map relative abundance for the whole province.





17

Square selection in remote areas

- limited to accessible squares
- Sample habitat in proportion to its occurrence in the 100-km block
- Proportion of habitat using LANDSAT
- Similarity indices to pick the squares most similar to the block

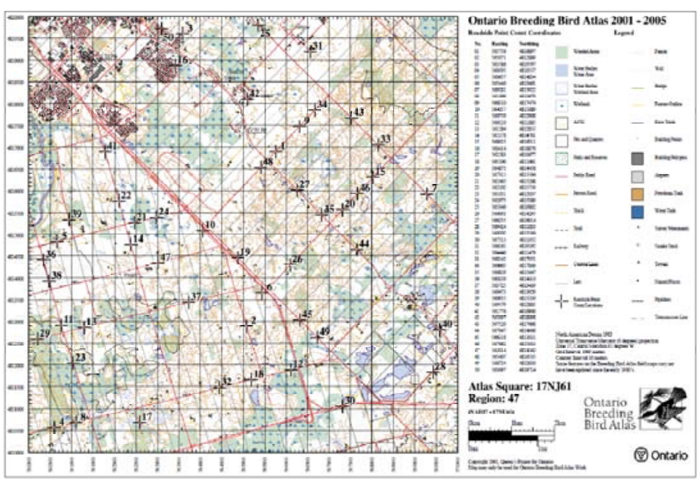
18

Point count locations in remote areas

- Sample habitat in square proportionate to occurrence in square
- E.g. square 16DH61 near Hudson Bay coast
- **Target number of point counts in this square**: 0 road side, 25 off road (19 in open wetlands, 2 in treed wetlands, 3 in tundra heath, 1 in rock outcrops and quarries).

19

Point count locations in road-accessible areas



Target number of point counts in this square: 20 road side, 5 off road (2 in deciduous forest, 1 in coniferous forest, 1 in mixed forest, 1 in pasture/grassland).

20

Identifying gaps in sampling of boreal forest birds

Trish Fontaine
Steve Matsuoka
& the BAM Group

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21

Goals & basic approach

- **Objective:** Identify poorly sampled areas, habitats, areas X habitats across the boreal.
  - BBS, BAM, BBS + BAM data.
- **Basic approach:** Proportional sampling minus proportion availability.

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Data

- **Geographic Stratification**: National Ecological Framework for Canada
  - Sampling unit: Ecodistrict (10,000 km^2 , *n* = 588).
  - Reporting unit: Ecozone (*n* = 9),
    Ecoprovince (*n* = 29), Ecoregions (*n* = 108)
- **Avian:** BAM (*n* = 51,081 points), BBS (*n* = 26,912 stops)
- **Habitat**: Land Cover Map of Canada 2005
  - 250-m resolution
  - Reclassified from 39 to 8 classes
- **Roads**: National Road Network 2.0

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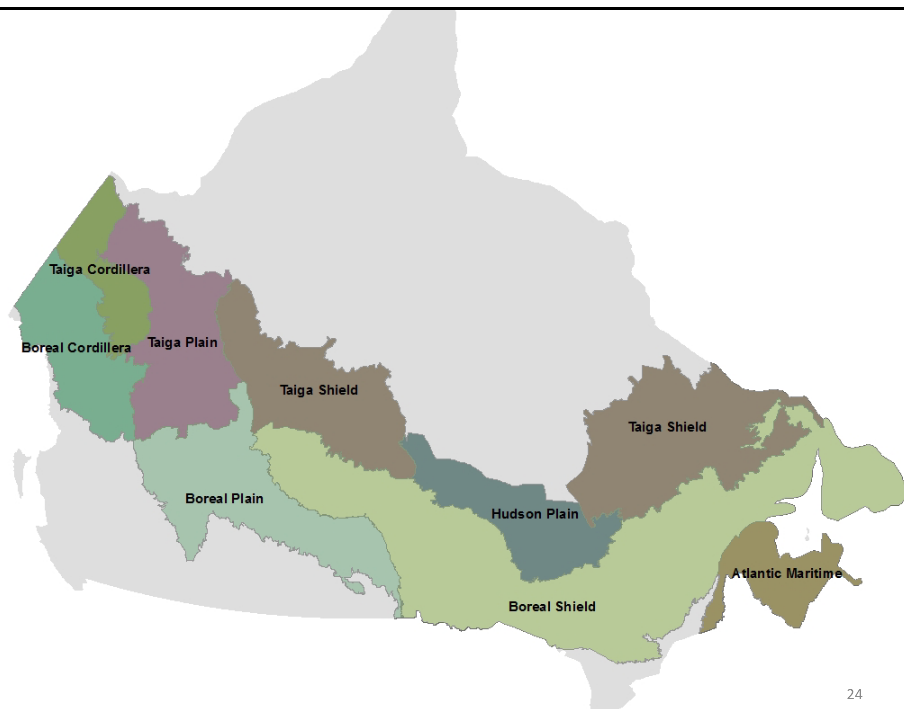
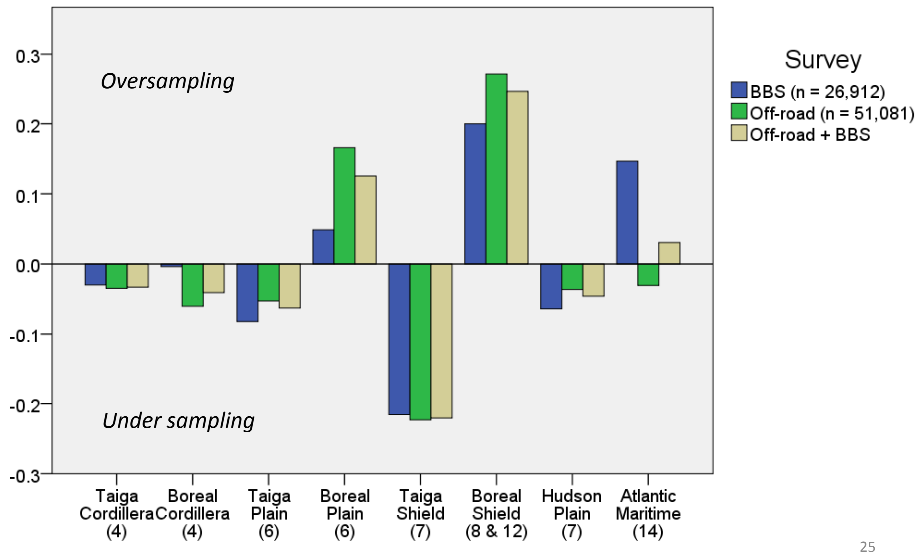
23



24

Sampling by Ecozone, transboreal (West to East)



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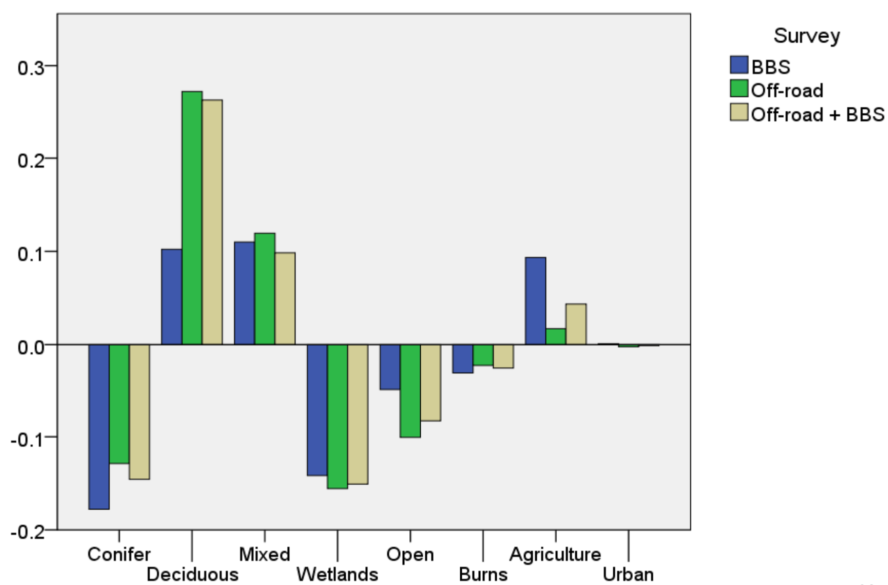
Sampling by habitat, transboreal



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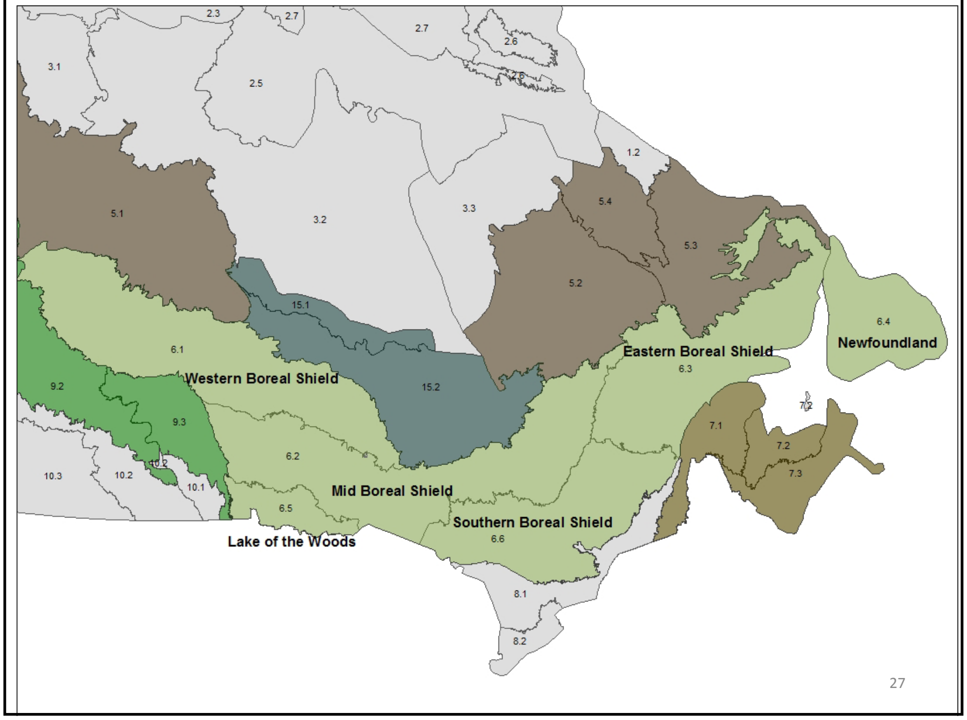
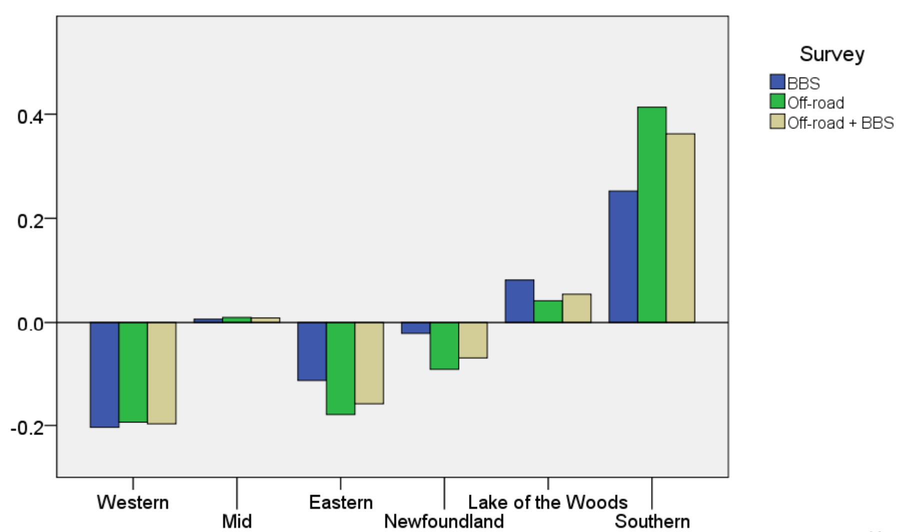


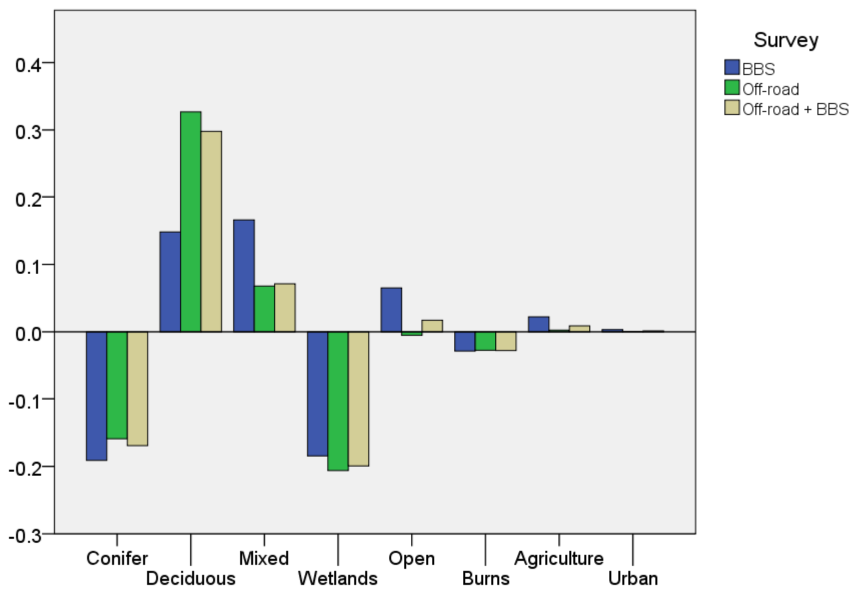
27

Sampling by Ecoprovince within the Boreal Shield Ecozone



28

Sampling by habitat, Boreal Shield



29

Next steps

- **Examine sampling bias relative to the road network.**
  - What habitats and regions can be sampled by roads?
  - How well does the BBS sample habitats along roads?
- **Online database of sampling gaps.**
  - Where they could be filled in on and off-road areas.
- **Other ideas?**

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30

The RAP experience

Balanced and model-based sample design in remote areas.

Cumming and Schmiegelow

Mar. 8, 2011

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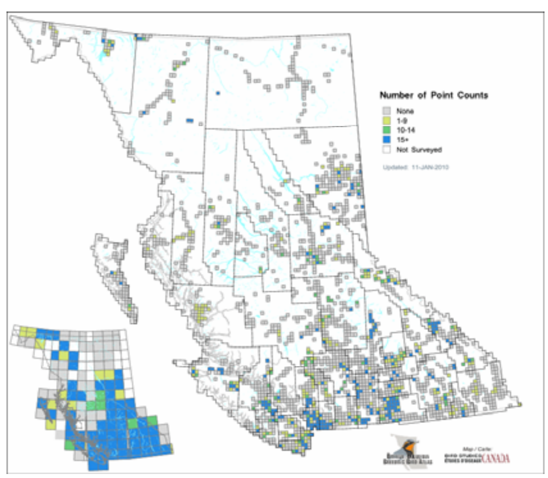
31

Hypothetical:

« We plan to sample some squares in remote areas.

Access, personel and $$$ are all limiting.

How should we chose our sample? »

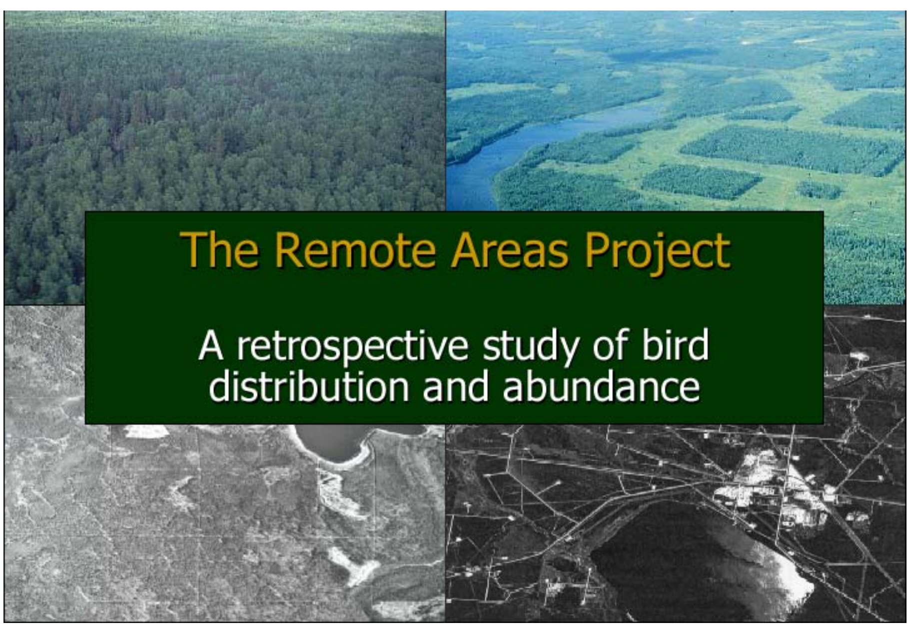


32

Depends on your objectives.

- Map breeding range?
- Sample all « habitats »
- Account for climate and vegetation?
- Multi-scale effects (patch in landscape)?
- Land use, climate change, conservation?
- Help BAM build better national models?
- Develop a « national Atlas »?
- Other big initiatives?
- Threatened species?
- Or all birds?

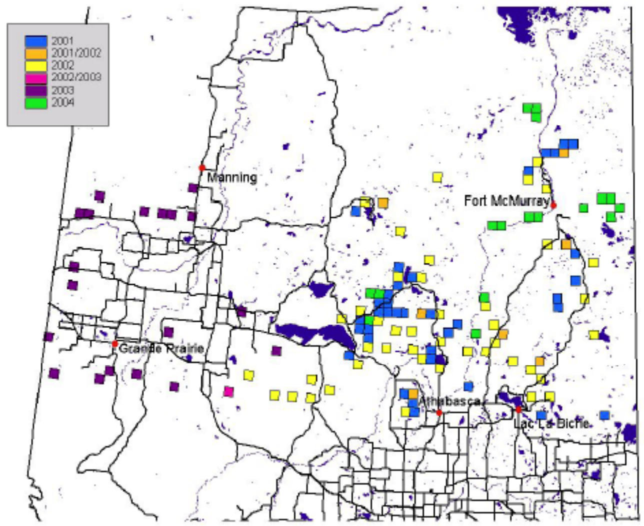
33



Schmiegelow and Cumming (2002)

34

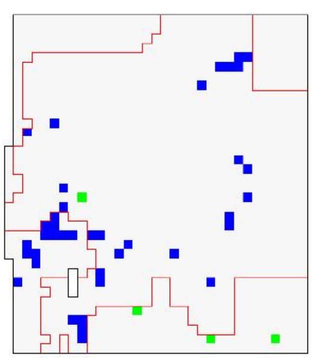
Figure 1: Remote Areas Project Sampled Landscapes (2001-2004)



35

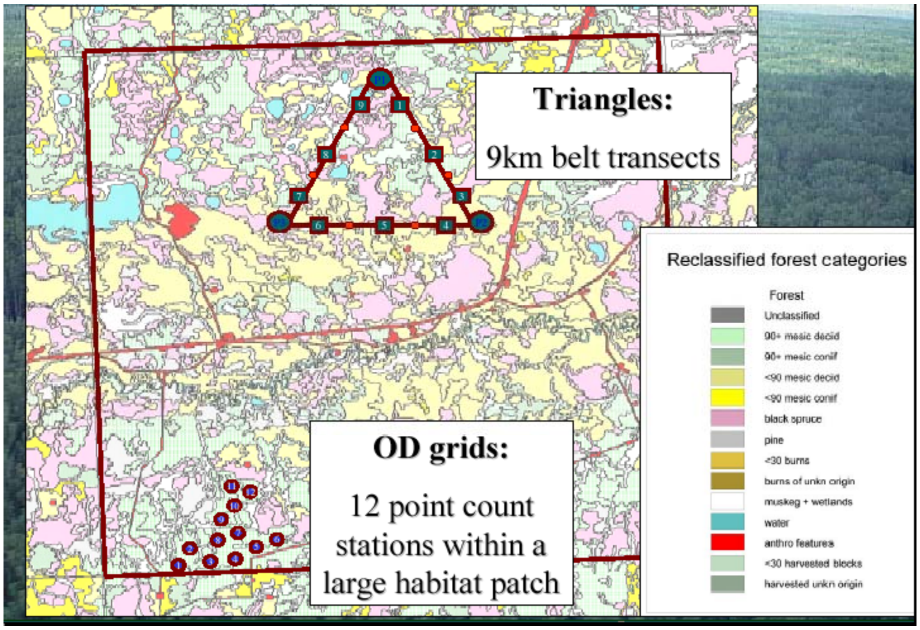
Stage 1: 2001, balanced design
Birds in habitat patches in landscapes.

Sample landscapes:



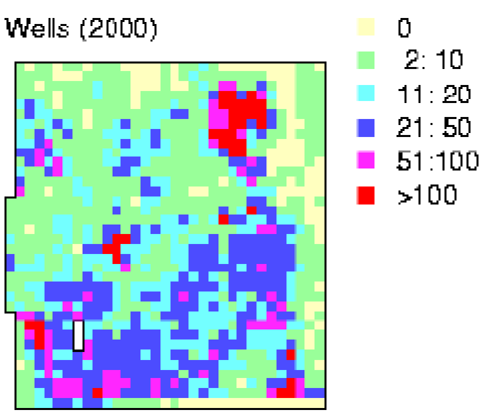
- A study area of 1,000 landscapes, like atlas squares.
- Mostly inaccessible (then)
- We had 4 landscape design variables.
- We could sample 50.
- How we did this?

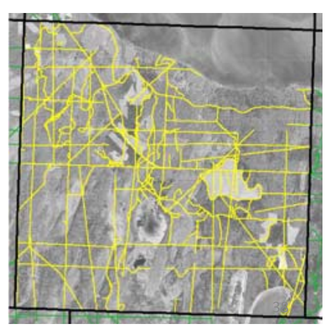
36



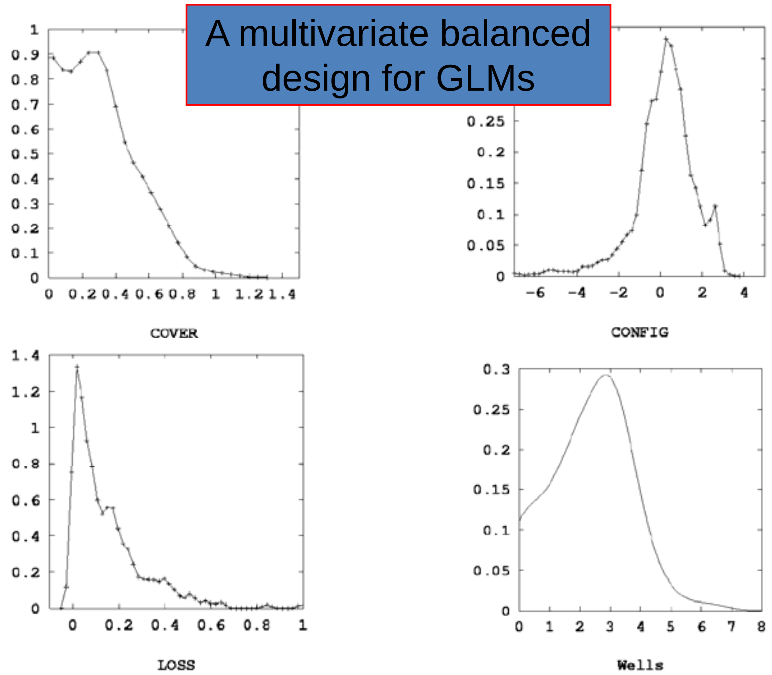
37

WELLS: density of well-sites, correlated with densities of roads and other linear features





A multivariate balanced design for GLMs



39

Sample construction algorithm

Iterative greedy minimisation of…

Goodness-of-fit statistics for the p=4 sample marginals.

Updates by steepest descent: chose best interval for worst marginal

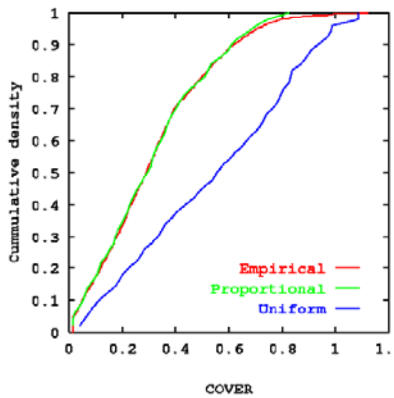
Add (highest weighted) feasible landscape from the interval

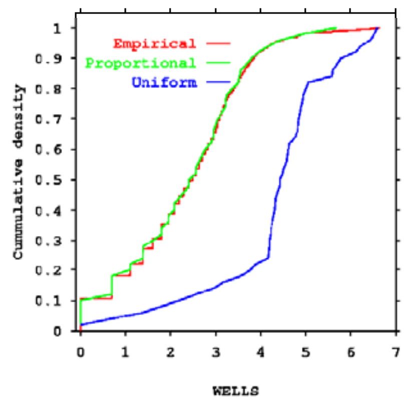
While (n < N)

40

Algorithm performance,
unconstrained

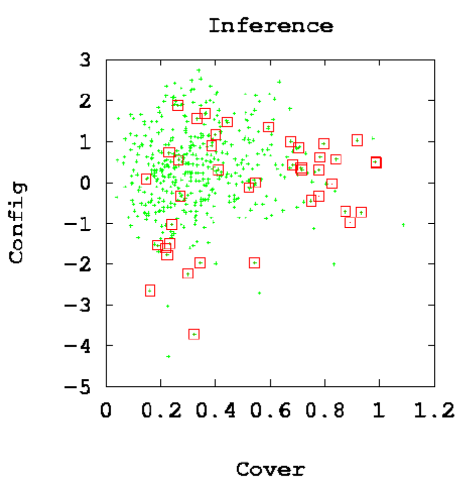
n=50, N=1115

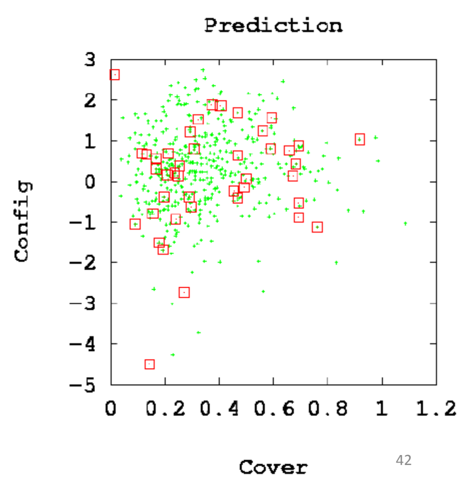




41

Alternate sampling objectives



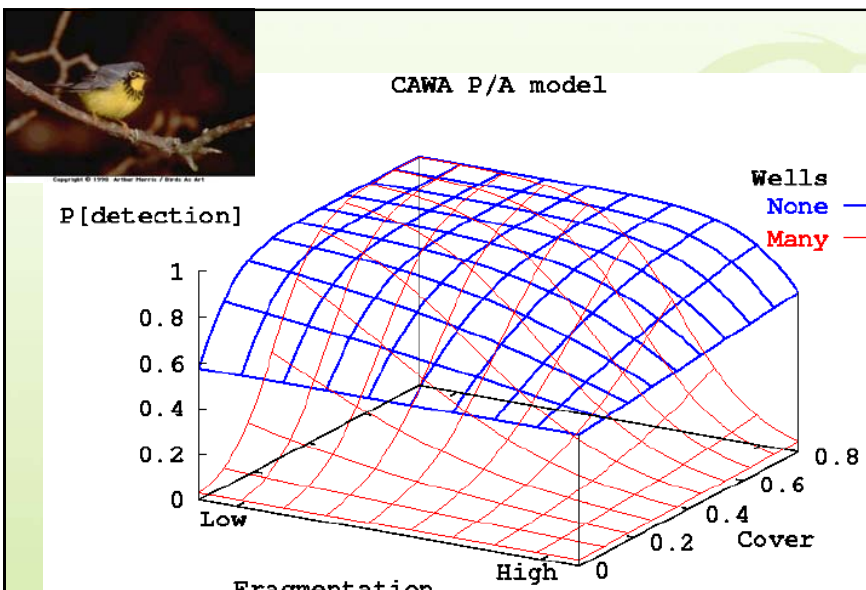


42

Season 2: Model Based

- Expanded the study region
- Completely re-defineed all the independent variables (sigh);
- Built GLMs from the 2001 data;
- Chose a few “interesting” models;
- Select a new sample based on estimation errors and predicted sampling errors.

43



logit(p) = 0.3 + 5.6 Cv – 2.46 Cv*Cf – 0.96 Wells

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44

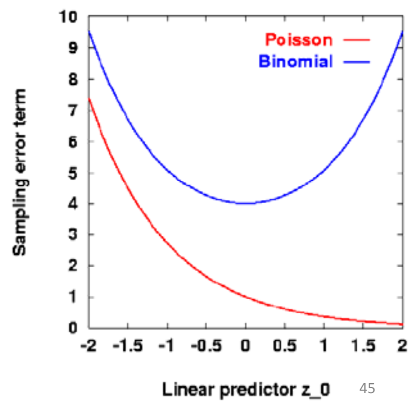
Selecting informative new locations by weighting prediction and intrinsic errors

Poisson

$$\mathrm{Var}(z_0 - \hat{z}_0) = \boldsymbol{x}_0 \,\mathrm{Var}(\hat{\boldsymbol{\beta}}) \boldsymbol{x}_0^\top + \frac{1}{\mu_0}$$

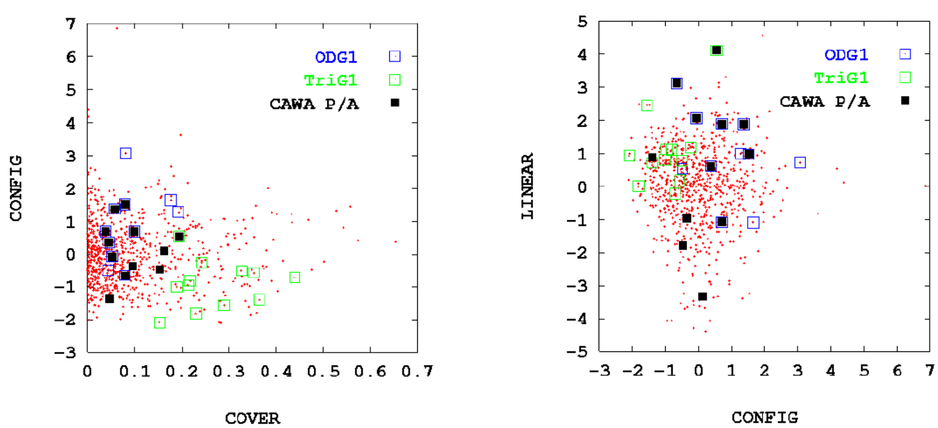
Binomial

$$\mathrm{Var}(z_0 - \hat{z}_0) = \boldsymbol{x}_0 \,\mathrm{Var}(\hat{\boldsymbol{\beta}}) \boldsymbol{x}_0^\top + \frac{1}{\pi_0(1-\pi_0)}$$

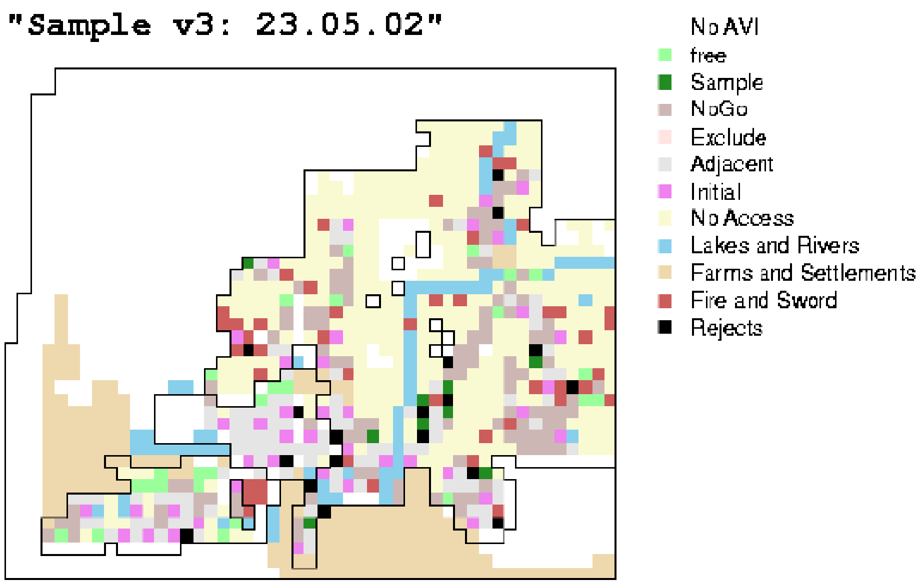


45

The new sample (n=50) focuses on different parts of the covariate space.



46



47

These approaches could be dusted off and applied to Atlas sampling needs and to future BAM-inspired surveys.

Next year….
Better technology may now exist.

BUT: we'd need to *agree* on spatial units, design variables, « habitat » and select carefully any « design » models.

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48