Boreal Avian Modelling Project

Boreal Avian Modelling Project

Projet de modélisation aviaire boréal

Annual Report
April 2017 - March 2018

Highlights from 2017-18

BAM pursues applied ecological research, collaborates with other parties to directly inform conservation and management of species, and develops data and data products to support research and management. All of the above are shared via a variety of communication mechanisms, and rely on attentive coordination of our distributed network of BAM team members.

Here are our main achievements from April 2017 to March 2018.

Research & Monitoring

Boreal Bird Density, Population Size, and Habitat Needs

- Importance of accounting for sampling bias in population size estimation demonstrated ▶ page 8
- Canada warbler select different habitat in eastern vs. western Canada, suggest new hierarchical models using forest resource inventory data ▶ page 11
- Updated Canada-wide BAM data products describing avian density, distribution, population size, and trends to be released in 2018-19 ▶ page 8

Impacts of Landscape Change and Climate Change on Boreal Birds

- Climatic factors and forest loss on breeding grounds have strong influence on boreal bird breeding abundance, suggest analyses across 46 long-distance migrants ▶ page 13
- Local densities of many old forest associated songbirds appear to decrease with increasing levels of anthropogenic disturbance ▶ page 16
- Predicting larger scale cumulative effects from local-scale models works well on average, but not on individual landscapes ▶ page 17
- Cumulative effects of human activities on birds in oil sands region demonstrated by three different analytical approaches ▶ page 18

Informing Conservation Planning for Boreal Birds

- Decision-making roadmap developed to inform spatial conservation prioritization of boreal bird habitats in Canada ▶ page 21

Development of Methods to Account for Imperfect Detectability of Species

- Species detectability is predictable based on species traits and the singing behaviours of closely related species ▶ page 23
- Recommendations outlined for application of time-removal approaches and their influence on density estimation ▶ page 23

Outcomes & Collaborations

BAM contributed to over 30 collaborative efforts to facilitate boreal bird conservation and management, involving non-governmental organizations, provincial and federal government agencies, industry, Indigenous Peoples, and academic institutions ▶ page 36

Conserving Species at Risk

- BAM continues scientific support for conservation prioritization for species at risk, including Canada warbler, olive-sided flycatcher, common nighthawk, and rusty blackbird ▶ page 27
- Conceptual model to guide identification of critical habitat for wide-ranging bird species approved for publication by Environment & Climate Change Canada ▶ page 12
- Management units for Canada warbler critical habitat identification to be delineated using geographically weighted regression ▶ page 12

Integrating Science, Policy, and Action to Support Conservation of Boreal Birds

- Special issue in Avian Conservation & Ecology, arising from 2016 Conservation of Boreal Birds workshop, will appear in late 2018 ▶ page 29

Linking Avian Conservation and Forest Management

- "Birds and Forestry" workshop hosted by BAM and the Sustainable Forestry Initiative, attended by 39 individuals from 27 academic, industry, governmental, or non-governmental institutions. Forthcoming workshop report to outline future collaborative opportunities ▶ page 33
- Expertise and research on avian and biodiversity conservation in relation to forestry contributed via several meetings and research projects ▶ summarized on page pages 34

Recommendations for Avian Sampling

- BAM's avian data in use to evaluate sampling design methods as part of Environment & Climate Change Canada's Boreal Monitoring Strategy ▶ page 35
- Locations of 2017 avian point count sampling by BC forest companies informed by BAM analyses ▶ page 35

Data Development

- Products currently available include:
  - national density maps for 103 songbird species and 17 waterfowl species or species groups;
  - climate-change informed projected distributions for 103 species;
  - maps of climate refugia;
  - maps of priority areas for conservation of Canada Warbler in Bird Conservation Region 14;
  - maps of species' probabilities of occurrence for 80 species.

  Email BorealAvianModellingProject@ualberta.ca to make a request ▶ page 40
- New data product distribution platform under development with launch anticipated for March 2019 ▶ page 39

Communications

- Site map for updated BAM website completed, with website launch planned for March 2019 ▶ page 45
- Publication of two BAM core papers, and additional four with significant BAM contributions ▶ page 46
- BAM research and conservation efforts showcased in more than 20 talks at international or regional conferences and targeted workshops ▶ page 48

Project Management

- Two post-doctoral fellows (Andy Crosby, Tati Micheletti) and 4 graduate students (Antoine Adde, Brendan Casey, Isolde Lane Shaw, and Ana Raymundo) joined the BAM team in 2017-18, supported by an NSERC

Strategic Partnership Grant on avian conservation in managed forests through statistical modelling and spatial simulation ► page 53

- Research Scientist Junior Tremblay (ECCC-S&T) joined the BAM team as a contributing scientist, focusing on landscape simulation, managed forests, and critical habitat for species at risk ► page 53
- Centralized resources created to support efficient team operations and collaboration, including an FAQ guide on team function and operations and a shared repository for file structures and code bases; these will also provide the basis for effective collaboration with external groups ► page 52
- Formal strategic planning effort launched in 2017-18 to identify BAM's mission, long- and short-term visions, objectives, and strategies to achieve the mission ► page 53

Contents

Project Team & Technical Committee

Erin Bayne, U.Alberta ..... Steering Committee
Steve Cumming, U.Laval ..... Steering Committee
Fiona Schmiegelow, U.Alberta ..... Steering Committee
Samantha Song, ECCC ..... Steering Committee

Nicole Barker, U.Alberta ..... Coordinating Scientist
Trish Fontaine, U.Alberta ..... Database Manager
Mélina Houle, U.Laval ..... Database Manager
Péter Sólymos, U.Alberta ..... Statistical Ecologist
Diana Stralberg, U.Alberta ..... Project Ecologist

Andy Crosby, U.Alberta ..... Post-doctoral Fellow
Francisco Dénes, U.Alberta ..... Post-doctoral Fellow
Lionel Leston, U.Alberta ..... Post-doctoral Fellow
Tati Micheletti, UBC ..... Post-doctoral Fellow
Alberto Suarez-Esteban, U.Alberta ..... Post-doctoral Fellow

Antoine Adde, U.Laval ..... PhD Student
Brendan Casey, U.Alberta ..... MSc Student
Isolde Lane Shaw, U.Laval ..... PhD Student
Ana Raymundo, U.Laval ..... PhD Student
Tara Stehelin, U.Alberta ..... PhD Student

Samuel Haché, ECCC ..... Contributing Scientist
Lisa Mahon, ECCC ..... Contributing Scientist
Steve Matsuoka, USGS ..... Contributing Scientist
Judith Toms, ECCC ..... Contributing Scientist
Steve Van Wilgenburg, ECCC ..... Contributing Scientist
Alana Westwood, Independent ..... Contributing Scientist

Marcel Darveau, DUC / U.Laval ..... Technical Committee
André Desrochers, U.Laval ..... Technical Committee
Pierre Drapeau, UQAM ..... Technical Committee
Charles Francis, ECCC ..... Technical Committee
Colleen Handel, USGS ..... Technical Committee
Keith Hobson, UWO ..... Technical Committee
Craig Machtans, ECCC ..... Technical Committee
Julienne Morissette, CFS ..... Technical Committee
Gerald Niemi, U.Minnesota ..... Technical Committee
Rob Rempel, OMNRF / Lakehead U. ..... Technical Committee
Stuart Slattery, DUC ..... Technical Committee
Phil Taylor, BSC / Acadia U. ..... Technical Committee
Lisa Venier, CFS ..... Technical Committee
Pierre Vernier, U.Alberta / BEACONs ..... Technical Committee
Marc-André Villard, UQAR ..... Technical Committee

Photo: Alberto Suárez-Esteban

About Us

Our Vision

Conservation of North American boreal-breeding birds and their habitats is guided by rigorous, credible, and collaborative science

Our Mission

BAM develops high quality scientific information, products, and guidance addressing pressing management needs

Our Objectives

1. **ASSEMBLE**, harmonize, and archive standardized boreal bird survey **data**.
2. **DEVELOP** or refine **statistical methods** to analyze these data, to:
    3. **PROVIDE reliable information** on boreal bird distributions, abundances, trends, and habitat associations;
    4. **FORECAST** population consequences of human activity and climate change;
    5. **CONTRIBUTE** to **conservation**, **management**, and **monitoring** of boreal birds and their habitats.
6. **BUILD SUPPORT** for boreal bird conservation via collaborations and outreach.
7. **FACILITATE** further research efforts by generating testable hypotheses about key mechanisms driving boreal bird populations.
8. **ENCOURAGE** public awareness and support education.

Our History

The Boreal Avian Modelling (BAM) Project was established in 2005 to address critical knowledge gaps challenging the management and conservation of boreal birds in Canada. BAM's work draws upon a large database created through an initial investment in assembling and harmonizing data contributed by individual research and monitoring efforts conducted in the Canadian and US boreal & hemi-boreal forest. Our strength draws from this foundation of collaboration.

Our research products are applied to many aspects of boreal bird management and conservation, including migratory bird monitoring, population estimation, determination of habitat requirements, population assessment and recovery planning for species at risk, environmental assessment, identification of priority wildlife areas, protected areas design, and land-use planning.

Our Structure

The BAM Project Team is made up of academic researchers, project staff and post-doctoral fellows, government scientists, and graduate students. BAM collaborates with federal and provincial governments, academics, industry, Indigenous Peoples, and non-governmental organizations with interests in the development and application of science for bird conservation and management.

Learn more at borealbirds.ca

Recognizing Collaborations

Given BAM's highly collaborative structure, we wish to appropriately acknowledge intellectual and financial contributions to projects described in this report. This year, we introduce a three-way classification of projects to indicate the alignment with BAM's core goals and the degree of collaboration involved.

CORE project: A project addressing BAM's core mandate, led from inception to completion by BAM Team Members

CO-PRODUCED project: A project jointly produced between BAM and external collaborator(s). These are often conceptualized outside of BAM before BAM involvement is solicited. BAM involvement could include intellectual contribution to project goals, data provision, analysis, and interpretation of results.

INFORMED project: A project addressing BAM's mandate with relatively little contribution from BAM (e.g., data or limited expert knowledge). Alternatively, a project using BAM data or intellectual contribution but not addressing BAM's core mandate.


Photo: Nicole Barker

Research & Monitoring

BAM's research contributes to conservation and management of boreal birds in two principle ways: 1) by providing the best available information; and 2) by advancing the theoretical foundations underpinning conservation and management within the boreal region.

Provision of information: Resource and species managers, policy-makers, and other decision makers must respond, assess, and triage based on available information. BAM strives to ensure the best information is available to facilitate evidence-based decision-making.

Theoretical foundations: BAM also proactively conducts research on species ecology, habitats, and human impacts, with intent to continually improve the intellectual standard, theoretical basis, and rigour of our products and advice.

Here we describe progress on our research projects from April 2017 - March 2018.

Avian Ecology & Population Status Assessment

Density, Abundance, & Population Size

We refined our method of estimating population size using Alberta as a test case, developed regional abundance models for British Columbia as part of a partnership with forestry companies, and developed abundance models for the Northwestern boreal as part of a PhD thesis.

❊ National density maps and population size estimates

In previous years, we developed an approach to modelling species' density and population sizes at national scale using Canada warbler as a model species (page 7; Haché et al. *in prep.*, Boreal Avian Modelling Project 2016). We intended to apply this approach to all species once finalized, producing updated national density maps. During 2017-18, after testing the approach on a sample of 12 species, we recognized that the analytical approach worked best when customized on a species by species basis. This precludes the intended automated analysis of >90 species. After some team discussion, we agreed to develop our next generation of density maps and population estimates using a machine learning approach. Since Boosted Regression Trees (BRTs) allow more complex interactions and curvilinear relationships between species abundance and environmental variables, we can more efficiently repeat the same analysis on >90 species. We will initiate the work in early 2018-19, anticipating completion of density maps and population size estimates by March 2019. [CORE project. Contact: Diana Stralberg and Péter Sólymos]

❊ Road-based sampling characteristics drive population size estimates in the boreal region

Since the early 2010s, we have tested and developed various methods to accurately and reliably estimate population sizes of North American boreal birds. In 2017-18, we compared BAM population estimates to

Partners in Flight (PIF) population estimates and quantified the factors contributing to differences (see box for more information on the research methods and results).

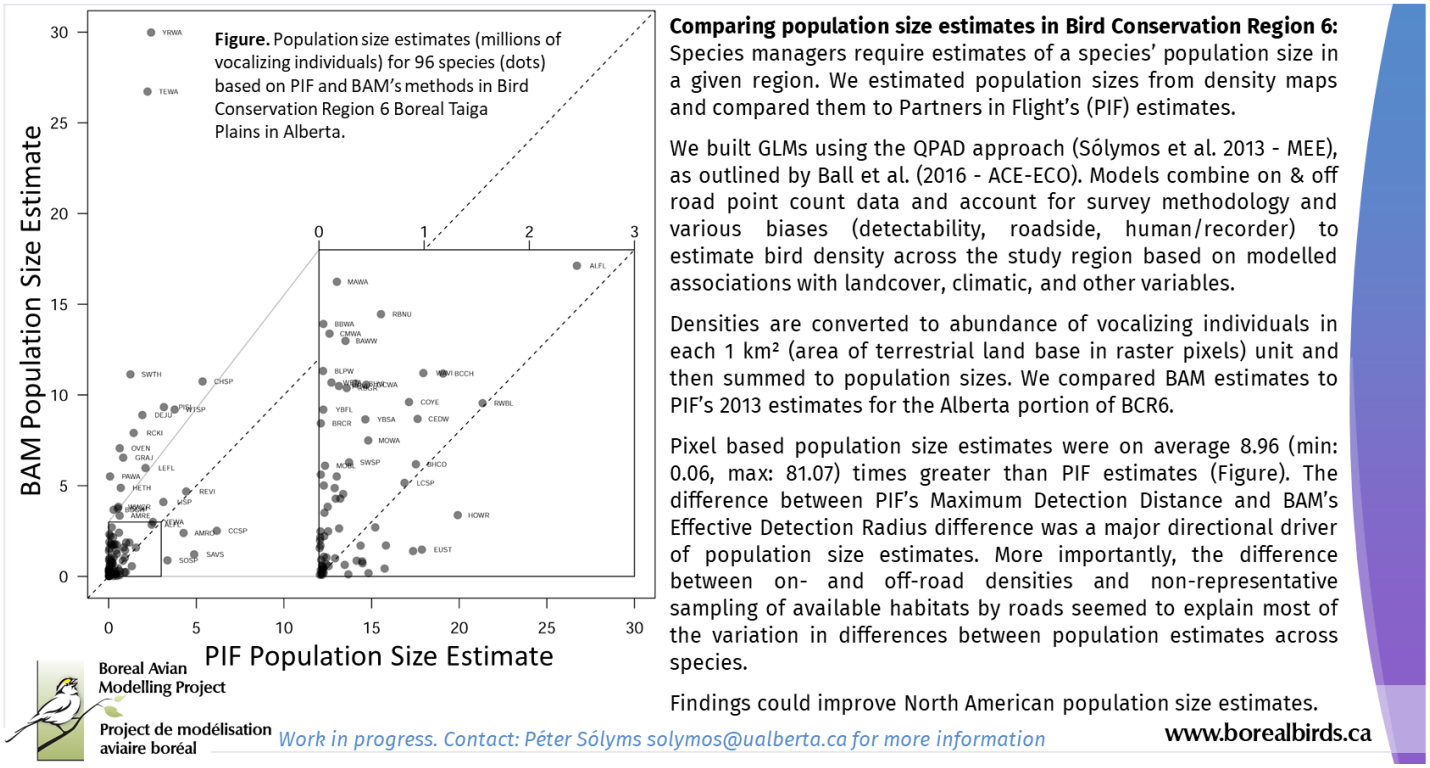


Figure. Population size estimates (millions of vocalizing individuals) for 96 species (dots) based on PIF and BAM's methods in Bird Conservation Region 6 Boreal Taiga Plains in Alberta.

Comparing population size estimates in Bird Conservation Region 6: Species managers require estimates of a species' population size in a given region. We estimated population sizes from density maps and compared them to Partners in Flight's (PIF) estimates.

We built GLMs using the QPAD approach (Sólymos et al. 2013 - MEE), as outlined by Ball et al. (2016 - ACE-ECO). Models combine on & off road point count data and account for survey methodology and various biases (detectability, roadside, human/recorder) to estimate bird density across the study region based on modelled associations with landcover, climatic, and other variables.

Densities are converted to abundance of vocalizing individuals in each 1 km² (area of terrestrial land base in raster pixels) unit and then summed to population sizes. We compared BAM estimates to PIF's 2013 estimates for the Alberta portion of BCR6.

Pixel based population size estimates were on average 8.96 (min: 0.06, max: 81.07) times greater than PIF estimates (Figure). The difference between PIF's Maximum Detection Distance and BAM's Effective Detection Radius difference was a major directional driver of population size estimates. More importantly, the difference between on- and off-road densities and non-representative sampling of available habitats by roads seemed to explain most of the variation in differences between population estimates across species.

Findings could improve North American population size estimates.

Boreal Avian Modelling Project
Project de modélisation aviaire boréal

Work in progress. Contact: Péter Sólyms solymos@ualberta.ca for more information

www.borealbirds.ca

We found that most of the variation in differences can be attributed to two factors: 1) methods for correcting species detectability; and 2) whether or not the survey design is representative of the region over which population estimates are generated. We are currently describing this work in a manuscript, which we expect to submit in 2018-19 (Sólymos et al. *in prep.*). [CORE project. Contact: Péter Sólymos]

❊ Regional models for two aerial insectivores using landcover, climate, and disturbance covariates

Tara Stehelin (BAM PhD student with Fiona Schmiegelow, University of Alberta) is mapping the abundance and distribution of olive-sided flycatcher and western wood-pewee in northwestern North America using habitat models. Results are meant to ultimately identify areas of conservation priority within previously identified potential refugia from climate change (Stralberg et al. 2018).

In 2017-18, current and future models were built using various climate, land cover, and disturbance layers for both species (see box for methodological details and preliminary results). In 2018-19, models will be finalized with additional covariates, uncertainty will be assessed, and the corresponding thesis chapter and manuscript will be finished. [CO-PRODUCED project. Contact: Tara Stehelin]

Density models for aerial insectivores:

Western wood-pewee and olive-sided flycatcher populations have declined nationally over the past 40 years. We built boosted regression trees based on climatic and other habitat factors to estimate and map species' densities across the northwestern boreal region (Figure).

Covariates with the greatest relative influence on western wood-pewee abundance included tree height, land cover, year, roads, and several climate variables, such as climate moisture index and seasonality (temperature difference).

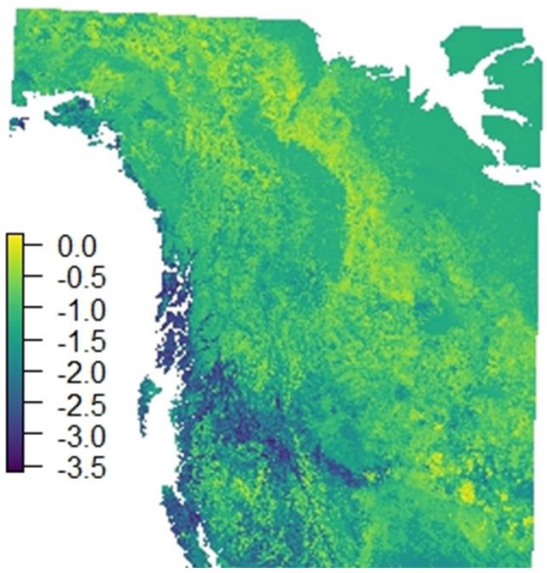


Figure. Predicted density (males / hectare) of western wood-pewee

Boreal Avian Modelling Project
Project de modélisation aviaire boréal

Work in progress. Contact: Tara Stehelin tstehelin@yukoncollege.yk.ca for more information

www.borealbirds.ca

❊ Regional density models to evaluate a stand ranking matrix used by forest companies

In 2017-18, we continued our evaluation of a tool being used by forest companies in BC to evaluate risk of incidental take of migratory birds. Specifically, we continued quality-checking data, completed initial analyses, presented preliminary results to partners, and summarized results in a report (see box for more details).

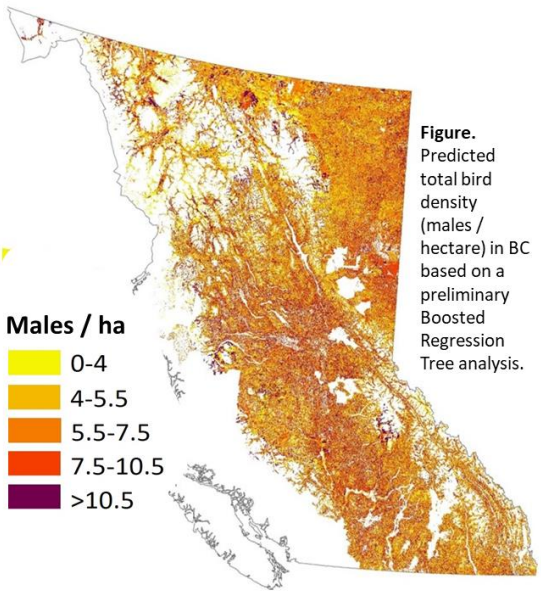


Figure. Predicted total bird density (males / hectare) in BC based on a preliminary Boosted Regression Tree analysis.

Evaluating a risk matrix and providing a data-driven alternative: Forest products companies are required to avoid harming birds or nests during their logging operations. Forest companies in British Columbia created a risk matrix tool to help evaluate the risk of incidental take (unintentional killing / harming / destruction / disturbance of birds / eggs / nest / young) from planned operations.

In the tool, individual forest stands are ranked from 1-6 representing expected nest density. Scores were based on ecological principles regarding bird abundance and forest attributes like age, height, and leading tree species.

BAM evaluated correspondence between forest stand ranks and bird density, using all BAM data available in BC. At the full study area extent, stand ranks did not correspond to total bird density. For some tree species groups in some ecological zones, ranks did correspond to total bird density.

As an alternative to the risk matrix, we produced a map of predicted total bird density based on a Boosted Regression Tree model of bird density in relation to forest attributes (Figure).

This map can be converted to a matrix that follows the same format as the existing tool. This data-driven matrix will yield information about total expected bird density in a given stand type, based on observed relationships with forest characteristics.

Boreal Avian Modelling Project
Project de modélisation aviaire boréal

Work in progress. Contact: Nicole Barker nbarker@ualberta.ca for more information

www.borealbirds.ca

We expect the work to continue in 2018-19, pending success of a Mitacs Accelerate grant with the Council of Forest Industries (COFI). We will write a manuscript describing this work during that time. Results and products from this analysis will be used in company-level operational forest management planning in the interior of BC. This work benefited from additional support from Canfor, West Fraser, and an Accelerate grant from Mitacs. [CO-PRODUCED project. Contact: Nicole Barker]

Habitat Requirements

Regional Variation in Habitat Selection

We began efforts to definitively address a long-standing question within BAM: Do species show differential habitat needs, use, or selection in different parts of their breeding ranges?

❊ Species relationships with stand-level forest composition and structure suggest differential habitat selection across their ranges

In 2017-18, with the addition of new BAM post-doctoral fellow Andy Crosby, we revived efforts to document and understand patterns of differential habitat selection for boreal birds. Specifically, we reviewed the literature, formulated hypotheses, assessed methods, created a database (see page 43), developed preliminary habitat models (see box for methodological details and preliminary results), and began drafting a manuscript.

In 2018-19, we will finish analyses a manuscripts describing this work. This project benefits from an NSERC Strategic Partnership Grant (page 18) [CORE project. Contact: Andy Crosby]

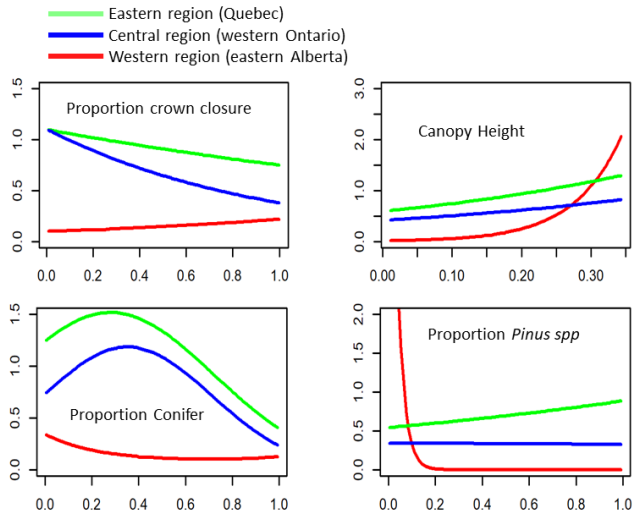


Figure. Canada warbler response to four forest attributes in 3 different regions of the Canadian boreal forest.

Estimating niche differentiation among regions: Expert opinion and small-scale studies suggest that several boreal-breeding birds may select habitat differently in different parts of their ranges.

Our goal is to quantify and describe these patterns of differential habitat selection for boreal birds and test hypotheses about the causes of the patterns.

We built hierarchical Poisson ANCOVA models to estimate differences in variable coefficients among regions. Forest composition and structure variables in the model were crown closure, canopy height, the quadratic of proportion conifer in the canopy, and proportion *Pinus spp.* in the canopy.

Our test species, Canada warbler, showed differences in intercepts and variable coefficients among regions in the eastern, central, and western boreal of Canada.

The results of this research will provide a deeper understanding of how species might respond to management activities in different regions.

Boreal Avian Modelling Project
Project de modélisation aviaire boréal

Work in progress. Contact Andy Crosby crosby@ualberta.ca for more information.

www.borealbirds.ca

Habitat for Species at Risk

We progressed significantly in our efforts to inform critical habitat identification for Canada warbler, olive-sided flycatcher, and common nighthawk (all Threatened, SARA Schedule 1) with the leadership of post-doctoral fellow Francisco Dénes.

❊ Letting the birds delineate spatial units for critical habitat identification and management

In 2017-18, we worked with ECCC to develop an approach to delineate spatial units over which critical habitat could be identified (see box for details on the method). In early 2018-19, we will complete analyses and propose delineated management units to ECCC. [CORE project. Contact: Francisco Dénes]

Are there ecologically-meaningful regions within which species at risk should be managed? We let the data decide: Delineation of management units is an important step in the identification of critical habitat for wide-ranging boreal species given possible spatial variation in habitat requirements and jurisdictional land management responsibilities.

We conducted exploratory analysis using geographically weighted Generalized Linear Models (R package GWmodel) of Canada warbler density in relation to land cover, road, and climate.

Models identified spatially varying relationships with environmental variables. Post-hoc cluster analyses could identify distinct spatial regions based on relatively homogenous abundances & responses to environmental covariates.

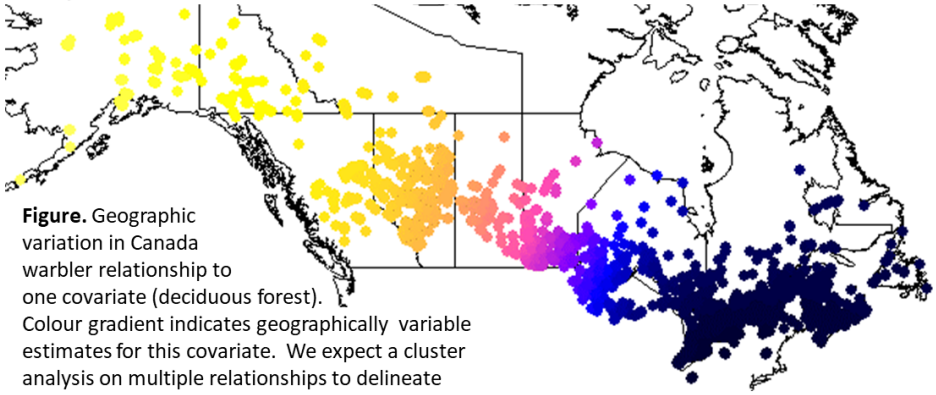


Figure. Geographic variation in Canada warbler relationship to one covariate (deciduous forest). Colour gradient indicates geographically variable estimates for this covariate. We expect a cluster analysis on multiple relationships to delineate discrete, ecologically meaningful spatial units.

Boreal Avian Modelling Project
Project de modélisation aviaire boréal

Work in progress. Contact Francisco V. Dénes voeroesd@ualberta.ca for more information

www.borealbirds.ca

❊ A conceptual model to guide identification of critical habitat

In 2017-18, as part of our efforts to provide science to inform critical habitat identification for Canada warbler, olive-sided flycatcher, and common nighthawk (page 27), we developed a systematic approach to guide identification of critical habitat for wide-ranging bird species (see box for more details and a simplified version of the conceptual model).

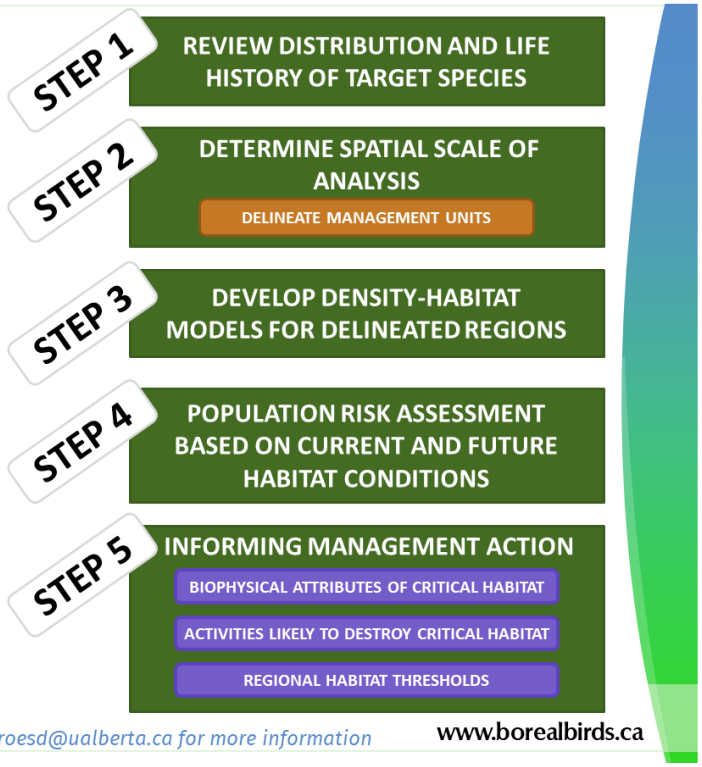
We have drafted a manuscript reviewing previous approaches and introducing our conceptual model (Dénes et al. *in prep.*). In 2018-19, we anticipate publication of the manuscript, plus presentation of the work at the North American Congress for Conservation Biology and at the International Ornithological Congress this summer. [CO-PRODUCED project. Contact: Francisco Dénes]

Guiding identification of critical habitat for wide-ranging bird species: When habitat is a limiting factor for species at risk of extinction, habitat protection is vital to their recovery and conservation.

In Canada, critical habitat is defined as "the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in a Recovery Strategy or in an Action Plan for the species" (Species at Risk Act, SC 2002, c 29).

The identification of critical habitat for bird species that have large breeding distributions in Canada is challenging for multiple reasons, including data availability, characteristics of the boreal forest, and characteristics of the species.

We reviewed recovery strategies for bird species breeding in the boreal or hemiboreal region of Canada. From our review, our experience with Canada warbler, olive-sided flycatcher, and common nighthawk, and discussion with ECCC, we proposed an approach for identifying critical habitat for wide-ranging, migratory, bird species (Figure).



Boreal Avian Modelling Project
Project de modélisation aviaire boréal

Work in progress. Contact Francisco V. Dénes voeroesd@ualberta.ca for more information

www.borealbirds.ca

❊ Manuscript describing our national Canada warbler model is nearing completion

In 2017-18, we received positive feedback from ECCC regarding our national density model for Canada warblers. We revised the manuscript, focussing on improved presentation of results. We anticipate submitting it to a journal in 2018-19. [CORE project. Contact: Samuel Haché]

Population Changes & Drivers

Contribution of Non-breeding Grounds

We continued exploring the possible contributions of non-breeding ground factors to species' breeding ground abundances.

❊ Signals of breeding and wintering weather and forest change in boreal bird population fluctuations

In 2017-18, we finalized analyses of wintering and breeding ground correlates of annual changes in breeding abundance for 46 species and a wrote draft manuscript (see box for methodological details and a preview of results). Our goal with this project is to understand and attribute the relative contributions of breeding versus wintering ground factors as possible causal mechanisms of population fluctuations of boreal breeding birds, and to examine migratory connections of bird populations.

We will submit a manuscript to a peer-reviewed journal by summer 2018 (Stralberg et al. *in prep.*) and presented results at the American Ornithological Society meeting in April 2018. [CORE project. Contact: Diana Stralberg]

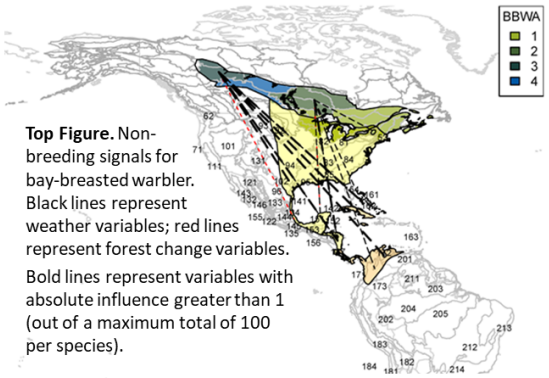
Evaluating important correlates of annual abundances: We looked for patterns across 46 long-distance migratory species to identify potential drivers of changes in annual abundance.

We used machine-learning techniques (i.e., boosted regression tree analysis), combined with annual density estimates (detectability-adjusted abundance estimates) and global weather and landcover data, to identify the primary correlates of annual changes in abundance.

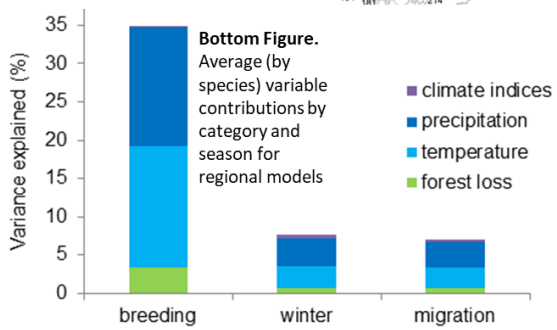
Across all species combined, the most predictive single variable was forest loss within the breeding ecoregion. Combined, however, breeding weather variables had the greatest overall (cumulative) influence on annual abundance, with precipitation and temperature having similar influence.

The influence of non-breeding variables was nearly an order of magnitude smaller, but signals were found for most species. Potential migratory connections emerging from this work were strongest in the western boreal region, where more bird data were available.

Our results to date generate numerous hypotheses about limiting factors and migratory connectivity that may be tested with more intensive research and modeling efforts.



Top Figure. Non-breeding signals for bay-breasted warbler. Black lines represent weather variables; red lines represent forest change variables. Bold lines represent variables with absolute influence greater than 1 (out of a maximum total of 100 per species).



Bottom Figure. Average (by species) variable contributions by category and season for regional models

Boreal Avian Modelling Project
Project de modélisation aviaire boréal

Work in progress. Contact: Diana Stralberg stralber@ualberta.ca for more information

www.borealbirds.ca

Climate Change

Climate Change Impacts

We contributed to two regional efforts to project bird abundance based on future landscapes under climate scenarios: one in Bird Conservation Region 4 and one in northern Alberta.

❋ Projected changes in future bird habitat diversity in Alberta

In 2017-18, we continued efforts to forecast the impacts of climate change on boreal bird communities while considering forest harvest and wildfire. Specifically, we refined LANDIS-II Landscape Change Model simulations and reviewed initialization of the parameters, especially vegetation cover maps (see box for more details).

In 2018-19, we anticipate completing simulations and analyses, and writing the manuscript, targeting a submission in March 2019. This project is a collaboration with the Laurentian Forestry Centre (Canadian Forest Service [CFS]) and S&T-Wildlife Research Division. [CO-PRODUCED project. Contact: Junior Tremblay or Diana Stralberg]

Future landscape simulation to understand impacts of forestry, natural disturbance, and climate change in Alberta: Objectives of this project are to offer relevant information on how boreal bird populations may be affected by climate change and forest harvest based on projected future forest composition and age structure. Furthermore, we will identify bird habitats, geographic areas, and bird species likely to be most vulnerable to climate change.

We projected future forest attributes within the Alberta-Pacific forest management area in northeastern Alberta using the LANDIS-II forest landscape model. Simulations included both stand- and landscape-scale processes that impact forest attributes under scenarios of different climate forcing and anthropogenic disturbance intensity.

We apply bird models to these simulated landscapes to derive bird population trends for various species, and to predict change in bird community.

Boreal Avian Modelling Project
Project de modélisation aviaire boréal

Work in progress. Contact Junior Tremblay junior.tremblay@canada.ca or Diana Stralberg stralber@ualberta.ca for more information

www.borealbirds.ca

❊ Avian responses to climate-mediated landscape changes in Bird Conservation Region 4

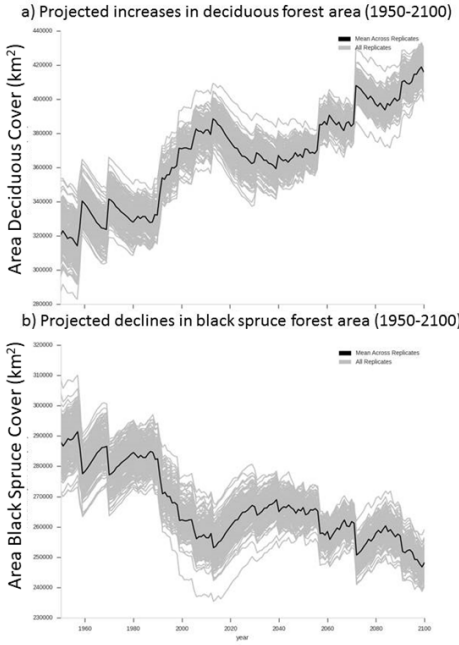
In 2017-18, we contributed to efforts to simulate bird response to landscape changes caused by increased fire severity and extent across the northwest boreal. We assembled BAM survey data from across the region and fit a preliminary species distribution model for the current time period for each of the 10 most common species. Meanwhile, the Scenarios Network for Alaska and Arctic Planning program completed the simulations of fire activity and landscape change for the region (see box for more details).

Climate change effects on birds via fire regimes and vegetation structure: Wildfires are expected to continue to increase in severity and extent across the northwest boreal causing regional shifts in forest cover, type, and age by the end of the century. We are simulating these landscape changes and their effects on bird population levels across the Northwest Interior Forest Bird Conservation Region (BCR 4) for several bird species, including declining species of concern.

Our goals are to (1) simulate changes in species distribution and breeding density in response to climate-mediated alterations to fire regimes to the end of the century, (2) project how public landowner responsibilities for bird populations in BCR 4 will change among agencies over time due to fire-mediated landscape changes, and (3) identify species and geographic areas that will be highly vulnerable to change as well as climate-change refugia that will remain stable for species over time.

Climate-mediated changes in fire ignition and spread and forest growth and succession across BCR4 are being simulated using a spatially explicit model, ALaska FRame-based EcoSystem COde.

We are fitting a generalized linear model (glm) to the BAM data for each of 25 species in BCR4 using topography, landcover, time-since disturbance, and climate variables as spatial predictors, and are then using this model to predict the spatial pattern of breeding density for both the current and simulated future landscapes.



Changes in forest area from 1950 to 2100 across the northwestern boreal simulated using boreal ALFRESCO. Grey lines are 200 replicate simulations, black lines show mean annual values across all replicates.

Boreal Avian Modelling Project
Project de modélisation aviaire boréal

Work in progress. Contact Steve Matsuoka smatsuoka@usgs.gov for more information.

www.borealbirds.ca

We expect to complete the analyses for this project in 2018-19. This project is a collaboration with the University of Alaska Fairbanks Scenarios Network for Alaska and Arctic Planning (SNAP), which is running the simulations of landscape change across the BCR. [CO-PRODUCED project. Contact: Steve Matsuoka]

❊ Timing mismatch between the breeding seasons and insect prey of two aerial insectivores

In 2017-18, Tara Stehelin (BAM PhD Student with Fiona Schmiegelow) continued her work examining relationships between insect abundance and bird breeding seasonality. The last insect samples were sorted and weighed, and initial models were developed (see box for methodological details and preliminary results).

In 2018-19, models will be finalized and the thesis chapter will be written in manuscript format. [INFORMED project. Contact: Tara Stehelin]

Mismatch in timing between insect abundance and the breeding season: In this project, Tara Stehelin (BAM PhD Student with Fiona Schmiegelow) is looking at the peak abundance of preferred insects in relation to the peak energetic demands of olive-sided flycatchers and western wood-pewees feeding insects to young.

We collected insect samples in the vicinity of olive-sided flycatcher and western wood-pewee territories for five seasons, identified them to Order, measured lengths, and weighed dry mass of samples. Each pair's territory was checked once every 3-5 days for changes in breeding status.

We generated Generalized Additive Mixed Models to quantify and describe bird breeding phenology and breeding success in relation to insect abundance and several environmental variables. Preliminary results indicate that insect abundance, temperature, and year explained most of the variation in breeding phenology and breeding success. Results were similar between the two species.

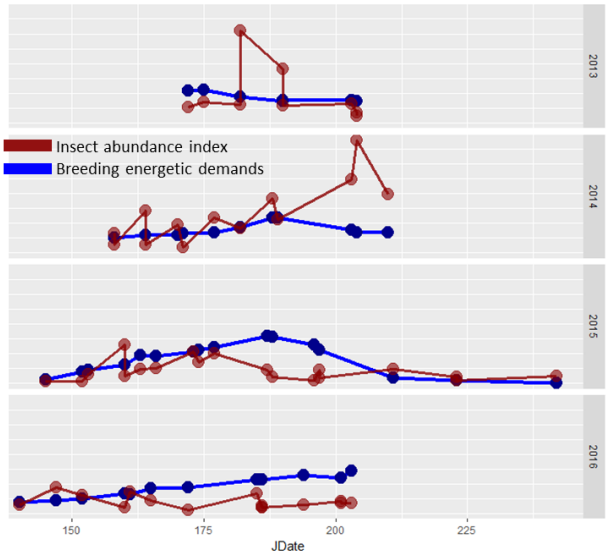


Figure. Insect abundance (index of biomass, in red) and breeding energetic demands of breeding olive-sided flycatchers (blue) across the breeding season.

Boreal Avian Modelling Project
Project de modélisation aviaire boréal

Work in progress. Contact: Tara Stehelin tstehelin@yukoncollege.yk.ca for more information

www.borealbirds.ca

Land-use Change

National Land-use Impacts

We continued to refine our national-scale work quantifying impacts of anthropogenic land-use change on boreal songbird density, and we initiated a new hindcasting effort to estimate the total effect of anthropic disturbances from 2000-2012 on boreal species abundances.

❊ Effects of anthropogenic disturbances on boreal birds at national extent

In 2017-18, we updated results and revised our manuscript regarding impacts of human disturbance on migratory songbird abundances populations at a national extent. We detected a generalized reduction in the density of many songbirds with associated with disturbances at both local (<100m) and neighborhood (100-400m) scales. We were also able to distinguish the effects of forest harvest from more alienating disturbances such as roads and energy infrastructure (see box for details on methods and results). We submitted the

manuscript to the "Conservation of Boreal Birds" special issue of Avian Conservation & Ecology (page 29; Suárez-Esteban et al. *in review*)). [CORE project. Contact: Alberto Suárez-Esteban]

Also in 2017-19, we initiated a new hindcasting effort to estimate the total effect of anthropic disturbances on species abundances within the boreal region of Canada from 2000 to 2012. To support this work, the Suarez-Esteban statistical model from above was re-implemented in SpaDES, a new environment for ecological modelling and spatial simulation (see description on page 25). [CORE project. Contact: Tati Micheletti]

Regional Land-use Impacts – Oil Sands Monitoring

We collaborated with ECCC, the Alberta Biodiversity Monitoring Institute (ABMI), and the Bioacoustic Unit at the University of Alberta to continue our contributions to Oil Sands Monitoring (OSM) by refining our analysis of land-use impacts in Alberta.

❊ Predicting population-level effects from local scale models of energy sector impacts

Managers are increasingly concerned about cumulative effects of multiple sectors on boreal birds. We have been testing various approaches to modelling cumulative effects in an effort to see how well local-scale monitoring can be used to predict consequences of cumulative effects at landscape scales (see box for more details on methods and results). A paper highlighting how well local-scale models predict the effects of forestry and energy sector activities was submitted to the "Conservation of Boreal Birds" special issue of Avian Conservation & Ecology (page 29; Leston et al. *in review*). This project benefited from additional funding from Oil Sands Monitoring. [CO-PRODUCED project. Contact: Lionel Leston]

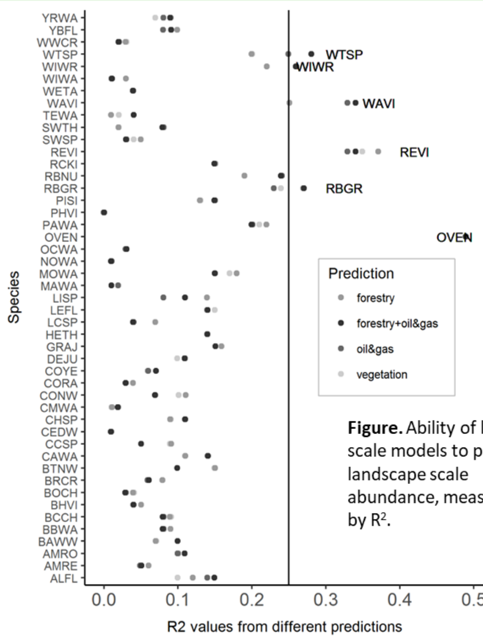


Figure. Ability of local scale models to predict landscape scale abundance, measured by R^2.

Can we confidently predict abundance or presence of each species in individual, specific landscapes? We sought to understand how well local-scale bird abundance models with individual point counts as replicates predicted bird abundance within landscapes much larger than point counts.

We used densities of 47 boreal songbird species in different Alberta Biodiversity Monitoring Institute (ABMI) vegetation classes generated from GLMs models with QPAD (Solymos et al. 2013 - MEE) offsets, and ratios of relative abundance of these species > or < 100 m from seismic lines, pipelines, and gas well-pads from Bayne et al. (2016 - Condor). We predicted boreal bird abundance within ABMI "landscapes" made of 3x3 arrays of point counts and compared predictions to observed total counts per landscape.

Local scale models were only adequate at predicting landscape abundance of 6 of 47 species, and only when potential outliers (top 1% of predicted abundances) were excluded from analysis, but were adequate for predicting presence of 27 of 47 species. Models with or without additive effects of energy sector development had similar predictive accuracy and on average overestimated or underestimated species at landscape scales by similar amounts (0-5 birds per 63-ha landscape).

We conclude that local scale models may not be as effective at predicting abundance as predicting presence within specific landscapes.

Boreal Avian Modelling Project

Project de modélisation aviaire boréal

Work in progress. Contact Lionel Leston leston@ualberta.ca for more information

www.borealbirds.ca

❊ Different methods of measuring cumulative forestry and energy sector effects appear similarly adequate

Three approaches are common used to model environmental impacts: Dose-response; zone of impact; and before-after control-impact designs. BAM and collaborators have tested how these various approaches influence quantification of cumulative effects in the Oil Sands Region.

Cumulative forestry and energy sector effects: We used a common dataset of point counts from 2002-2017 in the Alberta boreal forest region to quantify impacts of roadside, well-pad, seismic line, and pipeline effects on abundance of ~33 boreal bird species.

Footprint was measured using 3 different cumulative effects assessment (CEA) methods: categorical treatments (control-impact methods), the amount of footprint within 150 m of points (dose-response methods), and nearest distance to each footprint type from each point (zone-of-impact methods).

Results are variable among species (e.g., Figure), but suggest that:

1) different CEA methods produced similar direction of predicted effects of a given footprint, although zone-of-impact methods were most likely to detect negative effects;
2) larger effects were observed for roads and pipelines than wells and seismic lines;
3) different CEA models were adequate for predicting abundance or at least presence/ absence for many species at the station level;
4) different CEA methods produced similar landscape-level predictions of bird abundance; and
5) landscape-scale abundance was accurately predicted for about half the species.

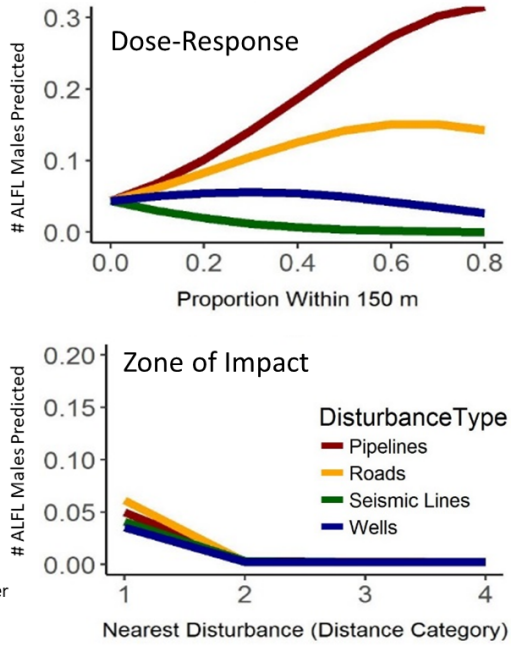


Figure. Number of male alder flycatchers predicted from cumulative effects models.

Boreal Avian Modelling Project
Project de modélisation aviaire boréal

Work in progress. Contact Lionel Leston leston@ualberta.ca for more information

www.borealbirds.ca

In 2017-18, we continued efforts to compare and synthesize results from the various methods. We generated models of oil and gas footprint effects on boreal birds using three methods to compare the predicted direction and magnitude of energy sector impacts on boreal birds (see box for more information on methods and conclusions).

A manuscript describing this work will be submitted in 2018-19 to either Avian Conservation & Ecology or Condor. This project benefited from additional funding from Oil Sands Monitoring. [CO-PRODUCED project. Contact: Lionel Leston]

Impacts of Forest Management

We welcomed 6 new BAM team members as part of an NSERC Strategic Partnership Grant focussed on supporting conservation of boreal birds through forest management practices. We also explored potential bird response to forest management plans built around caribou conservation, and contributed to analyses of over 20 years of experimental harvest data from the Calling Lake Fragmentation Study.

❊ NSERC Strategic Partnership Grant for Projects

In 2016-17, BAM received a Strategic Partnership Grant for Projects from NSERC (lead: Steve Cumming) focussed on facilitating bird conservation via sustainable forest management (SFM). By SFM, we mean maintaining economically viable harvest rates while preventing, minimizing, or mitigating human-induced population

declines of avian species and supporting natural forest biodiversity in the long-term. This highly collaborative grant has co-leads from three institutions and partner representatives from CWS and S&T.

At present, projects are expected to cover the following objectives:

- Test potential hypotheses explaining spatial variation in habitat selection and associations across Canada (Andy Crosby, University of Alberta, page 11);
- Build national models that relate bird abundance to adequate descriptors of bird habitat, such as number, size, density, and structure of forest patches within a landscape and project bird response to forest management scenarios (Andy Crosby + graduate student projects);
- Build models quantifying bird response to within-block treatments (Brendan Casey, University of Alberta);
- Evaluate use of LiDAR to describe understory structure (Brendan Casey; page 26);
- Quantify the historical range of variation in natural disturbance regimes and forecast long-term differences within managed landscapes (Ana Raymundo, Université Laval);
- Integrate avian population constraints and/or critical habitat objectives into strategic-level forest management plans in Québec (Isolde Lane Shaw, Université Laval);
- Develop management-sensitive models for waterfowl. These models will be embedded in a spatial simulation framework to enable forecasting and to evaluate proposed Best Management Practices (Antoine Adde, Université Laval);
- To aid the above projects, a post-doctoral fellow will assist in implementing spatial harvest simulators in SpaDES (Spatial Discrete Event Simulator, see page 25 for more details), and provide support for embedding avian abundance models for scenario analysis (Tati Micheletti, UBC/Pacific Forestry Centre).

❊ Predicting boreal bird population response to different forest harvest scenarios, including caribou conservation

In 2017-18, we continued our efforts to estimate impacts on boreal bird populations resulting from various management options in the Al-Pac forest management unit. We have begun applying avian habitat models to the landscapes forecasted under timber supply scenarios to anticipate bird response to the scenarios (see box for more details on methods and initial results).

In 2018-19, we will complete analyses and summarize them in presentations and manuscripts for a scientific journal. This work benefited from additional support from Al-Pac and an Accelerate grant from Mitacs. [INFORMED project. Contact: Lionel Leston]

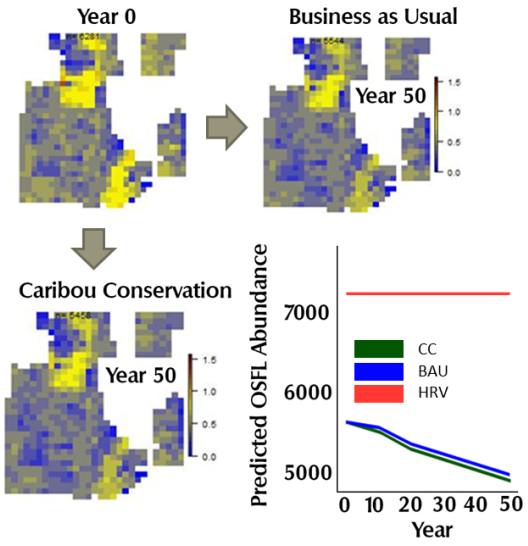


Figure. Change over time under the three scenarios (map for historical range of variation not shown)

Spatial harvest scheduling software and timber supply scenarios can be used to balance harvest needs of forestry companies with social and environmental values (e.g. protection of woodland caribou habitat).

Patchworks uses simulated annealing to minimize the total losses in economic, ecological, and social values associated with timber and pulpwood extraction, resulting in spatial harvest scenarios that balance a set of criteria.

We forecasted impacts on birds from three 50-year timber supply scenarios from Alberta-Pacific Forest Industries:

1. Caribou conservation (CC): ~ 20 year deferral of logging within woodland caribou habitat, with harvest pressure transferred to other forest stand types.
2. Business-as-usual (BAU): spatial harvest scenario without additional caribou habitat protection.
3. Historical range of variation (HRV): all human footprint is absent and forest age-structure is determined entirely by simulated forest fire disturbances.

Habitat models can be used to predict species abundance in Years 0, 10, 20, and 50 based on available forest age-structure output under each scenario.

We are just beginning to analyze results for 7 bird species.

Boreal Avian Modelling Project
Project de modélisation aviaire boréal

Work in progress. Contact Lionel Leston leston@ualberta.ca for more information

www.borealbirds.ca

❊ Avian response to forest structure and management using over 20 years of experimental harvest data

Long-term effects of changes in extent, structure, and configuration of Alberta's boreal forest resulting from forestry and development are unknown because most studies are short-term and observational. In collaboration with Alberta-Pacific Forest Industries (Al-Pac), BAM post-doctoral fellow Lionel Leston is using 24 years of experimental forestry data from the Calling Lake Fragmentation Project (~400 km^2; Schmiegelow et al. 1997) to quantify effects of forestry and forest regeneration on boreal birds.

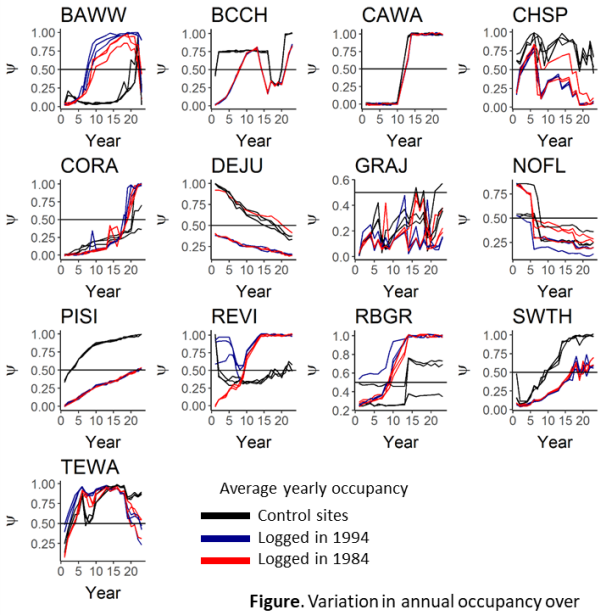


Figure. Variation in annual occupancy over time. Swainson's thrush (SWTH shows an example of possible spillover from unharvested stands).

Temporal pattern in species occupancy in experimentally harvested forests: We used more than 20 years of data from the Calling Lake Forest Fragmentation Study to assesses how long-term abundance of boreal birds is affected by temporary events such as logging, insect availability, and variation in the surrounding landscape.

We explored potential impacts of weather events on abundance of several boreal bird species within control sites and forest fragments.

Vector autoregression and panel regression methods enable us to assess both immediate and lagged effects of a predictor variable, either for 1 time-varying covariate (vector autogression models) or multiple time-varying and/or time-invariate covariates for each site or station (panel regression). Spatial panel regression models account for additional spatial autocorrelation among sampling units, enabling us to use point count stations as replicates rather than limit ourselves to the larger sites as replicates.

We found that increased occupancy of some species in regenerating cutblocks (blue & red lines) was preceded by increased occupancy in nearby unharvested forests (black lines), but that the opposite relationship was not observed, suggesting possible spillover of individuals from unharvested forests.

Our results so far suggest that estimated effects of forest fragmentation and recovery on boreal bird numbers will be confounded with time-varying factors in surrounding habitats.

Boreal Avian Modelling Project
Project de modélisation aviaire boréal

Work in progress. Contact Lionel Leston leston@ualberta.ca for more information

www.borealbirds.ca

This project, initiated in 2016, was intended to assess the state of recovery of boreal bird communities within harvested areas at Calling Lake that were logged in either 1984 or 1994. A manuscript was published in 2017-18 addressing occupancy related to year since harvest (Leston et al. 2018). Work on temporal variation related to surrounding episodic events was also initiated (see box for more details); this work will continue in 2018-19.

This long-term study has been supported by many organizations and over 100 field assistants during its 25-year history. The analyses presented above benefited from additional support from Al-Pac and an Accelerate grant from Mitacs. [INFORMED project. Contact: Lionel Leston]

Conservation Planning

Informing Conservation Prioritization

We explored methods to identify priority areas for boreal birds in Canada, identified priority areas for conservation of Canada warbler in BCR14, and created density models for four species at risk to support the planning process by the Moose Cree First Nation. Our work was also included in a release of products to support conservation in the northwestern boreal region.

❊ Strategies for identifying priority areas for passerine conservation in Canada's boreal forest

We continued our exploration of conservation prioritization scenarios to understand how assumptions and *a priori* decisions will affect the areas identified as priorities. In 2017-18, we converted a report into a manuscript that was submitted to the "Conservation of Boreal Birds" special issue of Avian Conservation & Ecology (page 29; Stralberg et al. *under revision*). This involved reformulating research questions and adding post-hoc analysis and comparisons of scenario performance (see box for overview of methods and results).

A framework to assist managers in selecting among conservation scenarios: Canadian Wildlife Service's "Zones of Interest" project aims to identify priority areas for boreal landbird species, which represent a conservation planning gap in Canada.

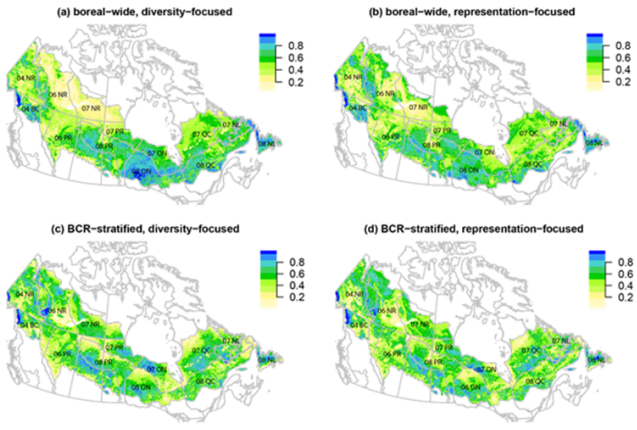


Figure. Mean rankings based on groups of scenarios: boreal-wide, diversity-focused (a) and representation-focused (b), and BCR subregion-stratified diversity-focused (c) and representation-focused (d). Highest Zonation ranks are in dark blue; lowest ranks are in yellow. Highest variation in Zonation ranks is in red; lowest variation is in blue.

BAM contributed to this project, identifing priority conservation areas for boreal landbirds, and developing a framework to assist managers in selecting among conservation scenarios based on conservation objectives.

We applied the Zonation conservation planning tool to species distribution model and other inputs to evaluate 128 alternative conservation scenarios.

We found large differences between solutions depending on constraints and conservation objectives, and relatively low conservation efficiency when considering the top-ranked 50%. However, we did find increasing consistency among solutions as multiple constraints were considered, and higher efficiency when considering just the most highly-ranked areas. In particular, stratifying solutions geographically resulted in more consistent priorities, although at the expense of efficiency. Other constraints, including climate change, disturbance- and uncertainty-discounting, and the selection and weighting of species, helped to further focus priorities.

This work provides a roadmap for decision-making with respect to conservation of habitat for boreal birds in Canada.

Boreal Avian Modelling Project
Project de modélisation aviaire boréal

Work in progress. Contact: Diana Stralberg stralber@ualberta.ca for more information

www.borealbirds.ca

We presented this work as an example for other similar efforts in other regions, and expect similar projects to emerge elsewhere (e.g., Canadian prairies).

In 2018-19, we anticipate this work being published, setting the stage for additional analyses involving multi-taxa considerations (e.g., caribou). [CO-PRODUCED project. Contact: Diana Stralberg].

❊ Identifying priority areas

BAM team members contributed to several efforts to identify priority areas for conservation:

- Identifying priority areas for different types of conservation action for Canada warbler in BCR 14 (Westwood et al. *in review*; see also page 28).
- Modelling species at risk to support the Moose Cree First Nation's Homelands Protection planning process (see page 32).
- Identifying ecological benchmarks in the Northwest Boreal Landscape Conservation Cooperative (page 32).

Methods & Tools

Acoustic Tools and Data

We informed the continued exploration into using acoustic signals to model common nighthawk habitat.

❊ Acoustic behaviour of common nighthawks can yield habitat models

Elly Knight (PhD student with the University of Alberta-Bioacoustic Unit and Program Manager for the WildResearch Nightjar Survey), is investigating the use of bioacoustics for understanding habitat associations of acoustic species. She is developing new tools including increased automation of species identification, individual identification, behavioural prediction, and distance estimation (see box for more information).

During 2017-18, Elly developed methods to automate the process of scanning audio files for common nighthawk detections (Knight et al. 2017) and built preliminary habitat models (see box for more details on methods and results; (Knight and Bayne 2017).

In 2018-19, she will build models that predict habitat function from acoustic recordings so that she can test hypotheses about common nighthawk habitat use at large spatial scales. She will also return to the McClelland Lake area this July 2018 to further test miniature GPS-microphones on common nighthawks.

Elly's work will contribute to the development of novel bioacoustic tools for studying avian species and towards understanding the habitat requirements of the common nighthawk, as part of efforts to inform critical habitat identification (page 27). The techniques developed in her thesis will inform BAM's ability to incorporate new types of data [INFORMED project. Contact: Elly Knight].

Common nighthawk acoustic behaviour can be used to predict habitat function: Conservation management is impeded by the lack of baseline data for many non-passerine, cryptic, or nocturnal species that are inadequately sampled by traditional monitoring programs.

We extracted detections of the common nighthawk (*Chordeiles minor*) from a large bioacoustic database using automated signal recognition software. Using boosted regression tree models, we built regional home range use and territory selection models. Home range selection was primarily explained by landscape scale geographic and climate variables and some avoidance of wetland areas. Territory selection was also strongly influenced by landscape scale climate variables, proportion of seismic lines, and areas with minimal poor fen.

Results produced from this study provide wildlife managers with more knowledge on the common nighthawk, and emphasize the importance of landscape scale conservation for highly-mobile species with large home ranges.

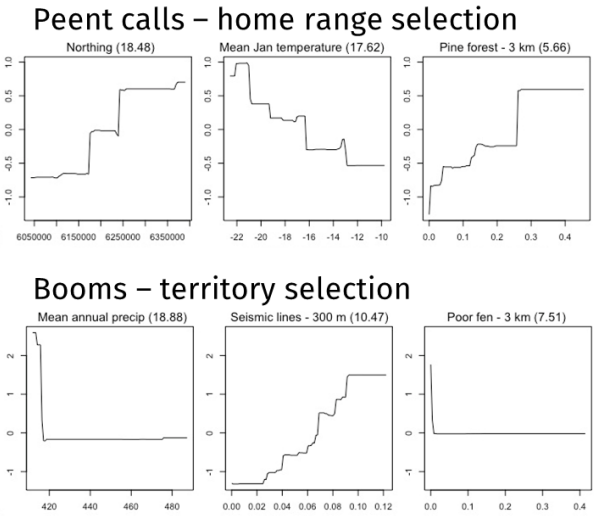


Figure. Marginal effect of top three variables for models built based on peent calls (top) and wing booms (bottom), corresponding to home range and territory selection, respectively.

Boreal Avian Modelling Project
Project de modélisation aviaire boréal

bioacoustic unit

Knight & Bayne. 2017. https://tinyurl.com/ABMI-coniBRT

www.borealbirds.ca

Species Detectability

We published a manuscript about influences of phylogenetic relationships and species traits on species detectability. We also submitted a manuscript with sample size dependent recommendations for time-removal models.

❊ Phylogeny and species traits predict bird detectability

In 2017-18, we published a paper in Ecography describing the relationship between phylogeny, species traits, and field - based estimates of the two processes that determine species detectability (singing rate = availability; detection distance = perceptability) for 141 bird species breeding in boreal North America (see box on next page for results; Sólymos et al. 2018b). [CORE project. Contact: Péter Sólymos]

❊ Recommendations for time-removal models

In 2017-18, we finished some work initially started in 2012-13 that examined how various factors can influence bias when applying time-removal models to correct for species' detectability (see box on next page for more details on methods and results). We finalized analyses and the associated manuscript, submitting to Condor in February 2018 (Sólymos et al. *under revision*). [CORE project. Contact: Péter Sólymos]

Disentangling how complex ecological and evolutionary mechanisms have shaped detectability in boreal birds: Avian acoustic communication has resulted from evolutionary pressures and ecological constraints. We therefore expect that auditory detectability in birds might be predictable by species traits and phylogenetic relatedness.

We evaluated the relationship between phylogeny, species traits, and field-based estimates of the two processes that determine species detectability (singing rate and detection distance) for 141 bird species breeding in boreal North America.

We used phylogenetic mixed models and cross-validation to compare the relative merits of using trait data only, phylogeny only, or the combination of both to predict detectability.

We found a strong phylogenetic signal in both singing rates and detection distances; however the strength of phylogenetic effects was less than expected under Brownian motion evolution. The evolution of behavioural traits that determine **singing rates** was more labile, leaving more room for species to evolve independently, whereas **detection distance** was mostly determined by anatomy (i.e. body size) and thus the laws of physics.

Such information can greatly inform single- and multi-species models but more work is required to better understand how to best correct possible biases in phylogenetic diversity and other community metrics.

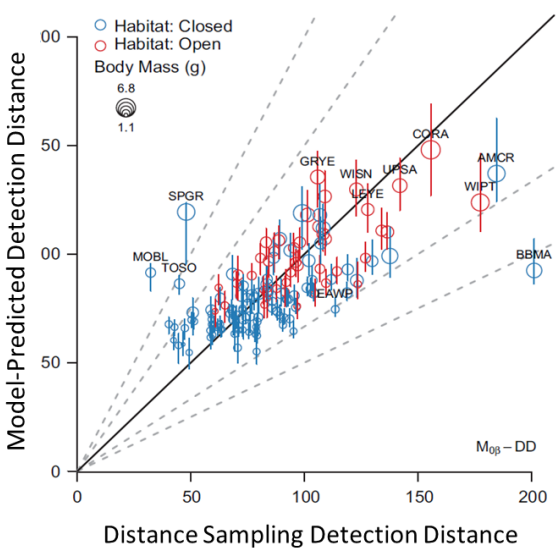


Figure. Leave-one-out cross validation estimates (y-axis) vs. empirically based estimates (x-axis) of detection distance. Each circle represents a species.

Boreal Avian Modelling Project
Project de modélisation aviaire boréal

Sólymos et al. 2018. doi: 10.1111/ecog.03415

www.borealbirds.ca

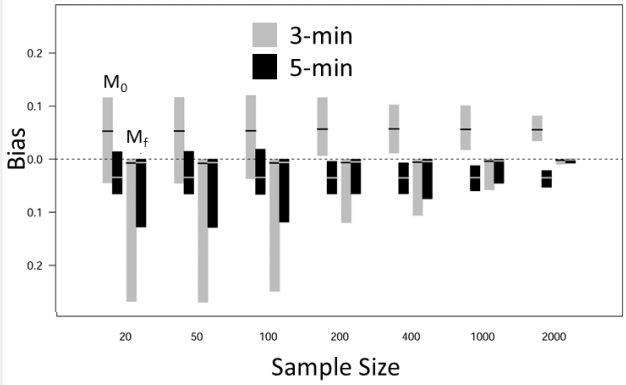


Figure. Sample size effects on bias in removal model predictions of the numbers of individuals of a species counted in a 10-min point count when using the counts of individuals from 3-min (grey) and 5-min (black) point counts. Data from 133 species with varying number of detections (horizontal axis) were used. Model types (M_0 = conventional & M_f = mixture model) shown side-by-side, boxes show 90% quantile range, lines represent the median.

Improving time-removal models to estimate species detectability: Nearly all avian field surveys underestimate abundances unless the estimates are adjusted for the proportion of birds present but undetected at the times and locations surveyed. Such adjustments require an estimate of the probability of detecting birds present during surveys (detectability).

The time-removal model applied to point-count surveys estimates the probability that a bird is available for detection as a function of the average number of detectable cues that an individual bird gives per minute (singing rate), and the known count duration. We evaluated the removal model to determine whether availability bias varies with duration, and whether fitting more complex parameterizations of the removal model can minimize such bias.

We compared conventional and finite mixture removal models with and without time-varying covariates for 152 bird species using data from northern North America. We found that model choice affected estimability of unknown model parameters and the bias and variance in the corrected counts.

Mixture models provided better fit and adjustment for count duration; however, reliable parameter estimation and minimized variance for mixture models required at least 200–1000 detections. Mixture models with time-varying proportion of infrequent singers were best supported across species, indicating that accounting for date and time related heterogeneity is important over large spatial scales when combining data across studies with different geographic locations, sampling time frames, or survey protocols.

We recommend mixture models where sample sizes permit, and conventional removal models for smaller sample sizes.

Boreal Avian Modelling Project
Project de modélisation aviaire boréal

Work in progress. Contact: Péter Sólymos solymos@ualberta.ca for more information

www.borealbirds.ca

Landscape Simulation

We initiated a concerted effort to integrate BAM avian abundance modelling into a spatial simulation framework to facilitate ecological forecasting of avian responses to climate and land-use change. This framework can help can assess potential effectiveness of conservation strategies, and will support our work to support conservation of boreal birds via sustainable forest management (page 18).

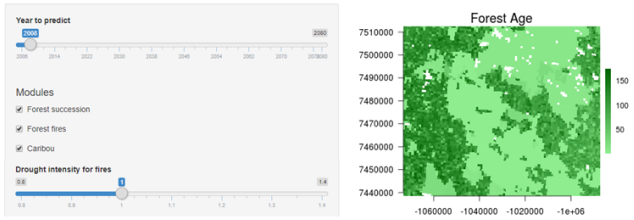
❊ Birds in SpaDES

SpaDES (Spatial Discrete Event Simulator) is a new suite of R packages for integrating ecological modeling and spatial simulation, developed over the past four years by Eliot McIntire (Pacific Forestry Centre) with significant support from both Natural Resources Canada (NRCan) and the Healthy Landscapes Program of fRI Research (see box for more details on the history and nature of SpaDES). SpaDES will be the primary engine for implementing the work of the BAM-related NSERC Strategic Partnership Grant (page 18), and more generally for linking BAM models of avian abundance to simulations of management actions (e.g. page 16). Post-doctoral fellow Tati Micheletti has begin integrating several of BAM's avian abundance models (e.g., page 16) with forest management and wildfire models developed by Cumming, and vegetation dynamics models implemented by McIntire and colleagues. A companion project funded by ECCC is implementing spatial versions of the caribou population models described in the Recovery Strategy for Woodland Caribou, boreal population (Environment Canada 2012). [CO-PRODUCED project. Contact: Tati Micheletti]

What is Spatial Discrete Event Simulation (SpaDES) and how can we use it to advance avian conservation? SpaDES is a new environment for integrating statistical data analysis, geospatial data manipulation, and spatial simulation modelling. SpaDES is implemented as a suite of R packages, and accordingly inherits all the continuing development in statistical sciences and GIS technology that R incorporates, as well as very powerful parallel computing support that enables applications at scale. An example SpaDES application, with user interface, can be seen on https://spades.shinyapps.io/ForestChange_ProofOfConcept/.

Linking landscape dynamics to avian habitat models is nothing new; BAM members pioneered these techniques in Canada 20 years ago, and many others groups have done so since. Unfortunately, most previously existing models of this kind suffer from the same limitations: they depend on proprietary or custom software; they were designed to support research on a single component of ecosystem dynamics (e.g. disturbance regimes, vegetation dynamics); adding new processes, such as projecting avian Species Distribution Models (SDMs), requires specialized programming skills; and there is no connection to the raw data and statistical modelling used to generate the SDMs, so updating is difficult and rarely accomplished in practice. The SpaDES design has proved to solve all these problems. Because of intrinsic modularity, new ecological modules can be written by anyone who knows a little R. As part of module initialization, simulation parameters can be estimated directly from data, using the full power of R's statistical packages, so updating is automatic. There are also powerful graphical facilities and support for the execution of simulation experiments.

Our companion NSERC Strategic Grant for Partnerships Project will be developing some integrated models of avian species distribution, vegetation dynamics, wildfire and forest harvesting over the 2019 project year. These initial efforts will demonstrate how BAM research can be linked to advanced spatial simulation and conservation planning tools, including the caribou population models being developed for SpaDES by ECCC and NRCan.



Boreal Avian Modelling Project
Project de modélisation aviaire boréal

Contact Eliot McIntire eliot.mcintire@canada.ca for more information

www.borealbirds.ca

Developing and refining other methods

We also contributed to methodological work related to using or classifying biophysical data and reporting cumulative effects.

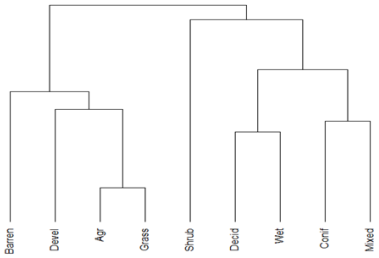
- We simplified land cover types into broader classes, based on data-driven patterns in bird response (see box for a description of the work) [CORE project. Contact: Péter Sólymos];

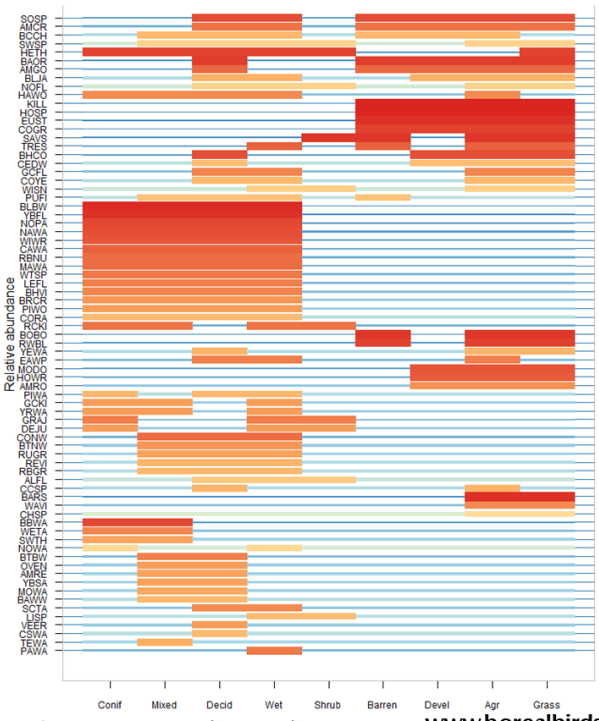
How do birds classify land cover classes? At times, it is necessary to aggregate land cover classes for species and regions where numbers of samples or detections would not allow meaningful habitat association assessment at finer thematic resolution.

We used the BAM database and North American Land Cover layer to identify land cover associations of bird species and derive a thematic land cover aggregation sequence.

We applied optimal partitioning as described in Kemencei et al. 2014 - Community Ecol, implemented in the opticut R package (Solymos & Azeria 2018 - CRAN).

We identified coarse habitat associations for 75 bird species. From this, we derived a hierarchical dendrogram of the land cover classes that would define the order of merging classes with inadequate sample sizes.





Boreal Avian Modelling Project
Project de modélisation aviaire boréal

Work in progress. Contact: Péter Sólymos solymos@ualberta.ca for more information

www.borealbirds.ca

- We initiated efforts to use LiDAR derived vegetation metrics to build occupancy models for canopy, understory, and shrub layer songbirds around Calling Lake, with a focus on LiDAR's capacity to quantify understory and shrub layer structure [CO-PRODUCED project. Contact: Brendan Casey];
- We collaborated with ABMI to develop a tool and web application that supports various government and industry needs related to quantifying industry sector effects on biodiversity ((Sólymos et al. 2018a; see box for an overview). This project benefitted from additional funding from Oil Sands Monitoring. [CO-PRODUCED project. Contact: Péter Sólymos]

Decision support tool for evaluating industrial sector effects:

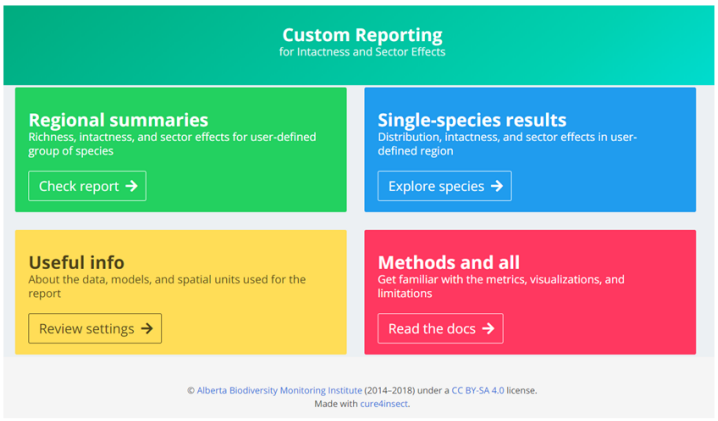
Quantification of the expected effect of an industrial sector on habitat supply for a species within a region is relatively complex because it must take into account the spatial aspects of the species' distribution, and location of sector specific footprints and native land cover.

Government and industry partner interest resulted in development of a computational tool and web application. It consists of a standardized file database, a software package (R extension package 'cure4insect' = **cu**stom **re**porting **for** **in**tactness and **sect**or effects), and a web interface.

https://abbiodiversity.github.io/cure4insect/

The R package is a decision support tool that provides an interface to enable custom reporting for intactness and sector effects based on estimates and predictions created by the Alberta Biodiversity Monitoring Institute (ABMI) in collaboration with the Boreal Avian Modelling (BAM) Project.

The tool is now in beta testing in Alberta for indicator development under the Biodiversity Management Framework, and in predicting future habitat supply under alternative forest management scenarios.



Web app: http://sc-dev.abmi.ca/ocpu/apps/ABbiodiversity/cure4insect/www/

Package: https://github.com/ABbiodiversity/cure4insect

Boreal Avian Modelling Project
Project de modélisation aviaire boréal

ABMI
IT'S OUR NATURE TO KNOW

Contact Péter Sólymos solymos@ualberta.ca for more information

www.borealbirds.ca

Outcomes & Collaborations

BAM facilitates the application of our work by collaborating with external groups. BAM's research and data products are improved by drawing on the expertise of others working on boreal birds, whether in academia, government, industry, NGOs, Indigenous Peoples, or other groups. Our results can inform not just management actions but also research questions, which may seek to test assumptions or uncertainties in BAM models.

We strive to support applications of our work to conservation and management of boreal birds, and we welcome collaborations with projects that align with our mandate for conservation of boreal birds.

Here we describe our efforts from April 2017 - March 2018 that target specific conservation and management needs.

Species at Risk

We contributed to species at risk conservation by advancing science to inform identification of critical habitat, by identifying priority areas for Canada warbler conservation in BCR14, and by building regional models for species at risk in the Moose Cree First Nation Homelands (described elsewhere, page 32).

❊ Informing critical habitat identification to aid species at risk

Defining critical habitat is required to inform recovery actions for species at risk. ECCC's recently developed Recovery Strategies for Canada warbler (Environment Canada 2016a), olive-sided flycatcher (Environment Canada 2016b), and common nighthawk (Environment Canada 2016c) did not identify critical habitat. Instead, they identified a Schedule of Studies required to inform critical habitat identification. BAM has been involved in this process since 2013-2014, contributing models, expertise, and data to ECCC, including a dedicated post-doctoral fellow, Francisco Dénes, to lead BAM's scientific efforts.

In 2017-18, BAM was represented at several ECCC meetings by Francisco Dénes, Samuel Haché, and Junior Tremblay, including a 2-day in-person meeting in Ottawa on February 14-15, 2018. Major research tasks for this past year included development of a framework to guide identification of critical habitat for these three species (page 12), and resolution of how to delineate management units (page 12).

In 2018-19, we will build regional-scale density models within each management unit, and continue progressing through the steps of the conceptual model (page 12).

This project relies on an ongoing collaboration with ECCC. [Contact: Francisco Dénes]

✳ Regional spatial models to support both land conservation and forest management planning for the threatened Canada warbler

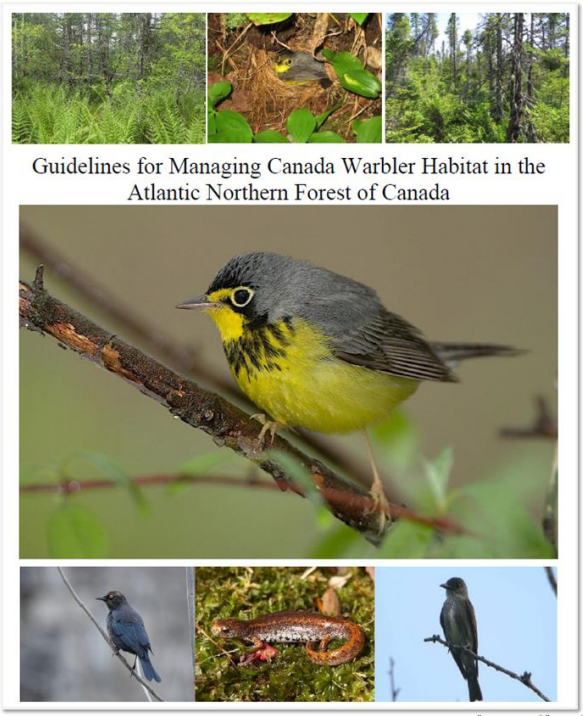
Two important steps for Canada warbler conservation and management are: identifying what habitat is important for the species; and how to appropriately manage it. In 2017-18, we contributed to habitat guidelines for the management of Canada warblers in the Canadian portion of BCR 14 (the Atlantic Northern Forest) and accompanying spatial products suggesting appropriate areas for their application (see box for more information).

Habitat management guidelines for Canada warbler:

In this highly collaborative project, we developed habitat management guidelines for the Canada warbler in the Atlantic Northern Forest of Canada.

These guidelines are designed to help managers engage in forestry activities so as to minimize their impact on Canada warbler habitat, and ensure a future supply of habitat is available. The full report and the 2-page field guide summary are available in both English and French: https://tinyurl.com/borealbirds-SAR. Guidelines for Northeast and Mid-Atlantic Regions US also available: https://tinyurl.com/cawahabmanUS

This work is a partnership between Environment and Climate Change Canada and High Branch Conservation Services, with support from Nature Canada, the Boreal Avian Modelling Project, and the Canada Warbler International Conservation Initiative.



Boreal Avian Modelling Project
Project de modélisation aviaire boréal

Work in progress. Contact Alana Westwood a.westwood@dal.ca for more information

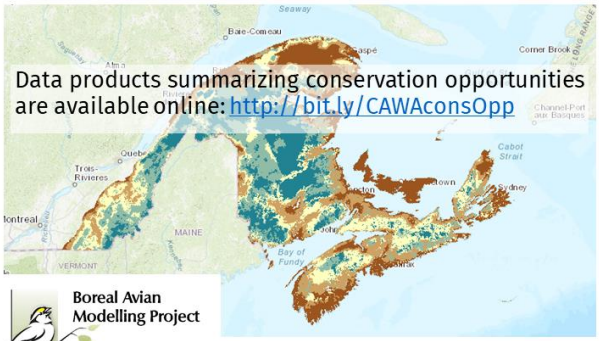
www.borealbirds.ca

Identifying regions to target conservation and management goals:

We created spatial products (maps and associated rasters) to suggest appropriate areas for application of habitat management guidelines. We used Zonation to prioritize areas based on different conservation and management goals (Figure).

Models based on current climate were more efficient (population of Canada warblers protected per unit area) than those based on future climate.

Merged mapping between different management objectives shows opportunities of greatest benefit/lowest loss, where forestry activity is likely to have the lowest relative risks on populations.



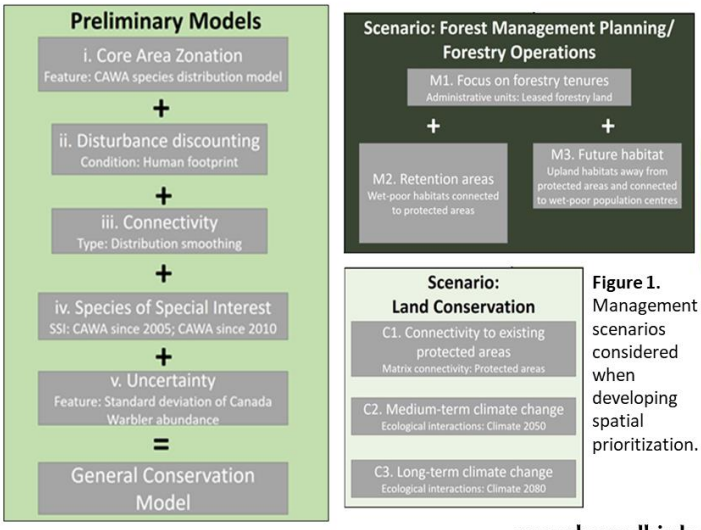


Figure 1. Management scenarios considered when developing spatial prioritization.

Boreal Avian Modelling Project
Project de modélisation aviaire boréal

Work in progress. Contact Alana Westwood a.westwood@dal.ca for more information

www.borealbirds.ca

Results are published on the BAM website (http://www.borealbirds.ca/index.php/species-at-risk) and Nature Canada's website. We also described the work in a manuscript submitted to the "Conservation of Boreal Birds" special issue of Avian Conservation & Ecology (page 29; Westwood et al. *in review*).

Partners are using the model to target management and conservation activities for Canada warblers in this region (http://bit.ly/CAWAconsOpp). Management guidelines are designed to help managers engage in forestry activities so as to minimize their impact on Canada warbler habitat, and ensure a future supply of habitat is available (see box for more details on the approach).

This work was a collaboration with individuals from ECCC, High Branch Conservation Services Ltd, and Nature Canada. [CO-PRODUCED project. Contact: Alana Westwood]

Integrating Science, Policy, and Action to Support Conservation of Boreal Birds

There are many currently active programmes focussing on the conservation and management of boreal birds. In 2015-16, BAM launched an initiative to encourage collaboration and communication among these various programmes. In 2016-17, we co-led with Marcel Darveau (Ducks Unlimited Canada [DUC]) a workshop at the North American Congress for Conservation Biology. In association with the workshop, we initiated a special issue of the journal Avian Conservation and Ecology on the topic of "Conservation of Boreal Birds".

In 2017-18, the special issue was confirmed with the journal, guest editors were identified (Cumming, Darveau, and Naujokaitis-Lewis [ECCC]), and papers were solicited. We expect the special issue to include up to 14 papers, including an introductory editorial and a closing synthesis paper. Individual papers will be available online as they are accepted (https://www.ace-eco.org/issues/view.php?sf=7).

BAM is contributing to several manuscripts submitted to this special issue.

✳ Complete list of manuscripts with BAM contributions

- **Editorial** – In addition to introducing the various papers within the special issue, it will summarize some key aspects of the North American boreal forest and boreal species as context for other papers in the issue. Manuscript is currently in progress.
- **Facilitating co-production of actionable boreal bird conservation science** – A review paper promoting the co-production of actionable conservation science for boreal birds (see box below for an overview of one figure). It focuses on identifying many of the players a researcher should target for collaborations, such as policy-makers, decision makers, and resource or species managers (Westwood et al. *in review*).
- **Players and mechanisms in the Alaskan boreal** – A review of the important conservation mechanisms in the Alaskan boreal (Matsuoka et al. *in review*).
- **Detecting trends in boreal avian populations** – A critical review of challenges and methods in separating signal from noise in boreal bird populations (Roy et al. *under revision*).
- **Review of climate-change impacts on boreal birds** – A review paper summarizing climate-change implications for the conservation of boreal birds. Manuscript is currently undergoing major revisions (Stralberg et al. *under revision*).

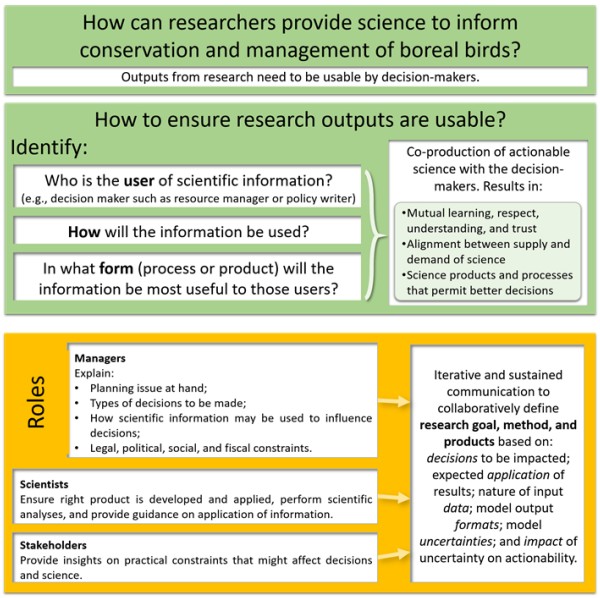


Figure. Overview of co-production as a means of producing actionable science. Adapted from Beier et al. 2017.

Conserving boreal birds in Canada through co-production: While researchers often intend for their results will be considered during the creation of policy, best-management practices, or land-use plans, much of this research remains 'on the loading dock', and is either not seen or not meaningfully considered by managers. Overwhelming evidence suggests that co-production of research makes results more actionable towards conservation and management applications. To co-produce actionable science, researchers must partner with other players in wildlife and natural resource management at all stages of the work, from planning to application.

Identifying the relevant players in the context of boreal birds in Canada, and the mechanisms they use for complication action, is complex. In effort to facilitate conservation of boreal birds via co-production, we provide a guide on how researchers can identify the relevant players relating to their research interests, some of the common mechanisms those players use for conservation, as well as how to meaningfully engage players in co-production of research.

Boreal Avian Modelling Project
Project de modélisation aviaire boréal

Work in progress. Contact Alana Westwood a.westwood@dal.ca for more information

www.borealbirds.ca

- **National land-use impacts** – Described above, page 16 (Suárez-Esteban et al. *in review*).
- **A framework for how to identify priority areas, given variable objectives** – Described above, page 21 (Stralberg et al. *under revision*).
- **Maritimes model for species at risk** – Description of a regional effort to model Canada warbler and olive-sided flycatcher and quantify relative contributions of parks to their populations. Manuscript is currently under review (Westwood et al. *in review*).
- **Supporting implementation of recovery action for the Canada Warbler** – Described above, page 28 (Westwood et al. *in review*).
- **Synthesis** – This paper will attempt to draw patterns from the papers in the special issue and suggest frameworks or guidelines for effective conservation of boreal birds, using systematic conservation planning as an example. Manuscript is currently at the outline stage.

Conservation & Land-use Planning

We created or contributed to several tools and products to inform conservation planning based on boreal bird distribution, abundance, and climate change refugia.

✳ Finding landscapes of stability and conservation efficiency in the face of climate change

Although managers need to acknowledge and anticipate change, a complementary strategy is to find and protect areas of relative stability as refuges for species and ecosystems from climate change. These "refugia" may be considered relatively efficient, low-risk conservation investments. In 2017-18, we contributed to several initiatives to identify potential refugia in the boreal.

With AdaptWest, Diana Stralberg co-developed an index of macrorefugia potential based on climate velocity, published in Global Ecology and Biogeography (Stralberg et al. 2018) [INFORMED project]. This index was used to identify refugia for boreal birds (see box for more details on development and application of this index). We described the work in a review paper submitted to the "Conservation of Boreal Birds" special issue of Avian Conservation & Ecology (page 29) and in a forthcoming report developed in collaboration with Boreal Songbird Initiative. [CO-PRODUCED projects. Contact: Diana Stralberg].

Climate refugia potential: We developed and revised a species-based index of refugia potential based on climate velocity (Stralberg et al. 2018).

We started with the premise that refugia locations vary by species, and should be considered with respect to individual species' environmental niches. But we also recognized that common climatic limitations on species distributions should result in high refugia overlap among species. Applying the concept of climate velocity—the speed that an organism must move to keep pace with climate change—our index identifies not just those areas in which species can persist, but also the climatically suitable areas to which they can reasonably relocate within the next century. We have applied this index to avian density models (Stralberg et al. 2015) to identify areas of high climate-change refugia potential for boreal birds.

We found that refugia potential for boreal forest songbirds is highest in coastal Labrador, in western mountainous regions, and in central Québec and Ontario. Refugia potential is generally lower in arid, western regions than in eastern boreal regions.

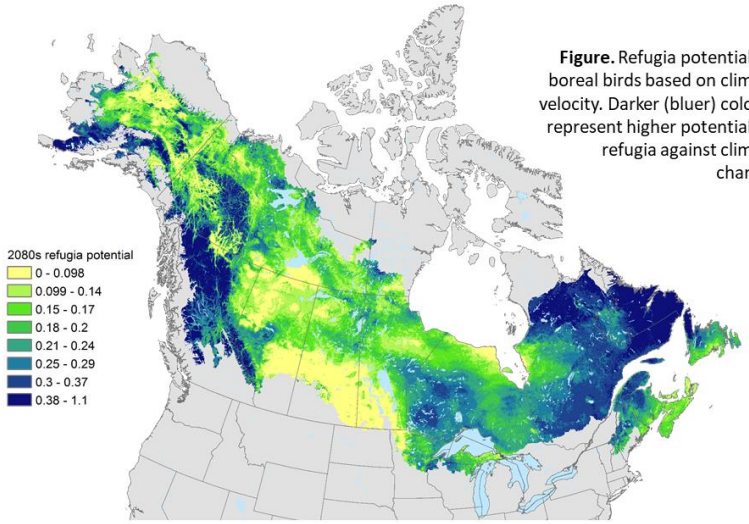


Figure. Refugia potential for boreal birds based on climate velocity. Darker (bluer) colours represent higher potential for refugia against climate change.

Boreal Avian Modelling Project
Project de modélisation aviaire boréal

Stralberg et al. in 2018. https://doi.org/10.1111/geb.12731

www.borealbirds.ca

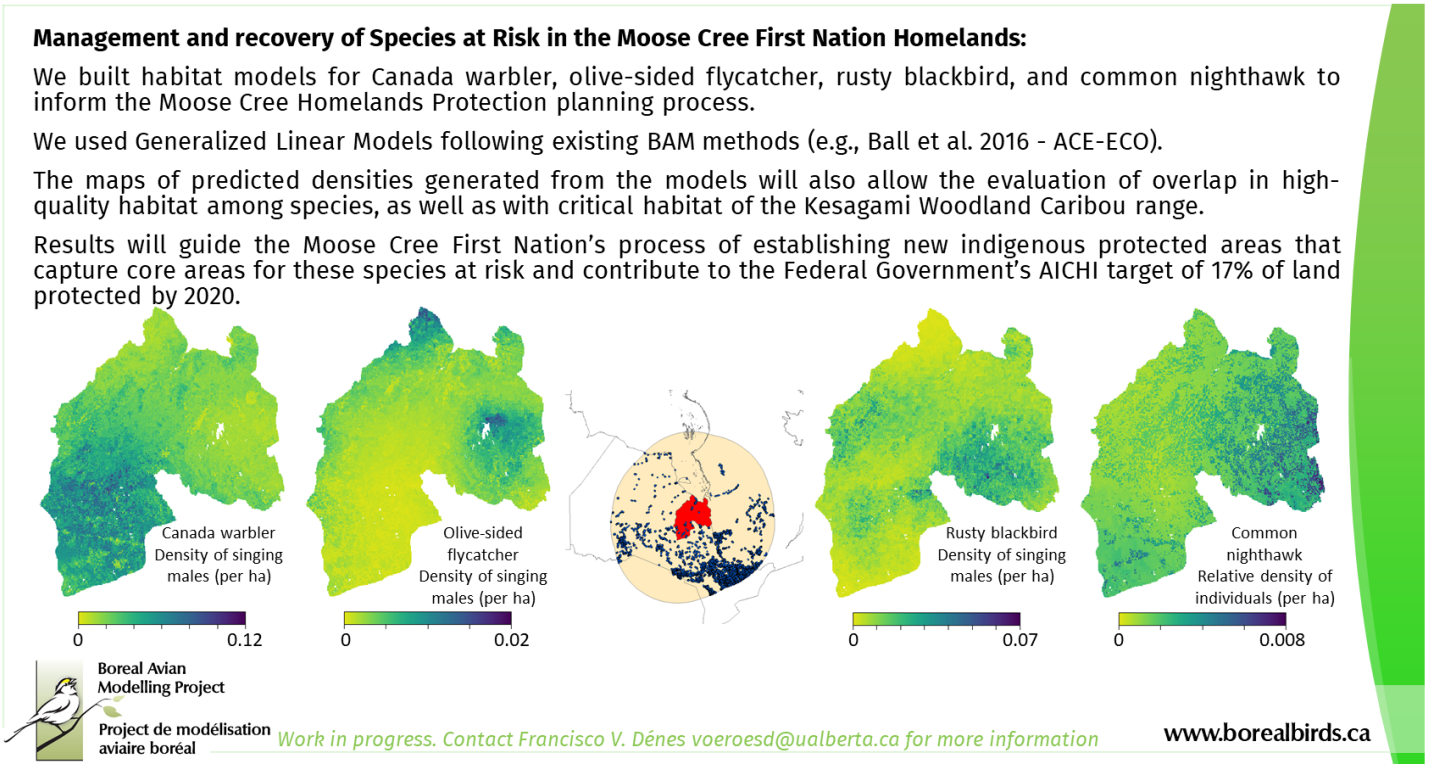
As indicated in the box above, northern ecosystems hold limited potential for climatic refugia. This is due to rapid rates of warming and consequently high climate velocity, especially in flat terrain. The vast North American boreal region may experience some buffering (resistance) and resilience against climate change due to large wetland complexes distributed across the landscape and a heterogeneous landscape maintained by a largely intact natural disturbance regime. To amass the expert knowledge required to characterize and identify potential refugia locations in the North American boreal region, a workshop was convened in Edmonton and attended by 31 boreal scientists from a wide range of disciplines. Several BAM Team Members were involved in organizing and/or participating in the workshop, which was focused on developing a framework to characterize refugia types of the greatest relevance for the boreal region. The framework is being developed into a manuscript intended for inclusion in a planned special issue in Frontiers in Ecology and Environment [INFORMED project.. Contact: Diana Stralberg].

❊ Protected areas planning to support recovery of Species at Risk in the Moose Cree First Nation Homelands

In 2017-18, we contributed to a project led by the Moose Cree First Nation, in collaboration with Nature Canada and the Wildlands League, to inform spatial conservation prioritization on their Homelands in relation to species at risk. Specifically, BAM contributed density maps and habitat associations for olive-sided flycatcher, Canada warbler, common nighthawk, and rusty blackbird (see box for methodological details and density maps).

In February, a two-day community meeting was held in Moose Factory to introduce partners to the Moose Cree of Moose Factory, and present an overview of the project the community. At this meeting, BAM's Francisco Dénes outlined how BAM models can be used to inform land management for species at risk. [CO-PRODUCED project. Contact: Francisco Dénes].

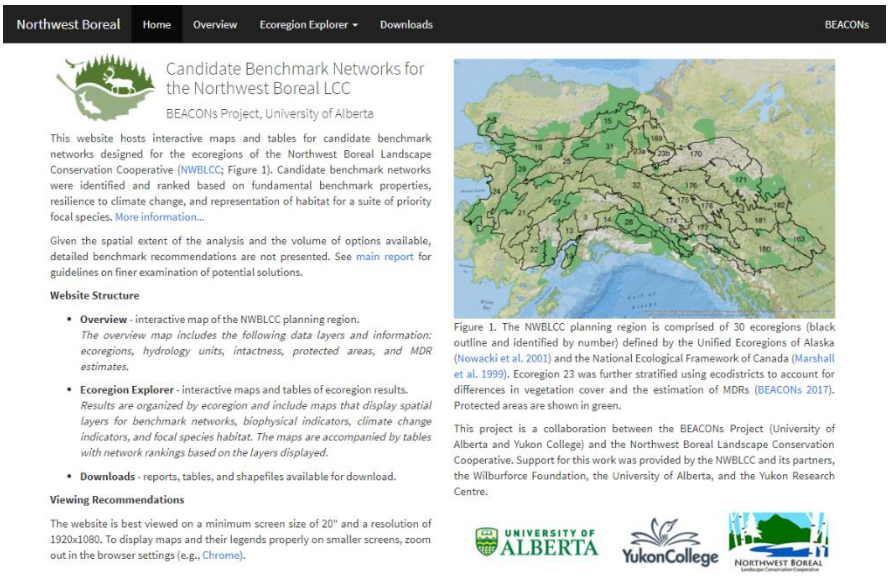
Also in 2017-18, BAM Team Members provided advice regarding sampling recommendations and use of automated recording units. Ontario CWS is offering several ARUs to help sample the Moose Cree Homelands.



❊ Northwest Boreal Landscape Conservation Cooperative

BAM's collaboration with the Boreal Ecosystems Analysis for Conservation Networks (BEACONs) Project advances boreal bird conservation through application of our products to on-the-ground conservation planning efforts in association with the Canadian Boreal Forest Agreement (CBFA) and the Northwest Boreal Landscape Conservation Cooperative (NWB LCC). Historically, BAM has provided models of current and projected future species density, and climate refugia for use in design and evaluation of protected areas networks.

In 2017-18, BEACONs released a suite of products to support pro-active conservation and identification of benchmark networks for this region (bit.ly/NWBLCCbenchmarks); some BAM products were included in this interactive portal. This work was accompanied by a report (Lisgo et al. 2017). [INFORMED project. Contact: Diana Stralberg].



Sustainable Forest Management

Through several communications and collaborative projects, we aimed to assess and improve the conservation value of forest management.

❊ Birds and Forestry Workshop

Supported by our Conservation Grant from the Sustainable Forestry Initiative (SFI), BAM hosted a workshop on October 25-26, 2017. In the several weeks prior to the workshop, we developed the agenda in collaboration with SFI (Andrew de Vries), the Canada Warbler International Conservation Initiative (Ted Cheskey [Nature Canada] & Alaine Campbell [CWS]), and our Conservation Grant partners. The goal of the workshop was for various participants from BAM, forest products companies, NGOs, federal governments, provincial governments, and First Nations to develop a common understanding of tools and processes used in forest planning, capabilities and limits of avian modelling and simulation techniques, and research and data needs.

Thirty-nine people attended the 1.5-day workshop, with attendees representing 27 academic, industry, governmental, or non-governmental institutions across the country. There were a number of active discussions, and break-out groups resulted in a wealth of suggestions to help shape future collaborative initiatives. This meeting produced over 8500 words of notes (31 pages), plus 12 PPT presentations and several pages of notes contributed by industry partners after-the-fact.

We condensed the material from presentations and discussions into a draft report summarizing the content and outcomes of the workshop. Our next step is to present it to workshop attendees for their feedback. We are particularly interested in ensuring that the sections summarizing industry needs, research and communication opportunities, and possible next steps reflect actual partner interests. [CO-PRODUCED project. Contact: Nicole Barker].

❊ Conservation impact of SFI certified lands

As part of our Conservation Grant from SFI, BAM will be exploring measurement of the potential biodiversity-related values of SFI-certified lands. In 2017-18, we decided on the analytical frameworks and recruited Pierre

Vernier of Boreal Ecosystems Analysis for Conservation Planning (BEACONs) to undertake this work. We expect preliminary analyses within 2018-19.

In addition to conducting our own research, BAM attended two meetings of the SFI Conservation Impact Sounding Board during 2017-18. These meetings provide an opportunity for scientists and conservationists to discuss the results of projects seeking to understand conservation values of SFI-certified forests. On Jun 21-22, 2017, Nicole Barker presented an overview of the BAM project and introduced our plans for our conservation impact research. On March 7-18, 2018, Nicole Barker contributed ideas related to co-production of actionable science. BAM also presented at the SFI Annual Conference (see below). [CO-PRODUCED project. Contact: Nicole Barker].

❊ Other forestry-related activities

- **Thinking about incidental take:** Three BAM team members contributed talks and the closing remarks at the Columbia Mountains Institute Forum on Avoiding Incidental Take of Bird Nests – from Law to Practice, held in April 2017 in Cranbrook, BC. The forum proceedings document is available online (http://cmiae.org/wp-content/uploads/Proceedings-Incidental-Take-2017_Final.pdf).
- **Appealing to the next generation:** BAM's work with boreal birds was featured in an Earth Rangers segment about SFI-sponsored work. BAM's Nicole Barker and Fiona Schmiegelow provided initial background text and literature to help Earth Rangers develop a script about the boreal forest and BAM's work.
- **Identifying research needs for birds and forest certification:** In September 2017, BAM's Nicole Barker was invited to speak at the Canadian Institute of Forestry's 2017 Forest Certification Science Forum about BAM's research and to sit on a panel discussing practical research to understand relationships between forest management and biodiversity. We discussed industry needs with the intent to identify discrete research projects. Three main research areas or projects were identified: 1) Development of monitoring guidelines by scientists; 2) Development of multi-species management tools; 3) Directed evaluation of best/beneficial management practices.
- **Importance of collaboration to conserve birds – BAM at the SFI Annual Conference:** In September 2017, BAM's Fiona Schmiegelow presented during the Collaborating for Conservation of Managed Forested Landscapes session at the 2017 SFI Conference. During her presentation, Fiona highlighted that the large scale of both BAM and SFI can yield important results. Fiona ended the presentation by inviting participation in the conversation about how to evaluate and achieve conservation impact for birds using sustainable forest management and the SFI standard.

- **Evaluation of forest companies' Nest Density Ranking Matrices:** Forest companies in British Columbia (BC) and Alberta have both developed risk matrices meant to provide a relative, non-quantitative ranking of bird density for forest stands. BAM was recruited to provide a data-driven

evaluation of these risk matrices, and provide recommendations for possible alternative tools. See page 10 for the BC project; the Alberta project is just getting started.

- **Research to facilitate bird conservation via sustainable forest management:** With our 6 new NSERC-funded BAM team members, we intend to demonstrate the possibilities for incorporating bird conservation when managing forests (see page 18 for more details).
- **Understanding impacts of different conservation strategies on birds:** We explored possible implications of implementing forest management strategies that conserve caribou habitat on boreal bird populations (see page 19 for more details).

Survey & Sampling Design

We provided data or analyses to guide avian sampling recommendations across the Canadian boreal and British Columbia, respectively.

ECCC's Boreal Monitoring Strategy

ECCC is continuing to refine and test a national framework for boreal bird monitoring that is being designed to provide accurate estimates of species status, trend, and distribution. The need to make monitoring designs as efficient as possible has led to increasing inclusion of sampling theory in the design. In particular, spatially balanced sampling designs and approaches to target greater effort in regions with higher variability (i.e. Neyman allocation) are being incorporated. Owing to a lack of data in some regions, proxy variables (e.g. variability in fire return intervals, temperature and precipitation) that should correlate with spatial and temporal variation in bird communities are being used to stratify sampling.

In 2017-18, we provided data to the Boreal Monitoring Strategy. These data are being used to validate the use of proxy variable estimates of variance in sampling strata. If variation in bird communities is linearly correlated with variance in proxy variables in strata where there is good sampling effort in the BAM dataset, then using proxy variables to allocate sampling effort in regions lacking bird data will be justifiable. [CO-PRODUCED project. Contact: Steve Van Wilgenburg]

Sampling more forest types in British Columbia

As part of our evaluation of a forest stand ranking matrix, we are assessing the sampling representation. In 2017-18, we quantified the numbers of existing point count surveys within each of the ~1400 forest stand types identified within the matrix. Forest companies and STRIX Ecological Consulting used this summary to guide their sampling in the 2017 field season, with the aim of improving sampling within all forest types. In 2018-19, we will integrate these new data into our British Columbia regional models (page 10). [CO-PRODUCED project. Contact: Nicole Barker]

BAM's Collaborative Activities at a Glance

In 2017-18, we contributed to the following efforts directly or by supplying data products:

❊ Avian Ecology

- BAM contributed data and methodological expertise to **Northern CWS**'s efforts to develop and apply an automated approach to delineate species' northern range limits based on known breeding locations (e.g. from BAM, BBS, eBird, etc). [Contact: Samuel Haché]
- We provided point count data on Canada warblers to support efforts to quantify breeding range, habitat associations, breeding windows, and species density to guide **Weyerhaeuser**'s forest management planning. [Contact: Erin Bayne]
- BAM team members became more active on **Partners in Flight (PIF)** working groups, actively working towards integrated methods for North American population estimation, possibly using eBird data. [Contact: Diana Stralberg]
- Wayne Thogmartin (**USGS**) has contributed to our comparison of BAM and PIF population size estimates (page 8). [Contact: Péter Sólymos]

❊ Habitat Requirements & Species at Risk

- BAM continues to support **ECCC** efforts to identify critical habitat for Canada warbler, olive-sided flycatcher, and common nighthawk (page 27), developing a conceptual model to guide critical habitat identification (page 12) and collaboratively deciding on an approach for identifying management units (page 12). [Contact: Francisco Dénes]
- We held several meetings with representatives from **Ontario CWS** in effort to facilitate coordination in our respective research related to Canada warbler and olive-sided flycatcher. [Contact: Nicole Barker]
- We participated in several conference calls with representatives from **Nature Canada**, **SFI**, **FPAC**, and the **Canada Warbler International Conservation Initiative** to remain updated on our respective projects regarding Canada warbler. [Contact: Nicole Barker]

❊ Population Change & Drivers

- Several BAM Team Members contributed figures, writing, or scientific expertise to the "Conservation of Boreal Birds" special issue of Avian Conservation & Ecology (page 29) paper examining trend estimation; co-authors include individuals from **CWS**, **National Audubon Society**, **USGS**, the **French Museum of Natural History**, the **Smithsonian Migratory Bird Center**, the **Institute for Bird Populations**, **Carleton University**, **CFS**, and the **University of Wisconsin-Madison**, among others. [Contact: Péter Sólymos]

❊ Land-use Change

- Urs Kormann (**Oregon State University**) is using BAM data to explore bird communities in forest plantations. The research is expected to proceed in 2018-19, and BAM team members will be invited to participate in the research at that time. [Contact: Nicole Barker]
- BAM competed preliminary analyses evaluating a forest stand ranking matrix in association with **Canfor**, **West Fraser**, and the **BC Council of Forest Industries (COFI)**, supported by a Mitacs Accelerate for Nicole Barker (page 10). We also launched a similar exercise with the Alberta Forest Products Association. [Contact: Nicole Barker].

- BAM continued our collaboration with **Al-Pac** to understand impacts of forest fragmentation on birds using data from the Calling Lake Fragmentation Study (page 18). [Contact: Lionel Leston]
- We began our NSERC Strategic Partnership Grant with co-leads from **Pacific Forestry Centre**, **Université Laval**, and **DUC,** and with partners from **S&T-Wildlife Research Division** and **CWS** (page 18). [Contact: Nicole Barker]
- BAM maintained its collaboration with **ABMI**, **Alberta Environment and Parks**, **Prairie CWS**, and the Bayne Lab at the **University of Alberta** via the Oil Sands Monitoring work in Alberta (page 17). [Contact: Erin Bayne and Judith Toms]
- We held a workshop with representatives from **Alberta Environment and Parks**, **Al-Pac**, **American Bird Conservancy**, **Bird Studies Canada**, **Central Canada SFI Implementation Committee**, **DMI**, **DUC**, **CWS**, **S&T-Wildlife Research Division**, **Fuse Consulting**, **Lac Seul First Nation**, **Lesser Slave Lake Bird Observatory**, **Louisiana-Pacific**, **Nature Canada**, **NCASI**, **Norbord**, **Ontario Ministry of Natural Resources & Forestry**, **SFI**, **STRIX Ecological Consulting**, **Tolko**, **Université Laval**, **West Fraser**, and **Weyerhaeuser** to understand bird-related priorities and research needs for forest management companies (page 33). [Contact: Nicole Barker]
- We contributed to the **SFI** Conservation Impact Sounding Board and conference (page 34). We also renewed discussions with the **American Bird Conservancy** exploring the potential for a North American perspective on bird conservation in SFI-certified forests. [Contact: Nicole Barker]

❊ Climate Change

- BAM contributed to outreach materials from the **BSI** on climate-change impacts on boreal bird distribution and abundance, and related climate-smart conservation strategies (page 30). [Contact: Diana Stralberg]
- We continued our work with **University of Alaska Fairbanks** and the **USGS** to quantify bird response to climate-mediated landscape changes in BCR4 (page 14). [Contact: Steve Matsuoka]
- We completed preliminary results for our work looking at climate change and vegetation impacts on bird habitat in Alberta, a collaboration with **S&T-Wildlife Research Division** and the **Laurentian Forestry Centre** (page 14). [Contact: Junior Tremblay]
- Diana Stralberg published a chapter from her Ph.D., demonstrating impacts of fire-mediated climate change on Alberta forests. This work involved individuals from the **University of Alberta, CWS, ABMI,** and **Northern Forestry Centre**. [Contact: Diana Stralberg]

❊ Conservation Planning

- Barker et al. (2014) rasters of waterfowl predicted density were provided to **Planit North**, the **Ka'a'gee Tu First Nation**, and the **Sambaa K'e First Nation** to support evaluation of Candidate Protected Areas. [Contact: Nicole Barker]
- BAM contributed expertise and data products to the **Nature Conservancy of Canada**'s Boreal Plains Atlas and a similar project in northern Quebec. [Contact: Diana Stralberg]
- **BEACONs**, as part of the **Northwest Boreal Landscape Conservation Cooperative**, posted benchmarks assessments using BAM data. Products on their interactive website included some produced by BAM or jointly by BAM and DUC (bit.ly/NWBLCCbenchmarks; page 32). [Contact: Diana Stralberg]
- BAM contributed to a proposal to the Aboriginal Fund for Species at Risk, led by **Nature Canada** and the **Lac Seul First Nation**. If successful, this project will contribute to conservation of species at risk

within the Lac Seul First Nation's homelands and managed forests (page 32). [Contact: Francisco Dénes]

- Both the **Wildlife Conservation Society** and the **Prairie Habitat Joint Venture** solicited presentations on our Zones of Interest work (page 21) to guide their own conservation planning efforts. [Contact: Diana Stralberg]
- Songbird density layers (page 40) and Zones of Interest (page 21) outputs provided to **CWS** to support a student project looking at how well the highest priority areas for landbirds are covered by the caribou ranges and to identify which species are well or under-represented within the ranges. [Contact: Diana Stralberg]

✳ Survey Design

- BAM has and will continue to contribute both data products and scientific expertise to **ECCC**'s Boreal Monitoring Strategy (page 35). [Contact: Steve Van Wilgenburg]
- We provided a summary of sampling coverage in BC to partner forest companies, which guided point count sampling during the 2017 field season by companies like **Weyerhaeuser** and **Interfor**. [Contact: Nicole Barker]

✳ Methods & Tools

- We obtained LiDAR data from **Alberta Agriculture and Forestry** to explore its utility in describing avian habitat. [Contact: Brendan Casey]
- BAM team members informed work by Elly Knight (**University of Alberta-Bioacoustic Unit**) to develop approaches to model and understand common nighthawk habitat use and selection (page 22). [Contact: Elly Knight]

✳ Data

- We continued our mutually-beneficial collaboration with the **ABMI**. In this collaboration, BAM receives ABMI data for use in continental-scale work, while a subset of BAM data (where permissions have been granted) are used by ABMI for Alberta-scale work. [Contact: Erin Bayne]
- BAM representatives attended an online workshop on *eBird Data Extraction in R with auk* hosted by the **Cornell Lab of Ornithology**, to better prepare ourselves for future interactions with eBird data. [Contact: Diana Stralberg]


Photo: Nicole Barker

Data Development

Where possible, we summarize our research in data products such as maps and data tables. We distribute our data products to scientists, managers, and other interested parties in external groups to facilitate conservation and management of boreal birds.

To support BAM's research, we assembled and now maintain a comprehensive database of avian and biophysical data. The BAM Avian Database, comprising more than 150 research, monitoring, or inventory projects, now includes more than 300,000 sampling events, collected from over 200,000 sampling locations. In addition to ongoing maintenance and updating, we continually search for opportunities to fill known gaps in temporal or spatial coverage.

BAM Data Products for Distribution

BAM has several data products available for use by scientists, managers, and others. This past year, we made significant progress towards development of a new data portal that is integrated with the BAM website. We intend for all products to be available online via our new data portal by March 2019.

✳ New data portal

In 2016-17, we initiated an effort to critically evaluate our website and mechanism for distributing data products. In 2017-18, we recognized that our current distribution platform was not achieving our needs, so we made the difficult decision to decommission BAM's DataBasin portal, effective April 1, 2018.

A new data portal is underway, using the GeoNetwork platform. This free, open-source platform is highly customizable, allowing us to create a data tool that displays and catalogues all discrete data, products, and information we may want to share. Not only will this new portal showcase raster products, like our DataBasin portal did, but it will also catalogue maps in image (e.g., jpeg) format, data tables, and metadata about geospatial products BAM uses in our own analyses. Depending on uptake from our users, this portal may also be used for archiving and cataloguing our written materials, such as reports.

In 2017-18, we began learning the GeoNetwork tool and tested capabilities for bulk uploads using R scripts to generate XML scripts for all species. We are currently developing our data dictionary and search terms, to enable users to find the data they need.

We expect to migrate all currently available products into our GeoNetwork portal within 2018-19. After that, we will begin cataloguing products that are not currently available online. [CORE project. Contact: Mélina Houle.

❊ Revamped BAM website to facilitate data product distribution

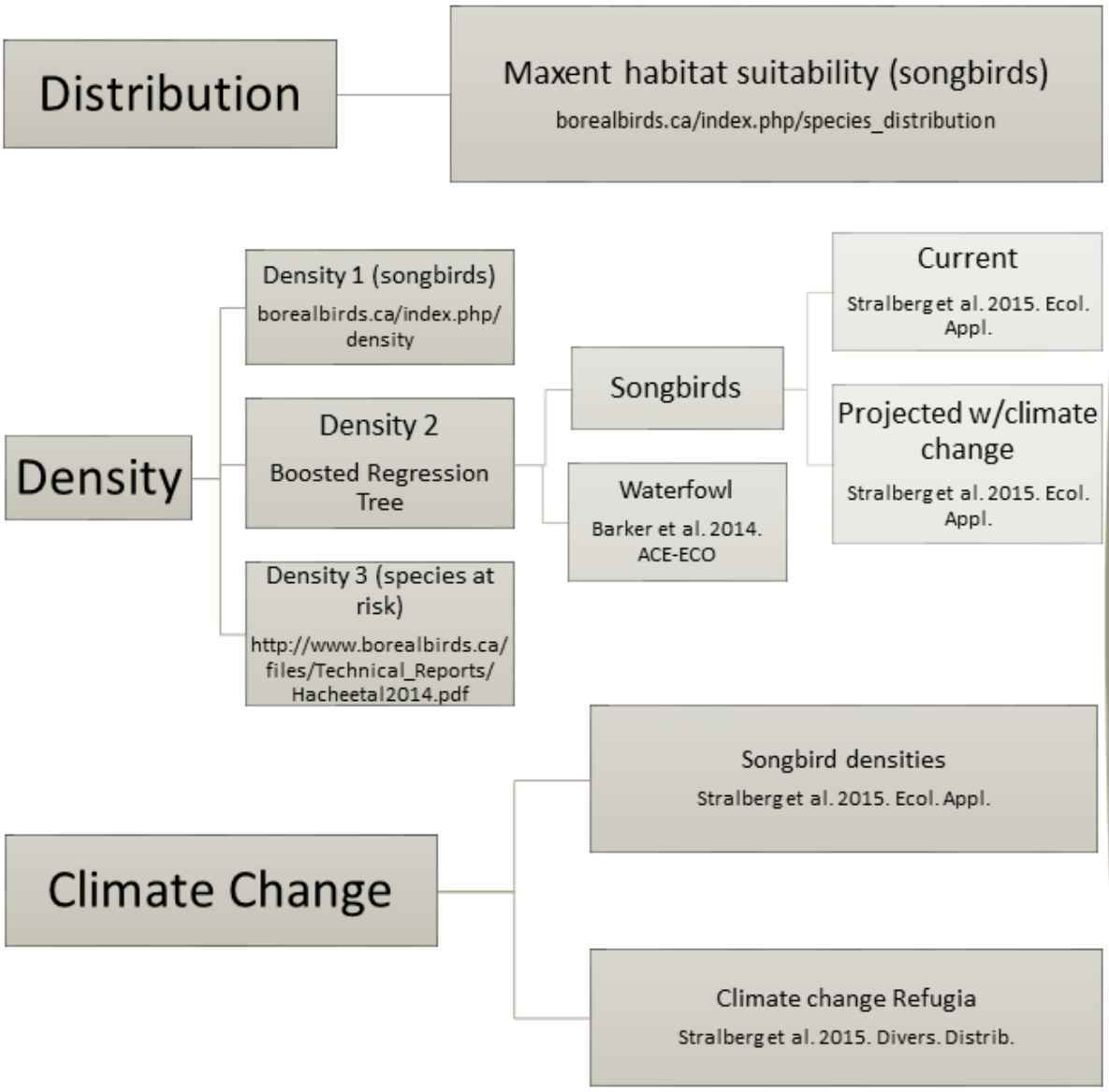
Alongside our creation of a new data portal, we are redesigning the BAM website (page 45). The revised platform will facilitate the user's ability to find information about or get access to specific products. [CORE project. Contact: Nicole Barker].

❊ Products available for distribution

The following information sheet summarizes what is currently available. Interested parties can contact the BAM Coordinating Scientist, Nicole Barker, at nbarker@ualberta.ca for more information or to request a product. [CORE project. Contact: Nicole Barker].

BAM Data Products

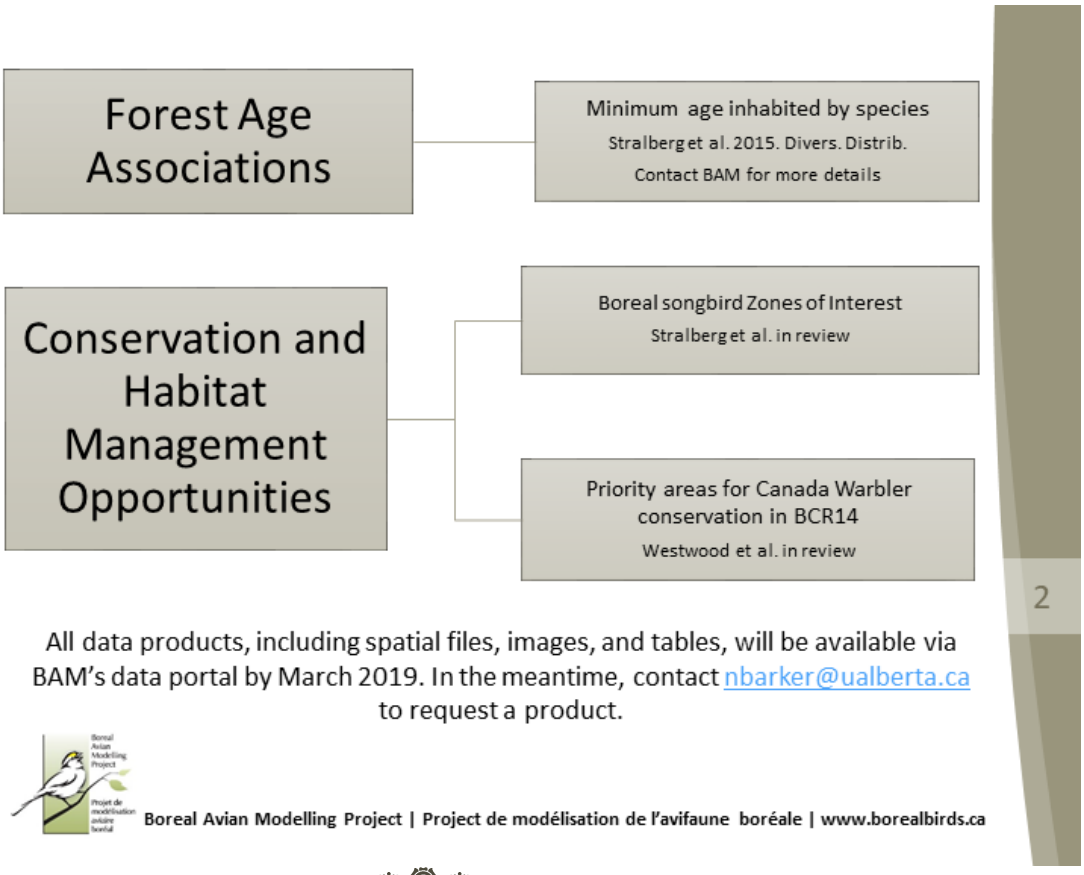
Last updated: March 30, 2018



1

All data products, including spatial files, images, and tables, will be available via BAM's data portal by March 2019. In the meantime, contact nbarker@ualberta.ca to request a product.

Boreal Avian Modelling Project | Project de modélisation de l'avifaune boréale | www.borealbirds.ca

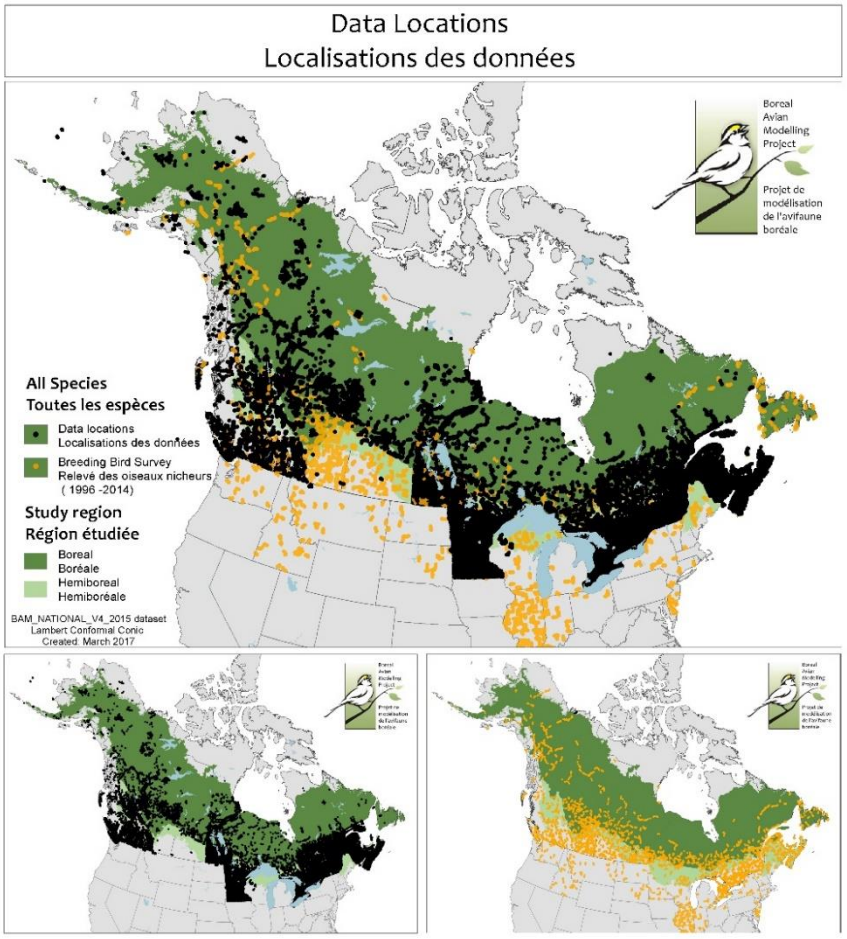


BAM Databases

The BAM Avian Database

This past year we focused on cleaning and integrating new data from the Québec Breeding Bird Atlas, the Manitoba Breeding Bird Atlas, and from all freely available point count data collected in British Columbia (via the British Columbia Ministry of the Environment's Wildlife Species Inventory portal).

This table summarizes the contents of the BAM Avian Database as of March 31, 2017. We expect version 5 to be available by August 2018. [CORE project. Contact: Nicole Barker].



	BAM Avian Database	BAM's BBS Database
Version (Year Updated)	V4 (2017)	V4 (2017)
# Projects	150	Data inclusive of 2014, all Canadian and Alaskan BBS routes and some routes from northern USA.
# Sampling Locations	201,062	65,609
# Sampling Events	328,603	670,453
# Bird Observations	3,057,409	4,901,199

The BAM Biophysical Database

Most BAM models use spatial layers depicting the conditions (e.g., landcover, climatic, etc) across the study area. In 2016-17, we initiated an effort to summarize the various products we've used in a single coherent, easy-to-read, and easily updatable format. This was originally on a Wiki-style page within the Google Sites framework. We since decided to combine this metadata catalogue with that for our own spatial data products (page 39). We also extracted a subset of our avian dataset that can be used with Forest Resource Inventory (FRI) data.

❊ What the forest looked like when the birds were observed: A temporally aligned, standardized, forest inventory database

Geospatial databases of Forest Resource Inventories (FRIs) are the primary forest management planning tool in Canada. These inventories also provide detailed information on canopy height and some characteristics of wetlands and other non-forested areas. FRI-based covariates are widely used in models of species distributions. Application to ecological studies at national extent has, until recently, been hampered by heterogeneity between provincial inventories and databases.

In annual reports from previous years (e.g., 2012-13, 2013-14), we described efforts to build the Common Attribute Schema for Forest Resource Inventories (CASFRI), which integrates almost the entire area covered by Canadian forest resource inventories. It contains more than 25,000,000 polygons covering nearly 4,000,000 km^2, almost the entirety of managed forests in Canada, in a custom data format that is consistent across jurisdictional boundaries, but loses none of the original information contained in the source data sets.

CASFRI supports our models of bird abundance in relation to forest attributes such as patch size, tree species composition, canopy height, and density (page 11). However, given the nature of both the BAM Avian Dataset and CASFRI, the year of avian survey at a location seldom matches the year of aerial photography for the the inventory at that location. As a result, CASFRI does not always describe the habitat surveyed. This can happen if a disturbance had occurred between the years of survey and photography; or simply because the forest itself had changed due to growth or succession. In 2017-18, in order to support analyses of differential habitat selection (page 11) we filtered the most recent BAM data set to remove all instances where: a) a gap of more than 10 years existed between the years of avian survey and photography; b) no known disturbance have taken

place in the interim; and c) the CASFRI had not been updated with a post-survey disturbance. This produced a dataset where the composition and structure of vegetation described in the CASFRI dataset corresponds to conditions on the ground at the time of the bird surveys, to the best of our abilities. This yielded a set of 32,817 usable BAM-CASFRI locations. In order to do this, it was first necessary to update the Ontario inventory with the latest version that includes crown closure attributes. This work was financed by NSERC grants held by Steve Cumming.

The process documentation and the scripts have been saved to BAM's code repository (page 52), facilitating replication of these efforts when either the BAM or CASFRI datasets are updated, and to provide as template for similar analyses. [CORE project. Contact: Andy Crosby].


Photo: Jeff Ball

Communications

BAM communicates research findings to academics, scientists, managers, and the general public through various means. We publish our results in traditional scientific journals, provide information for a variety of outreach efforts, and also maintain a website to disseminate our research findings.

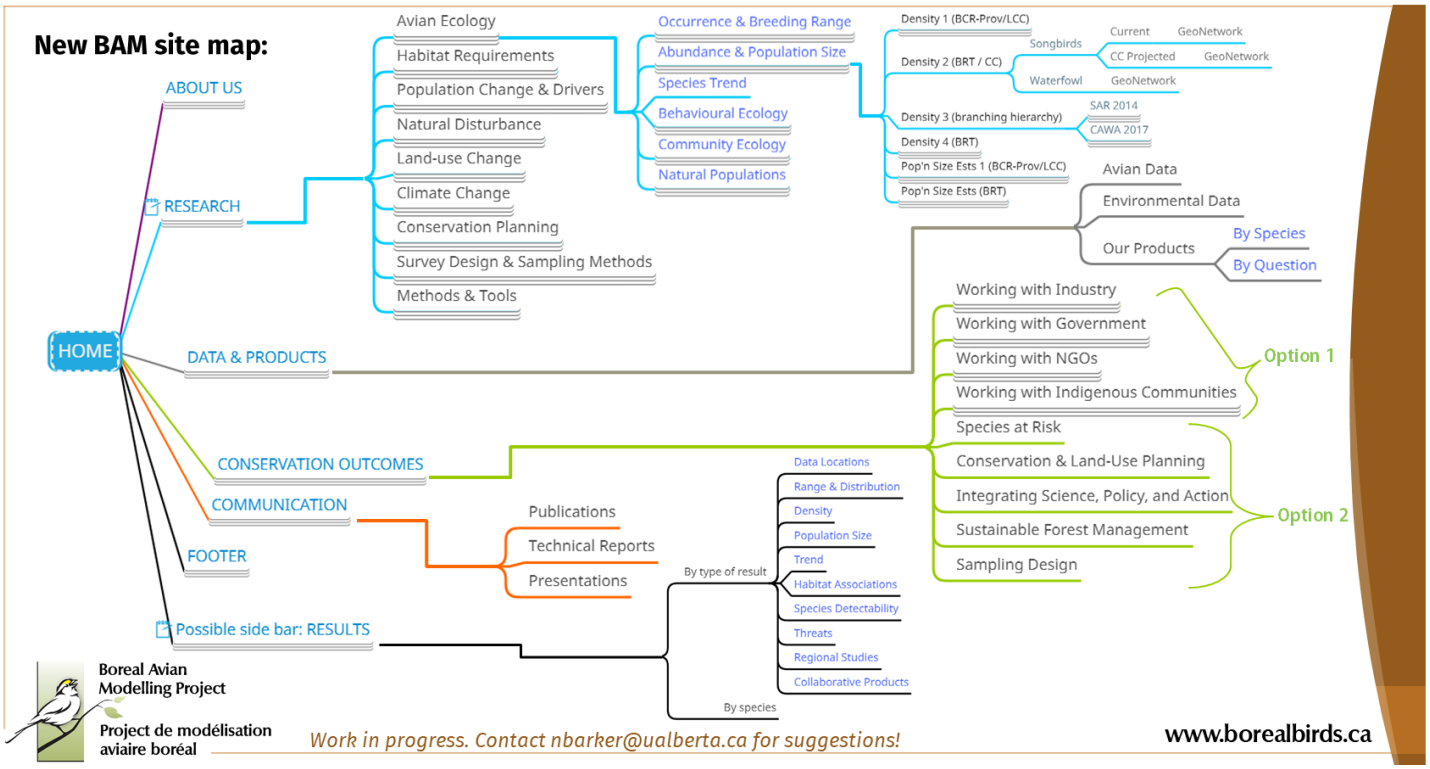
Website

We describe our research and distribute our data products via our website. This year we initiated a complete redesign of our website, based on a review we completed in previous years.

✳ BAM website updates and redesign

This year we made small improvements to our website to improve functionality until we can launch our fully revised website. We also began a major redesign of the BAM Website. The new website design is focussed on describing our past, current, and future research interests, findings, and products. Some major proposed changes include:

- Removal of some species-specific information, since other websites maintain more comprehensive and current versions: Life History, Breeding Ecology, and Conservation Status.
- Ability to access results and data products either by species or by type of research/ecological question.
- Addition of a blog to profile specific research projects
- Integration with our data portal (page 42). [CORE project. Contact: Nicole Barker].



Outreach & Publications

We communicate BAM research via webinars, publications in peer-reviewed journals, presentations, and reports. From January 2017 through March 2018, BAM led or significantly contributed to six papers in peer-reviewed journals, gave over 25 talks, poster, or workshop presentations, and organized 1 workshop, 1 webinar, and 1 conference side meeting.

BAM Publications

❊ BAM Core Publications

Publications from BAM Core projects.

Sólymos, P., S. M. Matsuoka, D. Stralberg, N. K. S. Barker, and E. M. Bayne. 2018. Phylogeny and species traits predict bird detectability. Ecography:early view. DOI: 10.1111/ecog.03415

Stralberg, D., S. M. Matsuoka, C. M. Handel, F. K. A. Schmiegelow, A. Hamann, and E. M. Bayne. 2017. Biogeography of boreal passerine range dynamics: past, present, and future. Ecography 40:1050-1066. DOI: 10.1111/ecog.02393

❊ BAM Co-produced Publications

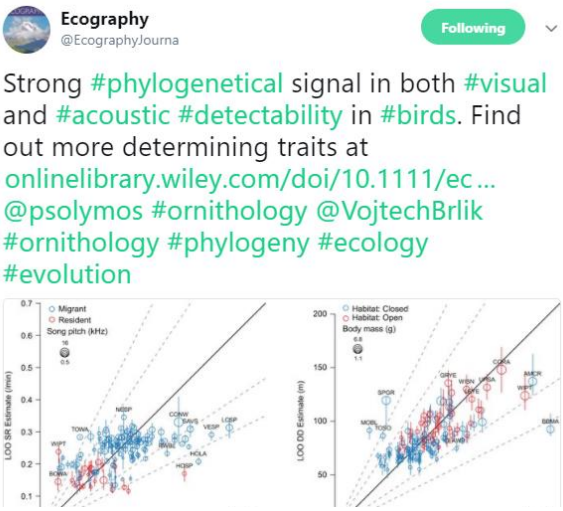
Publications from BAM Co-produced projects.

Stralberg, D., X. Wang, M.-A. Parisien, F.-N. Robinne, P. Sólymos, C. L. Mahon, S. E. Nielsen, and E. M. Bayne. 2018. Wildfire-mediated vegetation change in boreal forests of Alberta, Canada. Ecosphere 9:e02156. DOI: 10.1002/ecs2.2156

Sólymos, P., E. M. Bayne, and J. D. Toms. 2018. Estimating population trends for songbirds in Northern Alberta. Alberta Biodiversity Monitoring Institute, Edmonton, AB, Canada. URL: http://www.borealbirds.ca/files/Technical_Reports/JOSM_report_trend_estimation_20170407.pdf

Van Wilgenburg, S., P. Sólymos, K. Kardynal, and M. Frey. 2017. Paired sampling standardizes point count data from humans and acoustic recorders. Avian Conservation and Ecology 12. DOI: 10.5751/ACE-00975-120113

Yip, D., L. Leston, E. Bayne, P. Sólymos, and A. Grover. 2017. Experimentally derived detection distances from audio recordings and human observers enable integrated analysis of point count data. Avian Conservation and Ecology 12. DOI 10.5751/ACE-00997-120111



✳ BAM Informed Publications

Publications we're aware of that use BAM data, methods, or expert knowledge.

Anctil, A., H. Johansen, and J. Tremblay. 2017. Écologie de nidification du moucherolle à côtés olive dans un paysage sous aménagement forestier de la forêt boréale de l'Est. Le Naturaliste canadien 141:53–60. DOI: 10.7202/1039736ar

Carroll, C., D. R. Roberts, J. L. Michalak, J. J. Lawler, S. E. Nielsen, D. Stralberg, A. Hamann, B. H. Mcrae, and T. Wang. 2017. Scale-dependent complementarity of climatic velocity and environmental diversity for identifying priority areas for conservation under climate change. Global Change Biology 23:4508–4520. DOI: 10.1111/gcb.13679

Fuse consulting. 2017. Holiday card showcasing results from our regional model of Canada Warbler (Ball et al. 2016).

Haché, S., E. M. Bayne, M.-A. Villard, H. Proctor, C. S. Davis, D. Stralberg, J. K. Janes, M. T. Hallworth, K. R. Foster, E. Vasi, A. Grossi, J. Gorrell, and R. Krikun. 2017. Phylogeography of a migratory songbird across its Canadian breeding range: implications for conservation units. Ecology and Evolution DOI: 10.1002/ece3.3170.

Hunt, A. R., E. M. Bayne, and S. Haché. 2017. Forestry and conspecifics influence Canada Warbler (*Cardellina canadensis*) habitat use and reproductive activity in boreal Alberta, Canada. The Condor 119:832–847. DOI: 10.1650/CONDOR-17-35.1

Knight, E. C., and E. M. Bayne. 2017. Habitat Selection at Different Scales for a Declining Aerial Insectivorous Bird as Determined by Autonomous Recording Technology. Applied Research Reports, Alberta Biodiversity Monitoring Institute, Edmonton, AB, Canada. URL: http://www.abmi.ca/home/publications/451-500/478.html?mode=detail&page=2

Leston, L., E. Bayne, and F. Schmiegelow. 2018. Long-term changes in boreal forest occupancy within regenerating harvest units. Forest Ecology and Management 421:40–53. DOI: 10.1016/j.foreco.2018.02.029

Lisgo, K., F. K. A. Schmiegelow, P. Vernier, M. Edwards, and A. Suárez-Esteban. 2017. Ecological Benchmarks to Support Landscape Conservation Design in the Northwest Boreal LCC Planning Region. BEACONs Project, University of Alberta, and Yukon College, Whitehorse, YT, Canada. URL: www.beaconsproject.ca/nwb

Pankratz, R., S. Hache, P. Sólymos, and E. Bayne. 2017. Potential benefits of augmenting road-based breeding bird surveys with autonomous recordings. Avian Conservation and Ecology 12. DOI 10.5751/ACE-01087-120218

Stralberg, D., C. Carroll, J. H. Pedlar, C. B. Wilsey, D. W. McKenney, and S. E. Nielsen. in press. Macrorefugia for North American trees and songbirds: Climatic limiting factors and multi-scale topographic influences. Global Ecology and Biogeography. DOI: 10.1111/geb.12731

Tremblay, J. A., Y. Boulanger, D. Cyr, A. R. Taylor, D. T. Price, and M.-H. St-Laurent. 2018. Harvesting interacts with climate change to affect future habitat quality of a focal species in eastern Canada's boreal forest. PLOS ONE 13:e0191645. DOI: 10.1371/journal.pone.0191645

Tremblay, J., M. Robert, D. Hynes, M. Young, and B. Drolet. 2018. Range extension of the threatened Red Crossbill (*Loxia curvirostra percna*) in Canada: new insights from Anticosti Island, Québec. Avian Conservation and Ecology 13. DOI: 10.5751/ACE-01175-130110

Van Wilgenburg, S., K. Hobson, K. Kardynal, and E. Beck. 2018. Temporal changes in avian abundance in aspen-dominated boreal mixedwood forests of central Saskatchewan, Canada. Avian Conservation and Ecology 13. DOI: 10.5751/ACE-01145-130103

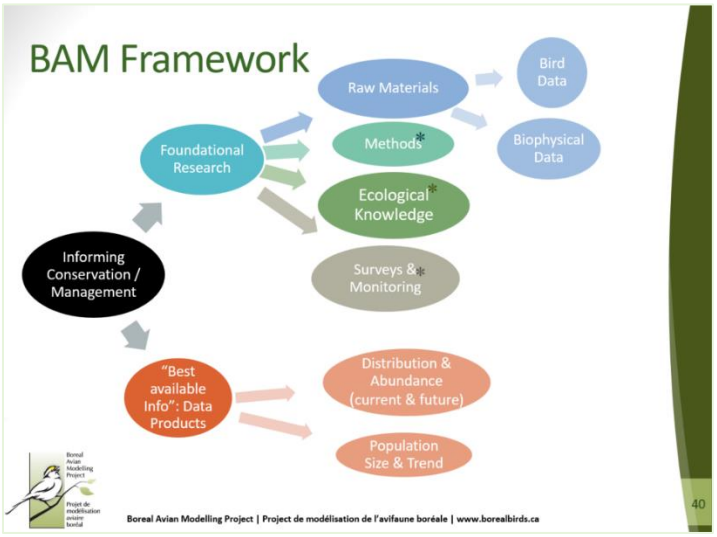
❊ Presentations

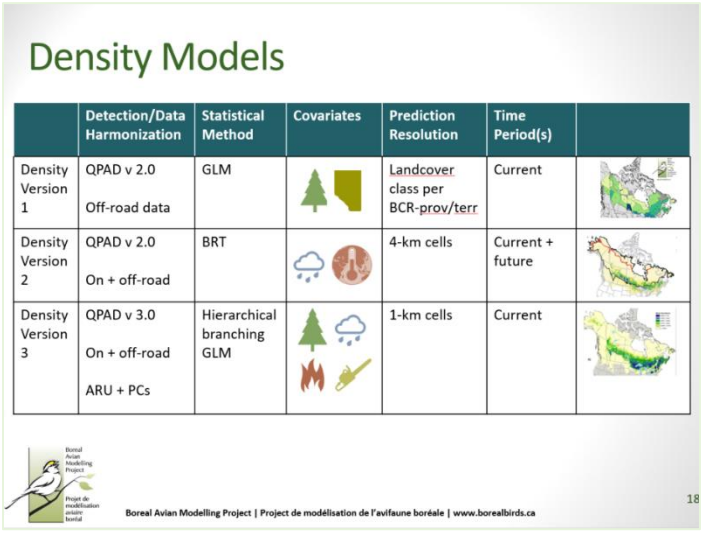
Barker NKS. Bird density in the BC Interior - Testing the Stand Ranking Matrix. Presentation to the COFI Migratory Birds Working Group (chair: Archie MacDonald). 2018 Jan 10: Vancouver, BC, Canada. (audience: 12)

Barker NKS. Bird Habitat Models: Examples from the Boreal Avian Modelling (BAM) Project. Talk at the BAM/SFI Birds & Forestry Workshop. 2017 Oct 25: Edmonton, AB, Canada. (audience: 39)

Barker NKS. Evaluating the value of Canadian boreal forests for avian biodiversity and species at risk. Invited talk at Canadian Institute of Forestry's 2017 Forest Certification Science Forum (chair: Wayne Bell). 2017 Sep 26: Ottawa, ON, Canada. (audience: 25)

Barker NKS on behalf of the Boreal Avian Modelling Project. Quantification of conservation-related values of SFI-certified forestlands for bird biodiversity and species at risk. Invited talk at Sustainable Forestry Initiative Conservation Sounding Board Meeting. 2017 Jun 22: Washington, DC, USA. (audience: 25)





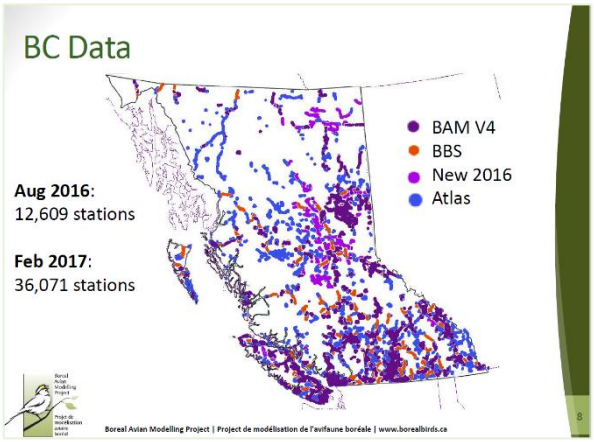
Barker NKS*, Drever MC, Stuart-Smith K, Trout L. Update on a Data-driven Test of the Stand Rating Matrix. Remote presentation to the COFI Migratory Birds Working Group (chair: Archie MacDonald). 2017 Feb 2: Vancouver, BC, Canada. (audience: 12)

Barker NKS*, Stralberg D*, Sólymos P*, Crosby AD*, Dénes FV*. Boreal Avian Modelling Project: Update to the ECCC Landbird Technical Committee - spotlight on Data Product. Invited talk at ECCC Landbird Technical Committee Meeting (chair: Nancy Mahoney). 2017 Nov 20: Online. (audience: 15)

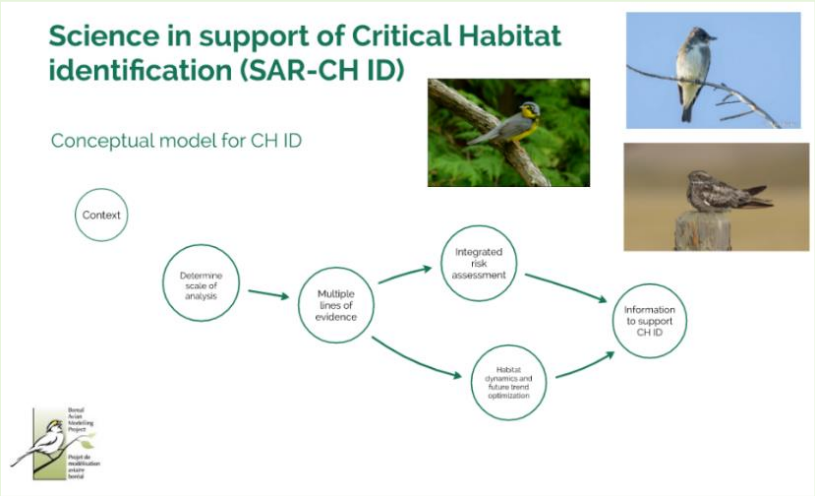
Barker NKS*, Stuart-Smith K, Trout L, Drever MC, Bayne EM. Bird density in the BC Interior – Testing a stand ranking matrix. Invited talk at Columbia Mountains Institute Avoiding Incidental Take of bird Nests: From law to practice workshop. 2017 Apr 26-27: Cranbrook, BC, Canada. http://cmiae.org/wp-content/uploads/Proceedings-Incidental-Take-2017_Final.pdf (audience: 150)

Bayne EM*. How many birds will I directly versus indirectly kill in my lifetime and which matters more? Invited talk at Columbia Mountains Institute Avoiding Incidental Take of bird Nests: From law to practice workshop. 2017 Apr 26-27: Cranbrook, BC, Canada. http://cmiae.org/wp-content/uploads/Proceedings-Incidental-Take-2017_Final.pdf (audience: 150)

Bayne EM*. How many birds will I kill in my lifetime directly vs. indirectly: Which matters more? Plenary at the joint meeting of the American Ornithological Society and Canadian Society of Ornithologists. 2017 Aug 3: East Lansing, MI, USA. (audience: 300)



Cumming SG*. Using forest resource inventory data for consistent, regional prediction of potential incidental take on managed forest lands. Talk at Columbia Mountains Institute Avoiding Incidental Take of bird Nests: From law to practice workshop. 2017 Apr 26-27: Cranbrook, BC, Canada. http://cmiae.org/wp-content/uploads/Proceedings-Incidental-Take-2017_Final.pdf (audience: 150)



Dénes FV*. Science in support of Critical Habitat identification (SAR-CH ID) - Conceptual model for CH ID. Remote presentation to the ECCC SAR Advisory Committee for Implementation of the Schedule of Studies to Identify Critical Habitat for Canada Warbler, Olive-sided Flycatcher, and Common Nighthawk 2017 Sept 26. (audience: 20).

Denés F. Bird habitat models - the making of a model (examples from the Boreal Avian Modelling Project). Talk at a Moose Cree First Nation community gathering. 2018 Feb 10: Moose Factory, ON, Canada. (audience:15)

Denés F. SAR SoS3 Advisory Committee F2F. Talk at the ECCC Schedule of Studies Advisory Committee Meeting. Update on development of conceptual model for identification of critical habitat for Canada Warbler, Olive-sided Flycatcher and Common Nighthawk. Discussions on regionalization approaches and management unit delineation. 2018 Feb 14: Ottawa, ON, Canada. (audience: 14)

Haché S. Update on BAM national models and leveraging temporally sparse data to identify possible causes for population change in boreal forest bird communities. Talk at the ECCC Schedule of Studies Advisory Committee Meeting. 2018 Feb 14: Ottawa, ON, Canada. (audience: 14)

Leston L*, Bayne EM, Schmiegelow FKA. Exploring long term effects of forest fragmentation and recovery on boreal birds. Talk at Alberta Chapter of The Wildlife Society Annual General Meeting. 2018 May 9-12: Lethbridge, AB, Canada. (audience: 300)

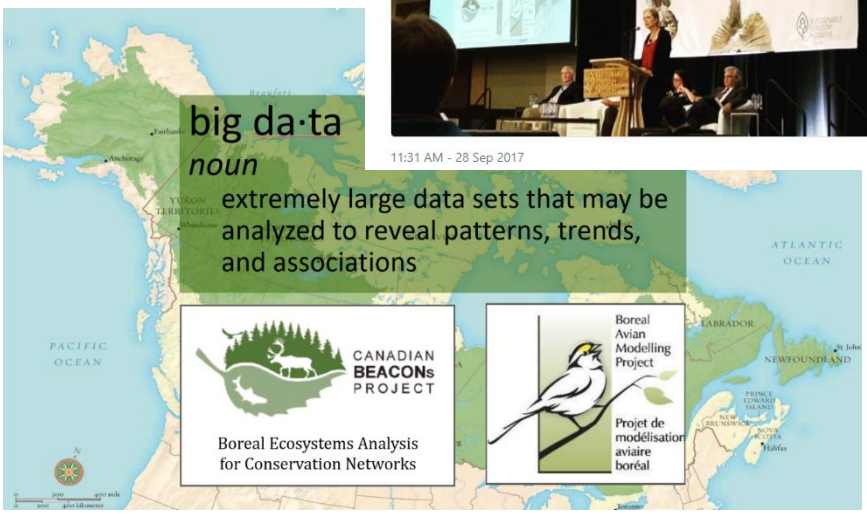
Leston L*, Bayne EM, Schmiegelow FKA, Dzus E. Twenty-four years of birds: Long-term effects of forest fragmentation and recovery on boreal bird communities. Talk at North American Forest Ecology Workshop. 2017 May 19-22: Edmonton, AB, Canada. (audience: 200)

Leston L*, Bayne EM, Dzus E. Forestry planning for the future of boreal birds and woodland caribou using Patchworks. Talk at Alberta Chapter of the Wildlife Society Annual Conference. 2017 Mar 17-19: Lac La Biche, AB, Canada. (audience: 200)

Schmiegelow FKA*. Collaborating for Conservation of Managed Forested Landscapes. Invited talk at the 2017 Sustainable Forestry Initiative Annual Conference. 2017 Sep 27-29: Ottawa, ON, Canada. (audience: 250)

Sólymos P*, Barker N, the BAM team. Boreal Avian Modelling (BAM) approach to population estimates. Remote presentation to the Partners In Flight Science Committee Meeting. 2017 Jul 12: Cornell Lab of Ornithology, Ithaca, NY, USA. (audience: 35)

Sólymos P*, Haché S*. 2017. National models to help critical habitat identification. Remote presentation to the ECCC SAR Advisory Committee for Implementation of the Schedule of Studies to Identify Critical Habitat for Canada Warbler, Olive-sided Flycatcher, and Common Nighthawk. (chair: Kathy St.Laurent). 2017 Mar 14: Online. (audience: 15)



Song S*. Bird conservation on managed forest lands - national vision. Invited talk at the BAM-SFI Birds & Forestry Workshop. 2017 Oct 25: Edmonton, AB, Canada. (audience: 39)

Stehelin T*. 2017. Olive-sided Flycatcher and Western Wood-Pewee project and results update on local breeding patterns and community dynamics in Yukon. Remote presentation to the ECCC SAR Advisory Committee for Implementation of the Schedule of Studies to Identify Critical Habitat for Canada Warbler, Olive-sided Flycatcher, and Common Nighthawk. (chair: Kathy St.Laurent). 2017 Apr 25: Online. (audience: 15)

Stralberg D*. Projecting boreal bird responses to climate change: considering uncertainty, time lags, barriers and refugia. Invited seminar at Point Blue. 2017 Apr 12: Petaluma, CA, USA. (audience: 25)

Stralberg D*, A Camfield, M Carlson, C Lauzon, NKS Barker, A Westwood, and FKA Schmiegelow. Which half? Strategies for identifying priority areas for passerine conservation in Canada's boreal forest. Presentation to Prairie Habitat Joint Venture. 2018 Feb 26: Online. (audience: 20)

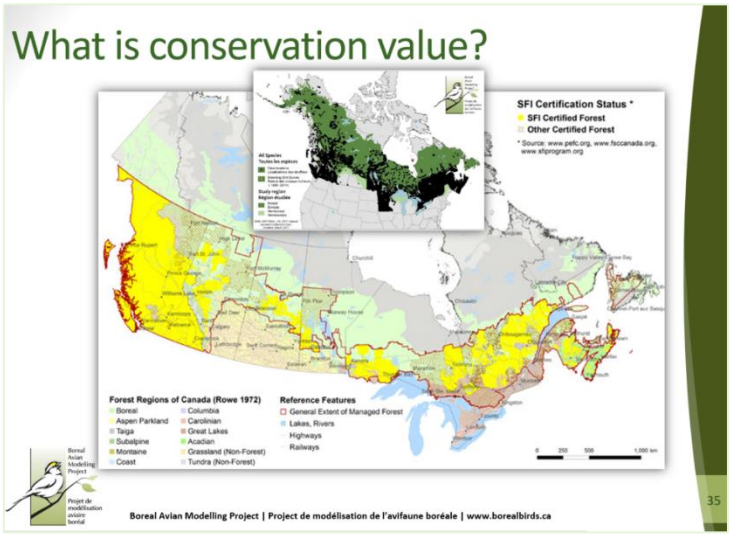
Stralberg DS*, Sólymos P, Barker NK, Bayne E, Schmiegelow FK, Song S. The end of the road: Challenges and solutions for avian abundance modeling in the remote North American boreal region. Invited presentation in symposium entitled "Advances in Citizen Science for Conservation & Management" at the American Ornithological Society meeting. 2018 Apr 13: Tucson, AZ, USA.

Tremblay J*, Boulanger Y, Cyr Dominic, Taylor AR, Price DP, Stralberg D, Sólymos P. Regional Applications: Spatio-temporal simulations of boreal bird habitats under climate change contexts. Talk at the BAM/SFI Birds & Forestry Workshop. 2017 Oct 25: Edmonton, AB, Canada. (audience: 39)

Van Wilgenburg SL*, Sólymos P, Kardynal KJ, Frey M. 2017. Paired sampling standardizes point count data from humans and acoustic recorders. Talk at the joint meeting of the American Ornithological Society and Canadian Society of Ornithologists. 2017 Aug 1-5: East Lansing, MI, USA. (audience: 40)

Westwood A, Lambert D, Reitsma L*. 2017. Bridging the research-management divide: A collaborative spatial approach to conservation for species at risk using the Canada Warbler (*Cardellina canadensis*). Poster at the joint meeting of the American Ornithological Society and Canadian Society of Ornithologists. 2017 Aug 2: East Lansing, MI, USA.

✳ Webinars & Workshops



Birds and Forest Management Meet & Greet with the Boreal Avian Modelling (BAM) Project. Side Event at the 2017 Sustainable Forestry Initiative Annual Conference. 2017 Sep 29: Ottawa, ON, Canada. (audience: 17)

BAM/SFI Birds & Forestry Workshop. Workshop organized by the Boreal Avian Modelling Project. 2017 Oct 25-26: Edmonton, AB, Canada. (participants: 39)

Climate-change refugia in Boreal North America: what, where, and for how long? Scientific workshop organized by Diana Stralberg with support from BAM steering committee (sponsored by the Wilburforce Foundation and the Canadian Forest Service). 2018 28 Feb-1 Mar: Edmonton, AB, Canada. (participants: 31)

Flash Overview of the Boreal Avian Modelling Project. Webinar co-organized by the Boreal Avian Modelling Project and the Sustainable Forestry Initiative. 2017 Oct 11: Online. (audience: 45)


Photo: Jeff Ball

Project Management

All BAM activities are supported by essential project management tasks, including the creation and revision of long-term institutional structure and legacy, coordination of team members and work plans, solicitation of funding, and other administrative duties.

Team Infrastructure

In 2017-18, the BAM team grew by seven people, many with no prior experience or knowledge of BAM's database, functioning, or methods. This past year, our Coordinating Scientist began creating guides to support smooth functioning of our now 27-member team.

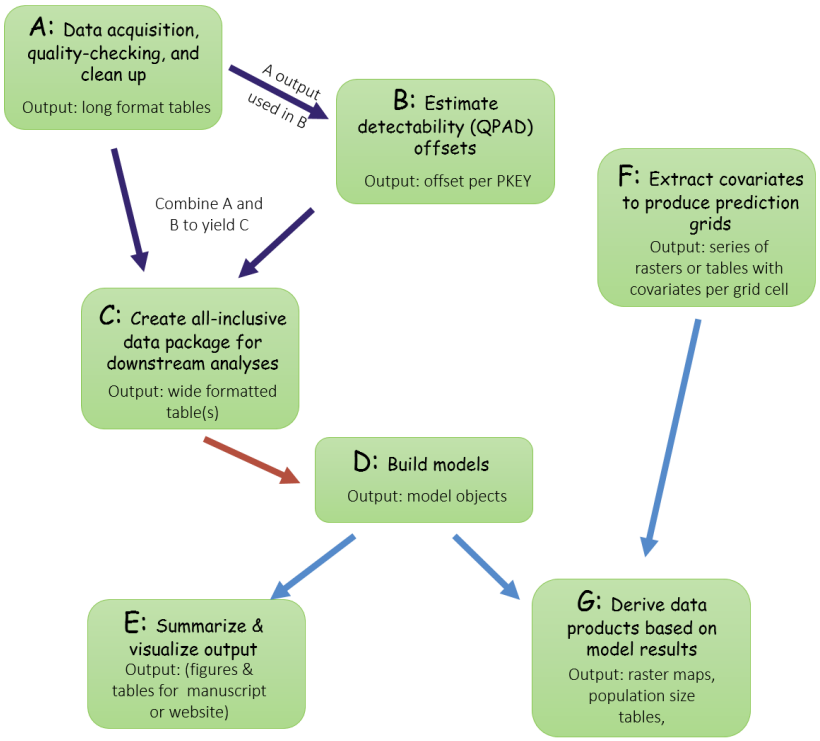
❊ "BAM Guide": Orientation and frequently asked questions for new team members

Many new BAM team members have the same questions. We began collecting these questions and their answers into a centralized, secure location. This BAM Guide Wiki can be accessed by BAM Team members, with specific URLs for each question. This provides a standardized set of procedures, and improves efficiency because the same question is now answered only once instead of every time a new team member joins.

This Wiki will be an ever-growing reference guide to which any BAM Team Member can contribute. [CORE project. Contact: Nicole Barker].

❊ Centralized data and scripts

When our team was smaller and team members worked on non-overlapping projects, individuals tended to interact with the data and scripts in their own way. Now that we're building on previous work and many team members are contributing to the same larger project, we needed to find a new approach. We have therefore moved towards centralized (password-protected) access to the BAM database for all BAM Team Members. We also encourage team members to keep their R code on GitHub to facilitate collaboration and sharing.



In 2017-18, we held training sessions to acquaint newer BAM team members with the BAM Database, Git, GitHub, and GitKraken. We also created tutorials on GitHub to help team members access the database. In 2018-19, we will continue expanding our selection of tutorials. Furthermore, each script written by a BAM team member is expected to be sufficiently transparent for other BAM team members to understand and replicate it. This will

improve team efficiency and collaboration capacity; facilitation of collaboration with external parties is also anticipated. [CORE project. Contact: Nicole Barker].

❊ Strategic planning

Since BAM was formed over 10 years ago, changes have occurred within the team and in the surrounding landscape of North American bird research and conservation initiatives. To reevaluate our place in this landscape, BAM's Steering Committee has initiated a strategic planning effort, facilitated by BAM's Coordinating Scientist. The effort will involve reflection on BAM's goals and vision, as well as strategies to achieve our goals. In 2017-18, we initiated stage one of our strategic planning, articulating Vision, Mission, and Values (page 6). In 2018-19, we will continue with the rest of the exercise, culminating with a written document outlining BAM's Strategic Plan. The intent of this document is to provide clarity, direction, and focus for our team members and collaborators. [CORE project. Contact: Nicole Barker].

The Structure of the BAM Project

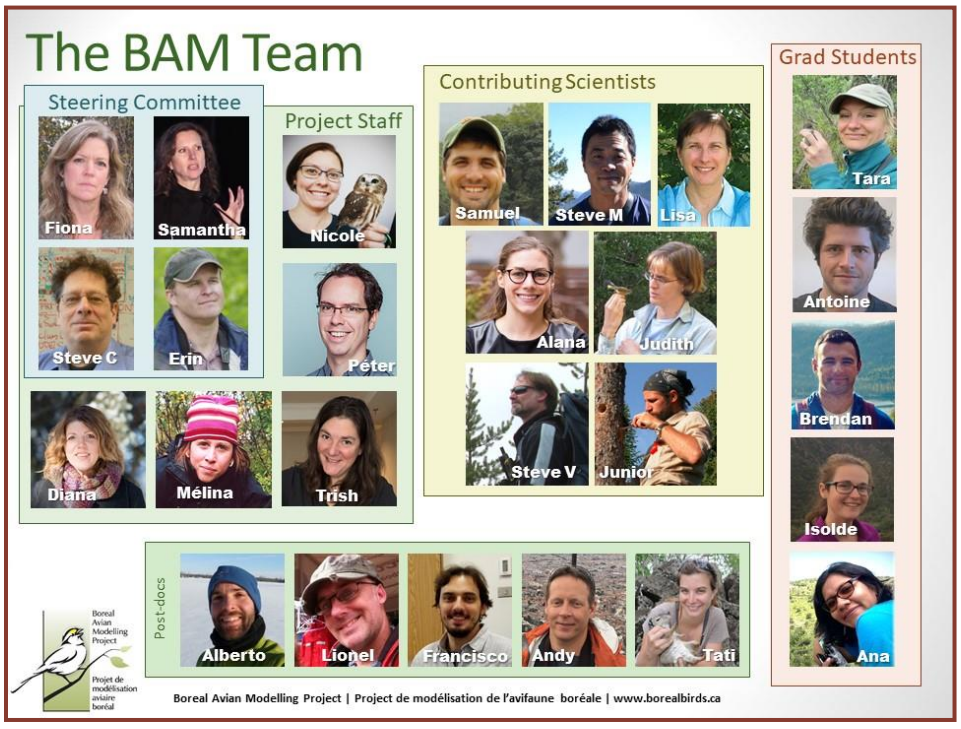
The BAM Team

The BAM Project is supported by a core team of researchers, staff, and students, as well as extensive contributions of time, expertise, data and financial support from many partners and organizations.

❊ Project Team

Steering Committee

- Erin Bayne, University of Alberta
- Steve Cumming, Université Laval
- Fiona Schmiegelow, University of Alberta
- Samantha Song, Environment & Climate Change Canada



Project Staff

- Coordinating Scientist: Nicole Barker, full-time. nbarker@ualberta.ca
- Database Manager: Mélina Houle, part-time. houle.melina@gmail.com
- Statistical Ecologist: Péter Sólymos, part-time. solymos@ualberta.ca
- Project Ecologist: Diana Stralberg, part-time. stralber@ualberta.ca
- Database Manager: Trish Fontaine, part-time

Post-doctoral Fellows: BAM welcomes Andy Crosby and Tati Micheletti, our new post-doctoral fellows. Both are associated with the NSERC Strategic Partnership Grant about sustainable forest management (page 18).

- Andy Crosby. crosby@ualberta.ca
- Francisco Dénes. voeroesd@ualberta.ca
- Lionel Leston. leston@ualberta.ca
- Tati Micheletti. tati.micheletti@triade.org.br
- Alberto Suarez Esteban. suarezes@ualberta.ca

Students: BAM welcomes four new graduate students to the BAM team, all associated with the NSERC Strategic Partnership Grant about sustainable forest management (page 18).

- PhD candidate with Fiona Schmiegelow: Tara Stehelin. tstehelin@yukoncollege.yk.ca
- MSc student with Erin Bayne and Steve Cumming: Brendan Casey. bgcasey@ualberta.ca
- PhD student with Marcel Darveau and Steve Cumming: Antoine Adde. antoine.adde.1@ulaval.ca
- PhD student with Steve Cumming and Eliot McIntire: Ana Raymundo. angeles-ana-paula.raymundo-sanchez.1@ulaval.ca
- PhD student with Frédéric Raulier and Steve Cumming: Isolde Lane Shaw. rachel-isolde.lane-shaw.1@ulaval.ca

Contributing Scientists: BAM welcomes Junior Tremblay as our latest contributing scientist

- Samuel Haché, Wildlife Biologist, Northern CWS. samuel.hache@canada.ca
- C. Lisa Mahon, Wildlife Biologist, Northern CWS. lisa.mahon@canada.ca
- Steve Matsuoka, Research Biologist, United States Geological Survey. smatsuoka@usgs.gov
- Judith Toms, Wildlife Biologist, Prairie CWS. judith.toms@canada.ca
- Junior Tremblay, Research Scientist, S&T-Wildlife Research Division. junior.tremblay@canada.ca
- Steve Van Wilgenburg, Wildlife Biologist, Prairie CWS. steven.vanwilgenburg@canada.ca
- Alana Westwood, Yellowstone to Yukon Conservation Initiative. a.westwood@dal.ca

Technical Committee

BAM's Technical Committee, composed of established avian researchers across boreal North America, serves to provide independent scientific advice to BAM.

- Marcel Darveau, Ducks Unlimited Canada / Université Laval
- André Desrochers, Université Laval
- Pierre Drapeau, Université du Québec à Montréal
- Charles Francis, CWS
- Colleen Handel, United States Geological Survey
- Keith Hobson, University of Western Ontario
- Craig Machtans, CWS Northern
- Julienne Morissette, Northern Forestry Centre
- Gerald Niemi, University of Minnesota – Duluth
- Rob Rempel, Ontario Ministry of Natural Resources & Forestry / Lakehead University
- Stuart Slattery, Ducks Unlimited Canada
- Phil Taylor, Acadia University
- Lisa Venier, Great Lakes Forestry Centre

- Pierre Vernier, University of British Columbia
- Marc-André Villard, Université du Québec à Rimouski

Support Team

Many additional people provide time and expertise to BAM project activities. This year, we would like to recognize the contributions of the following individuals:

- Connie Downes, Marie-Anne Hudson, and Kate Campbell (CWS): BBS data support
- Nash Goonewardena, Ian Paine, Michael Abley, Christie Nohos, Andrea Gougeon, Marina Offengenden, Marilyn Johnson (University of Alberta): Technical and administrative support
- Paul Morrill, Genevieve Beaulieu, Brad Grier: website design, programming, and support
- Denis Lepage and Catherine Jardine (Bird Studies Canada): Atlas data support
- Brendan Ward (Conservation Biology Institute): Data Basin support
- Laura Garland (University of Alberta): Data management support

Partnerships

Our partners have made important contributions to the success of the BAM project by providing avian data, access to environmental covariates, and financial support. The BAM project would not exist without the generous contributions of its funding and data partners. If you notice any errors, please inform the Coordinating Scientist (nbarker@ualberta.ca) as soon as possible so they can be corrected.

Funding Partners

We are grateful to the following organizations that have provided funding to the BAM Project:

Founding organizations and funders

Environment & Climate Change Canada
University of Alberta
BEACONs

Financial support to BAM in 2017-18

Aboriginal Fund for Species at Risk (AFSAR; project with Moose Cree First Nation)
Alberta Forest Products Association (AFPA)
Alberta Pacific Forest Industries Inc. (Al-Pac)
Boreal Ecosystems Analysis for Conservation Networks (BEACONs)
Boreal Songbird Initiative (BSI)
Canadian Forest Products Ltd. (Canfor)
Council of Forest Industries (COFI)
Environment & Climate Change Canada (ECCC)
Fuse Consulting
Mitacs Accelerate Program
Natural Sciences and Engineering Research Council of Canada (NSERC)
Oil Sands Monitoring (OSM)
Sustainable Forestry Initiative (SFI)
Northwest Boreal Landscape Conservation Cooperative (NWB LCC)
Université Laval
University of Alberta
Wilburforce
West Fraser Timber Co. Ltd.

Financial support for CASFRI

ECCC (within the Boreal Avian Modelling Project)
GEOIDE Network
Canada Foundation for Innovation
NSERC Discovery Grant
NRCan
Sustainable Forest Management Network
Nature Conservancy

Data Partners

The following institutions and individuals have provided or facilitated provision of bird and environmental data to the Boreal Avian Modelling Project. If you notice a name is missing, please inform the Coordinating Scientist (nbarker@ualberta.ca) so we can correct the omission.

❊ Avian Data

Institutions: Acadia University; Alaska Bird Observatory; Alaska Natural Heritage Program; Alaska Science Center; Alberta Biodiversity Monitoring Institute; Alberta Pacific Forest Industries Inc.; AMEC Earth & Environmental; AREVA Resources Canada Inc.; Avian Knowledge Network; AXYS Environmental Consulting Ltd.; BC Hydro; Bighorn Wildlife Technologies Ltd.; Bird Studies Canada; Canadian Natural Resources Ltd.; Canadian Forest Products Ltd.; Daishowa Marubeni International Ltd; Devon Canada; Environment and Climate Change; Fish & Wildlife Compensation Program; Golder Associates Ltd.; Government of British Columbia – Ministry of Environment & Climate Change Strategy; Government of Yukon; Hinton Wood Products; Hydro-Québec Équipement; Interfor; Kluane Ecosystem Monitoring Project; Komex International Ltd.; Louisiana Pacific Canada Ltd.; Manitoba Breeding Bird Atlas; Manitoba Hydro; Manitoba Model Forest Inc.; Manning Diversified Forest Products Ltd.; Maritimes Breeding Bird Atlas; Matrix Solutions Inc. Environment & Engineering; MEG Energy Corp.; Mirkwood Ecological Consultants Ltd.; NatureCounts; Ontario Ministry of Natural Resources; OPTI Canada Inc.; PanCanadian Petroleum Limited; Parks Canada (Mountain National Parks Avian Monitoring Database); Petro Canada; Pope & Talbot Ltd.; Principal Wildlife Resource Consulting; Regroupement Québec Oiseaux; Rio Alto Resources International Inc.; Saskatchewan Environment; Shell Canada Ltd.; STRIX Ecological Consulting; Suncor Energy Inc.; Tembec Industries Inc.; Tolko Industries Ltd.; U.S. Army; U.S. Fish and Wildlife Service; U.S. Geological Survey, Alaska Science Center; U.S. National Park Service; Université de Moncton; Université du Québec à Montréal; Université du Québec en Abitibi-Témiscamingue; Université Laval; University of Alaska, Fairbanks; 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: K. Aitken, A. Ajmi, B. Andres, J. Ball, E. Bayne, P. Belagus, S. Bennett, R. Berger, M. Betts, J. Bielech, A. Bismanis, R. Brown, M. Cadman, D. Collister, M. Cranny, S. Cumming, L. Darling, M. Darveau, C. De La Mare, A. Desrochers, T. Diamond, M. Donnelly, C. Downs, P. Drapeau, M. Drever, C. Duane, B. Dube, D. Dye, R. Eccles, P. Farrington, R. Fernandes, M. Flamme, D. Fortin, K. Foster, M. Gill, T. Gotthardt, N. Guldager, R. Hall, C. Handel, S. Hannon, B. Harrison, C. Harwood, J. Herbers, K. Hobson, M-A. Hudson, L. Imbeau, P. Johnstone, V. Keenan, K. Koch, M. Laker, S. Lapointe, R. Latifovic, R. Lauzon, M. Leblanc, L. Ledrew, J. Lemaitre, D. Lepage, K. Lewis, B. MacCallum, P. MacDonell, C. Machtans, K. Martin, S. Mason, C. McIntyre, M. McGovern, D. McKenney, L. Morgantini, J. Morton, G. Niemi, T. Nudds, P. Papadol, M. Phinney, D. Phoenix, D. Pinaud, D. Player, D. Price, R. Rempel, A. Rosaasen, S. Running, R. Russell, C. Savignac, J. Schieck, F. Schmiegelow, D. Shaw, P. Sinclair, A. Smith, S. Song, K. Sowl, C. Spytz, D. Swanson, S. Swanson, P. Taylor, S. Van Wilgenburg, P. Vernier, M-A. Villard, D. Whitaker, T. Wild, J. Witiw, S. Wyshynski, M. Yaremko.

Breeding Bird Atlas: We thank the Breeding Bird Atlas Projects of British Columbia, Manitoba, Maritimes, Ontario, and Québec for supplying data, the thousands of volunteers involved in the data collection, the regional coordinators, as well as the various atlas project partners: BC Field Ornithologists, BC Nature, Biodiversity Centre for Wildlife Studies, Bird Studies Canada, British Columbia Ministry of Environment, Federation of Ontario Naturalists, Louisiana Pacific, Manitoba Conservation, Nature Manitoba, The Manitoba Museum, Manitoba Hydro, The Nature Conservancy of Canada, Natural History Society of Prince Edward Island, Nature NB, Nova

Scotia Bird Society, Nova Scotia Department of Natural Resources, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, Pacific Wildlife Foundation, Prince Edward Island Department of Natural Resources, Regroupement Québec Oiseaux.

Breeding Bird Survey: We would like to also thank the hundreds of skilled volunteers in Canada and the US who have participated in the BBS over the years and those who have served as State, Provincial, or Territorial coordinators for the BBS.

❊ Biophysical Data

Institutions: BirdLife International & NatureServe; Global Land Cover Facility; Natural Resources Canada - Canada Centre for Remote Sensing & Canadian Forest Service; Numerical Terradynamic Simulation Group at the University of Montana.

Common Attribute Schema for Forest Resource Inventory (CASFRI): Alberta Pacific Forest Industries Inc.; Canadian Forest Products Ltd.; Forsite Consultants, Ltd.; Louisiana Pacific Canada Ltd.; Tolko Industries Ltd.; West Fraser Timber Co. Ltd.; Weyerhaeuser Company Ltd.; Blue Ridge Lumber; Buchanan Forest Products; Cenovus Energy Inc.; Daishowa Marubeni International Ltd.; Millar Western Forest Products Ltd.; Mistik Management Ltd.; Tembec Industries Inc.

Government of Alberta - Environment and Parks (formerly Environment and Sustainable Resource Development); Government of British Columbia - Forests, Lands & Natural Resource Operations; Government of Canada - Department of National Defence, Parks Canada Agency, Prince Albert National Park, Park, Wood Buffalo National Park; Government of Manitoba - Conservation and Water Stewardship; Government of New Brunswick - Natural Resources; Government of Newfoundland & Labrador - Natural Resources; Government of Nova Scotia - Natural Resources; Government of Ontario - Natural Resources; Government of PEI - Communities, Land and Environment (formerly Environment, Energy and Forestry); Gouvernement du Québec, Ministère de la Faune, de la Flore et des Parcs; Government of Saskatchewan - Environment; Government of the Northwest Territories - Environment and Natural Resources; Yukon Government - Energy, Mines and Resources.

References

Ball, J., P. Sólymos, F. Schmiegelow, S. Hache, J. Schieck, and E. Bayne. 2016. Regional habitat needs of a nationally listed species, Canada Warbler (Cardellina canadensis), in Alberta, Canada. Avian Conservation and Ecology 11.

Barker, N. K. S., S. G. Cumming, and M. Darveau. 2014. Models to predict the distribution and abundance of breeding ducks in Canada. Avian Conservation and Ecology 9.

Boreal Avian Modelling Project. 2016. Annual Report - April 2015-March 2016. BAM Annual Report, Boreal Avian Modelling Project, University of Alberta, Edmonton, AB, Canada.

Dénes, F., N. K. S. Barker, F. K. A. Schmiegelow, K. St-Laurent, A. R. Westwood, S. Haché, S. J. Song, P. Sólymos, and D. Stralberg. *in prep.* Critical habitat identification for boreal birds in Canada: Challenges, current practices, and a conceptual framework.

Environment Canada. 2012. Recovery Strategy for the Woodland Caribou (*Rangifer tarandus caribou*), Boreal population, in Canada. Environment Canada, Ottawa, ON, Canada.

Haché, S., P. Sólymos, T. Fontaine, D. Stralberg, N. K. S. Barker, A. Suárez-Esteban, A. R. Westwood, F. Dénes, E. M. Bayne, S. G. Cumming, F. K. A. Schmiegelow, and S. J. Song. *in prep.* Breeding density and population trend of a widely-distributed neotropical migratory songbird, the Canada Warbler (*Cardellina canadensis*). Journal of Applied Ecology.

Knight, E. C., and E. M. Bayne. 2017. Habitat Selection at Different Scales for a Declining Aerial Insectivorous Bird as Determined by Autonomous Recording Technology. Applied Research Reports, Alberta Biodiversity Monitoring Institute, Edmonton, AB, Canada.

Knight, E., K. Hannah, G. Foley, C. Scott, R. Brigham, and E. Bayne. 2017. Recommendations for acoustic recognizer performance assessment with application to five common automated signal recognition programs. Avian Conservation and Ecology 12.

Leston, L., E. M. Bayne, C. L. Mahon, P. Sólymos, J. R. Ball, J. Schieck, F. K. A. Schmiegelow, and S. J. Song. *in review.* Assessing the ability of local-scale models to predict cumulative effects on boreal birds at landscape scales. Avian Conservation and Ecology.

Leston, L., E. Bayne, and F. Schmiegelow. 2018. Long-term changes in boreal forest occupancy within regenerating harvest units. Forest Ecology and Management 421:40–53.

Lisgo, K., F. K. A. Schmiegelow, P. Vernier, M. Edwards, and A. Suárez-Esteban. 2017. Ecological Benchmarks to Support Landscape Conservation Design in the Northwest Boreal LCC Planning Region. BEACONs Project, University of Alberta, and Yukon College, Whitehorse, YT, Canada.

Matsuoka, S. M., J. C. Hagelin, M. A. Smith, T. F. Paragi, A. L. Sesser, and M. A. Ingle. *in review.* Pathways for avian science, conservation, and management in boreal Alaska. Avian Conservation and Ecology.

Roy, C., N. Michel, C. Burkhalter, K. Gurney, C. Handel, D. Messmer, K. Princé, C. Rushing, J. Saracco, R. Schuster, A. Smith, P. Smith, Sólymos, Péter, L. Venier, S. L. Van Wilgenburg, and B. Zuckerberg. *under revision.* Trajectories, trends, and cycles in boreal avian populations: how can we recover trends and cycles from noisy data? Avian Conservation and Ecology.

Schmiegelow, F. K. A., C. S. Machtans, and S. J. Hannon. 1997. Are boreal birds resilient to forest fragmentation? An experimental study of short-term community responses. Ecology 78:1914–1932.

Sólymos, P., ABMI, and BAM. 2018a. cure4insect: Custom Reporting for Intactness and Sector Effects. R package version 0.1-1.

Sólymos, P., S. M. Matsuoka, E. M. Bayne, S. J. Song, F. K. A. Schmiegelow, S. G. Cumming, S. Haché, D. Stralberg, S. L. Van Wilgenburg, F. Dénes, and A. D. Crosby. *in prep.* At the end of the road: Lessons from estimating population sizes of boreal birds in Alberta, Canada. TBD.

Sólymos, P., S. M. Matsuoka, S. G. Cumming, D. Stralberg, P. Fontaine, F. K. A. Schmiegelow, S. J. Song, and E. M. Bayne. *under revision*. Evaluating time-removal models for estimating availability of boreal birds during point count surveys: sample size requirements and model complexity. Condor.

Sólymos, P., S. M. Matsuoka, D. Stralberg, N. K. S. Barker, and E. M. Bayne. 2018b. Phylogeny and species traits predict bird detectability. Ecography:*early view*.

Stralberg, D., D. Berteaux, C. R. Drever, M. C. Drever, I. Naujokaitis-Lewis, and J. A. Tremblay. *under revision*. Conservation planning for boreal birds in a changing climate: A framework for action. Avian Conservation and Ecology.

Stralberg, D., A. Camfield, M. Carlson, C. Lauzon, A. Westwood, N. K. S. Barker, S. J. Song, and F. K. A. Schmiegelow. *under revision*. Which half? Strategies for identifying priority areas for passerine conservation in Canada's boreal forest. Avian Conservation and Ecology.

Stralberg, D., C. Carroll, J. H. Pedlar, C. B. Wilsey, D. W. McKenney, and S. E. Nielsen. 2018. Macrorefugia for North American trees and songbirds: Climatic limiting factors and multi-scale topographic influences. Global Ecology and Biogeography 27:690–703.

Stralberg, D., S. L. Van Wilgenburg, S. Haché, J. D. Toms, P. Sólymos, E. M. Bayne, S. G. Cumming, and F. K. A. Schmiegelow. *in prep.* Signals of breeding and wintering weather and forest change in boreal bird population fluctuations. Condor.

Suárez-Esteban, A., S. G. Cumming, E. M. Bayne, T. Micheletti, P. Sólymos, S. J. Song, D. Stralberg, and F. K. A. Schmiegelow. *in review*. Anthropogenic disturbances negatively influence boreal forest bird density at multiple spatial scales. Avian Conservation and Ecology.

Westwood, A. R., N. K. S. Barker, A. F. Amos, A. Camfield, K. Cooper, F. V. Dénes, S. Grant, L. McBlane, F. K. A. Schmiegelow, J. I. Simpson, S. M. Slattery, D. J. H. Sleep, J. Wells, and D. Whitaker. *in review*. Conserving boreal birds in Canada through co-production of actionable science: A how-to guide for identifying and engaging the key players. Avian Conservation and Ecology.

Westwood, A. R., D. Lambert, L. Reitsma, and D. Stralberg. *in review*. Bridging the research-management divide: Collaboratively pairing spatial modelling with on-the-ground guidelines to support implementation of recovery action for the Canada Warbler (*Cardellina canadensis*). Avian Conservation and Ecology.

Westwood, A. R., C. Stacier, P. Sólymos, S. Haché, T. Fontaine, E. M. Bayne, and D. Mazerolle. *in review*. How effectively do Maritime national parks protect bird species at risk? Avian Conservation and Ecology.

Boreal Avian Modelling Project

Annual Report April 2017 - March 2018

Contact Us

Boreal Avian Modelling Project
Department of Renewable Resources,
University of Alberta
751 General Services Building
Edmonton, AB T6G 2H1
1.780.492.8343
BorealAvianModellingProject@ualberta.ca

Suggested reference format:

Boreal Avian Modelling Project. 2018. Annual Report - April 2017-March 2018. Boreal Avian Modelling Project, University of Alberta, Edmonton, AB, Canada.

Boreal Avian Modelling Project
Projet de modélisation aviaire boréal

COVER PHOTOS:

Forested background, from Southwest Nova Biosphere Reserve, Nova Scotia: Alana Westwood

Bay-breasted Warbler: Ken Mattison (CC)

Map: Diana Stralberg; explanation on page 13

www.borealbirds.ca