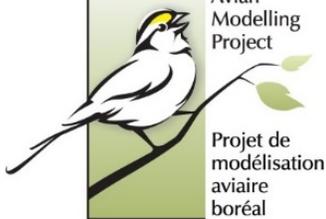


Boreal Avian Modelling Project



Annual Report
April 2018 – March 2019



Highlights from 2018-19

BAM conducts research in avian ecology and conservation, collaborates with other parties to directly inform conservation and management of migratory birds, 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 the coordinated efforts of our widely distributed team.

Here are our main achievements from April 2018 to March 2019.

Research & Monitoring

Boreal Bird Density, Population Size, Temporal Patterns, and Habitat Needs

- ✿ Demonstration of the effect of assumptions regarding detection distance and time-of-day corrections on population size estimation through comparison of BAM methodology with that of Partners in Flight. ► page 10.
- ✿ Improvement of national density modelling approach yields Canada-wide BAM data products for avian density, distribution, habitat-associations, and population sizes; only minor refinements necessary before public release ► page 11.
- ✿ Comprehensive review of waterfowl habitat association literature completed as a prelude to developing new national predictive models; finds consistent significant associations with covariates for water, climate, and vegetation ► page 12.
- ✿ Marked intra-specific differential habitat selection demonstrated for six migratory bird species within managed forests of boreal Canada ► page 13.

Threats Assessment: Impacts of Landscape Change and Climate Change on Boreal Birds

- ✿ Modelling and mapping the effect of forest harvesting from 2000-2012 on species' abundances in boreal Canada, as a prelude to a more comprehensive hind-casting study ► page 15.
- ✿ A long-term forest fragmentation study allowed detection of lagged effects of budworm outbreaks, harvest, and climatic indices on temporal patterns in bird abundances ► page 16.
- ✿ Climate change, harvest, and fire are likely to increase grassland-associated species and reduce coniferous-associated species in northeast Alberta, suggests a regional forest landscape simulation completed in the Forest Management Area (FMA) of Alberta-Pacific Forest Industries Inc. (Al-Pac) ► page 17.
- ✿ Projected bird abundances insensitive to caribou management strategic plans in the Al-Pac FMA, suggests a regional simulation study ► page 18.
- ✿ An incidental take risk assessment tool created by forest companies in Alberta shows a positive correlation between expert-derived ranks and quantitative estimates of bird densities; agreement to integrate spatial density predictions into a new iteration of the tool ► page 18.
- ✿ Climate change projections to 2100 in the northwestern boreal region suggest increased abundances of Western Wood-pewee but decreased abundances of Olive-sided Flycatcher ► page 22.
- ✿ Phenologies of avian insectivore breeding are not synchronous with abundance of their prey, according to ongoing study in the northwestern boreal region ► page 23.

Species at Risk Status, Recovery Planning, and Multi-species Management

- ✿ New methods for delineating spatial units for critical habitat identification developed; demonstrated here for the Canada Warbler ► page 24.
- ✿ Regional models of Canada Warbler density developed for Alberta and Nova Scotia to test a new approach to critical habitat identification co-developed by BAM and ECCC ► page 25.

Conservation Planning for Boreal Birds

- ✿ Regional models for 6 migratory bird species built to support land-use planning for Species at Risk by the Lac Seul First Nation ► page 26.
- ✿ Land-use planning by the Moose Cree First Nation supported by updating regional density models and assessing ecological representation ► page 27.
- ✿ Ecological representation assessed to evaluate potential conservation value for boreal songbirds in forestlands certified by Sustainable Forestry Initiative (SFI); interactive web-application developed to communicate results ► page 29.

Method and Tool Development

- ✿ BAM expert advice supports methodological advancements regarding automatic processing, storing, managing, and human-processing of sound recordings ► page 32.

Applications of BAM Results

BAM results have been applied by partners to facilitate and support conservation and management efforts related to monitoring design, threats assessment and management planning, priority areas assessment, and species at risk planning ► page 5 lists the various applications.

Data Development

- ✿ Products currently available include:
 - *NEW* national climate and vegetation-based density maps for >100 songbird species;
 - *NEW* population size estimates for >100 songbird species;
 - *NEW* habitat associations (densities per habitat type) for >100 songbird species per Bird Conservation Region;
 - *NEW* regional density maps for several species of conservation concern;
 - national climate-based 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 for 53 songbird species;
 - maps of priority areas for conservation of Canada Warbler in Atlantic Northern Forest (Bird Conservation Region 14);
 - maps of species' probabilities of occurrence for 80 species.
- ✿ Email BorealAvianModellingProject@ualberta.ca to make a request ► see page 33 for more details on available products.
- ✿ BAM's updated Avian Database now contains point count data from over 160 projects at more than 250,000 locations across North America ► page 36.
- ✿ In partnership with Alberta Biodiversity Monitoring Institute (ABMI), Bird Studies Canada (BSC), and CWS, BAM is moving towards improved access of avian data in Canada ► page 38.

Collaborations and Communications

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 ► a comprehensive list of collaborative projects starts on page 52.

Communications

- ✿ New BAM website constructed; existing content will be migrated over the next several months and then continuously populated as it is created ► page 42.
- ✿ Publication of 2 BAM core papers, 4 co-produced papers, and 6 BAM informed publications since January 2018 ► page 43.
- ✿ BAM research and conservation efforts showcased in more than 35 talks at international or regional conferences, targeted workshops, webinars, and collaborative meetings since January 2018 ► page 48.

Project Management

- ✿ One staff member (Hedwig Lankau) and one graduate student (Elly Knight) have joined the BAM team, bringing the size of the BAM Team to 26 people ► page 55.



Photo: Jeff Ball

Applications of BAM Results

In 2018-19, we contributed to several on-the-ground conservation and management efforts directly or by supplying data, data products, research findings, or other input.

Boreal landbird monitoring design

- ✿ Point count surveys were conducted within or near the Moose Cree First Nation (MCFN) homelands in summer 2018, following a sampling design created by BAM (part of our collaborative work with MCFN and Nature Canada, page 27).
- ✿ Data collection by forest management companies in Alberta will be influenced by BAM's evaluation of forest types that have not been adequately sampled within BAM's existing dataset (part of the Alberta risk matrix work, page 18).
- ✿ Environment & Climate Change Canada (ECCC)'s Boreal Monitoring Strategy (BMS) is using BAM data, data products, and scientific expertise to inform sampling decisions (page 30).
- ✿ Additional off-road trend monitoring was conducted in Alberta at locations of past point count surveys identified from the BAM database to test the utility of including temporally sporadic remeasurements in trend assessments.

Threats assessment and land-use impacts

- ✿ Alberta-Pacific Forest Industries' (Al-Pac) forest management planning decisions will be shaped by our evaluation of potential implications of caribou conservation for boreal birds (page 18).
- ✿ Decisions by forest companies in Alberta regarding incidental take risk management will be informed by BAM abundance models and data products (page 18).

Identification of priority wildlife areas & protected areas design and evaluation

- ✿ The MCFN, in association with Nature Canada and the WildLands League, will use BAM findings regarding representation of species at risk bird species within their traditional territory in their land-use planning process, and in their Indigenous Protected and Conserved Area (IPCA) proposal for the North French River Watershed (page 27).
- ✿ BAM's representation analysis and associated web-application, created in partnership with the Boreal Ecosystems Analysis for Conservation Networks Project (BEACONS), are contributing to the Sustainable Forestry Initiative's (SFI) understanding of the value of sustainable forest management for conserving avian biodiversity (page 29).

Species at risk conservation and recovery planning

- ✿ Conversations with ECCC are paving the way for broader adoption of BAM and ECCC's co-developed conceptual model for critical habitat identification (page 24).
- ✿ The management units identified by BAM for Canada Warbler have been accepted by ECCC for regional models and subsequent science to inform critical habitat identification (page 25).

Contents

2	Highlights from 2018-19
5	Applications of BAM Results
7	About Us
10	Research & Monitoring
10	Boreal Bird Density, Population Size, Temporal Patterns, and Habitat Needs
15	Threats Assessment: Impacts of Landscape Change and Climate Change on Boreal Birds
24	Species at Risk Status, Recovery Planning, and Multi-species Management
26	Conservation Planning for Boreal Birds
30	Boreal Landbird Monitoring Design
31	Method & Tool Development
33	Data Development
33	Data Products
36	Databases
40	Collaborations & Communications
40	Conservation of Boreal Birds Special Issue
42	Outreach & Publications
52	BAM Collaborative Activities at a Glance
55	Project Management
55	The Structure of the BAM Project
57	Partnerships
60	References

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
Méline Houle, U.Laval.....Database Manager
Hedwig Lankau, U.Alberta.....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

Antoine Adde, U.Laval..... PhD Student
Brendan Casey, U.Alberta..... PhD Student
Elly Knight, U.Alberta..... PhD 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
Junior Tremblay, ECCC.....Contributing Scientist
Steve Van Wilgenburg, ECCC.....Contributing Scientist

Technical Committee

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

About Us

Our Vision

Conservation of North American boreal-breeding birds and their habitats is guided by rigorous, credible, and collaborative science. BAM believes that North American bird populations can be recovered and sustained through thoughtful actions based on data-driven science.

Our Mission

BAM develops high quality scientific information, products, and guidance addressing pressing management needs. We pursue our vision of conserving North American boreal-breeding birds by providing data-driven science that fills information gaps to guide conservation action. We seek to understand species' large-scale habitat needs and the impacts of human activities, informing both regional and continental conservation.

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. **QUANTIFY** and **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 Project (BAM) was initiated in 2004 to address knowledge gaps associated with the management and conservation of boreal birds in North America.

BAM is built on the foundation of boreal bird data. The BAM database was created by collating and harmonizing avian data from the Breeding Bird Survey, Breeding Bird Atlases, and individual research, monitoring, and inventory efforts conducted across the Canadian and US boreal and hemi-boreal region.

BAM is working to develop rigorous analytical model-based approaches to support the conservation of the boreal forest region and the bird populations and communities that depend upon it. We have developed specialized statistical approaches to harmonize these datasets by correcting for survey methodology and species detectability to estimate density.

BAM models have a myriad of applications: they allow us to draw relationships between birds and their environment (e.g. vegetation, climate, disturbance) from regional to national scales, to predict their response to changes through time and across geographic areas, to explain population trends, to determine which habitats are important and why, to design monitoring efficiently and effectively, to assess how management decisions made now may affect birds in the future...just to name a few.

Our Structure

The BAM Project Team is comprised of academic researchers, government scientists, project staff, postdoctoral fellows, and graduate students

BAM is jointly coordinated by a Steering Committee, which advises on BAM's scientific direction, merit, and relevance. Day-to-day management is overseen by our Coordinating Scientist. Project execution is facilitated by a dedicated team of staff, post-doctoral fellows, and graduate students. Contributing Scientists provide expert advice and are involved in co-production of relevant science.

A National Technical Committee of boreal bird researchers from across the North American boreal and hemiboreal facilitates data-sharing and project collaboration. The collaborative nature of the project is further highlighted by the other individuals who have provided project assistance, input, and support over the years.

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 continue with the 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.

Learn more at www.borealbirds.ca

Proposed Major Activities for November 2016 – March 2019

We proposed projects in three parallel but inter-connected domains: 1) research & monitoring, 2) data development, and 3) collaboration & outreach, with several projects in each domain. In November 2016, we identified the following major activities:

Research & Monitoring

- Methods to Inform Critical Habitat Identification
- Detecting and Attributing Changes in Boreal Bird Breeding Populations
- Forecasting Future Bird Distributions & Populations
- Supporting Boreal Conservation and Management
- Advancing Methods
- Informing Monitoring Design

Data Development

- Expansion, Maintenance, and Accessibility of BAM Data and Products

Collaboration & Outreach

- Collaborations
- Outreach

Summaries of progress on these activities and others since November 2016 are provided below. In some cases, earlier progress is described to provide context.



Photo: Nicole Barker

Research & Monitoring

BAM's research contributes to conservation and management of boreal birds by providing the best available information and by advancing the theoretical foundations underpinning conservation and management within the boreal region.

Here we describe progress on our research projects from April 2018 - March 2019.

Boreal Bird Density, Population Size, Temporal Patterns, and Habitat Needs

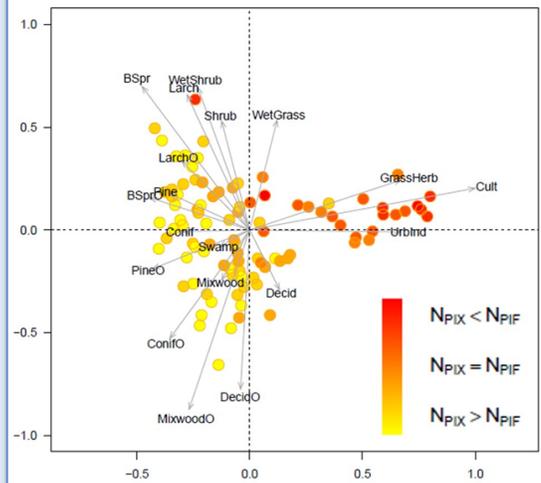
Models and products to support status assessment

Overview: A large part of BAM's effort is dedicated to developing approaches to estimate density, population size, and trend using heterogeneous datasets. In recent years, we have made significant progress towards an updated national modelling approach, which will yield new data products to support status assessment.

We finished a manuscript describing our method of estimating population size using Alberta as a test case, developed and tested our new generalized modelling approach, and completed a review of important environmental variables for waterfowl breeding distribution and abundance as part of a PhD thesis. Forthcoming data products include: population estimates for birds in Alberta; national density maps; national population estimates; and habitat-specific density estimates.

☛ Detection distance correction, habitat representation, and roadside bias influence population size estimates

Since the early 2010s, we have tested and developed various methods to accurately and reliably estimate population sizes of North American boreal birds. In 2018-19, we completed a regional comparison of BAM population estimates to Partners in Flight (PIF) population estimates, where we quantified the effects on population estimates of detectability, roadside bias, and other factors (see box for more details). We submitted a manuscript to *Condor* in early May 2019. [[CORE project](#). Contact: Péter Sólymos]



Land cover associations for 95 landbird species breeding in northern Alberta. Population sizes were estimated using the Partners in Flight (PIF) approach or a spatially explicit (PIX) approach: red/yellow colouring intensity of species names indicates the difference between the two estimates - colours follow a forest-to-open-fields gradient.

Detection distance correction, habitat representation, and roadside bias influence population size estimates: Knowing species' population sizes can help to evaluate the potential impact of anthropogenically caused mortality and to establish numerical population targets for managed populations.

We compared Alberta population size estimates derived from spatially explicit models (PIX) to those from the current Partners in Flight (PIF) approach, and developed a framework to attribute differences to detection distance, time-of-day, roadside count, and habitat representation components. These four aspects correspond to key assumptions of the PIF approach.

We found that key assumptions of the PIF approach were commonly violated. Differences in detection distance and correction for time-of-day explained much of the average difference in the two sets of population size estimates, but these adjustments left substantial unexplained inter-species variation. The roadside count and habitat representation components contributed among-species variation sufficient to change the population size ranking of the species.

Our results suggest that roadside count bias needs serious attention when roadside surveys are used to extrapolate over off-road areas. Habitat representation bias is likely prevalent in regions sparsely and non-representatively sampled by roadside surveys, such as the boreal region, and thus population size estimates for these regions need to be treated with caution for species showing large roadside bias.

Detection Distance	Accounts for much of difference between the methods
Time of Day	
Roadside Count	Substantial inter-species variation
Habitat Representation	

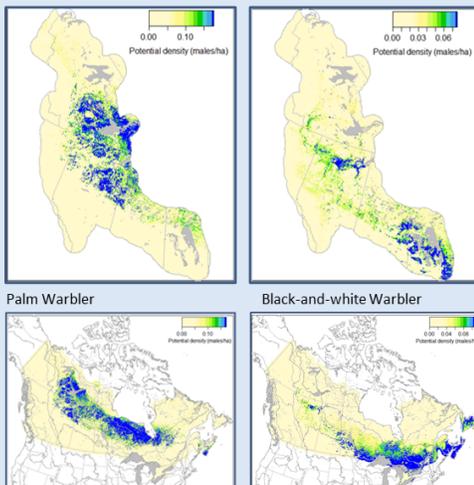


In Review. Contact: Péter Sólymos solymos@ualberta.ca

Testing a new generalized approach for making density maps, population estimates, and habitat-specific densities

One of BAM's primary goals is to provide national-scale species' density models. Previous efforts to model species' density and population sizes at national scale were time-consuming and labour-intensive. In 2017-18, we decided on a machine-learning approach for our next generation of density maps and population estimates. In 2018-19, we initiated these generalized national models in two test regions: Quebec and Bird Conservation Region 6 Boreal Taiga Plains (see box for more details on methods and results). We have

Sample density predictions based on models developed regionally by BCR and then stitched together to generate national coverage.



Testing a new generalized approach to generate density maps, population estimates, and habitat-specific densities: The development of habitat-specific density predictions at national extent poses several challenges: (1) Boreal birds are thought to have different habitat associations in different regions; (2) Predicting distributions over large areas requires fitting complex climate responses; (3) Dynamic habitat conditions of importance to boreal birds are not well described by static landcover classes.

To address these challenges, we have begun rolling out a new approach to model-building and prediction, which involves: (1) regional model development by spatial units; (2) a machine-learning approach to model-fitting and validation (boosted regression trees); and (3) the use of continuous, time-matched covariates as predictor variables.

The Phase 1 models are built for buffered and overlapping bird conservation regions (BCRs) and are based on tree species biomass and stand age for two distinct time periods (2000-2005 and 2006-2018), as well as topography, land use, and climate. Phase 2 models will be based on satellite imagery-derived annual indices, and will use smaller spatial units to improve temporal and spatial specificity. This project relied heavily on ARU data from remote locations, which involved converting ARU observations to point-count-equivalent data.

The primary purpose of these models is to derive: (1) spatially explicit density estimates; (2) population estimates by all combinations of BCR, province, and landcover stratum; (3) trend estimates by BCR and province. In addition, however, models will also be used as inputs to landscape change scenarios, to inform previously unknown abundance patterns and range limits, and to inform conservation planning priorities.



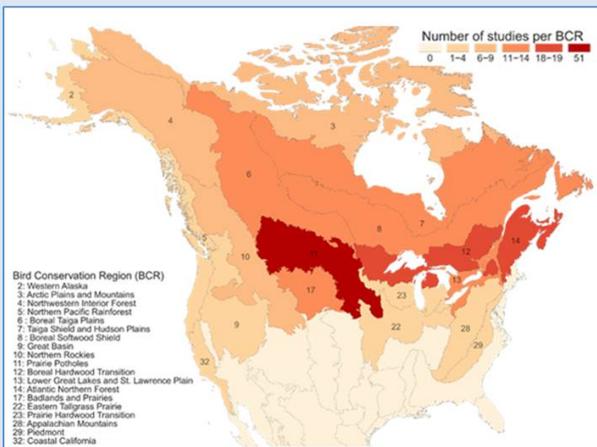
Work in progress. Contact: Péter Sólymos solymos@ualberta.ca or Diana Stralberg diana.stralberg@ualberta.ca

produced preliminary national products, but further refinement is needed before associated data products are released; we anticipate a release during 2019-20. Modelling efforts for BCR 6 benefited from additional funding from Canadian Wildlife Service (CWS) and are part of a collaboration with Université Laval, the Canadian Forest Service (CFS), CWS, Science & Technology (S&T), and the NWT Department of Environment and Natural Resources (page 21); the Quebec work (not presented) is a collaboration with the CFS and S&T. [CORE project. Contact: Diana Stralberg and Péter Sólymos]

Review of environmental variables influencing waterfowl distribution and abundance

Antoine Adde (BAM PhD student with Marcel Darveau and Steve Cumming, Université Laval) is mapping the abundance and distribution of waterfowl in Canada. A first step was to review the literature to summarize environmental variables known to affect breeding duck distribution and abundance in North America. In 2018-19, the literature review was completed, the work was presented at the North American Congress for Conservation Biology in Toronto, Canada, and a manuscript summarizing findings was drafted (see box for more details on methods and results). In 2019-20, we anticipate submitting the manuscript to Journal of Animal Ecology, Ecosphere, or Avian Conservation & Ecology. This project benefits from an NSERC Strategic Partnership Grant (page 19). This project is a collaboration with Ducks Unlimited Canada (DUC). [CO-PRODUCED project. Contact: Antoine Adde]

Environmental variables influencing waterfowl distribution: More than 40 million ducks migrate every spring to breeding grounds on the northern part of North America, including the prairie pothole and boreal regions (see Figure). Many studies over the last 50 years have sought to identify the environmental factors influencing the abundance and distribution of breeding ducks within these regions, but the results remain scattered through the literature.



Spatial variation in the number of studies from which information was extracted.

We reviewed 124 peer-reviewed studies from North America published between 1960 and 2018, to produce a quantitative summary of their findings, specifically to determine which environmental covariates have most frequently been shown to be correlated with the distribution or abundance of 15 species of breeding ducks. We considered two spatial scales of covariate, individual wetlands, and larger landscapes in which these were embedded.

At both landscape and local scales, wetland covariates were most commonly found to be significantly correlated with the abundance of ducks. The most important covariates were the total area and number of wetlands at the landscape scale, and indices of wetland size, flora, fauna, and water chemistry at the wetland scale. Climate variables were the second most important group of covariates, but covariates for landscape vegetation and landuse were also consistently important. We hope this effort to systematise the research findings to date will support scientists in orientating future research, and decision makers to in developing management and conservation strategies.



Work in progress. Contact: Antoine Adde antoine.adde.1@ulaval.ca

Manuscript describing our national Canada Warbler model updated with trend analyses

In recent years, BAM has tested methods for modelling density and population trends using Canada Warbler as a case study. In 2018-19, Adam Smith (CWS) collaborated on the manuscript summarizing this work, and helped contrast trends calculated using the BAM dataset and methods with those calculated using Breeding Bird Survey (BBS) data and methods. We revised the manuscript to include these new results and anticipate submitting it to a journal in 2019-20. This project is a collaboration with CWS. [CORE project. Contact: Samuel Haché]

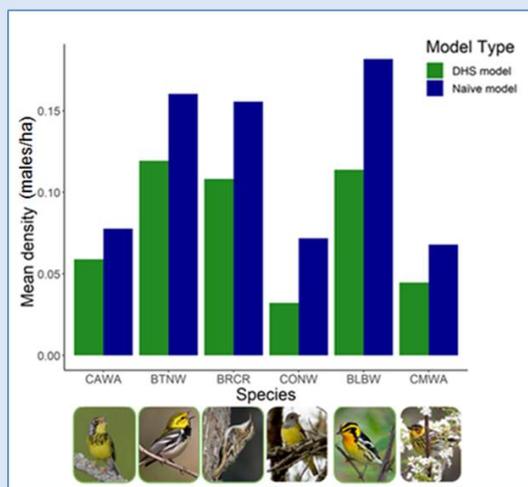
Habitat selection, availability, and needs

Overview: To facilitate and inform conservation and management decisions, BAM quantifies and describes species' habitat needs and how they vary across species' ranges. In recent years, we began to address a long-standing goal of quantifying large-scale regional variation in habitat selection. We also started examining finer-scale habitat modelling via a graduate student project.

In 2018-19, we submitted one of the several manuscripts we expect to come from our evaluation of spatial variation in habitat needs, use, or selection across breeding ranges. We also acquired LiDAR data within Alberta to support evaluation of its utility in small-scale, regional species distribution models.

☛ Differential habitat selection in boreal songbirds influences estimates of population size and distribution

BAM recently revived efforts to document and understand patterns of differential habitat selection for boreal birds. We asked “how do birds of the same species select or use different habitats across their geographic ranges?” in part to facilitate articulation of habitat associations across species' ranges. In 2018-19, we built models to test for differential selection of forest compositional and structural attributes among three regions for six species (see box for more details on methods and results). We submitted a manuscript in November 2018. Future work will apply the model framework across the entire range so that we have models individualized for different areas throughout species' ranges. This project benefits from an NSERC Strategic Partnership Grant (page 19). [**CORE project**. Contact: Andy Crosby]



Mean density estimates across 3 regions of the boreal forest for 6 migratory bird species. Estimates are from a differential habitat selection (DHS) model and a naive model that assumes constant habitat selection among regions.

Differential habitat selection in boreal songbirds influences estimates of population size and distribution: Anecdotal evidence suggests that species might select habitat differently in different parts of their range. Such differences could impact estimates of abundance and distribution.

We used hierarchical Analysis of Covariance models, with region-specific parameter estimates, to test for differential selection for forest compositional and structural attributes among three regions by six boreal bird species. We used the results of these models to quantify intraspecific niche overlap between regions and compared posterior predictive accuracy to models that did not account for Differential Habitat Selection (DHS).

We found strong evidence for DHS among regions for six boreal songbird species in both individual habitat attributes and overall niche space. We found a strong effect of region on selection of specific habitat variables for all six species. The proportion of niche overlap between regions was generally low, and models accounting for DHS had significantly higher posterior predictive accuracy according to the Watanabe-Akaike information criterion. Models that did not account for DHS overestimated density relative to DHS models. The higher predictive accuracy of our DHS models suggests that failure to account for spatial variability in habitat selection can lead to biased estimates of density and spatial distribution.



In Review. Contact: Andrew Crosby crosby@ualberta.ca

☛ Can new remote sensing tools improve species distribution models for birds in Alberta?

Brendan Casey (PhD Student with Erin Bayne, University of Alberta) is evaluating the benefits of using LiDAR-derived vegetation metrics, drone-based photogrammetry, Radarsat, and hyper-spectral imagery in species distribution models, compared to the more common remotely sensed forest attributes. In 2018-19, the Government of Alberta interpreted the LiDAR point cloud and provided metrics for canopy cover, canopy height, shrub density, among others. In 2019-20, this data will be combined with data from the Common Attribute Schema for Forest Resource Inventories (CASFRI) (page 38) and wet areas mapping, to build species distribution models for Canada Warbler, Yellow-rumped Warbler, and Philadelphia Vireo. This project benefits from an NSERC Strategic Partnership Grant (page 19) and is a collaboration with the Alberta Department of Agriculture and Forestry. **[CO-PRODUCED project]**. Contact: Brendan Casey]

.....ରକ୍ଷା.....କରଣ.....



Photo: Anjolene Hunt

Threats Assessment: Impacts of Landscape Change and Climate Change on Boreal Birds

National-scale impacts of land-use change

Overview: One of BAM's objectives is evaluation of the impacts of human activities on boreal bird habitat and populations. In recent years, we have made significant progress on addressing this question at national extent.

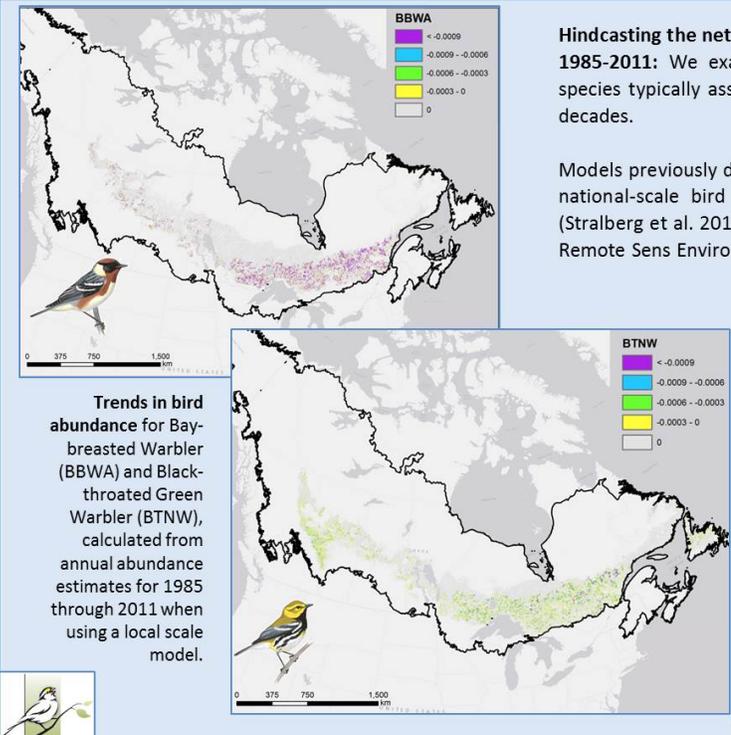
In 2018-19, our manuscript describing impacts of human disturbance on birds at national extent was reviewed, revised, and resubmitted to a special issue in Avian Conservation and Ecology regarding the Conservation of Boreal Birds. We also wrote the model into a Spatial Discrete Event Simulator (SpaDES) module and explored possible historical avian population changes using landscape simulation models.

☛ Effects of anthropogenic disturbances on boreal birds at national extent

One of BAM's long-time goals has been to quantify population consequences of anthropogenic disturbances. In 2018-19, our manuscript regarding impacts of human disturbance on migratory songbird abundances populations at a national extent, submitted to the "Conservation of Boreal Birds" special issue of Avian Conservation & Ecology (page 40), was reviewed, revised, and resubmitted. In 2019-20, we will develop and test an integrated version of the model used in these analyses, using a hierarchical Bayesian model structure. [[CORE project](#). Contact: Tati Micheletti]

☛ Hindcasting the net effect of forest harvesting on the abundance of boreal songbirds: 1985-2011

In 2017-18, we expanded on the above study to include a hindcasting effort, which estimates the total effect of anthropogenic disturbances on species abundances within the boreal region of Canada from 2000 to



BBWA

- < -0.0009
- 0.0009 - -0.0006
- 0.0006 - -0.0003
- 0.0003 - 0
- 0

BTNW

- < -0.0009
- 0.0009 - -0.0006
- 0.0006 - -0.0003
- 0.0003 - 0
- 0

Trends in bird abundance for Bay-breasted Warbler (BBWA) and Black-throated Green Warbler (BTNW), calculated from annual abundance estimates for 1985 through 2011 when using a local scale model.

Hindcasting the net effect of forest harvesting on the abundance of boreal songbirds: 1985-2011: We examined whether forest harvest has affected abundance of bird species typically associated with old forests in the boreal region over the past three decades.

Models previously developed by Suarez et al. (*in review ACE ECO*) enable prediction of national-scale bird abundances from 1985 to 2011 based on expected densities (Stralberg et al. 2015 Ecol Appl), and the percentage of disturbance (White et al. 2017 Remote Sens Environ) within 100 m and 500 m buffers from the point count.

By predicting abundances for each year, we can calculate change in annual abundances at each individual pixel, permitting mapping of trends in bird abundance from 1985 to 2011. We did this for two different spatial scales, namely local (100m buffer around the point count) and neighborhood (500m with a 100m annulus from the point count).

This project provides insight into impacts of forestry at local and neighbourhood scales, at pan-Canadian extent. The results might assist forest harvest planning towards more effective protection of bird habitat.

Work in progress. Contact: Tati Micheletti tati.micheletti@gmail.com

2012. In 2018-19, we completed analyses in SpaDES, a new environment for ecological modelling and spatial simulation (Chubaty and McIntire 2018), and started writing the manuscript. Results include maps depicting spatial patterns in trends across species' ranges (see box for more details). In 2019-20, we will submit the manuscript to Global Change Biology. This project benefits from an NSERC Strategic Partnership Grant (page 19), and is a collaboration with the CFS. [**CORE project**. Contact: Tati Micheletti]

..........

Regional-scale forestry case studies

Overview: Given the variation in forest structure and species composition, as well as variation in forest company practices across the country, BAM often develops or refines methodological approaches by using regional case studies. The intent is to generalize findings to the national scale in the future. With several collaborative projects, BAM has made significant progress exploring bird abundance in response to harvest and other factors.

In 2018-19, we refined time series analyses to retrospectively evaluate impacts of harvest, insect outbreaks, and weather on birds within the Calling Lake Fragmentation Project area. We progressed two landscape simulation studies within the Al-Pac Forest Management Area (FMA) exploring impacts of climate change, harvest, fire, and caribou management. We advanced work to understand impacts of residual tree retention on birds. This year saw substantial refinement of grad student projects associated with our NSERC Strategic Partnership Grant focussed on supporting conservation of boreal birds through forest management practices. We also contributed to idea development for a large collaborative birds and forestry initiative in Alberta, led by Erin Bayne.

☛ Long-term monitoring of changes in harvest area, weather, and insect outbreaks on boreal birds at Calling Lake

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. BAM post-doctoral fellow Lionel Leston is using 25 years of experimental forestry data from the Calling Lake Fragmentation Project (~400 km²; Schmiegelow et al., 1997) to evaluate possible influences of harvest, weather, and insects on boreal bird trends (see box for details). In 2018-19, refined analyses were completed (see box for more details on methods and results). In 2019-20, a manuscript will be submitted to a scientific journal. This long-term study has been supported by many organizations and over 100 field assistants during its 25-year history. The analyses presented below benefited from additional support from Al-Pac and an Accelerate grant from Mitacs. [**INFORMED project**. Contact: Lionel Leston]

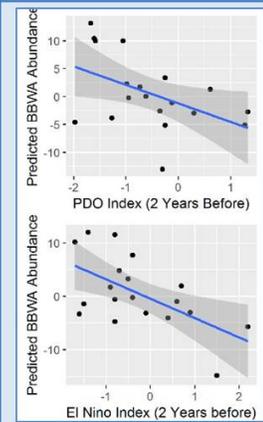


Figure 1. Bay-breasted Warbler abundance declined 2 years after stronger weather events associated with early green-up on breeding grounds (PDO) and drier winter grounds (El Niño index).

Long-term monitoring of changes in harvest area, weather, and insect outbreaks on boreal birds at Calling Lake, AB: Long-term monitoring enables ecologists to identify time-varying and delayed effects of harvest amount, insect outbreaks, and weather events that potentially influence avian survival, productivity, and abundance.

We performed time-series analysis (vector autoregression and panel regression models) on avian point count data from a long-term study at Calling Lake, Alberta (1993-2018). Since 1993, this region has experienced two passes of large-scale harvest in 1994 and 2006, and smaller amounts of harvest in other years.

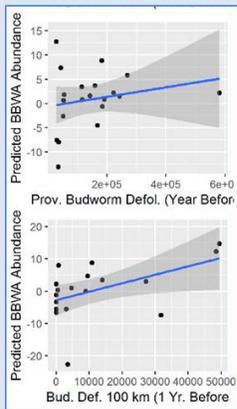


Figure 2. Bay-breasted Warbler abundance increased 1 year after increases in area defoliated by a prey item, spruce budworm, within Alberta and within 100 km of Calling Lake.

We found that bird species associated with older boreal forests were: 1) less abundant at stations with a greater amount of harvested forest within 100-600 m in the same year; and, 2) more likely to increase with time since harvest. In contrast, some species associated with shrub-lands or open lands declined with increasing time since harvest within 100-200 metres of stations. Short-distance migrant and resident species were more likely to respond positively than Neotropical migrant species to weather events associated with earlier spring green up, or weather events producing drier Neotropical wintering grounds conditions (with associated lower plant productivity and food, Figure 1). Several coniferous forest songbirds in the Calling Lake study area increased 1-2 years after increasing area of budworm defoliated forests (in hectares) within 100 km of Calling Lake (Figure 2).

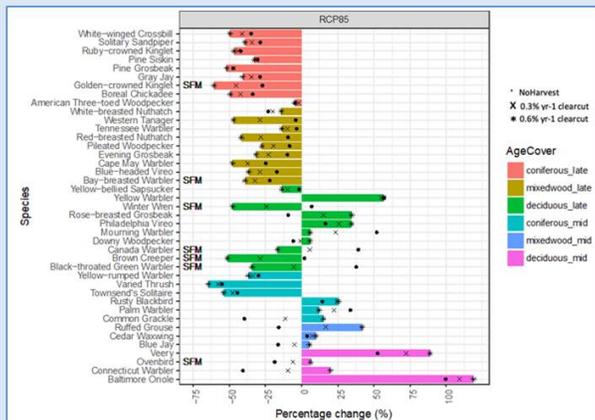
Our study found results consistent with known harvest effects on different species, but also demonstrated how species are affected by environmental changes occurring independently of harvest practices.



Work in progress. Contact: Lionel Leston leston@ualberta.ca

Adverse effects of climate change on boreal bird communities accentuated by natural and anthropogenic disturbances

In 2018-19, we continued efforts to forecast the impacts of climate change on boreal bird communities while considering forest harvest and wildfire. In collaboration with CFS researchers, we executed LANDIS-II Landscape Change Model simulations and described them in a manuscript in preparation for submission



Projected population changes (%) by 2100 for bird species associated with mature and old forest stands in northeastern Alberta based on no harvest (dot), current harvest (X) and high harvest (bars & *) scenarios for the RCP 8.5 (SFM: species sensitive to forest management).

Adverse effects of climate change on boreal bird communities accentuated by natural and anthropogenic disturbances: Climate change is expected to strongly influence boreal bird communities in the coming decades through changes in boreal forest composition and age structure. However most studies to date have not accounted for the lag in response of vegetation to climate change and the loss of habitat due to anthropogenic disturbances.

In this project, we aim to 1) project the evolution of forest landscapes according to four climatic scenarios and three forest harvest scenarios, and 2) predict trends of bird species, with a special emphasis on threatened species and those sensitive to forest management (SFM).

We used the LANDIS-II forest landscape model to project the impacts of climate change and anthropogenic disturbance (forest harvest) on boreal bird species in northeastern Alberta (>100 bird species).

Both forest harvest and climate-related drivers are projected to greatly impact bird communities in this region. A large proportion of forests is expected to convert to grasslands or young and mature deciduous forests. Accordingly, density of bird species associated with these habitats will likely increase. On the other hand, these changes will trigger sharp declines in conifer abundance and mature / old forest stands and consequently declines are projected for bird species associated with old forests, especially coniferous dominated forests. Under the most severe climate scenario, our simulations highlight that forest management could play an important role in the conservation of these species as the high harvest scenario (0.6% yr-1 clearcut) strongly accentuated bird density declines compared to the no harvest scenario, with an average of -37% and -22% of bird density declines respectively.

Our study stresses the importance of adapting forest management to best conserve and maintain old boreal mixedwood and coniferous forest habitats through upcoming changes in climate.

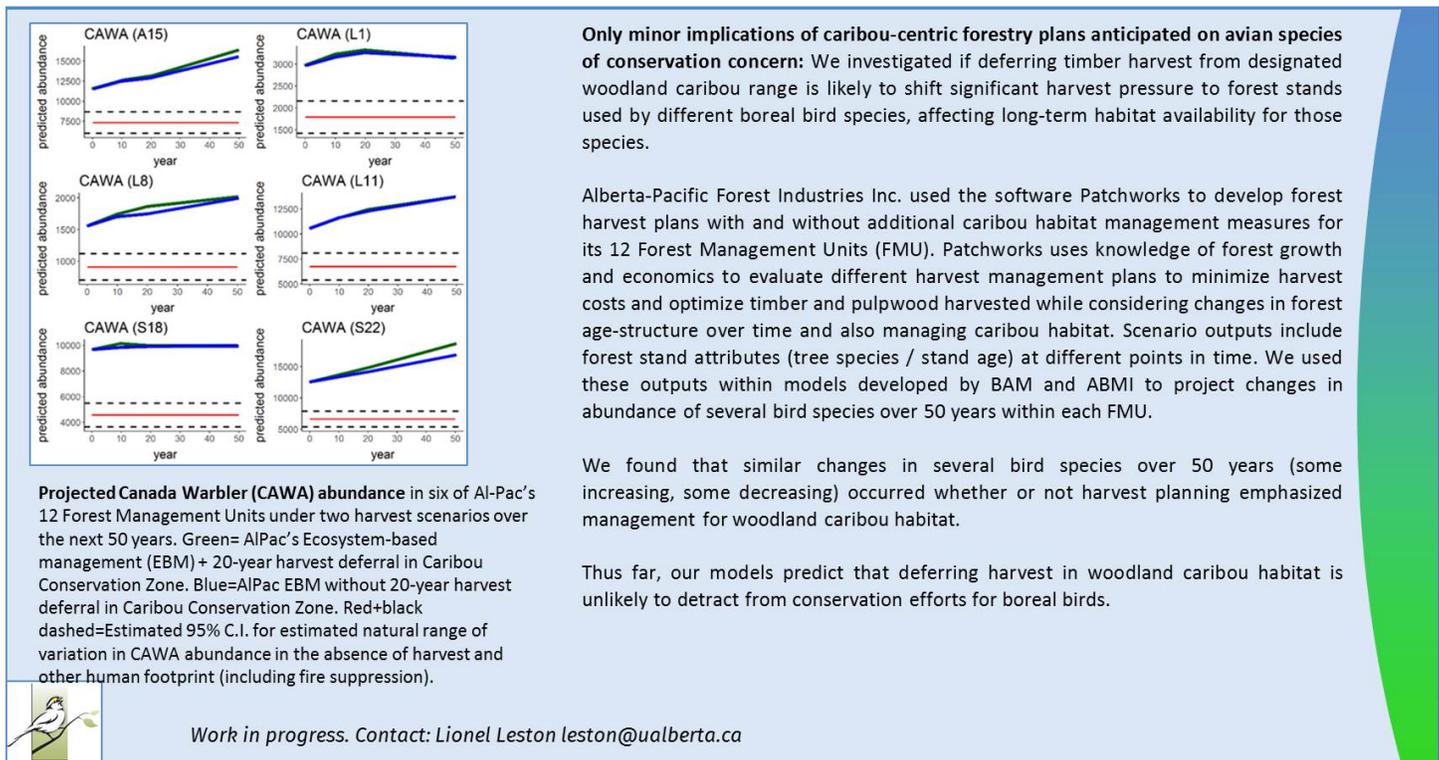


Work in progress. Contact: Junior A. Tremblay junior.tremblay@canada.ca

to the journal *Ecosphere* (see box for more details on methods and results). This project is a collaboration with the CFS and S&T. [CO-PRODUCED project. Contact: Junior Tremblay or Diana Stralberg]

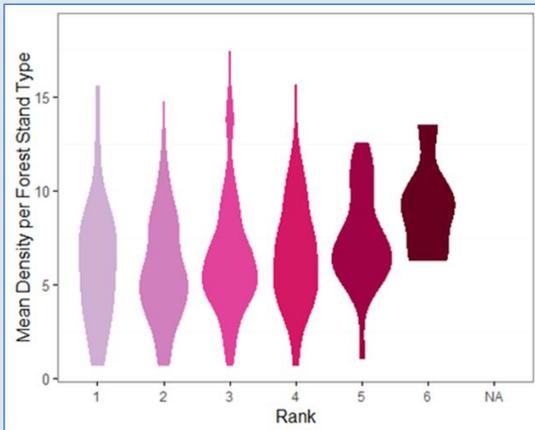
☛ Only minor co-benefits of caribou-centric forestry plans anticipated on avian species of conservation concern

As interest in caribou conservation continues to increase, there is also interest in understanding potential trade-offs or co-benefits with other species. In 2018-19, we continued our efforts to estimate possible population impacts on boreal bird populations resulting from various management options in the AI-Pac forest management unit. Using *cure4insect* (Sólymos, 2018), we applied avian habitat models to the landscapes forecasted under timber supply scenarios, including a caribou conservation scenario, to anticipate bird population response (see box for more details on methods and results). In 2019-20, we will submit a manuscript describing the results to a scientific journal. We will also extend this work using a custom-built ALCES Online simulator to explore impacts of fire and energy in addition to forestry. This work benefited from additional support from AI-Pac and an Accelerate grant from Mitacs. This project is a collaboration with AI-Pac and the Alberta Biodiversity Monitoring Institute (ABMI). [CO-PRODUCED project. Contact: Lionel Leston]



☛ Supporting harvest planning decisions regarding risk of incidental take

As a complement to previous work evaluating a tool being used by forest companies in BC to evaluate risk of incidental take of migratory birds, we are evaluating a similar tool developed for companies in Alberta. In 2018-19, we quality-checked data, completed initial analyses, performed an analysis of sampling gaps, and presented preliminary results to partners (see box for more details). In 2019-20, we will finish building regional density models and develop a data-driven tool for companies to use. [CO-PRODUCED project. Contact: Lionel Leston]



Observed bird abundances in forest stands assigned different risk levels of incidental take based on expert knowledge. Ranks are intended as proxies for bird abundance and are therefore assumed to indicate a greater chance of incidental take.

Evaluating and developing tools for predicting incidental take of birds during tree harvest in Alberta: Canadian forestry companies are required to avoid harming birds or nests during their logging operations. Forest companies in Alberta developed a risk matrix tool to help evaluate the risk of incidental harming, killing, destruction, or disturbance of birds, eggs, nest, or young in the course of their operations.

Individual forest stands are ranked from 1-6 based on ecological principles and forest attributes; high-ranking stands are expected to have higher abundances and therefore higher risk of incidental take.

Using the BAM point count survey database, we evaluated how well stand ranks correspond to detectability-corrected bird densities.

We found a weakly positive correlation between rank and bird density, indicating that ranks on average predict bird abundance. However, high variability indicates low predictive power for any given stand. We are now developing models to develop a data-driven risk matrix where ranks are determined by predicted abundances.



Work in progress. Contact: Lionel Leston leston@ualberta.ca or Nicole Barker nbarker@ualberta.ca

Impacts of residual tree retention on birds

Brendan Casey (PhD student with Erin Bayne, University of Alberta) is studying the influence of post-harvest residual tree retention on Alberta bird communities. Automated Recording Units (ARUs) were placed in 95 cutblocks in 2018, representing 5 harvest intensities (clear-cut, 95%, 75%, 50%, and 25%) at 4 age classes (5-10 years, 10-15 years, 15-20 years, and 20-25 years post-harvest). Acoustic data from the recordings is currently being extracted. In 2019-20, additional ARUs will be deployed in 35 to 50 additional sites—mostly representing high retention cuts. Models will evaluate bird response in different treatments at various time delays. A manuscript detailing the project's results will be complete by March 2020. This project benefits from an NSERC Strategic Partnership Grant (page 19). This project is a collaboration with the Bioacoustic Unit at the University of Alberta and the ABMI. **[CO-PRODUCED project]**. Contact: Brendan Casey]

NSERC Strategic Partnership Grant for projects on forestry and bird conservation

In 2016-17, BAM initiated a multi-year project to integrate avian abundance models into simulations of landscape dynamics and forest management planning. The purpose is to forecast consequences of forest harvesting on songbird populations. We will use simulation experiments to evaluate the trade-offs between timber supply and economic returns, songbird habitat management, and population objectives. This project is funded primarily by a Strategic Partnership Grant (SPG) for Projects from NSERC (lead: Steve Cumming, U Laval), and is led by academics from three universities with partner scientists from CWS and S&T.

In 2018-19, project goals were refined for all graduate students and post-doctoral fellows. Projects, which in many cases leverage previous or concurrent BAM efforts, are expected to cover the following objectives:

- Model spatial variation in habitat selection within the Canadian boreal region (Andy Crosby, University of Alberta, page 13);
- Build avian abundance models for integration in national and estate-level forest management planning tools (Andy Crosby);

- Quantify bird responses to within-block treatments (Brendan Casey, University of Alberta; page 19);
- Evaluate use of LiDAR to describe forest understory structure (Brendan Casey; page 14);
- Quantify the historical range of variation in avian abundances on natural landscapes, forecast long-term avian abundances in managed forests, and develop management strategies to minimise the difference (Ana Raymundo; Université Laval);
- Quantify the trade-offs between bird population and harvest volume objectives under strategic and operational forest management planning (Isolde Lane Shaw; Université Laval);
- Use pan-Canadian spatio-temporal waterfowl density models to create a new generation of spatial data products (Antoine Adde; Université Laval);
- Model and forecast the supply of large trees for cavity-nesting ducks in managed forests (Antoine Adde; Université Laval);
- Hindcast the impacts of cumulative forest harvesting and other anthropic disturbances since 1984 on songbird species' abundances in the Canadian boreal forest (Tati Micheletti, UBC/CFS)
- Apply hierarchical statistical models to disentangle the spatial scale of habitat loss and fragmentation effects on forest songbirds (Tati Micheletti, UBC/CFS; page 15);
- Provide software tools for integrating avian abundance models in SpaDES for ecological forecasting and scenario analysis (Tati Micheletti).

🌿 Proposed NSERC Collaborative Research & Development Grant to improve forest management for birds in Alberta

In collaboration with seven Alberta forest companies, the ABMI, CWS, S&T, the Bioacoustic Unit at the University of Alberta, BAM, and Alberta Environment and Sustainable Resource Development, Erin Bayne (U of Alberta professor and BAM Steering Committee Member) is developing a 5 year research and assessment program to support forest management for birds. The overarching goal is to create data- and science-based tools that forestry companies can use to manage and report on their environmental performance using birds as indicators. [**INFORMED project**. Contact: Erin Bayne]

Projects will address themes such as:

- Improving bird-habitat models for use in operational planning and reporting;
- Evaluating how within-block attributes & different harvesting strategies influence birds at varying times post-harvest;
- Determining the importance of forest patch edges;
- Assessing how novel harvesting processes can be used to manage species at risk;
- Using this information to develop company specific reports on the state of birds in the past, present, and future using various planning and information sharing tools.

A proposal for an NSERC Collaborative Research & Development (CRD) Grant is currently under development.



Impacts of oil sands activity on boreal birds in Alberta

Overview: In 2018-19, BAM continued efforts to publish three collaborative projects previously initiated with CWS Prairie Region and the ABMI under the Oil Sands Monitoring program in Alberta.

🌿 Publishing findings regarding cumulative effects and trends In the Oil Sands Region

In 2018-19, we revisited our evaluation of how well local-scale monitoring can predict consequences of cumulative effects at landscape scales, based on feedback from peer review. Results of new analyses are informative, and will be incorporated into a revised manuscript before March 2020 [**CO-PRODUCED project**. Contact: Lionel Leston]

We also refined our comparison of three methods for modelling environmental effects on bird populations. We are currently revisiting models based on new results from the above study, and plan to submit a revised manuscript in 2019-20. [**CO-PRODUCED project**. Contact: Lionel Leston]

In 2018-19, we published a report online that summarizes previous years' work applying our approach for trend estimation in the oil sands region (online: bit.ly/JOSM_trendreport). In 2019-20, we will update results and submit a manuscript for publication in a scientific journal. [**CO-PRODUCED project**. Contact: Péter Sólymos]

.....

Climate change impacts

Overview: After producing national scale projections of possible niche shifts resulting from climate change (Stralberg et al., 2015), BAM has shifted exploration of climate change to more specific questions, which are being executed at regional scales via collaborations. We have also begun exploring climate change impacts in a cumulative effects context, where climate change is one of several stressors on bird populations.

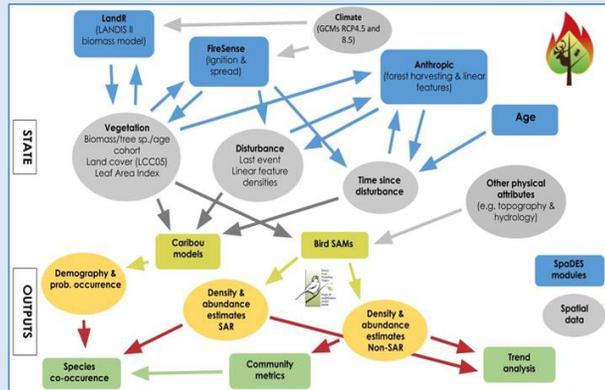
This past year, we contributed to an effort evaluating possible impacts of climate change and fire on birds and caribou in BCR 6, and another evaluating climate change impacts in BCR 4. We also explored possible impacts of climate change on breeding distribution and timing in two aerial insectivores in Canada's northwestern boreal.

🌿 Dynamic bird & caribou habitat with fire and climate change in BCR 6

In 2018-19, we contributed to a collaborative effort to support multiple-species modelling objectives of ECCC with respect to woodland caribou and migratory songbirds. The goal of the project was to forecast avian and caribou response to landscape and climate change within the Taiga Plains ecozone of the Northwest Territories, based on integrated models of forest stand dynamics and fire, all implemented in SpaDES (Chubaty & McIntire, 2018) a new system for spatial simulation and reproducible science (see box for more details on the approach).

To support this work, BAM developed new abundance models and spatial predictions for 83 bird species in BCR 6 using newly available point count and ARU data collected by ECCC (page 11). The results were summarized in a report (Micheletti et al., 2019) and will be presented in manuscripts to be prepared and submitted in 2019-20. This project is a collaboration with Université Laval, the CFS, CWS, S&T, and the NWT Department of Environment and Natural Resources. This project benefited from additional funding from CWS Northern Region. [**CO-PRODUCED project**. Contact: Tati Micheletti].

Data to decisions: integrating state-of-art simulation models to promote co-benefit analyses on human development, caribou, and birds on a dynamic landscape in the Northwest Territories: With this work, we hope to provide a better understanding of possible future caribou and boreal bird abundances considering natural disturbance, climate change, and human development.



To address this goal, we are building an integrated simulation model composed of human development models (anthropogenic disturbances), species abundance models (SAMs) for boreal landbirds, and demographic models for caribou. BAM contributed avian models, which incorporated newly collected data from autonomous recording units (ARU) in the far northern reaches of the Northwest Territories, including data from areas only accessible by winter ice roads.

Avian models were linked with spatial implementations of caribou habitat and demographic models from the 2011 Recovery Strategy for the Woodland Caribou. We used the R package SpaDES to generate a set of modules for this simulation as shown in the Figure. We projected these models to simulated future landscapes to calculate potential future bird and caribou responses.

Implications to boreal bird conservation:

This project represents an initial effort to implement a multi-species modelling approach at large spatial extents and including key ecological policies driving the availability for habitats for both birds and caribou. Results of this work may allow decision makers in the NWT to better assess potential co-benefits of future development plans, caribou, and boreal bird populations by providing projections of how the three components will respond to the current business-as-usual scenario over the next 100 years.

How the integrated modules and inputs work together.
 Blue boxes: SpaDES modules or groups of modules;
 Grey circles: Data;
 Yellow boxes: specific species models;
 Yellow ovals: model outputs;
 Green boxes: possible additional analyses for caribou and birds.



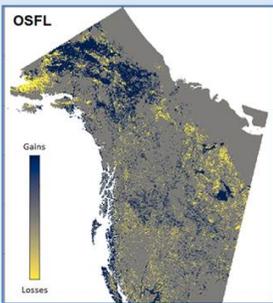
Work in progress. Contact: Tati Micheletti tati.micheletti@gmail.com

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

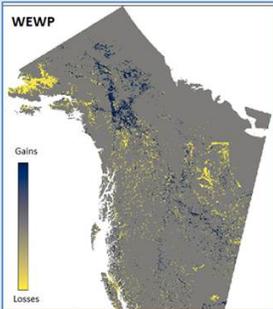
In 2018-19, we continued our contributions to a project that aims to simulate bird response to landscape changes caused by increased fire severity and extent across the northwest boreal forest in Yukon and Alaska. We anticipate completing analyses and a manuscript for this project in 2019-20. This project 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]

Western Wood-Pewee and Olive-sided Flycatcher in northwestern North America

Tara Stehelin (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 2018-19, models of current and future bird abundance were refined (see box for more details on methods and results). In 2019-20, models will be finalized with additional covariates, uncertainty will be assessed, and the corresponding thesis chapter and manuscript will be completed. [**CO-PRODUCED project**. Contact: Tara Stehelin]



Projected losses and gains (yellow and dark blue, respectively) in abundance for Olive-sided Flycatcher and Western Wood-Pewee between the baseline climatic conditions (1981–2010) and one future time period (RCP8.5 trajectory). Results for Olive-sided Flycatcher assume no time lag from vegetation change, while those for Western Wood-Pewee assume a 30-year time lag.



Predicting present and future distribution of Olive-sided Flycatcher and Western Wood-Pewee in northwestern North America: Northwestern North America is expected to experience some of the greatest changes in climate. Populations of long-distance migrants and aerial insectivores may be disproportionately impacted.

We used 15,637 records of Olive-sided Flycatcher and Western Wood-Pewee from 1,049 point-count surveys collected between 1992-2014 to generate abundance models of abundance over multiple climate scenarios and time periods. Boosted regression tree models included species-specific detectability offsets and a suite of 37 climate, landcover, topographical, and disturbance covariates at a 4 km scale. Models used climatic conditions from a baseline time period of 1981 – 2010 and two future time periods (2041-2070 and 2071-2100) under a comparatively high (RCP 8.5) and low (RCP 4.5) greenhouse gas emission trajectory.

Mean projected abundances were high in the far northwest, especially in riparian areas. Taking into account time lags from vegetation change, gains in distribution were predicted for the northern edge of range but losses were predicted in the southern part of the study area for both species -- with species-specific geographical patterns still intact (Figures). Total projected abundances declined across future scenarios for OSFL, but increased for WEWP.

Our results underscore the importance of planning proactively for future species-specific needs with climate change.



Work in progress. Contact: Tara Stehelin stehelin@ualberta.ca

🌿 Insect prey timing mismatch with Olive-sided Flycatcher

Tara Stehelin (PhD student with Fiona Schmiegelow, University of Alberta) continued her work examining relationships between insect abundance and timing of breeding for Olive-Sided Flycatchers and Western Wood-Pewees in northwestern North America. In 2018-19, models were refined (see box for more details on methods and results). In 2019-20, a manuscript describing the work will be written. **[CO-PRODUCED project.** Contact: Tara Stehelin]

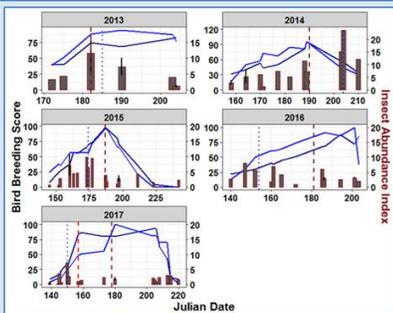


Figure 1. Breeding scores for Western Wood-Pewee (WEWP) and Olive-sided Flycatcher (OSFL) as a function of daily insect biomass (all orders) and large insect abundance (mostly Odonata).

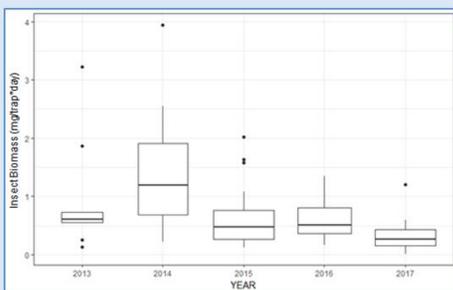
Phenological relationship between aerial insectivorous birds (Olive-sided Flycatcher and Western Wood-Pewee) and their potential insect prey in southern Yukon: Changes to phenology (timing of breeding or other annual cycle events) in relation to changes in climate have been documented for many species. Long-distance migrants and aerial insectivores may be particularly vulnerable to changes in spring events. Community-level information is required to investigate potential impacts of climate change on timing of life history events between interacting taxa of northern ecosystems.

Our objectives included examining feeding habits of Olive-sided Flycatcher and Western Wood-Pewee, describing insect and bird phenology and potential synchrony/asynchrony across the season, and comparing insect abundance among years (over a 5-year period).

We quantified daily nest survival and progression through breeding stages (“breeding score”) with daily insect abundance and temperature as predictors in GAMMs. Despite insect biomass varying widely from year to year, it was a significant factor in predicting breeding scores. Insect abundance and breeding scores of each species of bird seemed to peak at similar times in one year, but insect abundance peak seemed “too early” in three years of the study and “too late” in one (Figure 1). Insect biomass also declined across the five years of the study (Figure 2).

Although a five-year period is too short to assess long term change in phenology, these are the first quantitative results to describe phenology at the community-scale in northern-breeding aerial insectivores. They suggest that management at the community level may be essential in northern systems.

Figure 2. Insect biomass from Malaise traps



Work in progress. Contact: Tara Stehelin stehelin@ualberta.ca

Species at Risk Status, Recovery Planning, and Multi-species Management

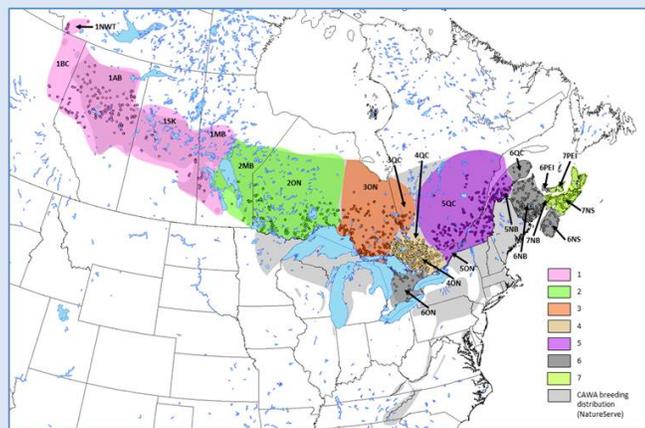
Conceptual model development and testing for critical habitat identification

Overview: BAM has worked closely with CWS and S&T for several years to produce science to inform critical habitat identification for species at risk. Recently, Olive-Sided Flycatcher and Common Nighthawk were downlisted to Special Concern, and therefore do not require identification of critical habitat. We are now focusing our efforts on Canada Warbler (Threatened, SARA Schedule 1) as a thorough test of the conceptual model for critical habitat identification we developed in previous years.

In 2018-19, we delineated management units over which Canada Warbler critical habitat identification could take place, and then developed regional Canada Warbler density models for Nova Scotia and Alberta.

Delineation of management units in support of critical habitat identification

In 2018-19, we worked with CWS and S&T to delineate spatial units over which critical habitat could be identified (see box for details on the method and results). In 2019-20, we will describe the approach in a scientific manuscript. This project is a collaboration with CWS and S&T. [**CORE project**. Contact: Francisco Dénes]



Management units delineated for critical habitat identification of Canada Warbler. Colours 1-7 represent regions of distinct CAWA density responses to habitat requirements (landcover class, tree height, and topography). These are subdivided along provincial/territorial boundaries to yield the critical habitat management units, identified with labels (e.g. 1AB)

Delineation of management units for critical habitat identification: Delineation of management units is an important step in the identification of critical habitat for wide-ranging boreal species given the possible spatial variation in habitat requirements and differing approaches to land management among jurisdictions.

Using geographically weighted generalized linear models, we identified spatially varying relationships between Canada Warbler density and environmental variables (land cover, tree height, topography, road presence, climate). Subsequently, we applied a multivariate clustering algorithm to landcover class, tree height, and topography coefficients from the geographically weighted model to group samples into spatially distinct clusters. We modified clusters based on the species' known distribution range. Finally, management units were subdivided using provincial/territorial boundaries within the identified clusters.

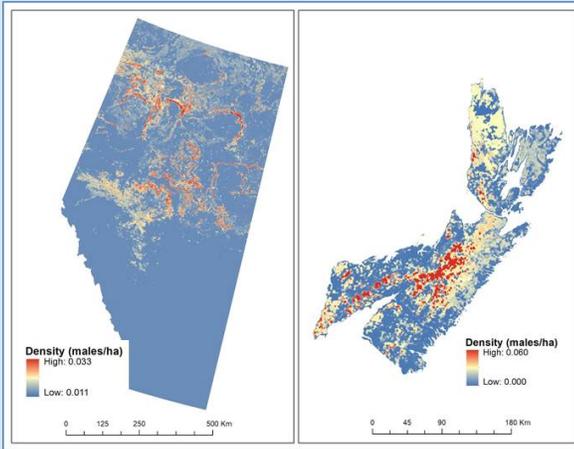
These management units will inform critical habitat identification for Canada Warbler by the Canadian Wildlife Service. The approach can facilitate future efforts toward the identification and implementation of critical habitat for wide-ranging boreal bird species.



Work in progress. Contact: Francisco Dénes voeroesd@ualberta.ca

Regional models in Alberta and Nova Scotia to support Canada Warbler critical habitat identification

Step 3 in our conceptual model for guiding identification of critical habitat for wide-ranging species involves the development of density models for all management units. In 2018-19, we built models for Alberta and northern Nova Scotia (see box for more details). In 2019-20, we will finalize model results and the move onto Step 4 of the conceptual model: population risk assessment. This project is a collaboration with CWS and S&T. [CORE project. Contact: Francisco Dénes]



Canada Warbler density predictions for Alberta (left) and northern Nova Scotia (right) critical habitat management units. Note different density scales.

Regional models for critical habitat identification: As part of the process we outlined for identification of critical habitat (CH) for wide-ranging migratory boreal birds, we used regional bird density-habitat models to predict the current size of regional populations.

We used machine-learning modelling techniques (i.e. boosted regression trees), combined with forest resource inventory, topography, hydrography, and human development data layers to generate detectability-adjusted Canada Warbler density predictions for two CH management units -- Alberta and northern Nova Scotia. For each grid cell, the cell-specific abundance estimate was the mean of 100 draws from a Poisson distribution with the cell-specific density estimate as the mean. We then calculated regional population size by summing the cell-level abundances for the entire management unit.

In subsequent steps of the conceptual model for CH identification, the regional models will be used to predict bird densities in simulated future landscapes, yielding estimates of future population size and, when compared to current population size, trend.

These quantities will inform regional population risk assessment. As well, the range of conditions that result in positive trends will form the basis to identify regional habitat thresholds and the biophysical attributes of CH.



Work in progress. Contact: Francisco Dénes voeroesd@ualberta.ca

.....

Conservation Planning for Boreal Birds

Identifying, designing, and evaluating priority wildlife areas and protected areas

Overview: One of BAM's primary goals is to inform conservation planning through the production and synthesis of avian habitat models. While we are constantly refining and improving our bird models, we simultaneously work to apply our current best models to a variety of appropriate planning questions.

We recently published a systematic assessment of boreal songbird priority conservation areas using BAM models (Stralberg et al., 2018). In 2018-19, we used BAM models within analyses to identify priority areas for boreal bird conservation. These efforts were executed in collaboration with research partners and NGOs, including BEACONS, Nature Canada, the SFI, and the Boreal Songbird Initiative (BSI).

Supporting land-use planning by the Lac Seul First Nation for Species at Risk

In 2018-19, we collaborated with Lac Seul First Nation (LSFN) and Nature Canada, using regional models to inform land-use planning decisions within the LSFN homelands and managed forests. We built regional habitat models for 6 species, and contributed to a proposal for an extension of the work. If funded, we will provide sampling recommendations to address data gaps, rebuild models with additional data, and work with partners to advise on priority areas and forest management plans in 2019-20. This project benefits from funding from the Aboriginal Fund for Species at Risk (AFSAR) via Nature Canada. This project is a collaboration with the LSFN and Nature Canada. [**CO-PRODUCED project**. Contact: Francisco Dénes]

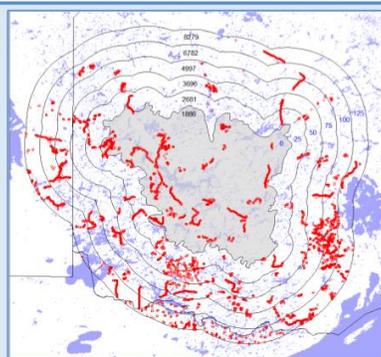


Figure 1. Locations of bird point counts within area buffers centred on the LSFN Territory (grey area). Blue numbers indicate area buffer widths (in km from LSFN Territory boundaries); black numbers are the cumulative number of point counts in the concentric areas.

Species at Risk in the Lac Seul First Nation Traditional Territory

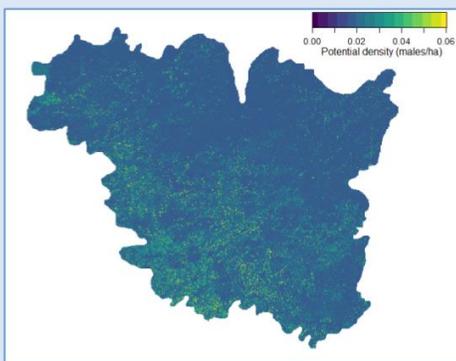
We built regional habitat models for Canada Warbler, Olive-sided Flycatcher, Common Nighthawk that increase the knowledge on the distribution and abundance of these species in the Lac Seul First Nation Traditional Territory. The limited number and non-random distribution of sampling locations (point counts) from the BAM dataset within the LSFN Territory hinders fitting abundance models for target species, but inclusion of point count data from the surrounding area can mitigate these issues. We evaluated spatial extents from zero up to 125 km from the LSFN Territory boundary, defined by incremental buffers of 25 km (Fig. 1), and compared the results of models fit with data from each buffer for each species.

The highest Canada Warbler densities were predicted in habitat classified as deciduous forest, followed by mixedwood forests. The highest Olive-sided Flycatcher densities were predicted for sites classified as wetland, shrubland, barren ground, urban development, and conifer forest. The highest Common Nighthawk relative densities were predicted areas classified as shrub habitat, conifer forest, barren ground and urban development.

The maps of predicted densities generated from the models (Fig. 2) will inform high-priority areas for target species, which in turn can support habitat/land protection initiatives. They will also allow the evaluation of overlap in high-quality habitat with other species of interest, such as Woodland Caribou.

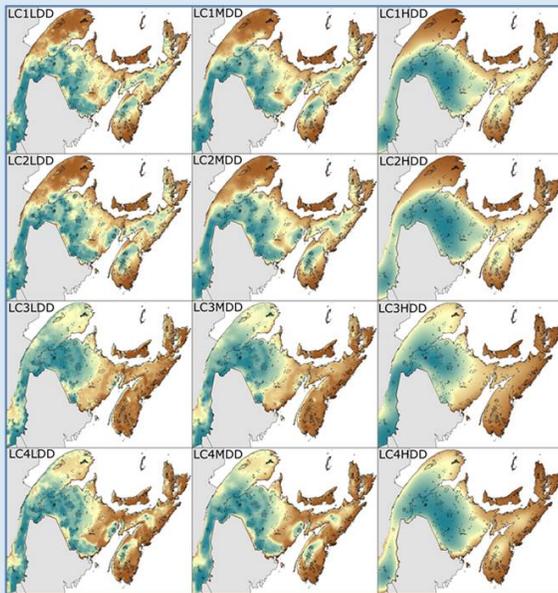
Contact: Francisco Dénes voeroesd@ualberta.ca

Figure 2. Canada Warbler mean density predictions (males/ha) for the Lac Seul First Nation Territory.



Supporting land conservation and forest management planning for Canada Warbler in the Atlantic Northern Forest

In 2018-19, we refined our work identifying priority regions where land conservation or forest management could be applied for Canada Warbler in BCR 14. Specifically, we performed additional analyses, prepared and submitted a manuscript to the Conservation of Boreal Birds special issue, and then revised and resubmitted the manuscript (see box for more details on methods and results). In 2019-20, we anticipate the paper will be published. This project was a collaborative effort with CWS, S&T, and High Branch Conservation Services, with support from Nature Canada and the Canada Warbler International Conservation Initiative (CWICI). [CO-PRODUCED project. Contact: Alana Westwood]



Conservation priorities based on Zonation analyses for four scenarios (rows) and three dispersal distances (columns).

Finding common ground: Regional spatial models to support both land conservation and forest management planning for the threatened Canada Warbler: When engaging in avian conservation and management across large landscapes, it is important to prioritize areas where different types of intervention actions might be applied.

We used the conservation planning software Zonation to evaluate scenarios for two different approaches to managing habitat for the Canada Warbler (*Cardellina canadensis*) in the Canadian portion of the Atlantic Northern Forest (Bird Conservation Region 14). Using predicted Canada Warbler population density as our base, we evaluated three sets of scenarios for land conservation and three for forest management, considering connectivity to protected areas, predicted future climate, degree of anthropogenic disturbance, recent observations of Canada Warblers, and dispersal limitations.

More northern and central regions away from coastlines were consistently prioritized for conservation, whereas areas prioritized for management were located in the Gaspé peninsula of Québec. Using a high dispersal distance estimate prioritized few aggregated hotspots, while a low dispersal distance estimate encouraged prioritization of geographically diverse populations.

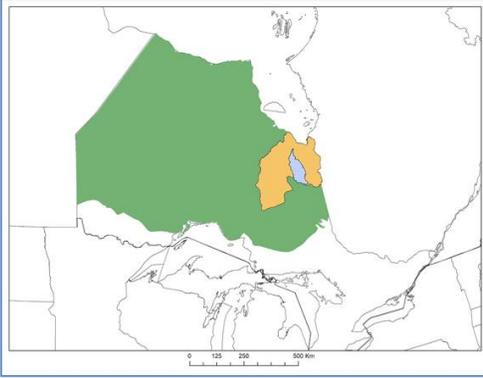
This “common ground” approach for multiple management objectives for the Canada Warbler could be replicated for other species or other regions.



Work in revision at Avian Conservation and Ecology. Contact: Alana Westwood, alana.westwood@canada.ca

Supporting the Pathway to Canada’s Target 1 in the Moose Cree First Nation Homelands: Avian ecological representation of the North French River Watershed

In 2018-19, as an extension of our 2017-18 work to inform spatial conservation prioritization on the MCFN Homelands in relation to species at risk (Page 32; Boreal Avian Modelling Project, 2018), we performed an extension to inform the evaluation of the French River Watershed as a potential protected area. Specifically, BEACONS and BAM evaluated how well the French River Watershed represents the larger ecological context in terms of species at risk populations (see box for more details on methods and results). This project is a collaboration with the MCFN, in collaboration with Nature Canada and the Wildlands League; it benefits from support from AFSAR via a grant to MCFN. [CO-PRODUCED project. Contact: Francisco Dénes]



Northern Ontario with the boreal forest of Ontario (green), the MCFN Traditional Territory (yellow) and the NFRW (blue) regions.

Avian ecological representation in the North French River Watershed in the Moose Cree First Nation Traditional Territory: In 2017-18, we contributed to a project led by the Moose Cree First Nation (MCFN), in collaboration with Nature Canada and the Wildlands League, to inform spatial conservation prioritization on their homelands in relation to species at risk. As an extension of this project, BAM was asked to provide a quantitative analysis of how ecologically representative the North French River Watershed (NFRW) is for bird populations.

Representation (R) index values for each species in the NFRW in relation to the two reference areas. Values greater than 1 indicate higher representation than expected. The regional model was 2018's regional model for the MCFN Homelands (Dénes et al. 2018 report) while the national model was from BAM's climate-based density models (Stralberg et al. 2015, Ecol Appl)

Reference area	Model Used	Bay-breasted Warbler	Canada Warbler	Common Nighthawk	Connecticut Warbler	Evening Grosbeak	Olive-sided Flycatcher	Rusty Blackbird
MCFN traditional territory	regional		0.70	1.23			1.75	1.07
	national	1.03	0.76		1.11	0.84	1.08	1.01
Ontario boreal	national	1.11	1.00		1.33	1.00	0.89	0.22

We quantified representation in relation to two reference areas: the boreal forest in Ontario and the MCFN homeland. Using bird density model outputs from our previous MCFN bird density analysis and also national scale products (Stralberg et al. 2015 Ecol Appl), we estimated the population size of seven bird species in the NFRW and the reference areas. We then calculated a representation index, *R*, by dividing the ratio of the population sizes of the NFRW and the reference by the ratio of the respective areas. *R* values greater than 1 indicate higher representation than expected in the NFRW based on the species' potential population in the reference area.

The ecological representation indices calculated for birds in the North French River Watershed will assist the MCFN's proposal to the Pathway to Canada Target 1 Challenge Grants to establish this region as an Indigenous Protected and Conserved Area.



Work in progress. Contact: Francisco Dénes voeroesd@ualberta.ca



BEACONS Project
University of Alberta and Yukon College

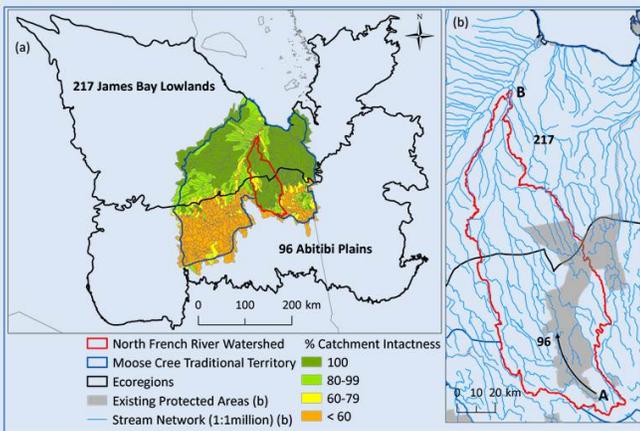


Figure 1. The North French River Watershed has high benchmark potential based on the fundamental attributes of size, intactness (a), and connectivity (b). (b) The watershed contains a fully connected stream network that flows from A to B towards James Bay. All headwaters are captured which eliminates threats from upstream disturbances.



Contact: Kim Lisgo kllisgo@ualberta.ca

Ecological Benchmark Potential of the North French River Watershed:

Protected areas have been the primary tool for conservation, but have not been enough given the significant loss of wilderness areas and changes to biodiversity globally. To halt degradation of terrestrial and freshwater systems, we must look beyond protected areas and recognize the significance of the matrix for maintaining healthy ecosystems.

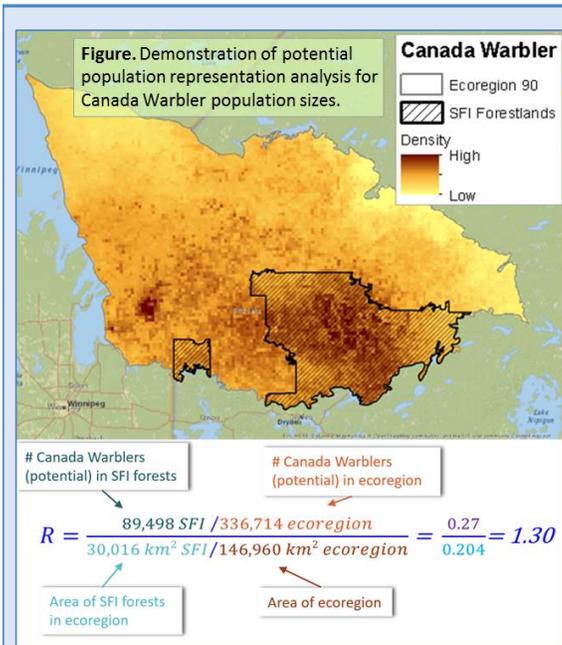
Within Canada's relatively intact boreal region, we have the globally-rare opportunity to plan proactively and maintain healthy ecosystems through sustainable land use practices in the matrix. This requires that we "learn while doing" via the implementation of management experiments, a key step within adaptive management. Management experiments require ecological benchmarks or controls to help us understand the effects of human activity on biodiversity and to distinguish these effects from natural variability and climate change.

The Moose Cree First Nation has proposed the North French River Watershed for protection (Figure 1a). To support their proposal, we evaluated the potential for the watershed to serve as an ecological benchmark for the Moose Cree Traditional Territory, and two ecoregions: James Bay Lowlands and Abitibi Plains. We found that the watershed is well designed to contribute to a network of ecological benchmarks for all three regions based on the fundamental properties of size, intactness, hydrologic connectivity, and representation.

☛ Evaluating conservation impact of Sustainable Forestry Initiative-certified lands using representation analysis

As part of our Conservation Grant from the SFI, BAM is exploring measurement of the potential biodiversity-related values of SFI-certified lands. In 2018-19, we conducted preliminary analyses and presented them to SFI and other partners (see box for description of methods).

We recently received a third Conservation Grant that will extend this work in two ways: 1) add a community ecology perspective to the conservation value assessment using additional metrics; and 2) open the door for a collaborative project with the American Bird Conservancy (ABC) to pursue cross-border conservation of birds. This project is a collaboration with the BEACONS Project, SFI, and several other government, academic, NGO, and industry partners (see page 57 for full list of partners). This project benefits from an SFI Conservation Value Grant. [CO-PRODUCED project. Contact: Andy Crosby]



Representation of SFI-certified lands for boreal birds

The Sustainable Forestry Initiative (SFI)'s Conservation Grants program funds projects that measure, demonstrate, or establish methodologies to illustrate the conservation-related values of SFI-certified forestlands.

BAM used representation analysis as one means of quantifying conservation value of SFI-certified forests for birds. The application of ecological representation in conservation biology is based on the objective of conserving the full range of biodiversity within a given geography.

We estimated representation using environmental surrogates (climate moisture, land cover, lake-edge density, and gross primary productivity) and bird density maps:

- Environmental variables – dissimilarity metric: The representation metric measures the difference between the distribution of the indicator in the target area versus the reference area. The statistic ranges from 0 to 1, where lower values indicate less difference, or greater similarity, between the areas.
- Species and species groups - core habitat and population: The area-adjusted proportion of the species population or core habitat within the SFI area indicates representation for species indicators. Values higher than 1 indicate higher representation than expected based on the species' potential population in the ecoregion. In the figure at left, SFI forests cover 20% of the ecoregion but could be expected to support 27% of the ecoregion's Canada Warbler population. This yields a ratio of 1.3, which is our representation score for Canada Warbler population in ecoregion 90 (higher than proportional representation).

Additional results are viewable in an interactive web-app: bit.ly/BAM-sfi-ConsValue

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



.....

Boreal Landbird Monitoring Design

Boreal monitoring strategy

Overview: For the past few years, CWS and S&T have been developing a boreal monitoring strategy to monitor the status, trends and distribution of boreal forest birds. Several BAM Contributing Scientists are involved in the effort.

In 2018-19, BAM continued supporting this effort through data contributions and discussions.

☛ Validating use of proxy variables for sampling stratification

In 2018-19, BAM data were acquired and a plan for evaluating the use of environmental variables as proxies for bird communities was developed. In 2019-20, analyses will be performed. This project is led by CWS.

[**INFORMED project**. Contact: Steve Van Wilgenburg]

Evaluating validity of environmental variables as proxies for bird communities to support national-scale boreal monitoring:

The Canadian Wildlife Service (CWS) is developing a boreal monitoring strategy to monitor the status, trends, and distribution of boreal forest birds. Given the remoteness of the boreal forest, an efficient design is needed to avoid excessive field and travel costs. Unfortunately, even datasets such as BAM are not sufficiently comprehensive to fully inform monitoring design. Therefore, CWS is testing a stratified sampling scheme in which a multivariate analysis of proxy variables is being used to allocate greater sampling effort to areas that are anticipated to have greater variability in bird populations. Variables such as inter-annual variability in historic precipitation, temperature, and burn rates are being used as proxies for variability in the bird community. This approach assumes that variability in bird community is directly related to variability in climate and habitat. Our goal is to use BAM data to test the assumption that proxy variables reflect variance in the bird community.

We plan to use bootstrap sub-sampling of the BAM data set to take stratified sub-samples of the data. We will calculate community similarity of these stratified samples against the community composition derived from a large sample size representative draw. Variance in the bird community will be estimated as the standard deviation in the community similarity metric between random sub-samples. We will then use least squares regression or mixed models to determine whether variance in the bird community is related to variability in our proxy variables.

This project should facilitate efficient sampling of boreal bird populations and thus enhance our ability to inform conservation and management.



Work in progress. Contact: Steve Van Wilgenburg steven.vanwilgenburg@canada.ca

.....ᐱᐅᐅᐅ.....ᐅᐱᐅᐅ.....

Method & Tool Development

Contributions to collaborative efforts

Overview: In early years, BAM dedicated a significant amount of time to develop the methodological tools necessary to handle BAM data and ecological questions. In recent years, BAM's focus has shifted to developing and applying the models, though we contribute to some methodological development, particularly in the form of collaborations.

In 2018-19, we contributed to two collaborative projects related to sound recordings. BAM contributed to research about automated sound recognition 'recognizers' to facilitate processing of sound recordings. We also contributed to the development of WildTrax, a web-based platform for processing, storing, and sharing recordings from ARUs.

Improvements to automated song recognition to facilitate processing of sound recordings

In 2018-19, Elly Knight (BAM PhD student with Erin Bayne, University of Alberta) completed and submitted manuscripts for two projects related to improving automated sound recording processing via recognizers (see box for details). Manuscripts are in revision at Remote Sensing in Ecology and Conservation, and in review at Ecological Applications, respectively. These projects are a collaboration with the University of Alberta Bioacoustic Unit. Elly Knight has benefitted from additional support from NSERC, the University of Alberta, the Alberta Society of Professional Biologists, and the Alberta Conservation Association. **[CO-PRODUCED project]**. Contact: Elly Knight]

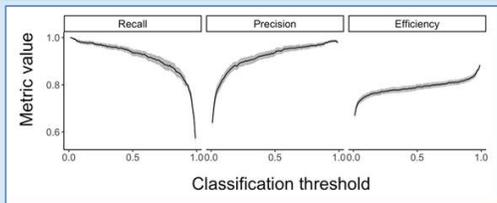


Figure 1. Performance metrics for prediction of true recognizer hits. Mean (line) and standard deviation (ribbon) were calculated across a range of classification thresholds for 100 bootstraps.

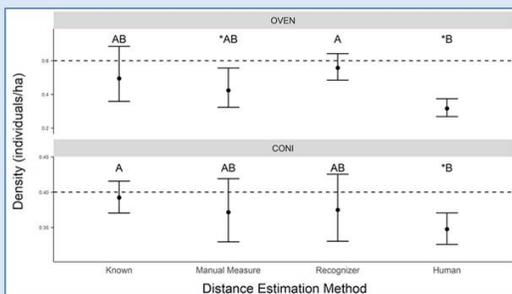


Figure 2. Mean and 95% confidence intervals of 1000 density estimates of Ovenbird (OVEN) and Common Nighthawk (CONI). Estimates are of a simulated point count with a density based on average territory size of each species (dashed line).

Bioacoustic automation: learning more, faster: The capacity to tackle large-scale ecological research questions about acoustic animals is increasing with the accrual of large bioacoustic datasets. However, methods to efficiently extract species detections from those bioacoustic datasets are required prior to using the data for ecological research. One approach is automated recognition, which involves training a computer algorithm, or "recognizer", to detect vocalizations of a focal species. We have developed two methods that improve the utility of automated recognition for studying acoustic animals.

The first method combines sound physics, classification principles, and ecology to improve the efficiency of automated recognition. All recognizers misclassify to some extent, and the number of false positive produced by some can make automated recognition untenable. Our method pre-screens recognizer results to filter out some of the false positives before the results are reviewed by a human observer. In a Common Nighthawk case study, we reduced effort by 73.7% while retaining 99% of true detections (Figure 1).

The other method uses sound physics to facilitate using recognizer results to estimate density. We used two example species to show that the relative sound level, or loudness, of a call as measured by a recognizer can be used to predict how far away that bird is (Figure 2). Those distance can then be used to produce density estimates that are less biased and more accurate than those derived from human observation.

Together, these two methods will facilitate accurate and efficient extraction of data to help biologists to use existing bioacoustic datasets to study habitat associations and determine population size for wide-ranging boreal bird species.



In Review. Contact: Elly Knight ecknight@ualberta.ca or Péter Sólymos solymos@ualberta.ca

WildTrax: A new multi-function platform to handle data from automated recording units

The Bioacoustic Unit at the University of Alberta, in collaboration with the ABMI, initiated WildTrax in 2017 (see box for more details on WildTrax). In 2018-19, BAM contributed to WildTrax discussions about data-sharing agreements, policies, and databases for tracking permissions. We also contributed spatial locations for all BAM data points within Alberta, to be loaded into WildTrax as a demonstration. The platform can be viewed at Wildtrax.ca. This effort benefits from additional funding from ECCC, and is a collaboration with CWS, S&T, the ABMI, and the University of Alberta Bioacoustic Unit. [INFORMED project. Contact: Erin Bayne]

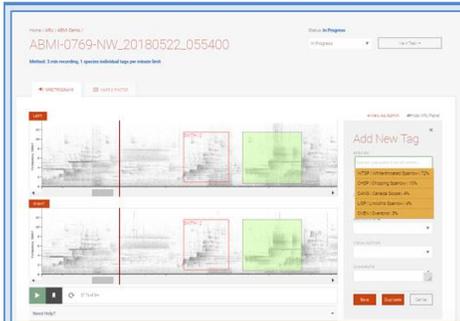


Figure 1. WildTrax processing interface with automated recognition.

WildTrax: WildTrax is a flexible, online user interface and associated database that stores, manages, and processes data from Autonomous Recording Units, among other sensors, and incorporates the latest developments in audio processing and automated recognition. The system allows transcribers (i.e. those processing the recordings) to log in and listen to and visualize the recordings in the form of a spectrogram (Figure 1). The transcriber then tags sections of the spectrogram where species are detected using boxes to identify duration of the species song on the X-axis and frequency range on the Y-axis. Processed data can be easily downloaded from the system in a wide format table.

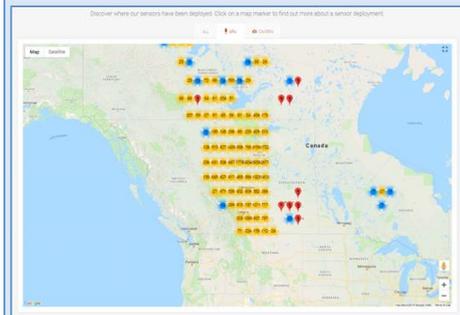


Figure 2. Map displaying all breeding bird data collected.

To help transcribers classify detected acoustic signals more quickly and consistently, we have operationalized a 75-species automated classification system to increase the number of species that can be automatically classified. When a transcriber draws a box around a species signal on the spectrogram, the classification system will automatically provide a “recommended” species identification to help the transcriber (Figure 1).

In terms of data, WildTrax will facilitate shared open data by allowing users to easily access their own data as well as provide access to other organizations (Figure 2). WildTrax is designed with these different goals in mind in terms of storage rules, permissions, passwords, and accessing interpreted data. Such open data sharing can influence boreal bird management via the amalgamation of multiple data sources.



Work in progress. Contact: Erin Bayne bayne@ualberta.ca

.....

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 160 research, monitoring, or inventory projects, now includes more than 350,000 sampling events, collected from over 250,000 sampling locations, plus the 1.3 million sampling events from 72,000 locations provided by the Breeding Bird Survey. In addition to ongoing maintenance and updating, we continually search for opportunities to fill known gaps in temporal or spatial coverage.

Data Products

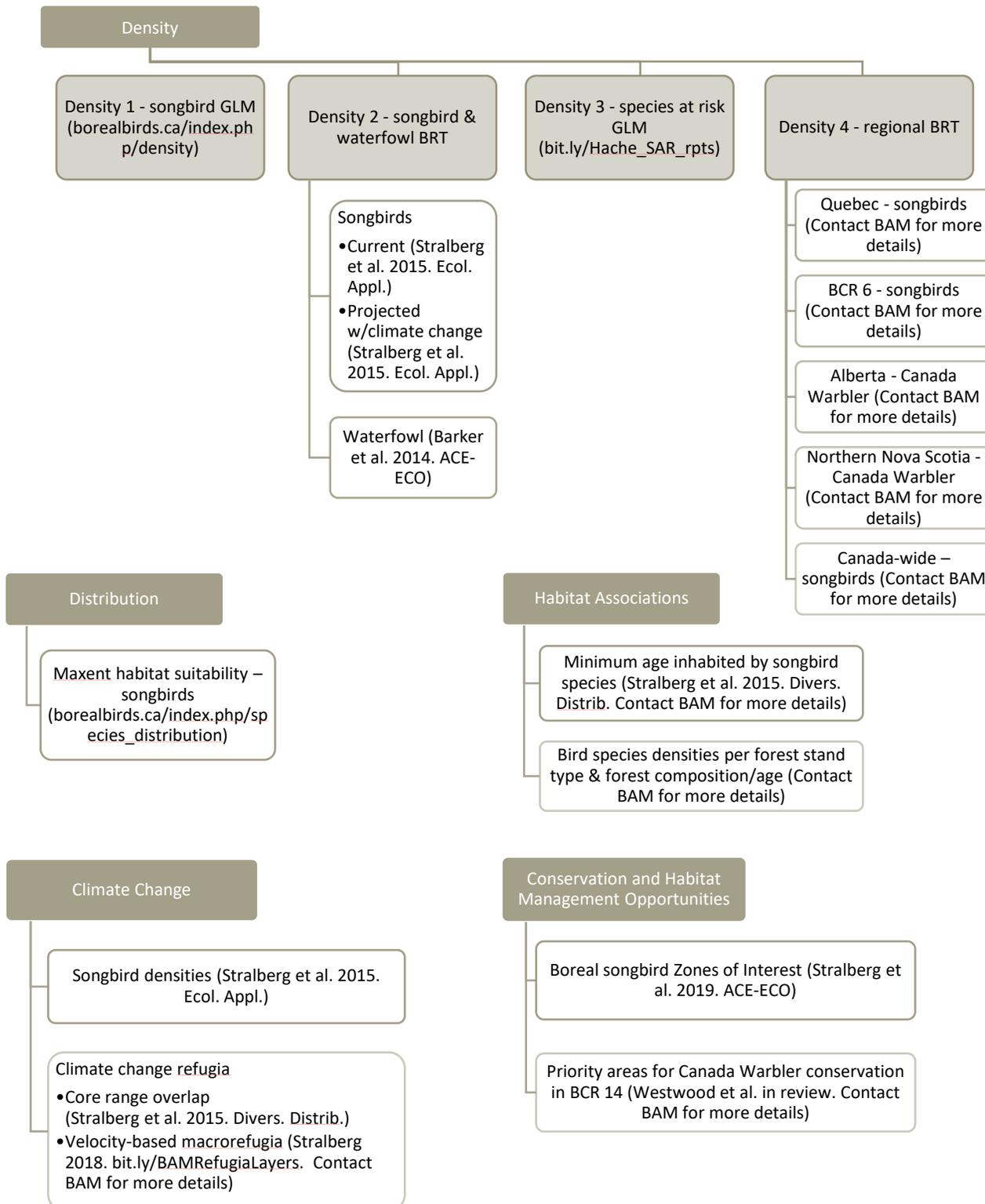
Overview: BAM has several data products available for use by scientists, managers, and others to support applications of our work to conservation and management of boreal birds.

In 2018-19, we produced several new data products through the research efforts described above. They are available upon request.

☛ Summary / Inventory of BAM's data products.

The following information sheets summarize products currently available upon request from BAM. Note that several products are derived from the same underlying models (i.e., Stralberg et al. 2015). Interested parties can contact the BAM at BorealAvianModellingProject@ualberta.ca for more information or to request a product. [**CORE project**. Contact: Diana Stralberg].

BAM Data Products - Last updated: March 29, 2019



Data portal under construction.
 Contact BorealAvianModellingProject@ualberta.ca
 to request a product.

🌿 Update on data product distribution platform

In 2017-18, we began migrating our data products to GeoNetwork. In 2018-19, we uploaded several BAM data products and began developing a library of keyword tags to facilitate sorting / filtering of products. This work is currently on pause due to a parental leave.

In the meantime, we are exploring the interest in, and feasibility of, including BAM data products in ABMI's online web tools and mapping portal, and other platforms for delivery. Meetings regarding collaborative data product delivery are a collaboration with the University of Alberta Bioacoustic Unit and ABMI, and benefit from additional funding from Canadian Wildlife Service (CWS).

.....



Databases

Avian Database Update (V5) and Acquisition of new Data

Overview: The BAM Avian Database is the cornerstone of much of BAM's research. In addition to ongoing maintenance and updating, we continually search for opportunities to fill known gaps in temporal or spatial coverage.

In 2018-19, we took significant steps towards enhancing the BAM dataset, both to facilitate internal transparency and ease-of-use, and to move towards making the database accessible to outside parties.

🌱 BAM Avian Database update

In 2018-19, we focused on cleaning and integrating new data from various projects and individuals. This past year we updated and integrated data from three provincial Breeding Bird Atlas (Quebec, Manitoba, and British Columbia), updated one long-term project, and added data from six new projects.

This table summarizes the contents of the BAM Avian Database as of April 10, 2019.

	BAM Avian Database	BAM's BBS Database
Version (Year Updated)	V5 (2019)	V4 (2017)
# Projects	166	Data inclusive from 1997-2017, all Canadian and Alaskan BBS routes and some routes from northern USA.
# Sampling Locations	252,293	72,466
# Sampling Events	358,018	1,380,548
# Bird Observations	3,416,339	11,103,084

In the past two years, we have solicited avian point count data from partners on our conservation value and risk matrix projects (pages 29 and 18, respectively). To date, we have received unrestricted access to one company's point count data, and project-specific permissions for another company's data. In 2019-20, we will continue soliciting point count data from forest products companies. [**CORE project**. Contact: Trish Fontaine].

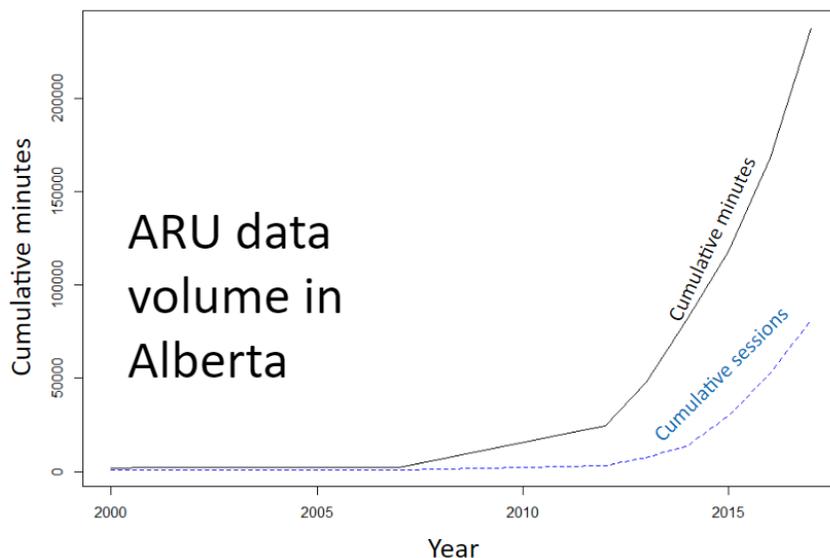
🌱 Filling known data gaps

In association with our incidental take risk matrix project in Alberta, we identified combinations of forest attributes that are not currently sampled by the BAM avian database. These gaps have been communicated to forest companies in a tabular format; creation of a map depicting spatial distribution of these gaps is underway for 2019-20. Companies will consult this information when selecting locations for future avian point count surveys. [**CO-PRODUCED project**. Contact: Lionel Leston]

Capitalizing on big data contained in ARU Recordings

The volume of ARU data has increased dramatically in the past decade. In many cases, ARU datasets fill crucial gaps in BAM spatial coverage (e.g., Northern regions). BAM has taken several steps towards capitalizing on ARU data. [**CO-PRODUCED project**. Contact: Erin Bayne]

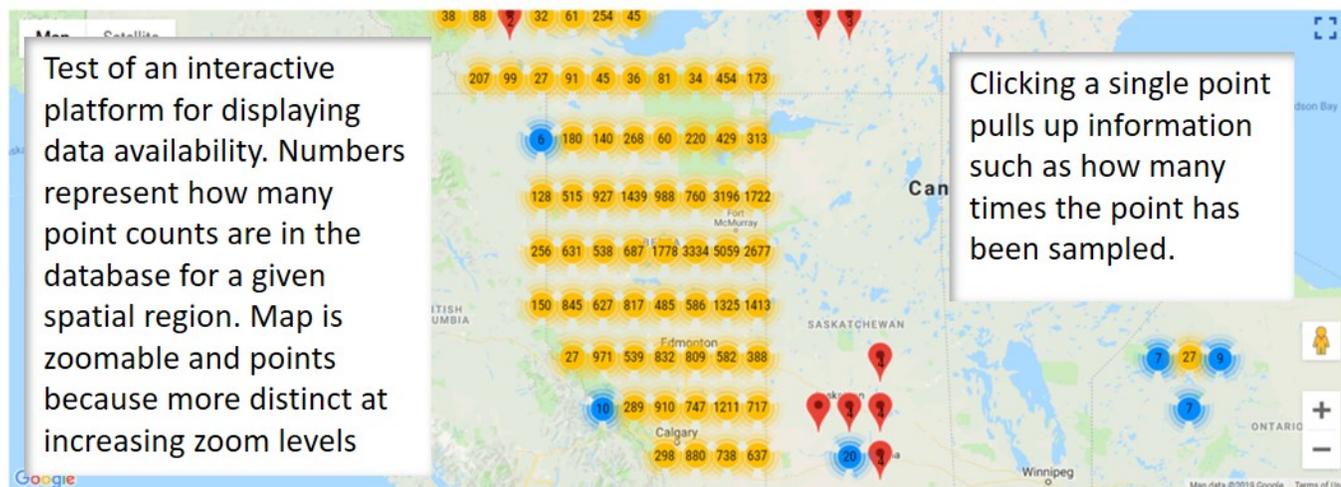
- Habitat modelling for Common Nighthawks relies on ARU data as part of Elly Knight's PhD project.
- ARU data were incorporated into density models in BCR 6 (page 11), providing data in regions that would otherwise be unsampled.
- The decision was made to exclude ARU data from BAM's Avian Database; instead, we will work with ABMI and the U of Alberta Bioacoustic Unit to develop protocols for extracting data from WildTrax into formats ready for BAM analyses.



Improving internal access to BAM's Avian Database

In 2018-19, we created an updated metadata-like document describing the fields and table structures associated with BAM's Avian Database. This document is intended to be internally facing, with the goal of expediting understanding of the database by BAM Team Members. In 2019-20, we will revise the document based on feedback from team members. [**CORE project**. Contact: Mélina Houle]

In 2018-19, we worked with ABMI and the U of Alberta Bioacoustic Unit to summarize aspects of the BAM database in a trial spatial and interactive map format on the WildTrax platform (page 32). In 2019-20, we will contribute to expanding the interactive map beyond this sample of datasets. We may also create additional summaries of the BAM database for communicating the potential of the database to external audiences.



Also in 2018-19, we are proposing to migrate BAM's Avian Database to PostGRES from SQL Server in collaboration with ABMI. In conjunction with this migration, this will involve pre-defined queries to facilitate access of BAM data by BAM team members. This project and the interactive map benefit from an open data contribution agreement with Environment and Climate Change Canada. [CO-PRODUCED project. Contact: Erin Bayne]

☛ Progression towards a public version of the BAM Avian Database

In the current age of big data, on-line citizen science (e.g., eBird), and a culture of open data, there is a new expectation of data availability. We believe that making the BAM harmonized point count database available to a broader audience will facilitate avian conservation and research. However, data contributions to BAM were made under expectation of no further distribution. We are committed to expanding access to the BAM database in a way that honours data partner wishes.

In 2018-19, BAM and ABMI co-developed a system for tracking permissions and data-sharing agreements. Following this, BAM's template data-sharing agreement was re-written to reflect new permission levels and a push towards fully open data. We also contacted some data partners to update data-sharing agreements for their previously contributed datasets. The new data-sharing agreement was used when soliciting new datasets and contacting existing data partners.

A test version of WildTrax has enabled the uploading of data-sharing agreements to a project. WildTrax functionality will be modified and updated accordingly based on feedback from BAM if data contributors require specific restrictions on their datasets. The BAM database, to be redesigned in 2019-20, will track permissions for datasets and attach copies of data-sharing agreements.

.....

Common Attribute Schema for Forest Resource Inventories (CASFRI)

☛ Expanding and updating the CASFRI

The Common Attribute Schema for Forest Resource Inventories (CASFRI) is a consistent, homogeneous spatial database containing an almost complete coverage of Canada's digital forest inventory data. CASFRI was developed over many years by Cumming's lab at Laval University, with the aid of John Cosco (Timberline Forest Inventory Consultants), ECCC GIS staff, and many data contributors, with financial contributions from ECCC, NRCAN, CFI, NSERC, The Sustainable Forest Management Network, and the Geoide Network. The purpose of CASFRI is to support detailed ecological modelling and conservation planning initiatives in Canada by linking distributions and abundances of e.g. forest songbirds to the indicators of forest state and structure that are used in forest management planning. CASFRI is currently being used in several BAM projects, including the differential habitat selection work (page 13), and to support sample design for the 2019 field season by BAM Contributing Scientists Steve Van Wilgenburg and Judith Toms. Starting in December 2018, NRCAN and Laval entered into a multi-year contract totalling more than \$300,000 to develop a new, open source version of the large suite of software tools that implement CASFRI. The goals of this contract are to enhance CASFRI so that it can:

- Be maintained in-house by NRCAN staff using open source technologies;
- Process new and old FRI datasets for the same forest areas and produce a harmonized FRI dataset time series; and

- Perform updates as new FRI datasets become available.

This new version, CASFRI 5.0, will continue to support BAM projects with a comprehensive, reliable, error corrected, and maintainable source of spatially enabled forest inventory data. Multi-temporal capacity is particularly important for linking avian data to the best available representation of the forest during the year of observation.

.....



Photo: Nicole Barker

Collaborations & Communications

BAM facilitates the application of our work by communicating to and collaborating with external groups. We communicate research findings via publication in traditional scientific journals, provide information for a variety of outreach efforts, and also maintain a website to disseminate our research findings.

Our 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, so welcome collaborations with projects that align with our mandate for conservation of boreal birds.

Here we describe our communications and collaborations from April 2018 - March 2019.

Conservation of Boreal Birds Special Issue

Overview: There are many currently active programs focussing on the conservation and management of boreal birds. BAM and Marcel Darveau (DUC) co-led a workshop at the 2016 North American Congress for Conservation Biology to encourage collaboration and communication among these various programs. 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".

The special issue is anticipated to include up to 10 papers, including an introductory synthetic editorial. The review and publication process will continue into 2019-20, and individual papers will be available online as they are accepted (bit.ly/COBB_SpecialIssue).

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.
- Coproducing actionable research for conserving Canada's boreal birds by building respectful partnerships" - A review paper promoting the co-production of actionable and respectful conservation science for boreal birds (Westwood et al., in review).
- Pathways for avian science, conservation, and management in boreal Alaska – A review of the important conservation mechanisms in the Alaskan boreal (Matsuoka et al., in review).

- Monitoring boreal avian populations: how can we estimate trends and trajectories from noisy data? - A review of challenges and tools associated with trend estimation in the boreal forest (Roy et al., in review).
- Review of climate-change impacts on boreal birds – A review paper summarizing climate-change implications for the conservation of boreal birds. (Stralberg et al., 2019; see box below for more details).

Components of climate-change vulnerability for 54 boreal-breeding passerine species. Long-term trend values are based on Canada-wide BBS trend estimates, converted to proportional change and log-transformed. Projected future change values are based on mid-century (2041-2070) climate-based mean density estimates for the North American boreal region, converted to proportional change and log-transformed. Symbols for each species are colored according to migratory status: black = long-distance migrant; gray = short-distance migrant; and white = resident or nomadic.

Conservation planning for boreal birds in a changing climate - A framework for action: The boreal forests of North America support billions of birds of over 300 species. The region remains mostly intact, but is expected to undergo major changes due to anthropogenic climate change over the next century.

We propose a vulnerability-adaptation framework to guide bird conservation based on species' individual vulnerability and exposure to climate change.

- For sensitive species with declining populations, conservation should focus on management of current threats and species recovery in situ to improve adaptive capacity and facilitate future shifts in distribution.
- Sensitive species with high exposure to climate change will warrant more extreme intervention, such as translocation or habitat manipulation.
- For species with lower sensitivity and stable populations, but high climate change exposure, long-term investments in protecting refugia and stepping stones will be most effective.

In general, across all species, land-based approaches that “conserve nature’s stage” by promoting geophysical diversity and habitat connectivity, maintaining natural disturbance dynamics, and facilitating broad shifts in bird distribution may prove most effective in maintaining species diversity.

Implementation of this framework will require large-scale, inter-agency coordination on recovery plans, as well as adaptive forest management, designation of critical habitat, and land protection.

Online: http://bit.ly/CC_COBB. Contact: Diana Stralberg diana.stralberg@ualberta.ca

- National land-use impacts – Our evaluation of impacts of human disturbance on migratory songbird abundances populations at a national extent, page 15 (Suárez-Esteban et al., in revision).
- A framework for how to identify priority areas, given variable objectives (Stralberg et al., 2018).
- Estimating the conservation value of protected areas in Maritime Canada for two species at risk: the Olive-sided Flycatcher (*Contopus cooperi*) and Canada Warbler (*Cardellina canadensis*) (Westwood et al., in press).
- Supporting implementation of recovery action for the Canada Warbler – Described above, page 28 (Westwood et al., in review).

.....ରଥେଓ.....ଧରଥେ.....

Outreach & Publications

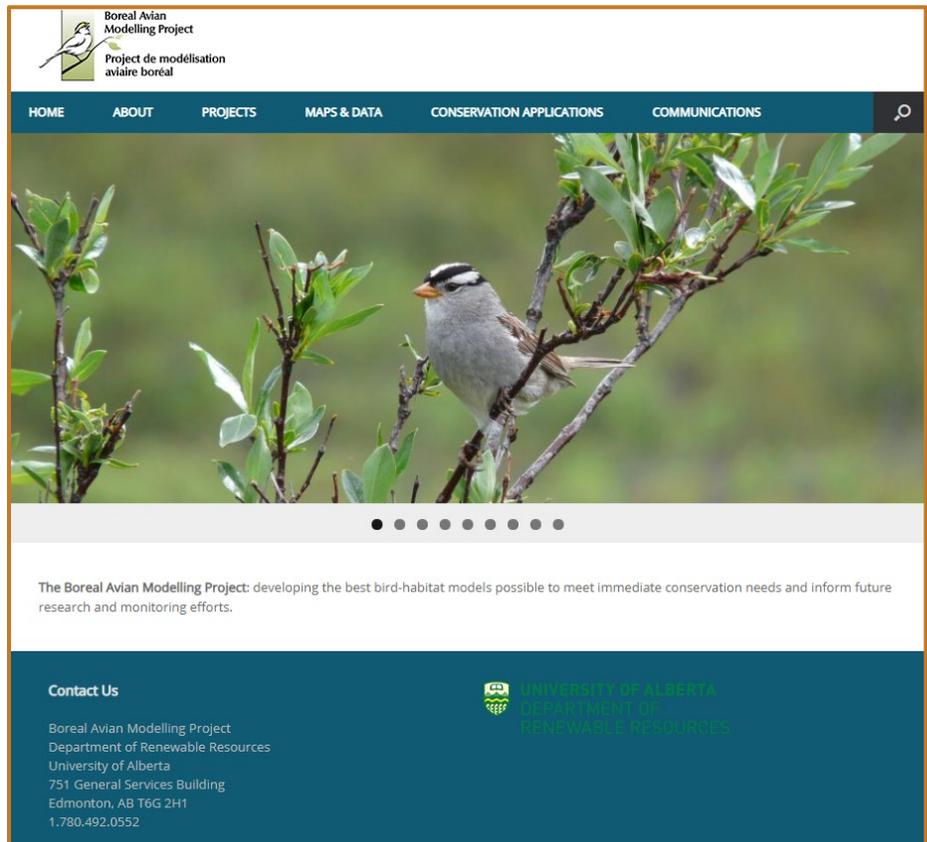
Online

Overview: We have modernized our online presence by designing a simpler website and migrating reports to a central location (Zenodo).

🌿 BAM's new website launched

In 2018-19, we redesigned our website and began migrating content to the new structure. Our goal with the redesign is to improve efficiency in finding and understanding materials for the reader.

The website was designed to be modular so that we can add updates and results as they are completed and released. To date, we have established the architecture and populated the About Us section. We will be populating other sections in English and French over the next fiscal year.

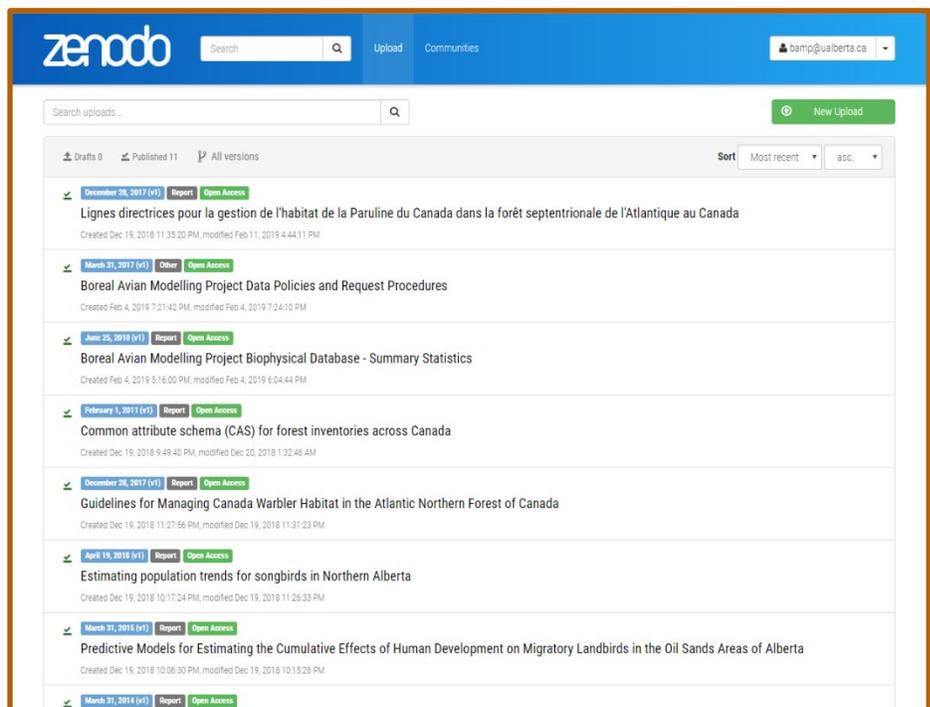


The website will be viewable at: bit.ly/BAM_online

🌿 Reports migrating to Zenodo

As part of our migration to the new website, we decided to store reports in a central location separate from the BAM website. We chose Zenodo in part because it provides DOIs and tracks versions. We have initiated upload of historical reports and will complete the task in 2019-20.

Boreal Avian Modelling Project. (2017), Boreal Avian Modelling Project Data Policies and Request Procedures, University of Alberta, Edmonton, AB, Canada, available



at: <https://doi.org/10.5281/zenodo.2556904>.

- Boreal Avian Modelling Project. (2018), Boreal Avian Modelling Project Annual Report - April 2017-March 2018, BAM Annual Report, Boreal Avian Modelling Project, University of Alberta, Edmonton, AB, Canada, available at: <https://doi.org/10.5281/zenodo.1313076>.
- Cosco, J.A. (2011), Common Attribute Schema (CAS) for Forest Inventories Across Canada, Technical Report, Prepared by J.A. Cosco, Chief Inventory Forester, Timberline Natural Resource Group for Boreal Avian Modelling Project and Canadian BEACONS Project, available at: <https://doi.org/10.5281/zenodo.2433719>.
- Cumming, S.G., Leblanc, M. and Lefevre, K. (2010), Boreal Avian Modelling Project Biophysical Database - Summary Statistics, Technical Report, Boreal Avian Modelling Project, Université Laval, Québec, QC, Canada, available at: <https://doi.org/10.5281/zenodo.2556831>.
- Haché, S., Sólymos, P., Fontaine, T., Bayne, E.M., Cumming, S.G., Schmiegelow, F.K.A. and Stralberg, D. (2014), Critical Habitat of Olive-Sided Flycatcher, Canada Warbler, and Common Nighthawk in Canada (Project K4B20-13-0367), Technical Report for Environment and Climate Change Canada, Boreal Avian Modelling Project, University of Alberta, Edmonton, AB, Canada, available at: <https://doi.org/10.5281/zenodo.2433885>.
- Matsuoka, S.M., Sólymos, P., Fontaine, T. and Bayne, E.M. (2011), Roadside Surveys of Boreal Forest Birds: How Representative Are They and How Can We Improve Current Sampling?, Report to Environment Canada, Canadian Wildlife Service, Boreal Avian Modelling Project, University of Alberta, Edmonton, AB, Canada, available at: <https://doi.org/10.5281/zenodo.1435868>.
- Matsuoka, S.M., Sólymos, P., Bayne, E.M. and Song, S.J. (2011), Suggestions for Collecting Additional Data during Point Count Surveys Conducted by Paid Breeding Bird Atlas Crews in Canada, Technical Report for Environment Canada, Boreal Avian Modelling Project, University of Alberta, Edmonton, AB, Canada, available at: <https://doi.org/10.5281/zenodo.1435887>.
- Sólymos, P., Bayne, E.M. and Toms, J.D. (2018), Estimating Population Trends for Songbirds in Northern Alberta, Technical Report, Boreal Avian Modelling Project, University of Alberta, Edmonton, AB, Canada, available at: <https://doi.org/10.5281/zenodo.2434306>.
- Sólymos, P., Mahon, C.L., Fontaine, T. and Bayne, E.M. (2015), Predictive Models for Estimating the Cumulative Effects of Human Development on Migratory Landbirds in the Oil Sands Areas of Alberta, Technical Report, Joint Oil Sands Monitoring: Cause-Effects Assessment of Oil Sands Activity on Migratory Landbirds, Edmonton, AB, Canada, available at: <https://doi.org/10.5281/zenodo.2434067>.
- Westwood, A.R., Harding, C., Reitsma, L. and Lambert, D. (2017), Guidelines for Managing Canada Warbler Habitat in the Atlantic Northern Forest of Canada, Technical Report, High Branch Conservation Services, Hartland, VT, USA, available at: <https://doi.org/10.5281/zenodo.2435733>.
- Westwood, A.R., Harding, C., Reitsma, L. and Lambert, D. (2017), Lignes Directrices Pour La Gestion de l'habitat de La Paruline Du Canada Dans La Forêt Septentrionale de l'Atlantique Au Canada, Technical Report, High Branch Conservation Services, Hartland, VT, USA, available at: <https://doi.org/10.5281/zenodo.2435820>.

BAM Publications

BAM Core Publications

Publications from BAM Core projects between January 2018 and March 2019.

2018 – January - December

Sólymos, P., Matsuoka, S.M., Cumming, S.G., Stralberg, D., Fontaine, T., Schmiegelow, F.K.A., Song, S.J., Bayne, E.M., 2018. Evaluating time-removal models for estimating availability of boreal birds during point-count surveys:

sample size requirements and model complexity. *Condor* 120, 765–786. <https://doi.org/10.1650/CONDOR-18-32.1>

THE CONDOR
Ornithological Applications

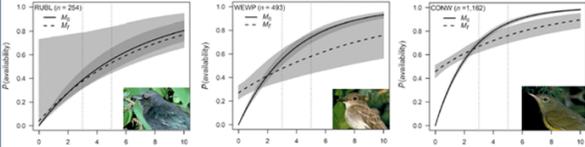
American Ornithology.org

Volume 120, 2018, pp. 765–786
DOI: 10.1650/CONDOR-18-321

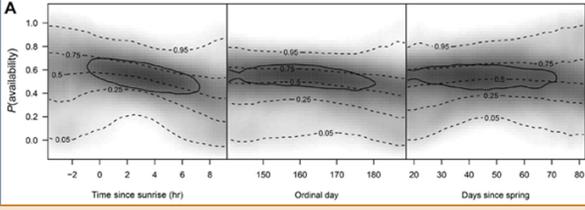
RESEARCH ARTICLE

Evaluating time-removal models for estimating availability of boreal birds during point count surveys: Sample size requirements and model complexity

Péter Sólymos,^{1,2*} Steven M. Matsuoka,^{2,3} Steven G. Cumming,⁴ Diana Stralberg,³ Patricia Fontaine,³ Fiona K. A. Schmiegelow,⁵ Samantha J. Song,⁶ and Erin M. Bayne⁷



A



Estimating probability of availability. The upper row shows availability probabilities as a function of count duration. The bottom row shows how availability probability changes with date and time when averaged over all the species.

Read more:
http://bit.ly/aos_blog_2018
http://bit.ly/RBlogger_RemovalModel_2018
http://bit.ly/ABMI_blog_2018

Online: bit.ly/RemovalModel_CONDOR. Contact: Péter Sólymos solymos@ualberta.ca

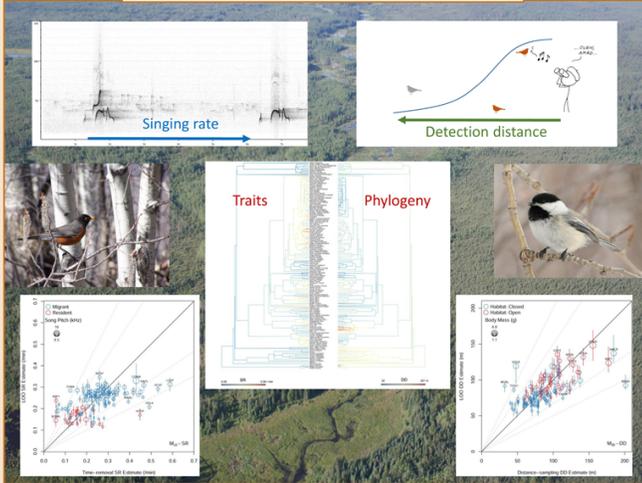
Sólymos, P., Matsuoka, S.M., Stralberg, D., Barker, N.K.S., Bayne, E.M., 2018. Phylogeny and species traits predict bird detectability. *Ecography* 41, 1595–1603. <https://doi.org/10.1111/ecog.03415>.

Research

Phylogeny and species traits predict bird detectability

Péter Sólymos, Steven M. Matsuoka, Diana Stralberg, Nicole K. S. Barker and Erin M. Bayne

EDITOR'S CHOICE



Phylogeny and species traits predict bird detectability: The number of birds counted in the field is an indicator for the true abundance that we have no way of observing directly. Statistical models to account for elements of detection (such as singing rates and effective detection distances) error require counts to be grouped by multiple time intervals, observers, distance bands, etc. This type of data is not very abundant for many species, and as a result, accounting for detectability is difficult.

We can use phylogenetic relatedness and trait information to help estimate singing rates and effective detection distances. We found that these two components of detectability were strongly correlated with the traits and the relatedness of species.

Our research provides the means to validate detectability estimates and to utilize these relationships to account for observation error when analyzing rare and data deficient species. Phylogeny and traits might be used to define groups of species for which the combined detection probabilities can be estimated jointly, or estimates available for closely related species can serve as a prior, alleviating sample size limitations.

Read & watch more:
http://bit.ly/Ecography_blog_2018
http://bit.ly/RBlogger_LifeHistory_2018
http://bit.ly/Vimeo_Abstract

Online: bit.ly/LifeHistory_Ecography. Contact: Péter Sólymos solymos@ualberta.ca

2019 – January - March

No BAM Core papers were published in January through March 2019.

🌿 BAM Co-produced Publications

Publications from BAM Co-produced projects between January 2018 and March 2019.

2018 – January - December

Stralberg, D., Camfield, A.F., Carlson, M., Lauzon, C., Westwood, A., Barker, N.K.S., Song, S.J., Schmiegelow, F.K.A., 2018. Strategies for identifying priority areas for songbird conservation in Canada's boreal forest. *Avian Conservation and Ecology* 13. <https://doi.org/10.5751/ACE-01303-130212>.



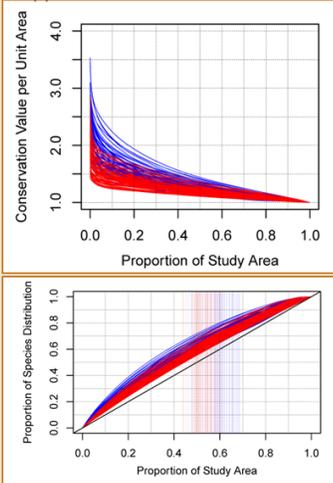
VOLUME 13, ISSUE 2, ARTICLE 12

Stralberg, D., A. Camfield, M. Carlson, C. Lauzon, A. Westwood, N. K. S. Barker, S. J. Song, and F. K. A. Schmiegelow. 2018. Strategies for identifying priority areas for songbird conservation in Canada's boreal forest. *Avian Conservation and Ecology* 13(2):12. <https://doi.org/10.5751/ACE-01303-130212>.
Copyright © 2018 by the author(s). Published here under license by the Resilience Alliance.

Research Paper, part of a Special Feature on Conservation of Boreal Birds

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

Performance curves for all 128 scenarios (blue = diversity-focused, red = representation-focused), representing (top) additive efficiency, the weighted average proportion of species conservation value (abundance) conserved by a given proportion of the study region, and (bottom) proportional efficiency, the ratio of bird conservation value to land area across study region thresholds. Vertical lines indicate study region proportions where additive efficiency, as shown by corresponding horizontal lines, is highest for a given scenario.



Conservation Value per Unit Area

Proportion of Study Area

Proportion of Species Distribution

Proportion of Study Area

1. prioritization metric (species representation vs. diversity),
2. geographic stratification,
3. degree of anthropogenic disturbance,
4. species' conservation status,
5. species' ecological association,
6. climate-change and uncertainty discounting.

Using the Zonation conservation planning tool, we evaluated landbird conservation priorities across the resulting 128 scenarios for 63 passerine species based on current and projected future density predictions.

We compared Zonation land rankings across scenarios, finding large differences between solutions depending on constraints and conservation objectives, with the largest gains in overall conservation value observed in areas ranging from 31% to 56% of the study region. This reflects the large range of conservation opportunities still present in the Canadian boreal region, and the widely dispersed nature of landbird distributions, which results in high substitutability among similar areas.

Although no single scenario can be viewed as prescriptive, we provide a roadmap for prioritizing boreal songbird conservation efforts across multiple conservation objectives.

Online: bit.ly/BAM_ZOI. Contact: Diana Stralberg diana.stralberg@ualberta.ca

Stralberg, D., Wang, X., Parisien, M.-A., Robinne, F.-N., Sólymos, P., Mahon, C.L., Nielsen, S.E., Bayne, E.M., 2018. Wildfire-mediated vegetation change in boreal forests of Alberta, Canada. *Ecosphere* 9, 1–23. <https://doi.org/10.1002/ecs2.2156>.

2019 – January - March

Westwood, A.R., Stacier, C., Sólymos, P., Haché, S., Fontaine, T., Bayne, E.M., Mazerolle, D., In press. Estimating the conservation value of protected areas in Maritime Canada for two species at risk: the Olive-sided Flycatcher (*Contopus cooperi*) and Canada Warbler (*Cardellina canadensis*). *Avian Conserv Ecol*.

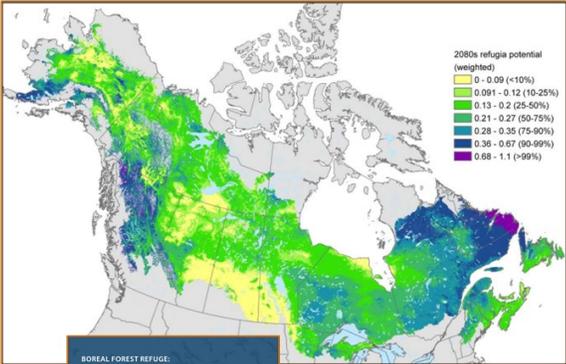
Stralberg, D., Berteaux, D., Drever, R., Drever, M.C., Naujokaitis-Lewis, I., Schmiegelow, F.K.A., Tremblay, J.A., 2019. Conservation planning for boreal birds in a changing climate: A framework for action. *Avian Conserv Ecol* 14(1):13. <https://doi.org/10.5751/ACE-01363-140113>

BAM Informed Publications

Publications we're aware of that use BAM data, methods, or expert knowledge, published between January 2018 and March 2019.

2018 – January - December

- Leston, L., Bayne, E., Schmiegelow, F., 2018. Long-term changes in boreal forest occupancy within regenerating harvest units. *Forest Ecol Manag* 421, 40–53. <https://doi.org/10.1016/j.foreco.2018.02.029>.
- Stralberg, D., Carroll, C., Pedlar, J.H., Wilsey, C.B., McKenney, D.W., Nielsen, S.E., 2018. Macrorefugia for North American trees and songbirds: Climatic limiting factors and multi-scale topographic influences. *Global Ecol Biogeogr* 27, 690–703. <https://doi.org/10.1111/geb.12731>.
- Tremblay, J.A., Boulanger, Y., Cyr, D., Taylor, A.R., Price, D.T., St-Laurent, M.-H., 2018. Harvesting interacts with climate change to affect future habitat quality of a focal species in eastern Canada's boreal forest. *PLoS ONE* 13(2). <https://doi.org/10.1371/journal.pone.0191645>.
- Tremblay, J.A., Robert, M., Hynes, D.P., Young, M.A., Drolet, B., 2018. Range extension of the threatened Red Crossbill (*Loxia curvirostra percna*) in Canada: new insights from Anticosti Island, Québec. *Avian Conserv Ecol* 13, 10. <https://doi.org/10.5751/ACE-01175-130110>.
- Van Wilgenburg, S.L., Hobson, K.A., Kardynal, K.J., Beck, E.M., 2018. Temporal changes in avian abundance in aspen-dominated boreal mixedwood forests of central Saskatchewan, Canada. *Avian Conserv Ecol* 13. <https://doi.org/10.5751/ACE-01145-130103>.
- Wells, J., Stralberg, D., Childs, D., 2018. Boreal Forest Refuge: Conserving North America's Bird Nursery in the Face of Climate Change. Boreal Songbird Initiative, Seattle, WA, USA. <https://www.borealbirds.org/sites/default/files/publications/report-boreal-birds-climate.pdf>



2080s refugia potential (weighted)

- 0 - 0.09 (<10%)
- 0.091 - 0.12 (10-25%)
- 0.13 - 0.2 (25-50%)
- 0.21 - 0.27 (50-75%)
- 0.28 - 0.35 (75-90%)
- 0.36 - 0.67 (90-99%)
- 0.68 - 1.1 (>99%)



End-of-century refugia index.
Multi-species refugia index for 2071-2100, averaged across 53 forest-associated boreal-breeding species, weighted by species' projected distributional responses to climate change and mapped by percentiles.

Velocity-based macrorefugia for boreal passerine birds: Climate refugia—areas of species persistence under climate change—may vary in proximity to a species' current distribution, with major implications for their conservation value. The concept of climate velocity—the speed at which an organisms must migrate to keep pace with climate change—is useful to compare and evaluate potential value of refugia. A velocity-based refugium for a given species represents areas of future climatic suitability that are in close geographic proximity to areas currently occupied by that species.

Velocity-based refugia layers were calculated for 53 forest-associated species based on spatial density models for baseline and projected future climates (2041-2070 and 2071-2100), and the shortest distance between them for individual species. The published refugia metric down-weights larger distances, given the low probability of natural dispersal and colonization success.

By combining the 53 maps, the highest weighted refugia values (99th percentile) were located in the mountains of British Columbia and along the Labrador coast; values in the 90th percentile were found throughout western mountains and in northern and eastern Quebec, and Newfoundland and Labrador. In general, the lowest weighted refugia values were found in western interior boreal regions.

Areas of high refugia value represent efficient conservation investments, considering uncertainties about future climate change. Our results were featured in a report by the Boreal Songbird Initiative, and have been incorporated into conservation planning efforts by the BEACONS Project.

Online: bit.ly/RefugiaLayers_2018, bit.ly/RefugiaGEB_2018, bit.ly/BSI_refugia. Contact: Diana Stralberg diana.stralberg@ualberta.ca

2019 – January - March

Matsuoka, S., J. Hagelin, M. Smith, T. Paragi, A. Sesser, and M. Ingle. 2019. Pathways for avian science, conservation, and management in boreal Alaska. *Avian Conservation and Ecology* 14. doi: [10.5751/ACE-01347-140115](https://doi.org/10.5751/ACE-01347-140115).

BAM Technical Reports

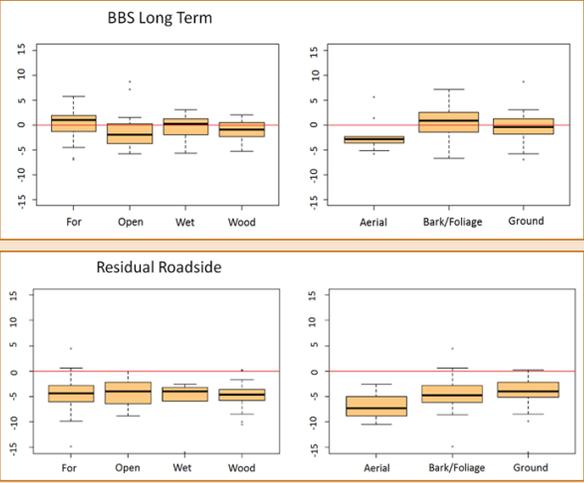
Reports describing BAM core and co-produced projects that were not peer-reviewed, completed between January 2018 and March 2019.

2018 – January - December

Boreal Avian Modelling Project. (2018), Boreal Avian Modelling Project Annual Report - April 2017-March 2018, BAM Annual Report, Boreal Avian Modelling Project, University of Alberta, Edmonton, AB, Canada, available at: http://www.borealbirds.ca/files/Technical_Reports/BAM.AnnualReport.2017_18.full.pdf.

Dénes, F.V. (2018), Species at Risk in the Moose Cree Homelands: Habitat Modeling of Bird Species at Risk in the Moose Cree Homelands, Report to the Moose Cree First Nation and Nature Canada, Boreal Avian Modelling Project, University of Alberta, Edmonton, AB, Canada.

Sólymos, P., Bayne, E.M. and Toms, J.D. (2018), Estimating Population Trends for Songbirds in Northern Alberta, Technical Report, Boreal Avian Modelling Project, University of Alberta, Edmonton, AB, Canada, available at: http://bit.ly/JOSM_trendreport.



Trend estimation in northern Alberta: Spatially and temporally replicated point count surveys, such as the North American Breeding Bird Survey (BBS) remain the ‘gold standard’ for estimating population trends at the extent of large planning regions and political jurisdictions. Limitations of BBS have been noted, so there has been an interest in developing regional monitoring programs (e.g. JOSM, ABMI) that are less reliant on the road network, and are thus less impacted by the roadside-related biases.

We used songbird data from Alberta to estimate population trends for 93 songbird species using on- and off-road bird survey data collated by ABMI and BAM. We investigated how estimates from our data set differ from official BBS trends for the province (Alberta, Bird Conservation Region 6).

Trends derived from combined on- and off-road data differed markedly from trends derived from only on-road data, even when we estimated roadside trend (see example trends to left).

Example trends (% annual change; y axis) for species with different life history traits (left: habitat associations; right: feeding stratum) according to different approaches (top: route level long term BBS trend; bottom: residual roadside estimate).

Online: bit.ly/JOSM_trendreport. Contact: Péter Sólymos solymos@ualberta.ca, Erin Bayne bayne@ualberta.ca, or Judith Toms judith.toms@canada.ca

Stralberg, D. (2018), “Velocity-Based Macrorefugia For Boreal Passerine Birds”, 28 June, available at: <https://doi.org/10.5281/zenodo.1299880>.

2019 – January - March

Micheletti, T., Stewart, F., McIntire, E.J.B., Eddy, I., Barros, C., Marchal, J., Stralberg, D., et al. (2019), Simulation Effects of Climate Change on Fire Regime: Implications for Boreal Caribou and Landbird Communities in the Northwest Territories, Technical Report.

🍂 Presentations

Presentations given by BAM Team Members between January 2018 and March 2019.

2018 – January - December

Adde, A., Darveau, M., Imbeau, L., Barker, N.K.S. and Cumming, S.G. (2018), "Environmental variables influencing the abundance and distribution of ducks in North America: a review", Poster presented at the North American Congress for Conservation Biology, July 21-26, 2018, Toronto, ON, Canada.

BAM Team. (2018), "Conservation value of SFI-certified lands for boreal birds - initial results of a representation analysis", Talk presented at the SFI Conservation Impact Webinar, Online, 7 December.

Barker, N.K.S. (2018), "Boreal Avian Modelling Project: An Introduction", Talk presented at the ABC-BAM Webinar Meeting, Online, 6 April.

Barker, N.K.S. (2018), "BAM's National Boreal Bird Modelling Approach", Talk presented at the ECCC Landbird Technical Committee Meeting, Ottawa, ON, Canada, 17 October.

Barker, N.K.S. (2018), "Bird density in the BC Interior - Testing the Stand Ranking Matrix.", Talk presented at the COFI Migratory Birds Working Group (chair: Archie MacDonald), Vancouver, BC, Canada, 10 January.

Barker, N.K.S. and Denés, F. (2018), "Identification of critical habitat for wide-ranging migratory birds: a conceptual model towards achieving self-sustaining populations", Talk presented at the ECCC Landbird Technical Committee Meeting, Ottawa, ON, Canada, 17 October.

Barker, N.K.S. and Leston, L. (2018), "Update on Alberta Stand Ranking Matrix", Update to Alberta Migratory Bird Project Partners, 25 October.

Barker, N.K.S., Schmiegelow, F.K.A., Vernier, P.R. and Crosby, A.D. (2018), "Conservation value of SFI-certified lands for boreal birds - initial results", Talk presented at webinar with Grant Partners, Online, 26 November.

Crosby, A.D., Bayne, E.M., Cumming, S.G. and Dénes, F.V. (2018), "Spatial variability in habitat selection for boreal birds", Poster presented at the International Ornithological Congress, Vancouver, BC, Canada, 19 August.

Denés, F. (2018), "Bird Habitat Models: Examples from the Boreal Avian Modelling (BAM) Project", Talk presented at the Lac Seul First Nation Workplanning Meeting, 4 December.

Denés, F. (2018), "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", Talk presented at the ECCC Schedule of Studies Advisory Committee Meeting, Ottawa, ON, Canada, 14 February.

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

Dénes, F.V., Barker, N.K.S., Crosby, A.D., Haché, S., Sólymos, P., Stralberg, D., Westwood, A.R., et al. (2018), "Identification of critical habitat for wide-ranging migratory birds: a conceptual model towards achieving self-sustaining populations", Talk presented at the North American Congress for Conservation Biology, Toronto, ON, Canada, 23 July.

- Dénes, F.V., Barker, N.K.S., Crosby, A.D., Haché, S., Sólymos, P., Stralberg, D., Westwood, A.R., et al. (2018), "Identification of critical habitat for wide-ranging migratory birds: a conceptual model towards achieving self-sustaining populations", Speed Talk presented at the International Ornithological Congress, Vancouver, BC, Canada, 19 August.
- Dénes, F. (2018), "Identification of critical habitat for wide-ranging migratory birds: A conceptual model towards achieving self-sustaining populations", Talk presented at the ECCC SAR3 Advisory Committee Meeting, 1 November.
- Haché, S. (2018), "Update on BAM national models and leveraging temporally sparse data to identify possible causes for population change in boreal forest bird communities", Talk presented at the ECCC Schedule of Studies Advisory Committee Meeting, Ottawa, ON, Canada, 14 February.
- Leston, L. (2018), "Long-term monitoring and predicting future of boreal bird communities", Speed Talk presented at the International Ornithological Congress, Vancouver, BC, Canada, 19 August.
- Leston, L. (2018), "Long-term monitoring and predicting future of boreal bird communities", Talk at SCO Early Careers Workshop presented at the International Ornithological Congress, Vancouver, BC, Canada, 19 August.
- Leston, L., Bayne, E.M. and Schmiegelow, F.K.A. (2018), "Exploring long term effects of forest fragmentation and recovery on boreal birds", Talk presented at the Alberta Chapter of The Wildlife Society Annual General Meeting, Lethbridge, AB, Canada, 9 May.
- Leston, L., Bayne, E.M., Dzus, E. and Cheyne, D. (2018), "Evaluating potential implications of caribou-centric forestry plans on other species of conservation concern", Talk presented at the North American Caribou Workshop: Working Together, Ottawa, ON, Canada, 1 November.
- Micheletti, T., Eddy, I., Schmiegelow, F.K.A., Suárez-Esteban, A. and Cumming, S.G. (2018), "Hindcasting the net effect of forest harvesting on the abundance of boreal songbirds: 1985-2011", Poster presented at the International Ornithological Congress, Vancouver, BC, Canada, 19 August.
- Sólymos, P. (2018), "At the end of the road: Comparing the PIF approach to a pixel-based approach for birds in Alberta", Talk presented at the Partners in Flight Science Meeting, Online, 12 July.
- Stehelin, T. and Schmiegelow, F.K.A. (2018), "Climate and habitat predictors of the Olive-sided Flycatcher and the Western Wood-pewee in northwestern North America", Speed Talk presented at the International Ornithological Congress, Vancouver, BC, Canada, 19 August.
- Stralberg, D. (2018), "Climate-change refugia in boreal North America: what, where, and for how long?", Talk presented at the Ecological Society of America annual meeting, New Orleans, LA, USA, 9 August.
- Stralberg, D., Camfield, A., Carlson, M., Lauzon, C., Barker, N.K.S., Westwood, A.R. and Schmiegelow, F.K.A. (2018), "Which half? Strategies for identifying priority areas for passerine conservation in Canada's boreal forest", Talk presented at the Prairie Habitat Joint Venture, Online, 26 February.
- Stralberg, D., Carroll, C. and Nielsen, S.E. (2018), "Incorporating climate-change refugia and connectivity in conservation planning: Assessment of climate-smart conservation priorities for protected areas networks", Talk presented at the BC Protected Areas Research Forum, Prince George, BC, Canada, 5 December.
- Stralberg, D., Nielsen, S.E., Carroll, C., McKenney, D.W., Pedlar, J.H., Wilsey, C.B., Price, D., et al. (2018), "Identifying climate-change refugia in the boreal forest region of North America", Talk presented at the North American Congress for Conservation Biology, Toronto, ON, Canada, 17 July.
- Stralberg, D., Sólymos, P., Barker, N.K.S., Schmiegelow, F.K.A. and Song, S.J. (2018), "The end of the road: Challenges and solutions for avian abundance modeling in the remote North American boreal region", Talk presented at the "Advances in Citizen Science for Conservation & Management" at the American Ornithological Society meeting, Tucson, AZ, USA, 13 April.

Tremblay, J.A., Boulanger, Y., Cadieux, P., Cyr, D., Taylor, A.R., Price, D.T., Stralberg, D., et al. (2018), "Impacts of climate change on boreal bird communities: Going beyond climatic suitability models", Poster presented at the International Ornithological Congress, Vancouver, BC, Canada, 19 August.

Tremblay, J.A., Boulanger, Y., Cadieux, Phillippe, Cyr, D., Taylor, A.R., Price, D.T., Stralberg, D., et al. (2018), "Adverse Effects of Climate Change on Boreal Bird Communities Accentuated by Natural and Anthropogenic Disturbances", Talk presented at the 25th Conference of The Wildlife Society, Cleveland, Ohio, USA, 8 October, available at:
https://www.researchgate.net/publication/328149801_Adverse_Effects_of_Climate_Change_on_Boreal_Bird_Communities_Accentuated_by_Natural_and_Anthropogenic_Disturbances.

Van Wilgenburg, S.L., Sólymos, P., Kardynal, K.J. and Frey, M.D. (2018), "Estimating densities of terrestrial wildlife using passive acoustic recordings: A pragmatic approach using paired human observations", Talk presented at the Joint meeting of the Acoustical Society of America and Canadian Acoustical Society, Vancouver, BC, Canada, 5 November.

2019 – January - March

BAM Team. (2019), "Boreal Avian Modelling (BAM) Project Overview", Talk presented at the Open Data Workshop for Avian Data in Canada, Edmonton, AB, Canada, 24 April.

Barker, N.K.S. (2019), "Application of models to date", Talk presented at the NSERC CRD Birds and Forestry Meeting, Edmonton, AB, Canada, 23 January.

Barker, N.K.S. and Williams, E. (2019), "Meeting in the Middle: Potential avenues for pan-American bird conservation", Talk presented at the SFI Conservation Impact Sounding Board, Washington, DC, USA, 9 April.

Bayne, E.M. (2019), "Boreal Avian Modelling (BAM) Project Overview", Talk presented at the Open Data Workshop for Avian Data in Canada, Edmonton, AB, Canada, 24 April.

Denés, F.V. (2019), "Identification of critical habitat for wide-ranging migratory birds: a conceptual model towards achieving self-sustaining populations", Talk presented at the Schedule of Studies Advisory Committee Meeting, Ottawa, ON, Canada, 27 February.

Leston, L., Bayne, E.M. and Schmiegelow, F.K.A. (2019), "Long-term monitoring of boreal bird community at Calling Lake Alberta, 1993-2018 and counting", Talk presented at the Western Canada Bird Banding Conference, Edmonton, AB, Canada, 29 March.

Leston, L., Bayne, E.M. and Schmiegelow, F.K.A. (2019), "Long-term monitoring of changes in harvest area, weather, and insect outbreaks on boreal birds", Talk presented at the Alberta Chapter of the Wildlife Society AGM, Canmore, AB, 22 March.

Sólymos, P. (2019), "Data integration and current models", Talk presented at the NSERC CRD Birds and Forestry Meeting, Edmonton, AB, Canada, 23 January.

Stehelin, T.E. and Schmiegelow, F.K.A. (2019), "Predicting present and future distribution and abundance of Olive-sided Flycatcher and Western Wood-pewee in northwestern North America using climate and landcover", Talk presented at the Biodiversity Forum, Whitehorse, YT, Canada, 2 March.

Stralberg, D., Wang, X., Parisien, M.-A., Robinne, F.-N., Mahon, C.L., Sólymos, P., Nielsen, S.E., et al. (2019), "Evaluating wildfire-mediated vegetation changes and climate-change refugia potential across Alberta boreal forests", Talk presented at the ABMI Information Forum, Edmonton, AB, Canada, 29 January.

🌱 Webinars & Workshops

Webinars and workshops organized or co-organized by BAM, hosted between January 2018 and March 2019.

2018 – January - December

“Boreal Avian Modelling (BAM) Project: Overview and 2017-18 Update”, (2018), Online, 24 September, Organized by BAM.

“SFI Webinar with Grant Partners”. (2018), Online, 26 November, Organized by BAM and SFI.

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

2019 – January - March

“NSERC CRD Birds and Forestry Meeting”. (2019), Workshop, University of Alberta, Edmonton, AB, Canada, 25 January, Organized by Erin Bayne.

.....*ଅନୁଷ୍ଠାନ*.....*ଅନୁଷ୍ଠାନ*.....

BAM Collaborative Activities at a Glance

In 2018-19, we contributed to the following efforts directly or by supplying data products:

☛ **Boreal Bird Density, Population Size, Temporal Patterns, and Habitat Needs**

- BAM continued contributions to discussions within **Partners in Flight (PIF)** regarding population estimation. Several BAM team members attended or presented (remotely) at the 2018 PIF Science Meeting in July 2018. [Contact: Péter Sólymos]
- We provided advice to support songbird modelling efforts by **Canadian Wildlife Service (CWS) Northern Region** in the Edézhzié Candidate Protected Area. [Contact: Diana Stralberg]
- Wayne Thogmartin (**United States Geological Service**) has contributed to our comparison of BAM and PIF population size estimates (page 10). [Contact: Péter Sólymos]
- Our review of waterfowl habitat associations was completed in association with Louis Imbeau (**Université du Québec en Abitibi-Témiscamingue**) and Marcel Darveau (**Ducks Unlimited Canada**; page 12). [Contact: Antoine Adde]
- Adam Smith (**CWS**) joined our manuscript on Canada Warbler population, density, and trend (page 12). [Contact: Samuel Haché]
- A grad student project examining use of LiDAR in species distribution models relies on the **Alberta Department of Agriculture and Forestry** to facilitate data-sharing (page 14) [Contact: Brendan Casey]

☛ **Threats Assessment: Impacts of Landscape Change and Climate Change on Boreal Birds**

- BAM advanced discussions with the **American Bird Conservancy (ABC)**, **Sustainable Forestry Initiative (SFI)**, and **NatureServe** exploring the potential for a cross-border project regarding bird conservation in SFI-certified forests [Contact: Andy Crosby]
- Our hindcasting effort to understand impacts of forestry on bird populations is a collaboration with the **Pacific Forestry Centre (Canadian Forest Service [CFS])** (page 15) [Contact: Tati Micheletti]
- BAM continued our collaboration with **Alberta-Pacific Forest Industries Inc. (Al-Pac)** to understand impacts of forest fragmentation on birds using data from the Calling Lake Fragmentation Study (page 16) and the potential impacts of caribou-specific harvest management plans on avian populations (page 18). [Contact: Lionel Leston]
- We continued our work looking at climate change and vegetation impacts on bird habitat in Alberta and conducted a similar evaluation in Québec, a collaboration with the **Laurentian Forestry Centre (CFS)** (page 17). [Contact: Junior Tremblay & Diana Stralberg]
- BAM continued working with forest products companies in BC and Alberta, along with the **BC Council of Forest Industries (COFI)** and the **Alberta Forest Products Association (AFPA)**, to evaluate and advance tools to inform incidental take risk assessment in each province (page 18). [Contact: Lionel Leston]
- Our evaluation of the impacts of residual tree retention (page 19) is a collaboration with the **Alberta Biodiversity Monitoring Institute** [Contact: Brendan Casey]
- We continued our work with **Pacific Forestry Centre (CFS)**, **Université Laval**, and **DUC**, and with input from **Science & Technology**, **CWS**, and **SFI** as part of our NSERC Strategic Partnership Grant (page 19). [Contact: Steve Cumming]

- We are contributing to a proposal for an NSERC CRD grant in association with the **Bioacoustic Unit** at the U of Alberta, **ABMI**, and **ECCC**. Potential partners include **AI-Pac**, **Canfor**, **Daishowa-Marubeni International Ltd. (DMI)**, **Norbord**, **West Fraser**, **Weyerhaeuser**; several conversations and meetings have taken place to date.
 - We presented our evaluation of the potential value of **SFI**-certified forests for birds to various partners at three webinars and the in-person **SFI** Conservation Impact Sounding Board meeting (page 50); partners include **AI-Pac**, **ABC**, **Boreal Ecosystems Analysis for Conservation Planning (BEACONS)**, **Bird Studies Canada (BSC)**, **CFS**, **Canadian Forest Products Ltd. (Canfor)**, **Center for Northern Forest Ecosystem Research**, **the Central and Western Canada SFI Implementation Committees**, **DMI**, **Domtar**, **DUC**, **EACOM Timber Corporation**, **ECCC**, **fRI Research**, **Fuse Consulting**, **Interfor**, **Nature Canada**, **NatureServe**, **Resolute**, **Tolko**, **Université Laval**, **University of BC**, **West Fraser**, and **Weyerhaeuser**. [Contact: Andy Crosby]
 - We worked with partners from **ABMI** and **CWS** to refine manuscripts describing work from the OSM program (page 21). [Contact: Lionel Leston]
 - We contributed to a project led by **Université Laval**, in collaboration with individuals from **CFS**, **CWS**, **S&T**, and the **NWT Department of Environment and Natural Resources**, with the goal of projecting landbird and caribou response to climate change, natural disturbance, and other factors (page 21) [Contact: Tati Micheletti].
 - BAM's work was featured in outreach materials from the **Boreal Songbird Initiative** on climate-change impacts on boreal bird distribution and abundance and the importance of refugia (page 47). [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 22). [Contact: Steve Matsuoka]
- 🍂 **Species at Risk Status, Recovery Planning, and Multi-species Management**
- BAM responded to requests for information to support a Lesser Yellowlegs COSEWIC status report (request from **Dendroica Environnement et Faune**) and an isotope analysis for Blackpoll Warbler (request from **Cornell**). [Contact: Erin Bayne and Diana Stralberg]
 - BAM continues to support **CWS** efforts to develop a standardized approach to identify critical habitat for wide-ranging species at risk, using Canada warbler as a test species (page 24). [Contact: Francisco Dénes]
- 🍂 **Conservation Planning for Boreal Birds**
- We built or updated regional models for species of conservation interest to support land-use planning by the **Moose Cree First Nation** and the **Lac Seul First Nation** (page 26). [Contact: Francisco Dénes]
 - BAM team members continued working with **CWS**, **S&T**, and **High Branch Conservation Services** to identify management and conservation opportunities to benefit Canada Warbler in BCR 14 (page 27). [Contact: Diana Stralberg]
 - We collaborated with **BEACONS** to evaluate ecological representation of the North French River Watershed to support the **Moose Cree First Nation**, **Nature Canada**, the **Wildlands League** in their Indigenous Protected and Conserved Area (IPCA) proposal (page 27). [Contact: Francisco Dénes]

☛ Boreal Landbird Monitoring Design

- Informed a sampling design for **Moose Cree First Nation** Homelands. [Contact: Francisco Dénes]
- We provided a summary of sampling coverage in Alberta to partner forest companies, to guide point count sampling during the 2019 field season by companies like **Weyerhaeuser**, **Al-Pac**, and **West Fraser**. [Contact: Lionel Leston]
- BAM has and will continue to contribute both data products and scientific expertise to **CWS's** Boreal Monitoring Strategy (page 30). [Contact: Steve Van Wilgenburg].

☛ Method and Tool Development

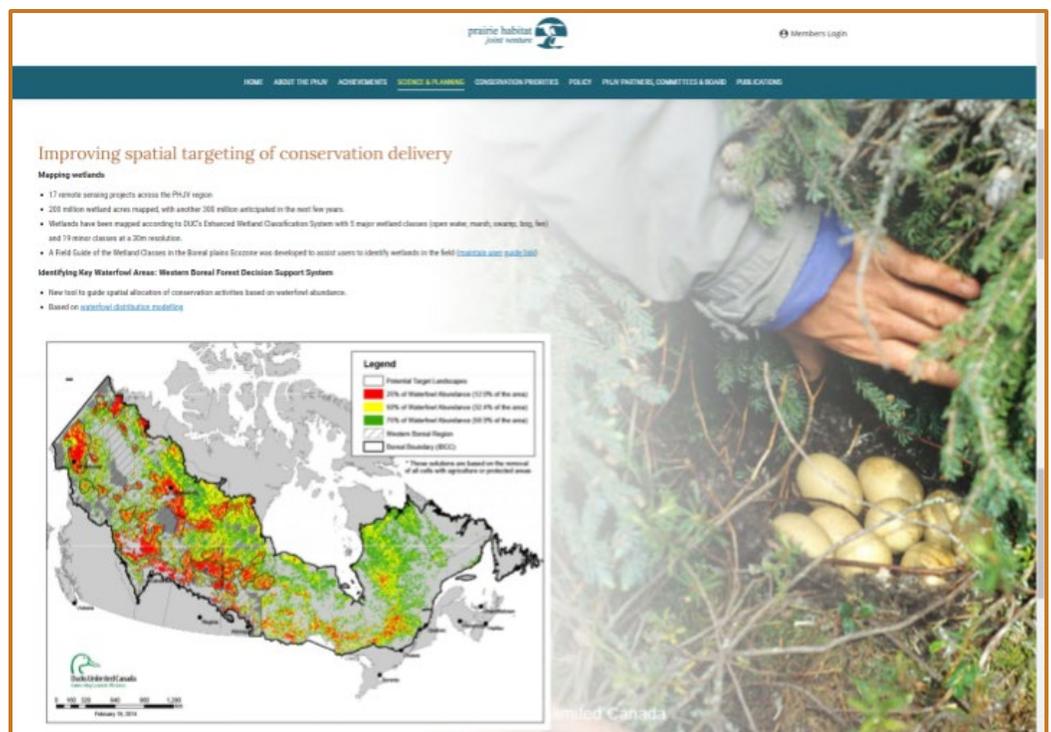
- The **cure4insect** R package, a collaborative effort between BAM and **ABMI**, supports industry sector effects on biodiversity. It was used in the evaluation of possible co-benefits of a caribou-centric harvest management plan with avian populations. [Contact: Péter Sólymos]

☛ Data

- We advanced our mutually-beneficial collaboration with the **ABMI**. We are working more closely together and with **CWS** and the **Bioacoustic Unit** to advance the state of open avian data in Canada, (pages 32 and 38). [Contact: Erin Bayne]

☛ Communications and Outreach

- The newly updated website for the **Prairie Habitat Joint Venture** (www.phjv.ca/) features results based on Barker et al. (2014) waterfowl predicted density maps.
- BAM was highlighted in the Fall 2018 newsletter from the **North American Bird Conservation Initiative** (NABCI). [Contact: Samantha Song]
- The Conservation of Boreal Bird special issue is a collaborative effort, with guest editors from **BAM/ULaval**, **DUC**, and **S&T**.



.....

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.

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

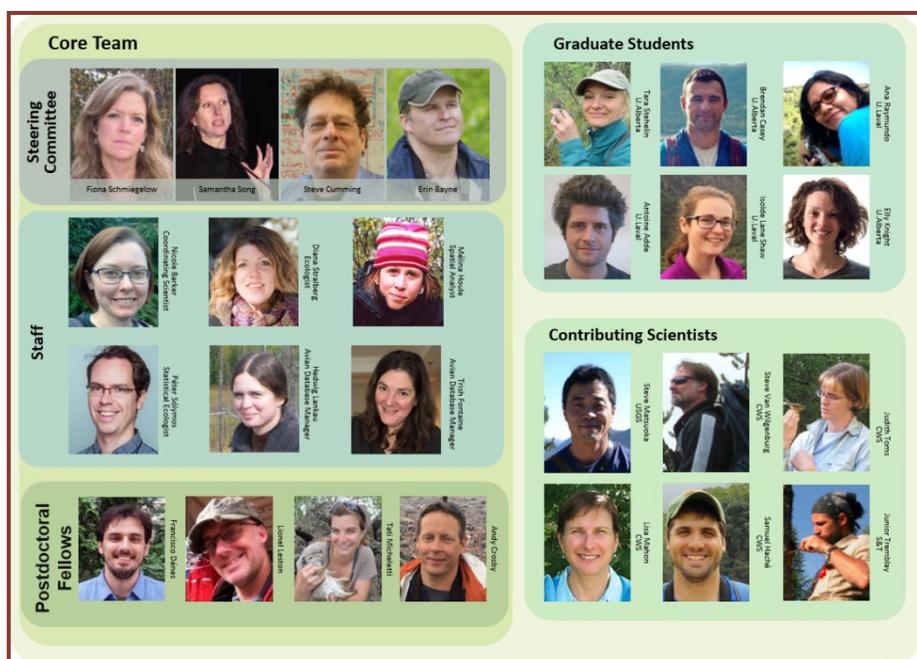
- Erin Bayne, University of Alberta
- Steve Cumming, Université Laval
- Fiona Schmiegelow, University of Alberta
- Samantha Song, Environment & Climate Change Canada

Project Staff: BAM welcomes Hedwig Lankau, who will be working with the avian database.

- 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. diana.stralberg@ualberta.ca
- Database Manager: Trish Fontaine, part-time. trish.fontaine@ualberta.ca
- Database Manager: Hedwig Lankau, part-time.

Post-doctoral Fellows: BAM wishes good luck to Alberto Suarez Esteban!

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



Students: BAM welcomes Elly Knight to the BAM team.

- PhD candidate with Fiona Schmiegelow: Tara Stehelin. tstehelin@yukoncollege.yk.ca
- PhD student with Erin Bayne: Elly Knight. ecknight@ualberta.ca
- PhD 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 Steve Cumming: Isolde Lane Shaw. rachel-isolde.lane-shaw.1@ulaval.ca

Contributing Scientists: BAM wishes good luck to Alana Westwood!

- 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

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
- Laura Garland (University of Alberta): Data management support
- Hana Ambury (University of Alberta): Administrative and website 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 us (BorealAvianModellingProject@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 2018-19

- | | |
|--|---|
| <ul style="list-style-type: none"> • Aboriginal Fund for Species at Risk (AFSAR; projects with Moose Cree First Nation and Lac Seul 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) | <ul style="list-style-type: none"> • Environment & Climate Change Canada (ECCC) • Fuse Consulting • Mitacs Accelerate Program • Natural Sciences and Engineering Research Council of Canada (NSERC) • Sustainable Forestry Initiative (SFI) • Université Laval • University of Alberta • Wilburforce • West Fraser Timber Co. Ltd. |
|--|---|

Financial support for CASFRI

- | | | |
|--|--|---|
| <ul style="list-style-type: none"> • ECCC (within the Boreal Avian Modelling Project) • GEOIDE Network | <ul style="list-style-type: none"> • Canada Foundation for Innovation • NSERC Discovery Grant • NRCan | <ul style="list-style-type: none"> • 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 us (BorealAvianModellingProject@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.

.....୧୩୦୩.....୧୩୩୦.....

References

- Boreal Avian Modelling Project. 2018. Annual Report - April 2017-March 2018. BAM Annual Report, Boreal Avian Modelling Project, University of Alberta, Edmonton, AB, Canada.
- Chubaty, A. M., & McIntire, E. J. B. (2018). SpaDES; Develop and Run Spatially Explicit Discrete Event Simulation (Version R Package Version 2.0.2). Retrieved from <https://CRAN.R-project.org/package=SpaDES>
- Matsuoka, S. M., Hagelin, J. C., Smith, M. A., Paragi, T. F., Sessler, A. L., & Ingle, M. A. (In review). Pathways for avian science, conservation, and management in boreal Alaska.
- Micheletti, T., Stewart, F., McIntire, E. J. B., Eddy, I., Barros, C., Marchal, J., ... Cumming, S. G. (2019). Simulation effects of climate change on fire regime: implications for Boreal Caribou and landbird communities in the Northwest Territories [Technical Report].
- Roy, C., Michel, N., Burkhalter, C., Flint, P., Gurney, K., Handel, C. M., ... Zuckerberg, B. (In review). Trajectories, trends, and cycles in boreal avian populations: how can we recover trends and cycles from noisy data?
- 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., Alberta Biodiversity Monitoring Institute, & Boreal Avian Modelling Project. (2018). cure4insect: Custom Reporting for Intactness and Sector Effects (Version R package version 0.1-1.). Retrieved from <https://github.com/ABbiodiversity/cure4insect>
- Stralberg, D., Berteaux, D., Drever, R., Drever, M. C., Naujokaitis-Lewis, I., Schmiegelow, F. K. A., & Tremblay, J. A. (In press). Conservation planning for boreal birds in a changing climate: A framework for action.
- Stralberg, D., Camfield, A. F., Carlson, M., Lauzon, C., Westwood, A. R., Barker, N. K. S., ... Schmiegelow, F. K. A. (2018). Strategies for identifying priority areas for passerine conservation in Canada's boreal forest. *Avian Conservation and Ecology*, 13(2): 12, 1–23. <https://doi.org/10.5751/ACE-01303-130212>
- Stralberg, D., Matsuoka, S. M., Hamann, A., Bayne, E. M., Sólymos, P., Schmiegelow, F. K. A., ... Song, S. J. (2015). Projecting boreal bird responses to climate change: The signal exceeds the noise. *Ecological Applications*, 25(1), 52–69. <https://doi.org/10.1890/13-2289.1>
- Suárez-Esteban, A., Cumming, S. G., Bayne, E. M., Micheletti, T., Sólymos, P., Song, S. J., ... Schmiegelow, F. K. A. (In review). Anthropogenic disturbances negatively influence boreal forest bird density at multiple spatial scales. *Avian Conservation and Ecology*.
- Westwood, A. R., Barker, N. K. S., Amos, A. F., Camfield, A. F., Cooper, K., Denés, F., ... Whitaker, D. (In review). Coproducing actionable research for conserving Canada's boreal birds by building respectful partnerships.
- Westwood, A. R., Stacier, C., Sólymos, P., Haché, S., Fontaine, T., Bayne, E. M., & Mazerolle, D. (In press). Estimating the conservation value of protected areas in Maritime Canada for two species at risk: the Olive-sided Flycatcher (*Contopus cooperi*) and Canada Warbler (*Cardellina canadensis*).
- Westwood, A. R., Lambert, D., Reitsma, L., & Stralberg, D. (In review). Finding common ground: Regional spatial models to support both land conservation and forest management planning for the threatened Canada Warbler (*Cardellina canadensis*).

Boreal Avian Modelling Project

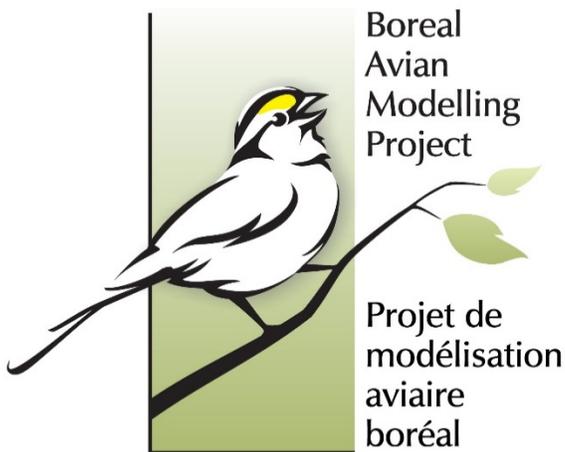
Annual Report April 2018 - March 2019

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. 2019. Annual Report - April 2018-March 2019. Boreal Avian Modelling Project, University of Alberta, Edmonton, AB, Canada.



COVER PHOTOS:

Lincoln's Sparrow (*Melospiza lincolnii*): Duxbury
Photographics ([@dux_photos](https://www.instagram.com/dux_photos))

www.borealbirds.ca
