## Boreal Ecosystem Recovery and Assessment (BERA) – October 23 meeting, 11:30 AM – 12:30 PM

## Project Outline

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| Using spatial *N*-mixture models to relate bird abundance data from acoustic recorders to remote-sensed forest structure data | |
| Lead | Name and affiliation of person primarily responsible: Lionel Leston [BERA, Bioacoustic Unit, University of Alberta] |
| Collaborators | * Gustavo Lopez Quieroz [BERA, University of Calgary] * Mustafizur Rahman [BERA, University of Calgary] * Silvia Alejandra Losada [BERA, University of Calgary] * Erin Bayne [BERA, Bioacoustic Unit, University of Alberta] * Julia Linke [BERA, University of Calgary] * Greg McDermid [BERA, University of Calgary] |
| Data Requirements | * Avian point count data (provided by the Bioacoustic Unit) * Coarse-scale habitat and footprint data (provided by the Alberta Biodiversity Monitoring Institute) * LIDAR point cloud data (provided by Greg McDermid and Mustafizur Rahman) * Coarse woody debris data (provided by Gustavo Lopez Quieroz) * Snag data (provided by Mustafizur Rahman [BERA, University of Calgary]) * Shrub structural (and floristic?) data (provided by Silvia Alejandra Losada) (IF AVAILABLE) |
| Project Dependencies & Contingency Plans | **Dependencies**:   * Transcription of remaining recordings from Kirby Grid (16 stations) * Habitat and human footprint for Kirby Grid (to be digitized by ABMI) * Point cloud layer (max veg ht., mean veg ht., pt hits on/near ground/at a certain height above ground (determine what scale of point cloud data, by next week) (available November 20) * Remote-sensing layers provided by Gustavo, Mustafiz, and Silvia (Coarse woody debris layer already available, snag data assumed to be ready, additional shrub layer may be available by March)   **Contingency Plans**:   * Alternate coarse layers available as rasters (Beaudoin layer) or with permission from Al-Pac, possibly Al-Pac AVI layer from 2016 * Base analyses just on the already transcribed station data (84 stations) |
| Deliverables | * Base model results (no fine-scale data) for 20 species of birds in different guilds or most common species (Nov 6) * Interim report (Dec 2019): models incorporating point cloud data, snags, coarse woody debris * Interim report (Mar 2019): models incorporating shrub layer (IF AVAILABLE) * Final report (May 2020) * Published paper (2020-2021) |
| Status | Start date: September 2019  Status: ongoing  Scheduled completion: May 2020 |

## Overview:

### Introduction: The structure of boreal forests in Alberta is changing with increasing forestry and energy sector development. There are much available vegetation and human footprint data at large extents within Alberta’s boreal forests for predicting the effects of human footprint on wildlife. These data include both shapefiles (e.g. Alberta Vegetation Inventory, Alberta Biodiversity Monitoring Institute wall-to-wall human footprint and vegetation layer) and remotely sensed data processed into rasters. However, these data are mainly available at a coarser scale of resolution (e.g. 250-m raster cells) or are summarized for shapefile polygons (e.g. stand type, % cover by dominant species in each stand). Many recent studies suggest that models of bird abundance are improved by including fine-scale vegetation structural data (e.g. crown height, canopy cover, shrub density) which are time-consuming and labor-intensive to obtain even over small extents. However, newer remote sensing techniques like LIDAR (Light Detection and Ranging) have become widespread and have been used to efficiently quantify fine-scale vegetation structure over large areas. Some recent studies have employed LIDAR based vegetation metrics at point count locations to predict bird abundance, and these studies have found that incorporating LIDAR-based fine-scale vegetation structural variables into models improves predictions of bird abundance.

There are additional remotely sensed fine-scale non-LIDAR data such as coarse woody debris and snag densities that may improve predictions of ground-nesting and cavity-nesting species as well. As with LIDAR, these data products are efficiently obtained across large extents.

### Objectives: To model how abundance of boreal birds (~20 species) varies with fine-scale vegetation structure associated with boreal forest regeneration along/adjacent to energy sector footprint like 2d and 3d seismic lines. We predict that models incorporating additional fine-scale data collected by drones and planes (e.g. LIDAR-based point clouds, coarse woody debris, snags, possibly shrub density) will improve prediction of bird abundance or occupancy relative to models without fine-scale data.

### Study Questions:

Are species associated with older forests and tree-nesting species more abundant/better predicted at sites with a higher density of LIDAR points at greater heights above ground?

Are shrub-nesting and ground-nesting species more abundant/better predicted at sites with a lower density of LIDAR points close to the ground.

Are shrub-nesting and ground-nesting species more abundant/better predicted at sites with a greater density of coarse woody debris.

Are cavity-nesting birds more abundant/better predicted at sites with a greater density of snags?

How does the abundance of different fine-scale vegetation metrics vary with the amount of, or distance from different kinds of human footprint, i.e. are the fine-scale vegetation metrics a potential mechanism through which human footprint affects the abundance of boreal birds?

## Study Site(s):

The “Kirby” grid ~45 minutes north of Calling Lake (UTMs: 489525-494943, 6131568-6136993). If similar coarse-scale and fine-scale remote-sensed data are available alongside point count data outside of the Kirby grid in Alberta’s boreal forest region, then a larger study area might be considered. We will be using indices of bird abundance from autonomous recording unit (ARU) stations, and individual recordings (3-4 per station) will be the unit of analysis. Data consists of counts of each species detected in each recording; actual abundance is not known but estimated.

## Study Species:

The 20 most common species, in terms of the number of stations with at least one detection of a given species, are: American Robin, Chipping Sparrow, Dark-eyed Junco, Golden-crowned Kinglet, Gray Jay, Hermit Thrush, Le Conte’s Sparrow, Lincoln’s Sparrow, Ovenbird, Palm Warbler, Pine Siskin, Red-breasted Nuthatch, Red-eyed Vireo, Ruby-crowned Kinglet, Swainson’s Thrush, White-throated Sparrow, White-winged Crossbill, Winter Wren, and Yellow-rumped Warbler. The least widespread of these species on the Kirby Grid was Red-breasted Nuthatch, detected at 10 of 84 stations with transcribed data. Other species of conservation interest (e.g. Black-throated Green Warbler, Brown Creeper, Canada Warbler) are either less widespread or were undetected at the Kirby grid.

Nine of the 20 species (Golden-crowned Kinglet, Gray Jay, Pine Siskin, Red-breasted Nuthatch, Ruby-crowned Kinglet, Swainson’s Thrush, White-winged Crossbill, Winter Wren, and Yellow-rumped Warbler) are associated with boreal forests older than 80 years and Ovenbirds are most abundant in mature boreal forests (~60-80 years old). These species would be predicted to be more abundant at sites with a greater density of LIDAR points higher above the ground. The remaining species are habitat generalists or associated with younger boreal forests. At least some of these species would be predicted to be more abundant at sites with a greater density of LIDAR points closer to the ground.

Five of the 20 species (Dark-eyed Junco, Le Conte’s Sparrow, Lincoln’s Sparrow, Ovenbird, Palm Warbler, White-throated Sparrow) are shrub or ground nesters whose numbers are predicted to be strongly related to the density of LIDAR points closer to the ground. Such species are also predicted to vary with the amount of coarse woody debris on the ground, given that the amount of coarse woody debris might influence the amount of other ground cover types (e.g. bare ground, herbaceous vegetation, woody vegetation).

Fifteen of the 20 species are tree-nesting species that are predicted to vary with the density of LIDAR points higher above the ground. One species (Red-breasted Nuthatch) is a cavity nester that is predicted to increase with the density of snags.

## Strategy:

September (Received bird data from 84 stations at Kirby grid; initial N-mixture model scripts developed; coarse woody debris layer received)

October 9 - meeting

October (Develop initial model scripts; acquire coarse-filter habitat and footprint data for base model; obtain snag data layer)

October 23 – interim meeting 11:30 Wed

Early November (Lionel: have base model ready and run model for 20 species, using just coarse-scale variables from ABMI; determine amount of spatial autocorrelation for each species to account for in analyses)

November 6 – present results from base model for ~20 species of the most common birds

November 20 (receive remaining remote-sensed layers: LIDAR-based point clouds from Mustafiz)

December (Lionel: add fine-scale data as it comes along to the base model)

January-March (initial results obtained; add additional point count data from Kirby grid as recordings are transcribed; maybe Silvia will have shrub data ready but don’t count on it)

May (final report)

Figure 1. Location of Kirby grid in Alberta. There are multiple BERA studies (different point colours) taking place on the Kirby grid. We will be using at least 84 of the 100 ARU stations (red points) in our analyses.



![A screenshot of a cell phone

Description automatically generated]()

## Methods:

### Coarse-scale vegetation and human footprint data: These data will be obtained from the Alberta Vegetation Inventory and Alberta Biodiversity Monitoring Institute, extracted to point counts at two spatial scales (150 m or local scale, and 1 km or landscape scale). These variables will be used to create a base model for each species. Such variables can include the dominant stand type or land use at local scale, forest age at local scale, and the proportions of different individual or combined land uses within 1 km. The variables selected for analysis will be based on previous ABMI/BAM/ECCC models for the 20 study species.

### LIDAR and other fine-scale data: These data will consist of point returns within different height intervals collected when scanning the Kirby Grid. The raw point returns can then be summarized within a buffer zone around each point count, or within an intermediate digital elevation/terrain/surface model at finer resolution (e.g. 1-2 m to distinguish individual shrubs). In either case, when summarizing LIDAR data within a buffer zone, previous studies have summarized LIDAR data at the extent of a study species’ territory size or found that different species responded most strongly to LIDAR variables at a variety of spatial scales. Thus, our LIDAR data will be summarized at 3 scales around each point count (50 m, 150 m, 500 m), to determine at which spatial scale different bird species are best predicted by LIDAR data. Based on territory sizes reported in the literature, Gray Jays are predicted to respond most strongly at the 500-m scale; Chipping Sparrow, Red-breasted Nuthatch, and Winter Wren are predicted to respond most strongly at the 150-m scale; and the remaining species are predicted to respond most strongly to LIDAR data at the 50-m scale. The mean and standard deviation (or coefficient of variation) of the density of point returns at different height intervals will be used as summary statistics. Standards of deviation (coefficients of variation) provide a measure of the heterogeneity in variables like shrub cover (point returns close to the ground) and canopy cover (point returns higher above the ground). The mean density of point returns at medium height intervals can indicate the presence of a forest understory.

Coarse woody debris volume is a metric currently available as a 100-m raster layer for the Kirby grid. There is also a shapefile layer derived from the same data source in which logs and snags are distinguished from each other, with the snag data being considered more accurate than the log data, since many logs are likely to be concealed by canopy vegetation.

### Bird Data: Multiple recordings of soundscapes at the ARU locations are similar to point counts that are visited multiple times to collect data of bird species abundance or occupancy. Counts or detections of birds during point counts or within recordings are estimates of true abundance or occupancy, since the probability of detecting a species that is present at a site is <1, due to environmental variables (detection covariates) affecting sound detection by humans (e.g. environmental noise, sound attenuation by vegetation) or singing activity by birds (weather, time of breeding season, time of day). If probability of detection is not accounted for, then estimates of relative abundance or occupancy from raw counts or detections will be biased. *N*-mixture and occupancy models are types of hierarchical models in which the number of birds counted is a function of two processes: those variables that affect abundance or occupancy of birds at sites; then, given that a species is present at a site, the probability of detecting that species due to detection covariates.

## Storyline:

Boreal forest bird communities are difficult to monitor effectively because much of their habitat is not easily accessible, especially since multiple visits to each survey point are necessary to accurately quantify bird abundance or occupancy as well as habitat features influencing abundance or occupancy. However, quantification of bird and habitat data in remote areas can be achieved efficiently for large numbers of sites by a combination of 1) remote sensing with drones or planes to collect fine-scale habitat data, and 2) use of programmable acoustic recorders or autonomous recording units to collect bird data over multiple recordings in place of human visits. Newer analysis techniques like *N*-mixture or occupancy models are then well-suited for estimating true abundance or occupancy of bird species at sites from multiple recorded visits while accounting for detection probability of each species on different visits due to weather, time of season and day, and environmental noise.

**Constraints, limitations, things to be aware of:**

Unless certain conditions are met (distances to individual birds in the recordings are known or can be estimated, either from noise levels, triangulation by closely-spaced ARUs, or simultaneous point count data collected by human observers with distance-sampling methods), point count data collected by ARUs can only provide measures of relative abundance, not densities of birds. The point counts in the Kirby grid are spaced 600 m apart, so cannot be used to triangulate bird locations and distances from ARUs. There are also no corresponding human observations of birds at the ARUs to use for estimating distances to birds. forest bird communities are difficult to monitor effectively because much of their habitat is not easily accessible, especially since multiple visits to each survey point are necessary to accurately quantify bird abundance or occupancy as well as habitat features influencing abundance or occupancy. Finally, counts of birds within ARU recordings are reliant on detection of bird sounds, so quietly or infrequently vocalizing bird species are less likely to be detected, and birds that are seen rather than heard will not be detected within recordings.

Eighty-four ARU point count stations and 3-4 recordings per ARU are currently available for analysis. This sample size will probably be insufficient for rarer species of interest such as owls, and some species of interest (e.g. Canada Warbler) have not been detected in the recordings transcribed so far.