Keeyask Generation Project

Terrestrial Effects Monitoring Plan

Olive-Sided Flycatcher And Rusty Blackbird Sensory Disturbance Monitoring Report

TEMP-2018-13

KEEYASK

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KEEYASK GENERATION PROJECT

TERRESTRIAL EFFECTS MONITORING PLAN

REPORT #TEMP-2018-13

OLIVE-SIDED FLYCATCHER AND RUSTY BLACKBIRD SENSORY DISTURBANCE MONITORING

Prepared for

Manitoba Hydro

By

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SUMMARY

Background

Construction of the Keeyask Generation Project (the Project) at Gull Rapids began in July 2014. The Keeyask Hydropower Limited Partnership (KHLP) was required to prepare a plan to monitor the effects of construction and operation of the generating station on the terrestrial environment. Monitoring results will help the KHLP, government regulators, members of local First Nation communities, and the general public understand how construction and operation of the generating station will affect the environment, and whether or not more needs to be done to reduce harmful effects.

Olive-sided flycatcher and rusty blackbird are migratory songbirds that are found in the Keeyask region. Both species are considered species at risk in Canada and are protected under the federal *Species at Risk Act* (SARA). In Manitoba, the olive-sided flycatcher is also listed as *Threatened* by *The Endangered Species and Ecosystems Act* (ESEA).

Why is the study being done?

Both the olive-sided flycatcher and rusty blackbird are near the edge of their breeding range in northern Manitoba and are found in relatively low numbers in the Keeyask region. These species are both protected under the SARA, and the olive-sided flycatcher is also protected under the ESEA in Manitoba. Both species have been experiencing widespread declines throughout their range and may be vulnerable to Project effects. As part of the Terrestrial Effects Monitoring Plan (TEMP), the effects of sensory disturbance from the Project on the distribution, abundance, and habitat of these species was examined.

Rusty Blackbird Perching on a Tree

Pair of Olive-sided Flycatchers

What was done?

In 2015, a pilot study was conducted to determine if sufficient numbers of olive-sided flycatchers and rusty blackbirds were present in the Keeyask region to conduct a justifiable study. Handheld recorders and automated recording units were used to verify the accuracy of observations and to collect data for improving the automated recording units. Survey points distributed throughout the Keeyask region were visited and the size and location of the birds' breeding territory was estimated. Based on the findings of 2015, the study continued in 2016 and into 2017. During these years, olive-sided flycatcher and rusty blackbird breeding territories identified in 2015 were re-visited and new territories were also located. After territory mapping, several automated recording units, designed to record bird calls, were placed in and around known bird territories. The recordings from these automated recording units will be used to determine the abundance, distribution, and territory sizes of birds in the Keeyask region and determine if there are any potential Project effects.

Biologist Setting up an Automated Recording Unit to Record Bird Calls

What was found?

The 2015 pilot study found sufficient numbers of olive-sided flycatchers and rusty blackbirds in the Keeyask region to support the study design. In 2015, 21 olive-sided flycatcher and 20 rusty blackbird breeding territories were mapped. In 2016 and 2017, 36 and 28 olive-sided flycatcher breeding territories were mapped, respectively, and 48 and 39 rusty blackbird breeding territories were mapped, respectively. Monitoring showed that breeding territories for olive-sided flycatcher and rusty blackbird were widespread in the Keeyask region and included areas close to the Project.

What does it mean?

A sufficient number of olive-sided flycatcher and rusty blackbirds were present in the Keeyask region to conduct a justifiable study of potential sensory disturbance effects on these species from Project construction. Data collection in 2016 and 2017 resulted in a large number of audio recordings that are currently being processed. Once processed, further examination of the audio recordings will be done to determine potential Project effects on the distribution, abundance, and breeding territory size of olive-sided flycatcher and rusty blackbird.

What will be done next?

Analysis of the audio recordings from 2016 and 2017 will be conducted to determine if there any potential effects of sensory disturbance from Project construction on olive-sided flycatchers and rusty blackbirds. The audio recordings will be used to determine the distribution and abundance of these species and how they relate to Project disturbance. Fieldwork for the study will continue in June 2019.

STUDY TEAM

We would like to thank Sherrie Mason and Rachel Boone of Manitoba Hydro for editorial comments, and Megan Anger of Manitoba Hydro, Ben Hofer of Custom Helicopters, and Ron Bretecher of North/South Consultants Inc., for logistical assistance in the field. We would also like to thank Dr. James Ehnes, ECOSTEM Ltd., for GIS-supported study design and cartography. .Taylor Toffan is gratefully acknowledged for her contribution to the Study Team. She is the talented artist behind the beautiful watercolor of an olive-sided flycatcher, which was reproduced as high-quality image by Maria Zbigniewicz, Manitoba Hydro on the report citation page.

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1.0 INTRODUCTION

Construction of the Keeyask Generation Project (the Project), a 695 megawatt hydroelectric generating station (GS) and associated facilities, began in July 2014. The Project is located at Gull Rapids on the lower Nelson River in northern Manitoba where Gull Lake flows into Stephens Lake, 35 km upstream of the existing Kettle GS.

The *Keeyask Generation Project Response to EIS Guidelines* (the EIS), completed in June 2012, provides a summary of predicted effects and planned mitigation for the Project. Technical supporting information for the terrestrial environment, including a description of the environmental setting, effects and mitigation, and a summary of proposed monitoring and follow-up programs is provided in the *Keeyask Generation Project Environmental Impact Statement Terrestrial Supporting Volume* (TESV). The *Terrestrial Effects Monitoring Plan* (TEMP) was developed as part of the licensing process for the Project. Monitoring activities for various components of the terrestrial environment were described, including the focus of this report, olive-sided flycatcher (*Contopis cooperi*) and rusty blackbird (*Euphagus carolinus*), and the availability of breeding habitat in the Keeyask region during the construction and operation phases.

Olive-sided flycatcher and rusty blackbird are migratory songbirds protected under the federal *Species at Risk Act* (SARA). The olive-sided flycatcher is listed as *Threatened* under Schedule 1 of the SARA and is listed as *Special Concern* by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). In Manitoba, the olive-sided flycatcher is listed as *Threatened* by *The Endangered Species and Ecosystems Act*. Its breeding habitat consists mainly of mature coniferous forest with open patches created by natural disturbance (*e.g.*, fire), wetlands, or forestry clear-cuts (Altman and Sallabanks 2012 in Environment Canada 2016). Snags (dead standing trees) and live trees left behind after logging are important for perching while foraging for flying insects in open areas (Altman and Sallabanks 2012 in Environment Canada 2016).

The rusty blackbird is listed as a species of *Special Concern* under Schedule 1 of the SARA and has no designation under *The Endangered Species and Ecosystems Act* of Manitoba. Despite being a migratory bird, the rusty blackbird is not protected under the *Migratory Birds Convention Act 1994*. During the breeding season, rusty blackbirds inhabit the boreal forest, using wetland habitat such as sedge meadows, beaver ponds, muskegs, swamps, riparian scrub, as well as shrubby patches of willow and alder, and sedge meadows (COSEWIC 2017). Its diet consists mainly of aquatic invertebrates such as insect larvae and snails, and also of grasshoppers, beetles, and spiders (COSEWIC 2017).

As part of the TEMP, pilot studies for olive-sided flycatcher and rusty blackbird were conducted in 2015, to identify and enumerate breeding pairs of birds in the Keeyask region. Sensory disturbance surveys were then initiated in 2016 and 2017, to determine if and how Project-related noise affects the distribution and abundance of each species. The north and south access roads were expected to be the main sources of sensory disturbance for olive-sided flycatcher and rusty blackbird; construction and work areas associated with the Project were also expected to contribute.

2.0 METHODS

2.1 2015 PILOT STUDY

The goal of the 2015 pilot study was to identify if sufficient numbers of rusty blackbird and olive-sided flycatchers were present in the study area to support a justifiable study design. Survey points were located throughout Study Zone 4 in an attempt to locate territories of breeding olive-sided flycatchers and rusty blackbirds. Four types of points were surveyed in 2015 (Table 1):

- Habitat association points - located every 50 m on 600 m long transects that were placed in high or intermediate-quality rusty blackbird and olive-sided flycatcher habitat throughout Study Zone 4. These points were established to provide information on habitat use in the Keeyask region for the expert information model to be developed following construction monitoring.
- Field points - located every 100 m on transects that were 600 m long, near major roads, or 300 m long near the Project footprint.
- Systematic points - roadside stop survey with points located every 300 m along PR280, the north access road, and south access road.
- Sample habitat association points - located every 50 m on 600 m transects that were placed in rusty blackbird and olive-sided flycatcher habitat. These points were established to provide information on habitat use in the Keeyask region for the habitat information model to be developed following construction monitoring.

Table 1: Point Types Surveyed for Olive-sided Flycatcher and Rusty Blackbird in 2015

Survey Point Type	No. Surveyed
Habitat Association	25
Olive-sided Flycatcher Field	110
Rusty Blackbird Field	63
Systematic	106
Sample Habitat Association	55
Total	359

Surveys were conducted from June 9 to July 9, 2015. Surveys began a half-hour before sunrise and lasted no later than 10:00 am. At each survey point, observers watched and listened for olive-sided flycatchers and rusty blackbirds for a period of 10 minutes (Photo 1). If no bird was heard or observed the observer travelled to the next survey point and repeated the process. When an olive-sided flycatcher or rusty blackbird was heard or observed at one of these locations, observers marked its position using a Global Positioning System (GPS) unit. The bird was observed until three perches were marked. This was defined as the birds' territory in 2015.

Territory sizes were not estimated as only three perch locations were collected. Observers maintained a sufficient distance from the bird in order to avoid disturbance and record natural perch locations.

Recorders (Tascam DR100-MKII) and first-generation automated recording units (ARUs) (Myrica System Inc.) were used to verify the observations (Photo 2). Both datasets were used to test the quality and capabilities of the second-generation ARUs.

Photo 1: Technician Conducting a Bird Survey

Photo 2: Recorders (Tascam DR100-MKII) (left) and First-generation ARUs (right) Were Used to Verify the Accuracy of Observations and to Collect Data for Testing the Second-generation ARUs

2.2 2016 TERRITORY MAPPING AND AUDIO RECORDING

Olive-sided flycatcher and rusty blackbird nesting territories identified during the 2015 pilot study were re-visited in 2016. Additional sites were also surveyed to increase the sample size of the territories. A total of 205 sites were surveyed for olive-sided flycatchers and rusty blackbirds.

In 2016, a paired habitat sample design was implemented to follow the TEMP (KHLP 2015). The types of survey points were changed to represent either Project-disturbed sites or reference sites. Project-disturbed sites (disturbed sites) were within 500 m of Project infrastructure, including the north access road (NAR) and south access road (SAR). Provincial Road 280 (PR280) was included to compare an existing source of sensory disturbance with Project-related sensory disturbance. The Keeyask Transmission Project (KTP) was also included in this study as a disturbed site to increase sample size and survey efficiency. For each disturbed site, a reference site, which was located in similar habitat, but beyond the expected range of sensory disturbance for olive-sided flycatchers and rusty blackbirds (500 m), was also surveyed (Table 2).

Surveys were conducted from June 1 to July 1, 2016. Surveys began half an hour before sunrise and lasted no later than 10:00 am. At each survey point, observers watched and listened for olive-sided flycatchers and rusty blackbirds for a period of 10 minutes. If no bird was heard or observed, the observer travelled to the next survey point and repeated the process. When a bird was heard or observed at a survey location, observers marked its position using a GPS unit. The bird was observed until at least five perches were marked. This was defined as the birds' territory in 2016. Observers maintained a sufficient distance from the bird in order to avoid disturbance and record natural perch locations. Details of each perch site, including tree species composition and tree height were collected.

Photo 3: Rusty Blackbird Perching on Tree

At disturbed sites, once bird territories were estimated, three to seven second-generation automated recording units (ARUs) (Photo 4) were placed in the centre of the territories, at distances of 100 metres (m), 300 m and 500 m from the nearest source of disturbance (disturbed sites) (Figure 1). In all, 119 recorders were placed at 32 territories (Table 2; Map 1) from June 12 to 29, 2016. The ARUs were programmed to begin recording half an hour before sunrise, and record for five minutes at 10-minute intervals. Forty-two, five-minute recordings were collected daily over the duration of the survey period.

Photo 4: Biologist Setting up a Second-generation Automated Recording Unit (ARU)

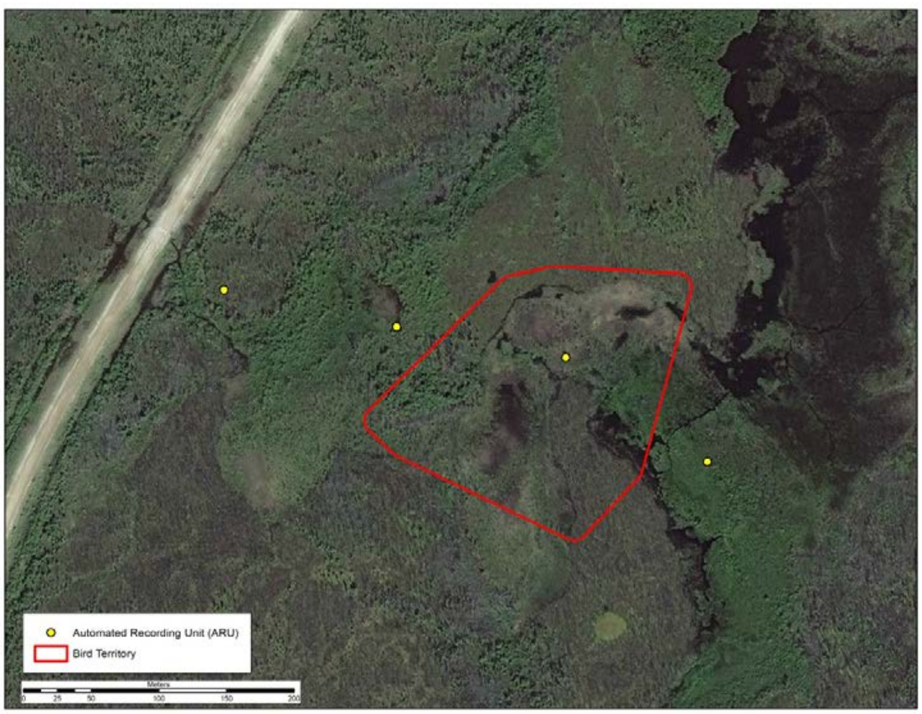


Figure 1: Example of ARU Placements Within a Disturbed Bird Territory

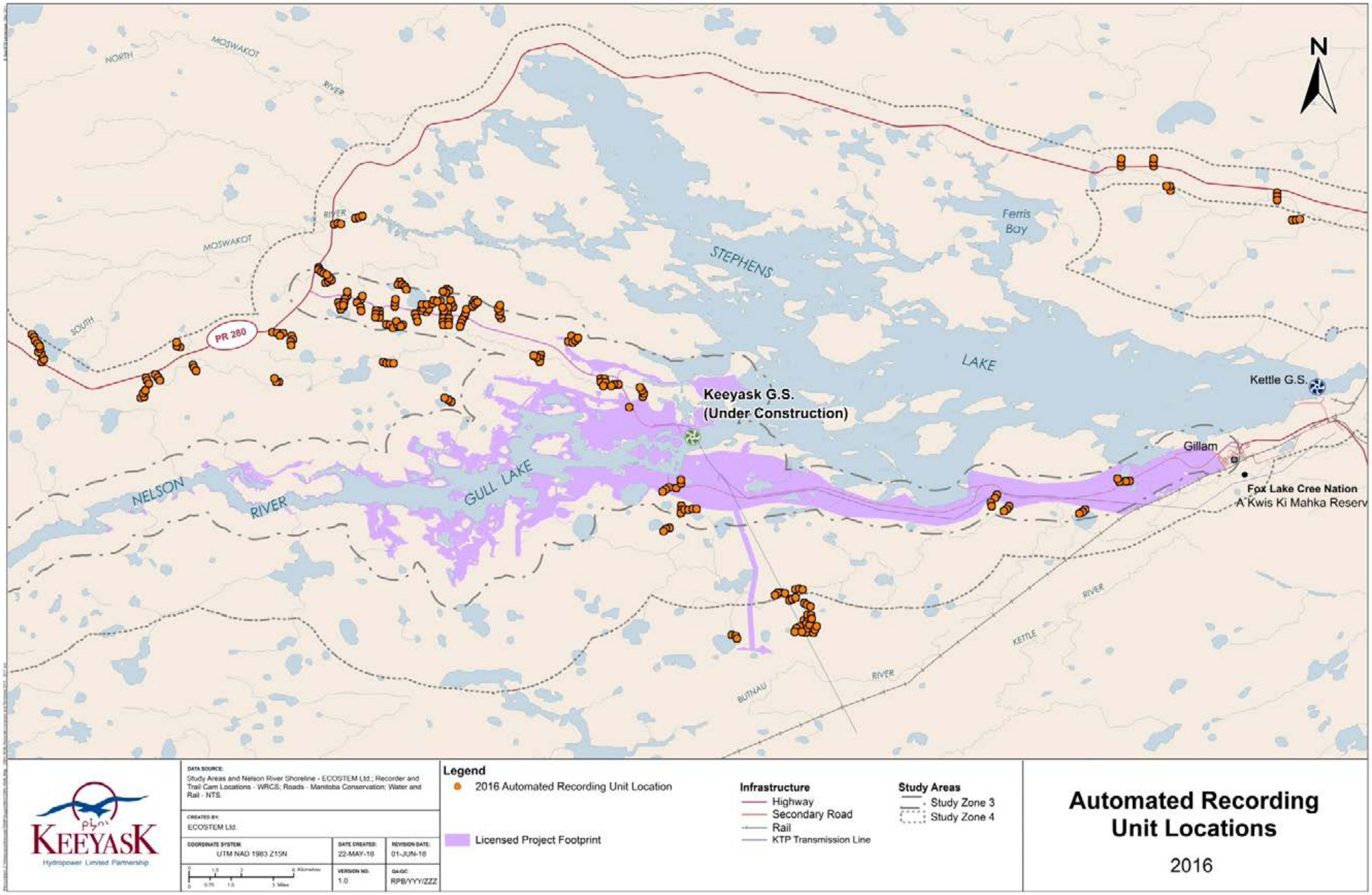
At reference sites, once bird territories were estimated, one to seven ARUs were placed at each of these reference sites, 100 m, 300 m, and 500 m from a non-habitat patch edge such that they were centrally located through the long side of the habitat patch. In all, 131 recorders were placed at 32 territories from June 14 to July 2, 2016 (Table 2; Map 1). The ARUs were programmed to begin recording a half-hour before sunrise, and record for five minutes at 10-minute intervals. Forty-two, five-minute recordings were collected daily over the duration of the survey period.

Table 2: Survey Effort for Olive-sided Flycatchers and Rusty Blackbirds at Disturbed and Reference Sites in 2016

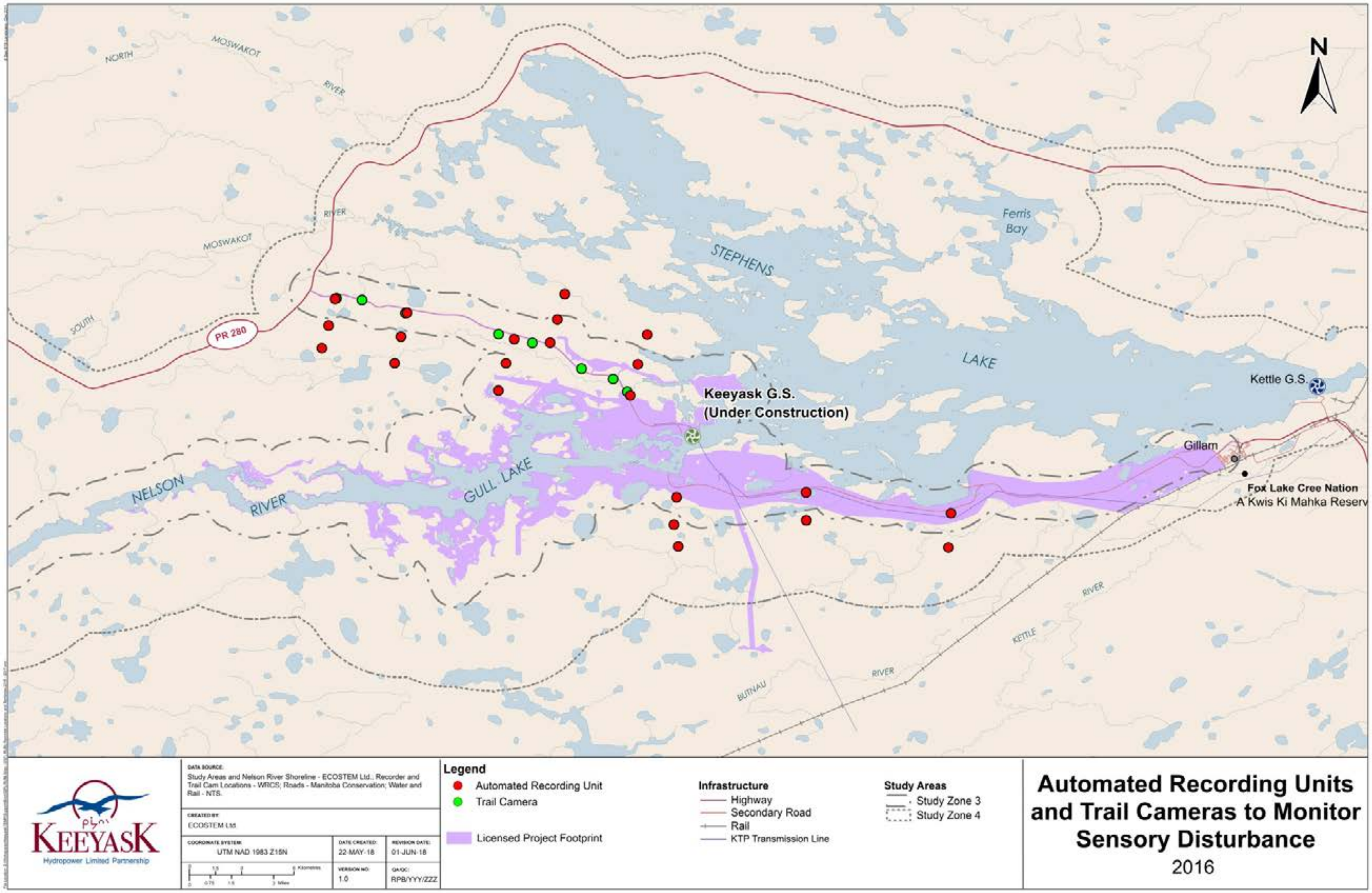
Disturbance Source	Disturbed		Reference		Total	
	No. Territories	No. Recorders	No. Territories	No. Recorders	No. Territories	No. Recorders
NAR	14	58	14	61	28	119
SAR	3	10	3	13	6	23
PR 280	10	32	10	39	20	71
KTP	5	19	5	18	10	37
Total	32	119	32	131	64	250

Olive-sided flycatcher and rusty blackbird territories were re-visited from June 19 to July 1, 2016, to verify that birds still inhabited them. If no birds were observed, a new site was selected, a territory was mapped, and ARUs were deployed within, as previously described. Audio recording units were typically left in place for 10 days; at three sites, ARUs were removed after four days at the end of the survey period, and some recorders remained in place for up to 20 days.

To monitor auditory and visual disturbance caused by Project construction, ARUs and motion-triggered trail cameras were set up along Project infrastructure. Twenty-two ARUs were placed along the NAR and SAR, and eight motion-triggered trail cameras were placed along the NAR (Map 2). The ARUs were programmed to record systematically for five minutes, every 15 minutes, 24 hours per day. Trail cameras were triggered by motion to photograph images of passing vehicles and equipment.



Map 1: Automated Recording Unit Locations on Olive-Sided Flycatcher and Rusty Blackbird Territories in 2016



Map 2: Locations of Automated Recording Units and Motion-triggered Trail Cameras to Monitor Sensory Disturbance in 2016

2.3 2017 TERRITORY MAPPING AND AUDIO RECORDING

Olive-sided flycatcher and rusty blackbird nesting territories identified in 2016 were re-visited in 2017. Additional sites were also surveyed to increase sample sizes. A total of 304 sites were surveyed for olive-sided flycatchers and rusty blackbirds. Survey points were established within Project-disturbed (disturbed sites) and reference areas (reference sites), similar to 2016, and followed the paired habitat sample design (KHLP 2015).

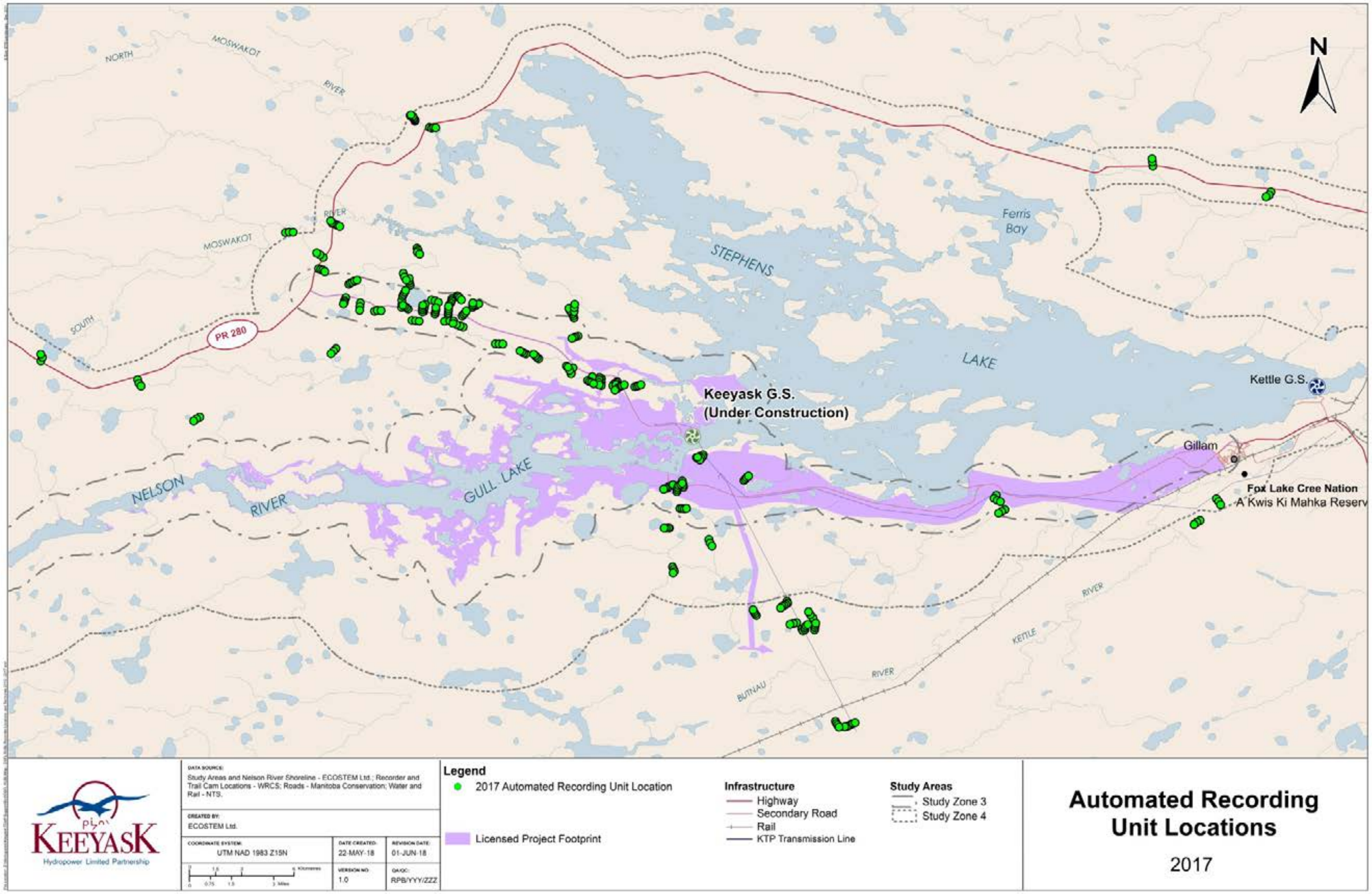
The methods used to map bird territories and deploy ARUs in 2017 were the same that were used in 2016 (see Section 2.2). Surveys were conducted from May 31 to June 29, 2017, and began a half-hour before sunrise and lasted no later than 10:00 am. In total, 152 ARUs were placed at 37 disturbed sites and 129 ARUs were placed at 69 reference sites (Table 3; Map 3). The ARUs were programmed to begin recording a half-hour before sunrise, and record for five minutes at 10-minute intervals. Forty-two, five-minute recordings were collected daily over the duration of the sample season.

Table 3: Survey Effort for Olive-sided Flycatchers and Rusty Blackbirds at Disturbed and Reference Sites in 2017

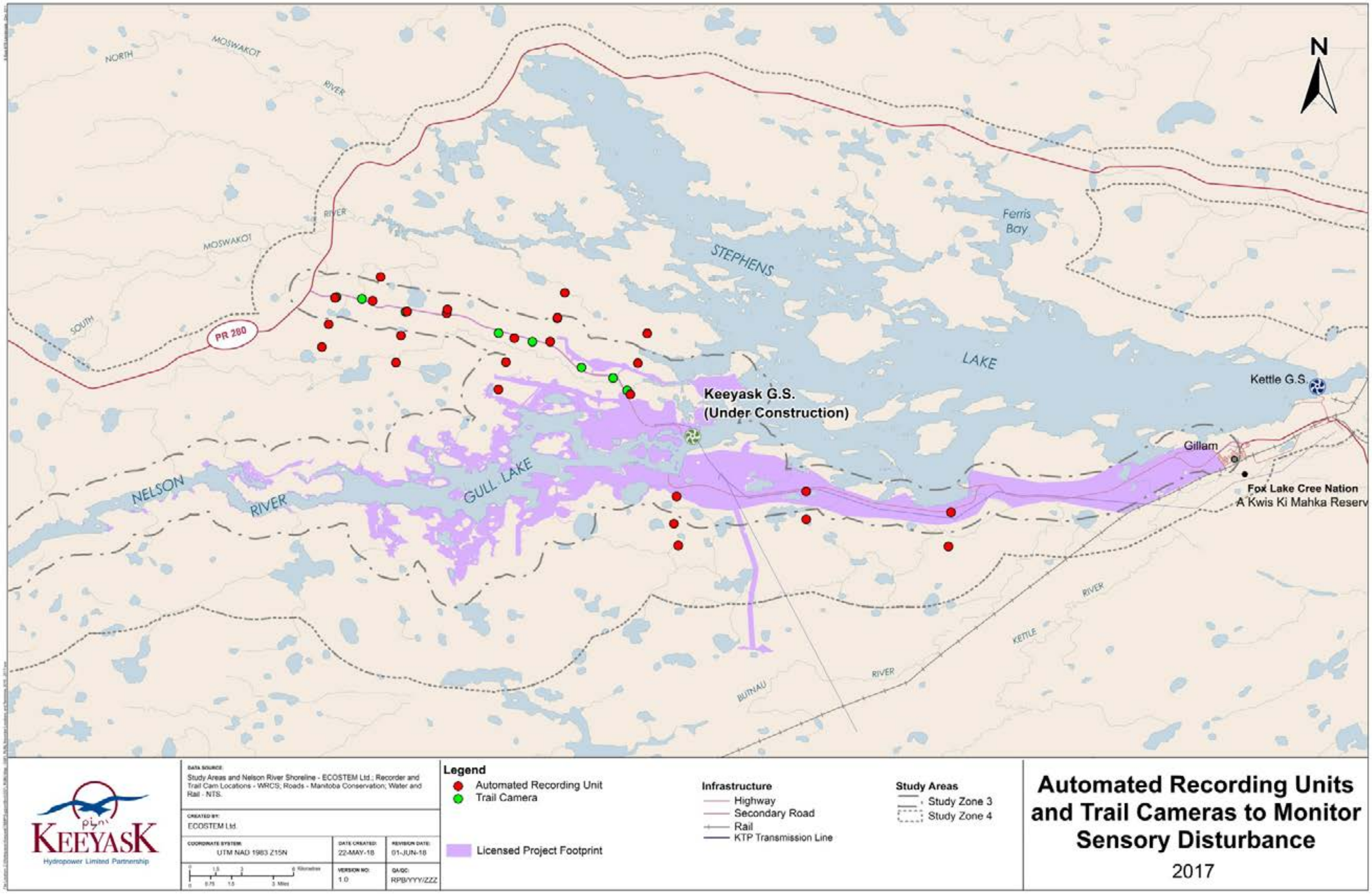
Disturbance Source	Disturbed		Reference		Total	
	No. Territories	No. Recorders	No. Territories	No. Recorders	No. Territories	No. Recorders
NAR	18	72	17	71	35	143
SAR	3	16	3	12	6	28
PR 280	8	29	4	18	12	47
KTP	8	35	8	28	16	63
Total	37	152	32	129	69	281

Olive-sided flycatcher and rusty blackbird territories were re-visited from June 13 to 28, 2017, to verify that birds still inhabited them. If no birds were observed, a new site was selected, a territory was mapped, and recorders were deployed within, as previously described. Audio recorders were typically left in place for 10 days; some recorders remained in place for up to 14 days.

To monitor auditory and visual disturbance caused by Project construction, ARUs and motion-triggered trail cameras were set up near Project infrastructure. Thirty-two ARUs were placed along the NAR and SAR, and eight motion-triggered trail cameras were placed along the NAR (Map 4). The ARUs were programmed to record systematically for five minutes, every 15 minutes, 24 hours per day. Trail cameras were triggered by motion to photograph images of passing vehicles and equipment.



Map 3: Automated Recording Unit Locations on Olive-Sided Flycatcher and Rusty Blackbird Territories in 2017



Map 4: Locations of Automated Recording Units and Motion-triggered Trail Cameras to Monitor Sensory Disturbance in 2017

2.4 AUDIO RECORDING SUPPORT AND ANALYSIS

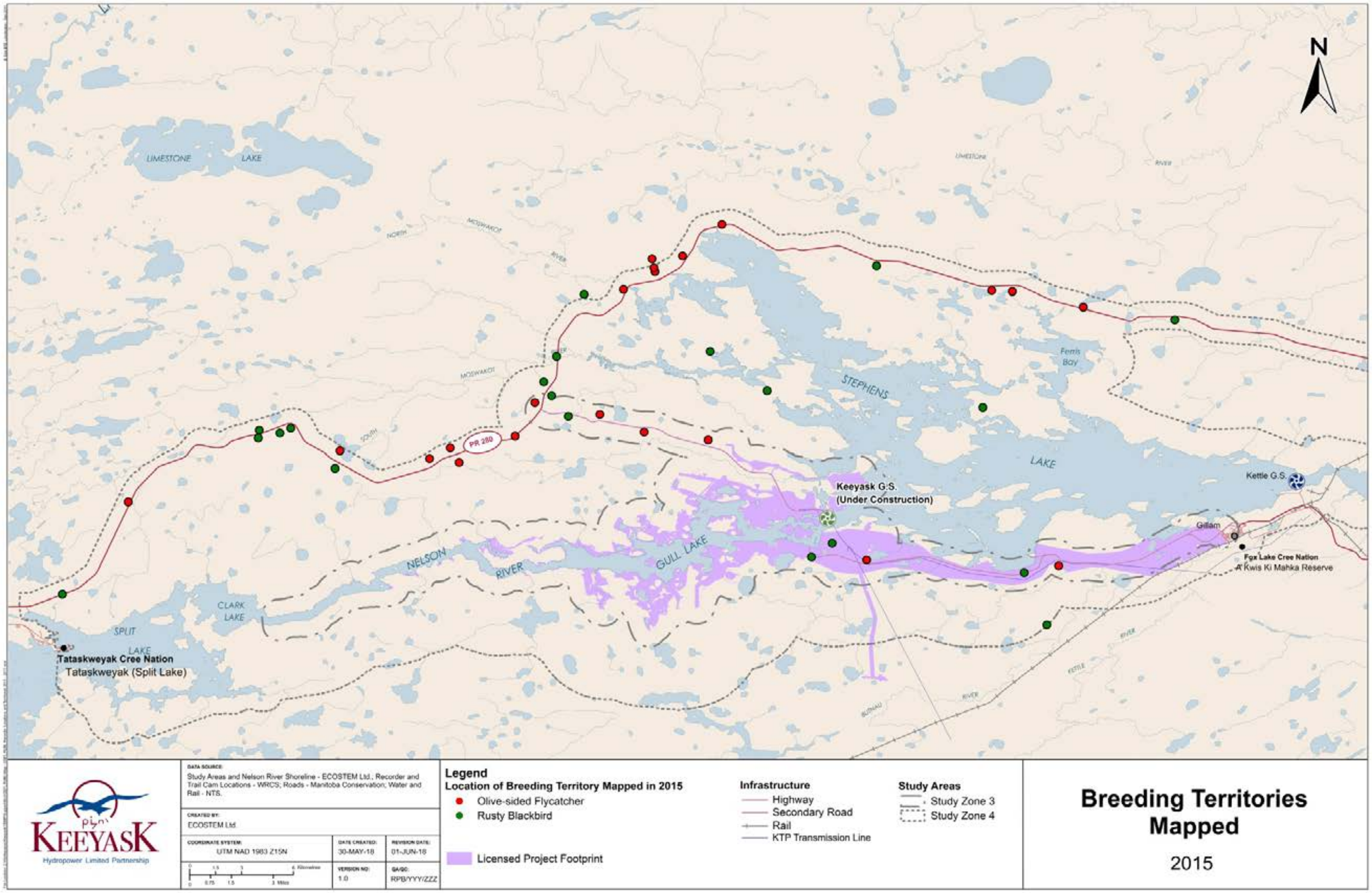
The audio recordings collected by the ARUs will be used to determine the presence and abundance of olive-sided flycatchers and rusty blackbirds, as well as estimate their territory size during the breeding season. Territory size and abundance estimates are being derived from data collected by the 4-channel recording system developed by Myrica Systems Inc. A detailed description of the methods to be used for the audio recording analyses can be found in Appendix 1.

3.0 RESULTS

3.1 2015 PILOT STUDY

A total of 261 locations were surveyed in 2015 for olive-sided flycatchers and rusty blackbirds. During the survey, 67 olive-sided flycatchers and 78 rusty blackbirds were observed, and 21 and 20 territories (three or more perches) were mapped, respectively (Map 5). Territory size was not estimated as only three perch sites were typically recorded.

Olive-sided flycatcher were commonly found in habitat types that included burns and riparian areas next to creeks, ponds and lakes. Rusty blackbird were commonly found in small ponds surrounded by open forest, marshes, beaver floods and occasionally next to roadside ditches. Habitat types for both species often overlapped when water and snags were present. Photos showing examples of olive-sided flycatcher and rusty blackbird habitat at Keeyask are found in Appendix 2.



Map 5: Olive-sided Flycatcher and Rusty Blackbird Territories Mapped in 2015

3.2 2016

A total of 205 locations were surveyed in 2016 for olive-sided flycatchers and rusty blackbirds. During the survey, 77 olive-sided flycatchers and 116 rusty blackbirds were observed, and 36 and 48 territories (five or more perches) were mapped, respectively (Table 4; Map 6).

A total of 680 perches were observed for olive sided-flycatcher in 2016. Perches typically consisted of snags or black spruce trees (*Picea mariana*), which consisted of 62% and 23% of all perches, respectively.

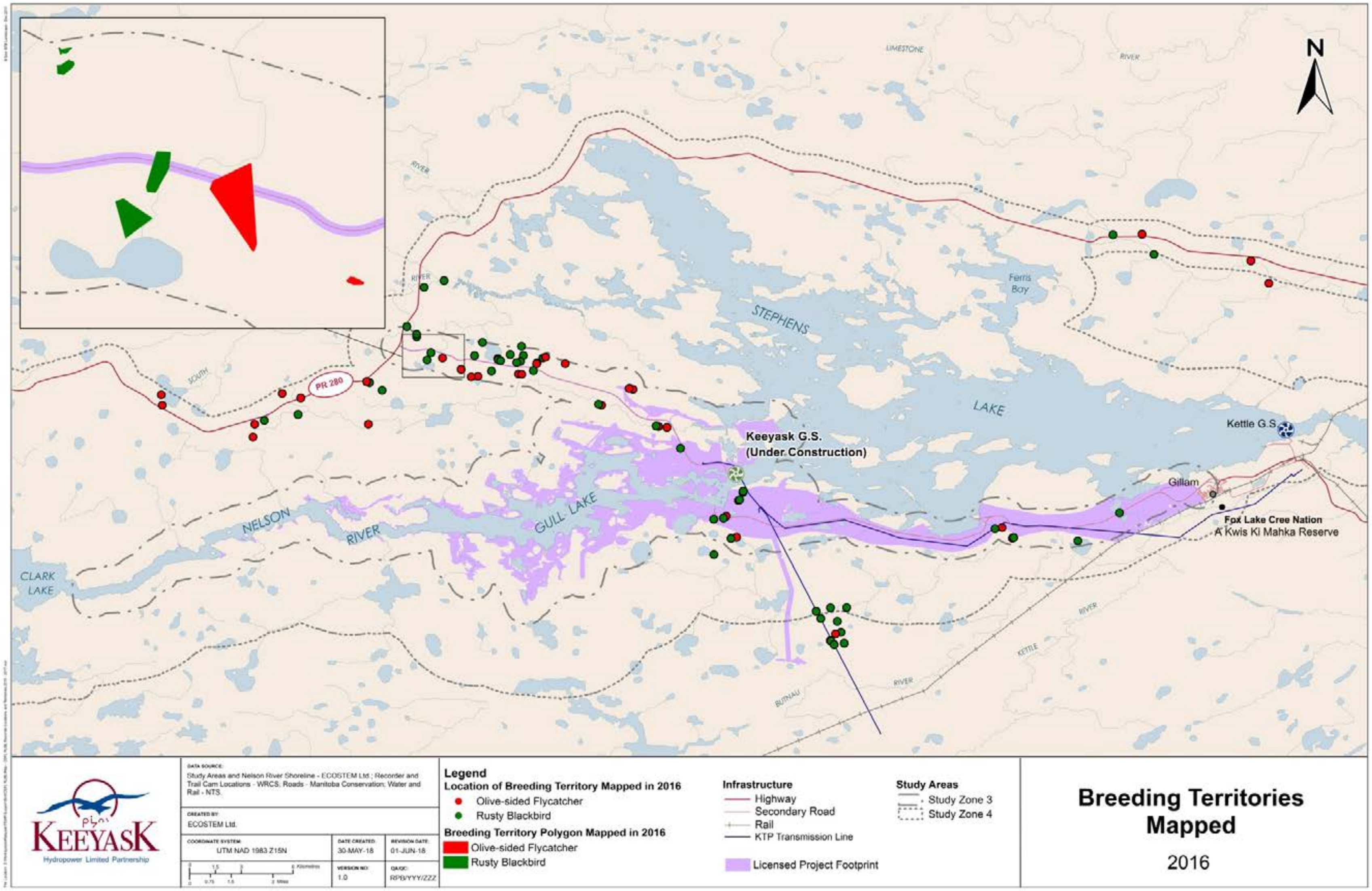
The territory size of olive-sided flycatchers ranged from 0.1-19.5 ha, and, on average, was 2.7 ha. Average territory size on disturbed sites was 2.8 ha, compared to 2.5 ha on reference sites.

A total of 1,166 perches were observed for rusty blackbird in 2016. Perches typically consisted of snags or black spruce trees, which consisted of 57% and 24% of all perches, respectively.

The territory size of rusty blackbirds ranged from 0.04-11.9 ha, and, on average, was 2.3 ha. Average territory size on disturbed sites was 2.2 ha, compared to 2.4 ha on reference sites.

Table 4: Number of Territories on Disturbed and Reference Sites in 2016

Disturbance Source	Olive-sided Flycatcher		Rusty Blackbird		Total
	Disturbed	Reference	Disturbed	Reference	
NAR	8	9	11	7	35
SAR	2	2	4	4	12
PR280	6	5	5	6	22
KTP	2	2	5	6	15
Total	18	18	25	23	84



Map 6: Olive-sided Flycatcher and Rusty Blackbird Territories Mapped in 2016

3.3 2017

A total of 304 locations were surveyed in 2017 for olive-sided flycatchers and rusty blackbirds. During the survey, 78 olive-sided flycatchers and 135 rusty blackbirds were observed, and 28 and 39 territories (five or more perches) were mapped, respectively (Table 5; Map 7). Additionally, four rusty blackbird nests were observed incidentally during the surveys (Appendix 3).

A total of 608 perches were observed for olive sided-flycatcher in 2017. Perches typically consisted of snags or black spruce trees, which consisted of 52% and 36% of all perches, respectively.

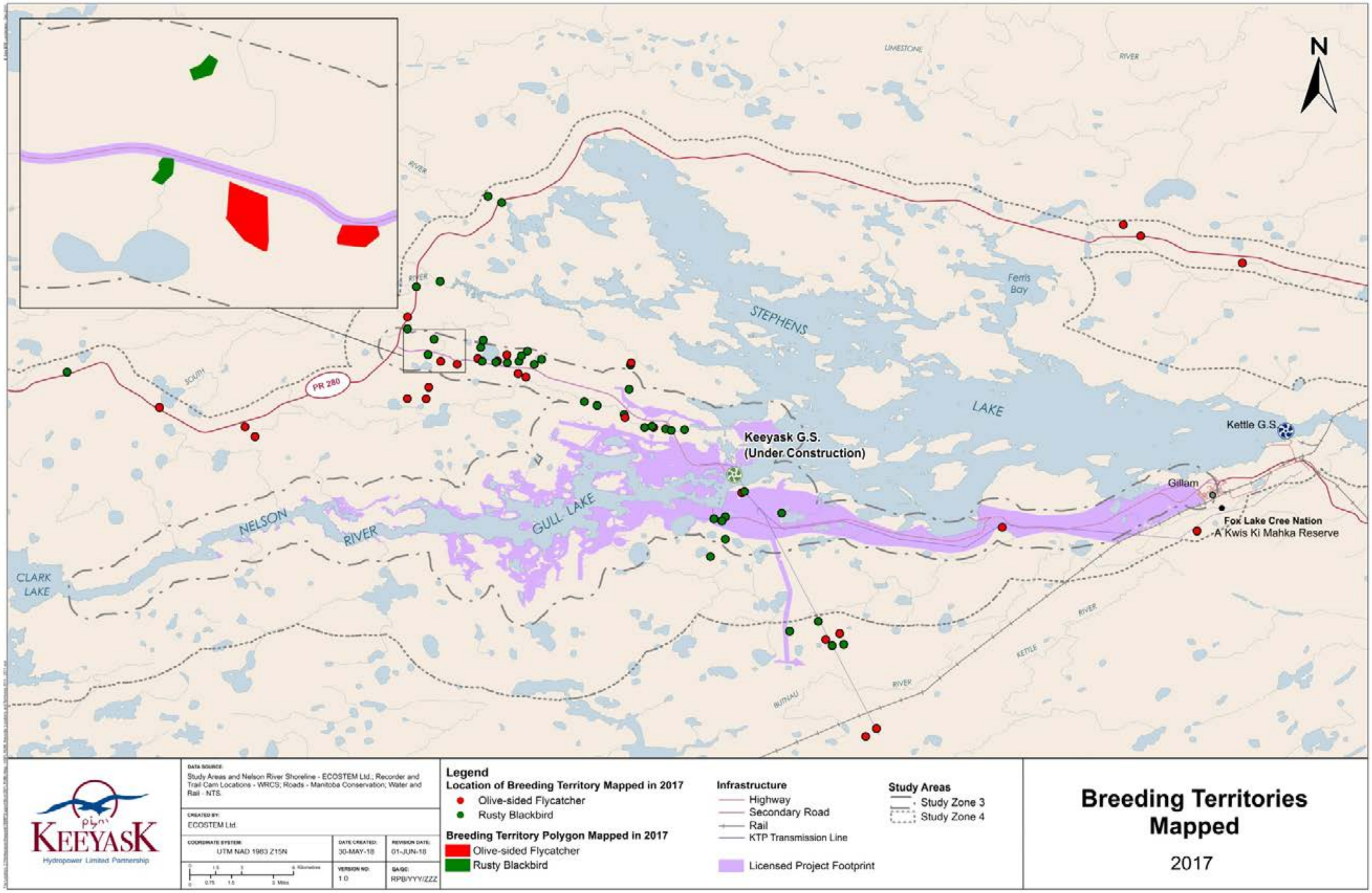
The territory size of olive-sided flycatchers ranged from 0.4-58.3 ha, and the average territory size was 7.1 ha. Average territory size on disturbed sites was 2.8 ha, compared to 13.7 ha on reference sites.

A total of 1,119 perches were observed for rusty blackbird in 2017. Perches typically consisted of snags or black spruce trees, which consisted of 58% and 25% of all perches, respectively.

The territory size of rusty blackbirds ranged from 0.3-12.2 ha, and the average territory size was 3.2 ha. Average territory size was 2.4 ha on disturbed sites, compared to 4.1 ha on reference sites.

Table 5: Number of Territories Disturbed and Reference Sites in 2017

Disturbance Source	Olive-Sided Flycatcher		Rusty Blackbird		Total
	Disturbed	Reference	Disturbed	Reference	
NAR	7	7	11	11	36
SAR	1	0	3	2	6
PR280	5	2	4	2	13
KTP	4	2	3	3	12
Total	17	11	21	18	67



Map 7: **Olive-sided Flycatcher and Rusty Blackbird Territories Mapped in 2017**

4.0 DISCUSSION

As the olive-sided flycatcher and rusty blackbird are species at risk and vulnerable to potential Project effects, understanding the potential impacts on their distribution and effectiveness of habitat in the Keeyask region is important. By mapping the breeding territories of these species, it will be possible to determine if Project disturbance is reducing habitat effectiveness. If habitat effectiveness is reduced, these species may exhibit larger breeding territories, as birds would be required to travel further distances within their territories to fulfill their requirements (food, nesting habitat, etc.) (Ortega and Kappen 1999; Diemer and Nocera 2014).

The 2015 pilot study found sufficient numbers of olive-sided flycatchers and rusty blackbirds in the Keeyask region to support the study design. Data collection in 2016 and 2017 resulted in a large number of audio recordings that are currently being processed. Once processed, further evaluation of the Project impacts on olive-sided flycatchers and rusty blackbirds will be conducted.

Olive-sided flycatcher and rusty blackbird breeding territories were found throughout Study Zone 4, suggesting that suitable breeding habitat is abundant in the study area. Territories of both species were found adjacent to disturbance sources, including the NAR, SAR, PR280, and KTP. A few territories incorporated the NAR, ditches, and the transmission line into a portion of its territory as edge habitat; in some cases, a few individuals appeared to have territories that spanned roads. Once processing of the recordings has been completed, further evaluation of potential Project effects on territory sizes and distribution will be conducted.

5.0 SUMMARY AND CONCLUSIONS

Monitoring conducted from 2015-2017 showed that breeding territories of olive-sided flycatcher and rusty blackbirds were found throughout Study Zone 4 and included areas adjacent to Project disturbance.

Automated recording units deployed in 2016 and 2017 successfully collected recordings, which will continue to be analyzed to determine the effects of sensory disturbance on breeding territory size and habitat use. Power analyses will be performed on the existing data once processed further, to improve the study design prior to the deployment of the automated recording units in June 2019.

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APPENDIX 1: AUDIO RECORDING ANALYSIS METHODS

Automated Recording Units (ARUs)

Although there is extensive precedent for using automated recording units (ARUs) for avian studies (Shonfield and Bayne 2017)[1], we had difficulty finding an ARU to meet our needs. In some of the species at risk studies proposed for the *Terrestrial Effects Monitoring Plan* (TEMP), for example, it was necessary to estimate distance and direction to the vocalizing birds. This required more than two channels of audio recording. Study design also demanded a large number of recorders to meet sample size requirements. After surveying the available technology, no recorders were found that could record four channels at a reasonable cost. Wildlife Resource Consulting Services MB Inc. commissioned Myrica Systems Inc. to design custom ARUs and a local contract assembler was hired to build them.

There were a number of criteria to be met in the ARU design:

- **Time accuracy**: ARUs contained a temperature-compensated quartz clock with an accuracy of +/- 2 minutes per year over a range of -40°C to 85°C.
- **Flexible time scheduling**: Timing parameters included start times, recording duration, interval, and number repetitions. Recordings can be corrected for sunrise and sunset over the season; units were loaded with daily sunrise and sunset times determined from National Oceanic and Atmospheric Administration (NOAA) calculations given the year, latitude, and longitude.
- **Lengthy unattended run time**: The design was optimized for minimal power consumption. ARUs could be powered from AA, D and 6V lantern batteries as required to meet recording time requirements.
- **Audio sensitivity**: Microphones were mounted in a separate case containing low-noise pre-amplifiers. Gain was set to match the sensitivity of human observers trained to identify bird calls.
- **Noise insensitivity**: Filtering was designed to remove frequencies above and below the range of interest for the bird species being recorded. This reduces, for example, wind noise. Microphones were also fitted with open-cell foam “windsocks”.
- **Environmental tolerance**: ARUs were designed and components chosen to operate in the full range of temperatures expected in the field. Microphone cables were sheathed in metal braid to resist chewing by rodents. Electronics were protected in weather proof cases.
- **Directionality**: Each of four microphones was mounted in a recessed hole on each face of a square enclosure. This provided a degree of audio isolation of each from its neighbours. The ‘north’ microphone was labelled on enclosures to permit alignment in the field.

[1] Shonfield, J. and Bayne. E.M. 2017. Autonomous recording units in avian ecological research: current use and future applications. Avian Conservation and Ecology 12(1):14. https://doi.org/10.5751/ACE-00974-120114.

- **Data storage**: ARUs were fitted with secure digital (SD) cards (8 gigabyte [GB] or 32GB) as appropriate for each study. The audio sampling rate was also varied to match study, storage, and analysis requirements (16.0 kilohertz [kHz] or 44.1 kHz). Files were compressed in Ogg Vorbis format (OGG) using a patent-and-royalty-free algorithm,, which provided no noticeable signal degradation. Each field recording consisted of two stereo recordings on the SD card (A and B). An audible time marker (click) was used to verify synchronization of the two stereo recordings.
- **Data identification**: Each ARU had a serial number label and was programmed with the same number in software. Recording file names contained the day of the year (DOY), hour (HH) and minute (MM) that the recording started. For example two stereo recordings would be labelled 1832110A.ogg and 1832110B.ogg. As a back-up, data were embedded within the audio file that included time, date, and serial number.

Pre-processing Data

For each survey year, field recordings from each recorder were copied from SD cards into a directory structure on a hard drive matching the respective year, study, and site. Each recording for olive-sided flycatcher and rusty blackbird was 300 seconds in length. Data from each year comprised several terabytes despite data being in compressed format. Data were kept in separate working and backup repositories.

Analysis of bird vocalizations was performed using the statistical package R[1]. In order for data to be analyzed in R, OGG files had to be converted to wave (WAV) format using either SOX[2] or LameXP[3]. It was determined that an audio bandwidth of 5.5 kHz was sufficient to recognize the species of interest in recordings. For this reason, OGG files were converted to WAV format with a sampling rate of 11.025 kHz; this reduced the storage volume of uncompressed data and speeded file reading during analysis.

[1]R (www.r-project.org), a free statistical analysis software environment. The Package ‘monitoR’ (https://CRAN.R-project.org/package=monitoR) was used. monitoR is described briefly in “A short introduction to acoustic template matching with monitoR.” Sasha D. Hafner and Jonathan Katz. February 14, 2018 (available from www.r-project.org) and in more detail in: “monitoR: Automation Tools For Landscape-scale Acoustic Monitoring - PhD Dissertation. Jonathan Katz. The University of Vermont. May, 2015.

[2]SOX (http://sox.sourceforge.net) is a free command line application for converting formats of and processing data in audio files.

[3] LameXP (http://lamexp.sourceforge.net) is a free audio file format converter with a windows front end.

Species Detection

Templates were created from exemplars of species vocalizations (calls) of interest. MonitoR uses a method called template matching to identify species by their sounds. The method can be thought of as taking a low-resolution spectrogram and measuring its correlation against the spectrogram of a whole recording. In fact, templates can be plotted as spectrograms.

It was necessary to use multiple exemplars for a given species to cover the range in variation of calls. It was also necessary to measure correlation against other non-target sounds (calls and environmental sound) that also had a high correlation with the same species.

Due to the very large collection of recordings for analysis, a balance needed to be struck between the detail of templates used and the speed of analysis; recording analysis with detailed templates would take much longer. Attention was also paid to the duration and frequency bandwidth chosen for each template. To reduce analysis time to a practical order of magnitude, a two-step process of analysis was required.

In the first step, a limited number of low-resolution templates were used to discover candidate calls of the target species, recognizing that there would be many false positives. These candidate calls were extracted as two-second sound clips with each clip starting one second prior to the centre of the call detection and running to one second after the centre of the call. Datasets were also created at this step that included clip file name and statistics about the candidate clip. A clip spectrogram was created for each clip that was useful for validation. By the second step, the volume of data had been greatly reduced and only clips were processed. These could then be analyzed at high resolution to remove most false positives.

Classification of clips involved setting a threshold for target and off-target calls and calculating a difference between the two; classification criteria were adjusted to achieve a false positive rate of less than 5%. A viewing system for validation was developed to allow experts to view each call (clip) as a spectrogram along with its classification and to listen to it by simply clicking on the spectrogram. Summary statistics were created for all detections to aid in validation.

Distance and Direction Estimation

Sound pressure level in decibels (SPL), which humans perceive as 'sound volume', has been shown to provide a good estimate of distance to a calling bird (Yip et al. 2017)[1]. Direction can be estimated using the equivalent of Interaural Level Difference (ILD); from a human perspective this would be equivalent to using sound volume as a cue about direction (Nelson and Suthers 2004)[2]. Although many automated direction estimation algorithms use Interaural

[1] Yip, D.A., Leston, L., Bayne, E.M., Sólymos, P., and Grover, A. 2017. Experimentally derived detection distances from audio recordings and human observers enable integrated analysis of point count data. Avian Conservation and Ecology 12(1):11. https://doi.org/10.5751/ACE-00997-120111.

[2] Nelson, B.S. and Suthers, R.A. 2004. Sound localization in a small passerine bird: discrimination of azimuth as a function of head orientation and sound frequency. The Journal of Experimental Biology 207: 4121–4133.

Time Difference (ITD), humans do not use this for frequencies high frequencies (Roman et al. 2003)[1]. There were several reasons why we were concerned that ITD might be unreliable in our studies. Some include: low signal to noise ratios (SNR), reverberation, environmental noise like wind, etc. In addition, our recording hardware was expected to have small differences that would be more pronounced at the high frequencies of bird calls. Microphones and circuits were identical by design, but tolerances in components were not and phase errors were expected. Exact synchronization of the two stereo recordings was problematic, even with the synchronization click that was used. We concluded that ILD was the best choice.

In order to calculate distance and direction to a singing bird recorded by the four-channel recorders, it was necessary to calibrate the system using bird songs recorded at varying distances. When a singing olive-sided flycatcher or rusty blackbird was observed, the observer would record the calls using a handheld recorder (Tascam DR100-MKII). The distance of the bird from the observer was estimated using a rangefinder or waypoints taken at the observers location and the bird's perch after it moved. Recordings were taken at approximately 20 m increasing increments until the bird could no longer be heard. Several dozen examples were collected using these techniques.

An algorithm was devised to find the peak root mean square (RMS) amplitude within each clip and convert it to a decibel value with an accurate time stamp. The four peak values were then used to triangulate the direction of the call; it was assumed that the calling bird was in the horizontal plane of the microphone array.

In the final data set, distance of the calling bird was estimated using decibel-distance curves created with field calibration recordings. Using the sound clips, distances were be estimated by choosing the largest decibel value measured by the four microphones.

[1] Roman, N., Wang, D., and Brown, G. 2003. Speech segregation based on sound localization. The Journal of the Acoustical Society of America 114: 2236–2252. https://doi.org /10.1121/1.1610463.

APPENDIX 2:
PHOTOS OF OLIVE-SIDED FLYCATCHER AND RUSTY BLACKBIRD HABITATS IN THE STUDY AREA

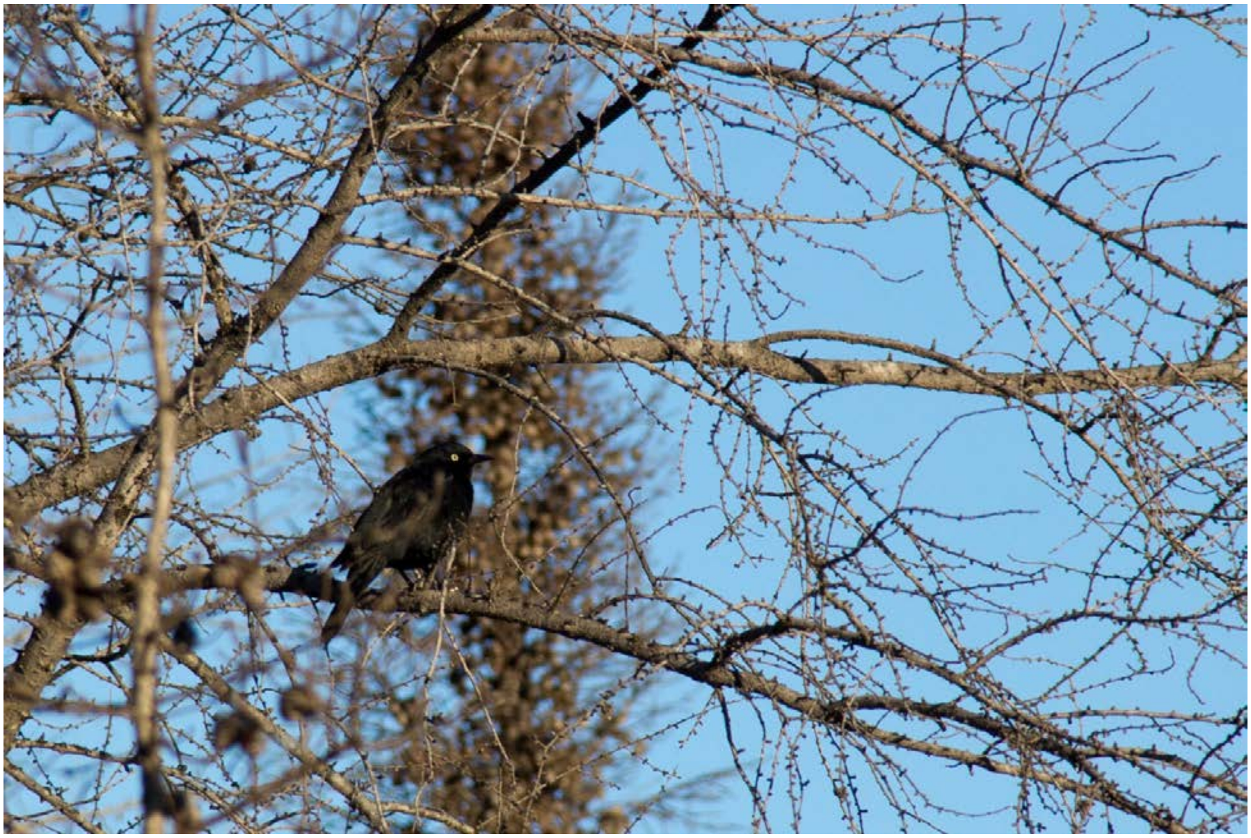

Photo 1: Rusty Blackbird

Photo 2: Olive-sided Flycatcher

Photo 3: Rusty Blackbird Habitat Adjacent to the North Access Road

Photo 4: Rusty Blackbird and Olive-sided Flycatcher Marsh Habitat Adjacent to the North Access Road

Photo 5: Mapping Olive-sided Flycatcher Habitat in a Recent Burn

Photo 6: Olive-sided Flycatcher Habitat in a Recent Burn

Photo 7: Olive-sided Flycatcher Habitat in a Recent Burn

Photo 8: Olive-sided Flycatcher Habitat Adjacent to a Transmission Line

Photo 9: Rusty Blackbird and Olive-sided Flycatcher Habitat Along a Creek and Beaver Flood

Photo 10: Rusty Blackbird and Olive-sided Flycatcher Habitat in a Beaver Flood

Note: This species is usually found using lower perches

Photo 11: Rusty Blackbird Perched High in dead Spruce next to a Pond

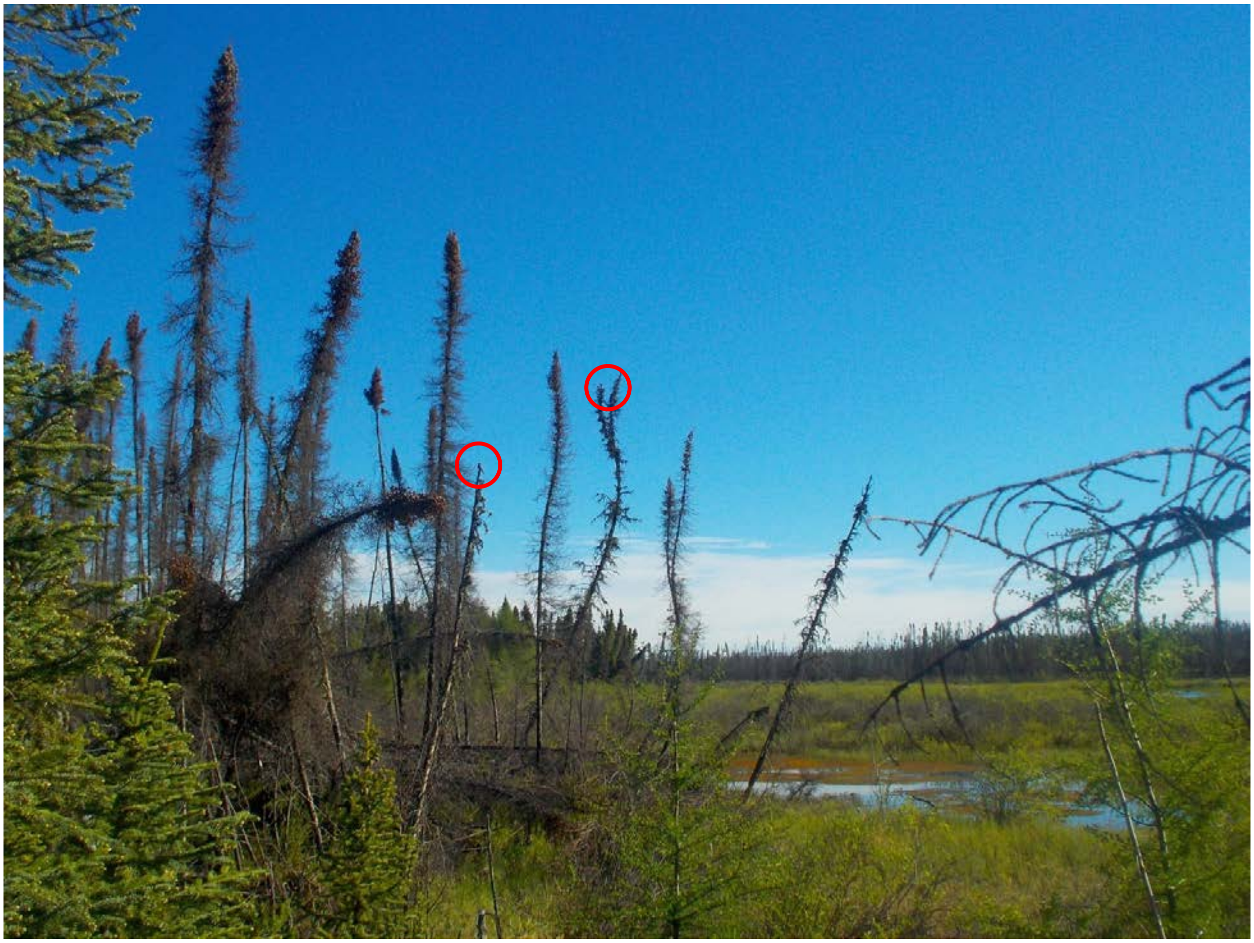

Photo 12: Olive-sided Flycatcher Pair Perched in Spruce Trees Next to a Pond

APPENDIX 3:
INCIDENTAL RUSTY BLACKBIRD NESTS

Table 1: Locations of Rusty Blackbird Nests Observed in 2017

Observation	Date	Site	UTM Coordinate
Rusty Blackbird Nest	4-Jun-17	T_10 NAR Di	15 V 351915 6254289
Rusty Blackbird Nest	18-Jun-17	N61 OSFL A2	15 V 350560 6250125
Rusty Blackbird Nest	14-Jun-17	T_20 RUBL Di	15 V 345336 6254873
Rusty Blackbird Nest	25-Jun-17	N20 RUBL Pa	15 V 345811 6255981

Photo 1: Rusty Blackbird Nest with Eggs