Keeyask Generation Project

Terrestrial Effects Monitoring Plan

Common Nighthawk Habitat Effects Monitoring Report

TEMP-2020-12

KEEYASK

Manitoba Conservation and Climate Client File 5550.00
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2019 - 2020

KEEYASK GENERATION PROJECT

TERRESTRIAL EFFECTS MONITORING PLAN

REPORT #TEMP-2020-12

COMMON NIGHTHAWK HABITAT EFFECTS 2018

Prepared for

Manitoba Hydro

By

Wildlife Resource Consulting Services MB Inc.

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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.

Predicted Project-related effects on common nighthawks are associated with changes in habitat availability and sensory disturbance. While some breeding habitat will be lost, a small, temporary increase in habitat in cleared Project areas is anticipated during construction. During studies for the Project's environmental assessment, common nighthawks were observed nesting in regenerating forests (burned areas) along the South Access Road route and foraging in wetlands, inland lakes, inland creeks, and along the Nelson River.

The common nighthawk is listed as Threatened under the federal *Species at Risk Act* and as Threatened under *The Endangered Species and Ecosystems Act* of Manitoba. The species is experiencing widespread population declines due in part to loss of breeding habitat. Common nighthawks nest on the ground in a range of open habitats such as forest clearings and edges and on suitable roofs in urban areas, and they forage on flying insects. They blend in with their surroundings and are mainly active at dusk and dawn. As such, they are difficult to detect during traditional daytime surveys. However, breeding activity can be identified by calls and by the booming sound made by territorial males as air rushes through their feathers.

This report describes the results of common nighthawk habitat effects monitoring conducted during the summer of 2018, the fifth year of Project construction. Monitoring for this study occurred at sites throughout the Gull and Stephens lakes area.

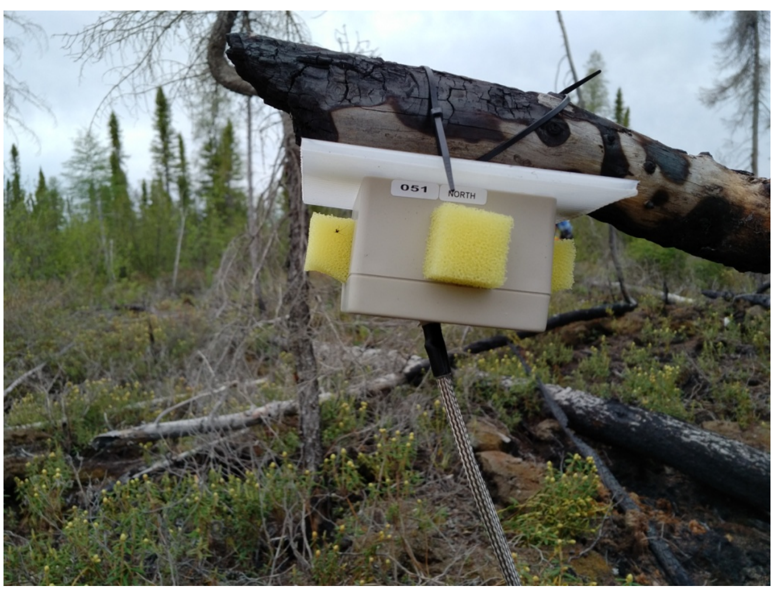
Why is the study being done?

As part of the Terrestrial Effects Monitoring Plan, habitat effects surveys for common nighthawk were initiated in 2016 and continued in 2017 and 2018, to evaluate Project-related changes in the distribution and abundance of suitable breeding habitat. This study will focus on quantifying the amount of breeding habitat that is lost or altered due to Project development.

A Common Nighthawk in the Keeyask Region

What was done?

Automated recording units were placed at 73 sites and recorded from July 8 to September 17, 2018. Sites were classified by their potential suitability as common nighthawk nesting habitat. The recorders were programmed to record for five minutes every 10 minutes from approximately 8:00 p.m. to 1:00 a.m. All recordings were processed and the presence or absence of common nighthawk calls was identified. Recordings collected from July 8 to August 7 were included in the results and all analyses of data for consistency with previous survey years. The accuracy of call identification was also tested.



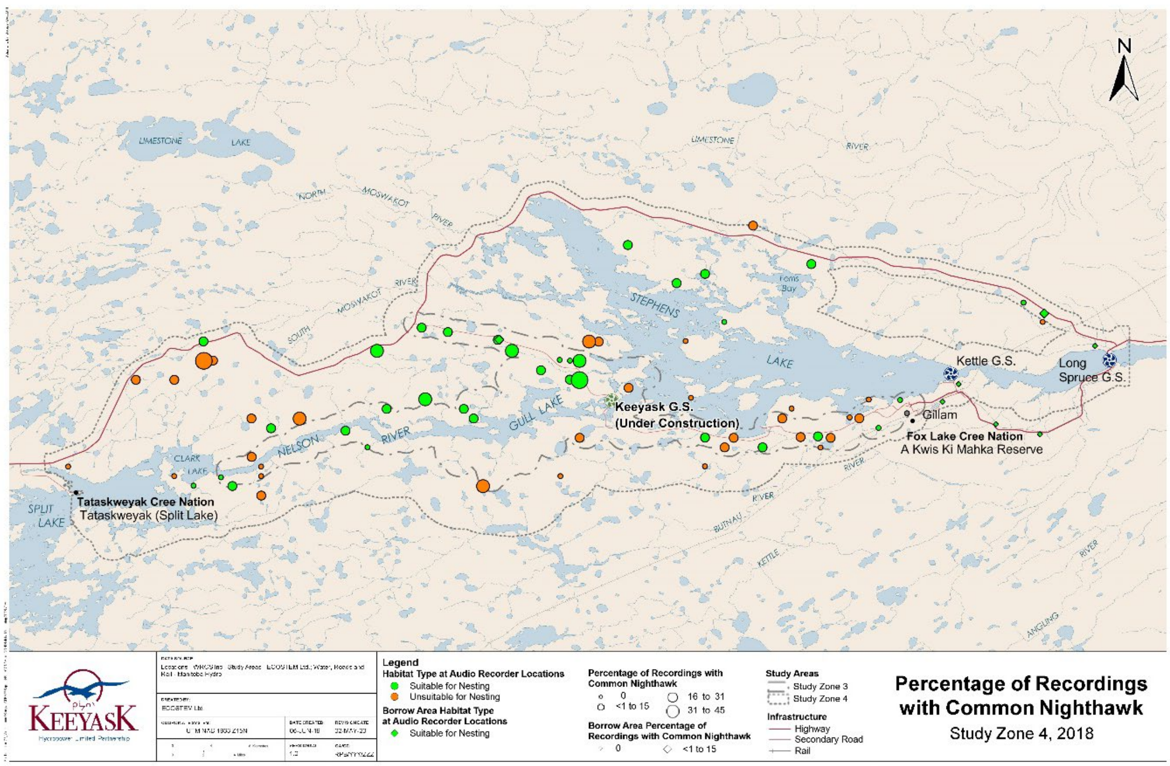
Custom Designed Automated Recording Unit (ARU) Deployed at Keeyask

What was found?

Common nighthawks were somewhat widely distributed in the Gull and Stephens lakes area and were recorded at 46 of the 73 sites surveyed in 2018, in habitats expected to be suitable and unsuitable for nesting. Individuals were detected at two borrow areas, which had been cleared and were possibly subject to disturbance but were considered to be suitable nesting habitat for common nighthawks.

Common nighthawks appeared to be most active until late July, roughly coinciding with the breeding season. As expected, most of their calls were recorded between 9:00 p.m. and 11:00 p.m., from dusk until just after sunset, a period when they are typically quite active.

Common nighthawks were less widely distributed in 2018 than in previous survey years. The percentage of sites at which common nighthawks were recorded declined from 2016 to 2018, with the largest decline between 2017 and 2018.



Percentage of Recordings with Common Nighthawks in the Gull and Stephens Lakes Area, 2018

What does it mean?

Common nighthawks were detected at many sites in the Keeyask region thought to be suitable for nesting, as expected. It is unclear, however, why the species was detected at a similar number of the sites thought to be unsuitable for nesting. Habitat patterns on the landscape likely influenced common nighthawk detections. Common nighthawk home ranges are typically large and several kilometres can separate foraging and nesting habitats. Common nighthawks foraging near unsuitable nesting habitat may have been recorded by the automated recording units within them, or habitat thought to be unsuitable for breeding may have been suitable for foraging.

What will be done next?

Common nighthawk field studies for the construction phase have concluded. More detailed, multi-year analyses of recordings will be performed and Project effects on common nighthawk habitat during construction will be evaluated.

STUDY TEAM

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Biologists and other personnel who designed or participated in field studies and drafted the results included:

- Robert Berger, Wildlife Resource Consulting Services MB Inc. (WRCS) – Design and reporting
- James Ehnes, ECOSTEM Ltd. – Design
- Andrea Ambrose, WRCS – Analysis and reporting
- Kevin McRae, WRCS – Field study lead
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- Tera Edkins, WRCS – Survey personnel
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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* (TE SV). The *Keeyask Generation Project 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, common nighthawk (*Chordeiles minor*), and the availability of breeding habitat in the Keeyask region during the construction and operation phases.

The common nighthawk is listed as Threatened under *The Endangered Species and Ecosystems Act* of Manitoba and under the federal *Species at Risk Act*. Its status has been recently re-examined by COSEWIC, and it was recommended to be downgraded to a species of Special Concern because its rate of decline has slowed and it is relatively abundant in boreal habitats (Government of Canada 2018). Environment Canada (2016) described the habitats and habits of the common nighthawk. The species is experiencing widespread population declines, due in part to loss of breeding habitat. Common nighthawks nest on the ground in a range of open habitats such as forest clearings and edges and on suitable roofs in urban areas, and they forage on flying insects. They blend in with their surroundings and are mainly active at dusk and dawn. As such, they are difficult to detect during traditional daytime surveys. However, breeding activity can be detected by calls and by the booming sound made by territorial males as air rushes through their feathers (Environment Canada 2016).

As part of the TEMP, habitat effects surveys for common nighthawk were initiated in 2016 and continued in 2017 and 2018, to evaluate Project-related changes in the distribution and abundance of suitable breeding habitat. While it is not expected to be limiting in the post-Project environment, the availability of suitable breeding habitat could have the greatest influence on common nighthawk distribution and abundance in the Keeyask region. The habitat effects study will evaluate how the Project changes the distribution and abundance of common nighthawk breeding habitat. In the future, results will validate the expert information habitat quality model defined in the EIS with data collected in a range of habitats. This validated and possibly refined habitat quality model will ultimately be used to evaluate how the Project changes the distribution and abundance of common nighthawk breeding habitat in the Keeyask region.

2.0 METHODS

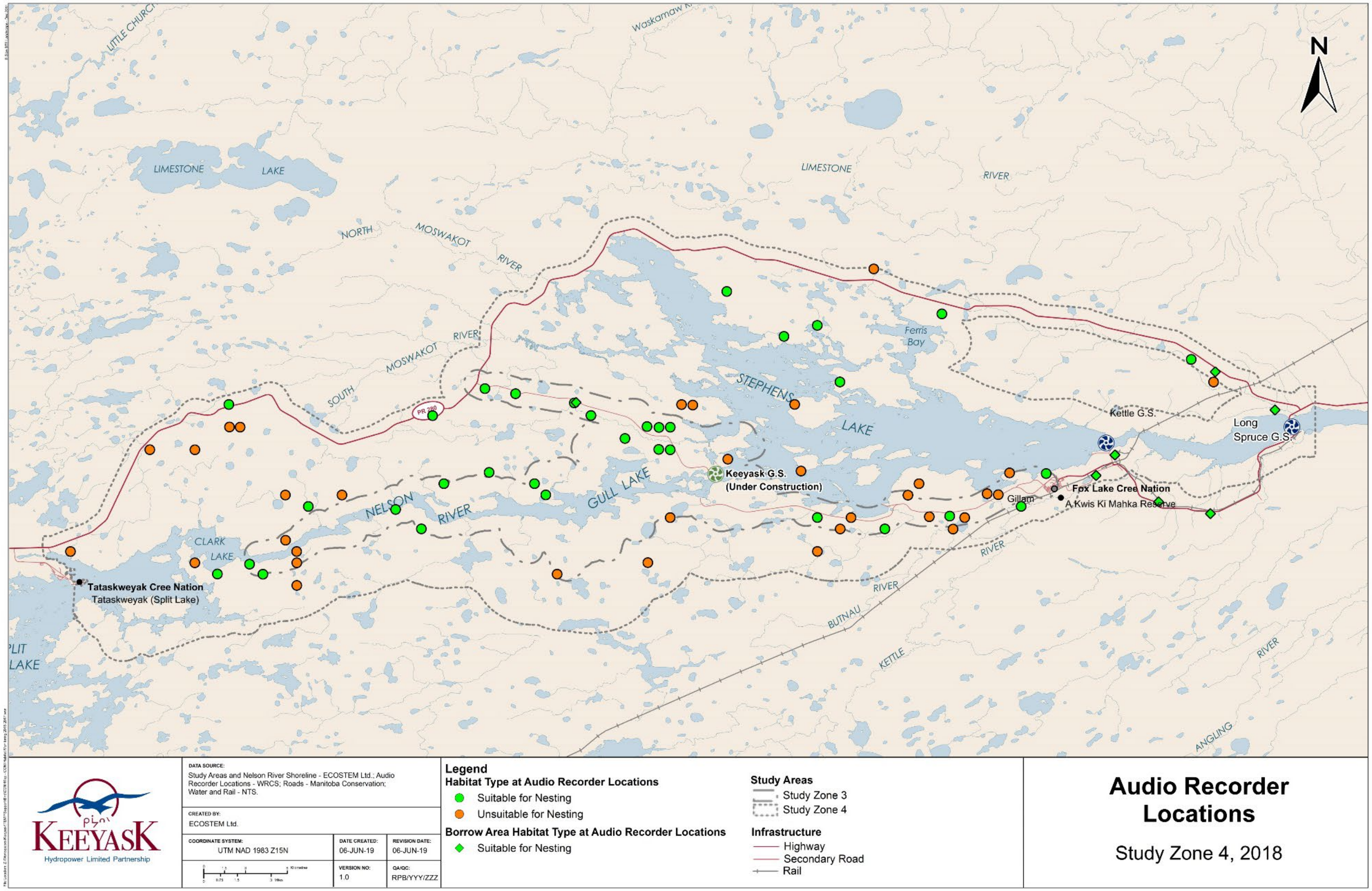
Common nighthawks are expected to be found in a higher proportion of their preferred nesting habitat types than in less suitable habitat types. In order to test which of the previously mapped terrestrial habitat and surface water patch types best incorporate environmental attributes that common nighthawks select for nesting, automated recording units (ARUs; Photo 1) were placed in a stratified random sample of available habitat types. Potential nesting habitat types were identified as recently burned on mineral soil, open vegetation on mineral soil, or borrow areas, which are considered broad habitat types and are in a landscape of complex habitat mosaics. All other terrestrial areas were considered unsuitable for common nighthawk nesting.

Photo 1: Four-microphone Automated Recording Unit Housed in Protective Case

In 2018, ARUs were placed at 73 sites (Map 1). Nineteen sites that were randomly selected in 2018 had also been surveyed in 2016 or 2017 and one site was surveyed in all three years (Appendix 1,Table A-1). Most sites were within Study Zone 4 and were classified by the potential suitability of nesting habitat as described above and by their position relative to Study Zone 3 (within or beyond; Table 1). Recordings were made from July 8 to September 17, 2018. The recorders were programmed to record for five minutes every 10 minutes from approximately 8:00 p.m. to 1:00 a.m. The time when common nighthawks are most active is 30 minutes before sunset (Knight et.al. 2016), which was covered by the recorder program. To identify the presence or absence of common nighthawk calls, analyses of bird vocalizations were performed using the statistical package R (Hafner and Katz 2018). A stepwise process was used to remove most false positives, where other species were initially identified as common nighthawks. Classification of audio 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% (see Appendix 2 for detailed analysis methods). All calls identified as common nighthawk were isolated and reviewed for potential false positives not removed during the initial identification process. For comparison with previous survey years when calls were only recorded throughout the month of July, only calls recorded from the nights of July 8 to August 7, 2018 were included in the results and all analyses of data.

Table 1: Number of Audio Recorder Sites in Study Zone 4, 2018

Habitat Type	In Study Zone 3	Outside Study Zone 3	Total
Nesting	24	16	40
Unsuitable	13	20	33



Map 1: Common Nighthawk Audio Recorder Locations in Study Zone 4, 2018

3.0 RESULTS

Common nighthawks (Photo 2) were somewhat widely distributed in Study Zone 4 in 2018 (Map 2). Calls were identified at 46 of the 73 sites surveyed (63%; Table 2). There was little difference in the percentage of sites at which the species was detected in habitat considered suitable for nesting and in unsuitable habitat. Common nighthawks were identified at a greater percentage of sites inside Study Zone 3 than outside.

Table 2: Sites where Common Nighthawk was Detected, 2018

Habitat Type	Position	Number	Percentage
Nesting	Inside Study Zone 3	17	71
	Outside Study Zone 3	9	56
	Total	*26*	*65*
Unsuitable	Inside Study Zone 3	10	77
	Outside Study Zone 3	10	50
	Total	*20*	*61*
All	Inside Study Zone 3	27	73
	Outside Study Zone 3	19	53
	Total	*46*	*63*

Between 528 and 773 recordings were made at the 73 sites surveyed (Appendix 1, Table A-2). At the 26 of 40 sites in habitat suitable for nesting where common nighthawk calls were identified, calls were detected on an average of 7.7% of recordings (range 0.1% – 38.5%) and on an average of 44.6% of survey nights (range 3.1% – 90.3%). At the 20 of 33 sites in unsuitable habitat where common nighthawk calls were identified, they were detected on an average of 6.4% of recordings (range 0.1% – 33.5%) and on an average of 39.2% of survey nights (range 3.3% to 87.1%).

Photo 2: Common Nighthawk in the Keeyask Region, June 2016

Borrow areas were considered potentially suitable nesting habitat. Common nighthawk calls were recorded at two of the nine borrow areas surveyed in 2018 (see Appendix 1,Table A-2), both of which had been cleared and may have been subject to disturbance from construction activities. They were detected on fewer than 2% of recordings at these two sites. Common nighthawks were recorded during relatively few (18.8% and 3.4%) survey nights in the two borrow areas.

At all sites in 2018, the number of recordings on which common nighthawks were identified was greatest the night of July 26 (n = 160; Figure 1). There were relatively few recordings with common nighthawk in August; however, the number of recordings per survey night fluctuated throughout the survey period. There were considerably fewer recordings on the nights of July 14, July 15, July 24, and August 4 than on other survey nights.

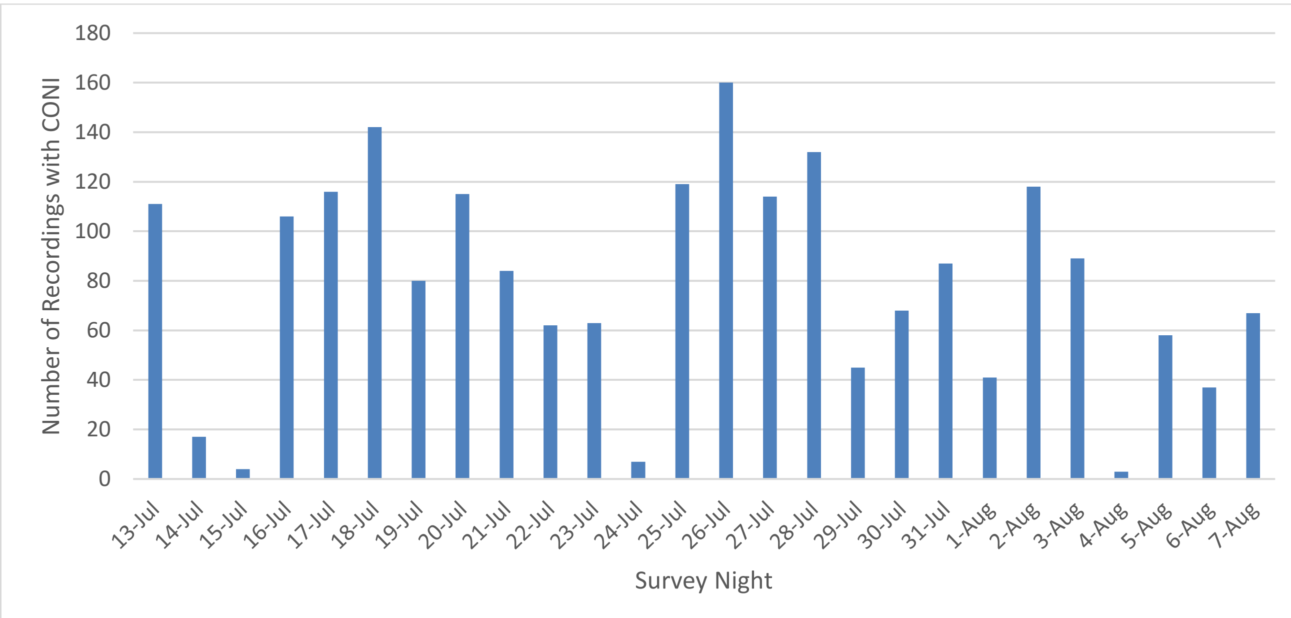
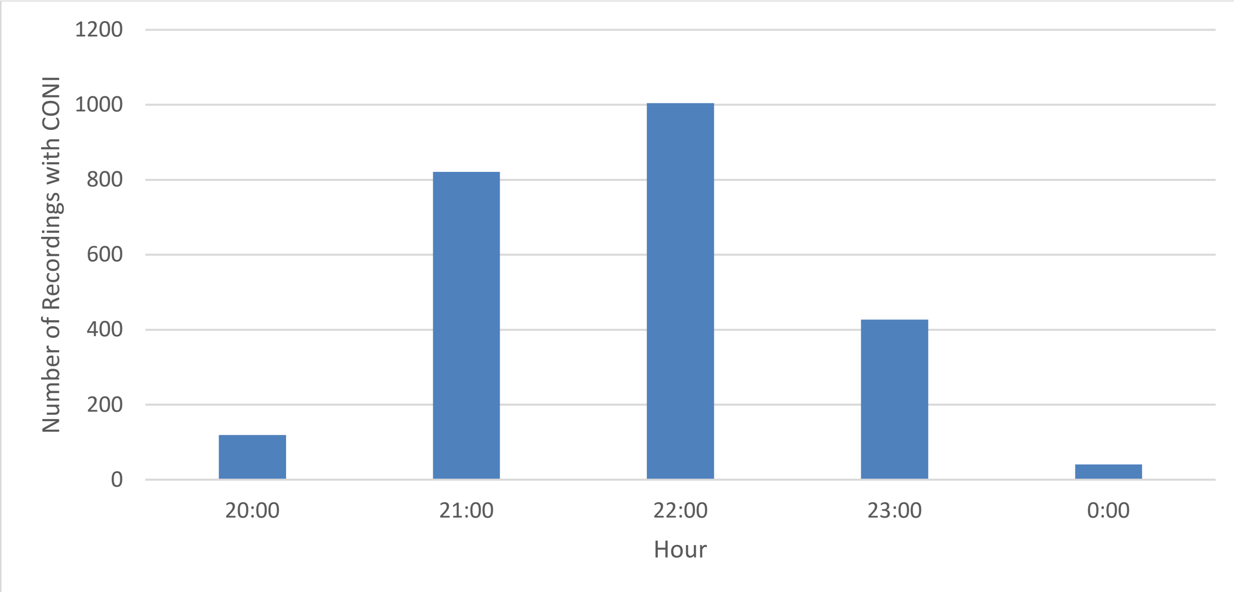


Figure 1: Number of Recordings with Common Nighthawk (CONI) per Survey Night, Across All Sites Surveyed in 2018

Common nighthawks appeared to be most active between 9:00 p.m. and 11:00 p.m. (Figure 2), at dusk and just after sunset. Relatively few recordings were made from 8:00 p.m. to 9:00 p.m. and from 11:00 p.m. to 1:00 a.m.



Note: One site, BI12, was not included due to a programming error.

Figure 2: Number of Recordings with Common Nighthawk (CONI) per Hour, Across All Sites Surveyed in 2018

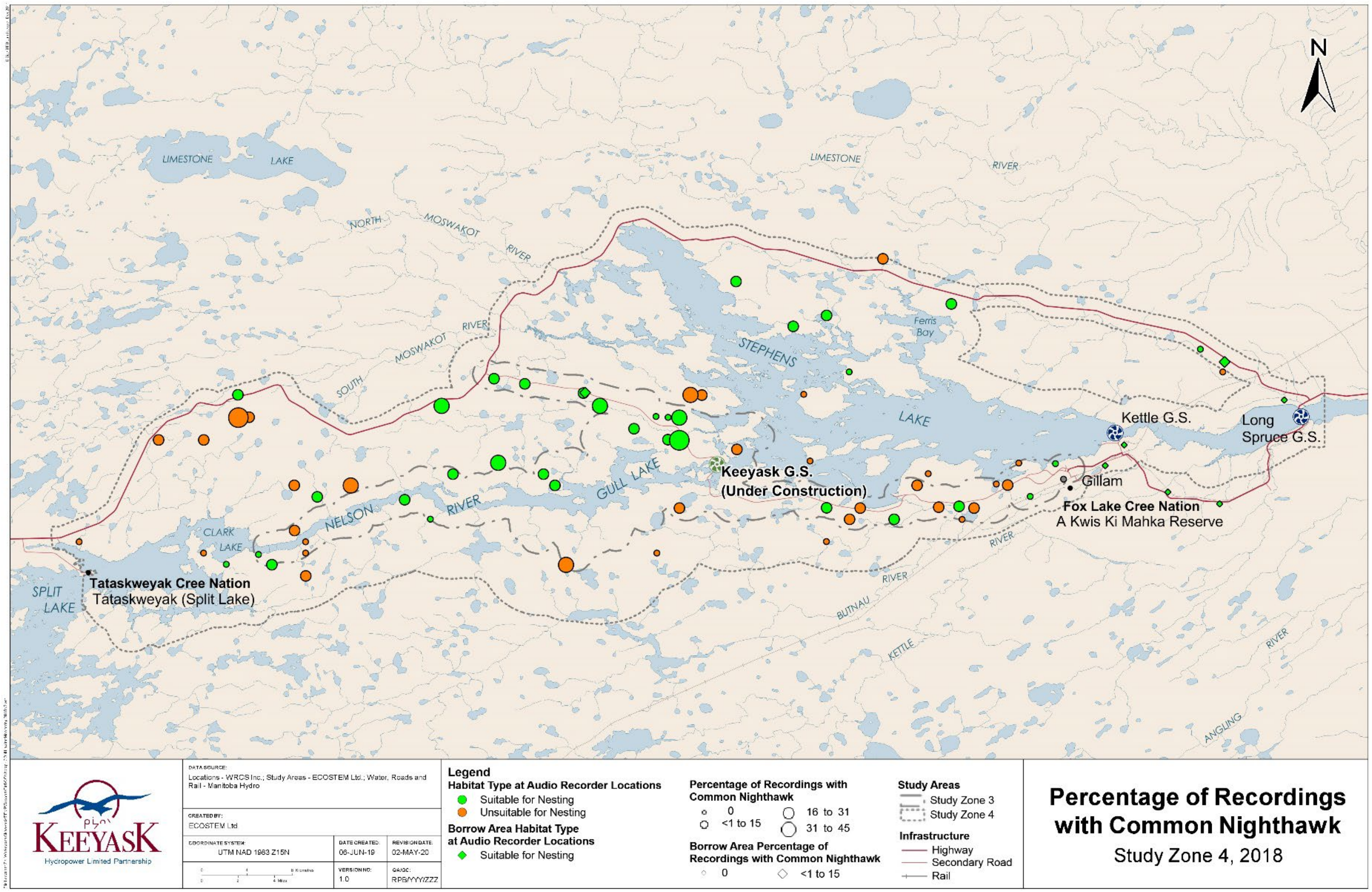
A total of 46,784 audio clips from 2018 were reviewed to ensure that all calls attributed to common nighthawk were correctly identified. Ninety-eight percent of common nighthawk calls were accurately identified (n = 45,965). There were 819 false positive identifications.

Three common nighthawk nests and one potential nest were incidentally reported between 2015 and 2017 at Project sites (Appendix 3). No reports of common nighthawk sightings were made in 2018. A common nighthawk mortality was reported in the construction area on April 29, 2018. A partially decomposed carcass was found on top of a storage container; the cause of death was unknown.

Common nighthawks were less widely distributed in 2018 than in previous survey years. The percentage of sites at which common nighthawks were recorded declined from 2016 to 2018 (Table 3). A larger decline was observed from 2017 to 2018 than from 2016 to 2017. The smallest decline was observed in unsuitable habitat from 2016 to 2017 and the largest decline was observed in the same habitat from 2017 to 2018.

Table 3: Percentage of Sites at which Common Nighthawk Was Detected, 2016–2018

				Percent Change	
Habitat Type	**2016**	**2017**	**2018**	**2016–2017**	**2017–2018**
Nesting	96	85	65	-11	-24
Unsuitable	94	90	61	-4	-32
All	95	87	63	-8	-28



Map 2: Percentage of Recordings with Common Nighthawk in Study Zone 4, 2018

4.0 DISCUSSION

Common nighthawk calls were identified at sites throughout Study Zone 4 in 2018, in habitat that is likely suitable for nesting and in areas considered to be less suitable habitat. It is unclear why the species was detected at many of the sites thought to be unsuitable habitat for nesting. It is possible that more distant birds could have been detected on the recorders in unsuitable habitat, or individuals passing through an area could have been recorded. As there was little difference in the frequency of detection in each habitat category (i.e., common nighthawks were recorded on similar percentages of recordings and survey nights in each), the latter seems unlikely. However, common nighthawk home ranges are typically large and several kilometres can separate foraging and nesting habitats (Environment Canada 2016). Common nighthawks foraging near unsuitable nesting habitat may have been recorded, or habitat thought to be unsuitable for breeding may have been adequate for foraging.

The EIS predicted that land clearing would result in a temporary gain of breeding habitat, but construction noise was expected to deter nesting in areas near Project activities. Seven sites were surveyed in borrow areas in 2018; common nighthawks were detected at two. However, the species was detected on few recordings at both sites in borrow areas and on a small proportion of the nights surveyed. These borrow areas may be on the periphery of the birds' territories, or individuals may have been passing through them.

Common nighthawks appeared to be most active until late July, roughly coinciding with their breeding season (Bird Studies Canada 2012). As expected, most of their calls were recorded between 9:00 and 11:00 p.m., at dusk and just after sunset, a period when they are typically most active (Environment Canada 2016). Relatively few common nighthawk recordings were made the nights of July 14, July 15, July 24, and August 4. A review of the recordings on these dates indicated that windy or rainy conditions influenced detections.

5.0 SUMMARY AND CONCLUSIONS

Common nighthawks were somewhat widely distributed in Study Zone 4 and were recorded at 63% of the sites surveyed in 2018, in areas of habitat expected to be suitable and considered unsuitable for nesting. Individuals were detected at two borrow areas that had been cleared and may have been subject to disturbance from construction activities. Common nighthawks were detected at a smaller percentage of sites in 2018 than in 2016 or 2017. Additional reviews of recordings will be conducted to ensure that no common nighthawk calls were missed during the analysis. Common nighthawk construction monitoring has concluded. More detailed, multi-year analyses of recordings will be performed for further evaluation.

6.0 LITERATURE CITED

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APPENDIX 1: TABLES

Table A-1: Recorder Locations for Common Nighthawk, 2018

Site	UTM Coordinate	Previous Survey Years
AA30	15 V 331496 6245496	
AF31	15 V 336236 6244222	
AH33	15 V 338508 6242505	2016
AI23	15 V 339501 6252523	
AJ29	15 V 340498 6246500	2017
AN28	15 V 344500 6247500	
AR29	15 V 348506 6246500	
AS30	15 V 349507 6245509	
AT37	15 V 350508 6238500	2017
AW23	15 V 353495 6252531	2017
AZ25	15 V 356501 6250497	2017
BB24	15 V 358455 6251556	
BB36	15 V 358523 6239515	
BC24	15 V 359508 6251477	2017
BC26	15 V 359491 6249536	
BD24	15 V 360505 6251498	2017
BD26	15 V 360499 6249501	2016
BD32	15 V 360497 6243503	
BE22	15 V 361500 6253501	2017
BF22	15 V 362494 6253457	
BI12	15 V 365499 6263501	
BI27	15 V 365591 6248671	
BN16	15 V 370552 6259528	
BO22	15 V 371498 6253513	
Bor_05	15 V 352185 6253676	2016
Bor_08	15 V 413951 6253018	2017
Bor_10	15 V 403663 6244888	
Bor_11	15 V 408234 6243848	
Bor_16	15 V 398136 6247223	
Bor_17	15 V 399806 6249040	
Bor_18	15 V 408670 6256389	2016
BP28	15 V 372058 6247619	
BQ15	15 V 373499 6260501	
BQ32	15 V 373499 6243511	2016, 2017
BQ35	15 V 373507 6240512	
BS20	15 V 375499 6255501	
BS33	15 V 375524 6242499	
BT32	15 V 376483 6243502	

Site	UTM Coordinate	Previous Survey Years
BV10	15 V 378490 6265497	
BW33	15 V 379469 6242506	
BY30	15 V 381507 6245487	2016
BZ29	15 V 382487 6246501	
C35	14 V 679029 6239916	
CA32	15 V 383397 6243577	
CB14	15 V 384510 6261518	2017
CC33	15 V 385492 6242483	
CD32	15 V 386522 6243501	
CF30	15 V 388506 6245610	
CG30	15 V 389489 6245528	
CH28	15 V 390487 6247453	
CI31	15 V 391508 6244495	
CK28	15 V 393723 6247395	2017
CX18	15 V 406539 6257497	
CZ20	15 V 408517 6255497	
J26	14 V 685226 6249499	
N26	15 V 318499 6249502	2016
N36	15 V 318489 6239503	
NAR01	15 V 344126 6254912	
NAR04	15 V 346838 6254455	
NAR09	15 V 352028 6253642	
P37	15 V 320488 6238515	
Q22	15 V 321499 6253503	
Q24	15 V 321555 6251514	
R24	15 V 322496 6251505	2017
S36	15 V 323327 6239382	2017
SAR06	15 V 385199 6243639	
T37	15 V 324508 6238495	
V30	15 V 326495 6245501	
V34	15 V 326510 6241500	2016
W35	15 V 327491 6240502	
W36	15 V 327505 6239508	
W38	15 V 327502 6237503	
X31	15 V 328520 6244486	

Table A-2: Audio Recordings for Common Nighthawk (CONI), 2018

Habitat Type	Site	Recordings			Survey Nights		
		Number	Number with CONI	Percentage with CONI	Number	Number with CONI	Percentage with CONI
Nesting	AF31	647	1	0.2	27	1	3.7
	AH33	767	0	0	32	0	0
	AI23	743	144	19.4	31	28	90.3
	AJ29	767	28	3.7	32	13	40.6
	AN28	767	148	19.3	32	24	75.0
	AR29	767	44	5.7	32	15	46.9
	AS30	767	3	0.4	32	1	3.1
	AW23	743	148	19.9	31	25	80.6
	AZ25	743	40	5.4	31	20	64.5
	BB24	743	0	0	31	0	0
	BC24	743	0	0	31	0	0
	BC26	743	104	14.0	31	22	71.0
	BD24	743	150	20.2	31	25	80.6
	BD26	767	295	38.5	32	28	87.5
	BI12	720	58	8.1	30	23	76.7
	BN16	719	36	5.0	30	16	53.3
	Bor_05	767	8	1.0	32	6	18.8
	Bor_08	695	0	0	29	0	0
	Bor_10	695	0	0	29	0	0
	Bor_11	695	0	0	29	0	0
	Bor_16	719	0	0	30	0	0
	Bor_17	695	0	0	29	0	0
	Bor_18	695	1	0.1	29	1	3.4

Habitat Type	Site	Recordings Number	Recordings Number with CONI	Recordings Percentage with CONI	Survey Nights Number	Survey Nights Number with CONI	Survey Nights Percentage with CONI
Nesting	BQ15	719	40	5.6	30	18	60.0
	BQ32	719	34	4.7	30	17	56.7
	BS20	719	0	0	30	0	0
	BW33	719	4	0.6	30	2	6.7
	CB14	719	69	9.6	30	21	70.0
	CI31	773	0	0	32	0	0
	CK28	719	0	0	30	0	0
	CX18	695	0	0	29	0	0
	NAR01	767	3	0.4	32	3	9.4
	NAR04	767	18	2.3	32	11	34.4
	NAR09	767	1	0.1	32	1	3.1
	P37	743	0	0	31	0	0
	Q22	743	8	1.1	31	7	22.6
	S36	647	0	0	27	0	0
	SAR06	719	40	5.6	30	16	53.3
	T37	743	2	0.3	31	2	6.5
	X31	767	76	9.9	32	13	40.6
Unsuitable	AA30	767	131	17.1	32	25	78.1
	AT37	767	131	17.1	32	24	75.0
	BB36	743	0	0	31	0	0
	BD32	743	2	0.3	31	2	6.5
	BE22	743	144	19.4	31	26	83.9
	BF22	743	39	5.2	31	18	58.1
	BI27	743	3	0.4	31	3	9.7
	BO22	719	0	0	30	0	0
	BP28	647	0	0	27	0	0
	BQ35	719	0	0	30	0	0

Habitat Type	Site	Recordings Number	Recordings Number with CONI	Recordings Percentage with CONI	Survey Nights Number	Survey Nights Number with CONI	Survey Nights Percentage with CONI
Unsuitable	BS33	719	8	1.1	30	5	16.7
	BT32	719	10	1.4	30	7	23.3
	BV10	719	1	0.1	30	1	3.3
	BY30	719	4	0.6	30	3	10.0
	BZ29	719	0	0	30	0	0
	C35	767	0	0	32	0	0
	CA32	647	1	0.2	27	1	3.7
	CC33	719	0	0	30	0	0
	CD32	719	22	3.1	30	13	43.3
	CF30	647	0	0	27	0	0
	CG30	719	6	0.8	30	6	20.0
	CH28	719	0	0	30	0	0
	CZ20	695	0	0	29	0	0
	J26	743	14	1.9	31	6	19.4
	N26	743	12	1.6	31	9	29.0
	N36	767	0	0	32	0	0
	Q24	743	249	33.5	31	27	87.1
	R24	743	51	6.9	31	23	74.2
	V30	767	46	6.0	32	20	62.5
	V34	767	89	11.6	32	24	75.0
	W35	767	0	0	32	0	0
	W36	528	0	0	23	0	0
	W38	767	4	0.5	32	2	6.3

APPENDIX 2:
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 weatherproof 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.
- Data storage: ARUs were fitted with secure digital (SD) cards (8 gigabyte [GB] or 32GB) as appropriate. The audio sampling rate was also varied to match study, storage, and analysis

[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.

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 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[2]. In order for data to be analyzed in R, OGG files had to be converted to wave (WAV) format using either SOX[3] or LameXP[4]. 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.

[2] 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.

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

[4] 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 (Figure B-1).

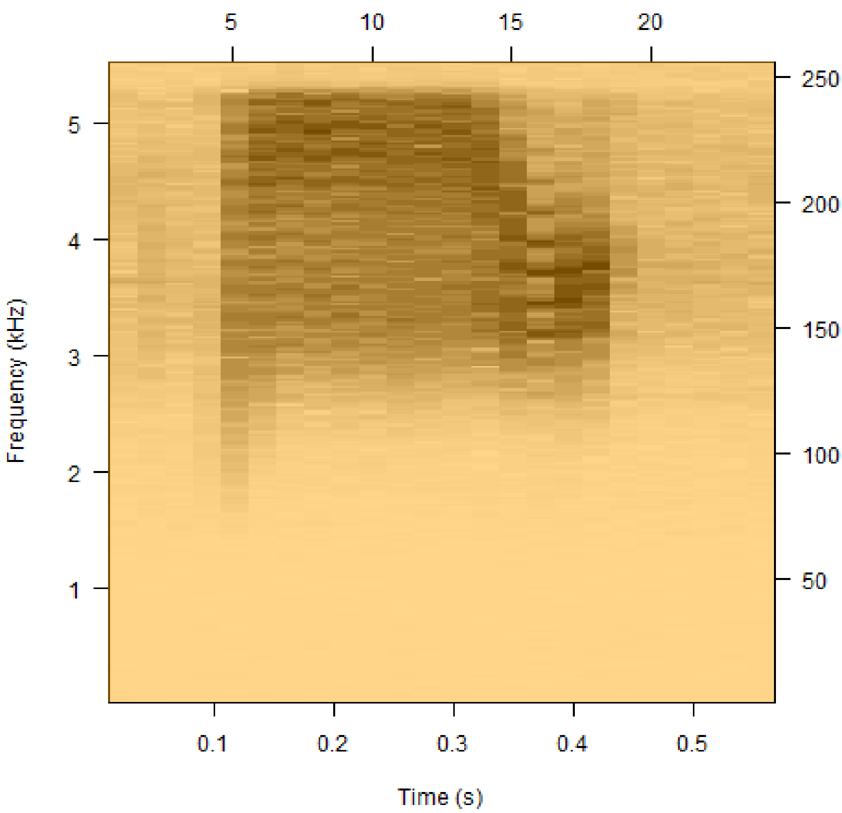

Figure B-1: Example Spectrogram of a Common Nighthawk Clip Extracted from a Recording

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 (Figure B-2) 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.

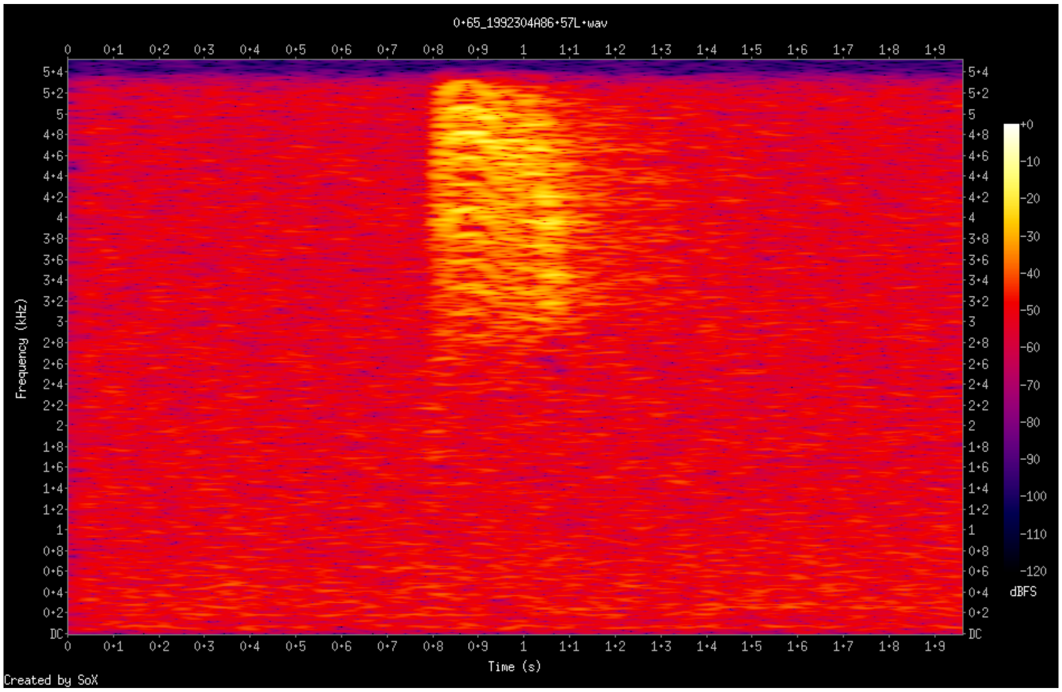

Figure B-2: Example Spectrogram of a Common Nighthawk Clip Extracted from a Recording

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. The graphic user interface is an HTML web page with an example shown in Figure B-3. Summary statistics were created for all detections to aid in validation. Examples are given in Figure B-4 and Figure B-5.

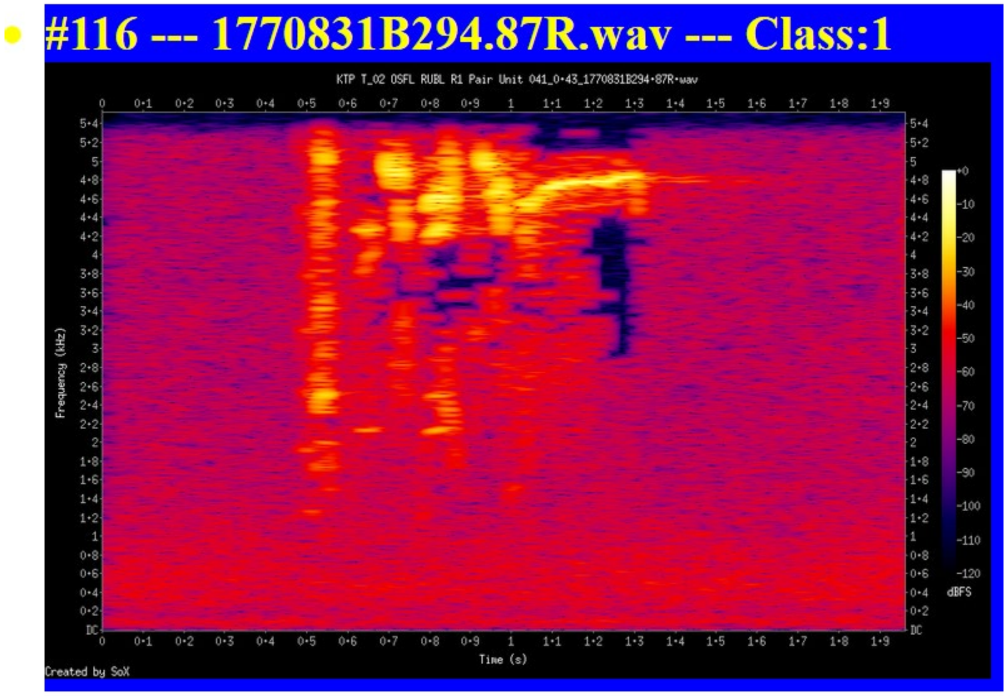

Figure B-3: Example of HTML Display of Classified Rusty Blackbird Clip. Clip #116 from the Recording made on Day 177 at 0831hr, 294.87sec into Recording B Observed on the Left (L) Channel. "Class:1" Indicates this is a Positive Result.

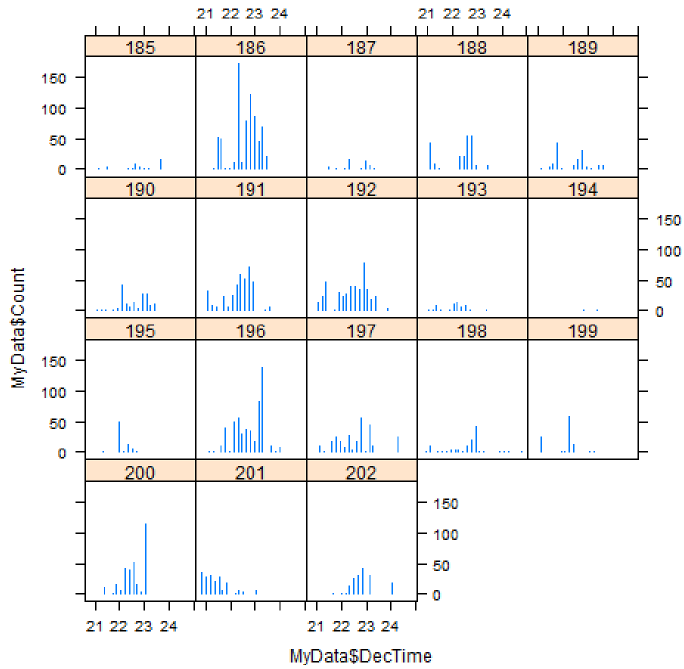

Figure B-4: Summary of Total Calls Detected for a Species within a Site and Year, Summarized by Day of Year and Hour of Day

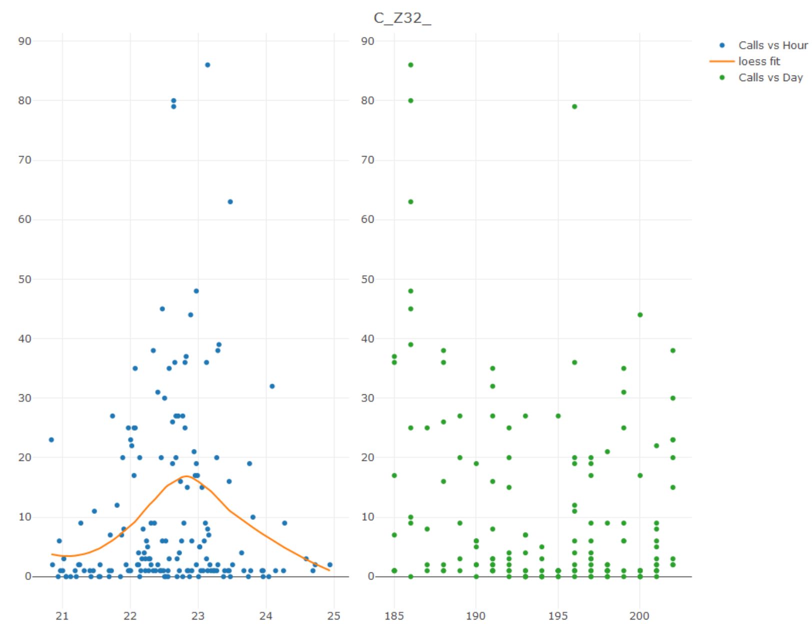

Figure B-5: Summary of Calls Detected for Common Nighthawk within a Site and Year, vs. Hour of Day and vs. Day of Year. Note the Peak in Calling at about 2300h as Expected for this Species.

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)[5]. 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)[6]. Although many automated direction estimation algorithms use Interaural Time Difference (ITD), humans do not use this for frequencies high frequencies (Roman et al. 2003)[7]. There were several reasons why there was concern that ITD might be unreliable in the studies. Some include: low signal to noise ratios (SNR), reverberation, environmental noise like wind, etc. In addition, the 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. It was concluded that ILD was the best choice.

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 (Figure B-6); it was assumed that the calling bird was in the horizontal plane of the microphone array. For common nighthawk, directionality was not achievable or valid since this species calls in flight and could be anywhere within a hemisphere surrounding 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 estimated by choosing the largest decibel value measured by the four microphones. For common nighthawks, distance estimation was problematic since they fly erratically while calling. Estimates were obtained from other researchers of the maximum recording distance expected for common nighthawk detected with the recorders (Figure B-7).

[5] 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.

[6] 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.

[7] 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.

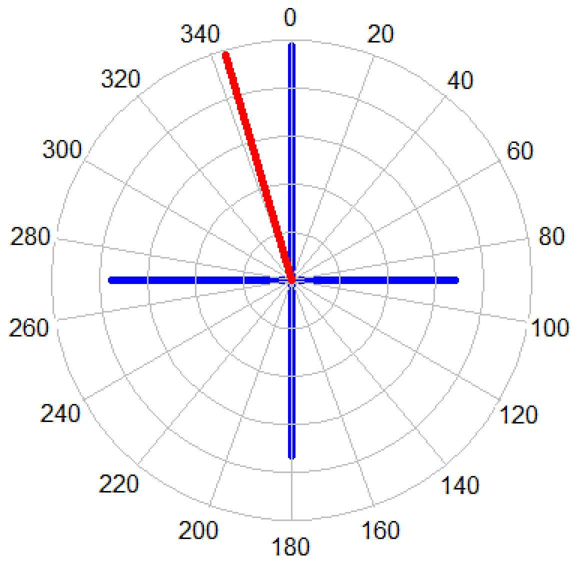

Figure B-6: Example of Direction Calculated from the Peak RMS Amplitude of a Clip from All Four Microphones

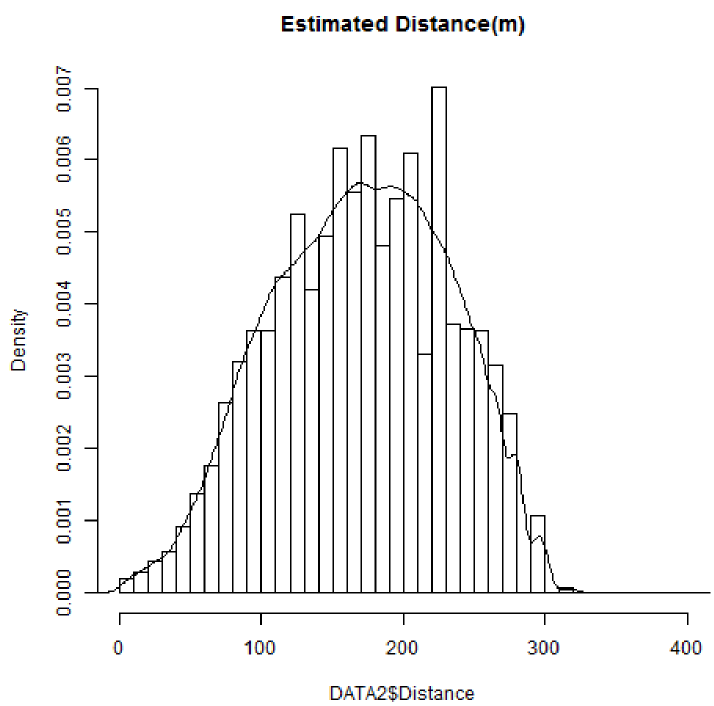

Figure B-7: Example of Distribution of Distance Estimates for Common Nighthawk in One Dataset

APPENDIX 3: INCIDENTAL OBSERVATIONS

Table C-1: Locations of Common Nighthawks and Nests at Project Sites, 2015 and 2017

Location	Date	Additional Details
15 V 358180 6251710	July 2015	Nest observed in the Km 15 borrow area; buffer established restricting construction activity (Photo C-1)
15 U 365894 6250105	July 2017	Nest observed in a borrow area; buffer established restricting construction activity (Photo C-2)
15 V 355174 6242506	July 2017	Nest observed in a clearing along the south dyke (Photo C-3)
15 V 357704 6243754	July 2017	Two individuals observed in a clearing along the south dyke (Photo C-4). Potential nest or roosting

Photo C-1: Common Nighthawk Nest with Two Eggs at Km 15 Borrow Area, July 2015

Photo C-2: Borrow Area Flagged Off to Protect Common Nighthawk Nest, July 2017

Photo C-3 Common Nighthawk Nest with Two Eggs in a Clearing along the South Dyke, July 2017

Photo C-4: Common Nighthawk in a Clearing along the South Dyke, July 2017