Columbia River Project Water Use Plan

KINBASKET AND ARROW LAKES RESERVOIRS

Reference: CLBMON-36

Kinbasket and Arrow Lakes Reservoirs: Nest Mortality of Migratory Birds Due to Reservoir Operations

Study Period: Year 9, 2016

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Head Office
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February 8, 2017

CLBMON-36: Kinbasket and Arrow Lakes Reservoirs: Nest Mortality of Migratory Birds Due to Reservoir Operations

Year 9, 2016

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Report prepared for: BC Hydro, Water Licence Requirements, Burnaby, British Columbia

February 8, 2017

Suggested Citation:

van Oort, H., J.M. Cooper, A. Peatt, and S. Beauchesne. 2017. CLBMON 36: Kinbasket and Arrow Lakes Reservoirs: nest mortality of migratory birds due to reservoir operations— Year 9, 2016. Unpublished report by Cooper Beauchesne and Associates Ltd., Qualicum Beach, BC, for BC Hydro Generation, Water Licence Requirements, Burnaby, BC. 32 pp. + Apps.

Cover photo: Bush Arm drawdown zone, Kinbasket Reservoir, 2016 (photo by Harry van Oort)

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Okanagan Nation Alliance

EXECUTIVE SUMMARY

Water Use Planning for the Columbia River provided guidance on the operations of hydroelectric reservoirs to improve ecological and recreational values. During this process, the multi-stakeholder Consultative Committee recognized that impacts of reservoir operations on breeding birds were potentially large, yet poorly understood. As a Water Licence Requirement, BC Hydro committed to research the impacts that reservoir operations have on the productivity of birds breeding in the reservoir drawdown zones of Kinbasket (KIN) and Arrow Lakes Reservoirs (ALR). CLBMON-36 is a 10-year monitoring program designed to fulfill this commitment. This report summarizes field study and analysis conducted in **2016**, **Year 9** of CLBMON-36.

At KIN, research has focussed on two regions. Canoe Reach (CR), near Valemount, BC, was monitored annually during the first eight years of the project (2008-2015); the more remote Bush Arm (BA) region, closer to Golden, BC, was monitored for four years (2010, 2011, 2012, 2016) in order to increase knowledge of breeding birds that utilize vegetation communities in the drawdown zone that were not well-represented at CR. At ALR, only one study area has been monitored - Revelstoke Reach (RR), which has been monitored annually since project inception (2008). All three study areas contain relatively high amounts of vegetated habitat, and appear to constitute the most important areas for breeding birds within the vast drawdown zones of these two reservoirs.

PROJECT OVERVIEW

Nest mortality: biogeography and site productivity monitoring

In Years 1-5, a focus of field research was to document how avian communities were distributed in the drawdown zones of KIN and ALR, and to document how nesting productivity was influenced by reservoir operations. New, previously un-sampled sites were chosen annually, stratified among habitat classes, and monitored during the entire breeding season with the goal of finding all nests within 3 m of the ground at each site. Sites with active nests were visited regularly (~ every 3 days) to monitor nest survival.

After field studies for Year 5 were completed, an initial examination of biogeographical and productivity data was made. The Year 5 Interim Report (Y5IR) showed that the cumulative increase in species richness documented by the study had levelled off at both reservoirs after Year 3, indicating that knowledge of the diversity of species regularly nesting in the drawdown zones of both reservoirs was near complete. Nonetheless, nests of additional uncommon species have continued to be located since that time, including Year 9. To date, 30 species have been discovered nesting in KIN's drawdown zone, and 65 species in ALR's. While we are confident that all regular species have been documented, additional rarities are likely to be discovered occasionally in the future.

It was evident by Year 5 that the project had attained a basic understanding of the biogeography of nesting communities within and among the various drawdown zone habitats of ALR and KIN. At both reservoirs, nesting was concentrated at higher elevations in the drawdown zones, where there is greater plant species diversity and a more complex vegetation structure. However, nesting was not restricted to these high elevation habitats, and extended to surprisingly low elevations in the drawdown zones where the habitat is devoid of vegetation. By Year 5, nesting was documented as low as 739.3 m ASL in KIN (~ 16 m below the historic maximum reservoir elevation), and as low as 433.2 m ASL in ALR (~ 8 m below the historic maximum reservoir elevation). The number of nests and diversity of species nesting varied considerably, depending on the habitat classes being monitored. In KIN, one habitat class (WS – Willow Sedge Wetland) had a species richness of 13 with an average of 2.4 nest attempts per ha of monitored habitat each year, while other habitats were never observed to be used for nesting. In ALR, one habitat class (BF – a unique floating bog habitat) had a species richness of 15, and an average of 11.9 nest attempts per ha of monitored habitat. There were also habitat classes in ALR where no nesting was observed (see Y5IR Appendix 1 and 2 for additional details).

The Y5IR revealed that active nests in the ALR drawdown zone were often submerged by annual reservoir operations (mean = 11.7% of monitored nests observed to have flooded). Nest submergence was less common in KIN (2.8%), and was not observed every year. Nest predation was the leading cause of nest failure in both reservoirs. Overall, nesting success was greater in KIN, compared with ALR due to lower rates of nest predation and submergence. The impact of nest flooding was not even among species at ALR; for some species, nest flooding was the leading cause of nest failure (e.g., Yellow-headed Blackbirds), while for others, it was a relatively unimportant impact, clearly something that must relate to species nesting habitat preferences.

A major result presented in the Y5IR was the production of the first empirically derived mechanistic model of nest activity as a function of elevation and time, allowing nest flooding rates to be modelled within the mapped parts of the drawdown zone.

Focal species research

In addition to the biogeography (community-level) study above, monitoring of focal species allowed some ecological processes to be explored within particular populations. This research explored how reservoir operations impact specific aspects of productivity including nest survivorship and the survivorship of juveniles post-fledging. Focal species were monitored by targeted nest searches and subsequent nest inspections, and by using radio telemetry to track juvenile survivorship. To determine juvenile survivorship, we attached small radio transmitters to nestlings and located them daily to determine each bird’s status. This approach allowed us to determine how reservoir inundation of post-fledging habitat affected their survival. To determine if juvenile survival is impacted by reservoir operations in reservoir drawdown zones, our approach was to contrast survival data in dry versus flooded habitats within the drawdown zone, and in drawdown zone habitats versus non-drawdown zone habitats.

Focal species monitoring has been ongoing since project inception for two species: the Savannah Sparrow (SAVS) in the CR study area, and the Yellow Warbler (YEWA) in RR. Focal species monitoring has been an increasing focus of field study since Year 5.

Since project inception, we have generated substantive nesting data for the ground-nesting SAVS in KIN. No formal analyses have yet been conducted on the CR SAVS data. The SAVS dataset is now large enough to begin some analyses, but a need remains to continue juvenile monitoring. The YEWA have been studied in collaboration with Dr. D.J. Green (and students) at Simon Fraser University (SFU). Due to the collaboration, three YEWA populations in the ALR drawdown zone have been intensively studied, with most breeding adults and fledged young being colour-banded each year. To date, one peer-reviewed paper has demonstrated that YEWA habitat selection in the ALR drawdown zone is adaptive, indicating that the drawdown zone habitats these birds select are unlikely to function as ecological traps. An additional paper has shown that YEWA (and Willow Flycatcher) are buffered from the effect of nest flooding to some degree because they are compensated for nest flooding by reduced predation rates at non-flooded nests positioned in flooded habitat. Our component study of juvenile YEWA survival using telemetry concluded in Year 7 (2014), and had sufficient data to show a negative impact of reservoir operations on juvenile survivorship.

SUMMARY OF YEAR 9 PROGRESS

In Year 9, field work continued in BA and RR. Both reservoirs had atypical operations in 2016. KIN had above average water levels (early filling) causing early nest flooding during the early- to mid-part of the breeding season. Towards the end of the breeding season, the rate of water level increase slowed down so that levels were relatively normal at that time of year. Although the operation of KIN in 2016 had less potential to flood nests compared with 2012, we observed the highest number of nest inundations at KIN compared to all years within the study period (i.e., 6 nests). Note that nest flooding would have been considerably under-represented in 2012 (i.e., greater than 2016) because road washouts caused monitoring to end early that year. The ALR filled to a relatively low and early maximum high level of just 437.2 m asl on June 12. Observations of nest flooding in the ALR was therefore much lower than normal (also 6 nests).

In 2016 we monitored two focal species (Yellow Warbler at ALR and Savannah Sparrow at KIN), and to document variation in breeding bird communities, we monitored 20.5 ha of mapped habitat at KIN and 28.1 ha of mapped habitat at ALR.

We located 286 nests from a total of 40 species; 43 of these were at BA (9 species), and 243 of were at ALR (39 species). Previously unrecorded species were observed nesting in the ALR drawdown zone: Blue-winged Teal (*Anas discors*), Northern Shoveler (*Anas clypeata*), Yellow-rumped Warbler (*Setophaga coronata*), and Tennessee Warbler (*Leiothlypis peregrina*). At the ALR, four nests were located from the federally listed Short-eared Owl (*Asio flammeus*; species of 'Special Concern' on *Species At Risk Act* Schedule 1); two of these were flooded by the reservoir. At ALR, 49% of monitored nests were successful, and 59% were successful at KIN.

In Year 9, 13 Savannah Sparrow nestlings were tagged for juvenile monitoring in the drawdown zone at BA. 33% of the tagged young survived the monitoring period; none of the young drowned in the rising reservoir pool. One juvenile was confirmed to have been eaten by a Common Gartersnake (*Thamnophis sirtalis*); other juvenile sparrows likely died from exposure to cool wet weather.

RECOMMENDATIONS FOR 2017

- Site selection in 2017 should continue to focus on filling knowledge gaps.
- We recommend working in Bush Arm again in 2017 rather than CR.
- Ideally, Cedar Waxwing nest should be monitored above the drawdown zone at new sites to increase spatial replication to test Hypothesis 1A.
- Analysis should be prioritized for the Year 10 final report.

With one year remaining in the CLBMON-36 study, the project is in a solid position and each management question, hypothesis and objective should be adequately addressed.

Keywords

River regulation, reservoir operations, nest mortality, habitat distribution, habitat suitability, flooding, submersion, nest monitoring, nest survivorship, juvenile survivorship, Yellow Warbler, *Dendroica petechia*, Savannah Sparrow, *Passerculus sandwichensis*, Arrow Lakes Reservoir, Kinbasket Reservoir, BC Hydro, British Columbia

ACKNOWLEDGEMENTS

Many people contributed during Year 9 of the CLBMON 36 project. BC Hydro WLR sponsored the project. CBA is very grateful to Susan Pinkus, Jason Watson, Trish Joyce, and Margo Sadler of BC Hydro for their ongoing support and management of this project. Comments from Ian Robertson were helpful and appreciated.

CBA collaborates with the Okanagan Nation Alliance (ONA) for delivery of CLBMON-36, with ONA biologists and technicians providing field and technical support, and insight into the perspectives and protocols of the Syilx (Okanagan) people. Bruce Weaver of the Okanagan Indian Band and Kayla Williams of the ONA contributed to field studies. Al Peatt managed the ONA's involvement and provided a technical review of this report.

We would like to acknowledge the hard work of Devon Anderson, Corey Bird, Emily Braam, James Bradley, Catherine Craig, Ryan Gill, Rianne Mariash, Michal Pavlik, Vicki Prigmore, Harry van Oort, Bruce Weaver, and Kayla Williams in collecting field data. Ryan Gill provided GIS mapping. Ryan Gill and Harry van Oort planned the field study program. Suzanne Beauchesne provided overall supervision and monitoring of crews. John Cooper acted as Project Manager and provided a technical review of this report.

CBA worked closely with Simon Fraser University throughout this study. Dr. David Green of Simon Fraser University coordinated some of the Yellow Warbler research in 2014, which was conducted by Michal Pavlik and Rianne Mariash. Dr. David Green provided scientific guidance to CBA.

Harry van Oort conducted all analyses.

Lesley-Anne Howes and Louise Laurin (Canadian Wildlife Service Bird Banding Office) processed bird banding and capture permits. All procedures followed in this study were approved by the Simon Fraser Animal Care Committee.

CBA would like to thank the Revelstoke community for providing safe and enjoyable home bases for field crews during the field season.

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1 INTRODUCTION

The regulation and impoundment of river basins causes considerable impact to riparian and wetland wildlife, initially through habitat destruction, and continually via the ongoing regulation of river discharge (Nilsson and Dynesius 1994). The Columbia River is one of the most modified and regulated large rivers in North America (Nilsson et al. 2005), with multiple dam projects existing in both the USA and British Columbia portions of the basin. Water storage reservoirs along the primary course of the Columbia River in BC include the Kinbasket Reservoir (KIN), Lake Revelstoke, and the Arrow Lakes Reservoir (ALR), positioned sequentially along the river's main stem (many other impoundments exist on the tributaries). The footprint impact of Columbia River basin reservoirs has been estimated to cause a loss of 26% of the wetlands, 21% of riparian cottonwood, and 31% of shallow water and ponds in BC portion of the basin (Utzig and Schmidt 2011). In place of these and other natural habitats that were lost, are the substantial drawdown zones of these reservoirs, typically comprised of steep, barren shorelines, with negligible value as habitat for wildlife.

Yet in some parts of reservoir drawdown zones in BC, important wildlife habitats persist, some with significance as nesting habitat for a variety of birds. In particular, the upper four meters of the drawdown zone in Revelstoke Reach (RR) at the north end of ALR is highly vegetated and known to be used by a diversity of birds during the breeding season (Boulanger 2005, Jarvis 2006, Quinlan and Green 2012, CBA 2013). The drawdown zones at Canoe Reach (CR) and Bush Arm (BA), both in KIN, also contain several vegetated areas suitable as nesting habitat (CBA 2010a, 2011, 2013). Because these remnant breeding habitats are located in reservoir drawdown zones, the operation of ALR and KIN reservoirs may have significant impacts on the productivity of resident bird populations (CBA 2013). It is possible that some nesting habitats within the reservoir act as ecological traps (Schlaepfer et al. 2002, Robertson and Hutto 2006, Anteau et al. 2012, CBA 2013), and/or that some drawdown zone populations act as population sinks (Pulliam 1988)[1]; both situations are a possibility due to potential flooding of nesting habitats, and nests during the breeding season (Wolf 1955, Espie et al. 1998, Anteau et al. 2012).

During the Columbia River Water Use Planning process (BC Hydro 2007), nest mortality caused by reservoir operations was identified as a critical issue. The primary concern was that the operations of ALR and KIN may reduce the productivity of breeding bird communities via nest submersion. This concern arose from earlier studies in RR that documented a high diversity of birds using drawdown habitats during the breeding season (Boulanger et al. 2002, Boulanger 2005), and pilot surveys that documented nest mortality resulting from reservoir operations (Jarvis 2003, 2006). Furthermore, the discovery of Short-eared Owl (*Asio flammeus*) nesting within the drawdown zone in 2002 (Jarvis 2003) highlighted the potential for reservoir operations to have negative effects on breeding bird species identified in the federal *Species at Risk Act* (SARA). Under the direction of the Columbia River Water Use Plan, and as one of their Water Licence Requirements (WLR), BC Hydro initiated CLBMON-36, a 10-year program designed to

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[1] Ecological traps occur when populations prefer/select unnatural habitats where reproduction is compromised (misguided preferences). Population sinks are sub-populations in a meta-population with intrinsic productivity that is insufficient to sustain the population size; their existence is sustained by immigration (demographic rescue) from other sub-populations.

determine the effects of reservoir operations (water level management) on breeding success of birds nesting in the drawdown zone of KIN and ALR, and to provide feedback and guidance on the efficacy of methods used to enhance breeding habitats for birds in reservoir drawdown zones (revegetation and wildlife physical works).

1.1 Objectives

The objectives of CLBMON-36 are as follows:

- Identify how drawdown zone habitats are used by breeding birds in Kinbasket Reservoir and Revelstoke Reach.
- Evaluate how the operations of the Kinbasket and Arrow Lakes Reservoirs influence nest survival.
- Evaluate how the operations of the Kinbasket and Arrow Lakes Reservoirs influence juvenile survival.
- Establish a nest flooding risk model for Kinbasket Reservoir and Revelstoke Reach.
- Assess how habitat management in the drawdown zones can be used to increase productivity, or reduce negative impacts of reservoir operations.

1.2 Management questions

To achieve the above objectives, the Terms of Reference (TOR) for CLBMON-36 list Management Questions that the research should address:

A. Which bird species breed in the drawdown zones and how are they distributed among the drawdown zone habitat classes?

B. What are the seasonal patterns of habitat use by birds nesting in the drawdown zones?

C. Do reservoir operations affect nest survival?

D. What are the causes of nest failure in the drawdown zone, and how do they differ among species, among habitat classes, and across elevation (i.e., position in drawdown zone)?

G. Do reservoir operations affect juvenile survival when water levels inundate post-fledging habitat?

H. How can the operations of the Kinbasket and Arrow Reservoirs be optimized to reduce nest submersions and/or improve avian productivity?

K. Can drawdown zone habitats be managed to improve nest survival and/or site productivity? If so, how?

1.3 Management hypotheses

Further to the Management Questions, several hypotheses were drafted to focus data collection and analysis:

H1: Inundation of nesting habitat caused by reservoir operations does not affect nest survivorship.

H1A: Nest survivorship in the drawdown zone is not different from nest survivorship above the drawdown zone.

H1C: Nest survivorship does not differ across elevations in the drawdown zone.

H1D: Rates of nest flooding do not differ across elevations in the drawdown zone.

H2: Inundation of post-fledging habitat does not affect juvenile survival.

H2A: Juvenile survival in the drawdown zone does not differ from juvenile survival above the drawdown zone.

The above **Objectives**, **Management Questions** and **Hypotheses** were refined in the CLBMON-36 TOR revisions in 2014. The TOR revision addressed several outstanding issues that were highlighted in previous reports (e.g., CBA 2013) and improved clarity. Notably, two Management Questions (E and F) were removed because they were not questions that could be answered by CLBMON-36, and two others (I and J) were amalgamated as one question (K). Similar editing to the objectives and hypotheses also occurred. A table showing how the revised objectives, questions and hypotheses are related is provided in Appendix 6-1.

1.4 Study areas

Field studies in 2016 were conducted at one study area in each of two reservoirs: RR (ALR) and BA (KIN; Figure 1-1).

1.4.1 Bush Arm, Kinbasket Reservoir

KIN is the upper-most reservoir along the Columbia River. The KIN reservoir impounds a 216-km section of the Columbia and Canoe Rivers, and is operated by BC Hydro for storage (12 MAF), power generation (1805 MW) and flood control downstream (BC Hydro 2007). It extends from Donald, 39 km northwest of Golden, north, down the Columbia River and further north up the Canoe River to ~ 7 km south of Valemount. The reservoir is regulated by outflow at the Mica Dam near the Columbia River's 'Big Bend' (input is unregulated), and is licensed to operate between 707.41 m and 754.38 m (BC Hydro 2007). Additional storage may be attained (to an elevation of 754.68 m) with approval from the BC Comptroller of Water Rights.

KIN drawdown zone habitats have been described and mapped by another WLR project (CLBMON-10; Hawkes et al. 2010) and this work informed the design of the CLMBON-36 monitoring regime (i.e., site selection). The first five years of bird studies under CLBMON-36 documented nesting in 13 of the described habitat types (see Appendix 6-2), with annual nest density estimates ranging up to 2.35 nests per hectare (CBA 2013). The habitat with the greatest nest density (WS = Willow-Sedge wetland), had the highest diversity of nesting species (13 species), and a mapped area of ~35 ha within the KIN drawdown zone.

Bush Arm (BA) is located at the southern end of the reservoir (Figure 1-1), and is formed where the Bush River flows west into the Columbia from the Rocky Mountains. The study area is about 24 km long and extends from Bear Island to the Bush River. Like most of Kinbasket Reservoir, the drawdown habitats are largely barren. The drawdown zone is rocky in places, but much of the area is comprised of unvegetated silt; old tree stumps are a common feature (Figure 1-2). Sedge wetlands and some shrub habitat occur sporadically along the upper elevations of the drawdown zone, typically near upslope seepages or wetlands (Figure 1-3). Reed canarygrass (*Phalaris arundinacea*), common cattail (*Typha latifolia*) and willow (*Salix* spp.) are established at one location. Some areas include small, rich, remnant wetland habitat, vegetated with willow and skunk cabbage (*Lysichiton americanus*).

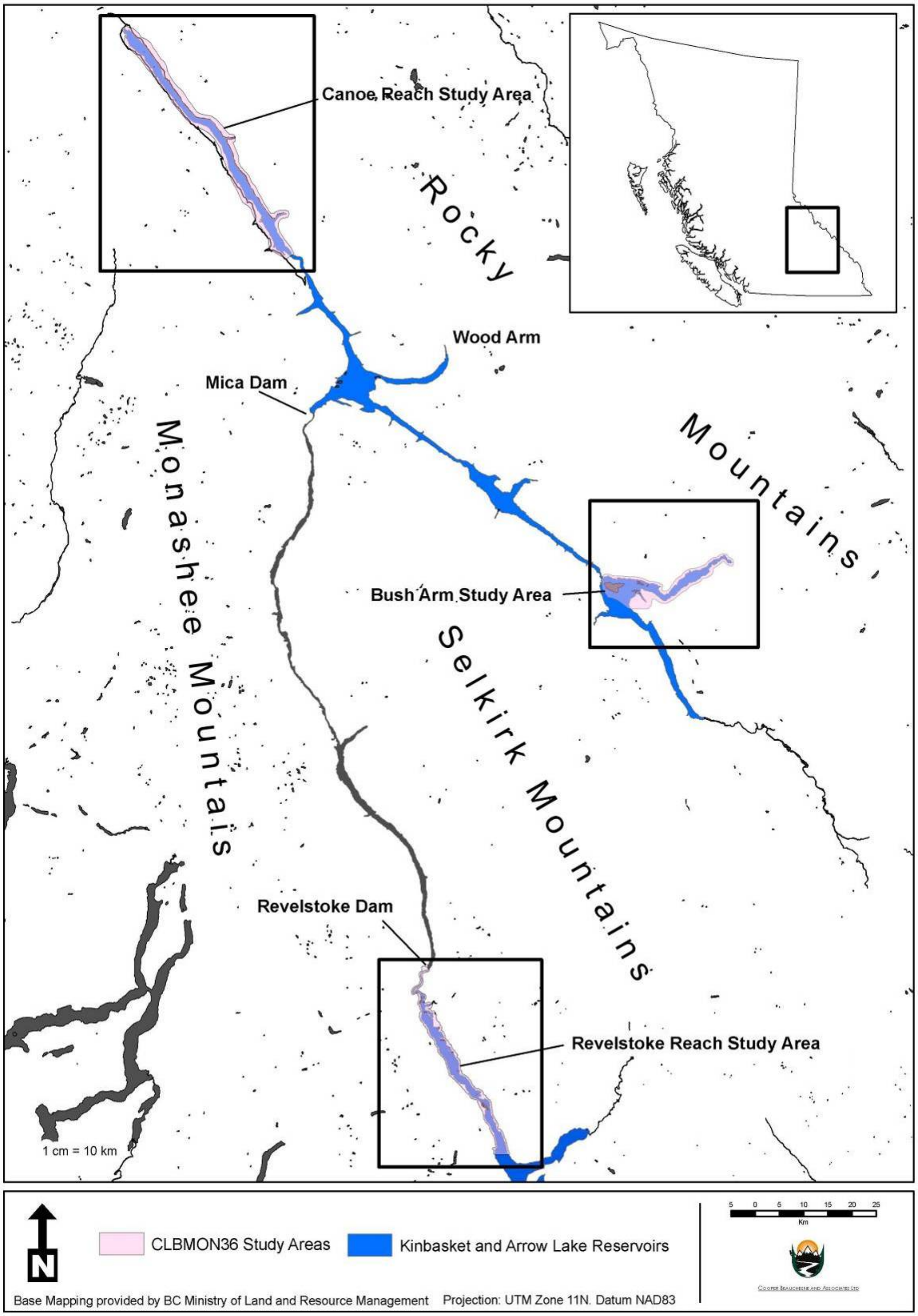

Figure 1-1: **Overview map of the three study areas (lakes are shown in black). Canoe Reach was not monitored in 2016**

BA occurs in the ICHmm (variant 1) biogeoclimatic subzone (Meidinger and Pojar 1991), and receives moderate precipitation, primarily from Pacific frontal systems that shed snow during the winter. As with Canoe Reach, the reservoir in Bush Arm is surrounded by steep slopes with managed coniferous forests.

Figure 1-2: Bush Arm drawdown zone is commonly unvegetated with stumps. This example of such habitat is classified as LL (Lady's Thumb–Lamb's Quarter)

Figure 1-3: At certain locations in Bush Arm drawdown zone where there is a source of ground water, a rich wetland vegetation community can exist. The unique drawdown zone habitat in this picture is classified as WS (Willow–Sedge Wetland)

1.4.2 Revelstoke Reach, Arrow Lakes Reservoir

The Hugh Keenleyside Dam is located approximately 8 km north of Castlegar. The completion of the dam in 1968 created the Arrow Lakes Reservoir, which extends approximately 240 km north to Revelstoke and has a licensed storage capacity of 7.1 MAF (BC Hydro 2007). The facility is capable of discharging 10,500 m^3/s (BC Hydro 2007) primarily through non-generating ports and spillways. Although the Hugh Keenleyside Dam was created primarily for flood control and water storage for downstream power generation in the U.S. (BC Hydro 2007), a 185-MW generating facility was added in 2002. The Arrow Lakes Reservoir is licensed to operate between 418.6 m and 440.1 m ASL. With approval from the Comptroller of Water Rights, the maximum allowable level is 440.75 m (BC Hydro 2007).

Situated between the Monashee and Selkirk Mountain Ranges, and directly below the Revelstoke Dam, RR forms the northernmost section of the Arrow Lakes Reservoir. From the Trans-Canada Highway, RR extends south for approximately 42 km (Figure 1-1). Habitats within the RR drawdown zone vary with topographic elevation. Grasses (e.g., *Phalaris arundinacea*), sedges (*Carex* spp.) and horsetails (*Equisetum* spp.) become well-established above 434 m ASL; willow (*Salix* spp.) and cottonwood (*Poplar balsamifera*) grow as low as 436 m ASL, but become well-established at 438 m (Figure 1-4), within a matrix of dense graminoid cover (Figure 1-4). Above 439 m, multi-storied mature cottonwood riparian forests have become established in some areas (e.g., Machete Island).

RR occurs in the ICHmm (variants 2 and 3) biogeoclimatic subzone (Meidinger and Pojar 1991), and receives heavy precipitation, primarily from Pacific frontal systems that shed snow during the winter. The drawdown zone is surrounded by steep slopes with managed coniferous forests.

Figure 1-4 Shrub savannah habitat in the drawdown zone of Revelstoke Reach (~438 m ASL). This habitat is often subjected to as much as 2 m of habitat flooding in the mid to late breeding season

1.5 Scope of work in 2016

This annual report presents data collected in Year 9 (2016). Similar to Years 6-8, a concentrated effort was made in Year 9 to conduct productivity and telemetry monitoring. In Year 9 we focused work on Savannah Sparrow (SAVS) in BA. Otherwise, field work continued with regular nest monitoring. On-going multi-year analysis projects continued in Year 9, but are not presented in this report[2].

2 METHODS

The methods followed those used in previous years (CBA 2016).

A large part of the field effort involved ‘Nest Mortality’ monitoring, which is a community-level nest monitoring program aimed at determining biogeographic distributions of communities, the causes of nest failure, and the overall productivity within the reservoir drawdown zones. To accomplish this, field technicians attempted to find and monitor all nests (less than 3 m above ground) at a selection of monitoring sites throughout the entire nesting season. Sites were chosen systematically to maximize spatial replication and stratification among habitat types identified in GIS maps.

In addition to the community-level Nest Mortality monitoring, we also focussed on finding and monitoring nests and the juvenile survival of several 'focal species'. The purpose of focal species monitoring was to examine factors influencing the survivorship of nests and of juveniles post-fledging. Field efforts attempted to generate larger sample sizes of nests for selected species for statistical purposes; there was reduced emphasis on finding every nest at a given site, and site boundaries were of less importance. Focal species monitoring was also conducted over multiple sites including some above the drawdown zone. In 2016, focal species monitoring centred on SAVS in CR, and YEWA in RR. Radio telemetry was implemented for SAVS in BA to monitor juvenile survival.

2.1 Site selection

Habitat categories for both reservoirs are described in Appendix 6-2. Maps of study sites are provided in Appendix 6-3 and Appendix 6-4.

Sites with high concentrations of focal species (SAVS and YEWA) were monitored annually, including 2016. In BA, two sites were monitored for SAVS juvenile survival study (Bush Arm Causeway, and km 87). In RR, colour-banded populations of YEWA were monitored at sites 21 (Drimmie Creek and 12 Mile Island), 28 (Machete Island) and 46 (Illecillewaet riparian shrub) in conjunction with SFU.

In RR, two unique sites were monitored at the community-level annually because they provided particularly important time series data. Site 39 (Montana Slough) contained the majority of the floating bog habitat. This habitat is unique, and becomes populated by breeding birds following their displacement by reservoir flooding elsewhere in the drawdown zone. Site 30 (at Airport Marsh) includes some of the best examples of water sedge, cattail and bulrush habitat, and includes the only colony of Yellow-headed Blackbirds in ALR. This site also provides nesting habitat for other regionally uncommon

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[2] Multi-year analyses will primarily take place during the winter following annual report submission for presentation in the Year 10 report

species such as Pied-billed Grebe, Virginia Rail, Sora, and Marsh Wren, and is known to be a site with particular relevance to the study of nest flooding impacts.

Site selection for community-level monitoring followed a systematic sampling design with new sites chosen annually. These sites were selected from each of the available habitat types. Site accessibility and habitat patch size/configuration were considered during site selection, but we did not have or use prior knowledge of the site's particular suitability for nesting when delineating the sites. Sites were monitored for at least one full breeding season. In KIN, we stratified the drawdown zone habitats by the vegetation communities identified by CLBMON 10 (Hawkes et al. 2010). In RR, we stratified the drawdown zone by vegetation communities identified by a habitat map developed by CBA (CBA 2012). Previously unknown private property access issues in BA prevented several of our key community monitoring sites from being monitored in 2016. This issue is resolved for 2017.

2.2 Field procedures

2.2.1 Nest searching

Sites were surveyed by walking slowly and systematically while looking for nests or signs of nesting activity. Birds exhibiting nesting behaviour (e.g., giving warning calls; carrying nest material, fecal sacs or food) were watched for clues of nest locations (Martin and Geupel 1993). In grassland habitats, rope dragging was used strategically to flush birds from nests, especially shortly prior to sites becoming submerged. Nest searching effort was adjusted based on the potential to find additional nests. For example, sites populated by numerous breeding adult birds but with relatively few known nest sites were prioritized for nest searching over sites where birds were not detected, or where all nests were known for most detected birds. Sites where no birds were detected were searched less frequently. In some cases (e.g., barren sites without any vegetation), nest searching required minimal effort due to lack of nesting habitat and lack of birds, but multiple visits to the site were made during the season. When active nests were located, sites were re-visited regularly for nest monitoring. In most cases, site visits included some additional nest searching but sometimes the sites were visited only for the purposes of taking nest observations.

2.2.2 Nest monitoring

Standard nest site data were collected at all nests (nest position, nest substrate, habitat, etc.). Active nests were monitored every three or four days until young fledged or the nest failed. Evidence of nest outcome was documented for each nest. A nest was considered to be successful if it fledged one or more young. Nest failure was categorized as being caused by nest predators or reservoir operations, or as failed for unknown reasons. Nest outcomes were designated as "unknown" if it was unclear whether the nest had been successful or had failed. Nests that had well-developed young late in the nestling phase were deemed to be successful if the last observation of the active nest was after the minimum number of days recorded for fledging by that species. Information about fledging periods was obtained from *The Birds of North America* species accounts (Poole 2010).

2.2.3 Focal species capture and monitoring

Targeted mist netting with call-playback was undertaken in areas with focal species. Mist nets were set up near territorial males, and an audio recording of the species' territorial song was played to lure the focal species into the nets. Once captured, birds were banded with a metal Canadian Wildlife Service (CWS) leg band inscribed with a unique number. Additionally, unique combinations of coloured plastic leg bands were applied to allow field biologists to identify and track these individual birds. Re-sighting colour banded birds assisted in mapping territories, monitoring juvenile survivorship and documenting local recruitment and dispersal.

To study juvenile survivorship of SAVS, we used radio-telemetry. Lotek PicoPip Aeg 317 (<0.45 g) telemetry transmitters were attached to one nestling per nest. Tagged birds were monitored daily using a Communications Specialists R-1000 receiver equipped with a three element Yagi antenna until ether the bird died, the transmitter battery expired, or the bird could no longer be found. Radio transmitters were attached with a fine elastic filament designed to drop off following expiry of the transmitter battery.

2.3 Data summary and analysis

Historic reservoir data includes all data from KIN (July 1, 1976 to present) and all data from ALR dating from completion of the Revelstoke Dam (January 1, 1985 to present).

All data manipulation, statistical computing and graphing was performed using R (R Core Team 2014). For Bayesian analyses, R was used to drive a separate program WinBUGS using the R2WinBUGS package (Lunn et al. 2000, Sturtz et al. 2005, Kéry 2010).

2.4 Permits

Bird handling and telemetry protocols were approved by the SFU Animal Care Committee (1038B-04). Banding was conducted under Federal Scientific Permits to Capture and Band Migratory Birds issued to John Cooper (#10663), Harry van Oort (#10663 F), and Catherine Craig (#10273 Al).

3 RESULTS

3.1 Year 8 summary

3.1.1 Reservoir operations

With the exception of 2015, the operations of KIN and ALR in 2016 differed greatly from previous years.

The KIN water elevation was ~ 733 m ASL in early May, above average historical levels. The surface elevation remained high until July when rate of filling slowed down, and the levels became more typical for the time of year (Figure 3-1).

The ALR water elevation was relatively high in early May (~ 434 m ASL) compared to historical levels. The water elevations increased during the spring with normal progression but reached maximum elevation very early, at just 437.2, on June 12 (Figure 3-1).

3.1.2 Other annual conditions

Relatively high rainfall was recorded at Revelstoke airport in May and July compared to the previous years of the project (Figure 3-2). Exceptionally warm temperatures were observed early in the summer followed by a prolonged period of cooler weather, and a warming trend late in the nesting season (Figure 3-3).

At RR, Airport Marsh and Machete Ponds had seemingly normal water levels in 2016. Notable observations in bird diversity in relation to previous years included the following:

- Several pairs of Tennessee Warbler nested in the region
- Several pairs of White-throated Sparrow appeared to be nesting near the mouth of the Illecillewaet River
- Brewer's Blackbird continued to have low abundance in the Revelstoke area compared with what was normal at the initiation of the project
- Savannah Sparrow were more abundant in the reservoir drawdown zone
- Western Meadowlark were present in relatively high numbers
- Cedar Waxwing was possibly less abundant than in previous years

In BA, the bird populations and conditions were comparable to the limited experience in previous years. Neither Cape May Warbler nor Yellow-bellied Flycatcher was observed in the area; both species had been detected nesting in previous years not far from the BA causeway.

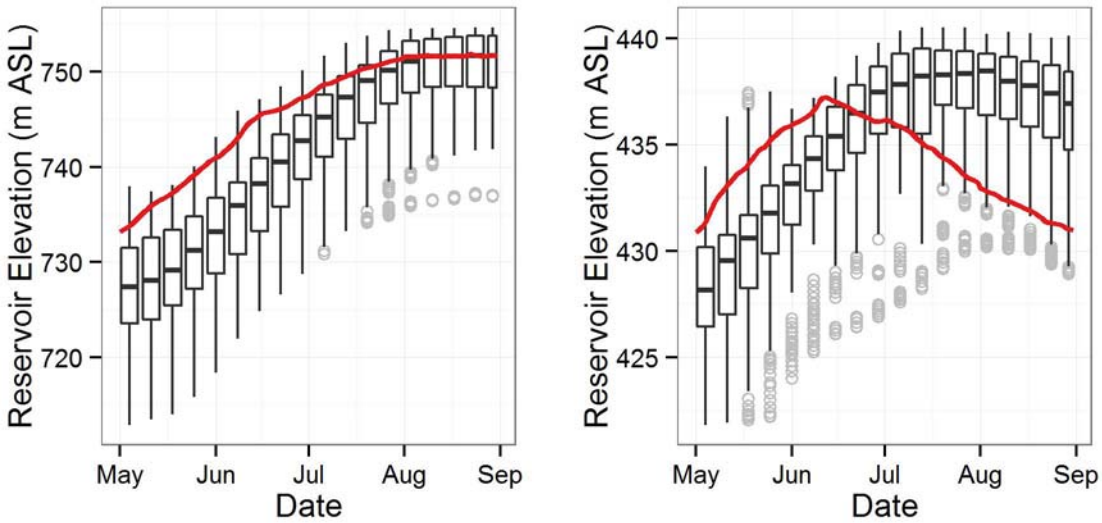

Figure 3-1: **Reservoir elevations at Kinbasket Reservoir (left) and Arrow Lakes Reservoir (right) plotted as weekly boxplots of historical data, with the 2016 elevations plotted in red. Note higher than normal levels at Kinbasket Reservoir and early transition to drafting phase at Arrow Lakes Reservoir in 2016**

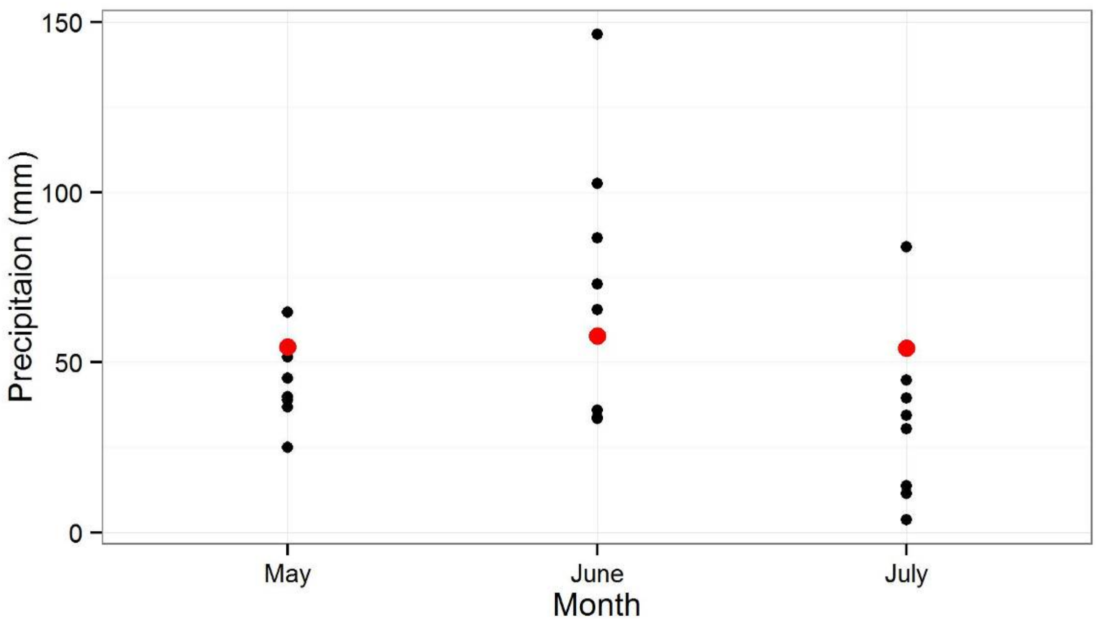

Figure 3-2: **Cumulative precipitation measured at the Revelstoke airport weather station during each year of CLBMON-36 monitoring**

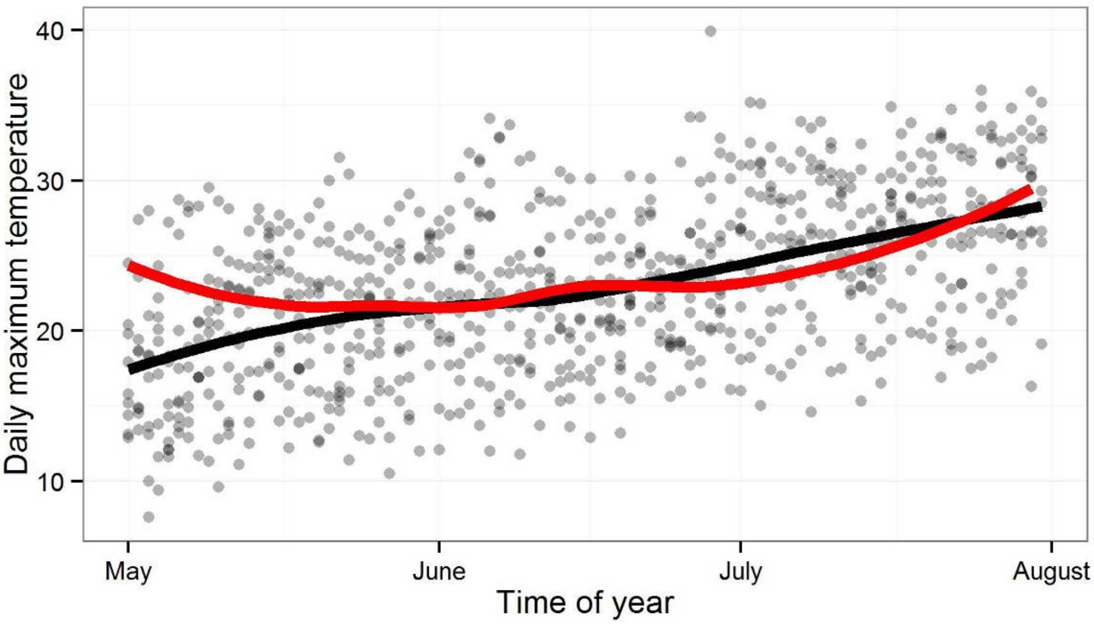

Figure 3-3: **Maximum daily temperatures measured at the Revelstoke airport weather station over the course of CLBMON-36 monitoring. The red smoother line represents maximum daily temperatures in 2016, and the black line represents typical maximum temperatures averaged over all years of the study**

3.1.3 Survey effort

In both study areas, crew schedules were coordinated so that surveys were conducted almost daily.

In BA, field sampling was conducted from May 27 to July 21. During this period, we monitored 13 community-level study sites. Additionally, focal species (SAVS) were monitored at another four areas. In total, there were 371 person-hours of survey effort in BA in 2016.

In RR, field sampling was conducted from April 1 to August 17. During this period, 18 community-level study sites were monitored. Focal species (YEWA) were monitored at three additional areas in RR. In total, there were 1238 hours of survey effort in RR in 2016.

3.1.4 Nest records

In 2016, 286 nests from 40 confirmed species[3] were located. Of these, 261 nests from 38 species were monitored until young fledged or the nest failed (Table 3-1).

In BA, 43 nests from 9 species were found which accounted for 15% of the nest records (Table 3-1); all nests located and monitored in BA were within the KIN drawdown zone.

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[3] The species for one teal nest was not confirmed.

In RR, 243 nests from 39 species were found, which accounted for 85% of the total nest records (Table 3-1). 238 (98%) of these nests (39 species) were located in the drawdown zone; the rest were located above the drawdown zone.

3.1.5 Bird Species at risk

Short-eared Owl (*Asio flammeus*) is designated as a species of 'Special Concern' in Schedule 1 of the federal *Species At Risk Act* (Wiggins 2008, Booms et al. 2014). Four nests of Short-eared Owl were located in Arrow Lakes Reservoir in 2016. Two of these nests, located in their primary breeding habitat were submerged by the rising water levels of the reservoir. The two other nests, both likely re-nesting attempts in secondary habitats, were unsuccessful due to predation. Common Nighthawk (*Chordeiles minor*), listed as 'Threatened' on Schedule 1, was occasionally observed roosting in the Arrow Lakes drawdown zone, but nesting was not suspected.

3.1.6 Nest monitoring results

Of the nests for which outcomes were determined (234 nests, 90% of all monitored nests), 116 (50%) were successful. Of the 118 documented nest failures (50% of nest outcomes), 80 (68%) failed due to predation and 11 (9%) failed due to reservoir inundation. The cause of failure for the remaining (non-flooded) 27 nests (23%) was uncertain.

Within the drawdown zones, nest success rate was highest in BA (59%); RR nests had a lower success rate (49%). At BA, 19% of all monitored nests with known outcomes failed due to reservoir operations; 3% of nests were submerged by reservoir operations at RR.

Table 3-1: Bird species and number of nests found in CR (Kinbasket Reservoir), and in Revelstoke Reach (Arrow Lakes Reservoir)

		Above Drawdown Zone		Within Drawdown Zone	
Common Name	Scientific Name	Bush Arm	Revelstoke Reach	Bush Arm	Revelstoke Reach
Pied-billed Grebe	*Podilymbus podiceps*	0	0	0	4
Canada Goose	*Branta canadensis*	0	0	0	12
American Wigeon	*Anas americana*	0	0	0	5
Mallard	*Anas platyrhynchos*	0	0	0	10
Blue-winged Teal	*Anas discors*	0	0	0	1
Cinnamon Teal	*Anas cyanoptera*	0	0	0	1
Northern Shoveler	*Anas clypeata*	0	0	0	1
Unidentified Teal	*Anas sp.*	0	1	0	0
Northern Harrier	*Circus cyaneus*	0	1	0	1
Virginia Rail	*Rallus limicola*	0	0	0	9
Sora	*Porzana carolina*	0	0	0	5
Killdeer	*Charadrius vociferus*	0	0	1	2
Spotted Sandpiper	*Actitis macularius*	0	0	5	9
Wilson's Snipe	*Gallinago delicata*	0	0	1	10
Long-eared Owl	*Asio otus*	0	0	0	1
Short-eared Owl	*Asio flammeus*	0	1	0	4
Western Wood-Pewee	*Contopus sordidulus*	0	0	0	1
Willow Flycatcher	*Empidonax traillii*	0	0	2	13
Least Flycatcher	*Empidonax minimus*	0	0	0	2
Dusky Flycatcher	*Empidonax oberholseri*	0	0	0	1
Eastern Kingbird	*Tyrannus tyrannus*	0	0	0	4
Red-eyed Vireo	*Vireo olivaceus*	0	0	0	2
Marsh Wren	*Cistothorus palustris*	0	0	0	4
Veery	*Catharus fuscescens*	0	0	0	2
American Robin	*Turdus migratorius*	0	0	0	1

Table 3.1 Continued		Above Drawdown Zone		Within Drawdown Zone	
Common Name	Scientific Name	Bush Arm	Revelstoke Reach	Bush Arm	Revelstoke Reach
Gray Catbird	*Dumetella carolinensis*	0	0	0	6
Cedar Waxwing	*Bombycilla cedrorum*	0	0	0	20
Tennessee Warbler	*Leiothlypis peregrina*	0	0	0	2
Yellow Warbler	*Dendroica petechia*	0	2	1	42
Audubon's Warbler	*Setophaga coronata*	0	0	0	1
American Redstart	*Setophaga ruticilla*	0	0	0	7
Common Yellowthroat	*Geothlypis trichas*	0	0	0	8
Chipping Sparrow	*Spizella passerina*	0	0	0	2
Clay-colored Sparrow	*Spizella pallida*	0	0	1	0
Savannah Sparrow	*Passerculus sandwichensis*	0	0	22	14
Song Sparrow	*Melospiza melodia*	0	0	2	11
Lincoln's Sparrow	*Melospiza lincolnii*	0	0	8	7
Red-winged Blackbird	*Agelaius phoeniceus*	0	0	0	1
Western Meadowlark	*Sturnella neglecta*	0	0	0	3
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	0	0	0	8
Unidentified songbird	*Unidentified songbird*	0	0	0	1

3.1.7 Nest submersion in 2016

Reservoir operations flooded 12 monitored nests from seven species (Appendix 6-5). All flooded nests in 2016 were built directly on the ground. Half (6) of these nests were flooded by the operations of the ALR, including two Short-eared Owl nests; the other 6 nests were in the KIN drawdown zone.

3.1.8 Juvenile survival

At BA, 13 nestling SAVS were tagged in the KIN drawdown zone for juvenile survival study. In general, survivorship of tagged juveniles was low in 2016 at BA, with only three surviving the observation period. Ignoring 4 failed tags, 33% of the successfully tagged young survived. Causes of death did not include reservoir flooding, although one of the young that we were unable to track was clearly exposed to inundation, possibly even evicted from the nest by the water. One tagged juvenile was eaten by a snake, another likely succumbed to parasites, and two died of exposure to poor weather. One tagged young died prior to fledging and appeared to have been pecked and removed by its parents.

3.2 Multi-year progress

3.2.1 Community-level monitoring

In 2016, 20.5 ha of mapped habitat was monitored at KIN and 28.1 ha of mapped habitat was monitored in ALR (Table 3-2 and Table 3-3). At KIN, monitoring sites with DR, MA, BR, and TP habitats improved representation across the vegetation communities (Table 3-2). At ALR, field efforts improved monitoring coverage of several habitats that had previously low levels of monitoring (e.g., BF, BR, BS, RB, SW and WS) in addition to also expanding monitoring effort over the most common habitat classes.

Table 3-2: Habitats monitored in Kinbasket Reservoir (CR and BA) from 2008 through 2016

Code	Vegetation Community	Total Area[1]	Monitored Area[2]	Effective 2015[3]	Effective 2016[3]
BR	Bluejoint Reedgrass	41.6	15.3	14.5	15.3
BS	Buckbean–Slender Sedge	12.0	8.4	8.4	8.4
CH	Common Horsetail	287.6	62.5	69.8	70.7
CO	Clover–Oxeye Daisy	136.5	35.4	84.6	84.6
CT	Cottonwood – Trifolium	20.3	4.8	6.4	6.7
DR	Driftwood	36.9	18.0	22.8	23.1
FO	Forest	159.6	2.4	2.6	2.6
KS	Kellogg's Sedge	210.7	43.1	81.6	86.4
LH	Lodgepole Pine–Annual Hawksbeard	0.5	0.5	0.5	0.5
LL	Lady's Thumb–Lamb's Quarter	1299.7	48.9	89.2	91.5
MA	Marsh Cudweed–Annual Hairgrass	140.3	11.7	10.3	11.7
RC	Reed Canarygrass	31.5	12.3	12.1	12.3
RD	Common Reed	0.6	0.6	1.2	1.2
SH	Swamp Horsetails	52.4	37.7	98.5	100.2
TP	Toad Rush–Pond Water-starwort	310.0	109.8	112.4	118.5
WB	Wool-grass–Pennsylvania Buttercup	128.9	58.1	122.7	124.5
WD	Wood Debris	70.0	27.7	27.7	27.7
WS	Willow–Sedge wetland	34.5	12.2	50.8	50.8

1. 'Total Area' is the sum of mapping for each habitat type within the reservoir.
2. 'Monitored Area' indicates the sum of the mapped area that has been monitored (2008 – present).
3. Some sites have been monitored more than one time. Considering sites that have been repeatedly monitored over time, the effective monitored area increases, which is summarized for the present year and the previous year.

Table 3-3: Habitats monitored in Arrow Lakes Reservoir (Revelstoke Reach) from 2008 through 2016

Code	Category	Total Area[1]	Monitored Area[2]	Effective 2014[3]	Effective 2015[3]
BE	Steep bedrock	5.8	0.0	0.0	0.0
BF	Floating bog	2.6	2.5	17.0	19.4
BR	Bullrush	12.7	7.0	55.0	61.9
BS	Submerged bouyant bog	4.2	4.2	18.1	20.0
CK	Creek	25.1	6.8	6.8	6.8
CT	Cattail	4.3	3.5	7.2	7.8
CW	Shrub wetland complex	12.2	7.5	7.5	7.5
EG	Equisetum grassland	56.6	17.9	17.9	17.9
GR	Gravel	193.5	5.4	5.4	5.4
LD	Low elevation draw	189.0	43.7	63.6	63.6
MG	Mixed grassland	1019.3	85.5	134.6	139.7
PG	Sparse grassland	372.4	43.4	44.9	45.5
PO	Pond	127.5	44.0	70.9	71.3
RB	Rocky bank	57.6	5.6	7.0	7.5
RC	Reed canarygrass	109.9	38.8	50.9	50.9
RF	Riparian Forest	77.1	32.3	59.4	60.4
SA	Sand	474.1	24.0	24.1	24.1
SB	Sand bank	10.4	2.5	3.4	3.4
SG	Sedge grassland	364.1	72.3	93.3	93.3
SH	Shrub savannah	323.5	84.8	109.7	116.5
SI	Silt	710.1	10.3	10.3	10.3
SR	Riparian shrub	25.8	8.7	12.9	13.4
SW	Swamp	1.2	2.4	2.1	2.4
TH	Thalweg	2068.6	1.3	1.2	1.3
UC	Upland conifer	43.1	0.5	0.6	0.6
UM	Upland mixed	109.8	5.8	10.5	10.5
UR	Urban	1.2	0.0	0.0	0.0
WM	Wet meadow	25.8	8.4	13.5	13.5
WS	Water Sedge	26.0	5.7	12.0	13.3

1. 'Total Area' is the sum of mapping for each habitat type within the reservoir.
2. 'Monitored Area' indicates the sum of the mapped area that has been monitored (2008 – present).
3. Some sites have been monitored more than one time. Considering sites that have been repeatedly monitored over time, the effective monitored area increases, which is summarized for the present year and the previous year.

3.2.2 Nesting species detections

A complete list of the number of nests for each species found nesting in the reservoir drawdown zones over the course of this study is provided in Appendix 6-6. In 2016, no new species were detected nesting in the KIN drawdown zone (cumulative count = 30 spp.). Four species found nesting in the ALR drawdown zone had not previously been recorded (Blue-winged Teal, Northern Shoveler, Tennessee Warbler and Yellow-rumped Warbler), bringing the total number of nesting species during this study to 65 (Figure 3-4).

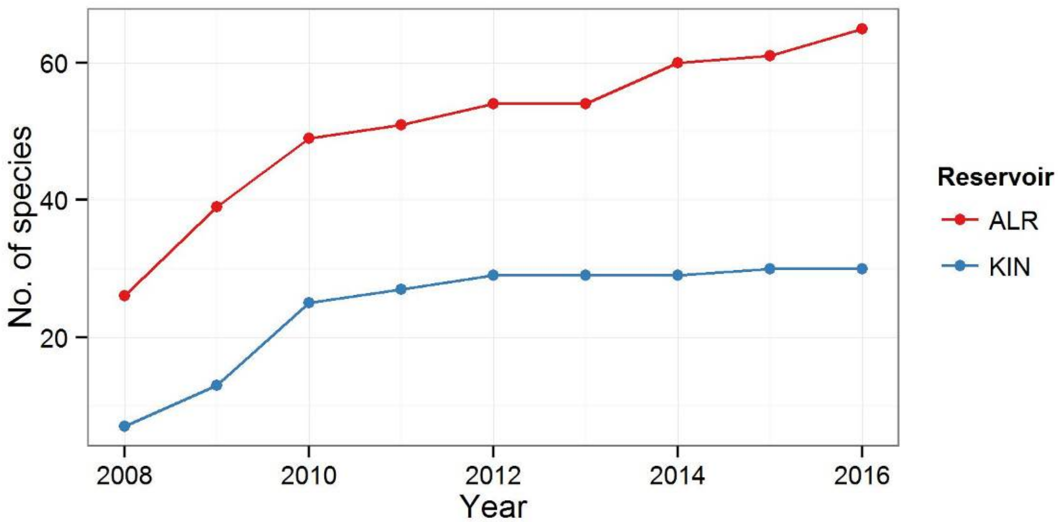

Figure 3-4: Cumulative count of species detected nesting in the drawdown zones of the Arrow Lakes Reservoir (ALR) and the Kinbasket Reservoir (KIN)

3.2.3 Nest submersion

Since 2008, there have been 188 nests (of 36 species) observed to have failed as a direct consequence of reservoir operations (Table 3-4); 22 nests (8 species) in KIN, and 166 nests (32 species) in ALR. At KIN, nest inundation was observed in 2010, 2011, 2012, 2013, 2015, and 2016. At ALR, nest inundation was observed in each year of the study except 2015. Of note, we observed more nests flooded by KIN in 2016 than in any of the previous years (Figure 3-5).

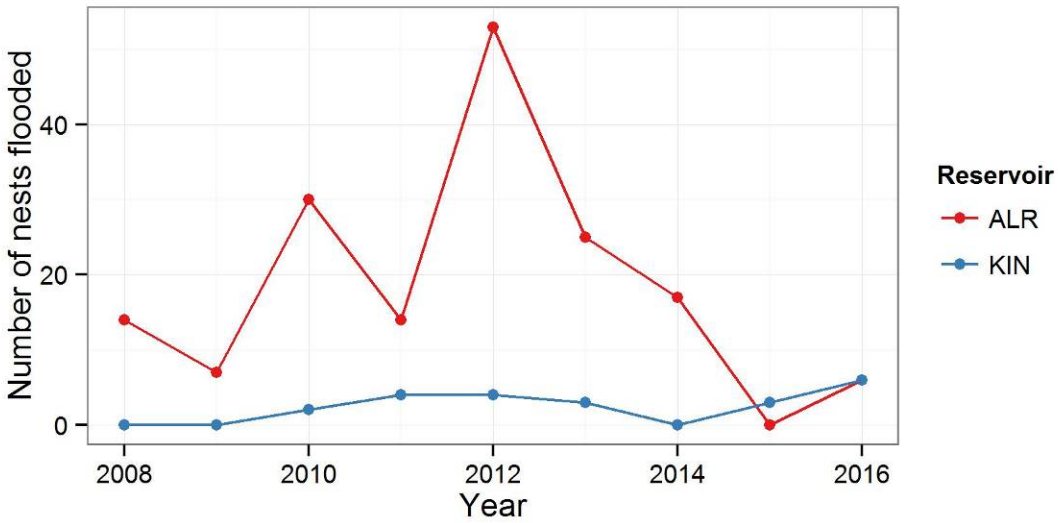

Figure 3-5: **Annual number of observations of nest flooding at Kinbasket (KIN) and Arrow Lakes Reservoir (ALR) during the study**

Table 3-4: Observations of nest submersion since 2008 by species in Kinbasket (KIN) and Arrow Lakes (ALR) Reservoirs

Type of Nest	Common Name	ALR	KIN
Ground	Common Loon	2	0
	American Wigeon	6	0
	Mallard	9	0
	Green-winged Teal	3	0
	Northern Harrier	1	0
	Killdeer	4	1
	American Avocet	1	0
	Spotted Sandpiper	4	5
	Wilson's Snipe	3	0
	Wilson's Phalarope	1	0
	Long-eared Owl	1	0
	Short-eared Owl	3	0
	Savannah Sparrow	7	11
	Lincoln's Sparrow	0	1
Low shrub or emergent vegetation	Pied-billed Grebe	2	0
	Virginia Rail	5	0
	Sora	2	0
	Marsh Wren	1	0
	Veery	2	0
	MacGillivray's Warbler	1	0
	Common Yellowthroat	15	1
	Chipping Sparrow	6	0
	Clay-colored Sparrow	2	0
	Song Sparrow	4	0
	Red-winged Blackbird	9	0
	Yellow-headed Blackbird	15	0
Shrub	Traill's Flycatcher	2	0
	Willow Flycatcher	15	1
	Dusky Flycatcher	1	0
	Eastern Kingbird	1	0
	Unidentified Flycatcher	2	0
	Gray Catbird	8	0
	Cedar Waxwing	7	0
	Yellow Warbler	20	0
Canopy	American Robin	0	1
	American Redstart	1	0
Cavity	Mountain Bluebird	0	1

4 DISCUSSION

CLBMON-36 is a 10-year project addressing knowledge gaps related to the management of reservoirs (their drawdown zone habitats, and their operations) to enhance avian productivity and minimize incidental destruction of nests caused by reservoir operations. This report summarizes progress made in the CLBMON-36 project in 2016, the 9th year of research. Below, we briefly review progress and observations made in 2016, and cumulative multi-year progress since 2008.

4.1 Year 9 (2016)

The ninth and penultimate year of CLBMON-36, 2016, had similar atypical reservoir operations at KIN and ALR as in the previous year, and the summer was relatively cool and rainy following a remarkably warm spring.

Being positioned near the head of the Columbia River and having a huge capacity for storage, the KIN water level traditionally reaches its annual maximum later in the year compared with the ALR and likely most other reservoirs in the Columbia basin. The typically delayed timing of the KIN hydrograph allows birds to nest in the upper part of its drawdown zone with low probability of nest flooding; nesting habitat becomes fully inundated, but this usually occurs after the nesting season has concluded. In both 2015 and 2016, KIN was operated to fill unusually early compared with previous years, which should have increased nest flooding potential. Indeed, the nest flooding impact observed in 2015 and 2016 were among the greatest observed during the nine years of CLBMON-36 monitoring. Compared with 2015 and 2016, the operation of KIN likely flooded more nests in 2012, but we were unable to make field observations for the entire 2012 season due to access issues at the Bush Arm study area.

In both 2015 and 2016, the early filling of KIN was coupled with relatively low water storage regimes at the ALR. The contrast with KIN was also seen in conditions during the winter, where ALR was drafted to relatively low levels compared with previous years (at least during this study), whereas KIN retained more water during winter. In the summer of 2016, ALR's peak elevation was low, at 437.2 m asl, similar to 2009, and ~ 2 m higher than the peak elevation in 2015. While no nests were observed to flood in 2015, the slightly higher water levels in 2016 resulted in some nest flooding, similar to what we observed 2009 – low compared with most other years. As we observed in 2009, nest flooding in 2016 was an issue for ground-nesting birds, not birds nesting in shrubs. At ALR we have observed a high variability in annual maximum water elevation during the study, which in reference to nest flooding is probably the single most important aspect of the ALR operation.

There were some unique aspects to the 2016 field season in regards to the birds that were nesting in the ALR. Chiefly, both Tennessee Warblers and White-throated Sparrow were present in the ALR drawdown zone. The former species was nesting in our study plots and two nests were located. White-throated Sparrows appeared to be breeding in the Illecillewaet riparian habitat, but no nests were located as that habitat was outside our study plots. Why these two boreal species settled in Revelstoke during the 2016 breeding season is a mystery. One hypothesis is that the spring forest fires in the boreal forest to the north (e.g., Fort MacMurray, Fort St. John) caused some migrants to backtrack south past the southern edge of their typical breeding range where vacant habitat could be found. There were also two pairs of Short-eared Owl nesting in the ALR drawdown zone in 2016, something that has not been observed since 2010. Like 2010, 2016 came after a low water year, providing extended period where conditions were conducive for vole population growth. These birds settled and started nesting unusually late compared with normal.

4.2 Multi-year progress and data gaps

4.2.1 Biogeography

As recommended in Year 8, we focussed on monitoring at Bush Arm (rather than at CR) in Year 9, where there were better options for improving representation among habitat types in our dataset. We were successful in monitoring at sites containing the target vegetation communities, but site selection was considerably hampered by access issues that we encountered. Most notably, access to the Bear Island/Surprise Rapids area at the mouth of Bush Arm was impacted due to new private property access limitations above the drawdown zone. During the field season, a new access route on public lands was found while conducting focal species work; this should enhance our ability to capitalize on Bush Arm habitat monitoring in 2017.

4.2.2 Species detection

With the high diversity and complexity of potential nesting habitat in the Revelstoke Reach drawdown zone, many species could nest there. During the course of CLBMON-36, we have progressively detected new species nesting in the ALR drawdown zone. In the first two years of the study, we had sufficient knowledge of the common species and their habitat distributions, but in the years following, monitoring has allowed us to confirm nesting of less common species throughout the RR drawdown zone.

With the detection of four new species in 2016, we have now detected 65 species nesting at the ALR (Revelstoke Reach) drawdown zone. As mentioned above, the discovery of Tennessee Warblers nesting is a regionally significant anomaly. However, the other three new additions to the species list (Blue-winged Teal, Northern Shoveller, and Yellow-rumped Warbler) were species that we have long suspected to be nesting in low densities in the ALR drawdown zone.

There are three species of cavity-nesting ducks that we have observed with broods: Common Merganser (*Mergus merganser*), Hooded Merganser (*Lophodytes cucullatus*), and Wood Duck (*Aix sponsa*), which could potentially be added to the CLBMON-36 drawdown zone species list. There is a historic record of a Wood Duck nest at Machete Island and broods are observed most years. Common Merganser likely breed above the drawdown zone frequently but could potentially nest at Machete Island. No young broods of Hooded Merganser have been observed, and the only evidence of breeding was from older broods (juveniles) that were mobile and may have bred elsewhere; nonetheless, we see no reason why Hooded Merganser might not occasionally breed at Machete Island.

Two woodpecker species that we have not detected nesting in the ALR include Red-naped Sapsucker (*Sphyrapicus nuchalis*) and Hairy Woodpecker (*Picoides villosus*); both would find excellent nest-building habitat at Machete Island, but the low abundance of coniferous trees may give this habitat low foraging suitability for these species. Other species that could potentially be recorded in the future include American Coot (*Fulica americana*), Northern Pintail (*Anas acuta*), Gadwall (*Anas strepera*), Western Kingbird (*Tyrannus verticalis*) and Barn Swallow (*Hirundo rustica*). The latter species was suspected of nesting at Drimmie Creek in previous years. Regardless, the community of species that nest regularly in the Revelstoke Reach drawdown zone (e.g., in sizeable populations) has been well documented.

From a habitat perspective, nesting opportunities are limited in the KIN drawdown zone due to the reduced complexity in the vegetation communities. As such, it is not surprising that we detected most of this greatly reduced nesting community early in the CLBMON-36 study, and the list of nesting species has been stable (e.g., completed) during most of the late part of the study. In KIN, we did not detect any new species nesting in the reservoir drawdown zone in 2016.

At this point in the study, the cumulative count of breeding species detected in the KIN and ALR drawdown zones will only increase by locating rarities. The general breeding bird communities have been well-documented and MQ-A has already been adequately addressed (Appendix 6-1).

4.2.3 Nest submersion

Similar to Year 8, Year 9 was marked by higher than normal nest flooding in KIN, and lower than normal nest flooding in ALR. Although we witnessed relatively high nest flooding impacts in KIN in 2016, the impact is still relatively low (compared with ALR) and productivity continued to be reasonably high in the KIN drawdown zone.

To date, we have observed that nest flooding is a factor affecting productivity for 36 species of birds, mostly in the ALR. As we have noted previously, nest submersion is something that needs to be considered at the species level to appreciate the significance of the impact. Qualitatively, our impression at the ALR is that species that nest in low elevation habitats in the reservoir drawdown zone (e.g., Savannah Sparrow, Western Meadowlark, Short-eared Owl), and those nesting directly on the ground (e.g., dabbling ducks and shorebirds), have higher chances of nest submersion, and are uncommon. We hypothesize that these populations are limited by reservoir operations, and would increase if nest flooding was not an issue. We have previously shown that nest flooding is also an important issue for species nesting in emergent vegetation (e.g., rails, grebes, blackbirds (CBA 2013, 2015). Species nesting in shrubs commonly suffer from nest flooding in the ALR, but this impact is compensated for to some degree by reduced nest predation for nests positioned over water (van Oort et al. 2015).

4.2.4 Focal species

In 2016, focal species research included Yellow Warbler monitoring in Revelstoke Reach and Savannah Sparrow monitoring in Bush Arm. The Yellow Warbler (general productivity) research is being conducted by Michal Pavlik and Dr. David Green (both at Simon Fraser University). The latter research focussed on the question of whether juvenile survival in the reservoir drawdown zone differs from survival rates in other habitats (i.e., above drawdown zone). At Bush Arm, we were able to find Savannah Sparrow nests within the drawdown zone primarily at two sites. The first site was in the drawdown zone by the Bush River causeway. Nesting habitat was located on both sides of the causeway and on both sides of the Bush River. In 2016, we maximized our effort at the causeway site, likely finding the majority of the nests in this area. The second site was near Bear Island, where our monitoring effort was less complete. Monitoring of Savannah Sparrows at Bear Island was impeded by poor access issues during the start of the nesting season, as noted above. Consequently, monitoring at the Bear Island area was delayed, and the site was not monitored to the full extent possible. In 2017, we expect that we will be able to increase the sample size of tagged Savannah Sparrows with improved knowledge of their nesting distribution, and of access to the sites. In addition to the above sites, we attempted to monitor Savannah Sparrows at Succour

Creek, however the density of nests at this site was very low, and the driving time high, so this site was not a practical option for the focal species work.

4.2.5 Adequacy of data to meet objectives, and test hypotheses

By the end of the 2017 field season, it is our view that CLBMON-36 will have generated adequate data to meet the objectives and address the Management Questions of this study (See Appendix 1).

The first objective of this project was to identify how the drawdown zone habitats are used by breeding birds. Both management questions relating to this objective have been well addressed with the data already collected. With the tenth and final year of the study, we may still discover other uncommon nesting birds, but the normal community of breeding birds, their seasonal abundance, and their habitat preferences are already well documented. By conducting the study over 10 years, annual variation will also be documented reasonably well.

The second objective of the study was to evaluate how reservoir operations influence nest survival. There is no doubt that reservoir operations are impacting survival of ground-nesting birds, and knowledge of their distribution and timing can be used to model the impact of reservoir operations directly. Careful thought needs to be given as how to best empirically test H1 for ground-nesting species (what is the control group?), but logically, it seems fair to assume that H1 must be rejected given that the negative impact must be additive to other sources of nest mortality. For shrub-nesting species, there is ample evidence that nests are flooded by reservoir operations, but we have already shown that this impact can not be interpreted in isolation of other impacts. For two common shrub-nesting species (Yellow Warbler and Willow Flycatcher), we found that nest survival was not impacted by habitat flooding (reservoir operations), because nest predation was reduced in flooded habitats, compensating for the increased risk of nest flooding (van Oort et al. 2015); as such, H1 was not rejected for shrub-nesting species in the analysis performed to date (note that this applies to nesting, not juvenile survival – so this should not be interpreted to imply that reservoir operations have no impact on overall productivity of these shrub nesting birds). Additional analysis work could potentially examine other shrub-nesting species, including impacts to those that nest very low in shrubs (e.g., Common Yellowthroats, Chipping Sparrow) or those that nest much higher (e.g., Cedar Waxwing). A more pressing analysis, however, would be to examine how habitat flooding impacts nests of birds in wetlands (e.g., at the Airport Marsh), where nesting over water already benefits these species by low nest predation rates. There are adequate data to test H1A, which contrasts survival below and above the drawdown zone, using Savannah Sparrow nest records at KIN (possibly for ALR), and Cedar Waxwing nest records at ALR. There is ample scope in the data to test H1C regarding nest survival as a function of nest elevation (e.g., in reference to full pool elevation) and to test H1D regarding probability of nest flooding as a function of nest elevation. We conclude that there is already a strong dataset for addressing all hypotheses and management questions of the second objective of the study (Appendix 1).

The third objective was to evaluate how the operations influence juvenile survival. Both hypotheses can be tested using radio-telemetry data which was collected following the Year 5 interim report. Yellow Warbler data was collected to test H2, regarding impact of reservoir operations on juvenile survival, and is currently being incorporated as a chapter of a Masters' thesis, and is being written up as a journal manuscript. This research rejected H2, as it indicated that survival was negatively impacted by habitat flooding (Dr.

D.J. Green *personal communication*). H2A, regarding differences above and below the drawdown zone will be addressed with the radiotelemetry data on juvenile Savannah Sparrow in the KIN drawdown zone. To date, this is the larger dataset on juvenile survival (site level replication was prioritized in this case), and we are confident that the data will be adequate to test this hypothesis (Appendix 1).

The final two objectives have already been met. The objective to build a nest flooding model for KIN and ALR was met in the Year 5 Interim report. The objective to assess how the drawdown zone habitats can be managed to increase productivity was addressed with a previous analysis looking at the benefit accrued by a potential Wildlife Physical Works project (CBA 2015). It was shown that if embankments and water control structures could isolate the Airport Marsh from the ALR drawdown zone, there would be a positive impact on productivity of the reservoir drawdown zone, for regionally significant breeding populations.

Currently, we see no major data gaps impeding the success of CLBMON-36.

4.3 Recommendations for the Year 10 work plan, and future analyses

- Site selection for the 2017 (Year 10) season should review and be informed by section 3.2.1, Table 3-2, and Table 3-3, and attempt to further fill knowledge gaps. Maintaining field operations in Bush Arm (rather than CR) would likely offer enhanced ability to fill knowledge gaps in KIN.
- Continued telemetry research on SAVS should occur at new sites.
- If possible, Cedar Waxwing nests at should be monitored at new sites outside of the ALR drawdown zone to enhance spatial replication to address H1A.
- Resources should continue to be allocated toward data analysis in the final years of the 10-year CLBMON-36 project.

5 ADDITIONAL REPORTING REQUIREMENTS

5.1 Banded birds

Birds were banded in accordance with national permit regulations. Only focal species were targeted, although incidental captures of a few non-focal species did occur, so these birds were also banded. All data were entered into Bandit 2.01 software and submitted to the Bird Banding Office of the Canadian Wildlife Service. No mortalities or injuries occurred.

5.2 Provincially- and SARA-listed species

Short-eared Owl (*Asio flammeus*) is designated as a species of ‘Special Concern’ in Schedule 1 of the federal *Species At Risk Act* (S.A.R.A.; Wiggins 2008, Booms et al. 2014). Four nests of Short-eared Owl were located in the Arrow Lakes Reservoir drawdown zone in 2016; none of these were on federally controlled land where S.A.R.A. prohibitions apply. Two nests were submerged by the rising water levels of the reservoir. The two other nests, both likely re-nesting attempts in secondary habitats, were unsuccessful due to predation.

Common Nighthawk (*Chordeiles minor*), listed as ‘Threatened’ on Schedule 1, was occasionally observed roosting in the Arrow Lakes drawdown zone, but nesting was not suspected or confirmed.

5.3 Species with provincial jurisdiction

All nest records were reported to the Ministry of Environment following the Wildlife Species Inventory standards.

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Appendix 6-1: Status of management objectives, questions and hypotheses

STATUS OF OBJECTIVES, MANAGEMENT QUESTIONS AND HYPOTHESES

OBJECTIVES	MANAGEMENT QUESTIONS	HYPOTHESES	YEAR 9 STATUS AND SUMMARY
Identify how drawdown zone habitats are used by breeding birds in Kinbasket Reservoir and Revelstoke Reach.	A. Which bird species breed in the drawdown zones and how are they distributed among the drawdown zone habitat classes? B. What are the seasonal patterns of habitat use by birds nesting in the drawdown zones?		• These MQ's have been addressed adequately. Additional rare or uncommon species will undoubtedly be observed with additional work, but we believe that the regular nesting species are well documented • Additional monitoring will improve knowledge of (1) birds nesting in uncommon habitat types, and (2) uncommon birds within habitat types, in addition to improving precision of density estimates. • Densities do appear to vary among years, so there is a benefit to monitoring for an extended period of time • Additional work can be done to summarize the data in new ways (e.g., elevational profiles for each species) • Additional information on seasonal patterns will be beneficial for uncommon species
Evaluate how the operations of the Kinbasket and Arrow Lakes Reservoirs influence nest survival.	C. Do reservoir operations affect nest survival? D. What are the causes of nest failure in the drawdown zone, and how do they differ among species, among habitat classes, and across elevation (i.e., position in drawdown zone)?	H1: Inundation of nesting habitat caused by reservoir operations does not affect nest survivorship. H1A: Nest survivorship in the drawdown zone is not different from nest survivorship above the drawdown zone. H1C: Nest survivorship does not differ across elevations in the drawdown zone. H1D: Rates of nest flooding do not differ across elevations in the drawdown zone.	• H1 has been addressed with a final analysis for shrub nesting species (van Oort et al. 2015) • H1A was addressed in the Interim report, but models need to be re-assessed and fit with new data. • H1C Analysis underway for winter 2016/17 • H1D Analysis underway for winter 2016/17
Evaluate how the operations of the Kinbasket and Arrow Lakes Reservoirs influence juvenile survival.	G. Do reservoir operations affect juvenile survival when water levels inundate post-fledging habitat?	H2: Inundation of post-fledging habitat does not affect juvenile survival. H2A: Juvenile survival in the drawdown zone does not differ from juvenile survival above the drawdown zone.	• All data to address H2 for YEWA are now collected, and final analyses and write-up are underway. • Data to address H2 for SAVS are still being collected (success of gaining adequate data will depend on reservoir operations). • Data to address H2A for SAVS are still being collected, and this component study is progressing well.
Establish a nest flooding risk model for Kinbasket Reservoir and Revelstoke Reach.	H. How can the operations of the Kinbasket and Arrow Reservoirs be optimized to reduce nest submersions and/or improve avian productivity?		• Models have been created and presented previously – these can be updated for Year 10
Assess how habitat management in the drawdown zones can be used to increase productivity, or reduce negative impacts of reservoir operations.	K. Can drawdown zone habitats be managed to improve nest survival and/or site productivity? If so, how?		• One well-supported suggestion for a physical works project has been delivered • The productivity and propensity of drawdown zone shrubs to function as ecological traps is still being assessed (see H1A-D). • Improving nesting habitat in the upper KIN drawdown zone would be ecologically valuable, given the low nest flooding impact of its operation

Appendix 6-2: Habitat classes / vegetation communities used in Kinbasket Reservoir and Revelstoke Reach

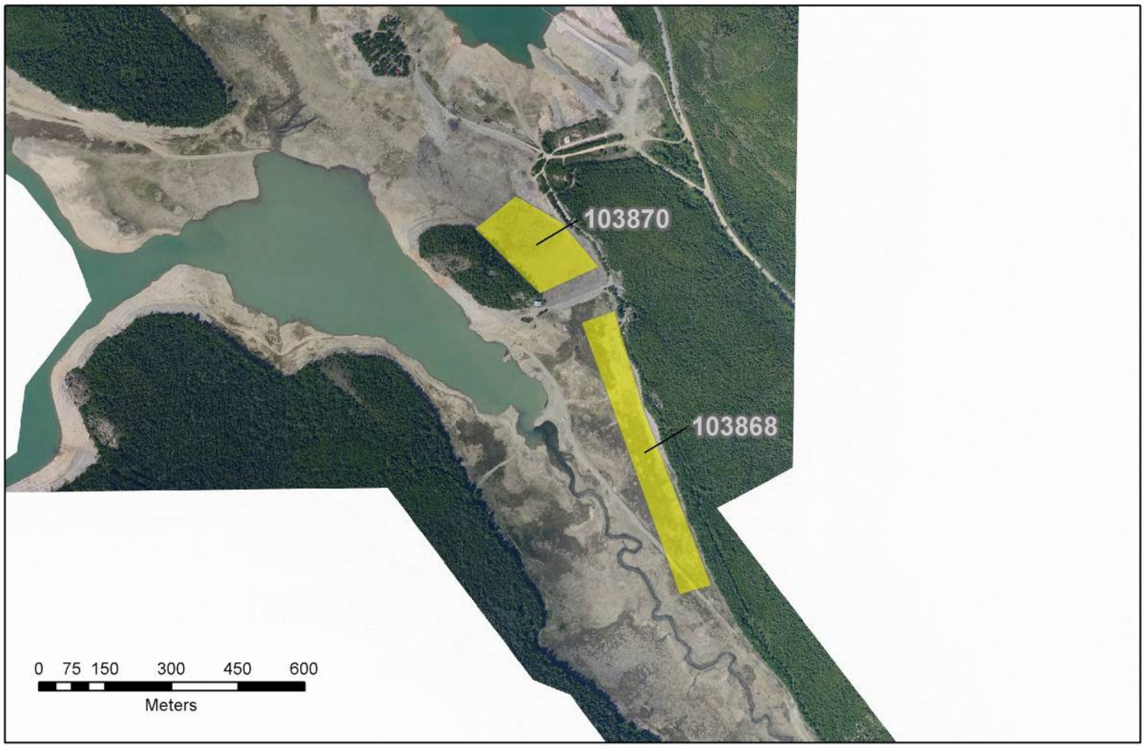
Vegetation communities within the Kinbasket Reservoir drawdown zone mapped by CLBMON 10 (Hawkes et al. 2010)

Code	Vegetation Community	Description
BR	Bluejoint Reedgrass	Above CH, often above KS
BS	Buckbean–Slender Sedge	Very poorly drained, wetland association
CH	Common Horsetail	Well drained, above LL or lower elevation on sandy, well-drained soil
CO	Clover–Oxeye Daisy	Well drained, typical just below shrub line and above KS
CT	Cottonwood – Trifolium	Imperfectly to well drained, above CO, below MC and LH
DR	Driftwood	Long, linear bands of driftwood, very little vegetation
FO	Forest	Any forested community
KS	Kellogg's Sedge	Imperfectly to moderately well drained, above CH
LH	Lodgepole Pine–Annual Hawksbeard	Well drained, above CT along forest edge, very dry site
LL	Lady's Thumb–Lamb's Quarter	Imperfectly to moderately well drained; the lowest vegetated elevations
MA	Marsh Cudweed–Annual Hairgrass	Imperfectly to moderately well drained; common in the Bush Arm area
MC	Mixed Conifer	Well drained, above CT along forest edge
RC	Reed Canarygrass	Imperfectly to moderately well drained; similar elevation to CO community
RD	Common Reed	*Phragmites australis*
SH	Swamp Horsetail	Poorly drained, wetland association
TP	Toad Rush–Pond Water-starwort	Imperfectly drained, above LL, wet sites
WB	Wool-grass–Pennsylvania Buttercup	Poorly drained, wetland association
WD	Wood Debris	Thick layers of wood debris, no vegetation
WS	Willow–Sedge wetland	Very poorly drained, wetland association

Vegetation communities within the Revelstoke Reach drawdown zone

Code	Category	Description
RF	Riparian forest	Riparian forest with cottonwoods and shrubs, with variable conifer component
UC	Upland conifer	Conifer-dominated upland forest
UM	Upland mixed	Upland forests typically containing high amounts of birch and white pine
EG	Equisetum grassland	Horsetail-dominated grassland
MG	Mixed grassland	Grasslands with variable mixture of graminoids
PG	Sparse grassland	Grasslands with sparse/low graminoid cover
RC	Reed canarygrass	Grasslands dominated by well-developed reed canarygrass cover
SG	Sedge grassland	Sedge-dominated grassland
SH	Shrub savannah	Shrub-savannah
SR	Riparian shrub	Riparian shrub
BE	Steep bedrock	Bluffy steep banks comprised of bedrock slabs or cliffs. Variable vegetation and coarse woody debris
RB	Rocky bank	Steep banks comprised of boulders, talus, and loose rocks. Variable vegetation and coarse woody debris
SB	Sand bank	Sand banks - usually failing. Variable vegetation and coarse woody debris
TH	Thalweg	Columbia River channel
CR	Coarse rocks	Coarse rocks, cobbles, boulders, etc.
GR	Gravel	Gravel, pebbles, etc.
SA	Sand	Sand
SI	Silt	Silt
UR	Urban	Residential, industrial, etc.
BF	Floating bog	Floating peat bog that provides island habitat
BR	Bulrush	Pond habitat with large stands or patches of bulrush
BS	Submerged buoyant bog	Peat bog that rises with water but becomes flooded
CK	Creek	Gravel/rocky creek channel or estuary
CT	Cattail	Cattail-dominated wetland
CW	Shrub wetland complex	Transitional, containing a mixture of wetland components, often with shrubs
LD	Low elevation draw	Muddy/clay depression or channel
PO	Pond	Open water pond habitat with variable amounts of submergent vegetation
SW	Swamp	High in the drawdown zone. Beaver ponds, skunk cabbage, alders, etc.
WM	Wet meadow	Sedge, grass, seasonally flooded area with depressions
WS	Water Sedge	Sedge-dominated marsh or fen

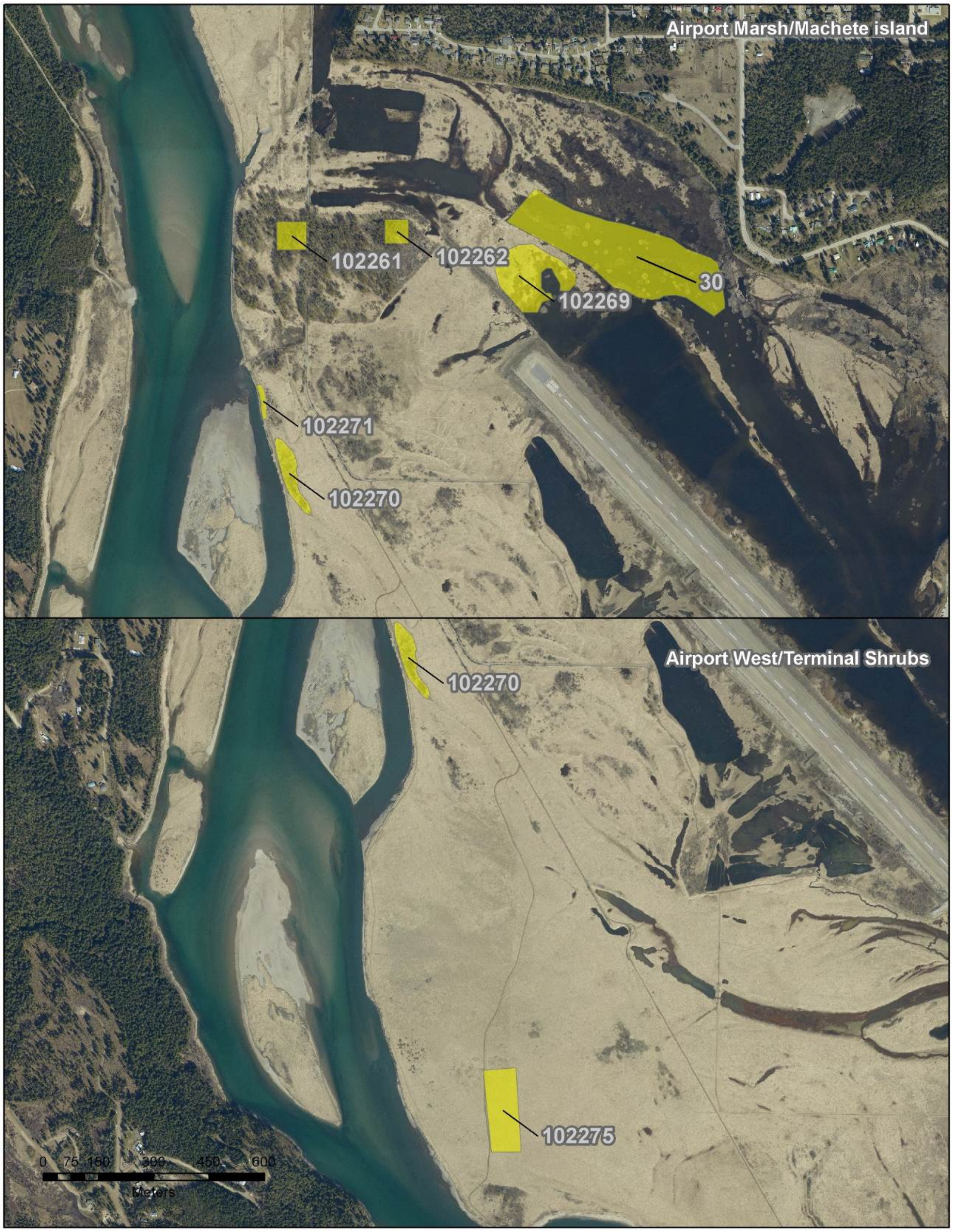
Appendix 6-3: Locations of nest mortality study sites at Bush Arm, Kinbasket Reservoir



Bush Arm – Succour Creek (Bush Harbour)

Bush Arm – north

Appendix 6-4: Locations of nest mortality study sites at Revelstoke Reach



Revelstoke Reach - North

Revelstoke Reach - Middle

Revelstoke Reach - South

Appendix 6-5: Nest mortalities due to reservoir operations (e.g., flooding) in 2016 in each study area (RR = Revelstoke Reach, BA = Bush Arm)

Area	Nest ID	Nest Position	Species	Elevation (m asl)	Nest Height (m)
ALR	103632	Ground	Mallard	436.2	0
ALR	103963	Ground	Spotted Sandpiper	436.5	0
ALR	103593	Ground	Spotted Sandpiper	435.9	0
ALR	103253	Ground	Northern Harrier	435.4	0
ALR	103885	Ground	Short-eared Owl	436.3	0
ALR	103860	Ground	Short-eared Owl	436.1	0
KIN	107045	Ground	Spotted Sandpiper	747.8	0
KIN	107082	Ground	Savannah Sparrow	749.7	0
KIN	107105	Ground	Savannah Sparrow	748.1	0
KIN	106965	Ground	Killdeer	746.8	0
KIN	106959	Ground	Lincoln's Sparrow	748.2	0
KIN	107114	Ground	Savannah Sparrow	749	0

Appendix 6-6: Nest records from the drawdown zones of Arrow Lakes Reservoir and Kinbasket Reservoir accumulated during nine years of the CLBMON-36 program. Nesting in the drawdown zones is defined by historical maximum water elevation, and determined for each nest record using the digital elevation model cross referenced against the nest coordinates. Nests elevated in vegetation above the high water elevation are included

Common Name	Scientific Name	Arrow Lakes Reservoir Drawdown Zone	Kinbasket Reservoir Drawdown Zone
Common Loon	*Gavia immer*	6	0
Pied-billed Grebe	*Podilymbus podiceps*	30	0
Canada Goose	*Branta canadensis*	97	1
American Wigeon	*Anas americana*	37	0
Mallard	*Anas platyrhynchos*	59	2
Blue-winged Teal	*Anas discors*	1	1
Cinnamon Teal	*Anas cyanoptera*	3	0
Unidentified Teal	*Anas sp*	4	0
Northern Shoveler	*Anas clypeata*	1	0
Green-winged Teal	*Anas crecca*	9	2
Ring-necked Duck	*Aythya collaris*	1	0
Unidentified Duck		4	0
Osprey	*Pandion haliaetus*	2	0
Northern Harrier	*Circus cyaneus*	3	0
Ruffed Grouse	*Bonasa umbellus*	1	0
Virginia Rail	*Rallus limicola*	45	0
Sora	*Porzana carolina*	44	0
Killdeer	*Charadrius vociferus*	33	29
American Avocet	*Recurvirostra americana*	1	0
Spotted Sandpiper	*Actitis macularius*	22	75
Wilson's Snipe	*Gallinago delicata*	48	16
Wilson's Phalarope	*Phalaropus tricolor*	2	0
Long-eared Owl	*Asio otus*	4	0
Short-eared Owl	*Asio flammeus*	6	0
Rufous Hummingbird	*Selasphorus rufus*	1	0
Downy Woodpecker	*Picoides pubescens*	1	0
Northern Flicker	*Colaptes auratus*	6	3
Western Wood-Pewee	*Contopus sordidulus*	8	0
Alder Flycatcher	*Empidonax alnorum*	2	2
Traill's Flycatcher	*Empidonax alnorum/traillii*	8	0
Willow Flycatcher	*Empidonax traillii*	142	14
Least Flycatcher	*Empidonax minimus*	15	1
Dusky Flycatcher	*Empidonax oberholseri*	5	4
Eastern Kingbird	*Tyrannus tyrannus*	14	0
Unidentified Flycatcher		9	2
Warbling Vireo	*Vireo gilvus*	8	0
Red-eyed Vireo	*Vireo olivaceus*	21	0
American Crow	*Corvus brachyrhynchos*	4	0

Tree Swallow	*Tachycineta bicolor*	1	2
Black-capped Chickadee	*Poecile atricapillus*	5	1
Marsh Wren	*Cistothorus palustris*	30	0
Mountain Bluebird	*Sialia currucoides*	1	14
Veery	*Catharus fuscescens*	31	0
Swainson's Thrush	*Catharus ustulatus*	3	3
Hermit Thrush	*Catharus guttatus*	1	0
American Robin	*Turdus migratorius*	37	10
Gray Catbird	*Dumetella carolinensis*	70	0
Cedar Waxwing	*Bombycilla cedrorum*	316	50
Tennessee Warbler	*Oreothlypis peregrina*	2	0
Yellow Warbler	*Dendroica petechia*	524	9
Yellow-rumped Warbler	*Dendroica coronata*	1	1
American Redstart	*Setophaga ruticilla*	70	1
Northern Waterthrush	*Parkesia noveboracensis*	1	0
MacGillivray's Warbler	*Oporornis tolmiei*	8	1
Common Yellowthroat	*Geothlypis trichas*	73	5
Unidentified Warbler		1	0
Chipping Sparrow	*Spizella passerina*	33	22
Clay-colored Sparrow	*Spizella pallida*	16	19
Vesper Sparrow	*Pooecetes gramineus*	0	5
Savannah Sparrow	*Passerculus sandwichensis*	36	312
Song Sparrow	*Melospiza melodia*	100	8
Lincoln's Sparrow	*Melospiza lincolnii*	12	32
Dark-eyed Junco	*Junco hyemalis*	0	2
Oregon Junco	*Junco h. oregonus*	1	0
Black-headed Grosbeak	*Pheucticus melanocephalus*	3	0
Lazuli Bunting	*Passerina amoena*	4	0
Red-winged Blackbird	*Agelaius phoeniceus*	60	0
Western Meadowlark	*Sturnella neglecta*	6	0
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	79	0
Bullock's Oriole	*Icterus bullockii*	2	0
American Goldfinch	*Spinus tristis*	1	0
Unidentified Bird		4	0
Unidentified songbird		1	0
Total		2240	649