Columbia River Project Water Use Plan

Kinbasket and Arrow Reservoirs Revegetation Management Plan

Wildlife Effectiveness Monitoring of Revegetation Efforts and Physical Works Trials in Kinbasket Reservoir

Implementation Year 9

Reference: CLBMON-11A

Final Report

Study Period: 2016

Okanagan Nation Alliance, Westbank, BC
and
LGL Limited environmental research associates
Sidney, BC

May 20, 2017

EA3451C

KINBASKET AND ARROW LAKES RESERVOIRS

Monitoring Program No. CLBMON-11A
Wildlife Effectiveness Monitoring of Revegetation Efforts and Physical Works Trials in Kinbasket Reservoir




Final Report

2016

Prepared for

BC Hydro

BC Hydro Generation

Water Licence Requirements
6911 Southpoint Drive
Burnaby, BC

Prepared by

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May 20, 2017

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Suggested Citation:

Wood, C.M., N. Johnston, and V.C. Hawkes. 2017. CLBMON-11A. Kinbasket and Arrow Lakes Reservoirs: Wildlife Effectiveness Monitoring of Revegetation Efforts and Physical Works Trials in Kinbasket Reservoir. Annual Report – 2016. LGL Report EA3451C. Unpublished report by Okanagan Nation Alliance, Westbank, B.C. and LGL Limited environmental research associates, Sidney, B.C., for BC Hydro Generation, Water Licence Requirements, Burnaby, BC. 53 pp. + Appendices.

Cover Photographs:

From left to right: log boom installation at the northwest side of Bush Arm Causeway, Western Tiger Beetle (*Cicindela oregona*), Savannah Sparrow nest at the treatment of Bush Arm Causeway North (*Passerculus sandwichensis*), and Goldenrod Crab Spider (*Misumena vatia*) on ox-eye daisy. Photos © Charlene Wood, 2016.

EXECUTIVE SUMMARY

The goal of CLBMON-11A is to monitor and assess the efficacy of revegetation efforts and physical works trials to increase the suitability of wildlife habitats in the drawdown zone of Kinbasket Reservoir (i.e., CLBWORKS-1 and CLBWORKS-16). Monitoring under CLBMON-11A was initiated in 2008 and was conducted annually from 2008 to 2012 by Cooper Beauchesne and Associates Ltd. The Okanagan Nations Alliance (ONA), in partnership with LGL Limited environmental research associates, has continued monitoring since 2013.

The objectives of this program include the design and implementation of an eleven-year monitoring program on selected indicator taxa to provide feedback on how to improve habitat for wildlife through adaptive management. Given the apparent failure of previous revegetation efforts, a new approach was required to answer the management questions of CLBMON-11A and the study was re-configured in 2014. The revised study now includes an assessment of the effectiveness of woody debris removal conducted in 2012 and 2014 at Canoe Reach. The wood debris removal treatment was incorporated into the study design as it is thought that the scouring effects of debris deposition and removal owing to variable reservoir levels combined with the presence of the wood itself prevents vegetation establishment and growth. The removal of wood within five study sites in Canoe Reach (Valemount Peatland North, Valemount Peatland South, Yellowjacket Creek, Packsaddle Creek North, and Packsaddle Creek South) is expected to promote revegetation, given previous revegetation failures within the drawdown zone. A log boom was installed around the Valemount Peatland North treatment site to potentially exclude wood deposition during future high water events.

Five study sites in Bush Arm were surveyed in the summer of 2015, for pre-treatment conditions (Chatter Creek, Goodfellow Creek, Hope Creek, Bush Arm Causeway North, and Bush Arm Causeway South). In Fall 2015, two of these sites were treated: Bush Arm Causeway South and Bush Arm Causeway North. At these treatments, ponds were cleared of wood debris, mounds were created, and live stakes and sedge plugs were planted. A log boom was installed in June 2016 at the Bush Arm Causeway NW treatment site to potentially exclude wood deposition during future high water events.

The focus of the 2016 monitoring year was to assess birds and ground-dwelling arthropods in the drawdown zone of Kinbasket reservoir, particularly at those sites that received physical works implementation.

Vegetation monitoring revealed large increases vegetation cover in the wood-debris removal treatment at Valemount Peatland North. This site was protected for wood debris deposition by a log boom enclosure, which likely contributes to the success of natural vegetation regrowth.

Unfortunately, two study sites at Canoe Reach were altered prior to monitoring in 2016. The Packsaddle Creek North and Packsaddle Creek South treatment and control sites were removed of wood debris in 2016. Thus, control plots were lost and treatment plots were “re-treated”. Bird surveys were not conducted at these sites and a subset of arthropod samples were taken to infer whether arthropod communities were more similar to the initial treatment communities monitored in 2014, as compared to the communities found in 2015 (1-year post-treatment).

Overall, 9,155 beetles and spiders were collected in 2016. Together, spider and ground beetle species assemblages were distinct between treatment and control

areas at Canoe Reach, despite site-specific differences. In 2014 and 2015, treatments were largely characterised by ground-running spiders (e.g., *Pardosa* spp.) and bare ground associated beetles species (e.g., *Bembidion planatum, Cicindela tranquebarica,* and *C. longilabris perviridis*). These open habitat species have decreased in abundance since the initial wood removal, and are expected to be replaced by species more tolerant of low-lying vegetative cover.

The turnover of arthropod species in treatments will signal changes in habitat quality that may relate to other wildlife in the drawdown zone of Kinbasket Reservoir (increased insect prey for amphibians, reptiles, songbirds, and insectivorous mammals; forage for ungulates; singing perches for songbirds; and nesting sites for sparrows). These patterns will continue to be assessed in the remaining three years of CLBMON-11A.

At Bush Arm, the monitoring is still very early since implementation of mounds (Fall 2015). So far, arthropod communities did not form distinct groups for treatment and control areas at BAC-N and BAC-S. Rather, arthropod species composition is structured more so by site-level differences (e.g., soil substrate). However, we expect to see shifts in species and assemblage composition similar to those seen in Canoe Reach if revegetation success results in increased vegetation cover at these sites (e.g., a decrease in bare ground associated species over time).

Bird surveys in 2016 revealed no difference in relative abundance or richness of birds between wood removal treatments and adjacent controls at Canoe Reach nor at Bush Arm. The lack of replication and low bird density in the drawdown zone limited our ability to make strong comparisons. Species that were found exclusively in the treatment plot at Valemount Peatland North were Chipping sparrow, Song Sparrow, and Western Meadowlark. Savannah Sparrow is expected to increase with increased cover of grasses and other low vegetation in the drawdown zone. Nesting evidence was relatively low overall, though this may reflect the small size of the plots relative to territory requirements of many breeding bird species. As vegetation establishes on treatment plots, we may see increased utilisation of the drawdown zone by ground or shrub-nesting bird species. We expect that an increase in invertebrate prey (e.g., beetles) on treatment plots with successful revegetation will result in increased detections of those bird species already utilizing the drawdown zone.

Our ability to address each of the management questions is summarized below. The current trends in our data will be monitored overtime for changes in vegetation and focal taxa (e.g., ground-dwelling spiders and beetles and breeding birds). Data collected in future survey years will clarify conclusions for each management question. In our response to answering the management questions we have equated revegetation to physical works (to better align with the current focus of CLBMON-11A).

MQ	Able to Address MQ?	Scope: Current supporting results	Scope: Suggested modifications to methods where applicable	Sources of Uncertainty
1: How effective is the revegetation program at enhancing and increasing the utilization of habitat in the drawdown zone by wildlife	Partially	Increased natural vegetation growth at treatment plots following wood removal and mount treatments Spider and beetle species assemblages are distinct between control and treatment plots at Canoe Reach, suggesting differences in habitat qualities resulting from treatments. Some bare-ground associated arthropods have declined in treatment plots since 2014, possibly due to vegetation cover increases	• Sample treated sites and controls annually (reference sites are not variable and can be sampled less frequently) • Protect the long-term integrity of study plots in the drawdown zone by installing physical barriers to exclude woody debris from treatment plots and maintain woody debris in control plots (e.g., install log booms)	• Lack of sampling prior to the application of the prescriptions at Canoe Reach • Natural annual population variation • Variable reservoir operations • Bi-annual sampling • Relationships between revegetation or woody debris removal success and site-specific characteristics (e.g., substrate type, soil moisture, aspect, landscape position, etc.) • No measures taken to ensure the long-term integrity of some study plots in the drawdown zone (e.g., log booms)
2: To what extent does revegetation increase the availability of invertebrate prey in the food chain	Partially	General arthropod relative abundance and biomass did not differ between treatment and control transects in revegetation areas (studied prior to 2014). Since 2014 wood removal at Canoe Reach, some sites show clear differences in arthropod abundance between treatment and control areas. Arthropod densities are expected to increase in treatment plots (relative to controls) where vegetation establishment is successful. Results of CLBMON-11B1 show support for correlation between insect biomass and songbird presence (e.g., Hawkes et al. 2012).	• Annual sampling at least of drawdown zone treatment and controls • Consider planting areas with high likelihood of success (i.e., Valemount Peatland North, where substrates are organic, vegetation is colonizing, a log-boom is setup to exclude wood debris, and arthropod abundance is high)	• Lack of sampling prior to the application of the revegetation prescriptions and woody debris removal • Annual population variation • Sampling frequency and variable arthropod phenology • Variable reservoir operations
3: Are revegetation efforts negatively impacting wildlife in the drawdown zone?	Partially	While some species are expected to decline overtime in treatment plots (initial bare-ground colonising arthropod species, exotic species), there is no evidence of negative impacts to wildlife caused by treatment prescriptions	• Management question is better-suited to other studies that currently occur in the region	• Lack of sampling prior to the application of the revegetation prescriptions and woody debris removal • Natural annual population variation • Lack of knowledge regarding wildlife use of the drawdown zone in the winter • Variable reservoir operations

MQ	Able to Address MQ?	Scope		Sources of Uncertainty
		Current supporting results	Suggested modifications to methods where applicable	
4: Which methods of revegetation are most effective at enhancing and increasing the utilization of wildlife habitat in the drawdown zone	Partially	The effectiveness of woody debris removal is likely dependent on site-specific attributes and whether measures are put in place to exclude wood accumulation during subsequent reservoir cycles. Woody debris removal appears to be initially effective at Valemount Peatland North, based on observation of high arthropod and amphibian abundance in the wood removal area since 2014. The effectiveness of physical works trials implemented at Bush Arm will be assessed in future years	• Protect the long-term integrity of study plots in the drawdown zone: install physical barriers to exclude woody debris from treatment plots and maintain woody debris on control plots (e.g., install log booms, where possible) • Characterize and catalogue site-specific attributes for all study areas in Kinbasket Reservoir, in order to understand differential responses to treatments	• Lack of sampling prior to the application of the revegetation prescriptions and woody debris removal • No measures taken to ensure the long-term integrity of treatment areas at all study sites • Relationship between revegetation or woody debris removal success and site-specific characteristics (e.g., substrate type, soil moisture, aspect, landscape position, etc.)

Monitoring under CLBMON-11A is currently scheduled to continue in 2017. The following is a summary of the recommendations made for the implementation of CLBMON-11A in future years:

1. **Future revegetation treatments in select areas of the drawdown zone.** Increasing the extent of revegetation areas will increase the likelihood of detecting any changes in wildlife utilization. Following the initial success of natural vegetation growth at the Valemount Peatland treatment area, this may be well-suited to supplemental enhancement by planting live stakes and sedge plugs. The current treatment plots could be split into planted (enhanced revegetation) and un-planted (natural revegetation) treatment areas. Revegetation efforts should be site-specific based on a prescription for that area. If future revegetation is to occur, consider the species of wildlife that are likely to benefit from the revegetation to ensure the appropriate mix of plants is used, that the total area planted is likely to influence wildlife use of the drawdown zone, and that the revegetation prescriptions be applied in a replicated manner with sufficient stratification. Assessing the efficacy of this future revegetation would require long-term monitoring beyond the current scope of this project.
2. **Increase number of treatment applications and install log booms.** Additional treatments (woody debris removal and/or mound and windrow sites) are needed at each reach to increase replication and to include sites with other soil seed bank profiles, soil fertility assays, evidence of nascent vegetation establishment, and recent land use history. Log booms should be installed around wood removal areas to protect the integrity of these treatments.
3. **Ensure control areas are maintained for the remainder of monitoring.** In 2016 two sites were re-treated, and along with the adjacent control plots at these sites (Packsaddle Creek: PS-S, PS-N), they were cleared of all wood debris. In order to monitor the effectiveness of treated areas, replicates must be retained.

Key Words: Kinbasket Reservoir, arthropods, ungulates, songbirds, woody debris, revegetation, physical works, effectiveness monitoring, drawdown zone, hydro

ACKNOWLEDGEMENTS

The authors express their appreciation to the following individuals for their assistance in coordinating and conducting this study: Michael Miller, Jeremy Gatten, Jaimie Fenneman, Nathan Hentze, Lucia Ferreira, and Julio Novoa (LGL Limited); Alan Peatt, Lisa Wilson, Alexis Friesen, Andrew 'Oly' Clarke, and Addison Fosbery (Okanagan Nation Alliance); Margo Sadler, Guy Martel, Mark Sherrington, Dean den Biesen, and Susan Pinkus (BC Hydro); and vegetation subject matter experts: Dave Polster (Polster Environmental) and Carrie Nadeau (Associated Engineering); Murray Chapple (Sterling Lumber); Robb Bennett, Claudia Copley, and Joel Gibson (Royal British Columbia Museum).

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ACRONYMS AND DEFINITIONS

The following terminology is used throughout this report. Definitions are presented in a logical, not alphabetical, order.

Revegetation or Revegetation Program: prior to 2014, the CLBWORKS-1 revegetation program entailed planting the drawdown zone areas of Kinbasket Reservoir in efforts to establish vegetation and enhance the drawdown zone for wildlife use. Since 2014, the terms 'revegetation' and 'revegetation program' are extended to include other aspects of CLBWORKS-1 and CLBWORKS-16 implemented in 2014, 2015, and 2016, such as physical works treatments (wood debris removal, wood debris and soil mounds/windrows, and log boom enclosures).

Drawdown Zone: the terrestrial portion of the reservoir that is inundated and exposed due to changing reservoir elevations, typically between 707.41–754.38 m ASL.

Upland: non-reservoir habitats above the drawdown zone that contain Reference Transects (see below).

Reach: refers to a broad geographic area of the reservoir used as the highest level of stratification for sampling. Two reaches within Kinbasket Reservoir were sampled for CLBMON-11A: Canoe Reach in the north and Bush Arm in the south. Specific sites are sampled within each reach.

Site: Sampling area within a reach in which treatments were applied and/or upland areas sampled. There are currently five sites monitored at Canoe Reach, which are abbreviated as follows:

- **VP-N:** Valemount Peatland North
- **VP-S:** Valemount Peatland South
- **PS-N:** Packsaddle Creek North
- **PS-S:** Packsaddle Creek South
- **YJ:** Yellowjacket Creek

The five sites are monitored at Bush Arm are abbreviated as follows:

- **CHT:** Chatter Creek
- **BAC-N:** Bush Arm Causeway North (northwest)
- **BAC-S:** Bush Arm Causeway South (southwest)
- **GDF:** Goodfellow Creek
- **HOPE:** Hope Creek

Pre-treatment: Sampling that occurred within a site prior to application of revegetation or physical works trials.

Treatment Type: Sampling location within a site consisting of one of three main treatment types, i.e., treatment, control, and reference, defined as follows:

- **Treatment.** Wood debris removal or wood debris and soil mound/windrow creation in the drawdown zone (<754 m ASL).

- **Control:** drawdown zone area adjacent to Treatment areas where woody debris was not removed and/or soil and wood mound/windrows were not created. These areas are situated at approximately the same elevation as the Treatments.
- **Reference:** These areas are immediately upland of the treatment and control sites and are representative of the non-drawdown zone, forested condition. These sites represent what would be in the drawdown zone if the reservoir was not there.

Additionally, sampling sometime occurred in the drawdown zone where treatment and control plots were not designated. These locations are referred to as**:**

- **Drawdown Zone (DDZ):** area of the drawdown zone that was sampled but not within a defined treatment or control area

1.0 INTRODUCTION

Kinbasket Reservoir is located in southeast British Columbia between the towns of Donald and Valemount. The reservoir was created in 1974 to serve as the primary storage reservoir for power generation on the Columbia system. The 216 km reservoir is licensed to fluctuate 46.9 meters in elevation (the drawdown zone) throughout a year, resulting in erosion and habitat degradation in the reservoir's upper elevations (741—754 m ASL) (BC Hydro 2005). A Water Use Plan (WUP) was developed in 2007 as a result of a multi-stakeholder consultative process to determine how to best operate BC Hydro's facilities on the Columbia River to balance environmental values, recreation, power generation, culture/heritage, navigation and flood control (BC Hydro 2007). The process involved a number of interest groups, First Nations, government agencies and other stakeholders collectively referred to as the Consultative Committee (CC)[1]. The goal of the WUP was to accommodate these values through operational means (i.e., patterns of water storage and release) and non-operational physical works (in lieu of changing reservoir operations).

During the water use planning process, both the need and opportunity to improve wildlife habitat in the upper elevations of Kinbasket Reservoir were recognized (BC Hydro 2005). The CC reviewed the operating alternatives and supported the implementation of physical works in the Kinbasket Reservoir to help mitigate impacts to wildlife and wildlife habitat in lieu of changing reservoir operations. The CC supported a reservoir-wide planting program (CLBWORKS-1) compatible with both the current operating regime and proposed operating alternatives to improve vegetation growth in the drawdown zone. Recognizing the need to assess the effectiveness of this program, the CC also recommended a number of studies to monitor and "audit" the effectiveness of planting efforts on vegetation communities and wildlife habitat use. This recommendation resulted in the creation of several monitoring programs including CLBMON-9 to assess the effectiveness of revegetation treatments in establishing vegetation communities within the drawdown zone, and CLBMON-11A, an 11-year monitoring program to assess the revegetation program effectiveness at increasing wildlife utilization within the drawdown zone of Kinbasket Reservoir. The terms of reference for CLBMON-11A (BC Hydro 2008) also states that this study's results will aid in more informed decision-making with respect to the need to balance requirements of wildlife that are dependent on wetland and riparian habitats, with other values such as recreational opportunities, flood control and power generation. The key water use planning decision affected by the findings of CLBMON-11A is whether revegetation, in lieu of changes to reservoir operations, is effective at enhancing wildlife habitat and reducing the negative effects of reservoir operations on wildlife. Results from this study will also support an adaptive management approach in refining the objectives and methods for enhancing wildlife habitat in the drawdown zone.

Monitoring was conducted annually from 2008 to 2012 by CBA (CBA 2009a, 2010b, 2011a,b) and by the Okanagan Nation Alliance and LGL Limited in 2013. Based on the conclusions and recommendations in Hawkes et al (2014), BC Hydro agreed that the methods applied during the first five years of the program were not well suited to answering the management questions associated with CLBMON-

[1] The Okanagan Nation Alliance did not participate in this process.

11A. For example, the wrong species of small mammal were being targeted, the productivity (i.e., seed load) of plants that would be consumed by granivorous small mammals had not been assessed, songbirds had not been considered as focal taxa, and the size of the revegetation prescriptions applied in the drawdown zone were likely of little benefit to ungulates given the proximity and spatial extent of suitable habitat adjacent to the drawdown zone. Overall, there did not appear to have been a connection made between the types of plants used in the revegetation program (CLBWORKS-1) and how the use of those species would benefit wildlife using the drawdown zone of Kinbasket Reservoir. In addition, the revegetation program has not been successful (Hawkes et al. 2013) and there was a need to adapt CLBMON-11A to ensure that data collected could be used to answer each of the management questions.

Starting in 2014 an assessment of the effectiveness of woody debris removal to promote the establishment and development of vegetation in the drawdown zone was initiated, as was the efficacy of a log debris boom to prevent the accumulation of woody debris, which would also function to promote the establishment and development of vegetation in the drawdown zone. The focal taxa selected to study the efficacy of woody debris removal and log boom installation were spiders, beetles, and birds (includes songbirds, grouse, waterfowl, shorebirds, etc.). Vegetation data were also collected, but will be assessed under CLBMON-9, with those results provided to CLBMON-11A to enable correlations between vegetation species composition and structure and the selected fauna. All of the taxa selected for study under CLBMON-11A have been studied in Kinbasket Reservoir since 2008 relative to both the revegetation trials, and more recently, the physical works (i.e., woody debris removal and log boom installation) trials.

2.0 OBJECTIVES AND MANAGEMENT QUESTIONS

The overarching goal of CLBMON-11A is to monitor and audit the efficacy of revegetation efforts (including physical works trials) in increasing the suitability of wildlife habitats in the drawdown zone of Kinbasket Reservoir. The objectives of this program include the design and implementation of an 11-year monitoring program for selected indicator taxa to facilitate the assessment of the treatments' success and provide feedback on how to improve habitat for wildlife through adaptive management. More specifically, the objectives as stated in the terms of reference are three-fold:

1. Develop an effectiveness-monitoring program to assess whether revegetation efforts in the drawdown zone of Kinbasket Reservoir improve habitat for wildlife.
2. Assess how effective the revegetation efforts are at improving habitat for wildlife in the drawdown zone between 741 m and 754 m ASL elevation.
3. Report and provide recommendations on the effectiveness of the revegetation program on improving habitat for wildlife in the drawdown zone in Years 5 and 10 (2012 and 2018, respectively)[2].

CLBMON-11A was initiated in 2008 and Objective 1 was completed with refinements to the study design incorporated annually. The monitoring of focal taxa was performed between 2008 and 2016 with some modifications to the

[2] The 5-year report that was to be developed in 2012 was deferred.

effectiveness monitoring program which were provided in Hawkes et al. (2013) and Wood et al. (2015).

2.1 Management Questions and Hypotheses

To meet the objectives of the monitoring program, BC Hydro identified several key management questions and four associated management hypotheses that were designed to help address both the management questions and the study objectives.

The four management questions, here with the 2014 modifications (strike-through/bold), are:

1. How effective is the revegetation program at enhancing and increasing the utilization of habitat in the drawdown zone by wildlife such as amphibians, birds, ~~small mammals~~, and ungulates?
2. To what extent does revegetation increase the availability of invertebrate prey (e.g. arthropods) in the food chain for birds, amphibians ~~and small mammals~~?
3. Are revegetation efforts negatively impacting wildlife in the drawdown zone? For example, does revegetation increase the incidence of nest mortality in birds or create sink habitat for amphibians?
4. Which methods of revegetation **or woody debris removal** are most effective at enhancing and increasing the utilization of wildlife habitat in the drawdown zone?

The management hypotheses to be tested by this study include:

H_1: Revegetation does not increase the utilization of habitats by amphibians in the drawdown zone.

- H_{1A}: Revegetation does not increase species diversity or seasonal (spring/summer/fall) abundance of amphibians in the drawdown zone.
- H_{1B}: Revegetation does not increase the abundance of amphibian prey (e.g. arthropods).
- H_{1C}: Revegetation does not increase amphibian productivity (e.g., egg laying and young of year survival).
- H_{1D}: Revegetation does not increase the amount of amphibian habitat in the drawdown zone.

H_2: Revegetation does not increase the utilization of habitats by birds in the drawdown zone.

- H_{2A}: Revegetation does not increase the species diversity or abundance of birds utilizing the drawdown.
- H_{2B}: Revegetation does not reduce nest mortality of birds that nest in the drawdown zone.
- H_{2C}: Revegetation does not increase the survival of juvenile birds in the drawdown zone.

H_{2D}: Revegetation does not increase the abundance of songbird, shorebird, or marshbird prey (e.g. arthropods).

H_{2E}: Revegetation does not increase the amount of bird habitat in the drawdown zone.

H_3: Revegetation does not increase the utilization of habitats by small mammals in the drawdown zone.

H_{3A}: Revegetation does not increase the diversity or abundance of small mammals in the drawdown zone.

H_{3B}: Revegetation does not increase the abundance of small mammal prey (e.g. arthropods).

H_{3C}: Revegetation does not increase the amount of small mammal habitat in the drawdown zone.

H_4: Revegetation does not increase the utilization of habitat by ungulates in the drawdown zone.

H_{4A}: Revegetation does not increase the seasonal abundance (winter/spring) of ungulates in the drawdown zone.

H_{4B}: Revegetation does not increase the abundance (tonnes per hectare) of ungulate forage.

H_{4C}: Revegetation does not increase the amount of ungulate habitat in the drawdown zone.

H_5: Revegetation does not increase the area of extent of high value wildlife habitat in the drawdown zone.

Management question 4, “Which methods of revegetation are most effective at enhancing and increasing the utilization of wildlife habitat in the drawdown zone” is not associated with a management hypothesis, but will be addressed under CLBMON-11A. Management hypotheses testing whether the amount of habitat has changed for each indicator taxon (i.e., H_{1D}, H_{2E}, H_{3C}, H_{4C}) are not addressed by CLBMON-11A, however hypothesis H_5 that generally evaluates amount of high value wildlife habitat will be evaluated.

As described in the terms of reference several of the indicator taxa will be monitored under separate Water Licence Requirements (WLR) monitoring programs (e.g., CLBMON-37/58 monitors amphibians and reptiles; CLBMON-36 monitors nest mortality in birds). Consequently, CLBMON-11A does not monitor specific variables (e.g., nest mortality) related to those taxa associated with these monitoring programs.

2.2 CLBMON-11A Study Limitations and Revised Program

The ability to address the above management questions and hypotheses is constrained by several factors:

- There was no pre-treatment sampling at revegetated areas and woody debris removal areas so comparisons before and after treatments cannot be made.
- The original revegetation sites (Appendix A) were not sampled every year and were limited in replication. Thus time series vary across sites and

treatments were unequal by sites and year. For example, some control transects were lost because revegetation treatments subsequently occurred at their locations. One site was destroyed by excavators (Windfall Creek) and a new site (Causeway) was added in 2010.

- Revegetated areas were typically too small to effectively influence use by certain species of wildlife (e.g., ungulates, and in most cases, small mammals); therefore it may be difficult to discern a treatment effect for these taxa.

Despite the overall assessment of ineffectiveness and issues associated with the original workplan, opportunities presented themselves to modify the program to assess the use of the drawdown zone by wildlife and to evaluate whether physical works programs, such as the woody-debris removal program (CLBWORKS-16), can effectively enhance wildlife habitat in the drawdown zone.

3.0 STUDY AREA

3.1 Physiography

The Columbia Basin in southeastern British Columbia is bordered by the Rocky, Selkirk, Columbia, and Monashee Mountains. The headwaters of the Columbia River begin at Columbia Lake in the Rocky Mountain Trench, and the river flows northwest along the trench for about 250 km before it empties into Kinbasket Reservoir behind Mica Dam (BC Hydro 2007). From Mica Dam, the river continues southward for about 130 km to Revelstoke Dam, then flows almost immediately into Arrow Lakes Reservoir behind Hugh Keenleyside Dam. The entire drainage area upstream of Hugh Keenleyside Dam is approximately 36,500 km^2.

The Columbia Basin is characterized by steep valley side slopes and short tributary streams that flow into Columbia River from all directions. The Columbia River valley floor elevation ranges from approximately 800 m near Columbia Lake to 420 m near Castlegar. Approximately 40 per cent of the drainage area within the Columbia Basin is above 2,000 m elevation. Permanent snowfields and glaciers predominate in the northern high mountain areas above 2,500 m elevation. About 10 percent of the Columbia River drainage area above Mica Dam exceeds this elevation.

3.2 Climatology

Precipitation in the basin is produced by the flow of moist, low-pressure weather systems from the Pacific Ocean that move eastward through the region. More than two-thirds of the precipitation in the basin falls as winter snow. Snow packs often accumulate above 2,000 m elevation through the month of May, and continue to contribute runoff long after the snow pack has melted at lower elevations. Summer snowmelt is reinforced by rain from frontal storm systems and local convective storms. Runoff begins to increase in April or May and usually peaks in June to early July, when approximately 45 per cent of the runoff occurs. The mean annual local inflow for the Mica, Revelstoke and Hugh Keenleyside projects is 577 m^3/s, 236 m^3/s and 355 m^3/s, respectively.

Air temperatures across the basin tend to be more uniform than precipitation. The summer climate is usually warm and dry, with the average daily maximum temperature for June and July ranging from 20–32°C.

3.3 Kinbasket Reservoir

The approximately 216 km long Kinbasket Reservoir is located in southeastern B.C., and is surrounded by the Rocky and Monashee Mountain ranges. The Mica hydroelectric dam, located 135 km north of Revelstoke, B.C., spans the Columbia River and impounds Kinbasket Reservoir. The Mica powerhouse, completed in 1973, has a generating capacity of 1,805 MW, and Kinbasket Reservoir has a licensed storage volume of 12 million acre feet (MAF; BC Hydro 2007). The normal operating range of the reservoir is between 707.41 m and 754.38 m elevation, but can be operated to 754.68 m ASL with approval from the Comptroller of Water Rights.

Kinbasket Reservoir is lowest during April to mid-May, fills throughout late spring and early summer, and is typically full by mid- to late-summer (Figure 3-1). Although there is some year to year variation, the general pattern is consistent. In 2012 and 2013 Kinbasket was filled beyond the normal operating maximum (i.e., > 754.38 m ASL) for the first time since 1997; in 2014 and 2015 water levels were kept below the normal operating maximum.

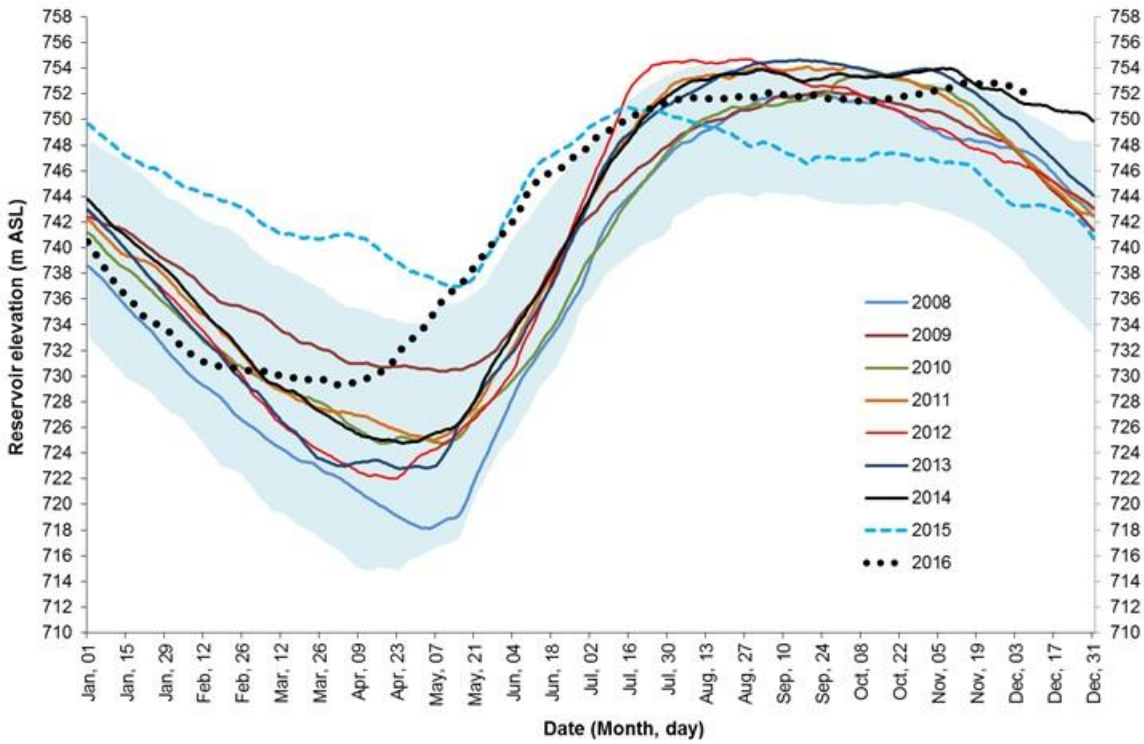

Figure 3-1: Kinbasket Reservoir hydrograph for the period 2008 through December 6, 2016. The shaded area represents the 10th and 90th percentile for the period 1976 to October 25, 2016; the dashed red line is the normal operating maximum

3.4 Biogeography

The reservoir is located predominately within the Interior Cedar-Hemlock (ICH) biogeoclimatic (BEC) zone and is represented by four subzone/variants (Table 3-1). The ICH occurs along the valley bottoms and is typified by cool, wet winters and warm dry winters. A small portion of the reservoir extends into the Sub-Boreal Spruce (SBS) BEC zone dh1 variant near Valemount. The climate of the SBS is continental, and characterized by moderate annual precipitation and seasonal extremes of temperature that include severe, snowy winters and relatively warm, moist, and short summers.

Table 3-1: Biogeoclimatic zones, subzones and variants occurring in Kinbasket Reservoir study area

SubZone	Zone Name	Subzone/Variant Description
ICHmm	Interior Cedar – Hemlock	mm: Moist Mild
ICHwk1	Interior Cedar – Hemlock	mk1: Wells Gray Wet Cool
ICHmw1	Interior Cedar – Hemlock	mw1: Golden Moist Warm
ICHvk1	Interior Cedar – Hemlock	vk1: Mica Very Wet Cool
ICHmk1	Interior Cedar – Hemlock	mk1: Kootenay Moist Cool
SBSdh1	Sub-Boreal Spruce	dh1: McLennan Dry Hot

3.5 Study sites

The southern end of the reservoir includes Bush Arm and the Columbia Reach. Bush Arm is characterized by flat or gently sloping terrain that was created by fluvial deposition from Bush River and other inflowing streams. These features are often protected from wind and wave action by the islands and peninsulas that protrude along the shoreline. This combination creates the largest variety of valuable wildlife habitat in the entire reservoir. Extensive fens and other wetlands have been identified, and a high diversity of plants is supported (Hawkes et al. 2007).

The extensive Valemount Peatland at the northern end of the reservoir supports the greatest diversity and abundance of wildlife in Canoe Reach. Historically, this peatland was likely a combination of sedge and horsetail fen and a swampy forest dominated by spruce (Ham and Menezes 2008). The wildlife habitat in the peatland varies from highly productive riparian and wetland habitat, to highly eroded sand and cobble parent material. Large areas are virtually devoid of vegetation and portions of the peatland are covered by deposits of wood chips from the breakdown of floating logs (Hawkes et al. 2007). Other notable habitats in the northern end of Kinbasket reservoir include wetlands and ponds on the gently sloping banks along the reservoir's eastern side. High quality wildlife habitat also occurs near Mica Creek at Sprague Bay and Encampment Creek.

In 2016, surveys were conducted in 10 study sites (Figure 3-2). Five sites were located in Canoe Reach and five sites were located in Bush Arm. Site names and codes are listed in Table 3-2.

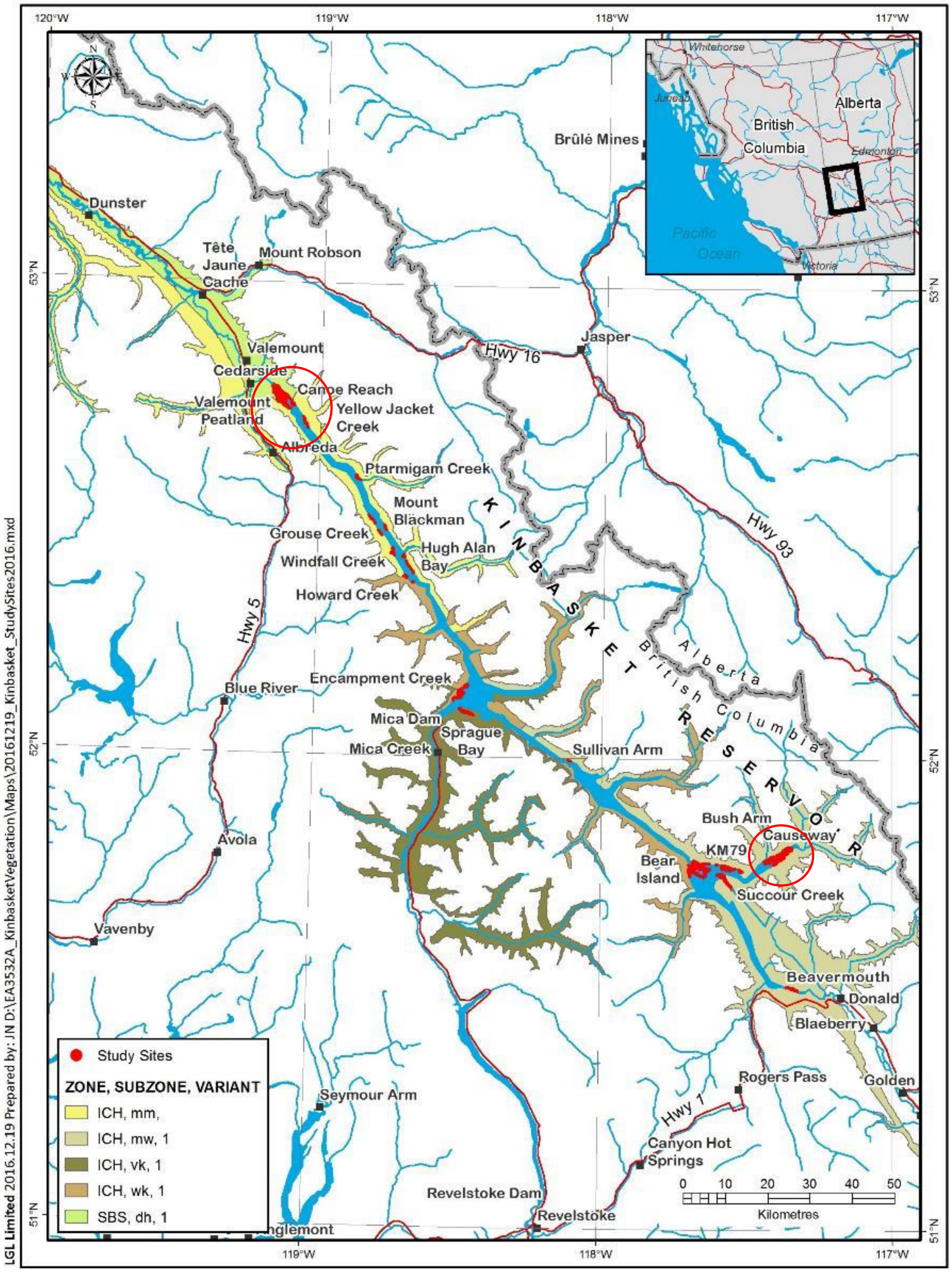

Figure 3-2: Location of Kinbasket Reservoir in British Columbia and locations sampled for CLBMON-11A in 2016 (inside red circles). Refer to Table 3-1 for descriptions of biogeoclimatic (BEC) zones.

3.6 Physical Works treatments

Large volumes of woody debris in the drawdown zone of Kinbasket Reservoir are a primary factor that prevents vegetation establishment and survival. Treatments were applied in five sites at Canoe Reach and two sites at Bush Arm under CLBWORKS-16 and CLBWORKS-1 (Table 3-2; Hawkes 2016b). At Canoe Reach, physical works trials were implemented to remove and exclude woody debris in response to low rates of vegetation survival in the planted plots in the drawdown zone of Kinbasket Reservoir. In 2012, wood debris were removed from VP-S, and in 2014 the remaining four sites were cleared of wood debris at Canoe Reach (YJ, VP-N, PS-N, PS-S). A log boom was also installed at VP-N as a trial to exclude wood accumulation following high reservoir flow events in an attempt to allow vegetation to naturally regenerate in this area. In 2016, the drawdown zone plots at PS-S and PS-N (treatment and control areas) were re-cleared of wood debris.

Table 3-2: Study sites established at Canoe Reach and Bush Arm of Kinbasket Reservoir. Plot type: treatment (T), control (C), and reference (R); DDZ= drawdown zone, UPL= upland forest. *indicates pre-treatment sampling; [1]plot previously monitored as a control, treated by wood removal in 2016, [2]re-treated plot previously monitored as a treatment, with further wood removal in 2016

	Site	Plot	Plot Description	2016 Surveys
Canoe Reach	**Packsaddle North (PS-N)**	T[2]	DDZ- woody debris removal (2014, 2016)	Arthropods, Vegetation
		"C"[1]	DDZ- woody debris removal (2016)	Arthropods, Vegetation
		R	UPL- upland forest	Arthropods
	Packsaddle South (PS-S)	T[2]	DDZ- woody debris removal (2014)	Vegetation-
		"C"[1]	DDZ- woody debris removal (2016)	Vegetation
		R	UPL- upland forest	-none-
	Yellowjacket Creek (YJ)	T	DDZ- woody debris removal (2014)	Arthropods, Birds, Vegetation
		C	DDZ- woody debris accumulation	Arthropods, Birds, Vegetation
		R	UPL- upland forest	Birds
	Valemount Peatland North (VP-N)	T	DDZ- woody debris removal (2014) & log boom installation	Arthropods, Birds, Vegetation
		C	DDZ- woody debris accumulation	Arthropods, Birds, Vegetation
		DDZ	DDZ- unaltered area adjacent to log-boom	Arthropods
		R	UPL- upland forest	Arthropods, Birds
	Valemount Peatland South (VP-S)	T	DDZ- woody debris removal (2012)	Birds
		R	UPL- upland forest	Birds
Bush Arm	**Bush Arm Causeway Northwest (BAC-N)**	T	DDZ- mound/windrow (2015)	Arthropods, Birds
		C	DDZ- unaltered	Arthropods, Birds
		R	UPL- upland forest	Birds
	Bush Arm Causeway Southwest (BAC-S)	T	DDZ- mound/windrow (2015)	Arthropods, Birds
		C	DDZ- unaltered	Arthropods, Birds
		R	UPL- upland forest	Birds
	Chatter Creek (CHT)	T*	DDZ- mound and/or windrow (proposed)	Arthropods, Birds
		C*	DDZ- unaltered	Arthropods, Birds
	Goodfellow Creek (GDF)	T*	DDZ- mound and/or windrow (proposed)	Birds
		C*	DDZ- unaltered	Birds
		R	UPL- upland forest	Arthropods, Birds
	Hope Creek (HOPE)	T*	DDZ- mound and/or windrow (proposed)	Birds
		C*	DDZ- unaltered	Birds
		R	UPL- upland forest	Arthropods, Birds

*indicates pre-treatment sampling

Physical Works trials to construct mounds and wind rows and clean ponds of wood debris in the drawdown zone of Kinbasket Reservoir were implemented at Bush Arm Causeway North and South (BAC-N, BAC-S) in Fall 2015 (Hawkes 2016a,b). The 2015 pilot project resulted in the construction of seven mounds in two locations, the cleaning of three previously wood-choked ponds in one location, and the removal of wood debris from the surrounding drawdown zone areas.

Additionally, these trials were aimed at increasing the topographic heterogeneity of the upper portion of the drawdown zone (i.e., making the flat and uniform surface conditions of the drawdown zone rough and more diverse). This method is proposed to create a diversity of current physical conditions and result in establishment of a diversity of plant species and thus increase site productivity (Polster 2011; Loreau 2010). The pre- and post- treatment state of the BAC-N and BAC-S sites are depicted in Figure 3-3 and Figure 3-4, respectively.

To protect areas cleared from wood debris at BAC-N (particularly the cleared wetlands), a log boom was installed in June 2016. Additional work focused on the planting of live stakes at the mounds at the BAC-S site. The effectiveness of these trials will be evaluated through future years of monitoring under CLBMON-9, CLBMON-37, and CLBMON-11A.

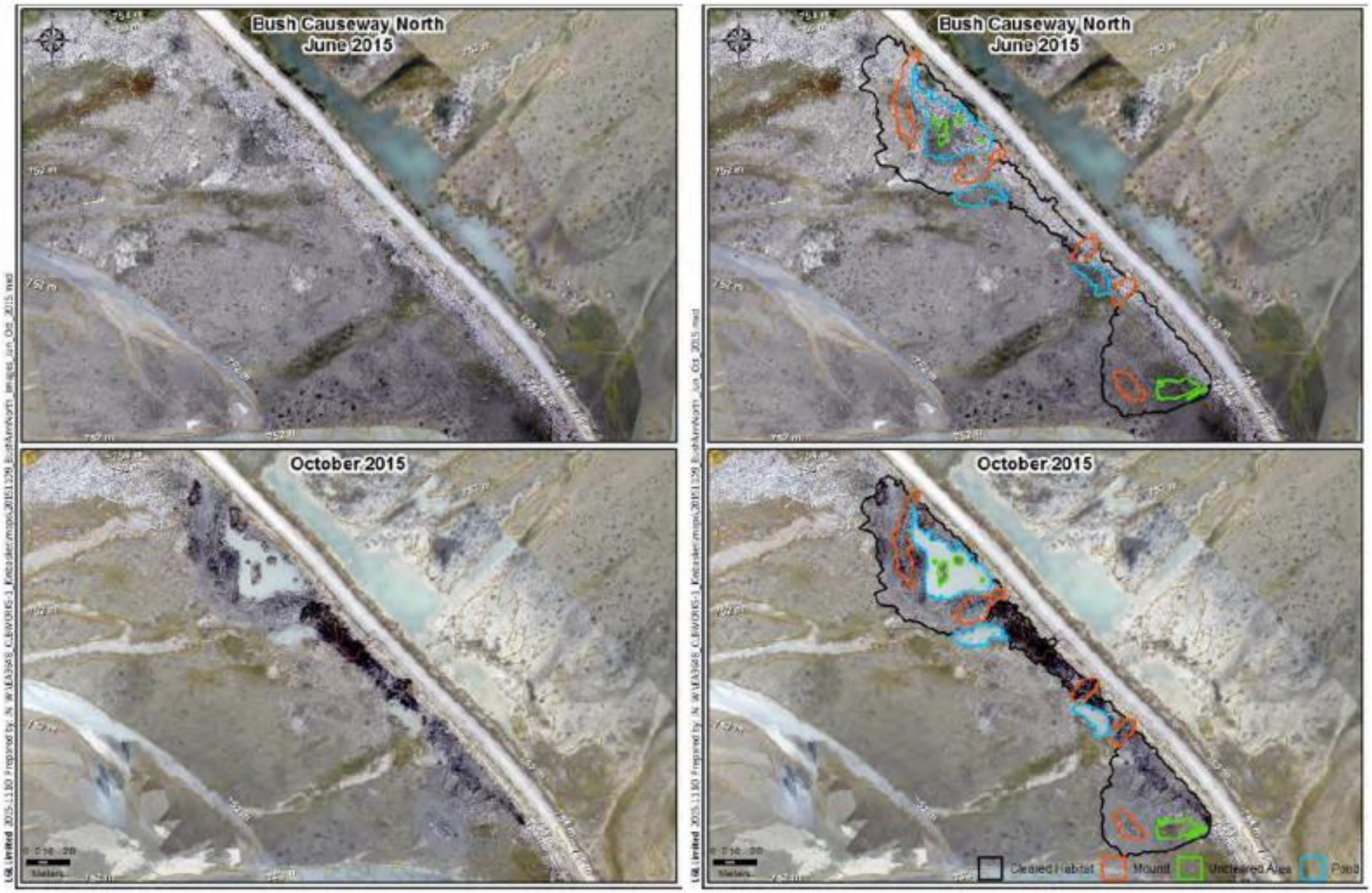

Figure 3-3: The Bush Causeway North site prior to construction (top left) and following clearing and construction of the mounds (bottom left). Polygons delineate the area cleared, not cleared, mounds, and ponds (top right, bottom right). Images obtained via drone (operated by Murray Chapple, Sterling Lumber)

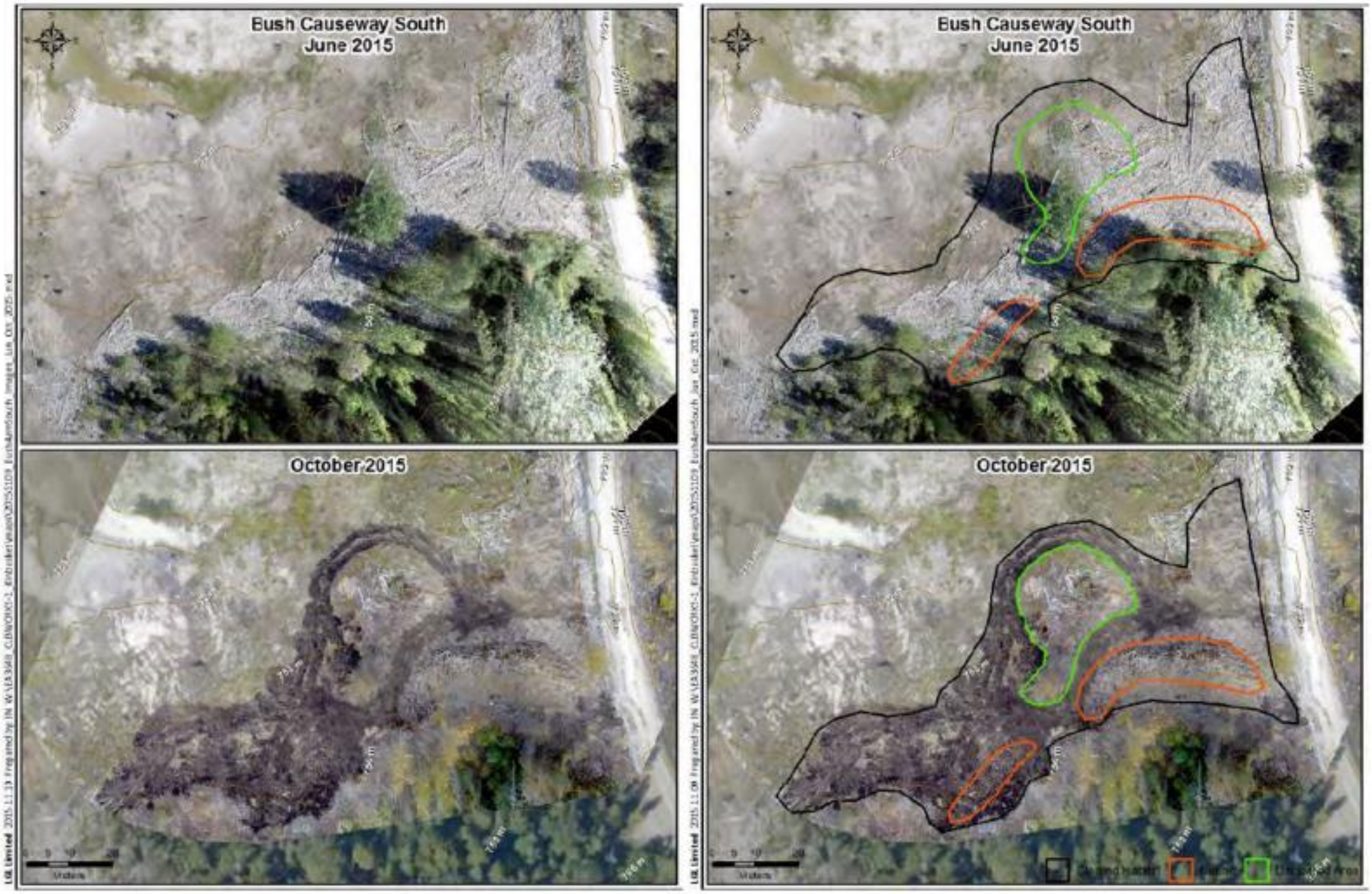

Figure 3-4: The Bush Causeway South site prior to construction (top left) and following clearing and construction of the mounds (bottom left). Polygons delineate the area cleared, not cleared, and the two mounds (top right, bottom right). Images obtained via drone (operated by Murray Chapple, Sterling Lumber)

4.0 METHODS

The focal taxa selected for study were ground-dwelling spiders and beetles and all breeding birds (songbirds and other birds such as grouse and shorebirds). Spiders and beetles were sampled using pitfall traps and birds via songbird point counts, line transects, and nest searches. The focal taxa align with those sampled under CLBMON-11A in previous implementation years. Vegetation data was collected at each of the treatments under CLBMON-9. Additional environmental and soil substrate data were collected to associate with arthropod and bird responses.

4.1 Environmental Conditions

Temperature and Relative Humidity data were collected during arthropod sampling to supplement arthropod data and assess changes in microclimate of treatments overtime. Onset® HOBO® data loggers (U23-002 HOBO Pro v2 External T/RH) were used in a subset of plots to measure per cent relative humidity and temperature over the period encompassing arthropod surveys. One logger was deployed at the approximate center of each plot in Canoe Reach (PS-N: T, C; VP-N: T, C, DDZ, R; YJ: T, C) and Bush Arm (CHT: T,C; HOPE: R; GDF: R; BAC-N: T,C, R; and BAC-S: T,C). Data loggers were held in place at the surface of the soil by attaching the base to a pin flag. Locations of all deployed data loggers are shown in maps within Appendix B.

Soil substrate was classified within the quadrats in vegetation transects by estimating per cent cover of the following substrate classes: live organic matter (LOM), dead organic matter, decayed wood, rock, mineral soil, and water.

4.2 Vegetation

Vegetation sampling was accomplished under CLBMON-9 and will be assessed therein. At Canoe Reach, sampling occurred on June 20-21 and July 13-14 in 2016. Upland reference transects were not sampled for vegetation in 2016.

We used modified belt-line transects to sample vegetation in woody debris treatment, control, and reference plots. At each of the five study areas in Canoe Reach (PS-N, PS-S, VP-N, VP-S, and YJ), three belt transects were established within each control, treatment, and reference area (reference vegetation only sampled in 2014).

Each belt transect was 20 m long and was sampled using five 4 m x 0.5 m quadrats in 2016. All vegetation within or overhanging each quadrat was identified to species, or in some cases to genus, and the per cent cover (to the nearest per cent) visually estimated, along with total covers for each stratum (herbs, shrubs, trees). Herb cover alone was assessed within the belt transects, while cover of woody species was visually estimated within the circular plots, using the same method as for herbs.

4.3 Terrestrial Arthropods

Ground-dwelling (‘epigaeic’) spiders (Araneae) and ground beetles (Coleoptera: Carabidae) are effective focal taxa for habitat monitoring. These taxa are easily and simultaneously sampled using pitfall traps (Marshall et al. 1994), comprise a large proportion of epigaeic arthropod abundance and diversity, occur in almost all terrestrial habitats, include both specialist and generalist species (Niemelä et al. 1993), can be studied across any gradient of habitat change, and respond to both fine-scale and landscape-scale environmental changes. Many other arthropod taxa are also collected by pitfall traps, as well as amphibians and small mammals.

The focal taxa align with those sampled under CLBMON-11A in the previous implementation years (Wood et al. 2015, 2016). These are species of spiders (Araneae) and species of ground beetles (Coleoptera: Carabidae).

4.3.1 Sampling Period

Terrestrial arthropods were sampled in two collection periods at Canoe Reach and Bush Arm in 2016 (Table 4-1). The collection periods were run continuously without trap closure between sample collections and total trap-effort was similar for the two reaches (15 days of trapping at Canoe Reach; 16 days at Bush Arm). The hour and minute of setup and collection were recorded for each trap so that trap-hours could be calculated. Trap disturbance resulting in loss of sample (e.g., reservoir inundation or animal disturbance) was recorded in order to account for the reduced sampling effort in data standardizations.

Table 4-1: Sampling period for terrestrial arthropods for 2016. Collection periods were run continuously between sample collection and traps were removed at the end of the second collection period

Reach	Trap installation	First collection	Second collection	Total trap-days[1]
Canoe Reach	June 10,11	June 16,17	June 23	
		~ 6 days	~ 6 days	~12 days
Bush Arm	June 13,14	June 19,20	June 25	
		~ 6 days	~ 5 days	~11 days

[1] number of days each trap array was collecting over the two collections

4.3.2 Survey Methodology

Arthropods were sampled with pitfall traps. We used 473 mL (16 oz.) clear plastic food tubs (Amcor®) as the pitfall traps (Figure 4-1), which were deployed in triangular arrays with ~1 m distance between traps. Pitfall trap cups were installed with a small trowel to a depth of approximately 10 cm so that the top rim of the cup was flush with the ground (Figure 4-1). In order to stabilize the soil around each trap, an outer cup receptacle was used. We inserted one pitfall cup inside the other and placed the trapping unit in each hole to prevent the hole from collapsing when collecting samples.

Pitfall traps were filled with ~100 mL of preservation fluid in order to kill and preserve arthropods. The type of fluid was chosen to suits the environmental conditions and frequency of trap collection (>1 day). We used propylene glycol as the preservation fluid because it provides excellent insect preservation and is non-toxic to wildlife that may consume the trap contents. In order to obtain unbiased samples for arthropod monitoring, traps were not baited (Marshall et al. 1994).

Figure 4-1: Pitfall trap installation showing individual traps (above) set at the level of the substrate and an array of three pitfall traps (below) with cover boards installed

Pitfall traps were covered with materials found within plots, such as small pieces of wood and flat rocks (Figure 4-1) to reduce evaporation, influx of rain and debris, and catch of vertebrates. Vertebrate by-catch was recorded as an incidental observation and the specimens were collected, labelled, and preserved for identification (donated to the Royal British Columbia Museum).

The three pitfall traps from each array were pooled as one sample unit when collected in the field. Contents from each sample unit were carefully transferred to a waterproof, plastic collection jar in the field (236 mL polypropylene snap cap specimen containers VWR®). Each sample was provided a unique collection label (one placed inside the sample jar, and labelled on the outside). The time (hh:mm) when each trap was installed and subsequently collected was recorded in order to appropriately standardize abundance of trap captures. Trap disturbance was recorded during a collection period and accounted for in catch-per-unit-effort calculations.

Preservation fluid was drained from samples in the laboratory/office shortly after field collection (≤ 2 weeks). Samples were carefully filtered with a fine mesh sieve (≤0.25 mm2), drained of preservation fluid, and transferred back into sample jars topped up with 70% ethanol for long-term preservation and storage.

4.3.3 Sampling and Replication

Terrestrial arthropods (spiders and beetles) were sampled using the methods outlined in the 2014 and 2015 reports (Wood et al. 2015, 2016). Methods were consistent with those described by the Resources Inventory Committee (1998d) and Biological Survey of Canada (Marshall et al. 1994). Trap arrangement and number of treatments sampled varied between reaches and are outlined as follows.

Canoe Reach

Arthropods were sampled within three study sites within Canoe Reach: Valemount Peatland North (VP-N), Packsaddle Creek North (PS-N), and Yellowjacket Creek

(YJ). Four treatments were studied within VP-N (T,C,R and "DDZ", which was untreated area between the treatment log boom and the control plot).

In each treatment type in Canoe Reach, nine sampling points were arranged in linear transects as detailed in Figure 4-2. Each transect was set within approximately the same elevation with transect "A" corresponding to the uppermost elevation and transect "C" corresponding to the lowest elevation. Each sampling point was comprised of an array of three pitfall traps, for a total of 27 pitfall traps deployed in each treatment plot.

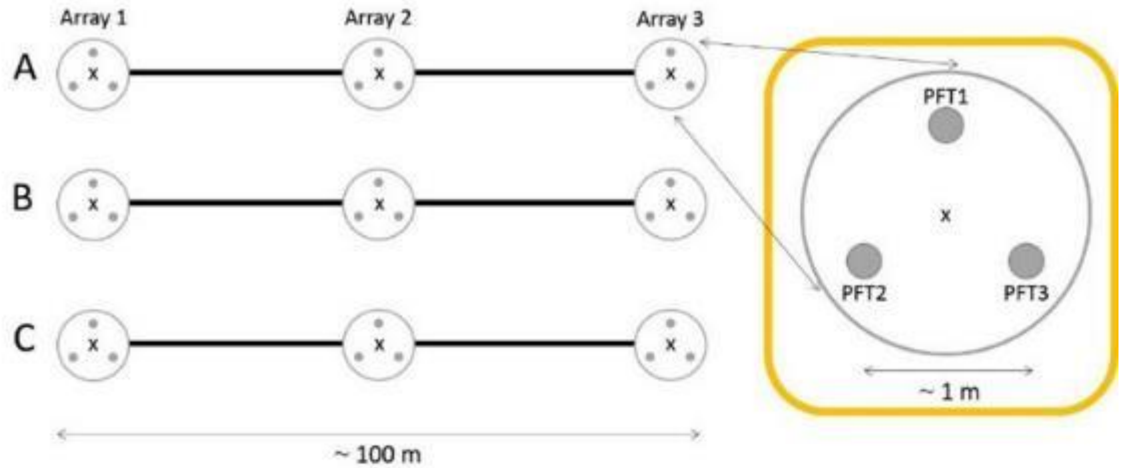

Figure 4-2: Schematic of the experimental design used to sample ground-dwelling arthropods in each treatment at Canoe Reach. Each treatment plot (left) contained nine individual trap arrays (right, yellow), arranged in linear transects. Pitfall arrays contained three pitfall traps (PFT; gray circles) arranged radially around a sampling station ('x'). Transects (black lines: A,B,C) were ~100 m in length with pitfall traps no closer than 1 m from each other. Transects were arranged according to elevation, such that "A" was always the uppermost transect and "C" was always the lowest transect.

Bush Arm

Arthropods were sampled within the five selected study sites at Bush Arm in 2015, including Chatter Creek (CHT), Goodfellow Creek (GDF), Hope Creek (HOPE), and two sites at Bush Arm Causeway (BAC-N and BAC-S). All sites were sampled prior to physical works trials being implemented in 2015, however in 2016 sampling occurred in a subset of these sites (Table 3-2). Each delineated treatment and control polygon were overlaid with a 5-m^2 grid. Within each treatment and control polygon, five grid cells were randomly selected for sampling with pitfall traps. As in Canoe Reach, all pitfall trapping points consisted of an array of three pitfall traps, which were pooled as single functioning replicates with each treatment area of each site (n= 5 trapping arrays at each treatment in each site).

4.3.4 Taxonomy and Natural History

Spider specimens were identified to species, where possible, by a local expert (Robb Bennett, Ph.D., Research Associate at the Royal British Columbia Museum). All beetles were identified to family and individuals of the families Carabidae ("ground beetles") were identified to species. Where beetle species did not align to described species and available keys, they were assigned unique morphospecies identities that are equivalent to species-level taxon groupings. The dissection of spider and beetle specimens was necessary for many specimens in order to examination traits in genitalia and determine species identities. Beetle classification was based on numerous taxonomic works, including, but not limited to: Arnett and Thomas (2001), Goulet (1983), Lindroth (1961-1969), and Pearson et al. (2006). The entomology collection at the Royal B.C. Museum (RBCM) in Victoria, British Columbia, was used as a reference for species identifications. Spider and beetle specimens were curated according to museum standards, and a reference collection was deposited at the RBCM. Immature specimens (beetle larvae and spiderlings) were excluded for all species-level data analyses.

4.4 Breeding Birds

4.4.1 Sampling Period

Songbirds and other breeding birds (e.g., shorebirds, grouse) were surveyed three times within the regional nesting period identified by Environment Canada (EC 2014). The regional nesting period identifies the time of year with the highest expected number of breeding bird species for a region, which occurs between mid-late May to mid-July for our study area. The time between surveys was 10 days; the first survey occurred between 28 and 30 May, the second between 10 and to 13 June, and the third between 23 and 26 June, 2016. All surveys commenced at Canoe Reach and ended at Bush Arm.

4.4.2 Survey Methodology

Survey methods were consistent with survey methods used in 2015 (Wood et al. 2016); line transects were used to survey the drawdown zone and variable-distance point counts were used to survey forest reference sites. All surveys followed Resource Inventory Standards Committee (RIC) protocols (1999), and line transect methods incorporated protocols outlined in Bibby et al. (2000). Surveys began at sunrise and ended within four hours (Ralph et al. 1995). Surveys only occurred under favourable conditions (i.e., no heavy wind or precipitation) to minimize variability in bird behaviour due to sub-optimal weather conditions.

Point count surveys occurred from stationary, pre-determined locations. All birds detected were recorded and distances from the observer were estimated to a distance band (i.e., 0-15 m, 15-30 m, 30-45 m, 45-60 m, 60-75 m, and >75 m), with a focus on birds within 75 meters (m) from the observer. A point count survey lasted 6 minutes, within which bird detections were categorized into detection time frames (0-3 minutes, 3-5 minutes, and 5-6 minute).

Line transects were placed within treatment and control areas of the drawdown zone, located relatively close to the shoreline and generally oriented parallel to the reservoir. In the sites at Canoe Reach, point count and line transects aligned with the middle transect (B) of the three pitfall-trapping transects applied for arthropod sampling. At Bush Arm, bird surveys were conducted in a straight-line that was laid in the middle of the delineated treatment and control polygons. All line transect surveys were conducted in a straight line between predetermined start and end locations, spaced 100-m apart. The observer traveled the length of the 100-m transect at a speed close to 1.2 km/h, which translated into a five-minute survey (Bibby et al. 2000). All birds detected were recorded and assigned two associated distances: the distance travelled along the transect (0-100 m) and the distance band perpendicular to the transect centreline (0-10 m, 11-25 m, 26-50 m, >50 m;

Figure 4-3). Although birds at all distances were recorded, the primary focus was on birds within 50 m of the transect centreline. As can be seen in the example provided in Figure 4-3, with bird detections represented by a blue "x", the Savannah Sparrow (SAVS) would have a 60-m distance along the transect line within the 25-50 m distance band.

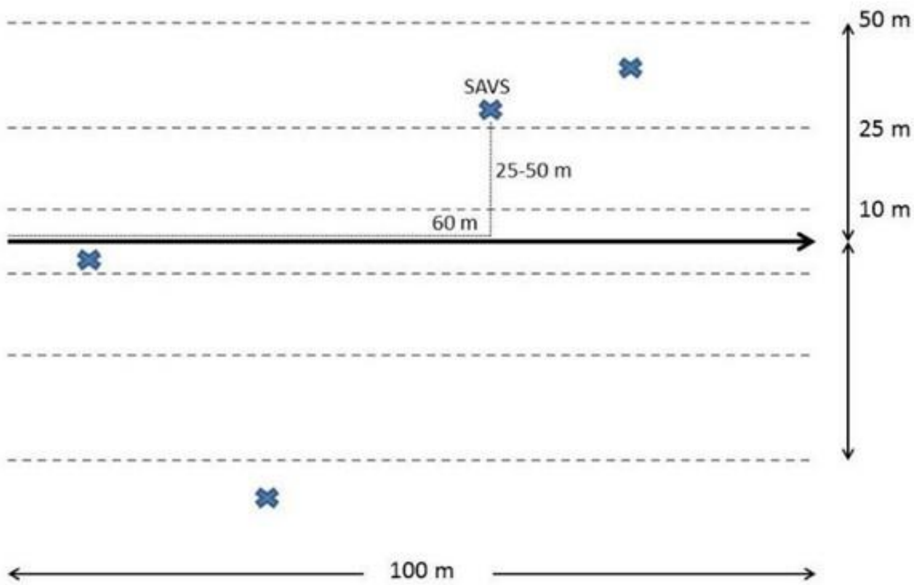

Figure 4-3: Schematic showing the line transect sampling design. The central transect is walked from left to right for 100 m. Birds (represented by blue "x") are recorded from various distance bands. Here an example is given for a Savannah Sparrow (SAVS) observation. Every bird has two associated distances recorded: (1) the distance along the transect to a point perpendicular to the bird (here 60 m), and the perpendicular distance from the transect to the bird (here in the 25-50 m distance interval). Birds are recorded from both sides of the transect, with the side noted based on the observer's direction of travel (here the sparrow is on the left)

The following data were collected at each point count station and line transect:

1. **Physical Information**: site name, station number, UTM coordinates, weather (average wind speed, temperature, relative humidity [measured by a Kestrel® 4000 Pocket Weather Meter], cloud cover, presence of precipitation), date, start and end time, and visit number;
2. **Bird observations (sight or sound)**: species, approximate age (adult/ juvenile/ unknown), sex (male/ female/ unknown), location of each detection (distance band and cardinal direction), detection type (song/ visual/ call), and fly-over (yes/ no).

Birds detected outside of survey times or survey locations were recorded as incidental observations. These are informative for generating a robust species list for each site but are not used in analyses.

4.4.3 Sampling and Replication

A total of 14 point-count stations and 15 line transects were surveyed at eight sites within the Kinbasket reservoir (Table 4-2). Six point-count stations and five line transects were surveyed at three sites in Canoe Reach. These were: Valemount Peatland North (VP-N), Valemount Peatland South (VP-S), and Yellowjacket

Creek (YJ). Each point count and line transect was surveyed three times, except for one line transect at Valemount Peatland South within Canoe Reach that was surveyed twice. All sites had the range of treatment types (reference, treatment and control) except for VP-S, which only had a treatment area (i.e., no control). Valemount Peatland North was the only site that received treatment because of the existence of a log boom that prevents woody debris accumulation, therefore the assessment of habitat use associated with woody debris removal will be assessed separately for this site. All other sites received woody debris removal two years prior to the 2016 bird survey period (i.e., in 2014), except for Valemount Peatland South which was four years prior (in 2012). Hence, due to the annual inundation of woody debris within treatment areas, results for treatment effectiveness will be confounded or obscured. Packsaddle sites (north and south) were not surveyed in 2016 because of the high degree of woody debris accumulation in 2016.

Table 4-2: Survey effort and type of survey conducted in Canoe Reach and Bush Arm in 2016

Reach	Treatment	Survey Type	No. of Survey Stations	No. of Surveys
Canoe Reach	Reference	Point Count	6	18
	Treatment	Line transect	3	9
	Control	Line transect	2	6
Bush Arm	Reference	Point Count	8	24
	Treatment	Line transect	5	15
	Control	Line transect	5	15

Eight point-count stations and 10 line transects were surveyed at five sites in Bush Arm (Table 4-2). These were: Causeway North (BAC-N), Causeway South (BAC-S), Chatter Creek (CC), Goodfellow Creek (GF), and Hope Creek (HC). All sites had the range of treatment types (reference, treatment and control) except for Chatter Creek, which did not have a reference site. Causeway North and Causeway South were the only locations that received woody debris removal in 2016, therefore the assessment of habitat use associated with woody debris removal will only be assessed for these sites (e.g., number of sites = 2). Data collected at all other sites within Bush Arm will be considered for assessing the pre-treatment reservoir condition, as was done in 2015 (Wood et al. 2016).

As noted in previous monitoring years, treatments within the drawdown zone are not of sufficient area to adequately replicate sampling within each site. Therefore, reference forest point counts and line transects within control and treatment sites are pooled within a reach to be used as replicates for comparisons.

4.4.4 Nesting Evidence

At both Canoe Reach and Bush Arm, all treatment and control plots were searched for nesting evidence over the same period as line transect surveys. Nesting evidence provides information on habitat use and suitability to ground nesting and shrub nesting birds in the drawdown zone, and is expected to increase in response to successful revegetation and enhancement of the drawdown zone, especially in the upper elevation bands of the reservoir. Given variability between species in the amount of time that can be needed to find a nest, nest searching included behaviour that indicated that a nest was close by when a nest could not be found but was strongly suspected (e.g., adult carrying food and not flying away, adult feeding a fledgling). Information recorded included species, behaviour, nest stage, nest substrate, number of eggs/ offspring, and UTM coordinates. Nests were flagged from a minimum of 10 m away and the distance, bearing and nest substrate was written on the flag (Thomas et al. 1997). Active nests were revisited upon subsequent surveys to assess nest status (success/ failure). Reference sites were not surveyed for nesting evidence because it is not informative to the effectiveness of revegetation and physical work trials.

4.5 Incidental Observations

Throughout the study period surveyors made note of incidental observations within (or nearby) study sites. All wildlife observations, tracks, and signs of habitat use were recorded at each site. Small mammals and amphibians incidentally collected during arthropod pitfall trap surveys were retained, identified to species, and donated to the Royal British Columbia Museum. Wildlife observations, were summarized in tables. Cumulatively over monitoring years these incidental observations will provide presence/non-detection or checklist information for non-target taxa at each study site.

5.0 DATA ANALYSES

Patterns in focal taxon abundance, richness, and composition were assessed across treatments and sites in Canoe Reach and Bush Arm for the 2016 monitoring period. Long-term and inter-annual responses will be examined in detail in future reporting years.

5.1 Data Standardizations

Vegetation and substrate classification data were standardized to the average cover per transect. Vegetation species were totalled per transect and averaged within each treatment within sites. For arthropods, relative abundance was standardized to the number of individuals collected per trap per day (CPUE per trap per 24 hr). Arthropod species richness was standardized to the number of species collected per trap day.

Prior to analysis of species richness and bird abundance, data were standardized for distance between surveys, distance from the observer, and species group. Two point-count surveys were used per site to increase distance between points and reduce potential overlap of survey areas. Within a survey, distance from the observer was constrained to contain only observations within 75 m from the observer at point count stations and within 50 m from the centreline of line transects. Despite such standardizations, constraints for distance from the observer may still result in the inclusion of habitat outside of target habitat (i.e., forest habitat adjacent to the drawdown zone).

In addition to distance from the observer, point count data were constrained by species group whereby only songbirds and swallows, swifts and hummingbirds were included for analyses. For both point counts and line transects, fly overs – considered detections of species not using the habitat – were omitted from analysis expect for swallows, swifts and hummingbirds, which forage on the wing and are usually only observed in flight.

Although called reference sites, bird data collected for point counts are not intended to be directly compared to treatment and control transects because the real objective is to understand the effects of treatment, and how treatment and control areas may differ over time. While the bird results from reference sites may be contrasted with control and treatment areas, we acknowledge that sampling methods and number of replicates differ, which make the data not directly comparable.

5.2 Barplots and Boxplots

Relative abundance and relative richness of focal taxa were examined through boxplots or bar plots. To aid the reader in interpreting boxplot graphs, the boxes represent between 25 per cent and 75 per cent of the ranked data. The horizontal line inside the box is the median. The length of the boxes is their interquartile range (Sokal and Rohlf 1995). A small box indicates that most data are found around the median (small dispersion of the data). The opposite is true for a long box: the data are dispersed and not concentrated around the median. Whiskers are drawn from the top of the box to the largest observation within 1.5 interquartile range of the top, and from the bottom of the box to the smallest observation within 1.5 interquartile range of the bottom of the box. Boxplots display the differences between groups of data without making any assumptions about their underlying statistical distributions, and show their dispersion and skewness. For this reason, they are ideal in displaying ecological data. All boxplots were created using R v. 3.2.4 (R Core Team 2016).

5.3 Group Means

Results of average temperature, relative humidity, and vegetation cover were tabulated with group means and confidence intervals. Confidence intervals were provided for $\alpha = 0.1$ (90%) and were calculated as ±1.645 x Standard Error.

Where statistical testing was performed, differences in relative abundance and corrected richness were compared using the Kruskal-Wallis rank sum test as a non-parametric alternative to analysis of variance. Post-hoc pairwise tests were corrected for multiple comparisons with the Bonferroni adjustment ($\alpha = 0.10$ / no. of comparisons). Kruskal-Wallis tests were performed using the R agricolae package (de Mendiburu 2014).

5.4 Species Assemblages

We performed non-metric multidimensional scaling ordinations (NMDS) to determine the major compositional variation in arthropod species assemblages in 2015 (spiders and ground beetles) and to examine relationships between treatments and environmental variables. NMDS maximizes the rank-order correlation between distance measures and the distance in ordination space. Points (i.e. samples) are moved to minimize mismatch between the two kinds of distance. Any specimens that were not identified to species-level (e.g., damaged specimens) were excluded from species richness and assemblage analyses.

Community composition data frequently contain a large number of zeroes, which tends to produce highly skewed frequency distributions. Transforming abundance data is often necessary to make them suitable for ordination analyses (Legendre and Gallagher 2001). Standardized species abundances (catch-per-trap-day) were Hellinger-transformed, whereby each taxon observation was relativized by the total taxon abundance, and square root transformed (Legendre and Gallagher 2001; Legendre and Legendre 2012). NMDS analyses were performed using the vegan package (Oksanen et al. 2014) in R.

5.5 Community Similarity

Similarity in species composition between treatment types and sites was assessed using cluster dendrograms with the Hellinger distance measure and the average-weight linkage method. Cluster analysis is used to define groups of samples based on their assemblage similarities. The cluster analyses are hierarchical and agglomerative, meaning that large clusters are composed of smaller clusters, and the analysis proceeds by joining clusters rather than by dividing them. Cluster analysis was performed in the vegan package in R using the hclust routine.

6.0 RESULTS

Target taxa (arthropods and breeding birds) were monitored in treatment areas at Canoe Reach and Bush Arm in 2016. Additionally, vegetation, substrate cover, and environmental variables were recorded as they are potential important characteristics of habitat quality. Following is a results summary of post-treatment responses in Canoe Reach and Bush Arm sites.

6.1 Site Conditions

6.1.1 Canoe Reach

Site-specific differences in temperature, humidity, light availability, and substrate composition may influence the vegetation and/or fauna (especially invertebrates) that occur in each treatment plot within sites. Trends in temperature and relative humidity varied among treatment areas in Canoe Reach (Table 6-1; Table 6-2).

It is still too early to determine if microclimate has changed in the treatment plots since wood removal in 2014. Assessing these long-term changes is complicated by the variable deposition of wood debris and consistency of experimental treatments (e.g., defunct control and re-treated treatment at PS-N and PS-S). However, trends in temperature and relative humidity will be explored in relation in revegetation success and wildlife responses in future years of the CLBMON-11A program.

Table 6-1: Average temperature (°C) for Canoe Reach sites during arthropod surveys in 2014 (27 June to 15 July), 2015 (19 June to 4 July), and 2016 (10 to 23 June). Means given in bold with 90% confidence intervals (CI) below. T= treatment, C= control, D= drawdown zone, R= reference

Site		2014			2015			2016			
		T	C	R	T	C	R	T	C*	D	R
Packsaddle Creek	**mean**	**19.8**	**20.9**	**16.9**	**21.3**	**20.3**	**15.3**	**14.0**	**13.3**	**-**	**-**
	90% CI	0.7	0.7	0.4	0.9	0.8	0.4	0.6	0.5	-	-
Valemount Peatland	**mean**	**19.4**	**18.4**	**20.0**	**18.2**	**17.8**	**19.4**	**14.0**	**12.7**	**12.3**	**13.3**
North	90% CI	0.8	0.6	0.9	0.7	0.7	0.9	0.5	0.4	0.4	0.6
Yellowjacket Creek	**mean**	**19.3**	**17.4**	**17.2**	**18.2**	**18.5**	**16.4**	**14.0**	**14.0**	**-**	**-**
	90% CI	0.6	0.4	0.5	0.6	0.7	0.5	0.6	0.6	-	-

*wood was removed from the Packsaddle control and treatment plots in 2016, thus the control plot no longer served as a control for this monitoring program

Table 6-2: Average relative humidity (%) for Canoe Reach sites during arthropod surveys in 2014 (27 June to 15 July), 2015 (19 June to 4 July), and 2016 (10 to 23 June). Means given in bold with 90% confidence intervals (CI) below. T= treatment, C= control, D= drawdown zone, R= reference

Site		2014			2015			2016			
		T	C	R	T	C	R	T	C*	D	R
Packsaddle Creek	**mean**	**63.2**	**55.4**	**77.2**	**65.8**	**67.5**	**93.1**	**74.4**	**77.4**	**-**	**-**
North	90% CI	2.3	1.9	1.4	2.5	2.3	0.8	2.0	1.8	-	-
Valemount Peatland	**mean**	**68.1**	**72.9**	**70.9**	**77.9**	**83.2**	**71.1**	**86.7**	**81.7**	**84.7**	**81.7**
North	90% CI	2.1	1.8	2.1	1.8	1.4	2.4	1.3	1.5	1.9	1.9
Yellowjacket Creek	**mean**	**66.7**	**88.3**	**78.3**	**78.0**	**78.5**	**88.5**	**77.7**	**91.5**	**-**	**-**
	90% CI	2.0	1.1	1.7	1.8	2.0	1.2	1.8	1.4	-	-

*wood was removed from the Packsaddle control and treatment plots in 2016, thus the control plot no longer served as a control for this monitoring program

As reported previously (Wood et al. 2016), substrate composition varied by site and treatment plot in Canoe Reach (Figure 6-1). The drawdown zone areas at VP-N and the control at YJ have less cover of mineral soil which may translate to site-specific differences in revegetation and taxon responses to applied treatments. Additionally, wood debris distributions continue to be variable year-to-year, Particularly at the Packsaddle Creek sites (Figure 6-2). Between 2014 and 2015 monitoring periods, woody debris deposition occurred on the Packsaddle Creek treatments. In contrast, results from CLBWORKS-1 suggest that the log boom installed at VP-N treatment was an effective means of reducing wood debris accumulation following a high water event.

Wood distributions were altered further in 2016 at the Packsaddle sites. These sites were re-treated by removal of wood debris, including both treatment and control areas. Thus, the PS-S and PS-N control plots had very low cover of wood relative to other Canoe Reach controls (Figure 6-1), and no longer function as “controls” for wood removal in this monitoring program.

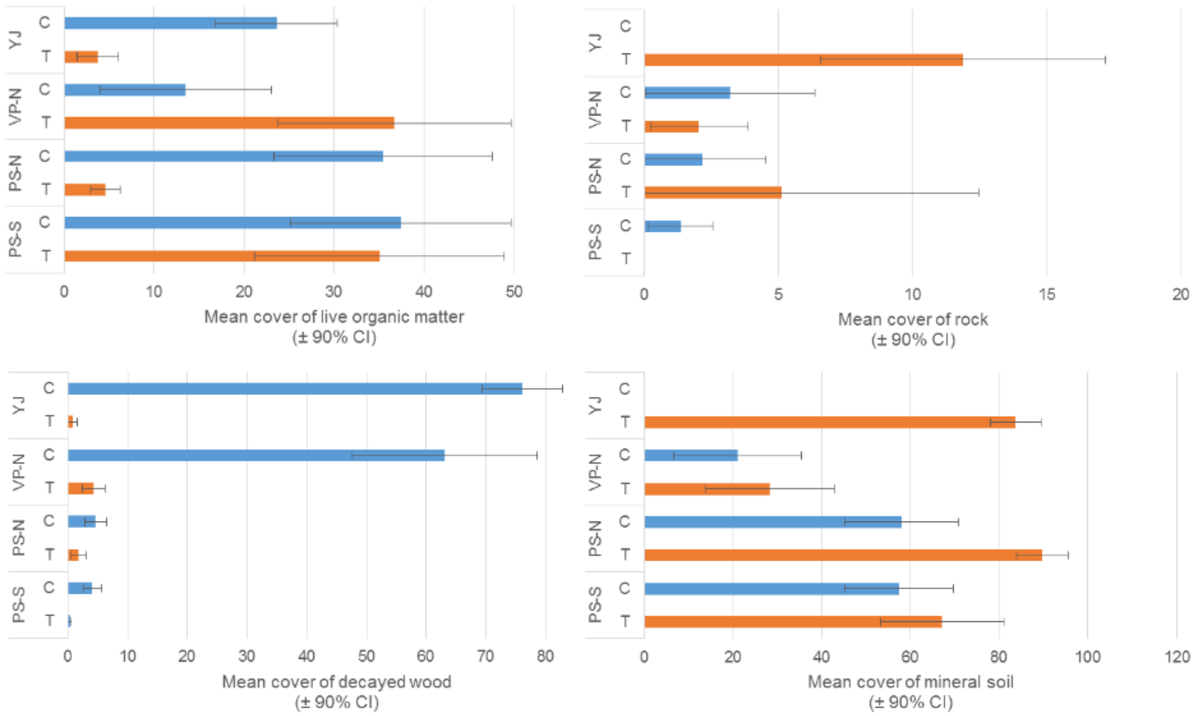

Figure 6-1: Mean (± 90% CI) per cent cover of vegetation, rock, decayed wood, and mineral soil recorded at treatment (T) and control (C) vegetation transects in Canoe Reach in 2016. Site codes are as listed in Table 3-2; CI= confidence interval

The change in wood distributions on treatment and control plots complicates our annual effectiveness monitoring of the wood removal program implemented in the drawdown zone at Canoe Reach. Cover of wood and underlying differences in soil substrates may alter distributions of vegetation, arthropods, and other fauna. Thus, interpretation of results must consider the context of these dynamic "treatment" and "control" areas, which are prone to changes on a year-to-year basis.

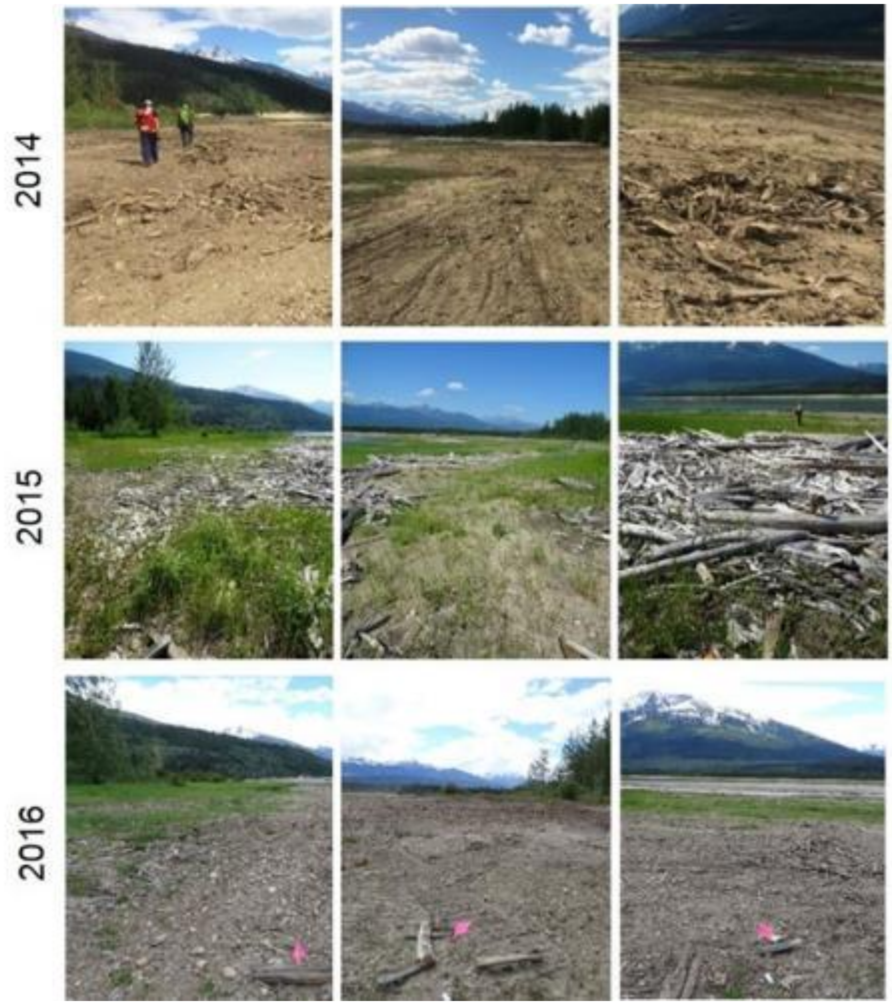

Figure 6-2: Treatment plot at Packsaddle Creek North (PS-N T) after initial wood removal in 2014 (top), one year post-treatment in 2015 (middle), and subsequent re-treatment in 2016 (bottom). Photo directions approximately southeast (left), northwest (centre), and west towards the reservoir (right) from the plot centre. Changes in vegetation and woody debris cover are apparent. A log boom was not installed at this site

Preliminary trial results suggest that terrestrial and wetland vegetation have increased where debris was removed and the log boom was installed to exclude further wood accumulation at VP-N treatment. Trends in vegetation cover were also highly variable between sites and treatments (Figure 6-1: live organic matter). Relative to the first year of wood removal, treatment plots at VP-N and YJ increased in vegetation cover (Figure 6-3, Figure 6-4). However, at most sites, treatments had comparable or lower vegetation cover as controls, except at VP-N, where the treatment plot has exhibited more successful revegetation relative to the VP-N control.

Trends in vegetation cover may become clearer in future years of monitoring and will shed light on site-specific characteristics that govern the effectiveness of treatment prescriptions. Following is a general summary of patterns in the vegetation data. Detailed assessment of changes in vegetation is treated under CLBMON-9.

Figure 6-3: Treatment plot at Valemount Peatland North (VP-N T) after initial wood removal in 2014 (left) and two years post-treatment in 2016 (right). Photo directions approximately northwest. A log boom was installed at this site

Figure 6-4: Treatment plot at Yellowjacket Creek (YJ T) after initial wood removal in 2014 (top), one-year post treatment in 2015 (middle), and two years post-treatment in 2016 (bottom). A log boom was not installed at this site

6.1.2 Bush Arm

Environmental conditions were monitored at study sites in 2015 and 2016. Most treatment and control areas were similar in terms of temperature and relative humidity in the drawdown zone of Bush Arm in 2015 and 2016 (Table 6-3). However, relative humidity differed between control and treatment areas at the Bush Arm Causeway North (BAC-N) site (consistent with pre-treatment differences). This site was more humid than nearby mature forest areas and had a milder temperature than the treatment sites at Goodfellow Creek and Hope Creek. Chatter Creek also exhibited pre-treatment differences in relative humidity between the delineated control and treatment areas, indicating that soil surface moisture is greater in the control polygon.

Table 6-3: Average temperature (°C) for Bush Arm sites in 2015 and 2016 during arthropod trapping sessions. Means given in bold with 90% confidence intervals (CI) below. T= treatment, C= control, R= reference

		2015* Temperature			2016 Temperature		
Site		T	C	R	T	C	R
Bush Arm Causeway	mean	**19.6**	**20.9**	**20.2**	**13.4**	**14.0**	**12.3**
North	90% CI	0.7	0.8	0.5	0.5	0.6	0.4
Bush Arm Causeway	mean				**13.5**	**13.8**	
South	90% CI				0.6	0.6	
Chatter Creek*	mean				**14.2**	**13.9**	
	90% CI				0.6	0.6	
Goodfellow Creek	mean	**23.6**	**23.7**	**19.4**			**12.4**
	90% CI	0.7	0.8	0.5			0.4
Hope Creek	mean	**24.0**	**24.9**	**19.2**			**14.3**
	90% CI	0.9	0.8	0.6			0.6

*Note: pre-treatment monitoring

Table 6-4: Average Relative Humidity (%) for Bush Arm sites in 2015 and 2016 during arthropod trapping sessions. Means given in bold with 90% confidence intervals (CI) below. T= treatment, C= control, R= reference

		2015* Relative Humidity			2016 Relative Humidity		
Site		T	C	R	T	C	R
Bush Arm Causeway	mean	**82.1**	**69.4**	**59.8**	**87.6**	**84.6**	**87.4**
North	90% CI	1.4	2.3	1.8	1.5	1.7	1.3
Bush Arm Causeway	mean				**83.6**	**83.6**	
South	90% CI				1.7	1.7	
Chatter Creek*	mean				**81.7**	**86.9**	
	90% CI				1.8	1.4	
Goodfellow Creek	mean	**55.6**	**55.0**	**62.7**			**83.6**
	90% CI	2.3	2.3	1.9			1.4
Hope Creek	mean	**53.0**	**51.0**	**71.6**			**87.6**
	90% CI	2.4	2.2	1.9			1.8

*Note: pre-treatment monitoring

Hawkes (2016a,b) reported initial vegetation growth (rose, black cottonwood, sedges, horsetail, grasses) on the mounds and in areas cleared of wood debris at Bush Arm Causeway North and South treatments (Figure 6-5). As vegetation establishment proceeds, monitoring under CLBMON-9 and CLBMON-11A will assess the effectiveness of these treatments.

Figure 6-5: Examples of natural vegetation establishment in mounds and cleared areas at Bush Arm Causeway. Top: *Rosa* sp., *Populus trichocarpa ssp. balsamifera* seedlings, and *Salix* sp. on mounds; middle: *Equisetum* sp. on cleared areas at BAC-N; and bottom: *Equisetum* sp. and *Calamagrostis* sp. on cleared areas of BAC-S. Natural vegetation establishment occurred within the first growing season following clearing in October 2015 [Photos from Hawkes 2016a]

6.2 Terrestrial Arthropods

During the past three monitoring years of CLBMON-11A, we have sorted and classified 7,181 adult spiders and 19,896 adult beetles. A summary of total abundance collected in each reach and each year is provided in Table 6-5.

In total, we have documented 19 distinct families of spiders; two were newly collected in 2016 (Telemidae and Pisauridae). Most spiders were in the family Lycosidae – Wolf spiders (53.7% by abundance), followed by the family Linyphiidae – Sheetweb and dwarf spiders (28.3%). Beetles have been classified into 41 families; two families newly collected in 2016 (Haliplidae and Trogossitidae). The vast majority of beetles were in the family Carabidae – Ground beetles (48.1%), followed by the family Staphylinidae – Rove beetles (27.4%).

Table 6-5: Total adult spider (Araneae) and adult beetle (Coleoptera) abundance collected in 2014, 2015, and 2016 pitfall trap surveys. Note: study sites and number of replicates varied between years

		Abundance (No. of Individuals)		
REACH	**YEAR**	**Araneae**	**Coleoptera**	**Total**
Canoe Reach	2014	2168	3450	5618
	2015	1727	8202	9929
	2016	2033	3860	5893
Bush Arm	2015	419	1956	2375
	2016	834	2428	3262
TOTAL		**7181**	**19896**	**27077**

6.2.1 Canoe Reach

Since implementation of wood removal at study sites in Canoe Reach, shifts in arthropod species composition and abundances have been noted (Wood et al. 2015, 2016). Some open-habitat spider and ground beetle species have declined with year since wood removal (Figure 6-6, Figure 6-7). Remaining years of monitoring are needed to determine if these trends hold over time.

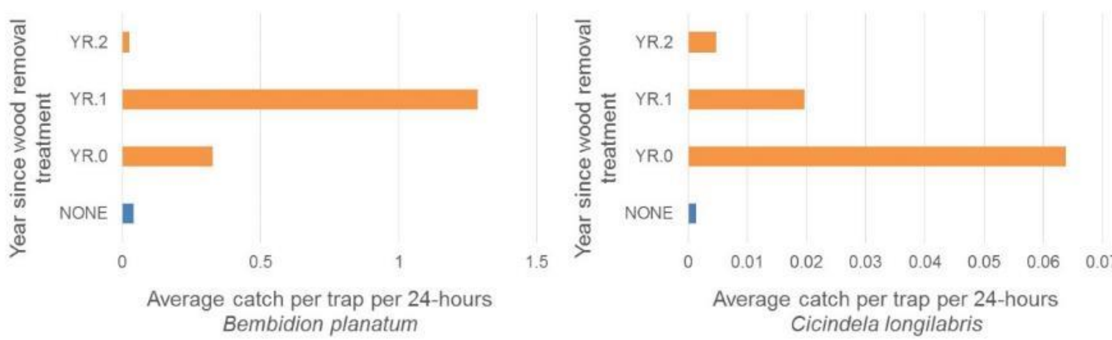

Figure 6-6: Relative abundance (adult catch per trap-day) of open-habitat ground beetles (*Bembidion planatum*, left, and *Cicindela longilabris*, right) across treatment plots at Canoe Reach by years since wood removal implementation. None= abundance in un-treated plots

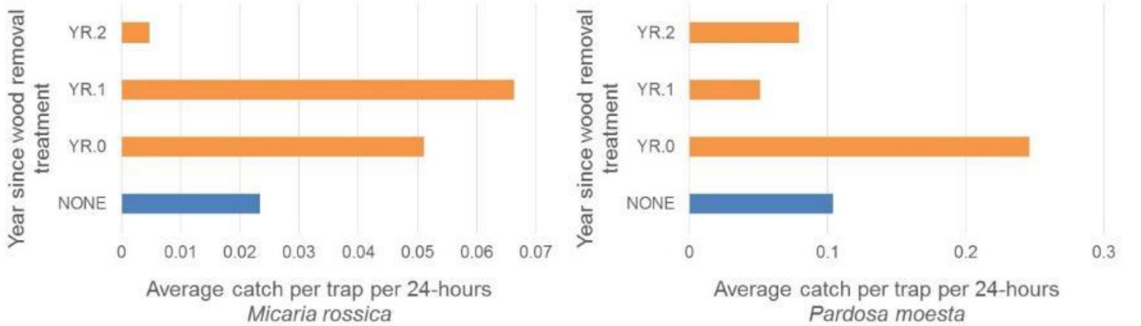

Figure 6-7: Relative abundance (adult catch per trap-day) of open-habitat spiders (*Micaria rossica*, left, and *Pardosa moesta*, right) across treatment plots at Canoe Reach by years since wood removal implementation. None= abundance in un-treated plots

Despite site-specific differences, arthropod species assemblages were clearly distinct among treatment types (Figure 6-8). As expected, communities were most stable overtime in upland reference sites (consistently cluster together). The arthropods of the Valemount Peatland treatment site are distinct from the other wood removal treatments (distant from other treatments in Figure 6-8), being more similar to the species composition of control plots.

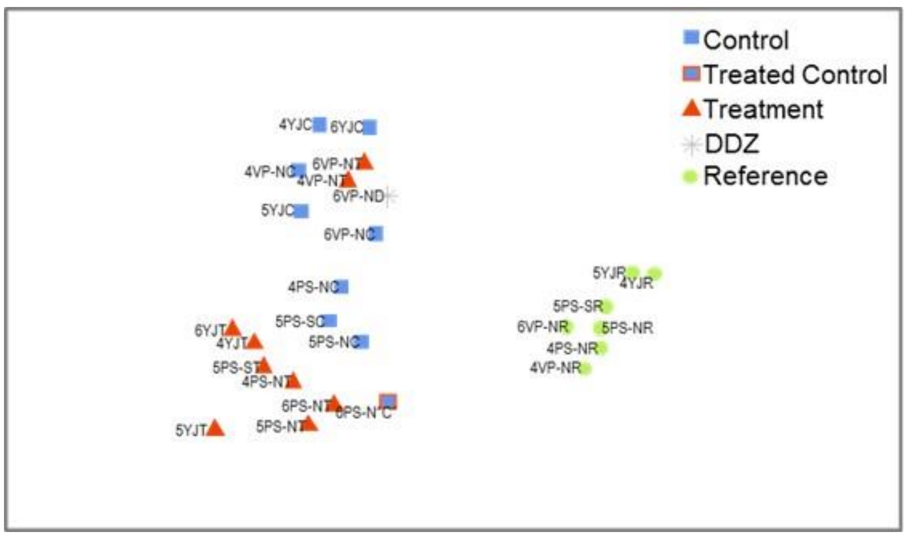

Figure 6-8: Non-metric Multidimensional Scaling (NMDS) ordination diagram of spider and ground beetle species assemblages from treatment types at each site in Canoe Reach in 2014, 2015, and 2016. Species assemblages are plotted for each treatment type, site, and year. The first number denotes the year of sampling, where 4= 2014, 5= 2015, and 6= 2016; site and treatment codes given in Table 3-2

6.2.2 Bush Arm

Arthropod species assemblages did not differ markedly since treatment application at BAC-N and BAC-S (Figure 6-9). Overall, in Bush Arm the arthropod assemblages are structured more by site-level differences than treatment and control areas. As shown in the cluster diagram (Figure 6-10), treatment and controls within a site usually group together, due to the similarity of arthropod assemblages. A few sites showed exception to this pattern. Chatter Creek and Hope Creek drawdown zone plots were very dissimilar in their arthropod assemblages (pre-treatment control and treatment). These pre-treatment differences are notable and will have to be examined carefully if treatments are applied in these drawdown zone areas. Note that treatments at Bush Arm were only applied in 2015, thus a longer response time may be needed to see changes in arthropods. If vegetation successfully establishes on/near mounds and created microsites on the treatment areas, arthropod composition and species patterns are expected to reflect these treatment differences.

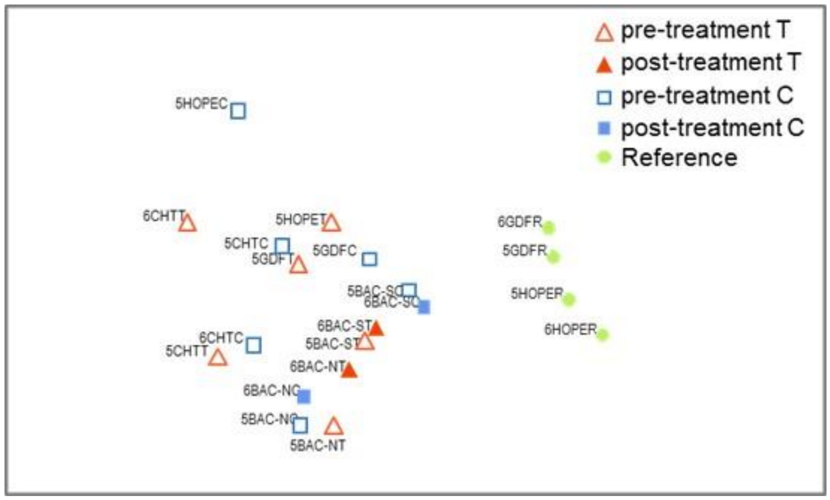

Figure 6-9: Non-metric Multidimensional Scaling (NMDS) ordination of spider and ground beetle species (Araneae and Carabidae) assemblages within each study site at Bush Arm in 2015 and 2016. T= treatment (wood removal/mounds), C= control (un-treated drawdown zone adjacent to T). Year of sampling denoted by the first number of site labels, where 5= 2015 and 6= 2016; site and treatment codes given in Table 3-2

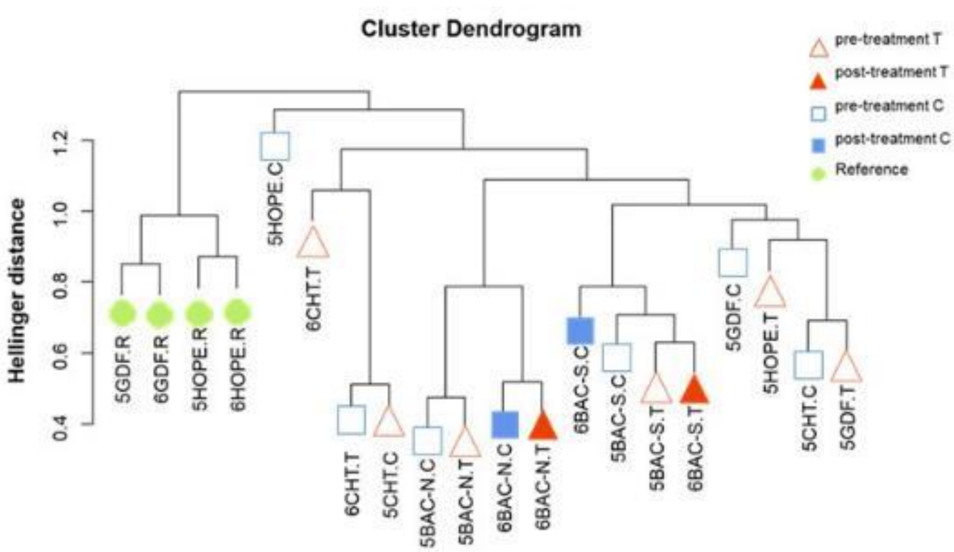

Figure 6-10: Non-metric Multidimensional Scaling (NMDS) ordination of spider and ground beetle species (Araneae and Carabidae) assemblages within each study site at Bush Arm in 2015 and 2016. T= treatment (wood removal/mounds), C= control (un-treated drawdown zone adjacent to T). Year of sampling denoted by the first number of site labels, where 5= 2015 and 6= 2016; site and treatment codes given in Table 3-2

6.3 Breeding Birds

A total of 59 species were recorded from all surveys conducted within both reaches in 2016, irrespective of the distance from the observer and species group (Table 6-6). Of these, surveys within reference plots recorded 48 species comprised of 479 observations. Line transect surveys at treatment and control sites recorded 51 species comprised of 286 observations (Table 6-6).

No species at risk were detected during surveys, but some were detected incidentally outside of survey periods (Section 6.4, Incidental Observations).

Table 6-6: Total number of species, observations and individuals recorded in 2016 during breeding bird point count and line transect surveys at Canoe Reach and Bush Arm within Kinbasket Reservoir. Data not constrained by distance from observer or species group. Pre-treatment, treatment, and control plots pooled in the "drawdown zone" category.

Species Group	Reference			Drawdown Zone			Total		
	Spp[1]	Obs[2]	Ind[3]	Spp	Obs	Ind	Spp	Obs	Ind
Hawks, Eagles, Falcons and Allies				2	2	2	2	2	2
Kingfishers and Allies	1	1	1	1	1	1	1	1	1
Loons				1	1	1	1	1	1
Upland Game Birds	1	5	5	2	1	1	1	6	6
Shorebirds, Gulls, Auks & Allies	2	8	8	2	14	15	3	22	23
Songbirds	38	448	456	40	260	279	45	708	735
Swifts and Hummingbirds	1	2	2				1	2	2
Waterfowl	1	3	3	2	1	1	1	6	6
Woodpeckers	1	12	13	3	5	5	4	17	18
Total	**48**	**479**	**488**	**51**	**285**	**309**	**59**	**764**	**797**

Note: [1]Spp = species; [2]Obs = Observations; [3]Ind = Individuals; [4]Drawdown zone category includes treatment and control plots.

After the application of data constraints, namely distance from the observer and species groups (see Section 5.1, Data Standardizations), a total of 38 species were detected, of which four species were represented by a single detection (Figure 6-11).

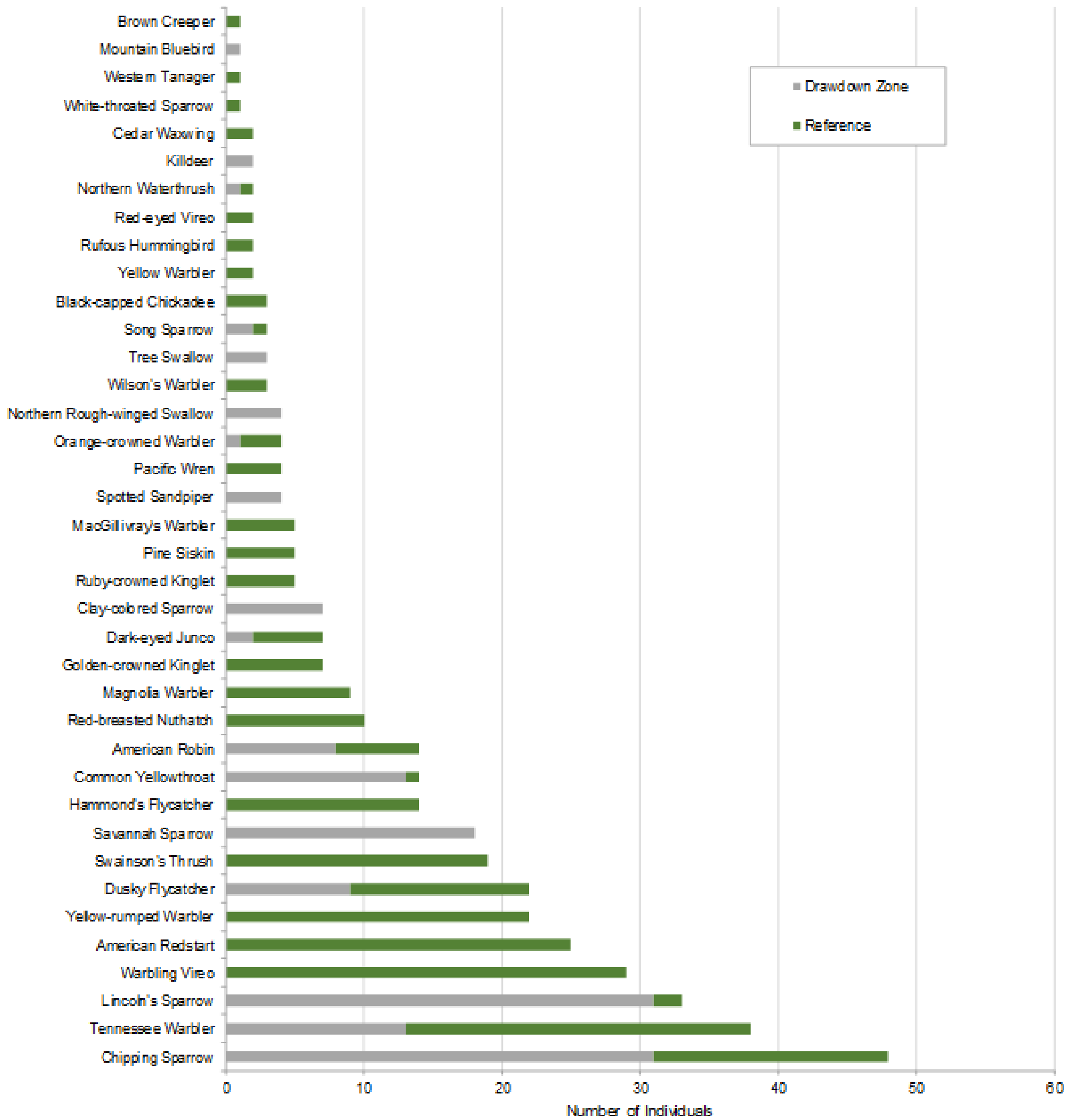

Figure 6-11: Total number of individual birds detected by species during point count (reference forest) and line transect (drawdown zone) surveys in 2016 at Bush Arm and Canoe Reach within Kinbasket Reservoir. Data constrained by distance from observer (i.e., 75 m point counts, 50 m transects) and species group.

Species that were only observed in the drawdown zone were Savannah Sparrow, Clay-coloured Sparrow, Spotted Sandpiper, Northern Rough-winged Sparrow, Tree Swallow, Killdeer, and Mountain Bluebird (Figure 6-11).

6.3.1 Canoe Reach

We found no differences in standardized bird abundance and species richness between controls and treatments within the drawdown zone (Table 6-7). However, these results are confounded by the return of woody debris to treatment sites during the inundation period in 2015, low sample sizes, and differences in effort between treatment types. Only Valemount Peatland North was free of woody debris accumulation in 2015 due to the presence of a log boom.

Table 6-7: Standardized abundance and number of bird species detected at survey stations in Canoe Reach in 2016. Data are constrained to include only birds within 75 m of point count stations or 50 m of line transects.

Treatment	Survey Type	No. of Surveys	No. of Spp	No. of Obs.	Spp/ Survey	Obs/ Survey
Reference	Point Count	18	25	135	1.4	7.5
Treatment	Line transect	9	8	21	0.9	2.3
Control	Line transect	6	9	28	1.5	4.7

Note: [1]Spp means species; [2]Obs means Observations

At Valemount Peatland North (VP-N), where the presence of a log boom prevented the accumulation of woody debris at the treatment plot, bird abundance and species richness did not differ between the treatment and the control site (Figure 6-12A). However, we only focused bird surveys in the single treatment site (i.e., VP-N), which does not provide sufficient data for conclusions (n=3 surveys/ treatment and control plot at VP-N). It is possible that within site differences may be obscuring differences between treatment plots at other sites.

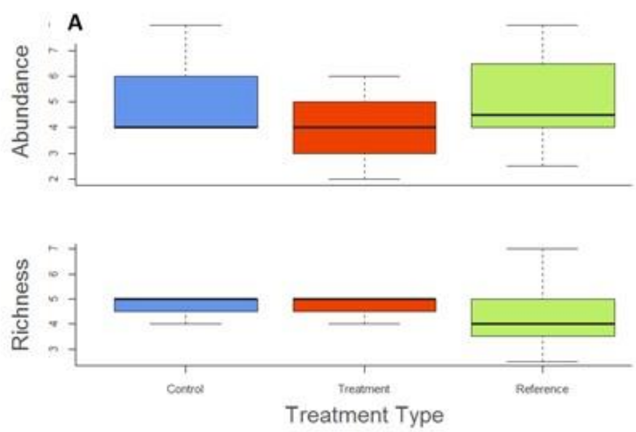

Figure 6-12: Boxplots of relative abundance (number of individuals per survey; top panel) and species richness (total number of species per survey; bottom panel) at Valemount Peatland North in 2016 (treatment in effect since 2014)

Species that were found exclusively in the treatment plot at Valemount Peatland North were Chipping sparrow, Song Sparrow, and Western Meadowlark (data constrained by distance from the transect centerline; Figure 6-13). Savannah Sparrow and Western Meadowlark may be responding to habitat that has opened in the treatment area by the log boom. Although not detected at Valemount Peatland North, Spotted Sandpiper was detected at other sites within the drawdown zone within Canoe Reach in 2016 (Figure 6-13), and were confirmed as breeding in 2015 (Wood et al. 2016). Additional surveys and nest searches for Savannah Sparrow and Spotted Sandpiper will continue to be monitored as indicators of revegetation success associated with woody debris removal. The creation and maintenance of treatment plots that prevent woody debris accumulation during inundation periods are therefore key for assessing revegetation success.

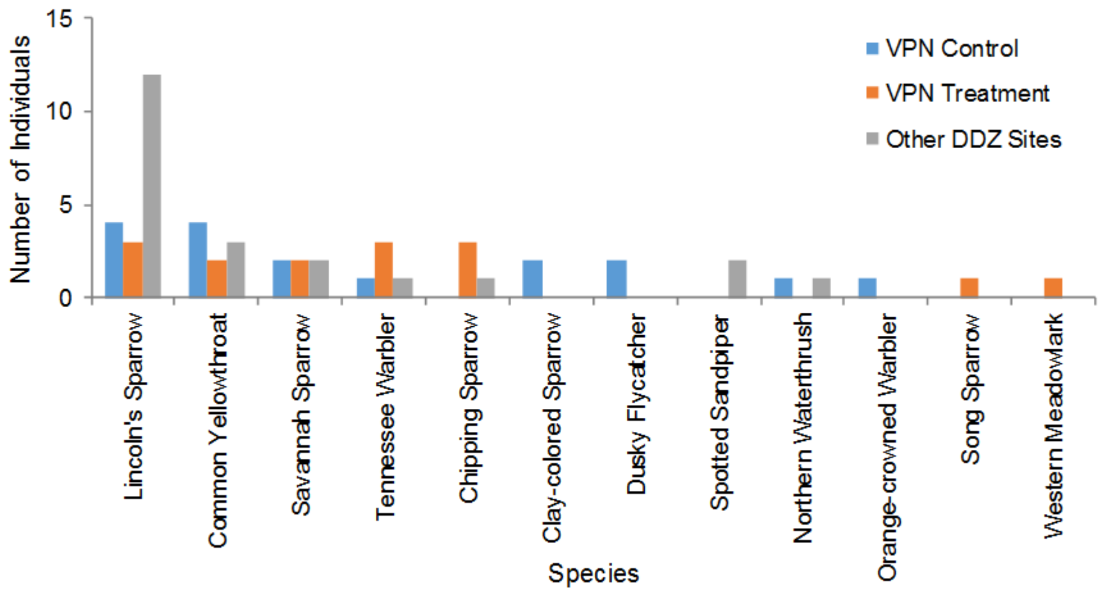

Figure 6-13: Number of Individuals per species detected during line transects at Valemount Peatland North (VP-N) control (blue) and treatment (orange) areas, and from two other sites within the drawdown zone (DDZ; grey) at Canoe Reach, Kinbasket reservoir (treatment in effect since 2014).

Point count surveys in reference forest detected 25 species from a total of 135 individuals (Figure 6-14; data constrained by distance and species group). Reference sites detected on average 15.7 species per site (max=20, min=12). Approximately two-thirds of the species detected in reference sites were unique to the reference treatment. Most of the species detected in reference sites are typical of forested or forest edge habitats.

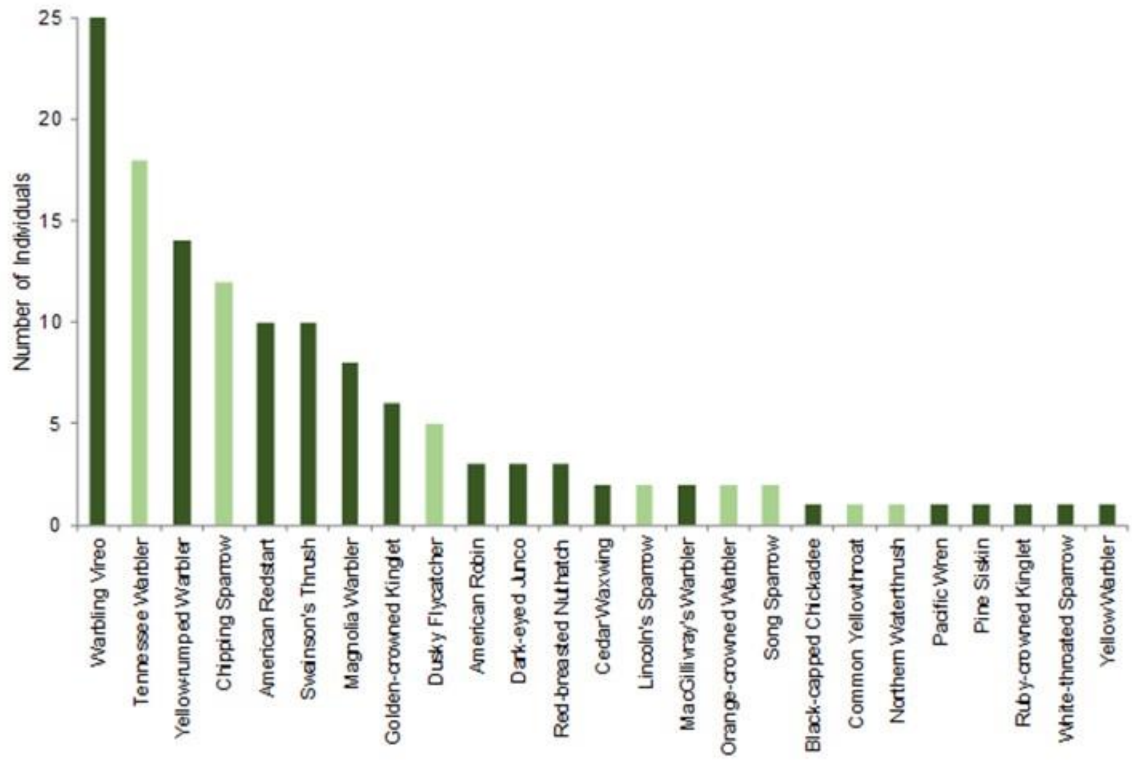

Figure 6-14: Number of individuals detected by species in forest reference plots at Canoe Reach, Kinbasket Reservoir. Dark green bars indicate species unique to reference plots; pale green bars indicate species also detected within the drawdown zone.

Nesting Evidence

One nest was found and five evidences of nesting (i.e., recently fledged flightless young; adult carrying food) were observed between 23-26 June within the drawdown zone at Canoe Reach (Table 6-8).

Table 6-8: Suspected and confirmed nesting activity within drawdown zone study plots in Canoe Reach in 2016. See Table 3-2 for site codes. N/A = not applicable (outside of treatment polygon)

Site	Species	Date Detected	Nest Substrate	Nest Stage	Treatment Type	Nest Fate
VP-S	Lincoln's Sparrow	16 June	Shrub	Nestling	Treatment	Unknown
VP-N	Lincoln's Sparrow	17-June	Ground	Nestling	Control	Unknown
YJ	Cedar Waxwing	5-July	Ground	Nestling	Control	Unknown
YJ	Tennessee Warbler	18-June	Ground	Fledgling	Control	Success
VP-N	Common Yellowthroat	18-June	Ground	Nestling	Control	Unknown
VP-N	Lincoln's Sparrow	5-July	Ground	Nestling	Control	Unknown

The one nest was found three metres above the ground in a tall willow at the edge of the control plot at Yellowjacket Creek. Three large nestlings were present in the nest and the adults were close by. Also at Yellowjacket creek, an adult Tennessee Warbler was observed in a short willow at the edge of the control plot feeding a flightless fledgling. Three detections of Lincoln's Sparrow carrying food and behaving in a territorial manner were made; two at Valemount Peatland North (control plot) and one at Valemount Peatland South (treatment plot), suggesting that a nest with nestlings was likely within 20 m of the areas detected. No Savannah Sparrow or Spotted Sandpiper nests were detected within plots at Canoe Reach in 2016.

6.3.2 Bush Arm

Of the five sites surveyed at Bush Arm, only Causeway North and Causeway South received physical works in treatment plots of the drawdown zone prior to surveys in 2016. All other sites remained untreated and are therefore classified as pre-treatment in this report, as was done for all Bush Arm sites in 2015 (**Table** 6**-**9; Wood et al. 2016).

Table 6-9: Standardized number of bird species detected and number of detections during 2016 surveys at Bush Arm

Treatment Type	Survey Type	No. Surveys	No. Spp[1]	No. Obs[2]	No. Spp/Survey	No. Obs/Survey
Reference	Point Count	24	28	224	1.7	9.3
Treatment[3]	Line Transect	6	14	19	2.3	3.2
Control[3]	Line Transect	6	10	20	1.7	3.3
Pre-treatment (Treatment)[4]	Line Transect	9	8	26	0.9	2.9

Note: [1]Spp = species; [2]Obs = Observations; [3]Surveys at Causeway North and Causeway South; [4]Surveys at Chatter Creek, Goodfellow Creek, and Hope Creek.

We found no differences in standardized bird abundance and species richness between controls and treatments at the two treatment sites (BAC-N and BAC-S; **Table** 6**-**9,A), or within pre-treatment sites located within the drawdown zone (**Table** 6**-**9,B). Baseline differences between sites likely exist, however replication within sites to increase sample size is not possible due to the small size of plots. Therefore, physical works at the other study sites after the inundation period in 2016 is needed to increase sample size for surveys in 2017.

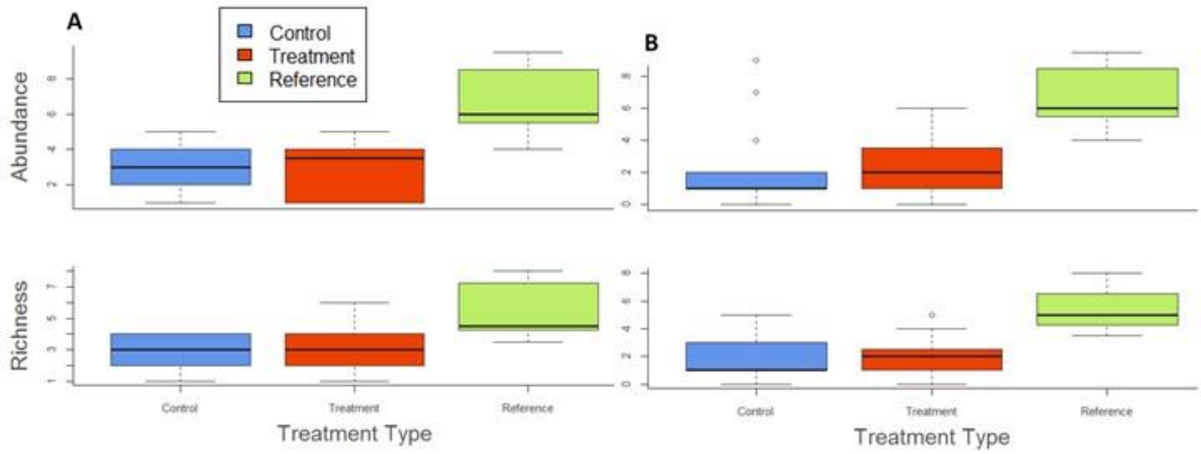

Figure 6-15: Boxplot showing relative abundance (number of individuals per survey; top panel) and species richness (total number of species per survey; bottom panel) at A), Causeway North and Causeway South in 2016 (both treated in 2015), and B), pre-treatment plots in 2015 and 2016 for each treatment type in Bush Arm, Kinbasket Reservoir.

Eight species were unique the drawdown zone at Bush Arm and were not detected at forest reference sites. These were: Savannah Sparrow, Lincoln's Sparrow, Clay-colored Sparrow, Common Yellowthroat, Killdeer, Tree Swallow, Spotted Sandpiper, and Mountain Bluebird (data constrained by distance from the transect centerline; Figure 6-16). These species are characteristic of open-habitats and were expected to be present within the drawdown zone of Kinbasket Reservoir. Barn swallow was also unique to drawdown zone sites but was only recorded incidentally (See Section 6.4, Incidental Observations).

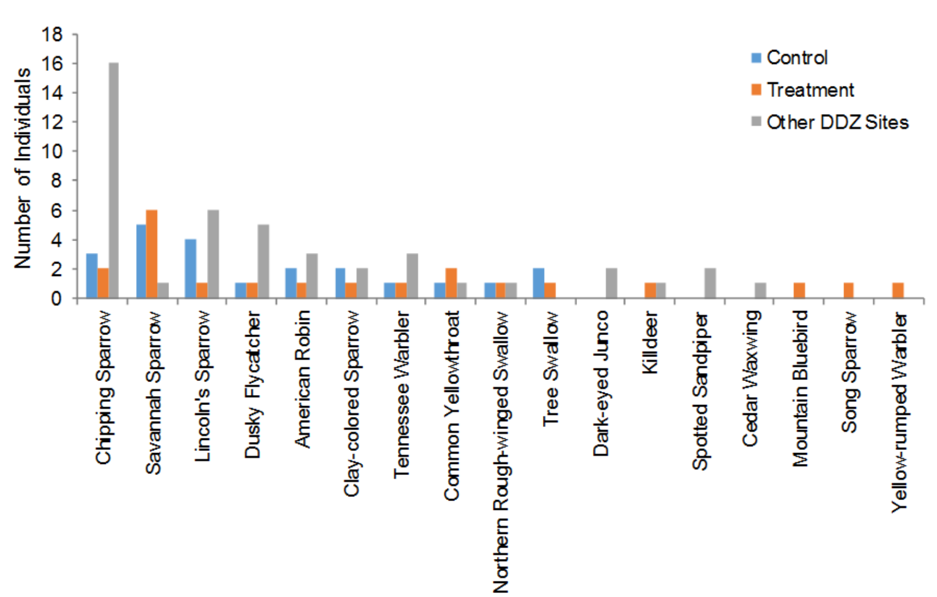

Figure 6-16: Number of individuals per species detected during line transect surveys in 2016 (treatment in effect since 2015) at Causeway North and Causeway South control (blue) and treatment (orange) areas, and from sites where no treatment was applied within the drawdown zone (DDZ; grey) at Bush Arm, Kinbasket Reservoir.

A total of 28 species represented by 224 individuals were recorded at reference forest sites (Based on constrained data, see Section 5.1, Data Standardizations). Fewer than a quarter of the species detected within reference plots were detected within drawdown zone plots (Figure 6-17). Species detected within reference sites were characteristic of forested habitats, or forest edge habitats for species also detected within drawdown zone plots.

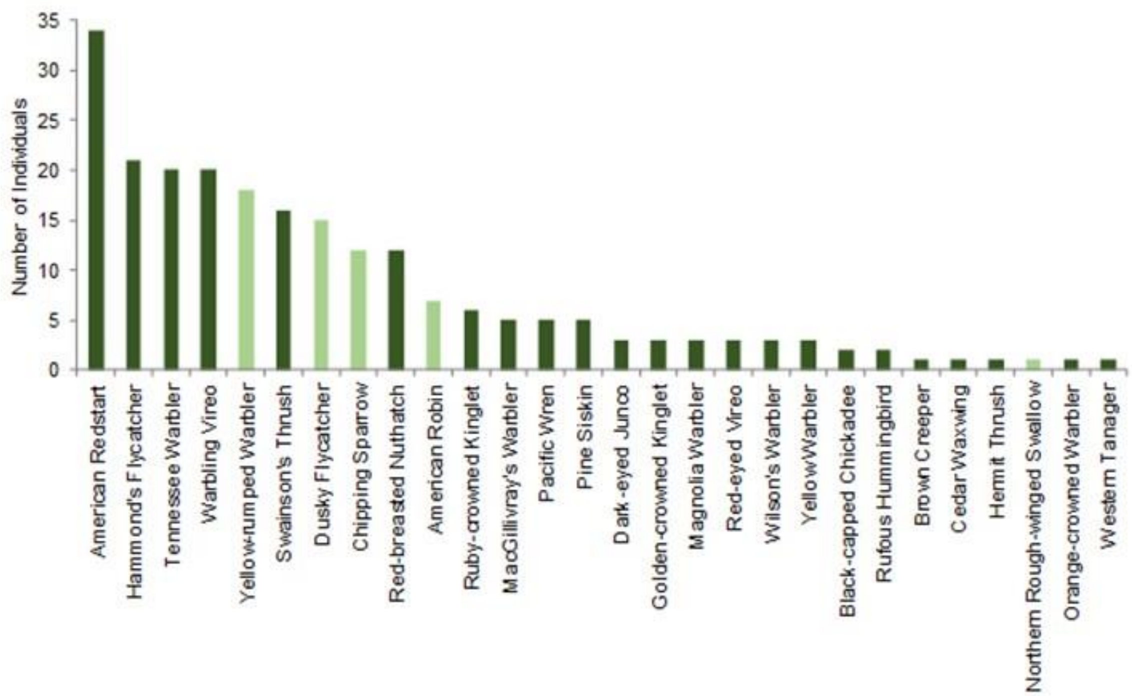

Figure 6-17: Number of individuals detected in forest reference plots in 2016 at Bush Arm, Kinbasket Reservoir. Dark green bars indicate species unique to reference plots; pale green bars indicate species also detected within the drawdown zone.

Nesting Evidence

A total of nine nests and three nesting evidences were detected within the drawdown zone at Bush Arm in 2016 (Table 6-10). One nest was found incidentally on May 1st during other activities in the area, and another nest was found at the end of May. One nest was found in early June, and six nests were found in late June.

Table 6-10: Suspected and confirmed nesting activity within drawdown zone study plots in 2016 at Bush Arm, Kinbasket Reservoir. See Table 3-2 for site codes. N/A = not applicable (unknown or outside of treatment polygon)

Site	Species	Date Detected	Nest Substrate	Nesting Stage	Treatment Type	Nest Fate
BAC-S	Killdeer	1 May	Ground	Incubation	Treatment	Unknown
BAC-S	Lincoln's Sparrow	30 May	N/A	Egg laying	N/A	Unknown
GDF	Mountain Bluebird	30 May/ 14 June	Cavity in stump	Nestling/ Fledgling	N/A	Success
CHT	Mountain Bluebird	12 June	Potential cavity in stump	Unknown	N/A	Potential Failure
BAC-S	Chipping Sparrow	13 June/ 21 June	Willow	Nest Building/ Incubation	Control	Unknown
BAC-N	Savannah Sparrow	21 June	Ground under small willow	Nestling	Treatment	Unknown
BAC-S	Savannah Sparrow	21 June	Ground under clump of grass	Incubation	Control	Unknown
CHT	Chipping Sparrow	25 June	N/A	Fledgling	N/A	Success
GDF	Clay-colored Sparrow	26 June	Willow	Nestling	Treatment	Unknown
GDF	Spotted Sandpiper	26 June	Ground	Incubation	Treatment	Unknown
HOPE	Mountain Bluebird	26 June	Cavity in stump	Nestling	N/A	Unknown
HOPE	Dark-eyed Junco	26 June	Ground	Incubation	Control	Unknown

No differences in nesting activity were found between control and treatment sites. Of the nine nests found, five were located on the ground, two in tree stumps within the drawdown zone outside of the study plots, and two in shrubs within the higher sections of the drawdown zone (Table 6-10). One potential Western Bluebird nest failure was identified by the detection of a female bluebird visiting a stump partially submerged, but could not be confirmed as nest failure due to deep water.

Both nests in stumps were occupied by Mountain Bluebirds. Nest holes were located at the top of the stump approximately 1.25 m above the ground, with the nest approximately 0.5 m from the ground (Figure 6-18). Two shorebird nests, one Killdeer and one Spotted Sandpiper, were found while incubating eggs (Table 6-10). Two nests with nestlings were found, one Cedar Waxwing and one Clay-coloured Sparrow. Nest success was observed for a Mountain Bluebird nest that was in a stump within the drawdown zone, and by observing nesting evidence of a chipping sparrow feeding a flightless fledgling (i.e., no nest found). As for Canoe Reach, should revegetation occurs through the strategic placement of physical works within the drawdown zone, ground-nesting species offer the greatest likelihood of short-term response through increased nesting activities.

Figure 6-18: Nest photos from the 2016 Bush Arm monitoring season. Top left: Savannah Sparrow nest at Causeway South. Top right: Mountain Bluebird nest in top of log at Hope Creek. Bottom left: Spotted Sandpiper nest at Goodfellow Creek. Bottom right: Chipping sparrow nest at Causeway South.

6.4 Incidental Observations

Incidental observations are useful for recording species that would otherwise not be detected during targeted surveys at each site. These incidental records of wildlife species contribute to the knowledge of these study sites at Kinbasket Reservoir. Our survey efforts were focused more extensively on drawdown zone areas in 2016 and thus, incidental observations are presented for those sites. Mammal presence at drawdown zone sites are summarized in Table 6-11.

As in previous years, deer tracks were the most commonly reported sign of wildlife in the drawdown zone. Deer were detected in the drawdown zone of all study sites in Canoe Reach and Bush Arm. Notable sightings in 2016 included tracks of brown bear (*Ursus arctos*) at the northwest end of the Bush Arm Causeway (BAC-N; sighted on June 20, 2016). North American river otter (*Lontra canadensis*) frequents the Chatter Creek drawdown zone site, noted by a prominent latrine flanking the old road between treatment and control polygons.

Table 6-11: Incidental sign of mammal presence (P) in the drawdown zone of Kinbasket Reservoir by site and reach in 2015 and 2016. Observations included visual sightings, tracks, scat, and other sign of all species, excluding small mammals. Deer species (White-tailed and Mule deer) are pooled due to difficulty in differentiating these species by pellets and tracks. BAC= Bush Arm Causeway, CHT= Chatter Creek, HOPE= Hope Creek, GDF= Goodfellow Creek, PS= Packsaddle Creek, and YJ= Yellowjacket Creek; N= North, S= South; M= Mammal

Species Code	Common Name	Bush Arm					Canoe Reach			
		BAC-N	BAC-S	CHT	GDF	HOPE	PS-N	PS-S	VP-N	YJ
M-URAR	Brown Bear	P								
M-URAM	Black Bear			P	P	P	P			P
M-CALU	Grey Wolf	P	P	P				P		
M-CALA	Coyote			P				P		P
M-LYCA	Canada Lynx		P							
M-LOCA	North American river otter		P	P						
M-ALAM	Moose			P	P					
M-CECA	Elk	P	P	P				P		
M-CERVID	Moose/Elk	P								
M-ODSP	Deer sp.	P	P	P	P	P	P	P	P	P
M-LEAM	Snowshoe hare					P				
M-MARTES	Wesasel sp.				P					
M-SOREX	Shrew sp.				P				P	
M-TAHU	Red squirrel									P

Table 6-12: Incidental visual and auditory detections of bird species in the drawdown zone of Kinbasket Reservoir by site in 2015 and 2016. BAC= Bush Arm Causeway, CHT= Chatter Creek, HOPE= Hope Creek, GDF= Goodfellow Creek, PS= Packsaddle Creek; N= North, S= South

Species Code	Common Name	Bush Arm					Canoe Reach				
		BAC-N	BAC-S	CHT	GDF	HOPE	PS-N	PS-S	VP-N	VP-S	YJ
B-AMRO	American Robin	1									
B-AWPE	American White Pelican						1				
B-BAEA	Bald Eagle				1				1		1
B-BARS	Barn Swallow	1	1								
B-BEKI	Belted Kingfisher		1								
B-BHCO	Brown-headed Cowbird			1							
B-BWTE	Blue-winged Teal								2		
B-CAGO	Canada Goose			1							
B-CEWA	Cedar waxwing	2									
B-CHSP	Chipping Sparrow		1								
B-COLO	Common Loon			1	2			1	1		
B-COME	Common Merganser				2						
B-EAKI	Eastern Kingbird			1							
B-GHOW	Great Horned Owl			1							
B-HAWO	Hairy Woodpecker		1								
B-KILL	Killdeer	5				2				1	
B-LCSP	LeConte's Sparrow		1								
B-LISP	Lincoln's Sparrow								1		
B-MOBL	Mountain Bluebird			3							
B-NOFL	Northern Flicker		1								
B-NOHA	Northern Harrier								1		
B-NRWS	Northern Rough-winged Swallow		1								
B-OSPR	Osprey						1	1	1	1	1
B-PISI	Pine Siskin	1									
B-PIWO	Pileated Woodpecker		1								
B-SACR	Sandhill Crane								1		
B-SORA	Sora								1		
B-SPSA	Spotted Sandpiper	1	2			1					1
B-SWTH	Swainson's Thrush	1									
B-WAVI	Warbling Vireo	2									
B-WIFL	Willow Flycatcher	1									

7.0 DISCUSSION

The efficacy of physical works trials, such as woody debris removal and creation of mounds/windrows of soil and wood are being assessed under CLBMON-11A and CLBMON-9 for enhancement of drawdown zone habitats. Future years of monitoring data are required to assess the short-term change in taxa abundance and assemblage composition. For example, the ground beetle *Bembidion planatum* prefers open habitats with bare ground and was a strong indicator of treatments at PS-N and YJ in 2014. As vegetation cover has increased, we have subsequently seen a reduction in abundance of this species in treatment plots at Canoe Reach. Likewise other bare ground associated taxa were shown to decrease since initial wood removal treatments (Figure 6-6; Figure 6-7), indicating that these taxa are sensitive and selective enough to signal habitat change.

Focal taxa selected for monitoring (ground-dwelling arthropods and birds) were selected due to their utility as indicators of habitat change. Our monitoring of these taxa is designed to detect responses to changes in environmental conditions, habitat quality, and/or prey densities in the drawdown zone of Kinbasket Reservoir resulting from treatment applications. So far, results have outlined the species-specific responses to treatments, and for arthropods site-specific differences have also been assessed. Future years will explore the cumulative change in focal taxa in treatments (compared to controls) as well as inter-annual changes. Where possible, site-by-treatment responses will be examined.

Whether post-treatment vegetation establishment is successful is yet to be determined and will likely to depend on site-specific attributes and exposure to wood debris accumulation or erosion from reservoir inundation. The effectiveness of revegetation and physical works trials that have been implemented in Kinbasket Reservoir are being assessed under the CLBMON-9 program. Focal taxa will continue to be monitored in order to determine if taxa are responding to local changes in habitat quality.

Additional log booms may prove useful to enhance natural revegetation of treatment areas. With two log-booms now installed, these trials can be assessed for efficacy during high reservoir events (e.g., filling to full pool). Maintaining the integrity of treatment and control plots is important to achieve the goals of this monitoring program. The loss of treatment and control plots at Packsaddle Creek compromises our study design in terms of studying birds as focal taxa. Additional efforts should be directed on limiting any new woody debris accumulation on the treatment plots. In the absence of protection, our experimental plots could be annually compromised by changes in woody debris distribution.

Within Canoe Reach, revegetation was most successful at the Valemount Peatland North site, due to the high organic matter content in the soil and installation of log booms around the treated area. In turn, we found the open-habitat arthropod fauna that were most indicative of these treatment areas in 2014 to decrease in abundance during the 2016 monitoring year. Species turnover will progressively result in assemblages that are associated with increased vertical structure and vegetation cover. Where non-native species (plants and beetles) occur, we expect there to be a slow replacement of those species by native species.

Following natural revegetation of the treatment plots, we expect increased richness and abundance of songbirds as a result of greater habitat heterogeneity. Of the songbird species using the drawdown zone, Savannah Sparrow is relatively common and this species is expected to colonize treatment areas following revegetation. Additional sparrow and warbler species would be expected if a shrub layer develops, which is most likely to happen at the upper elevations of the drawdown zone (i.e., >753 mASL). Overtime, this may lead to increases in the richness and abundance of songbirds in the drawdown zone. Increases in insect abundance may also translate to increased densities of breeding birds relative to pre-treatment conditions. Whether post-treatment vegetation establishment is successful is yet to be determined and will likely depend on site-specific attributes and exposure to woody debris accumulation or erosion from the reservoir.

The species richness and abundance of songbirds did not differ between control and treatment plots based on comparisons at each site that varied in the time since treatment (1 to 4 years). Evidence of nesting was generally low in all areas, which may reflect the small size of the plots relative to territory requirements of many breeding bird species. If vegetation establishes on treatment plots, the number of territories and nests of bird species might increase, indicating that the quality of the habitat has improved for birds. However, this could take some time as vegetation establishment is generally a slow process. Additional years of data will help determine trends related to bird richness, abundance, or nesting suitability.

7.1 Management Questions

The management questions as written were intended to assess the efficacy of the revegetation prescriptions applied under CLBWORKS-1 between 2008 and 2011 to enhance wildlife habitat in the drawdown zone. However, and as reported in Hawkes et al (2013), the revegetation prescriptions applied in the drawdown zone failed. One area (Bear Island) that was treated in 2013 continues to survive, but it is not currently a focus of CLBMON-11A.

The current status of our ability to answer each of the four management questions associated with CLBMON-11A is summarized below. We have responded to each question by referencing current data, which was collected to assess the efficacy of certain physical works (wood debris removal, log boom installation, and mound creation) to enhance the suitability of the drawdown zone for wildlife.

MQ1: How effective is the revegetation program at enhancing and increasing the utilization of habitat in the drawdown zone by wildlife such as amphibians, birds, small mammals, and ungulates?

Amphibians are currently only being monitored (under CLBMON-37 and CLBMON-58) at two locations associated with physical works: Valemount Peatland and the Bush Arm Causeway. During physical works implementation, a number of ponds have been cleared of wood debris, which has increased utilisation by Western Toad and Columbia Spotted Frog in these drawdown zone ponds. In addition to increased breeding at these cleared ponds, Hawkes (2016a) also reported growth of wetland vegetation in these ponds that were previously devoid of macrophytes.

Currently, bird abundance appears similar (low) in the control and treatment plots; however, it is too early to tell that the treatments are proving effective. Over time, and with an increase in the number of treatment sites consistently free of woody-debris accumulation, we would expect greater use of treatment sites by ground nesting species associated with open habitat, including Savannah Sparrow, Spotted Sandpiper, and Killdeer.

Small mammals are not currently being monitored under CLBMON-11A, however incidental captures in pitfall traps provide some opportunistic data on density of small mammals in treatment and control plots. In 2014, most drawdown zone plots had a higher density of shrews than upland reference sites. Year-to-year comparisons are not possible, but we expect shrews and granivorous small mammals to respond to treatment applications over the long-term if vegetation cover increases (along with arthropod abundance).

Ungulates are not currently being monitored in this study. The treatment areas are not appropriate for targeting these wildlife species. However, our incidental observations support that ungulates are traversing through the drawdown zone at many of the treatment sites and are likely to benefit if food plants of the appropriate forage species become established.

MQ2: To what extent does revegetation increase the availability of invertebrate prey (e.g. arthropods) in the food chain for birds, amphibians and small mammals?

Given the changing focus of CLMBON-11A as an assessment of the efficacy of wood debris removal and physical works in place of revegetation, this management question is not entirely relevant. We are currently monitoring the abundance of beetles and spiders at each site and treatment type. However, we are not monitoring all arthropod taxa that contribute to the diet of wildlife (e.g., aerial insects, caterpillars, grasshoppers) and we are not testing the consumption of arthropods or the diet preferences of birds, amphibians, and small mammals. Our data of ground-dwelling arthropods (spiders and beetles) show that abundance patterns are variable between sites and treatments and seem to be related more to underlying site-specific differences in soil substrate and moisture than to vegetation or physical works.

MQ3: Are revegetation efforts negatively impacting wildlife in the drawdown zone? For example, does revegetation increase the incidence of nest mortality in birds or create sink habitat for amphibians?

Based on other studies of nest mortality (CLBMON-36) and impacts on amphibians and reptiles (CLBMON-37 & 58), it is not known if revegetation or physical works trials have any negative impacts, but none are suspected thus far. We will continue to document nesting evidence and fate of nest in future years to help answer this management question. The recent results of CLBWORKS-1 (Hawkes 2017) suggest that clearing ponds in the drawdown zone of wood debris improves habitat suitability for pond-breeding amphibians (e.g., Western Toad) and the results of CLBMON-37 (Hawkes et al. 2016, draft) report on the continued use of the drawdown zone by amphibians. There is no indication that revegetation efforts applied under CLBWORKS-1 between 2008 and 2011 negatively affected amphibians.

MQ4: Which methods of revegetation are most effective at enhancing and increasing the utilization of wildlife habitat in the drawdown zone?

Our response to this question is based on an assessment of wood debris removal, log boom installation, and mound creation in the drawdown zone and not on the revegetation prescriptions applied under CLBWORKS-1 between 2008 and 2011. Based on the results obtained thus far for CLBMON-11A, it appears that woody debris removal has the potential to enhance and increase the utilization of wildlife habitat in the drawdown zone, particularly when treatment plots are fitted with an enclosure to exclude further wood deposition. Initial results from vegetation surveys suggest that treatment sites are rapidly and naturally recolonized by plant species. The longevity of vegetation on these plots is precarious due to the inevitable re-accumulation of wood each year. Thus, any positive effects observed in early years post-treatment may be short-lived.

7.2 Management Questions - Summary

Our ability to address each of the management questions is summarized below. The current trends in our data will be monitored overtime for changes in vegetation and focal taxa (e.g., ground-dwelling spiders and beetles and breeding birds). Data collected in future survey years will clarify conclusions for each management question. In our response to answering the management questions we have equated revegetation to physical works (to better align with the current focus of CLBMON-11A).

MQ	Able to Address MQ?	Scope		Sources of Uncertainty
		Current supporting results	Suggested modifications to methods where applicable	
1: How effective is the revegetation program at enhancing and increasing the utilization of habitat in the drawdown zone by wildlife	Partially	Increased natural vegetation growth at treatment plots following wood removal and mount treatments Spider and beetle species assemblages are distinct between control and treatment plots at Canoe Reach, suggesting differences in habitat qualities resulting from treatments. Some bare-ground associated arthropods have declined in treatment plots since 2014, possibly due to vegetation cover increases	• Sample treated sites and controls annually (reference sites are not variable and can be sampled less frequently) • Treat additional selected sites for physical works and implement pre-treatment sampling • Protect the long-term integrity of study plots in the drawdown zone by installing physical barriers to exclude woody debris from treatment plots and maintain woody debris in control plots (e.g., install log booms)	• Lack of sampling prior to the application of the prescriptions at Canoe Reach • Natural annual population variation • Variable reservoir operations • Bi-annual sampling • Relationships between revegetation or woody debris removal success and site-specific characteristics (e.g., substrate type, soil moisture, aspect, landscape position, etc.) • No measures taken to ensure the long-term integrity of some study plots in the drawdown zone (e.g., log booms)
2: To what extent does revegetation increase the availability of invertebrate prey in the food chain	Partially	General arthropod relative abundance and biomass did not differ between treatment and control transects in revegetation areas (studied prior to 2014). Since 2014 wood removal at Canoe Reach, some sites show clear differences in arthropod abundance between treatment and control areas. Arthropod densities are expected to increase in treatment plots (relative to controls) where vegetation establishment is successful. Results of CLBMON-11B1 show support for correlation between insect biomass and songbird presence (e.g., Hawkes et al. 2012).	• Annual sampling at least of drawdown zone treatment and controls • Select additional sites for physical works and implemented pre-treatment sampling (e.g., woody debris removal) • Consider planting areas with high likelihood of success (i.e., Valemount Peatland North, where substrates are organic, vegetation is colonizing, a log-boom is setup to exclude wood debris, and arthropod abundance is high)	• Lack of sampling prior to the application of the revegetation prescriptions and woody debris removal • Annual population variation • Sampling frequency and variable arthropod phenology • Variable reservoir operations
3: Are revegetation efforts negatively impacting wildlife in the drawdown zone?	Partially	While some species are expected to decline overtime in treatment plots (initial bare-ground colonising arthropod species, exotic species), there is no evidence of negative impacts to wildlife caused by treatment prescriptions	• Management question is better-suited to other studies that currently occur in the region	• Lack of sampling prior to the application of the revegetation prescriptions and woody debris removal • Natural annual population variation • Lack of knowledge regarding wildlife use of the drawdown zone in the winter • Variable reservoir operations

MQ	Able to Address MQ?	Scope		Sources of Uncertainty
		Current supporting results	Suggested modifications to methods where applicable	
4: Which methods of revegetation are most effective at enhancing and increasing the utilization of wildlife habitat in the drawdown zone	Partially	The effectiveness of woody debris removal is likely dependent on site-specific attributes and whether measures are put in place to exclude wood accumulation during subsequent reservoir cycles. Woody debris removal appears to be initially effective at Valemount Peatland North, based on observation of high arthropod and amphibian abundance in the wood removal area since 2014. The effectiveness of physical works trials implemented at Bush Arm will be assessed in future years	• Protect the long-term integrity of study plots in the drawdown zone: install physical barriers to exclude woody debris from treatment plots and maintain woody debris on control plots (e.g., install log booms, where possible) • Select additional sites for physical works and implement pre-treatment sampling (e.g., woody debris removal) • Characterize and catalogue site-specific attributes for all study areas in Kinbasket Reservoir, in order to understand differential responses to treatments	• Lack of sampling prior to the application of the revegetation prescriptions and woody debris removal • No measures taken to ensure the long-term integrity of treatment areas at all study sites • Relationship between revegetation or woody debris removal success and site-specific characteristics (e.g., substrate type, soil moisture, aspect, landscape position, etc.)

Monitoring under CLBMON-11A is currently scheduled to continue in 2018. The following is a summary of the recommendations made for the implementation of CLBMON-11A in future years:

RECOMMENDATIONS

1. **Future revegetation in select areas of the drawdown zone.** Increasing the extent of revegetation areas will increase the likelihood of detecting any changes in wildlife utilization. Following the initial success of natural vegetation growth at the Valemount Peatland treatment area, this may be well-suited to supplemental enhancement by planting live stakes and sedge plugs. The current treatment plots could be split into planted (enhanced revegetation) and un-planted (natural revegetation) treatment areas. Revegetation efforts should be site-specific based on a prescription for that area. If future revegetation is to occur, consider the species of wildlife that are likely to benefit from the revegetation to ensure the appropriate mix of plants is used, that the total area planted is likely to influence wildlife use of the drawdown zone, and that the revegetation prescriptions be applied in a replicated manner with sufficient stratification. Assessing the efficacy of this future revegetation would require long-term monitoring beyond the current scope of this project.

2. **Increase number of treatment applications and install log booms.** Additional treatments (woody debris removal and/or mound and windrow sites) are needed at each reach to increase replication and to include sites with other soil seed bank profiles, soil fertility assays, evidence of nascent vegetation establishment, and recent land use history. Log booms should be installed around wood removal areas to protect the integrity of these treatments.

3. **Ensure control areas are maintained for the remainder of monitoring.** In 2016 two sites were re-treated, and along with the adjacent control plots at these sites (Packsaddle Creek: PS-S, PS-N), they were cleared of all wood debris. In order to monitor the effectiveness of treated areas, replicates must be retained.

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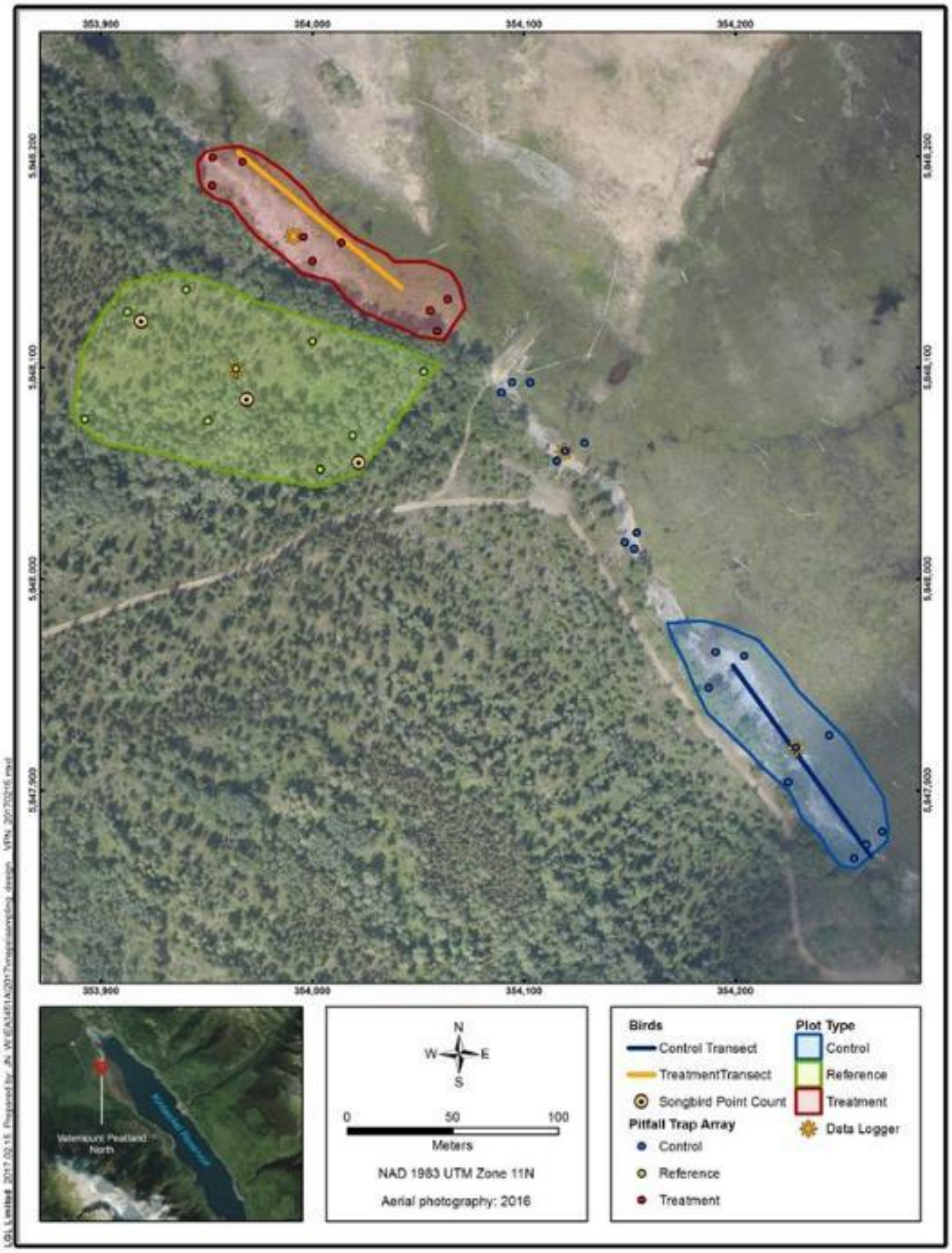
APPENDICES

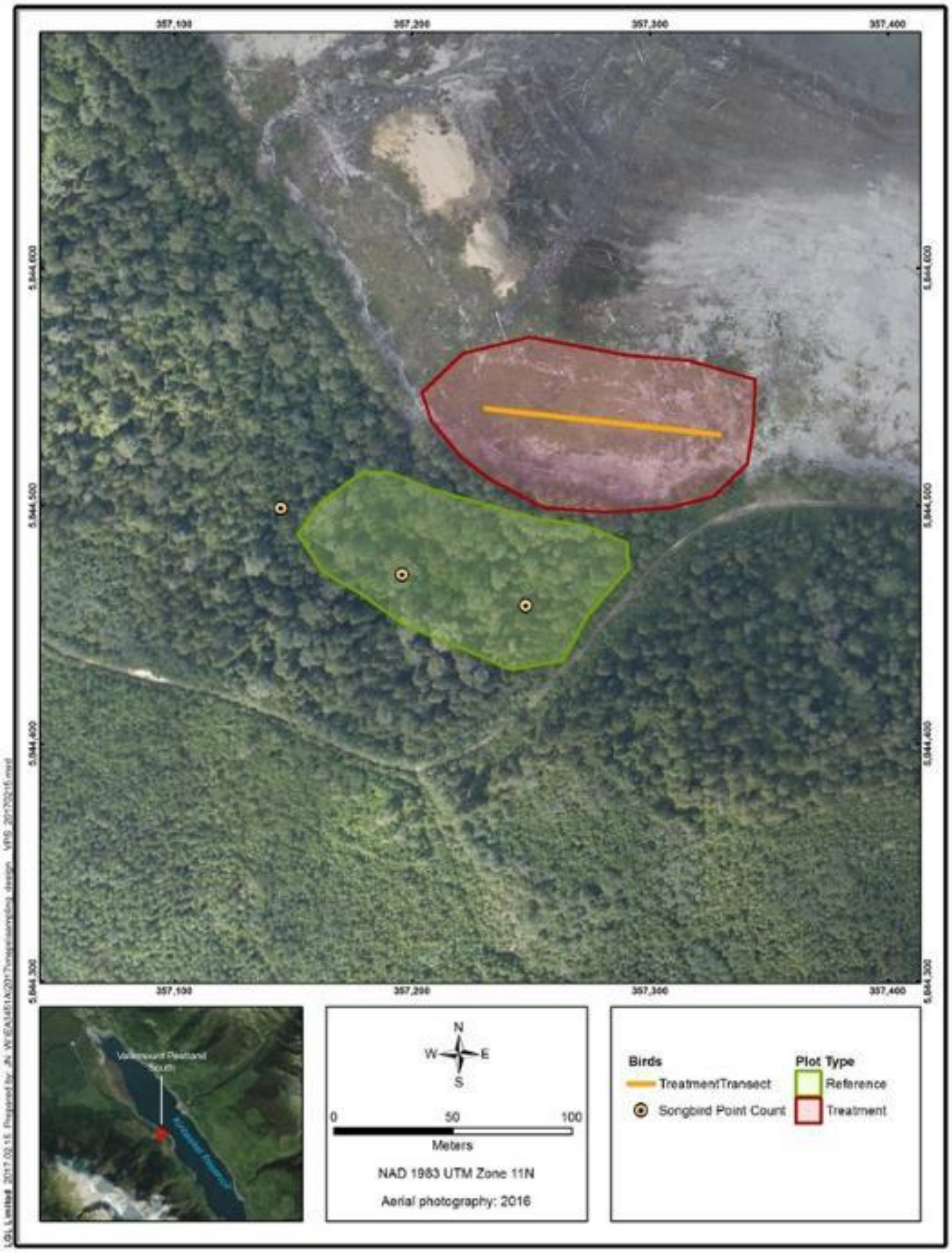
Appendix A: List of sites sampled in each year from 2008 to 2013. Site names were introduced in 2013 and are shown for planned sampling sites. "X" denotes that all taxa were surveyed for. "U" denotes where only ungulate pellet plot samples were collected. "N" denotes not sampled

Reach	Site #	2013 Site Name	Revegetation Treatment	Treatment Status	2008	2009	2010	2011	2012	2013
Canoe Reach	2				X	X	X	U	U	
	8	Valemount Peatland	PS/Seed		X	X	X	U	U	X
	9			Failed	X	X				
	12	Dave Henry Creek	PS		X	X	X	U	U	X
	15	Yellowjacket Creek	PS		X	X	X	U	U	X
	25	Ptarmigan Creek	LS/PS		X	X	X	U	U	N
	32		None	NA	X					
	33			Failed	X	X				
	34		PS	Failed		X				
Bush Arm	80	KM 88								X
	83				X	N	X	U	U	
	84				X	X	X	U	U	
	85			Failed		X				
	87	Hope Creek	PS		X	X	X	U	U	X
	88	Goodfellow Creek	LS/PS		X	X	X	U	U	X
	88b		Site Removed from 11-A study in 2009	NA	X					
	91		None	NA	X	X				
	121	Causeway	LS				X	U	U	X
Total					**14**	**13**	**10**	**10**	**10**	**7**

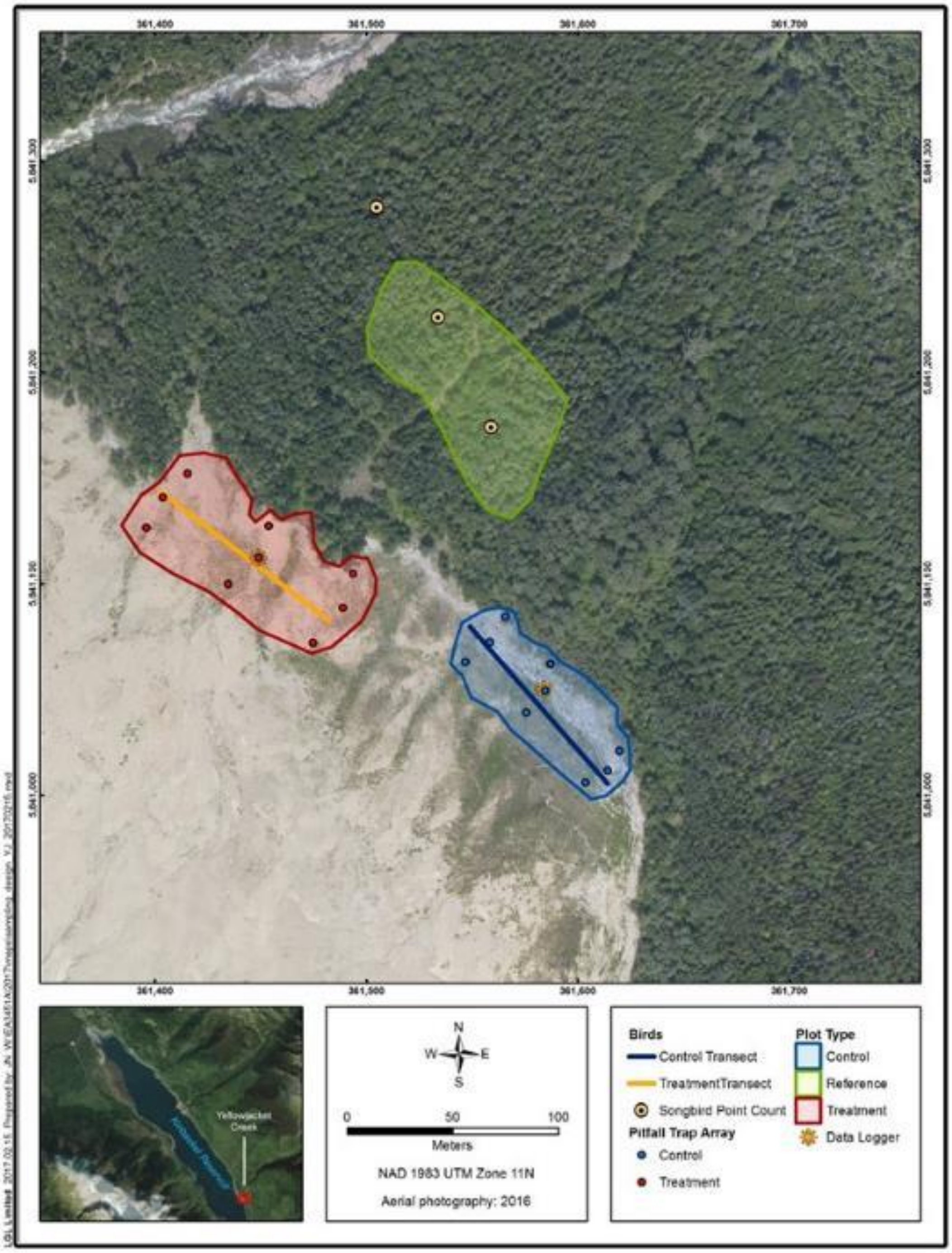
Appendix B: Maps of sampling locations during the 2016 monitoring period



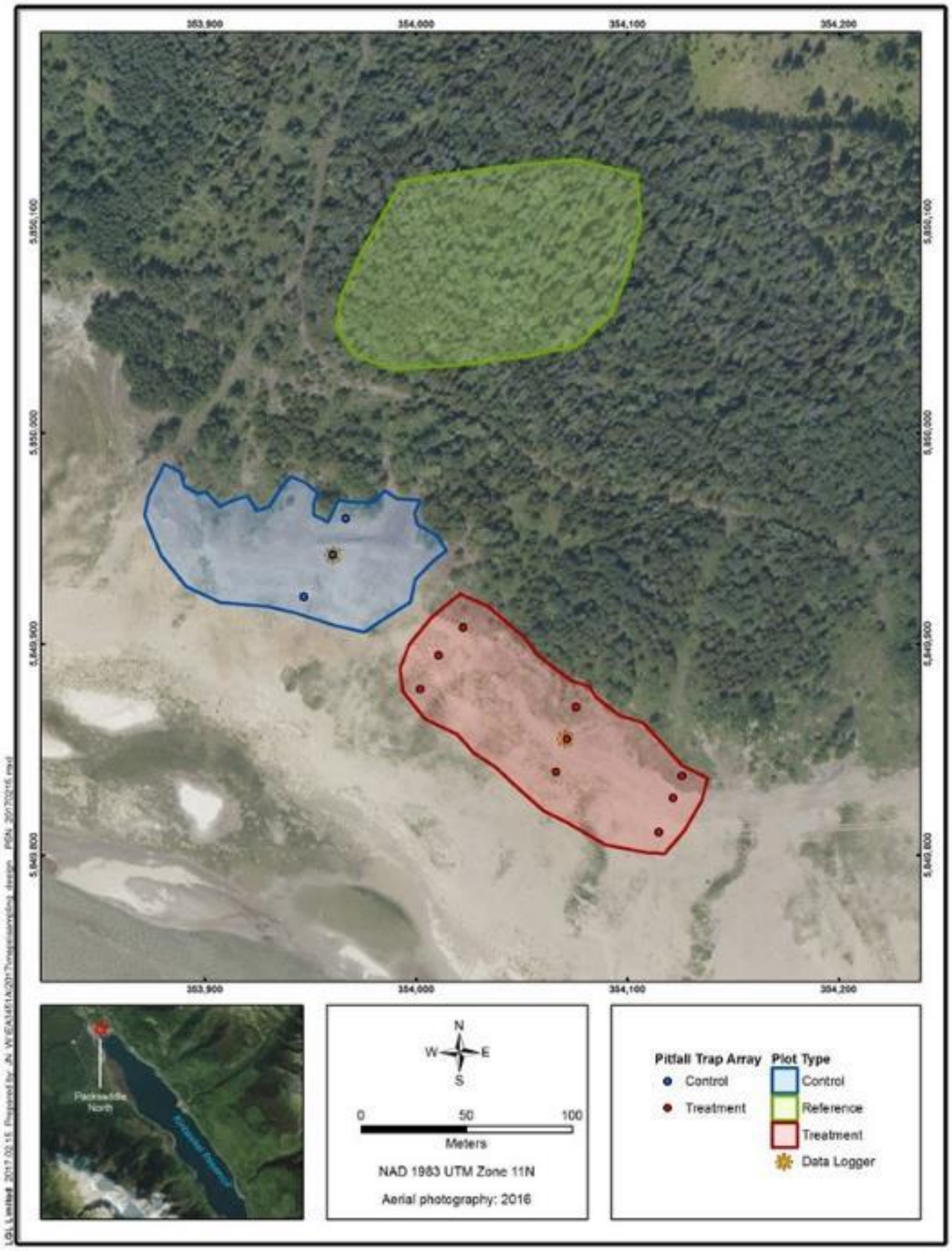
Map -1: Sampling locations at Valemount Peatland North site in 2016



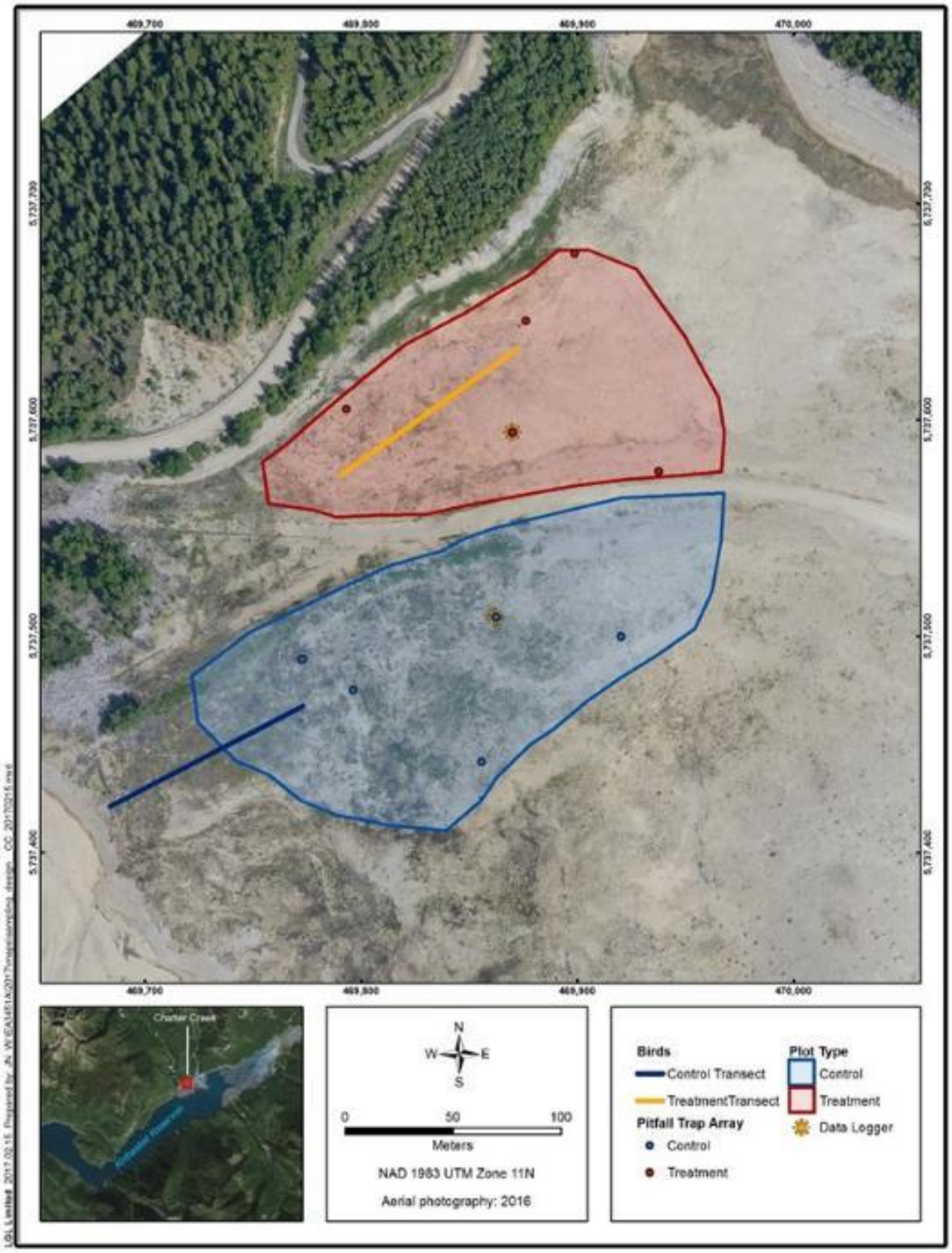
Map -2: Sampling locations at Valemount Peatland South site in 2016



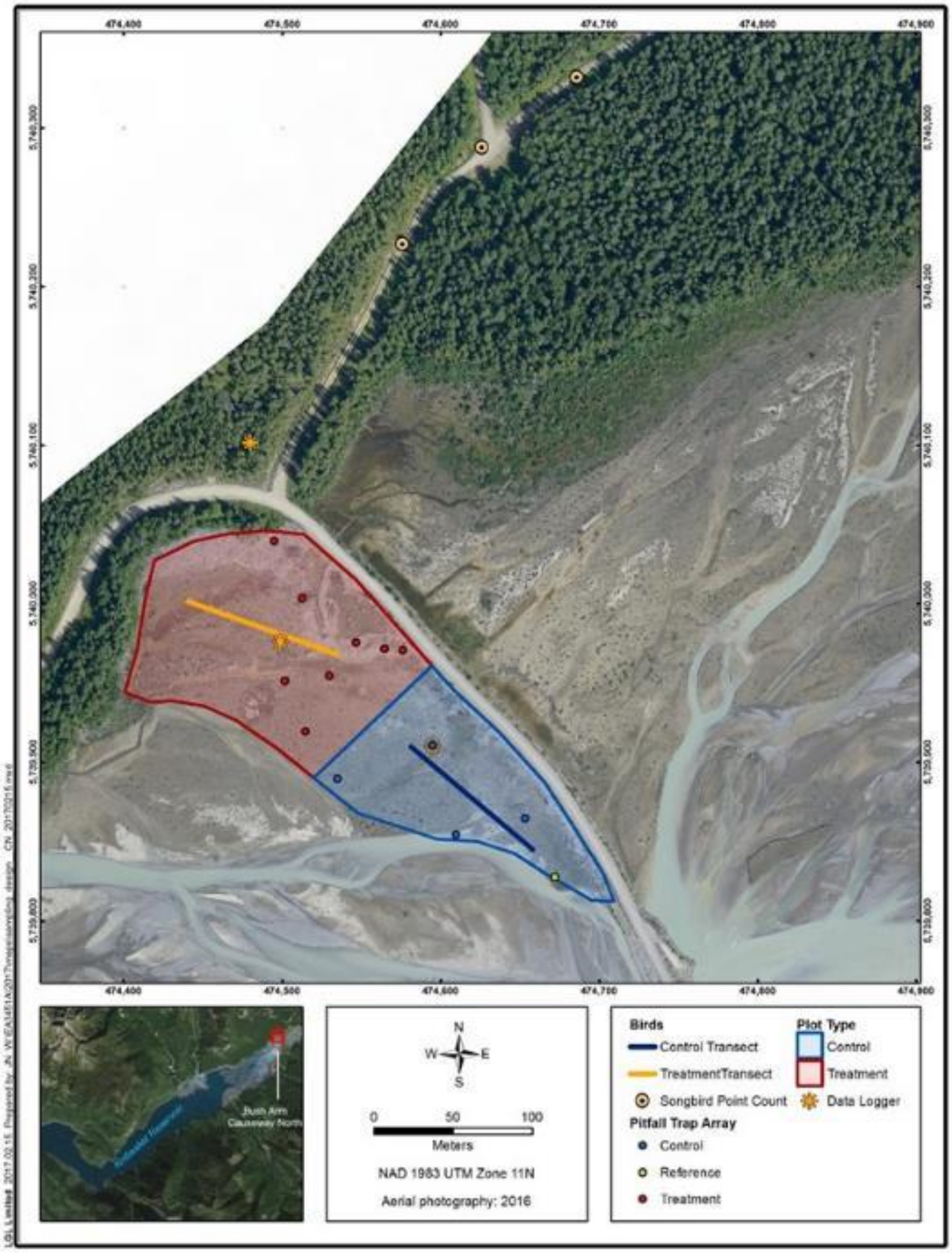
Map -3: Sampling locations at Yellowjacket Creek site in 2016



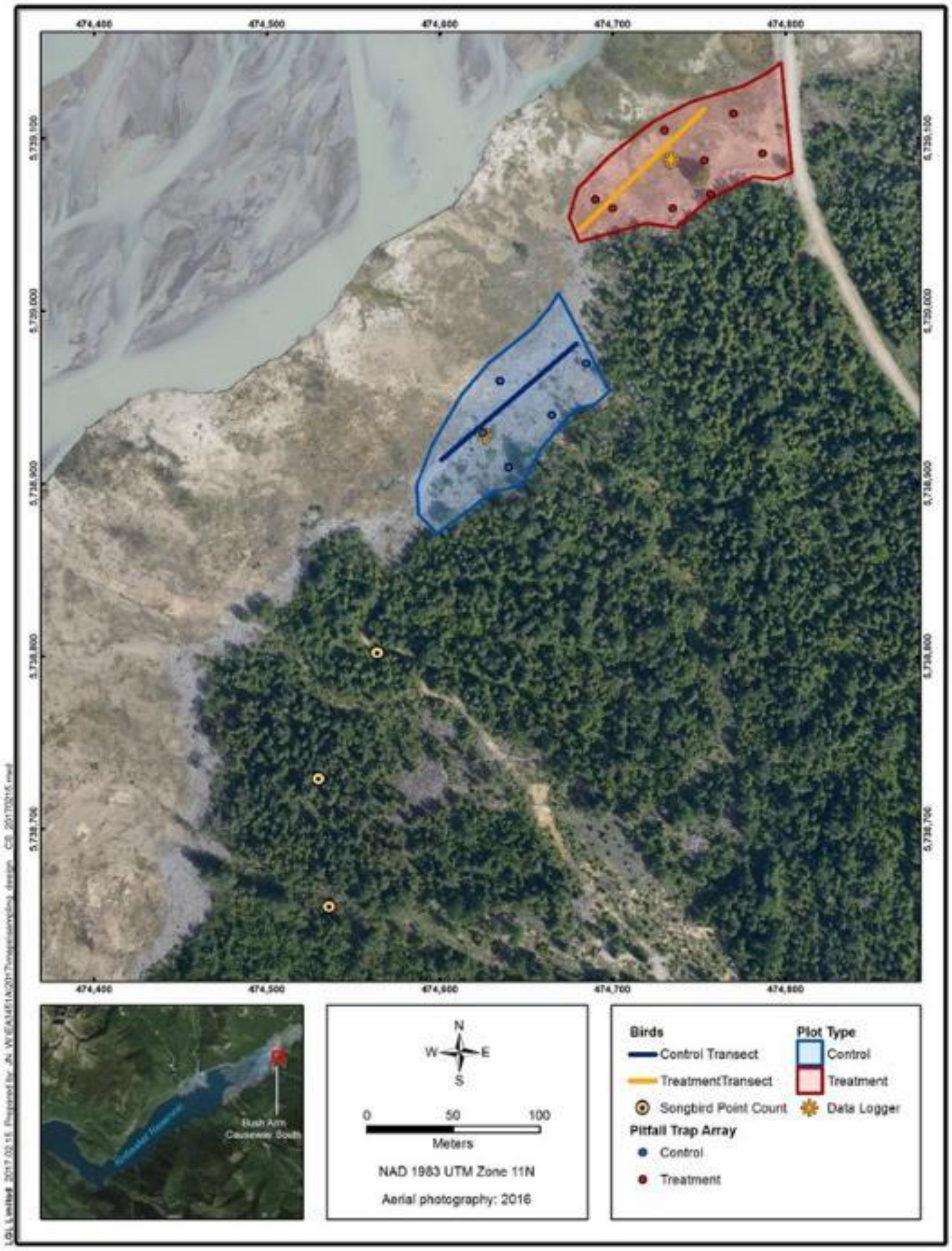
Map -4: Sampling locations at Packsaddle Creek North site in 2016



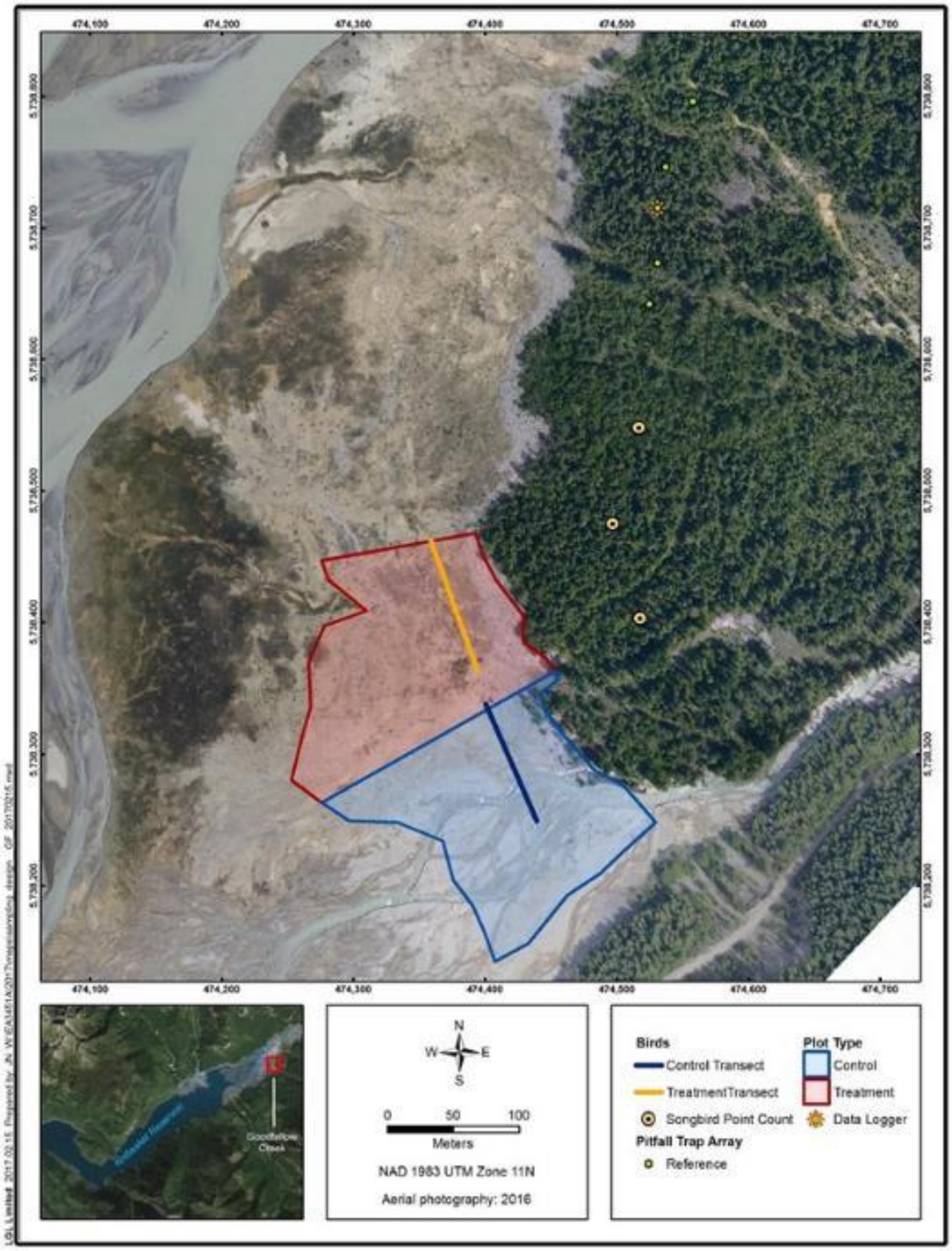
Map -5: **Sampling locations at Chatter Creek site in 2016**



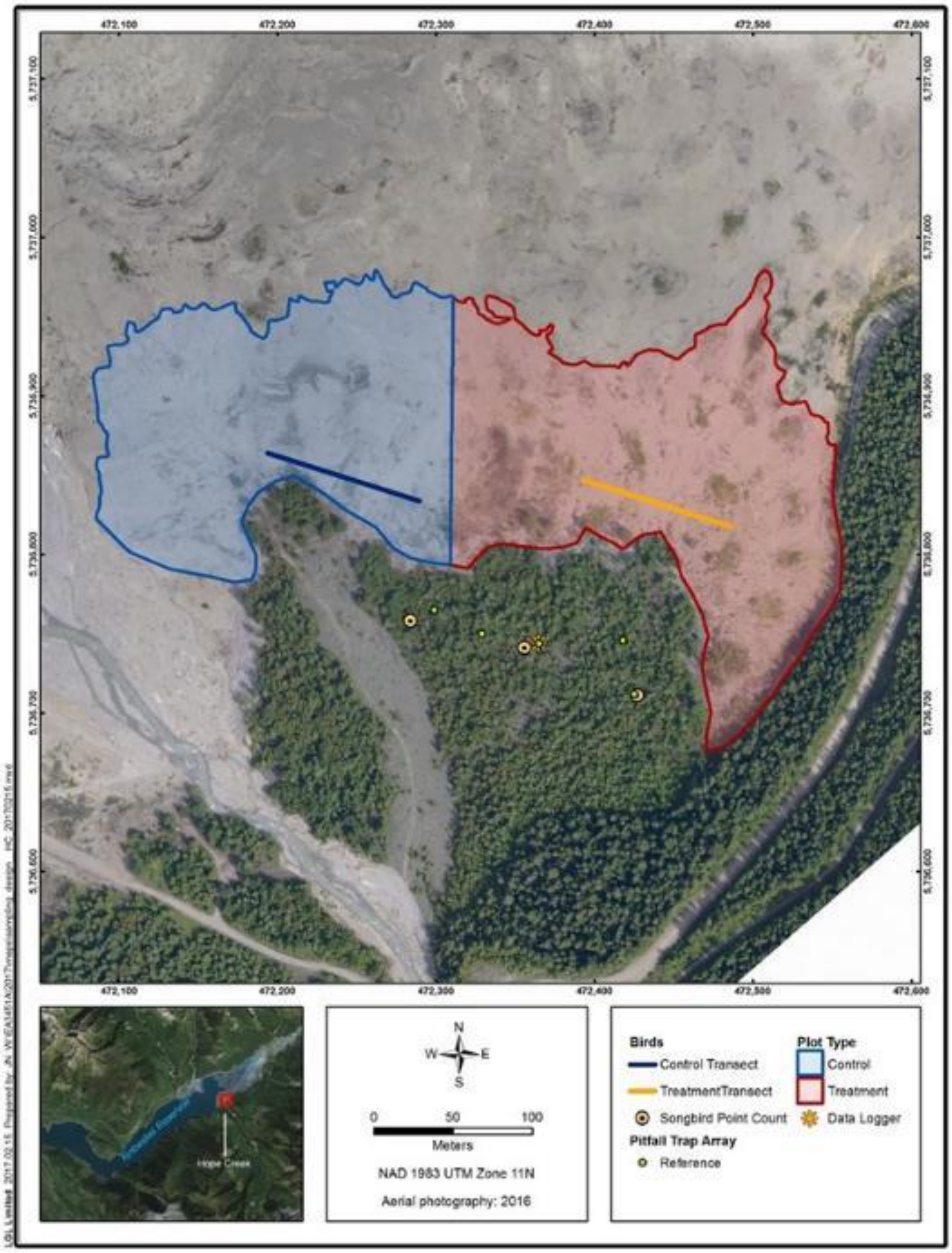
Map -6: **Sampling locations at Bush Arm Causeway NW site in 2016**



Map -7: **Sampling locations at Bush Arm Causeway SW site in 2016**



Map -8: Sampling locations at Goodfellow Creek site in 2016



Map -9: Sampling locations at Hope Creek site in 2016

Appendix C: Bird group, species name, code, and number of observations of all birds detected at all distances during 2016 songbird point count surveys in each treatment. Both reaches are combined (treatment= pre-treatment at Bush Arm); birds listed by taxonomic order. R= reference, C= control, T= treatment

Bird Group: Common Name	Code	Number Observed (all distances)		
		R	C	T
Waterfowl:				
Canada Goose	CAGO	3	1	
Upland Game Birds:				
Ruffed Grouse	RUGR	5	1	
Loons:				
Common Loon	COLO			1
Hawks, Eagles, Falcons and Allies:				
Bald Eagle	BAEA			1
Osprey	OSPR		1	
Shorebirds, Gulls, Auks and Allies:				
Killdeer	KILL		2	2
Spotted Sandpiper	SPSA	3	4	6
Wilson's Snipe	WISN	5		
Swifts and Hummingbirds:				
Rufous Hummingbird	RUHU	2		
Kingfishers and Allies:				
Belted Kingfisher	BEKI	1		1
Woodpeckers and Allies:				
Red-naped Sapsucker	RNSA	1		
Northern Flicker	NOFL	7	1	
Hairy Woodpecker	HAWO	3		2
Pileated Woodpecker	PIWO	1	2	
Songbirds:				
Willow Flycatcher	WIFL			2
Least Flycatcher	LEFL			1
Hammond's Flycatcher	HAFL	21		2
Dusky Flycatcher	DUFL	20	8	9
Warbling Vireo	WAVI	50	6	7
Red-eyed Vireo	REVI	3	2	
American Crow	AMCR			1
Common Raven	CORA	9	1	2
Tree Swallow	TRSW		2	1
Northern Rough-winged Swallow	NRWS	2	2	2
Black-capped Chickadee	BCCH	5		1
Red-breasted Nuthatch	RBNU	20	1	
Brown Creeper	BRCR	1		
Pacific Wren	PAWR	6		1
Golden-crowned Kinglet	GCKI	9		1
Ruby-crowned Kinglet	RCKI	9		

Bird Group: Common Name	Code	Number Observed (all distances)		
		R	C	T
Mountain Bluebird	MOBL	1		2
Swainson's Thrush	SWTH	52	3	5
Hermit Thrush	HETH	8		2
American Robin	AMRO	22	10	7
Varied Thrush	VATH	2		
American Pipit	AMPI	1		
Cedar Waxwing	CEWA	4		2
Tennessee Warbler	TEWA	39	12	11
Orange-crowned Warbler	OCWA	3	4	1
MacGillivray's Warbler	MACW	7	2	2
Common Yellowthroat	COYE	1	8	5
American Redstart	AMRE	45	10	10
Magnolia Warbler	MGNW	11	2	3
Yellow-rumped Warbler	YRWA	35	3	4
Yellow Warbler	YEWA	4		2
Wilson's Warbler	WIWA	3		1
Chipping Sparrow	CHSP	29	17	13
Clay-colored Sparrow	CCSP		4	3
Savannah Sparrow	SAVS		7	10
Song Sparrow	SOSP	3		2
Lincoln's Sparrow	LISP	3	16	10
Northern Waterthrush	NOWA	1	2	
White-throated Sparrow	WTSP	1	1	1
Dark-eyed Junco	DEJU	6	1	3
Western Tanager	WETA	2	2	1
Western Meadowlark	WEME			1
White-winged Crossbill	WWCR	1		
Pine Siskin	PISI	8	2	
Evening Grosbeak	EVGR	1	1	

Appendix D: Taxon List for spiders (Araneae) and ground beetles (Coleoptera: Carabidae) that were identified to species-level from 2014 to 2016. Total abundance is not standardized by sampling effort

			Canoe Reach			Bush Arm		
ORDER	Spp. Code	Sci. Name	2014	2015	2016	2015	2016	Total
Araneae	A-Agel.utah	*Agelenopsis utahana*		47	8	18		73
Araneae	A-Agro.orna	*Agroeca ornata*	6	23	17	15	8	69
Araneae	A-Agyn.allo	*Agyneta allosubtilis*		2				2
Araneae	A-Agyn.dani	*Agyneta danielbelangeri*					3	3
Araneae	A-Agyn.fabr	*Agyneta fabra*			2			2
Araneae	A-Agyn.loph	*Agyneta lophophor*	2		8			10
Araneae	A-Agyn.oliv	*Agyneta olivacea*	2		3			5
Araneae	A-Agyn.prot	*Agyneta protrudens*	4			2	7	13
Araneae	A-Agyn.simp	*Agyneta simplex*			2			2
Araneae	A-Alop.acul	*Alopecosa aculeata*	127	127	69	20	12	355
Araneae	A-Anti.brun	*Antistea brunnea*		0				0
Araneae	A-Aphi.mise	*Aphileta misera*			4			4
Araneae	A-Arge.obes	*Argenna obesa*				1	12	13
Araneae	A-Bath.brev	*Bathyphantes brevipes*	11	2	35			48
Araneae	A-Bath.pall	*Bathyphantes pallidus*	35	242	55	3	18	353
Araneae	A-Call.plut	*Callilepis pluto*	6		14			20
Araneae	A-Cavi.saxe	*Caviphantes saxetorum*					6	6
Araneae	A-Cera.brun	*Ceratinella brunnea*	5	4	4		4	17
Araneae	A-Cera.fiss	*Ceraticelus fissiceps*	15	25	4	1	5	50
Araneae	A-Club.cana	*Clubiona canadensis*	10	17	2	4		33
Araneae	A-Club.kast	*Clubiona kastoni*		2	2	4		8
Araneae	A-Club.kulc	*Clubiona kulczynskii*	17	20	3			40
Araneae	A-Club.norv	*Clubiona norvegica*	2					2
Araneae	A-Cnep.obsc	*Cnephalocotes obscurus*			1			1
Araneae	A-Coll.ksen	*Collinsia ksenia*	2	2	40	4	5	53
Araneae	A-Cryp.exli	*Cryphoeca exlineae*	8	2	1	6	11	28
Araneae	A-Cyba.moro	*Cybaeus morosus*		3		1	2	6
Araneae	A-Cyba.wabr	*Cybaeopsis wabritaska*	2					2
Araneae	A-Cycl.coni	*Cyclosa conica*	1					1
Araneae	A-Dict.colo	*Dictyna coloradensis*				1		1
Araneae	A-Dipl.bide	*Diplocentria bidentata*	6		1			7
Araneae	A-Dipl.rect	*Diplocentria rectangulata*	2	1	8		1	12
Araneae	A-Dipo.nigr	*Dipoena nigra*			3			3
Araneae	A-Dism.dece	*Dismodicus decemoculatus*	2	3	5			10
Araneae	A-Dolo.trit	*Dolomedes triton*			1			1
Araneae	A-Dras.negl	*Drassodes neglectus*	3	3	9	1		16
Araneae	A-Embl.annu	*Emblyna annulipes*	1	1				2
Araneae	A-Enop.intr	*Enoplognatha intrepida*	1					1
Araneae	A-Enop.marm	*Enoplognatha marmorata*		1	4			5
Araneae	A-Erig.alet	*Erigone aletris*		1	10			11
Araneae	A-Erig.atra	*Erigone atra*		3	4		44	51
Araneae	A-Erig.blae	*Erigone blaesa*	1	7	7	1	38	54
Araneae	A-Erig.dent	*Erigone dentigera*	15	4	80	2	66	167
Araneae	A-Erig.dent	*Erigone dentosa*				1		1
Araneae	A-Eula.arct	*Eulaira arctoa*		1	1			2
Araneae	A-Eula.obsc	*Eulaira obscura*					1	1
Araneae	A-Eury.arge	*Euryopis argentea*	62	8	17	1	8	96
Araneae	A-Eury.form	*Euryopis formosa*					1	1
Araneae	A-Eury.fune	*Euryopis funebris*				3	1	4
Araneae	A-Evar.pros	*Evarcha proszynskii*	3	2	3	3		11
Araneae	A-Fred.wilb	*Frederickus wilburi*		2				2
Araneae	A-Gnap.micr	*Gnaphosa microps*				1		1
Araneae	A-Gnap.musc	*Gnaphosa muscorum*	10	11	16			37
Araneae	A-Gnap.parv	*Gnaphosa parvula*	7	1	28		4	40
Araneae	A-Gnat.tacz	*Gnathonarium taczanowskii*	19	9	38		1	67
Araneae	A-Gram.angu	*Grammonota angusta*	1					1
Araneae	A-Gram.giga	*Grammonota gigas*			4			4
Araneae	A-Habr.deco	*Habronattus decorus*				2		2
Araneae	A-Hack.prom	*Hackmania prominula*		1			2	3
Araneae	A-Hahn.cine	*Hahnia cinerea*	8	1	2		1	12
Araneae	A-Hapl.euni	*Haplodrassus eunis*			1		1	2
Araneae	A-Hapl.hiem	*Haplodrassus hiemalis*	2	3	2		1	8
Araneae	A-Hapl.sign	*Haplodrassus signifer*	13	1	5			19

ORDER	Spp. Code	Sci. Name	Canoe Reach 2014	Canoe Reach 2015	Canoe Reach 2016	Bush Arm 2015	Bush Arm 2016	Total
Araneae	A-Hogn.fron	*Hogna frondicola*		6	4			10
Araneae	A-Hyps.flor	*Hypselistes florens*	13	1				14
Araneae	A-Ince.merc	*Incestophantes mercedes*	1					1
Araneae	A-Isla.flav	*Islandiana flaveola*			3		1	4
Araneae	A-Kaes.pull	*Kaestneria pullata*			1			1
Araneae	A-Lept.alpi	*Lepthyphantes alpinus*	67	134	10	1	1	213
Araneae	A-Lept.intr	*Lepthyphantes intricatus*	6	2	1	1	7	17
Araneae	A-Lept.turb	*Lepthyphantes turbatrix*	1	2	9			12
Araneae	A-Macr.mult	*Macrargus multesimus*		1				1
Araneae	A-Maso.sund	*Maso sundevalli*		1	3			4
Araneae	A-Merm.tril	*Mermessus trilobatus*	3	1	11	3	28	46
Araneae	A-Mica.aene	*Micaria aenea*	22	4	28	4		58
Araneae	A-Mica.cons	*Micaria constricta*	1					1
Araneae	A-Mica.puli	*Micaria pulicaria*	21	37	21	39	8	126
Araneae	A-Mica.ross	*Micaria rossica*	15	54	23		6	98
Araneae	A-Micr.mand	*Microlinyphia mandibulata*		1				1
Araneae	A-Micr.viar	*Microneta viaria*		3	1	1		5
Araneae	A-Misu.vati	*Misumena vatia*					1	1
Araneae	A-Neoa.agil	*Neoantistea agilis*	20	4	69	6	24	123
Araneae	A-Neoa.magn	*Neoantistea magna*				10	42	52
Araneae	A-Neon.nell	*Neon nelli*	2	1	1			4
Araneae	A-Neri.dign	*Neriene digna*	2	4		1	1	8
Araneae	A-Neri.radi	*Neriene radiata*			1			1
Araneae	A-Oedo.alas	*Oedothorax alascensis*	3		17			20
Araneae	A-Oedo.tril	*Oedothorax trilobatus*	6	5	6			17
Araneae	A-Oreo.fili	*Oreonetides filicatus*	8		1		1	10
Araneae	A-Oreo.flav	*Oreonetides flavus*			1			1
Araneae	A-Oreo.rect	*Oreonetides rectangulatus*			1			1
Araneae	A-Oreo.recu	*Oreophantes recurvatus*				1		1
Araneae	A-Oreo.rotu	*Oreonetides rotundus*		1				1
Araneae	A-Orod.cana	*Orodrassus canadensis*		1		1		2
Araneae	A-Pach.cler	*Pachygnatha clercki*	17	1	0			18
Araneae	A-Pard.fusc	*Pardosa fuscula*	103	2	143	3	1	252
Araneae	A-Pard.groe	*Pardosa groenlandica*	1			2	2	5
Araneae	A-Pard.lowr	*Pardosa lowriei*		4	3	7	5	19
Araneae	A-Pard.mack	*Pardosa mackenziana*	120	57	201	33	48	459
Araneae	A-Pard.moes	*Pardosa moesta*	113	77	76	1	2	269
Araneae	A-Pard.tesq	*Pardosa tesquorum*				9	20	29
Araneae	A-Pard.wyut	*Pardosa wyuta*	22	22	1	1		46
Araneae	A-Pard.xera	*Pardosa xerampelina*	680	373	569	101	269	1992
Araneae	A-Pele.flav	*Pelegrina flavipes*	1	1				2
Araneae	A-Pele.meng	*Pelecopsis mengei*	4	11	69			84
Araneae	A-Pele.moes	*Pelecopsis moesta*			4	2	29	35
Araneae	A-Pele.scul	*Pelecopsis sculpta*	5	10		9	12	36
Araneae	A-Phil.alas	*Philodromus alascensis*		7	3	1		11
Araneae	A-Phil.cesp	*Philodromus cespitum*		3	1			4
Araneae	A-Phil.onei	*Philodromus oneida*				1		1
Araneae	A-Phil.pern	*Philodromus pernix*	1					1
Araneae	A-Phil.plac	*Philodromus placidus*		1				1
Araneae	A-Phil.rufu	*Philodromus rufus*		1		2		3
Araneae	A-Phru.bore	*Phrurotimpus borealis*		1	6	9		16
Araneae	A-Pira.insu	*Piratula insularis*					1	1
Araneae	A-Pira.pira	*Pirata piraticus*	46	3	42	2	2	95
Araneae	A-Pity.cost	*Pityohyphantes costatus*		1				1
Araneae	A-Pity.cris	*Pityohyphantes cristatus*		1				1
Araneae	A-Poca.amer	*Pocadicnemis americana*	12	11	3			26
Araneae	A-Poca.pumi	*Pocadicnemis pumila*	3					3
Araneae	A-Porr.conv	*Porrhomma convexum*	1		2		1	4
Araneae	A-Robe.fusc	*Robertus fuscus*	3	4				7
Araneae	A-Robe.vige	*Robertus vigerens*	4	10	2		1	17
Araneae	A-Ruga.sexp	*Rugathodes sexpunctatus*	1					1
Araneae	A-Saar.samm	*Saaristoa sammamish*	6	1	15			22
Araneae	A-Scia.trun	*Sciastes truncatus*	7		2			9
Araneae	A-Scot.exse	*Scotinotylus exsectoides*			2	1		3
Araneae	A-Scot.pall	*Scotinotylus pallidus*	1					1
Araneae	A-Scot.pugn	*Scotinella pugnata*	3	12	21			36
Araneae	A-Scot.sanc	*Scotinotylus sanctus*	1	1	2			4
Araneae	A-Serg.mont	*Sergiolus montanus*				2	1	3

ORDER	Spp. Code	Sci. Name	Canoe Reach 2014	Canoe Reach 2015	Canoe Reach 2016	Bush Arm 2015	Bush Arm 2016	Total
Araneae	A-Sisi.mont	*Sisicottus montanus*	6	10			3	19
Araneae	A-Sisi.nesi	*Sisicottus nesides*					1	1
Araneae	A-Sisi.orit	*Sisicottus orites*	2	4			2	8
Araneae	A-Sisi.pano	*Sisicottus panopeus*		1				1
Araneae	A-Sisi.peni	*Sisicus penifusifer*					2	2
Araneae	A-Spir.mont	*Spirembolus monticolens*	8	16	5			29
Araneae	A-Stea.bore	*Steatoda borealis*		1	4			5
Araneae	A-Styl.comp	*Styloctetor compar*		4	4	9	6	23
Araneae	A-Styl.stat	*Styloctetor stativus*	5					5
Araneae	A-Symm.mini	*Symmigma minimum*	23	4			3	30
Araneae	A-Tapi.minu	*Tapinocyba minuta*	14	9	9	4	11	47
Araneae	A-Tenu.zela	*Tenuiphantes zelatus*	30	47				77
Araneae	A-Tetr.labo	*Tetragnatha laboriosa*		1		2		3
Araneae	A-Tetr.vers	*Tetragnatha versicolor*	1					1
Araneae	A-Than.form	*Thanatus formicinus*	3					3
Araneae	A-Tibe.oblo	*Tibellus oblongus*		1	5	1	1	8
Araneae	A-Troc.terr	*Trochosa terricola*	56	83	28	21	4	192
Araneae	A-Tuna.debi	*Tunagyna debilis*	2		13			15
Araneae	A-Usof.paci	*Usofila pacifica*					0	0
Araneae	A-Walc.atro	*Walckenaeria atrotibialis*	1	1	12	1	1	16
Araneae	A-Walc.cast	*Walckenaeria castanea*		4		1	3	8
Araneae	A-Walc.dire	*Walckenaeria directa*	32	42	10		1	85
Araneae	A-Walc.exig	*Walckenaeria exigua*	42	10	8	1	8	69
Araneae	A-Xyst.bene	*Xysticus benefactor*	4					4
Araneae	A-Xyst.brit	*Xysticus britcheri*	1					1
Araneae	A-Xyst.disc	*Xysticus discursans*					1	1
Araneae	A-Xyst.eleg	*Xysticus elegans*	3	1	1			5
Araneae	A-Xyst.elli	*Xysticus ellipticus*	13	1	6		1	21
Araneae	A-Xyst.fero	*Xysticus ferox*	1		1			2
Araneae	A-Xyst.luct	*Xysticus luctuosus*	1				1	2
Araneae	A-Xyst.mont	*Xysticus montanensis*		1				1
Araneae	A-Xyst.obsc	*Xysticus obscurus*	29	2				31
Araneae	A-Xyst.trig	*Xysticus triguttatus*		2				2
Araneae	A-Zelo.frat	*Zelotes fratris*	4	11	9	22	8	54
Araneae	A-Zelo.puri	*Zelotes puritanus*		2	2	4		8
Coleoptera	C-Agon.affi	*Agonum affine*			59		3	62
Coleoptera	C-Agon.cons	*Agonum consimile*	1		33			34
Coleoptera	C-Agon.corv	*Agonum corvus*		1	8			9
Coleoptera	C-Agon.cupr	*Agonum cupripenne*	7	10	23	204	268	512
Coleoptera	C-Agon.grat	*Agonum gratiosum*			5	3		8
Coleoptera	C-Agon.meta	*Agonum metallescens*	388	211	62	29	22	712
Coleoptera	C-Agon.muel	*Agonum muelleri*	7	8		69	14	98
Coleoptera	C-Agon.plac	*Agonum placidum*	1	40	9			50
Coleoptera	C-Agon.retr	*Agonum retractum*	80	148	75	5	59	367
Coleoptera	C-Agon.simi	*Agonum simile*					1	1
Coleoptera	C-Agon.sord	*Agonum sordens*	2	1	13			16
Coleoptera	C-Agon.sutu	*Agonum suturale*		1	1	101	28	131
Coleoptera	C-Agon.thor	*Agonum thoreyi*	6		3			9
Coleoptera	C-Amar.apri	*Amara apricaria*	1	1	1			3
Coleoptera	C-Amar.fami	*Amara familiaris*			1			1
Coleoptera	C-Amar.litt	*Amara littoralis*	12	9	15	10	15	61
Coleoptera	C-Amar.patr	*Amara patruelis*		1	6		1	8
Coleoptera	C-Amar.quen	*Amara quenseli*	2	5				7
Coleoptera	C-Amar.schw	*Amara schwarzi*			7			7
Coleoptera	C-Amar.sinu	*Amara sinuosa*			2	6	1	9
Coleoptera	C-Amar.torr	*Amara torrida*		5				5
Coleoptera	C-Amar.sp.1	*Amara* sp.1		1				1
Coleoptera	C-Amar.sp.2	*Amara* sp.2			2			2
Coleoptera	C-Amar.sp.3	*Amara* sp.3			1			1
Coleoptera	C-Bemb.bima	*Bembidion bimaculatum*		4	12	7	152	175
Coleoptera	C-Bemb.conv	*Bembidion convexulum*			2		2	4
Coleoptera	C-Bemb.incr	*Bembidion incrematum*	172	25	351	12	68	628
Coleoptera	C-Bemb.inte	*Bembidion interventor*				3	10	13
Coleoptera	C-Bemb.kupr	*Bembidion kuprianovii*	4	1	18	1	1	25
Coleoptera	C-Bemb.nigr	*Bembidion nigripes*	71	86	65	133	149	504
Coleoptera	C-Bemb.obsc	*Bembidion obscurellum*	88	62	95	19	74	338
Coleoptera	C-Bemb.petr	*Bembidion petrosum*			3	6	8	17
Coleoptera	C-Bemb.plan	*Bembidion planatum*	76	628	67	59	16	846

ORDER	Spp. Code	Sci. Name	Canoe Reach 2014	Canoe Reach 2015	Canoe Reach 2016	Bush Arm 2015	Bush Arm 2016	Total
Coleoptera	C-Bemb.quad	*Bembidion quadrimaculatum*	9	25	21	7	58	120
Coleoptera	C-Bemb.rupi	*Bembidion rupicola*	3	2	5	2	8	20
Coleoptera	C-Bemb.sord	*Bembidion sordidum*					2	2
Coleoptera	C-Bemb.sp.1	*Bembidion* sp.1	1		1		2	4
Coleoptera	C-Bemb.sp.2	*Bembidion* sp.2			2			2
Coleoptera	C-Bemb.tetr	*Bembidion tetracolum*	10	18				28
Coleoptera	C-Bemb.timi	*Bembidion timidum*				1	1	2
Coleoptera	C-Bemb.tran	*Bembidion transparens*		1	26		8	35
Coleoptera	C-Blet.huds	*Blethisa hudsonica*	12		18			30
Coleoptera	C-Blet.quad	*Blethisa quadricollis*	1		2			3
Coleoptera	C-Brad.leco	*Bradycellus lecontei*			1			1
Coleoptera	C-Brad.nigr	*Bradycellus nigrinus*	1		4			5
Coleoptera	C-Cala.adve	*Calathus advena*	2	3				5
Coleoptera	C-Cala.ingr	*Calathus ingratus*	173	298	108	116	45	740
Coleoptera	C-Calt.ingr	*Calthus ingratus*					9	9
Coleoptera	C-Cara.taed	*Carabus taedatus*	8	24	18			50
Coleoptera	C-Chla.lith	*Chlaenius lithophilus*				27	6	33
Coleoptera	C-Chla.nige	*Chlaenius niger*	1	1		15	4	21
Coleoptera	C-Cici.long	*Cicindela longilabris*	23	8	6	1	2	40
Coleoptera	C-Cici.oreg	*Cicindela oregona*		16	11	19	4	50
Coleoptera	C-Cici.repa	*Cicindela repanda*				3	1	4
Coleoptera	C-Cici.tran	*Cicindela tranquebarica*	3		3			6
Coleoptera	C-Cyli.terr	*Cylindera terricola*				5		5
Coleoptera	C-Cymi.crib	*Cymindis cribricollis*	7	12	15	5	4	43
Coleoptera	C-Dich.cogn	*Dicheirotrichus cognatus*	1					1
Coleoptera	C-Dysc.alti	*Dyschirius alticola*					5	5
Coleoptera	C-Dysc.sp.1	*Dyschirius* sp.1					1	1
Coleoptera	C-Elap.amer	*Elaphrus americanus*	1					1
Coleoptera	C-Elap.clai	*Elaphrus clairvillei*	3		15			18
Coleoptera	C-Elap.leco	*Elaphrus lecontei*				1		1
Coleoptera	C-Harp.affi	*Harpalus affinis*	10	30	1			41
Coleoptera	C-Harp.fulv	*Harpalus fulvilabris*	5	6	16			27
Coleoptera	C-Harp.laev	*Harpalus laevipes*					1	1
Coleoptera	C-Harp.lati	*Harpalus laticeps*		1	2			3
Coleoptera	C-Harp.nigr	*Harpalus nigritarsis*	7	2	6		1	16
Coleoptera	C-Harp.obni	*Harpalus obnixus*		5	2			7
Coleoptera	C-Harp.soli	*Harpalus solitaris*		5				5
Coleoptera	C-Harp.somn	*Harpalus somnulentus*	5	4	11		1	21
Coleoptera	C-Harp.sp.1	*Harpalus sp.1*	6	2				8
Coleoptera	C-Hete.ramo	*Heterosilpha ramosa*					1	1
Coleoptera	C-Lori.dece	*Loricera decempunctata*	125	15	16		1	157
Coleoptera	C-Lori.pili	*Loricera pilicornis*	11	4	5			20
Coleoptera	C-Misc.arct	*Miscodera arctica*	1		5			6
Coleoptera	C-Nebr.gebl	*Nebria gebleri*	1	1				2
Coleoptera	C-Nebr.obli	*Nebria obliqua*				1	4	5
Coleoptera	C-Noti.semi	*Notiophilus semistriatus*		2	2			4
Coleoptera	C-Noti.sp.1	*Notiophilus* sp.1					2	2
Coleoptera	C-Patr.foss	*Patrobus fossifrons*		3	46			49
Coleoptera	C-Patr.styg	*Patrobus stygicus*	4					4
Coleoptera	C-Plat.dece	*Platynus decentis*	9	37	3	15	4	68
Coleoptera	C-Plat.mann	*Platynus mannerheimi*	8		17			25
Coleoptera	C-Poec.lucu	*Poecilus lucublandus*				2	5	7
Coleoptera	C-Pter.adst	*Pterostichus adstrictus*	126	287	237	88	182	920
Coleoptera	C-Pter.comm	*Pterostichus commutabilis*					2	2
Coleoptera	C-Pter.ecar	*Pterostichus ecarinatus*				2	1	3
Coleoptera	C-Pter.herc	*Pterostichus herculaneus*	19	15	15	4	1	54
Coleoptera	C-Pter.mela	*Pterostichus melanarius*	16	17	45			78
Coleoptera	C-Pter.neob	*Pterostichus neobrunneus*	49	108	1			158
Coleoptera	C-Pter.patr	*Pterostichus patruelis*			2			2
Coleoptera	C-Pter.pens	*Pterostichus pensylvanicus*	127	438	137	1		703
Coleoptera	C-Pter.prot	*Pterostichus protractus*	47	99	37	61	14	258
Coleoptera	C-Pter.ripa	*Pterostichus riparius*	63	18	34	1	1	117
Coleoptera	C-Scap.angu	*Scaphinotus angusticollis*	42	156	12			210
Coleoptera	C-Scap.marg	*Scaphinotus marginatus*	44	154	31	2	9	240
Coleoptera	C-Scap.reli	*Scaphinotus relictus*				1		1
Coleoptera	C-Seri.boge	*Sericoda bogemannii*			1			1
Coleoptera	C-Synt.amer	*Syntomus americanus*	24	14	62	6	16	122
Coleoptera	C-Synu.impu	*Synuchus impunctatus*	4	66	53	20	39	182

			Canoe Reach			Bush Arm		
ORDER	**Spp. Code**	***Sci. Name***	**2014**	**2015**	**2016**	**2015**	**2016**	**Total**
Coleoptera	C-Trec.chal	*Trechus chalybeus*	5	1	7			13
Coleoptera	C-Tric.cogn	*Trichocellus cognatus*			4			4
Grand Total			**3973**	**4864**	**4025**	**1488**	**2171**	**16521**