Columbia River Project Water Use Plan

Kinbasket and Arrow Lakes Reservoir

Arrow Lakes Reservoir: Wildlife Effectiveness Monitoring and Enhancement Area Identification for Lower and Mid-Arrow Lakes Reservoir

Implementation Year 10

Reference: CLBMON-11B1

Final Report

Study Period: 2019

Okanagan Nation Alliance, Westbank, BC

and

LGL Limited environmental research associates
Sidney, BC

May 26, 2020

EA3450G

KINBASKET AND ARROW LAKES RESERVOIRS

Monitoring Program No. CLBMON-11B1

Wildlife Effectiveness Monitoring and Enhancement Area Identification for Lower and Mid-Arrow Lakes Reservoir




Final Report 2019

Prepared for

BC Hydro Generation

Water Licence Requirements
6911 Southpoint Drive
Burnaby, BC

Prepared by

Riley Waytes[1], M.Sc., Nathan T. Hentze[1], M.Sc., Charlene Wood[1], M.Sc., Virgil C. Hawkes[1], M.Sc., R.P.Bio, and Jeremy Gatten[1], B.Sc.

[1]LGL Limited environmental research associates

and

Okanagan Nation Alliance

Technical Contact: Virgil C. Hawkes, M.Sc., R.P.Bio.
vhawkes@gl.com; 1.250.656.0127
ONA Contact: David DeRosa; 1.250.687.4635

May 26, 2020

Suggested Citation:

Waytes, R., N.T. Hentze, C.M. Wood, V.C. Hawkes, and J. Gatten. 2020. CLBMON-11B1. Kinbasket and Arrow Lakes Reservoirs: Wildlife Effectiveness Monitoring and Enhancement Area Identification for Lower and Mid-Arrow Lakes Reservoir. Annual Report – 2019. LGL Report EA3450. Unpublished report by Okanagan Nation Alliance, Westbank, B.C. and LGL Limited environmental research associates, Sidney, B.C., for BC Hydro Generation, Water Licence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. 80 pp. + Appendices.

Cover photos:

From left to right: Beaton Arm beaver ponds; Eastern Kingbird (*Tyrannus tyrannus*); western tiger swallowtail (*Papilio rutulus*); and sedge plug at Burton Creek © Virgil C. Hawkes, LGL Limited.

EXECUTIVE SUMMARY

CLBMON-11B1, initiated in 2009, is a long-term wildlife monitoring project to assess the efficacy of revegetation prescriptions (i.e., those implemented under CLBWORKS-2) and wildlife physical works projects (i.e., those developed under CLBWORKS-29B and implemented under CLBWORKS-30), at enhancing the suitability of habitats in the drawdown zone of Arrow Lakes Reservoir for wildlife. To date, wildlife effectiveness monitoring under CLBMON-11B1 has occurred in all years since 2009, except 2012. Challenges associated with assessing revegetation success in previous sampling years led to the revision of the Terms of Reference for the CLBMON-11B projects in June 2017. This report is therefore guided by the 2017 Terms of Reference and refers only to work completed in the Arrow Lakes Reservoir in 2019.

Revegetation work was conducted in the reservoir drawdown zone from 2008 to 2011 under the CLBWORKS-2 program. Various revegetation prescriptions were applied: two multi-species seed mixes applied by hydro-seeding or hand seeding, graminoid seeds planted by drill seeding or hand, graminoid seedlings planted by hand, shrub seedlings planted by hand, live stakes planted by excavator or hand, modified brush layers, and fertilizer spread by hand or ATV. By far, graminoid plug seedling treatments involving Kellogg's sedge (*Carex lenticularis* var. *lipocarpa*) dominated the planting regime. Results of CLBMON-12, an effectiveness monitoring study of the revegetation efforts, indicate that the revegetation program has met with mixed success to date (Miller et al. 2016, Miller et al. 2018).

Several potential wildlife physical works projects were developed under CLBWORKS-29B (Hawkes and Tuttle 2016, Hawkes and Howard 2012). A feasibility design was prepared for one location at Burton Creek under CLBWORKS-30B (Kerr Wood Leidel 2017), and the first stage of the wildlife physical works projects was implemented in September 2019 (Miller and Hawkes 2019, draft). Baseline data collection was initiated in 2017 through CLBMON-11B1 and continued in 2018 and 2019. Fieldwork from 2020 onwards will focus on Wildlife Physical Works (WPW) monitoring.

Revegetation Effectiveness Monitoring and Results

The revegetation prescriptions applied in the drawdown zone would likely affect prey populations (i.e., terrestrial arthropods) before predator populations (e.g., songbirds and bats). Thus, since 2013 we have sampled songbirds and arthropods as focal taxa. In 2019, we surveyed arthropod populations in revegetation polygons with the use of pitfall traps. Responses of birds were monitored by point count surveys and nest searches. Additionally, baseline waterfowl and other water and shoreline-associated bird species were surveyed from April to September 2019 at Burton Creek, Edgewood South, and Lower Inonoaklin. These monitoring datasets were used to assess the efficacy of revegetation prescriptions and will be used as a baseline comparison with future habitat enhancements applied in the drawdown zone.

We also surveyed bat activity as well as general wildlife use of the drawdown zone at select sites. Bat data were collected by deploying autonomous recording units and subsequently analysing activity via automatic call classification

software. Additionally, in 2019 wildlife use of study sites was tracked with the use of wildlife cameras and incidental wildlife data.

In 2019, wildlife monitoring was stratified to occur in revegetation polygons selected on several criteria, including vegetation density, elevation level, and location relative to other revegetation polygons. Selected sampling areas for revegetation effectiveness monitoring were classified as follows (collectively termed “habitat types”):

1. Treatment: Stake. Areas of the drawdown zone that were revegetated by planting black cottonwood (*Populus trichocarpa*), willow (*Salix* sp.), and red-osier dogwood (*Cornus stolonifera*) stake prescriptions developed under CLBWORKS-2. Stake treatments were delineated in polygons.
2. Treatment: Graminoid. Areas of the drawdown zone that were revegetated by planting sedge (*Carex* sp.), rush (*Scirpus* sp.), or grass (*Calamagrostis canadensis*) seedlings during CLBWORKS-2. Graminoid treatments were delineated in polygons.
3. Control: Area of the drawdown zone that was not revegetated using the revegetation prescriptions developed for CLBWORKS-2 nor modified by physical works projects. Controls were placed in areas of similar elevation, topography, and substrate as treatment polygons and served as a general representation of drawdown zone conditions relative to treatments.

Monitoring of arthropods and birds occurred within five sites with revegetation treatments: Burton Creek, Lower Inonoaklin, Edgewood South, Edgewood North, and East Arrow Park. Arthropod sampling occurred in all fives sites within revegetated stake (n=9) and graminoid (n=20) polygons, as well as at associated controls (n=7). Bird point counts were in stake (n=4) and graminoid (n=4) polygons, and control areas (n=3) at all sites except East Arrow Park.

Bats were surveyed with two ARUs each located at Burton Creek, Lower Inonoaklin, and Edgewood South. Wildlife cameras were deployed at these sites as well, with six at Burton (specifically in the WPW area), two at Edgewood South, and two at Lower Inonoaklin. While the spatial scale of the CLBWORKS-2 polygons prevent comparisons of wildlife data for revegetation effectiveness, records of bats and other wildlife can allow the documentation of species at risk that utilize the Arrow Lakes Reservoir and serve as a record of comparison for future monitoring at the Burton Creek WPW site.

The results of wildlife effectiveness monitoring were variable with evident site-specific effects. This is consistent with findings in previous years.

Arthropods. Responses by arthropods to revegetation treatments were mixed. There were no clear overall effects of graminoid or stake revegetation on arthropods between sites. Vegetation survival density (i.e., revegetation success) was not consistently related to arthropod relative abundance, richness, or diversity.

Songbirds. High reservoir levels limited the availability of songbird surveys in the 2019 sampling year. In total 25 songbird surveys were detected from within 30 m of a point count centre. Most songbirds surveyed were wetland and shrub-associated species; ground-nesting passerines (e.g., Savannah Sparrow,

Western Meadowlark) were absent or seldom detected from point count areas. Patterns of species abundance and distribution in treatment and control areas were unclear, given a low sample size and unequal effort (limited by polygon availability during the sampling period) in 2019.

A total of 17 nests were found, which constituted breeding evidence for 10 species at Burton Creek, Edgewood South, and Lower Inonoaklin. Nine nests were found within stake treatment polygons (including ground nests) and one was found in a graminoid revegetation polygon (but in a cottonwood tree). Inundation by reservoir levels was not implicated in any documented nest failures in 2019.

Wildlife Physical Works Monitoring and Results

In 2019 we continued to characterise the baseline, pre-treatment condition of the wildlife physical works site at Burton Creek. Sampling occurred prior to commencement of the construction of the WPW area in September 2019. Monitoring of both bird and arthropod communities at the Wildlife Physical Works location was similar to that of revegetation communities. In addition, Malaise traps and targeted odonate surveys were used for monitoring pre-WPW conditions at Burton Creek. Wildlife cameras and ARUs set up at the Burton Creek pre-Wildlife Physical Works site allow for baseline comparisons of the physical works effectiveness.

We identified 21 families of Hymenoptera, 33 families of Diptera, four families and 10 species of Araneae, five families of Coleoptera, and seven species of Carabidae from pitfall and Malaise trap samples. Two non-native carabid species (*Pterostichus melanarius* and *Carabus granulatus*) were recorded, as was an adventive species of scarab beetle (*Onthophagus nuchicornis*). We detected three species of odonate during targeted surveys.

We recorded five species of songbirds from the five point count surveys in the WPW area in 2019. These five species, comprising 17 individuals, were mostly wetland and shrub-associated songbirds: Chipping Sparrow, Common Yellowthroat, Lincoln's Sparrow, Lazuli Bunting, and Rufous Hummingbird. In total 35 species of waterbird were detected between April and September. Waterfowl usage of the WPW location itself remained low, and was correlated with water levels, receiving more waterfowl detections during periods when it was inundated by the reservoir. Waterbirds were often detected along the reservoir shoreline, and thus moved up or down from the upland areas depending on reservoir elevation. The number of individuals was distinctly higher in August/September than April/May or June/July periods, due to larger concentrations of certain waterfowl and gull species. The baseline physical works data on bird usage are necessary as a performance measure for the wetland once fully constructed.

For other wildlife, we recorded 11 species of bat in the Wildlife Physical Works area, which were predominantly species of *Myotis*. The number of bat detections was lower at Burton Creek than other sites. White-tailed deer were the most recorded animal on wildlife cameras.

Key Words: Arrow Lakes Reservoir, songbirds, arthropods, bats, revegetation, effectiveness monitoring, drawdown zone, hydro

ACKNOWLEDGEMENTS

The authors express their appreciation to the following individuals for their assistance in coordinating and conducting this study: Harry van Oort, Mark Sherrington, and Susan Pinkus (BC Hydro); David DeRosa, Dixon Terbasket, and Addison Fosbery (Okanagan Nation Alliance); Bruce Weaver (OKIB); Dr. Robb Bennett, Claudia Copley, and Dr. Joel Gibson (Royal British Columbia Museum); Bonnie Zand (Bonnie's Bugs IPM); Michael Miller, Shane Johnson, Karle Zelmer, and Julio Novoa (LGL Limited), Gary Davidson, and Julia Burger (subcontracted by LGL Limited).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF MAPS

ACRONYMS AND DEFINITIONS

To ensure that readers of this report interpret the terminology used throughout, the following definitions are provided.

CPUE: Catch per unit effort. Refers to the number of individuals caught per trap, standardized to a 24-hour trapping period.

Study Site: refers to a broad geographic area of the reservoir used as the highest level of stratification for sampling. The wildlife effectiveness monitoring areas corresponded with select revegetation treatment areas and are shown in Figure 3-1.

Drawdown Zone: a general term referring to the area ≤ 440.1 m ASL in a study site which is influenced by reservoir inundation. The drawdown zone encompasses both control and revegetation treatment polygons and/or proposed Wildlife Physical Works (WPW) locations.

Revegetation Area: areas revegetated under CLBWORKS-2 between 2009 and 2011.

Revegetation Prescription: the prescriptions implemented in the revegetation areas. Only certain revegetation prescriptions were considered for monitoring (because of replication and total area treated). For simplicity, these were categorized as:

Habitat Type: Within each site, sampling was conducted in treatment polygons and associated controls, collectively referred to as habitat types. The habitat types are defined as follows:

> **Control:** area of the drawdown zone that was not revegetated using the revegetation prescriptions developed for CLBWORKS-2 nor modified by physical works projects. Controls were placed in areas of similar elevation, topography, and substrate as treatment polygons and served as a general representation of drawdown zone conditions relative to treatments.
>
> **Treatment:** area of the drawdown zone that was revegetated using one of the revegetation prescriptions developed for CLBWORKS-2. Wildlife effectiveness monitoring focused on areas that received live stake revegetation treatment and graminoid (plug seedling) treatment.
>
> > **Stake**: Areas of the drawdown zone that were revegetated by planting black cottonwood (*Populus trichocarpa*), willow (*Salix* sp.), and red-osier dogwood (*Cornus stolonifera*) stake prescriptions developed under CLBWORKS-2. Stake treatments were delineated in polygons.
> >
> > **Graminoid**: Areas of the drawdown zone that were revegetated by planting sedge (*Carex* sp.), rush (*Scirpus* sp.), or grass (*Calamagrostis canadensis*) seedlings during CLBWORKS-2. Graminoid treatments were delineated in polygons.
>
> **Wildlife Physical Works (WPW):** The first stage of the Burton Creek WPW project was implemented in the fall of 2019, after that year's sampling was completed. An additional WPW has been designed in Lower Inonoaklin but is not currently planned. The physical works in progress for Burton Creek include the creation of a series of tiered wetlands, mounding of soil to increase topographic heterogeneity, and a reed canarygrass (*Phalaris arundinacea)* removal trial.

1.0 INTRODUCTION

The Columbia River Water Use Plan was developed as a result of a multi-stakeholder consultative process to determine how to best operate BC Hydro's Mica, Revelstoke, and Keenleyside facilities to balance environmental values, recreation, power generation, culture/heritage, navigation, and flood control. The goal of the Water Use Plan is 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 to address specific interests.

During the Water Use Planning process, the Consultative Committee supported the following projects to enhance wildlife habitat in the Arrow Lakes Reservoir, in lieu of maintaining lower reservoir levels:

1) A revegetation program to increase vegetation growth in the drawdown zone (CLBWORKS-2).
2) A study to evaluate the feasibility of enhancing or creating wildlife habitat in the drawdown zone in Revelstoke Reach (CLBWORKS-29A).
3) A study to identify high-value wildlife habitat sites for enhancement or protection in the Mid and Lower Arrow Lakes Reservoir (CLBWORKS-29B).
4) CLBWORKS-30: The implementation of wildlife physical works identified in CLBWORKS-29A and CLBWORKS 29B.

Revegetation was implemented in the drawdown zone of Arrow Lakes Reservoir under CLBWORKS-2 during years 2008 to 2011. South of Revelstoke Reach, options for wildlife enhancement strategies were developed under CLBWORKS-29B (Hawkes and Howard 2012, Hawkes and Tuttle 2016). Wildlife physical works identified in CLBWORK-29B will be implemented under CLBWORKS-30B.

This report outlines monitoring and results of CLBMON-11B1 in 2019, which focus on revegetation treatments (CLBWORKS-2) and wildlife physical works baseline conditions (CLBWORKS-30B).

2.0 OBJECTIVES AND MANAGEMENT QUESTIONS

CLBMON-11B1 is the first module in a suite of related effectiveness monitoring studies in the Arrow Lakes Reservoir, all of which were developed under one common CLBMON-11B Terms of Reference (TOR) in 2009 (BC Hydro 2009). The objectives of the CLBMON-11B1 program, as defined in the revised 2017 Terms of Reference (BC Hydro 2017), are as follows:

1. Assess the effectiveness of the revegetation program (CLBWORKS-2) with respect to wildlife use of the drawdown zone of the Arrow Lakes Reservoir.
2. Assess the effectiveness of the wildlife physical works projects (CLBWORKS-30A, CLBWORKS-30B) at improving and/or sustaining conditions for nesting and migratory birds and wildlife in the drawdown zone of Arrow Lakes Reservoir.
3. Provide recommendations on revegetation or wildlife physical works methods or techniques most likely to be effective at enhancing or

protecting the productivity of wildlife habitat in the drawdown zone of the Upper and Lower Arrow Lakes Reservoir.

4. Monitor specific areas identified under CLBWORKS-29B as providing high value wildlife habitat to determine opportunities for protection and enhancement within the Arrow Lakes Reservoir.

A series of Management Questions are defined in the 2017 CLBMON-11B TOR (BC Hydro 2017). A discussion of these questions can be found in past reports of this program (e.g., Hentze et al. 2019) and will be fully addressed in a future, comprehensive report.

2.1 Key Water Use Decisions Affected

The Terms of Reference for CLBMON-11B1 indicate that the results of this study will aid in more informed decision-making with respect to the need to balance the 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 decisions affected by the results of this monitoring program are whether revegetation and wildlife physical works are effective in enhancing wildlife habitat. Results from this study will also assist in refining the approaches and methods for enhancing wildlife habitat through adaptive management.

2.2 Monitoring Schedule

The Terms of Reference for CLBMON-11B1 provides an outline of the monitoring schedule for this program (See BC Hydro 2017: Table 3). Below is a modified table, updated for components completed as of the writing of this report. A future comprehensive report will address the revegetation monitoring program in full. Fieldwork in 2020 and onwards will shift focus to post-treatment monitoring of wildlife physical works.

Table 2-1. Summary of monitoring schedule for CLBMON-11B1 (modified from BC Hydro 2017 TOR: Table 3). ✓ = completed, P = planned.

Component	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Revegetation														
Implementation	✓	✓	✓	✓										
Pre-treatment sampling	none	none	none	none										
Post-treatment sampling		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Wildlife Physical Works														
Implementation												✓	P	
Pre-treatment sampling	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Post-treatment sampling													P	P

3.0 STUDY AREA

The Hugh Keenleyside Dam, completed in 1968, impounded two naturally occurring lakes to form the Arrow Lakes Reservoir, an approximately 230-km long section of the Columbia River drainage between Revelstoke and Castlegar, B.C. (Figure 3-1; Carr et al. 1993, Jackson et al. 1995). Two biogeoclimatic zones occur within the study area: Interior Cedar Hemlock (ICH) and Interior

Douglas-fir (IDF). The reservoir has a north-south orientation and is set in the valley between the Monashee Mountains in the west and Selkirk Mountains in the east. Arrow Lakes Reservoir has a licensed storage volume of 7.1 million-acre feet (BC Hydro 2007). The normal operating range of the reservoir is between 418.64 m and 440.1 m above sea level (m ASL).

Sites were selected based on areas treated under CLBWORKS-2 (Keefer et al. 2009) that had evidence of revegetation success (Miller et al. 2018). Starting in 2017, sampling also occurred at sites where potential wildlife enhancement projects were being considered for development under CLBWORKS-30B.

The Burton Creek wildlife physical works (WPW) location was monitored in 2019, which is located south of Nakusp, on the east side of Arrow Lakes Reservoir. At the time of monitoring, the site was a depression with low vegetation species diversity, including non-native reed canarygrass (*Phalaris arundinacea*) (Figure 3-2; Figure 3-3). Most of the site was deemed unsuitable for aquatic invertebrates and aquatic macrophytes, although the locations of ponds A1 and A2 likley provided some suitable habitat for these species. While some wildlife use (e.g., songbirds and amphibians) has been documented from this area, an influx of waterbirds and other species during periods of inundation indicate that the area is underutilized by wildlife when reservoir elevations are lower, including during key periods for migration or nesting for animals. The proposed project would create approximately 2.8 ha of shallow wetland habitat. More details are provided in Section 4.2: Wildlife Physical Works (CLBWORKS-30B).

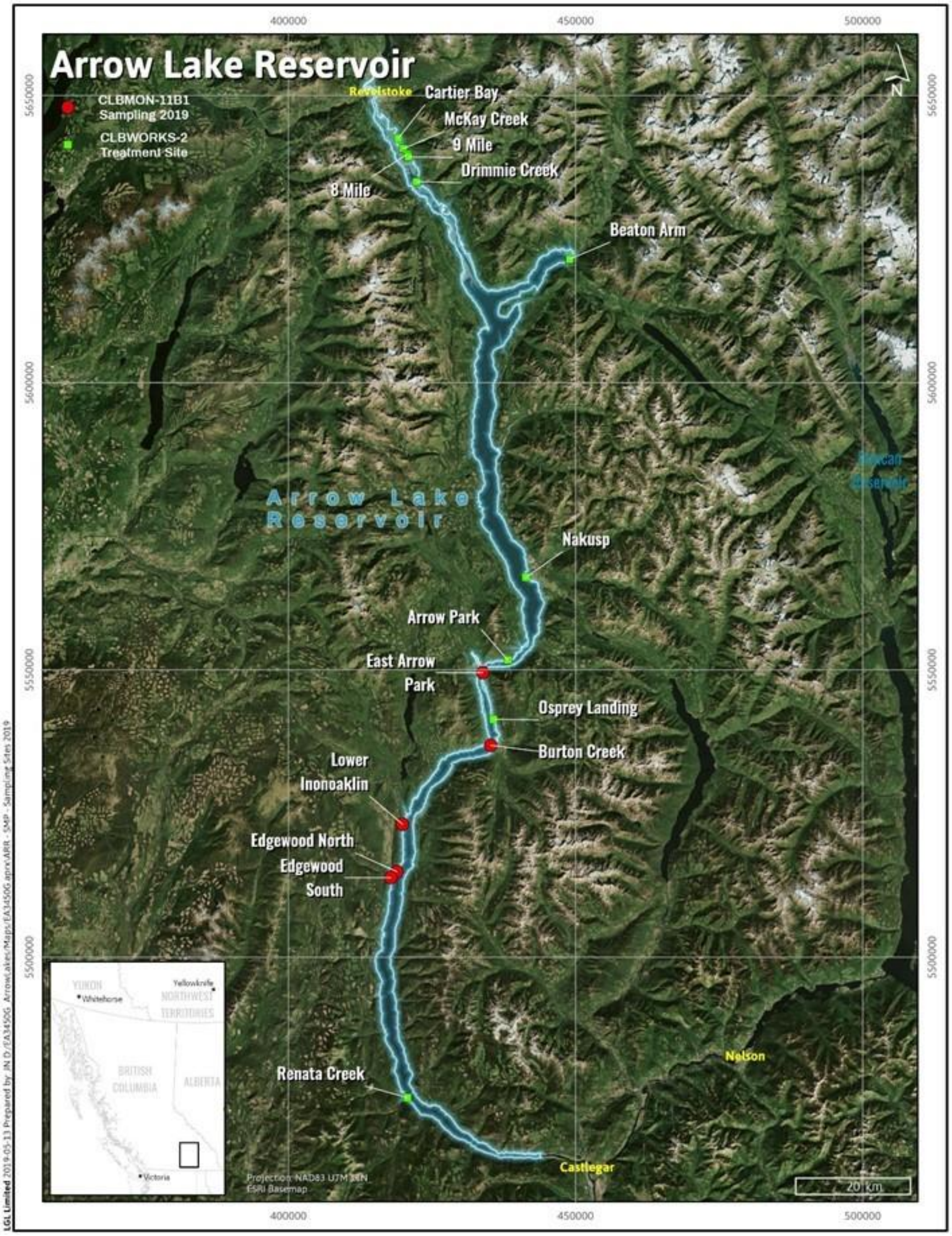


Figure 3-1. Location of 2019 wildlife monitoring sites within Arrow Lakes Reservoir in B.C. Note: birds were not surveyed at Edgewood North and East Arrow Park.

Figure 3-2. Pre-treatment (left) and post-treatment (right) photos of the Burton Creek Wildlife Physical Works location. Credit: M. Miller.

Figure 3-3. Photos of the pre-treatment (top) and post-treatment (bottom) Burton Creek Wildlife Physical Works location. Credit: R. Waytes and M. Miller.

4.0 METHODS

4.1 Revegetation Treatments (CLBWORKS-2)

Revegetation treatment prescriptions applied under CLBWORKS-2 were monitored annually under CLBMON-12, with broad-scale assessments of most revegetation polygons conducted in 2017 (Miller et al. 2018). The Arrow Lakes Revegetation Catalogue (Hawkes et al. 2018a) summarizes the details of each revegetation prescription application and polygon locations.

We summarized revegetation prescriptions and surviving vegetation densities by site for the target treatment polygons sampled under CLBMON-11B1 in 2019, utilising information provided by Miller et al. (2018) and Hawkes et al. (2018b). This included the 2017 vegetation densities for two broad revegetation types that were found to have had some revegetation success (Miller et al. 2018): graminoid seedling and shrub stakes.

Definitions are as follows:

Graminoid Seedling: Nursery grown seedlings of Kellogg's sedge (*Carex lenticularis* var. *lipocarpa*), Columbia sedge (*Carex aperta*), water sedge (*Carex aquatilis*), wool-grass (*Scirpus atrocinctus*), small-flowered bulrush (*Scirpus microcarpus*), and bluejoint reedgrass (*Calamagrostis canadensis*) were hand planted by professional tree planting crews using planting shovels.

Shrub Stake: Live stakes of black cottonwood, red-osier dogwood, and willow (primarily Scouler's and Bebb's Willow) were either planted by hand (HPL), with the aid of a mini-excavator (EPL), or both by hand and excavator (HPL/EPL). Stakes were planted to depths of 30 to 50 cm with the aid of a planting bar to create a pocket for the stake.

4.2 Wildlife Physical Works (CLBWORKS-30B)

All sampling in this report happened prior the Wildlife Physical Works (WPW) construction and represents baseline conditions (pre-physical works). Two WPW locations have been designated (Lower Inonoaklin and Burton Creek), but only one WPW has been selected for implementation (Burton Creek).The Burton Creek physical works location is adjacent to Highway 6 from which it is highly visible, and accessible via Robazzo Road (Figure 4-1). The site is well-used by the public for recreation (e.g., picnics, camping, ATV use, dog walking, etc.).

As of September 2019, the first phase of the physical works was enacted at Burton Creek. Five ponds (A1-A4 and B1) and two mounds (C2 and C3) were constructed at Burton Creek in September and October of 2019 (Figure 4-1; Miller and Hawkes 2019, draft). The constructed terrain was subsequently revegetated with a combination of native plants (sedges, shrubs, and trees) using locally salvaged material as well as nursery stock. The next planned phase of activity at Burton Creek includes the expansion of some ponds (A3 and A4), the construction of pond D1, and construction of mound C4. The environmental objectives for the physical works are found in Kerr Wood Leidel (2018). In general, current wildlife habitat suitability is low and is expected to increase substantially with the implementation of the physical works. This Burton Creek WPW project is expected to benefit wildlife including birds, amphibians, reptiles, mammals (bats), insects (e.g., dragonflies) and fish. Species with provincial or federal conservation designation that may benefit from this project include the provincially blue-listed and COSEWIC species of Special Concern, Western Toad (*Anaxyrus boreas*); the provincially blue-listed Townsend's Big-eared Bat (*Corynorhinus townsendii*) and Fringed Myotis (*Myotis thysanodes*); and the COSEWIC endangered Little Brown Myotis (*Myotis lucifugus*) (listed February 27, 2012). The relatively homogeneous habitat that will be enhanced suggests little to no risk with this physical works. However, there is always a risk that the created habitat will not function as desired and require future interventions to increase productivity or habitat suitability for wildlife and vegetation.

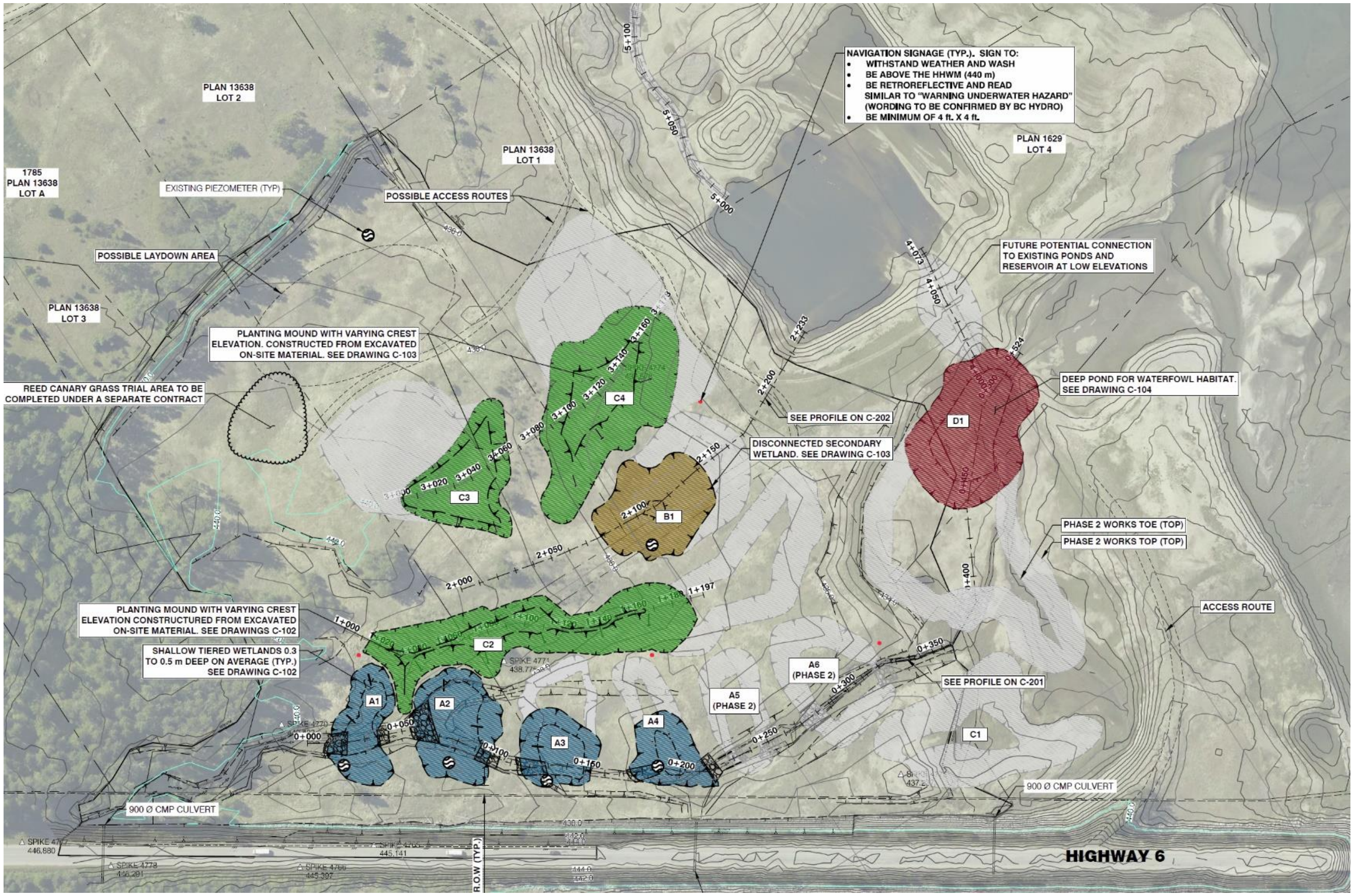


Figure 4-1. **Schematic of the designed physical works at Burton Creek.** The physical works incorporates elements of shallow tiered wetlands (blue polygons, secondary, stand-alone wetlands (brown), deep ponds (red), and planting mounds with varying crest elevations (green). Ponds A1-A4 and B1 and mounds C2 and C3 were constructed in September and October of 2019. Schematic from Kerr Wood Leidel (2018).

4.3 Experimental Design

4.3.1 Revegetation

To align wildlife sampling with CLBWORKS-2 revegetation prescriptions and CLBMON-12 revegetation effectiveness monitoring, we obtained shapefiles of the 2008-2011 treatment polygons from Keefer Ecological Services. Because we wanted to compare 2019 data collected at treated areas to non-treated (or control) areas, as well as to understand how vegetation density influenced the 2019 data, we used the following approach to identity treatment polygons in each site where revegetation prescriptions were applied:

1. Using ArcMap 10, we selected the treatment polygons of interest (successful[1] graminoid or stake treatments as identified by Miller et al. 2018)
2. From these polygons we chose revegetation polygons for arthropod sampling based on several criteria, including:
    a. A range of vegetation density (stakes per hectare, sph), where available: high (≥ 20000 sph graminoids, ≥ 2000 sph live stakes), moderate (≥ 10000 sph graminoids, ≥ 1000 sph live stakes), and low (< 10000 sph graminoids, < 1000 sph live stakes [calculated from 2017 CLBMON-12 data (Miller et al. 2018)];
    b. Elevation level (≥435 m ASL); and
    c. Location relative to other revegetation polygons. Revegetation polygons that extensively overlapped with each other were excluded to reduce potentially confounding results of multiple treatments on insect data.
3. Sampling locations for arthropods and birds were selected within treatment polygons, accounting for appropriate spacing between sampling locations (e.g., 30 m radius around point count stations thus >60 m between point count stations; 10 m minimum distance between pitfall trap arrays).
4. Control locations were selected at similar elevations and in proximity to treatment polygons, where possible. They represented the general conditions of the drawdown zone.
5. The number of songbird sampling station cells selected per treatment or control polygon was a function of polygon size and availability. Where possible, a minimum of two songbird point count stations were selected within each control and treatment polygon. Three pitfall trapping locations were selected within each control and treatment polygon.

The design to monitor revegetation effectiveness was carried out for arthropod sampling as shown in Table 4-1. While we intended to sample as many

[1] Success was herein defined as any revegetation polygon having at least one surviving transplant.

revegetation polygons as possible within each vegetation density category, polygons in each category that met all other criteria were not available at every site. We included as wide of a range as was possible given this limitation.

Table 4-1. Summary of treatment polygons sampled in 2019 for revegetation effectiveness monitoring. This includes sampling for arthropods as well as for songbirds (in parentheses). Vegetation survival density was based on CLBMON-12 data (Miller et al. 2018).

	Vegetation density			
Revegetation type	Low	Moderate	High	**Total**
Graminoid	9 (2)	9 (1)	2 (1)	**20 (4)**
Stake	5 (2)	1	3 (2)	**9 (4)**
Total	**14 (4)**	**10 (1)**	**5 (3)**	**29 (8)**

4.3.2 Wildlife Physical Works

The efficacy of the physical works constructed at Burton Creek will be assessed using a Before-After assessment. The data collected to date represent the before period with data collection occurring in the physical works locations related to arthropods, birds (songbirds and waterfowl), bats, amphibian and reptiles (obtained from CLBMON-37), and vegetation. Large mammal use (e.g., ungulates) of the physical works location was based on opportunistic observations of wildlife and associated signs, as well as the use of wildlife cameras.

Data collection methods at the physical works location were the same as those used to assess the effectiveness of revegetation treatments to provide habitat for wildlife. In addition to sampling for arthropods, songbirds and bird nests, and bats, data were collected on the occurrence and distribution of waterbirds. Waterbirds were surveyed at Burton Creek, Lower Inonoaklin, and Edgewood South (Eagle Creek) approximately bi-weekly throughout the months of April to September 2019. The occurrence of waterfowl, shorebirds, and other water-associated species (e.g., herons, loons) in the spring, summer and fall were mapped to provide an indication of the use of the area by birds during these periods.

4.4 Response Measures

An effectiveness monitoring program should be designed to determine how well management activities, decisions, or practices meet the stated objectives of the program (Marcot 1998, Noon 2003). Key to designing an effectiveness monitoring program is the selection of sensitive and readily measurable response variables that are appropriate to the objectives of the management action (Machmer and Steeger 2002); however, the selection of indicators (e.g., focal species) can be challenging (Andersen 1999).

The selection of indicator species/processes should be guided by their sensitivity to the management practice, the ease of collecting data, and the usefulness of the information to address the management activity (Chase and Guepel 2005).

Potential indicators may include habitat attributes, keystone species, species at risk, species that are sensitive to specific habitat requirements, or species that can be readily monitored (Feinsinger 2001, Chase and Guepel 2005). The selection of indicators should also be appropriate to the spatial scale of the applied management activity and must take into consideration factors that are external to the monitoring program, such as inter- and intra-specific competition, predation, climatic change, disease, time of year, and in the case of CLBMON-11B1, normal reservoir operations.

4.4.1 Terrestrial Arthropods

Arthropods, including spiders and beetles, are the most diverse group of organisms found in terrestrial environments. Terrestrial arthropods are often abundant across many different ecosystems and habitats. A diversity of specialist species makes arthropods useful in monitoring studies because they respond rapidly to changes in the local and/or surrounding environment (McGeoch 1998; Schowalter 2006). Monitoring of ground-dwelling beetles (Carabidae and Staphylinidae) and spiders (Araneae) has been particularly useful for monitoring effects in other large-scale monitoring studies across Canada (Buddle et al. 2000, 2006; Buddle and Shorthouse 2008; Klimaszewski et al. 2008; Pinzon et al. 2010; Work et al. 2008, 2013) and elsewhere. Even a small number of sampling units and few individuals can reliably reflect community structure, allowing for cost-effective, efficient sampling (Blanchet et al. 2015).

Arthropods are an important food source for many vertebrate taxa (e.g., birds, amphibians, and small mammals), and are integral to ecosystem processes such as decomposition, pollination, nutrient cycling, predation, and parasitism. Terrestrial arthropod abundance and diversity could be expected to increase with increasing vegetation structure and diversity (e.g., Humphrey et al. 1999; Söderström et al. 2001). Because of the trophic linkage between vegetation, arthropods, and songbirds, the inclusion of terrestrial arthropods as a focal species group to monitor makes intuitive sense. In addition, the relatively small spatial scale of revegetation polygons (min= 0.0024, mean= 0.62 ha, max= 7.4 ha) is better suited to arthropod monitoring than wildlife with larger ranges.

Arthropod Sampling

Terrestrial arthropods were sampled at five main study sites in 2019: East Arrow, Burton Creek, Lower Inonoaklin, Edgewood North and Edgewood South (Figure 3-1). This included sampling of 29 revegetation polygons, one Wildlife Physical Works location (Burton Creek), and 7 controls (untreated drawdown zone locations) (Table 4-2; also see Appendix A). The type of revegetation polygons consisted of nine stake treatments and twenty graminoid treatments. Lower Inonoaklin, Edgewood South, and Edgewood North had one control area each that represented the general conditions of the drawdown zone. Geographical separation between some of the revegetation polygons at East Arrow Park and Burton Creek necessitated additional control areas (Appendix A).

Consistent with previous years (e.g., Hawkes et al. 2011, 2014, 2018b; Sharkey et al. 2018; Wood et al. 2018; Hentze et al. 2019), arthropods were sampled via pitfall trap arrays. We eliminated Malaise trap sampling for testing revegetation effectiveness, as there was not enough space in revegetation polygons to have multiple independent Malaise trap samples. Instead, we increased the number of

Malaise traps in the Burton Creek WPW area to three per collection period as a descriptive measure of flying insect diversity. Each Malaise trap generated one sample to be used for diversity information (Table 4-2).

Pitfall arrays comprised four traps (473 mL clear plastic Amcor® food cups) inserted into the ground, spaced ~1 m apart at randomly determined sampling locations. Within each array, one pitfall trap was used to collect an arthropod diversity sample (used for arthropod identification, relative abundance, relative richness, diversity, and composition). The remaining three pitfall traps were used to collect a biomass sample (to measure dry weight of arthropod sample contents). Traps were filled with ~100 mL of preservation fluid (Propylene glycol, Univar Canada Ltd.) and checked daily to ensure functionality and record trap disturbance.

Three pitfall array units were established per treatment polygon or control area in the drawdown zone. Given the short temporal duration of our sampling and limited area of polygons, we chose a 10 m minimum spacing for randomly selecting array unit locations within each polygon. This inter-trap spacing distance for analyzing patterns of abundance, richness, and composition, aligns with that of Samu and Lövei (1995) and Bess et al. (2002).

Table 4-2. Summary of arthropod sampling in revegetation polygons and Wildlife Physical Works (WPW) in 2019. Using the selection criteria listed in Section 4.3.1, 20 graminoid and 9 live stake polygons were selected. The number of polygons was a function of the derived success based on CLBMON-12 data (Miller et al. 2018), elevation, and polygon location. Trap type indicates pitfall (PF) or Malaise (M) trap. Sample number indicates how many diversity (div) or biomass (bio) samples were derived in each location, in each collection period. Polygon ID is the CLBWORKS-2 treatment ID, which includes the year of treatment application and polygon number.

Site	Polygon ID	Elevation	Treatment	Survival density	Trap Type	No. of samples Collection 1	No. of samples Collection 2
Burton Creek	2009_64	436.78	Graminoid	Low	PF	3 div, 3 bio	3 div, 3 bio
	2009_65	436.35	Graminoid	Moderate	PF	3 div, 3 bio	-
	2011_20	435.68	Graminoid	Moderate	PF	3 div, 3 bio	-
	2010_2	436.49	Graminoid	Low	PF	3 div, 3 bio	3 div, 2 bio
	2009_5	435.84	Graminoid	Low	PF	3 div, 3 bio	-
	2010_9	436.20	Graminoid	Moderate	PF	3 div, 3 bio	-
	2009_25	439.59	Stake	Low	PF	3 div, 3 bio	3 div, 3 bio
	2009_26	438.03	Stake	Low	PF	3 div, 3 bio	3 div, 3 bio
	Control 1	437.67	Control	NA	PF	3 div, 3 bio	3 div, 3 bio
	Control 2	437.00	Control	NA	PF	3 div, 3 bio	2 div, 2 bio
	WPW	441.00	Pre-treatment	NA	PF	5 div, 5 bio	5 div, 5 bio
	WPW	441.00	Pre-treatment	NA	M	3 div	3 div
Lower Inonoaklin	2009_17	434.92	Graminoid	High	PF	3 div, 3 bio	-
	2009_19	437.39	Graminoid	Moderate	PF	3 div, 3 bio	-
	2011_23	436.95	Graminoid	Low	PF	3 div, 3 bio	-
	2011_24	435.35	Graminoid	Low	PF	3 div, 3 bio	-
	2009_14	435.65	Graminoid	Low	PF	3 div, 3 bio	-
	2009_13	437.26	Stake	High	PF	3 div, 3 bio	-
	2009_18	438.30	Stake	Low	PF	3 div, 3 bio	3 div, 3 bio
	Control	441.00	Control	NA	PF	3 div, 3 bio	3 div, 3 bio
Edgewood South	2009_1	436.74	Stake	High	PF	3 div, 3 bio	3 div, 3 bio
	2009_2	436.07	Stake	Moderate	PF	3 div, 3 bio	-
	2009_3	437.71	Stake	High	PF	3 div, 3 bio	3 div, 3 bio
	Control	436.84	Control	NA	PF	3 div, 3 bio	3 div, 3 bio
Edgewood North	2009_7	435.19	Graminoid	Moderate	PF	3 div, 3 bio	-
	2009_9	436.96	Graminoid	Low	PF	3 div, 3 bio	-
	2011_31	436.71	Graminoid	High	PF	3 div, 3 bio	3 div, 3 bio
	Control	436.27	Control	NA	PF	3 div, 3 bio	3 div, 3 bio

East Arrow Park	2009_41	436.84	Graminoid	Moderate	PF	3 div, 3 bio	2 div, 2 bio
	2009_43	435.88	Graminoid	Moderate	PF	3 div, 3 bio	-
	2009_49	436.92	Graminoid	Moderate	PF	3 div, 3 bio	3 div, 3 bio
	2009_48	437.46	Graminoid	Low	PF	3 div, 3 bio	3 div, 3 bio
	2010_24	437.43	Graminoid	Low	PF	3 div, 3 bio	3 div, 3 bio
	2009_58	435.19	Graminoid	Moderate	PF	3 div, 3 bio	-
	2009_47	438.22	Stake	Low	PF	3 div, 3 bio	3 div, 3 bio
	2009_54	438.84	Stake	Low	PF	3 div, 3 bio	3 div, 3 bio
	Control 1	436.21	Control	NA	PF	3 div, 3 bio	3 div, 3 bio
	Control 2	439.92	Control	NA	PF	3 div, 3 bio	3 div, 3 bio

To align with previous monitoring years and to capture temporal variation in arthropod abundance and composition, we intended to collect samples in two collection periods. In previous years collections were generally made in June and July, as abundance is generally lower in May (unpublished CLBMON-11B1 data from 2011 and 2013 monitoring). However, projected reservoir elevations earlier in the season and difficulties accessing sites in previous years necessitated that sampling shift to mid-May and June. Collection period one occurred between May 17th and May 26th and collection period two occurred between June 3rd to June 10th, with each trap operational for approximately 72 hours (exact dates for each trap are provided in Appendix B). Despite these efforts to expedite sampling, reservoir levels limited and prevented access to a number of sampling polygons during the second collection period (Figure 5-2). Excessive human disturbance (especially off-road vehicle use) during the May sampling may have also affected arthropod sampling (Figure 4-2). The 2019 monitoring season generated a total of 113 biomass and diversity pitfall samples in the first collection period and 65 biomass and 66 diversity pitfall samples in the second collection period (Figure 4-1), as well as six Malaise trap samples.

In addition to regular sampling, we also included targeted surveys for dragonflies and damselflies (Odonata) at the Burton Creek WPW site. We also sampled odonates at Edgewood South and Lower Inonoaklin to provide a broader scope of odonate species found at Arrow Lakes Reservoir. Observers counted and recorded all species encountered. Identification to species was done in the field or was confirmed later by photographs. Start and end time, location, and weather information were included for each survey. These surveys were consistent with those conducted in previous years (Hawkes et al. 2011).

Figure 4-2. Vehicle tracks in the drawdown zone at Burton Creek (Photo taken May 18, 2019).

Sample Processing and Identification

With the aid of taxonomic specialists, arthropods from diversity pitfall trap samples were counted and classified to species for all spiders (Araneae) and ground beetles (Coleoptera: Carabidae), and to family for non-carabid beetles (Coleoptera). Malaise trap sample contents were sorted and identified for families of Hymenoptera and Diptera.

Each biomass sample was weighed to the nearest centigram and placed in a drying oven. The samples were weighed each day during drying until the weight stabilized, indicating that drying was complete. On average, samples were dried for 76.2 hours (min= 47.0 hours, max= 118.6 hours). The final dry weight of each sample was then used in biomass calculations.

4.4.2 Birds

Monitoring the response of birds to management strategies has proven a pragmatic approach on several levels. For example, songbird monitoring can (1) measure the effectiveness of restoration and enhancement; (2) provide the necessary feedback for adaptive management; (3) guide restoration design by providing information on the health and habitat associations of the local bird populations; (4) be cost effective; and (5) provide education and outreach opportunities (Burnett et al. 2005). Because birds occupy an extremely diverse range of niches within an ecosystem and a relatively high position in the food chain, they are ideal indicators of environmental conditions (DeSante and Geupel 1987; Temple and Wiens 1989; Rich 2002). Along with the relative ease of study and the cost effectiveness of a songbird monitoring program, songbird monitoring provides researchers with feedback from a whole community of organisms, not just a single species. Thus, songbirds are model organisms for measuring the efficacy of restoration or enhancement projects. However, study designs need to account for the spatial characteristics of bird responses to restoration or enhancement projects, and they may not always be suitable for assessing fine-scale changes within broader landscape contexts.

Point Count Surveys

Time-constrained, variable-radius[2] point count surveys were used to assess the diversity and relative abundance of songbirds (Ralph et al. 1995). A total of 56 point count stations were identified prior to field surveys commencing (Appendix C), split between Burton Creek (21 potential points), Lower Inonoaklin (16 points), Edgewood North (11 points) and Edgewood South (8 points). In total, 21 point count stations were surveyable in 2019 at these four sites (Table 4-3, Appendix C). We attempted to survey each point count twice through the survey period; however, due to higher reservoir water levels, fewer point count stations could be surveyed on the second visit (Table 4-3). Treatment point counts were distributed in different revegetation polygons (Appendix C), depending on size and availability of polygons at each site. In total there were 4 graminoid polygons and 4 stake polygons, cumulatively containing 6 and 8 surveyed point count stations respectively (Table 4-3).

Table 4-3. Number of point count stations surveyed in 2019 by site, polygons, and treatment type. The number of polygons was a function of the derived success based on CLBMON-12 data (Miller et al. 2018), elevation, and polygon location. Station number indicates how many point count stations were surveyed in each visit in each location. Polygon ID is the CLBWORKS-2 treatment ID, which includes the year of treatment application and polygon number. WPW = Wildlife Physical Works.

Site	Polygon ID	Elevation	Treatment	Survival density	No. of stations Visit 1	Visit 2	Total
Burton Creek	2009_25	439.59	Stake	Low	3	2	3
	Control	437.67	Control	NA	1	1	1
	WPW	441.00	Pre-treatment	NA	4	2	4
Lower Inonoaklin	2009_18	438.30	Stake	Low	2	2	2
	2011_23	436.95	Graminoid	Low	3	0	3
Edgewood North	2009_7	435.19	Graminoid	Moderate	1	0	1
	2009_9	436.96	Graminoid	Low	1	0	1
	2011_31	436.71	Graminoid	High	1	0	1
	Control	436.27	Control	NA	1	0	1
Edgewood South	2009_1	436.74	Stake	High	1	0	1
	2009_3	437.71	Stake	High	2	1	2
	Control	436.84	Control	NA	1	1	1
Total					21	9	21

Point count surveys were conducted at Treatment (both stake and graminoid revegetation plots) and Control stations, as well as baseline stations within the proposed WPW area at Burton Creek (Appendix C). Treatment stations occurred within previously revegetated polygons, and Control stations within non-revegetated areas of the drawdown zone in proximity to treatment areas (Appendix C).

The timing of the songbird surveys (10-30 June, 2019) coincides with the height of the breeding season at which time locally breeding passerines are on territory and are highly vocal, enabling surveyors to document the number and diversity of breeding birds. Surveys commenced at sunrise and ended within ~4 hours of sunrise (Ralph et al. 1995). Songbird surveys were done during favourable weather conditions only (i.e., no heavy wind or precipitation) to standardize

[2] Variable in the sense that observations are categorized by distance from the point count centre

surveys and minimize variable detections associated with sub-optimal environmental conditions. All songbird surveys conformed to the provincial standard (RIC 1999).

The point count survey method involved standing at a fixed point within each control, treatment, and reference site and documenting all birds seen and/or heard during a 6-minute count period. The species of bird, as well as the distance (from the observer), were recorded. Additional data recorded included the sex and age class of the bird (when known) and the type of detection (call, song, or visual), and notes were made to differentiate fly-over birds from the rest of the detections. Furthermore, because the detectability of different bird species varies depending on the amount of time devoted to each survey (Bibby et al., 2000), the portion of the 6-minute count period in which each individual is detected was recorded (0-3 minutes, 3-5 minutes, 5-6 minutes).

At each point count station, the following data were collected:

1. **Physical information:** site number, point count number, GPS coordinates, weather (wind speed, temperature, relative humidity [measured with a Kestrel® 4000 Pocket Weather Meter], current survey conditions), date, time of day, visit number;
2. **Bird observations (sight or sound) in point count plots:** species, approximate age (adult/juvenile), location of each bird heard or seen within point count plot, location mapped on point count form, estimate of the horizontal distance between each detected bird and the observer, detection type (sight or sound);
3. **Bird observations outside point count plots:** incidental observations of birds located outside the point count area at each site.

Nest Searches

Nest searches were completed within the drawdown zone and immediately adjacent areas at all sites where point counts were conducted. Polygons were searched over the same date span as point count surveys, typically occurring after the point count period had ended for a given day. Nest searches were not limited by taxa, though focused on songbirds and shorebirds.

Waterbird Surveys

Surveys focused on waterbirds were completed on 17 dates from mid-April to mid-September (roughly every 9 days) (Table 4-4). These waterbird surveys were conducted in the Burton Creek area, with the goal of providing baseline waterbird information relevant to the proposed physical works, and at Lower Inonoaklin and near Edgewood South (Eagle Creek). Waterbird surveys were approximately 20 minutes (Eagle Creek) to 2.25 hours in duration (Burton Creek), with average count durations ranging from ~40 minutes to ~2 hrs (Table 4-4). During each survey period a map showing the survey area and approximated water levels for that date was provided, and the number and species of birds (all birds, but with a focus on waterbirds) was recorded onto the map.

Table 4-4. Waterbird survey sampling locations and dates in 2019.

Location	No. of Surveys	First Survey Date	Last Survey Date	Average Count Duration
Burton Creek	17	16 April 2019	13 Sept. 2019	1 hr 50 min
Lower Inonoaklin	16	16 April 2019	13 Sept. 2019	59 min
Edgewood South (Eagle Creek)	6	27 April 2019	13 Sept. 2019	39 min

4.4.3 Bats

There are 12 bat species potentially occurring in the West Kootenays, most confirmed by live capture studies (excluding *Myotis ciliolabrum*). Five of these twelve species are of conservation concern at the provincial and/or national level (Table 9-1.). While bats are not appropriate focal taxa for detecting differences between polygons on the spatial scale of the CLBWORKS-2 revegetation program, we selected bats for monitoring across the reservoir drawdown zone and non-drawdown zone habitats as these data are important documentation of species at risk utilizing Arrow Lakes Reservoir. In addition, these bat data may be useful for comparisons to the bat activity recorded in future years of monitoring at the Burton Creek WPW site. Bats were recorded at Burton Creek, Lower Inonoaklin, and Edgewood South in 2019. Further reporting of general Arrow Lakes Reservoir bat data is provided in Appendix D.

4.4.4 General Wildlife Signs and Cameras

Measures of wildlife use of the drawdown zone include incidental observations as well as wildlife camera photos. We conducted incidental surveys of wildlife use at all sites in addition to the standard sampling procedures. While the informal nature of these surveys precludes any rigorous testing, they do indicate what wildlife might be found at each site. The degree of specificity in identifying an animal was at the discretion of the observer and depended upon the type of wildlife sign (e.g. scat, tracks, physical presence) and the experience of the observer.

Six RECONYX® HyperFire 2™ cameras were set up in the proposed Burton Creek WPW area to monitor wildlife use and access to the area. Two wildlife cameras each were also deployed in Edgewood South and Lower Inonoaklin. Cameras were deployed from 21 May to 9 September 2019. Cameras were programmed to take ten photos with each trigger using the 'RapidFire' setting, which takes about two frames per second. After the last photo, each camera was set to have a quiet period for one minute. Trigger sensitivity was set to medium-high. Remote cameras have the potential to provide more complete information about the range of species using the existing habitat since they record 24 hours a day. It is expected that the proposed wetland project will increase habitat suitability for a variety of wildlife, thus, we expect an increase in species richness using this site.

4.4.5 Response Measures for Wildlife Physical Works Monitoring

The WPW was implemented in September and October of 2019, after 2019 sampling took place. Several performance measures were proposed to assess success of the Burton Creek physical works (Hawkes and Tuttle 2016). In 2018

(Hentze et al. 2019) and 2019, baseline conditions for arthropods, songbirds, and bats were investigated, conforming to methods described above for those groups. In addition, waterfowl and other water and shoreline-associated species (e.g., shorebirds, herons, loons) presence and abundance was determined with separate dedicated surveys from April to September 2019. Wildlife cameras were also deployed to indicate baseline wildlife use of the area in conjunction with incidental data collection. During the 2019 survey period the Wildlife Physical Works location was dominated by grasses, and no constructed wetland habitat existed at that time (construction began during autumn 2019). Evidence of use and establishment of species from a variety of taxonomic groups (e.g., macroinvertebrates, amphibians, native macrophytes) will be studied now that WPW construction has been implemented. The current (baseline) conditions of the pre-wetland area are monitored so that effective change for those groups can be quantified.

4.5 Data Analyses

In general, data analyses followed those performed in recent years (e.g., Wood et al. 2018; Hentze et al. 2019). Most of the results reported summarize the data collected in 2019 only. Analyses varied based on the study objective and qualities of the resultant dataset and are discussed for each section below.

4.5.1 Revegetation Treatments

Vegetation data were tabulated by site for the target revegetation polygons sampled in 2019. CLBWORKS-2 prescriptions (Keefer and Moody 2010; Keefer Ecological Services 2010 and 2011), area cover, and planting methodology are summarized for each revegetation type: graminoid seedling and shrub stakes.

Terrestrial Arthropods

The total number of diversity and biomass samples are given in section 4.4.1 (Terrestrial Arthropods; also see Table 4-2). All samples are from the 2019 monitoring year. To eliminate temporal pseudoreplication and unequal sampling effort, we limited interpretation of results to the first sampling period. All arthropod boxplots therefore only present data from the first sampling period. For variables that did not involve comparison (such as reporting arthropod families or species and associated abundances), all available data were used from both collection periods. In previous years there has been evidence of a site effect on results; thus, results were presented separately by site.

All analyses and visualizations (where performed) were conducted in the R programming language (R Core Team 2019).

Arthropod Relative Abundance (CPUE)

Relative abundance was calculated as catch-per-unit-effort (CPUE), equal to the number of adult spiders (Araneae), beetles (Coleoptera), or ground beetles (Carabidae) caught per pitfall trap sample, standardized to a 24-hour trapping period (i.e., individuals per trap-day). This metric was generated from diversity samples only. Boxplot graphs were provided for mean CPUE of pitfall trap samples. Pitfalls (n=3) were collected from each graminoid polygon (n=20), stake polygon (n=9), and control (n=7) in the first collection.

Arthropod Richness

We standardized richness for trapping effort (per 24-hour trap day) for each pitfall trap (n=3 per polygon) at each graminoid polygon (n=20), stake polygon (n=9), and control (n=7) in the first collection. This metric was generated from diversity samples only. Samples were rarefied to a sample size of two for comparison using the R package 'vegan' (Oksanen et al. 2018). Boxplot graphs were provided for rarefied richness of two groups (Araneae species and Carabidae species). For species richness comparisons, samples were limited to adult individuals identified to species (i.e., adult spiders and ground beetles).

Arthropod Diversity

We assessed arthropod diversity using the Shannon-Wiener index, standardized by trapping effort (per 24-hour trap day) for each pitfall trap (n=3 per polygon) in each graminoid polygon (n=20), stake polygon (n=9), and control (n=7) in the first collection. This metric was generated from diversity samples only. Boxplot graphs were provided for diversity of two groups (Araneae species and Carabidae species). Samples were limited to adult individuals identified to species.

Arthropod Biomass

Biomass was calculated as the dry weight of arthropods (mg) per trap-hour for each sample. This includes samples from pitfall traps (n=3) from each graminoid polygon (n=20), stake polygon (n=9), and control (n=7) in the first collection. This metric was generated from biomass samples only. Biomass pitfall trap results were presented via boxplot graphs.

Birds

Bird summaries were limited to passerines ("songbirds") and hummingbirds detected during point count surveys. For ease of reading throughout the report we collectively refer to these as "songbirds", and most bird detections were indeed of true songbirds. We limit analyses to detections within 30 m of the point count centre due to the very small widths of revegetation treatments that were applied. Extending detections to include observations >30 m precludes any discussion of treatment effects as the radius then extends beyond the treatment boundary. Birds detected as fly-overs were excluded from analyses, as these individuals may not be utilizing the treatment area containing the point count; the exception being swallows and hummingbirds which are included as they are almost exclusively detected in flight over drawdown zone areas.

Due to the limited amount of bird data resulting from 2019 surveys, the high number of singletons (single observations of species), and the uneven sampling effort (graminoid = 4 polygons, stake = 4 polygons) due to the greater inundation of graminoid polygons relative to stake polygons, no statistical analyses were performed on the 2019 songbird data.

Bats

Bat presence and activity was assessed by analyzing triggered recordings from Wildlife Acoustics Song Meter units using their automatic classification software (Kaleidoscope Pro v. 4.5.4). Kaleidoscope utilizes classifiers developed from libraries of species-verified recordings to generate complex algorithms used in the automated identification process. Species classifiers can be selected to match the expected bat fauna in an area. The classifiers for 11 species that have been confirmed in the West Kootenays were selected for use in analysis of 2019 Wildlife Physical Works pre-treatment data. Auto ID analysis is intended for use on recordings of single bats in a low clutter environment, but some environmental (e.g., rain, wind, surface echoes, temperature changes, etc.) and biological (e.g., number of bats present, distance of bats, etc.) factors cannot be controlled and thus recording quality may vary. In addition, the acoustic signatures of many bat species overlap in their frequency ranges, making it difficult to confidently differentiate some species (Table 9-2; also, Szewczak et al. 2011a,b). Thus, the assignment of species is based in part on a probability that the species is present, and we treat our classifications as indicative rather than definitive. Data collected by autonomous recording devices do not provide an indication of the number of individual bats present in a given area.

General Wildlife Signs and Cameras

We presented the results of incidental wildlife camera surveys in a table that summarized the category of wildlife (restricted to mammals and herptiles), associated signs, and number of observations. We also included the approximate total search time at each site from May to July.

Wildlife photographs were processed using Reconyx MapView Professional™. Each photograph was visually assessed for wildlife. If wildlife were present, they were sorted by species and number of individuals. Output from MapView files for individual cameras was pooled within each site to offer a comprehensive view of wildlife use of the area. We presented wildlife photographs by site, species, and the associated number of photographs. It should be noted that wildlife photographs are not directly related to animal abundance, as one animal can trigger multiple photographs and multiple cameras may record the same animal. These data should be used only as a general reference for what wildlife can be found in the area.

4.5.2 Wildlife Physical Works

Arthropods

The total number of diversity and biomass samples from both trap types (Malaise and pitfall) are given in section 4.4.1 (Terrestrial Arthropods; also see Table 4-2). All samples are from the 2019 monitoring year and data were used from both collection periods. Biomass and catch-per-unit effort were calculated with the same methods as for revegetation treatments (see Arthropod Relative Abundance (CPUE) and Arthropod Biomass, above). Arthropod diversity and abundance, including that of Coleopteran, Hymenopteran, and Dipteran families, as well as species of Carabidae and Araneae, were presented descriptively in bar graphs. The results of odonate surveys were presented in a table.

Birds

See Birds under Revegetation Treatments for data methods. Five point count locations were surveyed in the WPW area during summer 2019. No statistical analyses were performed due to low sample size.

Bats

See Bats under Revegetation Treatments for data methods.

General Wildlife Sign and Cameras

See General Wildlife Signs and Cameras under Revegetation Treatments for data methods.

5.0 RESULTS

5.1 Reservoir Conditions

Reservoir elevations in 2019 were lowest in February to April, hitting the lowest yearly point on February 3 (429.27 m ASL; Figure 5-1). Water levels increased after that, peaking on June 21 (438.92 m ASL). From a summertime peak, water levels typically drop until October/November when a secondary peak sometimes occurs. From that secondary peak, reservoir elevations then lower until the annual minima.

Compared to 2018, the reservoir raised earlier in June 2019, corresponding to the second arthropod survey and first songbird survey (Figure 5-2).

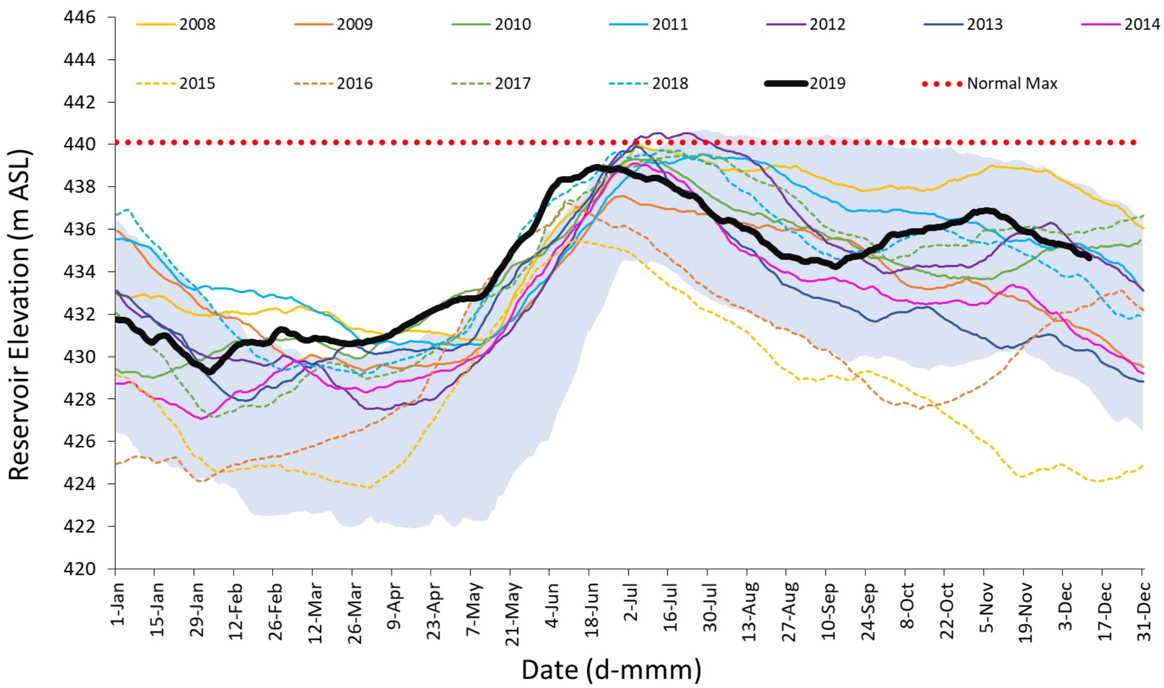


Figure 5-1. Arrow Lakes Reservoir elevations for 2008 to 2019. The 10th and 90th percentiles are shown for 1969-2019 (shaded area); m ASL= metres above sea level.

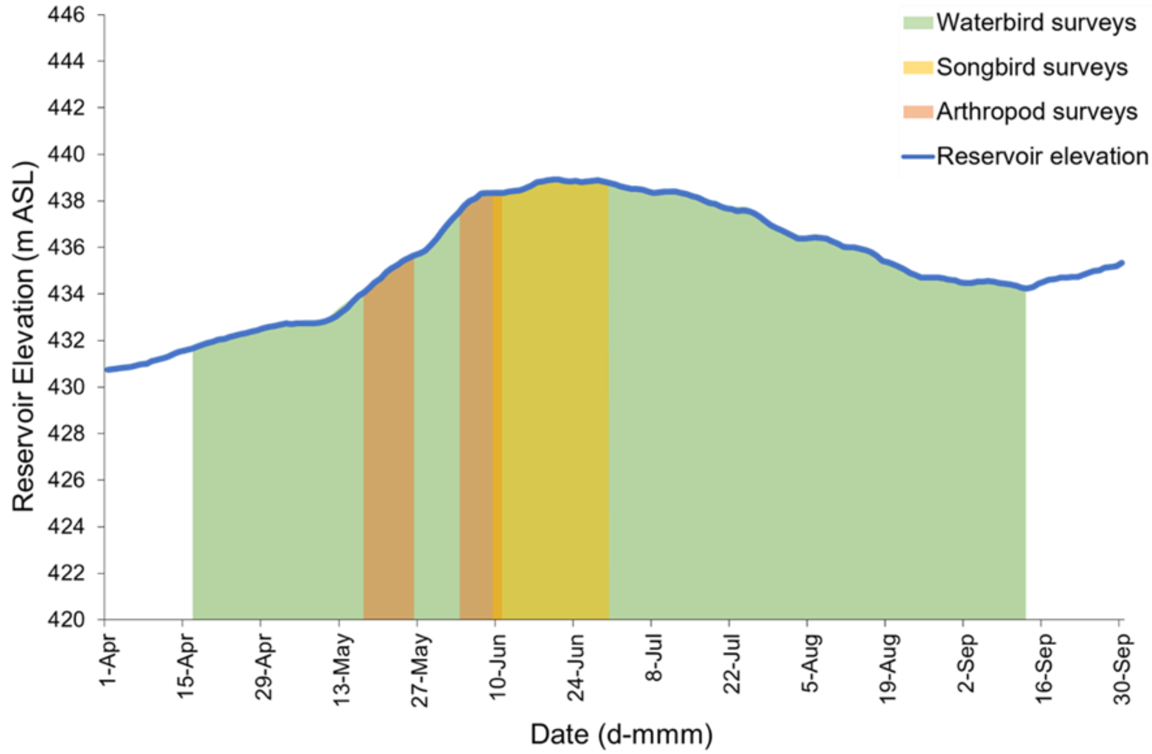


Figure 5-2. Reservoir elevation profile during the 2019 monitoring sessions for waterbirds, songbirds, and arthropods. Note: shaded areas are transparent to show overlapping surveys; waterbird surveys occurred on select days throughout the period shown.

5.2 Revegetation Treatments

The revegetation prescriptions for the treatment polygons sampled in each study area during CLBMON-11B1 in 2019 were summarized in Appendix E. Data collected under CLBMON-12 (Miller et al. 2018) indicated that transplant success was highly variable in the drawdown zone. The success rate for black cottonwood stakes at Lower Inonoaklin and Edgewood South was high. Stake survival was low at Burton Creek and East Arrow Park. Willow and dogwood stake survival was nil among sites sampled in 2019.

Sedge seedling plugs were most successful within polygons at Edgewood North and Lower Inonoaklin. However, survivorship of sedge plugs varied greatly among polygons within each site, such that the lowest densities were also observed at Lower Inonoaklin and Edgewood North. There were several factors listed that might limit transplant success, including operational effects related to inundation (e.g., erosion, deposition, wave scouring, wood debris scouring, and drought conditions) and non-operational effects (e.g. substrates, nutrients, rodent damage, ATV traffic, other human disturbances).

5.2.1 Arthropods

In the 2019 surveys, as with previous years, patterns in arthropod abundance, richness, and diversity varied by study site and taxon (Araneae versus Carabidae). Thus, results were presented for each separately to aid interpretation of patterns between revegetation treatments and controls. Each study site has unique conditions and should be considered as a case study.

Results showed mixed effects of revegetation treatments and varied by revegetation type and arthropod response measure (Table 5-1).

Table 5-1. Summary of effects of revegetation on arthropod survey categories in 2019. Revegetation treatment is indicated by 'Graminoid' or 'Stake.' Effects summarize all treatment polygons within the site and are positive (green, '+'), mixed (yellow, '+/-'), or negative/no effect (red, '-') relative to the control. Effect of vegetation density refers to whether the pattern of revegetation effectiveness might be linked to the vegetation survival density of the polygon.

Measure	Taxon	Site	Graminoid	Stake	Effect of vegetation density
CPUE	Spider	East Arrow Park	+/-	+	No
		Burton Creek	+/-	+/-	No
		Lower Inonoaklin	+/-	-	Possible
		Edgewood North	+/-	NA	No
		Edgewood South	NA	-	No
	Beetle	East Arrow Park	+/-	+/-	No
		Burton Creek	+/-	+/-	Possible
		Lower Inonoaklin	+/-	-	No
		Edgewood North	+/-	NA	Possible
		Edgewood South	NA	-	No
	Carabid	East Arrow Park	+/-	+/-	No
		Burton Creek	+/-	+/-	Possible
		Lower Inonoaklin	+/-	-	No
		Edgewood North	+/-	NA	Possible
		Edgewood South	NA	-	No
Diversity	Spider	East Arrow Park	+/-	+	No
		Burton Creek	+/-	-	No
		Lower Inonoaklin	+/-	-	Possible
		Edgewood North	+/-	NA	No
		Edgewood South	NA	+	Possible
	Carabid	East Arrow Park	+/-	+/-	No
		Burton Creek	-	-	No
		Lower Inonoaklin	+/-	-	Possible
		Edgewood North	+/-	NA	Possible
		Edgewood South	NA	+	No
Richness	Spider	East Arrow Park	+/-	+	No
		Burton Creek	+/-	-	No
		Lower Inonoaklin	+/-	-	No
		Edgewood North	+/-	NA	No
		Edgewood South	NA	+	No
	Carabid	East Arrow Park	+/-	+/-	No
		Burton Creek	+/-	-	Possible
		Lower Inonoaklin	+/-	-	Possible
		Edgewood North	+/-	NA	Possible
		Edgewood South	NA	+	No
Biomass		East Arrow Park	+/-	+	No
		Burton Creek	+/-	+/-	No
		Lower Inonoaklin	-	-	No
		Edgewood North	+/-	NA	Possible
		Edgewood South	NA	+/-	Possible

Arthropod Relative Abundance (CPUE)

Overall, there was no consistent pattern in how treatment type (graminoid or stake) affected the relative abundance (CPUE) of spiders (Araneae), beetles (Coleoptera), or (more specifically) ground beetles (Carabidae). Most sites showed both positive and negative (or neutral) effects of revegetation on spider and beetle CPUE. Exceptions were the positive effect of stake polygons at East Arrow Park on spider CPUE and the negative or neutral effect on spider and beetle CPUE of stake polygons at Lower Inonoaklin and Edgewood South. There was no clear effect of vegetation survival density on CPUE.

East Arrow Park

The median CPUE of Araneae at East Arrow Park was higher in two of the six graminoid revegetation polygons (Figure 5-3). There was no obvious effect of vegetation density on spider CPUE, as the highest and lowest CPUE in the graminoid polygons both corresponded with the same vegetation density level (low). Both stake revegetation polygons showed a higher median spider CPUE than the control, keeping in mind that one of the stake polygons (2009_54) was geographically closer to Control 2 than Control 1 and therefore corresponded more closely with those pitfall traps.

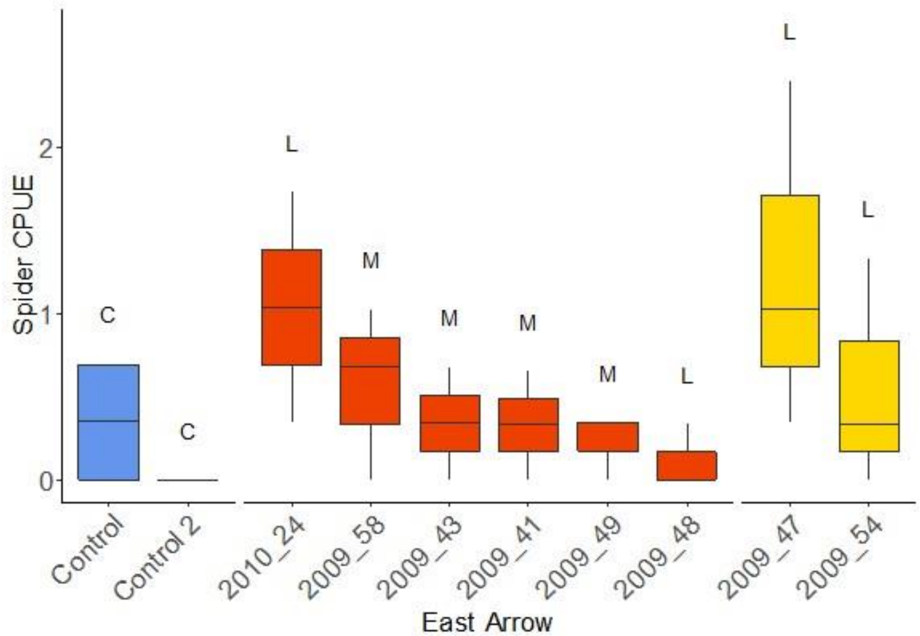


Figure 5-3. Catch per unit effort (CPUE) of adult spiders (Araneae) per trap, per 24-hours at East Arrow Park by revegetation treatment polygon. Controls (blue) were untreated areas of the drawdown zone, whereas graminoid (red) and stake (yellow) polygons were revegetation treatment areas. Each boxplot contains n=3 pitfall trap samples (constrained to data from collection 1 only). Letter labels correspond to estimated vegetation density, with ‘L’= Low, ‘M’= Moderate, and ‘H’= High; ‘C’= drawdown zone control. Control 2 and polygon 2009_54 were closer to each other geographically than to the other treatment polygons or control.

The median CPUE of beetles (Coleoptera) at East Arrow Park was higher in one graminoid and one stake polygon compared to the control (Figure 5-4). This pattern was largely the same when looking at only carabid beetles, although median carabid CPUE was slightly higher in a second graminoid revegetation polygon compared to the control. There was no obvious effect of vegetation survival density on beetle or carabid CPUE.

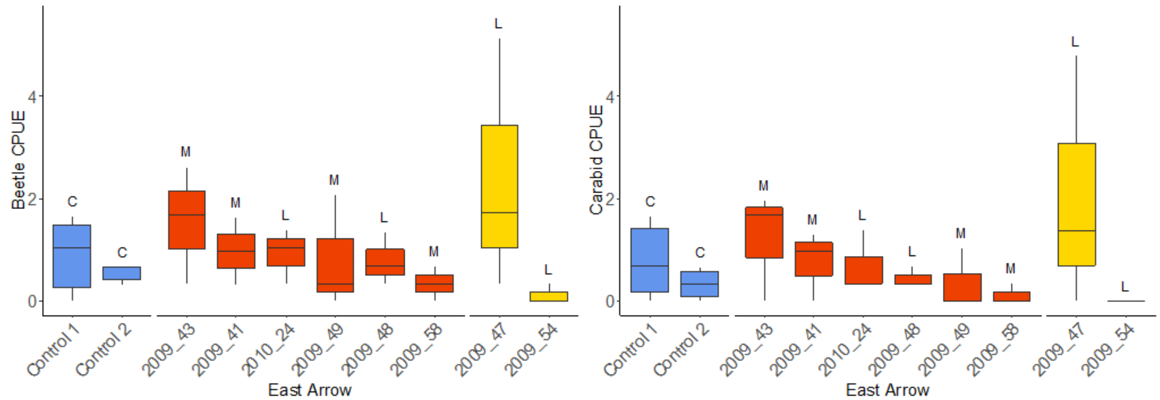


Figure 5-4. Catch per unit effort (CPUE) of adult beetles (Coleoptera; left) and ground beetles (Carabidae; right) per trap, per 24-hours at East Arrow Park by revegetation treatment polygon. Controls (blue) were untreated areas of the drawdown zone, whereas graminoid (red) and stake (yellow) polygons were revegetation treatment areas. Each boxplot contains n=3 pitfall trap samples (constrained to data from collection 1 only). Letter labels correspond to estimated vegetation density, with 'L'= Low, 'M'= Moderate, and 'H'= High; 'C'= drawdown zone control. Control 2 and polygon 2009_54 were closer to each other geographically than to the other treatment polygons or control.

Burton Creek

The CPUE of Araneae at Burton Creek was lower in the majority of revegetation polygons compared to the control, with the exception of one stake polygon (2009_25; Figure 5-5). Note that polygon 2010_2 corresponds most closely with Control 2, which was the closest control geographically. There was no obvious effect of vegetation density on spider CPUE.

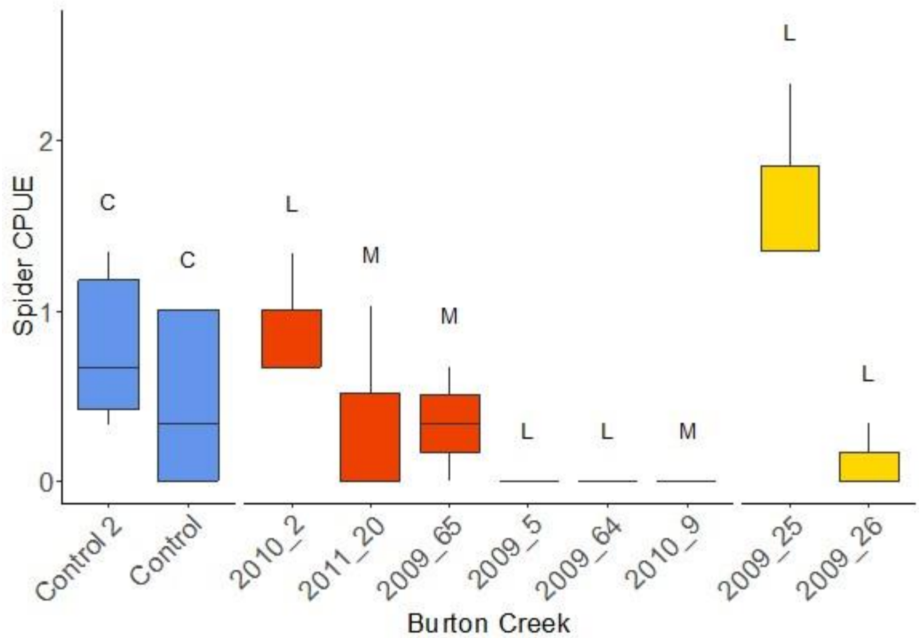


Figure 5-5. Catch per unit effort (CPUE) of adult spiders (Araneae) per trap, per 24-hours at Burton Creek by revegetation treatment polygon. Controls (blue) were untreated areas of the drawdown zone, whereas graminoid (red) and stake (yellow) polygons were revegetation treatment areas. Each boxplot contains n=3 pitfall trap samples (constrained to data from collection 1 only). Letter labels correspond to estimated vegetation density, with 'L'= Low, 'M'= Moderate, and 'H'= High; 'C'= drawdown zone control. Control 2 and polygon 2010_2 were closer to each other geographically than to the other treatment polygons or control.

The median CPUE of beetles (Coleoptera) at Burton Creek was higher in half of the graminoid revegetation polygons than the control, but similar or lower in stake revegetation polygons to the control (Figure 5-6). Median carabid CPUE was greater in most of the revegetation polygons compared to the control, with the exception of one stake and two graminoid polygons. Graminoid polygons of a moderate vegetation density seemed to have a higher median CPUE than controls, keeping in mind that the graminoid polygon 2010_2 was geographically closer to control 2 than control 1 or the other revegetation polygons. The northernmost sites (control 2 and polygon 2010_2) had a greater median CPUE than the control and revegetation polygons at Burton Creek proper.

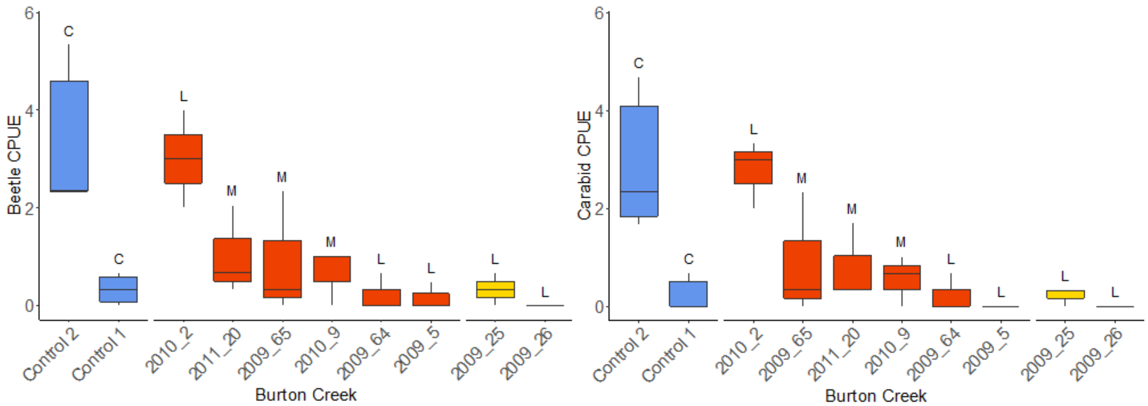


Figure 5-6. Catch per unit effort (CPUE) of adult beetles (Coleoptera; left) and ground beetles (Carabidae; right) per trap, per 24-hours at Burton Creek by revegetation treatment polygon. Controls (blue) were untreated areas of the drawdown zone, whereas graminoid (red) and stake (yellow) polygons were revegetation treatment areas. Each boxplot contains n=3 pitfall trap samples (constrained to data from collection 1 only). Letter labels correspond to estimated vegetation density, with ‘L’= Low, ‘M’= Moderate, and ‘H’= High; ‘C’= drawdown zone control. Control 2 and polygon 2010_2 were closer to each other geographically than to the other treatment polygons or control.

Lower Inonoaklin

With the exception of one graminoid polygon, the median CPUE of Araneae was higher in the control than the majority of the revegetation polygons (both stake and graminoid; Figure 5-7). The only graminoid revegetation polygon with a high vegetation density rating did perform better in terms of spider CPUE than the other graminoid polygons, although it also showed greater variation than the other polygons. There was not a similar pattern for vegetation density in the stake revegetation polygons.

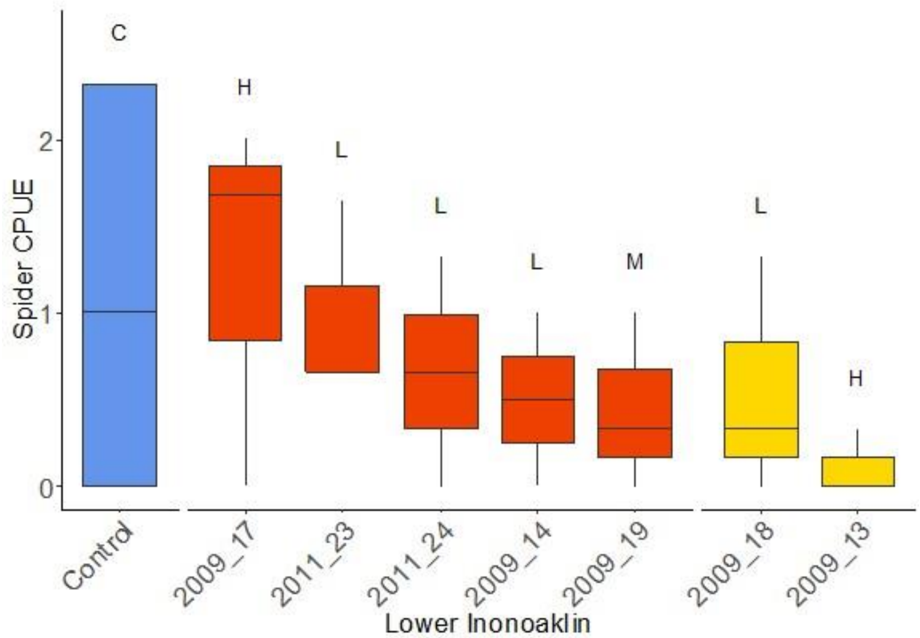


Figure 5-7. Catch per unit effort (CPUE) of adult spiders (Araneae) per trap, per 24-hours at Lower Inonoaklin by revegetation treatment polygon. Control (blue) was an untreated area of the drawdown zone, whereas graminoid (red) and stake (yellow) polygons were revegetation treatment areas. Each boxplot contains n=3 pitfall trap samples (constrained to data from collection 1 only). Letter labels correspond to estimated vegetation density, with ‘L’= Low, ‘M’= Moderate, and ‘H’= High; ‘C’= drawdown zone control.

Median beetle CPUE was greater in two of the graminoid revegetation polygons compared to the control (Figure 5-8) and similar or lower in other revegetation polygons. This pattern persisted for the median CPUE of carabid beetles. There were no clear effects of vegetation density on beetle or carabid CPUE.

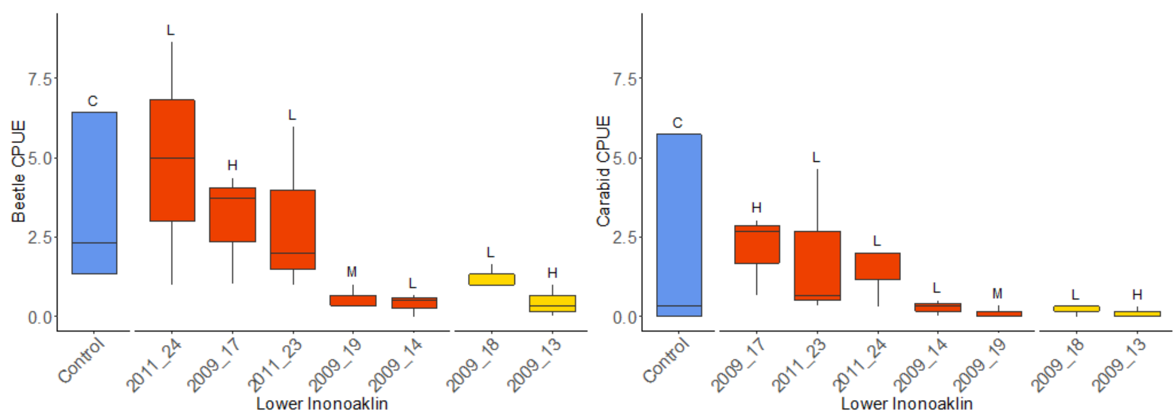


Figure 5-8. Catch per unit effort (CPUE) of adult beetles (Coleoptera; left) and ground beetles (Carabidae; right) per trap, per 24-hours at Lower Inonoaklin by revegetation treatment polygon. Control (blue) was an untreated area of the drawdown zone, whereas graminoid (red) and stake (yellow) polygons were revegetation treatment areas. Each boxplot contains n=3 pitfall trap samples (constrained to data from collection 1 only). Letter labels correspond to estimated vegetation density, with ‘L’= Low, ‘M’= Moderate, and ‘H’= High; ‘C’= drawdown zone control.

Edgewood North

Median Araneae CPUE at Edgewood North was higher in two of the three graminoid revegetation plots than the control (Figure 5-9). The effect of vegetation density on spider CPUE was not consistent; both high and low vegetation plots had similar median CPUE (although there was greater variability within the high vegetation survival density plot), and the moderate-rated plot had comparatively lower CPUE.

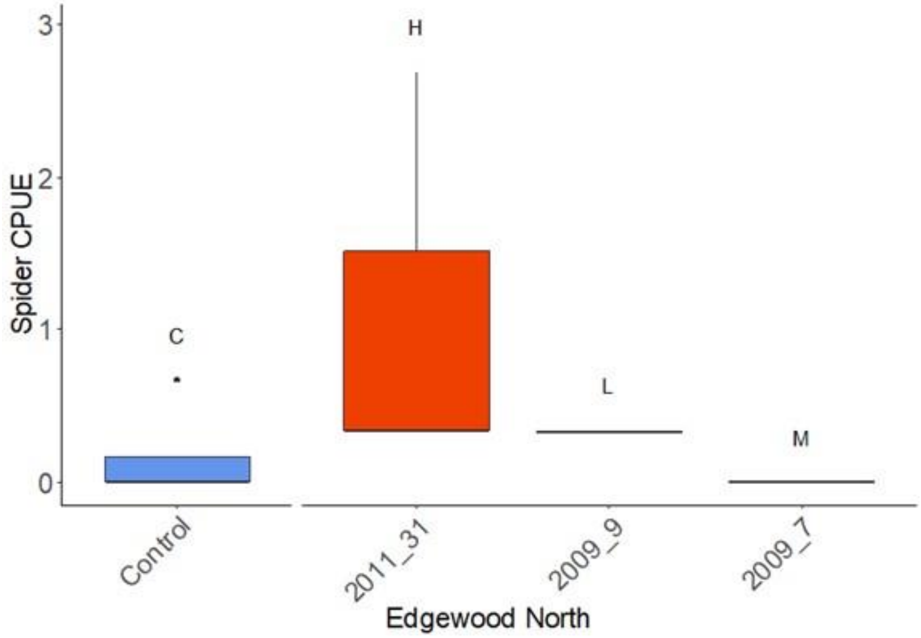


Figure 5-9. Catch per unit effort (CPUE) of adult spiders (Araneae) per trap, per 24-hours at Edgewood North by revegetation treatment polygon. Control (blue) was an untreated area of the drawdown zone, whereas graminoid (red) polygons were revegetation treatment areas. Each boxplot contains n=3 pitfall trap samples (constrained to data from collection 1 only). Letter labels correspond to estimated vegetation density, with 'L'= Low, 'M'= Moderate, and 'H'= High; 'C'= drawdown zone control. Note: y-axes are scaled differently.

Median beetle and carabid CPUE were greater in two of the three graminoid polygons compared to the control (Figure 5-10). These two polygons had high and moderate vegetation density, which suggests that the higher CPUE in these polygons could be related to vegetation density.

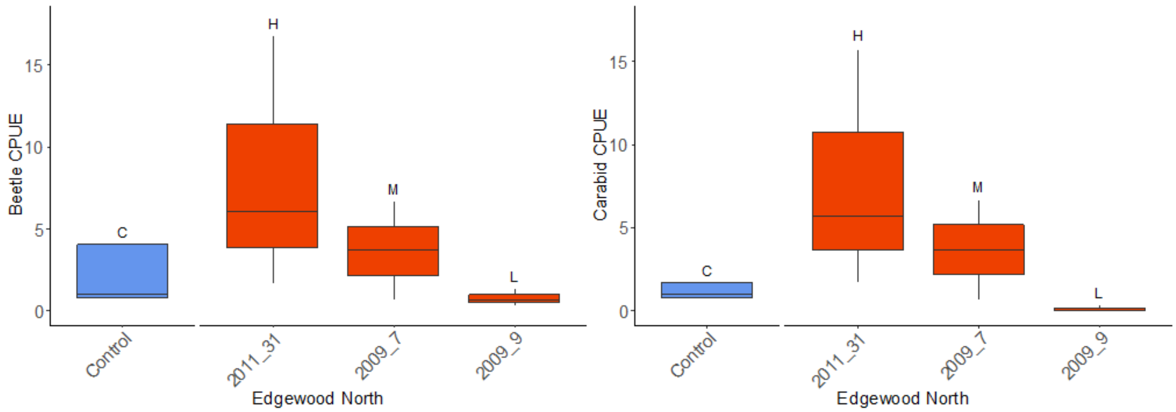


Figure 5-10. Catch per unit effort (CPUE) of adult beetles (Coleoptera; left) and ground beetles (Carabidae; right) per trap, per 24-hours at Edgewood North by revegetation treatment polygon. Control (blue) was an untreated area of the drawdown zone, whereas graminoid (red) polygons were revegetation treatment areas. Each boxplot contains n=3 pitfall trap samples (constrained to data from collection 1 only). Letter labels correspond to estimated vegetation density, with 'L'= Low, 'M'= Moderate, and 'H'= High; 'C'= drawdown zone control.

Edgewood South

Araneae CPUE at Edgewood South was lower in the stake revegetation polygons than the control (Figure 5-11). There was no clear positive effect of stake revegetation treatment on beetle or carabid CPUE (Figure 5-12). Vegetation density showed no consistent effect on CPUE.

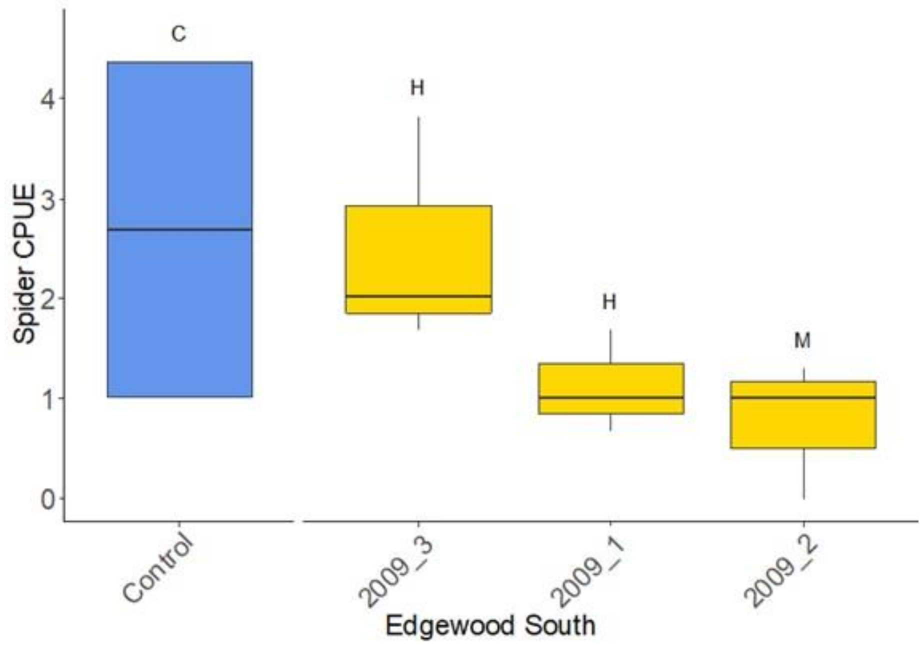


Figure 5-11. Catch per unit effort (CPUE) of adult spiders (Araneae) per trap, per 24-hours at Edgewood South (right) by revegetation treatment polygon. Control (blue) was an untreated area of the drawdown zone, whereas stake (yellow) polygons were revegetation treatment areas. Each boxplot contains n=3 pitfall trap samples (constrained to data from collection 1 only). Letter labels correspond to estimated vegetation density, with 'L'= Low, 'M'= Moderate, and 'H'= High; 'C'= drawdown zone control.

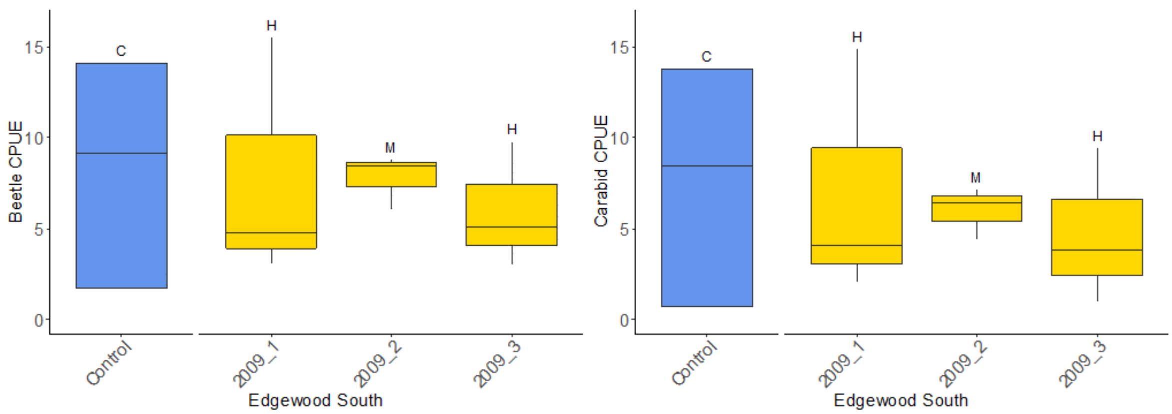


Figure 5-12. Catch per unit effort (CPUE) of adult beetles (Coleoptera; left) and ground beetles (Carabidae; right) per trap, per 24-hours at Edgewood South by revegetation treatment polygon. Control (blue) was an untreated area of the drawdown zone, whereas stake (yellow) polygons were revegetation treatment areas. Each boxplot contains n=3 pitfall trap samples (constrained to data from collection 1 only). Letter labels correspond to estimated vegetation density, with 'L'= Low, 'M'= Moderate, and 'H'= High; 'C'= drawdown zone control.

Arthropod Richness and Diversity

We captured a total of 394 adult spiders comprising 34 known and one unknown species (of the genus *Zelotes*) and 392 immature spiders from diversity pitfall traps located at the five sites. Lower Inonoaklin had the greatest diversity of species. The most numerous spider species collected at all sites was *Pardosa altamontis*, which are widespread, open-habitat, ground-hunting wolf spiders.

Most sites showed some positive relationship between revegetation treatment and Araneae species diversity or richness, although this effect was not consistent. Stake revegetation polygons at Lower Inonoaklin had a negative or neutral effect on spider richness and diversity. There was no clear effect of vegetation density and the reason behind the success of some but not all revegetation polygons is unclear. There was some evidence of a site effect, as Burton Creek had relatively low spider diversity and richness in many of the revegetation polygons compared to other sites.

We captured a total of 710 adult and 26 larval carabid beetles comprising 34 species from diversity pitfall traps. As with spiders, Lower Inonoaklin had the greatest diversity of species. Except for *Patrobus fossifrons* (found at both Edgewood South and Lower Inonoaklin), the most abundant carabid beetle species differed between sites.

As with Araneae, the effect of revegetation on carabid species diversity and richness was mixed. It was not consistently positive or negative, except for a general lack of effect of revegetation on carabid diversity at Burton Creek and of stake revegetation at Lower Inonoaklin, and a positive effect of stake revegetation on carabid richness and diversity at Edgewood South. In most cases there was no clear effect of vegetation survival density, except for a potential pattern at Edgewood North.

For a full list of the adult spider and carabid beetle species found, see Appendix F.

East Arrow Park

We captured a total of 89 adult spiders comprising 19 species (Figure 5-13) and 55 immature spiders from diversity pitfall traps at East Arrow Park.

Median Araneae diversity was higher in four revegetated graminoid and both stake polygons compared to the controls (Figure 5-14), although three of the graminoid and one of the stake polygons showed significant variation. Two graminoid polygons showed a similar diversity to the controls. The vegetation density rating of the polygons showed no consistent effect on diversity.

Adult Araneae richness showed a similar pattern to diversity (Figure 5-14), with four graminoid polygons having a higher median diversity than the control and two overlapping or with lower median diversity. The stake polygon 2009_47 showed a greater median richness than the control, and the stake polygon 2009_54 (which was geographically separated from other polygons and closer in proximity to control 2) likewise showed a greater richness compared to the control.

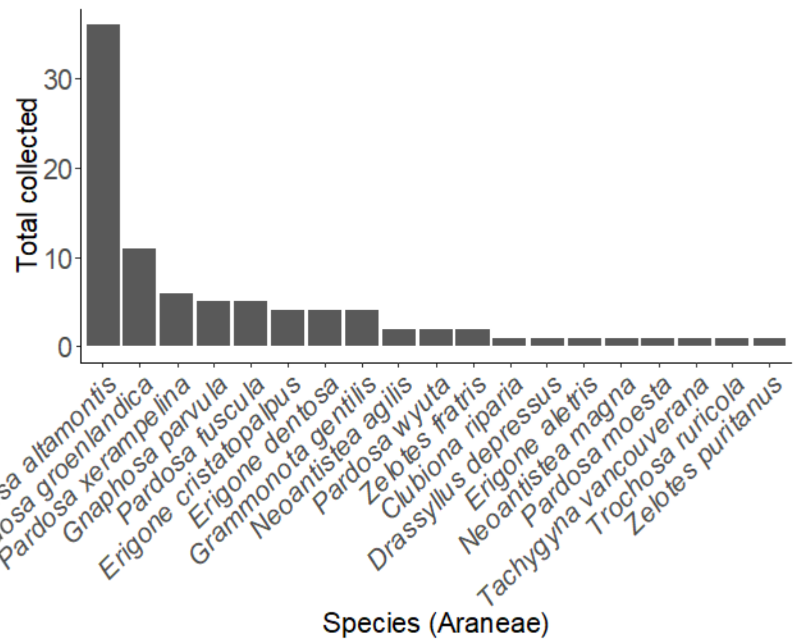


Figure 5-13. Total adult spider (Araneae) abundance by species from all pitfall trap samples at East Arrow Park. Totals not standardized by trapping effort.

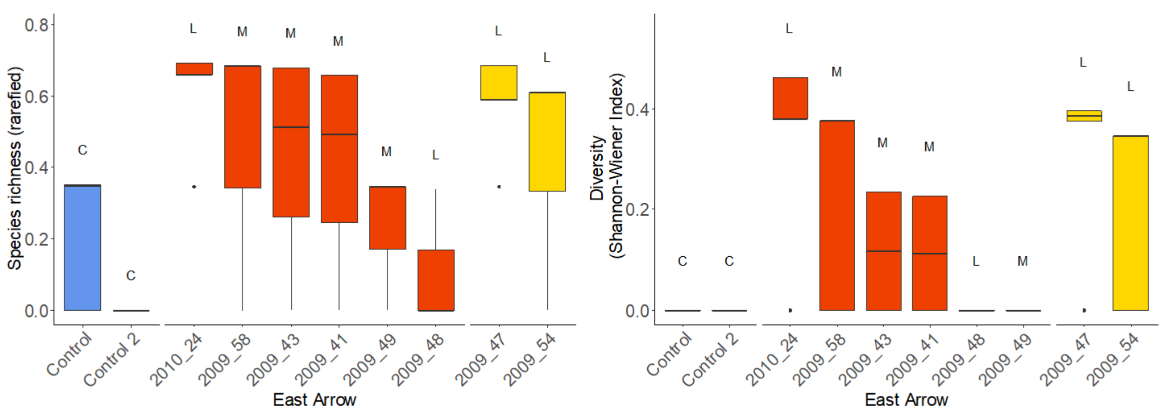


Figure 5-14. Rarefied richness (left) and diversity (right; Shannon-Wiener Index) of spider species per trap, per 24-hours at East Arrow Park by revegetation treatment polygon. Controls (blue) were untreated areas of the drawdown zone, whereas graminoid (red) and stake (yellow) polygons were revegetation treatment areas. Each boxplot contains n=3 pitfall trap samples (constrained to data from collection 1 only). Letter labels correspond to estimated vegetation density, with 'L'= Low, 'M'= Moderate, and 'H'= High; 'C'= drawdown zone control. Control 2 and polygon 2009_54 were closer to each other geographically than to the other treatment polygons or control.

We captured a total of 91 adult carabid beetles comprising 11 species (Figure 5-15) from diversity pitfall traps at East Arrow Park. The most encountered species was *Agonum corvus,* a native species.

Median species diversity was higher in one graminoid and one stake plot compared to the control (Figure 5-16); two of the graminoid plots had more variation than the control, but ultimately they and the majority of the revegetation polygons overlapped with the control. No consistent pattern emerged for the effect of vegetation density on carabid diversity.

Carabidae richness showed similar patterns to diversity, in that only two polygons (one graminoid and one stake) had a higher richness relative to the control (Figure 5-16). Carabid richness for other revegetation polygons was either similar or lower than the control.

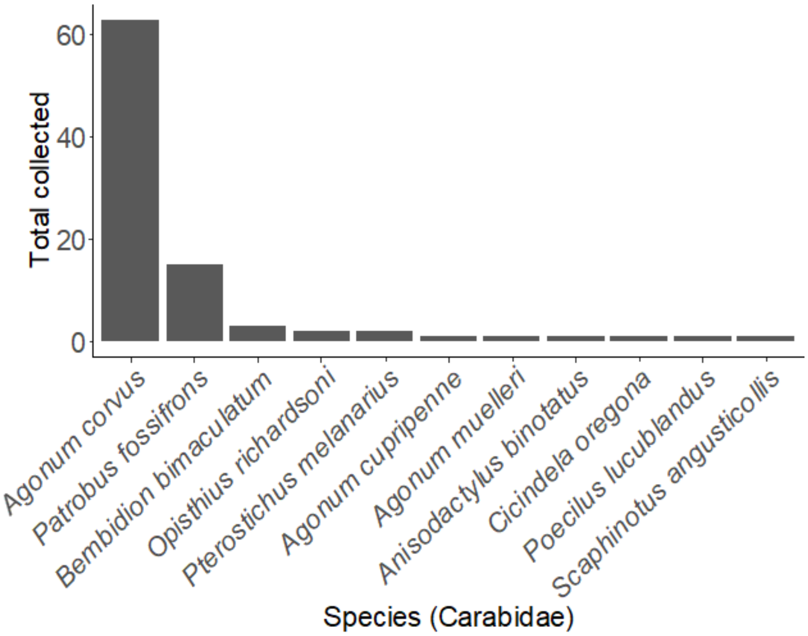


Figure 5-15. Total adult carabid beetle abundance by species from all pitfall trap samples at East Arrow Park. Totals not standardized by trapping effort.

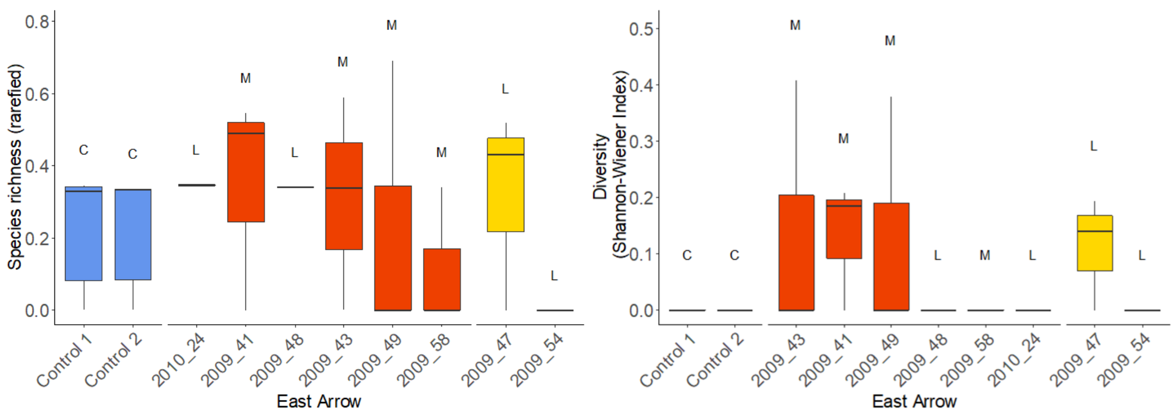


Figure 5-16. Rarefied richness (left) and diversity (right, Shannon-Wiener Index) of Carabid species per trap, per 24-hours at East Arrow Park by revegetation treatment polygon. Controls (blue) were untreated areas of the drawdown zone, whereas graminoid (red) and stake (yellow) polygons were revegetation treatment areas. Each boxplot contains n=3 pitfall trap samples (constrained to data from collection 1 only). Letter labels correspond to estimated vegetation density, with 'L'= Low, 'M'= Moderate, and 'H'= High; 'C'= drawdown zone control. Control 2 and polygon 2009_54 were closer to each other geographically than to the other treatment polygons or control.

Burton Creek

We captured a total of 131 adult spiders comprising 16 species (Figure 5-17) and 77 immature spiders from diversity pitfall traps at Burton Creek.

Median Araneae diversity was lower in most revegetation polygons compared to the control (Figure 5-18). The exception was a graminoid polygon (2010_2), which was geographically separated from the other revegetation polygons and had a higher median diversity than nearby control pitfalls (represented in control 2). Five of the revegetation polygons had exceptionally low diversity (four graminoid and one stake). Vegetation density had no obvious effect on diversity.

Araneae richness showed similar patterns to diversity (Figure 5-18), with only one graminoid polygon (2010_2) showing a higher median diversity than its associated control (Control 2).

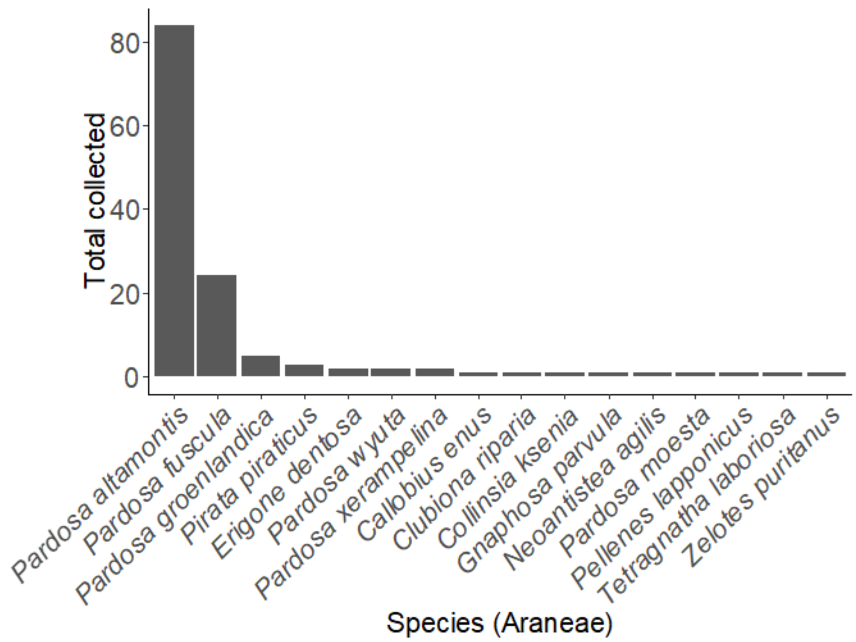


Figure 5-17. Total adult spider (Araneae) abundance by species from all pitfall trap samples at Burton Creek. Totals not standardized by trapping effort.

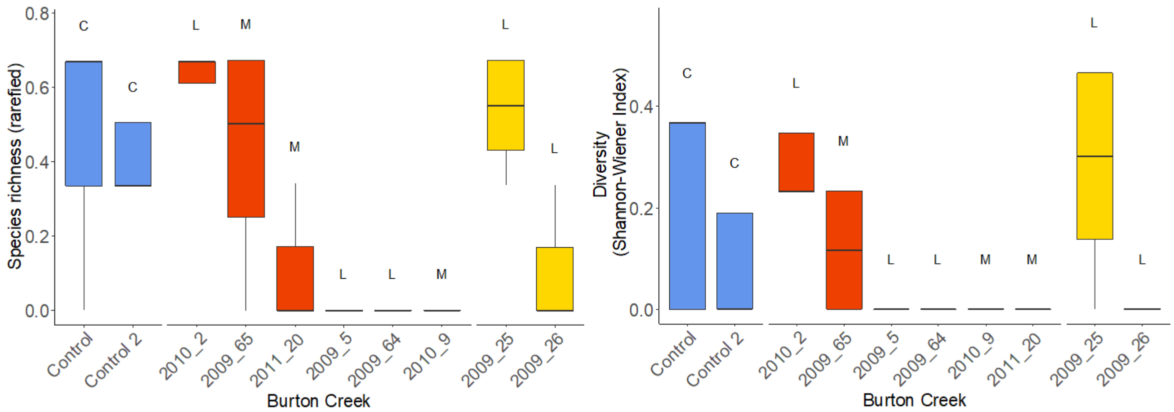


Figure 5-18. Rarefied richness (left) and diversity (right; Shannon-Wiener Index) of spider species per trap, per 24-hours at Burton Creek by revegetation treatment polygon. Controls (blue) were untreated areas of the drawdown zone, whereas graminoid (red) and stake (yellow) polygons were revegetation treatment areas. Each boxplot contains n=3 pitfall trap samples (constrained to data from collection 1 only). Letter labels correspond to estimated vegetation density, with 'L'= Low, 'M'= Moderate, and 'H'= High; 'C'= drawdown zone control. Control 2 and polygon 2010_2 were closer to each other geographically than to the other treatment polygons or control.

We captured a total of 94 adult carabid beetles comprising six species (Figure 5-19) and one larva from diversity pitfall traps at Burton Creek. *Bembidion bimaculatum* and *Patrobus fossifrons* were the most common species at Burton Creek.

Median carabid diversity largely overlapped with the control (Figure 5-20; note that polygon 2010_2 most closely corresponds with Control 2). Overall Carabid diversity was higher in the northernmost sites (Control 2 and polygon 2010_2). There was no obvious effect of vegetation density on carabid diversity.

Median carabid species richness was higher in three of the graminoid plots and one of the stake plots compared to the control (Figure 5-20). The three graminoid plots were all of moderate vegetation density, which could suggest some effect of vegetation density on carabid richness (but not diversity, as mentioned above).

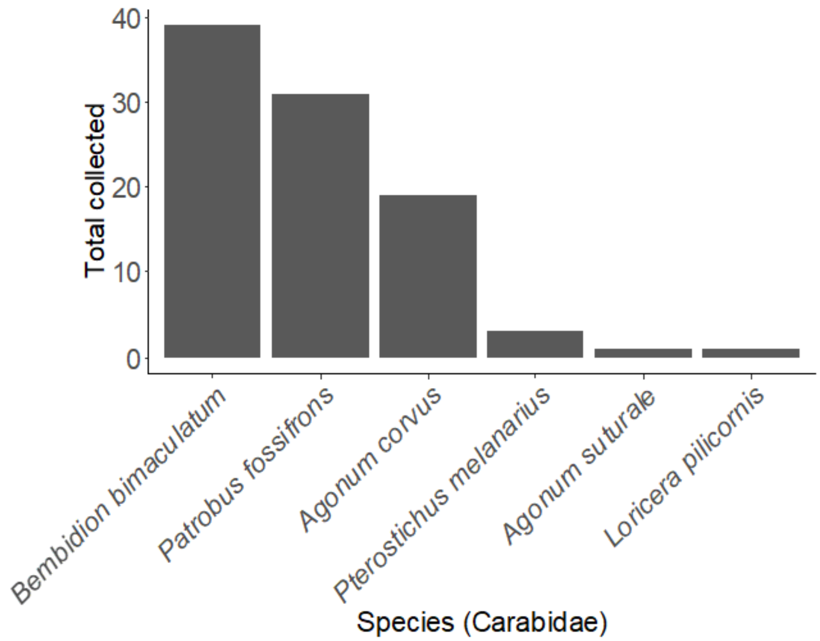


Figure 5-19. Total adult carabid beetle abundance by species from all pitfall trap samples at Burton Creek. Totals not standardized by trapping effort.

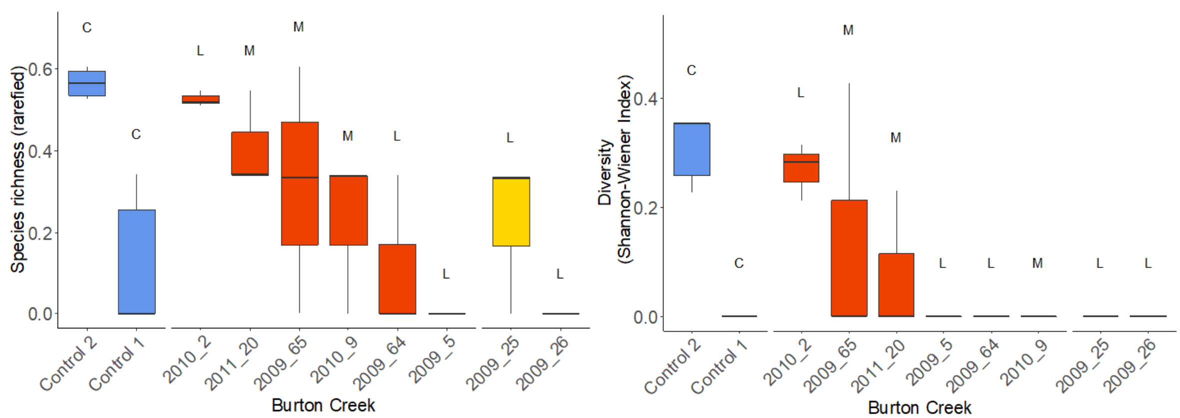


Figure 5-20. Rarefied richness (left) and diversity (right, Shannon-Wiener Index) of Carabid species per trap, per 24-hours at Burton Creek by revegetation treatment polygon. Controls (blue) were untreated areas of the drawdown zone, whereas graminoid (red) and stake (yellow) polygons were revegetation treatment areas. Each boxplot contains n=3 pitfall trap samples (constrained to data from collection 1 only). Letter labels correspond to estimated vegetation density, with 'L'= Low, 'M'= Moderate, and 'H'= High; 'C'= drawdown zone control. Control 2 and polygon 2010_2 were closer to each other geographically than to the other treatment polygons or control.

Lower Inonoaklin

We captured a total of 67 adult spiders comprising 21 species (Figure 5-21) and two immature spiders from diversity pitfall traps at Lower Inonoaklin.

Median Araneae diversity was greater in two of the graminoid plots compared to the control (Figure 5-22). These polygons were of high or medium vegetation density, while those that were of low density had median diversity comparable to or lower than that of the control. Conversely, both stake polygons showed a lower diversity than the control plot (regardless of vegetation density level).

Median Araneae richness was higher in four of the five graminoid treatment plots compared to the control (Figure 5-22), seemingly irrespective of vegetation density. Median richness in both stake polygons was lower than that of the control.

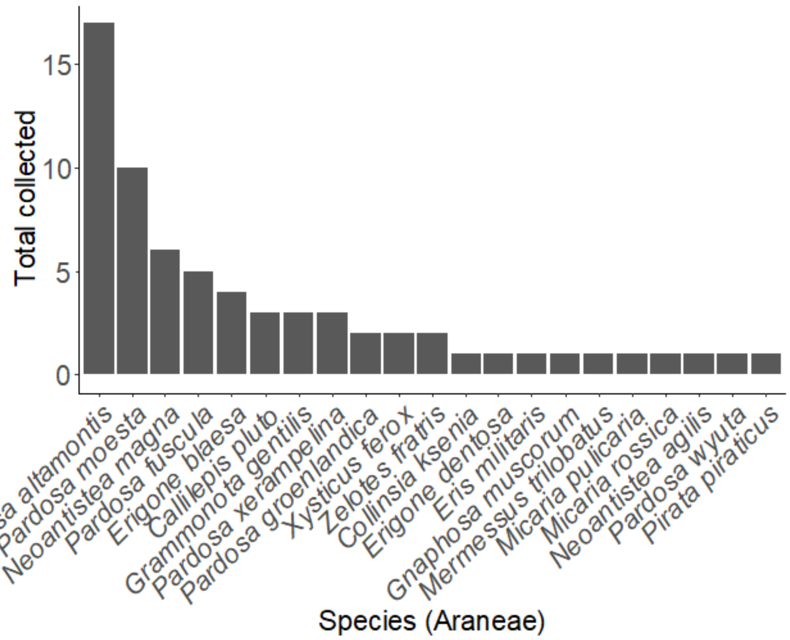


Figure 5-21. Total adult spider (Araneae) abundance by species from all pitfall trap samples at Lower Inonoaklin. Totals not standardized by trapping effort.

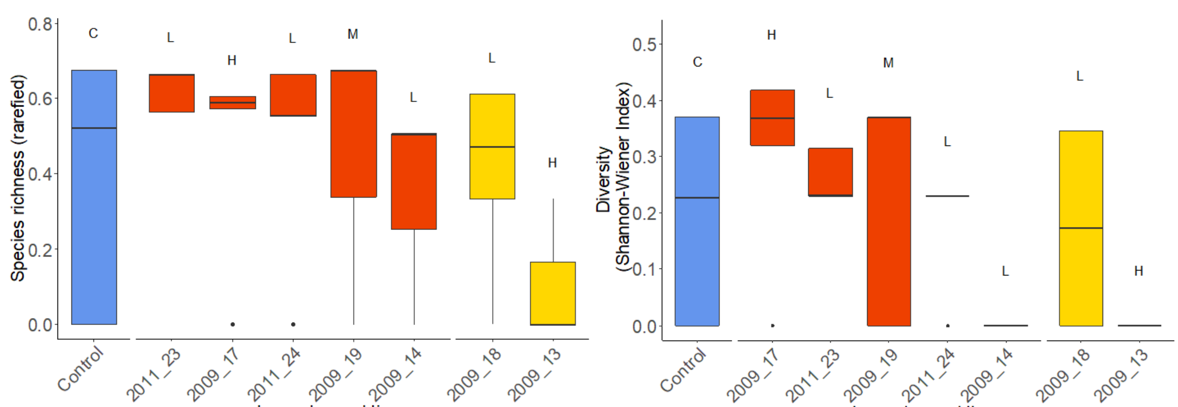


Figure 5-22. Rarefied richness (left) and diversity (right; Shannon-Wiener Index) of spider species per trap, per 24-hours at Lower Inonoaklin by revegetation treatment polygon. Controls (blue) were untreated areas of the drawdown zone, whereas graminoid (red) and stake (yellow) polygons were revegetation treatment areas. Each boxplot contains n=3 pitfall trap samples (constrained to data from collection 1 only). Letter labels correspond to estimated vegetation density, with 'L'= Low, 'M'= Moderate, and 'H'= High; 'C'= drawdown zone control.

We captured a total of 96 adult carabid beetles comprising 24 species and nineteen larvae from diversity pitfall traps at Lower Inonoaklin (Figure 5-23). Ten of the larvae were from a single pitfall trap (2011_24). The most common species was *Patrobus fossifrons*.

Median carabid diversity was greater in two of the graminoid plots compared to the control (Figure 5-24). While the graminoid polygon with high-rated density had the greatest carabid diversity, this pattern was not consistent with stake revegetation polygons and the moderate graminoid polygon had a lower or comparative median carabid diversity compared to the low-density revegetation polygons.

Carabid beetle species richness showed similar patterns to diversity (Figure 5-24) in that two of the graminoid revegetation polygons had a greater median richness than the control, but the rest of the revegetation polygons (both stake and graminoid) had comparative or lower richness than the control.

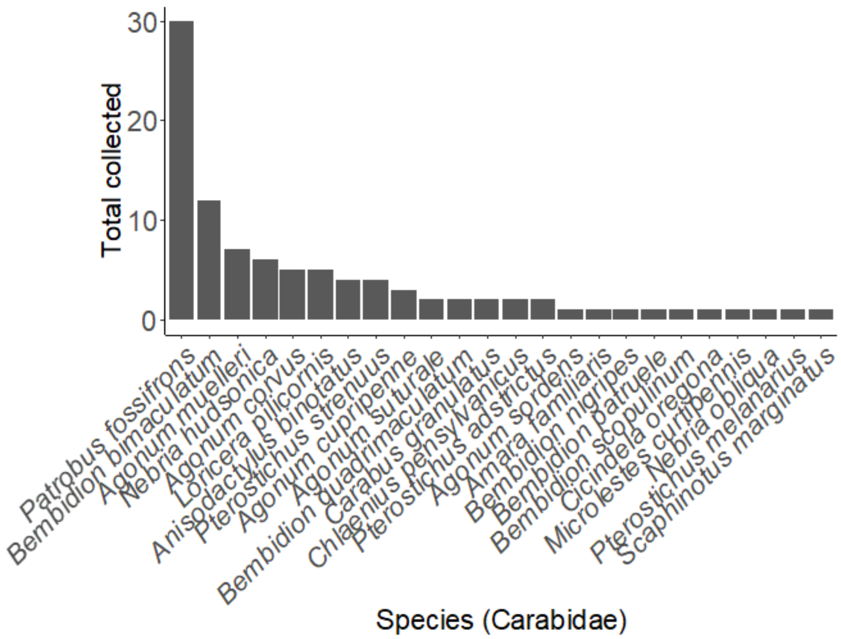


Figure 5-23. Total adult carabid beetle abundance by species from all pitfall trap samples at Lower Inonoaklin. Totals not standardized by trapping effort.

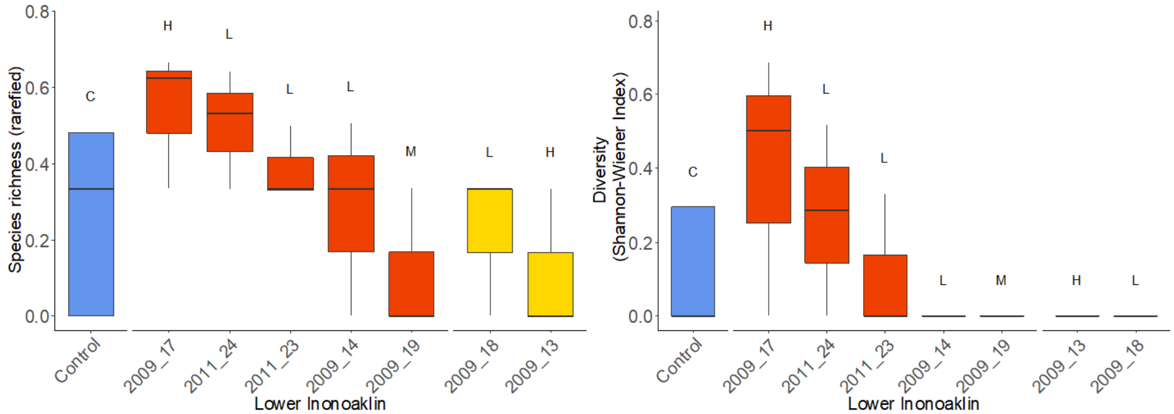


Figure 5-24. Rarefied richness (left) and diversity (right, Shannon-Wiener Index) of Carabid species per trap, per 24-hours at Lower Inonoaklin by revegetation treatment polygon. Control (blue) was an untreated area of the drawdown zone, whereas graminoid (red) and stake (yellow) polygons were revegetation treatment areas. Each boxplot contains n=3 pitfall trap samples (constrained to data from collection 1 only). Letter labels correspond to estimated vegetation density, with 'L'= Low, 'M'= Moderate, and 'H'= High; 'C'= drawdown zone control.

Edgewood North

We captured a total of 22 adult spiders comprising eight species (Figure 5-25) and six immature spiders from diversity pitfall traps at Edgewood North.

Median Araneae diversity at Edgewood North was greater that the control in one of the graminoid polygons (considered to be of 'high' density), while the other two graminoid polygons showed a much lower diversity than that of the control (Figure 5-26). Median Araneae richness at Edgewood North showed similar patterns to that of diversity (Figure 5-26).

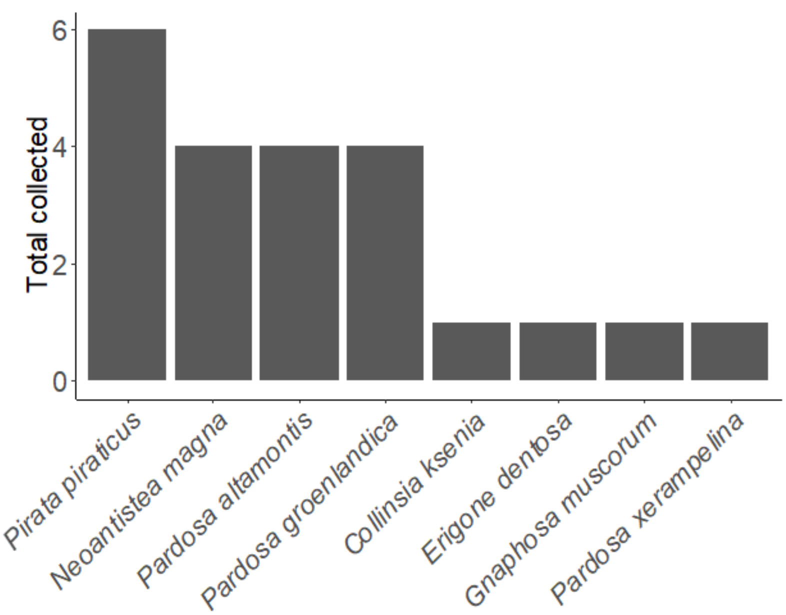


Figure 5-25. Total adult spider (Araneae) abundance by species from all pitfall trap samples at Edgewood North. Totals not standardized by trapping effort.

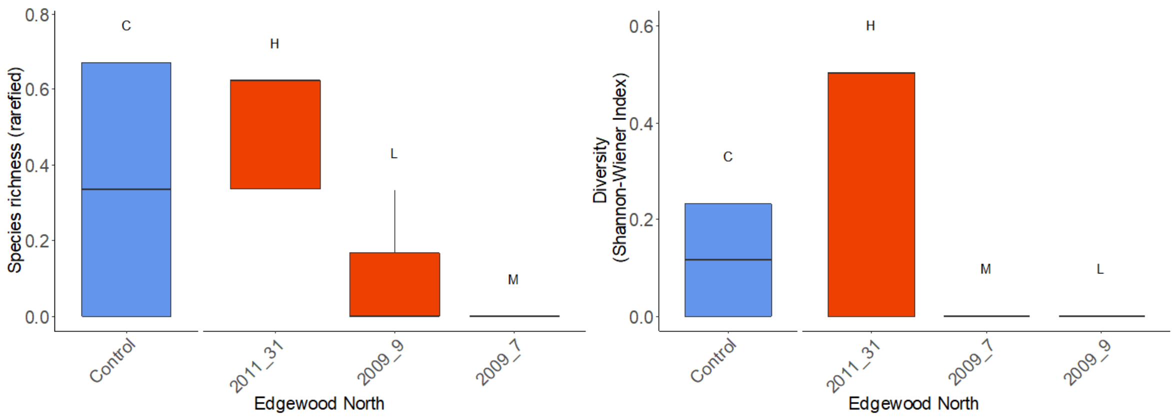


Figure 5-26. Rarefied richness (left) and diversity (right; Shannon-Wiener Index) of spider species per trap, per 24-hours at Edgewood North by revegetation treatment polygon. Controls (blue) were untreated areas of the drawdown zone, whereas graminoid (red) polygons were revegetation treatment areas. Each boxplot contains n=3 pitfall trap samples (constrained to data from collection 1 only). Letter labels correspond to estimated vegetation density, with 'L'= Low, 'M'= Moderate, and 'H'= High; 'C'= drawdown zone control.

We captured a total of 144 adult carabid beetles comprising 15 species (Figure 5-27) and three larvae from diversity pitfall traps at Edgewood North. *Nebria hudsonica* was the most common species captured.

Median carabid diversity was higher in one graminoid polygon and similar or lower in two others compared to the control (Figure 5-28). There was a potential effect of vegetation density, where the polygon with the highest vegetation density had the greatest median carabid diversity, and the polygon with the lowest vegetation density had the lowest median carabid diversity.

There was no clear effect of graminoid revegetation on carabid species richness compared to the control (Figure 5-28). The relationship between carabid richness and vegetation density was less clear than for carabid diversity, although the polygon with the low vegetation density rating had a lower richness than the moderate or high-density polygons.

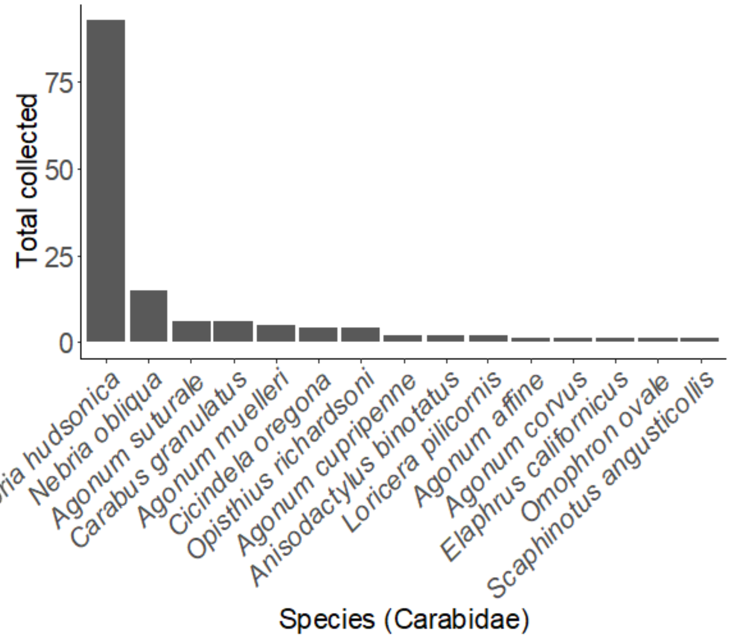


Figure 5-27. Total adult carabid beetle abundance by species from all pitfall trap samples at Edgewood North. Totals not standardized by trapping effort.

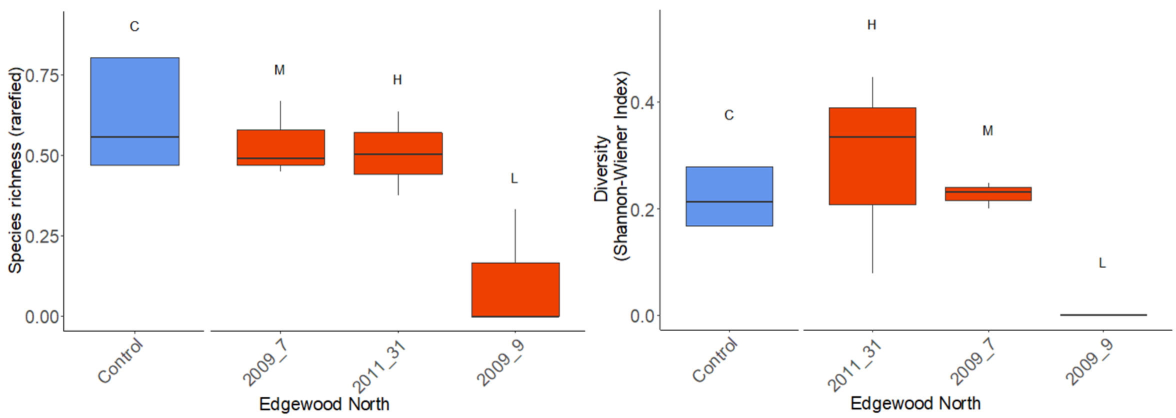


Figure 5-28. Rarefied richness (left) and diversity (right, Shannon-Wiener Index) of carabid species per trap, per 24-hours at Edgewood North by revegetation treatment polygon. Control (blue) was an untreated area of the drawdown zone, whereas graminoid (red) polygons were revegetation treatment areas. Each boxplot contains n=3 pitfall trap samples (constrained to data from collection 1 only). Letter labels correspond to estimated vegetation density, with 'L'= Low, 'M'= Moderate, and 'H'= High; 'C'= drawdown zone control.

Edgewood South

At Edgewood South, we captured 85 adult spiders comprising 14 known species (and one adult of the genus *Zelotes*) and 252 immatures (Figure 5-29). Median Araneae diversity and richness in all the stake polygons at Edgewood South were higher compared to the control (Figure 5-30).

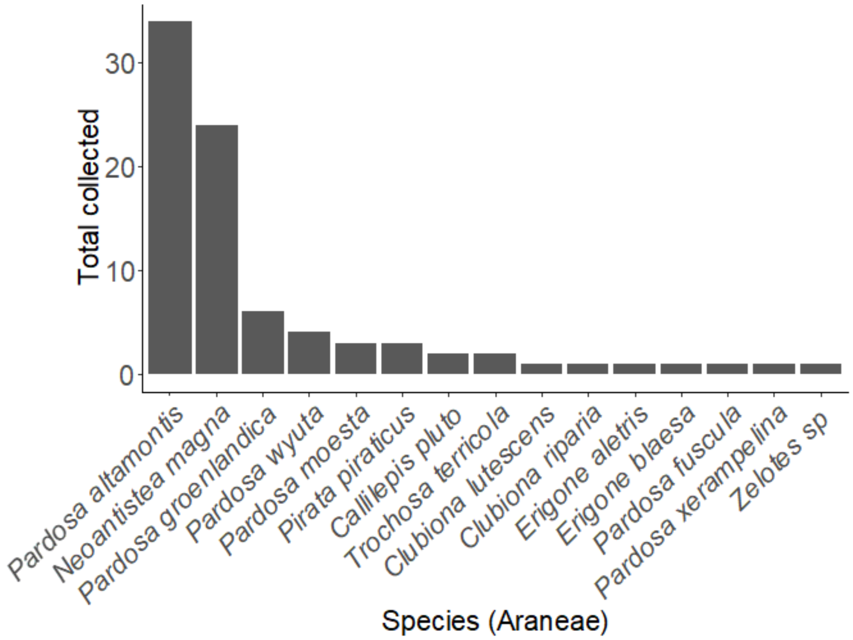


Figure 5-29. Total adult spider (Araneae) abundance by species from all pitfall trap samples at Edgewood South. Totals not standardized by trapping effort.

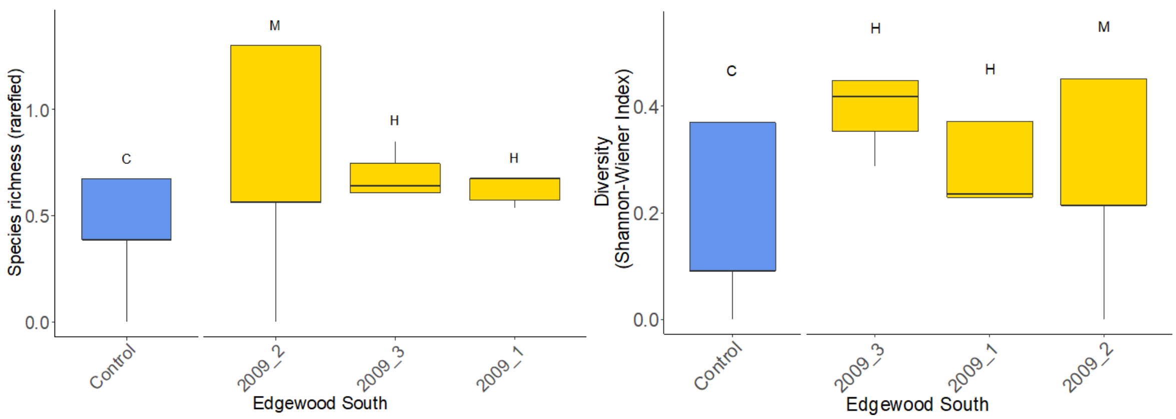


Figure 5-30. Rarefied richness (left) and diversity (right; Shannon-Wiener Index) of spider species per trap, per 24-hours at Edgewood South by revegetation treatment polygon. Controls (blue) were untreated areas of the drawdown zone, whereas stake (yellow) polygons were revegetation treatment areas. Each boxplot contains n=3 pitfall trap samples (constrained to data from collection 1 only). Letter labels correspond to estimated vegetation density, with 'L'= Low, 'M'= Moderate, and 'H'= High; 'C'= drawdown zone control.

At Edgewood South, we captured 260 adult carabid beetles comprising 20 known species (Figure 5-31) and two larvae. *Patrobus fossifrons* was the dominant species in the samples.

Median carabid species diversity and richness in all of the stake polygons at Edgewood South were higher compared to the control (Figure 5-32). There was no clear pattern in how vegetation density affected carabid diversity or richness.

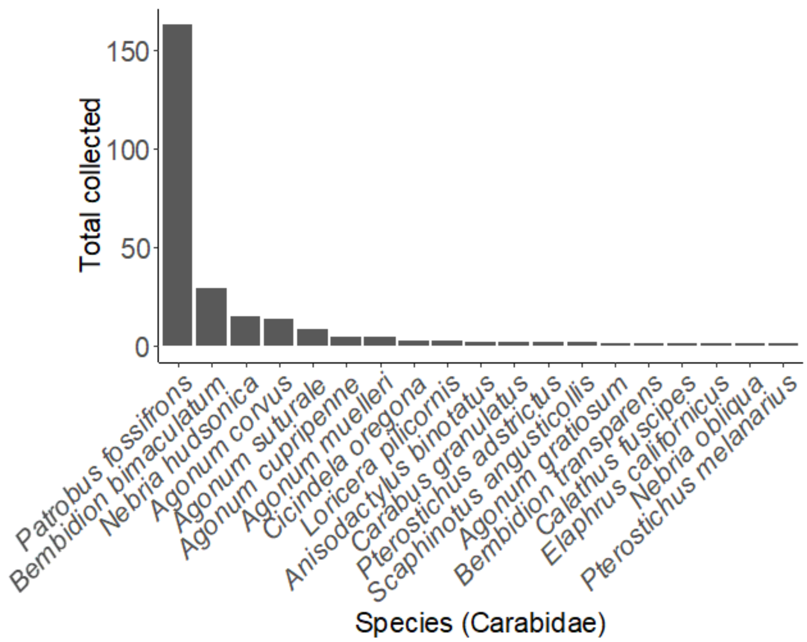


Figure 5-31. Total adult carabid beetle abundance by species from all pitfall trap samples at Edgewood South. Totals not standardized by trapping effort.

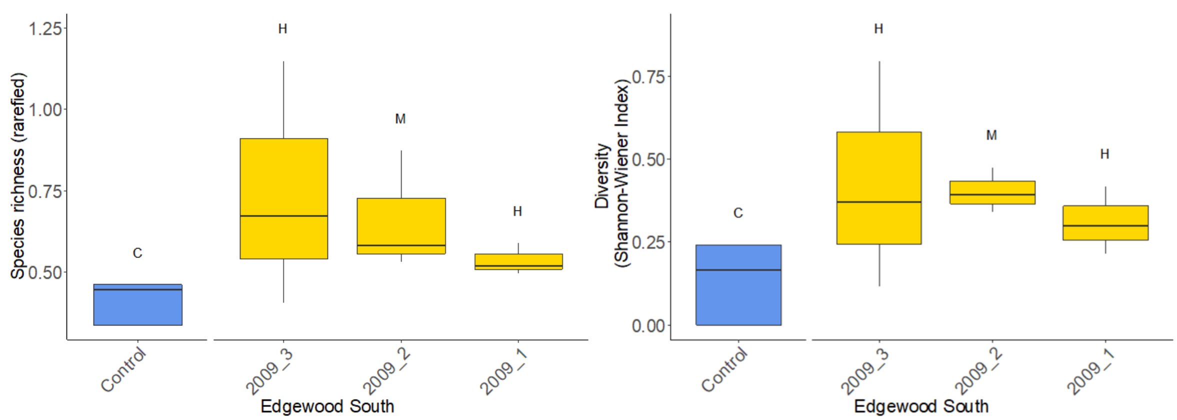


Figure 5-32. Rarefied richness (left) and diversity (right, Shannon-Wiener Index) of carabid species per trap, per 24-hours at Edgewood South by revegetation treatment polygon. Control (blue) was an untreated area of the drawdown zone, whereas stake (yellow) polygons were revegetation treatment areas. Each boxplot contains n=3 pitfall trap samples (constrained to data from collection 1 only). Letter labels correspond to estimated vegetation density, with 'L'= Low, 'M'= Moderate, and 'H'= High; 'C'= drawdown zone control.

Arthropod Biomass

We measured biomass in 20 graminoid and 9 live stake revegetation polygons across five sites during the first collection period in 2019. There was not a consistent effect of revegetation on biomass at most sites, and at Lower Inonoaklin the effect of revegetation on biomass was largely non-existent. The survival density of vegetation in the polygons (rated at high, moderate, or low; see Table 4-2) had no apparent positive effect on arthropod biomass.

East Arrow Park

Median arthropod biomass at East Arrow Park was higher in three of the six graminoid polygons than the control, although the control had a greater variation than the treatment polygons (Figure 5-33). Both stake polygons had a higher median biomass compared to the control. Greater vegetation density was not clearly linked to polygons with higher arthropod biomass.

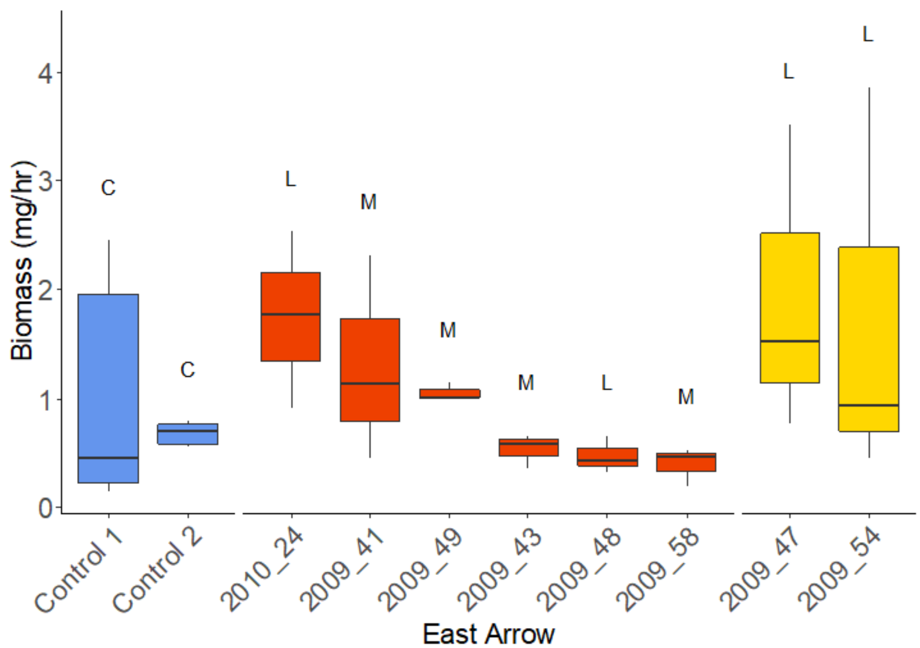


Figure 5-33. Arthropod biomass (mg) per trapping hour by revegetation treatment polygon at East Arrow Park. Controls (blue) were untreated areas of the drawdown zone, whereas graminoid (red) and stake (yellow) polygons were revegetation treatment areas. Each boxplot contains n=3 pitfall trap samples (constrained to data from collection 1 only). Letter labels correspond to estimated vegetation density, with 'L'= Low, 'M'= Moderate, and 'H'= High; 'C'= drawdown zone control. Control 2 and polygon 2009_54 were closer to each other geographically than to the other treatment polygons or control.

Burton Creek

Arthropod biomass largely overlapped between treatment polygons and drawdown zone controls at Burton Creek (Figure 5-34). One graminoid and one stake revegetation polygon had slightly higher median biomass than the control. Biomass was higher from pitfall traps in graminoid revegetation polygon 2010_2 and control 2 compared to other revegetation polygons or control 1. However, given that pitfall traps in polygon 2010_2 and control 2 were in close proximity to each other and geographically removed from the other revegetation polygons (Appendix A), this was likely just a function of location rather than effect of revegetation. Polygon 2009_5 had a much lower biomass than other revegetation polygons or controls, which could be due to the large absence of vegetation within the polygon (Appendix K). Otherwise, vegetation density did not seem to have a consistent influence on insect biomass.

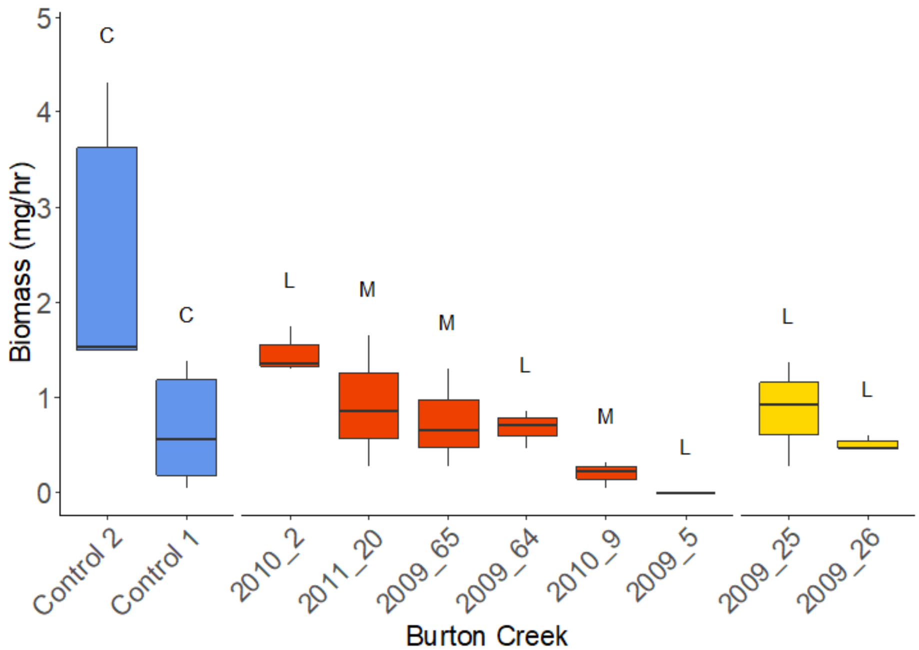


Figure 5-34. Arthropod biomass (mg) per trapping hour by revegetation treatment polygon at Burton Creek. Controls (blue) were untreated areas of the drawdown zone, whereas graminoid (red) and stake (yellow) polygons were revegetation treatment areas. Each boxplot contains n=3 pitfall trap samples (constrained to data from collection 1 only). Letter labels correspond to estimated vegetation density, with 'L'= Low, 'M'= Moderate, and 'H'= High; 'C'= drawdown zone control. Control 2 and polygon 2010_2 were closer to each other geographically than to the other treatment polygons or control.

Lower Inonoaklin

There were no clear trends for arthropod biomass at Lower Inonoaklin (Figure 5-35). The biomass in the revegetation polygons largely overlapped with that of the control. Vegetation density had no clear effect on biomass, although the two 'high' rated revegetation polygons were comparatively lower than other polygons for both stake and graminoid revegetation.

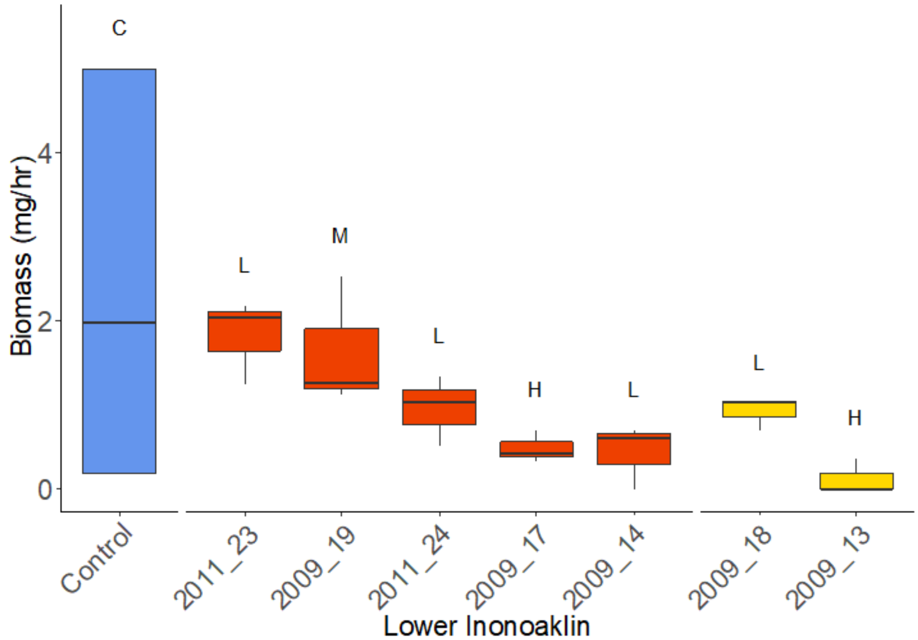


Figure 5-35. Arthropod biomass (mg) per trapping hour by revegetation treatment polygon at Lower Inonoaklin. The control (blue) represents untreated areas of the drawdown zone, whereas graminoid (red) and stake (yellow) polygons were revegetation treatment areas. Each boxplot contains n=3 pitfall trap samples (constrained to data from collection 1 only). Letter labels correspond to estimated vegetation density, with 'L'= Low, 'M'= Moderate, and 'H'= High; 'C'= drawdown zone control.

Edgewood North

Arthropod biomass at Edgewood North was higher in two of the graminoid revegetation polygons than in the control (Figure 5-37), although the 'low' rated polygon (2009_9) did overlap with the control biomass. Both graminoid revegetation polygons with 'high' and 'moderate' ratings overlapped with the 'low' rated polygon but had a comparatively higher median biomass.

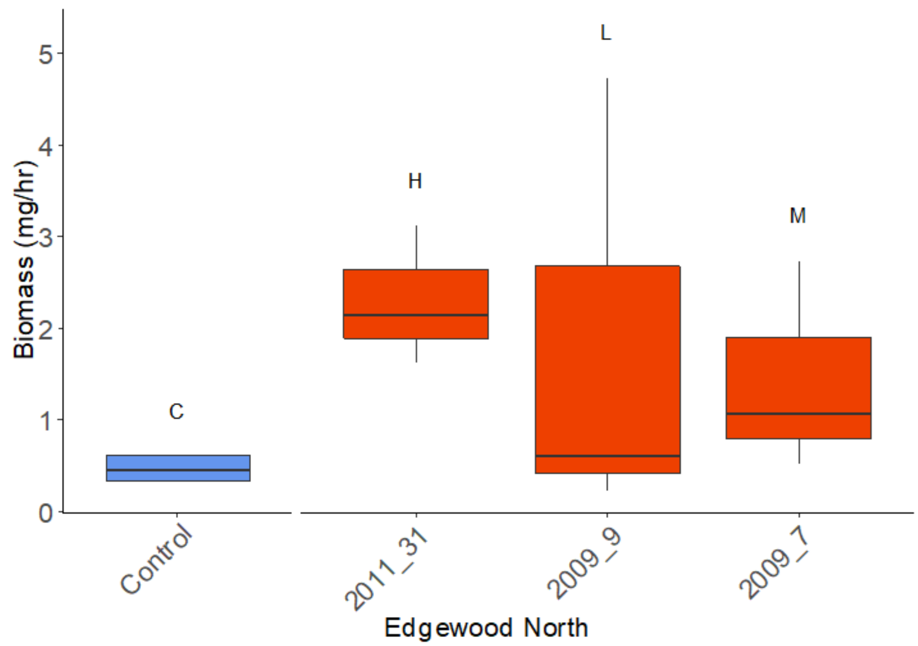


Figure 5-36. Arthropod biomass (mg) per trapping hour by revegetation treatment polygon at Edgewood South. The control (blue) represents untreated areas of the drawdown zone, whereas graminoid (red) polygons were revegetation treatment areas. Each boxplot contains n=3 pitfall trap samples (constrained to data from collection 1 only). Letter labels correspond to estimated vegetation density, with 'L'= Low, 'M'= Moderate, and 'H'= High; 'C'= drawdown zone control.

Edgewood South

The arthropod biomass in stake revegetation polygons at Edgewood South overlapped with the biomass in the control (Figure 5-37). Polygons with a high vegetation density had a greater median biomass than the polygon with a moderate density rating.

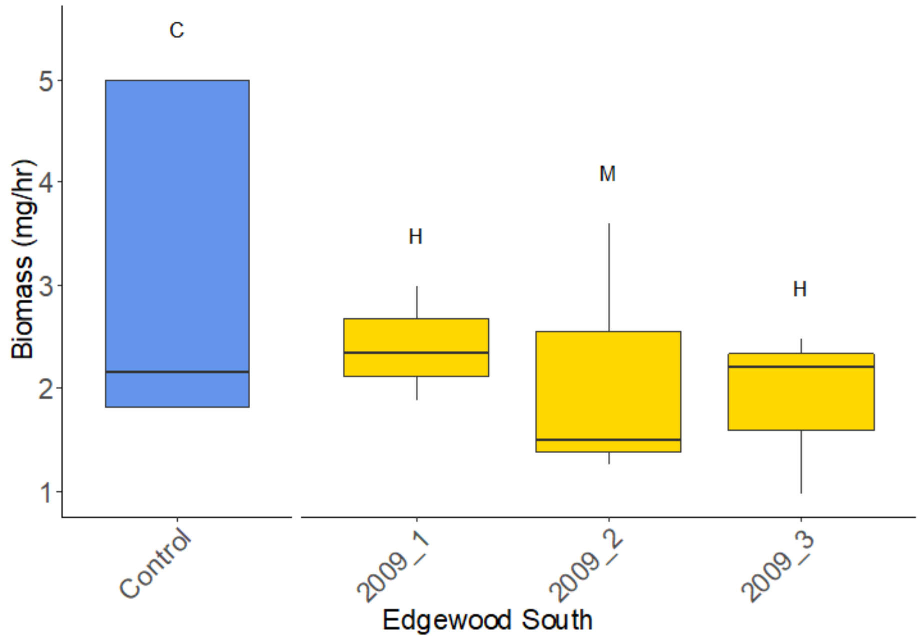


Figure 5-37. Arthropod biomass (mg) per trapping hour by revegetation treatment polygon at Edgewood South. The control (blue) represents untreated areas of the drawdown zone, whereas stake (yellow) polygons were revegetation treatment areas. Each boxplot contains n=3 pitfall trap samples (constrained to data from collection 1 only). Letter labels correspond to estimated vegetation density, with 'M'= Moderate and 'H'= High; 'C'= drawdown zone control.

5.2.2 Birds

Songbird species composition and similarity

The most frequently detected species within the constrained dataset (observations within 30 m) in the drawdown zone consisted mostly of wetland and shrub-associated species and aerial insectivores, such as warblers, flycatchers, and sparrows (Figure 5-38). Ground-nesting passerines were absent in this dataset (e.g., Savannah Sparrow), or rarely detected (e.g., Western Meadowlark).

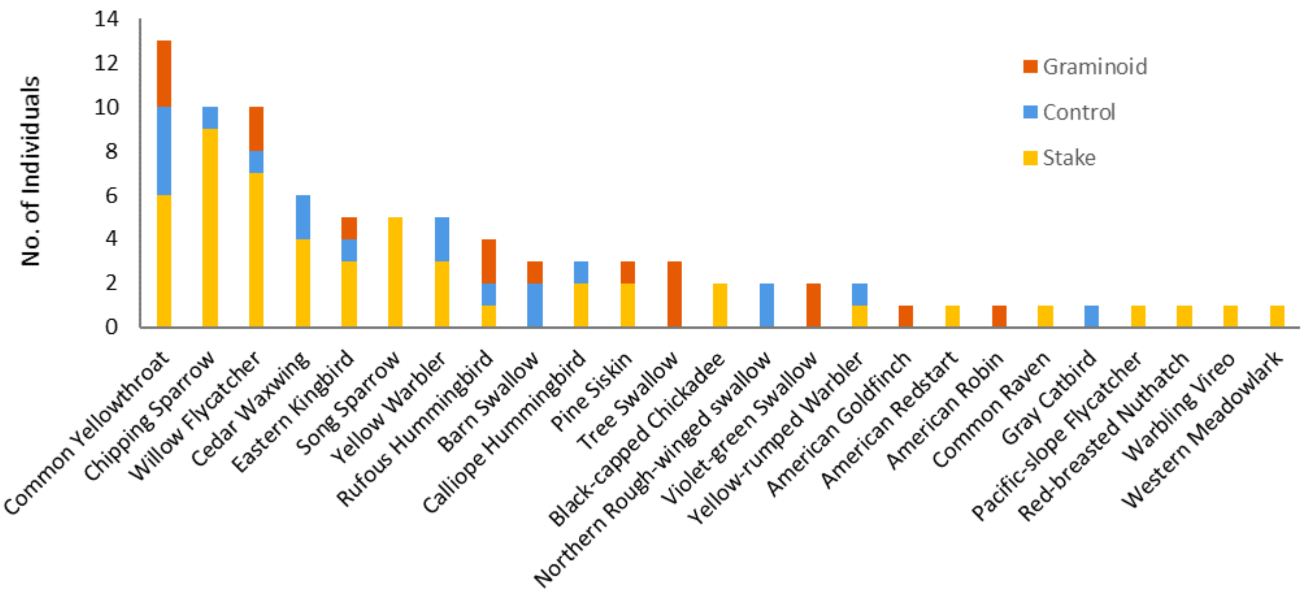


Figure 5-38. Number of individuals of all songbird (and hummingbird) species detected within 30 m of point counts during 2019 surveys by polygon type. Effort was not equal among treatments (control = 4 point counts, stake = 13 point counts, graminoid = 5 point counts).

Only four shared species were detected in stake and graminoid treatments and control points. These were Common Yellowthroat, Eastern Kingbird, Rufous Hummingbird, and Willow Flycatcher (Figure 5-38). Five species were shared between treatment and control only, and two between stake and graminoid treatment. Fourteen species were unique to a single polygon type, however, most of these were likely the result of low detection numbers rather than being truly unique based on some habitat attribute. Thirteen of these unique species were due to a single observation (an observation can consist of >1 individual bird) event of that species. Of unique species, only the Song Sparrow was detected multiple times from stake treatments, but all these observations were from one site (Lower Inonoaklin).

Nesting Evidence

In total, breeding evidence was found for 10 species from Burton Creek, Edgewood South and Lower Inonoaklin in 2019 (Appendix H). A total of 17 nests were found. Both ground (e.g., Spotted Sandpiper, Western Meadowlark) and shrub or tree (e.g., Cedar Waxwing, Willow Flycatcher) nests were located. The most frequently encountered was American Robin (4 nests), with breeding evidence detected from all three sites. Most nests were found in Burton Creek and Lower Inonoaklin, with about equal numbers from each. In total, nine nests were located within stake treatment polygons, and three additional ones were just outside the border of stake revegetation polygons. Nests in planted cottonwoods were found for American Robin and Cedar Waxwing at Lower Inonoaklin, and Willow Flycatcher and Chipping Sparrow at Edgewood South. One nest (American Robin) was found within a graminoid revegetation polygon, however this nest was in a cottonwood tree.

The date that nests were found ranged from June 8 to July 8. There were four probable nest successes and five probable nest failures, with a further eight having unknown outcome (Table 5-2). Inundation by rising reservoir levels was not directly implicated in any nest failures in 2019.

Table 5-2. The nesting fates of the 17 nests located during 2019 by study site. Refer to Appendix H for additional nest details.

	Nest Fates			
Site	**Success/Probable Success**	**Failure/Probable Failure**	**Unknown**	***Total***
Burton Creek	1	0	6	*7*
Lower Inonoaklin	3	3	0	*6*
Edgewood South	0	2	2	*4*
Total	*4*	*5*	*8*	*17*

5.2.3 Wildlife

Over May, June, and July 2019, roughly 25 hours were spent searching for signs of wildlife use (Figure 5-39). Our summary of incidentals focuses on mammals and herptiles found at the sites (Appendix L). While not quantifiable, signs of human use of the area (especially in the form of off-road vehicle tracks) were present and extensive at all sites.

There were signs of ungulate use at all sites (scat, tracks, fur, and bones). Signs at Edgewood South, Edgewood North, and Lower Inonoaklin were predominantly deer (*Odocoileus* sp.), while in addition to deer there were signs (scat and tracks) of Elk at East Arrow Park and Burton Creek. There were no signs of bears at Burton Creek, East Arrow Park, or Lower Inonoaklin, but Edgewood North and South both showed signs of bear presence, including tracks, scat, and signs of grubbing. River otter tracks were also found at both of those sites.

Figure 5-39. Examples of wildlife observations, including deer tracks (left), deer scat (middle), and bear scat (right). Photo credit: R. Waytes.

For herptile use of the sites, we found garter snakes at Burton Creek, Edgewood South, and Lower Inonoaklin. These consisted of two species, *Thamnophis elegans* and *T. sirtalis*. Western Toad tracks indicated their presence at East Arrow Park and Edgewood North; a western toad was also found at Lower Inonoaklin. Edgewood South had Columbia Spotted Frogs and a Northern Alligator Lizard, while a juvenile western skink was found at Lower Inonoaklin.

While not a vertebrate, we noted that the western bumble bee (*Bombus occidentalis*), a species of special concern, was observed foraging on flowers at Burton Creek, East Arrow Park, and Edgewood South.

In addition to incidental observations, we had wildlife cameras at Lower Inonoaklin, Edgewood South, and the Burton Creek WPW area (Appendix M). The majority of photographs at Edgewood South were of White-tailed Deer, followed by Snowshoe Hares, bears, and Mule Deer. Other wildlife photographed in this area included a Striped Skunk and a Wild Turkey. White-tailed Deer were also the most photographed wildlife at Lower Inonoaklin, followed by Canada geese. Other wildlife at Lower Inonoaklin included a Gray Catbird, Northern Saw-whet Owl, and Killdeer. Wildlife camera photos at the Burton Creek WPW area are discussed in more depth in section 5.3.5.

5.3 Wildlife Physical Works

Baseline data collection for certain groups (arthropods, songbirds, and bats) occurred in 2017, 2018, and 2019 and are summarized in this report, Wood et al. 2018, and Hentze et al. 2019. Additional data collected under CLBMON-37 indicated that two species of garter snake (*Thamnophis sirtalis* and *T. elegans*) are abundant at the site. Western Toad (*Anaxyrus boreas*), Columbia Spotted Frog (*Rana luteiventris*) and Pacific Chorus Frog (*Psuedacris regilla*) use habitats in and adjacent to the proposed physical works locations (see results in CLBMON-37 annual reports).

Before physical works construction in September 2019, the WPW site was characterized predominately by a graminoid vegetative cover (including reed canarygrass) (Hentze et al. 2019; Figure 5-40). The substrate was primarily composed of plant litter.

Figure 5-40. Reservoir-facing photo of pre-treatment Wildlife Physical Works site. Photo taken during first arthropod collection period on May 18, 2019 in the Arrow Lakes Reservoir. Photo credit: R. Waytes.

5.3.1 Arthropods

Average insect biomass ± SE at the pre-WPW site was 1.31 ± 0.30 mg/hr for pitfall traps (n=5) in the first collection and 3.45 ± 0.72 mg/hr for pitfall traps (n=5) in the second collection. The average catch per unit effort (CPUE) per 24-hour period for adult beetles in pitfall traps was 2.75 ± 1.44 for the first collection and 6.25 ± 1.93 for the second collection. The average CPUE for adult spiders in pitfall traps was 1.13 ± 0.48 for the first collection and 3.36 ± 0.24 for the second collection.

Malaise samples

We captured a total of 537 Hymenopterans comprising 21 families (Figure 5-41) and 4,839 Dipterans comprising 33 families (Figure 5-42). The 2019 Hymenopteran samples were dominated by parasitoid wasps, especially those in the family Diapriidae. These wasps typically parasitize flies, including fungus gnats. Similar to the 2018 Malaise trap samples, the most common Dipteran captured were midges (Chironomidae). The second most common Dipteran family was Sciaridae (fungus gnats).

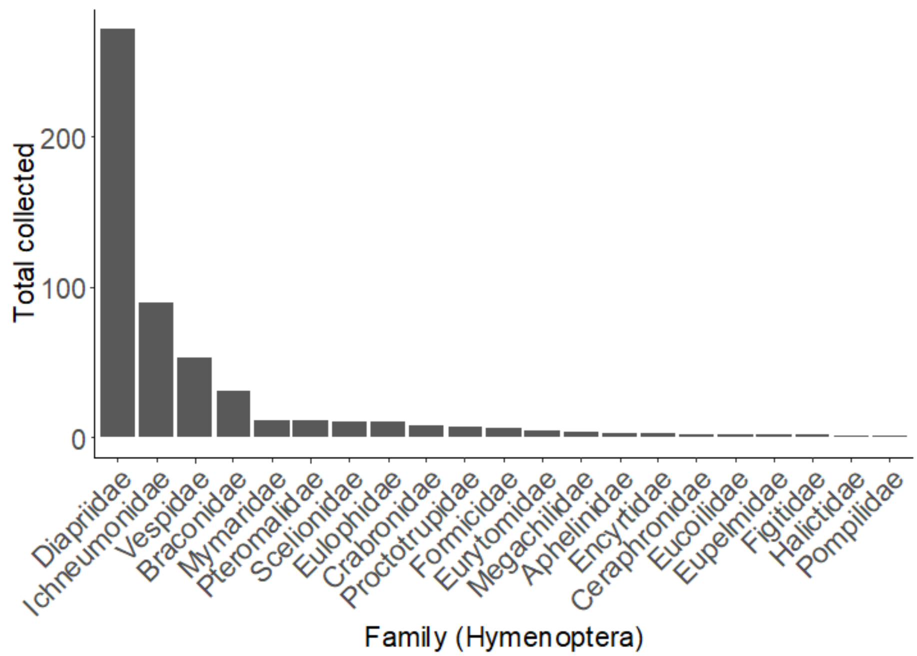


Figure 5-41. Hymenoptera families and associated abundances (not standardized to trapping effort) collected from all Malaise traps in the pre-treatment Wildlife Physical Works site (n=6). Samples were collected along the Arrow Lakes Reservoir in 2019.

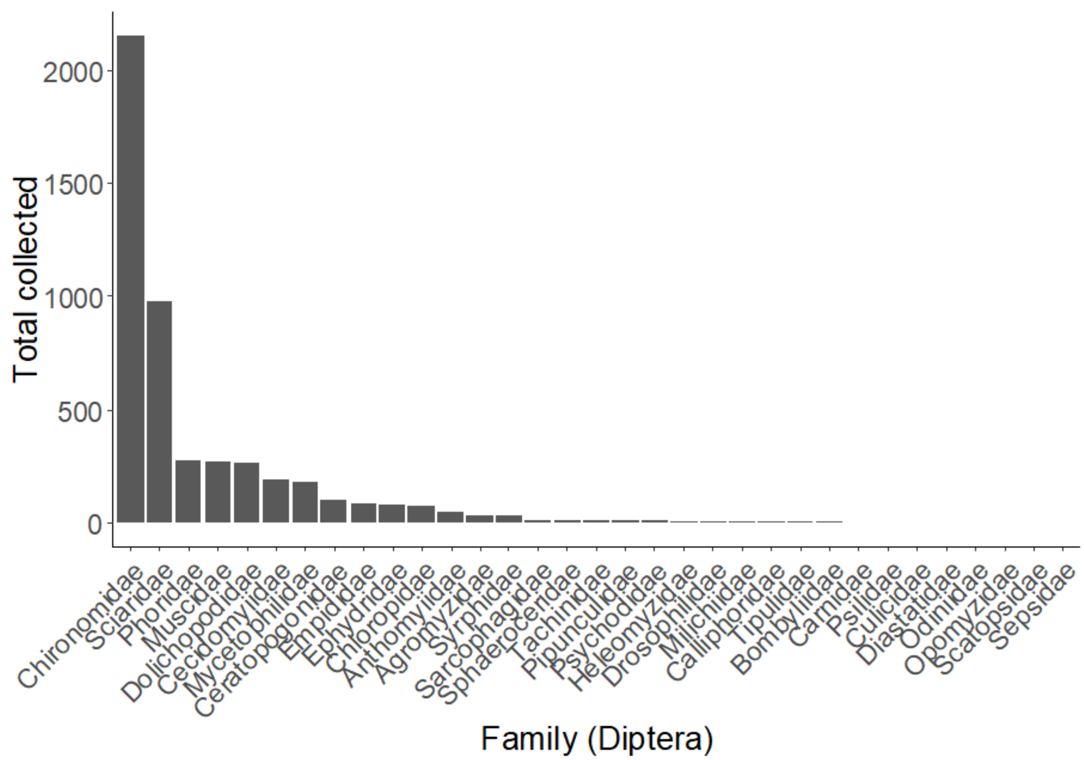


Figure 5-42. Diptera families and associated abundances (not standardized to trapping effort) collected from Malaise traps in the pre-treatment Wildlife Physical Works site (n=6). Samples were collected along the Arrow Lakes Reservoir in 2019.

Pitfall samples

We captured a total of 65 adult spiders comprising 10 species (Figure 5-43) and a total of 36 adult beetles comprising 5 families (Figure 5-44). In these samples there were 25 adult carabid beetles comprising 7 species (Figure 5-45). The number and diversity of adult beetles and spiders captured in 2019 was notably lower than that of 2018 (Hentze et al. 2019). Two adventive (non-native species) carabid species were found at this site: *Pterostichus melanarius* and *Carabus granulatus*. A beetle belonging to the family Scarabaeidae, *Onthophagus nuchicornis*, was also adventive. No adventive spider species were collected at Burton Creek WPW in 2019.

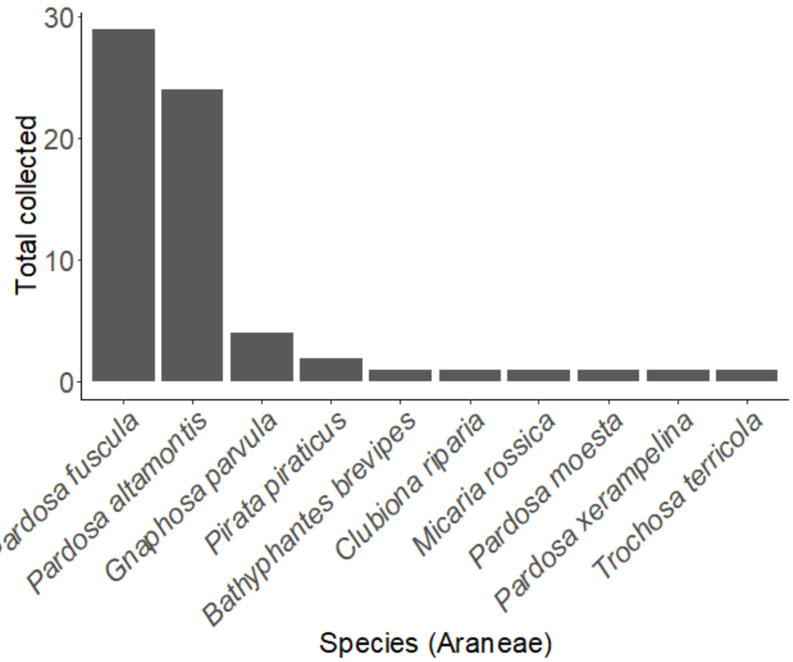


Figure 5-43. Araneae species and associated abundances (not standardized to trapping effort) collected from all pitfall traps in the pre-treatment Wildlife Physical Works site (n=10). Samples were collected along the Arrow Lakes Reservoir in 2019.

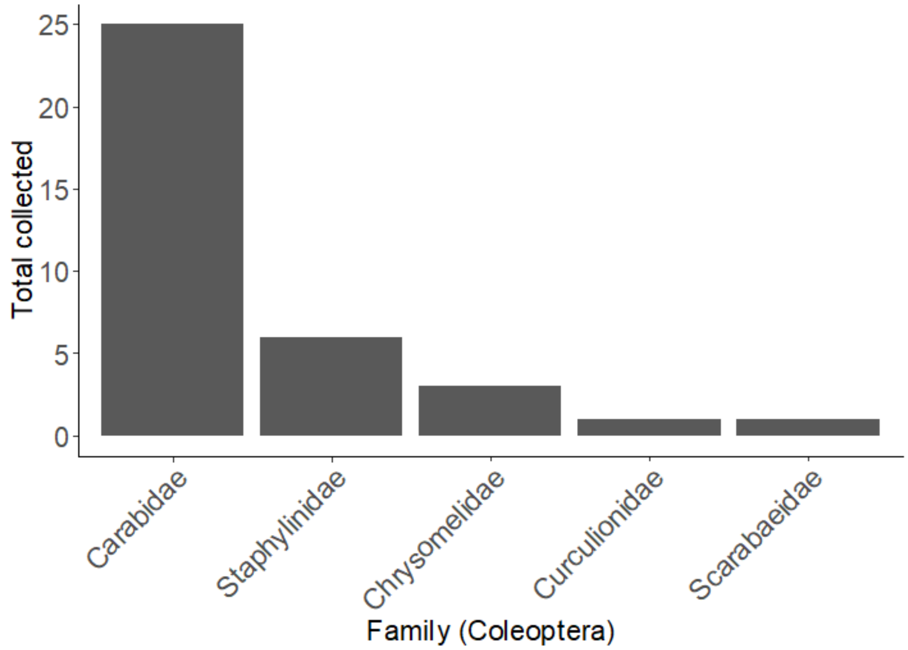


Figure 5-44. Coleoptera families and associated abundances (not standardized to trapping effort) collected from pitfall traps in the pre-treatment Wildlife Physical Works site (n=10). Samples were collected along the Arrow Lakes Reservoir in 2019.

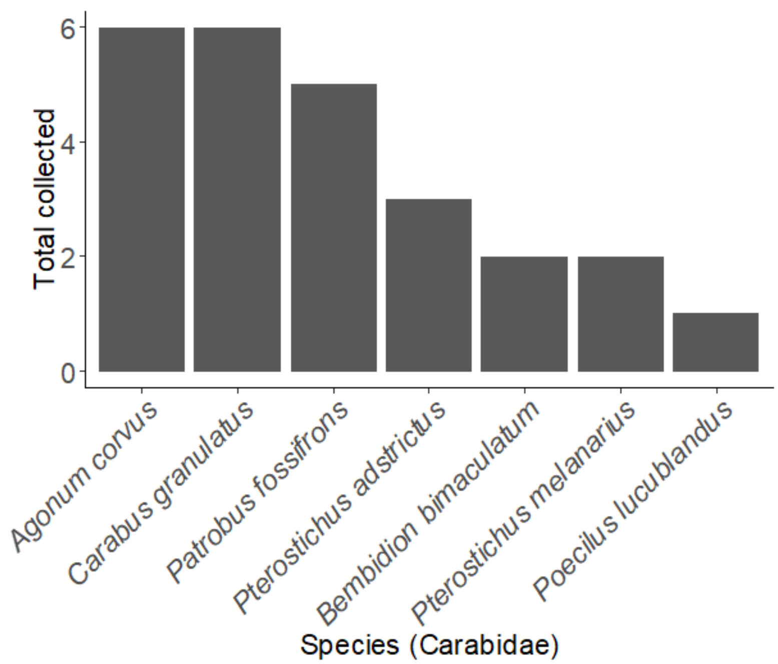


Figure 5-45. Species and abundances of carabid beetles (not standardized to trapping effort) collected from pitfall traps in the pre-treatment Wildlife Physical Works site (n=10). Samples were collected along the Arrow Lakes Reservoir in 2019.

Odonate surveys

In 2019 surveys, three odonate species were detected in the Burton Creek WPW area (Table 5-3). The most common species encountered was the Tule Bluet (Figure 9-2), a species of damselfly that is widespread in southern Canada. The other two species encountered, a Boreal Bluet and Variegated Meadowhawk (Figure 9-2), are also native to BC. Other species that have been found at Burton Creek in previous years (although not necessarily at the WPW site) include the Band-winged Meadowhawk, Hudsonian Whiteface, and the Paddle-tailed Darner (Hawkes et al. 2011). See Appendix J for a complete list of odonates collected in the 2019 surveys (including species at Edgewood South and Lower Inonoaklin).

Table 5-3. Dragonfly and damselfly (Odonata) species detected in the Burton Creek WPW area and their associated abundances. Surveys were conducted in July of 2019.

Family	Common name	Species	Number of individuals
Coenagrionidae	Boreal Bluet	*Enallagma boreale*	1
Coenagrionidae	Tule Bluet	*Enallagma carunculatum*	7
Libellulidae	Variegated Meadowhawk	*Sympetrum corruptum*	3

5.3.2 Birds

Seventeen individuals of five bird species were recorded within 30 m of the point count centre from the five point count locations surveyed in the WPW area during summer 2019: Chipping Sparrow, Common Yellowthroat, Lincoln’s Sparrow, Lazuli Bunting, and Rufous Hummingbird. Several of these were detected from the forest edge, such as the Chipping Sparrow and Lazuli Bunting.

In total, 35 species of waterfowl, loons, grebes, shorebirds, herons and kingfishers (for ease, we collectively refer to all these as “waterbirds” in this section) were recorded during spring through autumn waterbird surveys in 2019 at Burton Creek. With the exception of some loons and grebes, most waterbirds were detected from near the reservoir edge. As such, as reservoir elevations rose between April/May and June/July, waterbird numbers also increased at higher elevations of the reservoir (Appendix I). Waterbirds then followed the receding shoreline in August/September away from the WPW area (Appendix I). Waterfowl numbers remained similar in the April/May and June/July periods, but quadrupled in the August/September period (Table 5-4). This was mostly due to higher numbers of Canada Goose, Common Merganser, and gulls in that period. Within the proposed physical works location, there were few detections of waterbirds during April/May, but Mallards, Bufflehead, and Common Merganser were all detected near the edge of the proposed WPW area. Following inundation in June/July waterbirds including Mallards, Canada Goose, and Common Merganser were found within the proposed WPW area. Despite the larger number of birds overall, the August/September period had fewer detections within the proposed WPW area, but sightings included Great Blue Heron and Common Merganser (Appendix I).

At Lower Inonoaklin and Edgewood South waterbirds showed the same spatial trend of following the shoreline up or down as reservoir elevations changed. Waterbird numbers at Edgewood South followed a similar temporal pattern of abundance as Burton Creek, being approximately 50% higher in the

August/September period than the April/May or June/July periods, which were about equal to each other. At Lower Inonoaklin the pattern was different, being almost equal in April/May and August/September, and lowest during June/July when water levels were highest.

Table 5-4: Number of waterbirds detected from the Burton Creek area during dedicated waterbird surveys in 2019.

Species Group	Period		
	Apr/May (n=5)	Jun/Jul (n=6)	Aug/Sep (n=6)
Ducks and Geese	325	365	1214
Gulls	26	6	506
Shorebirds	5	39	29
Other Waterbirds	15	21	57
Total	*371*	*431*	*1806*

5.3.3 Bats

All 11 species of bat were detected by autonomous recording units from the wildlife physical works area. These were predominantly species of *Myotis*, especially Little Brown Myotis (*Myotis lucifugus*). The detectors at Burton Creek had the lowest bat detection rates compared to other sites. Of these, the detector BUWPW1 recorded the fewest calls (5.86 calls per detector-hour; Figure 9-1). The general proportion of detections per species were consistent with 2017 and 2018 results (Figure 5-46). However, we noted a large amount of within site (between-detector) variation, for unknown reasons (e.g., differences between the Burton WPW detectors).

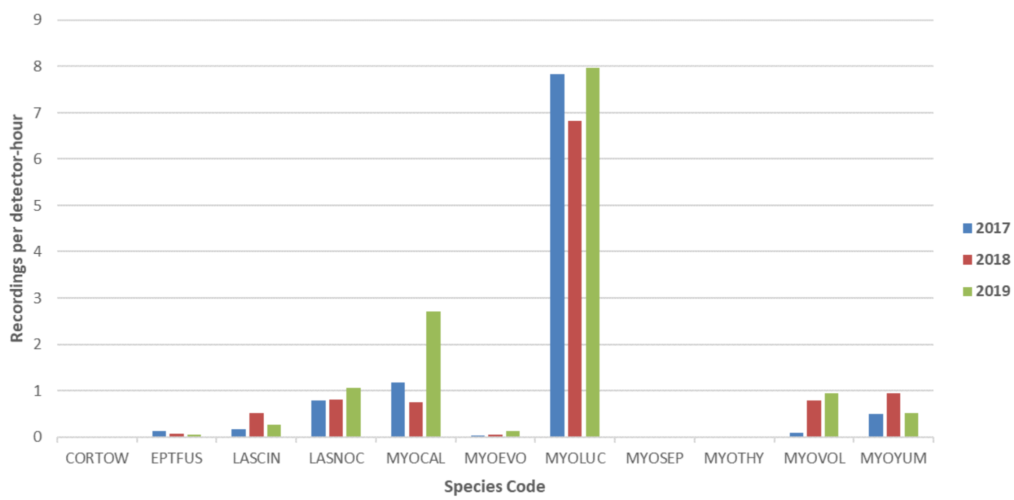


Figure 5-46. Proportion of recordings per detector-hour for all bat species documented by autonomous recording units deployed in Burton Creek Wildlife Physical Works area from 2017 to 2019. Species codes are provided in Table 9-1.

5.3.4 Amphibians and reptiles

Amphibians and reptiles were surveyed under CLBMON-37 from 2008 to 2018 (Hawkes et al. 2019). Overall, three species of amphibian and two species of reptile have been detected broadly across the Burton Creek study area (Figure 5-47). Of these species, Western Toad was previously designated as “near threatened” by the International Union for Conservation of Nature (IUCN; Hammerson et al. 2004) but was later assessed as “least concern” by the IUCN SSC Amphibian Specialist Group (2015). The Committee on the Status of Endangered Wildlife in Canada assessed the Western Toad as Special Concern (COSEWIC 2012) and it was listed under Schedule 1 of the Canadian Species at Risk Act (SARA) in 2005. The management objective outlined by Environment and Climate Change Canada (2016) is “to maintain stable or increasing populations distributed throughout the species’ present range in Canada”.

Figure 5-47. Location of amphibian and reptile species documented at Burton Creek in Arrow Lakes Reservoir, from 2008 to 2018 during CLBMON-37 surveys. Species codes: A-ANBO = Western Toad (*Anaxyrus boreas*), A-PSRE = Pacific Chorus Frog (*Pseudacris regilla*), A-RALU = Columbia Spotted Frog (*Rana luteiventris*), R-THEL = Western Terrestrial Garter Snake (*Thamnophis elegans*), R-THIS = Common Garter Snake (*T. sirtalis*). Source: Hawkes et al. (2020, draft).

5.3.5 Wildlife

There were 16,250 wildlife photographs taken at the Burton Creek WPW area from 21 May to 9 September 2019. Excluding photographs of humans, dogs, and vehicles, as well as photographs triggered by moving vegetation, 714 of these photographs were of animals using the area near to or in the WPW area. The most common species photographed in the WPW area was White-tailed Deer (694 photographs). Most photographs of White-tailed Deer were taken in June through August, and sighting levels were similar between these three months. White-tailed Deer were also photographed in May but to a lesser extent, likely because the cameras were set nearer to the end of the month. No deer were photographed in September until cameras were removed on the 9th, which may be due to the physical works construction activity. Other animals photographed were a cow Elk and her calf (14 photographs; June), a Black Bear (5 photographs; July), and a Northern Flying Squirrel (one photograph; August) (Figure 5-48). It is important to note that wildlife photographs are not directly related to animal abundance (as one animal can trigger ten photographs at a time, and multiple cameras may have photographed the same animal), so this data only a general indication of animal presence. See Appendix M for more detailed information on wildlife camera photographs at Burton Creek, as well as Edgewood South and Lower Inonoaklin.

Figure 5-48. Clockwise from top left, wildlife camera photographs of a White-tailed Deer, Elk calf, Black Bear, and Northern Flying Squirrel. Photographs were taken in the pre-construction WPW area of Burton Creek in 2019.

6.0 DISCUSSION

CLBMON-11B1, initiated in 2009, is a long-term wildlife monitoring project that aims to assess the efficacy of revegetation prescriptions and future wildlife physical works, for enhancing the suitability of habitats in the drawdown zone for wildlife. Based on previous recommendations, the current study focused on arthropod and songbird communities, selected for their potentially measurable responses to treatment effects in the drawdown zone of Arrow Lakes Reservoir.

This was the final year of revegetation monitoring under the Terms of Reference. The focus of 11B1 in upcoming years will focus on the monitoring of wildlife physical works. In addition to songbirds and arthropods, wildlife physical works monitoring also included measures of bat and other wildlife use of the pre-physical works sites.

6.1 Revegetation

Responses by arthropods to revegetation treatments were mixed. There was no indication that revegetation treatments consistently promoted arthropod communities.

If vegetation cover and/or structure were different for treatment areas than adjacent controls, arthropod responses were expected to differ. This is due to the high degree of specificity to habitat quality exhibited by terrestrial arthropods. For both ground-dwelling spiders and beetles, vegetation cover increases relative humidity of the soil surface, which provides favourable conditions for many species (Ziesche and Roth 2008; Antvogel and Bonn 2001; Buchholz et al. 2013). Additionally, beetle species (e.g., Carabidae and Staphylinidae) that develop in the upper layers of soil during their larval stages are highly selective to soil substrate composition, relative humidity, and in some cases salinity and pH of the soil. Spider species are strongly tied to changes in vegetation structure, as this provides different niches for spiders that specialize in different modes of prey capture (Hatley and MacMahon 1980; Uetz 1991). Sites with bare ground are usually dominated by spiders that do not require webs for prey capture (e.g., Wolf spiders, Crab spiders). Sites with low herbs such as sedges/grasses may provide a niche for the funnel-web building spiders and for species with lower tolerance to exposed sites. Higher vegetation provided by willows/shrubs provides habitat for web-building spiders of various species, while forested habitats provide numerous additional niches not provided by open habitats. These shifts in spider functional guilds were observed with vegetation increases in the drawdown of Kinbasket Reservoir (Wood et al. 2019). In particular, bare-ground habitats were dominated by ground-running spiders, but an increase in ambushers, sheet/funnel-weavers, and space-web weavers was correlated with vegetation recovery.

We found no consistent effect of revegetation treatment on arthropod biomass, CPUE, diversity, or richness. The effects of revegetation varied within site and between sites, which is largely consistent with findings in previous years.

There were no overall patterns that indicated whether graminoid revegetation was effective at promoting arthropod abundance or diversity. This is not unexpected when considering the low vegetation cover in many polygons (Appendix K). Within each site for most response variables considered, effects of graminoid revegetation ranged from positive to negative (Table 5-1). The only exceptions were for carabid diversity at Burton Creek and biomass at Lower Inonoaklin, which showed no positive effects of graminoid revegetation. While 2018 sampling did suggest some positive effects of graminoid revegetation on carabid diversity (Hentze et al. 2019), the lack of such a pattern in 2019 when considering a greater number of revegetation polygons suggests this relationship may have been the result of yearly variation or some other factor not directly related to revegetation.

The effects of stake revegetation on arthropod response measures were more consistent within each site but varied between sites. The stake revegetation polygons at Edgewood South promoted spider and beetle diversity, but negatively affected abundance (CPUE). Stake revegetation at East Arrow Park promoted spider abundance, diversity, and richness (as well as overall biomass), but had no clear effect on beetle abundance or diversity. Conversely, stake revegetation at Lower Inonoaklin had a consistently negative effect on both spider and beetle diversity and abundance, as well as overall biomass, compared to the control. Stake revegetation at Burton Creek had a similarly negative (or neutral) effect on spider and carabid diversity. Given the inconsistency of these results, it is still difficult to say whether stake revegetation has helped promote arthropod communities.

Due to the limited availability of stake revegetation polygons relative to graminoid revegetation polygons, we sampled many more graminoid than stake revegetation polygons (20 compared to 9). The relatively higher sample size for graminoid revegetation polygons may mean we have a more accurate idea of the effectiveness of graminoid revegetation relative to stake revegetation.

We expected that vegetation density might correlate to higher rates of revegetation success in promoting arthropod abundance or diversity. However, there was no clear pattern of the effect of vegetation survival density on whether a revegetation treatment was considered successful. In some instances, such as the high- and moderate-rated stake polygons at Edgewood South positively promoting carabid and spider diversity and richness, it is possible that vegetation survival density could indicate revegetation success. However, stake revegetation polygons that were similarly successful at promoting spider richness and diversity at East Arrow were rated as low density. The effects of a high-density rated stake revegetation polygon at Lower Inonoaklin were negative relative to the control and a low-rated stake revegetation polygon at that site.

Songbird species were also expected to respond to changes in vegetation structure and/or arthropod abundance. Areas containing stake and graminoid vegetation are likely to provide habitat for bird species that is not available in adjacent drawdown zone areas with bare ground. However, songbird point count data has been insufficient to detect a clear effect of revegetation treatments in comparison with adjacent drawdown zone controls. The number of bird detections is consistently low in treatment and control habitats, while variance is often high.

For this reason, bird nest data provided useful supplementary information on the utilization of bird nesting habitat within the drawdown zone. While not a main focus of CLBMON-11B1, nest surveys provided information on nesting habitat suitability. For example, the presence of songbird nests in planted cottonwoods was evidence that at least some birds utilized transplanted vegetation for nesting where suitable habitat characteristics exist. The most direct evidence of this are the detection of nests of species such as Cedar Waxwing and American Robin in planted cottonwoods (especially at Lower Inonoaklin). Ground nests (e.g., of Spotted Sandpipers) have occurred throughout the drawdown zone, and do not appear to be linked to any specific revegetation efforts, though ground-nesting passerines appear to be few or absent (e.g., Savannah Sparrow).

It should be noted that several other factors related to the original revegetation program may confound our results. For example, planting in revegetation treatment plots was sometimes applied to areas with poor growing conditions relative to non-treatment areas within the same site, resulting in a potential underestimation of revegetation effectiveness (Enns and Overholt 2013). Revegetation was not applied in a manner that accounted for the scale at which many organisms would utilize the drawdown zone (i.e., revegetation polygon size was smaller than the home range or territory size of many animals). Beyond inherent differences between treatment and control areas, our ability to detect any true changes are limited by within-site, among-site and among-year differences, and a lack of revegetation success. It is possible that other within-site factors unrelated to revegetation success may better explain arthropod use of the revegetation polygons, including proximity of polygons to the reservoir (and likelihood of inundation), proximity to forest or upland habitat, substrate composition, disturbance (especially human disturbance and off-road vehicle use), and time of year.

Patterns of reservoir activity necessitated moving arthropod sampling earlier in the year to allow access to more revegetation polygons. However, data from previous years have shown that arthropod biomass is greater later in the season, coinciding with periods of time when sampling polygons are inundated. As bird surveys cannot be moved to the same early period without being unduly influenced by migrating birds (as opposed to locally breeding ones), this creates a mismatch when linking bird and arthropod results. Furthermore, if a measure of success of revegetation effectiveness is access to revegetation within the polygon during critical life stages (whether by arthropods, birds, or other wildlife), then the unavailability of many revegetation polygons during times of year when there is greater animal activity (e.g., birds matching nesting activity with peak arthropod abundance) may be a limiting factor which reduces revegetation effectiveness to wildlife.

6.2 Wildlife Physical Works

The suitability of habitat in the Burton Creek pre-WPW area was considered to be low for most species groups considered (Hawkes and Tuttle 2016). This is consistent with 2019 assessments of wildlife in the area. We found a relatively low diversity of beetle species (consistent with the rest of Burton Creek), spider species, and dragonflies. Several of the beetles were non-native species. Parasitoid wasps, midges, and fungus gnats dominated Malaise trap samples.

Likewise, few songbirds were detected in the pre-WPW area, though a couple (Common Yellowthroat and Lincoln’s Sparrow) are wetland-associated species that may breed in the area. While the inundation of the pre-WPW area created a danger for nesting songbirds, this is also the time period when waterbirds moved into the WPW area as they followed the rising shoreline. The movement of waterbirds within the reservoir in tandem with reservoir elevations was distinct. While waterbirds were present during the entire sampling period, numbers swelled during fall as populations were higher (i.e., adults are joined by young-of-the-year) and birds congregated at migratory staging areas. These species and trends indicated the composition and timing of bird activity that can be expected post-WPW.

The use of wildlife cameras revealed wildlife activity in the area, which was largely dominated by White-tailed Deer. The species richness of bats in the area was as expected (n=11 species), but detection rates were low relative to other areas monitored in the Arrow Lakes Reservoir (Table 9-3)

The WPW construction at Burton Creek is anticipated to improve habitat suitability for wildlife including birds, amphibians, reptiles (Burton Creek currently has high suitability for snakes, which is not expected to change), mammals (bats), insects (dragonflies) and fish (among others). Species with provincial or federal conservation designation that will benefit from this project include the provincially blue-listed and COSEWIC species of Special Concern, Western Toad (*Anaxyrus boreas*); the provincially blue-listed Townsend's Big-eared Bat (*Corynorhinus townsendii*) and Fringed Myotis (*Myotis thysanodes*); and the COSEWIC endangered Little Brown Myotis (*Myotis lucifugus*) (listed February 27, 2012).

Monitoring at Burton Creek in 2019 and previous years will provide the data necessary to assess the effectiveness of the physical works to provide habitat for wildlife once complete. The data collected to date will provide a suitable baseline for those future comparisons, which will be the focus of fieldwork from 2020 onwards.

The first stage of physical works construction at Burton Creek began in September 2019. Following the completion of the design work associated with the physical works site, the performance measures suggested by Hawkes and Tuttle (2016) can be reviewed and revised as needed. The objectives and performance measures as outlined by Hawkes and Tuttle (2016) are as follows:

1. Creation of new wetland habitat in an area dominated by grasses (i.e., no current wetland habitat – see Section 4.2) and expansion of wetland habitats in the vicinity of ponds A1 and A2 (Figure 4-1).
    a. Temporal availability of wetland overlaps with the migratory bird (particularly wetland-associated species) and amphibian breeding seasons (May-August). The permanence of the wetland should be assessed (i.e., is the wetland available each year and for how long?)
    b. Minimum depth of pond required to support amphibian breeding and larval development (See Section 4.2).
2. Wetland productivity.
    a. Successful establishment of native macrophytes (planted or natural) into newly created wetlands within five years. “Successful establishment” is defined here as continuous species presence for at least two years.

Currently there are no macrophytes at the site proposed for physical works.

b. Successful natural establishment of native macroinvertebrates (e.g., odonates, cladocerans, gastropods) into newly created wetlands within 5 years. “Successful establishment” is defined here as continuous species presence for at least two years. The current biomass of macroinvertebrates at this site is nil.

c. Evidence of breeding by amphibians (specifically Western Toad). The number of egg strings or masses should be counted on an annual basis following the implementation of the physical works. Egg development should be tracked to determine if eggs metamorphose into froglets or toadlets. Western Toads currently breed in the ponds situated at elevations <434 m ALS, but do not breed at the site proposed for physical works.

d. Evidence of use of the wetland by waterfowl and shorebirds. Waterfowl have been observed using the area proposed for physical works, but only in small numbers, especially when inundated by Arrow Lakes Reservoir.

e. Evidence of use of habitat enhancements (e.g., nest boxes, floating islands) by target waterfowl species (which will need to be determined) following completion of construction.

f. Evidence of use of the constructed wetland by bats (as determine by autonomous recording units) and use of enhancements such as bat boxes, snags, or other enhancements).

7.0 RECOMMENDATIONS

In 2017, the Terms of Reference for CLBMON-11B1 were revised (Revision 1, June 29, 2017, BC Hydro 2017). The work completed in 2019 represents the second year of implementation under these revised Terms of Reference. The recommendations provided below are intended to refocus efforts towards assessing the suitability of the Wildlife Physical Works at Burton Creek now that construction has begun.

1. **Continue to monitor spring and fall migrant waterfowl and shorebirds** in proposed physical works areas to obtain a baseline dataset associated with these bird groups. This is necessary to assess if constructed wetlands or other physical works will provide suitable habitat for birds. We recommend increasing the number of waterfowl surveys from the spring (April) through the fall (October) to obtain a more accurate understanding of temporal and spatial trends for birds in this area. If possible, surveys during the spring through fall should also include Lower Inonoaklin to serve as a reference site for inter-annual variability in bird numbers, while also providing baseline information for any future WPW activities at that site.

2. **Conduct targeted surveys for amphibians and reptiles in the Burton Creek Wildlife Physical Works site.** These data would compliment those collected in previous years under CLBMON-37 and are important for effectiveness monitoring of the WPW treatment, since this is a key group expected to benefit from the constructed wetland complex.

3. **Document post-treatment wildlife use of Burton Creek Wildlife Physical Works site with remote cameras.** In 2019, remote cameras were installed at the proposed Burton Creek WPW site to assess pre-treatment wildlife occurrence. Monitoring with remote cameras should continue in 2020 to assess post-treatment wildlife use of the WPW area. It is expected that the proposed wetland project will increase habitat suitability for a variety of wildlife, thus, we expect an increase in species richness using this site.
4. **Assess wildlife browse on Wildlife Physical Works revegetation.** Wildlife activity in the Burton Creek WPW area can be a positive sign, as it indicates wildlife use of the area, but excessive browse may impact revegetation establishment and success. Examining the extent of wildlife browse on planted vegetation will allow us to understand the extent of wildlife interactions with revegetation in the area and could inform future management.
5. **Continue to conduct targeted surveys for odonates in the Burton Creek Wildlife Physical Works site.** CLBWORKS-29B specifically mentions odonates as taxa predicted to benefit from the creation of the wetland habitat at this site (Hawkes and Tuttle 2016). Baseline data on odonates that was gathered before the implementation of the WPW will serve as a comparison to future odonate surveys.
6. **Record incidental observations of aquatic macroinvertebrate establishment in constructed Wildlife Physical Works ponds.** The establishment and continued presence of native macroinvertebrates in WPW ponds can serve as one indication of wetland productivity and WPW success (Hawkes and Tuttle 2016). Observations of macroinvertebrate colonization of constructed ponds are recommended to be recorded during odonate and amphibian and reptile surveys.
7. **Deploy data loggers at the Wildlife Physical Works to collect microsite data.** Data loggers can indicate water quality, which will help our understanding of wildlife use of WPW ponds.

8.0 REFERENCES

Andersen, A.N. 1999. My bioindicator or yours? Making the selection. Journal of Insect Conservation 3:61-64.

Antvogel, H. and A. Bonn. 2001. Environmental parameters and microspatial distribution of insects: a case study of carabids in an alluvial forest. Ecography 24: 470-482.

B.C. Conservation Data Centre. 2019. BC Species and Ecosystems Explorer. B.C. Ministry of Environment, Victoria B.C. Available: http://a100.gov.bc.ca/pub/eswp/ (January 15, 2019).

BC Hydro. 2007. Columbia River project water use plan. BC Hydro Generation, Burnaby B.C.

BC Hydro. 2009. Columbia River Project Water Use Plan, Monitoring Terms of Reference: CLBMON 11B wildlife effectiveness monitoring of revegetation in Arrow Lakes Reservoir. BC Hydro, Burnaby, B.C. March 25, 2009.

BC Hydro. 2017. Columbia River Project Water Use Plan, Monitoring Terms of Reference: CLBMON 11B wildlife effectiveness monitoring of revegetation in Arrow Lakes Reservoir. BC Hydro, Burnaby, B.C. Revision 1, June 29, 2017.

Bess, E.C., R.R. Parmenter, S. McCoy, and M.C. Molles, Jr. 2002. Responses of a riparian forest-floor arthropod community to wildfire in the middle Rio Grande Valley, New Mexico. Environmental Entomology 31(5): 774–784.

Bibby, C.J., N.D. Burgess, D.A. Hill, and S. Mustoe. 2000. Bird Census Techniques. London: Academic Press. 302 pp.

Blanchet, F.G., P. Legendre, and F. He. 2015. A new cost-effective approach to survey ecological communities. Oikos 125(7): 975–987.

Buchholz, S., Hanning, K., and J. Schirmel. 2013. Losing uniqueness – shifts in carabid species composition during dry grassland and heathland succession. Animal Conservation 16: 661-670.

Buddle, C.M. and D.P. Shorthouse. 2008. Effects of experimental harvesting on spider (Araneae) assemblages in boreal deciduous forests. Canadian Entomologist, 140: 437–452.

Buddle, C.M., D.W. Langor, G.R. Pohl, and J.R. Spence. 2006. Arthropod responses to harvesting and wildfire: implications for emulation of natural disturbance in forest management. Biological Conservation, 128: 346–357.

Buddle, C.M., J.R. Spence and D.W. Langor. 2000. Succession of boreal forest spider assemblages following wildfire and harvesting. Ecography, 23: 424–436.

Burnett, R.D., T. Gardali, and G.R. Geupel. 2005. Using songbird monitoring to guide and evaluate riparian restoration in salmonid-focused stream rehabilitation projects. In: Ralph, C.J. and T.D. Rich. Bird Conservation Implementation and Integration in the Americas: Proceedings of the Third International Partners in Flight Conference. 2002 March 20-24. Asilomar, CA: US Department of Agriculture, Forest Service, Pacific Southwest Research Station 191: 533–536.

Carr, W.W., A.E. Brotherston, and A.I. Moody. 1993. BC Hydro Upper Arrow dust control program, revegetation and special studies: program summary and recommendations 1990–1993.

Chase, M.K. and G.R. Guepel. 2005. The use of avian focal species for conservation planning in California. USDA Forest Service General Technical Report PSW-GTR-191. 2005:130–142.

COSEWIC. 2012. COSEWIC assessment and status report on the Western Toad *Anaxyrus boreas* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xiv + 71 pp.

COSEWIC. 2013. COSEWIC assessment and status report on the Little Brown Myotis *lucifugus*, Northern Myotis *septentrionalis* and Tri-colored Bat *Perimyotis subflavus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xxiv + 93 pp.

DeSante, D.F. and G.R. Geupel. 1987. Landbird productivity in central coastal California: the relationship to annual rainfall, and a reproductive failure in 1986. Condor: 636–653.

Enns, K., and J. Overholt. 2013. CLBMON-12 Arrow Lakes Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis: 2013 Final Report. Addendum: REV5. Unpublished report by Delphinium Holdings Inc. for BC Hydro Generation, Water Licence Requirements, Castlegar, BC.

Environment and Climate Change Canada. 2016. Management Plan for the Western Toad (*Anaxyrus boreas*) in Canada [Proposed]. Species at Risk Act Management Plan Series. Environment and Climate Change Canada, Ottawa. iv + 38 pp.

Feinsinger, P. 2001. Designing field studies for biodiversity conservation. Island Press, Washington, D.C.

Garcia, P.F.J., S.A. Rasheed and S.L. Holroyd. 1995. Status of the western small-footed myotis in British Columbia. Wildlife working report; no. WR-74. 14 pp.

Hammerson, G., G. Santos-Barrera, and E. Muths. 2004. *Anaxyrus boreas*. The IUCN Red List of Threatened Species 2004: e.T3179A9654897. https://dx.doi.org/10.2305/IUCN.UK.2004.RLTS.T3179A9654897.en. Downloaded on 13 January 2020.

Hatley, C.L. and J.A. MacMahon. 1980. Spider community organization: Seasonal variation and the role of vegetation architecture. Environmental Entomology 9(5): 632-639.

Hawkes, V.C., P. Gibeau, K.A. Enns, J. Sharkey, J. Gatten, and J. Fenneman. 2011. CLBMON-11B1. Kinbasket and Arrow Lakes Reservoirs: Wildlife Effectiveness Monitoring and Enhancement Area Identification for Lower and Mid-Arrow Lakes Reservoir. Annual Report – 2010. LGL Report EA3164A. Unpublished report by LGL Limited environmental research associates, Sidney, BC, for BC Hydro Generations, Water Licence Requirements, Burnaby, BC. 98 pp. + Appendices.

Hawkes, V.C. and J. Howard. 2012. CLBMON-11B1. Kinbasket and Arrow Lakes Reservoirs: wildlife effectiveness monitoring and enhancement area identification for lower and mid-Arrow Lakes Reservoir. wildlife enhancement prescriptions. LGL Report EA3274. Unpublished report by LGL Limited environmental research associates, Sidney, BC, for BC Hydro Generations, Water Licence Requirements, Burnaby, B.C.

Hawkes, V.C. and K. Tuttle. 2016. CLBMON-29B. Arrow Feasibility Study of High Value Habitat for Wildlife Physical Works. 2016 Update. LGL Report EA3714. Unpublished report by LGL Limited environmental research associates, Sidney, B.C., for B.C. Hydro Generation, Water Licence Requirements, Burnaby, BC. 86 pp. + Appendices.

Hawkes, V.C., K.N. Tuttle, J.M. McAllister, and K.J. Meyers. 2020. CLBMON-37. Kinbasket and Arrow Lakes Reservoirs: Amphibian and Reptile Life History and Habitat Use Assessment. Draft Report 2008–2018. LGL Report EA3533F. 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, B.C. 67 pp. + Appendices.

Hawkes, V.C., J. Sharkey, N. Hentze, C. Wood, J. Gatten, and A. Solomon. 2018b. CLBMON-11B1. Kinbasket and Arrow Lakes Reservoirs: Wildlife Effectiveness Monitoring and Enhancement Area Identification for Lower and Mid-Arrow Lakes Reservoir. Annual Report – 2016. LGL Report EA3450. 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. 76 pp. + Appendices.

Hawkes, V.C., J. Sharkey, N. Hentze, J. Gatten, and P. Gibeau. 2014. CLBMON-11B1. Kinbasket and Arrow Lakes Reservoirs: Wildlife Effectiveness Monitoring and Enhancement Area Identification for Lower and Mid-Arrow Lakes Reservoir. Annual Report – 2013. LGL Report EA3450. 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. 63 pp. + Appendices.

Hawkes, V.C., T.G. Gerwing, P. Gibeau, D. Adama and M.T. Miller. 2018a. CLBMON-35 Arrow Lakes and Kinbasket Reservoirs plant response to inundation. Revegetation prescription catalogue: Arrow Lakes Reservoir. Draft. Unpublished report by LGL Limited, Sidney, BC. For BC Hydro, Burnaby BC. 70 pp.

Hentze, N.T., R. Waytes, C.M. Wood, V.C. Hawkes, and J. Gatten. 2019. CLBMON-11B1. Kinbasket and Arrow Lakes Reservoirs: Wildlife Effectiveness Monitoring and Enhancement Area Identification for Lower and Mid-Arrow Lakes Reservoir. Annual Report – 2018. LGL Report EA3450. 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. 69 pp. + Appendices.

Humphrey, J.W., C. Hawes, A.J. Peace, R. Ferris-Kaan and M.R. Jukes. 1999. Relationships between insect diversity and habitat characteristics in plantation forests. Forest Ecology and Management 113: 11–21.

IUCN SSC Amphibian Specialist Group 2015. *Anaxyrus boreas*. The IUCN Red List of Threatened Species 2015: e.T3179A53947725. https://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T3179A53947725.en. Downloaded on 13 January 2020.

Jackson, J.L., K. Hennebury, and D. Baker. 1995. The Technical and Research Committee on Reclamation. Proceedings of the 19th Annual British Columbia Mine Reclamation Symposium in Dawson Creek, B.C. pp 75–87.

Keefer Ecological Services Ltd. 2010. CLBWORKS-2 Arrow Lakes Reservoir Revegetation Program Physical Works. Phase 2 Report – 2010. Unpublished report by Keefer Ecological Services Ltd., Cranbrook, BC, for BC Hydro Generation, Water Licence Requirements, Castlegar, BC. 76 pp. + Apps.

Keefer Ecological Services Ltd. 2011. CLBWORKS-2 Arrow Lakes Reservoir Revegetation Program Physical Works. Phase 2 Report – 2011. Unpublished report by Keefer Ecological Services Ltd., Cranbrook, BC, for BC Hydro Generation, Water Licence Requirements, Castlegar, BC. 38 pp. + Apps.

Keefer, M.E. and R.J. Moody. 2010. Arrow Lakes Reservoir Planting and Monitoring Plan for 2010 CLBWORKS-2. Unpublished report for BC Hydro.

Keefer, M.E., R. Moody, T.J. Ross, A. Chapman and J. Meuleman. 2009. CLBWORKS-2 Arrow Lakes Reservoir revegetation program physical works report (2009). Unpublished report prepared by Keefer Ecological Services for BC Hydro, Castlegar, BC.

Kerr Wood Leidal Consulting Engineers. 2017. CLBWORKS-30B: Arrow Lakes Wildlife Enhancement Program. Feasibility Design Final Report. Wildlife Enhancement Program at Burton Creek. Prepared for BC Hydro Generations, Water Licence Requirements, Burnaby, BC.

Kerr Wood Leidel. 2018. Detailed design report: wildlife enhancement program at Burton Flats. Draft Report July 2018. KWL Project No. 0478.203. 156 pp.

Klimaszewski J., D. Langor, T.T. Work, J.H.E. Hammond, and K. Savard. 2008. Smaller and more numerous harvesting gaps emulate natural forest disturbances: a biological test case using rove beetles (Coleoptera, Staphylinidae). Diversity and Distributions 14: 969–982.

Machmer, M., and C. Steeger. 2002. Effectiveness monitoring guidelines for ecosystem restoration. B.C. Ministry of Environment, Victoria, B.C.

Marcot, B.G. 1998. Selecting appropriate statistical procedures and asking the right questions: a synthesis. *In* Statistical methods for adaptive management. Edited by V. Sit and B. Taylor. B.C. Ministry of Forests, Research Branch, Victoria, B.C.

McGeoch, M. A. 1998. The selection, testing, and application of terrestrial invertebrates as bioindicators. Biological Reviews of the Cambridge Philosophical Society 73, 181–201.

Miller, M.T., P. Gibeau, and V.C. Hawkes. 2018. CLBMON-12 Arrow Lakes Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis. Annual Report – 2017. LGL Report EA3545C. Unpublished report by Okanagan Nation Alliance, Westbank, BC, and LGL Limited environmental research associates, Sidney, BC, for BC Hydro Generations, Water License Requirements, Castlegar, BC. 52 pp + Appendices

Miller, M.T. and V.C. Hawkes. 2019**.** CLBWORKS-30B Arrow Lakes Reservoir Wildlife Enhancement Program. Burton Flats Planting Project (Phase 1). Draft Report – 2019. LGL Report EA3957. Unpublished report by LGL Limited environmental research associates, Sidney, BC, for BC Hydro Generation, Water Licence Requirements, Burnaby, BC. 41 pp.

Noon, B. R. 2003. Conceptual issues in monitoring ecological resources. *In:* Monitoring Ecosystems: Interdisciplinary Approaches for Evaluating Ecoregional Initiatives *Edited by* D. E. Busch, and J. C. Trexler. Island Press, Washington.

Oksanen, J., F. G. Blanchet, M. Friendly, R. Kindt, P. Legendre, D. McGlinn, P. R. Minchin, R. B. O'Hara, G. L. Simpson, P. Solymos, M. Henry, H. Stevens, E. Szoecs, and H. Wagner. 2018. vegan: Community Ecology Package. R package version 2.5-3. Available: https://CRAN.R-project.org/package=vegan

Pinzon, J. and J.R. Spence. 2010. Bark-dwelling spider assemblages (Araneae) in the boreal forest: dominance, diversity, composition and life-histories. Journal of Insect Conservation 14: 439–458.

R Core Team (2019). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Ralph, C.J., J.R. Sauer, and S. Droege. 1995. Monitoring Bird Populations by Point Counts. Gen. Tech. Rep. PSW-GTR-149. Albany, CA: US Department of Agriculture, Forest Service, Pacific Southwest Research Station. 187 pp.

Resources Inventory Committee. 1999. Inventory methods for forest and grassland of songbirds: No. 15. Standardized Inventory Methodologies for Components of British Columbia's Biodiversity. Ministry of Environment, Lands and Parks, Government of British Columbia, Victoria, British Columbia.

Rich, T.D. 2002. Using breeding land birds in the assessment of western riparian systems. Wildlife Society Bulletin: 1128–1139.

Samu, F. and G.L. Lovei. 1995. Species richness of spider community (Araneae): extrapolation from simulated increasing sampling effort. European Journal of Entomology 92: 633–638.

Schowalter, T.D. 2006. Insect Ecology: an ecosystem approach, second edition. Cambridge, Massachusetts: Elsevier Inc. Academic Press.

Sharkey, J., C. Wood, V.C. Hawkes, N. Hentze, and J. Gatten. 2018. CLBMON-11B1. Kinbasket and Arrow Lakes Reservoirs: Wildlife Effectiveness Monitoring and Enhancement Area Identification for Lower and Mid-Arrow Lakes Reservoir. Annual Report – 2015. LGL Report EA3450. 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. 60 pp. + Appendices.

Söderström, B.O., B. Svensson, K. Vessby, and A. Glimskär. 2001. Plants, insects and birds in semi-natural pastures in relation to local habitat and landscape factors. Biodiversity and Conservation 10(11): 1839–1863.

Szewczak, J.M., Corcoran, A.J., Kennedy, J.K., Ormsbee, P.C. & Weller, T.E. 2011a. Echolocation Call Characteristics of Western US Bats. Humboldt State University Bat Lab, Arcata, California. http://www.sonobat.com/download/WesternUS_Acoustic_Table_Mar2011.pdf

Szewczak, J.M., Corcoran, A.J., Kennedy, J.K., Ormsbee, P.C. & Weller, T.E. 2011b. Echolocation Call Characteristics of Eastern US Bats. Humboldt State University Bat Lab, Arcata, California. http://www.sonobat.com/download/EasternUS_Acoustic_Table_Mar2011.pdf

Temple, S.A. and J.A. Wiens. 1989. Bird populations and environmental changes: Can birds be bio-indicators? American Birds 43(2): 260–270.

Uetz, G.W. 1991. Habitat structure and spider foraging. In: McCoy, E.D., Bell, S.S. and Mushinsky, H.R., Eds., Habitat Structure: The Physical Arrangement of Objects in Space, Chapman and Hall, London, 325-348.

Ward, D.F., T.R. New, and A.L. Yen. 2001. Effects of pitfall trap spacing on the abundance, richness and composition of invertebrate catches. Journal of Insect Conservation 5: 47–53.

Wood, C., N. Hentze, V.C. Hawkes, and J. Gatten. 2018. CLBMON-11B1. Kinbasket and Arrow Lakes Reservoirs: Wildlife Effectiveness Monitoring and Enhancement Area Identification for Lower and Mid-Arrow Lakes Reservoir. Annual Report – 2017. LGL Report EA3450. 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. 57 pp. + Appendices.

Wood, C.M., N. Hentze, F. Papini, R. Waytes, and V.C. Hawkes. 2019. CLBMON-11A. Kinbasket and Arrow Lakes Reservoirs: Wildlife Effectiveness Monitoring of Revegetation Efforts and Physical Works Trials in Kinbasket Reservoir. Final Report – 2018. LGL Report EA3451F. 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, B.C. 35 pp. + Appendices.

Work, T., M. Koviula, J. Klimaszewski, D. Langor, J.R. Spence, J. Sweeney, and C. Hébert. 2008. Evaluation of carabid beetles as indicators of forest change in Canada. Canadian Entomologist 393: 393-414.

Work, T.T., J. Klimaszewksi, E. Thiffault, C. Bourdon, D. Paré, Y. Bousquet, L. Venier, and B. Titus. 2013. Initial responses of rove and ground beetles (Coleoptera, Staphylinidae, Carabidae) to removal of logging residues following clearcut harvesting in the boreal forest of Quebec, Canada. ZooKeys 258: 31–52.

Ziesche, T.M. and M. Roth. 2008. Influence of environmental parameters on small-scale distribution of soil-dwelling spiders in forests: What makes the difference, tree species or microhabitat? Forest Ecology and Management 255: 738-752.

9.0 APPENDICES

Appendix A: Maps of arthropod sampling locations for 2019

Map 1: Distribution of pitfall traps at East Arrow Park

Map 2: **Distribution of Malaise and pitfall traps at Burton Creek**

Map 3: **Distribution of pitfall traps at Lower Inonoaklin**

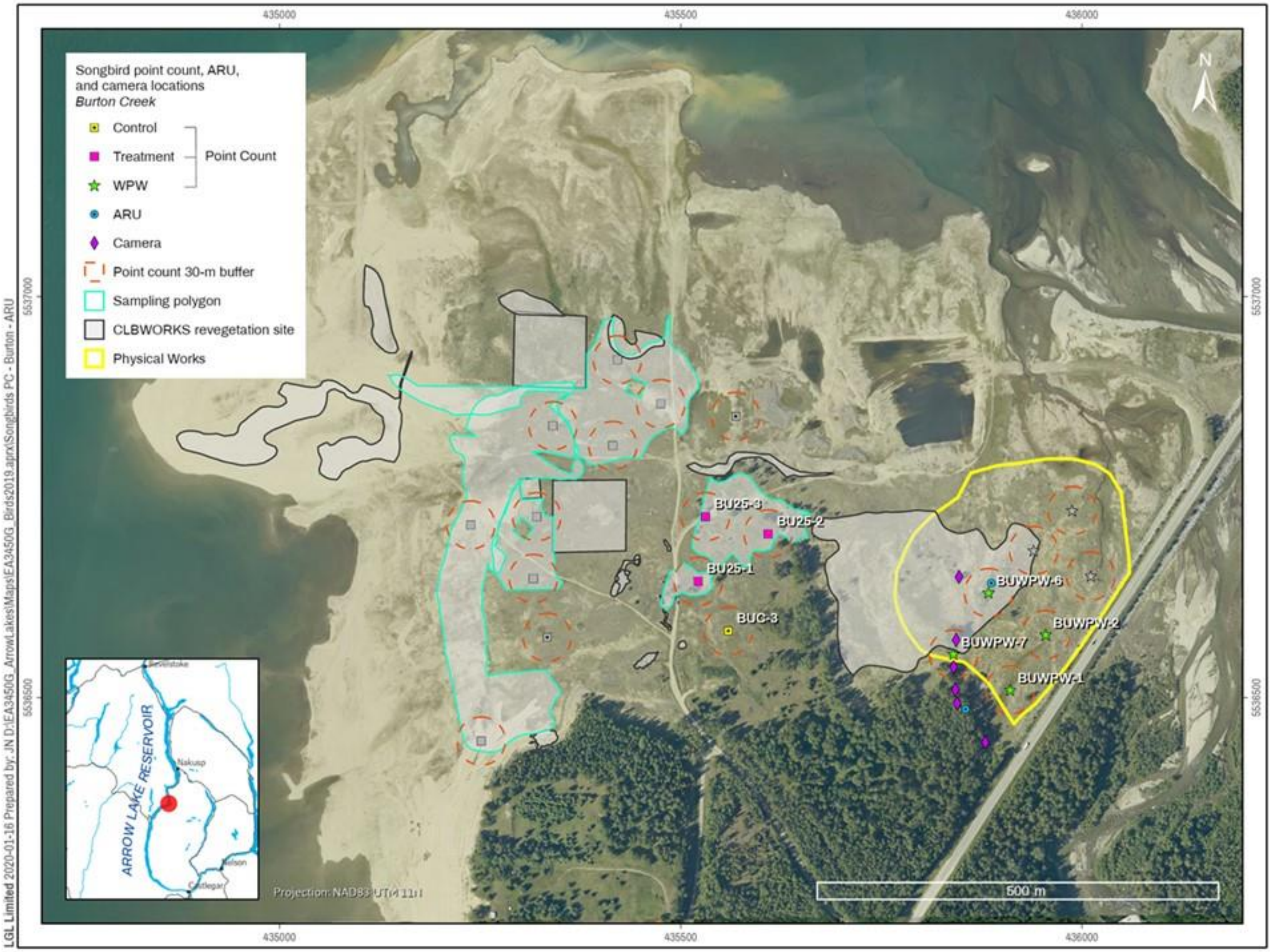
Map 4: **Distribution of pitfall traps at Edgewood North**

Map 5: **Distribution of pitfall traps at Edgewood South**

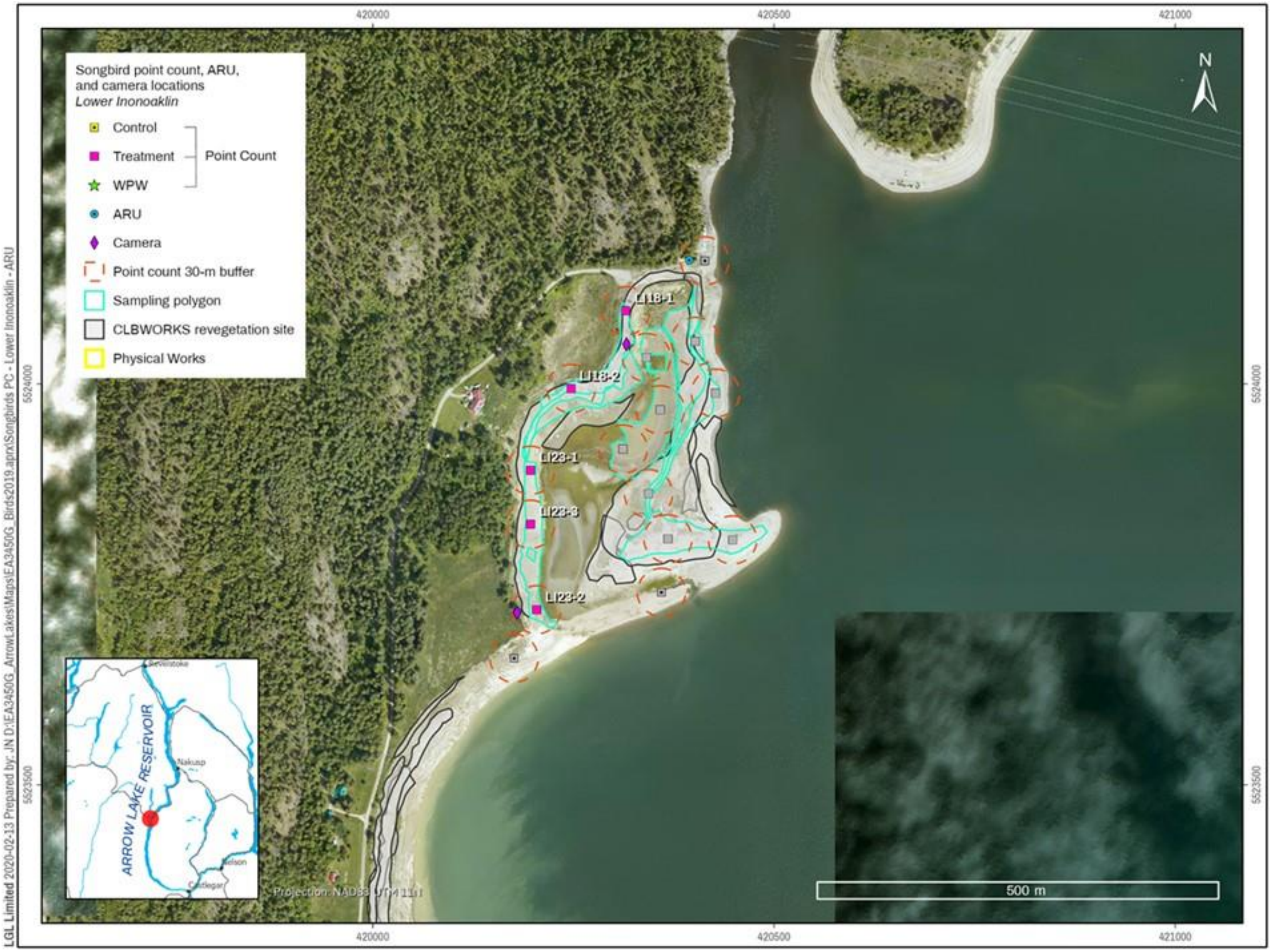
Appendix B: Dates of trap setup and collection for arthropod sampling in 2019. M = Malaise trap, P= pitfall trap array. Empty cells indicate that no collection was made (due to high reservoir elevation).

Site	Polygon ID	Trap	Collection 1	Collection 2
Burton	2009_64	P1,P2,P3	17 to 20 May 2019	3 to 4 June 2019
Creek	2009_65	P1,P2,P3	17 to 20 May 2019	
	2011_20	P1,P2,P3	17 to 20 May 2019	
	2010_2	P1,P2,P3	17 to 20 May 2019	3 to 4 June 2019
	2009_5	P1,P2,P3	17 to 19 May 2019	
	2010_9	P1,P2,P3	17 to 20 May 2019	
	2009_25	P1,P2,P3	17 to 20 May 2019	3 to 6 June 2019
	2009_26	P1,P2,P3	17 to 20 May 2019	3 to 6 June 2019
	Control 1	P1	17 to 20 May 2019	3 to 4 June 2019
		P2,P3	17 to 20 May 2019	3 to 6 June 2019
	Control 2	P4,P5	17 to 20 May 2019	3 to 6 June 2019
		P6	17 to 20 May 2019	
	WPW	P1-P5,M1,M2	17 to 20 May 2019	3 to 6 June 2019
Lower	2009_17	P1,P2,P3	22 to 25 May 2019	
Inonoaklin	2009_19	P1,P2,P3	22 to 25 May 2019	
	2011_23	P1,P2,P3	22 to 25 May 2019	
	2011_24	P1,P2,P3	22 to 25 May 2019	
	2009_14	P1,P2	22 to 24 May 2019	
		P3	22 to 25 May 2019	
	2009_13	P1,P2,P3	22 to 25 May 2019	
	2009_18	P1,P2,P3	22 to 25 May 2019	7-10 June 2019
	Control	P1,P2,P3	22 to 25 May 2019	7-10 June 2019
Edgewood	2009_1	P1	23 to 26 May 2019	7-10 June 2019
South		P2,P3	23 to 26 May 2019	8-10 June 2019
	2009_2	P1,P2	23 to 26 May 2019	
		P3	23 to 25 May 2019	
	2009_3	P1	23 to 25 May 2019	7-10 June 2019
		P2,P3	23 to 26 May 2019	7-10 June 2019
	Control	P1,P2,P3	23 to 26 May 2019	7-10 June 2019
Edgewood	2009_7		23 to 26 May 2019	
North	2009_9		23 to 26 May 2019	
	2011_31	P1,P2,P3	23 to 26 May 2019	7-10 June 2019
	Control	P1,P2,P3	23 to 26 May 2019	7-10 June 2019
East Arrow	2009_41	P1,P2	18 to 21 May 2019	4 to 5 June 2019
Park		P3	18 to 21 May 2019	
	2009_43		18 to 21 May 2019	
	2009_49		18 to 21 May 2019	4 to 7 June 2019
	2009_48	P1,P3	18 to 21 May 2019	4 to 5 June 2019
		P2	18 to 21 May 2019	4 to 6 June 2019
	2010_24	P1	18 to 21 May 2019	4 to 5 June 2019
		P2,P3	18 to 21 May 2019	4 to 6 June 2019
	2009_58		18 to 21 May 2019	
	2009_47	P2	18 to 21 May 2019	4 to 5 June 2019
		P1,P3	18 to 21 May 2019	4 to 7 June 2019
	2009_54		18 to 21 May 2019	3 to 6 June 2019
	Control 1	P2,P3	18 to 21 May 2019	4 to 7 June 2019
		P3	18 to 21 May 2019	4 to 6 June 2019
	Control 2	P4,P5,P6	18 to 21 May 2019	3 to 6 June 2019

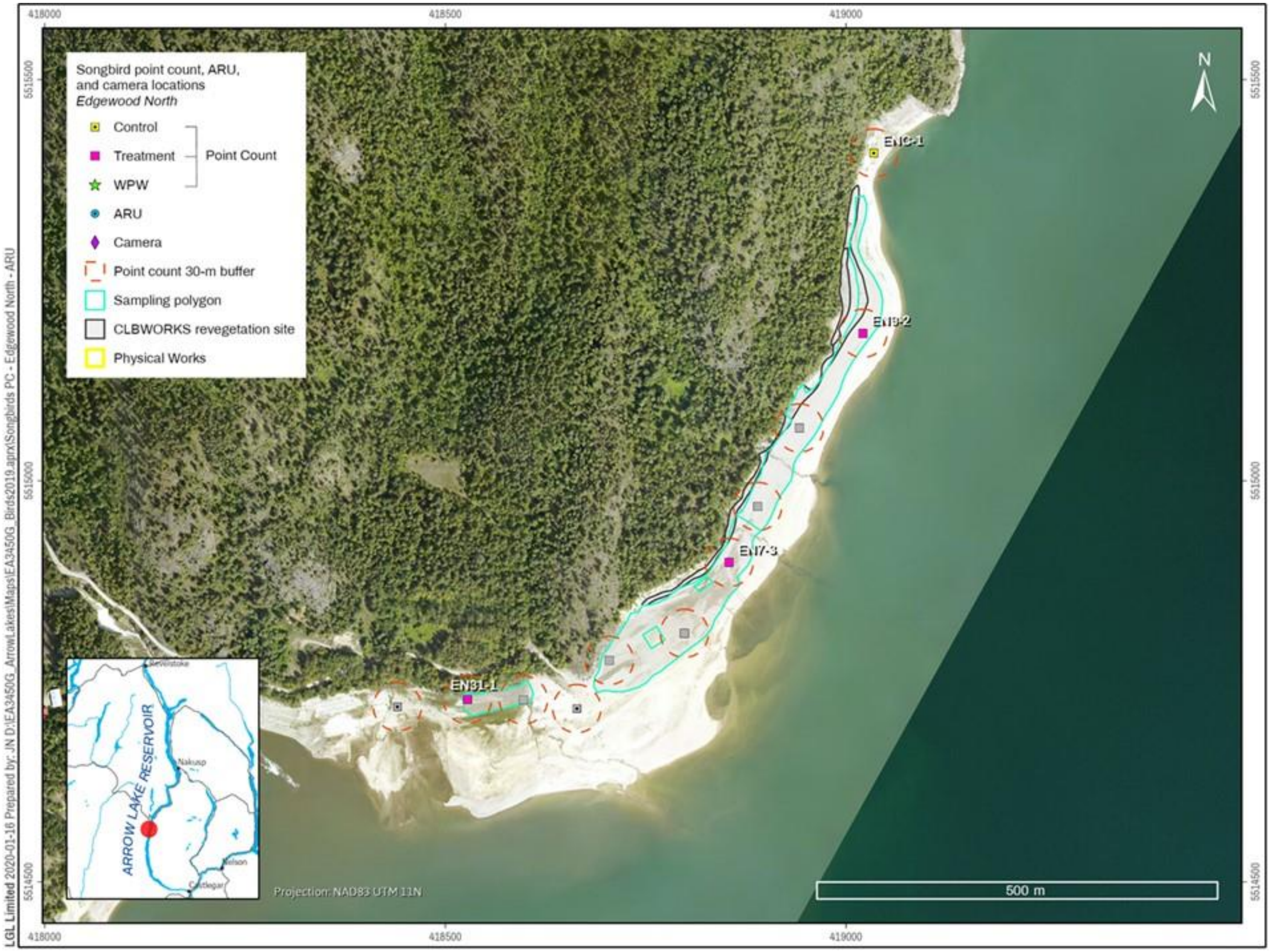
Appendix C: Maps of songbird point count and bat autonomous recording unit stations for 2019.



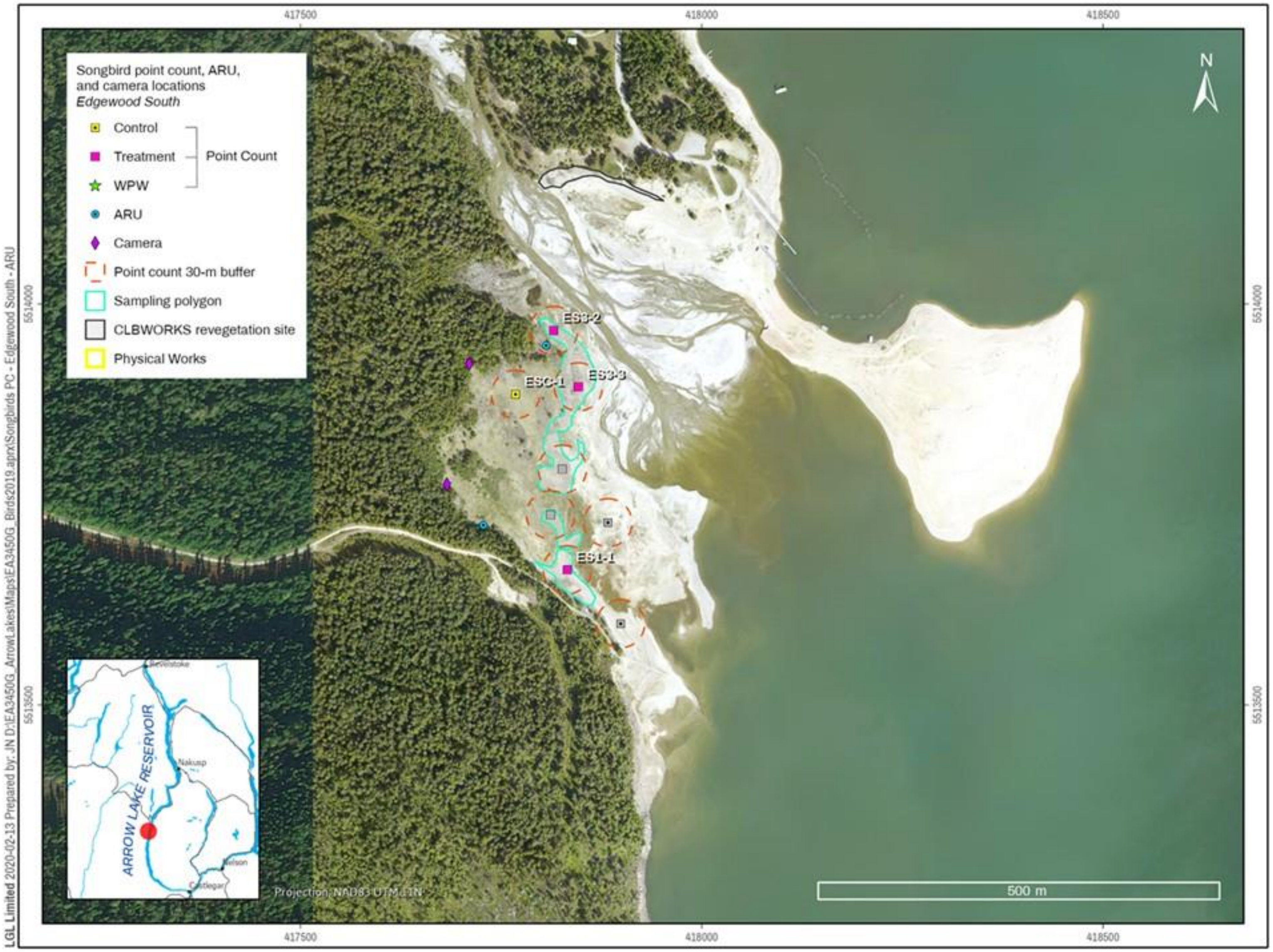
Map 6: **Distribution of songbird point count stations, wildlife cameras, and bat autonomous recording units at Burton Creek in 2019. Only those point count stations labelled were accessible in 2019.**



Map 7: **Distribution of songbird point count stations, wildlife cameras, and bat autonomous recording units at Lower Inonoaklin in 2019. Only those point count stations labelled were accessible in 2019.**



Map 8: **Distribution of songbird point count stations at Edgewood North in 2019. Only those point count stations labelled were accessible in 2019.**



Map 9: **Distribution of songbird point count stations, wildlife cameras, and bat autonomous recording units at Edgewood South in 2019. Only those point count stations labelled were accessible in 2019.**

Appendix D: Monitoring of bat species and activity across Arrow Lakes Reservoir in 2019.

Background

In British Columbia there are 15 known bat species, with an additional two species reported as accidental occurrences (e.g., outside of the normal range). Twelve of these species are thought to potentially occur in the West Kootenays (Table 9-1). Live-capture studies have confirmed the presence of all those species except Western Small-footed Myotis (*Myotis ciliolabrum*). Five of these twelve species are of conservation concern at the provincial and/or national level. While bats are not able to be used for detecting differences on the spatial scale of the CLBWORKS-2 revegetation polygons, we select bats for monitoring across the reservoir drawdown zone and non-drawdown zone habitats as these data are important documentation of species at risk utilizing Arrow Lakes Reservoir. In addition, these bat data may be useful for comparisons to the bat activity recorded in future years of monitoring at the Burton Creek wildlife physical works site.

Townsend's Big-eared Bat (*Corynorhinus townsendii*), Western Small-footed Myotis, Northern Myotis (*M. septentrionalis*), and Fringed Myotis (*M. thysanodes*) are blue-listed by the Conservation Data Centre (CDC), which is a status assigned to species that are particularly sensitive to impacts from human activities or natural events (BC CDC 2019). Federally, Northern Myotis and Little Brown Myotis (*M. lucifugus*) were emergency listed under the Species at Risk Act as Endangered (Dec. 17, 2014) due to the potential threat of White Nose Syndrome, a fungus caused by *Pseudogymnoascus destructans* that has been spreading westward since it was first documented in North America (COSEWIC 2013). Fringed Myotis is considered Data Deficient by COSEWIC, meaning there is not enough scientific information available to support status designation.

Table 9-1. Provincial and national status of bat species potentially occurring in the Lower and Mid-Arrow Lakes area

Common Name	Scientific Name	Code	Present	CDC Status	COSEWIC Status	SARA
Townsend's Big-eared Bat	*Corynorhinus townsendii*	COTO	Yes	Blue		
Big Brown Bat	*Eptesicus fuscus*	EPFU	Yes	Yellow		
Hoary Bat	*Lasiurus cinereus*	LACI	Yes	Yellow		
Silver-haired Bat	*Lasionycteris noctivagans*	LANO	Yes	Yellow		
California Myotis	*Myotis californicus*	MYCA	Yes	Yellow		
Western Small-footed Myotis	*Myotis ciliolabrum*	MYCI	Unverified	Blue		
Long-eared Myotis	*Myotis evotis*	MYEV	Yes	Yellow		
Little Brown Myotis	*Myotis lucifugus*	MYLU	Yes	Yellow	Endangered	1-E (2014)
Northern Myotis	*Myotis septentrionalis*	MYSE	Yes	Blue	Endangered	1-E (2014)
Fringed Myotis	*Myotis thysanodes*	MYTH	Yes	Blue	Data Deficient	3 (2005)
Long-legged Myotis	*Myotis volans*	MYVO	Yes	Yellow		
Yuma Myotis	*Myotis yumanensis*	MYYU	Yes	Yellow		

Methods

To study bat presence and distribution over and adjacent to the drawdown zone, Wildlife Acoustics Song Meter autonomous recording units (SM2BAT+ and SM3BAT) were deployed from May 17th to September 9th in 2019. Each unit was programmed with a schedule to document bats during two periods: i) half an hour before sunset for 5.5 hours, and ii) an hour before sunrise for 1.5 hours, for a total of 7 hours per 24-hour period.

A total of 6 bat detectors were deployed in the Lower and Mid-Arrow Lakes region from three sites: Burton Creek pre-WPW (n=2), Lower Inonoaklin (n=2), and Edgewood South (n=2). Based on the mobility of foraging bats, and the limited extent of revegetation treatments, we were unable to deploy bat detectors in a way that explicitly tests Treatment vs. Control areas.

Under ideal conditions, Wildlife Acoustics Song Meter detectors will sample bats in an airspace of 30 to 100 m from the microphone, with bats emitting higher frequencies (e.g., *Myotis septentrionalis*) detected more often in the 30 m zone and bats emitting lower frequencies (e.g., *Lasionycteris noctivagans* and *Lasiurus cinereus*) detected up to ~100 m from the microphone. The microphone paired with a Song Meter unit is omnidirectional, meaning that it will sample from almost all directions projecting out from the microphone. The microphones were set approximately 2 m above ground or higher, attached to either extendable aluminum poles or tree branches, and the pitch of the microphone was set at approximately 90° (horizontal).

Analysis

The same analysis methods as outlined in Section 0 were employed for bat recordings from drawdown zone locations. The only difference was the inclusion of an additional bat species classifier at one study site. Western Small-footed Myotis, which appears to be limited to dry, low elevation valleys in the interior of British Columbia (Garcia *et al.* 1995), was recommended for inclusion solely at Edgewood South (C. Lausen, PhD, Birchdale Ecological, pers. comm.). Bat frequencies are provided in Table 9-2. We present our bat detections as “indicative” rather than definitive.

Table 9-2. Typical frequencies (kHz) of calls from bat species expected to occur in habitats associated with the drawdown zone of the Lower and Mid-Arrow Lakes Reservoir

Species	Frequency (kHz)		
	Characteristic (f_c)	Highest Apparent (Hi f)	Lowest Apparent (Lo f)
Corynorhinus townsendii	21 - 26	40 - 45	19 - 23
Eptesicus fuscus	27 - 30	50 - 63	26 - 29
Lasiurus cinereus	18 - 22	21 - 31	18 - 22
Lasionycteris noctivagans	26 - 27	33 - 50	24 - 27
Myotis californicus	47 - 51	89 - 111	43 - 47
Myotis ciliolabrum	42 - 46	86 - 104	39 - 42
Myotis evotis	33 - 36	64 - 93	26 - 31
Myotis lucifugus	39 - 42	63 - 86	36 - 40
Myotis septentrionalis	40 - 47	95 - 114	32 - 42
Myotis thysanodes	23 - 26	57 - 88	17 - 22
Myotis volans	39 - 44	78 - 101	34 - 40
Myotis yumanensis	47 - 52	77 - 103	44 - 47

Bat species richness was summarized for each site. Similarly, the relative proportions of detections for each species were calculated and compared across sites. Data collected by autonomous recording devices do not provide an indication of the number of individual bats present in each area and the assignment of species is based on a probability that the species is present.

Results

The six bat detectors deployed in Lower and Mid-Arrow Lakes were operational for a combined total of 2,961 hours. A total of 97,479 bat calls were recorded, and 67,472 (60.6%) files were assigned to a species using the Kaleidoscope Pro software. All 12 bat species that are expected to occur in the study area were documented. The distribution of species detections is given in Table 9-3.

Little Brown Myotis (MYOLUC) was detected 32,835 times, making it the most frequently recorded species overall. Yuma Myotis (MYOYUM) was the next most commonly recorded species with 7,583 assigned detections. It was also the only species to have more associated recordings than MYOLUC at detector LI1. Of the larger bat species, Silver-haired Bat (LASNOC) had the highest number of detections (11,559), followed by Hoary Bat (LASCIN, 2,235). Townsend's Big-eared Bat (CORTOW) and Fringed Myotis (MYOTHY) were the most infrequently detected species with only 16 and 3 total detections, respectively.

Table 9-3. Recordings per detector-hour for bat detectors deployed in the Arrow Lakes Reservoir, summer 2019. Two detectors each were in the Burton Creek WPW area (BUWPW), Edgewood South (ES), and Lower Inonoaklin (LI). Richness refers to the total number of species detected. "-" indicates a species was omitted from analysis for the site based on low probability of occurrence. The most detected species at each detector is highlighted in light green. Species codes are provided in Table 9-1.

Species	BUWPW1	BUWPW2	ES1	ES2	LI1	LI2
CORTOW	0.00	0.01	0.01	0.00	0.00	0.00
EPTFUS	0.01	0.09	0.59	0.91	3.23	0.11
LASCIN	0.10	0.45	3.85	1.58	0.43	0.26
LASNOC	0.78	1.34	5.22	4.94	25.34	2.71
MYOCAL	0.64	4.79	6.29	2.16	5.01	2.59
MYOEVO	0.01	0.26	0.04	0.05	0.17	0.16
MYOLUC	4.12	11.86	10.70	18.94	13.17	16.01
MYOSEP	0.00	0.01	0.01	0.00	0.01	0.00
MYOTHY	0.00	0.00	0.00	0.00	0.00	0.00
MYOVOL	0.06	1.82	0.45	0.08	0.34	0.12
MYOYUM	0.14	0.88	0.38	0.41	26.18	1.47
MYOCIL	-	-	0.91	0.42	-	-
Richness	9	11	11	9	11	9

The number of bat recordings per detector-hour (measure of relative abundance) was highest at Lower Inonoaklin detector LI1, followed by detector ES2 at Edgewood South (Figure 9-1).

Relative abundance of species calls varied both within and across sites. All sites shared a greater prevalence of *Myotis* species compared to larger bat species (i.e., CORTOW, EPTFUS, LASCIN and LASNOC; Figure 9-1). Larger bat species combined represented on average ~28.4% of the total number of detections, ranging from 10.2% (at Burton Creek WPW) to 33% (at Lower Inonoaklin). For example, large bat species (i.e., CORTOW, EPTFUS, LASCIN and LASNOC) accounted for 39.3% of all classified bats by detector LI1, while these represented only 13.1% of recordings at neighboring detector LI2 (Figure 9-1). Species composition also varied within and across sites.

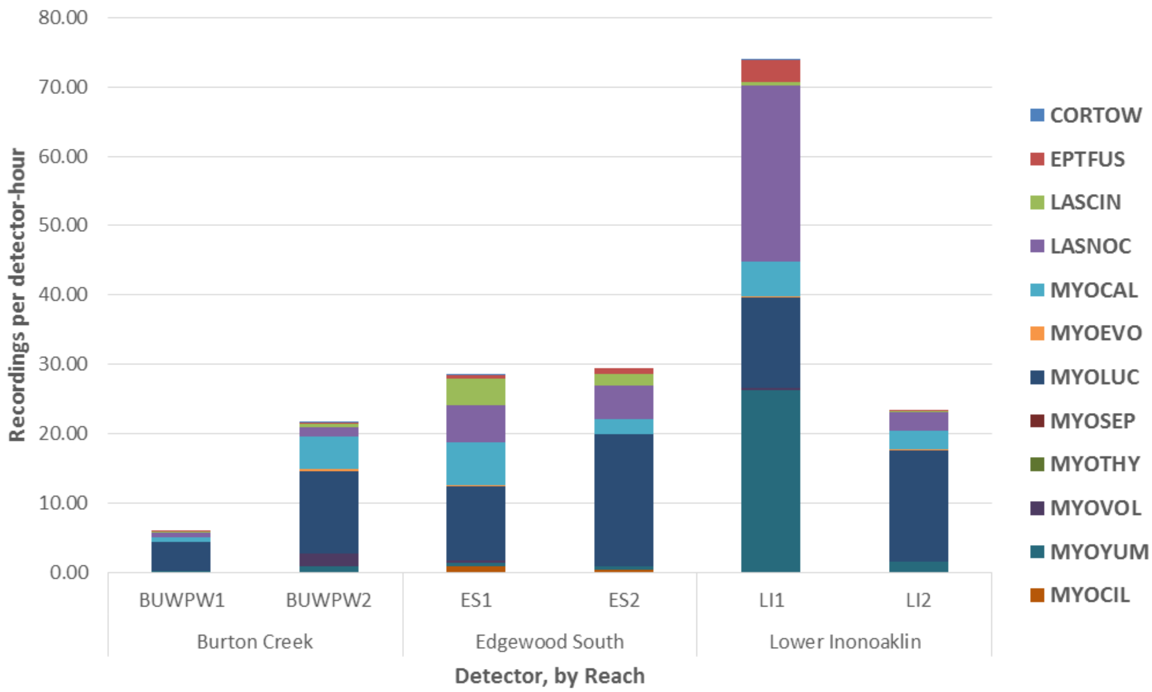


Figure 9-1. Relative abundance (recordings per detector-hour) of bat species by detector and site within Arrow Lake Reservoir, summer 2019.

Discussion

The results indicated a diverse assemblage of twelve bat species utilizing drawdown zone habitats within mid- and lower- Arrow Lakes Reservoir and are consistent with the findings of previous years (Hentze et al. 2019). The presence of species of conservation concern in this area is important to document. The federally endangered Little Brown Myotis (*M. lucifugus*) was the most detected species across all study sites. In British Columbia, this species is designated as secure (yellow), but in other areas of its range, this species has exhibited severe declines attributed in part to the spread of White-nose Syndrome (COSEWIC 2013). The federally endangered and provincially blue-listed Northern Myotis (*M. septentrionalis*) was found in low occurrence at all three sites. Likewise, the blue-listed Townsend's Big-eared Bat (*Corynorhinus townsendii*) was found in low occurrence at all three sites, while Fringed Myotis (*M. thysanodes*) was detected at Burton Creek and Lower Inonoaklin.

In addition, we found evidence of Western Small-footed Myotis (*Myotis ciliolabrum*) at Edgewood South. This species is blue-listed in British Columbia, which is the northern extent of its North American distribution. While not conclusive, these recordings suggest the potential that this site is being used by this bat species in 2019 and previous years (e.g., Hawkes et al. 2018b; Sharkey et al. 2018; Wood et al. 2018; Hentze et al. 2019).

Appendix E: Summary table of revegetation prescriptions in treatment areas sampled under CLBMON-11B1 in 2019. HPL= hand-planted live stake, EPL= excavator-planted live stake, PS= sedge plug. Transplant species prefix s= shrub, g= graminoid. Data source: CLBMON-12 (Miller et al. 2018).

Study Site	CLBWORKS-2 polygon	Area (ha)	Treatment*	Code	Transplant species
Burton	2009_25	1.22	stake	EPL/HPL	s-Black cottonwood s-Willow
	2009_26	0.15	stake	EPL	s-Black cottonwood s-Willow
	2009_5	1.30	graminoid	PS	g-Columbia sedge g-Water sedge g-Kellogg's sedge g-Wool-grass
	2009_64	2.34	graminoid	PS	g-Columbia sedge g-Water sedge g-Kellogg's sedge g-Wool-grass
	2009_65	0.74	graminoid	PS	g-Columbia sedge g-Water sedge g-Kellogg's sedge g-Wool-grass
	2010_2	1.76	graminoid	PS	g-Columbia sedge g-Kellogg's sedge
	2010_9		graminoid	PS	g-Columbia sedge g-Kellogg's sedge
	2011_20	3.83	graminoid	PS	g-Kellogg's sedge
East Arrow Park	2009_41	0.74	graminoid	PS	g-Columbia sedge
	2009_43	2.12	graminoid	PS	g-Kellogg's sedge
	2009_47	0.28	stake	HPL	s-Red-osier dogwood s-Black cottonwood s-Willow
	2009_48	1.31	graminoid	PS	g-Columbia sedge g-Kellogg's sedge
	2009_49	1.80	graminoid	PS	g-Columbia sedge g-Kellogg's sedge
	2009_54	0.21	stake	HPL	s-Red-osier dogwood s-Black cottonwood s-Willow
	2009_58	0.56	graminoid	PS	g-Columbia sedge g-Kellogg's sedge
	2010_24	0.41	graminoid	PS	g-Columbia sedge g-Kellogg's sedge
Edgewood North	2009_7	1.45	graminoid	PS	g-Columbia sedge g-Kellogg's sedge g-Water sedge g-Wool-grass
	2009_9	1.27	graminoid	PS	g-Columbia sedge g-Kellogg's sedge g-Water sedge g-Small-flowered bulrush
	2011_31	0.21	graminoid	PS	g-Wool-grass g-Kellogg's sedge g-Water sedge s-Red-osier dogwood
Edgewood South	2009_1	0.18	stake	EPL	s-Black cottonwood s-Willow
	2009_2	0.09	stake	EPL	s-Black cottonwood s-Willow
	2009_3	0.65	stake	EPL	s-Black cottonwood s-Willow
Lower Inonoaklin	2009_13	0.54	stake	EPL	s-Black cottonwood s-Willow g-Columbia sedge
	2009_14	0.18	graminoid	PS	g-Columbia sedge g-Kellogg's sedge g-Water sedge g-Small-flowered bulrush g-Wool-grass
	2009_17	0.72	graminoid	PS	g-Kellogg's sedge g-Wool-grass
	2009_18	0.39	stake	EPL	s-Black cottonwood s-Willow
	2009_19	0.43	graminoid	PS	g-Columbia sedge
	2011_23	0.72	graminoid	PS	g-Kellogg's sedge
	2011_24	0.72	graminoid	PS	g-Water sedge g-Wool-grass

*treatment category was assigned based on the dominant treatment prescription for each polygon

Appendix F: Spider and ground beetle species identified in 2019 diversity pitfall trap samples. Species listed with corresponding species codes. Presence (P) of each species is given for revegetation treatment (graminoid and stake), control, and Wildlife Physical Works (WPW pre-treatment) polygons.

Family	Species	Code	Control	Treatment	WPW
Order: Araneae (Spiders)					
Amaurobiidae	*Callobius enus*	*Call.enus*	P		
Clubionidae	*Clubiona lutescens*	*Club.lute*		P	
	Clubiona riparia	*Club.ripa*		P	P
Gnaphosidae	*Callilepis pluto*	*Call.plut*	P	P	
	Drassyllus depressus	*Dras.depr*		P	
	Gnaphosa muscorum	*Gnap.musc*	P	P	
	Gnaphosa parvula	*Gnap.parv*	P	P	P
	Micaria pulicaria	*Mica.puli*	P		
	Micaria rossica	*Mica.ross*		P	P
	Zelotes fratris	*Zelo.frat*	P	P	
	Zelotes puritanus	*Zelo.puri*	P	P	
Hahniidae	*Neoantistea agilis*	*Neoa.agil*	P	P	
	Neoantistea magna	*Neoa.magn*	P	P	
Linyphiidae	*Bathyphantes brevipes*	*Bath.brev*			P
	Collinsia ksenia	*Coll.ksen*		P	
	Erigone aletris	*Erig.alet*		P	
	Erigone blaesa	*Erig.blae*		P	
	Erigone cristatopalpus	*Erig.cris*	P	P	
	Erigone dentosa	*Erig.dent*	P	P	
	Grammonota gentilis	*Gram.gent*		P	
	Mermessus trilobatus	*Merm.tril*		P	
	Tachygyna vancouverana	*Tach.vanc*		P	
Lycosidae	*Pardosa altamontis*	*Pard.alta*	P	P	P
	Pardosa fuscula	*Pard.fusc*	P	P	P
	Pardosa groenlandica	*Pard.groe*	P	P	
	Pardosa moesta	*Pard.moes*	P	P	P
	Pardosa wyuta	*Pard.wyut*	P	P	
	Pardosa xerampelina	*Pard.xera*	P	P	P
	Pirata piraticus	*Pira.pira*		P	P
	Trochosa ruricola	*Troc.ruri*		P	
	Trochosa terricola	*Troc.terr*	P		P
Salticidae	*Eris militaris*	*Eris.mili*		P	
	Pellenes lapponicus	*Pell.lapp*		P	
Tetragnathidae	*Tetragnatha laboriosa*	*Tetr.labo*	P		
Thomisidae	*Xysticus ferox*	*Xyst.fero*	P		

Family	Species	Code	Control	Treatment	WPW
Order: Coleoptera (Beetles)					
Carabidae	*Agonum affine*	*Agon.affi*		P	
	Agonum corvus	*Agon.corv*	P	P	P
	Agonum cupripenne	*Agon.cupr*	P	P	
	Agonum gratiosum	*Agon.grat*		P	
	Agonum muelleri	*Agon.muel*	P	P	
	Agonum sordens	*Agon.sord*	P		
	Agonum suturale	*Agon.sutu*	P	P	
	Amara familiaris	*Amar.fami*	P		
	Anisodactylus binotatus	*Anis.bino*	P	P	
	Bembidion bimaculatum	*Bemb.bima*	P	P	P
	Bembidion nigripes	*Bemb.nigr*		P	
	Bembidion patruele	*Bem.patru*		P	
	Bembidion quadrimaculatum	*Bem.qdmac*		P	
	Bembidion scopulinum	*Bem.scopu*		P	
	Bembidion transparens	*Bemb.tran*		P	
	Calathus fuscipes	*Cala.fusc*	P		
	Carabus granulatus	*Cara.gran*	P	P	P
	Chlaenius pensylvanicus	*Chla.pens*		P	
	Cicindela oregona	*Cici.oreg*	P	P	
	Elaphrus californicus	*Elap.cali*		P	
	Loricera pilicornis	*Lori.pili*	P	P	
	Microlestes curtipennis	*Micr.curt*		P	
	Nebria hudsonica	*Nebr.huds*	P	P	
	Nebria obliqua	*Nebr.obli*	P	P	
	Omophron ovale	*Omop.oval*		P	
	Opisthius richardsoni	*Opis.rich*	P	P	
	Patrobus fossifrons	*Patr.foss*	P	P	P
	Poecilus lucublandus	*Poec.lucu*		P	P
	Pterostichus adstrictus	*Pter.adst*	P	P	P
	Pterostichus melanarius	*Pter.mela*	P	P	P
	Pterostichus strenuus	*Pter.stre*		P	
	Scaphinotus angusticollis	*Scap.angu*	P	P	
	Scaphinotus marginatus	*Scap.marg*	P		

Appendix G: Number of observations of all bird species detected from all distances during songbird point count surveys in 2019. Table sorted alphabetically by species code.

Bird Code	Common Name	Scientific Name	BC Status	COSEWIC	Study Site				
					BU	LI	EN	ES	Total
ALFL	Alder Flycatcher	*Empidonax alnorum*	Yellow	.	6	1			7
AMCR	American Crow	*Corvus brachyrhynchos*	Yellow	.	4				4
AMGO	American Goldfinch	*Spinus tristis*	Yellow	.	1		1	1	3
AMRE	American Redstart	*Setophaga ruticilla*	Yellow	.	17	4	1	4	26
AMRO	American Robin	*Turdus migratorius*	Yellow	.	14	2	1		17
BAEA	Bald Eagle	*Haliaeetus leucocephalus*	Yellow	Not at Risk	4	2		2	8
BASW	Barn Swallow	*Hirundo rustica*	Blue	Threatened	7	1		1	9
BCCH	Black-capped Chickadee	*Poecile atricapillus*	Yellow	.	3		2	2	7
BEKI	Belted Kingfisher	*Megaceryle alcyon*	Yellow	.	3	2		1	6
BHCO	Brown-headed Cowbird	*Molothrus ater*	Yellow	.	4	2			6
BHGR	Black-headed Grosbeak	*Pheucticus melanocephalus*	Yellow	.			1	1	2
BLSW	Black Swift	*Cypseloides niger*	Blue	Endangered	1				1
CAFI	Cassin's Finch	*Haemorhous cassinii*	Yellow	.				1	1
CAGO	Canada Goose	*Branta canadensis*	Yellow	.	4				4
CAHU	Calliope Hummingbird	*Selasphorus calliope*	Yellow	.		2		1	3
CAVI	Cassin's Vireo	*Vireo cassinii*	Yellow	.	3				3
CBCH	Chestnut-backed Chickadee	*Poecile rufescens*	Yellow	.	2				2
CEWA	Cedar Waxwing	*Bombycilla cedrorum*	Yellow	.	13	2	1	2	18
CHSP	Chipping Sparrow	*Spizella passerina*	Yellow	.	23	3	2	4	32
COLO	Common Loon	*Gavia immer*	Yellow	Not at Risk			1	1	2
COME	Common Merganser	*Mergus merganser*	Yellow	.	3	1			4
CORA	Common Raven	*Corvus corax*	Yellow	.	3	1	1		5
COYE	Common Yellowthroat	*Geothlypis trichas*	Yellow	.	40	8	1	1	50
DEJU	Dark-eyed Junco	*Junco hyemalis*	Yellow	.	1				1
DOWO	Downy Woodpecker	*Dryobates pubescens*	Yellow	.	1				1
DUFL	Dusky Flycatcher	*Empidonax oberholseri*	Yellow	.	4		2		6
EAKI	Eastern Kingbird	*Tyrannus tyrannus*	Yellow	.	7	5			12
GCKI	Golden-crowned Kinglet	*Regulus satrapa*	Yellow	.	3				3
GRCA	Gray Catbird	*Dumetella carolinensis*	Yellow	.	9	4	1	2	16
HAFL	Hammond's Flycatcher	*Empidonax hammondii*	Yellow	.	7		1	1	9
HAWO	Hairy Woodpecker	*Dryobates villosus*	Yellow	.	1	1		1	3
HEGU	Herring Gull	*Larus argentatus*	Yellow	.				1	1
HOME	Hooded Merganser	*Lophodytes cucullatus*	Yellow	.	1				1
KILL	Killdeer	*Charadrius vociferus*	Yellow	.		1			1

Bird Code	Common Name	Scientific Name	BC Status	COSEWIC	Study Site				
					BU	LI	EN	ES	Total
LEFL	Least Flycatcher	*Empidonax minimus*	Yellow	.	1	1			2
LISP	Lincoln's Sparrow	*Melospiza lincolnii*	Yellow	.	10				10
LZBU	Lazuli Bunting	*Passerina amoena*	Yellow	.	13				13
MACW	MacGillivray's Warbler	*Geothlypis tolmiei*	Yellow	.	6	2			8
MALL	Mallard	*Anas platyrhynchos*	Yellow	.	18	1		1	20
MOBL	Mountain Bluebird	*Sialia currucoides*	Yellow	.	5				5
MODO	Mourning Dove	*Zenaida macroura*	Yellow	.	1				1
NAWA	Nashville Warbler	*Leiothlypis ruficapilla*	Yellow	.			2	3	5
NOFL	Northern Flicker	*Colaptes auratus*	Yellow	.	7				7
NOSL	Northern Shoveler	*Spatula clypeata*	Yellow	.	1				1
NOWA	Northern Waterthrush	*Parkesia noveboracensis*	Yellow	.	2				2
NRWS	Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	Yellow	.	3			1	4
OSFL	Olive-sided Flycatcher	*Contopus cooperi*	Blue	Special Concern	1				1
OSPR	Osprey	*Pandion haliaetus*	Yellow	.	2	1	2	1	6
PAWR	Pacific Wren	*Troglodytes pacificus*	Yellow	.	2		1		3
PISI	Pine Siskin	*Spinus pinus*	Yellow	.	6	2	3	2	13
PIWO	Pileated Woodpecker	*Dryocopus pileatus*	Yellow	.	2	2			4
PSFL	Pacific-slope Flycatcher	*Empidonax difficilis*	Yellow	.			2		2
RBNU	Red-breasted Nuthatch	*Sitta canadensis*	Yellow	.	4	1	3		8
REVI	Red-eyed Vireo	*Vireo olivaceus*	Yellow	.	15	2	3	3	23
RNSA	Red-naped Sapsucker	*Sphyrapicus nuchalis*	Yellow	.	1	1	1		3
RUHU	Rufous Hummingbird	*Selasphorus rufus*	Yellow	.	3	1	1	2	7
SAVS	Savannah Sparrow	*Passerculus sandwichensis*	Yellow	.	5				5
SORA	Sora	*Porzana carolina*	Yellow	.	2				2
SOSA	Solitary Sandpiper	*Tringa solitaria*	Yellow	.				1	1
SOSP	Song Sparrow	*Melospiza melodia*	Yellow	.		5		3	8
SPSA	Spotted Sandpiper	*Actitis macularius*	Yellow	.	9	5	1	5	20
SPTO	Spotted Towhee	*Pipilo maculatus*	Yellow	.		1			1
SWTH	Swainson's Thrush	*Catharus ustulatus*	Yellow	.	8			3	11
TOWA	Townsend's Warbler	*Setophaga townsendi*	Yellow	.				3	3
TRSW	Tree Swallow	*Tachycineta bicolor*	Yellow	.		1			1
TUVU	Turkey Vulture	*Cathartes aura*	Yellow	.	1			2	3
VEER	Veery	*Catharus fuscescens*	Yellow	.	3	5			8
VGSW	Violet-green Swallow	*Tachycineta thalassina*	Yellow	.	2	1		2	5
WAVI	Warbling Vireo	*Vireo gilvus*	Yellow	.	5	1	1	4	11
WEME	Western Meadowlark	*Sturnella neglecta*	Yellow	.	11				11
WETA	Western Tanager	*Piranga ludoviciana*	Yellow	.	4	2		1	7

Bird Code	Common Name	Scientific Name	BC Status	COSEWIC	Study Site				
					BU	LI	EN	ES	Total
WIFL	Willow Flycatcher	*Empidonax traillii*	Yellow	.	5	9		4	18
WISN	Wilson's Snipe	*Gallinago delicata*	Yellow	.	5				5
WWCR	White-winged Crossbill	*Loxia leucoptera*	Yellow	.			1		1
WWPE	Western Wood-Pewee	*Contopus sordidulus*	Yellow	.	7			1	8
YEWA	Yellow Warbler	*Setophaga petechia*	Yellow	.	12	4	1	6	23
YRWA	Yellow-rumped Warbler	*Setophaga coronata*	Yellow	.	11	1	5	1	18
		Totals			382	91	43	76	592

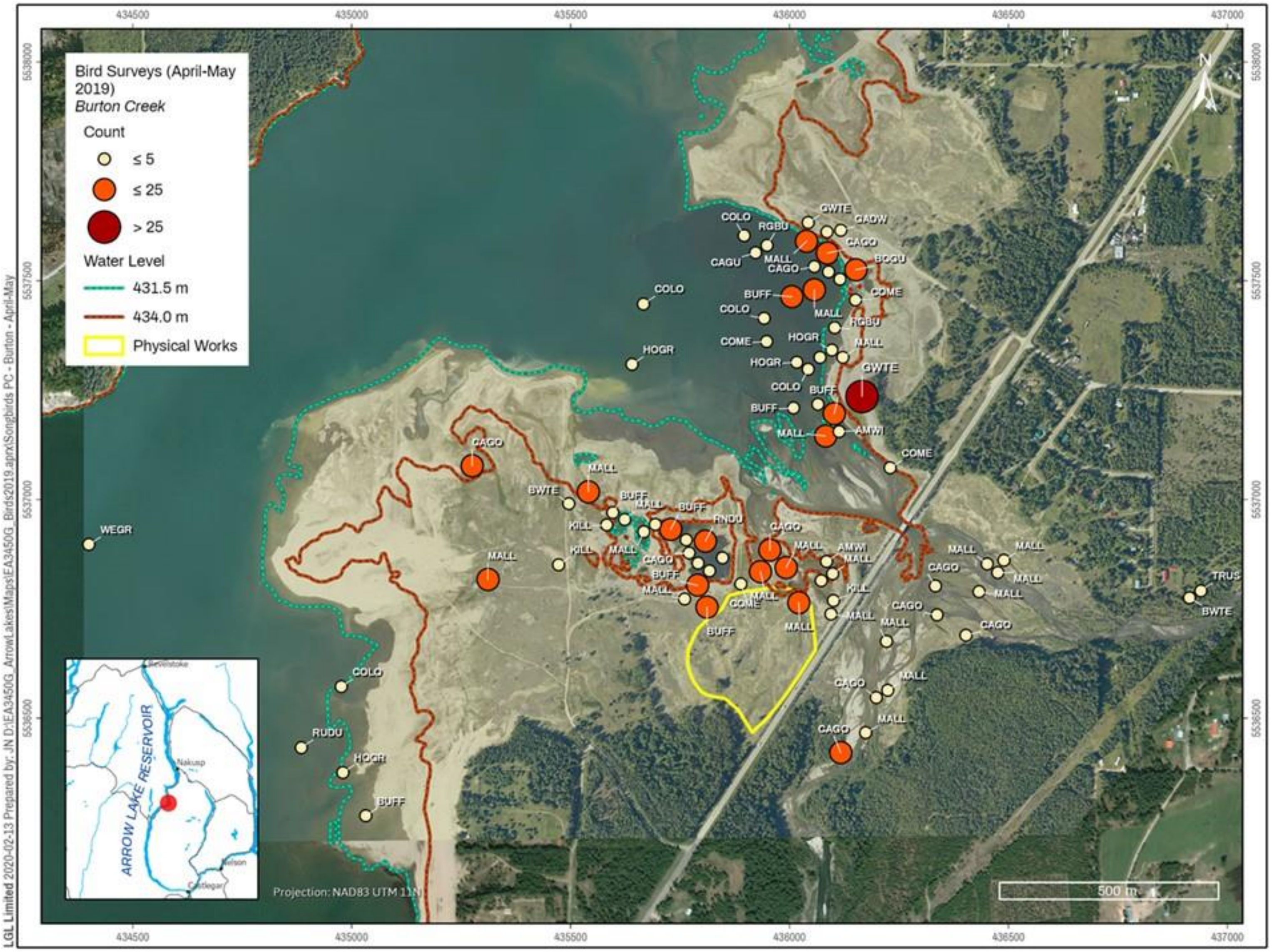
Appendix H: Bird nests located during 2019 nest surveys, including nest location and fate. Site: BU = Burton Creek; ES = Edgewood South; LI = Lower Inonoaklin.

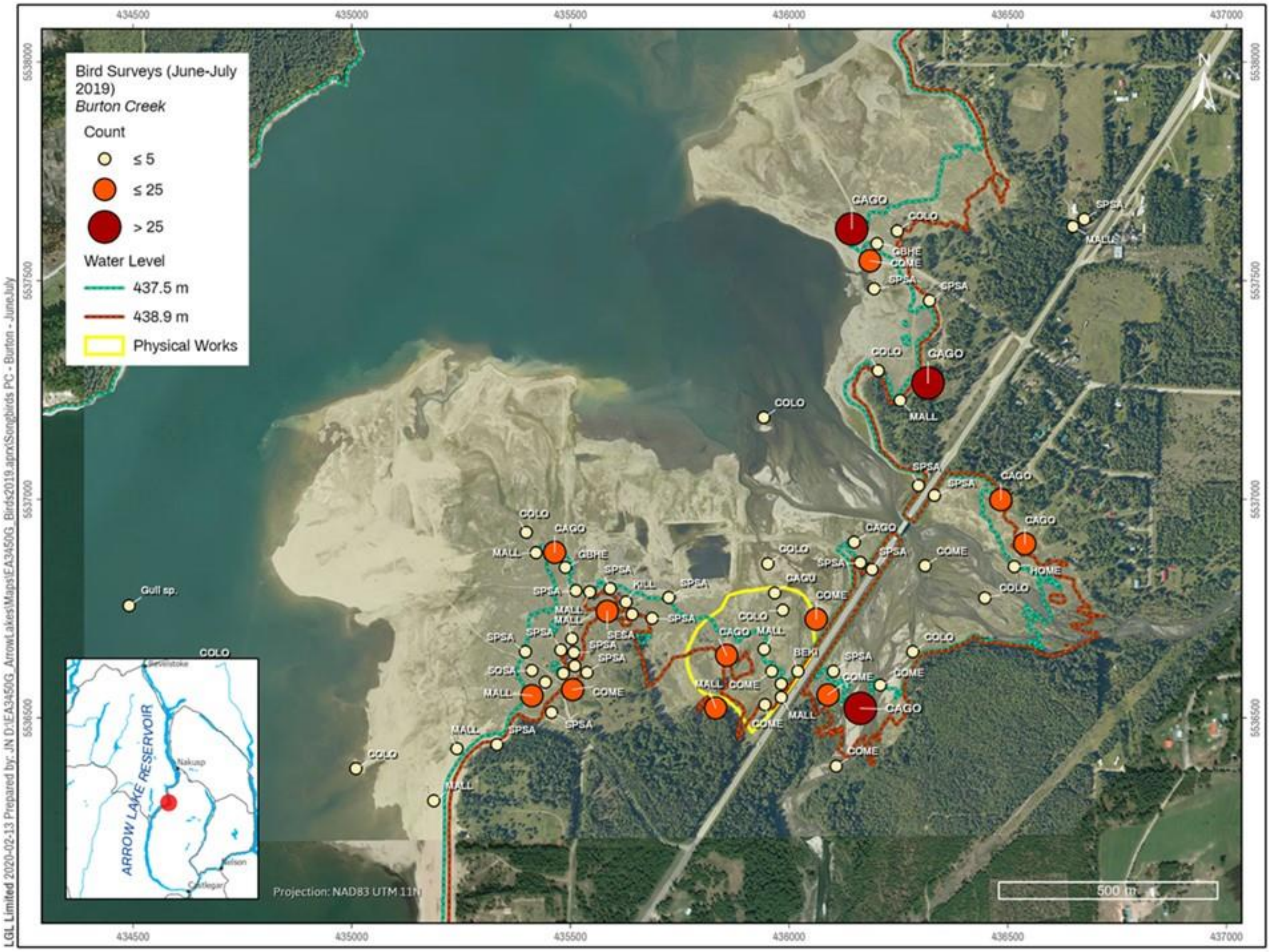
Nest	Site	Treatment	Species	No. Eggs	Substrate	Height (m)	Elevation (m)	Success/Fail
1	BU	TRT-S	American Robin	4	Tree (cottonwood)*	2.2	443	Unknown
2	BU	TRT-S	Common Yellowthroat	4	Grass	0	439	Probable Success
3	BU	Upland	Lazuli Bunting	3	Tree (deciduous)	1	442	Unknown
4	BU	TRT-S	Mallard	8	Ground	0	443	Unknown
5	BU	TRT-S	Spotted Sandpiper	4	Ground	0	443	Unknown
6	BU	TRT-S	Spotted Sandpiper	4	Ground	0	436	Unknown
7	BU	CON	Western Meadowlark	.	Grass	0	442	Unknown
8	ES	TRT-S	American Robin	.	Tree (cottonwood)*	5	430	Probable Fail
9	ES	Upland	Cedar Waxwing	4	Tree (cottonwood)	1.5	448	Unknown
10	ES	TRT-S	Chipping Sparrow	4	Tree (cottonwood)*	1.3	436	Unknown
11	ES	TRT-S	Willow Flycatcher	1	Tree (cottonwood)*	1.5	437	Probable Fail
12	LI	TRT-S	American Robin	2	Tree (cottonwood)*	1.6	439	Failed
13	LI	TRT-G	American Robin	0	Tree (cottonwood)	2.2	440	Probable Fail
14	LI	TRT-S	Cedar Waxwing	.	Tree (cottonwood)*	2	437	Probable Success
15	LI	TRT-S	Cedar Waxwing	5	Tree (cottonwood)*	0.8	441	Probable Success
16	LI	TRT-S	Gray Catbird	4	Shrub (rose)	1.1	440	Probable Success
17	LI	Upland	Willow Flycatcher	0	Shrub (rose)	2	440	Probable Fail

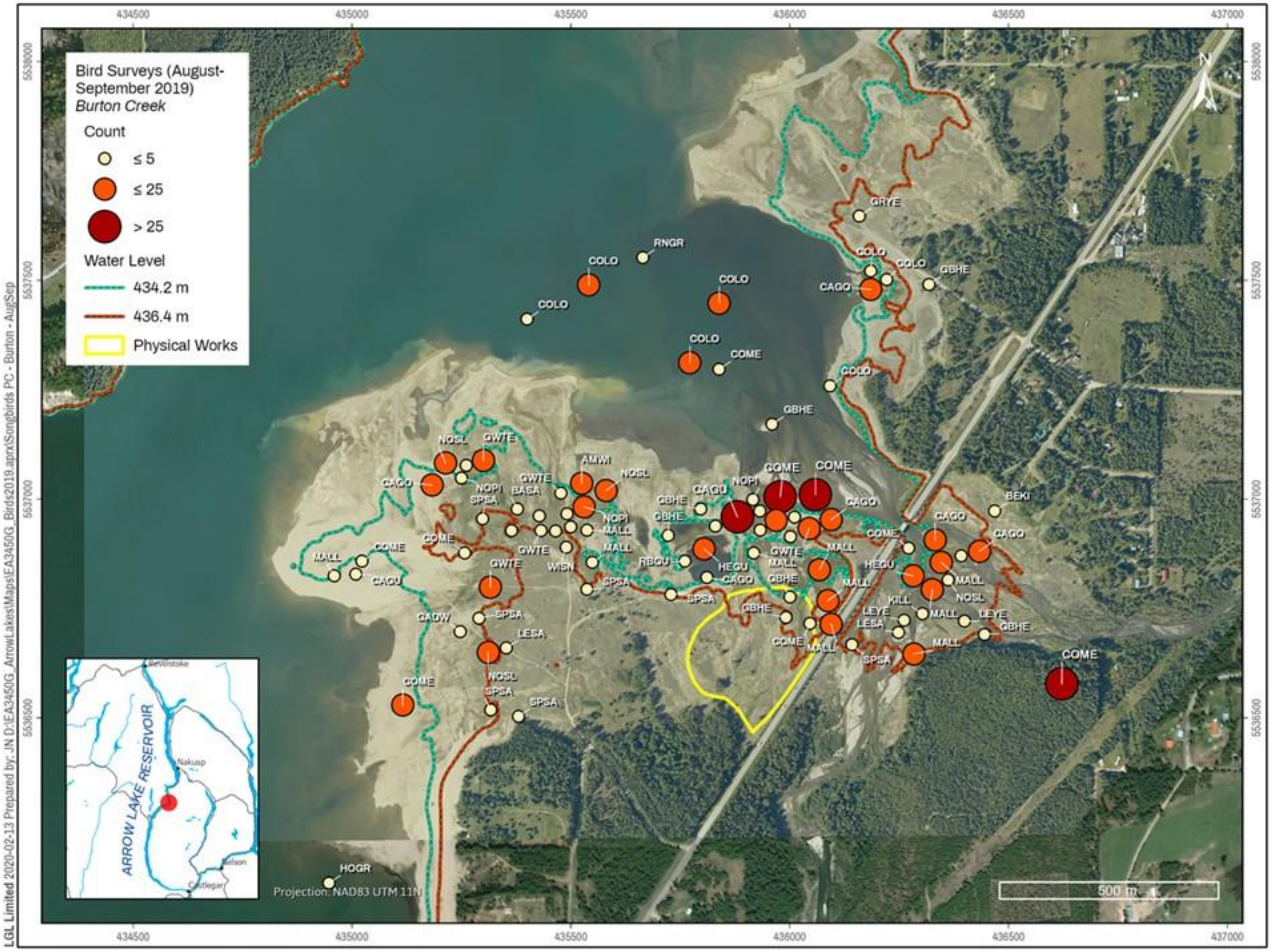
*Nest within cottonwood planted under the revegetation program.

LGL LIMITED
environmental research associates

Appendix I: Distribution of bird species using the Burton Creek wildlife physical works location (yellow polygon) and surrounding areas in April/May 2019 (first figure), June/July 2019 (second figure), and August/September 2019 (third figure).


Bird Surveys (April-May 2019)
Burton Creek
Count
≤ 5
≤ 25
> 25
Water Level
431.5 m
434.0 m
Physical Works
ARROW LAKE RESERVOIR
Revelstoke
Nakusp
Nelson
Castlegar
Projection: NAD83 UTM 11N
500 m
N
LGL Limited 2020-02-13 Prepared by: JN D:\EA3450G_ArrowLakes\Maps\EA3450G_Birds2019.aprx\Songbirds PC - Burton - April-May


Bird Surveys (June-July 2019)
Burton Creek
Count
≤ 5
≤ 25
> 25
Water Level
437.5 m
438.9 m
Physical Works
ARROW LAKE RESERVOIR
Projection: NAD83 UTM 11N
500 m
LGL Limited 2020-02-13 Prepared by: JN D:\EA3450G_ArrowLakes\Maps\EA3450G_Birds2019.aprx\Songbirds PC - Burton - JuneJuly


Bird Surveys (August-September 2019)
Burton Creek
Count
≤ 5
≤ 25
> 25
Water Level
434.2 m
436.4 m
Physical Works
ARROW LAKE RESERVOIR
Nakusp
Projection: NAD83 UTM 11N
500 m
LGL Limited 2020-02-13 Prepared by: JN

Appendix J: Surveys of odonate species across Arrow Lakes Reservoir in 2019.

Table 9-4. Odonate species collected at Arrow Lakes sites and their associated abundances. Survey time refers to the total time observers surveyed the site for dragonflies. Surveys were conducted from July 4-8 in 2019.

Site	Survey time (hr)	Species	Number of individuals
Burton Creek WPW	2.92	Boreal Bluet	1
		Tule Bluet	7
		Variegated Meadowhawk	3
Edgewood South	3.36	California Darner	1
		Chalk-fronted Corporal	1
		Darner sp.	1
		Four-spotted Skimmer	1
		Mountain Emerald	1
		Tule Bluet	3
Lower Inonoaklin	3.03	Blue-eyed Darner	2
		Eight-spotted Skimmer	2
		Four-spotted Skimmer	7
		Tule Bluet	7
		Western Forktail	1

Figure 9-2. Three odonate species encountered during 2019 Arrow Lakes surveys, the Tule Bluet (left), Blue-eyed Darner (middle) and Variegated Meadowhawk (right). Photos by J. Gatten.

Appendix K: Representative photographs of revegetation polygon vegetation surrounding pitfall traps in 2019. Photos are labelled with the polygon label (treatment year and polygon number) as well as treatment type.

East Arrow Park

2010_24 (graminoid)

2009_41 (graminoid)

2009_43 (graminoid)

2009_47 (stake)

2009_48 (graminoid)

2009_49 (graminoid)

2009_54 (stake)

2009_58 (graminoid)

Lower Inonoaklin

2009_13 (stake)

2009_14 (graminoid)

2009_17 (graminoid)

2009_18 (stake)

2009_19 (graminoid)

2011_23 (graminoid)

2011_24 (graminoid)

Edgewood South		
2009_1 (stake)	2009_2 (stake)	2009_3 (stake)
		

Edgewood North		
2009_7 (graminoid)	2009_9 (graminoid)	2011_31 (graminoid)
		

Appendix L: Incidental data on mammals and herptiles found at each site, collected in May, June, and July 2019.

Search time (in hours) indicates the approximate total time spent searching for signs of wildlife at each site.

Site	Search time (hr)	Animal	Signs	Number of observations
Burton Creek	7.3	Deer	Scat, tracks	11
		Ungulate	Scat, tracks, bones, fur	12
		Elk	Scat	3
		Garter snake	Physical presence	11
East Arrow Park	5.3	Deer	Scat, tracks	13
		Elk	Scat, tracks	4
		Moose	Scat	1
		Ungulate	Scat, tracks	6
		Western toad	Tracks	3
Edgewood North	2.2	Bear	Tracks, grubbing	3
		Deer	Scat, tracks	3
		Beaver	Tracks	1
		Hare	Scat	1
		River otter	Tracks	2
		Western toad	Tracks	1
Edgewood South	5.8	Bear	Scat, grubbing, tracks	4
		Deer	Scat, tracks	14
		Ungulate	Tracks	1
		River otter	Tracks	1
		Jumping mouse	Physical presence	1
		Skunk	Signs of digging for insects	1
		Northern Alligator Lizard	Physical presence	1
		Garter snake	Physical presence	14
		Columbia Spotted Frog	Physical presence	4
Lower Inonoaklin	4.7	Deer	Scat	4
		Garter snake	Physical presence	5
		Anura (tadpole)	Physical presence	1
		Western toad	Physical presence	1
		Western skink	Physical presence	1

Appendix M: Categories and associated numbers of wildlife camera photos taken at the Burton Creek WPW area, Lower Inonoaklin, and Edgewood south. Photos were taken from 19 May (Edgewood South), 21 May (Burton Creek), and 22 May (Lower Inonoaklin) to 9 September 2019. Photos are not standardized to trap effort and are pooled across six wildlife cameras (for Burton Creek WPW) or two wildlife cameras (Lower Inonoaklin and Edgewood South). If a category was lacking at a site, this was indicated with the '-' symbol.

Group	Identity	Burton Creek WPW	Edgewood South	Lower Inonoaklin
Mammals	Black bear	5	99	-
	Elk	14	-	-
	Flying squirrel	1	-	-
	White-tailed deer	694	193	136
	Mule deer	-	20	-
	Red fox	-	8	-
	Snowshoe hare	-	108	-
	Striped skunk	-	10	-
Birds	Wild turkey	-	14	-
	Canada goose	-	-	80
	Common raven	-	9	14
	Crow	-	-	5
	Gray catbird	-	-	29
	Killdeer	-	-	10
	Northern saw-whet owl	-	-	30
	Sparrow	-	-	7
Other	Vegetation/other	14807	10355	15884
	Unknown	5	2	-
	Human	1103	167	279
	Dog	-	5	4
	Human and dog	6	-	9
	Vehicle	4	-	-