Columbia River Project Water Use Plan

Kinbasket and Arrow Reservoirs Revegetation Management Plan

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

Implementation Year 7

Reference: CLBMON-11a

Final Annual Report

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Okanagan Nation Alliance, Westbank, BC

and

LGL Limited environmental research associates,
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Monitoring Program No. CLBMON-11A
Wildlife Effectiveness Monitoring of Revegetation in Kinbasket Reservoir




Final Annual Report

2014

Prepared for

BC Hydro Generation

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EXECUTIVE SUMMARY

CLBMON-11A, initiated in 2008, is a long-term wildlife monitoring project that aims to assess the efficacy of revegetation prescriptions (i.e., CLBWORKS-1) in enhancing the suitability of habitats in the drawdown zone of Kinbasket Reservoir for wildlife. Monitoring was conducted annually from 2008 to 2012 by Cooper Beauchesne and Associates Ltd. The Okanagan Nations Alliance (ONA), in partnership with LGL Limited environmental research associates, continued monitoring in 2013. Given the apparent failure of previous revegetation efforts, a new approach was required to answer the management questions of CLBMON-11A and in 2014, the study was re-configured. The revised study now includes an assessment of the effectiveness of using woody debris removal as a viable alternative revegetation method within the drawdown zone of Kinbasket Reservoir. Sampling in 2014 focused on five sites with woody debris removal in Canoe Reach, but other areas (e.g., Bush Arm Causeway) have been identified as potential sites for future study.

Within each of the five study sites, we established replicate control, treatment, and reference plots. Controls encompassed woody debris accumulation areas in the drawdown zone. These were paired with adjacent treatments, where woody debris was physically removed from the drawdown zone (no revegetation prescriptions were applied). An adjacent upland reference was established to monitor taxa in "non-drawdown zone" conditions. The focal species groups selected for this study in 2014 are terrestrial arthropods, ungulates, songbirds, and vegetation. Due to their utility in monitoring changes in habitat quality, we focused arthropod work on a species-level examination of ground-dwelling beetles (family Carabidae and Staphylinidae) and spiders.

Taxon surveys commenced shortly after woody debris removal occurred in 2014 and the results of statistical analyses revealed clear differences between control, treatment, and reference plots, particularly with respect to arthropods. Pitfall trap samples contained 6319 beetles and spiders; a total of 4661 specimens were identified to 201 species. These arthropod species showed clear responses to the removal of woody debris. Open-habitat, ground-running wolf spiders (e.g., *Pardosa wyuta*) and xerophilous ('dry-loving') tiger beetles (e.g., *Cicindela longilabris*) dominated treatment plots. These and three additional species were revealed as strong indicators of habitat change, with particularly high fidelity and specificity for treatment plots in 2014. Controls were also characterised by open-habitat arthropod species, but many had natural histories associated with cover objects (logs, stones) and greater soil moisture than treatment sites. Changes in the frequency occurrence and distribution of indicator taxa in subsequent surveys will serve useful in tracking the revegetation succession of these plots. Assemblages of all 201 arthropod species showed a considerable amount of similarity between treatment and control, but were distinct from reference sites. Some environmental variables, such as water cover, relative humidity, and mean daily temperature, explained differences between assemblages in control and treatment plots.

Patterns in the abundance and richness of birds were similar to arthropods. Richness, corrected for survey effort, was lowest in treatment plots. Relative abundance was similar between treatment and control plots, but significantly lower in treatment plots than reference plots. Nesting evidence was relatively low overall, though this may reflect the small size of the plots relative to territory

requirements of many breeding bird species. As vegetation establishes on treatment plots, we could see increased utilisation of the drawdown zone by ground or shrub-nesting bird species.

A common pattern that emerged from vegetation and arthropod surveys was that treatment plots had a higher abundance and richness of non-native species. This is not surprising, given that invasive species are often quick to colonise recently disturbed sites. As treatment plots recover from the initial disturbance of woody-debris removal, we expect a decrease in these non-native species. Ungulate pellet plots were generally uninformative. No pellets were recorded in either treatment or control plots. Incidental observations of wildlife activity (e.g., tracks, sightings) indicated that deer, black bear, and wolves utilise the drawdown zone. Deer tracks were detected more often in treatment plots than control sites, perhaps indicating a preference for travel through these sites.

Given the apparent failure of previous revegetation efforts, the new approach holds early signs of promise towards answering the management questions more fully. The 2014 survey year represents the baseline condition of woody-debris removal treatment plots. Unfortunately pre-treatment surveys were not approved in 2014, and thus, we are unable to draw causal links between taxon responses and the applied treatment. Additional years of study are required before conclusions can be reached regarding the value of woody debris removal and success of natural revegetation in treatment plots relative to traditional revegetation techniques. Our ability to address each of the management questions is summarized below.

MQ	Able to Address MQ?	Scope		Sources of Uncertainty
		Current supporting results	Suggested modifications to methods where applicable	
1: How effective is the revegetation program at enhancing and increasing the utilization of habitat in the drawdown zone by wildlife	Partially	In terms of woody debris removal, taxa responded similarly; relative abundance and richness were greater in non-drawdown zone reference sites. Five spider and beetle species were strongly associated with baseline woody debris removal plots and are highlighted as indicator species of the initial treatment condition.	• Increased frequency of sampling (i.e., annually) • Select other sites for physical works and implemented pre-treatment sampling (e.g., woody debris removal) • Protect the long-term integrity of study plots in the drawdown zone: install physical barriers to exclude woody debris from treatment plots and maintain woody debris on control plots (e.g., install log booms, where possible) • Consider the development of physical works prescriptions (e.g., analogous to CLBMWORKS-29B for Arrow Lakes Reservoir) • Catalogue revegetation areas (e.g., specific attributes or conditions related to success/failure of revegetation prescriptions)	• Lack of sampling prior to the application of the revegetation prescriptions and woody debris removal • Natural annual population variation • Variable reservoir operations • Widespread revegetation failure • Bi-annual sampling • Relationships between revegetation or woody debris removal success and site-specific characteristics (e.g., substrate type, soil moisture, aspect, landscape position, etc.) • Uncertain future for study plots laid out in 2014 following woody debris removal. Log booms were installed to protect one treatment plot from annual accumulation of debris, but no measures were taken to ensure the long-term integrity of other study plots in the drawdown zone

MQ	Able to Address MQ?	Scope		Sources of Uncertainty
		Current supporting results	Suggested modifications to methods where applicable	
2: To what extent does revegetation increase the availability of invertebrate prey in the food chain	Partially	General arthropod relative abundance, corrected richness, and biomass did not differ between treatment and control transects in revegetation areas. In the initial year of woody debris removal, at least one treatment plot was associated with a significantly greater relative abundance of ground beetles (Valemount Peatland North). Differences in arthropod abundance were most pronounced between drawdown zone and upland reference areas.	• Annual sampling for all groups • Select other sites for physical works and implemented pre-treatment sampling (e.g., woody debris removal) • Consider the development of physical works prescriptions (e.g., analogous to CLBMWORKS-29B for Arrow Lakes Reservoir) • Characterize and catalogue site-specific attributes for all study areas in Kinbasket Reservoir, in order to understand differential responses to treatments	• Uncertain correlation between the abundance or biomass of ground-dwelling arthropods and availability of suitable prey for vertebrate taxa (e.g., shrews and birds) • Lack of sampling prior to the application of the revegetation prescriptions and woody debris removal • Natural annual population variation • Variable reservoir operations • Bi-annual sampling
3: Are revegetation efforts negatively impacting wildlife in the drawdown zone?	No	In some treatment transects (e.g., Goodfellow Creek) there may be marginal benefits of revegetation, as evidenced by high elk pellet counts. Woody debris removal treatment plots had a greater number of non-native plant and beetle species colonizing the site in the initial survey year (2014); there is no evidence of negative impacts to wildlife caused by these species, but they will be monitored for changes overtime	• Management question is better-suited to other studies that currently occur in the region • Rewrite management question to align with this study	• Lack of sampling prior to the application of the revegetation prescriptions and woody debris removal • Natural annual population variation • Widespread revegetation failure • Lack of knowledge regarding wildlife use of the drawdown zone in the winter • Variable reservoir operations
4: Which methods of revegetation are most effective at enhancing and increasing the utilization of wildlife habitat in the drawdown zone	No	The effectiveness of the revegetation will not be addressed due to the failure of the vegetation prescriptions. The effectiveness of woody debris removal will be able to be assessed after more years of monitoring data is collected for comparison with the initial data collected in 2014. Under CLBMON-37, woody debris removal from one pond in the north of Valemount Peatland resulted in increased breeding activity of Western Toad (*Anaxyrus boreas*) and Columbia Spotted Frog (*Rana luteiventris*) relative to previous years (Hawkes et al. 2015).	• Protect the long-term integrity of study plots in the drawdown zone: install physical barriers to exclude woody debris from treatment plots and maintain woody debris on control plots (e.g., install log booms, where possible) • Select other sites for physical works and implement pre-treatment sampling (e.g., woody debris removal) • Characterize and catalogue site-specific attributes for all study areas in Kinbasket Reservoir, in order to understand differential responses to treatments	• Lack of sampling prior to the application of the revegetation prescriptions and woody debris removal • Uncertain future for study plots laid out in 2014 following woody debris removal. Log booms were installed to protect one treatment plot from annual accumulation of debris, but no measures were taken to ensure the long-term integrity of other study plots in the drawdown zone • Uncertain relationship between revegetation or woody debris removal success and site-specific characteristics (e.g., substrate type, soil moisture, aspect, landscape position, etc.)

Monitoring under CLBMON-11A, including the woody debris removal areas is currently scheduled to continue in 2016 (recommended to continue in 2015). The following is a summary of the recommendations made for the implementation of CLBMON-11A in future years:

1. **Revise focal taxa and survey methodology.** Remove the focus on ungulates (as detected through pellet plots), since pellets were not detected in drawdown zone plots in 2014 and further surveys are unlikely to contribute knowledge on ungulate use of the drawdown zone. Continued aerial surveys are recommended to determine areas of the reservoir with the highest ungulate use. Those areas could subsequently be targeted for enhancement by vegetation prescriptions.

   Concentrate focus on ground-dwelling spiders and beetle species which are strong indicators of underlying ecological conditions and most likely to respond to the treatments.

   Breeding bird survey methodology should be modified. Songbird point counts are a suitable sampling method for reference habitats, but their utility is limited on the scale of plots in drawdown zone. We recommend that line transects be used to survey songbirds in future years. This method is excellent in open areas, and aligns perfectly with the transect approach already being implemented for woody debris removal plots in 2014.

   Bats should be surveyed only in specific cases (e.g., if woody debris removal is implemented at ponds in the Valemount Peatlands or near the Bush Arm Causeway).

2. **Modify arthropod sampling design.** The arthropod survey methods implemented in 2014 should be modified to reduce the number of pitfall trap samples. The abundance of focal taxa collected in 2014 suggest that three pitfall trap arrays (n= 9 pitfall traps) installed per transect in each plot would provide sufficiently robust data to detect changes in taxa and assemblages over time. Collections could be constrained to two collection periods spanning 6 days, between June and August.

3. **Increase number of woody debris removal sites** for replication and to include sites with other soil seed bank profiles, soil fertility assays, evidence of nascent vegetation establishment, and recent land use history. For example, Pond 12 in Valemount Peatland and the west bank of the Bush Arm Causeway are prime sites for expanding the woody debris removal program for enhancement of wildlife habitats in the drawdown zone. In particular, the enhancement of these areas will benefit breeding amphibian and reptile populations.

4. **Pre-treatment sampling.** We recommend pre-treatment sampling to be implemented at the proposed new sites in 2015, with woody debris removal to occur in 2016. One of the limitations of this program is the lack of pre-treatment data, which makes it difficult to determine if any observed changes are treatment effects or related to pre-existing phenomena.

5. **Monitor the KM 88 site** to assess wildlife use of the areas treated in 2013, which represent a different prescription (larger sedge plugs, larger area, and higher density of planting).

6. **Consider the development of physical works prescriptions for the drawdown zone of Kinbasket Reservoir.** Developing prescriptions to protect or enhance high quality habitats that exist in the drawdown zone (e.g.,

Ptarmigan Creek, Bush Arm Causeway, Ponds in the Valemount Peatland) would contribute to an overall improvement in wildlife habitat suitability (if the physical works are built). For example, log booms should be developed at select sites to exclude additional log accumulation, and woody debris should be removed from those sites in accord with the study design. Additionally, efforts should be made at current study sites to limit any new woody debris accumulation on experimental plots. Control and Treatment plots should be protected by log booms, where possible, in order to ensure the long-term efficacy of this monitoring program.

7. **Consider modifying the sampling program of CLBMON-11A to occur annually.** Collecting ecological data on an annual basis would provide a better indication of the annual variability associated with those species groups and their use of the drawdown zone (with particular emphasis on the use of control and treatment sites), and especially on the post woody debris removal revegetation and faunal recolonization of these sites.

8. **Catalogue the current state of knowledge of revegetation areas and increase the total area revegetated in select areas of the drawdown zone.** The revegetation program would benefit from a review of current knowledge of revegetation prescriptions at all study sites in the drawdown zone of Kinbasket Reservoir. This would provide guidance in areas to target for enhancing success of revegetation. Subsequently, existing treatment areas could be expanded or additional treatment areas of the same prescriptions could be added to increase the number of replicates. Increasing the extent of revegetation areas will increase the likelihood of detecting any changes in wildlife utilization.

9. **Future revegetation.** Some areas might benefit from revegetation post-woody debris removal. The current treatment plots could be split into planted (enhanced revegetation) and un-planted (natural revegetation) treatment areas. Revegetation efforts should be site-specific based on a prescription for that area. If future revegetation is to occur, consider the species of wildlife that are likely to benefit from the revegetation to ensure the appropriate mix of plants is used, that the total area planted is likely to influence wildlife use of the drawdown zone, and that the revegetation prescriptions be applied in a replicated manner with sufficient stratification.

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

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ACRONYMS AND DEFINITIONS

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

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

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

Reach: refers to a broad geographic area of the reservoir used as the highest level of stratification for sampling. Two reaches within Kinbasket Reservoir were sampled for CLBMON-11A: Canoe Reach in the north and Bush Arm in the south. Only Canoe Reach was sampled in 2014. Specific sites are sampled within each reach.

Site: Sampling area within a reach in which treatments were applied and/or upland areas sampled.

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

- **Treatment.** Woody debris was removed from these areas. These sites parallel the shoreline, and extend down the drawdown zone from ~ 755 m ASL to ~ 752 m ASL. The actual elevation varied depending on local site conditions. The experimental unit is based on a linear transect of ~100 m in length.
- **Control:** Woody debris was not removed from these areas. These areas are situated at the same elevation as the Treatments.
- **Reference:** These areas are immediately upland of the treatment and control sites and are representative of the non-drawdown zone, forested condition. These sites represent what would be in the drawdown zone if the reservoir was not there.

WLR: Water Licence Requirements

1.0 INTRODUCTION

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

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

The terms of reference for CLBMON-11A (BC Hydro 2008) describe the objectives of the monitoring program, identify a suite of focal taxa (amphibians, birds, small mammals, ungulates and invertebrates) and provide recommendations for the study's implementation. A study design was developed in 2008 that monitors the response of terrestrial arthropods, small mammals and ungulates at control, treatment, and local reference sites (CBA 2010a).

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

Monitoring was conducted annually from 2008 to 2012 by CBA (CBA 2009a, 2010b, 2011a,b) and by the Okanagan Nation Alliance and LGL Limited in 2013. Based on the conclusions and recommendations in Hawkes et al (2014), BC Hydro agreed that the methods applied during the first five years of the program were not well suited to answering the management questions associated with CLBMON-11A. For example, the wrong species of small mammal were being targeted, the productivity (i.e., seed load) of plants that would be consumed by granivorous small mammals had not been assessed, songbirds had not been considered as focal taxa, and the size of the revegetation prescriptions applied in the drawdown zone were likely of little benefit to ungulates given the proximity and spatial extent of suitable habitat adjacent to the drawdown zone. Overall, there did not appear to have been a connection made between the types of plants used in the revegetation program (CLBWORKS-1) and how the use of those species would benefit wildlife using the drawdown zone of Kinbasket Reservoir. In addition, the revegetation program has not been successful (Hawkes et al. 2013) and there was a need to adapt CLBMON-11A to ensure that data collected could be used to answer each of the management questions. Beginning in 2013, a new approach was implemented to develop the use of arthropods (spiders and ground-dwelling beetles), ground- and grass-nesting birds, and ungulates as indicators of revegetation success.

In the most recent year of study (2014), monitoring occurred at sites treated under CLBWORKS-16 (the woody debris removal program) to assess whether the removal of woody debris promotes the establishment and development of vegetation communities, which in turn will increase the suitability of habitats in the drawdown zone for wildlife. This report details the results of this first year of monitoring woody debris removal as a revegetation method.

2.0 OBJECTIVES AND MANAGEMENT QUESTIONS

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

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

CLBMON-11A was initiated in 2008 and Objective 1 was completed with refinements to the study design incorporated annually. The monitoring of indicator taxa was performed between 2008 and 2014 with some sampling (i.e., ungulate pellet plots) conducted only after 2011. Additional modifications to the

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

effectiveness monitoring program are described in this document and an assessment of the efficacy of the revegetation program is provided in Hawkes et al. (2013).

2.1 Management Questions and Hypotheses

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

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

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

The management hypotheses to be tested by this study include:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

As described in the terms of reference several of the indicator taxa will be monitored under separate Water Licence Requirements (WLR) monitoring programs (e.g., CLBMON-37/58 monitors amphibians and reptiles; CLBMON-36 monitors nest mortality in birds). Consequently, CLBMON-11A does not monitor specific variables (e.g., nest mortality) related to those taxa associated with these monitoring programs. Table 2-1 illustrates the linkages between the management questions, the management hypotheses, and the different monitoring programs.

Table 2-1: Relationship between management questions, management hypotheses, and WLR studies undertaking effectiveness monitoring as identified in the terms of reference for CLBMON-11A. Studies are organized in columns by management questions (MQs)/themes and in rows by indicator species groups. "-" indicates where a MQ does not relate to a hypothesis. "NA" indicates where there is no existing study that addresses the MQ/hypothesis combination

	Management Question/Theme			
Hypothesis	**MQ1: Wildlife Diversity / Abundance**	**MQ2: Food Availability**	**MQ3: Negative Impacts**	**MQ4: Habitat**
	Amphibians			
H_{1A}	**CLBMON-37**	-	-	-
H_{1B}	-	**CLBMON-11A**	-	-
H_{1C}	-	-	**CLBMON-37/58**	-
H_{1D}	-	-	-	**CLBMON-37**
	Birds			
H_{2A}	**CLBMON-36/11A**	-	-	-
H_{2B}	-	-	**CLBMON-36**	-
H_{2C}	-	-	**CLBMON-36**	-
H_{2D}	-	**CLBMON-11A**	-	-
H_{2E}	-	-	-	**CLBMON-36**
	Small Mammals			
H_{3A}	**CLBMON-11A**	-	-	-
H_{3B}	-	**CLBMON-11A**	-	-
H_{3C}	-	-	-	**NA**
	Ungulates			
H_{4A}	**CLBMON-11A**	-	-	-
H_{4B}	-	**NA**	-	-
H_{4C}	-	-	-	**NA**
	General Habitat			
H_5	-	-	-	**CLBMON-11A**

2.2 CLBMON-11A Study Limitations and Revised Program

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

- The study design was limited by the small number of successful revegetation sites that in turn limited sample size for monitoring and reduced statistical power to detect treatment effects.
- There was no pre-treatment sampling at revegetated areas so comparisons before and after treatments cannot be made.
- There was a lack of replication in revegetation treatments across sites, thus different treatment effects could not be separated.
- Lack of replication of revegetation treatments across elevation gradients prevented stratification for this factor.
- The original 14 sites were not sampled every year, thus time series vary across sites. For example, some control transects were lost because revegetation treatments subsequently occurred at their locations. One site was destroyed by excavators (Windfall Creek) and a new site (Causeway) was added in 2010.

- Not all sites contained both treatment and control transects in 2008; this was remedied in 2009.
- Revegetated areas were typically of too small to effectively influence use by certain species of wildlife (e.g., ungualtes, and in most cases, small mammals); therefore it may be difficult to discern a treatment effect.

Finally, the apparent failure of the CLBWORKS-1 program to re-establish vegetation in the drawdown zone means that there are essentially no treatment effects to assess by the original CLBMON-11A study design. The findings of the CLBMON-9 report evaluating the CLBWORKS-1 revegetation effectiveness (Hawkes et al. 2013b) concluded that most transplanted plants were unable to cope with the combination of inundation timing, frequency, duration and depth, or with the by-products of these factors such as erosion, woody debris scouring, and drought conditions. The report also stated that it did not appear that either the quality or quantity of native vegetation in the Kinbasket Reservoir drawdown zone had increased as a result of the planting program. Failure of some revegetation treatments was also noted during Year 3 of the CLBMON-11A study (CBA 2011a).

Despite the overall assessment of ineffectiveness and issues associated with the original workplan, opportunities presented themselves to modify the program to assess the use of the drawdown zone by wildlife and to evaluate whether physical works programs, such as the woody-debris removal program (CLBWORKS-16), can effectively enhance wildlife habitat in the drawdown zone. To achieve this, the following recommendations presented in the 2014 workplan were implemented during this sampling year:

1. The focal taxa were modified to focus on species of ground-dwelling spiders and beetles, ungulates (pellet plots), and birds (with a focus on grass/ground-nesting species) as these taxa were more likely to exhibit measurable responses to habitat change in the drawdown zone. Small mammals were not monitored as they do not contribute data necessary to answering the management questions (see discussion in Hawkes et al. 2014).
2. Woody debris were removed from select sites to facilitate natural colonization and regeneration processes. This modification allows assessment of whether reducing woody debris accumulation on sites with dormant seed and/or rhizome banks can stimulate rapid regrowth, possibly providing a more cost-effective route to site remediation over the long-term than site stocking, and enhancing wildlife habitat suitability.

3.0 STUDY AREA

3.1 Physiography

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

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

3.2 Climatology

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

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

3.3 Kinbasket Reservoir

The approximately 216 km long Kinbasket Reservoir is located in southeastern B.C., and is surrounded by the Rocky and Monashee Mountain ranges. The Mica hydroelectric dam, located 135 km north of Revelstoke, B.C., spans the Columbia River and impounds Kinbasket Reservoir. The Mica powerhouse, completed in 1973, has a generating capacity of 1,805 MW, and Kinbasket Reservoir has a licensed storage volume of 12 million acre feet (MAF; BC Hydro 2007). The normal operating range of the reservoir is between 707.41 m and 754.38 m elevation, but can be operated to 754.68 m ASL with approval from the Comptroller of Water Rights (Figure 3-1).

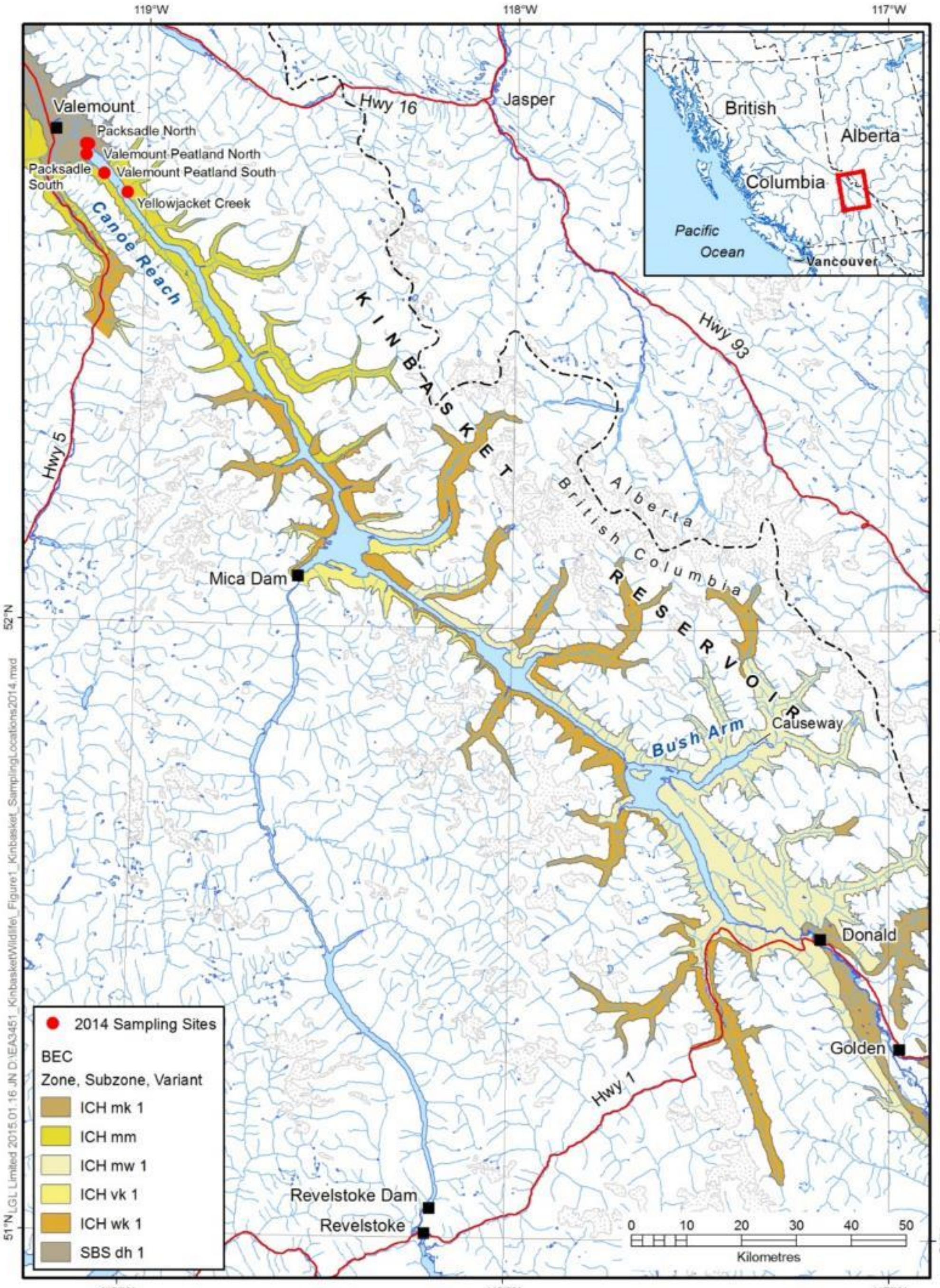

Figure 3-1: Location of Kinbasket Reservoir in British Columbia and locations sampled for CLBMON-11A in 2014. Refer to Table 3-1 for descriptions of biogeoclimatic (BEC) zones.

Kinbasket Reservoir is lowest during April to mid-May, fills throughout late spring and early summer, and is typically full by mid- to late-summer (Figure 3-2). Although there is some year to year variation, the general pattern is consistent. In 2012 and 2013 Kinbasket was filled beyond the normal operating maximum (i.e., > 754.38 m ASL) for the first time since 1997; in 2014 water levels were kept below the normal operating maximum.

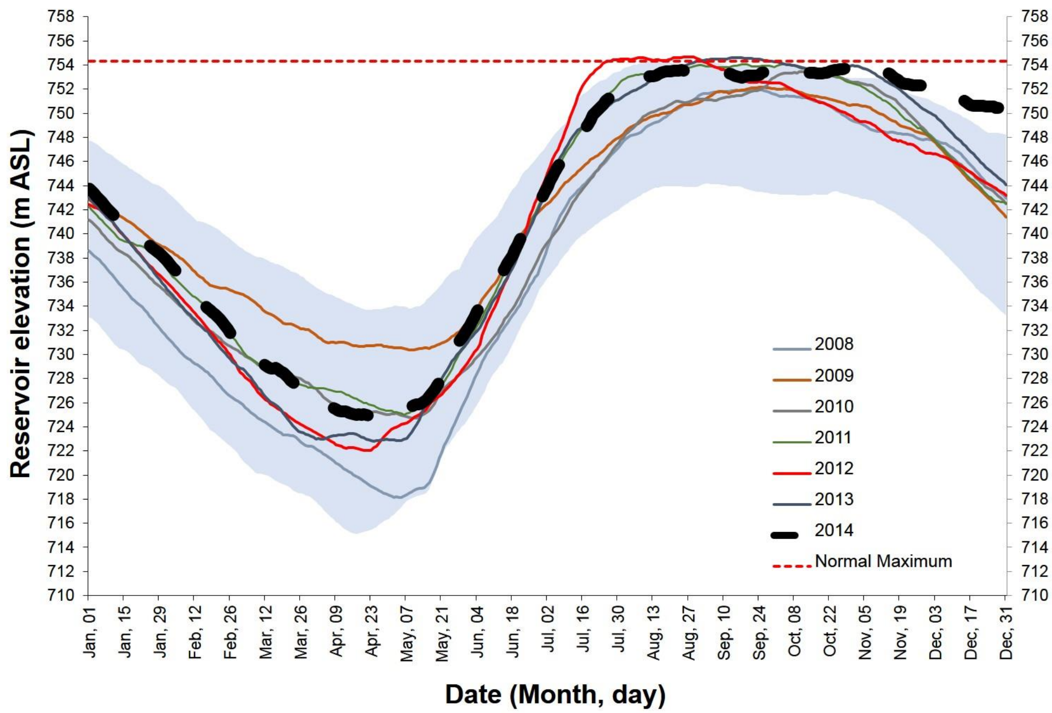

Figure 3-2: Kinbasket Reservoir hydrograph for the period 2008 through 2014. The shaded area represents the 10th and 90th percentile for the period 1976 to 2013; the dashed red line is the normal operating maximum

3.4 Biogeography

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

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

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

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

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

4.0 METHODS

4.1 Experimental Design

The CLBMON-11A study in 2014 was revised to assess the effectiveness of woody debris removal as an alternative or supplemental revegetation technique. To evaluate this, terrestrial arthropods (ground-dwelling beetles and spiders), songbirds, ungulate pellet plots, and vegetation were surveyed to determine abundance and diversity within and above the drawdown zone of Kinbasket Reservoir. The previous study design and sampling protocols (for instance, CBA 2009a, 2010a, 2011a, b, Hawkes et al. 2014) were altered for the 2014 study in order to monitor the effectiveness of woody debris removal. The revised design is described below.

A total of five sites were sampled in Canoe Reach, at the north end of Kinbasket Reservoir, in 2014 (Table 4-1; Map 9-1 to Map 9-6). Two sites, "Valemount Peatland North" and "Valemount Peatland South" were located on the west side of Canoe Reach, whereas "Packsaddle North", Packsaddle South", and "Yellowjacket Creek" were located on the east side of Canoe Reach. Site names and codes are listed in Table 4-1. Sampling site locations were based on areas with woody debris removal recently completed, underway, or with woody debris accumulation. In general these sites did not overlap with those selected in previous years of the study.

Table 4-1: Sites sampled in 2014, indicating the distribution of replicate treatment (T), control (C), and reference (R) plots

Reach	Site Name	Plot Type	Woody Debris Removal (Year)
Canoe Reach	Packsaddle North (PS-N)	C,T,R	2014
	Packsaddle South (PS-S)	C,T,R	2014
	Yellowjacket Creek (YJ)	C,T,R	2014
	Valemount Peatland North (VP-N)	C,T,R	2014
	Valemount Peatland South (VP-S)	T,R	2012
Total			

Sampling was focused on the upper 3 to 4 m of the drawdown zone (i.e., between ~752 and 755 m ASL). This zone comprises the greatest woody debris accumulation. The three main plot types were:

Treatment. Woody debris was removed from these areas. These sites are parallel to the shoreline and extend down the drawdown zone from ~ 755 m ASL to ~ 752 m ASL. The actual elevation varied depending on local site conditions. The experimental unit is based on a linear transect of ~100 m in length (Figure 4-2).

Control. Woody debris was not removed from these areas. These plots were situated adjacent to treatment plots, at approximately the same elevation.

Forested Reference sites. These areas are immediately upslope of the treatment and control sites and are representative of the non-drawdown zone, forested condition. These sites represent what would be in the drawdown zone if the reservoir was not there.

These are depicted in Figure 4-1. An additional plot type was sampled during songbird point counts at the Valemount Peatland North site only:

Drawdown Zone/Natural: These are sites of the same size as the treatment and control blocks that occur at the same elevation as the treatments and controls and are representative of the drawdown zone that is not covered by woody debris.

Figure 4-1: Photos depicting the three main plot types during the 2014 study year of CLBMON-11A. Pictured are: the treatment plot at Packsaddle North (top), the control plot at Valemount Peatland North (middle), and the reference plot at Valemount Peatland South (bottom)

Taxa were sampled along three parallel transects in each treatment, control, and reference plot. Transects were ~100 to 120 m in length at each plot, which approximated 1 m elevation gradients (where possible). Three transects were established and labelled "A", "B", and "C". The "A" transect was the uppermost, occurring at the highest elevation of the drawdown zone within control and treatment transects. The "B" transect was laid at approximately 1 m in elevation below transect "A", depending on the slope. The "C" transect was the lowest in elevation (~1 m below transect "B").

Transects were approximately linear, with five pitfall trap array stations established at even intervals (~20-30 m linear distance between array stations). Slight variation in transect bearing was required in some locations to account for local topography (e.g., curving shoreline) or shape of the treatment area. Coordinates of all sampling stations were recorded using GPS (Garmin 60Csx).

Three arthropod pitfall traps were deployed at each of the five array stations. Ungulate pellet plots were performed along the "B" transect running through the middle of the plot (at the start, middle, and end of transect B). Three songbird point counts were performed in each plot (except 2 plots in Yellowjacket control). To minimize overlap, the two end point counts were offset from the transect start/end point by approximately 10 m. Most point count stations aligned approximately with the 'B transect' used in arthropod surveys, pellet plots, and vegetation sampling.

Three vegetation belt transects were also assessed in each treatment, control, and reference area. Belt transects were arranged in a linear fashion; often spanned outside the edges of the treatment areas, but sampled similar substrate, and generally aligned with the 'B transect' used in arthropod sampling, ungulate pellet plots, and bird surveys. Details of survey methods for focal taxa are shown in Section 4.3.

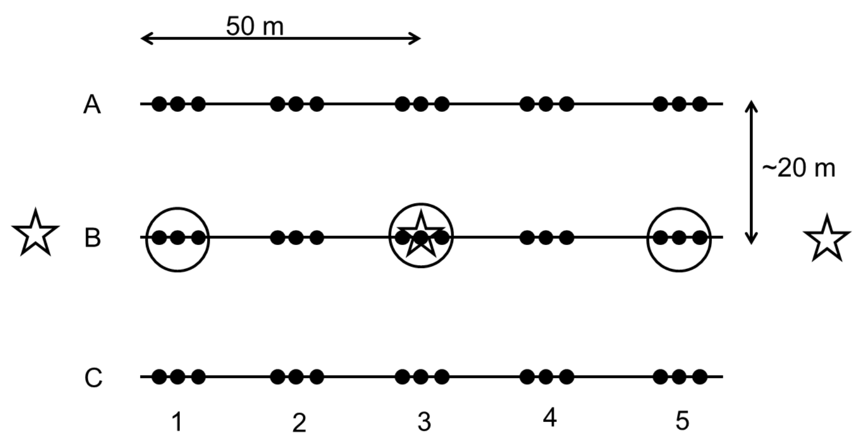

Figure 4-2: Schematic of sampling plots showing three pitfall traps (solid circles) sampled along each of three transects, three ungulate pellet plot (large, open circles), and three songbird point count stations (stars). Note that pitfall traps were actually arranged in a triangular fashion around each pitfall array station. Sampling stations (i.e., pitfall traps, ungulate pellet plots, songbird point counts) are not drawn to scale

4.2 Field Schedule

The 2014 field sampling schedule followed a similar timeline to that previously implemented under CLBMON-11A. Field sampling in 2014 was conducted primarily during June to count and clear ungulate pellet plots and to coincide with peak periods in abundance for invertebrates prior to inundation of drawdown zone transects. This timing also coincided with the height of the breeding season for most songbird species, at which time all locally breeding birds are on territory and are highly vocal, enabling surveyors to accurately document the number and diversity of breeding birds. As with many CLBMON projects, the sampling schedule was also determined by reservoir levels. For example, sampling at most control and treatment transects would not be possible during the late summer/autumn due to high reservoir levels.

4.3 Focal Taxa Sampling Protocols

Ground-dwelling spiders and beetles, ungulates, and songbirds were surveyed as focal taxa in 2014. These taxa align with those sampled in the previous implementation years, with exception of the removal of small mammals as a focal group, finer-scale focus on spiders and beetles in the arthropod sampling, and including songbirds (which were also surveyed in a pilot program in 2013). Sampling protocols were similar to methods used in the CLBMON-11B1 project (e.g., Hawkes et al. 2010, 2011, 2012), with modifications detailed below.

4.3.1 Terrestrial Arthropods

Terrestrial arthropods (spiders and beetles) were sampled at all sites using 500 mL pitfall traps (Figure 4-3). We used similar methods for pitfall trapping to previous years (Hawkes et al. 2014) and those used in CLBMON-11B1 (Hawkes et al. 2012), except where noted. Methods were consistent with those described by the Resources Inventory Committee (1998d), Marshall et al. (1994).

Pitfall traps were set up in triangular arrays with ~1 m sides. Each array contained three traps, i.e., one at each point of the triangle, inserted into the ground following a similar approach to CLBWORKS-11B1 (Hawkes et al. 2012). Pitfall trap cups were installed with a small trowel to a depth of approximately 10 cm so that the top rim of the cup was flush with the ground (Figure 4-3). Two cups (one on top of the other) were installed to prevent the hole from collapsing when the collection cup was removed to collect the sample.

Pitfall traps were filled with ~125 mL of collecting fluid in order to kill and preserve arthropods. Salt + soap water solution is only viable for use in short collections and was prone to evaporation in treatment plots, thus we altered the collection fluid to include 10% non-toxic propylene glycol (by volume). Traps were not baited as unbaited traps are the most useful for obtaining unbiased samples (Biological Survey of Canada 1994). To moderate exposure to the elements in the drawdown zone, pitfall traps were covered with materials found within plots, such as small pieces of wood and flat rocks (Figure 4-4).

Instead of utilising 1-day pitfall trap collections for arthropod analyses, which do not yield enough statistical rigour to assess ecological responses, the duration of collection period was extended. On average, pitfall traps operated for six collection days: i) 2/3 to 8/9 June, ii) 23/24 to 28/29 June, and iii), 8/9 July to 12/13 July. Thus, the collection periods spanned 7 days, 6 days, and 5 days for each collection, respectively. Sites were visited approximately every two days during collections to maintain the efficacy of pitfall traps (re-fill evaporated/spilled traps, replace disturbed traps, reset traps at soil level after periods of rain, and remove debris and vertebrate by-catch).

Figure 4-3: Close-up of photo of a pitfall trap installed at the south Valemount Peatland control site (array A1, adjacent to mature forest edge). The catch shown represents ~2 days of collection, and contains three large *Scaphinotus angusticollis* ground beetles that are specialist predators of snails and slugs (photo date: 11 July, 2014)

Figure 4-4: Paired photos demonstrating the typical setup of pitfall trap arrays in 2014, with three pitfall traps (yellow outline) installed around a central point (red marker). Note the use of cover object over pitfall traps (right). This photo was taken at Yellowjacket Creek treatment plot, pitfall array B3. A white HOBO T/RH datalogger can be seen at the base of the plot flag (photo date: 11 July, 2014)

The three pitfall traps from each array were pooled as one sample unit when collected in the field. Sample contents were transferred to a waterproof, plastic collection jar in the field and provided unique collection labels. The time (hour:minute) that each trap was installed and subsequently collected was recorded, in order to standardize abundance of trap captures. Traps that were disturbed by wildlife during a collection period, were re-set with the new start time recorded.

To avoid loss of specimens in the field and expedite the time it took to collect samples, collection fluid was drained from samples only after returning to the office. Within approximately 4 days of each collection, specimens were transferred into 70% ethanol for preservation and storage.

Due to the high abundance and diversity of spiders and beetles in the samples collected, not all samples could be sorted and processed. Table 4-2 summarizes the replicates subsampled for all analyses presented in this report. Three pitfall traps were processed (of the five collected) in each of the three (A,B,C) transects in each plot in each of three sites (of the five study sites). Additionally, only the first two collection periods were processed for use in data analyses.

Table 4-2: The number of samples collected from each plot type at sites sampled in 2014 arthropod surveys (top) and the number of selected replicate samples processed (bottom). Each sample consists of three pitfall trap contents pooled at each of 15 pitfall arrays per plot. CON = Control, TRT = Treatment, REF = Upland Reference (Mature Forest); PS-N = Packsaddle North; PS-S = Packsaddle South, YJ = Yellowjacket, VP-N = Valemount Peatland North, VP-S = Valemount Peatland South

		COLL 1			COLL 2			COLL 3			
	SITE	**CON**	**TRT**	**REF**	**CON**	**TRT**	**REF**	**CON**	**TRT**	**REF**	**TOTAL**
No. Collected	**PS-N**	15	15	15	15	15	15	15	15	15	**135**
	PS-S	15	15	15	15	15	15	15	15	15	**135**
	YJ	15	15	15	15	15	15	15	15	15	**135**
	VP-N	N/A	N/A	N/A	15	15	15	15	15	15	**90**
	VP-S	N/A	15	15	N/A	15	15	N/A	15	15	**90**
	5 SITES	**45**	**60**	**60**	**60**	**75**	**75**	**60**	**75**	**75**	**375**
No. Processed	**PS-N**	9	9	9	9	9	9	N/A	N/A	N/A	**54**
	YJ	9	9	9	9	9	9	N/A	N/A	N/A	**54**
	VP-N	N/A	N/A	N/A	9	9	9	N/A	N/A	N/A	**27**
	3 SITES	**18**	**18**	**18**	**27**	**27**	**27**	**27**	**27**	**27**	**135**

4.3.2 Songbirds

Time-constrained, variable-radius[3] point count surveys were used to assess the diversity and relative abundance of songbirds (Ralph et al. 1995). Each point count station was typically surveyed three times. Surveys commenced at sunrise and ended within ~4 hours of sunrise (Ralph et al. 1995). Songbird surveys were conducted only during favourable conditions (i.e., no heavy wind or precipitation) to standardize surveys and minimize variability in detections due to sub-optimal environmental conditions. Songbird point count surveys were consistent with Resource Inventory Standards Committee protocols (RIC 1999).

An observer stood at a point count center and documented all birds seen and/or heard within 75 m during a 6-minute count period. Furthermore, because 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). The following data were collected at each point count station:

[3] Variable in the sense that observations at varying distances from the point count centre are recorded.

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), sex (when known) and 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 (call, song, or visual). Notes were made to differentiate fly-over birds from the rest of the detections; and
3. **Bird observations outside point count plots:** incidental observations of birds located outside the point count area at each site.

4.3.3 Ungulates

Pellet group count surveys were conducted at three points along the B transect of each site (B1, B3, and B5; Figure 4-2). Pellet plots were circular with a 3.99 m radius (50 m^2), in conformance with the methods used in previous years (CBA 2011a; Hawkes et al. 2014). A minimum of 10 pellets in proximity to each other was needed to constitute a pellet group (Resources Inventory Committee 1998a). Each pellet group was identified to species (i.e., Elk (*Cervus canadensis*), Moose (*Alces alces*) and deer (*Odocoileus* sp.)), recorded, and physically cleared from the plot. All deer pellet groups were classified as “deer”, because identification to species, (i.e., White-tailed Deer (*Odocoileus virginianus*) and/or Mule Deer (*Odocoileus hemionus*)) was not possible (from pellets) in most cases. Scat from other species was recorded when reliably identified (e.g., bear, canids, snowshoe hare).

4.3.4 Vegetation

We used modified belt-line transects to sample vegetation in woody debris treatment, control, and reference plots. Vegetation transects were not performed in the “A”, “B”, and “C” transects used for other surveys, but rather, were overlaid across the study plot in one linear line. At each of the five study areas in Canoe Reach (Packsaddle North, Packsaddle South, Valemount Peatland North, Valemount Peatland South, and Yellowjacket), three belt transects were established within each control, treatment, and reference area (sometimes replicated just adjacent to plots, in similar substrate conditions). Each belt transect was 20 m long and was sampled along the entire length using ten 2 m X 0.5 m quadrats (Figure 4-5). All vegetation within or overhanging each quadrat was identified to species, or in some cases to genus, and the per cent cover (to the nearest 5 per cent) visually estimated, along with total covers for each stratum (herbs, shrubs, trees). To facilitate tree and shrub cover estimates in forested upland reference sites, circular 100 m^2 plots were established at each transect end using a tape measure. Herb cover alone was assessed within the belt transects, while cover of woody species was visually estimated within the circular plots, using the same method as for herbs (Figure 4-5). The location of each transect endpoint (0 m and 20 m) was georeferenced using a Garmin handheld GPS. Wire flagging was inserted into the ground at the transect endpoints to serve as temporary markers.

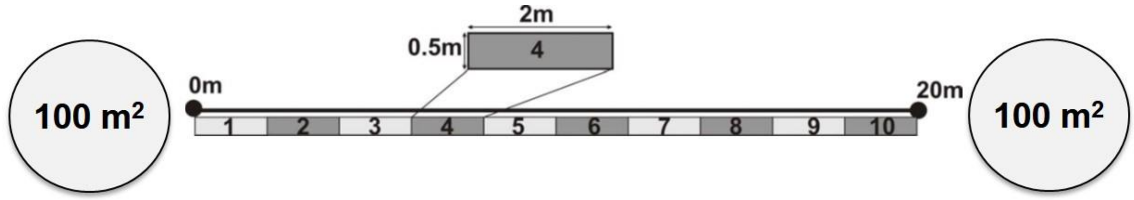

Figure 4-5: Schematic of the belt-line transect quadrat method used to sample vegetation communities in the drawdown zone of Kinbasket reservoir. Note: elements of this drawing are not scaled proportionately

4.4 Soil Substrate Environmental Data

Onset® HOBO® data loggers (The U23-002 HOBO Pro v2 External T/RH Data Logger) were used in a subset of plots to measure per cent relative humidity and temperature in the woody debris removal treatment plots, control plots, and forested reference plots. One logger was deployed at the center plot point (pitfall array station "B3") in each of the three plot types (treatment, control, and reference), within three sites (VP-N, PS-S, and YJ). The logger was fixed at the plot center by attaching it to the base of the flag marking the center of the array (see Figure 4-4). Additionally, as vegetation regenerates on treatment plots in future years, it will be informative to measure the change in soil surface temperature and relative humidity. These data are also useful environmental correlates of beetle and spider catch in pitfall traps, as temperature (generally the number of degree-days ≥15 °C) affects soil arthropod activity. Relative humidity might also help explain differences in particular arthropod and vegetation species between plots.

4.5 Data Analysis

4.5.1 Boxplots

Boxplots are used frequently in the results sections of this report. To aid the reader in interpreting these graphs, the following description is provided. In boxplot graphs, the boxes represent between 25 per cent and 75 per cent of the ranked data. The horizontal line inside the box is the median. The length of the boxes is their interquartile range (Sokal and Rohlf 1995). A small box indicates that most data are found around the median (small dispersion of the data). The opposite is true for a long box: the data are dispersed and not concentrated around the median. Whiskers are drawn from the top of the box to the largest observation within 1.5 interquartile range of the top, and from the bottom of the box to the smallest observation within 1.5 interquartile range of the bottom of the box. Boxplots display the differences between groups of data without making any assumptions about their underlying statistical distributions, and show their dispersion and skewness. For this reason, they are ideal in displaying ecological data. All boxplots were created using R v. 3.1.1 (R Core Team 2014).

4.5.2 Terrestrial Arthropods

Taxonomy and Natural History

Spider specimens were identified to species, where possible, by a local expert (Robb Bennett, Ph.D., Research Associate, Royal B.C. Museum). All beetles were identified to family and individuals of the families Carabidae ("ground beetles") and Staphylinidae ("rove beetles") were identified to species (excluding Staphylinidae: Aleocharinae due to the poor revisionary status of this subfamily in western Canada). Where beetle species did not align to described species and available keys, they were assigned unique morphospecies identities that are equivalent to species-level classifications. The dissection of male spider and beetle specimens was necessary for most specimens in order to examination traits in genitalia and determine species identities. Beetle classification was based on numerous taxonomic works, including, but not limited to: Arnett and Thomas (2001), Campbell (1973, 1979), Goulet (1983), Lindroth (1961-1969), Pearson et al. (2006), and Smetana (1995, 1971). The entomology collection at the Royal B.C. Museum (RBCM) in Victoria, British Columbia, was used as a reference for ground beetle identification. Spider and beetle specimens were curated according to museum standards, and a reference collection was deposited at the RBCM. Immature specimens (beetle larva and spiderlings) were excluded for all species-level data analyses.

Species-specific natural history information was used to examine patterns in functional guilds, exotic species, etc. Spiders were classified into various feeding guilds based on their mode of prey capture (according to Pinzon et al. 2013, after Uetz et al. 1999). These classifications are included with species lists (Appendix 9-C). Adventive (non-native) status of beetles was classified according to Bousquet et al. (2013). Additionally, the flight status of beetles was examined. Many beetle species have evolved a loss in flight ability, corresponding to shortening of the hind wings. Such "brachypterous" beetles with reduced wing length are less apt to disperse than their long-winged counterparts. Within some species the genetic traits for both long and short-winged individuals exist (e.g., *Pterostichus melanarius*). Such "wing-dimorphic" species often are insightful for indicating population stability. In the absence of immigration, wing-dimorphic populations tend to increase in the proportion of brachypterous individuals over time. In general, greater ratios of short:long wing beetles corresponds to a longer duration of the population in a given habitat. The wing-length was noted for most ground and rove beetle species in samples. Ground beetle flight status was also detailed in Larochelle and Larivière (2003), and was used to denote brachypterous and wing-dimorphic species in our species list (Appendix 9-D).

Subsampling, Replication, and Data Standardizations

Analyses were performed on a subset of the pitfall trap samples collected in 2014. Three pitfall traps were processed (of the five collected) in each of the three (A,B,C) transects in each plot in each of three sites (of the five study sites); summarized in Table 4-2. Pitfall trap array samples represent pseudoreplicates, and were pooled to provide summary statistics of replicate transects within each plot or site. The first two collection periods were processed for use in data analyses. At the Valemount Peatland North site (VP-N) only one collection was made, due to the schedule of the machine operators (debris removal was in progress during collection 1). Using pitfall trap start and end times (accurate to the nearest minute), arthropod abundance was standardized to catch-per-unit-effort (CPUE) equivalent to one pitfall trap day (24 hours). Richness is also presented in terms of number of species per pitfall day (24 hours), to correct for unequal survey effort. Hereafter, all analyses for arthropods are based on standardized abundance (CPUE) and standardized richness (spp. per trap day).

Relative Abundance and Richness

Relative abundance (catch-per-trap-day) and relative richness (number of species per-trap-day) of arthropods were examined through boxplots. Differences in relative abundance and corrected richness were compared using the Kruskal-Wallis rank sum test as a non-parametric alternative to analysis of variance (ANOVA). Post-hoc pairwise tests were corrected for multiple comparisons with the Bonferroni adjustment (α = 0.10 / no. of comparisons). Kruskal-Wallis tests were performed using the R agricolae package (de Mendiburu 2014).

Indicator Species

The indicator value method (Indicator Species Analysis (Dufrêne and Legendre 1997) allowed for the identification of indicator species which can be tested overtime to measure ecological change of treatment plot. Indicator Species Analysis (ISA) quantifies the value of each species' relationship to treatment types and sites or other categorical data. ISA is a useful method for identifying biological indicators for any combination of habitat types or sites of interest and has been routinely applied in arthropod studies (Dufrêne and Legendre 1997, McGeoch and Chown 1998; McGeoch et al. 2002).

An indicator value (IV) was calculated for each species j in each group k (for e.g., treatment type or site). IV is the product of two values, A_{kj} and B_{kj}. A_{kj} is a measure of species specificity (based on relative abundance), whereas B_{kj} is a measure of species fidelity (based on relative frequency of occurrence) across each sample unit in a treatment or site.

The inclusion of both the specificity and fidelity of species for calculation of indicator value is an important requirement for identifying useful bioindicators. For e.g., high specificity alone defines "characteristic species" but without consideration of fidelity, these species may be limited in their distribution across sampling points, limiting their ability to provide information on the progress of ecological change. Useful indicators will occur reliably among sampling units belonging to a treatment type or site.

Indicator values range from zero to 1 (perfect indication). A species was considered an indicator for a given habitat when its IV differed significantly from random (α = 0.05) after a Monte Carlo test based on 1999 permutations. Dufrêne and Legendre (1997) suggested an indicator value of 0.25 to designate indicator species. For our analyses we chose a more conservative threshold level of 0.50 for designating "strong" indicator species. All ISAs were performed in the R indicspecies package (De Caceres and Legendre 2009) and only strong and significant indicator species were included in results.

Indicator taxa selected by these analyses may be useful for monitoring long-term changes in treatment plots. Shifts in the frequency occurrence and distribution of these indicator taxa (and the emergence of different of indicator species) in subsequent surveys will serve useful in measuring the extent of change in treatment plots as natural regeneration proceeds. For instance, the turnover in these baseline indicator species may signal alteration in the ecological characteristics of the plot (e.g., progression from a bare-ground, freshly disturbed plot with low vegetation cover, to an early seral plot with some herb and shrub regeneration).

Community Similarity

Similarity in species composition across plot types and sites was calculated using the Sørensen similarity coefficient (Sørensen 1948), as follows:

% Sørensen Similarity = 2C / (A + B),

where A is the number of species present in site one, B is the number of species present in site two, and C is the number of species present in both site one and site two. This coefficient was chosen because it gives higher weight to species presences, which is more informative because species absences do not necessarily reflect environmental differences (Legendre and Legendre 2012).

To test for differences in species composition across strata we used Multi-Response Permutation Procedure tests (MRPP; Mielke and Berry 2001, McCune and Grace 2002). MRPP has the advantage of not requiring assumptions (such as multivariate normality and homogeneity of variances) that are seldom met with ecological community data. MRPP tests were performed in PC-ORD v. 6.08 with 4,999 permutations (McCune and Mefford 2011).

The test statistic of the MRPP procedure, T is calculated as:

$$T = \frac{\text{observed } \delta - \text{expected } \delta}{\text{standard deviation of expected } \delta}$$

Where δ is the weighted mean distance within groups (i.e., treatments or sites). Small values of δ imply a concentration of samples within groups in multi-dimensional space, and thus similarity of species assemblages. A negative value of T implies that the distance within groups was less than expected under the null hypothesis (more heterogeneous samples within treatments). Otherwise, T-values do not have standard bounds, since they are determined by the particular dataset, distance measure, and weighted-averaging method.

P-values for MRPP determine the probability of obtaining a δ as small or smaller than the observed by chance. These are calculated by Permutational Monte-Carlo tests, using integration of the Pearson type III distribution.

For a description of the effect size (independent of sample size) of differences in assemblages between treatments, the MRPP analysis calculates the "chance-corrected within-group agreement" statistic, A. When all samples are identical within treatments, then the observed $\delta = 0$ and $= 1$, the maximum value of A. An $A < 0$ implies that there is less similarity within groups than expected by chance. McCune and Mefford (2011) state that values of A < 0.1 are common in community ecology. A value of A > 0.3 indicates a large effect size. Thus, results with effect sizes less than zero were not considered ecologically significant and those with A < 0.1 were considered to have little ecological significance. We suggest the use of the following logical thresholds for interpreting the strength of effect size:

A < 0.1, little or no ecological significance

A < 0.2, low ecological significance

A < 0.3, moderate ecological significance

A > 0.3, high ecological significance

Arthropod Assemblages

We performed non-metric multidimensional scaling ordinations (NMDS) to determine the major compositional variation in arthropod species assemblages (spiders, ground beetles, and rove beetles) in plots and sites, and examine relationships with environmental variables. NMDS maximizes rank-order correlation between distance measures and the distance in ordination space. Points (i.e. plots) are moved to minimize mismatch between the two kinds of distance.

Community composition data frequently contain a large number of zeroes, which tends to produce highly skewed frequency distributions. Transforming abundance data is often necessary to make them suitable for ordination analyses (Legendre and Gallagher 2001). Standardized species abundances were Hellinger-transformed, whereby each taxon observation was relativized by the total taxon abundance, and square root transformed (Legendre and Gallagher 2001; Legendre and Legendre 2012). For ordinations of arthropods (spiders and beetles, combined), and for ordination of the spider community alone, Hellinger distance was used (minimized plot stress). Presence/absence Bray-Curtis distance was used for ordination of the beetle community. Correlations between the ordination axes and environmental variables were determined by 999 permutations. The most significant variables ($p < 0.1$) and species with high weighted average scores were plotted in figures to display major patterns. NMDS analyses were performed using the vegan package (Oksanen et al. 2014) in R.

4.5.3 Songbirds

Data summaries and basic statistics were produced to compare songbird use of habitats above and within the drawdown zone in Kinbasket Reservoir. As this was the first year of the woody debris removal, detailed statistical modelling or ordination techniques were not performed. Comparisons are made among plot types using non-parametric analyses of variance (Kruskal-Wallis test), with multiple comparisons corrected with a Bonferroni adjustment.

Point count methods apply mainly to songbirds and may fail to adequately detect other groups (e.g., grouse, waterbirds). Therefore only summaries are presented for major bird groups. Most detections of birds flying over were excluded from reported summaries because their presence overhead may not be indicative of their use of the habitat below. However, fly-overs were included for swallows (included within songbirds), swifts and hummingbirds, as they are seldom (swallows and hummingbirds) or virtually never (swifts) detected perched.

We examined individual species presence and counts for songbirds, swifts and hummingbirds within both 30 m and 75 m of point count centres to provide an overview of the avifauna documented within each plot type. Analyses in CLBMON-11A use the 75 m point count radius to compare differences in songbirds, swallows, swifts and hummingbirds between the drawdown zone and upland habitats, but only use songbirds detected within 30 m of the point count centre when assessing revegetation treatment effects. The 75 m buffer extends beyond treatment boundaries and into upland habitat at some locations, therefore this 30 m constraint helps ensures that only birds documented within a given treatment or control polygon will be used to assess treatment effects.

We assessed differences in species richness and relative abundance within and above the drawdown zone by reach by boxplot and using non-parametric comparative analytical techniques (Kruskal-Wallis test). Only observations within the 75 m point count radius were used for this assessment in 2014 because few observations were made within the 30 m point count radius and not at all plot types.

Analyses in CLBMON-11A use the 75 m point count radius to compare differences in songbirds, swallows, swifts and hummingbirds between the drawdown zone and upland habitats, but only use songbirds detected within 30 m of the point count centre when assessing revegetation treatment effects. The 75 m buffer extends beyond treatment boundaries and into upland habitat at some locations, therefore this constraint ensures that only birds documented within a given treatment or control polygon will be used to assess treatment effects.

4.5.4 Ungulates

Simple data summaries and plots were presented to compare presence and relative abundance of elk, deer spp. and moose across sites and transect types.

5.0 RESULTS

5.1 Environmental Conditions

Environmental conditions such as temperature, precipitation, and to a lesser extent relative humidity, can affect the activity of some animals. Weather data were obtained from Environment Canada's Mica Dam weather station (52°03'11.000" N 118°35'07.000" W; 579.10 m ASL) to create boxplots showing temperature and precipitation during April−September 2008−2010, 2012, and 2014 (Figure 5-1 and Figure 5-2).

Daily temperature varied by month from April to September ($F = 118.9$; $p < 0.001$) and among years ($F = 3.3$; $p = 0.01$), which is to be expected given inter-annual climate variability. Total rainfall was not statistically different between years ($F = 1.5$; $p = 0.17$), but was on a monthly basis, which is expected ($F = 2.2$; $p = 0.05$; Figure 5-2). The level of variation in precipitation and temperature is consistent with seasonal changes, and is not considered sufficient to affect the activity levels, and thus detections, of the focal taxa sampled in this study.

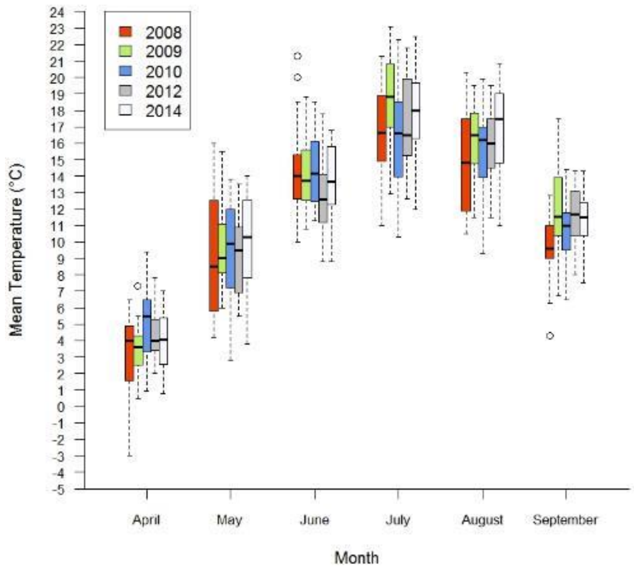

Figure 5-1: Daily mean temperature (°C) for April through September, 2008-2010, 2012, and 2014 as measured at Mica Dam, Kinbasket Reservoir. Data source: Environment Canada (http://climate.weather.gc.ca/index_e.html)

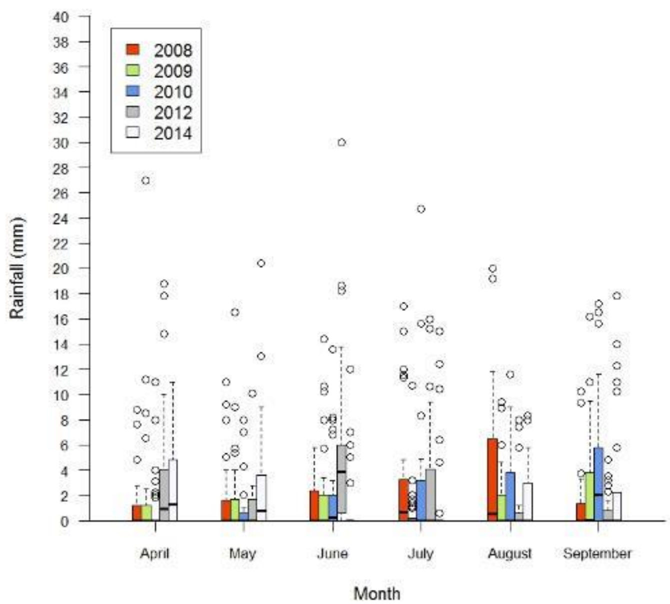

Figure 5-2: Daily precipitation (mm) for April through September, 2008-2010, 2012, and 2014 as measured at Mica Dam, Kinbasket Reservoir. Data source: Environment Canada (http://climate.weather.gc.ca/index_e.html)

5.1.1 Data Loggers

Data logger units recorded temperature and relative humidity values hourly, on the hour, from June 27 to August 5. Though most sampling occurred over the month of July, with only 4-5 days each in June and August, no temperature or humidity trends were obvious in that period, with average conditions varying widely among days. Temperature averaged 18.1 ± 7.7˚ C (SD) and relative humidity averaged 76.9 ± 24.2% (SD) (Figure 5-3).

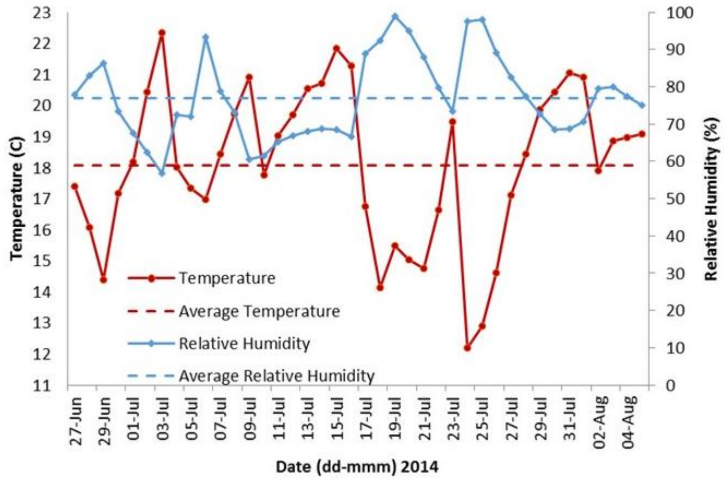

Figure 5-3: Daily mean (points and solid lines) and seasonal averages (dashed line) for temperature (red) and relative humidity (blue) as collected by dataloggers deployed at control, treatment, and reference transects in late June to early August, 2014

Temperature and humidity differences among plots within a given site may influence the vegetation or fauna (especially invertebrates) that occur there. Trends in temperature among treatment types appeared site specific (Figure 5-4). For example, at Valemount Peatlands North there was no difference in temperature among treatment, control, or reference plots ($p=0.806$). In comparison, there was a significant difference ($p<0.0001$) in temperature among treatment plots at Packsaddle South, with post-hoc comparisons finding differences between each treatment (i.e., all were unique). There was a significant difference in temperature among treatments at Yellowjacket ($p<0.0001$), where control and reference were similar and treatment was warmer. Despite the statistical significance, average differences in temperature among plots at a given site are low; typically being within 1-2 degrees.

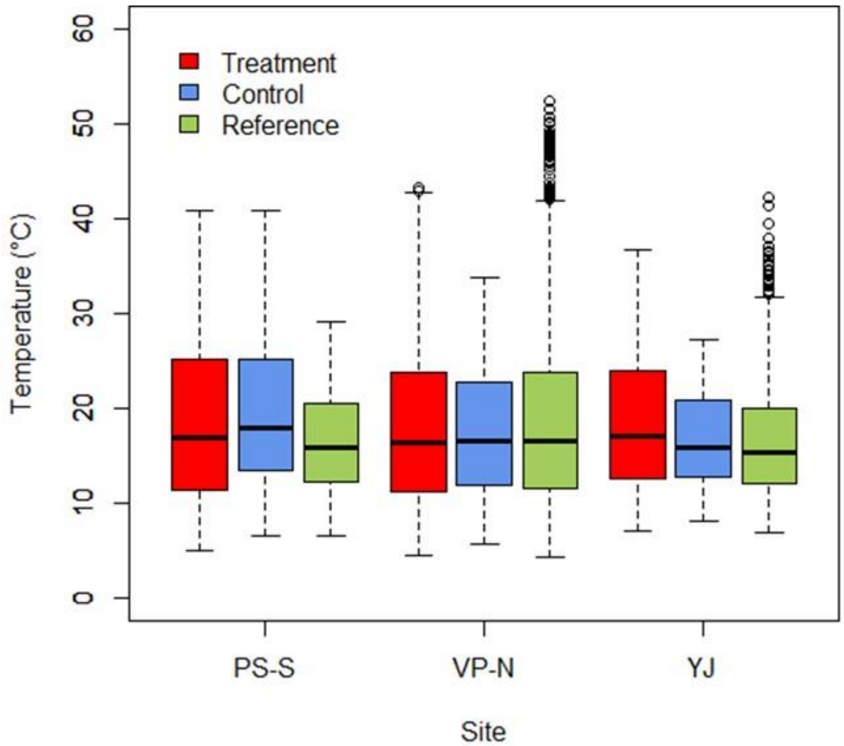

Figure 5-4: Boxplots illustrating temperatures recorded from three plots at three different sites (Packsaddle South: PS-S; Valemount Peatlands North: VP-N; and Yellowjacket: YJ)

Relative humidity values differed more dramatically among plots than did temperature (Figure 5-5). Again, there was no consistent response among sites. At each site, control, treatment and reference transects all differed from each other (Kruskal-Wallis test; all p-values <0.05). Relative humidity was most consistent among treatment plots within the Valemount Peatland North site.

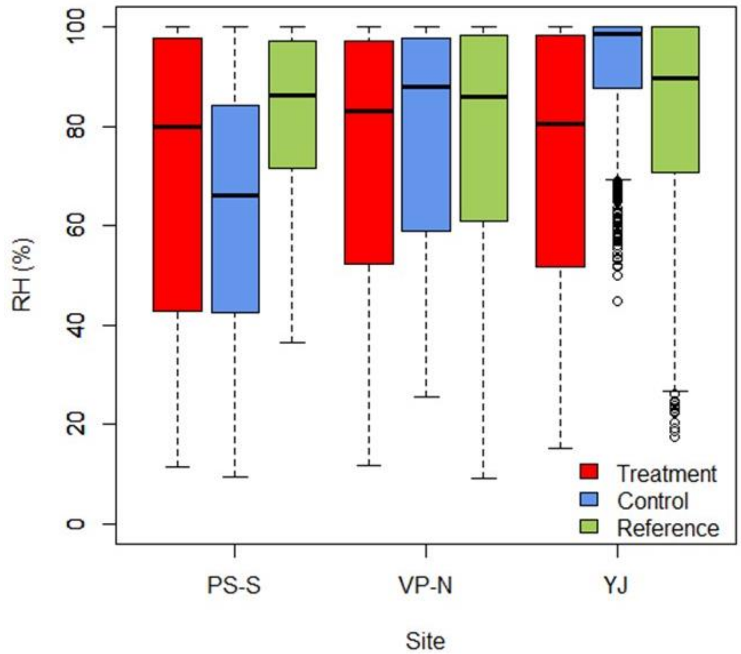

Figure 5-5: Boxplots illustrating relative humidity recorded from three plots at three different sites (Packsaddle South: PS-S; Valemount Peatlands North: VP-N; and Yellowjacket: YJ)

5.2 Reservoir Operations

The elevation of Kinbasket Reservoir during 2014 ranged from a low of 724.78 m ASL to a maximum of 753.92 m ASL (up to Nov. 8; Figure 3-2). Reservoir elevations were lowest from mid-March to mid-May. Water levels increased substantially from May through mid-July. Reservoir levels reached 753 m on 08 August, and remained relatively stable (between 753.00 and 753.92 m) throughout the remainder of the summer and fall.

Most work was conducted from June 3 to July 11, 2014. Water levels during this time period increased from 733.14 m ASL to 747.15 m ASL (Table 5-1), but all transects remained above the water level and our ability to sample pellets, arthropods, songbirds, or vegetation was unaffected.

Table 5-1: Kinbasket Lake Reservoir water elevations during field sampling periods in 2014. Note that start and end dates for taxa components are for the entire sampling period, but sampling was not continuous

			Reservoir Elevation (m ASL)		
Taxa Surveyed	Start Date	End Date	Min	Max	Mean
Pellet Plots	05 June	11 July	733.89	747.15	740.41
Songbirds	03 June	11 July	733.14	747.15	740.04
Arthropods	02 June	13 July	732.75	747.70	740.23
Vegetation	27 June	18 July	741.99	749.02	745.81
-	01 January	31 December	724.78	753.98	742.28

5.3 Arthropods

Overall, 6,319 individual arthropods (2,760 spiders and 3,559 beetles) were sorted and identified from the 2014 pitfall trapping session (Valemount Peatland North, Packsaddle Creek North, and Yellowjacket Creek sites only). Spiders comprised 15 different families in wide-ranging functional guilds, such as ambush predators (e.g., the crab spider *Xysticus obscurus*), foliage runners (e.g., the Leafcurling Sac Spider *Clubiona kulczynskii*), and orb weavers (e.g., the Thick-jawed Orb Weaver *Pachygnatha clercki*). Beetles were identified to 29 families; most of those collected (3,064 individuals) were in the target ground-dwelling beetle families (1,976 Carabidae specimens and 1,088 Staphylinidae specimens). There were a total of 201 species identified, with 95 species of spiders, 54 species of ground beetles, and 52 species of rove beetles (excluding the subfamily Aleocharinae).

5.3.1 Relative Abundance

The relative abundance (CPUE) of arthropods caught by pitfall traps was greatest in reference plots (3.8 individuals per trap-day), followed by control plots (3.7 individuals per trap-day) and was lowest in treatment plots (2.1 individuals per trap-day). Yellowjacket Creek housed the greatest relative abundance of arthropods (4.1 individuals per trap-day), followed by Valemount Peatland North (3.5 individuals per trap-day), and lastly, Packsaddle North (2.0 individuals per trap-day).

In general, spiders responded similarly to treatments across all sites, with the lowest spider abundance occurring in treatment plots in each site (Figure 5-6). This trend in low abundance was also found for beetles in treatment areas at PS-N and YJ, but not for the treatment at VP-N. Standardized beetle catch was greater in the treatment at VP-N than reference or control areas. For both spiders and beetles abundance patterns were inconsistent in control and reference plots.

Spiders were most abundant in the Yellowjacket Creek control plot, whereas beetles were most abundant in the Yellowjacket Creek reference plot (Figure 5-6). Ground Beetles, in the family Carabidae, were most numerous in the control plot at Yellowjacket Creek (Figure 5-7, left). Rove Beetles, in the family Staphylinidae, were dominant in the reference at Yellowjacket Creek (Figure 5-7, right), which accounted for the high overall beetle abundance in that area.

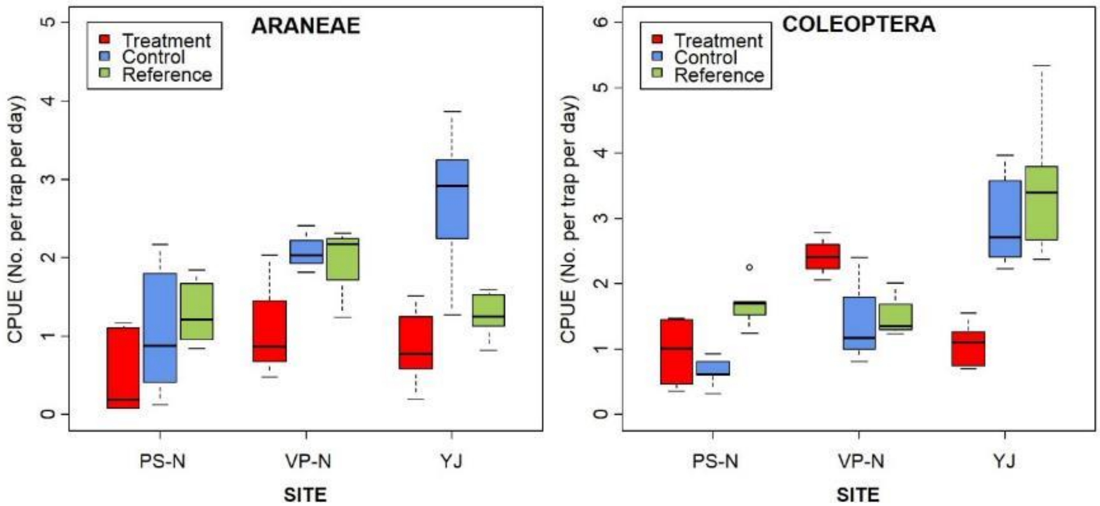

Figure 5-6: Variation in relative abundance (CPUE) of spiders (left) and beetles (right) caught in pitfall traps among plot types and sites in 2014. Beetle abundance includes all beetle families collected (not restricted to Carabidae and Staphylinidae). PS-N = Packsaddle North, VP-N = Valemount Peatland North, YJ = Yellowjacket Creek

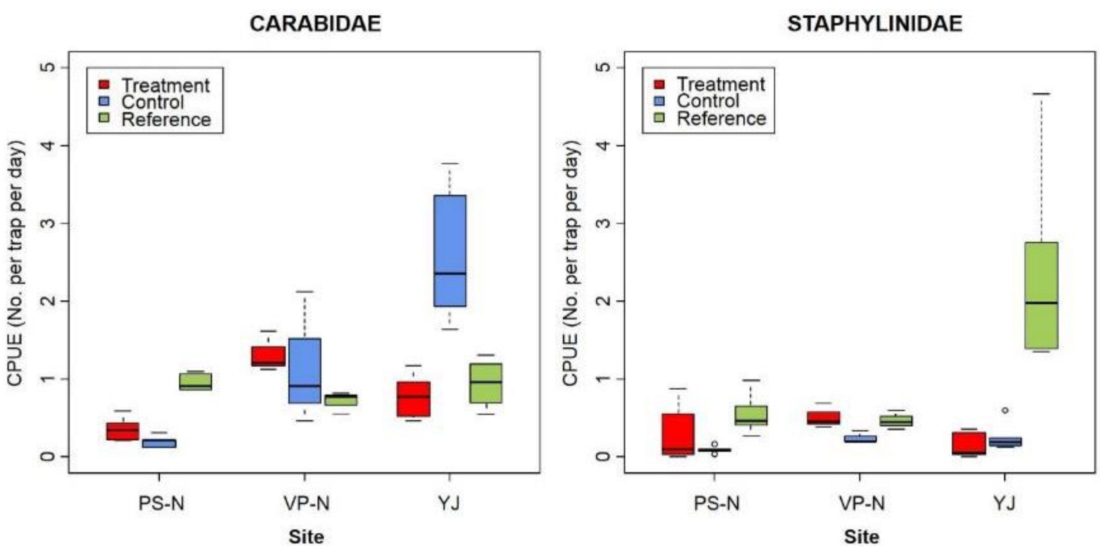

Figure 5-7: Variation in relative abundance (CPUE) of Ground Beetles (left) and Rove Beetles (right) caught in pitfall traps among plot types and sites in 2014. PS-N = Packsaddle North, VP-N = Valemount Peatland North, YJ = Yellowjacket Creek

5.3.2 Taxa Richness

Total richness of spiders, ground beetles, and rove beetles was greatest in Yellowjacket Creek site (140 spp. vs. 118 spp.; Table 5-2). Treatment plots had the lowest total species richness (all arthropods combined), followed by control, then reference plots (97 spp., 112 spp., and 116 spp., respectively; Table 5-2). This trend was mainly explained by spider richness, however, since reference plots had the lowest total beetle richness.

Mean species richness was highest at the reference sites, but was comparable for the drawdown zone control and treatment plots. One site, Valemount

Peatland North (VP-N) had greater species richness than Packsaddle North (PS-N) and Yellowjacket Creek. Richness of both spiders and beetles were elevated in Valemount Peatland North (Figure 5-8). The mean ranks of arthropod richness were significantly different between plots (X^2 = 11.19, 2 d.f., p<0.01), with reference plots containing the most species; no difference was detected between control and reference plots. Reference plots were found to be different than all other treatments for spider and beetle species examined alone (Spiders: X^2 = 14.22, 2 d.f., p<0.001; Beetles: X^2 = 8.32, 2 d.f., p=0.016). However, patterns differed between spiders and beetles.

Table 5-2: Total number of spider, ground beetle, and rove beetle species collected in each site and plot, including sampling effort. One pitfall trap collection was performed at Valemount Peatland North (VP-N), and two collections were performed for Yellowjacket (YJ) and Packsaddle North (PS-N) sites

SITES / PLOTS	No. of Traps	Total Trap Hours	Total Spp.	Spp. of Spiders	Spp. of Beetles
PS-N	162	20003.9	118	54	64
VP-N	81	9815.9	118	55	63
YJ	162	18004.8	140	62	78
Control	135	16553	112	45	67
Reference	135	15953.5	116	65	51
Treatment	135	15318.2	97	35	62
Grand Total	405	47824.6	201	95	106

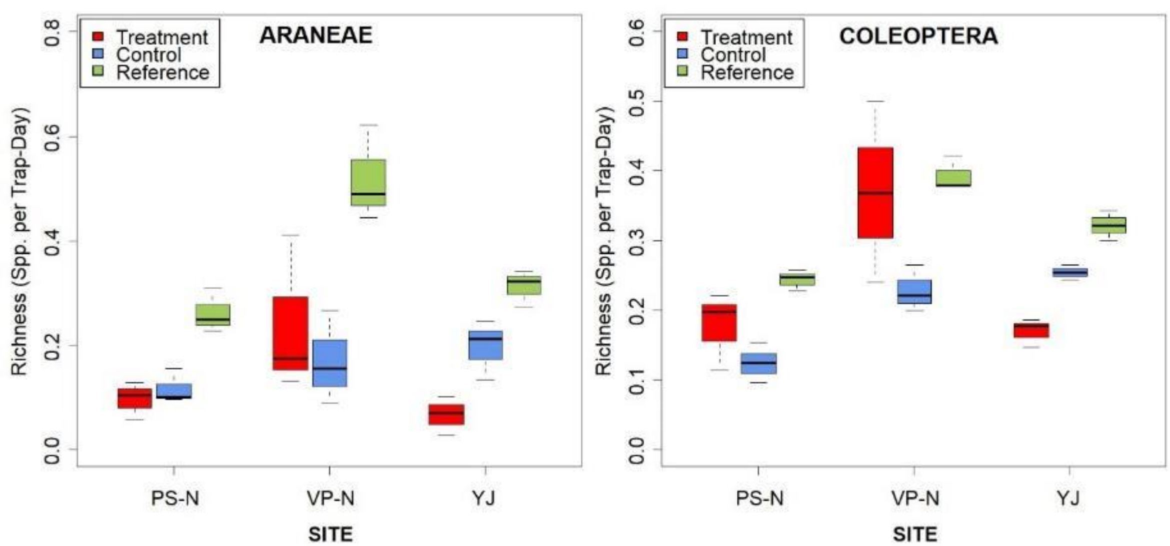

Figure 5-8: Variation in corrected species richness of spiders (left), Ground beetles and Rove beetles (right, pooled) caught in pitfall traps among plot types and sites in 2014. PS-N = Packsaddle North, VP-N = Valemount Peatland North, YJ = Yellowjacket Creek

1.1.1 Indicator Species

Indicator Species Analysis (ISA) revealed 63 strong indicator species for plot types (IV≥0.50, p<0.05; Table 5-3). Not surprisingly, reference sites had the greatest number of indicator species (20 spider spp., 15 rove beetle spp., and 10 ground beetle spp.). One large generalist predator rove beetle, *Dinothenarus pleuralis* (LeConte), was found in every reference plot (high frequency occurrence) and only in reference plots (high specificity), and thus was a perfect indicator of reference sites (IV= 1.0, p<0.001).

Ten species were indicators of control plots (6 ground beetle spp., 3 spider spp., and 1 rove beetle sp.). The best indicator of control plots was the spider *Pirata piraticus* (Clerck), which is a ground-running spider in the family Lycosidae (IV = 0.73, p<0.001). This species was only found in control plots (high specificity), however, it was only collected in two sites (VP-N and YJ), and thus it's fidelity for control sites is moderate. Beetle indicator species for control plots were generally riparian/moisture-associated species that are known to seek cover objects (logs, stones, litter) during the day (e.g., *Pterostichus riparius* (Dejean), *Bembidion nigripes* (Kirby), and *Loricera decempunctata* Eschscholtz).

Five indicator species were found for treatment (woody debris removal) plots, including four ground beetle species and one spider species (Table 5-3). The Thin-legged Wolf Spider *Pardosa wyuta* Gertsch and Long-lipped Tiger Beetle *Cicindela longilabris* Say are both open habitat specialists that are native to Canada. *C. longilabris* is xerophilous, being strongly associated with dry, sandy sites. The remaining three indicators of treatment plots are all non-native species (*Bembidion planatum* (LeConte), *B. obscurellum* (Motschulsky), and *B. tetracolum* Say) that are often found along open, sandy shores of lakes and rivers. Additionally, there were three indicator taxa that were most indicative of control and treatment plots together; thus the wolf spiders *Pardosa xerampelina* (Keyserling) and *P. moesta* Banks, and the ground beetle *Pterostichus adstrictus* Eschscholtz are indicators of the drawdown zone in general. These species are known to be associated with open habitats.

The indicator taxa revealed here provide a useful subset of taxa to monitor changes from the 2014 baseline ("zero-year") treatment condition. Altered frequency occurrence and distribution of indicator species may reflect changes in the habitat quality of plots. Monitoring these changes as revegetation progresses throughout the study will be central to assess the effectiveness of woody debris removal for enhancing the wildlife habitat in the drawdown zone of Kinbasket Reservoir.

Table 5-3: Summary of Indicator Species Analysis indicating the species with significant (p<0.05) and "strong" relatioships with treatment types (IV≥0.5). Control = CON, Treatment = TRT, Reference = REF; taxon groups are indicated as: A = Araneae, C = Carabidae, S = Staphylinidae; IV = Indicator Value

Plot	Indicator Species	IV	p-value
REF	*S-Dinothenarus pleuralis*	1.00	<0.001
REF	*C-Pterostichus pensylvanicus*	0.96	<0.001
REF	*C-Calathus ingratus*	0.94	<0.001
REF	*A-Walckenaeria directa*	0.93	<0.001
REF	*C-Agonum retractum*	0.92	<0.001
REF	*C-Scaphinotus marginatus*	0.86	<0.001
REF	*A-Lepthyphantes alpinus*	0.82	<0.001
REF	*A-Euryopis argentea*	0.82	<0.001
REF	*S-Tachyporus nitidulus*	0.78	<0.001
REF	*A-Ceraticelus fissiceps*	0.77	<0.001
REF	*C-Scaphinotus angusticollis*	0.77	<0.001
REF	*A-Walckenaeria exigua*	0.76	<0.001
REF	*C-Pterostichus protractus*	0.76	<0.001
REF	*S-Lordithon fungicola*	0.75	<0.001
REF	*S-Quedius labradorensis*	0.75	<0.001
REF	*A-Tapinocyba minuta*	0.73	<0.001
REF	*A-Oreonetides filicatus*	0.68	<0.001
REF	*A-Tenuiphantes zelatus*	0.68	<0.001
REF	*A-Xysticus obscurus*	0.68	<0.001
REF	*S-Ischnosoma splendidum*	0.68	<0.001
REF	*S-Quedius velox*	0.68	<0.001
REF	*C-Pterostichus neobrunneus*	0.67	<0.01
REF	*A-Lepthyphantes intricatus*	0.63	<0.001
REF	*A-Symmigma minimum*	0.63	<0.01
REF	*S-Scaphium castanipes*	0.63	<0.01
REF	*S-Carphacis nepigonensis*	0.63	<0.01
REF	*A-Bathyphantes pallidus*	0.63	<0.01
REF	*S-Tachyporus borealis*	0.63	<0.01
REF	*S-Anthobium sp.1*	0.61	<0.01
REF	*C-Pterostichus herculaneus*	0.61	<0.01
REF	*A-Pocadicnemis americana*	0.60	<0.01
REF	*A-Micaria pulicaria*	0.60	<0.01
REF	*A-Hypselistes florens*	0.58	<0.01
REF	*A-Hahnia cinerea*	0.58	0.01
REF	*A-Sciastes truncatus*	0.58	0.01
REF	*A-Agroeca ornata*	0.58	<0.01
REF	*S-Ischnosoma fimbriatum*	0.58	<0.01
REF	*C-Harpalus sp.1*	0.56	0.02
REF	*C-Carabus taedatus*	0.54	0.01
REF	*S-Actiastes foveicollis*	0.53	0.03
REF	*A-Ceratinella brunnea*	0.52	0.02
REF	*A-Pelecopsis sculpta*	0.52	0.03
REF	*S-Bolitobius sp.1*	0.52	0.03
REF	*S-Gabrius brevipennis*	0.52	0.03
REF	*S-Tachinus basalis*	0.52	0.03
CON	*A-Pirata piraticus*	0.73	<0.001
CON	*C-Loricera decempunctata*	0.72	<0.01
CON	*C-Agonum metallescens*	0.67	<0.01
CON	*A-Pardosa fuscula*	0.67	<0.01
CON	*C-Bembidion nigripes*	0.66	<0.01
CON	*C-Bembidion incrematum*	0.62	<0.01
CON	*C-Pterostichus riparius*	0.61	0.02
CON	*A-Pachygnatha clercki*	0.56	<0.01
CON	*C-Loricera pilicornis*	0.52	0.03
CON	*S-Tetartopeus niger*	0.52	0.03
TRT	*C-Bembidion planatum*	0.82	<0.001
TRT	*C-Bembidion obscurellum*	0.78	<0.001
TRT	*C-Bembidion tetracolum*	0.66	<0.001
TRT	*C-Cicindela longilabris*	0.66	<0.01
TRT	*A-Pardosa wyuta*	0.54	0.03
CON+ TRT	*A-Pardosa xerampelina*	0.95	<0.001
CON+ TRT	*C-Pterostichus adstrictus*	0.87	<0.001
CON+ TRT	*A-Pardosa moesta*	0.72	<0.01

5.3.3 Exotic Beetle Species

Pitfall trap samples contained a total of 11 beetle species that are known to be adventive in Canada. Exotic beetles were more abundant in treatment plots than control or reference plots (Figure 5-9, left; $X^2 = 15.56$, 2 d.f., $p<0.001$). Treatment plots also contained the greatest number of exotic beetle species (Figure 5-9, right; $X^2 = 14.81$, 2 d.f., $p<0.001$). Richness of exotic beetles was not significantly different between control and reference plots ($p>0.10$). The generalist ground beetles, *Pterostichus melanarius* (Illiger), *Harpalus affinis* (Schrank), *Bembidion tetracolum* Say, and *Agonum muelleri* (Herbst) were the most commonly occurring exotic species at treatment sites. The rove beetle *Philonthus cognatus* Stephens accounted for a large portion of the exotic beetle abundance in control plots, however it was only found at Yellowjacket Creek. This species has been reported to aggregate in large numbers on vegetation where it preys chiefly on aphids.

Results of the kruskal-wallis test for differences in mean ranks of exotic beetle abundance (CPUE) and richness (Spp. per trap-day) between sites were insignificant ($p>0.1$).

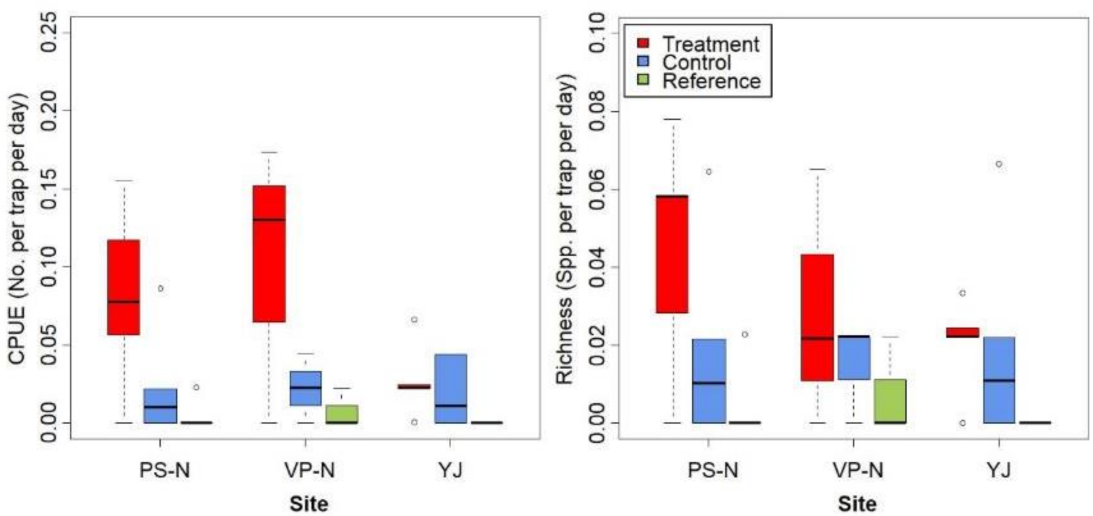

Figure 5-9: Variation in relative abundance (left) and richness (right) of exotic beetle species (Carabidae and Staphylinidae) caught in pitfall traps among plot types and sites in 2014. PS-N = Packsaddle North, VP-N = Valemount Peatland North, YJ = Yellowjacket Creek

5.3.4 Dispersal-Limited Beetle Species

The flight ability of ground beetles often reflects the condition of their habitat. Generally, large, weak-dispersing specialists decrease along a disturbance gradient. These species are replaced by small-bodied, generalist species with high dispersal ability in disturbed sites. Thus, it is often informative to record the wing morphology of ground beetles in pitfall trap samples.

Pitfall trap samples from Kinbasket Reservoir contained 19 beetle species with reduced flight ability (reduced or absent wings, i.e., “brachypterous”). The majority of brachypterous individuals and species were collected in reference plots, whereas treatment plots had the lowest catch and richness of short-winged beetles (Figure 5-10). Kruskal–Wallis tests were significant for differences in mean rank of standardized abundance (X^2 = 26.72, 2 d.f., p<0.001) and richness (X^2 = 27.86, 2 d.f., p<0.001) of brachypterous beetles. Pairwise comparisons reveal significant differences between all plots for abundance, yet for richness, only the reference plot was different from control and treatment. No significant differences were found between sites (p>0.1).

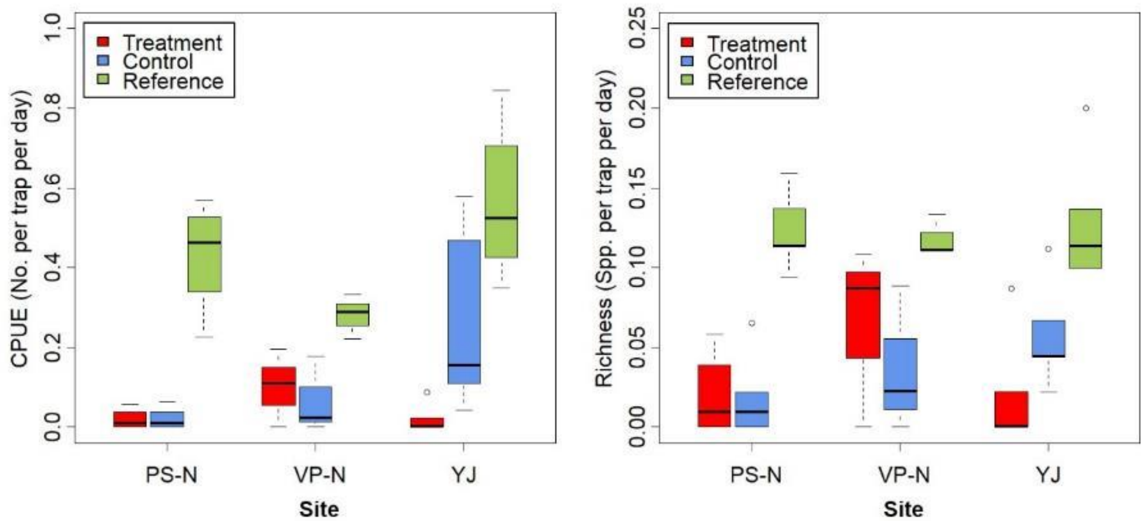

Figure 5-10: Variation in relative abundance (left) and richness (right) of short-winged beetle species (Carabidae and Staphylinidae) caught in pitfall traps among plot types and sites in 2014. PS-N = Packsaddle North, VP-N = Valemount Peatland North, YJ = Yellowjacket Creek

5.3.5 Arthropod Assemblages & Similarity

Similar to patterns observed with taxa in previous years, the arthropod species formed two distinct groups: one characteristic of the reference forest plots, and one associated with the control and treatment plots in the drawdown zone (Figure 5-11). Mature forest reference plots in Packsaddle Creek North (PS-N), Valemount Peatland North (VP-N), and Yellowjacket Creek (YJ) had similar composition of arthropod species (Figure 5-11: A). Average Sørensen Similarity was highest among reference sites (mean = 61.0%), due to a large number of species shared between reference sites. Thirty-one species of arthropods occurred in all three reference sites. Additionally, the arthropod assemblages in reference plots were significantly different from non-reference plots (control and treatment; Table 5-4).

However, control and treatment communities were not found to be significantly different and the effect size was insufficient (A < 0.1) for interpretation (Table 5-4). Control plots tended to have higher relative humidity and cooler daily temperatures than treatment plots (Figure 5-11: D). Control plots housed more hygrophilous beetle species (e.g., *Agonum metallescens*, *Pterostichus riparius*, *Bembidion nigripes*).

Table 5-4: Summary statistics for Multiple Response Permutation Procedure (MRPP) test of differences in arthropod composition between plot types. Distance measure: Hellinger dissimilarity; 201 spp.; 9 plots; * indicates statistical significance at α = 0.1. The test statistic, $\boldsymbol{T}$ is <0, indicating that species assemblages were more heterogeneous within groups (observed $\boldsymbol{\delta}$) than expected by chance (expected $\boldsymbol{\delta}$). The effect size, $\boldsymbol{T}$ is within the acceptable range (>0.1) for interpretation of effects in ecology for all comparisons except control vs treatment

MRPP (Treatment Type): observed δ= 0.60, expected δ = 0.73 $\boldsymbol{T}$ **= -2.88,** $\boldsymbol{A}$ **= 0.15,** $\boldsymbol{p}$ **= 0.01**				
Multiple comparisons	T	A	p-value	
Control vs. Reference	-2.89	0.20	0.022	*
Control vs. Treatment	0.43	-0.02	0.564	
Reference vs. Treatment	-2.79	0.18	0.023	*

Although sites were not found to be significantly different in arthropod composition (p>0.1), the control and treatment plots of Yellowjacket Creek (YJ) appeared more dissimilar than the control and treatment plots sampled at Valemount Peatland North (VP-N) and Packsaddle Creek North (PS-N; Figure 5-11: A). The drawdown zone arthropod communities at the VP-N and PS-N sites are more homogenous than the drawdown zone communities at YJ.

Examining spider (Figure 5-12) or beetle (Figure 5-13) taxa alone was not as informative as examining the communities together (Figure 5-11). Overall, in this baseline implementation year of woody-debris removal, we were able to observe immediate differences in the arthropod assemblages between plot types. Differences in arthropod assemblages were greatest between reference plots and drawdown zone plots, but there were some differences in species of control and woody debris removal treatment plots.

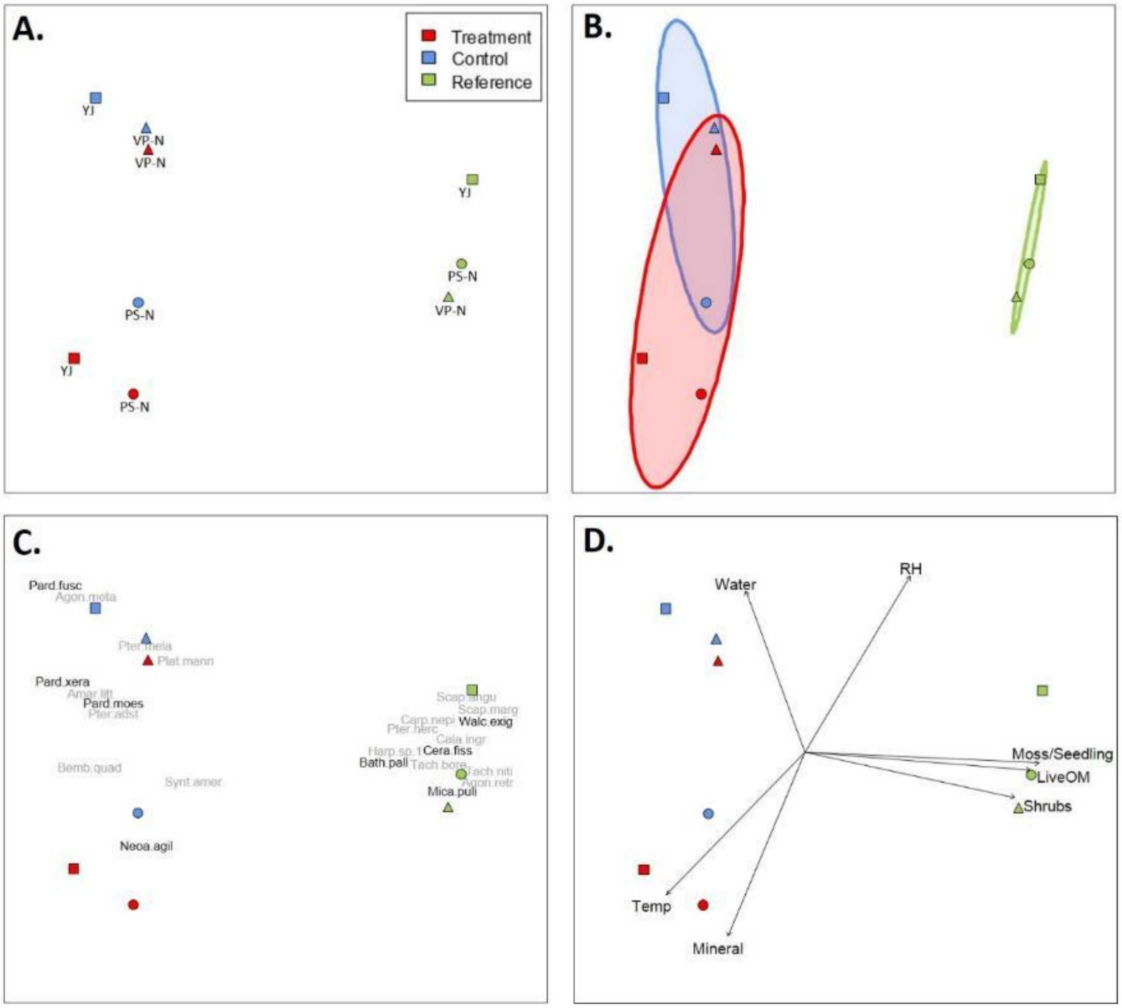

Figure 5-11: Non-metric Multidimensional Scaling (NMDS) ordination diagram of arthropod species (Araneae, Carabidae, and Staphylinidae) assemblages at plots within each site (A). Ellipses represent 95% confidence areas around treatment (red), control (blue), and reference (green) plots (B). Species with high weight average scores are overlaid (C), with spiders (black text) and ground/rove beetles (grey text). Environmental variables significantly ($p<0.1$) related with the axes are superimposed on the ordination (D). Taxa shown are those strongly associated with a given type of plot or site. Species codes are given in the appendices (Appendix 9-C; Appendix 9-D). Environmental vectors point in the direction of the gradient, with climate data (RH = Relative Humidity, Temp = mean daily Temperature) and per cent cover of substrate classes (e.g., cover of: water, moss/seedlings, LiveOM= Live Organic Matter, Shrubs, and Mineral Soil)

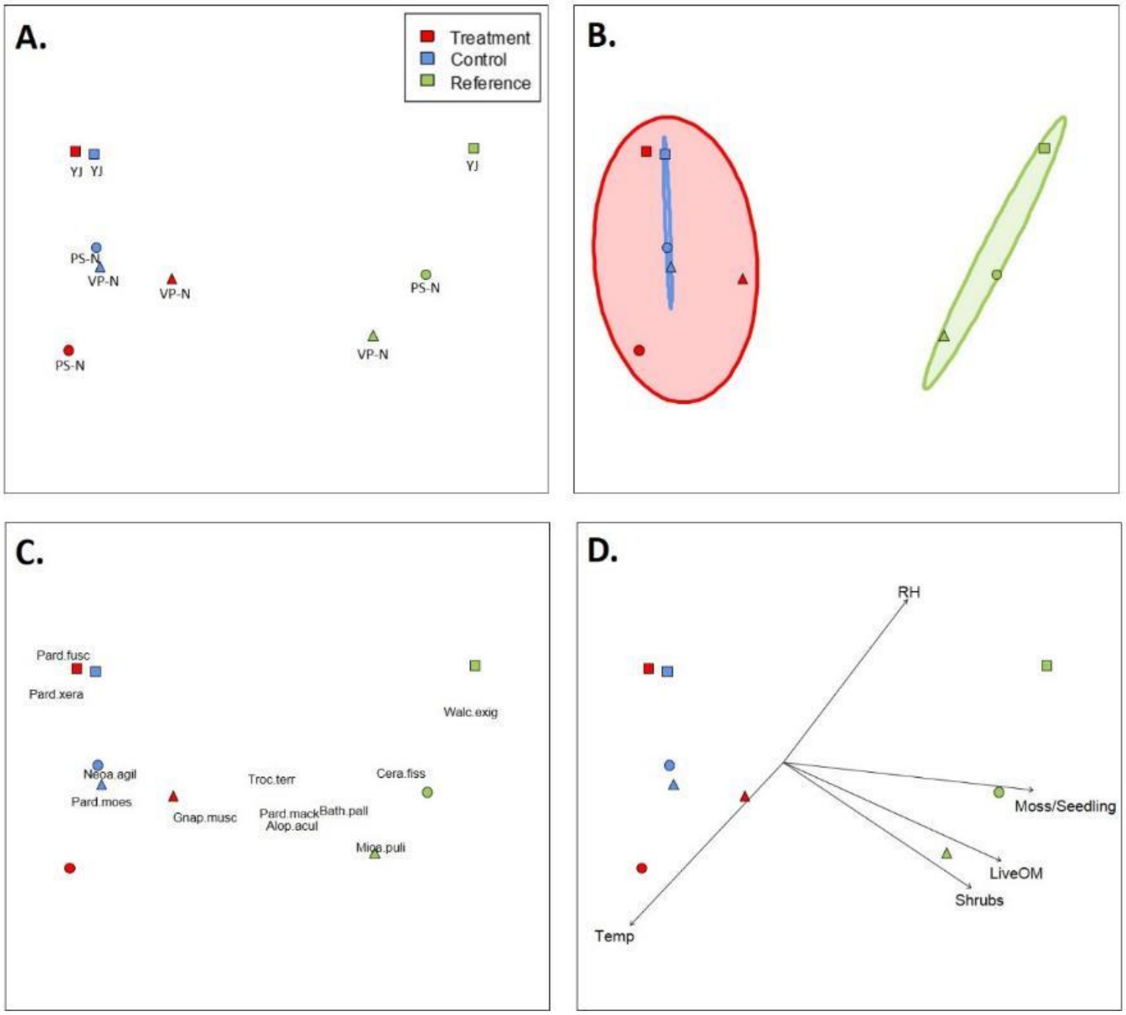

Figure 5-12: Non-metric Multidimensional Scaling (NMDS) ordination diagram of spider species (Araneae) assemblages at plots within each site (A). Ellipses represent 95% confidence areas around treatment (red), control (blue), and reference (green) plots (B). Species with high weight average scores are overlain (C). Environmental variables significantly ($p<0.1$) related with the axes are superimposed on the ordination (D). Species codes are given in the appendices (Appendix 9-C; Appendix 9-D). Environmental vectors point in the direction of the gradient

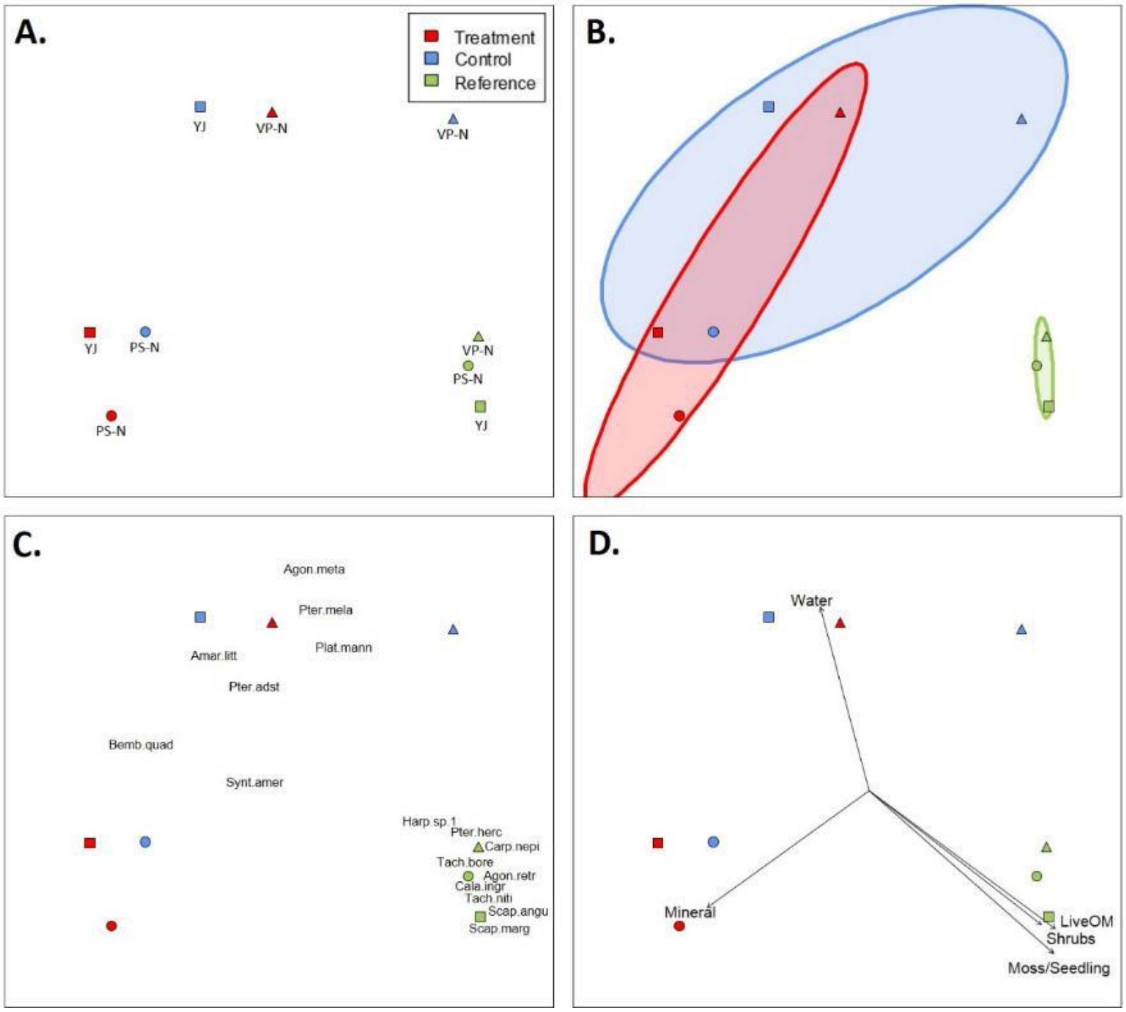

Figure 5-13: Non-metric Multidimensional Scaling (NMDS) ordination diagram of Ground and Rove beetle species (Coleoptera: Carabidae, Staphylinidae) assemblages at plots within each site (A). Ellipses represent 95% confidence areas around treatment (red), control (blue), and reference (green) plots (B). Species with high weight average scores are overlain (C). Environmental variables significantly (p<0.1) related with the axes are superimposed on the ordination (D). Species codes are given in the appendices (Appendix 9-C; Appendix 9-D). Environmental vectors point in the direction of the gradient.

5.4 Songbirds

A total of 49 point count stations were surveyed between June 3 and July 11, 2014. Each point count station was surveyed three times in that time period, with the exception of two points which were both surveyed twice. Sampling effort was not even among all treatments. Control, reference, and treatment groups had similar levels of sampling effort, with 40, 45 and 48 point counts completed respectively, while the natural treatment had only 12 point counts completed (Appendix 9 E). “Natural” sites will not be carried forward for sampling in future years. These were intended to fall within the control, treatment and reference plots; however, in this area bird sampling pre-dated the plot boundary establishment. They are retained here for completeness.

5.4.1 Songbird Richness and Composition

During point count surveys a total of 67 bird species representing 1,134 observations were recorded (Appendix 9-B). These included all bird species regardless of taxonomic grouping or distance from the observer. Considering only songbirds, swifts and hummingbirds within 75 m of the point count centre, the total number of species is 48 comprising 461 observations (Table 5-5). Only one species of conservation concern was located during these surveys: one observation of two Barn Swallows (*Hirundo rustica*) flying over the Valemount Peatlands North site. Barn Swallows are blue-listed provincially and designated Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

Table 5-5: Total number of species (Spp), observations (Obs) and individuals (Ind) of songbird, swifts and hummingbirds detected within 75 m of breeding bird point count surveys in 2014

	Control			Reference			Treatment			Natural			Total		
Group	**Spp**	**Obs**	**Ind**	**Spp**	**Obs**	**Ind**	**Spp**	**Obs**	**Ind**	**Spp**	**Obs**	**Ind**	**Spp**	**Obs**	**Ind**
Songbirds	34	164	183	24	177	183	23	90	92	10	27	29	46	458	487
Swifts and Hummingbirds	2	2	2	1	1	1							2	3	3
Total	**36**	**166**	**140**	**25**	**178**	**184**	**23**	**90**	**92**	**10**	**27**	**29**	**48**	**461**	**490**

[1]Obs refers to the total number of unique observations of birds. Thus, a flock of ten individuals would count as one observation. The majority of observations consist of a single individual.

[2]Ind refers to the total number of individuals recorded, regardless of association with other birds. Thus, one observation of a flock of ten birds counts as ten individuals. Note that due to repeated sampling at the same station, the real number of individuals detected over the entire sampling period will be somewhat less than the numbers given here.

Considering only songbirds, swifts and hummingbirds within 75 m, there were sixteen species represented by a single sighting. Conversely, the top ten most detected species (21% of species) accounted for 64% of all detections (Figure 5-14). The top five most detected species belonged to five different passerine families (Vireonidae, Parulidae, Turdidae, Tyrannidae, and Emberizidae). This indicates that the trends seen are likely more influenced by habitat or food preferences than factors intrinsic to one family of birds.

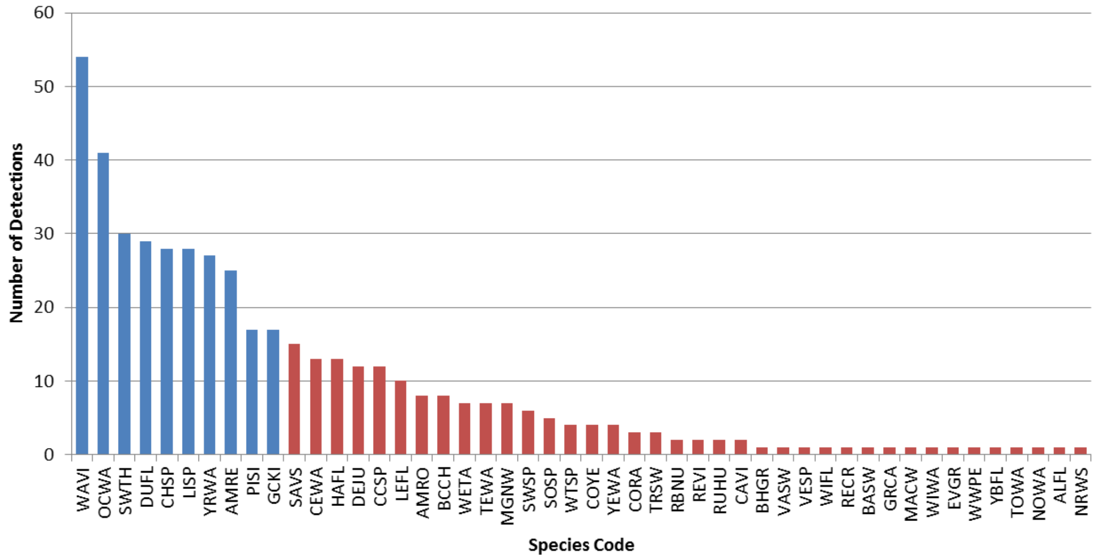

Figure 5-14: Number of observations of each species recorded within 75 m of all point count surveys in 2014. Blue bars show top ten most commonly detected species. One-third of all species detected are represented by a single observation

Four species were recorded in all four treatments (i.e., control, natural, reference, and treatment). These include the top two most commonly detected species (Warbling Vireo and Orange-crowned Warbler), and two others in the top ten most frequently detected species (Chipping Sparrow and Pine Siskin). Twelve species were recorded from three plots, ten from two plots, and 22 species were recorded solely from one plot. Of these 22 species, 13 were found in control sites, and two, three, and four species were unique to natural, reference, and treatment plots respectively. Many of the species unique to a treatment type were seldom detected, and are thus likely unique owing to chance of detection rather than factors intrinsic to where they were detected; the exception being certain species that prefer the more mature habitat of the reference plots. The assemblage of rare and unique birds is unlikely to be of much utility in assessing revegetation success following woody-debris removal owing to the stochastic uncertainty related to low sample sizes, but rather common species with determined habitat affinities should be considered, along with overall richness and abundance values among the treatments.

The number of species shared pair-wise between control, reference and treatments were similar, with fewer shared species between natural and any other plot type, likely owing to sample effort discrepancies (Table 5-6).

Table 5-6: The number of shared species between all plots. Numbers in shaded cells refer to the total number of species recorded from a given plot. Numbers in brackets refer to the percentage of total species in the plot labelled in the first column that are found in the respective plot of subsequent columns. For example, the control plot shares 19% of its total species with the natural plot, while the natural plot conversely shares 70% of its total species with the control plot.

	Control	Natural	Reference	Treatment
Control	36	7 (19)	19 (53)	16 (44)
Natural	7 (70)	10	5 (50)	7 (70)
Reference	19 (76)	5 (20)	25	16 (64)
Treatment	16 (70)	7 (30)	16 (70)	23

The richness (number of species per point count) varied within and among plots. A Kruskal-Wallis test with Bonferroni adjustment comparing the richness of the plots at the 75 m distance level found a significant difference ($p < 0.001$), with multiple pair-wise comparisons highlighting similarities and differences among the groups (Figure 5-15).

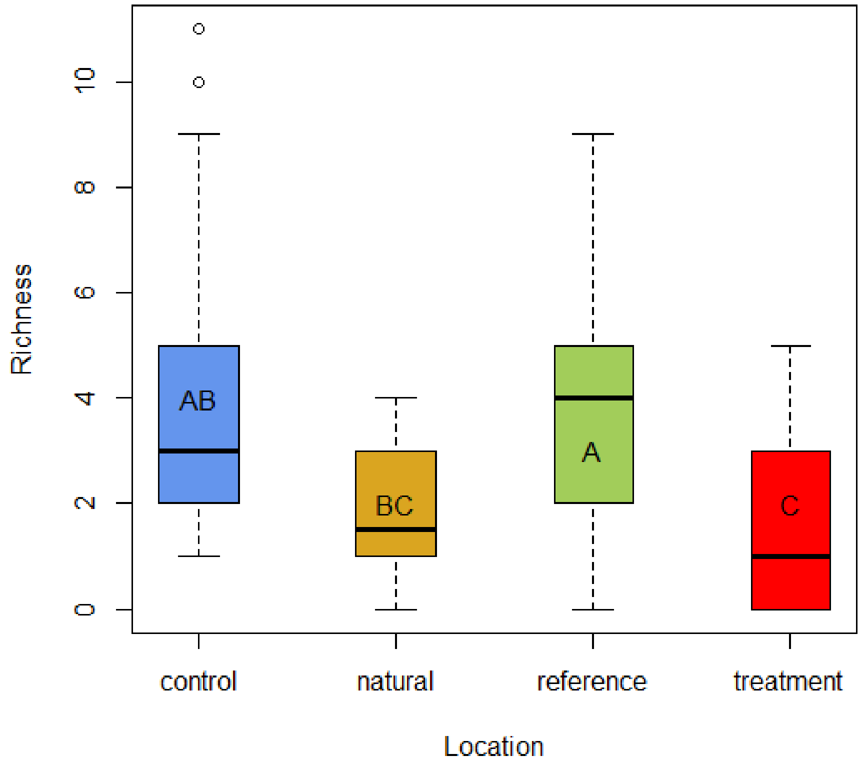

Figure 5-15: Boxplots showing richness (number of species per point count) at each treatment type. Letters within the boxplots indicate results of multiple non-parametric pair-wise comparisons. Like letters indicate statistically equivalent values. In general, control and reference sites have greater richness than natural and treatment sites, though the relationship between control and natural sites requires further investigation

Similar richness values do not necessarily imply similarity in bird communities. When corrected for sampling effort, the habitat affinities of some bird species become clearer (Figure 5-16). For example, Savannah Sparrows, which were detected both in control and natural sites, were relatively more abundant in natural sites. Others, like Chipping Sparrow, were more evenly detected from all plots. Such affinities are important to consider when assessing the relative effectiveness of various habitat prescriptions. Additional years of sampling are required before conclusions can be drawn, but it is expected that Savannah Sparrow will be a good indicator of habitat revival in the drawdown zone at treatment sites, based on these data.

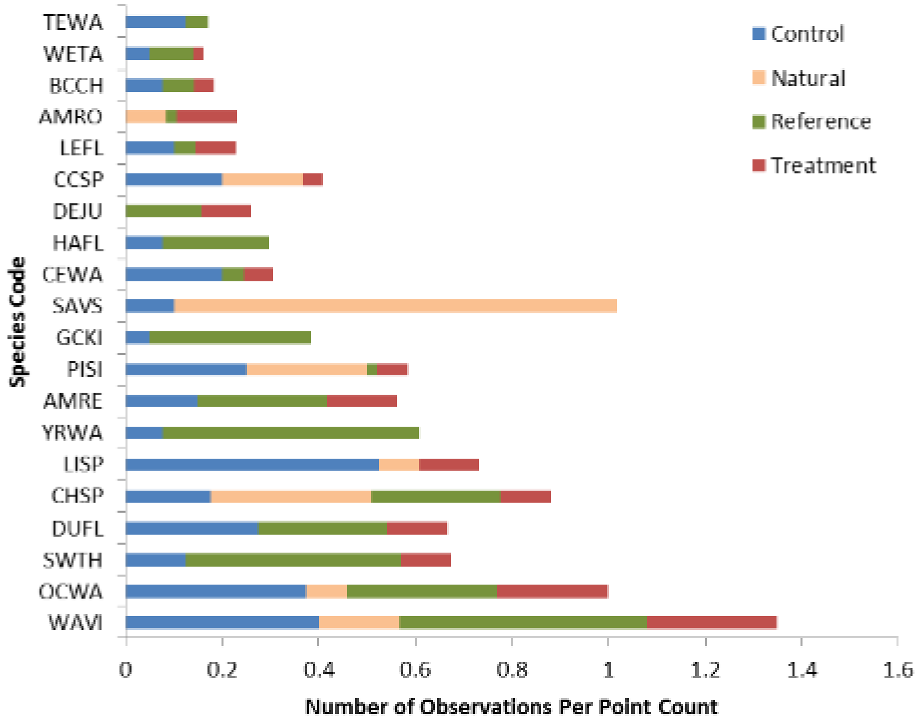

Figure 5-16: The number of observations of the twenty most commonly detected species corrected for sampling effort. Colours refer to plot type. Data are based on 75 m distance band from point count centre, and thus may include vegetation structure atypical of the plot of interest

Vegetation outside of the plot of interest can influence point count detections, especially where that vegetation occurs within a 75 m radius of the point count centre. As habitat prescriptions (e.g., woody debris removal, revegetation of drawdown zone) are often on smaller scales than that encompassed by the point count, we further constrained analyses of point count data to within 30 m of the count centre. Considering only bird observations within 30 m of the point count centre, there were a total of 25 bird species detected (Figure 5-17).

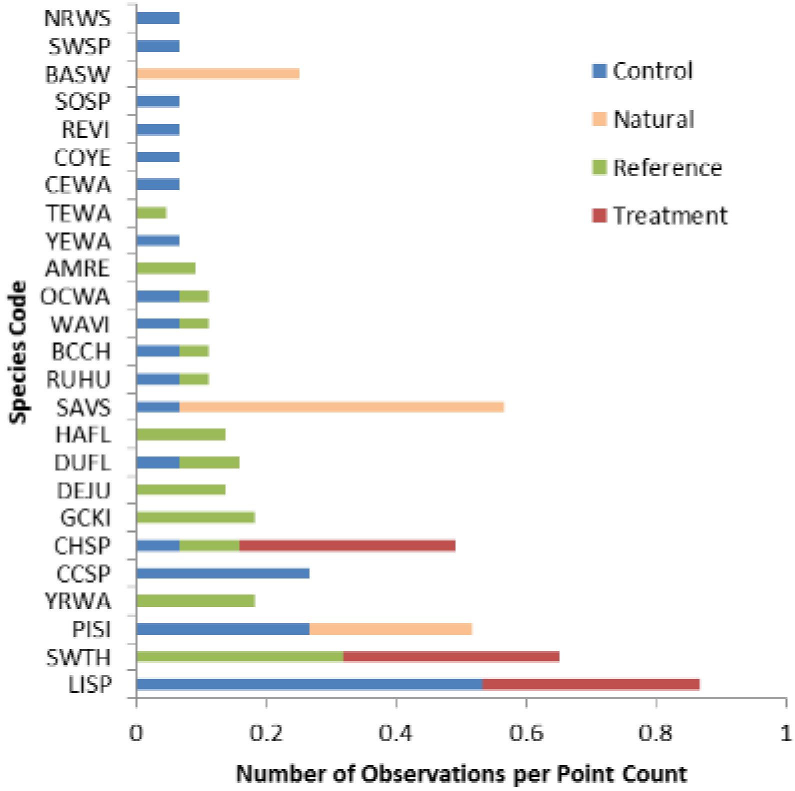

Figure 5-17: The number of observations of all species recorded within 30 m of the point count centre, corrected for sampling effort. Colours refer to treatment. Within a distance band of 30 m, data are limited but less likely to be influenced by adjacent habitats. Savannah Sparrow stands out as a potential focal species for assessing the effectiveness of woody debris removal

Fewer shared species occurred among plots based on a 30 m buffer, but this is reflective of the fewer total number of species owing to a smaller sampling area that likely encompasses less vegetation structure and diversity (Table 5-7). A Kruskal-Wallis test of richness among treatments, constrained to within 30 m of the point count centre, was significant at alpha = 0.10 (p-value = 0.059); however, post-hoc all-pairwise comparisons found no significant differences among the treatments. Looking at the mean values, both control and reference had greater richness than treatment and natural sites (which were equal). It is likely that some differences do exist, though greater power will be needed to detect a trend at this scale.

Table 5-7: The number of shared species between all plots based on observations within 30 m of a point count centre. Numbers in shaded cells refer to the total number of species recorded from a given plot. Numbers in brackets refer to the percentage of total species in the plot labelled in the first column that are found in the respective plot of subsequent columns. For example, the control plot shares 12% of its total species with the natural plot, while the natural plot conversely shares 67% of its total species with the control plot.

	Control	Natural	Reference	Treatment
Control	17	2 (12)	6 (35)	2 (12)
Natural	2 (67)	3	0	0
Reference	6 (46)	0	13	2 (15)
Treatment	2 (67)	0	2 (67)	3

5.4.2 Songbird Abundance

Abundance refers to the number of individuals detected per point count. Point count survey detections are comprised mostly of vocalizing birds. As such, we looked only at the number of singing males within 75 m of a point count centre when calculating abundance estimates, as this is most likely to correspond to the number of bird territories within the point count buffer. There was a significant difference in abundance among plots (Kruskal-Wallis test; p-value = 0.03). Reference and control sites had equal abundance, while control was also equal to treatment and natural sites (Figure 5-18).

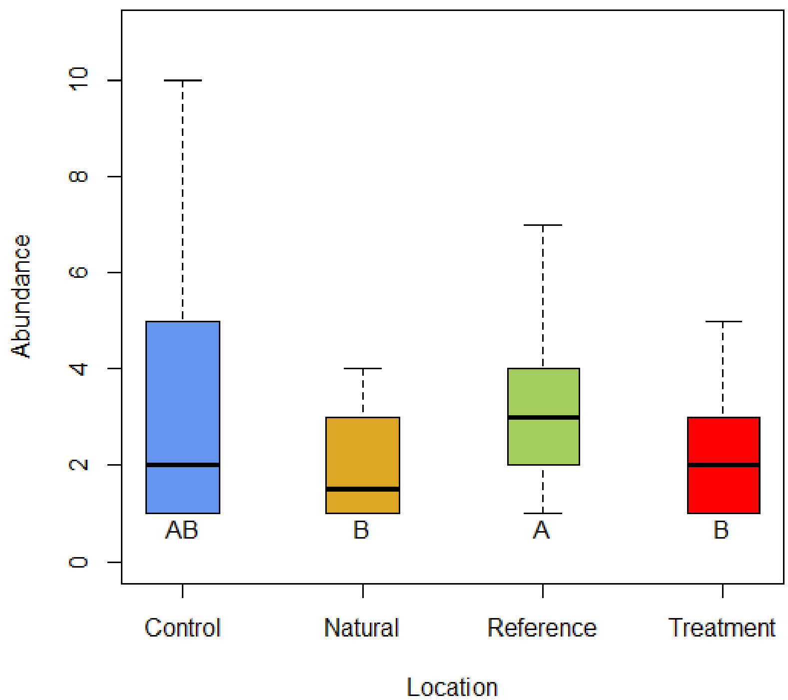

Figure 5-18: Boxplots showing abundance (number of individual singing males within 75 m of point counts) within each plot. Letters below the boxplots indicate results of multiple non-parametric pair-wise comparisons. Like letters indicate statistically equivalent values

Constraining the dataset to all detections within 30 m does not yield enough data points for formal analyses. Within 30 m there were no detections of singing males at any treatment plot, and only one within a “natural” plot. That there were detections within control and reference plots (n=7 and 10 respectively) could indicate that birds are more abundant in those treatments, but more data are needed. Overall, higher quality habitat is expected to support a greater abundance of breeding birds, and the abundance of songbirds within the treatment plots is expected to increase with revegetation success.

5.5 Nest Searching

Nest searching was conducted between June 3 and July 11, 2014, with most effort from late June onwards. In total, 35 hours and 14 minutes were spent nest searching (Appendix 9-F). Areas searched included control, reference, treatment, and “natural” (wetland/peatland outside of formal plots) habitats from Valemount Peatlands North (VN), Valemount Peatlands South (VS), Yellowjacket Creek (YJ), Packsaddle North (PN), and Packsaddle South (PS). Effort typically reflected the type of habitat to search, with the Valemount Peatlands North site having the greatest survey effort.

In total there were six active nests found (Table 5-8). These represented three species: Spotted Sandpiper, Lincoln’s Sparrow, and Orange-crowned Warbler. In addition, fledged young were found on three occasions (Table 5-8). Recently fledged young were likely to have hatched nearby, but not necessarily in the same plot, or even site. The species with recently fledged young were Spotted Sandpiper, Lincoln’s Sparrow, and American Redstart. The Lincoln’s Sparrow young were not yet capable of flight, and so likely fledged from a nest very near to where they were found (control plot of Valemount Peatlands North). Evidence of nesting was found on a further seven occasions, but no nest or young were found (Table 5-8). Such evidence consists of various behavioural cues (e.g., agitated behaviour and frequent alarm calls or adults carrying food). Species for which nesting evidence was obtained were Dusky Flycatcher, Black-capped Chickadee, Lincoln’s Sparrow, Savannah Sparrow, Chipping Sparrow, and Dark-eyed Junco.

Table 5-8: Number of active nests (A), fledged young (F), and probable nesting (N) found during nest searching efforts in 2014. Number of fledged young refers to the number of nests from which fledged young originated, not the number of individual birds, and probable nesting refers to the number of occasions when evidence of nesting was found for a bird/pair of birds that were previously unknown

	Site									
	PS			VN			YJ			
Plot Type	**A**	**F**	**N**	**A**	**F**	**N**	**A**	**F**	**N**	**Total**
CONTROL					1		2	1		**4**
REFERENCE			3		1	2	2			**8**
TREATMENT			1							**1**
Peatland				2						**2**
Wetland						1				**1**
Grand Total			**4**	**2**	**2**	**3**	**4**	**1**		**16**

Based on all nesting evidence (active nests, fledged young, and evidence of probable nesting), the reference plots appear to have the greatest amount of bird nesting activity, followed by controls. Only three sites had any current nesting activity found, with Valemount Peatlands North having the most activity of any site; though Yellowjacket Creek had the highest number of active nests. However, both reference plots and the Valemount Peatlands North site had the greatest amount of effort. When controlling for effort, Yellowjacket Creek had the highest rate of nesting evidence/hour of any site. Looking at treatments/habitat types, wetlands had the highest rate of nesting evidence per effort.

Finding nests and evidence of nesting is not just a function of the amount of effort spent searching, but also in the size and quality of the habitat. Larger areas with greater habitat structure and heterogeneity will likely have more nesting birds than small, homogenous areas. For example, the territory size of Savannah Sparrows ranges from 0.11 ha to 1.25 ha (Wheelwright and Rising 2008), and for Black-capped Chickadees breeding territories have averaged 1.8 ha to 5.3 ha, varying by population (Foote et al. 2010). Thus, we cannot simply look at the number of nests found per hour of effort as an indicator of breeding likelihood or potential at a site; rather, the amount and type of area searched needs to be considered if comparisons among areas are of importance.

5.6 Vegetation Sampling

Vegetation sampling occurred on June 27-28 and July 13-18, 2014. A total of 439 quadrats were sampled on 43 transects (Table 5-9). As this was the first year of the woody debris removal study, only limited statistical analyses were completed. As with other revegetation monitoring programs (i.e., CLBMON-9), it will take several years of data collection before the efficacy of woody debris removal on revegetating the drawdown zone can be adequately addressed. However, some changes were already noticeable.

Table 5-9: Number of transects, quadrats, and plant species detected within each treatment type in 2014

Plot Type	No. of Transects	No. of Quadrats	No. of Spp.	No. of Spp. per Quadrat
Control	12	115	33	**0.29**
Treatment	16	146	49	**0.34**
Reference	15	178	86	**0.48**
Total	43	439	124	**0.28**

There was a significant effect of plot type on vegetation species richness ($p<0.0001$). All pairwise comparisons were significant (all $p<0.05$). In most cases reference plots had a significantly higher number of species (Figure 5-19) than in other plots. While the response was somewhat less pronounced and varied between treatment and controls, in general control plots had higher species richness than treatments. In addition, the suite of species comprising the vegetation communities on those plot types was noticeably different.

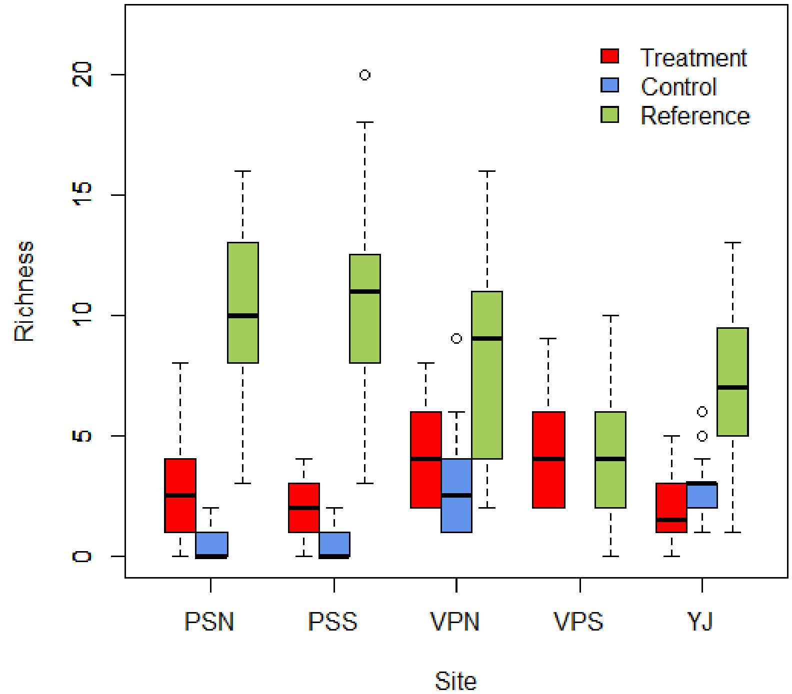

Figure 5-19: Boxplots showing species diversity per quadrat over all plots and sites

Reference plots are clearly more diverse, but also telling is the higher richness of treatment vs. control plots, even in the first year post woody debris removal. This is in part due to the proliferation of exotic species at these sites. The vegetation communities on reference areas were primarily composed of perennial forbs, evergreen and deciduous shrubs, and coniferous and deciduous trees. The overall species diversity for reference transects was 74 species, which is 35% more than the second most diverse plot (treatment transects; 48 species). Over 80% of the species recorded in reference area transects were unique to that treatment type. Only four species found exclusively in reference areas were common to all sites: Subalpine Fir (*Abies lasiocarpa*), Saskatoon (*Amelanchier alnifolia*), Bunchberry (*Cornus canadensis*), and Wild Lily-of-the-Valley (*Maianthemum canadense*).

One of the most noticeable differences between reference and non-reference plots was in the number of exotic species recorded (Table 5-10). Only three non-native plant species were recorded in reference transects, equalling one percent or less of the total vegetation cover within their respective quadrats. With the exception of Valemount Peatland South, the average live organic cover (i.e., living vegetation) for quadrats along reference transects was much higher than treatment and control quadrats. Trees greater than 5 m tall were excluded from quadrat sampling, so the true organic live cover is under-represented. Silt and organic matter (i.e., humus) were the dominant substrates for most reference areas, with the exception of Valemount Peatland South, which was characterized by a predominantly sandy substrate

Table 5-10: Numbers of exotic species, native species, and detections at each site and treatment combination. Numbers include shrubs and trees, which were only recorded along reference transects from shrub plots

Site	Plot	Exotic Species	Native Species	Perecentage Exotic	Exotic Detections	Native Detections	Percentage Exotic
Packsaddle North	Control	0	4	0.0	0.0	8.0	0.0
	Treatment	11	5	68.8	61.0	28.0	68.5
	Reference	1	37	2.6	2.0	336.0	0.6
Packsaddle South	Control	2	2	50.0	5.0	7.0	41.7
	Treatment	4	2	66.7	27.0	27.0	50.0
	Reference	2	38	5.0	9.0	346.0	2.5
Valemount Peatland North	Control	4	17	19.0	5.0	68.0	6.8
	Treatment	5	19	20.8	22.0	89.0	19.8
	Reference	1	34	2.9	2.0	272.0	0.7
Valemount Peatland South	Control	N/A	N/A	N/A	N/A	N/A	N/A
	Treatment	8	12	40.0	49.0	79.0	38.3
	Reference	0	20	0.0	0.0	146.0	0.0
Yellowjacket	Control	1	13	7.1	1.0	87.0	1.1
	Treatment	4	5	44.4	24.0	30.0	44.4
	Reference	0	24	0.0	0.0	243.0	0.0

The species composition of control areas primarily consisted of perennial and annual forbs, horsetails, grasses, sedges, and willows. Most species recorded on control transects were also found in treatment or reference areas; however, nine species were unique. Eight of the species that were only recorded in control areas were localized to one site, while Swamp Horsetail (*Equisetum fluviatile*) was detected at two sites. Overall species richness in control transects was 31 species, well below that of the 48 species detected on treatment transects. Common Horsetail (*Equisetum arvense*) was the only species that was found on at least one control transect at each site. The number of exotic species found along control transects was relatively low (n=6), with four species being the highest for any one site (Table 5-10). Organic live cover was variable over the four control areas sampled; with two sites averaging less than 0.5 per cent cover. The control area at Yellowjacket Creek had greater live cover (8.8%) owing to patches of horsetails and grasses across its three transects. The dominant substrate for control quadrats also varied considerably, but sand was the most prevalent. The control transects at Yellowjacket may have yielded higher organic live cover due to the influence of the dominant substrate, silt. Silt holds moisture better than any substrates, in turn creating prime growing conditions for plants such as horsetails and grasses.

That woody debris was removed from Valemount Peatland South in 2013 compared with 2014 at all other sites revealed an opportunity for comparison with more recently cleared treatments. The primary diversity of treatment areas comes from perennial and annual forbs, but grasses, sedges, and horsetails provide most of the vegetative cover. Lady's-thumb (*Persicaria maculosa*) and Common Horsetail were the only species found at all treatment sites, with the former being exclusively recorded along treatment transects. Twenty-two species were recorded exclusively in treatment plots, but only Lamb's-quarters (*Chenopodium album*), Bull Thistle (*Cirsium vulgare*), Annual Hawksbeard (*Crepis tectorum*), and Wormseed Mustard (*Erysimum cheiranthoides*) were found at two or more sites. Of the 20 species of exotic plants recorded during surveys, 18 were found in treatment areas (Table 5-10). This is to be expected, at least initially, as the treatment process is an environmental disturbance that opens up new habitat. Many exotic species are aggressive colonizers to disturbed areas, but become displaced by native species over time as the overall vegetation community develops.

The average organic live cover of treatment quadrats for three of the five sites was less than 0.5 percent. The highest organic live cover was found at Valemount Peatland South, which is the area that was treated in 2013 and has benefitted from a full growing season. The transects were established in areas that have patches of dense grass and sedge cover, which brought the average quadrat cover up to 20.8%. The uppermost elevation band that was sampled at that site was also affected by two quadrats having overhanging tree cover from the directly adjacent upland habitat. The dominant substrate recorded for the treatment areas was sand. While woody debris removal was conducted at all treatment plots, the removal process at Valemount Peatland North appeared to create a mosaic of exposed organic substrate, water, and sand. Presumably as a result of this heterogeneity, this site had the highest overall species diversity of any control or treatment plot.

5.7 Ungulates

Ungulate pellet plot surveys were completed between June 5th and July 11th. All plots remained above the water level of Kinbasket Reservoir for the survey period. A total of 16 ungulate fecal pellet groups (15 deer sp. and 1 Elk) were counted within the 42 survey plots, with an additional 8 pellet groups (1 deer sp., 6 Elk, and 1 Moose) observed outside the survey plots but within the sites (Table 5-11). All observations were recorded within reference areas.

Table 5-11: Total ungulate fecal pellet groups by site recorded in and out of survey plots in Canoe Reach, Kinbasket Reservoir, 2014. Deer species (White-tailed and Mule deer) are pooled due to difficulty in differentiating these species by pellets

Ungulate Species	Packsaddle North	Packsaddle South	Valemount Peatland North	Yellowjacket Creek	Totals
Moose	0	0	1	0	**1**
Elk	0	0	1	6	**7**
Deer spp.	13	1	2	0	**16**
Totals	**13**	**1**	**4**	**6**	**24**

Scat, tracks, and sign from other mammal species identified during surveys included: Wolf (*Canis lupus*), Coyote (*Canis latrans*), Black Bear (*Ursus americanus*), Snowshoe Hare (*Lepus americanus*), Red Squirrel (*Tamiasciurus hudsonicus*), and grouse species. The majority of all species observations were made in reference sites, followed by treatment sites, but varied by species (Figure 5-20). Reference sites had a higher diversity of species observed (n=6) than did treatment or control sites (both n=3).

Though deer fecal pellets were absent from drawdown zone control and treatment plots, deer tracks were noted through these areas. Given the ease of traversing the open habitat of treatment plots, this is not surprising. This ease of travel may also help explain why relatively fewer tracks were noted in control plots, where woody debris remains. Tracks in control plots may also be under-represented by virtue of the lack of register on wood or more heavily vegetated substrates. In other words, an observation bias is possible.

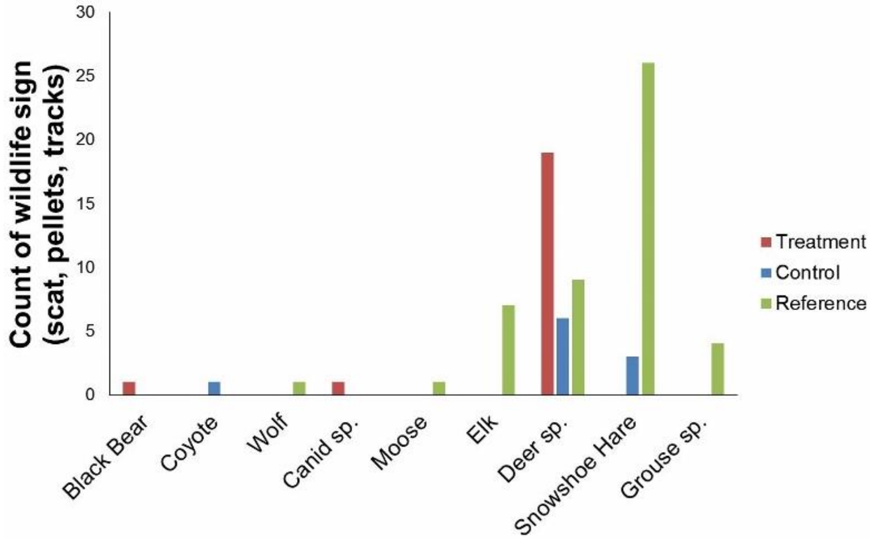

Figure 5-20: Count of species observations (scat, pellets, tracks etc.) by treatment type at Canoe Reach, Kinbasket Reservoir, 2014. n= 4, 5, and 5 for control, treatment, and reference sites, respectively

5.8 Incidental Observations

By-catch from pitfall traps provide some incidental observations and observations made during other studies in the area, lend a more complete picture of wildlife use within and outside of the drawdown zone. A total of 11 Long-toed salamanders, *Ambystoma macrodactylum,* were collected in ten pitfall traps. This species is quite cryptic during the day, and was recorded infrequently during amphibian surveys conducted in Valemount Peatland in 2014 during CLBMON-37. We collected *A. macrodactylum* at three of the five study sites in Canoe Reach: Packsaddle South (PS-S), Packsaddle North (PS-N), and Valemount Peatland North (VP-N). Most individuals were collected in reference sites (n = 8), with remaining salamanders collected along the uppermost pitfall trap transect (“A”), adjacent to reference sites (n = 2 and 1 for salamanders in treatment and control, respectively). One collected salamander was feeding on a green noctuid larva.

Relevant to this study, one pond in the north of Valemount Peatland was cleared of woody debris cover as part of the CLBMON-16 program during 2012. This pond was one of the most active breeding sites in Canoe Reach. Western Toad (*Anaxyrus boreas*) and Columbia Spotted Frog (*Rana luteiventris*) were both observed mating and laying eggs during day and night surveys at this pond.

Numerous small mammals were collected in pitfall traps during the arthropod sampling in 2014. They were not identified to species during this study, but represent at least 47 individual shrews (*Sorex* sp.) and 12 voles. The abundance of shrews in pitfall traps was not expected, especially given the poor catch of shrews in mammal trapping programs implemented in past years of CLBMON-11A. Captures of shrews was nearly even between plots, with 16 individuals collected in reference and treatment sites, and 15 individuals collected in control plot. All small mammals collected in pitfall traps during 2014 were retained, labelled, and preserved for future identification and donation to the Royal British Columbia Museum. Additionally, grey wolf, black bear, and deer have been observed using the drawdown zone of Kinbasket Reservoir.

6.0 DISCUSSION

Given the apparent failure of previous revegetation efforts, likely due to a combination of inundation timing, frequency, duration and depth, or with the by-products of these factors such as erosion, woody debris scouring, and drought conditions (Hawkes et al. 2013), the efficacy of woody debris removal to promote the establishment and development of vegetation in the drawdown zone shows early signs of promise towards answering the management questions of CLBMON-11A. Additional years of study are required before any conclusions can be reached regarding the value of woody debris removal and success of natural revegetation in treatment plots relative to traditional revegetation techniques. As such, current projections for long-term trends are limited. Initial treatment responses are encouraging; however, the success of the woody debris removal program hinges on whether measures are taken to keep treatment plots clear of wood for successive years.

Provided that treatment plots are protected from wood debris accumulation (by installation of log booms and/or the construction of mounds) we expect there to be an increase in the natural cover of vegetation on treatment plots. Within Canoe Reach, revegetation is expected to be most successful at the Valemount Peatland North site, due to the high organic matter content in the soil and installation of log booms around the treated area. In turn, we expect the open-habitat associated fauna that were most indicative of these treatment areas in 2014 to decrease in abundance. Species turnover will progressively result in assemblages that are associated with increased vertical structure and vegetation cover. Where non-native species (plants and beetles) occur, we expect there to be a slow replacement of those species by native species.

Following natural revegetation of the treatment plots, we expect increased richness and abundance of songbirds as a result of greater habitat heterogeneity. Of the songbird species using the drawdown zone, Savannah Sparrow is relatively common and this species is expected to colonize treatment areas following revegetation. Additional sparrow and warbler species would be expected if a shrub layer develops, which is most likely to happen at the upper elevations of the drawdown zone (i.e., >753 mASL). Overtime, this may lead to increases in the richness and abundance of songbirds in the drawdown zone. Increases in insect abundance may also translate to increased densities of breeding birds relative to pre-treatment conditions.

Currently, only one treatment area was protected in Canoe Reach in 2014, thus these predictions may apply only to the Valemount Peatland North site. All other treatment areas will likely accumulate woody debris from adjacent control areas and from other areas of Kinbasket Reservoir, which will make it difficult to detect treatment effects in these areas. One common pattern that emerged from vegetation and arthropod surveys was that treatment plots had a higher abundance and richness of non-native species. This is not surprising, given that invasive species are often quick to colonise recently disturbed sites. As treatment plots recover from the initial disturbance of woody-debris removal, we expect a decrease in these non-native species.

In 2014, we focused on species-level classifications of spiders, ground beetles, and rove beetles due to their utility as indicators of disturbance gradients (Niemela et al. 1993, Work et al. 2004, Cobb et al. 2007, Buddle et al. 2006, Larrivée et al. 2007; Pinzon et al 2012, 2013a). These taxa have been successfully used to monitor ecological changes in riparian, forest, and grassland ecosystems. Assemblages of all 201 arthropod species showed a considerable amount of similarity between treatment and control plots, but were distinct from reference sites. Some environmental variables, such as water cover, relative humidity, and mean daily temperature, explained differences between assemblages in control and treatment plots. The relative abundance and species richness of ground-dwelling arthropods was generally lower in treatment plots, which were dominated by open-habitat wolf spider and ground beetle species and five species were revealed as strong indicators for wood-removal treatment areas. Arthropod species characterising control sites were also open-habitat species, but those that seek shade under cover objects (logs, stones) during the day. Changes in the frequency occurrence and distribution of indicator taxa in subsequent surveys will be useful in tracking the revegetation of these plots.

The species richness and abundance of songbirds did not differ between control, treatment, and reference plots, but species composition did. Similarly, evidence of nesting was generally low in all areas, which may reflect the small size of the plots relative to territory requirements of many breeding bird species. Most nests detected belonged to ground or shrub-nesting species. If vegetation establishes on treatment plots, the number of territories and nests of bird species might increase, indicating that the quality of the habitat has improved for birds. However, this could take some time as vegetation establishment is generally a slow process. Currently, it appears that treatments may be of equivalent or lower suitability to breeding songbirds than controls. This is not unexpected given the short time period since woody debris removal, and more years of data will help determine trends related to bird richness, abundance, or nesting suitability.

Pellet plot data clearly indicated exclusive use of upland reference plots by ungulates with no pellets observed in either treatment or control plots. This trend is consistent with previous years' data collection. However, incidental observations of wildlife sign indicates that both treatment and control sites are being utilised to some degree by ungulates. For example, deer tracks were noted in treatment and control plots providing an indication that deer are at least transiting through these areas. The number of tracks observed was higher in treatment than control plots, but this is likely a function of the ease of travel through treatment areas (the wood had been removed).

Woody debris removal from a pond in the north of Valemount Peatland (adjacent to VP-N treatment plot) resulted in a short-term (<1.5 yr.) positive response from amphibians. Breeding activity was observed for both Western Toad and Columbia Spotted Frog. Species-specific responses might differ in other areas, but the utility of woody debris removal for enhancing pond-breeding amphibians habitat should be further examined in light of this result.

Given the revegetation failure, several recommendations are made regarding the revegetation program, including clarifying long-term goals, focusing effort where successes have been noted, consideration of the development of physical works in the drawdown zone of Kinbasket Reservoir to benefit wildlife (i.e., analogous to CLBWORKS-29B implemented in Arrow Lakes Reservoir; Hawkes and Howard 2012), and exploring the potential of woody debris removal to promote vegetation development (Hawkes et al. 2013). This study can be adapted to test the effectiveness of on-going reservoir management activities. Specifically, woody debris removal offers a unique opportunity to document changes in wildlife utilization of sites from a baseline state. Continuing the status quo is unlikely to reveal any unequivocal benefits to wildlife from revegetation prescriptions, given the high levels of vegetation mortality so far witnessed.

6.1 Management Questions

The current status of our ability to answer each of the four management questions associated with CLBMON-11A is summarized below.

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

The revegetation prescriptions applied were never considered relevant nor beneficial to amphibians, and they were not implemented explicitly to benefit most wildlife species. The revegetation program itself has been largely unsuccessful to date at increasing the percent cover or diversity of vegetation relative to untreated (control) locations (Hawkes et al. 2013). Hawkes et al. (2013) found that four to five-years post-planting, sedge plug survivorship was <5% and no deciduous shrub (willow, alder and cottonwood) stakes survived in the drawdown zone. These results held regardless of community type, elevation, geographic region, or prescription type.

The revegetation prescriptions themselves were also typically small, in some cases likely being smaller than the home range size of species that may utilize them (e.g., Savannah Sparrow can have breeding territories >1 ha [Wheelwright and Rising 2008]). The varying sizes of the revegetation prescriptions, lack of replication and stratified treatments, lack of revegetation success, and other inconsistencies in the CLBWORKS-1 planting methodology make it difficult to achieve more than speculation in regards to the program's effect on animal utilization of those habitats.

This study did not specifically sample amphibians, reptiles, or birds prior to 2013. Other studies have found that the revegetation prescriptions applied in the drawdown zone have been largely ineffective at benefiting amphibians or reptiles (i.e., CLBMON-58: Hawkes and Wood 2013). Benefits for other groups are inconsistent across time and reach, but given the widespread mortality of most revegetated areas, it is believed that the revegetation program has been ineffective at enhancing and increasing the utilization of habitat in the drawdown zone by wildlife.

Woody debris removals are now tested as an alternative revegetation method. Currently we have completed the initial baseline year of data on treatment effects, so no conclusions in terms of wildlife utilisation of these plots can be drawn. Treatment plots were favoured by tiger beetle species (*Cicindela longilabris* and *C. tranquebarica*). Three other ground beetle species and one wolf spider species were strongly associated with treatment plots (rarely found elsewhere; Table 5-3). Vegetation richness appeared higher in treatment areas, in part due to the presence of exotic species. This reflects the current condition of treatment plots as recently disturbed areas, but as vegetation establishes, there may be increased utilization of the drawdown zone by wildlife in those areas.

The example of woody debris removal from a pond adjacent to the Valemount Peatland North treatment plot is directly applicable to MQ1. Amphibian species increased utilisation of this pond as breeding habitat shortly after it was made available from clearing woody debris cover.

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

The 2014 iteration of this study did not examine differences in the revegetation prescriptions. There were no differences in biomass of arthropods (as a proxy for invertebrate prey availability) between control and treatment transects sampled in the drawdown zone (Hawkes et al. 2014). Even if differences had been detected, they would not have indicated a treatment effect because the prescriptions have been ineffective at increasing vegetation cover and abundance. In addition, there is no evidence that the revegetation prescriptions have provided any benefit (food or otherwise) to amphibians or reptiles.

In terms of woody debris removal, the catch-per-unit-effort of arthropods was inconsistent among treatment plots. It is plausible that taxon responses to woody debris removal depend largely on site or substrate characteristics (e.g., exposure, soil moisture, organic soil content) and this could account for the inconsistent response of arthropods to treatment plots at various sites. As a caveat, it is important to note that because pre-treatment sampling was not implemented prior to wood removal, we are unable to refute the possibility that plots had high densities of beetles before the woody debris was removed. By extension, we will only be able to assess this management question effectively after long term monitoring has provided insights to the change in treatment plots as natural revegetation occurs.

Insectivorous small mammals (*Sorex* spp.) were collected in roughly equal abundance across treatment, control, and reference plots (see section 5.7). Abundance of shrews did not coincide with plots that had high arthropod abundance. However, this study was not meant to survey small mammals and all captures were incidental. Any investigation of the food chain linkages between arthropod taxa and birds, amphibians, or small mammals is beyond the scope of the study.

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

This study does not address negative impacts to wildlife in the drawdown zone. The determination of nest mortality or sink habitats requires specific studies, with hypotheses not addressed under this study. Based on other studies of nest mortality (CLBMON-36) and impacts on amphibians and reptiles (CLBMON-37 & 58), it is not known if revegetation has any negative impacts, but none are suspected thus far, especially given that the revegetation prescriptions that were applied in the drawdown zone largely failed.

It is too early to tell what effects woody debris removal is having on wildlife in the drawdown zone, but it seems unlikely that such efforts will negatively impact wildlife in the long-term. In the short-term there may be some disturbance to the site related to the physical operation of woody debris removal. Non-native plant and beetle species were found in greater abundance and richness in treatment plots in 2014. However, this result is expected given exotic species ecological strategies that favour rapid colonisation of new sites. In addition, the lack of vertical structure in treatment plots (relative to control and reference plots) may temporarily displace certain invertebrate taxa. Many arthropod species are obligate specialists on woody debris and wood-decaying fungi. However, these taxa have largely evolved in stable systems (i.e. mature forests) that produce a consistent supply and wide variety of dead wood substrates. Few species are found in driftwood along lakeshores and oceans. There is no evidence that the woody debris removal treatments have negatively impacted wildlife in the drawdown zone; no negative effects are foreseen in the continuation of the woody debris removal program.

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

Based on the results obtained thus far for CLBMON-11A, it appears that all conventional methods of revegetation were ineffective at enhancing and increasing the utilization of wildlife habitat in the drawdown zone. As found in CLBMON-9 (based on four years of results), only the sedge plug revegetation treatment had any establishment success, but even then only in very limited areas (Hawkes et al. 2013).

Woody debris removal has the potential to enhance and increase the utilization of wildlife habitat in the drawdown zone, but more years are of study are needed to determine the effectiveness of this approach. Initial results from vegetation survey performed in 2014 suggest that treatment sites are rapidly and naturally recolonized by plant species; the number of plant species in treatment plots were higher than in control areas (Figure 5-19). Wildlife tracks were also greater in treatment plots than controls (Figure 5-20), despite that pellets were not found in either plot.

6.2 Management Questions - Summary

Our ability to address each of the management questions is summarized below (Table 6-1). The methods applied in previous years (e.g., small mammal live-trapping, ungulate surveys) are not well-suited to answering the management questions associated with CLBMON-11A. The program was modified for the 2014 sampling year, to concentrate on the efficacy of woody debris removal as an alternative revegetation technique. The current data represent the baseline condition of study plots, which will be monitored overtime for changes in vegetation and focal taxa (e.g., ground-dwelling spiders and beetles and songbirds). Data collected in future survey years will clarify conclusions for each management question. Our current ability to address each management question (based on revegetation prescriptions and woody debris removal), suggestions for modifying the program, and sources of uncertainty are summarized in Table 6-1.

Table 6-1: Outline of CLBMON-11A Management Questions (MQs), scope of results, methodological constraints, and sources of uncertainty for the 2014 monitoring year

MQ	Able to Address MQ?	Scope		Sources of Uncertainty
		Current supporting results	Suggested modifications to methods where applicable	
1: How effective is the revegetation program at enhancing and increasing the utilization of habitat in the drawdown zone by wildlife	Partially	In terms of woody debris removal, taxa responded similarly; relative abundance and richness were greater in non-drawdown zone reference sites. Five spider and beetle species were strongly associated with baseline woody debris removal plots and are highlighted as indicator species of the initial treatment condition.	• Increased frequency of sampling (i.e., annually) • Select other sites for physical works and implemented pre-treatment sampling (e.g., woody debris removal) • Protect the long-term integrity of study plots in the drawdown zone: install physical barriers to exclude woody debris from treatment plots and maintain woody debris on control plots (e.g., install log booms, where possible) • Consider the development of physical works prescriptions (e.g., analogous to CLBMWORKS-29B for Arrow Lakes Reservoir) • Catalogue revegetation areas (e.g., specific attributes or conditions related to success/failure of revegetation prescriptions)	• Lack of sampling prior to the application of the revegetation prescriptions and woody debris removal • Natural annual population variation • Variable reservoir operations • Widespread revegetation failure • Bi-annual sampling • Relationships between revegetation or woody debris removal success and site-specific characteristics (e.g., substrate type, soil moisture, aspect, landscape position, etc.) • Uncertain future for study plots laid out in 2014 following woody debris removal. Log booms were installed to protect one treatment plot from annual accumulation of debris, but no measures were taken to ensure the long-term integrity of other study plots in the drawdown zone

MQ	Able to Address MQ?	Scope		Sources of Uncertainty
		Current supporting results	Suggested modifications to methods where applicable	
2: To what extent does revegetation increase the availability of invertebrate prey in the food chain	Partially	General arthropod relative abundance, corrected richness, and biomass did not differ between treatment and control transects in revegetation areas. In the initial year of woody debris removal, at least one treatment plot was associated with a significantly greater relative abundance of ground beetles (Valemount Peatland North). Differences in arthropod abundance were most pronounced between drawdown zone and upland reference areas.	• Annual sampling for all groups • Select other sites for physical works and implemented pre-treatment sampling (e.g., woody debris removal) • Consider the development of physical works prescriptions (e.g., analogous to CLBMWORKS-29B for Arrow Lakes Reservoir) • Characterize and catalogue site-specific attributes for all study areas in Kinbasket Reservoir, in order to understand differential responses to treatments	• Uncertain correlation between the abundance or biomass of ground-dwelling arthropods and availability of suitable prey for vertebrate taxa (e.g., shrews and birds) • Lack of sampling prior to the application of the revegetation prescriptions and woody debris removal • Natural annual population variation • Variable reservoir operations • Bi-annual sampling
3: Are revegetation efforts negatively impacting wildlife in the drawdown zone?	No	In some treatment transects (e.g., Goodfellow Creek) there may be marginal benefits of revegetation, as evidenced by high elk pellet counts. Woody debris removal treatment plots had a greater number of non-native plant and beetle species colonizing the site in the initial survey year (2014); there is no evidence of negative impacts to wildlife caused by these species, but they will be monitored for changes overtime	• Management question is better-suited to other studies that currently occur in the region • Rewrite management question to align with this study	• Lack of sampling prior to the application of the revegetation prescriptions and woody debris removal • Natural annual population variation • Widespread revegetation failure • Lack of knowledge regarding wildlife use of the drawdown zone in the winter • Variable reservoir operations

MQ	Able to Address MQ?	Scope		Sources of Uncertainty
		Current supporting results	Suggested modifications to methods where applicable	
4: Which methods of revegetation are most effective at enhancing and increasing the utilization of wildlife habitat in the drawdown zone	No	The effectiveness of the revegetation will not be addressed due to the failure of the vegetation prescriptions. The effectiveness of woody debris removal will be able to be assessed after more years of monitoring data is collected for comparison with the initial data collected in 2014. Under CLBMON-37, woody debris removal from one pond in the north of Valemount Peatland resulted in increased breeding activity of Western Toad (*Anaxyrus boreas*) and Columbia Spotted Frog (*Rana luteiventris*) relative to previous years (Hawkes et al. 2015).	• Protect the long-term integrity of study plots in the drawdown zone: install physical barriers to exclude woody debris from treatment plots and maintain woody debris on control plots (e.g., install log booms, where possible) • Select other sites for physical works and implement pre-treatment sampling (e.g., woody debris removal) • Characterize and catalogue site-specific attributes for all study areas in Kinbasket Reservoir, in order to understand differential responses to treatments	• Lack of sampling prior to the application of the revegetation prescriptions and woody debris removal • Uncertain future for study plots laid out in 2014 following woody debris removal. Log booms were installed to protect one treatment plot from annual accumulation of debris, but no measures were taken to ensure the long-term integrity of other study plots in the drawdown zone • Uncertain relationship between revegetation or woody debris removal success and site-specific characteristics (e.g., substrate type, soil moisture, aspect, landscape position, etc.)

7.0 RECOMMENDATIONS

7.1 Revise the indicator taxa and survey methods to remove the focus on ungulates (pellet plots), and alter breeding bird survey methodology. We now have several years of data on ungulate use of the drawdown zone and reference areas. It is clear that ungulates utilize suitable upland sites extensively, but in most areas do not typically venture down into the drawdown zone, except where those areas are vegetated and are immediately adjacent to forested habitats (e.g., multiple sites in Bush Arm). It is unlikely that any new information will come to light by continuing to implement pellet plot surveys broadly. If ungulates remain a species of interest, then continued aerial surveys are recommended to determine areas of the reservoir with the highest ungulate use. Those areas could subsequently be targeted for vegetation prescriptions and additional ungulate surveys.

Songbird point counts are a suitable sampling method for reference habitats, but their utility is limited in treatment and control plots, where the plot extent is often small, and where detections are influenced by surrounding habitat types. Furthermore, the presence of a bird inside a plot, even a territorial male, does not necessarily infer the breeding-habitat quality of that site. A line transect (also called a strip transect) is very similar to a point count, but the observer records all birds heard or seen while walking a designated line. This method is excellent in open areas, and aligns perfectly with the transect approach already being implemented for other survey types in this study. By recording the observer distance along each line, as well as perpendicular distance from the line to the bird (as opposed to from the observer to the bird, as for point counts), this method also gives a better indication of the spatial location of bird territories, which can aid in nest searching. As the observer is in motion throughout the survey, it also allows for an increased probability of detecting non-vocalizing birds. Nest searches should also be formally implemented on treatment and control sites to document nesting attempts by ground or shrub-nesting birds. Nest searches complement the richness and abundance estimates by providing some indication of the quality of the habitat for breeding birds, including species that may not be readily detected via other survey methods. If vegetation increases in the treatments or other areas, especially after the establishment of shrubs or other vertical structure, we would expect the number of nests to increase in these areas over time.

Bats should be surveyed only in specific cases, owing to the difficulty in linking bat presence and activity to revegetation effects. For example, if woody debris removal is implemented at ponds in the Valemount Peatlands or near the Bush Arm Causeway, pre-and post-treatment bat monitoring would be justified.

7.2 Modify arthropod sampling design including survey effort and method, to optimize data collection. The number of pitfall trap arrays per transect will be reduced from five to three. Each transect in each plot will then consist of three individual traps installed at each of three pitfall trap array points (beginning, middle, and end of each transect). Plots will contain a total of nine trap array points (with three traps set in each). Sampling will be constrained to two collection periods (~6 days in duration). The abundance and diversity of arthropods collected under this scheme is similar to what we report here and produces a dataset with enough statistical power to monitor changes in the community over time.

In addition to pitfall trapping, vegetation sweeps may be performed in future years to improve collection of vegetation-associated arthropods. The addition of vegetation sweeping methods will be particularly useful in later years, if natural revegetation is successful in treatment areas.

7.3 Increase number of woody debris removal sites for replication and to include sites with other soil seed bank profiles, soil fertility assays, evidence of nascent vegetation establishment, and recent land use history. For example, Pond 12 in Valemount Peatland and the west bank of the Bush Arm Causeway are prime sites for expanding the woody debris removal program for enhancement of wildlife habitats in the drawdown zone. In particular, the enhancement of these areas will benefit breeding amphibian and reptile populations.

7.4 Implement pre-treatment sampling. One of the limitations of this program is the lack of pre-treatment data, which makes it difficult to determine if any observed changes are treatment effects or related to pre-existing phenomena. Currently control and treatment plots are paired, but there are statistical and interpretation benefits in sampling the exact same plot both prior to and after woody debris removal. We recommend pre-treatment sampling to be implemented at the proposed new sites in 2015, with woody debris removal to occur in 2016.

7.5 Monitor KM 88 in Bush Arm to assess wildlife use of the areas treated in 2013, which represent a different prescription (larger sedge plugs, larger area, and higher density of planting).

7.6 Consider the development of physical works prescriptions for the drawdown zone of Kinbasket Reservoir. Developing prescriptions to protect or enhance high quality habitats that exist in the drawdown zone (e.g., Ptarmigan Creek, Bush Arm Causeway, Ponds in the Valemount Peatland) would contribute to an overall improvement in wildlife habitat suitability (if the physical works are built). For example, log booms should be developed at select sites to exclude additional log accumulation, and woody debris should be removed from those sites in accordance with the study design.

Additional efforts should be directed on limiting any new woody debris accumulation on the 2014 treatment plots. In the absence of protection, our experimental plots could be annually compromised by changes in woody debris distribution. For example, cleared treatment plots may continually receive woody debris inputs, which would compromise their ability to assess the efficacy of woody debris removal for revegetation. Wood that was present on 2014 control plots could also be displaced, reducing the efficacy of these plots to act as experimental controls. Control and Treatment plots should be protected by log booms, where possible, in order to ensure the long-term efficacy of this monitoring program.

7.7 Consider modifying the sampling program of CLBMON-11A to occur annually. Collecting ecological data on an annual basis would provide a better indication of the trajectory of species and their use of the drawdown zone (with particular emphasis on the use of control and treatment sites), and especially on the post woody debris removal revegetation and faunal recolonization of these sites. More frequent sampling intervals will give stronger support to trends in vegetation success.

7.8 Catalogue the current state of knowledge of revegetation areas and increase the total area revegetated in select areas of the drawdown zone. The revegetation program would benefit from a review of current knowledge of revegetation prescriptions at all study sites in the drawdown zone of Kinbasket Reservoir. This would provide guidance in areas to target for enhancing success of revegetation. Following the cataloguing of revegetation areas, we recommend increasing the total area revegetated in the drawdown zone (i.e., expand existing treatment areas) or add additional treatment areas of the same prescriptions applied previously to increase the number of replicates. Increasing the extent of revegetation areas will increase the likelihood of detecting any changes in wildlife utilization.

7.9 Future revegetation. Some areas might benefit from revegetation post-woody debris removal. The current treatment plots could be split into planted (enhanced revegetation) and un-planted (natural revegetation) treatment areas. Revegetation efforts should be site-specific based on a prescription for that area. If future revegetation is to occur, consider the species of wildlife that are likely to benefit from the revegetation to ensure the appropriate mix of plants is used, that the total area planted is likely to influence wildlife use of the drawdown zone, and that the revegetation prescriptions be applied in a replicated manner with sufficient stratification.

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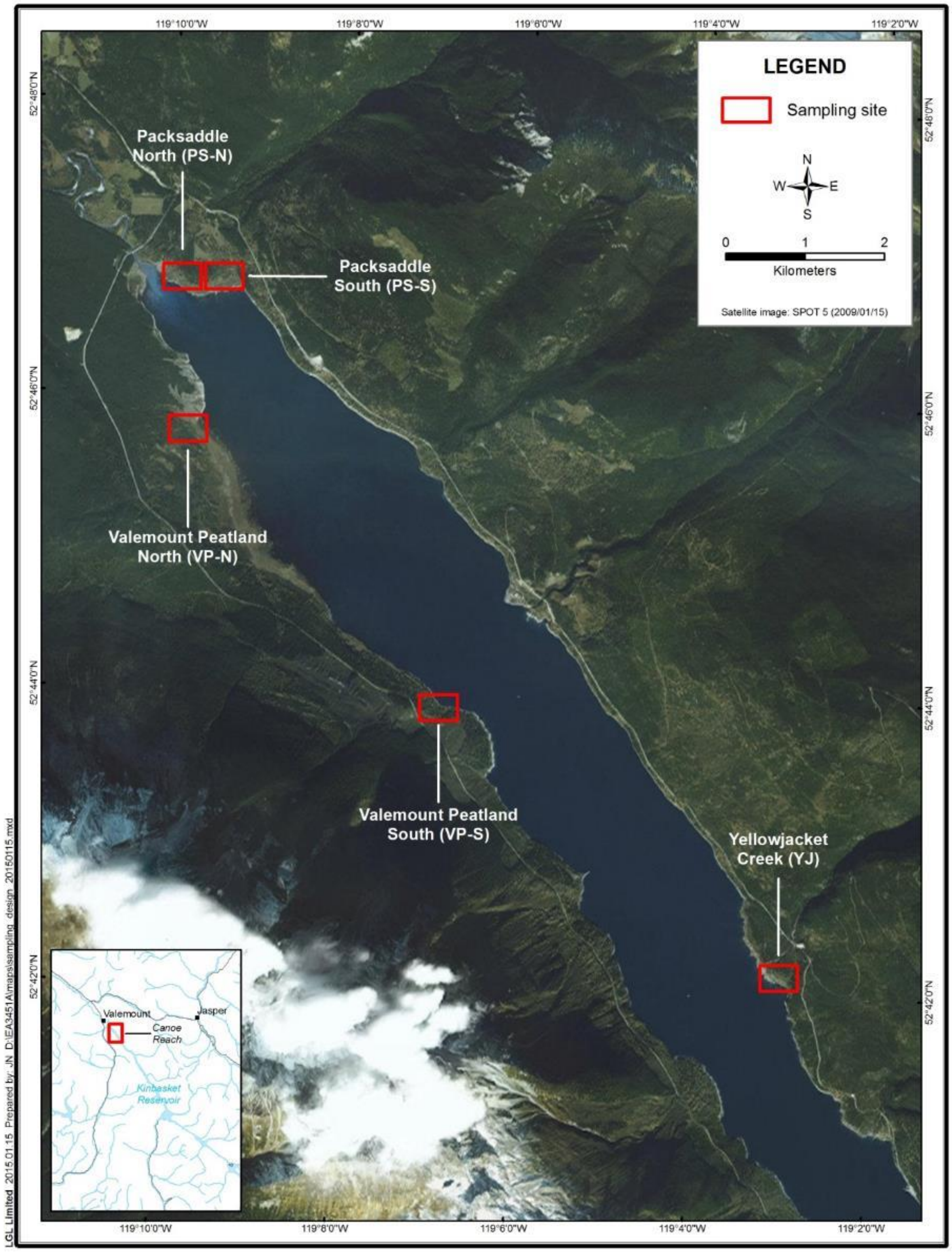
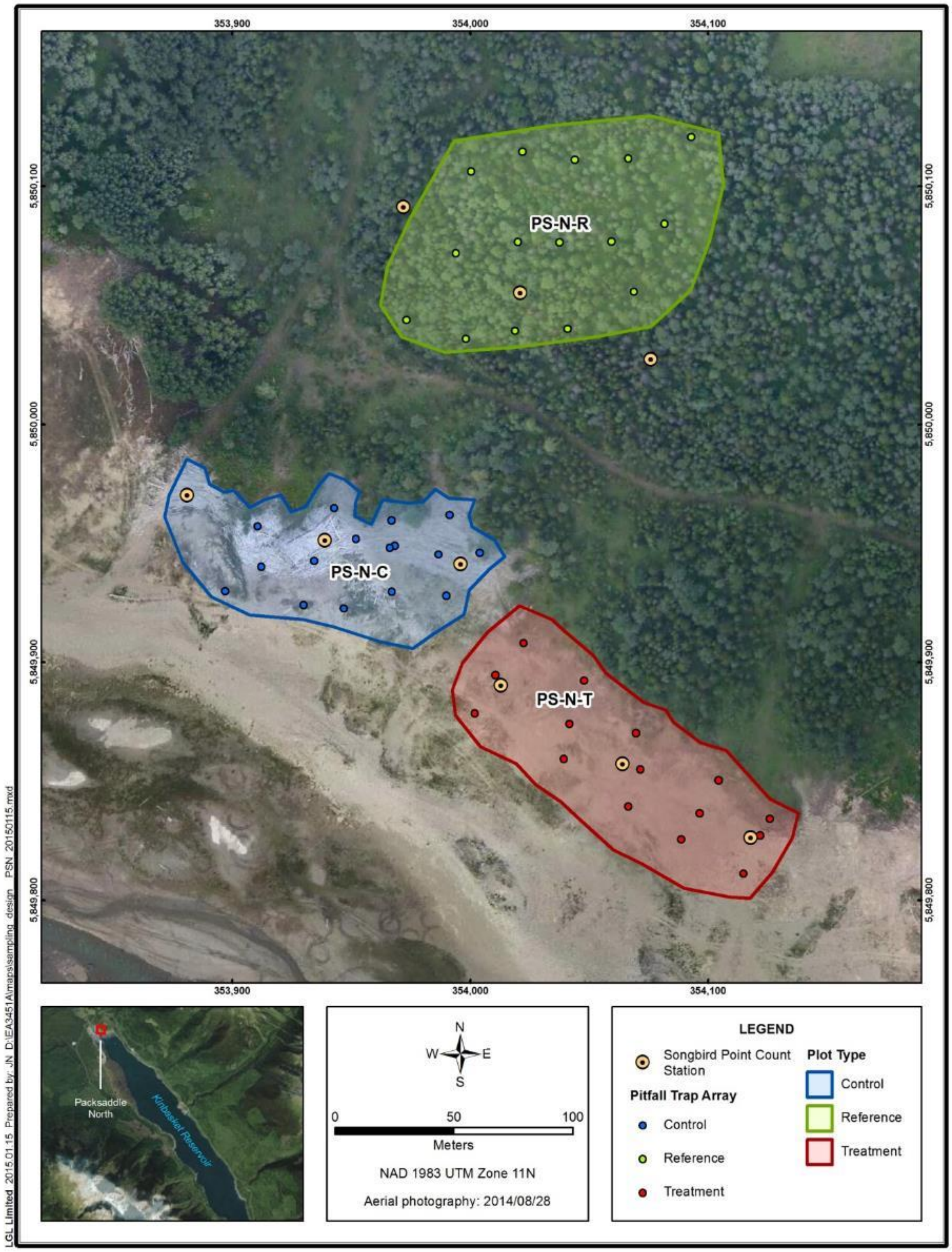
9.0 APPENDICES

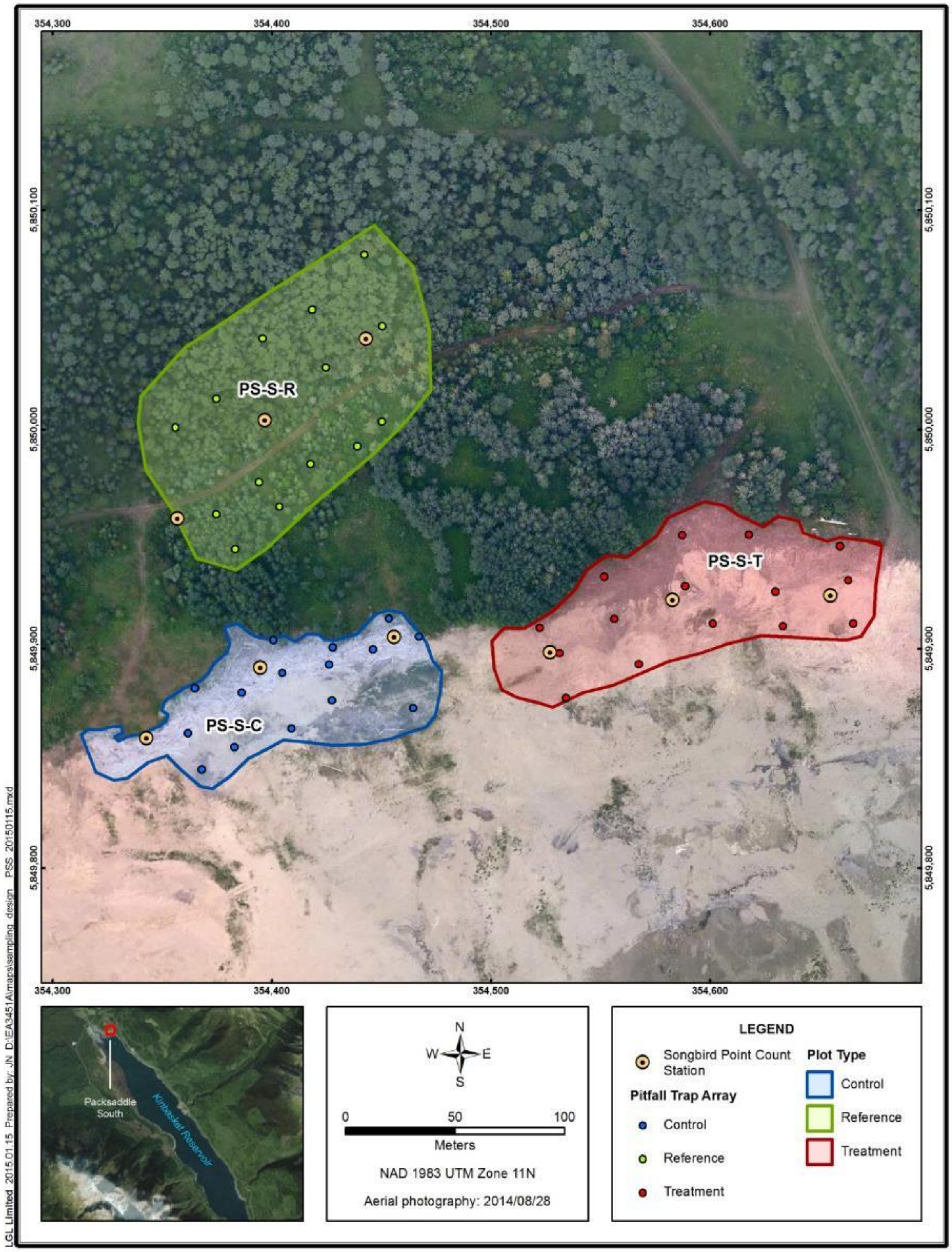
Appendix 9-A: Maps depicting pitfall trapping and songbird point count locations for Canoe Reach sampling in 2014



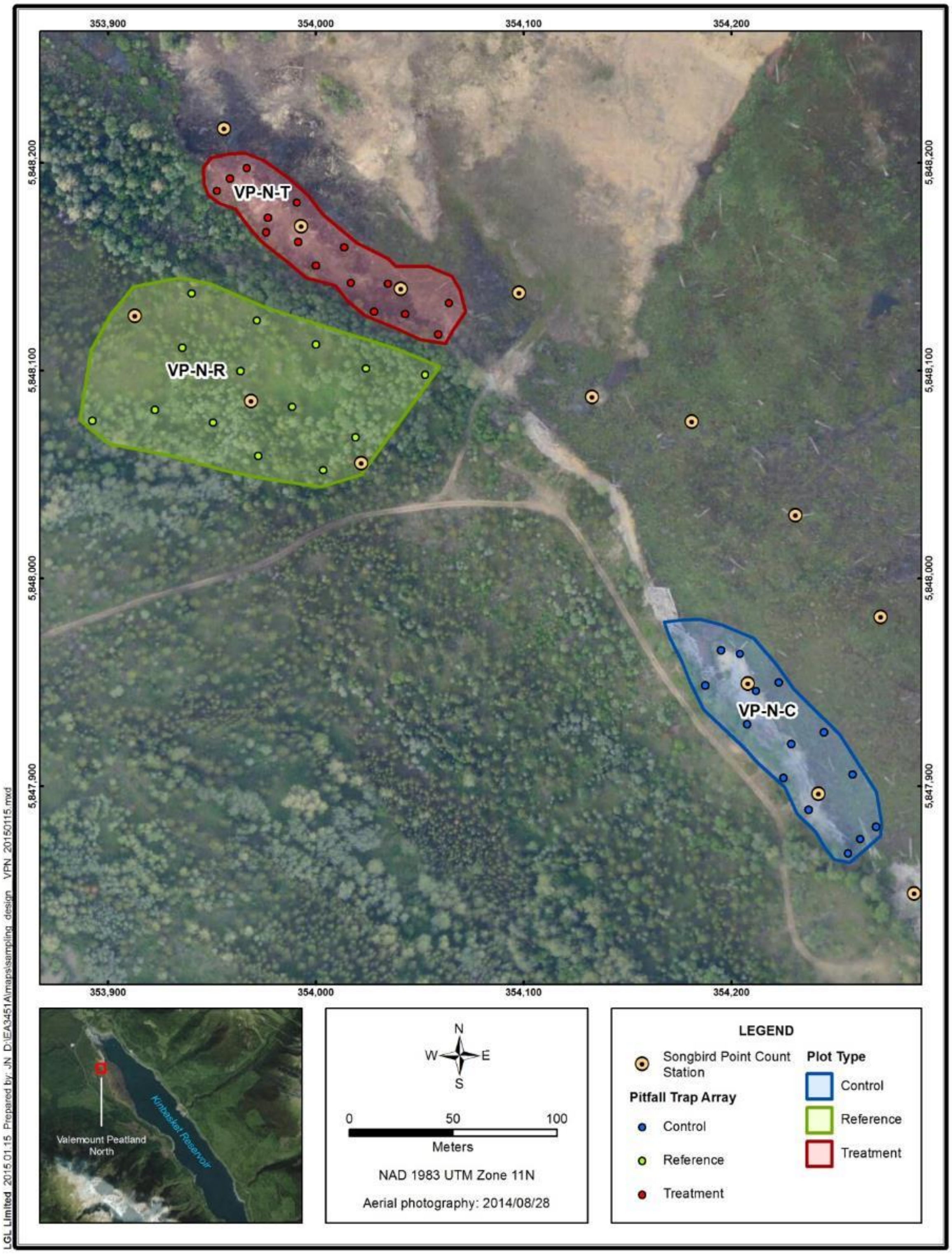
Map 9-1. Sampling sites in Canoe Reach, 2014



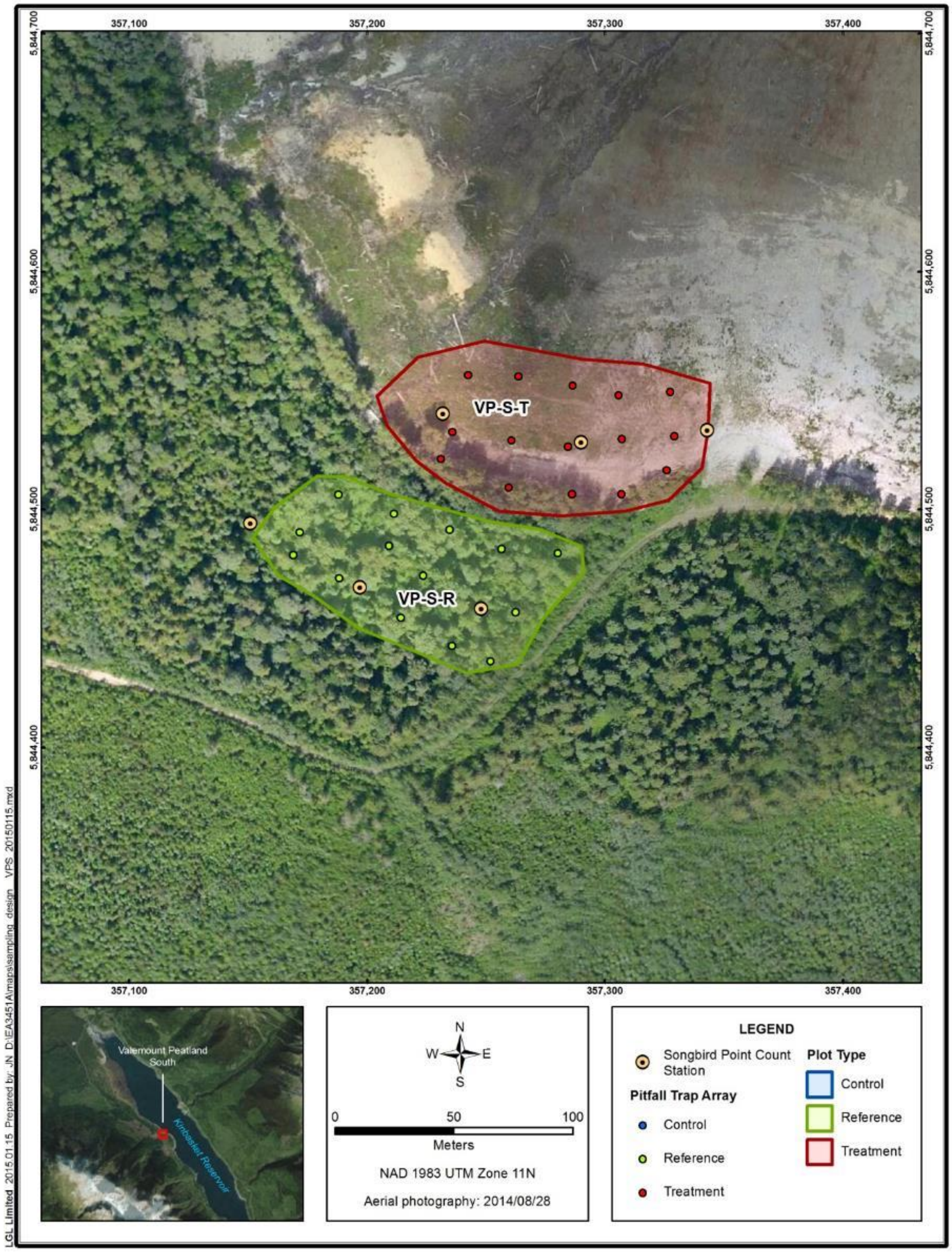
Map 9-2. Sampling locations at Packsaddle North, 2014.



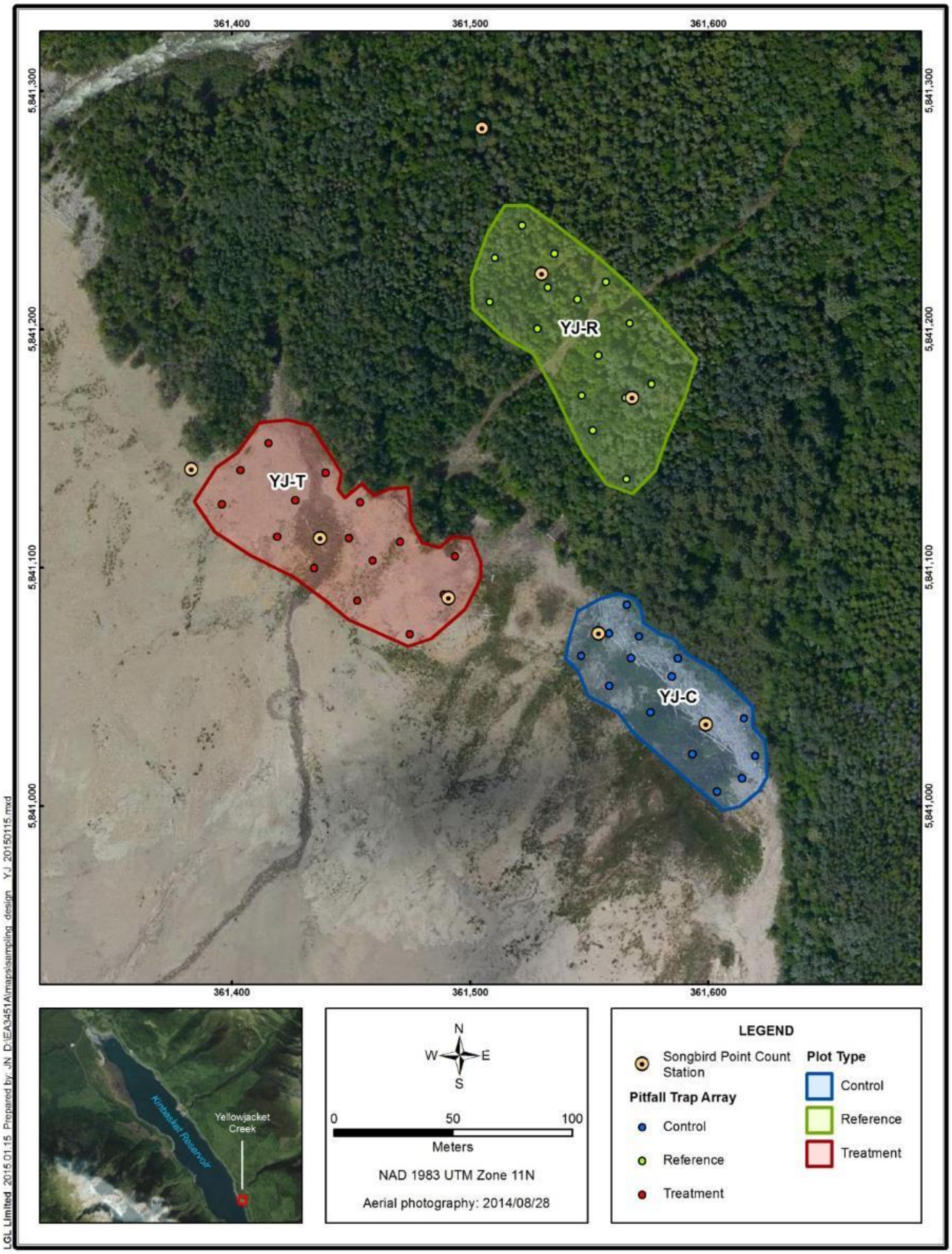
Map 9-3. **Sampling locations at Packsaddle South, 2014**



Map 9-4. **Sampling locations at Valemount Peatlands North, 2014**



Map 9-5. Sampling locations at Valemount Peatlands South, 2014



Map 9-6. Sampling locations at Yellowjacket Creek, 2014.

Appendix 9-B: Bird group, code, species name, and number of observations of all birds detected during 2014 songbird point count surveys in each plot type.

Group	Code	Common Name	Scientific Name	Plot Type				
				Control	Natural	Reference	Treatment	Grand Total
Hawks, Eagles, Falcons & Allies	OSPR	Osprey	*Pandion haliaetus*				2	**2**
Loons & Grebes	COLO	Common Loon	*Gavia immer*		1		1	**2**
Pheasants, Grouse, Quail & Allies	RUGR	Ruffed Grouse	*Bonasa umbellus*	3		5	2	**10**
Shorebirds, Gulls, Auks & Allies	KILL	Killdeer	*Charadrius vociferus*			1	2	**3**
Shorebirds, Gulls, Auks & Allies	SPSA	Spotted Sandpiper	*Actitis macularius*	2			10	**12**
Shorebirds, Gulls, Auks & Allies	WISN	Wilson's Snipe	*Gallinago delicata*	6	3	2		**11**
Songbirds	ALFL	Alder Flycatcher	*Empidonax alnorum*	2		1		**3**
Songbirds	AMCR	American Crow	*Corvus brachyrhynchos*	1	2			**3**
Songbirds	AMRE	American Redstart	*Setophaga ruticilla*	10	1	15	20	**46**
Songbirds	AMRO	American Robin	*Turdus migratorius*	4	3	6	11	**24**
Songbirds	BASW	Barn Swallow	*Hirundo rustica*		1			**1**
Songbirds	BCCH	Black-capped Chickadee	*Poecile atricapillus*	6	4	6	7	**23**
Songbirds	BHGR	Black-headed Grosbeak	*Pheucticus melanocephalus*	1				**1**
Songbirds	CAVI	Cassin's Vireo	*Vireo cassinii*	2		1	5	**8**
Songbirds	CCSP	Clay-colored Sparrow	*Spizella pallida*	11	4	2	7	**24**
Songbirds	CEWA	Cedar Waxwing	*Bombycilla cedrorum*	12		3	9	**24**
Songbirds	CHSP	Chipping Sparrow	*Spizella passerina*	12	8	18	7	**45**
Songbirds	CORA	Common Raven	*Corvus corax*	1	1	5	2	**9**
Songbirds	COYE	Common Yellowthroat	*Geothlypis trichas*	8				**8**
Songbirds	DEJU	Dark-eyed Junco	*Junco hyemalis*	3	1	12	10	**26**
Songbirds	DUFL	Dusky Flycatcher	*Empidonax oberholseri*	19	8	22	27	**76**
Songbirds	EVGR	Evening Grosbeak	*Coccothraustes vespertinus*			1		**1**
Songbirds	GCKI	Golden-crowned Kinglet	*Regulus satrapa*	2		18	4	**24**
Songbirds	GRCA	Gray Catbird	*Dumetella carolinensis*	1				**1**
Songbirds	HAFL	Hammond's Flycatcher	*Empidonax hammondii*	5		12	3	**20**
Songbirds	HETH	Hermit Thrush	*Catharus guttatus*		1			**1**
Songbirds	LEFL	Least Flycatcher	*Empidonax minimus*	9	2	5	8	**24**
Songbirds	LISP	Lincoln's Sparrow	*Melospiza lincolnii*	27	6	6	18	**57**
Songbirds	MACW	MacGillivray's Warbler	*Geothlypis tolmiei*	2		2	3	**7**
Songbirds	MGNW	Magnolia Warbler	*Setophaga magnolia*	5		8	10	**23**
Songbirds	MOCH	Mountain Chickadee	*Poecile gambeli*	1		1	2	**4**
Songbirds	NOWA	Northern Waterthrush	*Parkesia noveboracensis*	4				**4**
Songbirds	NRWS	Northern Rough-winged	*Stelgidopteryx*	3			2	**5**

Group	Code	Common Name	Scientific Name	Plot Type: Control	Natural	Reference	Treatment	Grand Total
		Swallow	*serripennis*					
Songbirds	OCWA	Orange-crowned Warbler	*Oreothlypis celata*	21	9	20	22	**72**
Songbirds	PAWR	Pacific Wren	*Troglodytes pacificus*	1		5		**6**
Songbirds	PISI	Pine Siskin	*Spinus pinus*	12	7	1	4	**24**
Songbirds	RBNU	Red-breasted Nuthatch	*Sitta canadensis*			4	2	**6**
Songbirds	RCKI	Ruby-crowned Kinglet	*Regulus calendula*	3		5	2	**10**
Songbirds	RECR	Red Crossbill	*Loxia curvirostra*	1				**1**
Songbirds	REVI	Red-eyed Vireo	*Vireo olivaceus*	4			3	**7**
Songbirds	SAVS	Savannah Sparrow	*Passerculus sandwichensis*	15	18	2	9	**44**
Songbirds	SOSP	Song Sparrow	*Melospiza melodia*	8		1		**9**
Songbirds	SWSP	Swamp Sparrow	*Melospiza georgiana*	6				**6**
Songbirds	SWTH	Swainson's Thrush	*Catharus ustulatus*	25	11	44	35	**115**
Songbirds	TEWA	Tennessee Warbler	*Oreothlypis peregrina*	10	4	7	8	**29**
Songbirds	TOWA	Townsend's Warbler	*Setophaga townsendi*	2				**2**
Songbirds	TRSW	Tree Swallow	*Tachycineta bicolor*			2	3	**5**
Songbirds	VATH	Varied Thrush	*Ixoreus naevius*				1	**1**
Songbirds	VESP	Vesper Sparrow	*Pooecetes gramineus*		2	2	5	**9**
Songbirds	WAVI	Warbling Vireo	*Vireo gilvus*	32	10	42	43	**127**
Songbirds	WETA	Western Tanager	*Piranga ludoviciana*	5		7	5	**17**
Songbirds	WIFL	Willow Flycatcher	*Empidonax traillii*	2			2	**4**
Songbirds	WIWA	Wilson's Warbler	*Cardellina pusilla*			2	1	**3**
Songbirds	WTSP	White-throated Sparrow	*Zonotrichia albicollis*	7		11	14	**32**
Songbirds	WWPE	Western Wood-Pewee	*Contopus sordidulus*	1			1	**2**
Songbirds	YBFL	Yellow-bellied Flycatcher	*Empidonax flaviventris*		2			**2**
Songbirds	YEWA	Yellow Warbler	*Setophaga petechia*	5				**5**
Songbirds	YRWA	Yellow-rumped Warbler	*Setophaga coronata*	9	1	28	7	**45**
Swifts and Hummingbirds	RUHU	Rufous Hummingbird	*Selasphorus rufus*	1		1		**2**
Swifts and Hummingbirds	VASW	Vaux's Swift	*Chaetura vauxi*	1				**1**
Waterfowl	CAGO	Canada Goose	*Branta canadensis*	1			5	**6**
Waterfowl	MALL	Mallard	*Anas platyrhynchos*	2				**2**
Waterfowl	SNGO	Snow Goose	*Chen caerulescens*				1	**1**
Waterfowl	TRUS	Trumpeter Swan	*Cygnus buccinator*				1	**1**
Woodpeckers	DOWO	Downy Woodpecker	*Picoides pubescens*	2				**2**
Woodpeckers	PIWO	Pileated Woodpecker	*Dryocopus pileatus*			1		**1**
Woodpeckers	RNSA	Red-naped Sapsucker	*Sphyrapicus nuchalis*			2	1	**3**
Grand Total				**338**	**110**	**339**	**347**	**1134**

Appendix 9-C: Taxon List for spiders (Araneae) identified to species-level. *Species codes used in ordination plots; **feeding guilds as per Uetz et al. (1999). Total abundance is not standardized by sampling effort

Family	Sci. Name	Auth.	SPP. CODE*	GUILD**	Grand Total
Amaurobiidae	*Cybaeopsis wabritaska*	(Leech)	Cyba.wabr	SF	2
Araneidae	*Cyclosa conica*	(Pallas)	Cycl.coni	OW	1
Clubionidae	*Clubiona canadensis*	(Emerton)	Club.cana	FR	10
	Clubiona kulczynskii	Lessert	Club.kulc	FR	17
	Clubiona norvegica	Strand	Club.norv	FR	2
Dictynidae	*Emblyna annulipes*	(Blackwall)	Embl.annu	SW	1
Gnaphosidae	*Callilepis pluto*	Banks	Call.plut	GR	6
	Drassodes neglectus	(Keyserling)	Dras.negl	GR	3
	Gnaphosa muscorum	(L. Koch)	Gnap.musc	GR	10
	Gnaphosa parvula	Banks	Gnap.parv	GR	7
	Haplodrassus hiemalis	(Emerton)	Hapl.hiem	GR	2
	Haplodrassus signifer	(C.L. Koch)	Hapl.sign	GR	13
	Micaria aenea	Thorell	Mica.aene	GR	22
	Micaria constricta	Emerton	Mica.cons	GR	1
	Micaria pulicaria	(Sundevall)	Mica.puli	GR	22
	Micaria rossica	Thorell	Mica.ross	GR	15
	Zelotes fratris	Chamberlin	Zelo.frat	GR	4
Hahniidae	*Cryphoeca exlineae*	Roth	Cryp.exli	SF	8
	Hahnia cinerea	Emerton	Hahn.cine	SF	8
	Neoantistea agilis	(Keyserling)	Neoa.agil	SF	19
Linyphiidae	*Agyneta lophophor*	(Chamberlin & Ivie)	Agyn.loph	WT	2
	Agyneta olivacea	(Emerton)	Agyn.oliv	WT	2
	Agyneta protrudens	(Chamberlin & Ivie)	Agyn.prot	WT	4
	Bathyphantes brevipes	(Emerton)	Bath.brev	WT	11
	Bathyphantes pallidus	(Banks)	Bath.pall	WT	35
	Ceraticelus fissiceps	(O. P.-Cambridge)	Cera.fiss	WT	15
	Ceratinella brunnea	Emerton	Cera.brun	WT	5
	Collinsia ksenia	(Crosby & Bishop)	Coll.ksen	WT	2
	Diplocentria bidentata	(Emerton)	Dipl.bide	WT	6
	Diplocentria rectangulata	(Emerton)	Dipl.rect	WT	2
	Dismodicus decemoculatus	(Emerton)	Dism.dece	WT	2
	Erigone blaesa	Crosby & Bishop	Erig.blae	WT	1
	Erigone dentigera	O. P.-Cambridge	Erig.dent	WT	12
	Gnathonarium taczanowskii	(O. P.-Cambridge)	Gnat.tacz	WT	19
	Grammonota angusta	Dondale	Gram.angu	WT	1
	Hypselistes florens	(O. P.-Cambridge)	Hyps.flor	WT	13
	Incestophantes mercedes	(Chamberlin & Ivie)	Ince.merc	WT	1
	Lepthyphantes alpinus	(Emerton)	Lept.alpi	WT	67
	Lepthyphantes intricatus	(Emerton)	Lept.intr	WT	6
	Lepthyphantes turbatrix	(O. P.-Cambridge)	Lept.turb	WT	1
	Mermessus trilobatus	(Emerton)	Merm.tril	WT	3
	Neriene digna	(Keyserling)	Neri.dign	WT	2
	Oedothorax alascensis	(Banks)	Oedo.alas	WT	3
	Oedothorax trilobatus	(Banks)	Oedo.tril	WT	6
	Oreonetides filicatus	(Crosby)	Oreo.fili	WT	8
	Pelecopsis mengei	(Simon)	Pele.meng	WT	4
	Pelecopsis sculpta	(Emerton)	Pele.scul	WT	5
	Pocadicnemis americana	Millidge	Poca.amer	WT	12
	Pocadicnemis pumila	(Blackwall)	Poca.pumi	WT	3
	Porrhomma convexum	(Westring)	Porr.conv	WT	1
	Saaristoa sammamish	(Levi & Levi)	Saar.samm	WT	6
	Sciastes truncatus	(Emerton)	Scia.trun	WT	7
	Scotinotylus pallidus	(Emerton)	Scot.pall	WT	1
	Scotinotylus sanctus	(Crosby)	Scot.sanc	WT	1
	Sisicottus montanus	(Emerton)	Sisi.mont	WT	6
	Sisicottus orites	(Chamberlin)	Sisi.orit	WT	2
	Spirembolus monticolens	(Chamberlin)	Spir.mont	WT	8
	Styloctetor stativus	(Simon)	Styl.stat	WT	5
	Symmigma minimum	(Emerton)	Symm.mini	WT	23
	Tapinocyba minuta	(Emerton)	Tapi.minu	WT	14

Family	Sci. Name	Auth.	SPP. CODE*	GUILD**	Grand Total
	Tenuiphantes zelatus	(Zorsch)	Tenu.zela	WT	**30**
	Tunagyna debilis	(Banks)	Tuna.debi	WT	**2**
	Walckenaeria atrotibialis	(O. P.-Cambridge)	Walc.atro	WT	**1**
	Walckenaeria directa	(O. P.-Cambridge)	Walc.dire	WT	**32**
	Walckenaeria exigua	Millidge	Walc.exig	WT	**42**
Liocranidae	*Agroeca ornata*	Banks	Agro.orna	GR	**6**
Lycosidae	*Alopecosa aculeata*	(Clerck)	Alop.acul	GR	**137**
	Pardosa fuscula	(Thorell)	Pard.fusc	GR	**100**
	Pardosa groenlandica	(Thorell)	Pard.groe	GR	**1**
	Pardosa mackenziana	(Keyserling)	Pard.mack	GR	**120**
	Pardosa moesta	Banks	Pard.moes	GR	**118**
	Pardosa wyuta	Gertsch	Pard.wyut	GR	**22**
	Pardosa xerampelina	(Keyserling)	Pard.xera	GR	**741**
	Pirata piraticus	(Clerck)	Pira.pira	GR	**44**
	Trochosa terricola	Thorell	Troc.terr	GR	**141**
Philodromidae	*Philodromus pernix*	Blackwall	Phil.pern	A	**1**
	Thanatus formicinus	(Clerck)	Than.form	A	**3**
Phrurolithidae	*Scotinella pugnata*	(Emerton)	Scot.pugn	GR	**5**
Salticidae	*Evarcha proszynskii*	Marusik & Logunov	Evar.pros	S	**4**
	Neon nelli	Peckham & Peckham	Neon.nell	S	**2**
	Pelegrina flavipes	(Peckham & Peckham)	Pele.flav	S	**1**
Tetragnathidae	*Pachygnatha clercki*	Sundevall	Pach.cler	OW	**17**
	Tetragnatha versicolor	Walckenaer	Tetr.vers	OW	**1**
Theridiidae	*Enoplognatha intrepida*	(Soerensen)	Enop.intr	SW	**1**
	Euryopis argentea	Emerton	Eury.arge	SW	**63**
	Robertus fuscus	(Banks)	Robe.fusc	SW	**3**
	Robertus vigerens	(Chamberlin & Ivie)	Robe.vige	SW	**4**
	Rugathodes sexpunctatus	(Emerton)	Ruga.sexp	SW	**1**
Thomisidae	*Xysticus benefactor*	Keyserling	Xyst.bene	A	**4**
	Xysticus britcheri	Gertsch	Xyst.brit	A	**1**
	Xysticus elegans	Keyserling	Xyst.eleg	A	**3**
	Xysticus ellipticus	Turnbull et al.	Xyst.elli	A	**13**
	Xysticus ferox	(Hentz)	Xyst.fero	A	**1**
	Xysticus luctuosus	(Blackwall)	Xyst.luct	A	**1**
	Xysticus obscurus	Collett	Xyst.obsc	A	**29**

**Spider guilds consisted of: A= Ambushers, FR= Foliage runners, GR= Ground runners, OW= Orb-weavers, S= Stalkers, SF= Sheet/funnel-weavers, SW= Space-web builders, and WT= Wandering-sheet/tangle-weavers

Appendix 9-D: Taxon List for beetles (Coleoptera) identified to species and morphospecies. *Species codes used in ordination plots. **Adventive status, where “x” = exotic species; flight ability, where “B” = reduced-wing species, “d” = wing-dimorphic species. Total abundance is not standardized by sampling effort

Sci. Name	Auth.	SPP. CODE*	Adventive /Flight**	Grand Total
Family CARABIDAE:				
Agonum consimile	(Gyllenhal, 1810)	Agon.cons		1
Agonum cupripenne	(Say, 1823)	Agon.cupr		7
Agonum metallescens	(LeConte, 1854)	Agon.meta		388
Agonum muelleri	(Herbst, 1784)	Agon.muel	[x]	7
Agonum placidum	(Say, 1823)	Agon.plac		1
Agonum retractum	LeConte, 1846	Agon.retr	[B]	80
Agonum sordens	Kirby, 1837	Agon.sord		2
Agonum thoreyi	Dejean, 1828	Agon.thor		6
Amara apricaria	(Paykull, 1790)	Amar.apri	[x]	1
Amara littoralis	Dejean, 1828	Amar.litt		12
Amara quenseli	(Schönherr, 1806)	Amar.quen		1
Bembidion incrematum	LeConte, 1860	Bemb.incr		172
Bembidion kuprianovii	Mannerheim, 1843	Bemb.kupr		4
Bembidion nigripes	(Kirby, 1837)	Bemb.nigr		71
Bembidion obscurellum	(Motschulsky, 1845)	Bemb.obsc		88
Bembidion planatum	(LeConte, 1847)	Bemb.plan		76
Bembidion quadrimaculatum	(LeConte, 1852)	Bemb.quad	[d]	9
Bembidion sp.1		Bemb.sp.1		1
Bembidion tetracolum	Say, 1823	Bemb.tetr	[x,d]	13
Blethisa hudsonica	Casey, 1924	Blet.huds		12
Blethisa quadricollis	Haldeman, 1847	Blet.quad		1
Bradycellus nigrinus	(Dejean, 1829)	Brad.nigr		1
Calathus advena	(LeConte, 1846)	Cala.adve		2
Calathus ingratus	Dejean, 1828	Cala.ingr	[d]	173
Carabus taedatus	LeConte, 1850	Cara.taed	[B]	8
Chlaenius niger	Randall, 1838	Chla.nige		1
Cicindela longilabris	Say, 1824	Cici.long		23
Cicindela tranquebarica	Herbst, 1806	Cici.tran		3
Cymindis cribricollis	Dejean, 1831	Cymi.crib	[d]	7
Dicheirotrichus cognatus	(Gyllenhal, 1827)	Dich.cogn		1
Elaphrus americanus	Dejean, 1831	Elap.amer		1
Elaphrus clairvillei	Kirby, 1837	Elap.clai		3
Harpalus affinis	(Schrank, 1781)	Harp.affi	[x]	10
Harpalus somnulentus	Dejean, 1829	Harp.somn		5
Harpalus sp.1		Harp.sp.1	[d]	18
Loricera decempunctata	Eschscholtz, 1833	Lori.dece		125
Loricera pilicornis	(Fabricius, 1775)	Lori.pili		11
Miscodera arctica	(Paykull, 1798)	Misc.arct		1
Nebria gebleri	Dejean, 1831	Nebr.gebl		1
Patrobus stygicus	Chaudoir, 1872	Patr.styg		4
Platynus decentis	(Say, 1823)	Plat.dece	[B]	9
Platynus mannerheimi	(Dejean, 1828)	Plat.mann	[B]	8
Pterostichus adstrictus	Eschscholtz, 1823	Pter.adst		126
Pterostichus herculaneus	Mannerheim, 1843	Pter.herc	[B]	19
Pterostichus melanarius	(Illiger, 1798)	Pter.mela	[x,d]	16
Pterostichus neobrunneus	Lindroth, 1966	Pter.neob	[B]	49
Pterostichus pensylvanicus	LeConte, 1873	Pter.pens		127
Pterostichus protractus	LeConte, 1860	Pter.prot	[B]	47
Pterostichus riparius	(Dejean, 1828)	Pter.ripa	[B]	63
Scaphinotus angusticollis	(Mannerheim, 1823)	Scap.angu	[B]	42

Sci. Name	Auth.	SPP. CODE*	Adventive /Flight**	Grand Total
Scaphinotus marginatus	(Fischer von Waldheim, 1820)	Scap.marg	[B]	44
Syntomus americanus	(Dejean, 1831)	Synt.amer	[d]	24
Synuchus impunctatus	(Say, 1823)	Synu.impu	[B]	4
Trechus chalybeus	Dejean, 1831	Trec.chal	[B]	5
Family STAPHYLINIDAE:				
Actiastes foveicollis	(LeConte, 1878)	Acti.fove		11
Anotylus nitidulus	(Gravenhorst, 1802)	Anot.niti	[x]	1
Anotylus sp.1		Anot.sp.1		1
Anthobium sp.1		Anth.sp.1		14
Bolitobius sp.1		Boli.sp.1		5
Carphacis nepigonensis	(Bernhauer, 1912)	Carp.nepi		20
Dinothenarus pleuralis	(LeConte, 1861)	Dino.pleu		65
Eusphalerum pothos	(Mannerheim, 1843)	Eusp.poth		64
Gabrius brevipennis	(Horn, 1884)	Gabr.brev		4
Gabrius picipennis	(Mäklin, 1852)	Gabr.pici		1
Gabrius shulli	(Hatch, 1957)	Gabr.shul		7
Gabrius sp.1		Gabr.sp.1		2
Gyrohypnus angustatus	Stephens, 1833	Gyro.angu	[x]	1
Heterothops conformis	Smetana, 1971	Hete.conf		43
Ischnosoma fimbriatum	Campbell, 1991	Isch.fimb		5
Ischnosoma pictum	(Horn, 1877)	Isch.pict		2
Ischnosoma splendidum	(Gravenhorst, 1806)	Isch.sple		13
Lordithon fungicola	Campbell, 1982	Lord.fung		69
Mycetoporus rugosus	Hatch, 1957	Myce.rugo		1
Mycetoporus sp.1		Myce.sp.1		1
Nitidotachinus tachyporoides	(Horn, 1877)	Niti.tach		2
Oxyporus occipitalis	Fauvel, 1864	Oxyp.occi		3
Paederus littorarius	Gravenhorst, 1806	Paed.litt		2
Philonthus aurulentus	Horn, 1884	Phil.auru		5
Philonthus carbonarius	(Gravenhorst, 1802)	Phil.carb	[x]	3
Philonthus cognatus	Stephens, 1832	Phil.cogn	[x]	18
Philonthus politus	(Linnaeus, 1758)	Phil.poli	[x]	4
Philonthus sp.1		Phil.sp.1		4
Proteinus sp.1		Prot.sp.1		7
Pycnoglypta campbelli	Gusarov, 1995	Pycn.camp	[B]	5
Quedius fulvicollis	(Stephens, 1833)	Qued.fulv		4
Quedius labradorensis	Smetana, 1965	Qued.labr		17
Quedius sp.1		Qued.sp.		2
Quedius velox	Smetana, 1971	Qued.velo		31
Reichenbachia sp.1		Reic.sp.1		2
Scaphium castanipes	Kirby, 1837	Scap.cast		7
Stenus assequens	Rey, 1884	Sten.asse		1
Stenus austini	Casey, 1884	Sten.aust		1
Stenus comma	LeConte, 1863	Sten.comm		6
Stenus immarginatus	Mäklin, 1853	Sten.imma		1
Stenus juno	(Paykull, 1789)	Sten.juno		10
Stenus mammops	Casey, 1884	Sten.mamm		2
Stenus sculptilis	Casey, 1884	Sten.scul		2
Stenus sp.1		Sten.sp.1		4
Stenus sp.2		Sten.sp.2		4
Stenus sp.3		Sten.sp.3		3
Tachinus basalis	Erichson, 1839	Tach.basa		4
Tachyporus borealis	Campbell, 1979	Tach.bore	[B]	14
Tachyporus nitidulus	(Fabricius, 1781)	Tach.niti	[B]	26
Tachyporus sp.1		Tach.sp.1	[B]	3
Tetartopeus niger	(LeConte, 1863)	Teta.nige		4
Trichophya pilicornis	(Gyllenhal, 1810)	Tric.pili	[x]	1

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Appendix 9-E: Total number of point count stations and surveys completed within each plot and the total number of species and observations detected within 75 m of those surveys. Richness and abundance estimates corrected for sampling effort are also shown.

Plot	No. PC Stations	No. PC Surveys	No. Spp	No. Obs	No. Spp / Survey	No. Obs / Survey
Control	14	40	36	166	0.90	4.15
Natural	4	12	10	27	0.83	2.25
Reference	15	45	25	178	0.56	3.96
Treatment	16	48	23	90	0.48	1.88
Overall Total	**49**	**145**	**48**	**461**	**0.33**	**3.18**

Appendix 9-F: Nest search effort (minutes) within each site and treatment combination

Plot	Site					Grand Total
	PS-N	PS-S	VP-N	VP-S	YJ	
Control	111	81	234		83	509
Reference	147	253	297	173	199	1069
Treatment	65	69	32	52	51	269
Peatland			218			218
Wetland			49			49
Grand Total	**323**	**403**	**830**	**225**	**333**	**2114**